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THE
ANATOMY OF VERTEBRATES.

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ON THE ANATOMY OF VERTEBRATES.

VOL. III.

MAMMALS.

BY

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ERRATA.

Page 26, four lines from bottom, *premise* '§ 197. *Muscles of Perissodactyla.*'
,, ,, thirteen lines from bottom, *for* '(*sterno-humeralis*),' *read* '(*cephalo-humeralis*).'
,, 49, note [1] *for* 'VI.,' *read* 'VI″.'
,, 72, note [3] *for* 'CXXXI′.,' *read* 'CXXXI.'
,, 81, note [5] *for* 'I.″.,' *read* 'XXIV″.'
,, 100, sixteen lines from top, *premise* 'A. *Lyencephala.*'
,, 120, fig. 95, *for* 'XXXIX″.,' *read* 'XXIX″.'
,, 129, note [1] *for* 'IX′.,' *read* 'IX″'.
,, 144, note [2] *for* 'LVIII′.,' *read* 'LVIII″.'
,, 206, to description of fig. 152, *add* 'Human.'
,, 212, note [1] *for* 'XCIII.,' *read* 'XCIII″.'
,, 251, note [1] *for* 'CV″.,' *read* 'CIX″.'
,, 255, below cut 20, *for* V″.,' *read* 'CV″.'
,, 266, note [1] *for* 'XXV″.,' *read* 'XXXIX″.'
,, 368, last line, *for* 'first true molar,' *read* 'first lower true molar.'
,, 412, note [1] *for* 'CXXII″.,' *read* 'CXXII′.'
,, 424, note [1] *for* 'CXXII″., XXIII.,' *read* 'CXXII′. vol. xiii.'
,, 427, five lines from top, *for* '§ 327,' *read* '§ 227;' and so on to '§ 399, p. 715,' *for which read* '§ 299.'
,, 428, ten lines from top, *for* 'fig. 359,' *read* 'fig. 389.'
,, 450, 'fig. 354,' *for* 'CXXII′.,' *read* 'CXXII″.'
,, 460, note [1] *for* 'CXXI.,' *read* 'CXXII′.'
,, 473, note [1] *for* 'CCXXII″.,' *read* 'CXXII′.
,, 479, note [2] *for* 'CXII″.,' *read* 'CXXII′.'
,, 515, note [5] *for* 'Ib.,' *read* 'CLXXIX″.'
,, 535, note [2] *for* 'XCVIII″.,' *read* 'XCVII′.'
,, 536, note [4] *for* 'CXCII″,' *read* 'XXXIV″.'
,, 542, note [1] *for* 'CXLIII″.,' *read* 'CXXXI″.'
,, 536, note [4] *for* 'CXCII″.,' *read* 'XXXIV″.'
,, 622, twelve lines from top, *for* 'fig. 489,' *read* 'fig. 489, *i.*'
,, 637, fourteen lines from bottom, for 'glossa,' *read* 'fossa.'
,, 718, *for* '§ 400,' *read* '§ 300;' and so on to '§ 428, p. 813,' *for which read* '§ 328.'
,, 790, nineteen lines from top, *for* '*Palæotheria*,' *read* '*Spalacotheria.*'

THE

ANATOMY OF VERTEBRATES.

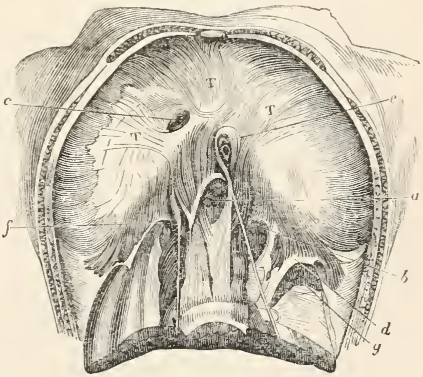
CHAPTER XXVII.

MUSCULAR SYSTEM OF MAMMALIA.

THE muscular tissue in the present as in the preceding Vertebrate classes presents the two conditions of striped and unstriped elementary fibres: the striped kind, comprising all the voluntary muscles with those of the heart, are red: deeper coloured in *Cetacea* and *Carnivora* than in *Ungulata*: deeper in the pectoral muscles of *Cheiroptera* than in those of the legs: paler in the pectorals and other muscles of the fore-legs of the Kangaroo than in the 'psoæ' and those of the hind-legs: palest in some *Rodentia*.

§ 192. *The Diaphragm.*—The chief characteristic of mammalian myology is the diaphragm, vol. ii., fig. 139, *d*, which, as such, is not more completely developed in Man than in the Monotreme. It is the partition between the thoracic and abdominal cavities, fig. 1, vaulted and convex toward the thorax, fig. 2, and consists of carneous and tendinous parts, the latter chiefly in the expanded or aponeurotic form. The carneous fasciculi are divided into the 'costal' or greater and the 'vertebral' or smaller muscles. The costal portions arise from the ensiform cartilage, and those of the eighth to the twelfth ribs, by fasciculi which interdigitate with those of the 'transversalis abdominis' muscle. They ascend and expand, arching and converging to be inserted into the external 'ligamentum arcuatum,'

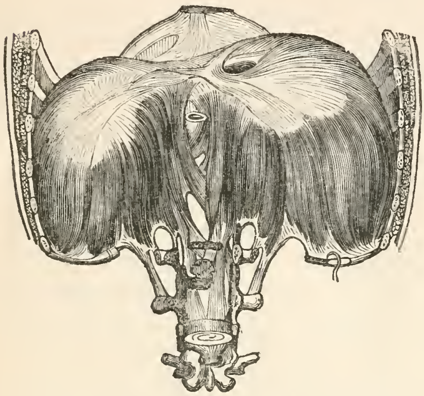
1



Human diaphragm ; abdominal surface.

fig. 1, *d*, and into the aponeurosis called 'centrum tendineum' or 'cordiform tendon,' ib., T. This centre is widely notched toward the spine, and divided anteriorly into three tracts, of which the right is usually the largest. Between the right and middle tracts is the orifice, *c*, for the inferior vena cava ('postcaval' of Mammals). Behind the tendon, and to the left of the median line, is the orifice, *e*, for the œsophagus and pneumogastric nerves: the aorta, *a*, passes from the chest to the abdomen between the 'crura' of the lesser muscle. The right 'crus' in Man arises from the three or four upper lumbar vertebræ; the left crus does not descend so low: both muscular bundles expand as they rise, decussate at the œsophageal opening, and are inserted into the posterior concavity of the central tendon and internal ligamentum arcuatum, fig. 1, *f*.

2



Human diaphragm. Thoracic surface from behind.

The diaphragm is most muscular, longest, and most oblique in Cetacea, in which the central tendon is almost obsolete: by rising so far back, it permits the proportional extension of the lungs, which in the Dugong and Manatee act as air-bladders. In the perissodactyle Ungulates, in which the moveable ribs are numerous and continued to near the pelvis, the diaphragm is also extensive, and much arched toward the thorax.

§ 193. *Muscles of Monotremata.*—To give an account of the muscular, as fully as that of the osseous, system of the Mammalia, would not be attended with the same advantages, even if a detailed myology comported with the scope and extent of the present work. This part of Mammalian anatomy will therefore be limited to the notice of a few select examples. Fig. 3, from Meckel,[1] shows the more remarkable muscles of the Ornithorhynchus. The animal is dissected from the ventral surface; the great 'panniculus carnosus,' 1, is reflected from the right side, and the deeper-seated muscles are shown on the left. The panniculus carnosus, which is remarkable for its thickness, encompasses nearly the whole body, adhering most firmly to the external skin, but separated from the subjacent muscles, especially where it covers the thorax, abdomen, the arm, and the thigh, by a copious and lax cellular tissue; and in the female, at the abdominal region, by the mammary glands. The fibres are chiefly longitudinal, but at the lower part of the neck become transverse. The obtuse posterior end of the muscle is attached by three or four fasciculi to the dorsal aspect of the caudal diapophyses. The legs and the arms protrude through oblique apertures in this muscular tunic; some of the anterior fasciculi are inserted by a short tendon into the pectoral ridge of the humerus; and others, still more anterior, are attached to the cranium, the lower jaw, and lower lip. A strip of fibres, which is cut off at 1*, is attached to the os hyoides; another fasciculus (1′) spreads over the cheek-pouch, F, and assists in emptying that receptacle of the food.

---

[1] LXXI.

The *trapezius*, 9, is divided into two muscles; the posterior portion is an oblong slender triangle arising by a broad tendon from the tenth and eleventh vertebræ and ribs, and inserted by a short strong tendon behind the extremity of the spine of the scapula; the anterior portion arises from the occiput and tendinous raphé connecting it with its fellow of the opposite side, and is inserted into the spine of the scapula, and into the outer half of the clavicle.

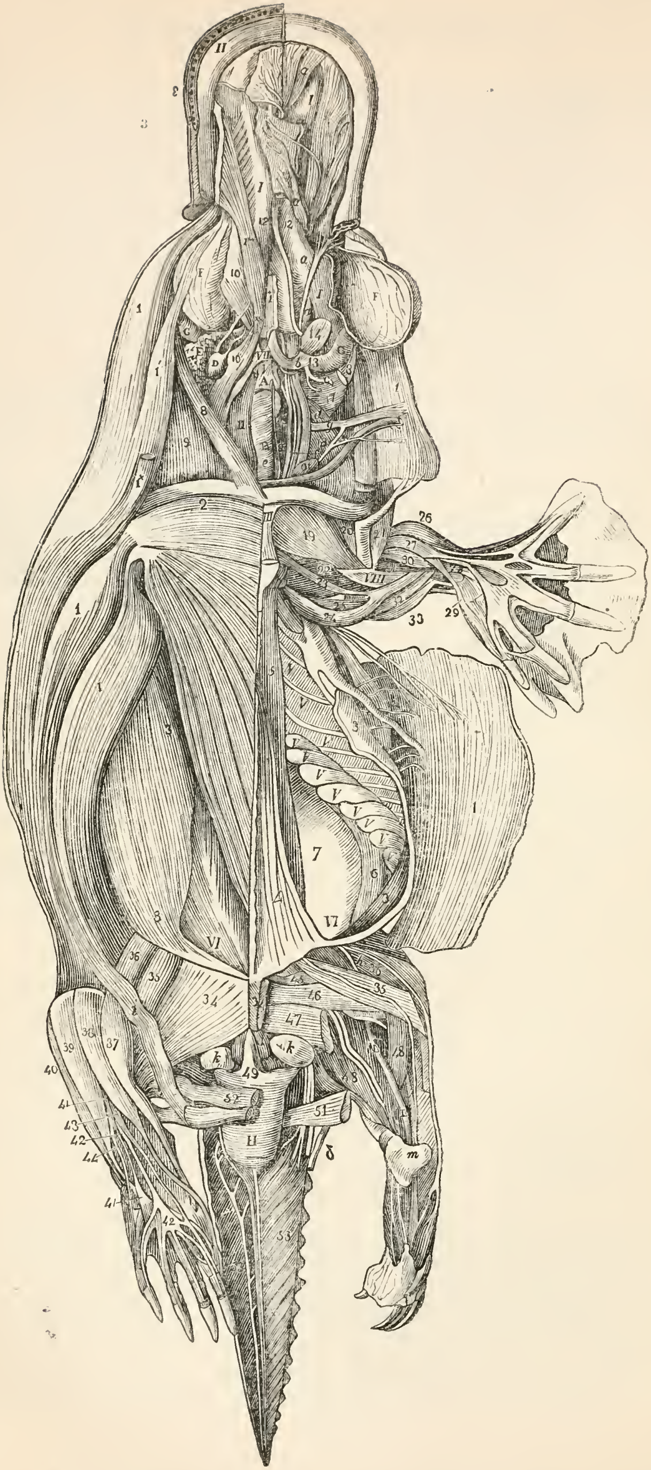
The *latissimus dorsi*, a very long and broad muscle, arises from the spines of all the dorsal and lumbar vertebræ and from the eleven posterior ribs; it is inserted by a broad and strong tendon into the distal half of the ulnar margin of the humerus, and, with part of the 'panniculus,' into the fascia attached to the olecranon and spreading over the fore-arm. At its anterior part this muscle may be separated into a superficial and deep stratum. The *rhomboideus* is a single muscle, but thick and long, inserted into the narrow base of the scapula.

The *splenius capitis* is united by an intermediate tendon with the opposite muscle, and is inserted into the mastoid process.

The *biventer cervicis* and the *complexus* are distinct throughout their whole course, which extends from the anterior dorsal and posterior cervical spines to the occiput; the complexus is the longest and thickest muscle, and divides into an external, shorter, and deeper-seated portion, and an internal, longer and superficial portion.

The *sacrolumbalis* arises from the dorsal extremity of the ilium, is attached to the ribs, over which it passes in its course to its insertion into the transverse processes of the four or five posterior cervical vertebræ: it is continued by the '*cervicalis ascendens*' to the atlas.

The *longissimus dorsi* is a much thicker and narrower muscle,


II
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44
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δ
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53

Muscular system, ventral aspect. *Ornithorhynchus paradoxus.* LXXXV and extends from the dorsal aspect of the sacrum along the spine to the third or fourth cervical vertebra. It is continued forward by the *transversalis cervicis* and *trachelo-mastoideus*, which are blended into a single oblong muscle arising from the anterior dorsal and inserted into the transverse processes of the six lower cervical vertebræ and the mastoid process.

The *sterno-mastoid* is a double muscle on both sides, one portion being superficial, 8, the other deep-seated; each arises separately from the episternum, and is separately inserted into the mastoid. The *omo-hyoideus*, 10, and *mylo-hyoideus*, 10, have a common insertion into the hyoid. A muscle, 1″, arising from the basi-hyal and expanding to be inserted into the lower lip, serves to retract this part. The *sterno-hyoideus*, 11, joins the *hyoglossus*. The *genio-hyoideus*, 12, and the *stylo-hyoideus*, 13, have the normal relations: the *biventer maxillæ*, 14, is a short thick muscle, inserted near the bend, representing the angle, of the jaw.

The caudal muscles are powerfully developed. The oblique fibres of the inferior or deflector muscles are shown at 53; they are removed on the other side to expose the anterior caudal nerves, *i*. The *obliquus externus abdominis*, 3, 3, arises from all the vertebral ribs, except the first, and from the dilated extremity of the ilium; it is inserted by a strong tendon into the outer extremity of the marsupial bone, VI, then expands into an aponeurosis which is attached to the internal margin and base of that bone, and into the symphysis pubis, decussating with the tendinous fibres of the opposite muscle: it does not split to form an 'abdominal ring.'

The *obliquus internus*, 6, arises from the anterior part of the ilium, expands, and is inserted into the broad cartilages of the seven posterior ribs, V, V.

The *transversus abdominis*, 7, is a thicker muscle, and arises from both the ilium and the lumbar diapophyses; its tendon passes behind the recti to blend with that of the opposite muscle, and with the aponeurosis of the *obliqui externi*, in the linea alba.

The *pyramidalis*, or superficial rectus, 4, is here, as in the ordinary Marsupials, of very large size; it arises from the whole inner margin of the marsupial bone; its fibres converge toward and are confluent at the linea alba with those of its fellow, and it gradually terminates in a point opposite the posterior part of the sternum. It depresses the ribs, shortens the abdomen, and protracts the marsupial bone.

The *rectus abdominis*, or posterior rectus, 5, arises from the posterior margin of the marsupial bone, and is inserted into the cartilage of the first rib, the manubrium sterni, and the coracoid bone.

The *diaphragm* presents the structure which is characteristic of the true mammiferous animal. The lesser muscle arises from the first lumbar and four last dorsal vertebræ, and expands to be inserted into the central tendon, which chiefly receives the fibres of the greater muscle arising from the cartilages of the eleven inferior pairs of ribs.

The *pectoralis*, 2, is of very striking dimensions; the origin of the superficial portion extends from the acromion and episternum, along the sternum and linea alba, almost to the pubis; a deeper-seated portion arises from the six osseous sternal ribs; the fibres of both portions converge to be inserted into the largely-developed pectoral or anterior crest of the proximal half of the humerus.

The *pectoralis minor* is attached to the coracoid, and the *subclavius* is likewise inserted, as in some other quadrupeds, into this bone, which is no longer a subordinate process of the scapula in the Monotremes.

The *subscapularis* is a narrow muscle, and narrower in reality than at first sight it appears to be, since the *supraspinatus*, from the inflection of the spine and acromion, arises from the same aspect of the scapula, and appears to form the anterior fasciculus of the *subscapularis*; its distinct insertion into the anterior tubercle of the head of the humerus points out its true nature.

The *infraspinatus*, 20, and the large *teres major* cover the whole external surface of the scapula.

The *deltoid* is divided into an anterior and a posterior portion. The anterior portion, 19, arises from the anterior extremity of the coracoid, and is inserted into the summit of the deltoid crest of the humerus: the posterior part, 21, arises from the anterior and superior apex of the scapula, and is inserted into the lower half of the deltoid crest. There are also two muscles to which the name *coraco-brachialis* may be applied, a superior one, 22, and an inferior one, 25.

The *biceps brachii* arises by two heads; one, 23, arises from the sternal extremity of the coracoid, the other, 24, also arises from the coracoid; the common tendon is inserted into the middle of the radius.

The other muscles of the anterior extremity adhere closely to the Mammalian type. The *extensor carpi radialis*, 30, sends three tendons, to be inserted respectively into the second, third, and fourth metacarpal bones. There is a single common *flexor digitorum*, as well as *extensor digitorum*, 27.

The *extensor digiti minimi*, 26, the *indicator*, 28, the *extensor* *pollicis*, 29, the *pronator teres*, 32, and the *flexor carpi radialis*, 33, are all remarkable for their strength in the Ornithorhynchus, and are still more powerfully developed in the Echidna.

The most remarkable muscle on the palmar aspect of the fore arm is the *flexor carpi ulnaris*, which arises by two separate heads, the longer one from the broad olecranon, the shorter one from the internal condyle of the humerus; the common tendon is attached to the os pisiforme and the metacarpals of the fourth and fifth digits.

The *psoas magna* and *iliacus internus* form a single muscle, having the usual origins, and inserted by a common tendon into the large internal trochanter.

The *psoas minor* is the largest of these muscles. It arises from the sides of five dorsal vertebræ, and its strong tendon is implanted in the remarkably developed ilio-pectineal process. It depresses the pelvis, and with it also the tail and the pelvic extremities.

The *ectogluteus* is larger than is usually the case with quadrupeds; its insertion extends to the plantar fascia and the bone which supports the spur. The *mesogluteus*, *entogluteus*, *pectineus*, 45, *biceps flexor cruris*, *gracilis*, 34, *sartorius*, 35, *rectus femoris*, 36, *adductores femoris*, 46, *semitendinosus*, 47, *semi-membranosus*, *vastus externus*, offer no notable deviations from the usual structure. A strip of fibres, 49, descends from the gracilis to the *sphincter cloacæ*, H. A muscle, called by Meckel 'flexor accessorius a caudâ ad tibiam tendens,' 51, arises from the transverse processes of the anterior caudal vertebræ, and converges to be inserted into the tibia. Another peculiar adductor of the leg, which might be termed 'intertibialis,' 52, is attached by its extremities to both tibiæ; its fleshy belly passes across the sphincter cloacæ, H, and is connected with a strip of the panniculus carnosus, *i*.

The *gastrocnemius*, 48, derives its largest origin from the produced and expanded head of the fibula, and its smaller belly from the internal femoral condyle; its tendon is implanted in the calcaneum. The homotopy between the *gastrocnemius* and *flexor carpi ulnaris* is strikingly illustrated in the Ornithorhynchus.

The *soleus* arises from the head of the fibula and from a large proportion of the tibia; it is nowhere blended with the gastrocnemius, but is inserted by a thick and short tendon into the astragalus.

The *abductors* of the outer digits of both the hand and foot are well developed for the purpose of expanding the web which connects the toes.

In the figure the following muscles of the leg are shown—viz. 37, *tibialis anticus*, 38, *extensor hallucis longus*, 39, *peroneus longus*, 40, *peroneus brevis,* 41, *extensor digitorum profundus,* 42, *extensor digitorum sublimis,* 43, a portion of the same muscle corresponding with the indicator of the fore leg, and 44, *extensor digiti quinti accessorius.*

§ 194. *Muscles of Marsupialia.*—The most common posture of the Kangaroo is often termed the 'erect;' yet the conditions of this posture are very different from those in the human subject. The trunk, instead of resting upright on two nearly vertical pillars, is here swung upon the femora as upon two springs, which descend from the knee-joints obliquely backward to their points of attachment at the pelvis; and the trunk is propped up behind by the long and powerful tail, vol. ii., fig. 211.

In Man the massive and expanded muscles which find their attachment in the broad bones of the pelvis, especially at the posterior part, are the chief powers in maintaining the erect posture. But in the Kangaroo the *glutæi* offer no corresponding predominance of size; the narrow prismatic ilia could not, in fact, afford them the requisite extent of fixed attachment.

The chief modifications of the muscular system in relation to the erect position of the trunk in the Kangaroo are met with on the anterior part of the base of the spinal column. The *psoæ parvæ,* for example, present proportions the reverse of those that suggested their name in human anatomy. They form two thick, long, rounded masses, which take their origin, fleshy, from the sides of the bodies and base of the diapophyses of the lower dorsal and all the six lumbar vertebræ, and from the extremities of the three last ribs; the fibres converge penniformwise to a strong, round, middle tendon, inserted in the well-marked tubercle or spine of the pubis, already noticed.

The abdominal muscles include a *pyramidalis* as remarkably developed as in the Monotremes. In the Phalanger, fig. 4, the *external oblique,* besides the usual origin by digitations from the ribs, also arises from the *fascia lumborum*; it is inserted fleshy into the summit of the marsupial bone, *a,* over which its strong inner tendon is spread: the external oblique becomes aponeurotic at a line continued from the marsupial bone outward, with a gentle curve, toward the anterior extremity of the ilium; and in the opposite direction, or inward, the carneous fibres of the external oblique terminate in an aponeurosis along a line parallel with the oblique outer margin of the pyramidalis; the fascia continued from the latter boundary of the fleshy fibres passes over, or dermad of, that muscle, and meets its fellow at the linea alba; it is homologous with the anterior layer of the sheath of the rectus in ordinary Mammalia. It is seen reflected from the pyramidalis, at *b*, fig. 4. The aponeurosis continued from the external and inferior boundary of the carneous fibres divides as usual into two distinct portions. One, *a*, corresponding to the internal or mesial pillar of the abdominal ring, spreads its glistening fibres, as above described, over the dermal surface of the marsupial bone, *c*, to which it closely adheres: the other column, *d*, contracts as it descends obliquely inward, forms, like 'Poupart's ligament,' the upper boundary of the space through which the psoas and iliacus muscles and femoral vessels and nerves escape from the pelvis, and is finally inserted, thick and strong, into the outer end of the base of the marsupial bone.

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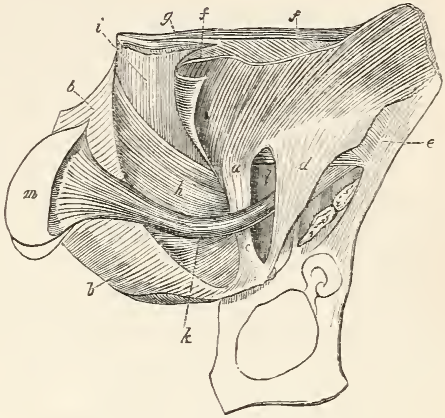

Abdominal muscles, *Phalangista vulpina*.

This bone is so connected with the pubis that its movements are almost limited to directions forward and backward, or those concerned with the dilatation and diminution of the abdominal space; the contraction of the abdominal muscles must draw the bones inward so as to compress the contents of the abdomen, and so far as the connections of the bone permit, which is to a very trifling degree, the external oblique may draw it outward toward the ilium. In some Marsupials, as the Koala, the triceps adductor femoris sends a slip of fibres to the external angle of the base of the marsupial bone, and would more directly tend to bend that bone outward.

The upper or anterior fibres of the *internal oblique* have the usual origin; the lower ones, *e*, arise fleshy from the outer and anterior spine of the ilium, and for an inch along an aponeurotic chord extended from that process to the upper part of the acetabulum: these carneous fibres pass inward and slightly upward, and terminate close to the outer margin of the rectus, where they adhere very strongly to the transversalis, but give off a separate sheet of thin aponeurosis which is lost in the cellular sheath of the posterior rectus.

The fleshy fibres of the *transversalis abdominis, f,* are closely connected by dense cellular tissue with those of the internal oblique; they are arranged in finer fasciculi, and have, as usual, a more transverse direction; they terminate along the same line as those of the internal oblique in an aponeurosis, *g,* which is continued along the inner or central surface of the posterior rectus to the median line. The lower boundary of the fleshy fibres of the transversalis is parallel with the line extended transversely between the anterior extremities of the ilia; a fascia, less compact than an aponeurosis, is continued downward from this margin, and envelopes the cremaster and the constituents of the spermatic chord, as they pass outward and forward beneath the lower edge of the internal oblique.

The *pyramidalis, h,* arises from the whole inner or mesial margin of the marsupial bone, from which the fibres diverge, the lower ones passing transversely across the interspace of the bones, and meeting at a very fine raphé, or linea alba; while those fibres from the anterior ends of the marsupial bones gradually exchange their transverse direction for one obliquely forward. The breadth of each pyramidalis opposite the upper end of the marsupial bone is more than an inch, the thickness of the muscle one line.

The *rectus abdominis, i,* comes off from the pubis along the inner part of the strong ligamentous union of the broad base of the marsupial bone, and expands as it ascends until it attains the level of the ensiform cartilage, when it diminishes as it is inserted into the sternal extremities of the ribs reaching to the manubrium sterni and first rib in the Dasyures, as in the placental Carnivores. The slight indications of tendinous intersections are confined to the posterior or central superficies of the muscle.

The *cremaster, k,* in the Phalanger and Opossum, is not a fasciculus of fibres simply detached from the lower margin of the internal oblique or transversalis, but arises by a narrow though strong aponeurosis from the ilium, within and a little above the lower boundary of the internal oblique, with the fibres of which the course of the cremaster is not parallel; it might be considered as a part of the transversalis, but it is separated by the fascia above mentioned from the carneous part of that muscle. Having emerged from beneath the margin of the internal oblique, the cremaster escapes by the large elliptic abdominal ring, *l,* bends round the marsupial bone near its free extremity, and expands upon the *tunica vaginalis testis.* In the female it has the same origin, course, and size, but spreads over the mammary glands at the back of the pouch. If the anterior fascicles of the diverging and embracing fibres be dissected from the posterior ones, the appearance of the cremaster dividing into two layers is produced.

The principal modifications of the muscles of the pectoral extremity are here described as they exist in the *Perameles lagotis*.

The *trapezius* has its origin extended from the skull, along the cervical and dorsal spines, to the fascia covering the lumbar portion of the latissimus dorsi: its fibres converge to be inserted along the spine of the scapula, the anterior ones being directly continued into the pectoralis major, whereby it becomes an extensor of the humerus and a protractor of the fore extremity.

The *latissimus dorsi* arises chiefly from the broad aponeurosis covering the muscles of the lumbar region of the spine, and from the spines of the six posterior dorsal vertebræ; the fibres gradually converge, the muscle increasing in thickness as it diminishes in breadth, and terminating in a strong flattened tendon one inch before its insertion at the upper third of the humerus. It is connected, as in most brutes, up to and including the Gorilla, with an accessory extensor (*omo-anconeus*)[1] of the antibrachium. This extensor takes its principal origin by fleshy fibres from the terminal half inch of the fleshy part of the latissimus dorsi, and continues fleshy, slightly diminishing in size to its insertion at the apex of the olecranon. To remedy the inconvenience of an origin from a yielding and flexible part, a thin aponeurotic slip, in *Perameles*, attaches a part of the base of the superadded muscle and the corresponding portion of the latissimus dorsi to the sheath of the teres major, and to the inferior costa of the scapula near its posterior angle. The *supraspinatus*, a strong penniform muscle, exceeds the *infraspinatus* in breadth by as much as the supra-spinal fossa is broader than the infra-spinal one: it has a broad and strong insertion into the great outer tuberosity of the humerus. The *infraspinatus* is inserted into the upper and posterior part of that tuberosity. The *deltoides* is a comparatively small muscle; it arises from the anterior half of the spine of the scapula and from a fine aponeurosis covering the infraspinatus; its fibres converge to be inserted in the upper part of the deltoid ridge. A thin small strip of muscle arises from about the middle of the inferior costa of the scapula, beneath the infraspinatus; its fibres pass forward and join the lower margin of the small deltoid, thus bracing and enclosing the tendon of the infraspinatus.

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[1] LXXX'. p. 289 (1846): the muscle is termed 'dorso-épitrochlien' by Duvernoy in the Gorilla, *i''*. p. 80 (1855), where it is inserted into the inner condyle of the humerus.

In claviculate marsupials the deltoid is larger, and consists of three fasciculi.

The *teres major* is a strong sub-compressed muscle arising from near the posterior half of the inferior costa of the scapula, and joining, as before stated, the tendon of the latissimus.

The *triceps extensor* has its long portion arising from the anterior third of the inferior costa of the scapula; its second head comes from the posterior part of the proximal third of the humerus; the third portion takes its origin from the whole of the posterior part of the humerus; in addition to these, the olecranon receives the above-described fourth superadded slip from the latissimus dorsi.

The *pectoralis major* is, as usual in the Marsupial and many higher quadrupeds, a complicated muscle; it consists of an anterior or superficial and a posterior or deeper portion; the anterior portion receives the strip of fibres before mentioned from the trapezius, there being no clavicle or clavicular ossicle interposed in the Perameles; its fibres converge, increasing in thickness as they diminish in breadth, and are inserted into the anterior and outer part of the strongly developed pectoral ridge. The second and main portion of the pectoralis arises from the whole extent of the sternum; its fibres are twisted obliquely across each other as they converge to be inserted into the inner part of the pectoral ridge; some of the internal and posterior fibres of this portion of the twisted pectoral pass obliquely upward and behind the anterior fasciculi, and are inserted into the coracoid process, thus representing the pectoralis minor. Beneath this latter portion of the pectoral, a long and slender muscle passes to be inserted into the anterior part of the tuberosity of the humerus; this may likewise be regarded as a dismemberment of the pectoralis major, but it arises from the fascia of the rectus abdominis, below the cartilages of the lower ribs. Thus the strong pectoral ridge of the humerus is acted upon by muscles having a range of origin from the occiput and cervical vertebræ along the whole extent of the chest to the beginning of the abdomen.

The *biceps* is a powerful muscle, although its short head from the coracoid process is suppressed. The long head has the usual origin and relation to the shoulder-joint; its tendon is very thick and short. The fleshy belly joins that of the strong brachialis internus, situated at the external side of the humerus, whence it takes its principal origin from the short deltoid ridge, closely connected there with the second portion of the triceps, and deriving some fleshy fibres from the lower and outer third of the humerus. The portion of the biceps arising by the long head soon resolves itself into two distinct penniform muscles; the tendon of the outer one joins that of the brachialis, and this conjoined tendon simply bends the fore-arm, while the inner tendon bends and pronates; the latter, which is a direct though partial continuation of the biceps, is inserted into the ordinary tubercle of the radius; whereas the outer tendon is attached to the fore part of the proximal end of the ulna. The muscles which arise from the internal condyle of the humerus are the *pronator teres,* which has the usual origin, insertion, and relative proportions, and next a large *palmaris longus.* There are, likewise distinct and strong fasciculi of muscles corresponding to the *flexores carpi ulnaris* and *radialis,* and to the *flexor sublimis digitorum.* The strong ridge continued from the olecranon to the posterior and inner part of the ulna gives origin to a great proportion of the oblique fibres of the *flexor profundus*; but both this and the *flexor sublimis* terminate in a single thick and strong tendon, which after passing the wrist divides into those corresponding with the perforating and perforated tendons concentrated, in *Perameles,* upon the three long middle fingers. The *pronator quadratus* runs the whole length of the interosseous space, passing from the radius a little obliquely downward to the ulna. The *supinator longus,* arising as usual from the upper part of the strongly developed ridge above the outer condyle, sends its tendon across the carpal joint, which tendon divides before it crosses, and is inserted by one of its divisions into the base of one of the metacarpal bones of the index finger, and by the other into the adjoining metacarpal bone.

These are the principal muscles of the fore extremity which require notice. Their modifications, in respect of number and strength, relate to the act of digging up the soil, which is habitual in the Bandicoots, as it is for the purpose of obtaining food, and not for shelter. It is for this purpose that the three middle digits of the hand are developed at the expense of the other two, which are rudimental; the whole power of the deep and superficial flexors is concentrated upon the fossorial and well-armed fingers; and, by the single common tendon in which the fleshy fibres of these muscles terminate, they move them collectively and simultaneously. Thus variety of application, and especially the prehensile faculty, are sacrificed to the acquisition of force for the essential action. In no Marsupial is the hand so cramped as in the *Perameles,* excepting in the *Chœropus,* where the functional and fossorial fingers are reduced from three to two. It is in relation to this condition, doubtless, that the clavicles are wanting in these genera, while all other Marsupials possess them. In these the biceps has the usual two origins: the flexor sublimis digitorum is distinct from the flexor profundus in *Didelphys.*

The muscles of the hinder extremity are chiefly remarkable in the Kangaroo for their prodigious strength and unusual number: the accessory muscle of the *biceps cruris,* e. g., arises from a caudal vertebra, and, with that from the ischium, forms two strong fasciculi, one inserted into the outer femoral condyle, the other into fascia covering the gastrocnemii. The pyriformis is also a double muscle. The *sartorius* has its insertion so modified that it becomes an extensor instead of a flexor of the tibia: it is chiefly fixed to the tibial side of the gristly patella, and by fascia into the capsular ligament of the knee-joint and the anterior proximal tuberosity of the tibia. In a Dasyure (*Das. macrurus*) I found that the sartorius had a similar disposition and office. In this ambulatory carnivorous Marsupial the *external* and *middle glutæi* are so disposed as to extend the thigh, while the *internal glutæus* inflects and rotates it inward. In a Bandicoot (*Perameles lagotis*) the *sartorius* ran nearly parallel with and dermad of the *rectus,* and was inserted into the upper part of the patella. Besides this sesamoid, which is rarely developed in other Marsupials, I found a thick cartilage attached to its upper part and interposed between the common tendon of the recti and vasti, removing that tendon further from the centre of motion, and increasing the power of the extensor muscles of the leg. The *rectus femoris* has its two origins very distinct, and its homotypy with the biceps of the upper extremity is obvious. The *gracilis* is a very thick and strong muscle. The *biceps flexor cruris* in the Perameles is a muscle of very great strength; it terminates in a strong and broad aponeurosis, which extends over the whole anterior part of the tibia, being attached to the rotular tuberosity of that bone, and terminating below in the sheath of the tendo Achillis, whereby this muscle becomes an extensor of the foot.

All the equipedal Marsupials, whether burrowers as the Wombat, climbers as the Koala, Phalangers, and Opossums, or simply gressorial, as the *Dasyuridæ,* have the tibia and fibula so connected together as to allow of a certain degree of rotation upon each other, analogous to the pronatory and supinatory movements of the bones of the antibrachium, and the muscles of the leg present corresponding modifications. None of the analogous carnivorous, pedimanous, or rodent Placentals present this condition of the hind leg. In the Kangaroo, the *gastrocnemii* almost rival those of Man in the bulk of the fleshy part.

In the *Dasyurus macrurus,* the *plantaris,* instead of rising from the femur, has its fixed point in the fibula, from the head to half-way down the bone, fleshy; its tendon passes obliquely inward, and glides behind the inner malleolus to its insertion in the plantar fascia, so that it rotates the tibia inward besides extending the foot. The *soleus* has an extensive origin from the proximal to near the distal end of the fibula. There are, as usual, three deep-seated muscles at the back of the leg. Of these three the muscle homologous with the *tibialis posticus* is readily recognised; its tendon glides behind the inner malleolus, and is inserted into the inner or tibial cuneiform bone.

The muscle which has the relative position and origins of the *flexor longus pollicis*, sends its tendon by the usual route to the sole of the foot, where it divides and distributes a flexor tendon to all the toes except the rudimental hallux; it has the same disposition in the Opossums, where the hinder thumb or great toe is fully developed: for this modification, however, the Comparative Anatomist is already prepared by meeting with such common office of the muscle in the first step from Man, viz. in the Orang, Gorilla, and Chimpanzee.

The third deep-seated muscle, being situated internal to the two preceding ones, may be the homologue of the *flexor digitorum communis longus*; it nevertheless sends no tendon to the toes nor even to the tarsus, but its fibres pass from the tibia obliquely outward and downward between the preceding muscle and the interosseous ligament to the fibula, where they are exclusively inserted so as to oppose the plantaris and rotate the foot outward. This muscle closely adheres to the interosseous fascia, and thus resembles in its

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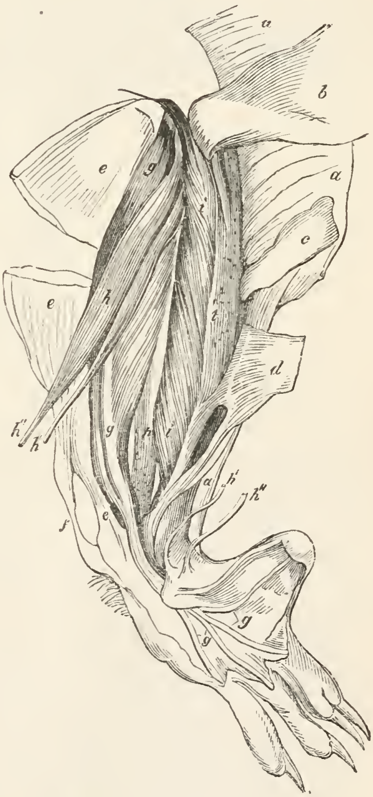

Muscles of leg, *Phalangista vulpina.*

attachments the pronator quadratus of the fore limb: it is most developed in the pedimanous climbing Marsupials, where the rotation of the foot is more frequent and extensive.

Fig. 5 shows this modification of the muscles of the hind-foot in the *Phalangista vulpina*; *a*, is the expanded tendon of the *sartorius*; *b*, *gracilis*; *c*, *semitendinosus*; and *d*, *semimembranosus*; both these muscles are inserted, as in many other quadrupeds, low down the tibia: *e*, *gastrocnemius*; *f*, *plantaris*; *g*, the homologue of the *flexor longus pollicis pedis*; *h*, *tibialis posticus*; this muscle divides and is inserted by two tendons, *h′* and *h″*, into the internal and middle cuneiform bones; *i*, the rotator muscle of the tibia.

In the muscles on the anterior part of the leg, the *extensor brevis digitorum* has its origin extended into this region, and is attached to the outside of the fibula. There are three *peronei*; the external one is inserted into the proximal end of the fifth metatarsal: the tendon of the middle peroneus crosses the sole in a groove of the cuboid like the peroneus longus: the internal peroneus is an extensor of the outer or fifth toe. The *Perameles lagotis*, among the saltatorial Marsupials, presents a different condition of the extensors of the foot from that above described. The *gastrocnemii*, *soleus*, and *plantaris* all arise above the knee-joint, and the tendon of the plantaris, after sheathing the tendo Achillis and traversing the long sole, is finally inserted into the base of the metatarsal bone of the fourth or largest toe; thus this muscle, which is strongly developed, bends both this toe and the knee, while it extends the foot.

In the Kangaroo the flexor of the toes rises from the outer tuberosity of the tibia, its fleshy part covers the back of the leg beneath the soleus, the tendon passes to the sole and divides into a large tendon for the principal toe, fig. 211, *iv*, a smaller tendon for the outer toe, *v*, and a still smaller tendon which goes to the two slender inner toes. The muscle seems to combine the homologues of the *flexor hallucis* and *flexor digitorum*, with, perhaps, also that of the *tibialis posticus*.

§ 195. *Muscles of Lissencephala.*—The *Rodentia* closely resemble the Marsupialia in their muscular system; with like modifications according to the absence or presence of clavicles, and to the gradatory, saltatory, scansorial, and fossorial movements of the species respectively. They have not the marsupial modifications of the cremaster and abdominal muscles, nor the rotatory muscle of the tibia; but certain Rodents show peculiarities of the masseter which will be noticed in connection with the organs of mastication.

The *Insectivora* afford examples of special muscular developement in the fore part of the trunk and pectoral limbs of the Mole, fig. 6, and in the muscles which act upon the prickly skin of the Hedgehog, figs. 7 and 8.

The dermal muscles are powerful and extensive in all Insectivora: in the Mole (*Talpa europæa*), fig. 6, the insertion of one of these is seen at *a*: it assists in retracting the trowel-like fore limb; and, when this is the fixed point, draws forward the pelvis and thigh. The muscles of the scapula are singularly developed and modified: the trapezius operates upon the short base of the elongate bone with great advantage. The anterior portion, *d*, arising from the occiput, derives further strength from the ossified 'nuchal ligament,' and is inserted at *e*: the part answering to the posterior fibres of the muscle, *f*, arises as far back as the lumbar vertebræ to be similarly inserted into the base of the scapula, antagonising the former. The '*splenius capitis*,' *h*, derives fibres from the nuchal style, as well as from certain dorsal and cervical vertebræ: it is inserted into the paroccipital region of the cranium. The *sterno-mastoid*, *g*, joined by a 'cleido-mastoid' from the cubical clavicle, is a very powerful muscle which expands to be inserted into the lateral part of the superoccipital and fascia covering the mandibular angle. The deltoid, *k*, coextensive with

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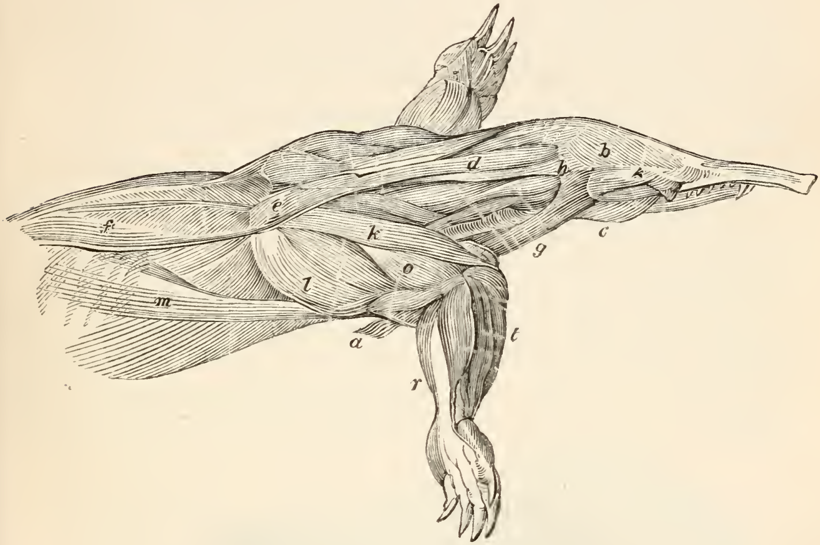

Muscles of the fore part and limbs of a Mole (*Talpa europæa*). XLIII.

the scapula, acts through its length with great power upon the well-developed humeral ridge. The 'teres major,' *l*, commencing at the thickened base of the scapula, and deriving fibres from the lower facet of that triedral bone, combines to be inserted into the humerus with part of the latissimus dorsi, *m*; a strip from which muscle is extended to the olecranon. The triceps, *o*, arising from both scapula and humerus, is extremely broad and thick, calling for an extended olecranon for adequate insertion. Part of the powerful flexors of the hand (*fl. digitorum*, *q*, *fl. carpi ulnaris*, *r*), and part of the extensors, *t*, are shown in this view. The pectoralis consists of five thick fasciculi, four of which rise from the sternum, and one from the clavicle: they converge to be implanted into the great humeral 'crista pectoralis:' to these is added a fasciculus of which the homologue may be traced in *Cetacea* and *Ungulata*, passing transversely from one insertion of the pectoral to the other, and serving to combine both trowels in vigorous fossorial action. Of the muscles of the jaws the 'temporalis' is shown at *b*, and the 'masseter' at *c*.

The Hedgehog (*Erinaceus*) manœuvres its armour of spines by means of powerfully developed and specially arranged cutaneous muscles. By putting any part of the integument on the stretch, the spines are erected, and their points held firm against the assailant: by the same act of stretching the skin, the proportion thereof to which the prickly armour is restricted can be drawn over the whole of the exposed surface of the animal, which in this act rolls and squeezes itself into the shape of a ball. In fig. 7, the Hedgehog is dissected as in the ordinary posture, or unrolled. The layer of muscle, *a*, *a′*, *a′*, consists of concentric fasciculi, thin over the middle of the back, *a*, and becoming thicker toward the periphery, *a′*, *a′*, which is well defined. All the

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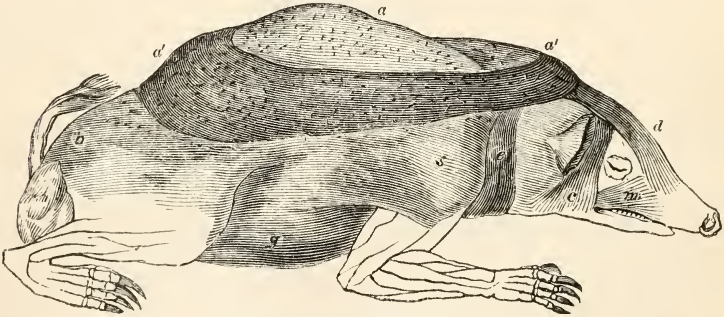

Dermal muscles of the Hedgehog. XLIII.

fibres are closely attached to the derm, and to the fibrous capsules of the roots of the spines. To the circumference of this circular muscle are attached shorter ones at right angles: a pair of these, *b*, arise from the caudal diapophyses, pass forward and expand to interblend with the posterior periphery: a second pair, *d*, with attachments to the nasal and premaxillary bones, pass backward over the forehead to the anterior periphery: a third pair, *e*, arising from the fore part of the sternum, pass forward and outward, diverging, and ascending in front of the shoulder to the antero-lateral part of *a*. A muscle, *c*, from fascia external to the mandibular angle, ascends between the auditory meatus and the eyeball, and combines with *d* in operating on the fore part of the great orbicular muscle.

When the Hedgehog assumes its offensively defensive position it bends and retracts the head and draws forward the pelvis, curving the back, as in fig. 8: the converging slips *b*, *c*, *d*, *e*, pull down the orbicular muscle, which relaxes to slip over the projecting parts: the peripheral part, *a′*, *a′*, having descended below these, contracts, and encloses the head, limbs, and body, in an orbicular form. In resuming the normal position the sphincter relaxes, the head is rotated forward, the pelvis and tail are drawn back, the limbs begin to extend themselves: the orbicularis, *a′*, *a′*, is pushed up beyond the meridian, and then contracts, disposing itself, after full extension of the parts beneath, upon the dorsum of the animal, as in fig. 7. Superficial sheets of muscle, extending from the shoulder joint backward, *s*, and over the abdominal region, *g*, concur with the above-described in the motions of rolling and unrolling the animal. One of the lateral muscles of the snout is shown at *m*, the masseter at *c*.

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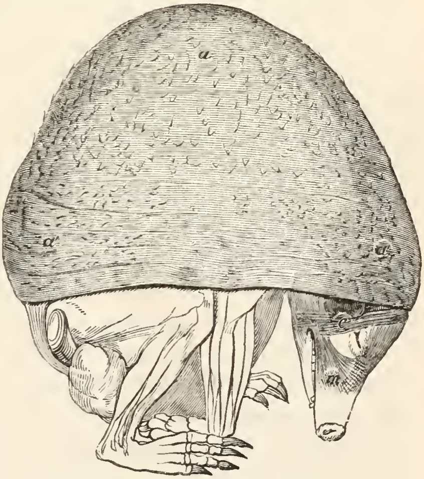

Orbicularis dermal muscle, Hedgehog, half unrolled.
XLIII.

In the order *Bruta* the most notable modifications of the muscular system are met with in the Anteaters.

On reflecting the skin from the under part of the head in *Myrmecophaga jubata*, there is seen a feeble developement of a panniculus carnosus in the form of thin transverse fasciculi occurring at intervals of from two to three inches, where they underlie the rami of the slender elongated under-jaw. These muscular strips (*dermogulares*) have their attachments exclusively in the integument, and aid in accommodating its movements to the alternating expansion and contraction of the great gular dilatation near the base of the tongue. The transverse fasciculi are crossed by a longitudinal strip of cutaneous muscle (*dermolabialis posticus*) on each side of the under part of the head and neck; the strip emerges from beneath the fore part of the great subpectoral gland; it diminishes in breadth and increases in thickness as it extends forward, assuming near the mouth the character of a muscle independent of the skin, where, passing beneath the tendon of the *retractor anguli oris*, it is inserted into, or blends with, the fibres of an accessory portion of the *orbicularis oris.*

A shorter longitudinal muscular strip (*dermolabialis anticus*) arises from the integument below the fore part of the preceding muscle, becomes free as it advances, and is inserted into the proper orbicularis oris.

The flattened and slightly separated fasciculi of the *dermo-abdominalis* arise from the fascia covering the anterior and inferior part of the sternum and contiguous sternal ribs; also from a median raphé of the subcutaneous fascia, attached to the linea alba, and extending two-thirds of the way towards the pubis. The anterior two-thirds of the above muscular sheet are joined by a broad layer of similar flattened fasciculi covering the side of the thorax, and the muscle so formed passes obliquely downward and outward, converging to form a thick fleshy band, about two inches broad, which is continued along the inner and upper part of the thigh, and becomes slightly twisted prior to its attachment to the aponeurosis covering the knee-joint.

The posterior portion of the *dermo-abdominalis* consists of thinner and more scattered flattened fasciculi which pass outward and downward, and, as they diverge from the median line, are lost in the subcutaneous fascia covering the tendinous expansion of the *obliquus externus abdominis.* Between the *dermo-abdominalis* and the proper abdominal muscles there is a moderately thick layer of elastic cellular tissue.

In the dissection of the head of the Great Anteater, three pairs of long and slender muscles are met with, which relate to the movements of the head.

The *sternocervicalis* arises from the upper and outer angle of the manubrium sterni, close to the inner (mesial) side of the sternomaxillaris, by a thin tendon, which soon becomes fleshy, and the slender muscle gradually contracts to be inserted into the fourth cervical vertebra.

The *sternomastoideus* arises from the outer angle of the manubrium sterni, by a tendon which, at one inch from its origin, becomes a fleshy flat muscle; this gradually increases in thickness to a rounded form, then contracts, and forms a tendon inserted into the paroccipital.

The *sternomaxillaris* arises from the inner side, near the upper and outer angle of the manubrium sterni, and from the manubrial fascia, central of the clavicular fascia, and of the origins of the sternomastoideus and sternocervicalis. Its origin is by a flat short tendon: an aponeurosis passes from one tendon to that of the fellow muscle. The fleshy part forms a long slender band, which passes forward, and, about four inches from its origin, sends off a slender fleshy strip to the ceratohyoideus. It then advances as a slender round fleshy muscle, which degenerates into a subcompressed tendon about half an inch in length, opposite the *compressor salivaris.* Resuming its fleshy structure, it forms an anterior subcompressed belly, ten inches in length, and from four to five lines in diameter. This gradually contracts, and terminates in a slender tendon three inches long, which expands to be inserted into the outer and under part of the maxillary ramus, six inches in advance of the angle of the jaw.

To the action of the pair of muscles so inserted is mainly due that characteristic movement of the head of the Great Anteater when it composes itself to sleep, and draws its head downward and backward between the fore-limbs, in contact with the chest. The mouth is small, and susceptible of so slight an opening as not to require for that action the usual modification of this part of the sterno-cleido-mastoideus muscle.

The proper muscles of the jaws consist of the temporalis, the masseter, and the pterygoidei. The chief peculiarities of the muscles in the present species relate to the unusual developement and movements of the tongue. The *mylohyoideus* is of unusual extent, and is divisible into different portions: two of these represent the normal mylohyoideus, and extend from the symphysis mandibulæ backward as far as the ascending ramus of the jaw. A third portion arises fleshy from the inner side of that ramus, whence its fasciculi radiate toward the middle line, in a somewhat twisted course, the anterior ones passing beneath the second or normal part of the mylonyoideus. The fourth portion at its anterior part arises from the angle of the jaw, then from the base of the cranium, and afterward from a strong fascia extended thence backward, between the post-cranial prolongations of the nose and mouth; the posterior and longest fasciculi come off more outwardly, and radiate to spread over and blend with the gular fasciculi of the sternoglossi, passing outward and downward, and then bending inward to envelope that part of the hyoid apparatus. All the fibres of the fourth portion terminate in a median raphé, which is less marked than in the anterior portion. The fibres of the posterior division of the mylohyoideus, especially those which are attached to the under surface of the posteriorly prolonged nasal canal, form a kind of muscular sheath for the basal part of the muscles of the tongue.

The *cerato-hyoideus* arises from the cerato-hyal: its fibres converge and form a fasciculus which is inserted into the commissural tendon of the genio-hyoid, and is connected with a strip from the *sternomaxillaris.* After giving attachment to the foregoing two muscles, and to the anterior constrictor of the pharynx, its extremity is attached to the *stylo-hyoideus* muscle.

In most mammals the hyoid arch, by the length of the ossified part of the stylohyal and the extent of the ossification of the ceratohyal is almost restricted to hinge-movements forward and backward upon the proximal joints of the stylohyals as a fixed point; so that the basihyal with the tongue cannot be very far protruded or retracted. In the *Myrmecophaga jubata* the usual place of the stylohyal is occupied by a long and slender muscle, the *stylohyoideus,* which arises from the petromastoid, and after a course of five inches is inserted into the ceratohyal, here the first bone of the hyoid arch. Supposing the stylohyoideus to contract one-third of its length, it would protract the hyoid arch to the same extent: in which act it combines with the geniohyoideus. The retraction of the hyoid arch is provided for by the sternothyroidic and their continuations, the thyrohyoidei.

The *geniohyoideus* arises by a single tendon from the symphysis of the jaw, runs back beneath the raphé of the anterior mylohyoideus, slightly expands beneath the raphé of the middle mylohyoideus, then again contracts and again expands, and at about ten inches from its origin becomes diffused into fleshy fibres, which gradually acquire a breadth of six lines, continue back in close connection with the mylohyoideus to the commissural tendon, and there expand, the lateral borders being attached thereto. Here a mid-line of separation appears, and the muscle bifurcates into two flat fasciculi, which are inserted into the angles of the basihyal.

The *sternothyroidei*, fig. 9, *p*, *p*, come off from the sixth, seventh, and eighth sternal bones, and from the seventh and eighth sternal ribs near their articulations therewith. The interthoracic extent of these muscles is six inches. Behind the manubrium the left muscle sends off a small fasciculus of fibres to the right one, and the right reciprocally to the left. Where the decussation takes place there is a tendinous intersection at the fore part of the muscle. In advance of the interchange of fasciculi the sternothyroidei diverge and emerge from the chest, beyond which cavity they are fleshy throughout their extent, and are inserted into the lower and fore part of the thyroid cartilage.

Sternoglossus, ib. *g*, *i*. This remarkable muscle arises fleshy from the lateral border of the dilated xiphoid and last sternal bone, and from its junction with the last two true ribs. Linear tendinous intersections mark the part of the muscle within the chest. Emerging from beneath the manubrium, it advances as a flat fleshy muscle. Opposite the hyoid it is perforated by a lingual artery, between four and five inches in advance it is perforated by the lingual nerve, *h*, and here its inferior stratum is resolved into flattened fasciculi of fibres which decussate or combine with those of the opposite muscle. About six inches in advance of the basihyal these fasciculi spread over a dilated membranous portion of the buccal cavity, at the lower part

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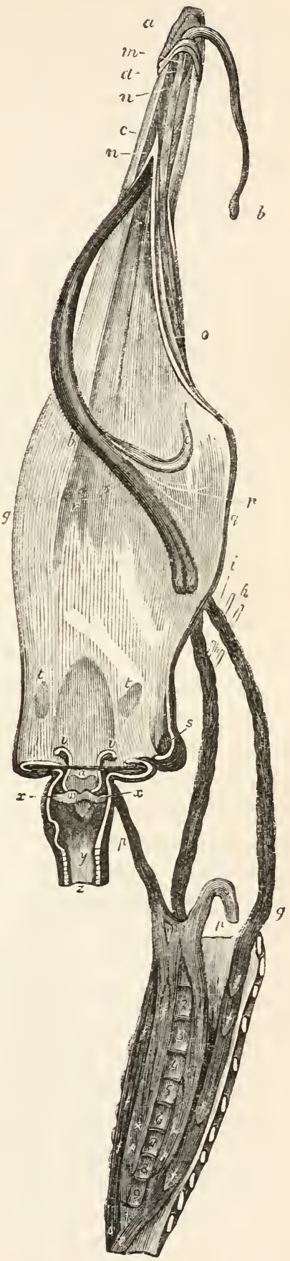

Muscles of Tongue, Great Anteater.

of which the base of the tongue is situated, and here they converge and blend with corresponding flattened fasciculi, sent off from the lower part of the genioglossi, as these pass backward to the base of the tongue. The main continuation of the sternoglossus, *i*, forms a rounded slender muscle, which raises the buccal membrane so as to form the back part of the frænum linguæ, penetrates the back part of the base of the tongue, and constitutes a great proportion of its substance.

The *genioglossus*, ib. *m*, *n*, *o*, has a complex origin, by a middle portion, from the short symphysis mandibulæ, and by a flattened penniform series of fibres, form the lower border of the mandibular rami for the extent of four inches behind the symphysis. The symphysial origin is round and slender, and belongs more directly to the proper tongue-muscle: the ramal origins seem to be the more special fixed point of the subgular fasciculi. The fibres of the latter origin pass obliquely backward and inward, converging to a middle raphé, to which the symphysial origin closely adheres. The two origins of the muscle are blended into one for about three inches beyond the point of attachment, in which extent the muscle forms a moderately thick depressed mass along the middle of the under part of the mouth. It then begins to expand, and to detach from its under surface those subgular fasciculi, which diverge and unite with the corresponding dismemberments of the sternoglossi. The main part of the genioglossus enters, as a single muscle, the fore part of the base of the tongue, carrying into the floor of the mouth a fold of buccal membrane forming the fore part of the frænum linguæ.

Beneath the insertions of the geniohyoidei, a pair of more slender muscles, *epihyoglossi*, come off from the median ends of the epihyals. These muscles, after a brief course, expand into a thin layer, resolve themselves into separate fasciculi, and combine an inch in advance of their origin to form a layer about eight lines in breadth below the middle line of the post-lingual part of the mouth, which layer slightly diminishes in size as it approaches the commissure of the sternoglossi, and, with them, penetrates the back part of the frænum linguæ.

§ 196. *Müscles of Cetacea.*—In the *Cetacea* the muscles of the trunk are chiefly developed: those of the limbs are restricted to the pectoral pair. Swimming is the principal mode of progression in the muticate orders of *Gyrencephala*: but the phytophagous *Sirenia* have the power, in order to feed upon marine or littoral plants, of crawling at the bottom of the sea and shuffling along the shore by means or aid of their anterior members, which in the true Cetacea are exclusively natatory organs.

The head, in these, has so little mobility, that its axis can be but slightly altered, without that of the body altering also. With bones so short, so little mobile, and extensively co-adapted or anchylosed, as the vertebræ of the neck, muscles proportionately reduced should correspond. The cervical muscles are, nevertheless, much the same in number as in other Mammals; but their shortness and thinness, principally in those attached to the atlas and the axis, are extreme. The homologue of the 'splenius capitis,' fig. 10, *h*, is the best developed: it comes off from the anterior dorsal and cervical series of neural spines, and its fibres converge to be inserted into the paroccipital ridge.

The muscles of the back present no other important modifications than their great developement, especially where they are prolonged upon the caudal vertebræ. Thus the *longissimus dorsi* and the *sacro-lumbalis* are attached anteriorly to the skull, and posteriorly transmit their tendons, the first to the end of the tail, the second to all the transverse processes of this part of the spine, associating its movements, especially in the vertical direction, with those of the back. The *levator caudæ* takes its rise above the five or six dorsal vertebræ, under the *longissimus dorsi*, and often in this part blends with it; it then extends freely as far as the extremity of the tail, where the two muscles unite together again by their tendons. They are opposed by a *depressor caudæ*, of great thickness, which proceeds from the thoracic region, attached by tendinous slips to the ribs and the contiguous transverse processes; it is inserted into the hæmal arches of the tail. A muscle passes from the rudimental bones of the pelvis to the hæmapophyses of the anterior portion of the tail. The great *recti abdominis* and *obliqui ascendentes* muscles are continued backward from the abdomen, and attach themselves behind to the sides of the anterior caudal vertebræ. By this aggregation of muscles the tail of the Cetacea expands to proportions of the trunk, and acquires the prodigious strength which it possesses for propelling the most gigantic of the species, with ease and swiftness, through the water; and, by means of the horizontal expansion of the caudal fin, it enables them to readily ascend to the surface to respire and again seek protection in the deep abysses of the ocean.

In the great pectoral muscle, part of which is shown in fig. 10, at *g*, the costal origin is extensive, and the portion which comes off from the short sternum, passing transversely each to its own humerus, closely resembles the transverse connecting fasciculus in the Mole.

The muscle answering to 'levator scapulæ,' *b*, rises from the paroccipital, as well as from the cervical diapophyses: it expands to be inserted into the fore and upper angle of the scapula and the fascia covering the 'infraspinatus:' it is a protractor, or forward rotator, of the scapula. The 'rhomboideus,' *a*, is the raiser of the blade-bone. Two strong muscles attached to the paroccipital and mastoid, pass, one, *e*, to the sternum (sternomastoideus), the other to the humeral tuberosity (sterno-humeralis). The 'latissimus dorsi,' *f*, is short and slender, coming off by a few digitations from the ribs, and inserted into the humerus and by an extended aponeurosis into the olecranon. The 'supraspinatus' is small: it is covered by the 'deltoid,' *i*. The 'infraspinatus,' *c*, is a broad and thin sheet of muscle. Behind it is a 'teres major,' *k*, also of broad and flat form; and a thick and narrow 'teres minor,' *l*. The 'serratus magnus' does not extend forward beyond the ribs of the dorsal vertebræ.

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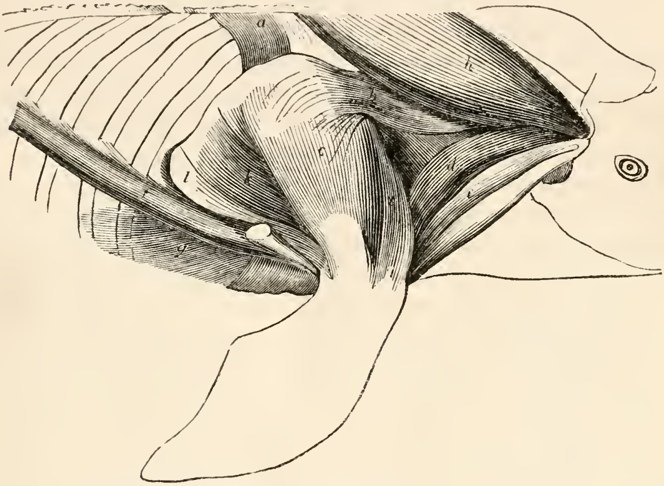

Muscles of pectoral fin, *Delphinus*.

In the Ungulate series the muscular system has been traced out in both Perisso- and Artio-dactyle species, but most completely in the Horse, figs. 11–13. In this sensitive quadruped the dermal muscles are well developed, enabling it to shake the whole skin, rattling the harness which may be attached thereto, and to vibrate particular portions on which an insect or other irritant may have alighted. This 'panniculus carnosus' is thick upon the neck, whence it passes downward, becoming 'aponeurotic' upon the fore-limb: the sheets upon the sides and fore part of the trunk send a flat tendon to be inserted, with that of the latissimus dorsi, into the humerus: and other fasciculi pass downward over the muscles of the antibrachium, and terminate in a fascial expansion over the carpo-metacarpal segment. The posterior part of the panniculus spreads over the loins, and, descending, degenerates into an aponeurosis, which forms, in the male, a sheath for the penis: the hinder portion encases the rump and thigh in a strong carneo-aponeurotic covering, which accompanies the fascia lata to the hind leg. On removing the panniculus carnosus, the superficial proper

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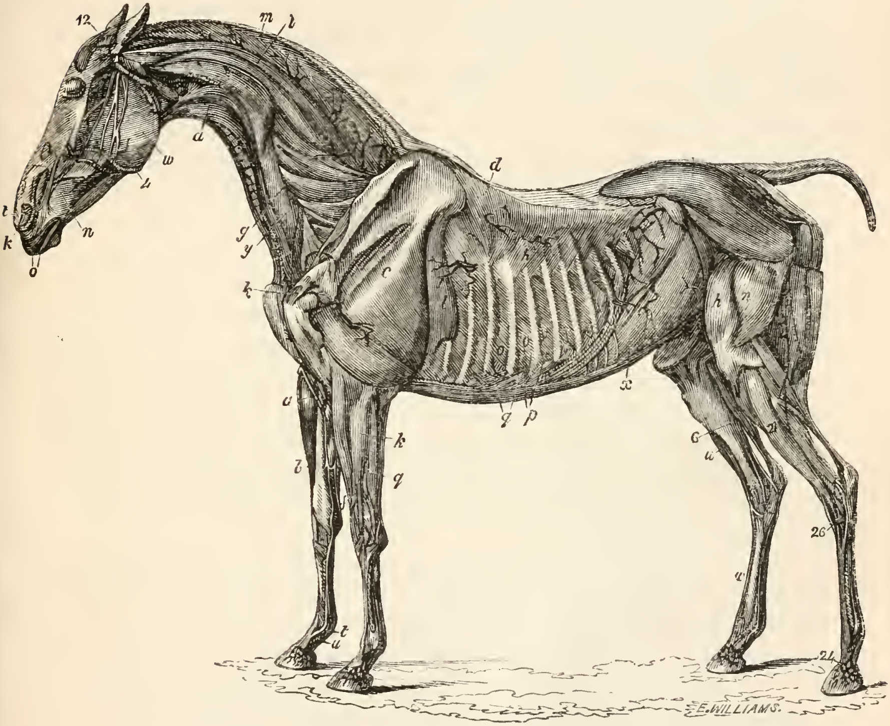

Myology of the Horse. 11''.

muscles of the trunk and limbs are exposed, as in the side view, fig. 11.

The 'spinalis dorsi' repeats closely the characters of that muscle in Man. Its continuation, the 'spinalis cervicis,' is in the Horse of great strength and importance: its origin commences from the second dorsal spine, which origin is continued for about one-third of the way down that spine toward its root: it arises likewise from the third dorsal spine and the ligamentum nuchæ; from these origins it runs forward to be implanted by strong and distinct tendons into the spines of the anterior cervical vertebræ.

The 'longissimus dorsi' is situated immediately external to the spinalis, taking its origin from the common mass of muscle that arises beneath the lumbar fascia, as well as from the spinous processes of the loins and sacrum, whence it runs forward to be inserted by a double set of tendons into the transverse processes of the loins and back, and also into the posterior ribs near their angles. Its continuation, the 'transversalis colli,' consists of very powerful fasciculi, inserted respectively into the diapophysial parts of the last five cervical vertebræ.

The 'sacro-lumbalis' arises, in conjunction with the latissimus dorsi, from the back of the sacrum, and also by flat tendons from all the ribs, except two or three of the most anterior; and its slips are inserted by as many distinct tendons into the inferior edge of all the ribs, except two or three of the hindmost, and also into the transverse process of the seventh cervical vertebra. The continuation of this muscle, the 'cervicalis ascendens,' is chiefly remarkable for the strength of its tendinous insertions into the middle vertebræ of the neck.

The 'multifidus spinæ,' in the dorsal region, arises by numerous tendons from the metapophyses of the sacral, lumbar, and dorsal vertebræ; each slip running forward to be inserted into the neural spine of the vertebra in front of that from which it derives its origin, the whole forming a thick mass, which fills up the hollow situated between the spinous and transverse processes. In the neck a similar disposition exists.

Besides the 'intertransversarii colli,' there is a series of muscles arising from the prezygapophyses of the first dorsal and five last cervical vertebræ, and inserted, severally, into the side of the centrum in advance: they are called by Stubbs 'intervertebrales.'[1]

The 'longus colli' arises from the transverse processes of the third, fourth, fifth, and sixth vertebræ of the neck, from which origins it runs upward to be inserted by distinct tendons into the

[1] ii.

anterior part of the bodies and transverse processes of the vertebræ above them, and into the anterior surface of the atlas.

The muscles which raise or straighten the tail are the following:—

The 'sacro-coccygeus superior' arises from the third and succeeding sacral spines, and from those of the anterior caudal vertebræ. The fleshy mass formed from these origins gives off numerous slender tendons: the first of these is the shortest, and runs inward to be inserted into the base of the first caudal vertebra, in which the articular apophyses are wanting. The second tendon is inserted in a similar manner into the succeeding vertebra; the third into the next, and so on to the end of the tail. Each tendon is lodged in a sort of ligamentous canal, which forms a sheath for it throughout its whole course. When these two muscles act in concert the tail is raised.

The 'interspinales superiores' form a continuation of the interspinous series of vertebral muscles; but as the spinous processes of the tail are short, and soon replaced by tubercular rudiments of the neurapophyses, these muscles are here disposed obliquely, being more widely separated posteriorly than they are in front.

The muscles which depress the tail all take their origin in the interior of the pelvis, and are prolonged to a greater or less extent along the inferior aspect of the tail. They form four pairs of series of muscles, called the 'ileo-coccygei,' and 'sacro-coccygei inferiores;' the latter are the more direct antagonists of the sacro-coccygei superiores, and their tendons are received into sheaths resembling those upon the upper surface of the tail, and are inserted successively into the base of each caudal vertebra, beginning about the seventh.

The muscles adapted to move the tail laterally are arranged in two sets; the 'ischio-coccygei externi,' a few fibres of which, in the Horse, are connected with the termination of the rectum and the 'intertransversales.'

The muscles derived from the vertebral column which serve immediately for the movements of the cranium have nearly the same origins as in the human subject, but are comparatively of much greater strength, owing to the inclined position of the head with respect to that column. They may be divided into such as proceed, 1st, from the atlas; 2nd, from the axis; and, 3rd, from the posterior cervical vertebræ and ligamentum nuchæ. To the first set belong

The 'rectus posticus minor,' 'rectus anticus,' 'rectus lateralis,' and 'obliquus superior.'

The muscles derived from the axis are the 'rectus posticus major' and the 'obliquus inferior.'

The 'complexus' commences from the prezygapophyses of the third cervical vertebra, continues its origin from all those of the neck below that point, as well as from those of the first dorsal: also by a strong tendon from the transverse processes of the second and third dorsal vertebræ: from these origins it runs forward to be inserted by a strong round tendon into the super-occipital close to its fellow of the opposite side: in this course it is connected by numerous tendinous processes with the ligamentum nuchæ.

The 'trachelo-mastoideus' arises from the oblique processes of the third, fourth, fifth, sixth, and seventh cervical and first dorsal vertebræ, and from the transverse processes of the second and third vertebræ of the back; it runs forward external to the last-mentioned muscles to be inserted by a strong tendon into the paroccipital. The above muscles are overlapped by the 'splenius capitis,' which, arising by strong tendinous processes from the spinous processes of the two superior dorsal and two last cervical, and also extensively from the ligamentum nuchæ, runs forward to be inserted into the transverse processes of the fifth, fourth, and third cervical vertebræ, and into the transverse ridge of the super-occipital.

The muscles of the ribs and sternum present, in the Horse, a disposition little differing from that of the corresponding muscles in Man: they are the 'scaleni,' the 'intercostals,' the 'levatores costarum,' the 'serratus posticus,' *d*, and 'serratus anticus,' *l*, and the 'triangularis sterni,' the two latter of which must be regarded as depressors of the ribs, and consequently acting the part of muscles of expiration.

The walls of the abdomen are composed of five pairs of muscles, to which the same names are applicable as are bestowed upon them by the anthropotomist; but the rectus abdominis is much more extensively developed. Arising from the os pubis, it passes forward enclosed in its usual sheath to be inserted into the ensiform cartilage and into the cartilaginous terminations of the third, fourth, fifth, sixth, seventh, eighth, and ninth ribs, and also into the sternum between the cartilages of the third and fourth ribs. There are even fleshy fibres derived from this muscle prolonged as far forward as the articulation between the first rib and the sternum.

Muscles of the anterior extremity. The 'trapezius' consists of that part only which is called the ascending portion in the human subject, and which is inserted into the posterior margin of the spine of the scapula. The 'sterno-mastoid' is present, but the 'levator anguli scapulæ,' the cleido-mastoid, and the clavicular portions of the trapezius and deltoid are all replaced by the muscular expansion which, taking its origin from the paroccipital and from the transverse processes of some of the superior cervical vertebræ, passes downward in front of the head of the humerus and descends along the inner surface of the fore-arm, into which it is ultimately inserted.

The 'trachelo-acromialis' arises from the transverse process of the atlas and of the four following cervical vertebræ, descends toward the shoulder-joint, making its appearance externally between the two divisions of the trapezius, which it separates; it then spreads out over the acromial portion of the scapula, and descends as far as the middle of the humerus. This muscle draws the shoulder upward and forward in the Tapir, and is implanted into the aponeurosis which covers the deltoid: while, in the Horse, it has its insertion into the middle portion of the humerus by two aponeurotic tendons, which embrace the brachialis internus muscle.

The 'serratus major anticus' arises from the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ, and also from the external surfaces of the six superior ribs: its origins extending as far backward as the insertion of the tendons of the sacro-lumbalis: from this extensive origin it passes backward around the chest to be implanted into the base of the scapula, its insertion occupying nearly half of the internal surface of that bone. It forms, with its fellow on the opposite side, a kind of sling, by which the trunk is suspended.

The 'pectoralis minor' is represented by a muscle, which, arising from the sternum and from the first, second, third, and fourth ribs near their sternal terminations, runs upward and backward to be inserted into the superior costa of the scapula near the base of that bone; it also contracts tendinous attachments with the aponeurotic covering of the teres minor and other scapular muscles.

The 'rhomboideus' arises entirely from the ligamentum nuchæ, and from the spines of the anterior dorsal vertebræ, whence it runs outward to be affixed to the base of the scapula.

The 'omo-hyoideus' is represented by a strong muscular fasciculus, from the coracoid tubercle.

The 'sterno-mastoideus,' or sterno-maxillaris, arises from the anterior end of the sternum, and, running forward strong and fleshy, is inserted by a flat tendon into the inferior maxilla underneath the parotid gland, sending, however, another tendon to be implanted into the root of the paroccipital.

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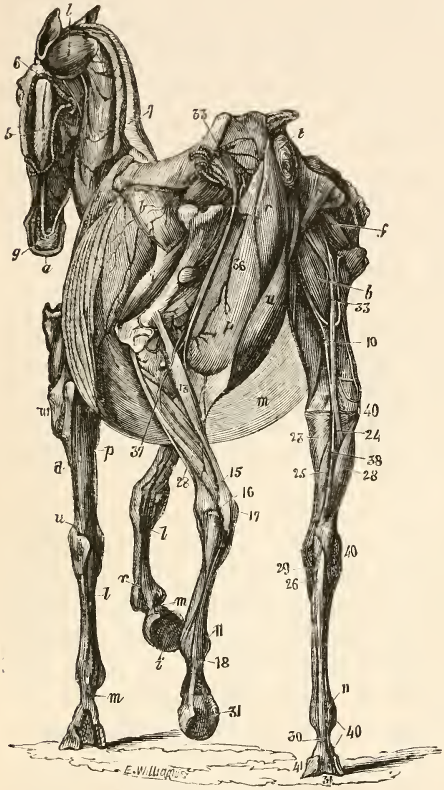

Myology of the Horse. II''.

Muscles inserted into the humerus.

The 'pectoralis major,' from the aponeurosis of the external oblique, from the two hinder thirds of the sternum; and from the fore part of the sternum. The first of these portions winds round to be inserted into the head of the humerus; the second ends in a fascia, which descends over the fore-arm, while the third, running in a transverse direction over the inferior portion, is inserted into the humerus along with the 'levator humeri proprius' between the biceps and the brachialis internus: a part of the sternal portion joins the corresponding portion of the opposite side to form the 'muscle common to both arms,' by the action of which the two fore-legs are made to cross each other.

The 'latissimus dorsi' is powerfully assisted in its action by the cutaneous muscle already described, a strong tendon from which is inserted into the humerus along with that of the latissimus dorsi. Both are intimately connected with the tendon of the teres major, and from this combination of tendons arises one of the heads of the triceps extensor cubiti.

The 'supraspinatus,' the 'infraspinatus,' the 'subscapularis,' the 'teres major,' and the 'teres minor,' with similar attachments, differ in their proportions from those in the human subject, dependent upon the shape of the scapula.

The ‘deltoid’ extends forward in nearly the same direction as the infraspinatus, and has been named by hippotomists the ‘abductor longus brachii.’ The ‘coraco-brachialis’ takes its origin from the tubercular remnant of the coracoid situated upon the superior costa of the scapula: the biceps has but one origin, with which the coraco-brachialis is in no way connected. The ‘brachialis internus,’ fig. 12, *w*, has the same arrangement as in the human subject: it is the ‘short flexor of the fore-arm.’ The ‘triceps extensor cubiti,’ fig. 11, *c*, consists of three portions similar to those named in the human anatomy the long extensor, the short extensor, and the brachialis externus: there is also a fourth portion, derived from the common tendon of the latissimus dorsi and teres major, by the intervention of which it takes its origin from the inferior margin of the scapula.

As might be expected from the construction of the bones of the forearm, both the pronator and supinator muscles are wanting. The ‘extensor carpi radialis,’ fig. 11, *a*, *b*, is here single, arising from the anterior part of the external condyle of the humerus, and from the external surface of that bone for a considerable distance: it forms a strong fleshy belly, terminating in a powerful tendon, which runs to be inserted into the base of the anterior surface of the metacarpal. This muscle seems, from the extent of its origin, to represent the long supinator and the two radial extensors of the wrist combined, and all three thus co-operate in the extension of the wrist. There is but one ‘flexor carpi radialis,’ fig. 12, *p*; it arises from the external condyle of the humerus, and is inserted into the posterior surface of the base of the metacarpal, forming the antagonist to the preceding muscle. The ‘flexor carpi ulnaris’ arises from the posterior part of the external protuberance of the os humeri, and also by a distinct head from the protuberance situated above the internal condyle; its tendon is inserted into the pisiform bone and into the base of the rudimentary metacarpal beneath it. The ‘extensor carpi ulnaris’ arises from the posterior part of the external condyle of the humerus, and is inserted, like the preceding, into the os pisiforme, whence it is prolonged beneath the carpus, so as to perform the office of a flexor of the wrist. The ‘extensor communis digitorum,’ fig. 11, *k*, arises from the external condyle of the humerus and from the contiguous fascia, also from the upper and lateral part of the radius; its fleshy belly is strong, and terminates in a single tendon, which runs over the foot to be inserted into the last phalanx, having previously given off a slip to join the tendon of the extensor minimi digiti.

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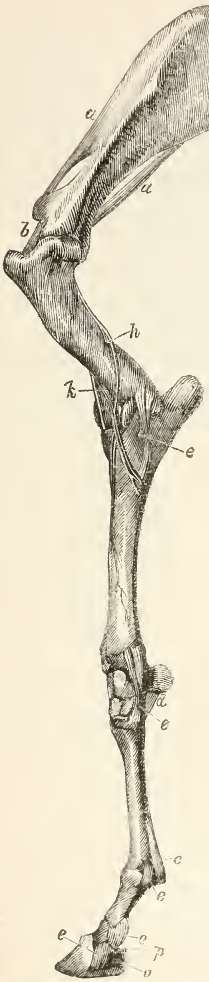
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Ligaments of the fore-limb, Horse. II''.

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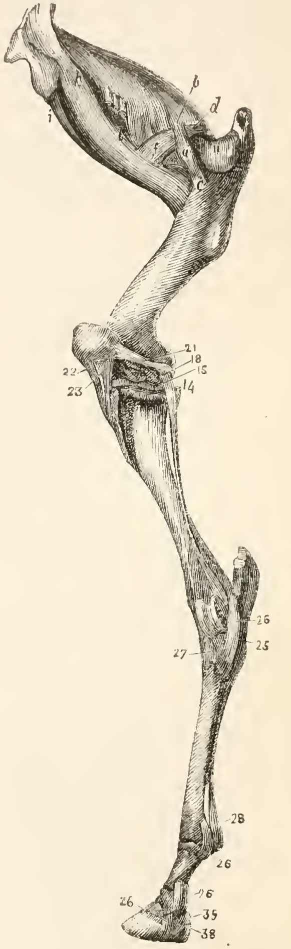
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Deep muscles of the thigh and ligaments of the pelvic limb of the Horse. II''.

The 'extensor proprius minimi digiti' is represented by two muscles: one of these, called the 'extensor of the pastern,' fig.

11, *q*, is inserted by the intervention of a strong tendon into the side of the first phalanx of the functional toe. The second muscle, placed between the above and the preceding muscle, furnishes a similar tendon, which, after passing in front of the carpus, becomes united at an acute angle with that of the former, the two co-operating with each other in extending the foot. The tendon of the 'abductor longus pollicis' is implanted into the internal surface of the base of the metacarpal, so that it thus becomes an extensor of the foot: it is the 'oblique extensor of the cannon' in Hippotomy. The 'flexor digitorum sublimis perforatus' and the 'flexor profundus perforans' arise in common from the internal protuberance of the os humeri, and the two are confounded together for a considerable distance, when the two muscles separate to form two distinct tendons; of these, that belonging to the flexor sublimis, fig. 12, *l*, *m*, runs beneath the annular ligaments of the carpus, to be inserted into the base of the proximal phalanx, previously dividing to give passage to the tendon of the profundus, *i*, on its way to be implanted into the last phalanx.

The following are the principal ligaments of the fore-limb, fig. 13; *a*, the 'post-scapular,' *c*, the 'prescapular,' which extend the base of attachment of scapular muscles; *b*, the ligamentous band strengthening the fore part of the capsule of the shoulder-joint; *k*, similar ligaments strengthening the capsule of the elbow-joint; *e*, *e*, internal lateral ligaments of the successive joints; *d*, 'pisiform' ligament; *c*, ligament from the inner splint-bone (metacarpal II) to the sesamoid behind the metacarpo-phalangial joint; *o*, 'outer cartilage of the hoof;' *p*, inner cartilage of the hoof.

Muscles of the hind-limb. The ectogluteus is a comparatively slender muscle, deriving its principal origin from the sacral fascia, but also reinforced by a long slender fasciculus, which descends immediately from the upper portion of the ilium. Its insertion is into the third trochanter and external rough surface at the upper part of the thigh bone, and also by strong tendinous aponeuroses into the fascia lata.

The 'mesogluteus,' fig. 11, *v*, is the principal muscle in this region; it arises extensively from the sacro-iliac aponeurosis, and from the external surface of the ilium; it is implanted into the outer surface of the great trochanter, and is prolonged, by means of a strong posterior fasciculus, toward the lower extremity of the femur.

The other muscles inserted into the great trochanter—namely, the 'entogluteus,' fig. 12, *f*, the 'quadratus femoris,' the 'obturator externus,' the 'obturator internus,' the 'gemelli,' and the 'pyramidalis'—present a disposition similar to that which they have in the human body.

The muscles passing between the pelvis and the lesser trochanter, and also those that arise from the pubis to be implanted into the internal surface of the thigh, are the 'psoas magnus,' the 'iliacus,' the 'pectinæus,' and the 'triple adductor,' fig. 12, *p*.

The flexor muscles of the leg are the 'biceps flexor cruris,' the 'semimembranosus,' the 'semitendinosus,' the 'sartorius,' the 'gracilis,' and the 'poplitæus,' all of which are enclosed by the dense fascia of the thigh, which is kept tense by the action of a 'tensor vaginæ femoris.' The last-named muscle, called also the 'musculus fasciæ latæ,' arises from the anterior portion of the crest of the ilium, whence it descends obliquely downward, enclosed between two layers of the fascia, covering the thigh, into which it is strongly inserted.

The extensor muscles of the leg—viz., the 'rectus,' fig. 11, *h*, the 'vastus internus,' fig. 12, 7, the 'vastus externus,' fig. 11, *n*, and the 'cruræus'—offer in all quadrupeds the same general disposition as in Man, the three last forming one great common muscle, 'trifemoro-rotuleus.' The anterior margin of the thigh is formed by the 'sartorius,' which here, from its position and office, has been named by hippotomists the 'long adductor of the thigh.'

The 'biceps cruris' arises by a single origin, which is derived from the ischium, and the neighbouring ligaments and fascial expansions. This muscle covers a large proportion of the outer surface of the thigh: its principal insertion is into the head of the fibula, but it likewise throughout its whole length contracts extensive and important attachments with the fascia lata, so that it also becomes a powerful extensor of the thigh. There is, however, a distinct portion of the biceps derived from the sacrosciatic aponeurosis, the fibres of which are directed obliquely from before backward, which, meeting the ischiatic portion at an angle, form with it a kind of raphé, which is prolonged for some distance. This muscle is called 'vastus longus' in Hippotomy. The 'gracilis,' fig. 12, *u*, is a very considerable muscle; it is called by hippotomists the 'short adductor of the thigh,' whilst they usually give the name 'gracilis' to the semitendinosus. The 'semimembranosus' and 'semitendinosus' have the same origin and general arrangement as in Man; but both of them are inserted into the tibia by a broad aponeurosis, extending much lower down than in the human subject, a circumstance which causes the leg to be permanently kept in a semiflexed condition.

The 'gastrocnemius,' fig. 11, 6, is relatively less carneous than in Man: the 'solæus' is slender and feeble: but the 'plantaris,' fig. 12, 13, is remarkably developed; it arises from the fossa above the external femoral condyle: its tendon, 15, is continued downward, and runs over the extremity of the os calcis, where it is enclosed in a sheath; passing on from this point, it divides, 18, to be inserted upon each side of the posterior surface of the proximal phalanx towards its inferior extremity, here giving passage between its two insertions to the tendon of the long flexor of the toe, which it serves to bind down closely to the pastern when the fetlock joint is bent, thus seeming to perform the functions both of the 'plantaris' and of the short flexor of the toes.

The 'tibialis anticus,' fig. 12, 37, is implanted into the anterior surface of the base of the metatarsal, so as to be an extensor of that portion of the foot. The 'tibialis posticus' is seen at 25 and 26, fig. 12. The 'popliteus,' ib. 23, is a powerful muscle. The three 'peronei' are represented by a single muscle, the tendon of which becomes conjoined with that of the long extensor of the digit, with which, when in action, it co-operates. The flexor muscles are reduced to a state of extreme simplicity; the short flexor communis is wanting; the 'plantaris,' as described above, has a double insertion into the base of the great pastern bone, and presents a similar disposition to that of the flexor perforatus in digitate quadrupeds, while the 'flexor communis longus perforans,' fig. 12, 28, here serving a single tendon, 29, appropriated to the solitary toe, passes on as usual to be inserted into the last phalanx, 30, 31. The homologue of the 'flexor longus hallucis' exists in the Horse, notwithstanding the absence of the hallux; but, instead of its usual destination, it here becomes affixed to the tendon of the flexor communis perforans, to which it forms a powerful auxiliary.

The 'extensor communis,' fig. 11, 21, terminates in a single tendon, 26, which is inserted into the dorsum of the last phalanx of the foot: it receives, however, in its course, a few fleshy fibres, *w*, derived from the metacarpal and representing the 'extensor brevis' of unguiculate quadrupeds.

In fig. 14, showing the chief ligaments of the hind limb, are represented the 'iliacus internus,' *i*, *k*, *l*, and the 'epicotyloideus,' *a*, a small and peculiar muscle, which arises by a flat tendon, *b*, from above the origin of the rectus cruris, *d*, and is inserted at the fore and outer part of the neck of the femur, *c*, below the head:

its fibres are attached to the capsular ligament. 21 is the 'rotulo-condylar ligament;' 22 the 'rotular ligament;' 23 the 'external rotular ligament;' 10 the 'condylo-fibular ligament;' 15 the 'external semilunar cartilage;' 25 the 'calcaneal ligament;' 26, 26, the 'external lateral ligaments' of the ankle and succeeding joints; 27 the 'ant-oblique ligament;' 28 the ligament from the outer splint-bone (metatarsal IV) to the sesamoid behind the metacarpo-phalangial joint: 38 and 39 are cartilages of the hoof.

Muscles of the hyoid arch. The 'sterno-hyoideus' and the 'sterno-thyroideus' form a single muscle, which divides to be inserted into both the larynx and os hyoides. The 'omo-hyoideus,' fig. 11, *a*, is a very strong muscle. The 'stylo-hyoideus' furnishes a sheath to the longer portion of the digastricus, and extends from the furcate extremity of the stylohyal to the base of the thyrohyal. There is also a 'cerato-hyoideus' extending between the thyrohyal and the thyroid cartilage. The 'paroccipito-styloideus' is a short thick muscle, derived from the paroccipital, whence it descends toward the angle of the stylohyal, into which it is inserted, above the origin of the stylo-hyoideus.

Facial muscles. The 'occipito-frontalis' has the usual origin from the posterior part of the cranium, whence, running forward, it covers the skull with its tendinous aponeurosis, and, in front, spreads in muscular slips upon the forehead, some of which, fig. 11, 12, extend downward, to spread over those of the orbicularis palpebrarum.

Situated upon the outer side of the orbit there is another descending slip of muscle derived from the lateral cartilage of the ear, which, by elevating the external canthus of the eye, contributes to the expression of that organ.

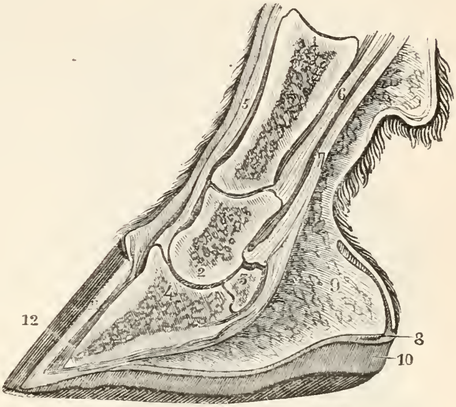
The 'levator anguli oris,' fig. 11, *n*, is inserted into the upper lip and margin of the nostril: it has two origins, derived from the surface of the superior maxillary bone, between which the lateral dilator of the nostril and upper lip passes to its destination. The 'zygomaticus' is a depressor of the external angle of the eye, as well as an elevator of the corner of the mouth, its fibres being intermixed with those of the orbicularis palpebrarum, as well as of the orbicularis oris.

The 'long dilator of the nostril, and elevator of the upper lip' arises at a little distance below the inferior margin of the orbit; and, passing between the two origins of the levator anguli oris, terminates in a tendon, which becomes connected with that of the opposite side, and then spreads out in front of the upper lip.

From the tendon of the last muscle arises the 'anterior dilator of the nostril,' fig. 11, *t*, which, acting upon the interior nasal cartilage, powerfully expands the aperture of the nose. The 'orbicularis oris,' fig. 11, *o*, the 'levator labii superioris,' the 'elevator of the chin,' and the 'depressors of the lower lip, and angle of the mouth,' are well developed.

The anatomy of the limbs of the Horse would be incomplete without a notice of the structure of the terminal segment of these best of terrestrial locomotive organs, in the perfection of which the whole mechanical force is concentrated on a single hoof.

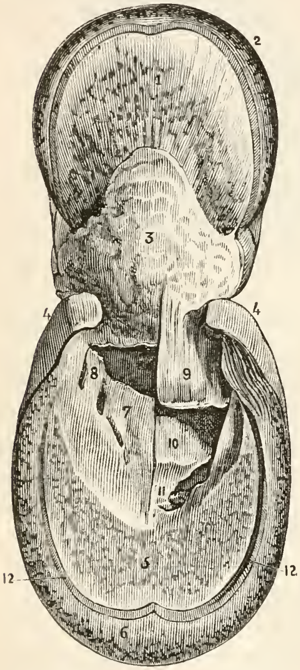
15



Vertical section of the middle or functional digit of the fore-foot of the Horse. III″.

The longitudinal section of the huge finger that forms the foot or 'hoof' of the horse, fig. 15, shows the structure of the three phalanges—proximal 1, middle 2, and distal or ungual 4, with that of the sesamoid, or nut-bone 3, adding to the lever-power of the division of the tendon, 7, of the flexor profundus, going to the last phalanx: the insertion of the tendon of the 'flexor sublimis,' 6, and that of the tendon of the common 'extensor,' 5, are also shown. The hoof-box of the ungual phalanx is denser at its periphery, 12, than at its base, 10, but is not continuous over either surface; the former part is the 'wall,' the latter the 'floor' of the horny or 'insensible' hoof. The wall, or 'external wall,' has the form of a hollow cone obliquely truncate above, so that it is highest in front, 12, becoming vertical, and lower as it extends backward, losing density, degenerating partly into the elastic tissue, 9, but being mainly inflected inward, toward the centre of the sole, where it blends with the horny 'floor,' and forms the 'internal wall:' this supports the superincumbent softer elastic tissue, and partly that called the 'frog,' fig. 16, 3, for which a triangular space is left between the inflected parts of the 'internal wall.' Thus the posterior part of the periphery and of the floor of the 'hoof' is left uncovered by the horny box, which is accordingly free for a certain degree of elastic expansion and contraction, especially posteriorly. The inner surface of the 'wall' is produced into a number of subvertical lamellæ, fig. 17, 3, with which interdigitate corresponding lamellæ, ib. 17, from the periosteum of the ungual phalanx: the first are called the 'horny lamellæ,' the second the 'vascular' or 'sensitive lamellæ.' At the interspace between the inflected parts or prongs of the 'wall' projects the mass of elastic subcorneous tissue called by the French farriers 'fourche,' and misnamed by the English 'frog.' In the horizontal section of the hoof, fig. 16, in which a part, 2, is reflected back, the 'frog,' 3, is seen to extend to the centre of the sole: its exposed outer surface is the hardest and most horny; but this tissue is not so thick as some farriers, misapplying the paring-knife, suppose: it gradually passes into elastic tissue: it is impressed at its middle part by the 'cleft of the frog,' and is reflected upon the 'internal wall.' In fig. 16, 2, 6, is the section of the 'wall;' 3, the upper surface of the 'frog;' 4, 4, are the parts of the 'wall' called the 'heels;' 5, parts of the sole called the 'bars;' 7—11 indicate the boundaries of the space lodging the frog; 12, are the 'vascular lamellæ.' The horny matter of the sole possesses more elasticity than that of the wall: the sole is slightly concave toward the ground, abutting by its lower circumference against the wall: it is cleft to its centre by the triangular space through which the frog projects.

16

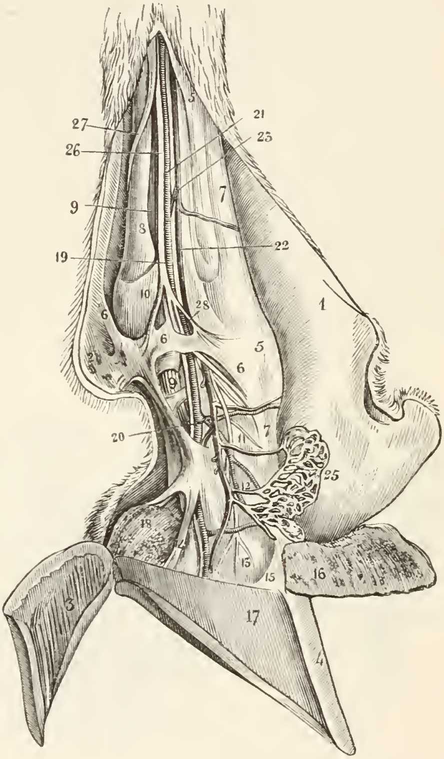


Transverse section of the hoof of the Horse. 111''.

In fig. 17, 1 is the skin reflected; 2, soft elastic tissue, with oil, forming a cushion behind the metacarpo-phalangial joint; 3, 'wall' of the hoof turned back, showing the horny lamellæ; 4, section of front part of the 'wall;' 5, 6, ligamentous parts of metacarpo-phalangial joint; 7, tendon of common 'extensor;' 8, 9, 10, those of the deep and superficial flexors; 15, expansion of the great anterior cartilage of the hoof; 16, the 'coronary frog-band' reflected; 17, the 'vascular lamellæ;' 18, elastic portion of the 'frog;' the 'coronary venous plexus' is shown at 15.

In the Indian Rhinoceros the panniculus carnosus is more discontinuous than in other Perissodactyles, but where it exists is of unusual thickness. One sheet at the side of the thorax sends its fascia into the interstice of the dermal fold in front of the fore limbs. A similar portion behind is inserted into the posterior fold of the skin, suggesting that such permanent folds served the purpose of affording a firmer insertion to the aponeuroses of the cutaneous muscles than a plane surface could have done. Two sheets of panniculus rise, broad and thick, one on each side of the anterior part of the abdomen from the superficial fascia, and, passing backward, terminate in aponeuroses covering knee-joint. As the patellæ are higher than the line of the abdomen, in the erect position of the animal, the preceding muscles afford additional support to that bulky part, some of the weight thus being transferred to the hind-legs, which, reciprocally, are by these muscles drawn forward in locomotion.[1]

17



Dissection of the digit forming the Horse's foot. III''.

§ 198. *Muscles of Artiodactyla.*—In the Ruminant division of the Artiodactyle Ungulates the 'panniculus carnosus' is better developed than in the non-ruminant group, *e. g.* the hog and the hippopotamus. The fixed points from which, in the ox, the well-developed sheets of dermal carneous fibres act on the skin are the scapula, mandible, ilium, pubis, and patella: a subjacent layer of fascia allows the play of the 'panniculus' independently of the main masses of the muscular system, fig. 18. To the sheet of carneous fibres spreading from the scapular fascia over the neck the term 'cutaneus colli' is applied: to a thinner layer extending from the fore part of the neck over the forehead and cheeks to the lips, that of 'cutaneus faciei.' The thick layer expanding from the supra-scapular attachment over the shoulder and part of the fore-limb is the 'cutaneus humeri;' that which extends from the iliac and pubic fascia lata, and from the patella, forward, expanding upon the abdomen, is the 'cutaneus abdominis:' the 'musculus preputialis,' in the Bull, is a derivation from the foregoing dermal muscle.

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[1] v''. p. 36.

The 'trapezius,' fig. 18, 10, 11, answers to the scapular division of that muscle in Man; it arises in the Ox from the neural spines of the anterior half of the thorax, and from the 'ligamentum nuchæ.' In the Giraffe it is in two portions: one arises from the transverse processes of the fifth and sixth cervical vertebræ, its fleshy part is thick and strong but expands as it passes downward and backward and finally is lost in a strong fascia overspreading the shoulder-joint; the second portion is thin and broad, arises from the ligamentum nuchæ, and is inserted into the fascia covering the scapula.[1] The 'masto-humeralis,' fig. 18, 8, 8, may represent the 'cleidal' part of the trapezius in claviculate Ungulates: it arises by an aponeurosis from the ligamentum nuchæ, and, by a tendon, from the paroccipital; the chief and more superficial portion is inserted into the humerus, the deeper portion into the sternum. The 'latissimus dorsi,' fig. 18, 12, in

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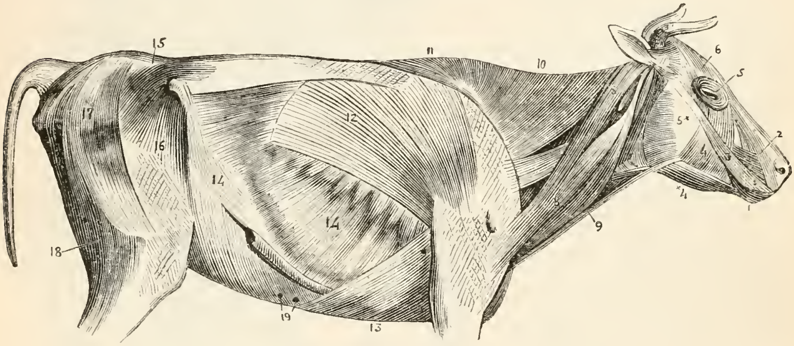

Superficial muscles of the Cow. IV''

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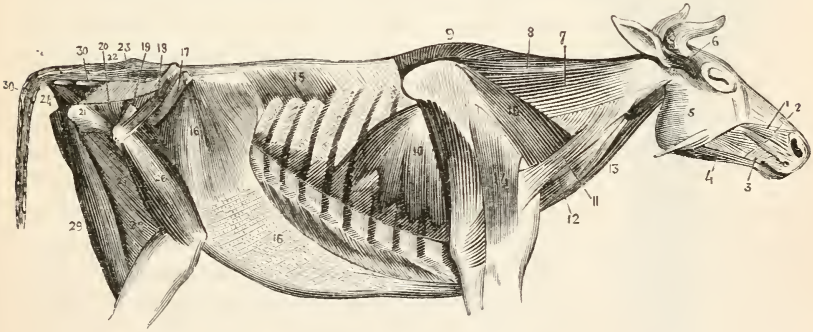
[1] XCVII. p. 234.

the Ox, as in the Horse, is a comparatively small muscle, and acts upon both humerus and antibrachium. The 'rhomboideus,' fig. 19, 9, is not single, as in the Horse and Giraffe, but consists in the Ox of pre- and post-rhomboid portions: the former rises from the nuchal ligament, as far forward as its occipital insertion: the latter from the spines of the two or three anterior dorsals; both converge to be inserted into the base of the scapula.

The 'splenius capitis,' fig. 19, 7, arises from the anterior dorsal and posterior cervical spines; the fibres diverge to a flat tendon inserted into the paroccipital and the ridge rising therefrom. In the Sheep an insertion of a small fasciculus into the diapophysis of the atlas represents the 'splenius colli.' The 'scaleni' form three strong muscles in the *Camelidæ,* in the Giraffe four, which rise from the fourth to the seventh cervical vertebræ and are inserted into the manubrium sterni and first rib. The 'scalenus anticus' in the Cow is shown at 12, fig. 19. The 'sterno-maxillaris' arises from the manubrium and divides, at 9, fig. 18, to be inserted into the paroccipital and mandibular angle.

19



Deep muscles of the Cow. IV''.

The 'levator anguli scapulæ,' fig. 19, 8, arises from the pleurapophyses of the third and fourth cervical vertebræ, and is inserted into the anterior angle of the scapula: it seems part of the following muscle.

The 'serratus magnus,' fig. 19, 10, has an extensive origin from the pleurapophyses of the anterior half or two-thirds of the dorsal series, forward, to that of the fifth cervical inclusive, by 'dentations,' or an angular strip from each: the fibres converge, ascending beneath the scapula, to be inserted into the cartilaginous suprascapula. Thus, as the fore-part of the trunk is, as it were, slung upon the two great serrate muscles which principally support the weight of the deep chest of the Ruminants, the interposition of the elastic cartilages between the upper attachments of the muscles and the capitals of the bony columns of the two fore-legs is attended with the same advantage as is obtained by slinging the body of a coach upon elastic springs.

The main body of the 'pectoralis major,' fig. 18, 13, rises from the sternum and ensiform cartilage, the fibres converging to the tendon inserted in the outer tuberosity of the humerus: the anterior derivative from this muscle, effecting the crossing of the fore-limbs, is present in Ruminants as in Solipeds and Cetaceans. Two muscles converge to an insertion answering to that of the 'deltoid;' one is the superficial portion of the 'masto-humeralis,' fig. 18, 8, fig. 19, 11; the other, *ib.* 14, arises from the spine and post-spinal fossa of the scapula: the latter is the proper homologue of the 'deltoid.'

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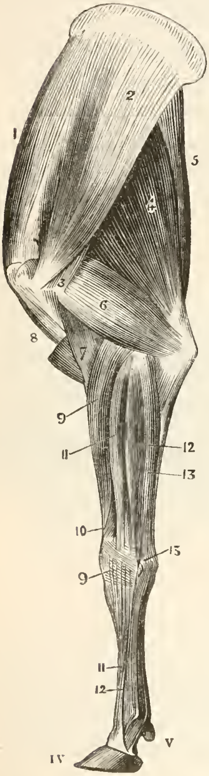


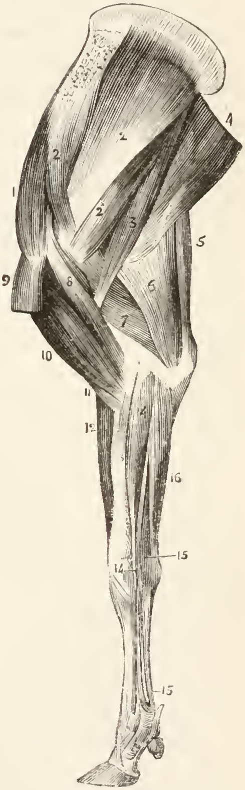
Muscles of fore-limb, Cow; from the outer (ulnar) side. IV''.

The 'supra- or pre-spinatus' is shown at 1, figs. 20 and 21; it is inserted by a double tendon into the fore and inner tuberosities of the humerus: the 'infra- or post-spinatus,' fig. 20, 2, has a single strong insertion into the outer tuberosity. The insertion of the 'teres major' is seen at fig. 20, 3.

The subscapularis, fig. 21, 2 and 2^{x}, consists of two chief masses, and corresponds in length and narrowness with the bone from which it originates; it consequently produces, like the muscles on the opposite surface of the scapula, more rapid and extensive motion of the humerus, to the inner tuberosity of which it is attached. The 'coraco-brachialis,' fig. 20, 8, arises from the tuberous representative of the coracoid; its insertion into the humerus extends down to the inner condyle. The 'biceps brachii,' fig. 21, 10, shows an origin from the coracoid as well as the chief one from above the glenoid cavity of the scapula. It is inserted into the radius, below the usual tuberosity, and also sends a strip of tendon to the antibrachial aponeurosis. In the *Camelidæ* the tendon of origin is double, but approximated, and encloses a sclerous sesamoid as it passes over the head of the humerus. The 'brachialis internus' rises from the neck of the humerus; its insertion, fig. 21, 11, is anterior to that of the biceps. The massive muscles answering to the 'triceps extensor' are the 'extensor longus,' figs. 20 and 21, 5, the 'ext. latus,' fig. 20, 4, the 'ext. medius,' fig. 21, 6, and the 'ext. brevis,' fig. 21, 7. The 'anconeus externus,' fig. 20, 6, appears to be another part of this system of muscles acting on the trunk through the scapula and reciprocally on the supporting limb. A small fasciculus, fig. 21, 13, arising from the inner part of the distal end of the humerus, and inserted into the upper half of the radius, acts feebly as a flexor, and seems to represent the 'pronator teres' of Unguiculates. The 'extensor carpi radialis,' fig. 21, 12, is inserted into the fore-part of the 'cannon-bone.' The 'flexor carpi radialis,' fig. 21, 14, sends its tendon behind the carpal joint to the back part of the cannon-bone. The muscle, fig. 20, 10, which is inserted into the inner (radial) side of the cannon-bone, has an homologous origin with that of the 'abductor pollicis.'

The 'extensor digitorum longus,' fig. 20, 11, sends its two tendons in front of the carpus and cannon-bone; the inner one is inserted into the middle phalanx of the inner (vol. ii. fig. 193, *iii*) digit; the outer tendon divides, to be inserted into the ungual phalanges of both functional digits. The 'extensor brevis digitorum,' fig. 20, 12, is inserted into the middle phalanx of the outer (ib. *iv*) functional digit. The 'flexor carpi ulnaris,' fig. 20, 13, is inserted into the 'pisiforme' and outer side of the head of the cannon-bone. The 'flexor perforans digitorum,' fig. 21, 15, sends its flat and strong tendon behind the cannon-bone, near the lower end of which it divides, and perforates the corresponding divisions of the 'flexor perforatus,' to be inserted into the ungual phalanges of the digits, *iii*, *iv*, fig. 193, Ox, vol. ii. The 'flexor carpi ulnaris internus,' fig. 21, 16, is inserted into the 'pisiforme.'

21



Muscles of the fore-limb, Cow from the inner (radial) side. IVth.

The ectogluteus, fig. 18, 15, arises from the fore part of the ilium and sacral fascia, and is inserted into the lower part of the great trochanter; it is closely connected with the 'tensor fasciæ femoris.' This muscle, fig. 18, 16, arising from behind the outer iliac tuberosity, expands upon the thigh, and is lost in fascia covering the knee-joint, and attached to the spine of the tibia, whereby the muscle becomes, with the rectus, a flexor of the thigh. There is a 'sartorius' crossing obliquely the inner side of the thigh, and inserted aponeurotically into the inner side of the head of the tibia. The 'mesogluteus,' fig. 19, 18, arising from the outer side of the ilium, is inserted into the outer part of the great trochanter. The 'entogluteus,' *ib.* 19, rises above the acetabulum, and is inserted into the upper part of the great trochanter. The 'biceps femoris,' fig. 18, 17, 18, arises from the sacro-sciatic fascia and from the ischial tuberosity; the fasciculi from both origins unite to form a broad muscle (the 'vastus longus' of Hippotomy), which is inserted by a strong aponeurosis into the head of the tibia and fascia of the leg. The 'iliacus internus' is shown at 17, fig. 19: 23, 24, and 30, *ib.*, are muscles of the tail. The 'vastus externus,' fig. 19, 26, covers the whole of the outer part of the thigh-bone, from the great trochanter; it is inserted into the patella and head of the tibia; a small part of the 'rectus femoris' appears in front of its upper part. The 'gracilis' is a large broad muscle, arising from the pubic symphysis, and inserted into a long tract of the tibia. The 'adductor magnus' is seen at 27, the 'semitendinosus' at 28, and the 'semimembranosus,' or 'adductor tibiæ longus,' at 29, fig. 19. The last two muscles are blended in the Hog. The 'tibialis anticus' arises from the inner side of the fore part of the head of the tibia by a strong tendon; the muscular part swells into the chief of those on the fore part of the leg; the tendon of insertion splits to give passage to that of the 'peroneus longus,' and is inserted into the outer side of the head of the metatarsal. There is an extensor of the middle phalanx of each functional toe; the tendon of the long 'extensor digitorum' bifurcates at the end of the metatarsus for insertion into the ungual phalanx of the same toes.

The chief peculiarity of the flexors of the digits of the hind-foot in hoofed quadrupeds is the accession of muscles not so applied in most other mammals. Thus the 'gastrocnemius,' besides its insertion into the heel-bone, sends a strong tendon along the back of the metatarsal, to the phalanges, where it expands and bifurcates, each division again splitting for the passage of that of the 'flexor perforans,' before being inserted into the middle phalanges. In like manner the homologue of the 'tibialis posticus' combines its tendon with that of the 'flexor perforans;' such common tendon expanding behind the metatarsal, and splitting to perforate the tendon of the preceding flexor in its way to the last phalanx.

Of the abdominal muscles, the 'obliquus externus' is shown in fig. 18, 14; its broad tendon is perforated by the mammary artery and vein, at 19. The 'obliquus internus' is seen at 16, fig. 19.

I found the following conditions of the hyoid muscles in the Giraffe:[1]—The 'mylo-hyoideus,' thick and strong, arose from the internal surface of the lower jaw, and was inserted into the raphe dividing it from its fellow of the opposite side. It adhered firmly to the 'genio-hyoideus:' this arose by a well marked tendon from the symphysis menti, and had the usual insertion. The 'genio-glossus' arose by a tendon close to the inner side of the tendon of the 'genio-hyoideus;' its fleshy belly had a considerable antero-posterior extent, and diminished to a very thin edge at its anterior margin. The 'digastricus' had the usual origin, and was inserted, broad and thick, into the under side of the lower jaw. The 'stylo-hyoid' was remarkable for the slenderness and length of its carneous part. The most interesting modifications in the muscles of the os hyoides were found in those which retract that bone. The muscle which, as in some other ruminants, combines the offices of the 'sterno-thyroideus' and 'sterno-hyoideus,' arose by a single long and slender carneous portion from the anterior extremity of the sternum; this origin was nine inches long, and terminated in a round tendon, six inches long; the tendon then divided into two, and each division soon became fleshy, and so continued for about sixteen inches; then each division again became tendinous for the extent of two inches, and ultimately carneous again, when it was inserted into the side of the thyroid cartilage, and thence continued in the form of a fascia to the hyoid. This alternation of contractile with non-contractile tissue gave a striking example of the use of tendon in limiting the length of the contractile part of a muscle to the extent of motion required to be produced in the part to which the muscle is attached. Had the sterno-thyroideus been continued fleshy as usual from its origin through the whole length of the neck to its insertion, a great proportion of the muscular fibres would have been useless; for as these have the power of shortening themselves by their contractility one-third of their own length, if they had been continued from end to end in the sterno-thyroidei, they would have been able to draw the larynx and hyoid one-third of the way down the neck; such displacement, however, is neither required nor indeed compatible with the

[1] xcvii'. p. 232.

mechanical connections of the parts; but, by the intervention of long and slender tendons, the quantity of the contractile fibre is duly apportioned to the extent of motion required for the larynx and os hyoides. The 'omo-hyoideus' was adjusted to its office by a more simple modification; instead of having a remote origin from the shoulder-blade, its fixed point of attachment was brought forward to the nearest bone (the third cervical vertebra) from which it could act upon the hyoid to the due extent.

In all *Herbivora* the muscles more directly worked in mastication, *e. g.* the 'masseter' and 'pterygoidei,' are proportionally more developed than the biting muscles, *e. g.* 'temporales;' but there are degrees of difference; in those Ungulates in which the canines are most developed, as *e. g.* the Hog and Camel tribes, the temporal muscles are larger. In all Ungulates the chief depressor of the jaw, or opener of the mouth, passing from the paroccipital to the mandibular angle, has a single fleshy belly; it is, however, the homologue of the 'digastricus' in Man.

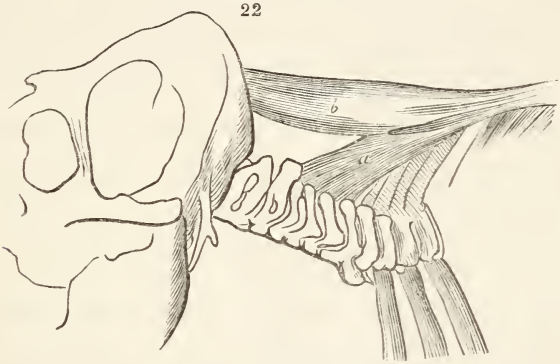
One of the muscles proceeding from the neural arches of the dorsal vertebræ to the occiput is tendinous, along a portion of its mid-course, in most unguiculate Mammals: it is called 'biventer cervicis' in Anthropotomy. Contiguous muscular fasciculi extending from the neural spines of the anterior dorsals to those of more or less of the cervical series, are termed 'spinalis cervicis.' The pair of fibrous masses with like attachments, but in which the striated fibre is almost wholly reduced to the yellow elastic tissue in Ungulates, is commonly known as the 'ligamentum nuchæ.'

In the Giraffe this mechanical stay and support of the long neck and head commences from the sacral vertebræ, and receives fresh accessions from each lumbar and dorsal vertebra, as it advances forward; the spines of the anterior dorsal vertebræ become greatly elongated to afford additional surface for the attachment of new portions of the ligament, which appears to be inserted, on a superficial dissection, in one continuous sheet into the longitudinally extended but not elevated spines of the cervical vertebræ, as far as the axis; the atlas, as usual, is left free for the rotatory movements of the head; the ligament passes over that vertebra to terminate by an expanded insertion into the occipital crest. It consists throughout of two bilateral moieties. In the specimen I dissected, the nuchal ligament, *in situ*, measured 9 feet in length: an extent of 6 feet was removed, which immediately contracted to 4 feet.

In the Camel the ligamentum nuchæ arises, broad and thin, from the anterior dorsal spines, but gathers substance as it advances and becomes condensed into a pair of cords which receive accessions from the cervical spines, by which the ligaments seem bound down so as to follow the curve of the neck: the insertions are into the superoccipital. Posteriorly a continuation of the ligament may be traced spreading out and losing itself in the base of the single hump of the Dromedary, and as far back as that of the hind hump in the Camel.[1]

The relative size and insertions (*a* cervical, *b* nuchal) of the ligamentum nuchæ of the Elephant are shown in fig. 22. Much of the same kind of yellow elastic tissue is combined with the aponeuroses of the abdominal muscles in the Elephant, Rhinoceros,[2] and Giraffe, in reference to the capacity and heavy contents of parts of the alimentary canal.

22



Ligamentum nuchæ, Elephant.

§ 199. *Muscles of Carnivora.*—The commencement of certain facial muscles that reach their full developement in Man may be discerned in the Unguiculates. Small detached sheets of muscular fibre, 'cervico-facial' or 'platysma myoïdes,' are attached to the skin at the side of the neck, spread upon the lateral integuments of the face, and, in the Cat, show a special arrangement or developement by affording a muscular capsule to the bulb of each long hair of the whiskers, upon the chin, lips, cheeks, and eyebrows, to which they give the impressive movements of those sensitive parts. Both the 'occipital' and 'frontal' parts of the human 'occipito-frontalis' are also present in the Cat

The muscles of the jaws in *Carnivora* are chiefly remarkable for the large proportional size of the 'temporalis,' with which the 'masseter,' by the more vertical disposition of its fibres than in *Herbivora*, combines in the act of forcibly closing the mouth. The 'pterygoidei' are small and not very distinct from each other. The 'digastric' is a powerful muscle and seemingly 'monogastric,' but many tendinous filaments in the middle of the carneous substance indicate the division which is established in higher Gyrencephala. In the Lion it arises by a strong tendon from the paroccipital; and its action may be seen in the effort the animal makes to disengage the mandible from ligamentous parts of its food. In the Felines the latissimus dorsi has its chief insertion into the tendinous arch, bridging over the biceps, and, with the 'dermo-humeralis' similarly inserted, it acts upon the inner side of the upper part of the humerus, but sends a strong aponeurosis between the external and scapular 'heads' or portions of the triceps to be continued upon the antibrachial fascia: in the Dog, a distinct fasciculus of the muscle combines its tendon with that of the 'scapular' portion of the triceps. In the Seal-tribe the retractile action of the latissimus dorsi is extended, by the aponeurotic insertion, to the palmar aspect of the pectoral fin. The homologue of the 'serratus posticus superior' is largely developed in the Lion, extending its anterior attachments to the nape. The 'protractor scapulæ' arises in Felines from the diapophyses of the atlas, axis, and third cervical, and is inserted into the spine of the scapula near the acromion. The origins of the 'great pectoral muscles' interblend and cross each other in Felines, so as to seem to form a common adductor muscle of the fore-limbs; but the mass of the fibres resolves itself into four almost distinct muscles, answering to the 'large pectoral' and grand pectoral of Hippotomists, and including the 'sterno-trachiterien' and 'pectoantébrachial' of Straus-Durckheim. The 'pectoralis minor' in the Dog is inserted into the upper part of the glenoid cavity of the scapula. In unguiculate, and especially claviculate, Gyrencephala, the deltoid conforms by the greater extent of origin and size to the more varied movements of the humerus, as compared with the ungulate order. In the Cat the deltoid consists of an anterior portion arising from the acromion, and a posterior one from the spine, of the scapula: in the Bear only the acromial portion is developed. In nonclaviculate *Carnivora* the 'masto-humeralis' is present: in claviculate species the 'cleido-cucullaris' and 'cleido-mastoideus' are its divisions: the former, in Felines, rises from the paroccipital crest, and from the neural spines of the anterior cervicals, passes back and down to the transverse ligamentous tract in which the clavicular ossicle is developed; the 'cleido-mastoid' is inserted into two outer thirds of the clavicular bone, whence is continued a fleshy belly descending along the fore-part of the brachium, in front of the biceps, to be inserted into the tuberosity of the radius: it answers to 8, fig. 18, in Ungulates. The biceps, in Felines, derives its single head from the upper rim of the glenoid cavity, and is inserted into the bicipital tuberosity of the radius. The 'brachialis internus' is a long muscle on the outer side of the humerus, and is inserted into the lower wall of the sigmoid cavity of the ulna. The 'triceps extensor' is represented by three or more muscles, distinct in their fleshy part, and remarkable for their volume in Felines: their common tendon incloses the olecranon like a strong capsule. Besides the foregoing there are three shorter extensors, one of which is represented by the human 'anconeus;' but all belong to the same system as the tricipital extensor. The 'pronator teres' is proportionally large: in the Lion its carneous part extends far down the fore-arm: in the Cat it ends in the tendon inserted about half way down the radius. The 'palmaris longus' is also more developed than in man. The 'supinator longus,' on the other hand, has a short and slender fleshy portion; and this relates to the habitual prone position of the paw in *Carnivora*. The flexors and extensors of the carpus and manus closely accord with those of Man, but with excess of fleshy fibres in the larger Felines; and a minor degree of distinction of some muscles, as, *e. g.*, the 'flexores digitorum,' and 'extensores pollicis.' The 'extensor longus pollicis' has its origin from the outer wall of the sigmoid cavity of the ulna and the upper third of that bone: its long and slender tendon is inserted into the first phalanx of the pollex, but usually, also, into that of the index. By this insertion, as well as by its high origin, it is less differentiated from the 'common extensor digitorum' than in Man. There is no 'extensor brevis pollicis.' The 'indicator' is represented, in Felines, by a short and slender muscle from the lower half of the outer side of the ulna: its tendon glides through the same carpal synovial sheath as that of the extensor longus pollicis: it has not a separate insertion into the index, but blends with the tendinous division of the common extensor going to that digit. The differentiation establishing the muscle as a true or independent 'indicator' has not yet come about.

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[1] vi.

[2] v‥. p. 36.

The 'flexor sublimis' is a powerful muscle and the principal bender of the paw in ordinary locomotion; its origin is restricted to the humerus; its insertions are extended into all the five digits by the fasciæ attached to the sides of the metacarpo-phalangial joints, as well as the ordinary perforated tendons into the sides of the first and second phalanges. The 'flexor profundus' arises by five heads from the antibrachium, which form a common flattened tendon, along the carpus; this first detaches a tendon to the ungual phalanx of the pollex, and, at the metacarpus, divides into the four tendons similarly inserted into the four long digits. In each the insertion, fig. 36, *b*, is into the lever-like process from the palmar part of the bone of the last phalanx. It is this muscle which overcomes the retractile force of the elastic ligaments, ib. *a*, of the claws, and concentrates the power of all five upon the part seized. There is no separate 'flexor longus pollicis.'

In the hind limb of Felines, the psoas and iliacus are more obviously parts of the same muscle than in Man: a fasciculus of the 'psoas' sends a tendon to the pubis; but the main body of the muscle acts upon the inner trochanter. In the Cat a detachment of the small ectogluteus descends to be inserted into the patella. The much longer mesogluteus has five origins from lumbar, sacral and caudal vertebræ, and from the crista ilii: its tendon goes to the great trochanter. The 'gracilis' is relatively large. The muscle at the foremost part of the thigh, in Felines, answers to the 'sartorius' and 'rectus femoris;' there is also a 'tensor fasciæ,' which sends an aponeurosis over the fore part of the knee-joint and a tendon to the inner part of the head of the tibia. The 'biceps flexor cruris' receives a slender accessory fascicule from an anterior caudal vertebra; besides its normal insertion it is continued by fascia into the 'tendo achillis.' In the Lion, a special muscle, 'caudo-femoralis,' from the same vertebræ is inserted by its own long tendon into the outer condyle of the femur. The Bear has not the latter muscle. The largest part of the 'gastrocnemii' muscles is at or near to their femoral origins: the tendons of each are at first distinct, and finally blend by expansions which spread over the calcaneum. The soleus is small, and rises from the fibula: its tendon unites with that of the gastrocnemius externus. The tendon of the 'plantaris' combines with that of the 'short flexor' of the toes to augment the power of bending their phalanges: its fleshy part is relatively much greater than in Man.

§ 200. *Muscles of Quadrumana.*—In this series, up to the apes, the panniculus carnosus exists; but is reduced to a thin sheet of carneous fibres from the dorso-lumbar fascia, spreading over the *latissimus dorsi,* and again degenerating to fascia attached to the inner side of the humerus. The 'platysma myoïdes' begins to be defined, in the Aye-aye, as a pair of broad thin layers, arising from pectoral and clavicular fascia, and ascending over the front and sides of the neck, mandibular rami, and cheeks. In the Orangs and Chimpanzees it supports the large cervico-pectoral air-sac communicating with the larynx.

From the Aye-aye to the Gorilla,[1] with a few exceptions, there is a 'cleido-mastoideus' as well as a 'sterno-cleido-mastoideus;' but in some Baboons (*Macacus*) the distinct fasciculus from the clavicle has not been found. In an Orang I found the cleidal part inserted into the diapophysis of the axis vertebra.

The term 'digastricus' is applicable to that mandibular muscle in all *Quadrumana*, although the partition by tendon of the anterior from the posterior belly is not complete in many. In most, as in the Aye-aye, the anterior portions of the pair occupy the anterior interspace of the mandibular rami. The middle tendinous part is attached to the hyoid, except where it is feebly marked, as in *Stenops*. The intermediate tendon of the omohyoid is not found save in the higher tail-less Apes.

In all *Quadrumana* the power of the arms in drawing up the trunk is increased by the accessory muscle from the ordinary tendon of the 'latissimus dorsi,' which extends its action from the upper to the lower end of the humerus (interior condyle), and to the olecranon. The 'rhomboidei' extend to the occiput in Macaques, Baboons, and the Orang. The 'protractor scapulæ' ('acromio-trachelien,' Cuv.) exists in most *Quadrumana* below the Apes; in these the 'levator anguli scapulæ' is distinct from the 'serratus magnus; but is the fore part of that muscle in Baboons.' In the Gibbons (*Hylobates*) the two portions of the 'biceps flexor cubiti' are more powerful and unite lower down the humerus than in other *Quadrumana*, and the inner portion derives an origin from near the pectoral ridge of the humerus: their common tendon is inserted beneath the radial tubercle, and into the antibrachial fascia. In *Stenops* the biceps has only its 'long head' or origin: that from the coracoid process is, at least, not distinct from the coraco-brachialis. The 'triceps extensor cubiti' is complicated in *Quadrumana* by the accessory fasciculus in connection with the tendon of the latissimus dorsi. The lower portion of the 'internal head' of the triceps has also a distinct origin or fasciculus from the entocondyloid ridge in *Chiromys* and *Tarsius*; in *Stenops* it arises more from the back part of the humerus.

The deep and superficial flexors of the fingers are distinct, but a remnant of that blending which exists in most lower mammals may be seen in the short connecting tendon which in the Aye-aye[2] passes from the ulnar belly of the 'flexor sublimis' to the division of the 'flexor profundus,' giving off the tendon to the middle finger. The fleshy part of both flexors, but especially of the deeper one, is continued nearer to the hand, in *Lemuridæ* and most other

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[1] CII. p. 30, pl. xi. fig. 1, 22 *d*.

[2] CII. p. 34, pl. xi. fig. 4, *e*.

Quadrumana, than in Man, thus enabling the muscles to continue their action as finger-benders when the hand itself is flexed. The fasciculus of the 'flexor profundus' which sends the tendon to the last phalanx of the thumb, is more distinctly a 'flexor longus pollicis' in Apes than in lower *Quadrumana*. In the Aye-aye it adheres to the supplementary carpal and fascia on its way to the thumb, and thus opposes both the last phalanx and the 'pad' at the base of the thumb in the act of grasping. The 'flexor brevis,' the 'abductor,' the 'adductor,' and 'opponens pollicis' are present in the Chimpanzee and Gorilla, as are likewise the 'extensor longus' and 'extensor brevis.' In the Orang these muscles begin to be confounded; in most lower *Quadrumana* they are blended together. The homologue of the 'extensor indicis' of Man bifurcates and sends a tendon to both the index and medius digits; the homologue of the extensor minimi digiti likewise splits and sends a tendon also to the annularis; so that, while in Man the index and minimus only have two extensor tendons, all four fingers (*ii—v*) have them in most *Quadrumana*. The hand is thereby the stronger as a suspensor of the body from a bough.

The 'ectogluteus' is feebly developed compared with that in Man: the Gorilla, though receding far in this respect, recedes the least. The homologue of the 'gracilis' is relatively larger in all *Quadrumana* than in Man, and its insertion is extended lower down the leg. In *Stenops* the vastus externus contributes a fasciculus to the rectus femoris; in *Chiromys* it is as distinct as in higher *Quadrumana*. But here the mesogluteus exceeds the ectogluteus in size, although the latter is supplemented in the Gorilla by fleshy fasciculi from the ischial tuberosity, which spread their insertions from that of the ectoglutæus down the femur to the internal condyle, apparently representing the adductor magnus. In both Orang and Chimpanzee a muscle from the outer border of the ilium to near the acetabulum is inserted into the under and outer part of the great trochanter and rotates the thigh inwards.[1] The gastrocnemii have a greater length and minor breadth and thickness of the fleshy part: the soleus rises from the fibula exclusively, and joins the gastrocnemii low down.

§ 201. *Muscles of Bimana.*—The myologies of Anthropotomy reduce the need of noticing human muscles here to some comparison with those of highest Apes, bringing out the ordinal characteristics of the limbs, and to the illustration of those giving expression to the face and reflecting the action of the organ that marks Man's place in Creation as the type of a distinct sub-class.

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[1] 'Scansorius,' Trail, xxxv''. 'Invertor femoris,' xxxiv''. p. 68.

Figures 23 and 24 give a view of the superficial muscles and tendons of the fore-arm and hand of a full-grown male Gorilla and Man of correct relative size. The portion of the triceps is seen in the Gorilla at 2″; in Man at 5′, in whom the origins of the carneous fibres of that part from behind the inter-muscular septum are continued lower down the humerus. The 'brachialis anticus' is seen at 4, fig. 23, and 17, fig. 24. This muscle is not so completely differentiated from the deltoid and supinator longus in the Gorilla as in Man, nor so individualised as a single muscle: its two portions being more distinct. The biceps, fig. 23, 3, maintains in Man more of its full fleshy character to the sending off of the tendon, 3′, to the rough posterior margin of the tuberosity of the radius, gliding over the anterior smooth surface of that process with an intervening 'bursa.' The aponeurosis, 3″, sent off to the fascia of the fore-arm crosses the 'pronator teres.' This muscle, 8, fig. 24, is attached to the outer side of the radius below the middle of the bone in the Gorilla, but rather above it in Man. The double origin, viz. from the inner humeral condyle and the coronoid process of the ulna, is better defined in Man, fig. 23, 6. The 'palmaris longus,' fig. 23, 8, arising as a distinct muscle in Man from the inner humeral condyle, is a fasciculus, 5, of the 'flexor carpi ulnaris' (3, fig. 24) in the Gorilla; but, as this muscle is subject to variation, and sometimes absent in Man, it may show analogous inconstancy in the Gorilla. The flexor carpi ulnaris is inserted into the pisiforme in both Man and Ape, but the fleshy and tendinous parts are better defined, and the latter relatively longer and more slender in Man, fig. 23, 9. The flexor carpi radialis arises in Man, fig. 23, 7, from the inner condyle, from the antibrachial fascia and septa continued therefrom between the pronator teres, 6, and palmaris longus, 8; but in the Gorilla, fig. 24, 4, it derives a considerable accession of

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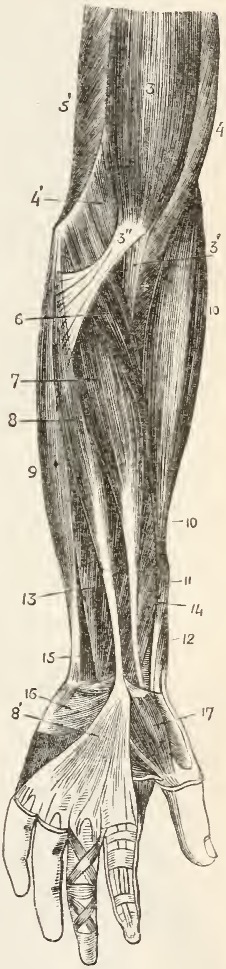

Muscles of the fore-arm and hand, Man.

fibres directly from the radius, and its tendon is shorter and much thicker than in Man. In both it passes through a pulley provided by the trapezium to its insertion into the base of the metacarpal of the index. The tendon of the supinator longus in the Gorilla, fig. 24, 4′, is also shorter and thicker, and is not crossed, as in Man, by the extensors of the metacarpal and first phalanx of the pollex (fig. 23, 11 and 12) before its insertion into the styloid process of the radius. Part of the carneous mass of the flexor sublimis digitorum is seen at 13, fig. 23, and 6′, fig. 24. External to this a greater proportion of the flexor profundus appears in the Gorilla, fig. 24, 6, than in Man, fig. 23, 15. The flexor longus pollicis, fig. 23, 14, expends its force in the Gorilla, fig. 24, 20, upon both the pollex and index, furnishing tendons to the distal phalanx of each, but the largest and most direct being that to the index. There are modifications of minor importance in the origin of this muscle which tend to give it a

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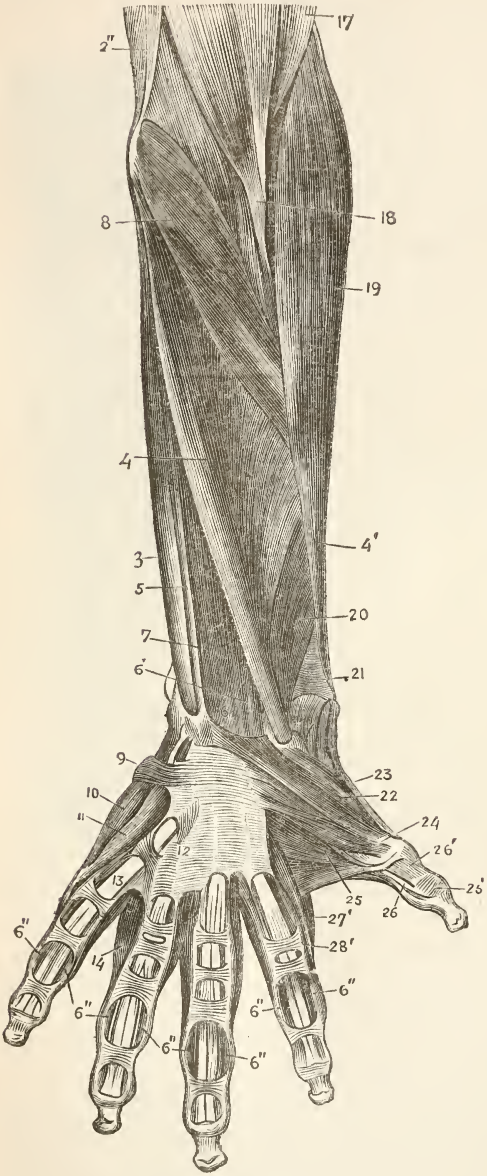


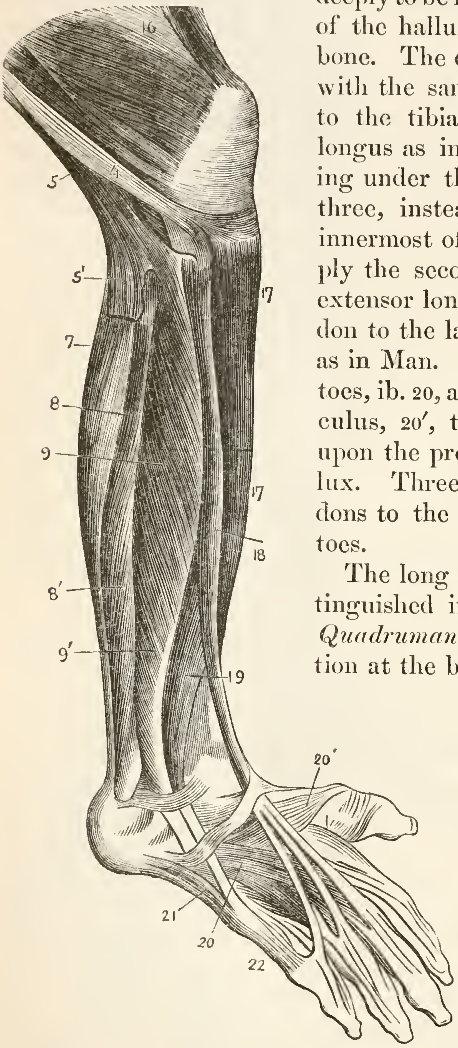
Muscles of the fore-arm and hand, Gorilla. 1″.

character of being part of the system of the 'flexor profundus' in the Gorilla.

The relations of the tendons of the superficial and deep flexors to each other and to the digits are much alike in Man and Ape, but the tendons are relatively broader, and their restraining and strengthening sheaths and bands stronger in the Gorilla; those formed by the oblique decussating ligamentous fasciculi, as in the mid-finger of fig. 23, are more distinctly shown in Man than in the Ape. The muscles acting on the metacarpal and first phalanx of the pollex—fig. 24, 22, 'abductor,' ib. 24, flexor brevis, ib. 25, adductor—are longer and more slender in the Gorilla. The abductor in Man is shown at fig. 23, 17. In the Gorilla the 'abductor minimi digiti' is shown at fig. 24, 10; the 'flexor brevis' at 11; the tendon of the flexor profundus at 13; that of the 'flexor sublimis' at 6′. Two of the 'lumbricales' are shown at 14 and 28, and one of the interossei at 27, fig. 24. The carneous part of the common extensor of the fingers is continued to the wrist in the Gorilla; three strong tendons go to the second, third, and fourth digits, and a fourth, less strong, to the fifth digit. This digit also receives the tendon of an extensor minimi digiti, and the index a small tendon of an 'indicator' which is more completely blended with that of the ordinary extensor, besides being more feeble, than in Man. The extensors of the metacarpal, first and last phalanges of the pollex, are present in the Gorilla, but of smaller size than in Man.

In the Gorilla the portion of the biceps cruris derived from the ischiadic tuberosity, and inserted, fig. 25, 4, into the outer part of the head of the tibia, is more distinct than in Man from that, ib. 5, derived from the femoral linea aspera and inserted into the head of the fibula, and which expands, 5′, upon the cnemial fascia. The external gastrocnemius, fig. 25, 7, continues longer distinct from the internal, and both present longer but narrower and thinner carneous portions than in Man. The soleus, ib. 8, arises exclusively from the fibula and is much narrower than in Man, where it also derives fibres from the oblique line of the tibia and from the middle third of its internal border. The margins of the tendon of the soleus first unite with those of the gastrocnemius, the middle part continues distinct to near the calcaneum. The plantaris has not been met with in the Gorilla. The peroneus longus, fig. 25, 9, has a longer carneous and shorter but thicker tendinous part in the Gorilla than in Man: the course and insertion of the tendons are the same. The peroneus brevis, ib. 19, very closely repeats the characters of that muscle in Man. The 'tibialis anticus,' fig. 25, 17, commences by a broader and more fleshy origin, but gradually decreases as it descends, not swelling out into the well-marked 'belly,' as in Man: the tendon divides more distinctly and deeply to be inserted into the metatarsal of the hallux and the entocuneiform bone. The extensor longus digitorum, with the same relations at its origin to the tibialis anticus and peroneus longus as in Man, divides, after passing under the annular ligament, into three, instead of four tendons; the innermost of which subdivides to supply the second and third toes. The extensor longus hallucis sends its tendon to the last phalanx of the hallux, as in Man. The short extensor of the toes, ib. 20, also sends off a strong fasciculus, 20′, the tendon of which acts upon the proximal phalanx of the hallux. Three other fasciculi send tendons to the second, third, and fourth toes.

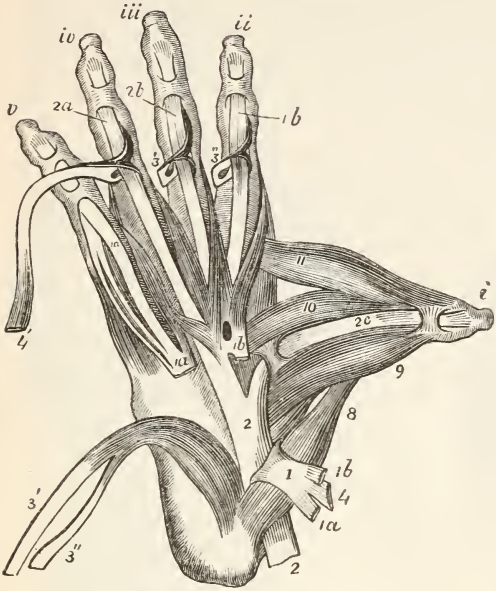
25



Muscles of the leg and foot, Gorilla. I''.

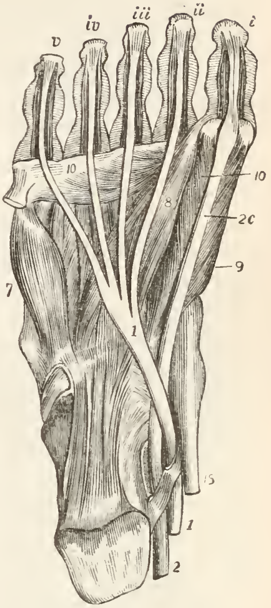
The long flexors of the toes are distinguished in the Gorilla, as in lower *Quadrumana*, by their relative position at the back of the leg. The one toward the inner or tibial side sends its tendon through a strong ligamentous synovial sheath behind the inner malleolus to the sole, where it divides into three chief tendons which are connected with those of the 'flexor accessorius.' In fig. 26, the divisions of the long tibial flexor, 1, are cut and reflected; 1*a* goes to the fifth toe; 4 is the perforated tendon of the fourth toe, 4′, reinforced by carneous fibres from the deeper surface of the main tendon; 1*b* is the tendon to the last phalanx of the second toe.

26



Muscles of the foot, Gorilla. I''.

27



Muscles of the foot, Man.

The long fibular flexor of the toes, arising from the back part of the fibula and interosseous ligament, grooves by its tendon the posterior part of the tibia, the astragalus and the calcaneum, and divides at the sole, fig. 26, 2, into the perforating tendons of the hallux, 2*c*, the third, 2*b*, and the fourth, 2*a*, toes. The portion of the flexor brevis which rises from the calcaneum divides into two tendons which form the perforated ones of the third, 3′, and second, 3″, toes. The short muscles giving the grasping power to the hind thumb are, 8, ‘abductor hallucis,’ 9, ‘flexor brevis hallucis,’ 10 ‘adductor obliquus hallucis,’ and 11, ‘adductor transversalis hallucis.’ The lumbricales and interossei are powerfully developed. In the Orang the long fibular flexor sends no tendon to the hallux.

The ordinal modification of the hind- or lower- limbs for the whole work of sustaining and moving the body, in *Bimana*, is accompanied by well marked and considerable modifications of the toes, the chief of which are illustrated by comparison of the figure, 26, from the highest ape, with fig. 27. The long fibular flexor now becomes the ‘flexor longus hallucis,’ and concentrates its force exclusively on the tendon, 2, 2*c*, which goes to the last phalanx of the hallux, *i*; this tendon is twice the size of any of the divisions of that of the long flexor on the tibial side. This is limited to the function implied by the name ‘flexor longus digitorum pedis,’ its tendon, fig. 27, 1, sending off successively the perforating tendons to the second, third, fourth, and fifth toes. In fig. 27, are shown the insertion of the ‘tibialis posticus,’ 15; the ‘flexor brevis minimi digiti,’ 7; the ‘flexor brevis pollicis,’ inserted into the outer, 9, and inner, 10, sesamoids, the adductor pollicis, 8, and the peculiar ‘transversalis pedis,’ 10, arising from the under surface of the distal and of the fifth metatarsal, crossing three of the other metatarsals, to be inserted into the outer side of the proximal phalanx of the hallux, blending there with that of the ‘adductor pollicis.’

The heel being the lever-power by which the whole superincumbent weight of the body is raised in the peculiar ‘walk,’ or bipedal gait, of Man, muscles that are distinct in quadrupeds are here, contrary to ordinary rule, blended, or have a common insertion. Not only the outer and inner gastrocnemius, but the soleus, and even the plantaris, might be regarded as so many origins of the same muscle, which combine and concentrate their forces upon the calcaneum.

The ‘panniculus carnosus’ of quadrupeds is reduced in *Bimana* to the ‘platysma myoides,’ fig. 28, *p*, *p*, *p*, which extends from the upper and fore part of the chest upward over the front and side of the neck to the mandible and lower part of the face, where the two muscles meet below the symphysis. The middle fibres are attached to the base of the jaw, and posteriorly ascend to the fascia of the masseter; the anterior ones ascend with the depressor anguli oris and quadratus menti to the lower lip and angle of the mouth. In many instances there is a strip from the parotid fascia which converges to this angle, and constitutes the ‘risorius santorini.’ The platysma draws down the lower part of the face, or, by a slighter action, the lower lip: the ‘risorial’ slip tends to raise the angle of the mouth. Most of the muscles of the face are attached at one part to bone, at another to skin or to some other muscle. The skin of the human face is remarkable for its tenuity, flexibility, and abundant supply of vessels and nerves; its vascularity tinting the cheeks and lips: it is more adherent and the subjacent cellular tissue is denser along the median line than at other parts.

The ‘orbicularis oris,’ fig. 29, *o o*, has no attachment to bone.

It consists of two semi-elliptic planes of muscular fibres which surround the mouth and interlace on either side with those of the 'buccinator' and other dilators of the oral orifice. The external or peripheral surface adheres to the skin, the internal or posterior surface is covered by the mucous membrane of the mouth. Acting as a whole it closes the mouth, bringing the lips in contact and pressing them firmly together, but the upper and lower halves can act separately, or the fibres of one side may contract while the others are quiescent, so that different parts of the lips may be moved by different portions of the muscle, which may be regulated or antagonised by the muscles which converge to the mouth. A pair of accessory strips to the orbicularis, 'accessorii orbicularis superioris,' rise from the alveolar border of the premaxillary, and arching outward on each side are continuous at the angles of the mouth with the other muscles there inserted. A second pair, 'naso-labiales,' descend from the septum of the nose to the upper lip, but with an interval, corresponding with the depression on the skin beneath that septum.

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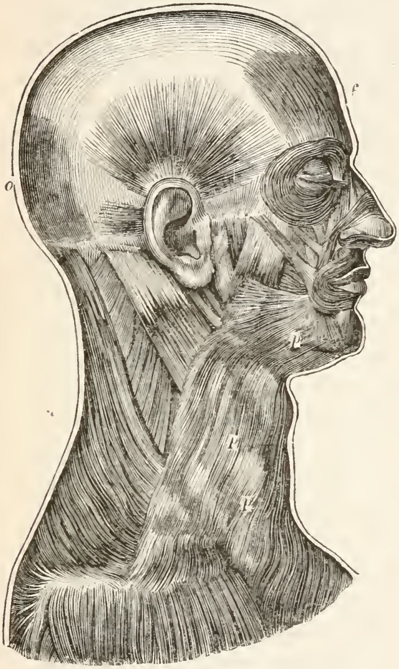

Superficial muscles of the head and neck.

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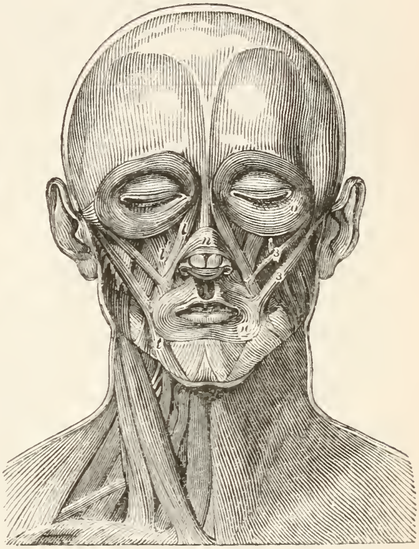

Muscles of the face.

The 'levator labii superioris,' fig. 29, *l*, arises from the lower margin of the orbit, and descends to be inserted into the orbicularis and the skin of the upper lip. The 'levator anguli oris,' fig. 29, *c*, arises below the suborbital foramen and descends, inclining outward, to the angle of the mouth, blending its fibres with those of the zygomatici and orbicularis. The 'zygomaticus major,' fig. 29, 3, is cylindrical, rising from the malar and descending obliquely inward to a similar insertion at the angle of the mouth. The zygomaticus minor, fig. 29, 3, arises in front of the zyg. major, and passing downward and inward to the angle of the mouth, where it is continuous with the outer margin of the levator labii superioris. The levator menti is a conical fasciculus arising from the incisive fossa of the mandible, external to the symphysis, and expanding as it descends to be inserted into the integument of the skin. The 'depressor labii inferioris,' fig. 30, *d*, arises from the inner half of the external oblique line of the mandible, and is partly also continued from the platysma: its fibres ascend, inclining inward to be attached to the lip, where they blend with those of the orbicularis oris. The 'depressor anguli oris,' fig. 29, *t*, arises from the external oblique line of the mandible: its fibres ascend and converge to the angle or commissure of the lips, blending with the other insertions at that part.

The buccinator, fig. 30, *b*, arises from both upper and lower jaws and the pterygo-maxillary ligament: its fibres line the cheek and converge toward the angle of the mouth, where some decussate, the lower ones going to the upper segment of the orbicularis, the upper ones to the lower segment, while other fibres are continued forward into the corresponding lip. The buccinator acts, in antagonism with the orbicularis, in spirting fluids from the mouth and in playing on wind instruments. In mastication the buccinator presses the food from between the cheek and gums into the cavity of the mouth. It assists also in deglutition when the mouth is closed, by pressing the food backward. The 'levator labii superioris alæque nasi' arises from the nasal process of the maxillary, descends obliquely outward and divides, a short strip being attached to

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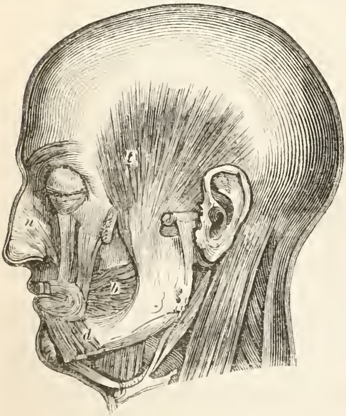

the cartilage of the ala nasi, the outer and longer strip to the skin of the upper lip near the nose, and becoming blended with the orbicularis and levator labii proprius. The 'triangularis nasi,' or 'compressor naris,' figs. 29, and 30, *n*, arises from the maxillary external to the incisive fossa: its fibres proceed upward and inward, expanding to an aponeurosis continuous, over the bridge of the nose, with that of the opposite muscle. The 'depressor alæ nasi' is a short flat muscle radiating upward from the myrtiform or incisive fossa of the maxillary; it sends upper fibres to the septum and back part of the alæ nasi and lower ones into the orbicularis oris. The 'orbicularis palpebrarum,' fig. 29, *o*, surrounds the orbit and eyelids: it arises from the internal angular process of the frontal, from the nasal process of the maxillary, and by a short tendon at the inner angle of the orbit. It rapidly expands to form a broad thin elliptical plane of fibres: the palpebral portion is thin and pale: the orbital portion is thicker and of a reddish colour. The action of the muscle is that of a sphincter, the curved fibres in contraction approaching the centre: but as they are fixed at the inner side the skin to which the muscle is attached is drawn toward the nose, and becomes corrugated into folds which converge toward the inner canthus. The ' corrugator supercilii, is a small triangular muscle placed at the inner end of the eyebrow, arising from the same end of the superciliary ridge: its fibres pass upward and outward to be inserted into the under surface of the orbicularis palpebrarum. It depresses the eyebrow, and, in conjunction with its fellow, throws the integuments into vertical folds as in the act of frowning. The 'occipito-frontalis' consists of an anterior and posterior carneous expansion united by a broad 'epicranial,' aponeurosis. The anterior muscle, fig. 28, *f*, consists of two lateral portions, each connected inferiorly with the integument of the corresponding eyebrow, and slightly overlapped by the 'orbicularis.' The posterior or occipital portion, ib. *o*, also consists of a pair, attached inferiorly to the upper curved line of the superoccipital, and to the mastoid. The fibres are parallel and nearly vertical. The action of this muscle is most apparent upon the skin of the forehead and the eyebrows: it raises the latter and throws the former into transverse wrinkles.

§ 202. *Locomotion of Mammals.*—In the movements of the human frame the three kinds of lever are exemplified. Those of the head upon the atlas are on the principle of the first kind, fig. 31, in which the fulcrum F is between the power P and the resistance W. When the body is raised on tip-toe by the action of the muscles on the heel-bone, fig. 37, *k*, the action is that of the second kind of lever, in which the resistance (of the tibia on the astragalus), as in fig. 32, W, is between the fulcrum F (afforded by the ball of the hallux), and the power *a* (tendo achillis).

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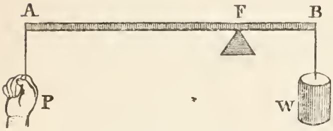

Lever of the first kind.

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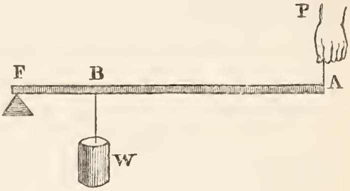

Lever of the second kind.

In lifting a weight in the hand by motion of the fore-arm only, fig. 33, the elbow-joint is bent; the power (of the flexors of the fore-arm) being applied (as by the biceps, *p*) at *a*, between the fulcrum (elbow-joint) *f*, and the resistance *w* or *b*, according to the third kind of lever exemplified in fig. 34.

The mechanism of the pulley is exemplified in the passage of the tendons of the peronei muscles through the groove of the external malleolus of the human ankle-joint, in the tendon of the obturator internus gliding through the groove in the os ischii, in the tendon of the circumflexus palati passing through the hamular process of the sphenoid bone, in the tendon of the obliquus superior gliding through the ring attached to the frontal bone, and in several other instances where a change of the directions of the limbs results from tendons passing over joints, through grooves in

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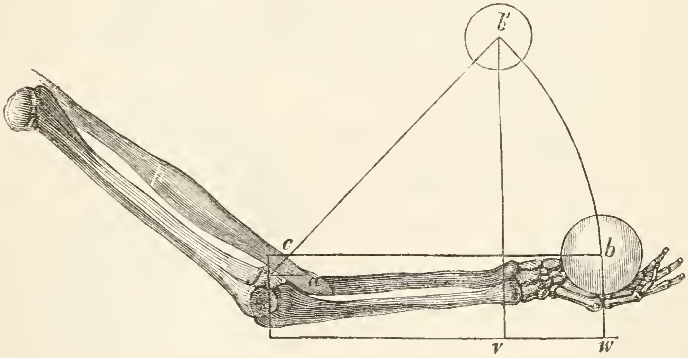

bones, or under ligaments, by which the muscles are capable of producing effects on distant organs without disturbing the symmetry of the body, an effect which, owing to the limited power of contraction in the muscles, could be accomplished in no other way.

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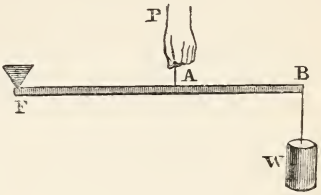

Lever of the third kind.

The joints in the mammalian skeleton are chiefly of two kinds, ‘ginglymoid’ or hinge-joints, and ‘enarthrodial’ or ball-and-socket joints. In Man the former are less definitely fitted for motion on one plane than in most brutes. The arm and fore-arm move in concentric planes upon the elbow-joint; the knee-joint allows a certain rocking motion of the leg upon the thigh; the ankle-joint has a greater latitude of motion, and the foot may be directed out of the plane of the leg's motion.

Atmospheric pressure exercises its influence upon joints. Dr. Arnott estimates the amount of that on the knee-joint at 60 lbs.; Weber of that on the hip-joint at about 26 lbs.: in the hip-joint of the Megatherium the pressure could not have been less than 150 lbs.

A. *Swimming.*—Quadrupeds with inflated lungs are of less specific gravity than water, and swim by alternate extension and flexion of their legs; the effective stroke being the act of extension, when the limb presents a larger area to the water than in flexion: this is seen in the Horse, which strikes the water with the expanded and subconcave surface of the hoof, but draws the convex conical part through the water in the bending of the limb preparatory to the next effective stroke. In the best water dogs the digits are connected by webs, which are stretched in the back or down-stroke, folded in the return movement. The feet of the Otter are broader, especially the hind ones, and more fully palmated. The Seals and Whales have the limbs fashioned as fins.

Man, with the chest well expanded, is lighter than water: the presence of mind which counteracts the tendency produced by immersion in a cold and dense medium to expel the air from the lungs is the first safeguard against drowning; and next, if the art of swimming has not been learnt, to keep the head immersed to the mouth and nose, and to refrain from the misdirected struggles of terror which tend only to hasten on the catastrophe.

In swimming, the hands and feet are employed so as to present the greatest surface to the water in the effective stroke, the least in the preparatory movement; in this the hands are brought near the mesial plane, with the palmar surfaces parallel to each other; they are then thrust forward by the extension of the arm, with the points of the fingers in advance to cut the water with the least resistance; when the hands have nearly reached their greatest distance from the centre of gravity, they are rotated by pronation, so that the palms are directed at an oblique angle outward and downward; they are then forced backward by the abduction of the whole arm through a large arc of a circle, having the shoulder-joint for its centre, and the length of the arm for its radius; the fore-arm is then flexed, and carried into its former position preparatory to making another stroke. During the extension of the arm, the feet are drawn toward the centre of gravity, with their convex surface directed obliquely backward by the extension of the ankle and flexion of the hip and knee joints, and during the abduction of the arm the flat surfaces of the feet are driven forcibly backward and downward by the sudden extension of the leg. From the ratio of the areas of the hands and feet, and the ratio of the difference of their velocities in the two strokes, there results such a preponderance of the force in the vertical direction upward and in the horizontal direction forward as is sufficient to keep the respiratory openings above the surface of the water, and to overcome the resistance which the water opposes to the motion of the body, due to its figure and velocity.

B. *Moving on Land.*—In mammalian quadrupeds the limbs are usually long, and support the trunk horizontally, uplifted from the ground, as on columns expanded at their base. The uppermost long bone is single, the next two form a pair, side by side, and these rest on more numerous ossicles, transferring the weight upon the base of two, three, four, or five diverging piles: the single hoof of the Horse seems an exception, but it, too, expands to its base. The shafts of the long bones are hollow, agreeably with the principle of combining greatest strength with least weight. According to the lightness and speed of the quadruped, the limb-bones are inclined to each other's axes at a greater angle. In the colossal Elephant and Megathere they rest on each other almost vertically, in supporting the trunk. The horizontal trunk and produced head and neck of quadrupeds cause the largest proportion of the weight to fall upon the front pair of supporting columns, of which, accordingly, the angles of the joints are less, and the direction more vertical than in the hind pair, as is well exemplified in the hoofed kinds (vol. ii. figs. 307, 309, 310).

In walking, the Horse, if the right side be in advance, moves first the left hind-leg, second the right fore-leg, third the right hind-leg, fourth the left fore-leg; propelling the centre of gravity forward over a space equal to the length of the first step. When the left hind-leg is in the act of advancing, the trunk is supported on the other three legs and is balanced on a triangular instead of a parallelogrammical basis. A succession of movements of the four legs, in the above order, constitutes the progression by walking in most quadrupeds; its rapidity depends on the time occupied in the series of movements by which the limbs effect the step. In a large well-made Horse one foot may move the length of a step in a second of time, when each leg may swing during one quarter and rest on the ground three quarters of a second. Rapid walkers do it in less time, and the interval between putting down one leg and lifting another becomes inappreciable. In quadrupeds with limbs unusually long in proportion to the trunk there is a modification of the act of walking: the Camel and Giraffe seem to swing along by moving the two right limbs together and alternately with the two left limbs. But, though in a quick walk the two legs of the same side seem to be moved forward simultaneously, and are both off the ground at the same time through the greater part of the step, yet on close inspection the hind-leg is seen to be first lifted from the ground, and after a very brief interval the fore-leg of the same side.[1] In this way of walk the trunk is balanced on a linear basis of support, alternately transferred from one side to the other. In the Giraffe the long neck is then stretched out in a line with the back, giving the animal a stiff and awkward appearance; but this is lost when they commence their graceful undulating amble: the motions of the legs are now peculiar; the hind-pair are lifted alternately with the fore, and are carried outside of and beyond them by a kind of swinging movement.[2]

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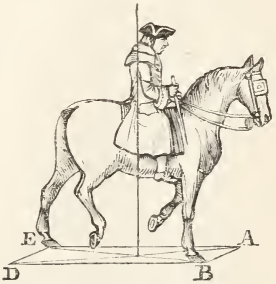


In the pace of the Horse called the 'trot,' the legs move in pairs diagonally, those marked B, E, fig. 35, e.g. being raised as soon as A, D, strike the ground: the bases of support are alternately in the lines A, D, B, E; and the undulations from the projection of the trunk are in the vertical, not as when walking

[1] XCVII′. p. 244.

[2] Ib. p. 244.

in the horizontal, plane. Moreover, in the rapid trot, each leg rests a short time on the ground and swings a longer time.

The gallop includes three combinations of movements of the limbs. When the Horse begins the gallop on the right hind-leg, the left one reaches the ground first; the right hind and left fore-legs next, simultaneously, and the right fore-leg last; this is termed the *gallop of three beats.* In the gallop where the four legs strike the ground successively, the left hind-foot reaches the ground first, the right hind-foot second, the left fore-foot third, and the right fore-foot fourth; this is the 'canter,' or *gallop of four beats,* but it is not the kind of movement adapted for great speed. The gallop wherein the legs follow the same order as in the trot—that is, the left hind and right fore-feet reaching the ground simultaneously, then the right hind and left fore-feet—is the order in which horses move their feet in racing, where the greatest speed is required, and is called the *gallop of two beats.* In the 'amble,' the two legs on one side rest on the ground and propel the centre of gravity forward, whilst those on the opposite side are raised and advanced, and, on taking a new position on the plane of motion, the former pair are raised and advanced in a similar manner: these successive actions are accompanied by considerable lateral motion. This resembles the gallop of the Giraffe, and is a result of special training in the Horse. In the ordinary gallop, the centre of gravity moves in a vertical plane, and describes the path of a projectile. The space passed over on the plane of motion is equal to the horizontal velocity of the centre of gravity multiplied by the time. According to Sainbell, the horse Eclipse, when galloping at liberty and with its greatest speed, passed over the space of twenty-five feet at each stride or leap, which he repeated $2\frac{1}{3}$ times in a second, being nearly four miles in six minutes and two seconds. Flying Childers was computed to have passed over eighty-two feet and a half in a second, or nearly a mile in a minute. In both these famous racers the muscular system had been allowed to gain its full developement, as at four years, before being exercised for the course: modern impatience strains and spoils the muscles by the chief prizes being allotted to three-year-old horses.

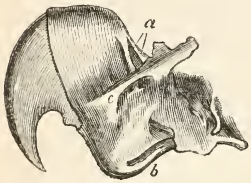
In many Marsupials and Rodents the hind-legs are shorter than the fore-legs, the disproportion being greatest in the Kangaroos and Jerboas. In slow progression the Kangaroo supports the body on the tail and fore-legs, while the hind-legs are simultaneously moved forward outside and in advance of the fore-legs; the base of support being here transferred from a triangle to a transverse line. In full speed the tail is rigidly outstretched to afford a firm fulcrum to muscles passing from the caudal vertebræ to the pelvis and hind-limbs: the short fore-limbs are tucked up to the chest so as to offer the smallest surface to the air, and the animal progresses in a series of bounds by simultaneous movements of the hind-limbs.

The Rabbit, in moving slowly, advances the fore-feet two or three steps alternately. The body being thus elongated, the hind-legs are suddenly extended and drawn forward simultaneously: it thus, as it were, walks with the fore-legs, and leaps with the hind. The Hare is under disadvantage with its long hind-limbs in running down-hill, owing to the great inclination of the axis of the trunk to the plane of motion, and it usually zigzags as it descends; but it gains proportionally in the ascent, and its speed on level ground, through the size and strength of the chief propelling limbs, is very great. The degree of flexion of the trunk accompanying the movements of these and other quadrupeds is indicated by that in which the neural spines converge toward the single vertical one marking the centre of motion, and it is commonly greatest in the unguiculate quadrupeds.

The verticality of the long and narrow tarsus and metatarsus producing the 'digitigrade' character of the type *Carnivora*, combines with the geometrical and physical relations of the other parts of the limbs to give them their superior speed and agility. In the Dogs and Cats the oblique scapula, being unfettered by bony (clavicular) connection with the sternum, enjoys the freedom of rotation which characterises it in the swift Ungulates. The humerus in the Lion (vol. ii. fig. 337) has its axis directed downward and backward, forming with that of the scapula an angle of 110°. The olecranon projects so far behind the axis of rotation in the elbow-joint as to constitute a powerful lever for the extensors of the fore-arm. The hind-limbs are longest, and the bones are inclined more obliquely to each other than in the fore-limbs, subserviently to elasticity and power in springing. The calcaneum is produced on the same principle as the olecranon, but forms the more powerful lever of the two. The last perfection is given to the limbs of *Carnivora* by the modifications of the toes of Felines, whereby their tread is noiseless, and the claws exempt from the wear and tear of progressive motion. It is effected by a joint allowing the ungual phalanges to be brought in extension above the middle phalanges, elastic ligaments being adjusted to keep the joint so extended, and by a thick cushion of soft elastic substance beneath the joint or parts of the phalanges transmitting the superincumbent weight to the ground.

In the toes of the fore-foot the last phalanx is retracted on the ulnar side of the second phalanx. The principal elastic ligament arises from the outer side and distal end of the second phalanx, and is inserted into the upper angle of the last phalanx: a second arises from the outer side and proximal end of the second phalanx, and passes obliquely to be inserted at the inner side of the base of the last phalanx: a third arises from the inner side and proximal end of the second phalanx, and is inserted at the same point as the preceding. The tendon of the 'flexor profundus perforans' is the antagonist of these ligaments. The toes of the hind-foot are retracted in a different direction, viz. directly upon, and not by the side of, the second phalanx; and the elastic ligaments are differently disposed. They are two in number, arise from the sides of the second phalanx, and converge to be inserted at the superior angle of the last phalanx. In fig. 36, *a* is the pair of elastic ligaments; *b*, the tendon which pulls out and works the claw; *c*, inelastic ligament continued from the 'extensor' tendon, which is mainly inserted into the second phalanx.[1]

36



Elastic ligaments of Lion's claw.

The main purport of the modifications of the motory system in *Quadrumana* is to make them climbers. By the developement and direction of the hallux the hind-foot is converted into a hand, with unusual power of prehension, especially in the Gorilla; the joint of this hand is so modified as to give it a free motion excentric to the axis of the leg, whereby its outer edge is applied to the ground; the whole hind-limb is shortened, disproportionately so in the best climbers (vol. ii. fig. 180), in which also the hind-limb may be unfettered, for its acts of manipulation, by the absence of the 'ligamentum teres' of the hip-joint (*Pithecus*). The length of the iliac bones relates to elongation of the muscles for rotating the hind-limb and hand more quickly and through greater spaces. Correlatively, the scapular arch approximates to the condition of the pelvic one by the extension of complete clavicles to the manubrium, and the head of the humerus is received into a deeper and more secure socket than in *Bimana*. This is well exemplified in the long-armed Gibbons, which enjoy the peculiar mode of locomotion called 'brachiation.' The body is set into pendulous vibration by the action and reaction of the muscles of one arm and of the trunk, the force finally attained and the swing being such as to propel the animal some distance through the air; a bough is seized by the opposite out-stretched arm, and the momentum is applied in aid of a repetition of the action to gain a longer launch. I have myself witnessed, in the London Zoological Gardens, an aerial leap of upwards of fifteen feet so effected by the long arms of a captive Hylobat. M. Duvaucel, observing them in their native forests, testifies to their passing through a distance of forty feet from bough to bough. Mr. Martin, when curator of the Zoological Society's Museum, watching the same female *Hylobates agilis* which had been the subject of my own study of the brachiating mode of motion, states that, 'a live bird being set at liberty in her presence, she marked its flight, made a long swing to a distant branch, caught the bird with one hand in her passage, and attained the branch with her other hand, her aim both at the bird and the branch being as successful as if one object only had gained her attention.'[1]

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[1] The dissections of the Lion's foot showing the above-described modifications of the elastic ligaments are Nos. 287A and 288A, Physiol. Series, vol. i. xx.

In most of the Platyrhine monkeys the tail is prehensile, and becomes, in *Ateles* more especially, a fifth independent organ of grasping.

In ordinary progression on the ground the *Quadrumana* move as quadrupeds; but the higher tailless Catarrhines (Apes), instead of setting the palm or outer margin of the fore-hands, like the inferior families, to the ground, apply the back of the second phalanges of the flexed fingers, the skin covering which has a broad and thick callosity, whence these apes are sometimes called collectively, 'knuckle-walkers.' The longer-armed kinds, in slow movement, support the body upon the knuckles, as upon a pair of crutches, and swing the hind-limbs forward between them. In more rapid movement they sway the trunk and hind-limbs in a sort of sidelong sweep, progressing by a kind of shambling amble. The tracks of the Gorilla show this to be the habitual mode of progression along the ground.[2] Station or motion on the lower limbs only is shown to be difficult by its awkwardness and the shortness of time during which it can be maintained. The walk is a waddle from side to side, the huge superincumbent body being balanced by swinging movements of the long arms, or by clasping the hands behind the head. When so pursued as to be driven to stand at bay, the Gorilla, like the plantigrade Bear, raises himself on the hind-hands, so as to have his powerful arms and fists free for the combat.

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[1] XLVIII″.

[2] XIII‴. p. 532.

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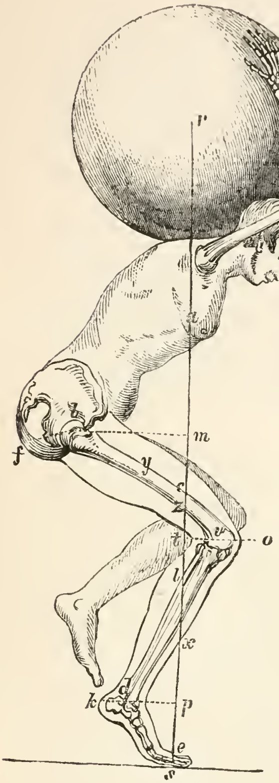

The *Bimana* are as expressly adapted to station and movement on the ground as are the Quadrumana to climbing in the forest. There is no known connecting link between the lowest variety of Man and the highest species of Ape. No animal is served by arms, at once so large and variously flexible and applicable as Man; in none are the terminal divisions of the limb so distinct in their power and adaptibility.[1] The mechanism of the vertebral column and limbs which makes Man a 'plantigrade biped,' and the only one in the Animal Kingdom, is as perfect in the Mincopie,[2] Australian, or Boschisman, as in the most advanced member of the white race. The locomotive frame of any variety would equally serve as the subject of such elaborate analyses of the mechanical conditions of 'standing,' 'walking,' 'running,' 'leaping,' &c. as have been given by Borelli,[3] Barthez,[4] Roulin,[5] Gerdy,[6] and W. & E. Weber,[7] to whose works, and especially the latter, the reader is referred for this interesting branch of Animal Mechanics.

[1] LXIV·. [2] XXXVII··. [3] CXXXI·.
[4] XIV··. [5] XV··. [6] XVI··. [7] XII··.

Figure 37 exemplifies a Man stooping with a load, and sustained in that position by the glutei, *f*, the quadriceps femoris, *y*, and the gastrocnemii, *l*. If the weight *r* be 120 lbs., that of the bearer 150 lbs., and if the line *r s* be the direction of the force of gravity cutting the femur and tibia in *c* and *x*, the centre of gravity of the Man being at *b*, and the common centre of gravity of the Man and his load at *a*, then the weight of the Man from the head to *b* will be $= \frac{150}{2}$ lbs. $= 75$ lbs., and that of the section *b* to *c*, by supposition, $= 47$; therefore the weight of the are $a\ b\ c = 75 + 47 = 122$, also by supposition the section $c\ v\ x = 20$, and consequently the whole are $a\ b\ v\ x = 142$; the distances of the directions of the muscles from the axes of the joints to the distances of the line of gravity are, according to Borelli, in the following ratio,—$\frac{1}{2}$ the distance *f b* is to the distance *m b* as 1 is to 8; $\frac{1}{2}$ *o v* is to *t v* as 1 to 6; $\frac{1}{2}$ *k d* is to *p d* as 1 to 3; and *t v* to *b m* as 3 to 4; hence he derived certain proportions, from which he estimated that the extensor muscles of the leg, to sustain this weight, exerted a force $= 6032$ lbs., being more then fifty times the weight.

CHAPTER XXVIII.

NERVOUS SYSTEM OF MAMMALIA.

§ 203. *Myelon.* — The myelon in Mammals, as in Birds, quits, in the course of developement, the hinder part of the neural canal, moving and concentrating forwards, and leaving the concomitantly elongated roots of the nerves, between their places of exit at the intervertebral foramina and their places of attachment to the myelon, as an indication of the primitive extent of the nervous axis.

It is remarkable that the Monotrematous order, so restricted in its representative genera, should present the two extremes of this developemental difference in the length of the myelon. The Ornithorhynchus hardly departs from the condition of the lizard, the myelon extending into the sacrum, and having the intravertebral nerve-roots limited to the short canal of the caudal region; whilst in the Echidna, fig. 38, the myelon moves forward to the middle of the dorsal region, *d*, where it ends in a point, and leaves all the canal behind occupied by the elongated nerve-roots and shrunken emptied myelonal sheath, answering to the ‘cauda equina’ and ‘filum terminale’ of anthropotomy, but of extraordinary length.

In the Ornithorhynchus the myelon fills closely the neural canal: it is thickest at its commencement and at the lower two-thirds of the cervical region; it is more slender in the back, especially near the loins; it is slightly enlarged in the lumbar region, and gradually terminates in a point at the end of the sacral canal. The short and thick myelon of the Echidna presents the two usual enlarge-

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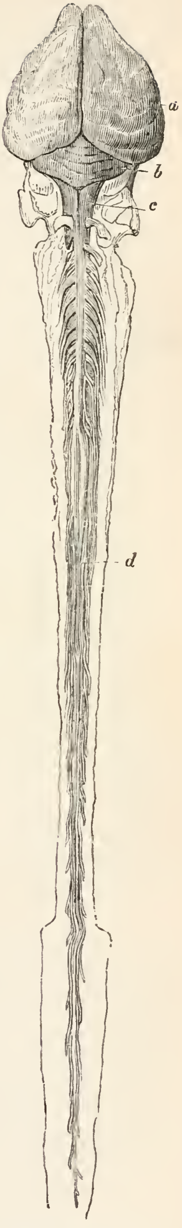

Brain and spinal chord, Echidna, half nat. size.

ments, giving origins respectively to the nerves of the pectoral and pelvic extremities, the slightly contracted intermediate portion being extremely short.

In the Marsupialia the myelon usually extends to the sacrum, and presents both brachial and pelvic enlargements which correspond with the relative size and muscularity of the extremities to which they furnish the nerves; the latter enlargement is consequently most marked in the Kangaroo, fig. 39, but does not exhibit the rhomboidal sinus of this part in Birds. The disposition of the layer of grey matter enveloping the central medullary tract in each lateral moiety of the chord is shown in the three situations marked 1, 2, and 3; the superior expansion and complexity of the grey matter in the anterior columns of the pelvic enlargement, 3, accords with the predominance of the locomotive over the sensory functions in the long and strong saltatory legs of the Kangaroo.

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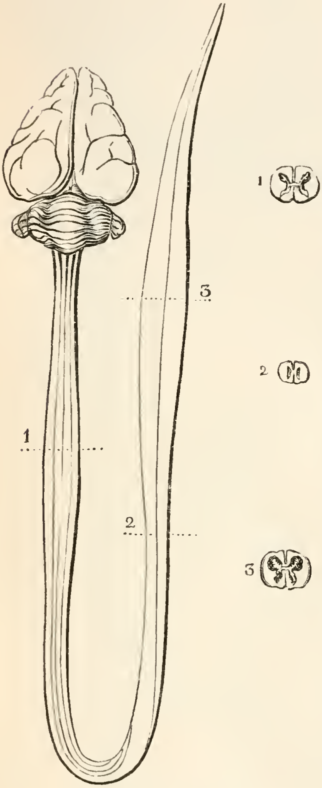

Myelencephalon, *Macropus*.

In the *Lissencephala* we have again examples of the concentrative protraction of the myelon into the dorsal region, as e.g. in some *Cheiroptera* and in the Hedgehog. From the coincidence of the condition of the myelon with the tegumentary covering in *Erinaceus* and *Echidna*, we are led to ask, whether the shortness of the solid chord, and the great length of the succeeding nerves within the neural canal, have any physiological relation with the habit, common to both the placental and monotrematous hedgehogs, of rolling the body into a ball when torpid or asleep, or when the tegumentary armour is employed in self-defence. In the bat it would seem to be concomitant with the reduced size and function of the pelvic limbs: but, in the Noctules (*Vespertilio noctula*), the myelon extends to the lumbar vertebræ. The anterior enlargement is the chief one in *Cheiroptera*, and is close to the medulla oblongata, as it is likewise in the *Cetacea.* In most Rodentia the myelon terminates in the lumbar region, but in the rabbit it extends a little way into the sacrum. In the mouse the relative proportion of the myelon to the brain is as 22 to 100.

In the *Cetacea* and *Sirenia,* the myelon presents only the anterior enlargement, which is very near the brain, and is remarkable for the close aggregation of the origins of the nerves from that part. The myelon is closely invested by the dura mater, which is directly perforated by the nerves, and the sheath terminates at the pointed end of the myelon, not being continued as such, over the 'cauda equina.' The myelon is small in proportion to the size of the body, shows the central canal, and, Hunter remarks, 'is more fibrous than in other animals; when an attempt is made to break it longitudinally, it tears with a fibrous appearance, but transversely it breaks irregularly.'[1]

In the Elephant the dura mater surrounds the myelon less closely than in the *Cetacea,* and the roots of the nerves have a longer course within the sheath. In the Giraffe[2] I found the myelon closely invested by the dura mater, which was thinner on the dorsal than on the ventral side: it is chiefly remarkable for the length of the cervical portion, which from the corpora pyramidalia to the pectoral or brachial enlargement measured four feet three inches. The elongation of this part during fœtal developement proceeding by uniform interstitial addition, the roots of the nerves become equally separated from each other; and, as the lowest filament of one root was not further removed from the highest of the next below, than this from the succeeding filament of the same root, such filaments were extended over an unusual space of the myelon; the root of the third cervical coming from a tract of not less than six inches in length: the contrast between the cervical myelon of the Porpoise and Giraffe in this respect is striking.

With the singular exceptions of the Echidna, Hedgehog, and certain bats, the mass of the myelon bears a direct ratio to that of the body throughout the Mammalian series, and its structure is essentially the same. In the adult human male it a little exceeds an ounce in weight: its tissue is firmer than that of the brain. As in all Vertebrates, the ventral and dorsal surfaces are respectively divided into equal moieties by a longitudinal fissure, of which the dorsal is deepest, and, in the Mammalia, closest. In Man, the interfissural plate of pia mater can be shown to be a fold in the ventral (anterior) fissure, fig. 40, *a,* but is confluent as a single delicate layer of vascular tissue in the dorsal (posterior) one, ib. *c*. A layer of white neurine accompanies the ventral fold, which, when withdrawn, shows the fissure to be closed by such layer, perforated by numerous holes for capillaries: its fibres are transverse and form the ‘white myelonal commissure.’ The depth of the ventral fissure is greatest at the pectoral enlargement of the myelon, and gradually diminishes towards the ‘cauda equina.’ The deeper dorsal fissure penetrates fully one-half of the dorso-ventral diameter of the myelon through the greater part of its course, but becomes shallower in the lumbar region: it is bounded by a layer of grey neurine, connecting the same tissue in each lateral moiety of the myelon, which layer forms the ‘grey myelonal commissure.’

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[1] xciv. p. 374.

[2] xcvii′.

In the developement of the myelon, as of the encephalon, the central part contains a fluid which is reduced by the endogenous growth of neurine, on approaching maturity; it remains in the myelon, as its ‘canal,’ which is obvious in the cold-blooded Vertebrates,[1] and is exposed, in birds, as the ‘ventricle of the pelvic enlargement,’ as it is in the ‘fourth ventricle’ of all Vertebrates, where it bears the name of ‘calamus scriptorius’ in anthropotomy. The myelonal canal is more obvious in lower mammals [2] than in Man, and in the fœtus than in the adult; in whom, whilst unobliterated, it is surrounded, like the more obvious myelonal canal in Reptiles, by the grey commissural neurine. The canal is lined by ciliate cells.[3] The lateral columns of this tissue, united by the commissure, are thicker but less peripherally extended in the ventral, *g*, than in the dorsal, *h*, portions of the myelon. In transverse section the grey neurine resembles a comma, the concavity of which is directed outward, the head, fig. 40, *g*, is surrounded by the peripheral white neurine, and the tail, ib. *h*, *i*, is produced to the issue of the dorsal (posterior) nerve-roots, ib. *k*. The proportions of the grey and

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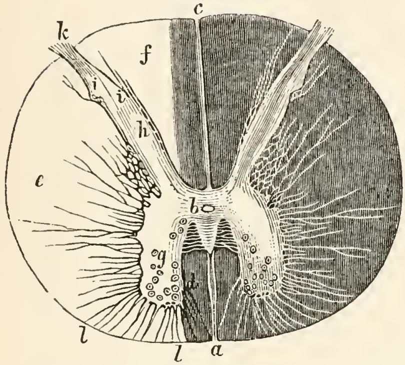

Transverse section of the human myelon, close to the third and fourth cervical nerves. Magnified ten diameters. xviii''.

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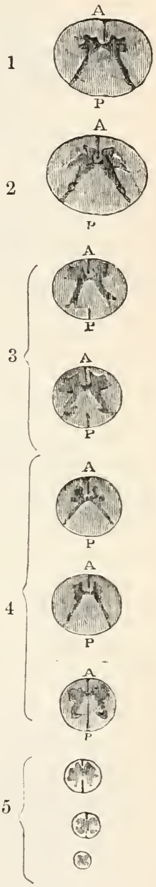
[1] vol. i. pp. 272, 296. [2] xx. vol. iii. p. 43, no. 1362. [3] xviii''.

white neurine vary in different parts of the myelon. In fig. 41, 1 is a section at the fore (upper) part of the pectoral enlargement, the head of the comma is small, the tail narrow: in the middle of the enlargement, section 2, the head is larger, with more distinct processes, the tail is thicker. In the dorsal region, sections 3, the grey matter is more reduced than in the neck. In the lumbar region, sections 4, it again expands, the head shows the stellar character, is fenced off from the ventral periphery by a smaller extent of white neurine; the tail is thicker, but here becomes shorter and seems not to reach the dorsal surface. Near the termination of the myelon the comma-shape is lost, and the grey neurine reduced to a subcylindrical tract, slightly notched laterally and surrounded, save at the commissure, by the white neurine. Of this tissue the largest proportion exists in the cervical part of the myelon and its enlargement, where the small columns called 'posterior pyramids' are continued from the dorsal part of the medulla oblongata, contracting to a point, near the end of the brachial enlargements, and there allowing the proper dorsal (posterior) columns of the myelon to come into contact at the posterior fissure. The difference in the proportions of white and grey neurine in the ventral and dorsal tracts of the myelon coincides with the different nervous endowments of the pectoral and pelvic limbs: in the former volition and sensation are greatest; in the latter reflex actions with diminished sensibility: the exercise of the arms and hands induces more calls upon cerebral action, that of the legs and feet operates more exclusively through physical changes of the lumbar part of the myelon itself: hence, therefore, the need of a greater proportion of the reproductive or grey tissue. Numerous multi-caudate vesicles are present in the grey neurine, and linear tracts are continued from the major part of its periphery, as seen in transverse section, towards that of the myelon, accompanied by capillary vessels which enter the pia mater.

41



Transverse sections of the human Myelon.
A. Anterior or 'ventral.'
P. Posterior or 'dorsal.'

The proportion of the neural canal to the myelon varies in different mammals: it is greatest in the Cetacea, Sirenia and Seal-tribe, the space between the myelon and neural arches being occupied by blood vessels, which, in those aquatic orders, are chiefly arterial plexuses. In land-mammals and Man the veins predominate, having more or less of the character of sinuses, as shown in the section of the lumbar vertebra, fig. 42, where the communication of the ‘perineural’ veins, *d*, with those of the tissue of the vertebral centrum, is shown. But the most constant fluid external to the myelon is that which has been called ‘cerebro-spinal.’ In the dorsal region of the neural canal, in Man, the position of this fluid is shown in fig. 43, where *c* is the myelon, with its pia mater and arachnoid, *m* the dorsal or posterior septum, *n* the nerve-roots, and *s s* the sub- or ent-arachnoid space. The use of the uniform support and defence afforded by the interposition of this fluid between the myelon and the hard walls of the neural canal is obvious.[1]

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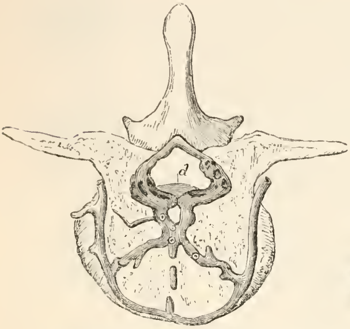

Communication of the ‘perineural’ sinus with the veins of vertebral centrum. VII″.

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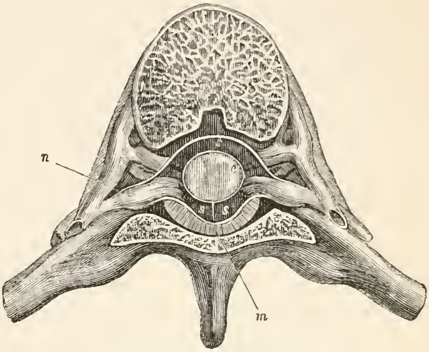

Transverse section of dorsal vertebra and contents of its neural canal. XIX″.

The arachnoid is disposed about the myelon, as about the brain, after the manner of the serous membranes; it consists of an exterior or ‘parietal layer’ reflected upon the myelon to form the internal or ‘myelonal’ layer. If a section be made through a pair of nerve-roots, those e.g. of the fifth cervical, fig. 44, the arachnoid is seen to be continued as a loose sheath, about the inter-neural part of the root, *n n*, and is reflected so as to form small culs-de-sac, at the orifices of emergence.

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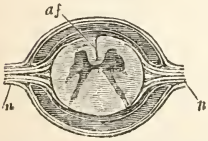

Transverse section of the myelon and its membranes across the roots of the fifth cervical nerves.

In Man the myelon is loosely invested by the ‘dura mater,’ to which it is attached by processes of the arachnoid called 'ligamentum denticulatum,' and the nerve-roots.

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[1] XIX″. In which the effects of the removal of this fluid in the Dog are described.

§ 204. *Encephalon, its primary divisions.*—The encephalon, or brain, of Mammals, like that of lower Vertebrates, Turtle, fig. 45 (vol. i., Shark, fig. 187, and Lepidosiren, fig. 186), presents four primary segments or divisions, indicated by as many superincumbent, originally vesicular, masses, or pairs of masses; but consisting, not only of those, but of tracts of the myelencephalic columns from which those masses are successively developed.

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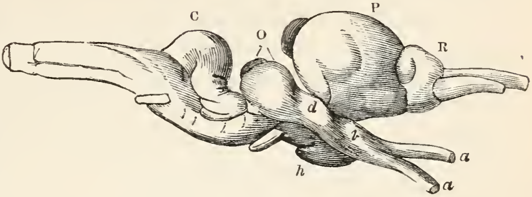

Brain of a Turtle (*Chelone*), side view.

The hindmost division, or 'epencephalon,' fig. 46, C, consists of the enlarging parts of the myelencephalic columns, *a*, called 'medulla oblongata,' of the superincumbent mass, *c*, originally a pair in the human fœtus (fig. 47, *c*), called 'cerebellum,' and of a transverse commissure of that body, called 'tuber annulare' or 'pons varolii,' *p*; the three parts, so named in anthropotomy, are subordinate elements of one and the same primary division of the encephalon.[1]

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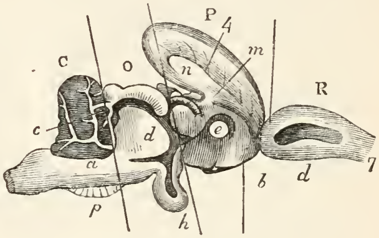
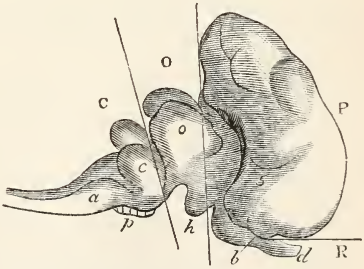


Brain of Opossum (*Didelphis*), side view.

The next division includes the parts of the myelencephalic columns which support, and from which are developed, the optic lobes, *o*: it is the 'mesencephalon,' figs. 45, 46 and 47, O. With the columnar elements are the parts called the 'fillet,' and 'processus a cerebello ad testes' in anthropotomy, including the 'third ventricle' and its prolongations into the vascular appendages



Brain of human fœtus, at four months, side view.

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[1] The severance of the 'pons,' and raising it, in association with parts of another segment, to the rank of a distinct primary division as 'mesocephalon,' and the severance of the 'medulla oblongata' from the cerebellum, as a co-equal division, called 'metencephalon,' indicate the warping of the judgment through habitual contemplation of the characteristically modified and developed parts of the human brain.

called 'pineal' and 'pituitary' *h*, glands: a second pair of ganglionic masses are developed in Mammalia behind the optic lobes, *o*, and received from the old anthropotomists the name of 'testes,' the more constant and important pair being the 'nates,' and the whole, from their arrested condition in Man, forming the 'corpora 'quadrigemina' or 'bigemina.'

The third primary division of the brain includes the 'crura cerebri' with the reinforcing or recruiting ganglions called 'thalami optici' and 'corpora striata,' and the superincumbent masses called 'cerebral hemispheres:' it is the 'prosencephalon,' figs. 46 and 47, P.

The foremost primary division of the brain includes the anterior termination of the columnar tracts, called 'crura rhinencephali,' and the appended vesicular mass, called 'olfactory lobe;' it is the 'rhinencephalon,' ib. R. The nature and value of this division are masked, in Man, by the arrest of its developement and the contrast of the excessive expansion of the vesicular part of the antecedent division. Accordingly the 'crura rhinencephali' are termed 'olfactory nerve' with its 'roots,' and the primary vesicle is the 'bulb of the olfactory nerve,' of anthropotomy.

Each primary encephalic division has its cavity or cavities called 'ventricles.' The epencephalic prolongation of the myelonal canal is the 'fourth ventricle:' its continuation into the primary vesicle is the 'cerebellar ventricle:' it is persistent in fishes (vol. i. p. 275, fig. 178, *c*), reptiles (ib. p. 295, fig. 193), and birds (vol. ii. p. 120, fig, 45), but is obliterated in Mammals where the cerebellum is solid. The 'myelonal canal' passes forward as the 'third ventricle,' and 'iter' or communicating canal between that and the 'fourth.' Its continuation into the optic lobes, retained in oviparous Vertebrates (vol. i. p. 278, fig. 182, *h*, *b*, p. 279, fig. 183, *d*, p. 295, fig. 193, 3, vol. ii. p. 120, fig. 45, *o*,) is obliterated by growth of neurine in Mammals; as is also its ascending canal to the 'pineal appendage;' the descending one to the 'hypophysis' is retained as the 'infundibulum.'

Each cerebral hemisphere begins in Mammals, as in lower Vertebrates, as a bladder with a thin wall of brain-substance, the cavity including, potentially, all the anthropotomical 'horns,' 'fore,' 'aft,' and 'under,' of the 'lateral ventricle,' which are subsequently meted out by endogenous growths of grey and white neurine, in size and shape according to the group or genus.

In most Mammals which derive so important a share of their ideas through the olfactory sense, the 'lateral ventricle' is continued into the 'rhinencephalon,' as shown in fig. 46, *d*. So that all the essential parts of a primary encephalic division, viz. the columnar as 'crus rhinencephali,' the superimposed mass, and the cavity exemplifying the nature of the olfactory bulb as a 'primary vesicle' of the brain, are present.

§ 205. *Macromyelon.*—The epencephalon consists of the macromyelon and cerebellum. The term 'macromyelon' is not exactly the equivalent of the 'medulla oblongata' of anthropotomy, the authorities in that department of anatomy having applied the phrase in different senses. With Willis,[1] it included the part of the brain beneath the cerebellum and cerebral hemispheres, 'all that substance,' e.g., which reaches from the cavity of the callous body and conjuncture in the basis of the head to the hole at the hinder part where the same substance, being further continued, ends in the 'spinal marrow.' With Vieussens,[2] the 'oblong marrow' included the columns of the neural axis between the 'spinal marrow' and the 'cerebral hemispheres,' with the 'crura cerebri' and their ganglionic enlargements, called 'optic thalami,' and 'corpora striata.' Winslow[3] defines the 'medulla oblongata' as the medullary basis common to both cerebrum and cerebellum. Haller[4] restricts the 'medulla oblongata' to the intracranial myelonal columns, as far as the 'pons varolii.' Rolando[5] prefers the older view of its extent. Chaussier,[6] again, distinguishes the portions of the intracranial columns crossed by the transverse commissural fibres of the cerebellum as a primary division of the brain, under the name 'mesocephale;' and this term has been extended by Todd[7] to include the 'corpora quadrigemina' with the 'processus cerebelli ad testes,' and part of the floor of the fourth ventricle.

But the developement of the human brain and its several stages, represented by the conditions at which it is arrested in lower vertebrates, show that the transverse commissural fibres which cross or decussate with the intracranial myelonal columns, whether under the name of 'pons,' or 'trapezoid bodies,' or 'arciform fibres,' are subordinate adjuncts to other parts, chiefly the cerebellum; while the distinct and superimposed masses called 'corpora quadrigemina' include the true correlatives of the cerebrum and cerebellum, as primary vesicles of the brain.

By 'macromyelon,' therefore, I signify the intracranial prolongations of the myelonal columns as far forward as their emergence from the 'pons,' or cerebellar commissure: in this tract they are reinforced by masses of grey neurine, and the transverse commissural fibres are so intermixed with the longitudinal ones as to compel their being combined in description as in delineation, figs. 48, 56. But, before quitting the Mammalian class, the reduction of the ‘pons,’ concomitantly with that of the side-lobes of the cerebellum, as in figs. 51 and 53, is such as significantly to testify against its title to be regarded as a primary division of the brain; and in birds a ‘tuber annulare’ or ‘pons varolii,’ ceases to appear upon the under surface of the myelencephalous tract above defined. From this tract the cerebral nerves, from the fifth to the hypoglossal or ninth inclusive, arise.

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[1] xxi″. p. 5.
[2] xxii′.
[3] xxiii″.
[4] xxviii″.
[5] l″.
[6] xxvi″.
[7] xxvii″. p. 684.

In advancing to the formation of the macromyelon growing central tracts of the myelonal columns come to the periphery, and push aside the medial tracts on both the ventral and dorsal surfaces. On the former, fig. 48, they decussate, as they appear, at *d*, and, with a contiguous portion of the anterior myelonal columns, *b*, expand to form the ‘prepyramidal bodies,’ *p*. The rest of the anterior columns, *b*, with the contiguous antero-lateral column, in their course along the macromyelon, are associated with a mass of grey matter occasioning a swelling out of the surface, called the ‘olivary bodies,’ ib. *o*. A thin layer of superficial fibres which, in lower Mammals with non-prominent ‘olives’ pass outward, as a ‘trapezoid layer,’ in Man curve round the exterior of the olivary prominences, and constitute the ‘arciform fibres,’ ib. *A*.

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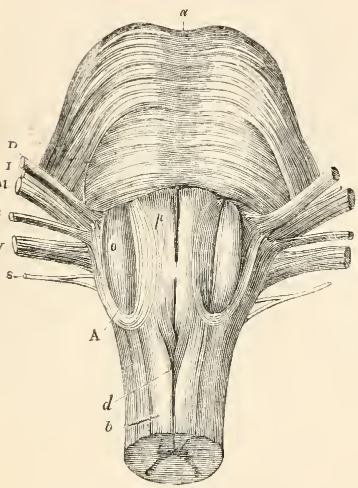

Macromyelon, anterior or ventral aspect. Man, nat. size.

The transverse fibres defining anteriorly the ‘prepyramids’ and ‘olives’ increase in mass, from the lowest Mammals (*Ornithorhynchus*, fig. 51, *c*, *Didelphys*, fig. 53, *b*), to Man, fig. 48, *a*. As they arch over the fore part of those macromyelonal tracts they have been called ‘pons;’ but their true position is that of an inverted or suspended bridge: their developement is in the ratio of that of the side-lobes of the cerebellum.

On the posterior or dorsal surface of the myelon the deep-seated tracts become superficial at a greater distance from the skull than on the ventral surface, and do not decussate; they expand as they enter the macromyelon, and form the 'post-pyramidal bodies,' fig. 49, Y. The posterior myelonal columns which they push aside, diverge as they are continued into the macromyelon, and combine with the contiguous lateral columns to form the post-restiform tracts, X. In advance of the post-pyramids, still deeper columns of the myelon come into view, as the 'teretial tracts,' ib. A, F, bounding the sides of the fissure, called 'calamus scriptorius,' at the floor of the expanded macromyelonal canal called 'fourth ventricle.' This is over-arched by the cerebellum, here bisected, and one half reflected at R; the peduncle or 'crus' of the opposite half being shown at U. The thin layer roofing the ventricle anterior to the crus is called 'valve of Vieussens,' B.

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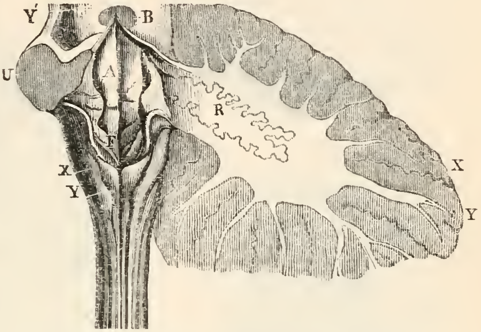

Macromyelon, posterior or dorsal aspect, with section of cerebellum. Infant, nat. size.

Sections of the macromyelon, as at fig. 50, show the form of the grey matter, called 'corpus dentatum,' of the olives, *o o*, and the relative position of the enlarging columns. Those on each side the fissure A, are the prepyramids; those on each side the fissure P, are the post-pyramids; the lateral or restiform tracts intervene between them and the olivary tracts, *o*.

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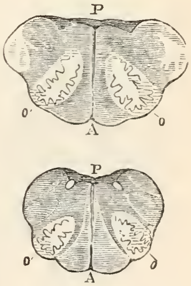
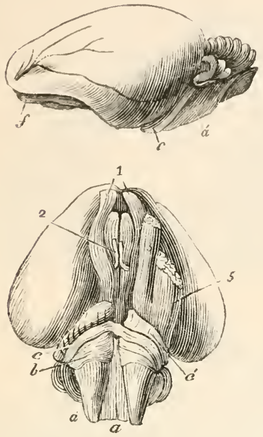


Transverse sections of the macromyelon, at the parts marked X and Y fig. 49. Man, nat. size

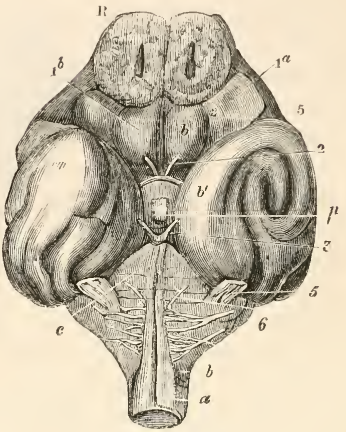
In the Monotremes the macromyelon is large in proportion to the rest of the brain, but the 'pons' bears relation to the cerebellum in its smallness. The prepyramids, figs. 51 and 52, *a*, are long, narrow, flat, and contract as they approach the pons, especially in the Ornithorhynchus; the olives, fig. 51, *a*, fig. 52, *b*, are also long and flat, but expand as they approach the pons, and are crossed, before reaching it, by the 'trapezoid' homologues of the 'arciform' fibres in Man. The distinction between the olivary and pre-restiform tracts is less marked. The grey matter is small in the olivary tracts, and does not form a 'corpus dentatum.' The pons is flat, it forms a narrow transverse band in the Ornithorhynchus, fig. 51, *c*; these fibres cover a greater antero-posterior extent of the macromyelon in the Echidna, and give the pons a triangular form.

51



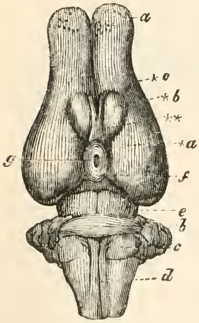
Side view and base of brain, Ornithorhynchus.

52



Base of brain, Echidna.

53



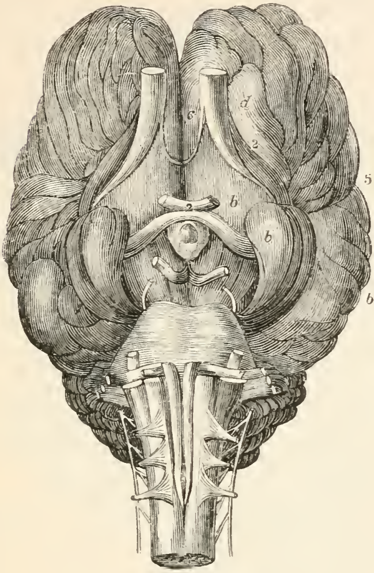
Base of brain, Didelphys.

In the Opossum the pons, fig. 53, *b*, is reduced almost to the proportions of that in the Ornithorhynchus; the prepyramidal, *d*, and olivary tracts are similar, and the latter are crossed by as well-marked a trapezoid arrangement of transverse fibres, *c*.

The prepyramidal tracts come to the surface at a greater distance from the pons, in most Mammals, than in Man, and thus resemble more the postpyramidal tracts; this character is shown in the Horse, fig. 54, Dolphin, fig. 60, *b*, and Baboon, fig. 62. In the anthropoid Apes, the proportions of the prepyramids (fig. 112, Orang) approach those in Man, and the arciform disposition of the superficial layer of crossing fibres begins to prevail, and to allow the olives, which are likewise here more prominent, to come into view. Although the olives are less prominent in *Delphinus* than in the Apes, they are equally uncovered by the trapezoid fibres: and show internally the arrangement of grey matter called ‘corpus dentatum.’ The pons, fig. 60, 5, *c*, by its prominence and antero-posterior extent, corresponds with the great lateral developement of the cerebellum, *e*.

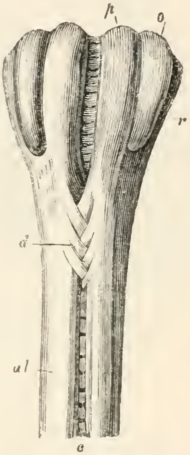
When the prepyramids, fig. 55, *p*, are divaricated in the human macromyelon, the median fissure, which is wider and shallower than that, *c*, below the decussation, shows the same cribriform character of its ‘floor,’ formed by the penetrating vessels from the fold of pia mater which lined it. A further extent of divarication shows transverse fibres uniting the halves of this part of the macromyelon, and decussating with longitudinal fibres, as in fig. 56. The section of the prepyramid on each side of *a*, fig. 57, shows its triangular figure and the restriction of grey matter to the ‘nuclei,’ *r*, *s*; they are mainly composed of white longitudinal fibres which enter the pons above its lower or peripheral transverse fibres, and interlace with the fibres of a higher plane: at the entry each pyramid is constricted, as at fig. 56, *p*, but soon expands. The proportion of the decussating and non-decussating tracts of the prepyramidal columns is shown in fig. 56, where *p* is part of the right prepyramid cut across near the pons and reflected to show the decussating fasciculus, *d*, and the non-decussating fasciculus, *n*, continued through the pons, P: the decus-

54



Base of the Brain, Horse

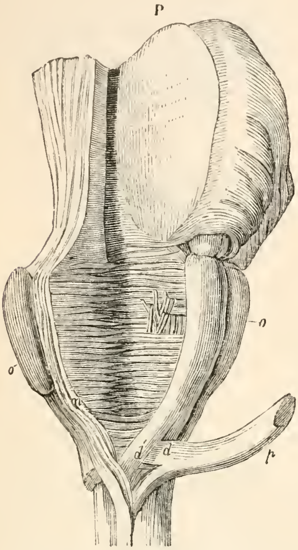
55



Postpontal part of Macromyelon, anterior or ventral aspect. Man, XXXIII''.

sating fasciculus of the left prepyramid is shown at *d'*. The fibres of the outer white neurine of the olives are longitudinal, and are continued forward above the pons, as shown at *f*, fig. 66.

56



Dissection of macromyelon, seen obliquely from the right side. Man, XXXIII''.

The nucleus of grey matter sinks deep into the macromyelon, as shown in the sections, figs. 50, *o* and 57, *g*; its section in any direction presents the undulated course of the white capsule suggesting the anthropotomical term 'corpus dentatum.'

The lateral or restiform columns, diverging, as in fig. 49, *x*, are mainly continued into the cerebellum, of which they form the hinder or 'inferior peduncle,' fig. 66, *r*. Recruiting grey neurine is developed in their interior. The post-pyramidal columns, contracting as they diverge and ascend, are closely applied to the restiform tracts, but are continued, as the 'fasciculi graciles,' into the crura cerebri.

Stilling[1] has enriched anatomy with the following magnified view of a transverse section of the macromyelon, one half of which shows the structures as seen by transmitted light, fig. 57. The anterior or ventral fissure, *a*, is here seen to be much deeper than the opposite one, *b*, represented by the 'calamus scriptorius.' The septum or raphe, *c*, of the lateral moieties is a compact white neurine; *d*, *v*, are the prepyramidal columns, of which *r* is the large nucleus, *s s* the smaller nuclei; the roots of the hypoglossal nerve, *l*, run along the interspace between the pyramids and olives. Of the latter the nucleus is shown at *g*, with its plicated capsule of white neurine; a small mass of grey substance is situated near the olivary one at *u*; *x* indicates grey matter and *i* gelatinous matter, near the roots of the vagal nerves, *k k*. The nucleus of the vagus is *h*, with the root of which nerve is also connected the white longitudinal fibres, *m*. Whether *g* be exclusively related to the hypoglossal, or is the place of origin (part of the larger root) of the trigeminal, is undetermined; *n* is the 'soft column,' *o* the wedge-like column; *f* is the nucleus of the restiform body. The transverse or arciform fibres covering this lateral column are marked *p*, those continued over the olives, *w*, and those over the prepyramids, *v*; they form the trapezium in lower Mammals.

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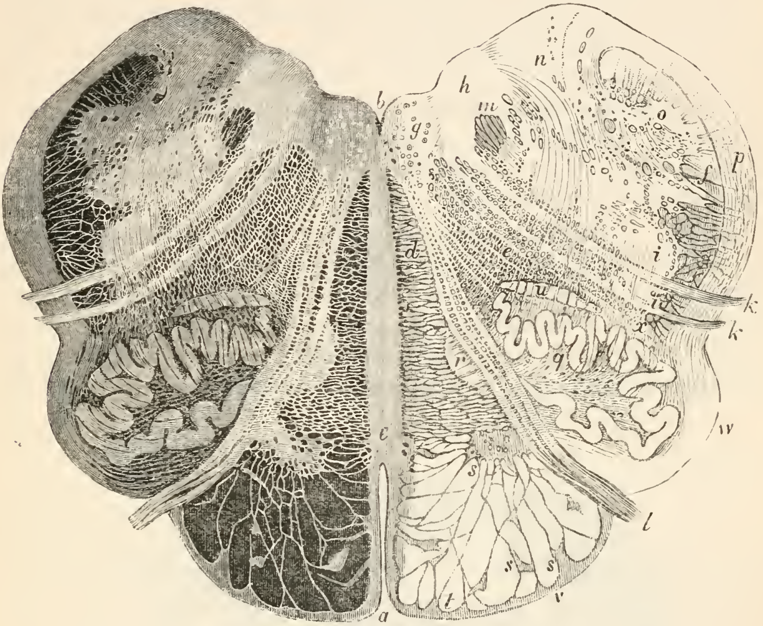
[1] XVIII''.

The nucleus in the trapezium, on each side of the raphe, so closely resembles, at a higher section, the olivary body, that it has been termed the 'upper olive'; it makes its appearance near where the lower olives first diminish in size. In the Sheep it appears as a group of large stellate multipolar cells, and these cells are more numerous in the Rodents, and still more so in the Cat. In the Rabbit the upper olivary body is convoluted in three or four turns; in the Mouse it consists of a wavy mass of large and numerous cells; its structure is especially distinct in the Cat.

57



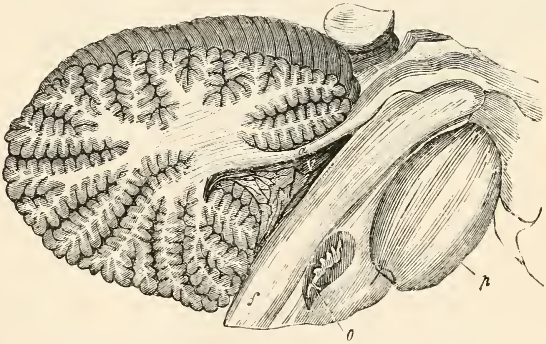
Transverse section of the macromyelon through the lower third of the olivary bodies. Magnified ten diameters.

The 'post-pyramidal' and 'restiform' nuclei are present in all Mammals. The olivary bodies consist of layers of small cells penetrated by the arciform filaments, by which they are connected with each other and with the raphe; they are not absent in the Sheep. The transverse section of the human medulla oblongata in the region of the first cervical nerve is more circular, less elliptical, than in the Sheep and most lower Mammals. The restiform and postpyramidal nuclei are relatively larger, but the *Quadrumana* and *Carnivora* approach the human structure in this particular; the Cat, e.g., shows an intermediate condition between those in *Ruminantia* and *Bimana*.[1]

In comparing the macromyelon of the Mammal (fig. 50) and Fish (vol. i. fig. 172) the usual course of structural differentiation seems to be reversed; a greater number of longitudinal tracts are definable in that of the Sturgeon or Shark than in that of Man. But the superior character is more seeming than real; the superaddition of ascending fibres in the higher Vertebrate tends to obliterate the boundary lines and seems to blend tracts—the 'funicular' and post-pyramidal, e.g. in the Mammal, which are distinguishable in the Fish.

§ 206. *Cerebellum.*—The posterior and restiform columns, pushed aside by the postpyramidal and teretial tracts in approaching the macromyelon, diverge and expand into a fibrous stem, which, arching over the fourth ventricle, developes the central transversely folded lobe, answering to the cerebellum of the Shark (vol. i. fig. 187, *c*) and Bird, and expands into lateral lobes characteristic of the Mammalian class. The myelonal tracts, which in describing the brain from behind forward may be said to enter into the formation of the cerebellum, fig. 66, *r*, leave it, after some expenditure and exchange of substance, as 'departing'

58



Vertical section of the median lobe of Cerebellum and Macromyelon.

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[1] The progress of chemistry has lent new and valuable aids to the unravelling of the minute, but physiologically most interesting, structures of the myelon and macromyelon. A solution of chromic acid is one of the best for preliminary immersion of slices of their tissues for a few weeks; these, if afterwards put into alcohol, are hardened, but become less brittle than if kept longer in the acid.

restiform tracts, ib. *t*, continued into the basis of the mesencephalon, forming also those called 'processus cerebelli ad testes,' united above by the thin layer of medullary matter called 'valve of Vieussens,' fig. 49, B. The progressive increase of the lateral lobes is attended by corresponding developement of the system of transverse or arciform fibres constituting the 'pons varolii,' which, entering the cerebellum at the 'infero-lateral' or 'semilunar fissure,' fig. 64, *h*, *i*, interblend with the longitudinal 'entering' and 'departing' columns, and constitute the commissural part of these lobes.

In Anthropotomy the part where the formative and commissural tracts join on entering the cerebellum are collectively called its 'crus,' the tracts being its constituent 'peduncles;' thus the entering or posterior and restiform tracts, which are the 'homotypes' of the 'crura cerebri,' are termed the 'inferior or posterior peduncles,' or 'processus ad medullam oblongatam,' fig. 66, *r*; the emerging restiform tracts, called 'processus ad cerebrum,' and 'processus ad testes,' are the 'superior or anterior peduncles,' ib. *t*; whilst the entering fasciculi of the 'pontal or varolian commissure' are the 'middle peduncles' or 'processus ad pontem,' fig. 64, *i*.

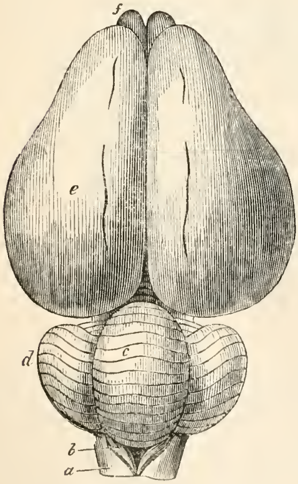
These latter are porportionally least in the lowest, and largest in the highest, species of Mammals. In all, the formative columns on entering the white axis receive grey or 'recruiting' matter for the developement of accessory fibres, relating in size and complexity to the increase of the cerebellum, and chiefly of its lateral lobes. In the Monotremes, figs. 51 and 52, the 'pontal' or cerebellar commissure is a thin layer of transverse fibres of small antero-posterior extent; the true character of the real 'crura cerebelli,' or formative fasciculi, is here well exemplified. The cerebellum, fig. 38, *b* (*Echidna*), consists mainly of the median lobe, which being transversely folded presents in vertical section that arrangement of grey and white matter called 'arbor vitæ.'

In the Marsupial Order, the cerebellum presents close-set, subparallel, transverse convolutions; few in the climbing Koalas and Opossums, fig. 46, *c*, more numerous in the locomotive Kangaroos: it is remarkable, as in Monotremes, for the large proportional size of the median or vermiform lobe as compared with the lateral lobes, especially in the carnivorous and insectivorous Marsupials, where this condition is associated with a corresponding diminution of their commissural band as shown in the view of the base of the brain of an Opossum, fig. 53, *b*. In the Kangaroos, Perameles, Phalangers, and Koala, the hemispheres or lateral lobes of the cerebellum are characterised by a small subspherical lateral process or appendage, *c, c*, fig. 74, which is lodged in a peculiar fossa of the petrosal above the internal meatus: there are corresponding but less produced processes in the Dasyures and Opossums, they do not project in the Wombat. On the upper surface of the cerebellum the medullary substance or nucleus appears superficially at a small tract on each side the vermiform process, marked with an asterisk in figures 74 and 75.[1] The simple disposition of the arbor vitæ is shown in fig. 46, *e*.

In the Lissencephala, the cerebellum in the *Insectivora*, fig. 76, and *Cheiroptera*, resembles that of the Opossums; in the *Rodentia* the lateral lobes, fig. 59, *d*, show a greater increase, which is most marked in the swift running Hares, fig. 81, *l, l*. As this developement is not accompanied with a concomitant growth of the cerebrum, the cerebellum is proportionally greater to the rest of the brain in Rodents than in other mammalian orders.

The Cetacean brain is remarkable for the large proportional size of the cerebellum, fig. 60, and especially of its lateral lobes, *c*. On the under surface may be distinguished the main part of the lateral lobe, *e*, the oblique lobule, *f*, that which answers to the 'amygdaloid lobe' and the 'floccus' of Reil, *h*. Each is subdivided by the chiefly transverse anfractuosities into numerous lamellæ. The middle lobe, fig. 93, *a*, is not symmetrical but inclined, like the skull, to one side, in *Delphinus*. The grey nucleus or 'corpus fimbriatum' is well developed. The 'pons,' fig. 60, *c*, is now large and prominent.

59



Upper surface of the brain, Agouti.

In the Ungulata, the relative size of the lateral lobes increases with the bulk of the species, and attains its maximum in the Elephant; in the *Rhinoceros*, *Giraffe*, fig. 86, *Ox*, and *Horse*, fig. 61, the middle lobe is contorted, especially above. The common castration of the latter quadruped has afforded abundant evidence that the cerebellum is in no degree affected thereby in size or form.[2]

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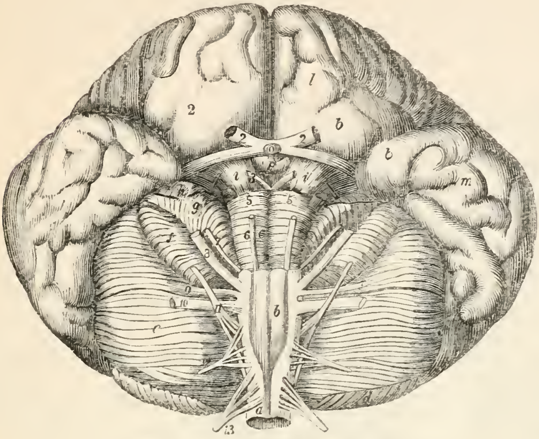
[1] LXX′. pl. v, figs. 3 and 4.

[2] XLI″.

In *Carnivora* the smallest species (fig. 89, Stoat) have the smallest lateral lobes in proportion to the middle one.

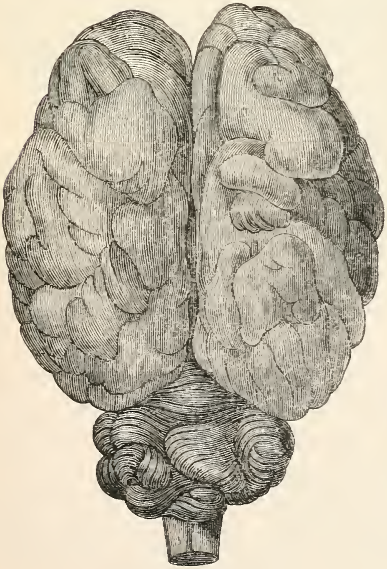
60



Base of the brain, Delphinus Delphis.

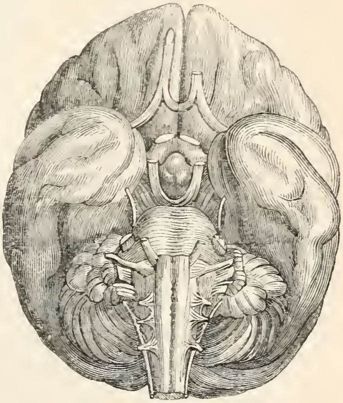
In the *Quadrumana* the middle lobe is proportionally largest in the *Lemuridæ* and smaller Platyrhines. The appendicular lobule is present in the Aye-aye[1] and other *Lemuridæ*, and is lodged in a special pit of the petrosal. In the larger Catarhines the lateral lobes increase in size, and lose, or incorporate, the appendix; they show the lobular groups of lamellæ, especially on the under surface, fig. 62, as in *Cetacea*, and in *Man*. The 'flocculus,' fig. 64, *n*, to which the origin of the acoustic nerve can be traced, is present in all *Quadrumana*, and is well marked in

61



Brain of the Horse.

62



Base of brain Baboon.

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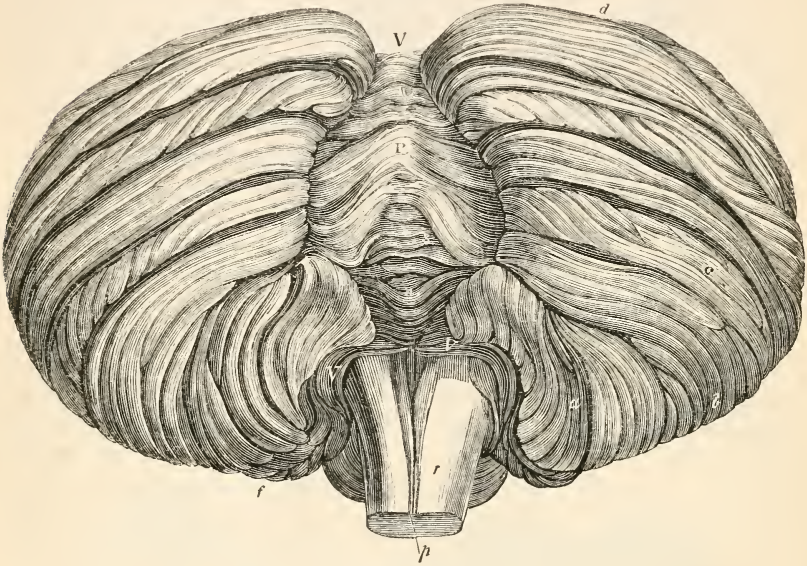
[1] CIII. p. 56, fig. 3, 3.

the timid and sharp-eared nocturnal Aye-aye, being associated with large external ears and a well developed auditory organ.[1]

In Man the lateral lobes of the cerebellum acquire their largest proportions, are called 'hemispheres,' fig. 63, *c*, and reduce the middle lobe, which is the most constant part in the vertebrate series, to the semblance of a subordinate adjunct, called 'vermiform process,' ib. P, in Anthropotomy.

63



Under surface of Human Cerebellum. XXVII''.

The characteristic form of the human cerebellum is manifested, according to the developmental law ('Preface,' vol. i. p. xxi.) before its surface becomes convoluted, and when the large hemispheres are represented by smooth vesicles of neurine, fig. 47, C, *c*. It resembles the cerebellum of the bony fish and frog in the smoothness of the surface, but has assumed in the fœtus at four months the recognisable specific form. The cerebellum is, in fact, more unique and definitely human at the embryonic period than when fully developed; it then weighs, or averages, 5 oz. 4 dr. in the male, and 4 oz. 12 dr. in the female.[2]

When the under surface is exposed by removing or reflecting the macromyelon, as in fig. 63, the middle lobe, P, is seen at the bottom of a valley (*vallecula*, Haller, V) dividing the hemispheres,

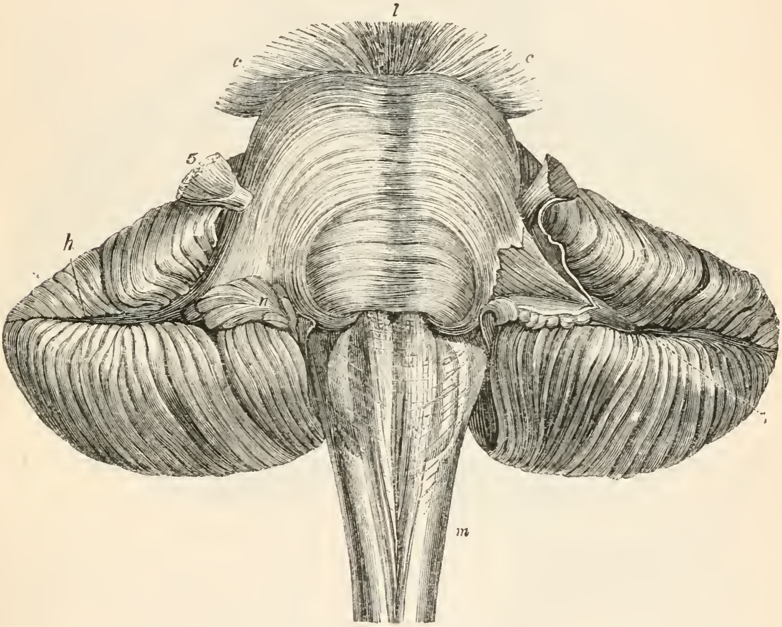
[1] CII'.

[2] XI''. and XLIX''. p. 4 (1862).

the convexities of which rest in the occipital fossæ. This surface of the middle lobe ('inferior vermiform process,' Anthropotomy) is transversely folded or 'ringed.' The broader and more prominent folds form the 'pyramid,' ib. P; the succeeding narrower folds, the 'uvule,' ib. *n*. The extremity of the vermiform process which projects into and closes the fourth ventricle, inferiorly, is the 'nodule.' On the inferior surface of the 'hemispheres' Anthropotomists define, with Reil,[1] 'biventral,' fig. 63, *b*, 'slender,' ib. *c*, and 'post-inferior' lobes, *d*. The smaller group of folds is the 'amygdala,' ib. *a*; the still smaller group, *f*, is the 'flocculus.'

The anterior surface of the cerebellum, seen in connection with the macromyelon, as in fig. 64, shows the 'semilunar fissure,' *h*, penetrated by the formative and commissural columns, *i*: the relative position of the 'flocculus,' *n*, is here best shown; the macromyelon passes into myelon at *m*. On the upper surface of the cerebellum, fig. 65, its most prominent part is that of the middle lobe, called 'superior vermiform process,' V: the hemispheres are almost flat: they are here subdivided into the 'square lobe,' ib. A, and the 'post-superior lobe,' P. The lateral lobes exceed the

64



Antero-inferior view of epencephalon, Man. XXV''.

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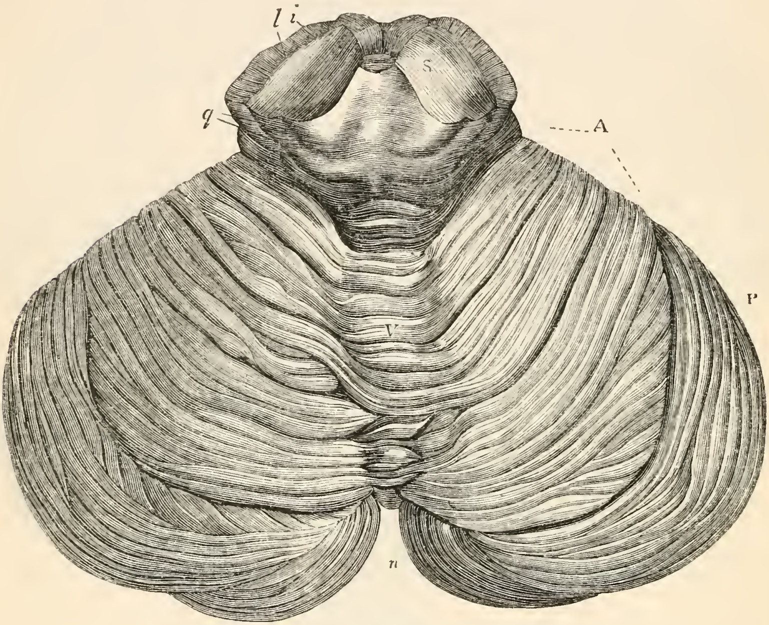
[1] XLII''.

middle lobe in antero-posterior extent, leaving an anterior or 'semilunar' fissure, and a narrower 'posterior notch,' ib. *n*, the groups of lamellæ bounding which are called, by some, 'post-inferior lobes.' The hemispheres are commonly but not constantly symmetrical; both these and the middle lobe consist of numerous lamellæ, of white covered by grey neurine; the interlamellar fissures are penetrated by folds of pia mater. The lamellæ are collected into groups, forming the 'lobes' of the hemispheres, which are divided by deeper fissures. The lamellæ of the middle or 'vermiform' part are fewer, and more transverse or vertical than those of the hemispheres; they are also thicker, single ones answering to, and connecting, two or more of the hemispheral lamellæ, fig. 65, V.

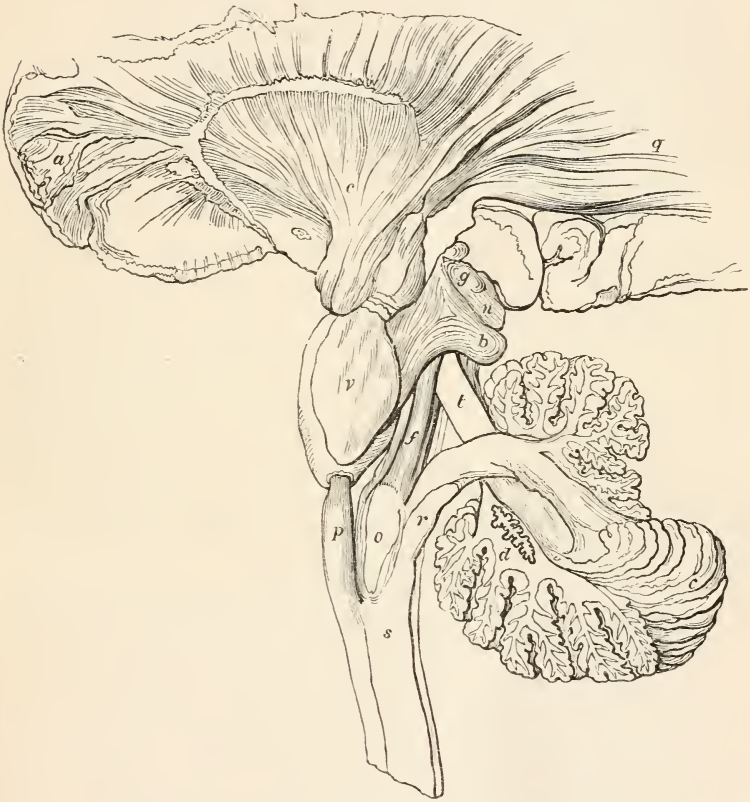
65



Upper surface of the cerebellum, and mesencephalon, Man.

A vertical section of either hemisphere, or of the median lobe, displays a ramification of fibrous matter, the smaller or ultimate branches of which are enveloped by laminæ of grey matter. This appearance suggested to the older Anthropotomists the name of 'arbor vitæ,' which it retains. The trunk of the tree is represented by a central nucleus of white matter, fig. 66, *d*, from the upper and lower surfaces of which branch off, some at a right, others at an acute angle, several laminæ, each of which forms the stem of a number of other branches. Each of the primary branches is the foundation or central stem of a lobule. Laminæ of fibrous matter are seen branching from both sides of it immediately after its separation from the nucleus. Sometimes the primary branch bifurcates, and each division of it forms the stem of what may be called a sub-lobule. If we suppose that one of the primary branches is composed of a certain number of laminæ

66



Dissection of the formative columns of the ep-, mes- and pros-encephalon.

of fibrous matter, the secondary ramifications from it will in a great degree correspond. In most instances these secondary branches subdivide into two or more tertiary ones, which, as well as the branch from which they spring, are enclosed in grey matter. A vertical section of the median lobe, fig. 58, gives a similar appearance to that of the hemispheres, fig. 66, *c*. The central nucleus breaks up into primary branches, which become the centres of the lobules of which it consists. The ramifications of the nucleus, whether of the median lobe or of the hemispheres, pass from it only in the vertical plane or from before backwards; in the latter direction, however, to a very slight extent. The fibrous matter of the median lobe is continuous with that of the hemispheric lobules. By reason of this disposition of the fibrous matter, the surface exposed by a horizontal section through the entire cerebellum consists of a plane of white matter bounded on the sides and behind by a narrow cortex of grey matter.

'The white matter consists exclusively of fibres, chiefly of the tubular kind, and of all degrees of size. These, in the more distant ramifications, penetrate the vesicular matter of their grey cortex, and form some unknown connection with its elements. The grey matter consists of three layers, readily distinguishable by the naked eye from their difference of colour. The external layer is the darkest, and consists chiefly of granular and vesicular matter. The next or intermediate layer is of a light colour, and is composed of a stratum of fine nucleus-like particles. The third layer has the greatest thickness, and is immediately in contact with the fibrous matter; it is intermediate in point of colour to the other two, and consists of numerous vesicles of the caudate kind, especially with branching processes and nerve-tubes of all sizes. The dark colour of the external layer is doubtless owing in a great measure to the great numbers of capillary vessels which enter it; the greater paleness of the inner stratum is to be attributed to the intermixture of the white fibres, whilst the light colour of the middle stratum is intrinsic.'[1]

The lower or hinder crus, fig. 66, *r*, on entering the cerebellum curves backward, expanding on the outer side of the converging and onwardly continued fibres which constitute the upper or 'anterior crus,' *t*. In the part of the 'nucleus' connected with the latter is developed a plicated capsule of grey or vesicular matter, *d*, also exposed in section at R, fig. 49, and called 'corpus dentatum;' it supplies accessory white fibres to those diverging from, or converging to, the crura; with these are interlaced the commissural fibres of the pons.

Thus an influence ascending from the myelon, by the restiform tracts, fig. 66, *s*, *r*, to the cerebellum, may be propagated from that body, by the crus, *t*, to the mesencephalon, and thence to the cerebrum. Conversely, cerebral influence may pass through the mesencephalon by the 'processus and testes,' ib. *t*, fig. 66, to the cerebellum, and thence by the restiform tracts, ib. *r*, to the myelon, *s*: while the transverse fibres of the pons, ib. *v*, associate all the parts of one cerebellar hemisphere in action with the other, and are intimately connected and interlaced with the longitudinal fasciculi forming the crura cerebri.

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[1] XXVII″. p. 692.

If it be considered that the maintenance of the erect position by Man demands unusual power of regulating and combining muscular movements, whether with or without the cognisance of the mind, and that he exercises or can exercise a greater variety of modes of locomotion than any lower animal, flight alone being inexecutable, the characteristic size and complexity of the human cerebellum would accord with such view of its functions; and the general results of the experiments of Flourens[1] and Majendie[2] concur with the inferences which, in the main, may be drawn from comparative anatomy (vol. i. p. 287).

§ 207. *Mesencephalon.*—Part of the columnar fibres continued from the epencephalon proceed directly to the prosencephalon, traversing the pons, fig. 66, *p*, *v*. The olivary tracts, ib. *f*, proceed first to the mesencephalon, which likewise receives the crus, *t*, or continuation of the restiform tract, *r*, after having undergone cerebellar developement and connections.

The mesencephalic basis is traversed by a forward continuation of the primitive myelonal cavity—the 'iter a quarto ad tertium ventriculum'—which latter, fig. 105, *b*, is a vertical expansion of the 'iter,' extending upward into the pedicle of the conarium ('pineal gland,' ib. *f*), and downward into that ('infundibulum') of the hypophysis ('pituitary gland,' ib. *v*). The sides of this ventricular fissure are partially glued together by grey matter continuous with that in the interior of the 'thalami,' and called 'soft commissure' in front of *b*, fig. 105.

In the Monotremes the mesencephalic crus ('processus a cerebello ad testes'), receiving a tract, answering to the 'fillet of anthropotomy, expands into the optic lobe ('nates,' ib.), forming chiefly its exterior white layer: the primitive cavity of this vesicle becomes filled with grey matter. The layer ('valvula') uniting the two crura becomes thickened by transverse white fibres behind the optic lobes, and these, in higher mammals, swell into a second pair of tubercles ('testes,' ib.), which usually exceed the 'nates' in breadth, but are less in length; they now form the 'corpora bigemina, or quadrigemina' of anthropotomy. The above difference in the proportion of the two pairs is exemplified in fig. 73, *b*, *Didelphys*, and fig. 75, B, *Phascolomys*, in the Marsupial order; by fig. 79, *Lepus*, and fig. 80, 8, 9, *Cavia*, in the *Rodentia*; and by fig. 67, *Talpa*, in the *Insectivora*. Both *Ly-* and *Liss-encephala* manifest their inferior position in the present class, and affinity to oviparous Vertebrates, by the larger proportion of the mesencephalon (fig. 46, O) to the prosencephalon, than in *Gyrencephala*. In most Marsupials (*Dasyurus*, fig. 72; *Didelphys*, fig. 73), in many Rodents (fig. 81, *Lepus*; fig. 80, *Castor*), in all Insectivores (fig. 76, *Rhynchocyon*), and in Bats, the bigeminal bodies are more or less exposed between the cerebrum and cerebellum. As in *Amblyopsis* (vol. i. p. 278, fig. 175), so in *Talpa*, the optic lobes, fig. 67, *c*, do not show a reduction of bulk commensurate with that of the visual organ; yet there is a degree of such relationship in Mammals. Thus the Ungulates which have large eyes have the optic lobes or nates, fig. 68, *a*, proportionally larger than they are in a Carnivorous quadruped with a similar-sized brain. In both the 'testes,' ib. *b*, are broader, but in *Felis* they also rise higher; whilst in Ungulates, and especially Ruminants, the 'nates' show the greater vertical developement.[1] In all Carnivores the 'testes' have a minor antero-posterior extent than the 'nates.' The white bands or tracts ('brachia' in anthropotomy), extending along the outer sides of the bigeminal bodies to the thalami and commencement of the optic tracts, fig. 68, *d*, are prominent in the higher *Quadrumana* and in Man. In most *Gyrencephala* the white fibres continued from the optic lobes develope an oblong nodule, ib. *e*, also containing grey matter ('corpus geniculatum' of anthropotomy), which in the human brain is divided into an external and internal portion.

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[1] LV″. and LXIV.

[2] LVI″.

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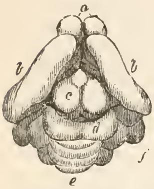
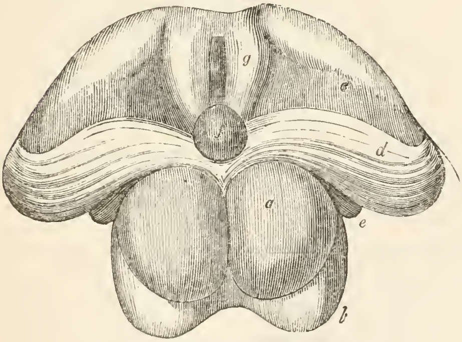


Brain of Mole.

68



Mesencephalon, upper view, Horse.

The 'crura cerebri' formed by the pre- and post-pyramidal and 'teretial' tracts, expand in passing beneath the bigeminal bodies, and receive accessions from grey matter continuous with that of the macromyelon, but so dark as to have received the name 'locus niger' when exposed in section. They are divided by the third ventricle, and swell out respectively at their upper part, through the superaddition of formative neurine, into the bodies called 'thalami optici,' fig. 68, *c*, figs. 71 and 75, *t*. The free surface is white, but the grey matter constitutes their chief bulk, and is partially divided by the longitudinal fibres into an outer and an inner portion: from the latter the soft commissure is continued. The optic tracts, fig. 68, *d*, commencing at the optic lobes and geniculate bodies, bend round the outer and back part of the 'thalami,' from which they derive accessory filaments to form the optic nerve. In connection with the mesencephalon must be noted the tract of white fibres continued from the fornix, on each side the third ventricle anterior to the soft commissure, to a nodule, conspicuous in *Gyrencephala* behind the infundibulum, and forming a pair ('corpora albicantia' in anthropotomy) in Apes, fig. 112, and Man.

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[1] This difference I exemplified in the preparations, nos. 1326 A and 1326 B, XX. vol. iii. p. 30.

§ 208. *Prosencephalon.*—As the 'crura cerebri' enter the prosencephalon, they are augmented by further accessions of formative neürine in masses which in the human brain have received the names 'nucleus tæniæformis,' 'nucleus lenticularis,' and 'nucleus caudatus.' The latter projects into the prosencephalic ventricle, as the 'corpus striatum,' figs. 70, *s*, 75, *r*. But this name extends or applies also to the deeper-seated grey masses, which are so interblended with the diverging white fibres as, in section, to give alternate white and grey striæ. The accession of white fibres from these formative nidi, diverging to form the basis of the cerebral hemispheres, causes the form expressed by the term 'fibrous cone,' fig. 66, *c*. The grey matter again appears as a thin superficial covering or 'cortex' of the expansion of the white fibres: and this grey matter contains cells similar to those in the corpus striatum.

In most *Ly-* and *Liss-encephala*, and in a few of the smallest kinds of *Gyrencephala*, the prosencephalic vesicles retain the outward uniformity of surface which they have in birds and reptiles: unlike those of the mes- and ep-encephalon, they are so little united together that they are called and seem to form distinct 'hemispheres.' These are connected together in all Mammals as in Birds by the cord-like fasciculus of transverse fibres, figs. 69 and 73, *c*, called 'anterior commissure.' But the main distinction lies in the superaddition to the 'diverging' or 'crural' fibres of other 'commissural' tracts either 'longitudinal,' connecting parts of the same hemisphere, or 'transverse,' and bringing a greater proportion of the two hemispheres into mutual communication. But there are steps in this differentiation.

Each hemisphere of the cerebrum begins as a vesicle of neurine, the cavity of which receives the growth from the 'crura' forming the 'corpus striatum.' This, in Birds, mainly fills the 'ventricle' or remnant of the primitive cavity of the sac. But, in Mammals, the wall of the vesicle is augmented by folds, of which the first and most constant is pushed from the mesial or inner side of the ventricle into its cavity, giving rise to the convexity, figs. 70, 71, *h*, fig. 75, *n*, representing the part called 'hippocampus' in anthropotomy. The 'fissure upon which the hippocampus is folded'[1] is numbered 4 in the 'Table of Cerebral Fissures,' p. 136, as in fig. 69, *et seq.*

In *Lyencephala* it extends from the fore part of the inner surface of the hemisphere backward and downward in a curve with the concavity toward the centre or 'nucleus cerebri,' fig. 69, *b*. It is not, however, a mere doubling of the wall of the hemispheral vesicle; longitudinal fibres are developed therein for commissural office; they cause a definite production of the lower part of the fold within the ventricular cavity called hippocampal band (*tænia hippocampi*), or, because in Man it is plaited, '*corpus fimbriatum*:' its inferior hinder termination is in the 'pes hippocampi;' its upper or anterior one becomes the 'posterior pillar' of the fornix. 'Fornix' is the anthropotomical term for the anteriorly continued and transversely connected longitudinal fibres of the hippocamp: the 'posterior pillars,' fig. 69, *a*, one from each hemisphere, converge as they advance, are united by a commissure of their own, ib. *o*, beyond which some fibres pass forward and radiate upon the inner surface of the fore part of the hemisphere; while others bend down, as the 'anterior pillars' of the fornix, pass between the anterior commissure, ib. *c*, and the nucleus cerebri, *b*, and terminate in the mammillary body already mentioned.

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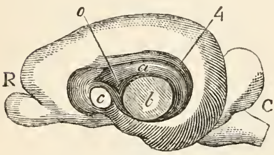

Inner surface of hemisphere. Vertical section of brain, Ornithorhynchus.

Delicate fibres, running on the inner surface of the hemisphere at right angles to the line of the hippocampal fissure, are continued into the ventricle, where they cover the longitudinal fibres developed in the hippocampal fold, and which form the main part of the hippocamp and its anterior extension.[1]

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[1] So defined in LXX'. p. 90 (1837)

This fold and its concomitantly developed longitudinal and transverse or arched fibres, constitute a great and abrupt distinction and rise in structure in the Mammalian brain as compared with the Avian one, and indicate that birds are an offshoot from the lower *Ovipara*, forming a branch apart.[2]

In *Ornithorhynchus* the postero-inferior parts of the hemispheres are brought into connection with the antero-internal parts by the longitudinal fibres, while the antero-internal parts of the hemispheres are connected with each other through the transverse fibres at the approximated anterior ends of the folds, where the stratum connecting those ends together, and radiating the fibres upon the inner surface of the anterior lobes of the hemispheres, and over the inner wall of the ventricle, is thickest.[3]

The greater part of the hemispheral cavity or ventricle is overarched in *Lyencephala* by the inner leaf of the hippocampal fold, and its developements called 'tænia hippocampi' and 'fornix.' The transverse fibres connecting the tænia hippocampi and terminating that body anteriorly in *Lyencephala*, are carried, in the ascending Mammalian series, by the growth of the hemispheres anterior to them, as it were by a movement of rotation, from before upward and backward, until, in Man, they become the 'psalterial fibres' which connect the posterior 'genu' of the corpus callosum with the 'tænia hippocampi,' these being compared to the 'frame' and the transverse fibres to the 'strings' of the harp, by the old anthropotomists. The superaddition of cerebral matter above and anterior to *c*, figs. 69, 73, is associated with transverse commissural fasciculi, progressively added, from behind forward, and now overarching the lateral ventricles, and fulfilling all the functions, relations, and definitions of the anthropotomical 'corpus callosum,' figs. 78, *l*, and 123, C. Its hind part is embraced by the 'callosal convolution,' ib. O.[4]

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[1] These fibres are shown at *x*, fig. 4, pl. vii. LXX'., which gives a view of the hippocampal fold from the ventricular or 'lateral' side, as 'part of a thin stratum of medullary fibres arching over the hippocampus major, and continued therefrom into the internal wall of the ventricle,' p. 95.

[2] If we could examine the brains of *Dinosauria* or *Dicynodontia*, the actual gap in the series of cerebral structures might be better filled.

[3] From this point in the lowest (Lyencephalous) mammals, as in the embryo of the highest, the growth of the great supraventricular body of transverse commissural fibres forming the 'corpus callosum' begins: 'Anterior fibres of the "tænia hippocampi" continued into the anterior lobes of the hemispheres.' LXX'. p. 95, pl. vi. figs. 4 and 6, *o'*; and pl. vii. fig. 4, *x*.

[4] The part marked B in the *Echidna* has become the part marked N in Man. Pls. XXXVI. and XXXVIII. of XLIII''.

Such are the essential characters of the Mammalian 'prosencephalon.' The chief modifications of the Mammalian brain, as above characterised, will next be noticed in the different leading groups of the class.

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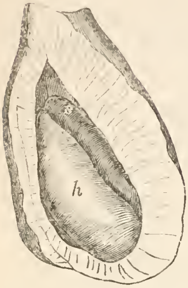

Lateral ventricle, Echidna.

A. *Lyencephala.* In the *Ornithorhynchus*, the brain, figs. 52 and 69, is to the weight of the body as 1 to 130; the hemispheres are triangular, depressed, the broader posterior part overlapping the optic lobes, and reaching to the cerebellum. With the exception of the hippocampal fissure, fig. 69, 4, and the depression lodging the rhinencephalic crus, the surface is unbroken or smooth, with a few vascular impressions diverging from the fore part. The medulla oblongata is broad and depressed; the corpora pyramidalia, fig. 51, *a*, are in very low relief; the corpora olivaria, *a'*, expand as they advance; they are crossed anteriorly by the 'corpora trapezoidea,' *b*, which are large; the 'pons,' *c*, is narrow: anterior to it is a large ganglionic body, *c'*, from which issues the huge trigeminal nerve, 5. The longitudinal groove between the optic lobes is shallow; it is wanting in the small and low 'testes.' The hippocampus is the chief prominence within the ventricle of the hemisphere; the corpus striatum is long and narrow.

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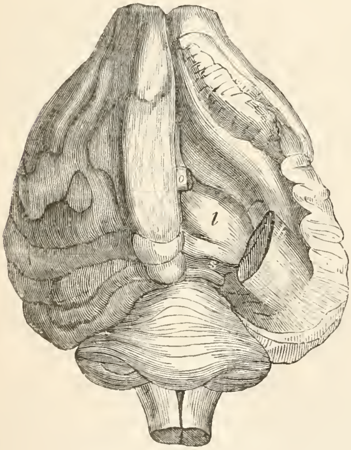

Brain and lateral ventricle, hippocampus removed Echidna.

The brain of the *Echidna*, fig. 71, is relatively larger than in the *Ornithorhynchus*, and the exposed outer surface of the hemispheres is extended by convolutions. The cerebral hemispheric cavity is mainly occupied in both Monotremes by the 'hippocamp,' fig. 70, *h*, which constitutes a great part of its floor as well as inner wall. This, with much of the hippocamp, is removed in fig. 71, to show the proportions of the 'corpus striatum,' *s*, and to bring into view the thalami, *t*; these are divided from the 'nates,' *r*, by a linear groove; the 'testes,' *s*, are half the size of the 'nates,' and the median longitudinal groove, which is shallow between the nates, is not continued further back.[1] Like the water-shrews, the *Ornithorhynchus* has a smooth cerebrum; the *Echidna,* like the Great Ant-eaters and the Sloths, has a convoluted one. Besides the long and deep 'hippocampal fold,' the fore part of the mesial surface shows a beginning of the supercallosal one; behind which it is also notched vertically by the mesial ends of the upper transverse folds,[2] fig. 71. Of these, three nearly parallel ones extend across the broad posterior part of the upper surface of each hemisphere, their outer ends inclined forward; anterior to them is a larger convolution bent upon itself so as to form the inner boundary of the anterior half of the upper surface. In the angle of the above are two oblique folds inclining 'mesiad' toward the contracted fore part of the hemisphere. The base of the brain, fig. 52, shows a few short foldings of the surface of the great natiform protuberances, *b′*. The principal folds sink about a line's depth into the substance of the cerebrum. The rhinencephalon is enormous, ib. R. Some of the fibres of the great anterior commissure bend forward, and are continued into each of its crura. The outer part of the crus, ib. 1 *a*, continued from that of the prosencephalon, emerges from the fore margin of the natiform protuberance, from which it has a reinforcement of fibres; the inner division, tumid with added grey neurine, ib. 1 *b*, is also very broad. The prosencephalic cavity or 'ventricle' is continued into the rhinencephalon, and is exposed in fig. 52, by removal of the thin floor which rests upon the large 'cribriform plate.' The 'pineal' and pituitary (ib. *p*) appendages of the prosencephalon offer no monotrematous characters.

There is not that difference of size between the *Ornithorhynchus* and *Echidna* which would lead us to connect therewith the convolution of the hemispheres in the latter animal; what is known of their habits suggests no superiority of psychical power and resource in the land- over the water-monotrematous Insectivore. Increased extent of the walls of the hemisphere in no degree influences the developement of a supraventricular transverse commissure; the seeming small one exposed at *o*, fig. 71, is hippocampal or psalterial. This low phase of Mammalian brain-growth is essentially related to the common monotrematous conditions of generation.

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[1] My observations on this state of the 'corpora quadrigemina' in Monotremes accord with those of Laurent and Eydoux on the Echidna, and of Meckel on the Ornithorhynchus. 'En comparant les tubercules quadrijumeaux de l'Échidné à ceux de l'Ornithorhynque, nous avons facilement constaté ce que l'a déjà été par Meckel pour ce dernier, c'est-à-dire qu'on ne peut pas distinguer les tubercules postérieurs des antérieurs, et que ce que Meckel a remarqué chez l'Ornithorhynque et exprimé en ces termes : "Eminentia quadrigemina magna, posterior tamen verè percipienda, ut ferè bigemina esset," est encore plus prononcé dans les tubercules du cerveau de l'Échidné, qui sont réellement *bijumeaux* simplement.' LVII″. p. 164.

[2] Well given in LVII″. pl. ix. fig. 4 : omitted in the diagram of a similar section in XLIII″. pl. xxxvii. fig. 7.

The brain bears a small proportion to the body in the Marsupial order; in the Ursine Dasyure, fig. 72, it is as 1 to 520; in the Wombat, as 1 to 614; in the great Kangaroo, as 1 to 800. In smaller Kangaroos the disproportion is less; thus in the Tree-kangaroo (*Dendrolagus inustus*) I found it as 1 to 250. The brain is relatively largest in the smaller species of Petaurists and Phalangers.

The cerebral hemispheres do not extend over the cerebellum in any of the species, and in some, as the Dasyures and Opossums, they leave the optic lobes exposed. In the Phalangers and Petaurists, the Opossums, Perameles, the insectivorous Phascogales, and the smaller Dasyures, the exposed surface of the cerebral hemispheres is unconvoluted. In the *Dasyurus ursinus*, fig. 72, *b*, this surface is broken by a few slight indentations, two of which may indicate the beginnings of the 'medi-lateral' longitudinal folds.

In the Wombat an ectorhinal fissure bounds the outer side of the olfactory tract at the base of the brain;[1] from the anterior moiety of this fissure three or four smaller ones curve upward upon the sides of the hemispheres, one of which answers to the 'fissura Sylvii,'[2] but is less defined than in the Kangaroo. On the upper surface a short transverse fissure marks off the outer part of the anterior lobe of the cerebrum, and behind this each hemisphere exhibits a few detached shallow fissures.

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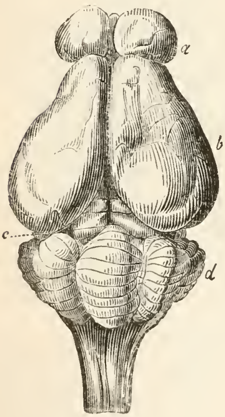

Brain of Dasyurus ursinus.

The American Opossums show a range in size from that of a mouse to that of a cat, and the Australian Dasyures rise from the same diminutive extreme (*Antechinus pusillus*) to the size of the wolf (*Thylacinus*). But the cerebral hemispheres are as smooth in *Didelphys Virginiana*[3] as in *D.* (*Philander*, *Microdelphys*) *murina*; and the great Ursine Dasyure, fig. 72, shows but a few short and shallow indentations of the exposed cerebral surface.[4] *Thylacinus* has the anterior apex of the hemisphere marked off by a deeper transverse fissure, extending to the inner surface. In the Herbivorous Marsupials the fissures are more definite, deeper, and rather more numerous in the larger (*Macropus major*, fig. 74) than in the smaller species (*Hypsiprymnus*). All Marsupials have the hippocampal fissure, fig. 46, 4, fig. 73, *i*, coextensive with the antero-posterior range of the prosencephalic cavity, and arching over all the commissural apparatus of the hemispheres. The concomitant extent of the convolution (hippocampus major) is shown in LXX′. pl. vii. figs. 3 (*Didelphys*) and 4 (*Macropus*), in the exposure of the ventricle from the outer side. In *Didelphys*, fig. 73, the surface of the hemisphere above the fissure is feebly impressed by blood-vessels; in *Thylacinus* there is a short fissure above the back part of the hippocampal one; in *Phascolomys* and *Macropus* there is also an anterior one which bends or bifurcates at its fore part.[1] These fissures mark the level of the roof of the lateral ventricle; the surface below forming the thin mesial wall of the cavity, fig. 75, *q*, which in the higher Placentals is defined, as the 'septum lucidum,' by a corpus callosum from the part above, On the upper surface of the hemisphere, in *Macropus major*, a longitudinal part of the fissure, fig. 74, 8, marks off a medial convolution, *l*, at the anterior half, and occasionally it is prolonged backward by the fissure, 10, as in the left hemisphere of fig. 74. But there is continued from 8, in both hemispheres, a fissure extending outward, which bounds behind the part of the hemisphere impressed by the 'sylvian fissure,' 5. The

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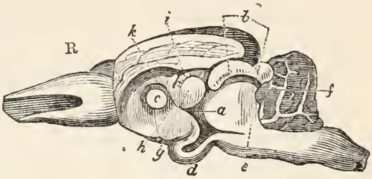
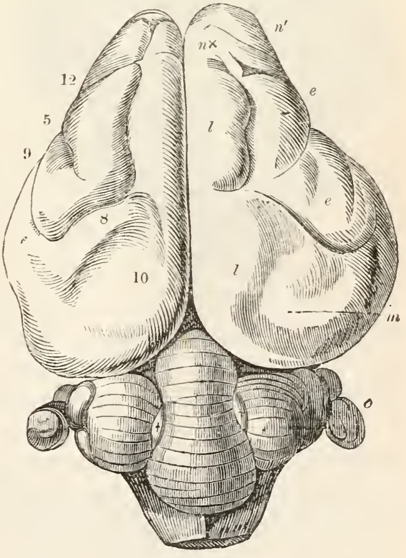
[1] LXX' Pl. v. fig. 8.
[2] Ib. fig. 3.
[3] Ib. fig. 6.
[4] Ib. fig. 5.

73



Didelphys Virginiana.

74



Brain of Macropus major.

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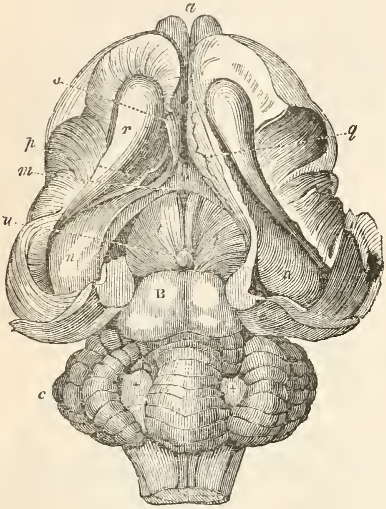
[1] LXX′. pl. vi. figs. 4 and 6, *q*, *q*.

sylvian convolution, *e*, *e′*, folded on 5, is divided behind by the fissure, 9, from the post-sylvian fold, *f*. The contracted anterior part of the hemisphere is marked off by a feeble coronal fissure, 12, and is partially divided into a superfrontal fold, *n*×, and a subfrontal fold, *n′*. In the broad hind part of the hemisphere are the medial, *l*, and lateral, *m*, tracts.

On separating the hemispheres of the brain of the Wombat, not only the bigeminal bodies, B, fig. 75, and pineal gland, ib. *u*, but the thalami, ib. *t, t*, are brought into view, and instead of a broad corpus callosum, we perceive, situated deeply, a small commissural medullary band, ib. *m*, passing in an arched form over the anterior part of the thalami, and extending beneath the 'labia hippocampi,' the supraventricular part of the hemispheres, *q*, being thus, as in the bird and monotreme, disconnected with each other. On gently raising the labia[1] from above the commissure and pressing them outward with the handle of a scalpel, the instrument passes into the fissure upon which the hippocampus, ib. *n*, is folded. The mesial wall of the hemisphere is continued from the upper labium of the hippocampus, and is composed of a thin lamina of medullary substance analogous to a detached layer of the septum lucidum. In the Kangaroo the mesial parietes of the lateral ventricles are thicker. In both Marsupials they receive the thin layer of fibres, fig. 75, *o*, passing from the commissure, *m*, over the upper lip of the hippocampal fold, to radiate vertically upon the anterior half of the inner wall of the ventricle. These fibres are figured in LXX′. pl. vi. fig. 4, *o′* (Wombat), and fig. 6, *o′* (Kangaroo), and are described as the 'anterior fibres of the tænia hippocampi continued into the anterior lobes of the hemispheres.'[2]

75



Phascolomys fusca.

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[1] These are not to be confounded with the 'labia cerebri' of anthropotomy.

[2] The author of XLIII″. figures, in pl. XXXVI. fig. 4, a more extensive series of transverse fibres which he describes, p. 644, as being lost beneath the 'labia cerebri,' as the margin of the 'callosal fold' is called by some authors. The surface of the diva-

The crura cerebri, which, in the Opossum, *e*, fig. 53, are left exposed below, like the optic lobes above, by reason of the small proportional size of the cerebrum, are more completely concealed in the brain of the Kangaroo and Wombat. The natiform protuberances form a great proportion of the under part of the cerebral hemispheres in all the Marsupials; the ectorhinal fissure which indents their base in the Wombat and Kangaroo, runs along the side of the hemisphere to the outer side of the olfactory lobe in the Opossum, indicating the large relative size of the basirhinal fold or tract. Behind the commissure of the optic nerves is seen a broad and short infundibulum supporting the pituitary body, *g*, fig. 53, and posterior to this is the single corpus albicans. The optic lobes, fig. 73, *b*, are solid; a pair of similar but smaller ones rise behind, and form with them a 'bigeminal' mass: the anterior divisions or 'nates,' B, fig. 75, have a greater longitudinal diameter than the posterior ones or 'testes,' which have a greater transverse developement. The difference in the relative developement of the nates and testes between the herbivorous and carnivorous Marsupials is less than in the corresponding Placental quadrupeds.

The posterior transverse fibres of the hippocampal commissure are continued, fig. 75, *m*, outward and backward beneath the more longitudinal fibres, which overlap them as they pass forward to the anterior cerebral lobes and pass into the substance of the hippocampi, *n*. Thus the commissure, which is brought into view on divaricating the cerebral hemispheres in the Wombat, is seen to be partly the bond of union of the two hippocampi majores in the transverse direction, like the 'lyra' of anthropotomy, and partly of the hippocampus and the fore and inner parts of the hemisphere in the longitudinal and vertical directions. It mainly fulfils the function of the fornix, not only as being the hippocampal commissure and continued backward and downward as 'posterior pillars;' but by sending down from the inferior surface two small nerve-like processes, which extend vertically, behind the anterior commissure, to the corpus albicans,

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ricated hemispheres is left entire, and whether the fibres diverge into the substance of the roof of the ventricles is not shown. In LXX'. pl. vi. figs. 4 and 6, the requisite dissection is made and figured, and the transverse fibres are shown to be lost beneath the 'labia hippocampi'—that is, to be continued into the hippocampi, not into the supraventricular substance. Other dissectors of the brain of a *Macropus Benettii* and of *Phascolomys* might compare the appearances with those figured in the 'Philosophical Transactions,' 1837, pl. vi. figs. 4 and 6, and in the 'Philosophical Transactions,' 1865, pl. xxxvi. fig. 4.

at the base of the brain. The superior view of the connections of the hippocampal commissure of the Wombat is given at *m*, *n*, *o*, fig. 75.[1]

The artery of the plexus choroides, entering with the fold of pia mater at the lowest part of the hippocampus, is richly spread upon the small production of that fold, ib. *p*, beneath the margin of the 'tænia' near the passage by which it is continued into the fold and plexus of the opposite ventricle. This intercommunication between the two prosencephalic cavities exists in all Mammals, and is defined in anthropotomy as the 'foramen Monroianum.' The pineal appendage, ib. *u*, is small compared with its 'crura,' which, as in all other Mammals, are continued backward from the fore and inner parts of the thalami, *t*.

A well-marked ectorhinal fissure extends from the natiform protuberance, defining externally its 'basirhinal tract'[2] and the forward continuation of the 'crus rhinencephali.' A longitudinal white streak[3] divides the outer and inner portions of that crus. The prosencephalic cavity is continued into the large rhinencephalon, figs. 73 and 46, R, *d*.

The characteristics of the Marsupial brain are, its small relative size, small proportion of cerebrum, convolutions wanting, or few and symmetrical in those Marsupials possessing them, large proportional anterior commissure, and still larger hippocampi; some fibres arch across from one to the other hippocampus, answering to the 'lyra,' and forming the beginning of the great transverse commissure or 'corpus callosum' of higher Mammals; the fibres radiating upon the fore and inner wall of the ventricle are the anterior terminations of the great longitudinal commissure answering to the 'fornix' in anthropotomy. The 'corpus striatum,' fig. 75, *r*, is relatively small and inferior in position to the hippocampus, being partially overlapped thereby.

B. *Lissencephala.*—I demonstrated the characters differentiating the first step in the developement of the 'corpus callosum' of the Hedgehog, in the longitudinal section of the brain[4] prepared and added to the Hunterian series of Comparative Anatomy in 1834, by contrast with a similar section of the brain of the Opossum[5] and Dasyure;[6] placing a plate of mica in the fore part of the hippocampal fissure in each, which accordingly passes above the transverse commissural system ('lyra of fornix') in the Marsupial, and beneath the abruptly superadded 'corpus callosum' in the placental Insectivore. In a similar section of the brain of the Squirrel[1] the corpus callosum is of greater relative extent, as it is in all Rodents as contrasted with Insectivores. Concomitantly with the appearance of the new series of transverse fibres bringing the hemispheres into communication above their ventricles, the anterior commissure is diminished in size.

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[1] Haller showed his appreciation of the essential nature of these 'fere fornicis ipsius cruribus.'

[2] LXX'. pl. v. fig. 8, 1*a*.

[3] Ib. 1*c*.

[4] No. 1323 D, XX. vol. iii. (1835), p. 29; and see XLIII''. pl. XXXVII. fig. 7.

[5] XX. no. 1323 B.

[6] XX. no. 1323 C.

Notwithstanding this difference in the kind and arrangement of the transverse connecting fibres of the hemispheres, these do not present a corresponding rise of developement. In the snouted Shrews of Africa the brain, fig. 76, offers outwardly as low a condition as in the Opossum or Dasyure. All the four primary segments are in view; the epencephalon, C, mesencephalon, O, prosencephalon, P, and rhinencephalon, R, succeed each other longitudinally from behind forward, as in *Reptilia.* The multiplication of grey and white matter above the medulla oblongata mainly distinguishes the brain of the active Shrew from that of the slow Tortoise, fig. 45; and the lateral lobes of the cerebellum carry appendages, as in the Opossum. The anterior bigeminal bodies, O, much exceed the posterior ones in size. A feeble and interrupted indication of the medilateral longitudinal fissure marks the upper surface of the hemispheres. These are much contracted anteriorly. A short callosal fissure is added to the hippocampal one on the inner surface of the hemisphere. The rhinencephala are long, large, and pyriform. In the Hedgehog (*Erinaceus*) the ectorhinal fissure is apparent in the upper view of the brain through the great relative size of the crura rhinencephali.

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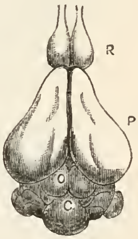

Brain of Rhynchocyon LXXXIV'.

The Bats resemble the terrestrial *Insectivora* in their cerebral surface, as do also the smaller Rodents. In some of the larger ones, Agouti, e. g. (vol. ii. p. 270, fig. 146), the medilateral fold is better defined: but the Beaver shows no trace of this, although the hemispheres are broader anteriorly: they are more expanded here in the equally smooth cerebrum of the Porcupine, fig. 77. The Rodents show some variety in the shape of the cerebrum. In the *Leporidæ*, fig. 79, *a*, it is lozenge-shaped, with the anterior borders longer, and converging to a narrower (though obtuse) apex, than the posterior ones. In the Pacas the cerebrum is broader, with both ends more obtuse and larger, and the hinder third is broader. In *Castor*, fig. 78, it presents a full ovate figure. In *Hystrix*, fig. 77, it is subquadrate, through increasing breadth of the fore part. On the medial surface of the hemisphere the 'hippocampal fissure' is confined to the hinder half; the 'callosal fissure' is superadded, commencing at the 'splenium' or posterior genu of the great commissure, and running along its upper surface to the anterior genu; it is shallow, but now defines the true 'labium cerebri.' On the under surface the ectorhinal fissure, figs. 83 and 84, 2, has the same extent as in the Wombat; it diverges, as it recedes, further from its fellow, in fig. 83, through the greater breadth of the basirhinal protuberances, *h*. A few short fissures rise from its anterior half a little way upon the hemisphere in the Cavies, as in the Wombat. In the Porcupine the sylvian fissure, figs. 77, 84, 5, is well marked, though short, and there is a feeble indication of the 'coronal fissure,' 12.

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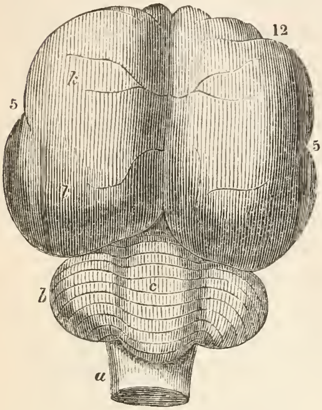
[1] XX. no. 1323 H.

77



Upper surface of the brain of the Porcupine.

In the smaller and especially the insectivorous *Bruta* the brain presents the lissencephalous type, having smooth, low, triangular hemispheres, leaving the mesencephalon as well as epencephalon in view posteriorly. *Dasypus* has the fore part less contracted than *Myrmecophaga*, at least than *M. didactyla*. In *Bradypus* the anterior expansion gives an ovate form to the hemispheres; and now, besides the hippocampal, callosal, ectorhinal, and sylvian fissures, the upper surface shows the medilateral, suprasylvian, and frontal ones. The medilateral bends outward anteriorly, defining the 'anterior lobe' impressed by the short angular or triradiate 'frontal' fissure. The above fissures mark out a medial, lateral, sylvian, postfrontal, and prefrontal convolutions. On the inner surface a supercallosal fissure now defines a 'convolution of the corpus callosum,'[1] the lower margin of which, resting on that body, is the 'labium cerebri' of anthropotomy: in Sloths, as in Shrews and Rodents, it is anterior to and distinct from the 'hippocampal' fissure and fold.

In all *Lissencephala* the hemispheres present the following structure, the rise in which, as compared with that in *Lyencephala,* is independent of the smallness and smoothness of those divisions of the brain.

Taking that of the Beaver (*Castor fiber*), e. g., and comparing its prosencephalon with the sub-convolute one in *Phascolomys* or *Macropus,* we find, on divaricating the hemispheres, that the 'corpus callosum' is brought into view, and on removing the cerebral substance to a level with this body, as in fig. 78, its fibres are observed to diverge into the substance of each hemisphere, some bending upward, but a greater proportion arching downward and commingling with those that diverge from the cerebral nuclei. The portions of the brain which are removed in thus tracing the extent of the corpus callosum bring into view the corpora bigemina, B, and the pineal gland, *u*; but the optic thalami are concealed by the great commissure above described. If the posterior margin of the corpus callosum be raised, its inferior surface is found to be closely connected or continuous with the transverse commissural band of fibres, arching over the anterior part of the optic thalami, and passing outward and backward along the floor of the lateral ventricles into the substance of the hippocampi, which are almost as large as in the Wombat. The anterior part of the corpus callosum is bent downward, and it is attached along the middle line of its inferior surface by a uniting medium of medullary substance, the beginning of the 'septum lucidum,' to the hippocampal commissure or fornix; the tæniæ hippocampi send forward, as in the Wombat, a delicate layer of medullary fibres which

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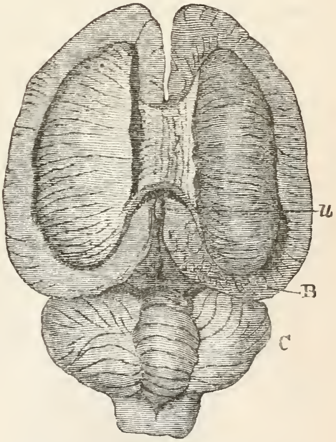

Dissection of brain to show corpus callosum, Beaver.

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[1] 'Ourlet' and 'internal convolution' of Foville, xxv″.

spread over the mesial surface of the anterior lobes, and are homologous with those marked *o′* in fig. 75, and in figs. 4 and 6, pl. vi. LXX·.

The corpus callosum being removed, and the commissural fibres of the hippocampi being left behind, the view of the Beaver's brain now corresponds with that obtained in the dissection of the brain of the Wombat, fig. 75. The artery of the plexus choroides, ib. *p*, in both the Beaver and Wombat, enters the lateral ventricle, where the hippocampus commences at the base of the hemisphere, and the plexus is continued along the under surface of the tænia hippocampi, and passes beneath the fornix, through the usual foramen, to communicate with its fellow in the third ventricle immediately behind the anterior crura of the fornix, which are sent down in the Beaver, as in the Wombat, from the centre of the inferior surface of the hippocampal commissure.

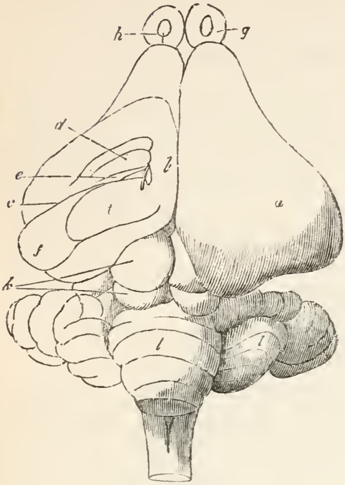
If we expose the lateral ventricle by removing its outer parietes in a marsupial and placental quadruped, the hippocampus major, the tænia hippocampi, the plexus choroides, and the foramen Monroianum are brought into view. If a style be thrust transversely through the internal wall of the ventricle, immediately above the hippocampal commissure, in the placental quadruped, it enters the opposite ventricle and perforates the septum lucidum, passing below the corpus callosum. If the same be done in the Marsupial brain, the style passes into the opposite ventricle, but is immediately brought into view from above by divaricating the hemispheres.

The commissure, answering to the 'lyra,' represents the beginning of the corpus callosum; but this determination does not invalidate the fact that the great commissure which unites the supraventricular masses in the Hedgehog, Beaver, Bat, and all other placentally developed mammals is a definite superaddition for more effectually associating the hemispheres in whatever motion or change they may undergo in the actions of the brain.

All *Lissencephala* show a large proportional size of the hippocampi, fig. 79, *f* and *e*, a small 'corpus striatum,' *d*, and large 'bigeminal bodies,' *k*, which bear the same proportion to each other as in *Marsupialia*. The smaller the brain, the larger is the share which the mesencephalon takes in its formation, as in the Shrews and Moles (fig. 67).

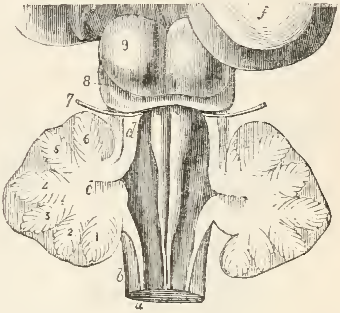
The rhinencephalon, fig. 79, *g*, fig. 81, *e*, is connected by a broad and complex 'crus' with the under part of the hemispheres, having the 'outer root,' fig. 82, *x*, which is continued from the basirhinal tract,[1] ib. *h*, the 'inner root,' *y*, and the intermediate 'perforate body or tract,' ib. *r*: the lateral ventricle is continued into the rhinencephalon (fig. 79, *h*).

79



Lepus. *d* Corpus striatum. *e* Tænia semicirc. *f* Hippoc. major.

80



Mesencephalon and section of cerebellum, Agouti. XXXII''.

The chief brain-characters of the *Lissencephala* are, the non-extension of the cerebrum over the cerebellum, the paucity and

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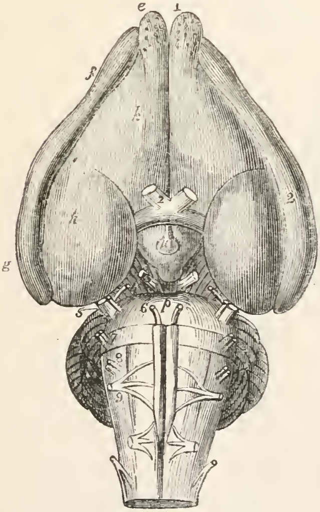
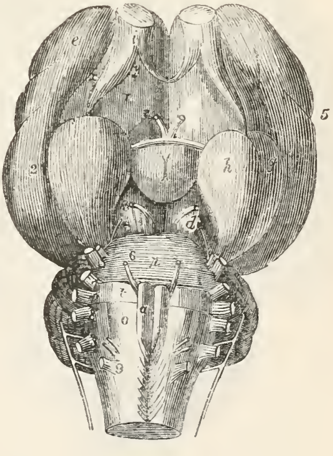


Base of the brain, Agouti. XXXII''.

82



Base of the brain, Porcupine (*Hystrix cristata*). XXXII''.

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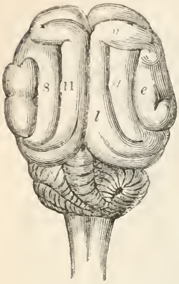
[1] Part of the 'natiform protuberance' or 'lobe of the hippocampus' of some anthropotomists.

simplicity of folds on the exposed surface of the hemispheres in a few, their absence in most; the connection of the two hemispheres by a 'corpus callosum,' as well as by the 'lyra' and 'anterior commissure,' the absence of the 'septum lucidum,' and the proportionally large hippocampi and bigeminal bodies.

C. *Gyrencephala.*—In this subclass the prosencephalon is relatively larger, extending backward more or less over the cerebellum with a concomitantly developed 'corpus callosum,' the connection of which with the 'fornix' is now maintained, not only by the 'lyra,' but by the attenuated vertically extended subjacent parts of the medial walls of the lateral ventricles called 'septum lucidum,' their interspace being the 'fifth ventricle' of Anthropotomy, fig. 118, *n*.

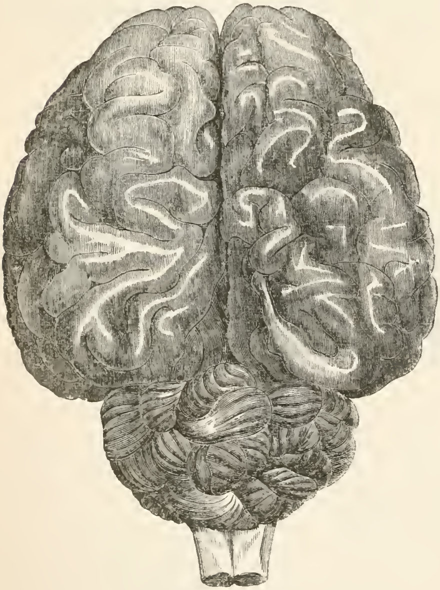
83



Brain of Cat, *Felis domestica.*

In some of the smallest species of Gyrencephala the exposed surface of the cerebral hemispheres may be smooth, or with few and simple fissures (fig. 96, *Hyrax*; fig. 101, *Tragulus*; and vol. ii. fig. 147). This state does not, however, relate to reduction of hemispheres, but may coexist with their extension over the whole cerebellum,[1] as in some small *Quadrumana*, fig. 109, *Midas* and *Callithrix*; but the increase of superficial grey matter by fissures and folds is now the rule.

84



Brain of Giraffe. XCVII.

Three leading patterns of convoluted surface, which, from the prevalent direction of fissuring, may be termed the 'oblique,' 'longitudinal,' and 'transverse,' are presented by the *Gyrencephala*, and are exemplified, respectively, in the ungulate, unguiculate, and quadrumanous divisions of the subclass. Notwithstanding, in these general variations homologous primary convolutions may be traced. The *Proboscidia*, fig. 108, and *Cetacea*, fig. 85, show excess of convolution of the cerebral surface.

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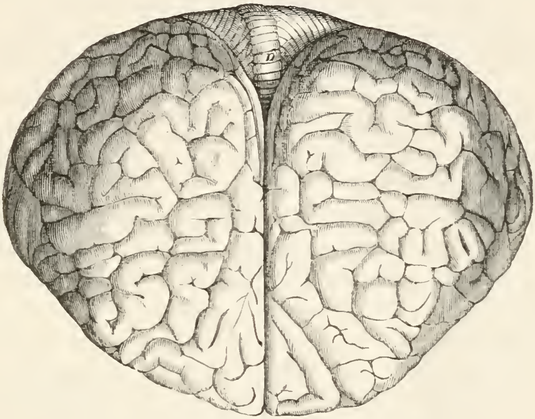
[1] LXX. pl. v., fig. 2 (1836).

Erasistratus[1] affirmed the convolutions to be most numerous in the brain of Man, and associated them with his superior intelligence. Willis[2] pointed out that the convolutions, though present, were fewer in brutes than in Man; that the Ape had more of them than the Fox or Dog, &c.; that paucity was associated with regularity and symmetry of folding and with more definite and limited instincts, while the want of symmetry of the more richly convoluted brains was associated with greater diversity and freedom of mental operations. By these remarks Willis initiated the comparative anatomy and physiology of this part of the brain. Vicq d'Azyr[3] noted the symmetry of the convolutions in the brain of the Monkey, and contrasted it with the want of such symmetry in Man. Malacarne[4] first defined a particular convolution, that, viz., which overlies and follows the contour of the corpus callosum. Tiedemann does not enter upon the comparison of the convolutions; but he first showed the order and periods of their successive appearance in the human brain.[5] Serres[6] stated them to be too inconstant to characterise species or families of Mammalia. I early made observations to test this question, and in 1833 I communicated the results in regard to the convolutions of the cerebrum in the *Felidæ*,[7] distinguishing the 'folds' by letters, and the 'fissures' by figures;[8] and finding that their

85



Brain of the Dolphin, *Delphinus Delphis*. XXIX" homologues could be traced from species to species in that family, I distinguished most of them by names. I further entered upon their classification, and defined the 'primary' and 'secondary' fissures and folds, showing that the 'secondary fissures were in general less symmetrical than the primary ones' (xlvii··. p. 134), and that the differences observable in the brains of the *Felidæ* were due chiefly to the absence of more or less of the secondary convolutions in the smaller species; 'in the common Cat the principal fissures, or anfractuosities, are less obscured by fissures of the second degree than in the larger Felines' (ib. p. 133).[1] M. Leuret, in citing this attempt to bring the convolutions within the domain of comparative anatomy,[2] has extended, in association with his colleague, M. Gratiolet, the like comparison to other species and families of Mammalia. Foville[3] arranges the cerebral convolutions into those of the 'first,' 'second,' 'third,' and 'fourth orders,' characterised partly by position, partly by direction; and, in each order, they are subdivided into 'groups.' This system, based mainly on the study of the parts in the human brain, has its utility limited to Anthropotomy; the comparisons not having been carried to the extent requisite for defining the cerebral fissures according to their order of appearance or constancy in the Mammalian series. Prior to the appearance of both these works I had continued my observations as opportunities presented themselves; and gave the result of such extended comparisons in the Course of Lectures delivered at the Royal College of Surgeons of England in 1842: my diagrams there, in which homologous convolutions are indicated by colours, may still testify in part to the extent to which the comparisons had been carried; the main aim which I had in view being the determination of the homologous and superadded convolutions in the more complex prosencephalon of Man.[4]

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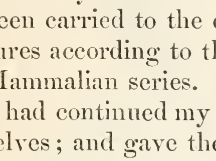
[1] XLIV". [2] XXI". [3] XLV". [4] XLVI". [5] XXX". [6] XXXII". [7] XLVII".

[8] This mode of notation has been reversed by a subsequent author, but no advantage from the innovation is pointed out, or seems to be gained thereby.

In the Carnivora, to the rhinal, figs. 90, 92, 2, hippocampal, fig. 86, 4, callosal, ib. 7, and sylvian, fig. 90, 5, fissures, are added, in the smallest species (*Putorius*), the fissures 8 and 14, fig. 87. The first, commencing near the posterior part of the hemisphere, at 11, extends forward, equally bisecting that part of the surface between the interhemispheral and sylvian (5) fissures, then bends outward parallel with and in front of the sylvian fissure. That marked 14 extends

86



Inner surface of hemisphere, *Felis.*

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[1] The preliminary sketch of the history of this part of cerebral anatomy is from the 13th Lecture of the Hunterian course for 1842.

[2] xlii··. vol. i. p. 380.

[3] xxv··. (1844).

[4] 'Medical Times,' Nov. 12, 1842, vol. vii. p. 101.

from the interhemispheral fissure outward and slightly forward. The upper part of the hemisphere is thus here divided into tracts which may be termed 'medial' *l*, *m*, sylvian *e*, e', *g*, and frontal $n^{\times}$.

In a small Plantigrade, the Coati (*Nasua*), we find a longitudinal fissure, fig. 88, 11, 11, which diverges outward as it advances; and a fissure, fig. 90, 8, which is in advance of and parallel with the sylvian, 5, but curves backward overarching that fissure and subdivides the cerebral tract between the fissure, 5, and the one marked 11. Here, therefore, is a ground of choice, whether, viz., the fissures 8 or 11 in the Coati be the homologue of that marked 8 and 11 in the Stoat. The homology of 14 is clearer, and the tract anterior thereto is more definitely or deeply subdivided into a superfrontal fold $n^{\times}$, and a midfrontal one n'', figs. 88, 89, Coati, Fox.

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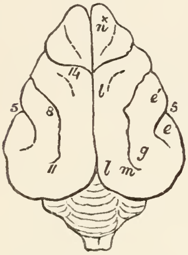
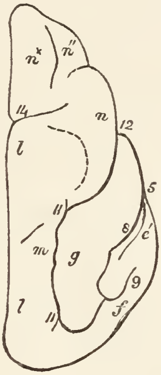


$n^{\times}$
14
l'
5
8
e'
5
e
g
11
l
m

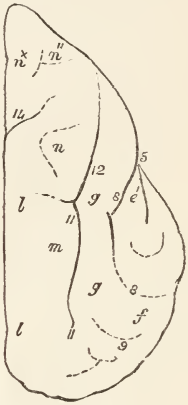
Brain, upper view,
Stoat, *Putorius*.

88



$n^{\times}$
n''
14
n
12
l
5
11
8
e'
m
g
9
l
11
f

89



$n^{\times}$
n''
14
n
5
12
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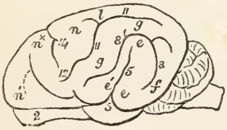
g
8
e'
11
m
g
8
f
l
11
9

Coati. Fox.
Upper surface of right hemisphere.

90



l
11
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g
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3
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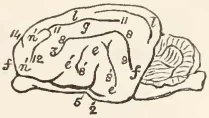
e
n'
5
2

91



l
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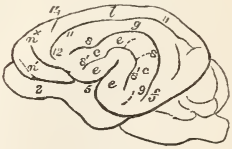
92



14
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11
$n^{\times}$
11
8
e
12
c
8
n'
8
e
c
2
5
e
9
f

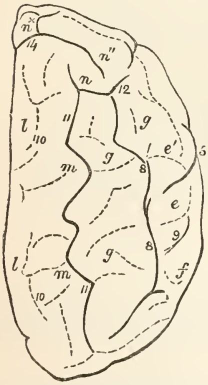
Coati. Cat. Fox.
Side view of brain.

In the Cat, figs. 83, 91, the longitudinal course of the fissures 11 and 8 is more extensive; the oblique fissure 12 crosses the anterior end of 11, and marks out an anterior tract which is divided, transversely, by 14. A fissure, 10, following the hinder contour of the hemisphere, bends forward, between 11 and the interhemispheral one, as if to subdivide the medial tract, fig. 83, *l*, and is continued far forward in the larger *Felidæ*, though shallow like a secondary fissure. The sylvian fold, *e*, *e′*, also begins to be subdivided by the secondary fissures 8′, 8′, fig. 91, which are more fully established, arching over the sylvian fissure, at 8′, in the *Canidæ*, fig. 92, Fox. On the inner surface of the hemisphere the supercallosal fissure, fig. 86, 7′, in the Cat, rises anteriorly diverging from the callosal one, 7; the frontal fissure, 14, extends backward into their interspace: the marginal fissure, ib. 6, runs parallel with the supercallosal one, 7′, and is longer in the larger felines; in which most of the primary folds are impressed by short secondary fissures.[1]

The cerebrum of the *Canidæ*, figs. 89, 92, Fox, is longer and narrower anteriorly than in *Felidæ*, fig. 83. The frontal fissure, fig. 89, 14, marks out a longer anterior lobe: the medial fold, ib. *l*, *l*, is more longitudinal, less bent outward anteriorly; the lateral or supersylvian fold *g*, *g*, has a like character: the sylvian fold, fig. 92, *e*, *e′*, is subdivided by the secondary fissure, 8′, arching over the sylvian one, 5. The coronal fissure, 12, is now recognisable. The anterior lobe is equally divided by the frontal fissure, fig. 89, 14, into the postfrontal tract, *n*, and the prefrontal, *n″*, *n*×. Most of the primary folds are marked by secondary fissures, and the number, extent, and depth of these chiefly distinguish the brain of the Dog from that of the Fox.

The brain of the Bear (*Ursus*) is more oblong than that of the Fox. The frontal fissure marks out as long an anterior part, in which the subfrontal *n′*, midfrontal *n″*, and superfrontal *n‴*, tracts are indicated by secondary fissures: but the medial fold, *l*, is more extensively bent outward. The medilateral fold, *m*, is still more bent outward anteriorly from the longitudinal course. Secondary fissures impress the surface of several of the primary folds, especially the broad anterior part of the medial one. The cerebrum attains its greatest relative size and complexity of structure, in the present group, in the Seal family, fig. 93. The horizontal contour of the brain is almost circular, and the surface of the hemispheres offers, at first view, numerous convolutions; but a comparison of their relative depth serves to distinguish the secondary from the primary ones, which latter are the follow-

93



Seal (*Phoca*). Upper surface of right hemisphere.

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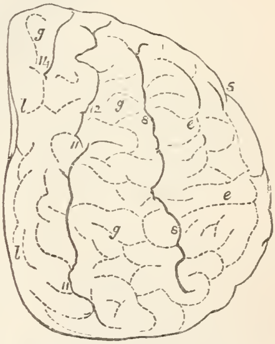
[1] xlvii″. pl. 20, figs. 1–3 (*F. jubata*).

ing:—The prefrontal lobe, n'', $n^{\times}$, as defined by the fissure 14, fig. 93, is shorter than in the Felines; both medial *l*, medilateral *m*, and supersylvian *g*, folds, are longitudinal and parallel, but with outlines wavy through secondary fissures. The sylvian fissure, 5, marks the sylvian fold, which is not continuously or well defined, the lateral fissures being too irregular and interrupted. The ectorhinal fissure, through the vertical extension of the natiform protuberance, is more interrupted than in other *Carnivora*; but it is continued backward from the sylvian fissure and defines the mesial non-convoluted part of that protuberance (basirhinal tract). The orbital fold, bounding the outer crus and side of the rhinencephalon, is defined by the entorbital fissure, more extensively and definitely in the Seal than in most other Carnivora. The mass of the hemispheres behind the sylvian fissures is relatively greater than in other *Carnivora*, and a larger proportion of the cerebellum is covered thereby.

94



Delphinus; upper surface of right hemisphere.

The general parallel longitudinal course of the primary folds, *e*, *g*, *l*, characteristic of the hemispheres of *Carnivora*, is more strictly preserved in the *Cetacea*, fig. 94; but with great increase of cerebral substance, and especially of the exterior layer, by the very numerous secondary fissures, which mask the true character of the primary ones, 11 and 8, until a comparison of the relative depth unfolds it.[1]

Although the olfactory nerve be not developed in *Delphinidæ*, the rhinal, fig. 60, *b*, and basirhinal, *b′*, tracts are defined by the ectorhinal fissure, 2, a circumstance significative of the derivation of this marine family from some form of the Mammalian class, retaining, as in *Balænidæ*, the usual provision of nerves of special sense. In fig. 95 are shown the extent of the corpus callosum, *b*, the depth of the cerebral fissures, and the proportions of the ‘corpus striatum,’ *d*, *k*, the optic thalamus, *i*, and the hippocampus, *g*, with its unusually broad ‘tænia,’ *h*, or free border continued into the ‘fornix.’ A beginning of the ‘posterior horn’ of the lateral ventricle is now first shown.

‘The primary cerebral convolutions in the hoofed Mammals have a general disposition, converging from behind forward as far as the anterior third of the cerebrum, and thence diverging, but in different degrees.'[1] Both Artiodactyle and Perissodactyle orders include species as small as a rabbit; yet the Pigmy Chevrotain (*Tragulus*, fig. 101) and the Rock-Coney (*Hyrax*, fig. 96) alike manifest the essential gyrencephalous characters in the extent to which the cerebrum (prosencephalon) covers the cerebellum, and the degree in which its surface is folded: both, likewise, manifest the Ungulate convolutional pattern, albeit exemplified in the simplest measure by them in their respective groups. The brains of both *Tragulus* and *Hyrax* show the following

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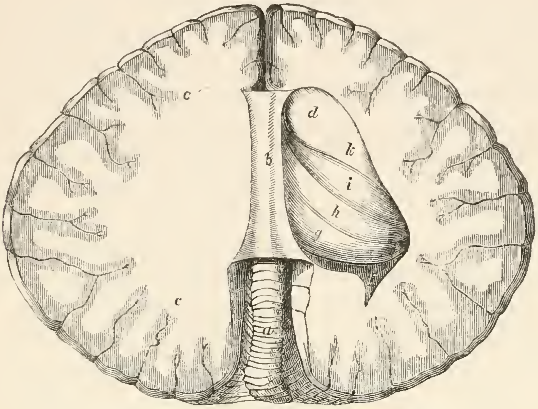
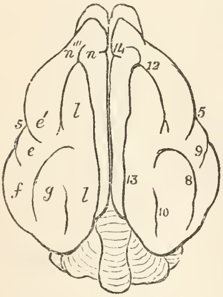
[1] The preparation of the Porpoise’s brain, by which I showed this structure in the ‘Hunterian Course’ of 1842, is probably still preserved in the Museum of the Royal College of Surgeons: the primary convolution *g* is removed.

95



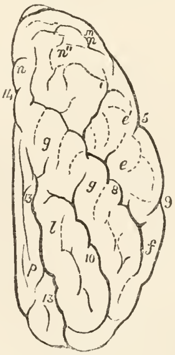
Horizontal section of cerebral hemispheres, *Delphinus*. XXXIX''.

96



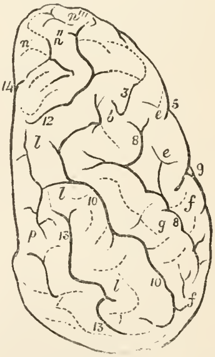
Upper surface of brain, Hyrax.

97



Horse.

98



Rhinoceros.

Upper surface of right hemisphere.

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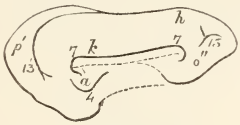
[1] v''. p. 53.

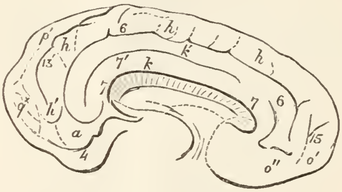
primary fissures: ecto- and ento-rhinal, hippocampal, fig. 99, 4, sylvian, fig. 106, 5, callosal, fig. 99, 7, lambdoidal, figs. 96, 101, 13, and entolambdoidal, fig. 99, 13′, supersylvian, fig. 101, 8, and lateral or medilateral, ib. 10. In *Tragulus,* fig. 101, this is slightly indicated: in *Hyrax,* fig. 96, 10, it is longitudinal but short. *Hyrax* also shows a frontal fissure, ib. 14, and the postsylvian fissure, ib. 9. But the chief difference is seen in the course of the fissure 13, which, impressing the inner and posterior side of the hemisphere at fig. 99, 13′, converges toward its fellow in *Tragulus,* but diverges as it advances, in *Hyrax,* and extends beyond the frontal fissure, 14, simulating the longitudinal one in the same part of the brain in the Agouti, Sloth, and Aye-aye. Its fore-part runs into the superfrontal fold, *n,* or divides it from the subfrontal, *n‴*. We may trace the homologue of 13, interrupted by secondary fissures, marking off a less elongated mesial tract of the brain, in the Horse, fig. 97, and Rhinoceros, fig. 98. The primary fissures, in *Hyrax,* define the following folds: viz., sylvian, figs. 96, 106, *e, e′,* postsylvian, ib. *f,* part of supersylvian, ib. *g,* blending with the medilateral or medial, *l,* the entolambdoidal, fig. 99, *p′,* rising to the upper surface, confluent with the tract representing the superfrontal, $n^{\times}$; in like manner the sylvian, fig. 96, *e′,* blends with the subfrontal tract, ib. *n‴*. On the inner surface of the hemisphere, the hippocampal fold, fig. 99, *a,* the callosal, *k,* and entolambdoidal, *p′,* are defined; with an indication of a falcial fold, *o″*. The ectorhinal fissure at the base of the brain bounds the outer side of the rhinencephalic part, and divides it from the more exterior part of the ‘natiform protuberance.’

99



Hyrax.

100



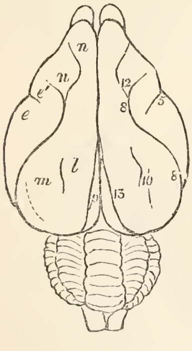
Rhinoceros.

Inner surface of hemisphere.

In the larger Perissodactyles, the expansion of the hinder part of the hemispheres is attended with a greater recession of the supersylvian fissures, fig. 97, Horse, and fig. 98, Rhinoceros, 8, outward and backward; they also become deeper, more continuous, and more wavy: the lateral or medilateral fissure, 10, is now developed to a similar extent, running parallel with 13 and 8, and with more depth in *Rhinoceros,* fig. 98, than in *Equus,* fig. 97. Both *l* and *g* bend outward anteriorly, in *Rhinoceros*, in a more definite way than in *Equus*. The anterior lobe, marked off by the short fissure, 14, is relatively larger in every dimension in the great Perissodactyles, and is broader and deeper in the Horse than in the Rhinoceros. The tract of the inner or mesial surface of the hemispheres above the callosal fissure, fig. 100, 7, is impressed by the parallel 'marginal' fissure, ib. 6, in both large Perissodactyles; and the callosal fold so defined is subdivided by a secondary intermediate 'supercallosal' fissure, $7'$, more continuous in the Rhinoceros than in the Horse, into the 'callosal proper,' *k*, and the supercallosal, k', folds. Beside the falcial fissure, 15, there is a prefrontal secondary fissure; and the septal or postfalcial surface, p', $q^{\times}$, is extended by secondary fissures. The increase and complexity of the upper convoluted surface of the hemispheres in the larger Perissodactyles are due to the full establishment of primary fissures, upon the plan sketched out in *Hyrax*, to their more wavy course, and to the superaddition of secondary fissures, indicated by interrupted lines in figs. 97 and 98.

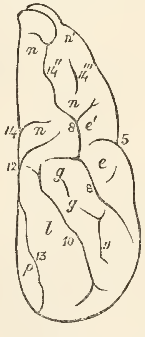
In passing from the Pigmy Musks to the brains of larger *Artiodactyles*, we find the fissure which is feebly indicated at 10, fig. 101, *Tragulus*, fully developed in figs. 102 and 103, and dividing the triangular tract into the oblique folds *l* and *g*: which I hold to include the same parts of the cerebrum as the more longitudinally disposed folds lettered *g*, *l*, *m*, in *Carnivora*. In some small *Cervidæ* the secondary fissure, 11, is not present: in most it is, as also in the hollow-horned Ruminants, Giraffe, Camel-tribe, fig. 105, *Auchenia*, *Suidæ*, fig. 104, and *Hippopotamus*. The lambdoidal fissure, 13, retains its character, as in *Tragulus*, viz. short, anteriorly convergent, and continued on the inner surface of the hemi-

101



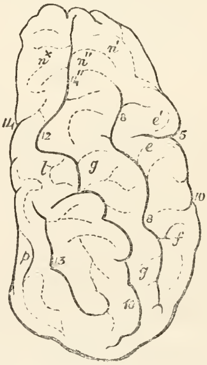
Tragulus.

102



Cervus.

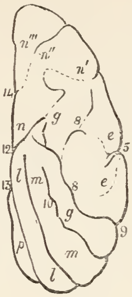
103



Giraffe.

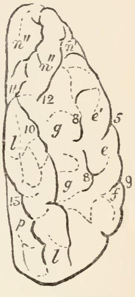
sphere; not so longitudinally extended along the mesial margin of the hemisphere as in *Hyrax* and *Equus*. The folds, *l* and *m*, figs. 102-105, come into contact at the middle part of the interhemispheral fissure, and show their character as medial ones, in the larger Artiodactyles. In *Cervus*, fig. 102, *l* and *g* blend anteriorly, and are continued into the frontal tract, *n*, the anterior longitudinal subdivisions of which are marked off by the short fissures, 14′ and 14″. In the Giraffe, fig. 103, the primary fissure, 10, is continued by a bend which may indicate 12, into the midfrontal fissure, 14″; in most Ruminants the supersylvian fissure, 8, extends into 14″. On the inner surface the same course of complexity adds to the primary hippocampal, 4, callosal, 7, and entolambdoidal, 13′, fissures, shown by *Tragulus* and *Hyrax*, the marginal, 6, supercallosal, 7′, and falcial, 15; the supercallosal, which is interrupted in the Sheep and Ox, is continuous in the Giraffe. Less significant secondary fissures impress both fore and hind parts of this surface. Below the sylvian fissure, 5, and fold, *e*, *e′*, a narrow undulated ‘subsylvian’ fold, *f′*, fig. 107, Giraffe, divides them from the ectorhinal fissure, 2: it is not present, at least as a convolute tract, in Perissodactyles: it is well marked and rises high up the sylvian fissure in Proboscidians, fig. 108, *f′*. We shall meet with this sub- or entosylvian tract again: it attains its greatest extent of surface in Man.

104



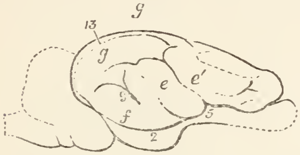
Sus.

105



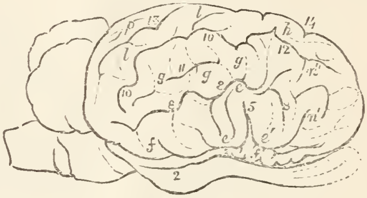
Auchenia.

106



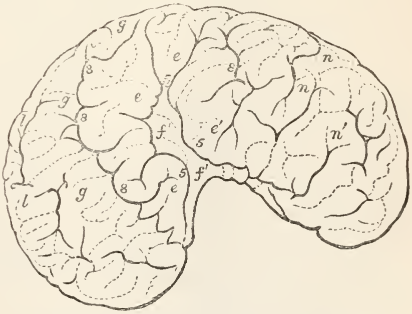
Hyrax.

107



Giraffe.

108



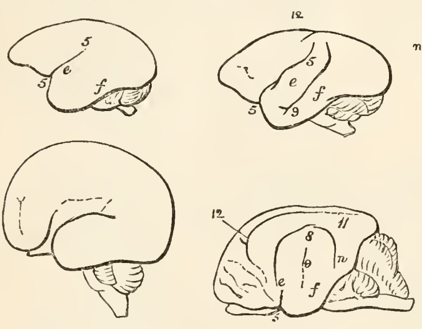
Elephant; side view of cerebral hemisphere.

The sylvian, *e*, and supersylvian, *g*, folds are more undulated, or interrupted, and less neatly defined in the Ungulata, at least in the larger species, than in the Carnivora. They are still less defined in the richly convoluted brains of the Proboscidia, fig. 108, and Cetacea, fig. 94.

With regard to the Ungulata the choice of 10 or 13 for the medilateral fissure 10, fig. 91, in Unguiculata, may long be undecided, and consequently the choice of 10 or 11, for the homologue of the lateral fissure 11; but the determination of the supersylvian fissure, 8, will probably be accepted, and on this basis, with the relations of 13, 13′, figs. 96—107, to the inner surface of the hemisphere, I am now, as in 1842, guided in the above determinations.

In the *Lemuridæ* the cerebrum does not extend over the whole of the cerebellum, fig. 109, Aye-aye: it does so in both platyrhine and catarhine groups: but there are species of *Quadrumana* more diminutive than any of the Ungulate Mammals, and with this infantile character is associated a fœtal smoothness of the cerebral surface, irrespective of the relative size of the hemispheres, figs. 109 and 116, *Midas*.

109



Every quadrumanous brain shows the ectorhinal, fig. 111, 2, entorhinal, ib. 3, hippocampal, fig. 110, 4, callosal, 7, marginal, 6, and sylvian, fig. 109, 5, fissures. In the Galagos and Slow Lemurs a beginning of other fissures appears on the upper surface; but they are not fully marked until the species attain the size of the Aye-aye and Lemur.

In *Chiromys* the fissure, fig. 109, 11 (Aye-aye),[1] commencing in advance of the posterior border of the hemisphere, advances, slightly diverging, to the anterior fourth: and there marks out an incipient coronal fissure, 12: it then bends inward and is continued into a fissure, apparently answering to that marked 14 in *Felis*. The supersylvian fissure, ib. 8, *e*, *n*, arches over the sylvian, 5, and postsylvian, 9, fissures and folds; the postsylvian fold, *f*, being defined by a short postsylvian fissure, 9. Subfrontal and midfrontal folds are indicated by a shallow subfrontal fissure. On the inner surface, fig. 110, besides the hippocampal, 4, callosal, 7, and marginal, 6,[1] fissures, a post-hippocampal, 4′, bifurcates, and defines entolambdoidal, *p′*, and septal, *s*, folds. There is also the beginning of a falcial fissure, 15′, and fold, *t*. The vertical extension of the natiform protuberance, fig. 111, *f′*, arrests the ectorhinal fissure, 2, at the sylvian one, 5. The Aye-aye agrees with the Lemurs and all Quadrumana in this respect; the homology of *b*, fig. 111, with the basirhinal fold, figs. 52, *b′*, 82, *h*, in *Ly-* and *Liss-encephala*, is masked by such interruption of the fissure, 2, in *Quadrumana*.

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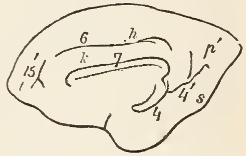
[1] CIV. pl. xii. figs. 3, 2; it combines, also, the character of the medilateral, 10, in *Carnivora*.

110



Inner surface of cerebral hemisphere, Aye-aye.

In *Lemur* proper the lateral fissure (between *l* and *g*, fig. 116) is shorter than in *Chiromys* and is not distinct from the supersylvian: in some species it bends outward more abruptly, in so far marking more plainly the coronal fissure, 12, as in higher *Quadrumana*, and indicating a longer anterior lobe than in *Chiromys*: a frontal fissure, 14‴, appears there. In the main we recognise in the cerebrum of *Chiromys* and *Lemur*, as in that of *Carnivora*, the primary division of the upper mass of the hemisphere into subparallel folds, medial, *l*, medilateral or supersylvian, *g*, and sylvian, *e*; but, shorter and more bent as they recede from the middle line; with indications of a longer anterior lobe or tract. The hippocampal fissure is prolonged into a 'post-hippocampal,' fig. 110, 4′, as in higher *Quadrumana*.

In the diminutive Platyrhine (*Midas*, Geoffr., figs. 109, 116) the smoothness of the upper surface of the hemisphere is broken only by the extension thereon of the sylvian fissure, 5. In the next stage (*Callithrix*) a 'postsylvian fissure,' ib. 9, is added, and the hemisphere may also show a longitudinal fissure, fig. 116, 8, 12, curving, like the supersylvian, over the end of the sylvian, 5, and postsylvian, 9, fissures; but which, in relation to the interhemispheral fissure, corresponds rather with the lateral, fig. 89, 11, of *Carnivora*: the large anterior tract may show a short frontal fissure, fig. 104, 14‴. In all the small Platyrhines (*Midas*, *Calli-*

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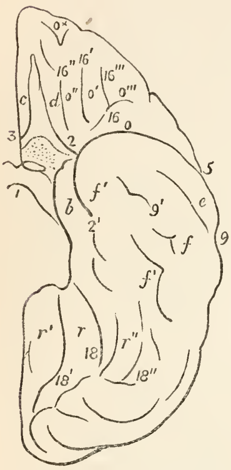
[1] CII. This has also the character of the 'supercallosal,' 7′, fig. 117.

thrix, fig. 109) the sylvian fissure, 5, and fold, *e*, are directed more obliquely from above and behind, downward and forward, than in the Aye-aye, ib., and most Lemuridæ: this character appears to be due to the preponderating growth of the frontal lobes, and becomes more marked as the *Quadrumana* rise in the scale. We next find that each hemisphere is divided into an anterior, middle, and posterior tract or region by two deep and extensive fissures, 12 and 13, *Macacus*, fig. 109, and *Cebus*, fig. 116, which, from their respective correspondence in position with the coronal and lambdoidal sutures, bear the same names.

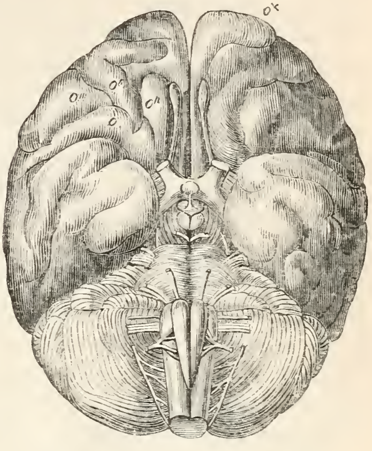
111



Under surface of cerebral hemisphere, *Macacus*.

In *Cebus* the sylvian fissure, fig. 116, 5, is overarched by a subangular one defining the fold, *g*; from the angle a fissure, 13, extends to the interhemispheral one, and is continued deeply down the inner or mesial surface. Outwardly the lambdoidal fissure, 13, defines and undermines a posterior part of the hemisphere, by raising which the continuation of the postsylvian fold, *f*, may be traced beneath it. The chief difference between the catarhine and lemurine hemispheres, at the inner surface, is the superaddition and interposition of the entolambdoidal fissure, 13′, between the post-hippocampal, 4′, and marginal or super-callosal, 7′, fig. 117; the entolambdoidal being sometimes continued into the post-hippocampal fissure, as in fig. 118, 13′—4′. The almost transverse fissure, fig. 116, 12, divides the large anterior from the middle lobes. In the latter, however, may be recognised the short tract, *l*, *m*, combining the 'medial' and 'medilateral' folds, but more transversely disposed than in *Carnivora*; pushed out, as it were, by the backward growth of the anterior lobe. Secondary fissures there indicate frontal, *n*, mid-frontal, *n″*, and superfrontal, *n′*, folds. One or two longitudinal occipital fissures mark out corresponding folds, *q″*, *q‴*. The ectorhinal fissure, fig. 111, 2, sinking into the sylvian one, 5, may have a continuation in the anteroposterior fissure, ib. 2′, which divides the 'natiform protuberance' into a medial or basirhinal, *b*, and a lateral moiety, *f′*. In most Catarhines the coronal fissure, 12, figs. 114, 116, extends, from within, more obliquely forward and outward; the homologues of the platyrhine fissures and folds are clearly seen, as marked by the figures and letters in *Macacus* and *Cebus*, fig. 116. Secondary fissures subdivide the orbital as well as the frontal and falcial surfaces of the anterior lobe: the surface resting on the orbital plate of the frontal bone, in the Orang's brain, fig. 112, shows the following convolutions:—'postorbital,' o, midorbital, o', entorbital, o'', ectorbital, o'', and antorbital, $o^{\times}$. That which lies external to the rhinal fissure or depression is not subdivided into ectorhinal and entorbital folds as in Man, fig. 120, *d*, o''. Similar secondary chinks furrow the occipital lobe, on the tentorial surface of which the tentorial fold, fig. 111, *r*, the entotentorial, r', and ectotentorial, r'', are now defined by the fissures, 18, 18′, 18″. These folds are more or less continuous with the basirhinal, *b*, and subsylvian, f', tracts. The increasing number of secondary fissures and the greater depth and more winding course of the primary ones mainly characterise the brain in the Orang (vol. ii. fig. 148) and Chimpanzee, fig. 114. The tract between the interhemispheral and supersylvian fissures is subdivided into medial, *l*, medilateral, *m*, and supersylvian, *g*, folds, fig. 116, Chimpanzee: we have evidently here the corresponding parts of the hemispheres that form these folds, or parts of them, in *Carnivora*.

112



Base of the brain, Orang-utan. xxix″.

D. *Archencephala.*—The same principle carried abruptly to an extremely greater degree, as in figs. 115, 116, *Homo*, associated (as compared with *Gorilla*, e. g.,) with a greater proportional bulk of the brain to the body, and with a still greater proportional size of the cerebrum to the rest of the brain, characterise the *Archencephalous* subclass, from the lowest varieties (Australian, Boschisman, Hottentot) to the highest. These proportions have thoroughly stood the severest tests, as where the diminutive female in such varieties has been selected to exemplify the brain-characters, with a view of reducing the chasm between the gyr- and archencephalous brains to a minimum.

Before entering into the details of the complex convolutional surface of the human cerebrum, I may premise some recapitulatory remarks.

'We are guided to the homologous parts of the cerebral hemispheres throughout their range of developement in the Mammalian class, in a great measure, by their relations to other parts of the brain. The portions more immediately surrounding the cerebral crura,[1] those which overarch the corpora striata and thalami and overlie the olfactory crura, or at least their beginnings, can hardly be doubted to be corresponding parts in all Mammals. The inferior prominences behind the "crura rhinencephali," forming the "protuberantiæ natiformes" of some anthropotomists (*b′* basirhinal fold), the inverted hippocampal fold, its labia and fissure, are plainly determinable throughout the class, as is also the sylvian fissure, 5, somewhat less constant, dividing the part of the hemisphere terminated by *f′*, figs. 113 and 115, and sometimes called "inferior lobe," from the part which is in front of it: the superadded cerebral substance to the above more constant parts of the hemispheres is that which, in Man, advances, overlaps, and extends beyond the olfactory lobe, and that which extends backward in like relation to the cerebellum.

'If one can predicate homology of any folds or fissures of the cerebral superficies, throughout the Mammalian class, it must be at the above-defined middle part of the more developed hemispheres, and especially at those fissures, viz. 2, ectorhinal, 4, hippocampal, 5, sylvian, 7, callosal, 7′, supercallosal, that are the most constant throughout the series. The upper surface of the hemispheres, as we have seen, is subject to different ways of folding: in *Echidna* the plaits go across, in *Felis* along it, while in *Bos* and *Simia* they run askew, yet contrariwise; in one from behind forward and inward, in the other forward and outward. It may seem, to some, that each leading division of *Gyrencephala* should have its own system of nomenclature and symbolism of brain-folds—that homologous convolutions can only be satisfactorily determined within the limits of such groups as *Ungulata, Unguiculata, Quadrumana.* In a degree this is true; the grounds of homology are such in regard to some folds (6 and 7′) as to leave room for difference of choice; but there are others that have a surer basis for homologising. Take, for example, the "sylvian fissure," 5: the fold *e*, that immediately overarches and forms it, is determinable: one part of the fold forms the anterior, the other the posterior, lip of the fissure: they are united or continuous by the overarching part in most *Unguiculates* and *Ungulates.* The homology of the sylvian fissure and fold is not obscured by the minor intersylvian convolutions, which are exposed in the Sheep and Elephant, and are concealed in higher Quadrumana and Man, where they constitute the "*gyri breves*" of Arnold;[1] nor is that of the anterior lip by the interruption of the ectosylvian fissure, 8′, in the Cat, fig. 91, whereby the sylvian is divided into parallel vertical folds, which, with the intervening sylvian fissure, are overarched by the higher supersylvian fissure, ib. 8. In *Quadrumana* the posterior part of the supersylvian fissure, fig. 109, 8, sometimes runs into one, 9, behind and parallel with the sylvian, 5. In *Stenops* the detached "post-sylvian," 9, is short and straight, as in the Cat.

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[1] Subsequently defined as 'prosencephalic.'

'In the Marmozets (*Midas*, Geof. *Hapale*, Bl. *Jacchus vulgaris*) the sole superficial fissure on the exposed surface of the hemisphere is the sylvian, figs. 109, 116, 5, and this determines the contiguous part of the hemisphere, *e*, to be the homologue of the sylvian fold. When the postsylvian fissure appears, as in *Callithrix*, fig. 109, 9, the postsylvian fold, *f*, is defined: it is certain that we now have the homologues of the folds so named and numbered in Unguiculates, figs. 90–92; and the advantage of their determination would be lost were we to apply new names to these folds and fissures as if they were distinct and superadded parts in the quadrumanous and bimanous brains. The next fissure which appears, in the *Quadrumana*, answers to that marked 11, 8, in *Putorius*, fig. 87, which is longitudinal and bends more or less outward anteriorly: it divides, in fig. 116, *Callithrix*, 8, the cerebral surface above the sylvian and postsylvian fissures lengthwise, into two pretty equal tracts, and tends to mark off an anterior part or lobe of the hemisphere.

'Proceeding with the more typical *Quadrumana*, we find that the progressive expansion of the cerebrum, which has carried it backward over the cerebellum, and augmented the outward and downward extension of the part behind the sylvian fissure, has also added so much to the anterior lobes as seems to have pushed backward the rest of the hemisphere, and gives the sylvian, *e*, and postsylvian, *f*, folds a more oblique direction from above, downward and forward, than in most lower *Unguiculates*. In the Otter, indeed, and Lion, the sylvian and presylvian fissures are similarly oblique: but the posterior part of the sylvian fold does not project outward so far beyond the anterior part as in *Quadrumana*: this development, together with the interruption of the supersylvian fissure, and the extension of secondary fissures at right angles and anterior to the sylvian fissure, tend to mark the homology of the forepart of the sylvian fold in *Quadrumana*. Its upper part is now defined from the forepart or "anterior lobe" of the brain, by the fissure 12, figs. 109, 116, which, instead of being continued with or from the longitudinal one, as in *Lemur*, fig. 116, 8, extends from without, obliquely inward and backward, to or near to the interhemispheral fissure. It is that which, from being first well defined by the Italian anatomist[1] in the human brain, has been called "fissura Rolandi," but which I term "coronal," or "coronal part" of the medilateral fissure, in Ferines, figs. 88–92, 12.'

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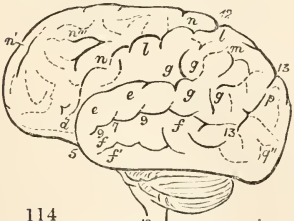
[1] IX′.

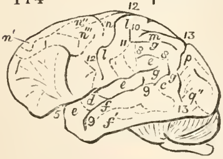
In the side view of the human hemisphere, fig. 115, the fissures are indicated as follows:—2, ectorhinal, external to the crus rhinencephali, it is longer and more conspicuous in the lower Mammals, fig. 107, 2, 5, sylvian, 8, supersylvian, 9, postsylvian, 9′, subsylvian, 12, coronal, 13, lambdoidal, 14, frontal (or postfrontal), 14′, superfrontal, 14″, midfrontal, 14‴, subfrontal, $14^{\times}$, ectofrontal, 17, occipital (or superoccipital), 17′, exoccipital, 17‴, ectoccipital. The folds or convolutions are: — *d*, ectorhinal, *e*, sylvian, *f*, postsylvian, *f′*, subsylvian, *g*, supersylvian, *l*, medial, *m*, medilateral (*l* and *m*, as in *Quadrumana*, are less distinct from each other, as well as shorter and more oblique, than in *Carnivora*), *n*, frontal (or postfrontal) *n′*, superfrontal, *n″*, midfrontal, *n‴*, subfrontal, $n^{\times}$, ectofrontal, *p*, lambdoidal, *q*, superoccipital, *q′*, midoccipital. Homologous fissures and folds in the brains of the infant, fig. 113, and chimpanzee, fig. 114, are indicated by similar figures and letters.

Infant.

113

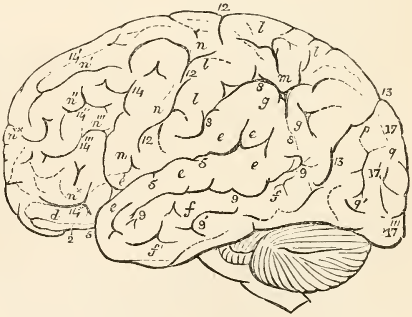


114



Chimpanzee.

.115



Homo. Adult.

In the upper view of the human hemisphere, fig. 116, the following fissures are marked:—5, sylvian, 8, supersylvian, 9, postsylvian, 12, coronal, 13, lambdoidal, 14, frontal, 14 , superfrontal, 14″, mid-frontal, 17′, exoccipital, and $17^{\times}$, postoccipital. The folds are:—*e*, sylvian, *l*, medial, *m*, medilateral, *n*, postfrontal, *n′*, superfrontal, *n″*, midfrontal, *n‴*, subfrontal, *o*, ectorbital, *p*, lambdoidal, *q*, occipital, *q″*, suroccipital, *q‴*, suboccipital.

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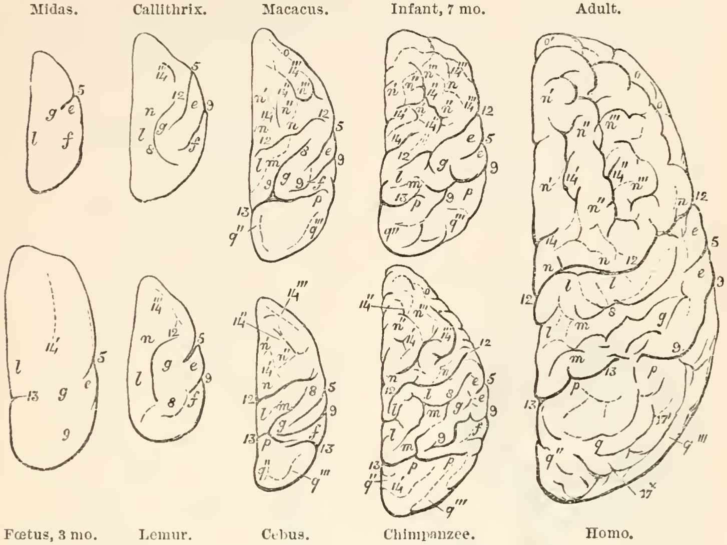
[1] xxiv″.

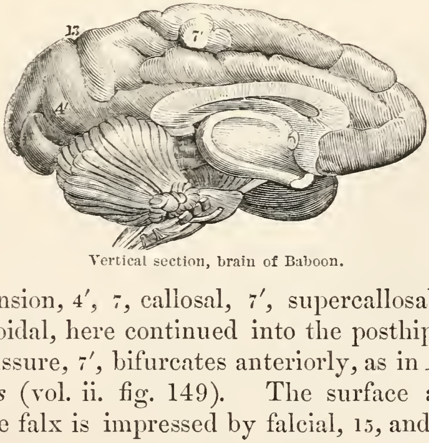
116


Midas. Callithrix. Macacus. Infant, 7 mo. Adult.

Fœtus, 3 mo. Lemur. Cebus. Chimpanzee. Homo.

The primary fissures on the internal (mesial) surface of the hemisphere, fig. 118, are 4, hippocampal, with its long bifurcate posterior extension, 4′, 7, callosal, 7′, supercallosal, 6, marginal,[1] 13′, entolambdoidal, here continued into the posthippocampal; the supercallosal fissure, 7′, bifurcates anteriorly, as in *Papio*, fig. 117, 7′ and *Pithecus* (vol. ii. fig. 149). The surface applied to the fore part of the falx is impressed by falcial, 15, and subfalcial, 15′,

117



Vertical section, brain of Baboon.

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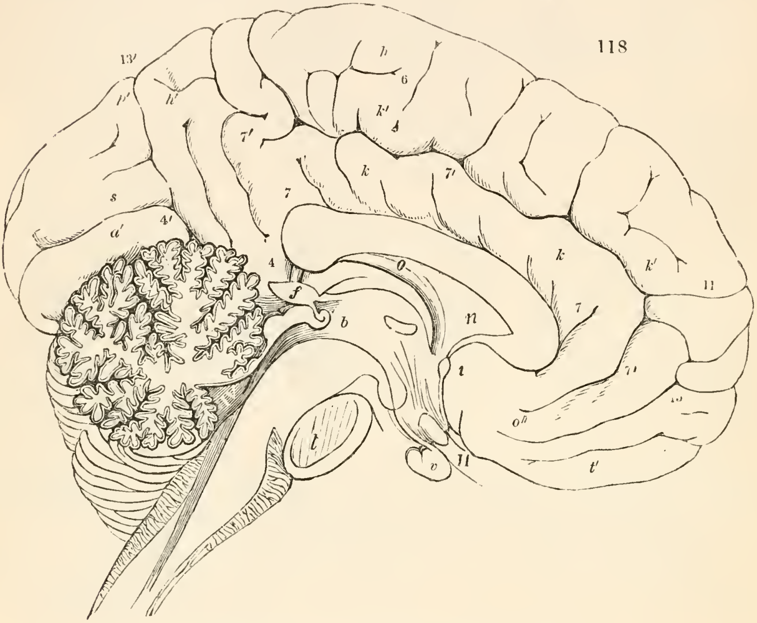
[1] This is seldom so distinct or continuous as in the larger ungulates.

fissures, more or less parallel with 7′. The principal folds defined by the above fissures are:—*a′*, posthippocampal, *k*, callosal, *k′*, supercallosal, *h*, marginal, *h′*, postmarginal, *t*, falcial, *t′*, subfalcial (which is the inner surface of *c*, entorhinal), *p′*, entolambdoidal, *s*, septal.

Anthropotomists have primarily divided the hemispheric masses into groups of convolutions or 'lobes:' some into three, viz., the 'anterior,' 'middle,' and 'posterior' lobes; others into five. These latter are termed 'central' (*lobus centralis*), 'frontal' (*lobus frontalis*), 'parietal' (*lobus parietalis*), 'temporal' (*lobus temporalis*), 'occipital' (*lobus occipitalis*).

118



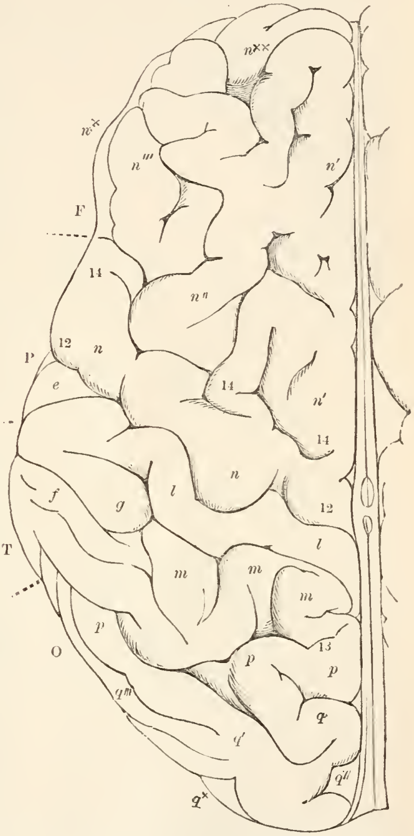
Vertical section, half nat. size, Human Brain. XL''.

The central lobe ('Stammlappen,' Huschke) answers to the 'Insel' of Reil, and is not visible outwardly; it includes the 'gyri breves,' and is, by some, held to be peculiar to *Quadrumana* and *Bimana* (but see figs. 117, 118, *f′*, *f′*).

The 'frontal lobe,' fig. 119, F, includes so much of the anterior lobe as lies in advance of the 'frontal fold,' *n*, *n*, and is subdivided above into the superfrontal, *n′*, midfrontal, *n″*, subfrontal, *n‴*, ectofrontal, $n^{\times}$, and 'prefrontal,' $n^{\times\times}$, folds: it is an artificial division of the part, most naturally defined, both in *Quadrumana* and Man, by the coronal fissure, 12, from the rest of the hemisphere.

The 'parietal lobe,' P, includes the frontal fold, *n*, *n*, the anterior and superior parts of the sylvian, *e*, and supersylvian, *g*, folds, with the medial, *l*, and medilateral, *m*, folds.

119



Superior surface of the right hemisphere of the adult human brain, two-thirds nat. size.

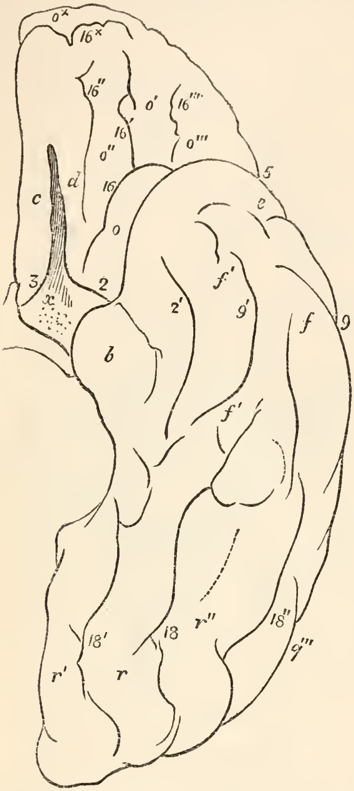
The 'temporal lobe,' T, includes the posterior part of the sylvian fold, the postsylvian, and subsylvian folds, fig. 115, *f*, *f′*, and also part of the supersylvian fold, *g*.

The 'occipital lobe,' O, is a more natural division, including all the part of the hemisphere which lies behind the lambdoidal fissure, 13.

The anterior lobe has three surfaces, one applied to the calvarial part of the frontal bone, another to the orbital plate, a third to the falx. Each of these are impressed by secondary fissures, which I have called 'frontal,' 'orbital,' and 'falcial,' accordingly. The frontal fissures mainly affect a longitudinal direction, but run behind into a transverse one. This is the 'frontal,' or 'postfrontal,' fig. 119, 14; it is more or less extensive and parallel with the coronal fissure, ib. 12. The most constant of the longitudinal fissures pretty equally bisects the frontal surface; it is the 'midfrontal' fissure, fig. 116, 14″; the fissure above or internal to it is the 'superfrontal,' 14′, that beneath or external is the 'subfrontal,' fig. 115, 14‴; beneath this again and upon the outer and back part of the frontal lobe is a deep and constant longitudinal fissure, usually bifurcate, the ectofrontal, ib. $14^{\times}$.

The fissures on the orbital surface present much analogy to the frontal ones. The posterior one is transverse and usually curved with the convexity forward; it is the orbital or postorbital, fig. 120, 16; the most constant of the longitudinal fissures which extend forward from the orbital one, I call 'midorbital,' ib. 16′; that to the inner side is the entorbital, 16″; that to the outer side, the ectorbital, 16‴; a transverse fissure anterior to these is the antorbital one, 16×. The ecto- and ento-rhinal fissures, 2, 3, distinct posteriorly, run into each other where they form the groove lodging the slender 'crus rhinencephali' of the human brain. The cerebral folds thus marked out are the entorhinal, *c* (which is the under surface of the subfalcial, fig. 118, *t′*), the ectorhinal, *d*, which, in *Ly-* and *Liss-encephala*, *Ungulata*, and most *Carnivora*, is continued backward, uninterruptedly, into the basirhinal tract, *b*; external to *d*, fig. 120, are the postorbital, *o*, midorbital, *o′*, entorbital, *o″*, ectorbital, *o‴*, antorbital, *o*×. The postorbital tract passes backward into 'Reil's Island.' The ectorbital, *o‴*, merges into the ectofrontal, *n*×, fig. 119, of which it may be called the under surface: attention has been called to the coincidence of loss or defect of speech with lesion in that fold or locality of the brain.[1] The tracts connecting some of the folds of which the homology with those of lower mammals is determinable, are noted, in anthropotomy, as 'annectant gyri' ('plis de passage,' LIX··).

120



Under surface of hemisphere, human cerebrum.

On the falcial surface of the frontal lobe the most constant fissures are two that affect a longitudinal course; the upper one, which seems to be a continuation of the 'marginal' fissure, is the 'falcial,' fig. 118, 15; the parallel one below is the 'subfalcial,' 15′.

The posterior lobe of the hemisphere, marked off by the lambdoidal fissure, 13, has three principal surfaces: one applied to the superoccipital plate, one applied to the falx, and one resting on the tentorium.

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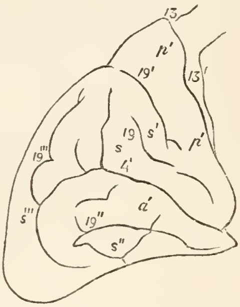
[1] LXXII·· and LXXIII··.

On the occipital surface are several but irregular fissures, which, from their position, may be termed mid-, super-, ent-, and post-occipital; they define, more plainly in *Quadrumana* than in Man, the lambdoidal, fig. 119, p, suroccipital, q'', midoccipital, q', suboccipital, q''', and postoccipital, $q^{\times}$, folds. On the tentorial surface they affect a longitudinal wavy course, and are commonly three in number; of these, the middle one is the 'tentorial' fissure, fig. 120, 18, the inner one the 'entotentorial,' ib. $18'$, the outer one the 'ectotentorial,' $18''$. On the surface next the falx, or septum dividing the hemispheres, fig. 121, the fissures have a radiating tendency from the anterior angle outward: the most constant and important of these, in Man, has already received the name of 'posthippocampal,' being a continuation of that deep fissure the corresponding fold of which partly protrudes into the posterior horn of the ventricle, as the 'hippocampus minor;' the rest I called 'septal' fissures, reserving the term 'falcial' to those on the corresponding surface of the anterior cerebral lobe. The fissure above the 'posthippocampal' is the 'septal' fissure, 19; that beneath the posthippocampal is the 'subseptal,' $19''$; the fissure between the septal and entolambdoidal, $13'$, fissures is the superseptal, $19'$; their outer ends are frequently lost in a fissure following more or less extensively or interruptedly the posterior contour of the posterior lobe; this is the postseptal fissure, $19'''$; it is peculiar to Man. The folds so defined on the septal surface are: the entolambdoidal, p', superseptal, s', septal, s, posthippocampal, a', subseptal, s'', and postseptal, s'''.

121



Inner or septal surface of posterior lobe, human cerebrum.

The human brain, in its development, passes through stages in some degree like those which are permanent in and characteristic of the Quadrumana, in respect to its cerebral folds and fissures; but it early manifests its distinctive archencephalous proportions, fig. 109, Fœtus. About the twentieth week the fissures begin to appear upon the upper surface of the hemispheres, fig. 116, three months' Fœtus. After the 'hippocampal' and 'callosal' have cleft the inner surface, and the 'ectorhinal' and 'sylvian' the under surface, the entolambdoidal ascends upon the mesial side of the upper surface (fig. 116, 13); the postsylvian, 9, appears; then a faint trace of the longitudinal fissure, fig. 116, $14'$, indicative of the midfrontal and ectofrontal tracts. The 'coronal,' fig. 113, 12, is speedily followed by the 'postsylvian' 9. A more or less interrupted fissure divides lengthwise the sylvian or supersylvian fold, ib. *g*, from the median, *l*, and medilateral, *m*, tracts. The lambdoidal fissure, 13, extends toward the outer part of the hemisphere: the pre-coronal tract of brain is fissured into subdivisions, chiefly longitudinal: the fœtal brain, at seven months, figs. 113, 116, resembles, in superficial cerebral marking, that of the latisternal apes, ib., Chimpanzee, but is broader anteriorly, deeper and longer behind.

In the foregoing summary we have seen that the fissures which break the surface of the mammalian brain are of different kinds, degrees, and values. Some, in the course of development and elevation of the primary masses, divide one from the other; as the cerebrum from the optic and olfactory lobes, the cerebrum from the cerebellum, and this from the macromyelon. Some subdivide primary masses into symmetrical halves, as e.g., the inter-hemispheral fissure, the inter-olfactory fissure, and the shallower indent between the mammalian optic lobes or 'nates.' One or two fissures of the cerebrum make folds that project into the hemispheral cavity or ventricle, e. g. the hippocampal and, in Man, the posthippocampal: most are confined to its crust or wall, and of these, as I showed in 1833, some, from their relative constancy, depth, and symmetry, may be termed 'primary,' while others are of 'secondary' or inferior rank.

The following are those which are noted by figures in the illustrations of the present work:—

Cerebral Fissures, in the order mainly of their constancy in the Mammalia.

Figures.	
1.	Interhemispheral.
2.	Ectorhinal.
$2'$.	Basirhinal.
3.	Entorhinal.
4.	Hippocampal.
$4'$.	Posthippocampal.
5.	Sylvian.
6.	Marginal.
$6'$.	Postmarginal.
$6''$.	Premarginal.
7.	Callosal.
$7'$.	Supercallosal.
8.	Supersylvian.
$8'$.	Ectosylvian
9.	Postsylvian.
$9'$.	Subsylvian.
10.	Medilateral.
11.	Lateral.
12.	Coronal.
13.	Lambdoidal.
$13'$.	Entolambdoidal.
14.	Frontal or Postfrontal.
$14'$.	Superfrontal.
$14''$.	Midfrontal.
$14'''$.	Subfrontal.
$14^{\times}$.	Ectofrontal.
15.	Falcial.
$15'$.	Subfalcial.
16.	Orbital or Postorbital.
$16'$.	Midorbital.
$16''$.	Entorbital.
$16'''$.	Ectorbital.
$16^{\times}$.	Antorbital.
17.	Occipital or Midoccipital.
$17'$.	Superoccipital.
$17''$.	Entoccipital.
$17'''$.	Ectoccipital.
$17^{\times}$.	Postoccipital.
18.	Tentorial.
$18'$.	Entotentorial.
$18''$.	Ectotentorial.
19.	Septal.
$19'$.	Superseptal.
$19''$.	Subseptal.
$19'''$.	Postseptal.

The following are the cerebral folds which are indicated by letters in the illustrations of the present work, with the synonyms of original labourers in this field of anatomy:—

CEREBRAL FOLDS IN THE ORDER OF THEIR CONSTANCY IN MAMMALS.

Letters	Rolando. xxiv″.	Leuret. xl″.	Gratiotle. lix″.
P Hemisphere			
a Hippocampal	La circonda che copre il corno d' ammone	Lobe d'Hippocampe.	
a′ Posthippocampal	Gyrus uncinatus. ix″.	iii. p. Troisième circonvolution postérieure.	
b Basirhinal		Crochet.	
c Entorhinal	Radica interna del solco che riceve il nervo olfattorio.		Partie antérieure du grand marginal.
Ectorhinal			Orbital interne.
e Sylvian	1–5 che circonda la scissura del Sylvio	Circonvolution d'enceinte de la scissure de Sylvius: its hind part is (in Man)	Pli pariétal ascendant.
e′ Presylvian		i. p. Première circonvolution supérieure.	
f Postsylvian		ii. p. Seconde circonvolution postérieure.	Pli temporo-sphénoidal.
f′ Subsylvian		iii. p. Troisième circonvolution postérieure.	
f″ Entosylvian	Isola di forma quasi triangolare: gyri breves, Arnold.		
g Supersylvian			Pli angulaire.
h Marginal		A. Partie interne de la troisième circonvolution antérieure.	Grand marginal, ou pli de la zone externe.
h· Postmarginal			Lobule quadrilaterale.
k Callosal	Circ. cristato: gyrus fornicatus, Arnold.	I. Circonvolution interne qui se contourne sur le corps calleux. Circonvolution de l'ourlet, Foville.	Pli du corps calleux.
k′ Supercallosal			
l Medial	c. del margine degli emisferi	*s′* (and part of) circonvolution transverse medio-pariétale.	Deuxième pli pariétal ascendant, et étage supérieur du grand marginal.
m Medilateral		ib.	ib.
n Frontal (or post-frontal)		*s* Première circonvolution supérieure	Premier pli pariétal ascendant.
n′ Superfrontal		iii. a. Troisième circonvolution antérieure.	Frontal supérieur.
n″ Midfrontal		ii. a. Seconde circonvolution antérieure	Frontal moyen.
n‴ Subfrontal		i. a. Première circonvolution antérieure	Frontal inférieur.
*n** Ectofrontal.			
*n*** Prefrontal.			
o Postorbital	Insula Reilii (in part) ix″		Orbital postérieur.
o′ Midorbital			ib. moyen.
o″ Entorbital		Circonvolutions sus-orbitaires	ib. interne.
o‴ Ectorbital			ib. externe.
*o** Antorbital			
p Lambdoidal			Premier pli de passage externe, ou étage supérieur du lobe occipital.
p′ Entolambdoidal			Pli interne du lobe occipital.
q Occipital			
q′ Midoccipital			Pli supérieur du lobe occipital.
q″ Suroccipital			Occipital moyen, et second pli de passage ext.
q‴ Suboccipital			Occipital inférieur, et troisième pli de passage externe.
*q** Postoccipital.			
r Tentorial			Pli temporal inférieur.
r′ Entotentorial		ii. p. Seconde convolution postérieure	Pli temporal moyen antérieur.
r″ Ectotentorial			Pli temporal inférieur.
s Septal			Lobule occipital.
s′ Superseptal			ib.
s″ Subseptal			Pli temporal moyen antérieur.
s‴ Postseptal.			
t Falcial			Partie antérieure du grand marginal.
t′ Subfalcial.			

Each hemisphere is a bag of neurine folded or laid upon its expanding stem, the hollow of the bag being the ventricle. This, in the embryo, is capacious and simple, the wall being very thin. It becomes thickened in different degrees at different places, most so at the upper and outer sides. The wall, thus thickened, protrudes at certain parts into the cavity, dividing and shaping it into parts or recesses which Anthropotomy calls 'horns,' from their curvature in Man. In lower Mammals the primitive cavity commonly retains more of the general shape of the hemisphere, and in most Quadrumana, the lower more especially, the part accompanying the broad supracerebellar expansion of the hemisphere is of corresponding capacity. The Orang, among Apes, still shows the primitive character of this part of the ventricle: in the Chimpanzee and Gorilla the growing walls reduce and begin to shape it as a 'horn,' showing also a beginning of a protuberance within it. In *Archencephala* the moulding of the 'posterior horn' is completed by the predominance of the internally protruding wall ('partie enroulée,' Leuret), to which, now, the term 'hippocampus minor,' or 'pes hippocampi minor,' rightly applies.[1] The fibres of the stem, augmented in number at each accumulation of grey reuniting matter, diverge into and form the main part of the wall in greatest proportion in the *Lyencephala*.

The stem or 'crus' is formed by the prepyramidal tracts, fig. 66, *p*, the olivary tracts *f*, the teretial and postpyramidal tracts, fig. 49, Y, and so much of the cerebellar tracts, fig. 66, *t*, as may not have been expended in the formation of the 'nates,' *b*, 'testes,' *n*, 'geniculate bodies,' *y*, and their common basis. Thus the crus or stem of the hemisphere includes tracts of the myelon, connected respectively with the sensory and motory roots of the nerves. The part of the 'crus prosencephali,' below or in front of the 'locus niger,' consists of white fibres in a coarsely 'fasciculate' arrangement, fig. 123, *d*: the part above, derived from the teretial, postpyramidal, and cerebellar tracts, is softer, with mixed grey matter, and forms the 'tegmentum,' ib. *c*. The fasciculate fibres, after passing through and being reinforced by the grey matter of the striated body, diverge in curves, fig. 66, *c*, fig. 122, *s*, of which many bend downward and outward, suggesting the term 'fibrous' or 'radiated' cone; in Man they are traceable chiefly in the sylvian, postsylvian, entosylvian, supersylvian, medilateral, medial, and marginal folds, and into the major part of those of the anterior lobe, fig. 122, *a*. The tegmental or posterior fibres are, in Man, more directly connected with the transversely arched fibres of the great commissure: others, diverging to the posterior lobes, *e*, *b*, become connected or continuous with the longitudinal commissural system of the fornix. Figure 123 is a dissection of the inner surface of the hemisphere. C is the section of the corpus callosum, the fibres of which diverge upon the roof of the ventricle, intersecting the radiating fibres, fig. 122, *s*, and passing into all the folds, which are thus brought into communication with those of the opposite hemisphere. The fibres of the 'callosal' fold, fig. 123, *o*, *o*, are chiefly longitudinal, are continued behind, into those of the hippocampus, and in front into those extending from the fornix upon the falcial surface of the anterior lobe: externally

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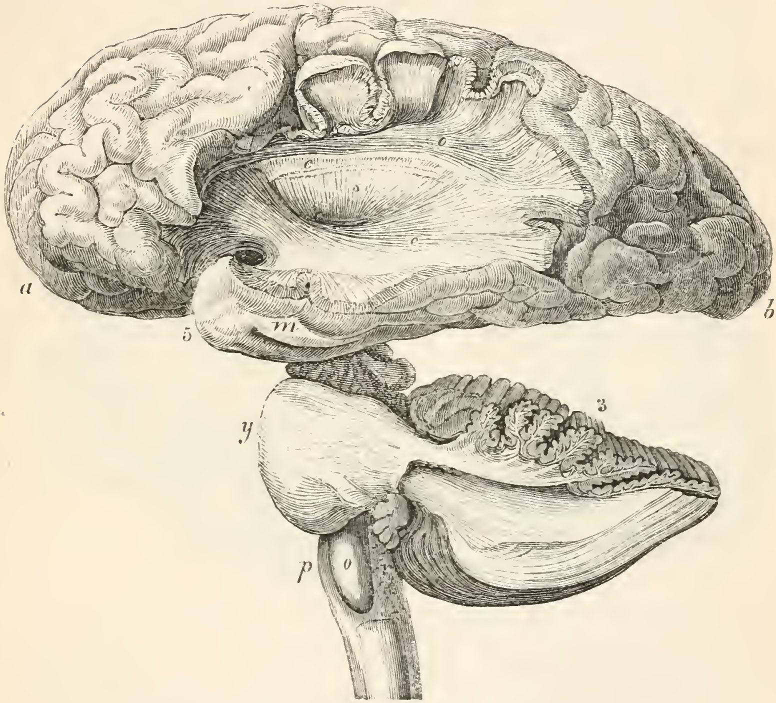
[1] The judicious and painstaking anatomist GRATIOLET seems to have foreseen some late misconceptions of the nature of the hind part of the primitive ventricular cavity in the Quadrumanous brain, in the following note :—'Toutefois, il ne peut être considéré comme un signe d'*élévation*, car il est beaucoup plus grand en égard à la partie enroulée du ventricule dans les singes, où son développement est énorme, que dans l'homme, où la partie enroulée l'emporte évidemment sur lui. Cette remarque,' he justly adds, 'est d'une haute importance.' XL''. vol. ii. p. 75.

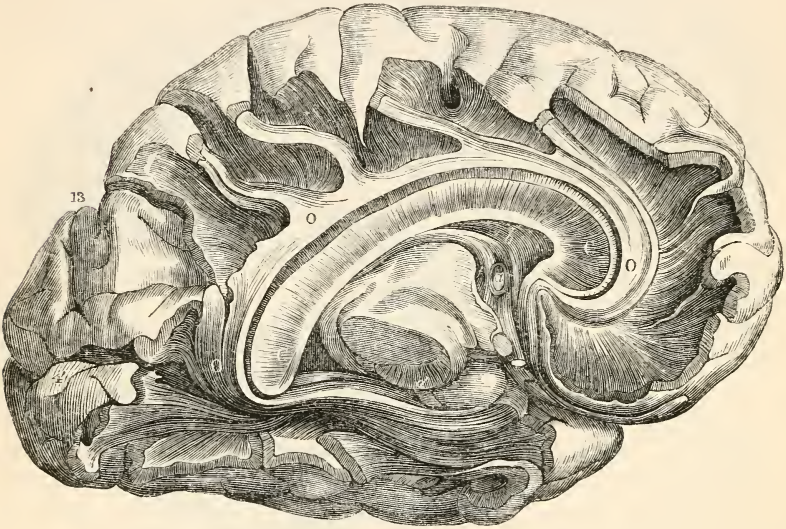
122



Dissection of cerebrum and cerebellum, from the outer side. XXXIII''.

they form the 'superior longitudinal commissure,' fig. 122, *o*; and fibres are traceable from both extremities to the 'perforated space,' figs. 82, 120, *x*. The dissection, fig. 122, shows also the longitudinal fibres extending from the anterior to the inferior and posterior lobes, and forming the 'external longitudinal commissure,' *e*, above which are seen part of the radiating fibres, *s*, interlacing with those of the corpus callosum, *c*; which is overarched by the outermost of the superior longitudinal commissural fibres, *o*. Above these are shown the fibres which mainly form the convolutions, but which include not only the 'radiating' fibres, but those of the 'transversely commissural' and 'longitudinally commissural' kinds: they terminate in or blend with the grey matter which forms the outer crust of the hemisphere. In a section of this substance in a recent brain, a white line is seen to separate it into two layers, as in fig. 124. More closely scrutinised, the following strata have been defined from the surface downward:—a thin superficial white layer, a thick reddish grey layer, the intermediate white layer, a thicker grey layer, a third thin white layer, and the deepest grey layer receiving the radiating fibres of the white or medullary cerebral neurine.[1]

123



Dissection of the left hemisphere of the brain, from the inner side. XXXIII''.

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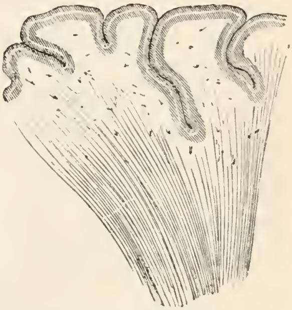
[1] In the contemporary Reports of my Hunterian Course of Lectures, 1842, the chief conclusions of the comparative anatomy of the superficial grey substance in

The anterior commissure—the most constant of the transverse system—is relatively largest in *Lyencephala*, figs. 69, 73, *c*. In the human brain a similar transverse section of it shows its insignificant dimensions, fig. 123, *a*. Traced transversely, in them, it passes, as in a special canal, across the lower part of the corpora striata, bends backward, and expands as it radiates into the middle of each hemisphere. It indicates the small part of the human cerebrum which is homologous with the main part of that of birds and marsupials. But the increase of the mammalian over the avian brain begets the added structures for association of added parts, already described. In Man, each anterior pillar of the fornix, after leaving the 'thalamus,' descends and is bent upon itself before ascending, the bend projecting at the base of the brain, behind the 'infundibulum,' as the 'corpus albicans,' or 'mammillare,' fig. 128, *m*.

124



Section of grey and white neurine of prosencephalic convolutions. Man.

In the *Lissencephala*, where a corpus callosum is first established, it might seem, in a dissection from below, that the outer fibres of the 'radiating cone' curved over the lateral ventricle, and were constricted lengthwise as they ran into each other across the interhemispheral fissure, as in the dissection of the Beaver's brain, fig. 78: but it is deceptive. There is no actual continuity of any of the ascending radiating fibres of the crus cerebri with those which spread out in transverse curves from the corpus callosum. The two systems are everywhere closely interlaced; but the fibrous character of the commissural series is lost,

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mammalian brains was summarised by the Reporter for the 'Medical Times,' as follows :—'A symmetrical arrangement, more or less regular or complex, can always be traced between the foldings of the two hemispheres, and the more regular in proportion to the simplicity of the convolutions: the foldings of the cerebral substance follow likewise, both in the embryonic development of a complex brain, and in the progressive permanent stages presented by the mammalian series, a regular determinate law: some convolutions being more constant than others, and these being traceable through the greatest number of brains, and recognisable even in the human brain, where, at first sight, they are obscured by so many accessory convolutions.' 'The Lecturer then demonstrated, in a considerable number of prepared brains of different animals, and in a large series of diagrams, in which the corresponding convolutions in the brains of different animals were marked by the same colours, the facts establishing this important generalisation.'—*The Medical Times*, Nov. 12, 1842, vol. vii. p. 101. Report of 13th Lecture, delivered May 16th, 1842.

under the microscope, before it quits the ventricular wall to descend, with the radiating fibres, into the crus. From this stage in the mammalian series the great transverse commissure grows with the growth and complexity of the hemisphere. It consists mainly of white or fibrous neurine, but some grey matter ('nucleus lenticularis') is superadded to the inferior fibres external to the radiated cone, and between this and the 'island of Reil' there is also a thin layer of grey neurine ('nucleus tæniæformis').

Always maintaining its closest connection with the part of the fornix called 'lyra,' or hippocampal commissure, whence its development began, the increasing body of transverse fibres extends forward and upward, with a bend or 'genu,' fig. 123, C, O, corresponding in extent with elevation and expansion of the front lobes of the cerebrum. In Man its narrow anterior beginning is connected by the 'lamina cinerea' with the optic commissure, receives a small part of the grey substance of the thalamus, and sends off two bands, called 'peduncles of the corpus callosum,' which, diverging, pass backward across the 'perforated space' to the lower part of the sylvian fold. The corpus callosum, expanding as it rises, bends backward, and presents on its upper surface a medial longitudinal groove, called 'raphe,' bounded laterally by the white 'striæ longitudinales:' it terminates behind in a slightly down-bent, thickened, free border or 'pad.' Some way in advance of this the attachment of the under surface of the corpus callosum to the fornix begins, and, as the hemispheres increase in the placental series, so does the extent of the filmy inner walls of the lateral ventricles ('septum lucidum,' Anthro., fig. 123, *b*) between the body of the fornix and the great superadded transverse commissure, the fibres of which extend over the roof of those ventricles. The most intelligible illustrations of the comparative anatomy of this interesting part of the cerebral structure is obtained by dissecting and exposing the lateral ventricle from the outer side, as in the views of the brains of the Opossum, Kangaroo, and Ass, showing the relative proportions of the hippocampus, and of the part of the inner wall distinct therefrom, called 'septum lucidum,' in LXX′, pl. vii. In fig. 5, the vascular fold of pia mater called 'choroid plexus' is shown passing beneath the fore part of the 'tænia hippocampi' through the canal of communication between the lateral ventricles, in both marsupial and placental brains. The supraventricular neurine, being folded upon its stem, the cavity is a reflection of the external surface, and is lined by a continuation of the pia mater, although the fissure by which it enters the 'ventricle' becomes contracted to a very small extent of the base exterior to the crus. From this point begins the fold extending, as 'choroid plexus,' from one ventricle to the other by the fissure called 'foramen Monroianum' in Anthropotomy. On the interior surface of the hemisphere the pia mater is reduced to an epithelium, the cells of which are less flat in the lateral ventricles than in that continuation therefrom called 'third ventricle.' The part of the interhemispheral fissure overarched by the great transverse commissure is the 'fifth ventricle.' For other differentiated and definite parts in the archencephalous brain—the subjects of the 'bizarre' nomenclature of Anthropotomy—reference may be made to the minute and exact monographs which have been published on that part of the human structure.

§ 209. *Size of Brain.*—The brain grows more rapidly than the body, and is larger in proportion thereto at birth than at full growth. But there is a difference in this respect in different Mammalian orders. The brain of the new-born Marsupial is less developed relatively than in higher Mammals, and grows more gradually or equally with the subsequent growth of the body.[1] So, in the degree in which a species retains the immature character of dwarfishness, the brain is relatively larger to the body: it is as 1 to 25 in the pygmy Petaurist, but is as 1 to 800 in the Great Kangaroo; it is as 1 to 20 in the Harvest Mouse, but is as 1 to 300 in the Capybara; it is as 1 to 60 in the little two-toed Ant-eater, and is as 1 to 500 in the Great Ant-eater. The brain weighs 6 grains in the Harvest Mouse (*Mus messorius*), and the same in the Common Mouse (*Mus musculus*); but the weight of the Harvest Mouse is 112 grains, whilst that of the Common Mouse is 327 grains. The brain of a Porpoise, 4 feet long, may weigh 1 lb. avoird.; that of a Whale (*Balænoptera*) 100 feet in length does not exceed 4 lbs. avoird.[2] In Artiodactyles the brain of a pygmy Chevrotain (*Tragulus pygmæus*) is to the body as 1 to 80; in the Giraffe[3] it is as 1 to 800. In Perissodactyles the brain of the Hyrax is as 1 to 95, whilst that of the Indian Rhinoceros is as 1 to 764.[4] The brain of the Elephant may be three times heavier than that of the Rhinoceros, but a full-grown male would probably weigh down four Rhinoceroses. In Carnivora the brain of the Weasel is to the body as 1 to 90; in the Grisly Bear it is as 1 to 500; in Quadrumana the brain of the

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[1] LXXV′, p. 347, pl. vii. figs. 9–12.

[2] SCORESBY, in a *Balæna mysticetus* of 65 feet in length, found the weight of the brain to be 3 lbs. 12 oz.

[3] XCVII·.

[4] V″.

Midas Marmoset is to the body as 1 to 20; in the Gorilla it is as 1 to 200.

But such ratios do not show the grade of cerebral organisation in the Mammalian class: that in the Kangaroo is higher than that in the Bird, though the brain of a Sparrow be much larger in proportional size to the body: and the Kangaroo's brain is superior in superficial folding and extent of grey cerebral surface to that of the Petaurist. The brain of the Elephant bears a less proportion to the body than that of Opossums, Mice, and proboscidian Shrews, but it is more complex in structure, more convolute in surface, and with proportions of pros- to mes-encephalon much more nearly those in the human brain. The like remark applies to all the other instances above cited.

The weight of the brain, without its membranes, in a full-grown male Gorilla is 15 oz. avoird. I estimate that of the entire body as being nearly 200 lbs.: in the relatively larger brains of the small species of *Quadrumana* the convolutions are fewer, or may be absent, as in *Midas.*

In Man alone is a bulk of body, greater than in any Quadrumana save Gorilla, associated with a large size as well as with the highest stage of complexity of the cerebral organ. This is, perhaps, the most notable and significant fact in Comparative Anatomy.

The weight of the brain in the adult male averages about 49 oz. avoird., and ranges from about 35 oz. to 65 oz. In the adult female the weight of the brain averages about 43 oz. and a half, and ranges from 32 to 54 oz. The mean difference is thus about five ounces and a quarter. The brain has advanced to near its term of size at about ten years, but it does not usually obtain its full development till between twenty and thirty years of age, and undergoes a slight decline in weight in advanced life.[1]

The brain, without dura mater, of an Australian female, of 5 feet 3 inches high, weighed 32 oz.; that of a Bushwoman, 5 feet high, is estimated, in LIII″,[2] at 30·75 oz. In European females the brain has been found as low in size; but the requisite observations to determine the range and the average of cerebral development have hitherto been made only on Europeans.[3] The weight of the brain of the male Hottentot, 3 lbs. 2 oz. avoird., dissected by WYMAN,[4] encourages the expectation of analogous results. The human brain is exceeded in weight by that of the Elephant and the Whale, but is absolutely heavier than in all other animals. In the proportionate size of the cerebrum to the cerebellum the human brain surpasses that of all Mammalia: it is as 8 to 1.

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[1] If the capacity of a cranium in cubic inches be ascertained, a fair and instructive notion of the weight of the brain may be obtained by estimating that of a cubic inch of it at 259·57 grains. [2] LVIII′. [3] XLIX″, L″, LXI″. [4] LVIII″.

The brain in some individuals distinguished for intellectual power has been found of unusual size, and remarkable for the number and depth of the cerebral convolutions: the brain of Cuvier weighed upwards of 64 oz. The superficies of the cerebrum of the mathematician Gauss was estimated by Wagner at 341 square inches, while that of an ordinary wage-man was 291 inches.

We know not the size of brain in the Melanian inventor of the 'throwing-stick,' or of that of the deductive observer of the properties of the broken branch bent at the angle of the 'boomerang.' Such benefactors of their race were, perhaps, as superior to ordinary Australians in cerebral development, as the analogous rare exceptions in intellectual power have been found to be among Europeans.[1]

§ 210. *Membranes of the Brain.*—The encephalon, like the myelon, is immediately invested by an areolo-vascular tunic called 'pia mater:' it adheres to and follows all the foldings of the surface, is continued into the ventricles, and there forms processes called 'velum interpositum' and 'choroid plexus.' It is the area on which the vessels undergo the requisite degree of diminution for penetrating the cerebral substance; and, when withdrawn, the proportion of such vessels pulled out of that substance gives the flocculent appearance of the inner surface of the membrane which Anthropotomy calls 'tomentum cerebri.'

The movements of the brain are served by a delicate serous sac, called the 'arachnoid.' The outermost membrane, called 'dura mater,' adheres to the inner surface of the cranium, and consists of a dense inelastic fibrous tissue. It sends a process or duplicature inwards between the cerebrum and cerebellum called 'tentorium,' and a second between the cerebral hemispheres called 'falx.' In the Ornithorhynchus a bony plate extends from the cranium into the falx (vol. ii. p. 323, fig. 204, B). A ridge of bone extends a short way into the tentorium in some marsupials: it is thin in Kangaroos and Phalangers, thick in Thylacines, but of less extent here than in the Wolf, (vol. ii. p. 504). In the Cachalot a bony plate projects from the superoccipital into the back part of the falx[1]: the tentorium receives a bony plate in many *Delphini*.[2] In Seals both the tentorium and hind part of the falx are ossified, and a thick ridge enters the fore and under part of the falx between the rhinencephalic fossæ. The tentorium is ossified in the *Carnivora* to the extent, and in the families, noted in vol. ii., where the conditions of such bony plate are discussed at p. 506.[3] A short tentorial ridge projects anterior to the cerebellar fossa of the petrosal in *Lemur macaco*.[4] The tentorial margin of the petrosal is slightly produced in *Cebus*, and to a greater extent in *Ateles*. In other Quadrumana, as in Man, the sole ossification co-extended with any part of the dura mater is that called 'crista galli' in Anthropotomy. An unossified process from the middle of the posterior border of the tentorium, extending from the internal occipital crest, projects into the notch between the hemispheres of the human cerebellum, and is termed 'falx minor' and 'falx cerebelli.'

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[1] Tables of size and weight of Mammalian brains will be found in XII, XLI″, XXXII″.

§ 211. *Nerves of Mammals.*—The olfactory nerves are absent in all the *Cetacea* save those with baleen, in which they are few and small; they are present in all other Mammals, and are sent off in greater number from their cerebral centre—the rhinencephalon—than in lower Vertebrate classes.[5] The *Ornithorhynchus* is the

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[1] XLIV. p. 442.

[2] Ib. No. 2500, p. 453.

[3] A more extensive series of comparisons of the interior of the skull has tended to rectify the physiological view entertained at the period of the publication of the posthumous edition of the 'Leçons d'Anatomie Comparée,' of Cuvier, vol. ii. p. 290; vol. iii. p. 155.

[4] XLIV. p. 722.

[5] Anthropotomists still describe the connections and course of the 'crura rhinencephali' as the origins of the olfactory nerve; although they recognise that, 'unlike other nerves, a large proportion of grey matter is mixed with the white fibres,' &c. (LXII″. vol. ii. p. 583, 1866), and might rectify the notion by many weightier anatomical conditions. Some even maintain the view by such remarks as the following: 'As it is known that in the first development of the ear the peripheral part or vestibular expanse, as well as the rest of the acoustic nerve, is originally formed by the extension of a hollow vesicle from the first or hindmost fœtal encephalic compartment, so in the case of the crus cerebri, although the peripheral or distributed part (crus rhinencephali or olfactory nerve) is of separate origin from the hemispheric bulb, this latter part is comparable in its origin with the acoustic vesicle.' I have paraphrased the argument of the editors of LXII″ (vol. ii. p. 584), to show that development, as a vesicle in connection with nervous centres, is no ground of homology or homotypy. Whenever a false homology has to be maintained, the earliest and obscurest phenomena of embryonal development are usually resorted to in support of such view.

The terminal expansion of the acoustic nerve is in an organ which begins as 'a follicle or hollow vesicle;' the terminal expansion of the optic nerve is also in a vesicle; and the true olfactory nerves expand terminally on what began as a follicle or vesicle, which form is retained, little altered, in Fishes. The vascular pituitary membrane supporting that expansion is the homotype of the choroid supporting the retina. No doubt the cerebellum is at first a vesicle, as is the optic lobe, and the hemisphere, and the olfactory lobe; and each may claim to be regarded as the sole known instance of the olfactory nerve quitting the skull by a single foramen, as in Birds and Lizards (*i. e.* one from each rhinencephalon). In the *Echidna* the contrast in the vast number of nerves and the concomitant extent of the 'cribriform plate' is extraordinary. Those from the grey tract proceed to 'Jacobson's organ.' The number of olfactory nerves and extent of the pituitary surface on which they spread is very great in Marsupials. In the *Insectivora* the Hedgehog is most remarkable in this respect. Both Herbivorous and Carnivorous *Gyrencephala* have numerous olfactory nerves: some of the *Phocidæ* show this character in excess. The number of the olfactory nerves decreases, with the diminished size of the rhinencephalon, in *Quadrumana*, up to Man, where they seldom exceed twenty in number, and are least in proportion to the size of the body. They become flattened and expanded where they spread upon the vascular pituitary membrane.

The optic nerves are smallest in the Moles (*Talpa*), largest in the Giraffe. They arise from the bigeminal bodies, chiefly from the nates and optic thalami, in *Lyencephala* and in some *Lissencephala*, to which origin are superadded in other *Lissencephala* and in *Gyr-* and *Archencephala*, fibres from the corpora geniculata, along the tract marked *d*, fig. 68. In the groups in which the eyes are relatively largest, *Ungulata* and *Rodentia*, *e. g.*, the larger proportional size of the homologue of the optic lobes, fig. 68, *a*, is significant of its important relationship with the origin of the nerves of vision: the 'thalami' do not show the like increase; their larger size in *Quadrumana* and *Bimana* relates more to their function as recruiting ganglia of the prosencephalon. The optic nerves, nevertheless, seem to be derived more wholly from the 'thalami' in Man than in most lower Mammals, whence the Anthropotomical name of those parts. This character is shown in the fœtal brain at the fourth month, fig. 125, where *c* shows the optic tract quitting the thalamus, *e*: the optic lobe, *f*, has not yet undergone its subdivision into 'nates and testes.' The liberated nerves bend downward and

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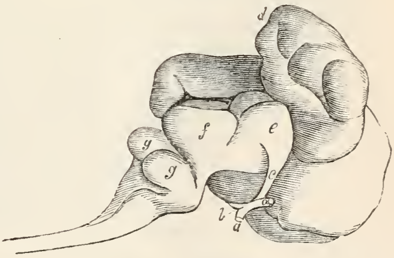

Origin of optic nerves. Fœtal brain at four months.
CCII.

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homotype of the eye-ball, on the ground taken, in LXII" for viewing the olfactory bulbs as nerves, and not as encephalic lobes. The grand old anatomists had truer views of these 'processes of the brain,' as on some other points, than their successors forward, converging and meeting beneath the brain at their confluence, called 'chiasma opticum,' *a*, *b*. The fasciculi of primitive fibres are here arranged as shown in fig. 126. The outer ones, *b*, pass onward to form the outer side of the nerve *a*, the middle fasciculi cross the chiasma obliquely, and, after decussating the corresponding fasciculi of the other tract, contribute to the formation of the opposite nerve: the inner fasciculi curve across the back part of the chiasma, and are continuous with the corresponding fasciculi of the opposite tract, being strictly 'commissural:' a similar arrangement prevails with a few fasciculi at the fore part of the chiasma. The hinder commissure is more common, and appears as a little tænial border of the chiasma, in some Mammals, down to the rodents. Pathology gives evidence of a partial decussation, in some instances, as in the preparation, fig. 127; in which the right optic nerve, *a*, was atrophied; the left one, *b*, healthy; with a partially wasted left optic tract, *c*, while the right, *d*, retained more of its normal size.[1]

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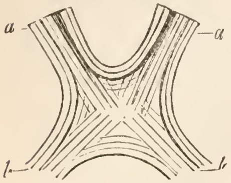

Optic chiasma; Man. CCII.

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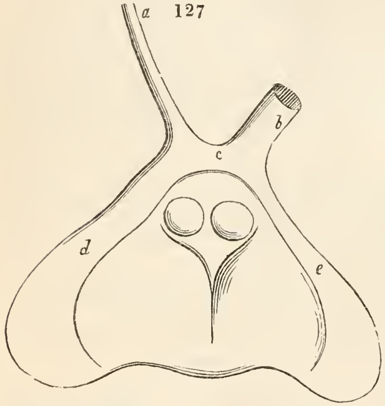

Atrophied right optic nerve and tract; Human. CCII.

The Mammalian chiasma ceases to show the laminated arrangement (vol. ii. p. 122, fig. 47) common in Birds and Reptiles. The nerve, beyond the chiasma, has a strong neurilemma, which sends processes from its inner surface: in some, e. g. *Cetacea*, converging as longitudinal septa from the circumference to the centre of the nerve; in most forming longitudinal canals for the neurine, and giving it the character of a cylindrical aggregate of tubes. This is enclosed in a sheath of dura mater, extending to the sclerotic, into which it is partly continued, where the nerve pierces that coat of the eye-ball. Another peculiarity is seen in the small artery running along the centre of the nerve, and ramifying upon its terminal expansion as the 'arteria centralis retinæ.'

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[1] There have been cases, however, where the tract of the same side as the atrophied nerve showed more wasting than that of the opposite side.

In some Marsupials the optic nerve grooves the orbito-sphenoid, escaping by a cleft continuous with the fissura lacera anterior[1]: in higher Mammals the nerve escapes by a special 'foramen opticum.' The extra-cranial parts of the nerves are remarkably long in Whales,[2] and in all *Cetacea* they diverge from the chiasma

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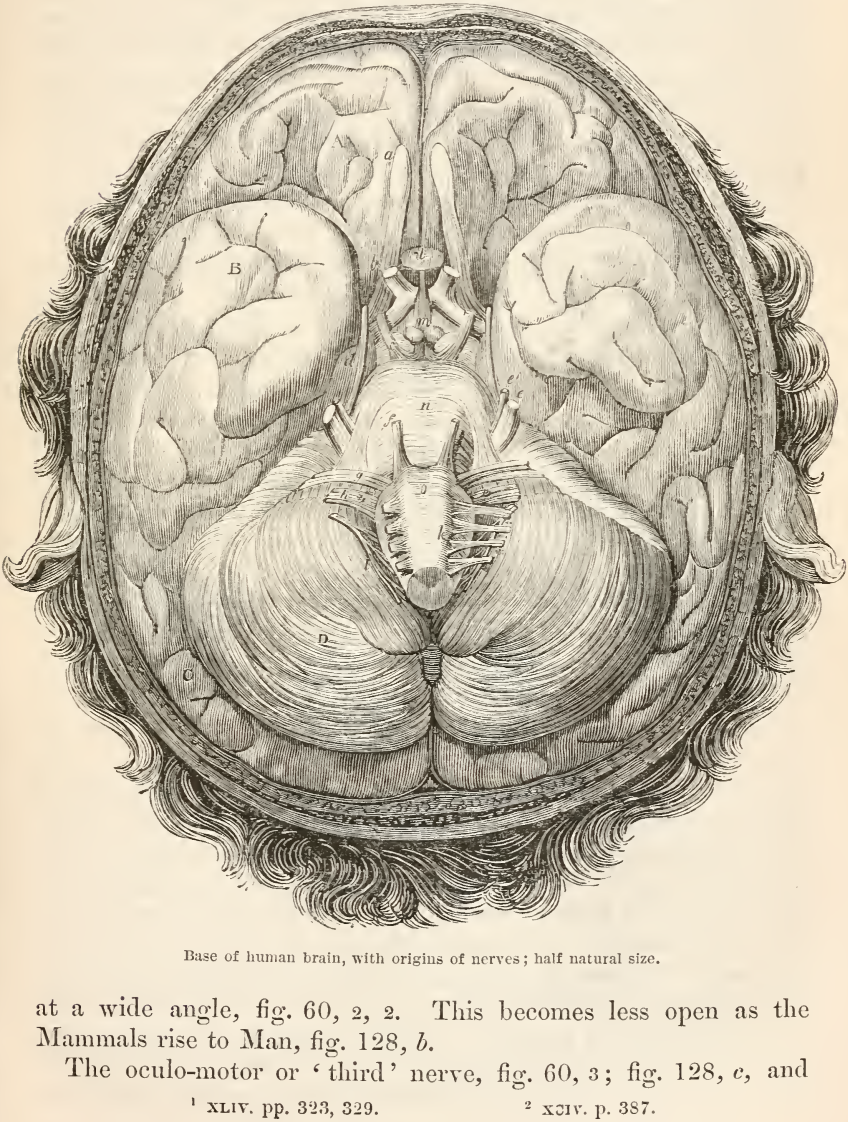

Base of human brain, with origins of nerves; half natural size.

at a wide angle, fig. 60, 2, 2. This becomes less open as the Mammals rise to Man, fig. 128, *b*.

The oculo-motor or 'third' nerve, fig. 60, 3; fig. 128, *c*, and the 'fourth,' fig. 128, *d*, have the same origin, distribution, and connections with the sympathetic, as in Man. The branch of the 'third' nerve, which runs along the lower part of the eye-ball, between the 'inferior' and 'external' rectus muscles, and supplies the 'obliquus inferior,' is connected, usually by a short thick cord, with a 'lenticular ganglion;' but this is not so well defined in some Mammals, and the ciliary nerves are usually fewer than in Man. The 'fourth' nerve supplies the 'obliquus superior' muscle. In the Sheep this nerve receives some branches from the ophthalmic division of the 'fifth' nerve. Besides the 'rectus externus,' the sixth nerve, fig. 128, *f*, in most Mammals, supplies an additional muscle, the 'retractor oculi.' The 'fifth' or 'trigeminal' nerve, fig. 128, *e*, *e′*, is commonly the largest of the cerebral nerves, and resembles the myelonal nerves, fig. 136, in having a ganglionic, fig. 230, 9, 10, and a non-ganglionic, ib. 11, portion, the latter being 'motory,' supplying muscles, the former distributed to sensitive and secerning surfaces. This distinction is better marked in Mammals than in Birds and Reptiles: like which, however, the ganglion is single, not divided, as in most Fishes (vol. i. figs. 201, 202). The size of the 'fifth' nerve relates to the perfection or sensitiveness and application of those surfaces, not to the proportion of the facial to the cranial part of the head. Thus we find the fifth or trigeminal nerve of largest relative size in the *Ornithorhynchus paradoxus*, which uses, like the duck, its beak as a tactile instrument in the detection of its food. Emerging from the ganglion, fig. 51, *o′*, anterior to the pons, ib. *c*, it soon divides into three branches, the first and second appearing as one. The first and smallest division divides into two equal branches: the superior or ethmoidal branch enters the nose, combines, in part, with the olfactory, for the service of the pituitary membrane; but mainly emerges from the nasal cavity, supplies the skin at the upper part of the face, and, by a branch continued from between the nasal and premaxillary bones, is distributed to the nostrils and contiguous integument. The second division of the fifth is two lines broad and one line and a half thick: after emerging by the foramen rotundum, the chief part of it passes through the ant-orbital canal, and divides into two branches, distributed, the one to the nasal or upper parietes of the face, the other to the lateral or labial integuments. The palatine branch divides into a posterior smaller nerve, which passes through the posterior palatine foramen: the anterior and larger branch emerges from the anterior palatine canal, and supplies Jacobson's organ at the floor of the nose and the palatine membrane.

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[1] XLIV. pp. 323, 329.

[2] XCIV. p. 387.

The third division of the fifth is broader but thinner than the second; it leaves the cranium by the foramen ovale, and is distributed as usual, mainly to the sensitive labial integument of the lower jaw, fig. 3, *a*, *a*: its non-ganglionic part goes to the manducatory muscles.

In the *Echidna* the trigeminal is of smaller size, and its first and second divisions are much less in proportion to the third, which supplies, from its ganglionic part, the sensitive and secreting surface of the long tongue. This size of the lingual branch of the trigeminal is still more marked in the Pangolins and Anteaters, especially in *Myrmecophaga jubata*. A distinct gustatory nerve, communicating with a motory 'facial' nerve by a 'chorda tympani,' is a mammalian characteristic of the trigeminal. In the Hedgehog the nasal branch is the largest of the first division: after dismissing a few ciliary nerves it quits the orbit and enters its special canal at the fore part of the large cribriform plate, and divides on entering the nasal cavity into the external and septal branches, the latter being the largest, and richly spread upon the pituitary membrane of the septum and inferior turbinal. The bulbs of the vibrissæ in the Hedgehog and other *Insectivora* use a large proportion of the facial branches of the maxillary and mandibular divisions of the fifth. In Rodents the dental branches of these divisions are large, and especially the nerves sent therefrom to the active and persistent pulps of the scalpriform incisors; and they show, especially in the mandible, a recurrent course, as I found in the dissection of the Porcupine, fig. 129, *i.[1] The nasal and labial nerves are large in Moles and Shrews, especially the long-snouted kind (*Rhynchocyon*). But the chief peculiarity of

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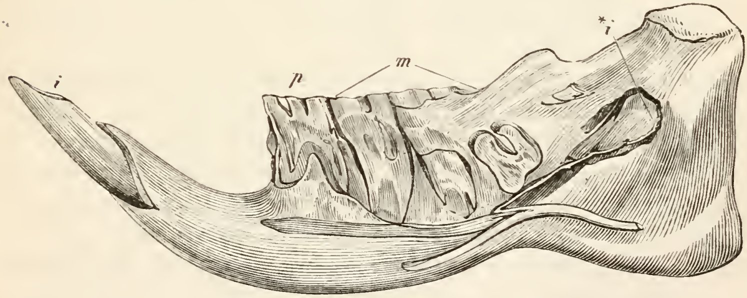

Lower jaw of the Porcupine (Hystrix cristata).

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[1] xx. vol. i. p. 103, prep. no. 357B.

the trigeminal in *Talpidæ* is the share which the ophthalmic division of the ‘fifth’ takes in the function of the reduced eye-ball, as a warner of light. In fig. 130, *a* is the trigeminal, *b* the ganglionic part, *c* the third or mandibular division, *f* the second or maxillary division, *d* the first or ophthalmic division, of which the branch going to the eye, *e*, is large, while that going to the nose, *g*, is small, reversing the proportions in the Hedgehog. In many *Lissencephala* the part to which the root of the trigeminal can be traced makes a small prominence on each side the fore end of the ‘calamus scriptorius.’ In the Elephant the superorbital and superficial nasal branches of the ‘first’ division, but more especially the ‘facial’ branch of the ‘second’ division, which emerges from the antorbital foramen, present a large size in relation to the proboscis. The size of that foramen is not, however, always indicative of that of the nerve. In many *Rodentia* a part of the masseter traverses, with the antorbital nerve, the foramen in question, which is, then, enormous, as in figs. 234, 238, 241, *v* (vol. ii. p. 377). The dentary branch of the maxillary exceeds that of the mandibular division of the fifth in the Elephant, to meet the demands of the persistent matrix of the tusk. But this difference in the size of the nerves supplying the upper and lower jaws is maximised in the *Balænidæ*, in relation to the active and extensive growth of baleen in the upper jaw, and the absence of teeth or their substitutes in the lower jaw. The palatine nerves supplying the baleen-pulps are as thick as the finger in *Balæna mysticetus*. In the Porpoise (*Phocæna*) an orbital branch joins a plexus near the fore part of the orifice of the eye-lids, sent off from the ‘seventh’ or facial nerve, from which union branches pass to the muscles and membrane of the blow-hole. The maxillary branch sends off a ‘subcutaneus malæ,’ which combines with the facial nerves to supply the inferior palpebral muscle, and spread upon the hind part of the palpebral opening. There are five or six antorbital branches which run forward between the maxillary periosteum and the superincumbent muscular and tegumentary layer, emerging to spread upon the latter where it forms the upper lip or margin of the mouth, and also sending a recurrent branch to the blow-hole. A large branch of the maxillary passes

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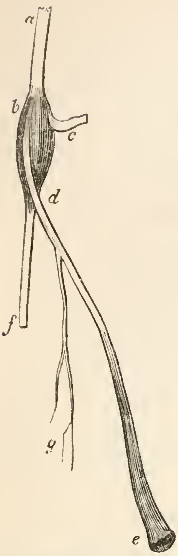

Trigeminal nerve of Mole. LXIII''.

through the foramen near the upper opening of the nasal passage, and ramifies upon the plicated membranes of the blow-hole. The dental nerves are large from both maxillary and mandibular divisions of the fifth: the gustatory branch is, relatively, small; and sends off a filamentary 'chorda tympani,' which may be traced to the trunk of the facial, and is connected, in its course, with the carotid plexus of the sympathetic.

In Ruminantia the first division of the 'fifth' subdivides into frontal and nasal: the latter supplies the upper part of the septum and the superior turbinal, and sends a few branches to the fore part of the nose, which meet these filaments reflected from the second division of the fifth. The branches to the lacrymal and harderian glands, to the eyelids, and the larger one which passes out of the orbit to the integuments of the temple, and which chiefly supplies the horn-core, or the growing antler, may be traced back distinctly to the Gasserian ganglion. The second division of the fifth, escaping by the foramen rotundum, sends antorbital branches to supply the upper lip, the nostril, and the pituitary membrane at the lower part of the nose. It also sends off the lateral nasal, receiving the 'vidian' nerve, and supplying the inferior turbinal: lastly, the 'palatine' and upper dental nerves. The ganglionic part of the third division gives off the 'buccal nerve,' connected with an 'otic ganglion,' supplying the superficial muscles and skin behind the angle of the mouth, and communicating with branches of the 'seventh' or facial nerve; the large branch dividing into the inferior dental and gustatory nerves, the latter receiving the 'chorda tympani:' lastly, the external auricular, passing behind the mandibular ramus, joining the middle branch of the 'seventh,' and supplying the muscles of the ear, but mainly distributed to its sensitive surface.[1] The non-ganglionic part of the fifth supplies the temporal, masseter, and pterygoid muscles, also the mylohyoid and anterior part of the occipito-hyoid or digastric: the part going to the otic ganglion is continued therefrom to the internal pterygoid and to the muscles of the soft palate. A ganglion called 'submaxillary' and situated near the deeper part of the gland so named, is connected by filaments with the gustatory nerve.

In Swan's dissection of the cerebral nerves of the jaguar he found the superior nasal sending a branch to join the one from the lenticular ganglion to form ciliary nerves, and then pass forward to send one branch into the nose and another to the skin at the inner angle of the eye. The naso-palatine received the vidian nerve, and the 'spheno-palatine' ganglionic enlargement was conspicuous at the junction.[1] The largest portion of the maxillo-dental nerve supplied the great canine tooth. The gustatory nerve gave a branch to the lining membrane of the mouth and passed forward dividing into branches which communicated with the 'ninth' in their course to the surface of the tongue.

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[1] See dissection of the trigeminal of *Bos*, in LIV, pl. xxxii. fig. 3.

Such *Quadrumana* as have been dissected with this view show all the main characters, connections, and accessory ganglions, of the fifth, which are so fully described in late works on the anatomy of Man. The apparent origin or place of emergence of the fifth nerve is at the middle 'crus' of the cerebellum, fig. 128, *e*, *e′*. The smaller, or non-ganglionic root *e′*, being sometimes divided by a few of the commissural or 'crural' fibres from the larger portion *e*. This, fig. 131, 10, contracts as it goes into the substance of the macromyelon, and may be traced to behind the olivary body, ib. 3, where it is continuous with the teretial and restiform columns, and apparently with the grey matter, fig. 57, *g*. The motor root, fig. 131, 11′, passes into the macromyelon anterior to the sensory root, and seems to go, in part at least, to the prepyramidal tract; but Stilling traces it to grey matter at the floor of the fourth ventricle. The recession of the non-ganglionic from the ganglionic roots as they sink into the macromyelonal substance is more patent in some Fishes (vol. i. p. 302).

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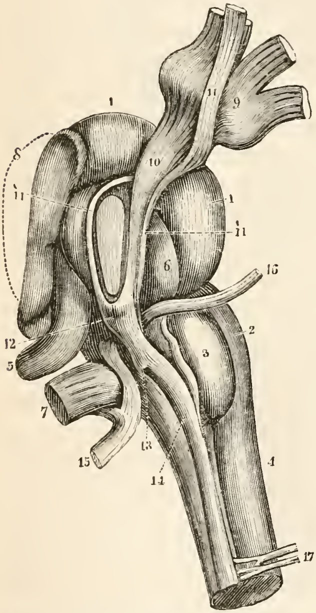

Macromyelon and origin of the fifth nerve, Man; natural size. CCVIII.

Hunter's dissection of the human trigeminal (XCLIV. p. 189, in 1754), in which he discovered, independently of *Cotunnius*, the nasopalatine branch, led him to enunciate the important principle that nerves from distinct origins, supplying a particular organ, give it distinct faculties. The nose receives the endowment of smell from its peculiar nerve—the olfactory: 'the other nerves of this part, derived from other origins, only conveying common sensation.' 'It is upon this principle the fifth pair of nerves may be supposed to supply the eye and nose in common with other parts, and upon the same principle it is more than probable, that every nerve so affected as to communicate sensation, in whatever part of the nerve the impression is made, always gives the same sensation as if affected at the common seat of sensation of that particular nerve,' ib. p. 190.[1]

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[1] LIV. pl. XXXI. fig. 3, 5. SWAN also shows it in the calf, pl. XXXVI. fig. 3, 11. ALCOCK found the spheno-palatine ganglion in a rabbit, dog and horse, as well as in the cat and cow. CCVIII. p. 286.

The nerve which is homologous with the 'ramus opercularis seu facialis,' and some other branches of the non-ganglionic part of the 'fifth,' in Fishes (vol. i. p. 303), is more distinct in its origin, at least its apparent one, in Mammals, and is reckoned in Anthropotomy as a separate cerebral nerve, under the name of 'facial,' or as a part, 'portio dura,' of the 'seventh pair,' with which it has less real relation or connection than with the fifth. It is essentially the complementary proportion of the motory or non-ganglionic part of that great myelonal nerve of the head. In fig. 131 is shown the point, behind the olivary tract, where the facial, 16, diverges from the smaller portion of the motor division accompanying the sensory division of the trigeminal: its angle of divergence is wide, and its place of emergence is behind the 'pons,' close to that of the acoustic nerve, fig. 128, *g*. It enters, therewith, the internal auditory foramen, leaves the acoustic to enter its own canal in the petrosal, called 'aqueduct of Fallopius' in Anthropotomy, passes downward behind the tympanic bone (as in Birds), and emerges by a foramen called 'stylo-mastoid.' The facial nerve supplies the muscles of the mouth, nose, eyelids, ear-conchs, and the cutaneous muscles of the head and beginning of the neck. In the Porpoise, the facial nerve, on quitting the petrosal, gives small branches to the cutaneous muscular layer of the ear-opening and parts behind, communicating with filaments of the cervical nerves: a branch ramifies on the mylohyoid muscle. From the trunk of the facial a slender nerve passes to above the mandibular joint, then bends forward, enters into, and receives a filament from, a sympathetic plexus, and quits it to join the third division of the fifth: this answers to the 'chorda tympani.' The trunk of the facial is, then, continued forward, superficially, along the slender jugal bone, toward the eye-opening, supplies the 'angularis oculi posticus,' and the muscles of the under eyelid: in advance of this it supplies the 'angularis oculi externus,' and forms a large plexus, in connection with branches of the trigeminal. From the plexus pass filaments to the muscles of the blow-hole and its plicated sacs.

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[1] One of the observations and experiments on which Hunter founded this conclusion, is given, in Latin, by Sir C. Bell, in his original Essay, LXIV″, p. 11 (1811). So, also, Sir Charles writes:—'The key to the natural system of the nerves will be found in the simple proposition, that each filament or tract of nervous matter has its peculiar endowments independently of the others which are bound up along with it, and that it continues to have the same endowment throughout its whole length.' LXV″, p. 70.

In Mammals with a well developed parotid the facial traverses that gland; it divides there into three principal branches in the Calf[1] and Dog;[2] whilst in the Hog, the trunk is continued forward to near the fore part of the masseter, before dividing into maxillary and mandibular portions, and the auriculo-palpebral branches come off more separately from the long trunk. In *Quadrumana*, as in Man, the chief branching of the trunk takes place at the hind margin of the masseter after the post-auricular nerve is sent off: from the upper of the main divisions pass the nerves to the temple and eyelids as well as to the nose and upper lip. A slight enlargement of the facial near its entry into the 'fallopian aqueduct'—its petrosal canal—is called 'geniculate ganglion,' which receives a petrosal branch of the vidian nerve, and one from the superficial petrosal which unites the otic ganglion with the tympanic nerve. Prior to the ganglion the facial is connected by one or two filaments with the acoustic nerve: beyond the ganglion it receives a petrosal filament of the sympathetic. The 'chorda tympani,' fig. 259, *c*, leaves the trunk of the facial before it quits its canal, enters the tympanum, crossing the tympanic bone and the ear-drum, behind the handle of the malleus, *b*, to emerge by an aperture at the inner end of the 'glaserian fissure:' then passing downward and forward it joins the gustatory. In the Horse and Calf I traced, in 1836,[3] the superficial petrosal branch, or backward continuation of the vidian nerve, fig. 132, *h*, into the seventh, penetrating its sheath, but remaining distinct, and separating into many filaments, ib. *b*, with which filaments of the seventh nerve, ib. *b*, *k*, *f*, are blended, and a ganglion formed, ib. *g*, by the superaddition of grey matter; the chorda tympani, ib. *m*, is here continued partly from this ganglion, partly from the seventh or portio dura, ib. *b*. I did not at that time distinguish the fasciculus, *b*, called 'portio intermedia' of the facial from the main trunk, *a*. The chief point, however, as to the 'chorda tympani' not being a branch of that main trunk of the facial, receives corroboration from the special researches of Morganti[1] into this intricate and difficult part of neurotomy.

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[1] LIV. pl. XXX. fig. 3. [2] Ib. fig. 2.

[3] In reference to the expression of Hunter, relative to the chorda tympani, 'I am almost certain it is not a branch of the seventh pair of nerves, but the last described branch from the fifth pair.' XCIV. (1837) p. 194, and 'Note *a*.'

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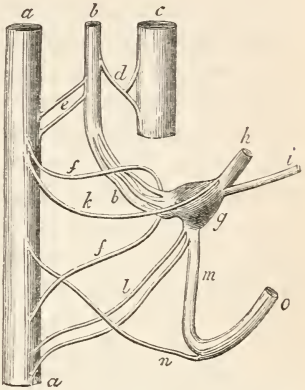

Diagram of the 'portio intermedia,' with the ganglionic origin of the 'chorda tympani.' LXXII″.

In the subjoined diagram of the result of his dissections, fig. 132, the portio intermedia, *b*, is separated from the vestibular division of the acoustic *c*, and from the main trunk of the facial *a*, with both of which it lies in close contact. The filament *d* connects *b* with *c*, and receives one from the latter. Two filaments *e* connect the 'intermediate' with the main portion of the facial, *a*. The intermediate portion is resolved into filaments, *b*, before joining the ganglion, *g*, the nature of the 'grey or ash-coloured tissue' of which has been established by the microscopic demonstration of the 'ganglion-corpuscles' (LXVI″, p. 549). With this ganglion are connected the superficial petrosal branch of the vidian, *h*, from the spheno-palatine ganglion, and the smaller nerve, *i*, from the 'otic ganglion:' filaments *k*, *l*, from the facial, *a*, and the chorda tympani, *m*. Morganti, however, traces a filament *n* to that nerve directly from the facial.

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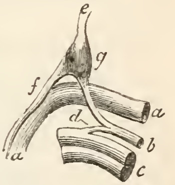

Relations of the chorda tympani and vidian nerve to the 'seventh' nerve Sheep, magnified two dia meters. LXVI″.

In the Sheep, fig. 133, the 'portio intermedia' *b*, is more closely connected, by *d*, with the acoustic nerve, *c*; and sends a shorter and thicker division to the 'geniculate' ganglion *g*, by which it is more directly continued into the 'vidian' branch *e*; the 'chorda tympani,' *f*, being continued mainly from the ganglion, but also, in a smaller degree from the facial, *a*. The branch from the 'portio intermedia,' *b*, I described as the 'vidian' crossing the 'portio dura,' *a*.

The acoustic nerve, fig. 131, 15, rises from the floor of the fourth ventricle, chiefly in connection with grey matter constituting the 'acoustic nucleus.' The nerve consists of an anterior and posterior portion the course of which is more oblique in Man than in most Mammals owing to the great thickness of the cerebellar crus, ib. 7. In the Cat the posterior root is very large, is a thickened band of fibre from the fusiform cells of the posterior portion of the nucleus; the band passes along the floor of the fourth ventricle, joining fasciculi from the cerebellar crus and those of the anterior root. This 'consists of two portions, of which the chief penetrates the medulla beneath the restiform body and enters both parts of the acoustic nucleus: the other portion runs backward along the upper border of the restiform body, which it accompanies over the superior peduncle to the inferior vermiform process of the cerebellum.'[1] The 'flocculus,' fig. 64, *n*, with which the acoustic nucleus is connected, is large in the Cat, the Aye-aye, the timid Rodents, and all the small Mammals with acute hearing; it is relatively small in the Sheep and most Ungulates.

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[1] LXX″.

The acoustic nerve quits its origin in contact with the facial, fig. 128, *g*, a small artery to the labyrinth runs between them: it takes a short course to the 'meatus internus,' longer in *Cetacea* than in other Mammals, receives a filament or two from the intermediate part of the facial, figs. 132, 133, *d*, on entering the meatus, and then divides. The part penetrating the fore half of the cribriform plate supplies the cochlea; its large size is a mammalian characteristic, and is most remarkable in the *Cetacea*: the posterior division, answering to the main part of the acoustic in lower Vertebrates, is spent upon the vestibule and semicircular canals.

The eighth cerebral nerve, in anthropotomical enumeration, includes the three nerves called 'glosso-pharyngeal,' 'vagal,' fig. 128, *h*, and 'spinal accessory,' ib. *l*. The roots of the glosso-pharyngeal are traceable to a nucleus of grey matter at *n*, fig, 57. The vagal nuclei, ib. *h*, are forward (in Man upward) extensions of the grey or vesicular myelonal columns from which the spinal accessory rises: they lie on each side of the hypoglossal nuclei, ib. *g*, on the floor of the fourth ventricle, but are united by the commissure forming the roof of the central canal before this opens into the ventricle: higher up the vagal roots penetrate the 'caput cornu,' like the posterior or dorsal myelonal roots. There is a partial decussation at the raphe.

Both glosso-pharyngeal and vagal nerves emerge at the angle between the olivary and restiform tracts of the macromyelon, *k*, *k*, fig. 57, and are soon joined by the aggregate of the roots of the 'spinal accessory:' these, commencing at about the fifth cervical, advance, between the dorsal roots of the cervical nerves and the ligamentum denticulatum, gathering successive slender accessions, all of which, originating as above defined, emerge at the dorsal border of the restiform tract.

The glosso-pharyngeal is relatively smaller in Mammals than in Birds (vol. ii. p. 124), is mainly distributed to the back part of the tongue and to the pharynx in all Mammals; passing thence to the 'flocculus' in its way to the jugular foramen, it retains its proper fibrous sheath, and usually presents the two enlargements called 'jugular' and 'petrous' ganglions, before emerging from the skull. From the petrous ganglion a filament enters the tympanum, where it joins a plexus from the sympathetic, and supplies the membrane continued into the eustachian tube. The pharyngeal branches are joined by filaments from the vagus and sympathetic to form the pharyngeal plexus. Filaments are sent to the tonsils and fore part of the epiglottis; those to the tongue supply the muscles at its base and the mucous membrane covering the base and sides of the tongue, some filaments terminating in the fossulate papillæ.

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[1] xx″.

In the Porpoise the glosso-pharyngeal divides at its exit from the skull into a smaller and larger branch. The former is distributed to the sphincter of the lower or palatal part of the nasal canal, and unites there in a plexiform way with a branch of the vagus. The larger division supplies the palate and base of the tongue, and the muscles between the pyramidal larynx and the hyoid. Some filaments pass to the anterior ganglion of the sympathetic.

The glosso-pharyngeal is figured, in LIV. pl. xxxi. fig. 2, 9, and pl. xxxii. fig. 3, 22 (*Bos*), showing its communications with the 'vagus' and sympathetic; also ib. ib. fig. 3, 13 (*Felis*) showing connections with the gustatory branch of the trigeminal. In fig. 134, from the human subject, the emergence of the glosso-pharyngeal, 4, from the post-pyramidal, *c*, and post-myelonal, *g*, tracts is shown at 2: the petrosal ganglion and connecting filaments with that of the upper vagal ganglion at 8 and 10: 7 is the auricular branch of the vagus, 9 the 'ramus anastomoticus' of Jacobson, 13 the trunk of the glosso-pharyngeal.

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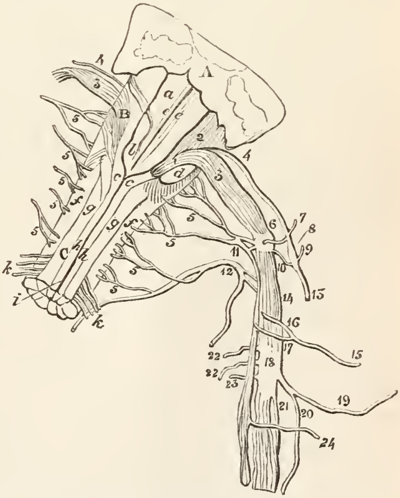

Origins and connections of the constituents of the 'eighth' or pneumogastric nerve, Man. LXVII".

The vagus, fig. 134, 3, or 'pneumogastric' from the important organs—the lungs and stomach—which it supplies, sends branches also to the larynx, trachea, and heart. As in other Vertebrates, it has the longest course, widest distribution, and most numerous connections, of any of the cerebral nerves; but is noted, in Mammals, by receiving the accessory nerve, ib. 5, 11, 12, from a greater extent of the myelon: the recurrent branches of the vagus are more exclusively distributed to the trachea and larynx, and send a smaller supply of nerves to the œsophagus than in Birds or Reptiles.

From the remarkable length of the neck of the Giraffe, the condition of the recurrent nerves attracted my attention in dissecting that animal: they were readily distinguishable at the upper third of the trachea, but when sought for at their usual origin, this was less obvious. Each nerve was not due, as in the short-necked Mammals, to a single branch given off from the vagus, continued of uniform diameter round the contiguous great vessel and throughout their recurrent course, but it received several small filaments derived from the trunk of the vagus at different parts of its course along the neck.[1] Branches of the superior laryngeal nerve directly perforated, as in some other quadrupeds and in the Porpoise, the thyroid cartilage, and were joined, in a greater proportion than in Man, by branches of the recurrent, before distribution to the laryngeal muscles, of which, however, the crico-thyroid owes its supply chiefly to the upper laryngeal and the rest to the recurrents. In Quadrumana, as in Man, the internal laryngeal perforates the thyrohyoid membrane at the interval between the hyoid bone and thyroid cartilage. The upper laryngeal is proportionally larger in the Orang, Chimpanzee, and Gorilla, and mainly supplies the capacious laryngeal sac in those apes.

In the Porpoise the left recurrent winds round the end of the arch of the aorta, near the remains of the ductus arteriosus; the right recurrent winds round the subclavian immediately before the origin of the posterior thoracic: both recurrents send filaments to the œsophageal plexus from the sympathetic on their forward course to the larynx. After the origin of the recurrents, the vagal trunk sends off the cardiac branch, which, uniting with sympathetic filaments, forms the plexus supplying the heart. Next are sent off the nerves to the bronchial plexuses; finally the vagal trunks pass with the œsophagus through the diaphragm, the left on the ventral, the right on the dorsal side, and combine with branches from the sympathetic to supply the complex stomach and the numerous spleens.

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[1] xcvii'.

Most Mammals exhibit the grey enlargement of the vagus after its exit from the jugular foramen, but less distinctly divided into an upper, fig. 134, 6, and lower, ib. 18, ganglion, than in Man. The principal branches—e. g. 7, auricular; 10, interganglionic; 15, pharyngeal, deriving one filament, 16, from the vagus, the other, 17, from the 'spinal accessory;' 19, 20, superior laryngeal, the recurrent, cardiac, pulmonary, œsophageal, and gastric—are the same as in Man, likewise their connections with contiguous nerves, and especially, as by the 'filaments,' 21, 22, with the upper sympathetic ganglion.

The spinal accessory, besides its portion, ib. 11, blending with the trunk of the vagus, distributes branches to the trapezius, masto-humeralis, and sterno-maxillaris, in Ungulates; to the cleido-cucullaris and cleido-mastoideus, in Carnivores; and to the trapezius and sternomastoid in Quadrumanes and Man. The condition of existence of a spinal accessory is not the extension of muscles from the skull to the thorax for the acts of respiration, but the general homology of the scapular arch as the hæmal one of the occiput: accordingly the nerve is found in all Vertebrates[1]; and only when the development of the appendage of that arch calls for its displacement, and attracts for the manifold motive and sensitive requirements of the limb, successive nerve-bundles from the part of the myelon co-elongating with the neck, are the root-filaments of the 'accessory' drawn down beyond their normal, intercranial, place of origin, as at 5, 5, fig. 134.

The macromyelonal, by some called 'respiratory,' centres, to which the origins of the several divisions of the 'eighth pair' have been traced, are connected by means of longitudinal fasciculi and cell-columns, continuous with those in the cervico-dorsal regions of the myelon, with the trigeminal nerves, and with both anterior (lower and middle roots of the 'accessory') and posterior cornua of the myelonal grey matter, fig. 40, *g*, *h*: thus ministering to a series of motions, both direct and reflex, of high importance.

The roots of the ninth or hypoglossal nerve may be traced to groups of nerve-cells in front of the central canal, ib. *b*, just above the upper cervical nerves, apparently a continuation of the cell-columns from which the ventral or motor roots of the spinal nerves arise: some of the roots decussate at the raphe, but most of them sink deep into the nucleus. They are connected with each other, with the roots of the vagus, and with those of the spinal accessory by means of large multipolar cells. In the Giraffe the lower roots emerge, like a small 'accessory,' from the cervical part of the myelon.

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[1] For the homologue of this nerve, see, in Fishes, vol. i. p. 307; in Reptiles, ib. p. 313; in Birds, vol. ii. p. 125.

The main roots of each hypoglossal quit the macromyelon, between the prepyramid and olive, figs. 81, 82, 9, usually in two bundles, which escape, in many *Marsupials*, by two precondyloid foramina: but in most Mammals the bundles, perforating separately the dura-mater, pass out by a single precondyloid foramen, and then unite. The nerve is closely connected with the vagus, and contiguous cervical ganglion of the sympathetic, passes between the carotid and jugular, then forward between the basihyal and hyoglossus, and is continued into the substance of the geniohyoglossus beneath the tongue to its tip.

In the Porpoise a small branch of the 'ninth' is distributed to the sphincter muscle of the posterior nostril, before the supply to the muscles of the hyoid and tongue is sent off from the main part of the nerve-trunk, which is relatively small in *Delphinidæ*. In the Giraffe the motor nerve of the tongue is larger in proportion to the body than in the Ox: it is largest in the Pangolins and Anteaters, in relation to the great length of the tongue, and frequency and extent of its muscular motions. As the size of the 'ninth' governs that of its special outlet from the skull, the precondyloid foramen indicates that the great extinct tree-uprooting Sloths (*Mylodon, Megatherium*) applied a long flexible prehensile tongue to the plucking off the branches of their prostrated aliment, in a greater degree, even, than is now witnessed in the Giraffe.[1]

Among the connections of the ninth are some with branches of the superior laryngeal to the sterno-hyoid and sterno-thyroid, associating the movements of the tongue with those of the larynx.[2] In *Quadrumana* the cervical branch assumes more the characters of the 'descendens noni' of Anthropotomy, and supplies the additional differentiated muscles of the hyoid. The ninth, like the 'accessory,' is essentially a motor nerve, and I have not seen a distinct ganglionic or dorsal root in any Mammal.

The last, lowest, or hindmost, of the motory nerves of the head is that which supplies the muscles of the occipital or fourth hæmal, or scapular, arch; and the origins of which, fig. 134, 5, 5, in the course of growth of the neck and cervical part of the myelon are drawn down beyond the cranium. In the Vertebrates, retaining the typical connections of the arch, the homologue of the 'spinal accessory' retains its cranial place of origin, as well as the connections with the ganglionic or sensory part of the nerve. The next cranio-motory nerve, in advance, is that which supplies the muscles of the parietal or third hæmal, or hyoidean, arch. Both ninth and spinal accessory have their ganglionic or sensory complement in the 'vagus:' and, with reference to the place of origin of that nerve, it may be remembered that both heart and breathing organs belong to the head in Fishes.

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[1] For the light which may be derived from both nervous and arterial foramina in the interpretation of fossil bones, see xcv′, pp. 37, 57, pls. vi. vii. xvi. fig. 2, *c*.

[2] A good view of the distribution of the 'ninth' in the Jaguar is given in LIV, pl. xxxi. fig. 3, 19.

The second, or frontal, or mandibular, hæmal arch has its ganglionic nerves from the third division of the fifth, its non-ganglionic by that part of the trigeminal supplemented by certain branches of the 'facial.' The rest of the facial represents the motory portion, as the first and second divisions of the ganglionic part of the fifth are the sensory portions of the nerve of the nasal or maxillary hæmal arch and its clothing. The 'sixth,' 'fourth,' and 'third' are parts of the cranial motory nerve-system applied to a special organ of sense.

The myelonal nerves indicate the segments of the axis enclosed in their protecting vertebral rings: both segments and nerve-pairs being called into being according to the requirements of the trunk and limbs of the species. The head-segments and trunk-segments directly succeed each other in Protopteri and Teleostomi (vol. i. pp. 7, 14); but in Mammals, as in other air-breathing Vertebrates, neck-segments and nerves are interposed; and, as the scapular appendage becomes developed into a jointed limb, requiring a more backward position through its size, or one of more freedom for the exercise of various movements, it attracts, as it were, the requisite nerve-force from the successive points or segments of the myelon, and chiefly from a post-cranial or cervical portion.

The development of nerves, as of vessels, is not primary and independent, but secondary and subordinate to the parts needing them. If the appendage of a hæmal arch retain its archetypal simplicity, as in *Protopterus* (vol. i. p. 163, fig. 101), one pair of nerves serves it: if it grows to a maximum of size and number of digital divisions, it may attract its nerve-supply from fifty successive segments of the myelon (LIV. pl. xi. *Raia batis*). In Mammals eight or nine segments succeeding the encephalon minister nervous power to the scapular arch and its appendage, the latter chiefly drawing upon the last three, four, or five pairs, which are proportionally large.

Because the neural arch and corresponding muscular segment have conditioned the beginning of the corresponding pair of spinal nerves, it does not follow that the specially enlarged and endowed appendage of such segment is archetypically an aggregate of as many appendages as the nerve-pairs from which it has attracted branches in the course of its growth and development. But, on this assumption have rested the conclusions that the scapula was an aggregate of all the cervical pleurapophyses, and that the humerus was the coalescence of the five diverging appendages retaining their primitive and typical freedom in the five digits: and, by parity of reasoning, the scapula of the Skate should be an aggregate of more than fifty pleurapophyses, &c.

I assume that anatomists are agreed that the bone, vol. i. fig. 101, B, 51, is the homologue of 51, in fig. 101, A: that the scapula of the Amphiuma answers to the bone so called in other Reptiles and in Birds: and that the occipitally attached scapula of the Lepidosiren is the homologue of the similarly named and connected bone in other Fishes. But the long cylindrical rib-like 'scapula' of the Lepidosiren is one element, and the diverging segmented appendage of the scapular arch manifests the like essential unity. Now, the bifurcation of the distal segment of the homologous diverging appendage in *Amphiuma* does not make the unsplit part (fig. 101, B. 53) an aggregate of two appendages, nor its scapula, *ib.* 51, an aggregate of two ribs. And the same may be predicated of five or any greater number of radiated divisions of the terminal part of the scapular appendage. But the pectoral fin of the Skate is the pectoral filament of the Mud-fish, the fore-leg of the Quadruped, the wing of the Bird, the arm and hand of Man: i.e. they are homologous parts—though with a supply of muscles, nerves, and vessels, according to their respective sizes, shapes, and uses. Say that the appendage in Lepidosiren, fig. 101, A, 53–57, is a dermal development, and that the *humerus, radius,* &c. in its higher homologues, are skin-bones, and not parts of the endo-skeleton: it does not follow that the scapular arch, ib. 51, 52, is, also, part of the dermo-skeleton. What, then, is it? This question I propounded, in 1846,[1] in reference to all the parts of the vertebrate skeleton of which anatomists were at one in respect to their special homology: it applies to the basioccipital (vol. i. fig. 77, 1) and other elements of the occiput of the Fish, as well as to the scapular arch therewith connected. What is the basioccipital? Anatomists are agreed that the 'basilar process of the occipital bone' (Anthropotomy) is its homologue: in other words, that the same bone or osseous element may be pointed out from the Cod-fish up to Man. But at this point the above question may be met by the averment, that it need not be asked: that there is no ground for homological generalisation higher than the special one. Such anatomists rest on the step beyond which Cuvier refused to pass. With him parts were homologous because they served similar purposes, or were under like teleological conditions of existence. Neither the final nor the mechanical causes of separate basi-, ex-, and super-occipitals, of basi- and ali-sphenoids, parietals, &c. in the skull of the fœtal Bird or Kangaroo, have been explained[1]; and as I am unable to conceive of them, and am in no wise helped by the averment of inheritance, I retain my conviction that the basilar process of the human occipital bone is the centrum of the hindmost cranial vertebra; having, moreover, traced the scapular arch and appendage to its extreme of simplicity in *Protopterus* and *Lepidosiren*, I accept the light which such condition throws upon its general homology, as the hæmal arch of the same (occipital) cranial vertebra.

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[1] LXXIV'', p. 276.

If there be cartilaginous fishes that combine a fœtal gristly condition of skull with a maximised development of scapular appendage, I conclude that the backward displacement of the sustaining arch, from its type-position, is a consequence of such development, and prefer to allow my reasoning as to the nature of a limb to be guided by the state and conditions of such appendage in the vertebrate series, rather than by the state of the cranium in one part thereof. It is not probable that the pectoral fin of Shark or Skate shows the condition under which the appendage of the scapular arch first appeared in fishes.[2]

On laying open the neural canal, and exposing the myelon by slitting up and reflecting the 'dura-mater,' as in fig. 135, the roots of the nerves are seen, which go off in lateral pairs, and escape at the intervals of the vertebræ: they are called the 'spinal' or 'myelonal' nerves. One bundle of the radical filaments proceed from the antero-lateral, the other bundle from the postero-lateral fissure, and between the bundles passes a delicate fold of the arachnoid, which is attached by an angular process, *d*, to the dura-mater at the interval, usually, of each nerve (p.78). The anterior or ventral and the posterior or dorsal bundles converge, separately perforate the dura-mater, and unite, at the intervertebral foramen, into a single 'nerve.'

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[1] Messrs. Seeley and Spencer dispute the priority of such explanation and don't give it. xci″ and xcii.″

[2] Respect for the conductors and editor of lxxv″ has led me into the above digression; and as they meet what they consider the 'main defect' (ib. p. 123) of the present work by an 'argumentum ad verecundiam,' I would observe that the individual who first perceives, or discovers, the general homology of the basioccipital, the scapula, or other part of the hindmost segment of the skull of a cod-fish, puts himself in advance of, and more or less in antagonism with, others. If his perception be true, but not accepted, it is not his fault that 'he be right and everybody else wrong.' Such a state of things has happened more than once in the history of science, but it is happily transitory; the many moving one-ward, the one onward.

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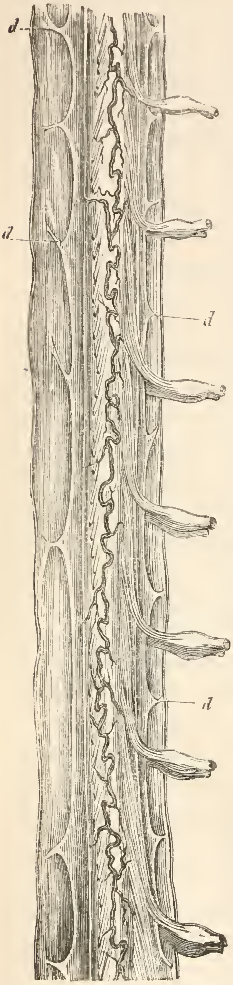

Portion of myelon, with roots of nerves of one side. Human, natural size.

In the Elephant the posterior roots come off abruptly in a few, large, and distinct bundles: the anterior roots emerge from a longer extent of their furrow, are numerous and small, and form several bundles before passing through the dura-mater. The same characters of the anterior and posterior origins are seen in *Cetacea*, in which the two roots preserve their distinct course before uniting, after perforating the dura-mater, longer than in other Mammals. In the human subject, especially at the cervical part of the myelon, the anterior root, fig. 136, A, is the smallest; its finer filaments form more delicate fasciculi, aggregating into two, before uniting, as a flat band, with the posterior root. Of this the filaments, P, are larger, and blend with the cell-substance of a ganglion, G, before uniting with the anterior root to form the nerve-trunk, *c*.

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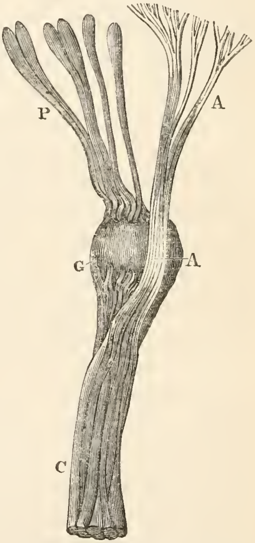

Roots of myelonal nerve, magn.

The capital experiment which has immortalised the name of Charles Bell was suggested by the above anatomical fact, and I quote his original account of it from the extremely rare little tract, which he printed for private distribution in 1811.[1]

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[1] LXIV''.

Believing that he could 'trace down the crura of the cerebrum into the anterior fasciculus of the spinal marrow, and the crura of the cerebellum into the posterior fasciculus, I thought,' he writes, p. 21, 'that here I might have an opportunity of touching the cerebellum, as it were, through the posterior portion of the spinal marrow, and the cerebrum by the anterior portion. To this end I made experiments which, though they were not conclusive, encouraged me in the view I had taken.'

'I found that injury done to the anterior portion of the spinal marrow convulsed the animal more certainly than injury done to the posterior portion, but found it difficult to make the experiment without injuring both portions.'

'Next considering that the spinal nerves have a double root, and being of opinion that the properties of the nerves are derived from their connections with the parts of the brain, I thought that I had an opportunity of putting my opinion to the test of experiment, and of proving at the same time that nerves of different endowments were in the same cord, and held together by the same sheath.

'On laying bare the roots of the spinal nerves, I found that I could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow, without convulsing the muscles of the back; but that on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed' (ib. p. 22).

The ventral as well as the dorsal roots of the spinal nerves are traceable to the contiguous parts of the grey tract, the latter more immediately, as at *k*, fig. 40. They are severally connected with, but do not constitute, the white columns from which they emerge. Comparative anatomy testifies plainly against the anterior and posterior columns being aggregates and brainward continuations of the motory and sensory roots. Thus, in the instance of such unusual elongating growth of the myelon as takes place in the neck of the fœtus of the Giraffe, as many of the roots of a nerve, the origin of which may be so extended by interstitial myelonal increase, incline tailward as headward (p. 75). And accurate experiment gives the same response, sensation continuing or being heightened in parts supplied by nerves beyond the place of the myelon of which the dorsal or posterior columns have been divided.

The most constant anatomical concurrence with sensory function is the ganglion, fig. 136, G, fig. 131, 9.

In all Mammals the trunk, fig. 136, C, formed by the union of the two roots soon divides into an anterior and a posterior primary set of nerves. The posterior or dorsal are usually the smaller division, and, bending backward, soon subdivide into external and internal branches. The pairs of nerves are classified, according to the regions of the vertebral column where they emerge, into ‘cervical,’ ‘dorsal,’ ‘lumbar,’ ‘sacral,’ ‘caudal,’ and offer numerical differences corresponding with those of the vertebræ, in the Mammalian series. Each is anterior to the corresponding bony segment, and, for the most part, escapes between that and the segment in advance; but the notch of the ‘conjugational foramen’ is always deepest at the fore part of the neurapophysis answering to the nerve, and is directly perforated thereby in many instances; as, e. g. that of the atlas by the first cervical in the Tapir,[1] and also that of the axis by the second cervical in the Hyrax.[2] Most of the cervical and the dorsal vertebræ are perforated by their corresponding nerves in the Hog and Peccari;[3] and some dorsals and lumbars are so perforated in most Ruminants.[4] Therefore, I count the ‘suboccipital’ nerve as the first cervical one, and reckon the ‘eighth cervical’ of Anthropotomy as the ‘first dorsal.’

Some details of the distribution of the myelonal nerves in *Monotremata* are given in LXXXI·. In the *Cetacea* they have been described by Stannius[5] and Swan[6] in *Phocæna communis.*

In the Porpoise, the first cervical has a distinct posterior root, smaller than the anterior one, but with a small ganglion; beyond which the two unite, as usual. The posterior or dorsal branches supply the occipital and contiguous integument, and the tegumentary and other muscles passing to the occiput; supplying, also, small branches to the ‘masto-humeralis.’ The anterior or ventral branch passes along the scalenus, joins corresponding branches from the second and third cervicals, and, in combination with the ‘descendens noni,’ supplies the sterno-hyoid and sterno-thyroid muscles. The second and succeeding cervical nerves are larger. A posterior branch of the second perforates the masto-humeralis, and supplies the integument of the neck. Other posterior branches of this and following cervicals supply the interspinales, spinalis cervicis, splenius capitis, and the more superficial muscles and integument at the fore and dorsal parts of the trunk: ventral branches go to the scalenus anticus, levator anguli scapulæ, and contiguous muscles. The fourth cervical contributes the largest part of the ‘phrenic nerve,’ but it receives a filament from the third cervical, sometimes from the second; always from the fifth. The left phrenic passes a short way along the scalenus anticus; as it sinks deeper, it gives a filament to the pectoralis major, passes over the aortic arch and trunk of the vagus in entering the thorax, passes along the anterior mediastinum, and then along the pericardium to the left side of the diaphragm. The right phrenic crosses the subclavian, or trunk of the brachial artery, in entering the thorax, and supplies the right half of the diaphragm. A small branch of the anterior division of the fifth cervical, a large branch of that of the sixth, a still larger one of the seventh, and a smaller contribution from the first and second dorsal nerves combine to form the axillary plexus, prior to which are sent off nerves to the scalenus anticus, subscapularis, teres major, and latissimus dorsi. From the plexus is continued a branch beneath the triceps, which quickly radiates small filaments, one of the largest of which is continued along between the radius and ulna; a second branch passes along the inner side of the triceps to the olecranon; a third branch goes between the hind border of the scapula and the triceps outward and forward, it supplies the infraspinatus and deltoid, and ends in the periosteum and skin at the fore part of the humerus. Many small twigs are sent to the subscapularis muscle. The hindmost and strongest branch goes obliquely outward and backward, giving filaments to the latissimus dorsi, and bends over the chest to the sternum, along the side of which it distributes itself to the serratus magnus and contiguous muscles attached to the ribs; it answers to the 'external thoracic nerve.' There are thirteen pairs of dorsal nerves, each dividing into a dorsal and intercostal part. The dorsal division bends over the rib-neck in the anterior vertebræ, and over the lengthening diapophysis in the posterior ones, and subdivides into a superficial and deep part; the latter supplies the spinales, interspinales, and the fascia of the muscles of the back; the superficial nerves contribute to the longissimus dorsi, and levatores costarum, in their way to the skin of the back and its muscles. The ventral divisions of these nerves are less distinctly subdivided into external and internal fasciculi than in quadrupeds. The first intercostal sends a communicating branch to the axillary plexus, before its normal distribution, as in the other intercostals, to the muscles so called, which are perforated toward the sternum by the branches going to the ventral integument. The nerves answering to lumbar and sacral of Quadrupeds divide into dorsal and ventral fasciculi. The former go to the intertransversales, spinales, interspinales, sacrolumbalis, and longissimus dorsi; and to the superincumbent fascia and tegument. There are intercommunicating filaments between the dorsal divisions of the second, third, and fourth lumbar nerves. Some of the ventral branches pierce the intertransversalis before penetrating the fascia of the psoas, on their way to the oblique and straight abdominal muscles; but the main proportion is taken by the psoas. Anterior branches from the seventh, eighth, and ninth lumbar nerves diverge from the ordinary course or distribution, and partially unite with a plexus extending to and supplying the muscles which connect the ischial or pelvic bones with the abdominal and caudal muscles and those of the attached parts of the sexual organs. The above nerves evidently represent the lumbar plexus developed in Quadrupeds for the hind-limbs, but their chief distribution is as 'pudendal' nerves. The anterior or ventral divisions of the caudal nerves mainly combine to form a nerve-trunk on that aspect of the tail, which is resolved into many small parallel transverse branches, from which are supplied the muscles and teguments of that part of the tail. The dorsal divisions are similarly distributed, but only a very small proportion goes to the skin.[1]

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[1] XLIV, p. 501.

[2] Ib. p. 522.

[3] Ib. pp. 543, 563.

[4] Ib. p. 579.

[5] LXXVI··.

LIV, 2d ed. p. 156.

In the Ungulate series the distribution of the spinal nerves has been followed by the hippotomists in the Horse and Cow; by Swan in the Ass;[2] and I have made observations on that part of the anatomy of the Rhinoceros and Giraffe.

Several branches from the superior cervical ganglion of the sympathetic join, in a plexiform manner, the anterior division of the first cervical; this also receives a filament from the descendens noni, which previously communicates either with the trunk or a filament from the par vagum; afterwards it joins the pharyngeal plexus, and is distributed to the sterno-hyoid and sterno-thyroid muscles. The nerve given to the serratus magnus proceeds from the sixth cervical with the phrenic; but the phrenic afterwards communicates with a branch of the seventh, given to the pectoralis major. The axillary plexus in the Ass, also in the Pig, is formed from the seventh cervical and the first and second dorsal nerves. The superior scapular nerve proceeds chiefly from the seventh cervical; but in some degree from the first dorsal, and is sent to the supra- and infra-spinati muscles of the scapula. Branches proceeding from all the nerves forming the plexus are given to the great pectoral muscle; a nerve proceeding principally from the last cervical and first dorsal supplies the subscapularis, teres major, and latissimus dorsi, then takes a circumflex course to the deltoid, and external head of the triceps, and finally passes down the limb to the skin. The external branches of the third and fourth dorsal nerves, also, supply the skin; the internal cutaneous nerve is sent off from the ulnar. The musculo-cutaneous is formed chiefly by the last cervical, and partly by the first dorsal; it contributes to the formation of the median nerve, then pierces the coraco-brachialis to terminate on the biceps. The median is mainly formed by the first two dorsal nerves; it sends a branch to the biceps, brachialis internus, and supplies the skin on the posterior and inner part of the fore-leg. After supplying the flexors on the fore-leg, it sends a nerve close to the bone which gives filaments to the periosteum, and passes to a muscle answering to the flexor longus pollicis: it then passes underneath the annular ligament, and sends a large branch obliquely over the flexor tendons to communicate with the ulnar nerve, and descends, giving off branches to the skin at the inner side of the foot, which communicate with the inner portion of the deep palmar branch of the ulnar: it then passes to vascular lamellæ attached to the hoof, fig. 17, 17, to terminate on these, on the villous part of the sole and the ligaments of the joints. The ulnar nerve arises from the first and second dorsals; at the middle of the arm it sends off the internal cutaneous nerve, and at the elbow gives some branches to the short extensor and the elbow joint; it passes down, covered by some fibres of the flexor muscles, and at the wrist sends off the dorsal branch to the skin at the posterior and outer part of the fore-leg; it passes underneath and to the inner side of the flexor carpi ulnaris, and then underneath the annular ligament, and gives off the deep palmar nerve: it receives the branch from the median, and descends, giving branches to the skin and ligaments at the outer side of the foot, after these have communicated with the outer branch of the deep palmar; it passes into the foot, covered by the vascular lamellæ connected with the hoof, and terminates on these, the villous part of the sole and the ligaments of the joint. The deep palmar gives some filaments to the ligaments, and divides into two principal branches, one to pass on the inner side to give filaments to the joints, the periosteum, and ligaments, and communicate with the branches of the median sent to the skin and ligaments at the inner side of the foot, the other to give filaments to the periosteum and ligaments, and communicate with branches of the ulnar, having a similar destination on the outer side of the foot. The musculo-spiral nerve arises from the seventh cervical and first and second dorsal nerves: after supplying the heads of the triceps, it passes round the humerus, and gives branches to the two large extensors at the back of the fore-leg, and sends a branch, somewhat expanded, down to the carpal joints, but not swelling into a ganglion, as in Man; it then pierces the rudiment of the short supinator, to supply a muscle answering to the long supinator on the outer side of the back of the fore-arm.

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[1] Swan well notes the difference between the mode of supply to the natatory tail, i.e. by a few trunks in Cetacea derived from a remotely situated myelon, and that in Fishes, by many nerve-pairs from a contiguous myelon: also the great proportion of motory as compared with sensory filaments; the tail being not only the main motive instrument in Whales, but capable of 'giving hard blows without feeling much pain.' LIV. p. 165.

[2] LIV, 2d ed. pp. 153, *et. seq.*

In the Pig, the median in the fore-arm is much larger than the ulnar; it receives a small communicating branch from the ulnar near the wrist, and then supplies the inner small toe (*ii*), both sides of the inner large toe (*iii*), and the inner side of the next (*iv*). The ulnar gives off the dorsal branch, and then sends the deep palmar to the interosseous muscles; it contributes a small branch to the median, and then supplies the outer side of the large toe (*iv*), and the adjoining small toe (*v*). The greatest portion of the dorsum of the foot is furnished by the radial branch of the spiral nerve, and the rest by the dorsal branch of the ulnar.

In the Ass there are eighteen pairs of dorsal nerves, the anterior or ventral divisions of which pass between the ribs, are distributed to the intercostal and abdominal muscles, the hindmost perforating the psoas muscle. There are five lumbar and six sacral nerves, besides four or five caudal. The third lumbar sends off a branch, which gives a branch to the great psoas muscle, and one to join the fourth for the anterior crural nerve; it then becomes the external cutaneous nerve to pass on the outer side of the thigh; it sends off another large branch corresponding with the external spermatic, which communicates with a large branch of the third lumbar ganglion of the sympathetic, gives a branch to the small psoas muscle, and then passes underneath the lower border of the abdominal muscles, to which it sends a branch, and becomes distributed on the mamma. The anterior crural nerve arises from the third, fourth, and fifth lumbar nerves: the obturator arises from the fourth and fifth lumbar, and first sacral nerves: the sciatic arises from the three first sacrals: the principal part of the third and fourth sacrals, joined by a small branch from the portion of the sciatic arising from the second, give off the internal pudendal to pass at the side of the arch of the pubes, distribute filaments to the neck of the bladder, and terminate on the clitoris, vagina, and external parts, and the connecting muscle and membrane between these and the mamma. A branch of the external spermatic may be traced downward, and a branch of the internal pudendal upward, towards each other. Another part of the junction of the fourth and fifth, with sometimes a branch from the sixth sacral, joins the hypogastric plexus, and sends branches along the inferior uterine artery to the neck of the uterus and vagina, and is then distributed to the bladder, urethra, vagina, and rectum. The remaining part of the fifth and sixth sacrals forms the beginning of the anterior caudal nerve, to which the anterior trunks of the remaining spinal nerves below it become united; the posterior trunks of these nerves form the posterior caudal nerve; both of these are continued to the extremity of the tail, communicating by branches, and supplying one-half of each anterior or posterior surface.[1] The gluteal nerves are sent from the two first sacrals at their junction with the sciatic, and terminate on the glutei and tensor fasciæ. A nerve given off from the sciatic supplies the gracilis and gemelli, and is continued down to the quadratus femoris. The anterior crural nerve supplies the sartorius, rectus femoris, vasti, and cruræus. The saphenus nerve descends with the vein, giving numerous filaments to the ligaments and skin, and communicating at the side of the foot with the inner branch of the deep plantar nerve, and through this with a branch of the inner plantar, to be distributed on the skin at the side of the foot. The obturator nerve supplies the adductors and the large muscle corresponding with the gracilis. The sciatic nerve gives branches to the semimembranosus, semitendinosus, and biceps; it then divides into the posterior tibial and the peroneal, both of which give branches to the biceps. The posterior tibial sends a branch down at the back of the gastrocnemius, and on the outer side of the tendo Achillis to the fascia, on that side of the hock: it then passes between the heads of the gastrocnemius muscle, to which and the large muscle representing the posterior tibial and the flexors of the toes it gives branches; it descends on the inner side of the tendo Achillis, giving branches to the fascia, &c. on the inner side of the hock, near which it divides into the inner and outer plantar nerves; the inner sends off a large branch obliquely over the flexor tendon to join the external plantar nerve; it passes down on the inner side of the tendon, giving branches to the sheath, fascia, and integuments; near the foot it gives off a large branch, which communicates with the inner branch of the deep plantar nerve, to be distributed on the skin at the inner side of the foot; it gives branches to the skin of the heel, and then passes down to the hoof, covered by the vascular lamellæ, and distributing branches to these and the villous stratum of the sole. The external plantar passes between the flexor tendons, and then on the outer side of these, and gives off the deep plantar nerve; it is continued down on the outer side of the tendon, gives filaments to the sheath and fascia, receives the branch from the inner plantar, and gives off a branch which communicates with the outer branch of the anterior tibial nerve, and is distributed on the side of the foot; its ultimate distribution resembles that of the posterior tibial. The deep plantar gives filaments to the ligaments, then divides into two branches; the inner passes down beneath the tendon, then near the edge of the bone to the foot to communicate with a branch of the saphenus nerve, and of the inner plantar, to be distributed on the skin at the inner side of the foot; the outer branch passes near the edge of the bone, gives a branch to the ligaments, and then joins the outer branch of the anterior tibial nerve. The peroneal nerve passes to the outer side of the leg, and gives small branches to the fascia and skin; it sends the long branch downward which gives filaments to the fascia, and terminates in the skin covering the dorsum of the cannon-bone. It gives filaments to the ligaments and fascia on the outer side of the knee-joint, and branches to the peroneal muscle, the extensors of the toes, and the anterior tibial muscle. It gives off the anterior tibial nerve, which passes down the leg between the peroneal and anterior tibial muscles, then between this and the bone along with the anterior tibial artery underneath the annular ligament, where it divides into two branches; the outer one gives filaments to the joint, and is contained with the anterior tibial artery on the outer side of the cannon-bone, giving filaments to the periosteum, and on the outer side of the foot receiving the outer branch of the deep plantar nerve; it then becomes connected with a branch of the outer plantar nerve, and is distributed on the ligaments and skin on the outer side of the foot; the inner branch of the anterior tibial passes down on the cannon-bone, gives filaments to the periosteum and fascia, and terminates on the skin at the inner side of the foot.

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[1] LIV, p. 160.

In the Pig, the posterior tibial nerve, having given branches to the muscles of the leg, and sent the branch down at the back of the gastrocnemius muscle to the outer side of the leg, gives filaments to the inner side of the heel, and near the part divides into the inner and outer plantar nerves; the inner is continued onwards, and supplies the small inner toe (*ii*), the first large toe (*iii*), and the inner side of the next (*iv*). The outer plantar nerve passes underneath the flexor tendon, and is continued onward to divide for the outer side of the second large toe, and the outer small toe; it sends the deep plantar into the sole to supply the short muscles situated there. The anterior tibial nerve gives branches to the ligaments at the back of the foot, and sends a branch to supply the toe, *ii*, and the inner side of *iii*; the rest of it gives branches to the small muscles on the back of the foot, and then passes forward to join the branch of the peroneal given to the outer side of *iii*, and the inner side of *iv*[1]; the continuation of the peroneal after emerging just above the instep supplies the outer side of *iii* toe, both sides of *iv* and *v*, the branch sent to the outer side of *iii* and the inner side of *iv* receiving a branch of the anterior tibial.

In the order *Carnivora*, the distribution of the nerves has been described and figured by Swan, in the Fox (LIV, p. 150, pl. 33), and in the Jaguar (ib. p. 161), from which the following account is chiefly abridged. In the Fox the anterior trunk of the first cervical passes forward, and sends up two filaments to the junction of the trunk of the par vagum with the glosso-pharyngeal, the ninth, the accessory, and the superior cervical ganglion of the sympathetic; it gives branches to the recti antici, and then joins the descendens noni, to be distributed to the sterno-hyoid and sterno-thyroid muscles. The posterior trunk supplies the recti capitis postici and obliqui sup. et inf. The anterior trunks of the second and third cervical nerves give branches to the recti capitis antici, then unite to communicate with the accessory, and divide into branches, which are distributed on the cutaneous muscle and skin at the side of the face and neck and external ear. The fourth cervical gives a branch to join the accessory and others to the trapezius, and is then distributed to the cutaneous muscle and skin at the side of the neck. The fifth cervical nerve gives a branch to the accessory, and to the trapezius, and then pierces this to terminate on the skin at the lowest part of the neck. The posterior or dorsal division of the second cervical nerve gives branches to the splenius, complexus, and other muscles, close to the posterior part of the spine, and then sends a branch through the complexus towards the occiput, which gives filaments to the muscles inserted into the back of the ear, but is chiefly distributed on the skin of this part. The posterior division of the third cervical is similarly distributed. That of the fourth cervical gives branches to the complexus and other muscles close to the spine, and then terminates on the skin. The posterior divisions of the sixth and seventh also give branches to the muscles and skin; the first dorsal supplies the muscles only. The phrenic nerve is formed by a branch from the fifth and sixth cervicals: it passes over the pericardium to the diaphragm, and on the right side is placed close to the post-caval vein. In the Jaguar, the phrenic also arises from the fifth and sixth cervicals, and receives a branch from the first thoracic ganglion. The axillary plexus is formed by the last two cervical and first two dorsal nerves. In the Fox the axillary plexus is formed by the sixth and seventh cervical and first and second dorsal nerves, but the greatest part of the sixth, after receiving a branch from the seventh, gives a large branch to the integuments on the anterior part of the shoulder-joint, and then passes to form the superior scapular nerve, and terminates on the supra- and infra-spinate muscles. Branches from the sixth and seventh cervical and first and second dorsals are given to the pectoral muscles; a branch from the seventh cervical is given to the serratus magnus, and branches from the sixth and seventh go to the subscapularis. The circumflex nerve arises from the union of the sixth and seventh cervical nerves; it gives branches to the subscapularis and teres major muscles, and then divides and sends a branch to the infra-spinatus muscle and the deltoid, and branches to the integuments on the outer side of the arm.

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[1] See vol. ii. p. 308, fig. 193, *Hippopotamus,* which resembles the foot of the Hog.

The internal cutaneous nerve is sent off by the ulnar; it passes down the arm, and, near the inner condyle of the humerus, divides into branches to be distributed to the skin at the ulnar side of the fore-arm. The smaller internal cutaneous nerve is the external branch of the third dorsal after its egress from between the ribs; it pierces the broadest muscle of the back, and divides into branches, to be distributed on the skin at the inner and posterior part of the arm. The musculo-cutaneous nerve arises from the seventh cervical with the outer portion of the median, gives a branch to the pectoralis and coraco-brachialis, and then passes off to terminate on the biceps. The seventh cervical, having given off the homologue of the musculo-cutaneous, the remaining part gives off a branch which sends one back to the brachialis internus, behind the tendon of the biceps, and then gives branches to the skin of the fore-arm, in the place of the cutaneous portion of the musculo-cutaneous nerve in Man; it then joins the branch from the first and second dorsal nerves, about an inch above the elbow, to form the median nerve, which is small as compared with that in Man. The nerve thus formed passes under the origin of the pronator teres, and gives branches to this, the flexor carpi radialis, and the superficial and deep flexors of the digits; it then passes, by the side of the radial flexor and between the digital flexors, through the annular ligament; it is continued in the fore-paw between the tendons of these muscles, at the division of which it sends off branches; it gives filaments to the skin of the palm, and a branch to the rudimental pollex,[1] another to the inner side of the index (II), and a branch to be joined by one from the deep palmar for the outer side of the index and the inner side of the medius (III); another branch also to be joined by a branch from the deep palmar for the outer side of the medius and the inner side of the annularis (IV). The ulnar nerve is formed by the first and second dorsals; it descends behind the inner condyle of the humerus, covered by thick fascia and by part of the flexor sublimis; it then passes down the fore-arm between the flexors of the fingers and the ulnar flexor of the wrist. In the fore-arm it is larger than the continuation of the median nerve: it sends a branch to the ulnar side of the superficial and deep flexors of the digits and the ulnar flexor of the wrist: near the hand it sends a branch to the back of this part to communicate with the radial branch of the musculo-spiral nerve, and then proceeds to the outer side of the fifth digit (V); it passes deeply, confined by a ligament at its entrance, into the palm, and sends a branch for the inner side of the fifth digit and the outer side of the fourth; the rest of the nerve, forming the deep palmar, divides into branches, which terminate on the interosseous and other small muscles situated in the palm, and give branches to join those of the median sent to the outer side of the index and the inner side of the medius digit; also to the outer side of this and the inner side of the annularis. The distribution of the median nerve is nearly the same in the Felines, but the trunk traverses the entocondyloid canal. The musculo-spiral nerve has a slight communication with the sixth cervical, but is principally formed from the seventh and first and second dorsals; it gives branches to the different heads of the triceps muscle, and winds round between the inner and large heads of the triceps to the outside of the arm, and divides into two large branches; one gives off a cutaneous branch to the outer side of the fore-arm, and then descends in the place of the radial, giving branches to the skin, and dividing to terminate on the skin at the back of the paw and the side of each digit, except the outer side of the fifth, and communicate with the dorsal branch of the ulnar; the other, in passing to the back of the fore-arm, gives a branch to the long and the short supinator muscles; it then divides to terminate in the extensor carpi radialis and the extensor digitorum, whilst a long branch passes on and gives filaments to the extensors of the pollex and to the wrist-joint, but does not terminate on this part in a ganglion, as in Man and Quadrumana.

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[1] Vol. ii. p. 306, fig. 191, *Hyæna*, I, which also serves to exemplify the homology of the digits of the fore-paw in the Dog and Cat.

There are thirteen pairs of dorsal nerves, and their principal deviation from those in Man consists in a smaller size, a more direct course, and a less distribution on the abdominal muscles, and by those at the lower part of the thorax being covered by an extension of the origin of the psoas muscle, also in the anterior cutaneous branches supplying the different portions of the elongated mammary glands in the female, as well as the skin. The posterior or dorsal divisions, after supplying the muscles connected with the spine, the sacro-lumbalis and longissimus dorsi, send a branch between these and the latissimus dorsi to the skin. The anterior or ventral divisions of the lumbar and sacral nerves supply principally the parts connected with the lower extremity, the bladder and rectum; the dorsal divisions of the second and third lumbar nerves supply the skin as well as the sacro-lumbalis and other muscles connected with the dorsal parts of the vertebræ; the dorsal divisions of the succeeding lumbar nerves are distributed to the muscles only; the dorsal divisions of the sacral nerves supply the muscles on that surface of the tail. The nerves are not very different from those in Man, except in their number, and consequently in their conjunction a little higher or lower for forming the nerves of the lower extremity. The anterior divisions of the three first lumbar nerves give filaments to the psoas muscle, and then pass forward to terminate in the abdominal muscles and skin. The fourth gives filaments to the psoas and internal iliac muscles, and sends a branch to join one from the third to form the external spermatic on the external iliac artery, which passes through the external abdominal ring to the spermatic chord; in the female this was distributed on the posterior division of the mammary gland; it sends off another branch which gives a filament to the external iliac artery, and then joins the sixth; the rest of the fifth passes down on the exterior of the thigh to the skin, and forms the external cutaneous nerve. The sixth receives a branch from the fifth, gives filaments to the internal iliac muscle; part of it is then joined by a large branch from the seventh to form the anterior crural nerve; the other part, after receiving a large and small branch from the seventh, becomes the obturator nerve. The seventh, having given off the preceding branches, joins the first and second sacrals and a branch of the third for forming the sciatic nerve. The junction of the first and second sacral gives a branch to the pyriform muscle, and a larger one to pass out at the ischiatic notch to supply the gluteal muscles and the tensor fasciæ. Some branches derived from the second and third sacral nerves combine with the hypogastric plexus for supplying the bladder and rectum, and others from the pudendal nerves for the muscles connected with the anus and tail. A branch of the second sacral nerve joins the third for forming the anterior caudal nerve, which receives the anterior trunk of each remaining spinal nerve, and passes deep in the anterior part of each side of the tail, giving off branches into its course; the posterior or dorsal trunks of the same nerves form a nerve, which also sends off branches to the dorsal muscles and skin of the tail.

The anterior crural nerve passes between fibres of the iliac muscle, then under Poupart's ligament at the inner side of the sartorius; it gives branches to this, to the rectus femoris, the external and internal vasti, and the cruralis, and sends off the saphenus nerve, which descends across the thigh to the inner part of the leg, communicates with a filament from the obturator, and is continued to the foot, giving filaments in its course to the fascia and skin. The obturator nerve, on emerging from the pelvis, gives branches to the pectineal muscle, the triceps, and gracilis, and sends a branch to communicate with the saphenus nerve; several fine branches pass down on the inner side of the thigh for the fascia and integuments. The sciatic nerve, on emerging from the pelvis, communicates with the internal pudendal; it sends a branch to the internal obturator muscle, and one which gives a filament to the upper portion of the gemelli, and then passes behind the tendon of the internal obturator to the lower portion of the gemelli and quadratus muscles. The sciatic passes close to the insertion of the internal obturator muscle, and upon or behind the gemelli and quadrati muscles, then behind the trochanter covered by the origin of the biceps to which it gives a branch: it sends off a large branch which divides into others for the semimembranosus and semitendinosus muscles. About the middle of the thigh it separates into the posterior tibial and peroneal nerves.

The posterior tibial nerve sends off a long slender branch which descends on the posterior part of the gastrocnemius muscle to the outer side of the leg, sends a branch behind the tendo Achillis to the posterior tibial nerve, and is distributed on the skin at the outer side of the leg and heel. It then gives branches to the gastrocnemius, and passes between the heads of this and gives branches to the flexor of the toes, the tibialis posticus and the flexor longus hallucis; it then passes down the leg on the inner side of the tendo Achillis, and receives the branch from the long slender branch sent underneath this tendon. It passes behind the inner condyle of the tibia, and divides into the inner and outer plantar nerves: the inner plantar gives a branch to the inner side of the second toe, and then communicates with a branch of the deep plantar, and divides for the outer side of the second and the inner side of the third; it also communicates with a branch of the deep plantar given to the outer side of the third toe and the inner of the fourth; the outer plantar nerve passes between the flexor tendons, and sends a nerve to the outer side of the foot and the last toe; it gives off the deep plantar, which passes underneath the short flexor of the toes, and divides into branches, and gives filaments to each of the small muscles situated in the sole of the foot, and a branch to communicate with one from the inner plantar nerve: it then divides for the outer side of the second toe (the innermost in the Fox and most digitigrades) and the inner side of the third, and one for the outer side of the third and the inner of the fourth, and another for the outer side of the fourth and the inner of the fifth toe. The peroneal nerve gives a small branch to the biceps and filaments to the fascia near the knee; it then divides the anterior tibial nerve, sends off branches to the anterior tibial muscle, the long extensor of the toes, and the long peroneal, and descends with the anterior tibial artery, beneath the annular ligament, and gives branches to the ligaments of the foot; it passes onwards, and is joined by a branch from the continuation or dorsal branch of the peroneal, and divides for the outer side of the second and the inner side of the third toe. The continuation or dorsal branch of the peroneal, gives branches to the short and third peroneal muscles, and passes behind the long peroneal, and emerges between this and the long extensor of the toes; it passes over the annular ligament, and sends a branch to the outer side of the foot and the fifth toe; on the back of the foot it sends the branch to join the anterior tibial nerve; it separates into two branches, the first divides for the outer side of the third and the inner side of the fourth toes, the other for the outer side of the fourth and the inner side of the fifth or outermost toe.

The chief characters of the minutely detailed distribution of the myelonal nerves of Man, in works on his anatomy, are found in most *Quadrumana*. Mr. Swan has remarked that the saphenus nerve is proportionally larger in a Baboon: and he also notices the large size of this nerve in the Jaguar. The nerves of the palm are proportionally smaller in Apes than in Man, and do not terminate in such thick brushes of filaments at the tips of the fingers; but the branches from the musculo-spiral and ulnar nerves to the back of the hand are larger in proportion than in Man.[1] Many Quadrumana have the ganglion on the termination of the spiral nerve at the back of the wrist; but in the *Felidæ* there is only a slight enlargement at that part of the nerve.

§ 212. *Sympathetic system.*—This, as an addition to the general nervous system, is a speciality of the Vertebrate subkingdom: as such it dawns in Myxinoids, at the confluence and intestinal production of the two vagal trunks, and is differentiated by progressive steps, till it attains the general condition defined in vol. i. p. 318, § 57.[2]

Where it begins in the series there the chief centres are afterwards established, as the semilunar ganglions and solar plexus, so called from the multitudinous rays that diverge therefrom; they are early and distinctly visible in the mammalian embryo. The ganglions of the sympathetic vary in the proportion of the grey or cellular and filamentary or tubular constituents. The cellular part forms a greater proportion of the semilunar ganglions in Man than in most lower Mammals: and it is greater in *Carnivora* than in hoofed quadrupeds. The filaments radiating from the semilunar ganglions collect themselves into interlaced groups named after the viscera they mainly supply, as, the 'gastric,' 'hepatic,' 'splenic,' 'mesenteric,' 'renal,' 'spermatic,' &c.: the chief branches of all these plexuses attach themselves to the arteries of the several organs: in the large gastric plexus of the Ruminants they accompany these to the several divisions of the complex stomach. In the *Carnivora* branches of the superior mesenteric pass in a more definite form to the aggregate of mesenteric glands at the root of the mesentery. In Perissodactyles, in which the cæcum and colon are remarkable for size and complexity, the superior mesenteric plexus, supplying these parts of the large as well as the small intestines, is proportionally larger than in other Mammals, especially as compared with the inferior mesenteric plexus in *Carnivora* and *Quadrumana*. In the Baboon the cæcum and about one foot of the colon is supplied by the superior mesenteric plexus, and the remaining five feet of the large intestine by the inferior one. In *Carnivora* this supplies about the terminal half of the large intestine. In the baboon Swan noticed a communication between the right phrenic nerve and the semilunar ganglion.[1]

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[1] LIV. p. 193. Much of the foregoing description is abridged from this rich storehouse of Comparative Neurology.

[2] This true idea of the series of ganglions and nerves, called 'sympathetic' in Man, once clearly attained, will leave little room for speculations as to whether the nervous system of insects answers to the myelencephalic or sympathetic part, exclusively, of that of Vertebrates.

The trunk, advancing or ascending from each semilunar ganglion, is an aggregate of cords (‘splanchnic nerve,’ Anthropotomy), which, perforating the diaphragm, separate to form communications with a variable number of the thoracic ganglions of the sympathetic. In the baboon Swan traced the origins or connections of the right splanchnic nerve with two thoracic ganglia in advance of the left, this extending over the heads of five posterior ribs, and the other over seven, each expanding into a small ganglion at the bottom of the chest. In the hedgehog the splanchnic nerve extends over the heads of the four last ribs, and, receiving filaments from the sympathetic, forms a plexus on the sides of the vertebræ, as in the baboon; but separates from the trunk of the sympathetic higher in the chest. In the jaguar this separation occurs a little above the diaphragm: in the hog at the passage through the diaphragm. But ‘these variations do not seem to make any difference either in the formation of the semilunar ganglion, or the branches preceding from them.’[2]

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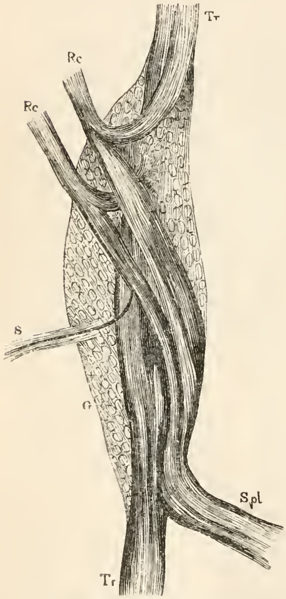

Sixth thoracic ganglion of sympathetic, Rabbit. LXXVIII''.

Kölliker has given the subjoined view, fig. 137, of the communication of the splanchnic, *Spl*, with the myelon by the ‘rami communicantes’ *Rc*, *Rc*, and with the ganglion of the sympathetic, G, from which it derives its grey fibres. From the trunk of the sympathetic *Tr* and the ganglion the nerve *s* to the intercostal artery is sent off.

In Mammals the parts regarded as ‘trunks,’ or ‘main chords’[3] of the sympathetic, form a symmetrical pair extending along the sides of the centrums, forward to the basioccipital, and backward to the coccyx: anteriorly, or above, they pass to ganglions and plexuses, within, or about, the cranial cavity; below or behind, they converge and unite, generally, in a terminal 'coccygeal' ganglion. In their course the cords cross, ventrally, the issuing trunks of the spinal nerves, with which they are connected by short threads, including grey and white filaments, and there usually swelling into ganglions. The grey or gelatinous thread is most probably a contribution from the ganglion to the myelonal nerve, the white thread is sent from the nerve to the sympathetic ganglion: it consists of tubular nerve-fibres, and these predominate in the 'rami communicantes' of the rabbit and cat.[2] Under a power of sixty diam. after addition of dilute solution of soda Drummond found such fibres continued mainly from the myelonal end or origin, fig. 138, C, of an intercostal nerve, and converging to form the communicating branch, RC, with the sympathetic ganglion. A few filaments, *a*, *a*, disappear among those of the intercostal nerve rather in the direction of its outward course. Traced to the sympathetic ganglion, as in fig. 139, they diverge,

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[1] LIV. p. 115.
[2] Ib.
[3] ‘Prolongations,’ SWAN. LIV. passim.

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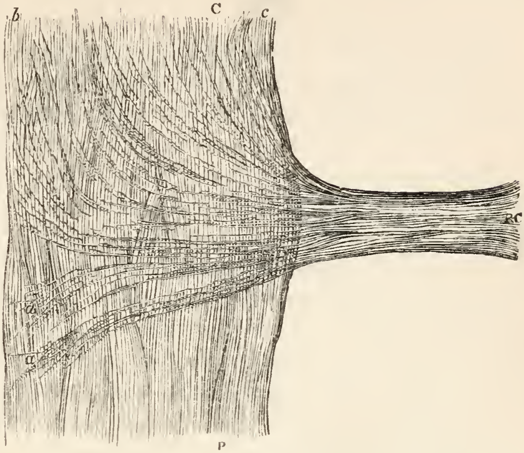

Section of sixth intercostal with communicating branch to sympathetic. Rabbit (mag. 60 diam.). LXXVII''.

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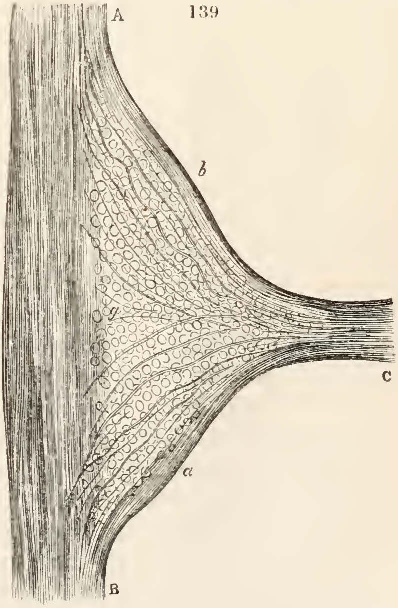

Fourth thoracic ganglion, with course of fibres received by the communicating branch, C, from the myelon. (Mag. 70 diam.) LXXVII''.

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[1] LXXVII''. p. 446.

spreading over its cellular part *g*, most of them passing either forward at *b*, or backward at *a*, and thus adding to the substance of the main trunk, A, B.

These ganglionic enlargements are more distinct from, and proportionally larger than, the cords in Man and Unguiculates, than in Ungulates and some lower Mammals. There is also some difference in the character of the cords themselves. In the *Quadrumana* and *Carnivora*, dissected by Swan, as well as in the hedgehog and rabbit, the cord was 'thick and narrow' as in Man: but in the ass, calf, and goat it was broad and flat, and composed of parallel threads communicating with each other. In the ass it continues of almost the same breadth nearly throughout the thorax. 'In the calf, after the thoracic plexus is given off, it becomes narrower; it then, in descending, gradually gets broader after its communication with each intercostal nerve, and appears rather to have had a branch added to it by, than to have given one to, each nerve.'[1] The thoracic portion of the sympathetic supplies nearly the same parts as in Man. In the jaguar, branches from several of the thoracic ganglia of the right side unite and communicate with the right posterior pulmonary plexus, and then cross the spine to communicate with the left posterior pulmonary plexus. In the calf, a similar plexus gives off the more inferior cardiac nerves to the left auricle and ventricle: it proceeds from four or five of the thoracic ganglia of the right side, and communicates with the vagal nerve: branches extend across the spine behind the gullet, and communicate with some from a similar plexus on the left side. The first or anterior thoracic ganglion is commonly notable for its size, and sends off filaments of communication with the vagal, recurrent, and phrenic nerves. The cord between the first thoracic and last cervical ganglion is short, and usually divided, or traversed, by the 'subclavian' or 'trunk of the brachial' artery. In Man the two ganglions seem to blend into one. The lower cervical is always a notable ganglion: the inferior cardiac nerves proceed from it. The sympathetic trunk divides and passes forward along the neck: the smaller portion, along the vertebrarterial canal, answers to the cervical part of the trunk in birds: the larger portion extends in close connection with the trunk of the vagus, and 'in the calf it has sometimes very small ganglia' imbedded in it, which give filaments to accompany the small arteries.'[2] In the hedgehog and rabbit this connection between the sympathetic and vagus is less intimate. In this part of the sympathetic there is an anterior or superior cervical ganglion as well as the inferior one; but, in Man, a small 'middle cervical' is added. In the vertebrarterial tract communications are made with the successive spinal nerves, as in the thorax, but without the ganglionic enlargements, at least so conspicuous. This seems to be more truly the forward continuation of the trunk than the cord connected with the vagus.

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[1] LIV. p. 115. [2] Ib. p. 113.

In the hog branches from the superior cervical pass forward to the second division of the fifth and to the sixth nerve: 'there is not a distinct vidian nerve passing in a canal of bone, as in the calf and ass; but the branch most resembling it can be traced on the second trunk of the fifth to the place where the palatine and lateral nasal nerves proceed.'[1] In the sheep two small and two larger filaments ascend from the superior cervical ganglion and form a plexus, from which the vidian nerve passes to the lateral nasal and two branches to the gasserian ganglion. In the ass the superior cervical ganglion has a more elongate form, and sends branches which form a plexus round the entocarotid: some filaments, joining others from the glossopharyngeal, supply the lining membrane of the tympanum. The chief offsets communicate with the second division of the fifth, the sixth, and facial nerves; the vidian passes forward at the inner side of the eustachian tube, traverses its bony canal, and joins the branch from the second trunk of the fifth, which divides into the lateral nasal and palatine, but there is no 'sphenopalatine ganglion' at the junction. The chief plexuses in the cephalic part of the sympathetic are the ento- and ecto-carotid and the cavernous. These are more directly derived from the superior cervical ganglion. The plexus about the vertebral artery formed by the accompanying portion of the sympathetic is continued to the basilar artery and its cerebral branches. From the lower part of the superior cervical ganglion the superior or long cardiac nerve is sent off: also nerves to the common carotid, the pharyngeal plexus, and to communicate with the vagus, spinal accessory, ninth, and suboccipital nerves. Swan remarks that the superior cervical ganglion, 'in many' (mammalian) 'instances corresponds in bearing a proportionate size to that of the second trunk of the fifth.'[1] The greatest proportion of the sympathetic continued from that ganglion, passed to the front of the gasserian, giving off the first and second trunks of the fifth. He failed to find a distinct sphenopalatine ganglion in the monkey and baboon.

'In the baboon and ass the three first lumbar ganglia of the sympathetic send branches to the semilunar ganglion, to the renal, spermatic, and aortic plexuses.'[1] The uterine nerves are derived from the hypogastric plexuses; they accompany the vessels along the broad ligaments; most separate therefrom before reaching the uterus: others retaining a plexiform arrangement about the vessels, show minute ganglia in their course, fig. 140. In long-tailed Mammals the sympathetic is continued beyond the azygous ganglion on the caudal artery, sometimes as a pair of cords (jaguar).[2]

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[1] LIV. p. 112.

[2] Ib. p. 110.

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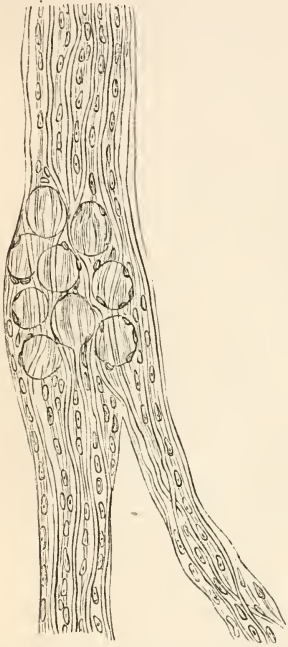

Small ganglion from posterior wall of the cervix of an impregnated uterus of a Cow. LXXVII''.

In all Mammals examined to this end filaments of the sympathetic have been traced, with those of the third and fifth, to the ophthalmic ganglion, sending off the ciliary nerves: and the general result of this branch of Comparative Neurology tends to establish the conclusion that every myelencephalic nerve contains some proportion of filaments from the sympathetic, whilst every sympathetic ganglion, reciprocally, receives some filaments from the myelencephalic system. These, however, are so modified as to be unequal to the transmission of volitional influence to the organs mainly supplied from the sympathetic ganglions: but they may be the media of conveying thereto involuntary influence and the stimulus of violent emotions: and, conversely, they may convey the sensations of pain from the irritated ganglion to the encephalon. The sympathetic system mainly governs nutritive and secretive processes and involuntary movements; it influences the contractile power of bloodvessels, the coats of which, in all Mammals, show a considerable plexiform supply from the sympathetic system.

§ 213. *Organs of Touch.*—In considering such parts in Mammalia, the sensibility of their highly organised integument, exemplified by its agitation in the horse on the contact of a fly, must be distinguished from the special adaptations of parts or appendages of the skin for purposes of tactile exploration. Increased supply of bloodvessels and nerves to a part of the tegument which is thin, soft, or papillose, exalts its sensibility; as, for example, in the lips, at the end of a teat, of a clitoris or penis, and to a degree, in the latter instances, approaching the character of a special sensation. In land-mammals the hair is not developed on the more sensitive surfaces, and the skin there is commonly thinnest. Man exemplifies the maximum of dermal sensibility through the comparative thinness and general nakedness of his integument. That which covers the broad tips of the fingers is unusually vascular, and richly supplied with penicellate plexuses of nerves: the filaments to the papillæ seem to terminate in condensed corpuscles of cellular tissue, certainly continuous with the terminal neurilemma—the 'corpuscula tactus' or 'axile' corpuscles,—occupying, each, the centre of a papilla. The digital papillæ average in Man $\frac{1}{100}$th of an inch in length, with a basal diameter of $\frac{1}{250}$th of an inch; they are conical with a rounded apex. Each is supplied by a branch from the arterial plexus of the cutis: they do not project, like the lingual papillæ, beyond the epithelial level. Tactile papillæ, usually of a larger or coarser kind, are developed on the digital integument in *Quadrumana*, and on the naked surface of the skin of the prehensile tail (*Ateles*); also on the naked terminal integument of the nose of quadrupeds, especially when, as in the pig, mole, and shrew, it is produced as an exploratory 'snout,' fig. 297, or forms, as in tapirs and elephants, a 'proboscis.' Certain of the papillæ of the prominences commonly so called, fig. 149, on the surface of the tongue are tactile, but whether also gustatory, or distinct from those that taste, is undetermined. The marginal integument of the upper and lower mandible of the *Ornithorhynchus* is eminently tactile.

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[1] LIV. p. 117.

[2] Ib. p. 117.

Certain hairs acquire a size, length, firmness, and such a connection of their sclerous basal capsule and bulb with sensory nerve-filaments, as to receive very delicate impressions by contact with extraneous objects or impulse: they are termed 'vibrissæ' or whiskers. The bulb and capsule[1] of the whisker is sunk deep into the substance of the derm, and is inclosed in a sclerous capsule,[2] which in the walrus[3] shows an almost cartilaginous hardness. The bristles, in that marine carnivore, have the firmness of horn, and act as a staff, in a way analogous to that held and applied by the hand of the blind man.[4] The varieties in the character of vibrissæ are, in like manner, adapted to receive and communicate the impressions affecting particular species, or special localities—eyebrows, cheeks, lips—where they may be developed. Whiskers are long and fine in the crepuscular cats; still longer in the nocturnal aye-aye.

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[1] xx. vol. iii. (1835), pl. xliii., fig. 7, *f*, 'internal theca.'

[2] Ib. *e*, 'external theca.'

[3] Ib. fig. 10.

[4] The analogy of this action in aquatic mammals to the impressions conveyed by vibrations continued from the surrounding medium along the gelatinous contents of

The corpuscular thickenings of the neurilemma with the soft centre to which the terminal nerve-filament may be traced ('Pacinian bodies,' vol. i. p. 324, figs. 213, 214) are related to the present simplest and most diffused kind of sensation. The degree in which any given part of integument can discriminate two distinct contacts is shown by the intermediate distance at which they begin to be felt as a single impression. Obtuse points of a pair of compasses, e. g. applied, to the skin, with successive degrees of approximation until they feel as one point, have shown the different discriminating power of different parts of the surface of the human body, which, in the main, is expressive of the degrees of general sensibility of such parts. The following are instances in the decreasing ratio of acuteness of feeling or discriminating power:—tip of the tongue, palmar surface of terminal joint of finger, red surface of lip, tip of nose, palm of hand, skin of cheek, sole of foot (parts of), buttocks and adjoining part of thighs, loins, back.[1]

As the seats of special sense are almost devoid of common sensation, so surfaces with peculiar kinds of the latter, as the teat, penis, or the skin of the axilla, palm and sole susceptible of the sensation called 'tickling,' have low degrees of tactile discrimination. For the phenomena and relations of the sense of temperature, see LXVIII″.

The horn-cased feet of the Ungulates, devoid of prehensile power, need no nicety of touch; but they have a sensitiveness by which the degrees of firmness of soil, e. g., may be appreciated; and this is due to the disposition of a highly vascular and nervous stratum into fine and long villi on the sole, and into numerous close-set lamellæ, fig. 17,[2] 17, which, interdigitating with soft horny lamellæ in the inner surface of the wall of the hoof, relate, at the same time, to its renewal and firm attachment to the terminal phalanx.

In Cetacea the peripheral surface of the derm is produced into fine and long papillæ, highly vascular, and connected with nerve-

the tubes whose buried base receives the sensitive nerve, in certain Fishes (vol. i p. 325), was first appreciated by HUNTER. XX. vol. iii. p. 55.

[1] For further details and gradations see LXVIII″. vol. ii. p. 516, and LXIX″.

[2] XX. vol. iii. p. 58, preps. nos. 1410–1413.

filaments from the subdermal plexus. HUNTER placed his demonstrations of this structure in the series of tactile organs, and remarks:—'These villi are soft and pliable, they float in water, and each is longer or shorter according to the size of the animal. In the Spermaceti Whale they are about a quarter of an inch long; in the Grampus, Bottle-nose, much shorter; in all they are extremely vascular;[1] they are sheathed in corresponding hollows of the epiderm.'

The naked skin in Cetacea is even, smooth, and polished, in most instances: the numerous longitudinal plaits along the under and forepart of the body in fin-whales (*Balænoptera*, fig. 217, *c*), would allow of transverse expansion; yet the thorax which they cover needs not such provision. It is peculiar to the swifter-swimming whales that pursue mackerel and herring, and may serve to warn them of shoals, by appreciation of an impulse of the water rebounding therefrom, and so conveying a sense of the propinquity of sunken rocks or sand-banks. Sensitiveness to movements of the ambient ocean is indicated by certain observed phenomena. Thus whale-fishers aver that when a straggler is attacked its fellows will bear down from some miles' distance, as if to its assistance; and it may be that they are attracted by perception of the vibration of the water caused by the struggles of the harpooned whale or cachalot. But, in the main, tactile or discriminative sensibility is very low in the Cetacean order. The thick hard and short vibrissæ on the lips of *Sirenia*, appear to relate rather to prehension than exploration of food.

The extent of surface and delicate organisation of the parts of the skin forming the wings and ear-conchs of those of the Bat-tribe that pursue volant insects (vol. ii. fig. 156), and the antennal nose-leaves of many species (*Rhinolophidæ*), relate to the perception of atmospheric impulses rebounding from surfaces near which the Bat approaches in flight. Thus, when deprived of sight, and with the ears and nostrils plugged up, as in Spallanzani's questionable experiments, he avers that the Bat was capable of directing its flight with the same security and accuracy as before, guiding its course through passages just large enough to admit it without coming into contact with the sides, and even avoiding numerous small threads which were stretched across the room in various directions, the wings never touching any of them. The delicate sensibility of the membranous integument meets all the conditions of the crepuscular or nocturnal flying of the bat, without involving a new and peculiar 'sixth sense,' as deduced by the narrator of the above experiments. Like the antennæ of some insects, the ear- and nose-leaves of some Bats have rapid vibratile movements; such, at least, have been observed in captive specimens, each pinna moving independently of the other: 'it looked as if he were feeling for sound and smell.'[1] The nasal leaf is livid or flesh-coloured in *Rhinolophus*. In the bats of passive food, such as the Vampires (*Desmodi*) that are attracted by scent in a direct flight to the large living body they suck, and, when gorged, flit lazily back to drowse away a long digestion in their murky retreats; or such as the Roussettes (*Pteropi*) that wing their way to fruit trees, and, after feeding, suspend themselves in sleep to the branches; the auricular and nasal tegumentary appendages are small and simple: such sensitive tactile guides or warners in flight are only needed in the bats of active food, which must follow in swift evolutions, like the swallows, but in gloom, the volatile insects that people the summer air at dawn or dusk.

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[1] xx. vol. iii. p. 57, nos. 1403–1405.

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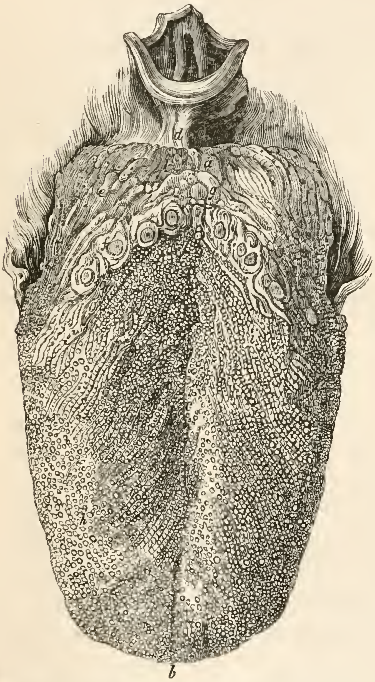

Human tongue, gustative surface, or 'dorsum.' CCXL.

§ 214. *Organ of taste.*—The tongue attains in mammals its full development as an organ of taste; and, as respects the extent and organisation of the gustative surface, in the highest degree in Man, fig. 141. The chief distinction of this from a tactile surface is that the sensitive papillæ are on processes rising above the epithelial level, said processes being commonly called 'papillæ.' As we descend in the mammalian series the mechanical offices of the tongue predominate over the sensitive ones. In the Giraffe, Pangolins, Anteaters, and Echidna, its most obvious office is that of prehension; and in the Ornithorhynchus it supports teeth, horny like those of the jaws, and it has mechanical modifications in relation to the cheek pouches. In all Mammals the dorsum of the tongue is more or less papillose, and in most the papillæ offer the three conditions called 'conical,' fig. 150, 'fungiform,' fig. 149, and 'fossulate,' fig. 148, *f.*

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[1] LXXIX''. p. 65.

The tongue is well developed and freely movable in all Marsupials, and the epithelium covering the conical papillæ is rarely condensed into spines. In the carnivorous species, as the *Dasyuri,* the conical papillæ are minute and soft, but directed backward, so as to give a slight roughness to the tongue when stroked in the opposite direction: under a lens they appear like fine shagreen. Near the base of the tongue in *Dasyurus viverrinus* there are three fossulate papillæ, in triangle, with the apex toward the epiglottis. A small fibrous or sclerous rudiment of the 'glosso-hyal,' called 'worm,' or *lytta,* lies lengthwise beneath the tip of the tongue. In the Perameles, besides the minute and generally diffused simple papillæ, there are fungiform ones, of larger size, placed at distances of nearly a line apart, and raised about a third of a line above the surface of the dorsum. The fossulate papillæ correspond in number and arrangement with those of the Dasyures, but the entire tongue is relatively longer and more slender, especially in *Per. lagotis.* In some species of Opossum, as *Didelphys Philander,* the margin of the tongue is fringed with a series of fine long papillæ. In *Didelphis virginiana* the conical papillæ of the fore part of the dorsum are retroverted and sheathed with hard epithelium. In the Phalangers there is a thickening at the edge of the frænum linguæ, but no true lytta: the dorsal papillæ resemble those of the Dasyures, but are somewhat more obtuse. In the Kangaroo there is a callous ridge along the middle of the under surface of the free extremity of the tongue, and a corresponding furrow along the dorsum: the latter is common to all the Marsupials. In the Wombat and Koala the dorsum of the tongue rises somewhat abruptly from a furrow surrounding its base; its form is narrow, moderately deep, diminishing in this respect to the tip, which is rounded. In both the Kangaroo and Koala there is a single large fossulate papilla near the base of the tongue. In *Dendrolagus* there are three such, arranged in a triangle with the apex turned forward.

Most Rodentia show two well-marked divisions of their usually deep and compressed tongue: an anterior, which from its vascular and papillose surface is the main seat of taste, and a posterior or intermolar tract, which rises somewhat abruptly above the level of the preceding and brings the food to that of the triturating surface of the molars.

The tongue seems to fill the narrow mouth of Rodents more compactly than usual, commonly bearing the impress of the palatal furrows on its dorsum and of the grinding teeth on its sides: the free apex is short and usually obtuse, seldom if ever protruded beyond the scalpriform incisors. In the coipu (*Myopotamus*) it is acuminate and covered with small retroverted shining velvety papillæ; the free part is three quarters of an inch in extent: the basal portion of the dorsum is less abruptly elevated than usual: it has but two fossulate papillæ, as in the capybara and *Leporidæ*. The squirrels and most other Rodents have three fossulate papillæ forming a triangle, but in marmots they range almost in a line. In *Capromys* the apex is rounded, free for half an inch, and impressed by small follicular apertures: the conical papillæ are minute, but near the base become larger and retroverted: here numerous delicate lines converge toward the epiglottis: the intermolar part of the dorsum is less elevated. The Agoutis (*Dasyprocta*) differ from the Cavies, Beavers, and Hares, in the gradual elevation of the intermolar part of the dorsum: the apex is subacuminate, minutely papillose above, with a middle longitudinal furrow: at the root are many elongated processes covered by a thickish epithelium. In the beaver the membrane on the sides of the tongue descends a very little way, and is reflected upon the inside of the cheeks, in advance of the molar teeth. In the porcupine (*Hystrix*) one sees a series of scale-like or wedge-shaped processes, with the free margin divided into two or three points, on each side of the tongue.

In *Insectivora* the tongue offers little worthy of notice: most have three basal fossulate papillæ, in triangle with retroverted apex. *Tupaia* shows a long frænum continued to near the apex, and having, on either side, a thickish fimbriate fold. In *Vespertilio murinus*, among the Bats, the papillæ at the fore part of the tongue have a firm epithelium; some soft obtuse fungiform papillæ show a serial arrangement: two fossulate papillæ are near the base. In *Phyllonycteris Poeyi* the papillæ are retroverted and especially long and setose on the edges of the tip; which is narrowed and canaliculate. In *Artibeus* the fore part of the tongue is roughened by very short papillæ; those behind are larger. In *Monophyllus* the apical papillæ are so long as to give a pennicellate character to the tip of the tongue, but this relates rather to its prehensile function, as in probing night-blowing flowers for minute insects. The same brush-like character is observable in the conical papillæ of many other Bats: in the Vampires (*Desmodus*) such modification is subservient to suction. In some kinds of *Pteropus* the conical papillæ have a hard epithelium and terminate in many points: the fossulate papillæ at the base are three in number in this genus.

The contrast in extensibility of tongue is very great in the Lissencephalous group, as, e. g., between the *Rodentia* and *Bruta.* Viewed as orders, the first offer the least, the latter the greatest, power of protrusion and mobility of the lingual organ in the whole Mammalian class: but the unimportance of this character as telling against affinity is shown by a similar contrast between the two representatives of the Monotrematous order, *Ornithorhynchus* and *Echidna.* The characteristics of the tongue in *Bruta* are due to the development of its motory rather than its sensory attributes, are attended with increase of the hypoglossal more than of the glossopharyngeal or trigeminal nerves, and relate to the acquisition rather than to the discrimination of alimentary matters. In the family (*Loricata*) of the order including the most promiscuous feeders, the tongue is better endowed with the power of testing the sapid qualities of the miscellaneous organic substances in the rubbish of the forests among which the Armadillos are habitually poking their pig-like snouts. Relegating, therefore, the notice of the tongue of the purely phyllophagous and myrmecophagous *Bruta* to a future chapter, I shall here merely state that, in the Armadillo, the tongue tapers to the free end, has a convex dorsum, transversely wrinkled and finely papillose: at about an inch from the root, in *Dasypus Peba*, there are two fossulate papillæ[1] on the same transverse line, behind which a medial furrow extends to the epiglottis.

The tongue has but little mobility and a small extent of free margin in any Cetacean. In the Porpoise the tip is fringed by obtuse processes of varying length, but all short, fig. 296, *h*, the dorsum is flat, devoid of papillous processes, and smoothly covered by a level of thick epithelium. In the Grampus a similar fringe extends some way back on each lateral margin of the tongue. Anteriorly these margins are made irregular, in the Cachalots, by fissures and warty prominences. The Whales have not the fringed or verrucose marginal structure. The tongue in them is chiefly remarkable for its huge size even relatively to the body; and this is mainly in breadth and depth. When swollen by putrefaction the fore part may be protruded a little way as in fig. 217. The dorsum, devoid of papillæ, has its membrane thrown into numerous minute wavy or subparallel folds. The root of the tongue, in Hyperoödon, shows many pores of glandular follicles, anterior to which are four large fossulate papillæ, with a few obtuse conical papillæ at the sides: a similar structure here occurs in the tongue of the Cachalot, which Hunter compares to 'a feather bed:' but the comparison is more applicable to that in the whale-bone Whales: for the tongue is firmer and more muscular in the Cachalot and other toothed *Cetacea*, than in those with baleen. Most Cetacea offer a marked contrast to the other Mammals in having the skin of the tongue separated from the flesh by a layer of blubber. As a rule, in Mammalia, the vascular and sensitive lingual membrane adheres as closely to the muscular tissue as does the very similar skin of the snail: its sanguine tint in Balænidæ is not obscured by pigment: but in some *Delphinidæ* this is present of a leaden colour.

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[1] Daubenton states that he saw not any papillæ even with a strong magnifier, CXXII′, vol. x. p. 242; and De Blainville appears to have been led by this statement to affirm of the 'glands calycinales des Edentés,' that 'quelquefois elles sont nulles,'—LXXX″, p. 255,—of which, however, I have seen no instance.

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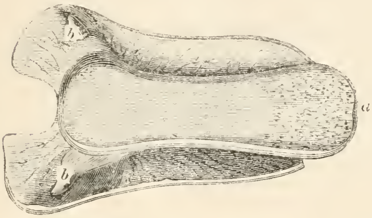

Tongue of Dugong (*Halicore*).

In *Sirenia* the tip of the tongue, fig. 142, *a*, projects a little more freely, but does not reach the fore part of the mouth: the tongue is narrower in proportion to its length; but is chiefly remarkable for the excess of development of the epithelium. In the Dugong this covering of the conical papillæ at the fore part of the dorsum gives it the appearance of being beset with spines. A large, but short thick, retroverted horny process projects from each side of the base of the tongue, ib. *b, b*. The conical papillæ in *Manatus* have a less firm epithelium, and are longer and finer than in the Dugong; they are limited to the apex and part of the dorsum. The fossulate papillæ are numerous, extending on each side the dorsum from the anterior third to near the base of the tongue. The lingual epithelium appears to have reached the maximum of development in the now extinct boreal Manatee (*Rhytina Stelleri*).

The tongue of the Elephant is tied down, as in the Cetacea, and a part of the dorsum is made by muscular action to represent the tip when it projects: in relative size to the head it offers the extreme contrast to the tongue of the Whale: it is not only short, but narrow, and represents, apparently, the intermolar part of the tongue in Rodents. It is, however, eminently gustative: the membrane is highly vascular, with very numerous minute and rather obtuse conical papillæ, and a few large fossulate ones near the base.

In the Rhinoceros the tongue is broad and flat, a little expanded anteriorly, and becoming narrower and deeper as it passes backward: there is a small protuberance on the dorsum, between the posterior grinders, divided by a median furrow: the large fossulate papillæ are principally collected, in a group of ten or twelve, on each of these risings; the fine close-set pointed papillæ on the fore part of the tongue resemble short hairs; behind these papillæ the epithelium is condensed into a thick callous stratum, and becomes thinner at the posterior glandular part of the tongue. There is a 'lytta' beneath the anterior flattened freely projecting part or tip of the tongue.[1] The horse has a relatively longer and narrower tongue, with a greater extent of free-tip, with much and various motion and prehensile power: the base of the tongue is steadied and the origin of the 'linguales' extended by the glossohyal (vol. ii. fig. 305, E, *g h*): the surface of the dorsum is smooth and firm, the conical papillæ being minute and close-set; there are a few fungiform papillæ along the sides, and three large fossulate ones at the base; the free ends of the former kind are subdivided or papillose. The tongue of the Hippopotamus is remarkable for its terminal expansion and flatness: it is slightly notched at the middle of the broad tip: the conical papillæ are numerous and small; the prominent part of its large fossulate papillæ are cleft into smaller ones. In the Hog the edges of the fore half of the tongue are fimbriate: near the base are two fossulate papillæ; behind which are numerous coarse retroverted conical papillæ, subserving deglutition. The lingual margins are not fimbriate, in *Phacochœrus*: the fossulate papillæ are two, as in *Sus*, and the anterior two-thirds of the dorsum are beset with firm gustative papillæ.[2] Numerous small conical papillæ give a villous character to the dorsum of the free fore-part of the tongue of the Camel; among which larger obtuse fungiform papillæ are dispersed here and there; mostly at the under side near the margin: the dorsum rises at the intermolar region, the conical papillæ increase in size, and very large fossulate papillæ are placed in a row on each side: the mid-prominence is here, also, subdivided; and the secondary papillæ usually surround a secondary fossa, fig. 143, *b*. The tongue of the Llama is similarly divided into a free, gustative, and prehensile part, and a deeper intermolar masticatory and deglutitional part. The conical or filiform papillæ are most delicate and minute, extending over the dorsum of the anterior division, and upon the sides of the fore part of the posterior one. A shallow longitudinal channel impresses the middle of the dorsum of the free part. The fungiform papillæ are scattered along its margins, being largest at their under part, and here also appear in a distinct longitudinal group at the middle in advance of the frænum. The callous processes and fossulate papillæ in the intermolar part resemble those in the Camel. In true Ruminants the conical papillæ in the fore part of the tongue are elongate, retroverted, and sheathed by an epithelium harder than in the *Camelidæ*: the fungiform papillæ, and the large irregular callous projections on the intermolar part are repeated: the fossulate papillæ are usually rounded and less in size. In some ruminants, e. g. Aurochs (*Bison europeus*), the tongue is of a deep leaden colour. The muscular, vascular, and nervous structures of the long, prehensile tongue of the Giraffe, fig. 144, are described in detail in XCVII′ (pp. 221–224): and in relation to the gustative function it need only here be noted that the epithelium is thickest at the apex, on the upper surface of which it sheathes the conical papillæ,

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[1] v″. p. 39.

[2] LXXXIX″. p. 64.

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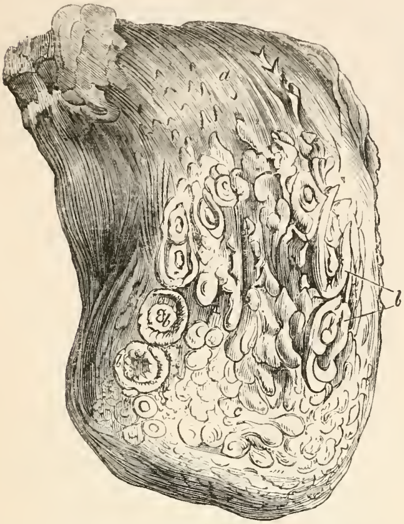

Base of tongue, Camel. LXXXI″.

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Tongue of the Giraffe. XCVII′.

and forms minute retroverted spines, which occasion the rasp-like roughness which is felt in the tongue of the living animal. The upper superficial layer of the lingualis, which acts more directly on these papillæ, and is by some called 'notoglossus,' is conspicuously differentiated from the main mass at this part of the tongue. The deeper transverse fibres decussate with those of the opposite side, the 'septum albescens' being but partially present in the tongue of Ruminants. In the Giraffe a dark leaden-coloured pigment is developed beneath the epithelium, covering the anterior half of the tongue, in relation, perhaps, to its frequent exposure, under a tropical sun, in the prehension of the leafy food: the pigment assumes a black colour over the prominent round fungiform papillæ, which are somewhat sparingly scattered, like coarse grains of gunpowder, over the dark-coloured portion of the tongue; from fifteen to twenty fossulate papillæ are arranged in an irregular longitudinal row on each side of the raised intermolar part of the tongue. As the organ is mainly a prehensile one, its structures thereto adapting it will be described in connection with the preparatory instruments of digestion.

In most Carnivora the septum is complete, and the 'fibræ transversæ' are firmly attached to it, instead of decussating. The lower margin of the septum is thickened, and in many species includes the long cylindrical fibrous body, representing the 'glosso-hyal,' called 'lytta,' and in Dogs, where it attains its largest size, 'the worm.'[1] It may help by its elasticity, and that of its sheath, in the act of lapping. In the Seals the apex of the tongue is bifid and fringed with delicate papillæ; they are less marked on the upper flattened surface: towards the base are the 'fossulate papillæ,' behind which the lingual membrane is puckered into rugæ and beset with numerous follicles. In the Bears the apex of the tongue is entire, expanded, and impressed above by a medial longitudinal groove: the conical papillæ are minute and close-set, with soft epithelium: those at the under part of the margins are coarser. In *Subursus Thibetanus* with the simple papillæ are intermixed small white petiolate papillæ: near the base are eleven large fossulate papillæ forming two sides of a triangle whose apex is turned backward. The tongue of the Kinkajou (*Cercoleptes*) shows seven fossulate papillæ similarly placed and arranged; but it has a long and large 'lytta,' ligamentous anteriorly, cellular posteriorly, in a sheath of circular fibres.[2]

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[1] XX. vol. iii. p. 83, nos. 1514 (*Hyæna*), 1514A (*Jackal*).

[2] LXXXII″. p. 122.

In the Hyæna the tongue has a circular group of conical papillæ near the fore part of the dorsum sheathed by horny epithelium, forming retroverted spinules. In Felines they cover a larger proportion of that part of the tongue, forming a powerful rasp in the great species.[1] The gustative papillæ are very fine and setose, intermingled with the horny ones, and more abundant towards the margins, where also the larger petiolate papillæ are scattered. In the Lion the tongue appears of considerable length in consequence of the distance between the hyoid and the bony palate.[2] The soft palate is of proportional extent, and all that part of the tongue co-extended therewith is represented by a smooth faucial membrane: as it advances it becomes covered with large soft retroverted papillæ; then there appear four large fossulate papillæ, anterior to which the simple conical papillæ continue, increasing in size to near the tip. In the Jaguar there intervenes between the epiglottis and the proper base of the tongue a smooth faucial mucous tract, like that in the Lion, of three inches extent. In the Leopards, Ounces, Lynxes and Cats, the larynx and tongue are in close proximity. No Carnivore shows a raised intermolar part of the tongue. It is equally absent in Quadrumana. In this order Hunter noted in a *Lemur Mongoz*, L., which he dissected, that 'the tongue has a part underneath, shaped like a bird's tongue, so that it might be called double-tongued.'[3] This long flattened process, bifid at the apex, is shown to be continued forward from the frænum in the prep. No. 1516.[4] A like structure is shown in *Loris* (No. 1518); and two smaller frænal processes are shown in the tongue of another Lemurine species (No. 1517). This lingual character has since been found to prevail throughout the Strepsirhine group[5] down to and including the Aye-aye (*Chiromys*). In this animal the frænal or sublingual plate[6] has a short and simple apex, behind it a filamentary longitudinal gristly ridge or 'lytta,' projects from the middle of the under surface of the tongue. A narrow free fold of membrane is continued backward from each side of the base of the frænal plate to the corresponding side of the pharynx: a like structure obtains in the Galagos and Pottos, and supports the terminations of the ducts of the submaxillary and sublingual glands. In *Perodicticus* the broad apex of the frænal process is jagged.[7] The conical papillæ are short, subobtuse, and rather large, proportionally, in the Aye-aye, becoming more so toward the fauces. The fossulate papil læform a transverse pair. In Galagos and most other *Lemuridæ* there are three fossulate papillæ, in a triangle, with the apex backward.[1] Obtuse or fungiform papillæ are interspersed with the conical kind in *Lemur* proper. The tip is sharp-edged in *Lemur* and *Microcebus*, round and obtuse in Galago and Aye-aye.

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[1] xx. vol. iii. nos. 1509–1513.

[2] The corresponding modification of the hyoid arch in *Felidæ* is noticed in vol. ii. p. 506.

[3] ccxxxvi. vol. ii. p. 29.

[4] xx. vol. iii. p. 84.

[5] lxxxiii″, to lxxxviii″.

[6] cii′. p. 41, pl. xii. figs. 8 and 9, *a*.

[7] lxxxv″. pl. 8, figs. 8 and 9.

In some of the Platyrhines the tongue is long, slender, and somewhat pointed, e.g., *Callithrix*: in which the fossulate papillæ are three in number, with the apex of the triangle backward. The ‘sublingua’ is rudimental or obsolete in these and in catarhine *Quadrumana*, in which the tongue gains in thickness and depth: the fossulate papillæ continue to be three in number, but the general structure of the tongue closely resembles that in Man.

The human tongue, fig. 141, mainly differs from that in *Quadrumana* in being, so to speak, less massive, less deep relatively to its length and breadth, with a greater proportion of its margin free, and for a greater extent. It is the most perfect of all tongues in its gustative and other sensibilities, and especially in the rapidity, freedom, and variety of its movements; whence its applicability to the numerous exigencies of articulate speech, as well as to prehension, mastication, insalivation and deglutition of alimentary substances.

Of the muscles moving the tongue some, e.g. ‘stylohyoid;’ ‘digastricus,’ mylohyoid,’ ‘geniohyoid,’ ‘sternohyoid,’ act upon it through the medium of the hyoidean arch: others, e.g. ‘styloglossus,’ ‘genioglossus,’ ‘hypoglossus,’ ‘palatoglossus,’ arising from extrinsic points pass or are inserted into the tongue's substance: a third class of fibres mainly constitute that substance in which they both begin and end, and are called the ‘intrinsic muscles,’ and collectively ‘linguales.’ In the transverse section, fig. 145, the genioglossi, *d*, are seen decussating vertically with the central intrinsic fibres, *c*: these are nominally distinguishable from the ‘peripheral mass’ of these fibres, *b*, owing to their greater number and more compact arrangement at this

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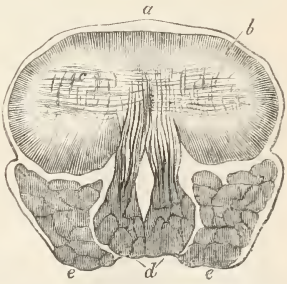

Transverse section of Human tongue, at the fore part of the frænum CCXL.

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[1] LXXXV''. pl. 8, fig. 7.

part; in a section anterior to the genioglossi the peripheral layer is uninterrupted. The central mass consists of transverse and vertical fibres, the latter not wholly intrinsic but partly derived from the genioglossi: the peripheral mass mainly consists of longitudinal fibres, of which those along the upper and under surfaces are intrinsic, those on the sides of the tongue in part derived from the styloglossi.

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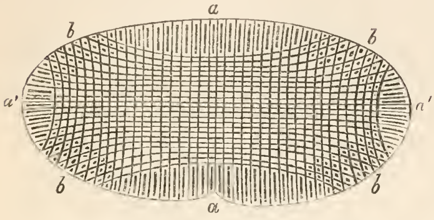

Plan of intrinsic muscles of tongue. CCXL.

As exemplified in the plan, fig. 146, the vertical and transverse fibres decussate in the centre, and there exclude the longitudinal fibres: the vertical ones diverge and spread as they approach *b*, *b*, and cease near the margins *a′*, *a′*; the transverse also diverge, as they approach *b*, *b*, and disappear near the upper and under surfaces *a*, *a*. The vertical emerge from the transverse as they come near the upper and under surfaces *a*, *a*, and the transverse extend freely from the vertical to attain the lateral margins *c*, *c*. The longitudinal fibres, which appear as discs in transverse section, fig. 147, *c*, are seen near the periphery, where the diverging vertical and transverse fibres leave room for them, as at *b*, *b*, and in greater proportion at the surfaces *a a*, *c c*. Thus, at certain portions of the tongue, three sets of fibres traverse the same area, in as many distinct directions and at right angles one with the other; the arrangement being so that the crossing of the fibres of any two sets forms

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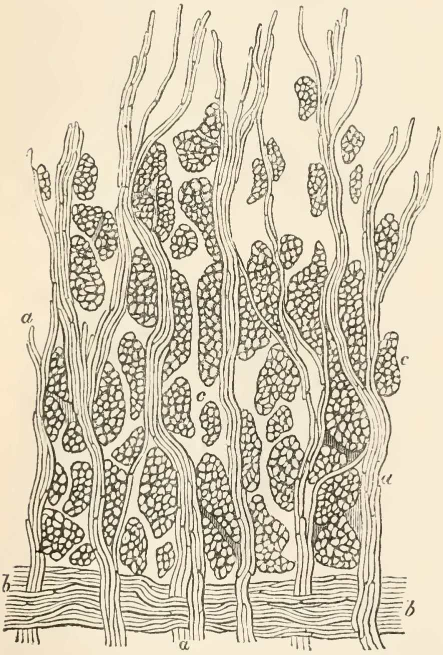

Section of cortical layer, upper part of tongue. (30 diam.) CCXL.

a net, the meshes of which in successive layers become canals through which the fibres of the third set pass; hence in whatever plane they be viewed, two sets are seen, in profile, crossing, and one, in section, perforating; by which arrangement they mutually support and conduct each other, independently of connective tissue, the dispensing with which allows for the aggregation of so much more muscular tissue in the tongue's substance. In fig. 147, a magnified view is given of a section from the upper surface, *a*, in fig. 145: *a* are the vertical fibres extending to that surface, beyond the uppermost transverse fibres, *b*, and decussating with the longitudinal fibres shown in section at *c*. This complex arrangement becomes simplified toward the apex: the longitudinal fibres first ceasing, next the vertical ones, and the transverse alone being continued to the tip.[1]

The skin of the tongue is divided into the papillose, glandular, and smooth, mucous, or faucial areæ: the latter, fig. 141, *d*, has about half an inch of longitudinal extent when not stretched, and answers to the much more considerable tract in the Lion. The glandular area is defined anteriorly by the fossulate papillæ, ib. *f*, here arranged 'en chevron,' four on each side converging toward the backwardly turned point: behind this is sometimes seen a fossa devoid of papilla, the 'foramen cæcum' of Anthropotomy. The papillose area extends over the major part of the tongue to its tip and down the sides along part of the under surface; it is roughened by papillæ which extend from the medial groove in oblique series forward and outward, repeating in the main the arrangement of the fossulate or glandular papillæ.

The tongue-skin presents a basal areolar tissue, so dense in the glandular and papillose areæ as to resemble the corium: at the faucial area and under surface of the tongue it softens into the character of that of the mucous membrane of the cavity with which it is continuous: where it overlies the muscular part of the tongue, as in fig. 145, *a*, it is closely adherent thereto, and is thickest at the middle line: peripherally it projects as 'papillæ,' sinks into 'fossulæ,' and is inverted to form the ducts or orifices of mucous follicles. The epithelium is scaly, thick and distinguishable into a deep layer adherent to the corium and a superficial layer which readily desquamates. The so-called 'papillæ' are processes of the corium, rather analogous to the villiform ones in the intestinal mucous membrane of some animals (vol. ii. p. 170), and subdividing, as in those, into the 'villi' or papillæ truly answerable to those of the skin; the tongue-papillæ or processes differ, therefore, from the true dermal papillæ in standing freely out from the surface of the epithelium, which is moulded upon them, and does not plaster them over to its own level. The so-called lingual papillæ are of three kinds, 'fossulate' or circumvallate, 'fungiform,' and 'conical,' many of the latter being also called 'filiform.'

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[1] For further and more minute details of this exquisite arrangement of the muscular tissue for the functions of the tongue, reference should be made to the admirable article CCXL, in which the accomplished author, HYDE SALTER, first described it.

The fossulate papilla, fig. 148, *a*, is large, obtuse, subpedunculate, and arises from a fossa, *b*, by the thickened and often crenate borders of which, *c*, it is surrounded. The nerves and vessels enter the papilla at its pedicle; and the expanded summit subdivides into the secondary true papillæ, plastered over by the epithelium. The average number of fossulate papillæ in Man is eight, arranged as in fig. 141, *f*: there be sometimes ten, rarely more; often fewer than eight, but not less than four. Their arrangement may vary to that of an almost transverse line. They are supplied by branches of the glossopharyngeal; are very vascular; and, from the thinness of the epithelium, appear red when injected.

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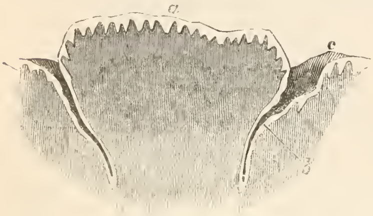

Section of fossulate papilla (16 diam). CCXL.

The 'fungiform papillæ,' fig. 149, B, are subpedunculate, but smaller than the fossulate and rounder: they are scattered over the sides and tip of the tongue, and on the dorsum anterior to the fossulate series. They are rather larger than the filiform, and conspicuous by their red colour. They are covered by

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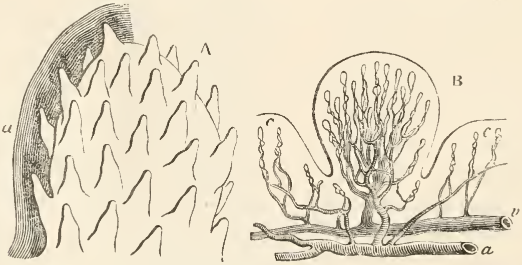
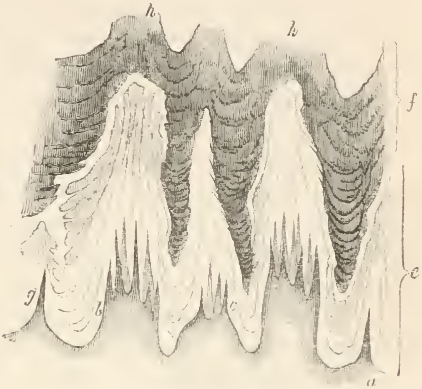


Fungiform papillæ. CXI''.

secondary papillæ, ib. A, in which the capillaries diverge and divide to form their brush of loops, as in fig. 149, B, receiving each its capillary loop, into the fasciculus of which the branch of the artery *a* and vein *v* subdivides on entering the mushroom-like papilla or process.

150



Conical papillæ. CCXL.

The conical papillæ clothe as in a close-set pile the anterior two-thirds of the dorsum: they are longest at the mid-line near the centre of the tongue, smallest near the sides and at the tip. The cone-form, with secondary papillæ down its sides, fig. 150, merges into the cylindrical form, fig. 151, with a terminal brush of filaments. The excess of the scaly covering of these, ib. *a*, *b*, *c*, forms the so-called 'fur' of the tongue, which becomes separated from the deeper layer of epithelium, *d*. In the conical variety, fig. 150, *a* is the basal membrane, *b*, *c*, the 'processes,' subdividing into secondary or true papillæ, *e*, the deep layer of epithelium, *f*, the superficial layer, *h*, the points from which the filamentary prolongations would have projected: these sometimes resemble fine hairs. The function of such filiform papillæ appears to be 'portative' and 'protective,' that of the conical papillæ mainly 'tactile,' that of the fungiform and fossulate ones 'gustative:' behind the latter are the principal mucous follicles.

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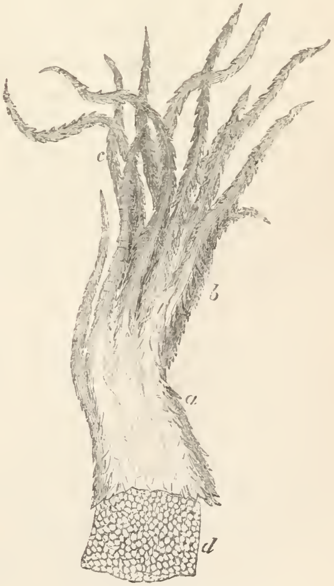

Filiform papillæ. CCXL.

The so-called gustatory branch of the fifth supplies the fungiform, conical, and filiform papillæ; the glossopharyngeal serves the fossulate papillæ and the mucous tract behind: the ninth or hypoglossal is expended upon the muscular tissue.

§ 215. *Organ of Smell.*—Most Mammals are remarkable for the degree in which the sense of smell is serviceable. The class is characterised by the extent of the pituitary surface and the size and number of the olfactory nerves; nevertheless, both extremes are therein exemplified, although the family (*Delphinidæ*) in which the organ is wanting is exceptional and maximised development the rule.

The progress is not, as with the organ of taste, *pari passu* with the rise in the class: both Man and monkeys are below most quadrupeds in olfactory endowments. In hoofed ones smell is important in the the discrimination of wholesome from noxious food: taste would be a tedious test, the sapid matter needing to be moved about or masticated, mixed with fluid, and more or less dissolved, before the tongue can exert its gustative power; but 'smell is done at once.'[1] Most flesh-feeders scent afar their food.

In Mammals, as in all air-breathers, the odorous atoms strike upon the olfactory membrane at the entry of the breathing passages, where the atmosphere is filtered, as it were, through the organ of smell before reaching the windpipe; and most effectively and instructively in the pinnigrade *Carnivora*.

The olfactory organ in Mammals receives its special endowment from nerves which rise in numbers from their proper encephalic centre, fig. 46, 47, R. They pass out by as many holes in the plate of the prefrontal, which is thence called the 'cribriform,' or, from the Greek-root, 'ethmoid:' but the sieve-like structure is a strictly mammalian peculiarity consequent on the multiplicity of olfactory nerves, and is only affected by a single exception in this class, the Ornithorhynchus adhering to the wider Vertebrate rule.

The nerves carry out with them, each an investment of the brain-membranes; the dura mater losing itself in the periosteum, the pia mater in neurilemma, the arachnoid being reflected back. The nerves are grouped in all Mammals into a set for the septum, and a second for the upper or ethmo-turbinals, a third or middle short set being, in some, distinguishable for the labyrinth or roof of the nasal chamber. The branches of the second set, after expanding on the ethmo-turbinal, usually converge to become connected with the lateral nasal branch of the 'fifth.' Their mode of distribution is best seen on the ethmo-turbinal:

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[1] XX. vol. iii. p. 86.

here they divide, subside, expand, and anastomose with each other, forming a reticulate nervous expanse, with long and narrow meshes, and becoming impacted in the central or inner layer of the olfactive membrane. This membrane is continued into the pituitary one, covering the inferior spongy bone or 'maxillo-turbinal' supplied mainly by the fifth. Both tracts, and especially the latter, are richly supplied with arteries opening into numerous large plexiform veins on the peripheral side of the membrane, occasioning or resembling, there, a cavernous structure, and admitting of such change in the quantity of blood therein as must be attended with concomitant degrees of laxity or tension of the scenting membrane itself.[1] This at the attachment of the turbinals is continuous with the lining of the nasal chamber; which itself becomes modified into the more delicate and still less vascular membrane of the contiguous or accessory air-sinuses. The nasal membranes are finally continued at the posterior aperture into the mucous membrane of the fauces and pharynx, and at the anterior one into the integuments of the face. The pigmental layer of the skin is soon lost within the nose, the colour of the pituitary and olfactory membranes being due to the abundant blood sent to them. Numerous mucous crypts are imbedded in the pituitary part of the nasal membrane.

The cavity containing the organ of smell is formed by the prefrontal, vomerine, nasal, sphenoid, pterygoid, palatine, maxillary, and premaxillary bones, and may be continued by extension of air-sinuses into all the bones of the cranium, figs. 154 and 157. The cavity is divided by a medial partition of bone and gristle in varying proportions, the bone being contributed by the prefrontals, the vomer, and by ridges of the nasals, palatines, maxillaries, and premaxillaries, with which the vomer may articulate. Each half of the cavity is a passage for the respiratory currents of air, opening anteriorly upon a more or less produced and mobile part called 'nose,' 'snout,' or 'proboscis,' and posteriorly into a cavity containing the larynx or beginning of the windpipe; sometimes, as in *Cetacea* and in Marsupials at their mammary stage, containing the larynx exclusively, but commonly communicating also with more or less of the pharynx. In the section of the human skull, fig. 152, the outer wall of the right nasal passage is shown, with the communicating frontal, 3, and sphenoidal, 4, sinuses; 1 is the nasal bone, and *a* the nasal spine of the frontal, forming the fore part of the roof, *c*, the basisphenoid, forming its back part; the 'cribriform plate and spine' of the prefrontal completing the roof: *b* is the nasal plate of the maxillary bounding laterally the anterior aperture; *d*, pterygoid, similarly bounding the posterior aperture: the floor of the passage is formed by the premaxillary, 7, the maxillary, *k*, and the palatine, 6. At the upper part of the outer wall is a thin quadrilateral part of the prefrontal sculptured by grooves and apertures for the olfactory nerves; the posterior part, *f*, is a little curved, and leaves a space into which the sphenoidal sinus opens. The convolute, thin, reticulate, bony, and gristly lamina, called 'superior turbinal,' is here attached, below which is the division of the general passage, called 'superior meatus.' This is bounded below by a similar longer and larger 'turbinal,' called 'middle spongy bone' in Anthropotomy, but usually less distinct from the upper part of the 'ethmo-turbinal' in lower Mammals. The part of the passage between the middle and lower turbinal is the 'middle meatus,' into which the 'antrum' or maxillary sinus opens. The lower turbinal is the largest of the three, and longest retains its individuality: below it is the 'inferior meatus,' *h*, into which the lacrymal canal opens.

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[1] LXXXII''. p 278, and LIV. p. 128. (The second edition of this valuable and original work, 4to, 1864, is the one cited in the present volume.)

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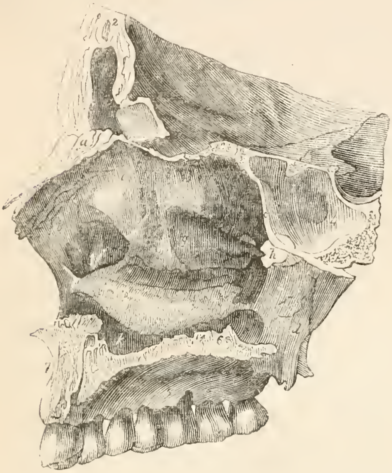

View of the outer wall of the nasal cavity on the right side.

In most lower Mammals there is a turbinal process from the frontal and nasal bones; which, from its relative position in their horizontally elongated nasal chamber, is called the 'superior spongy bone' (oberste muschel, Gurlt), by Hippotomists; it is not the homologue of that so called in Anthropotomy.

At the floor of the lower meatus, close to the premaxillo-maxillary ridge supporting the fore part of the septum, is a depression or groove lined by a glandular tract of the pituitary membrane which, in Ungulates, is extended upon a long and narrow gristly sheath at that part, and communicates with the palate by the foramen incisivum. From one to three of the ental branches of the olfactory, traceable from a yellowish grey part of the rhinencephalon, are continued down to this tract; but it is principally supplied, like the lower turbinal, by the naso-palatine nerve.[1]

Characteristic of the mammalian organ of smell is the great provision made by bony and gristly laminæ for the support of the olfactory membranes. The original extent of these primitive capsules is augmented, as in a branchial organ, by manifold plicæ and processes, usually so curved and contorted as to suggest the resemblance to turbinate univalves. The neurapophyses transmitting the nerves of the nasal segment of the skull are reduced, as has been shown, in Mammals, almost to their essential function; as such they appear in *Cetacea* (vol. ii. p. 421, fig. 287, 14). So reduced and withdrawn from outward view, they are further masked in the rest of the class by the agglutination thereto, or outgrowth therefrom, of the turbinal olfactory capsules: the whole, as agglomerated in them, receiving the name of 'sieve-bone' (æthmoid), from the exceptional peculiarity of the number of olfactory nerves in the Mammalian class. In fig. 153 is given an oblique view of this complex bone with the anchylosed sphenoid in the Hog. The confluent mesial laminæ of the prefrontals project as 'crista galli' dividing the rhinencephalic fossæ: to the under or outer part of the cribriform or perforated laminæ of the neurapophyses the parts of the olfactory capsules called 'labyrinths,' *q*, and ethmoturbinals, *s*, are anchylosed: the maxilloturbinals, *p*, remain longer distinct, and ultimately coalesce with the superior maxillaries. The convolute plates attached to the roof of the nasal chamber, fig. 157, *b*, here called 'naso-turbinals,' are in most quadrupeds added to those shown in figs. 152 and 153.

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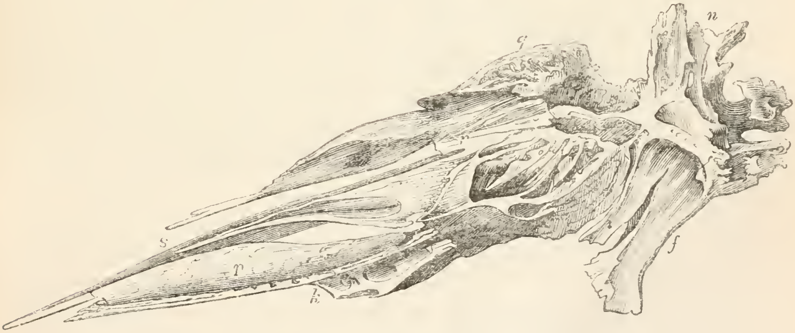

Osseous parts of olfactory capsules. Hog.

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[1] xc″, cxii″.

In the *Ornithorhynchus* one olfactory nerve quits each rhinencephalon and escapes from the skull by a single foramen at the fore part of the prefrontal plate: it divides on entering the nasal cavity into septal and turbinal branches. The membrane receiving the former is supported wholly on a bony plate: the turbinals are partly bony, and partly gristly: a prenasal ossicle is formed in the forepart of the nasal septum.

The olfactory nerves in the *Echidna* are extremely numerous, and the cribriform plate is large and encroaches upon the fore part of the cranial cavity as a convex protuberance. The ethmoturbinals are of corresponding size, composed of a series of vertical processes which expand and subdivide as they pass toward the floor of the very long nasal passage. I have shown the lateral expanse of these turbinals by a horizontal section in No. 1707, XLIV. p. 318.

The olfactory nerves and the osseous cavities and laminæ destined for the protection and support of the pituitary membrane offer a remarkable proportional development in all the Marsupials, and more especially in the Insectivorous and Carnivorous tribes. Certain species of Kangaroo, of the subgenus *Osphranter*, Gould, remarkable for their acuteness of smell, have the turbinated bones so large that the lateral expansion of the nasal cavity forms a marked feature in the skull. The characters of the osseous parts of the nasal cavity, in this order, are given in vol. ii. p. 348. Through the defective ossification of the palate the convolutions of the inferior turbinals are visible in the dry skull at that part; e.g. in *Perameles lagotis* (vol. ii. fig. 222) and in *Thylacinus*. In the latter marsupial the fine lacework perforation of the inferior turbinals is well shown.

In the Hare the inferior turbinal is large, longitudinally lamellate, and shows in well-injected specimens the highest degree of vascularity: the complexity of its medial or septal surface contrasts with the simplicity of that in Felines. The ethmoturbinals are divided into three principal lamellæ: the nasal cavity is long but narrow: the maxillary sinus is small. In the Agoutis the nasal chamber is more expanded: the ethmoturbinals which consist each of four rather short longitudinal lamellæ, are divided from the maxillo-turbinals by a protuberance from the mesial wall of the large maxillary sinus: there is a small 'Jacobson's' process from the premaxillary at the lower and fore part of the nasal cavity. In the Paca (*Cœlogenys*) the olfactory cavity extends backwards beneath the rhinencephalic one. In the Porcupines through the enormous development of sinuses from the olfactory cavity it extends backward beyond the rhinencephalic one, which it appears to encompass. The latter cavity is defined by a well-marked ridge from the prosencephalic part of the cranium. The vomer is deeply cleft posteriorly, and coalesces with the ethmoturbinals. The fore part of the vomer articulates with the median ascending process of the premaxillary arching over the wide vacuities which lead from the nasal passages to the prepalatine apertures. Besides the maxillary sinuses others are developed in the frontals, squamosals, alisphenoids and orbitosphenoids, with bony septa converging to the rhinencephalic fossæ. No nasal sinuses or aircells are developed in the skull of the aquatic beavers. In the voles (*Arvicola*) a canal leads from the crescentic orifice at the fore part of the antorbital aperture into the lower part of the nasal meatus, above the prepalatine fissures. In the rat (*Mus decumanus*) it terminates below the attachment of the anterior turbinal to the premaxillary. In all *Muridæ* the olfactory cavity is very narrow; the ethmoturbinal small and but little divided; the lower turbinal is elevated in position. The external nose is short and, as in most Rodents, is clothed with hair save at the middle of the septum.

In *Insectivora* the olfactory organ is better developed than in *Rodentia.* The ethmoturbinal of the mole has not fewer than eight primary lamellæ; but the maxilloturbinal is comparatively simple: the external nose is developed into a snout, with well-marked muscles for various and powerful movements. The development of this part is such in some African *Insectivora,* fig. 297, as to have earned for them the name of 'Elephant-Shrews.' The naked outer border of the nose in the common hedgehog is dentated: and the edge of the snout is fringed in *Condylura* with a circle of soft processes. But these, like the still more extraordinary dermal appendages in certain bats (*Rhinolophus*) relate to touch.

The armadillos and anteaters enjoy an acute sense of smell. In *Dasypus sexcinetus* the rhinencephalic almost equals the epencephalic division of the cranial cavity: but the olfactory chamber extends backward to beneath the prosencephalic division, and the ethmoturbinals are remarkably extensive and complex: the maxilloturbinal is comparatively simple. The turbinal plate of the nasal almost equals the facial plate in extent. The chief expansion of the cranium is caused by the large olfactory cavity, and the part extending therefrom into the frontals raises them in *Chlamyphorus* into a pair of domes (vol. ii. fig. 272, *a*). In most Armadillos the external nose or snout is strengthened by a pair of prenasal ossicles. The rhinencephalic chambers are large in

Orycteropus (ib. p. 404); but the olfactory ones are far more remarkable for both size and complexity. In the true Anteaters (*Myrmecophaga*) the ethmoturbinals, though large, are less developed than in armadillos. The inferior turbinal is a long slightly rolled up lamina. In sloths, as described in vol. ii. p. 406, the olfactory chamber extends backward above the rhinencephalic one into the frontal bone, and below it into the sphenoid. The extension of air-sinuses therefrom is still greater in the extinct megatherioids (ib. 407).

The baleen-bearing whales are those of the *Cetacea* which alone have olfactory nerves, although all possess the 'crura rhinencephali.' The pituitary membrane supported by the turbinal bone is remarkable for the plexus of large vessels behind it. The cetacean modifications of the nasal passages will be described with the respiratory organs, to which they mainly relate.

In *Sirenia* the nostrils are subterminal, at the top of the obtuse muzzle, and provided with movable gristles: the nasal passages contain both ethmo- and maxillo-turbinals, the latter, like the former, gristly; the small almond-shaped bones wedged into the fore part of the frontals are, as Cuvier held, nasals, not turbinals.[1] The nasal passages are short, narrow, subvertical: the ethmoturbinal is short and longitudinally lamellate. The olfactory nerves are fewer and the cribriform plates smaller in the Dugong than in the Manatee.

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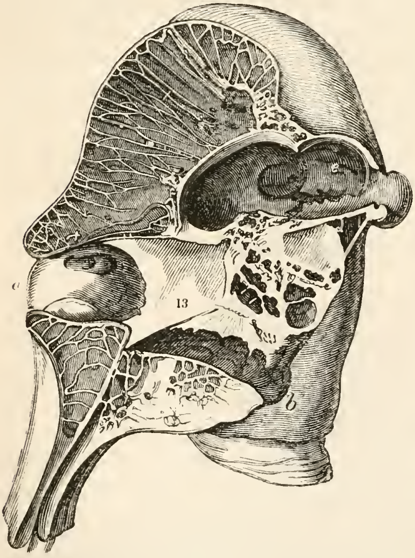

Section of Elephant's skull, showing nasal passage.

In the Elephant that part of the nasal cavity, fig. 154, which is appropriated to the essential parts of the olfactory organ is contracted and narrow, and the passages, *a*, *b*, are relatively short: they are, however, much prolonged by the accessory appendage, called 'trunk,' at the extremity of which open the nostrils (vol. ii. p. 282, fig. 162, *n*), and are as much expanded by the surrounding air sinuses, which pervade every bone of the cranium. The bony nasal passage is continued in almost a straight line from the anterior aperture, *a*, to the posterior one, *b*. The vomerine part of the septum, 13, extends from the presphenoid about half-way to the anterior aperture. At the upper part of the cavity, so divided, the ethmoturbinals are situated, which are moderately plicated: the maxillary turbinal is, also, comparatively simple in character.

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[1] 'Cornets inférieurs,' De Bl.; civ'. Gravigrades, p. 39.

In the Tapir the shorter proboscis terminates by a small pointed extremity between the nostrils. The snout is covered with hair to the base of the terminal appendage; the hair on the upper part tending upward or backward, that on the sides toward the tip. The cribriform plate is not simply perforate, but is reticulate, with long radiating meshes, the latter closed by dura mater: it sends down curved lamellæ, sheathing the olfactory nerves. The ethmoturbinal consists of as many convolute divisions attached to, or continued from, those processes, in a pedunculate way; and each is perforated by many foramina through which branches of the olfactory pass to the pituitary membrane. The maxillary turbinal is elongate and simply convolute. The nasal cartilages show the chief modification, the alar portions, fig. 155, *n*, being continued backward, expanding, and filling the peculiar grooves of the skull (vol. ii. p. 449) between the nasal bones and orbits, *o*: here the cartilages are semiconvolute, convex, and entire outwardly, excavated on the inner side, the cavity being continued by a groove into the nasal one at the sides of the outer aperture: from the character of the lining membrane, it may be regarded as an extension of 'Jacobson's fossa.' The 'levator rostri,' or raiser of the short proboscis, fig. 155, *a*, arises from the process of the lacrymal, runs in a fibrous sheath, converging to its fellow, and is inserted into the upper or fore-side of the part which, together, they raise, or, acting separately, draw to their own side. A broader muscle, 'retractor labii,' *b*, from the same origin expands to its insertion at the side of the labial part of the base of the proboscis. Beneath this is the muscle, *c*, which rising from the lower border of the lacrymal, spreads upon the

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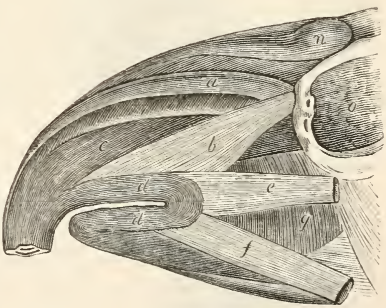

Alinasal cartilage (*n*) and muscles of trunk, Tapir. xciii''.

side of the proboscis, and is intimately connected with the 'orbicularis oris,' *d d*; *e* is the zygomatic, *f* the depressor anguli oris, *g* the buccinator.[1] The external nose of the Rhinoceros is combined with the upper lip and prolonged in a minor degree, but with a like arrangement of muscles, for prehensile purposes. The nose of the Horse is chiefly peculiar for the power of the dilating and contracting each nostril, such movements being subserved by a lateral semilunar cartilage, fig. 156, *k*,; by a depression or fold of contiguous skin, called 'false nostril' in Hippotomy, and by the homologues of the muscles of the combined nose and lip of the Tapir. In fig. 156, *a* is the 'levator rostri;' *b* is the 'retractor labii alæque nasi;' *c* is the muscle called 'transversus nasi,' in Hippotomy; *e* is the zygomaticus; *f* marks the insertion of a muscle, 'pyramidalis' of Hippotomy, which arises by a slender tendon from the maxillary, and gliding beneath the labial part of *b*, expands to be inserted, fleshy, into the outer border of the nostril and contiguous skin-folds.

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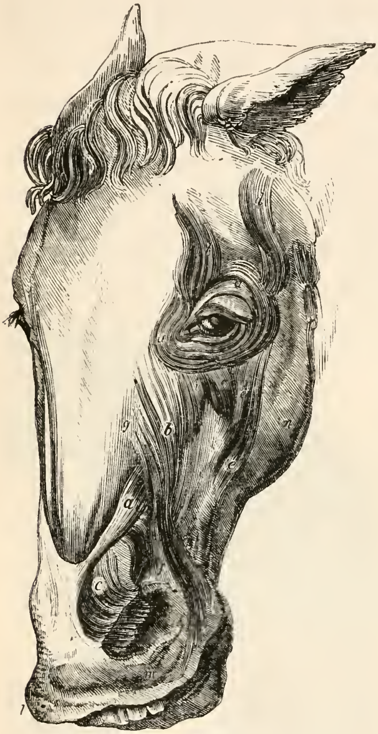

Muscles of nostrils and upper lip, Horse.

The Horse is remarkable for the size of the rhinencephalon and the extent of the cribriform plate transmitting its nerves to the nose: they pass upon a series of about ten short longitudinal folds directed forward and a little downward, forming the 'ethmoidal labyrinth' of Hippotomy, the upper larger division being the 'ethmoturbinal;' a longer, larger, more simply disposed plate, attached to both prefrontals and nasals, and chiefly descending from the latter bones, forms the 'nasoturbinal:' beneath this is the 'maxilloturbinal,' of about the same vertical extent, and almost the same length. The bony septum contributed by the coalesced prefrontals, forms, superiorly, about one-fourth of the general partition: the vomer extends, beneath it, along about three-fourths of the lower third of the septum, but subsides to a point; the major part of the septum is gristly.

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[1] xciii. pp. 20–26.

In the Hippopotamus the nostrils are relatively small, prominent, wide apart, and are served by muscles which open and close them like the eyelids, besides protruding and retracting them. The accessory sinuses of the nasal chamber are very little developed. Their extent and size offer a great contrast in the Hog-tribe, in which the essential parts of the olfactory organ are also relatively larger and more complex. The rhinencephalon is large, with many nerves, and the cribriform plate of great extent: the 'labyrinthic' part of the capsule attached to its under or outer surface forms nine or ten longitudinal, slightly diverging folds, fig. 153, *q*, the three or four uppermost of which coalesce to form the ethmoturbinal, which is long, slender, subconvolute, and attenuated to a fine point forward, ib. *s*. This figure gives an oblique view of the 'labyrinth,' *q*, and ethmoturbinal, *s*, of the right and left sides. The nasoturbinal is of moderate length. The somewhat deeper and more convolute 'maxilloturbinal' is shown at *p*: the accessory 'nasopalatine' fossa, at *k*. The pterygoid, *f*, bounding the posterior nasal opening is excavated and expanded above by a sinus continuous with those of the sphenoid, *n*. The accessory sinuses of the nasal chamber are very considerable in the Hog-tribe: the frontal ones (vol. ii. p. 468, fig. 315, 11, young Pig) extend backward over the calvarium to the occiput in the Boar: a structure well shown in the Babyroussa, No. 3346,[1] in which preparation the extension of the sphenoidal sinus (ib. fig. 315, *f*) into the base of the pterygoid is demonstrated, where it is divided into an external and internal compartment. In *Phacochœrus* the pterygo-nasal fossa is simple, and the frontal are almost separated from the parietal sinuses by the near approximation of the inner to the outer table of the skull. The pterygo-nasal fossæ are absent in *Dicotyles*. In all *Suidæ* the external nose is somewhat prolonged and truncate, the nostrils opening upon a naked disc: the cartilages of the nose form a complete tube, which is a continuation of the bony nostrils, and near the end of the snout the cartilaginous septum becomes ossified, and forms the prenasal ossicle (ib. fig. 315, *o*).

In the Ox the cribriform plate is relatively smaller and the olfactory nerves fewer than in the Horse: the labyrinthic part of the ethmoid consists of about six short narrow longitudinal folds, most of which coalesce to form a larger and more simple ethmoturbinal than in the Horse; the nasoturbinal is very long and slender: the maxilloturbinal of much greater extent, especially in vertical diameter: it terminates forward obtusely. In the Sheep the nasoturbinal is relatively deeper and less pointed than in the Ox. The nasal passages, from the lower border of their anterior outlet, traverse nearly three-fourths of the longitudinal extent of the long and slender skull of the Giraffe, fig. 157. The upper folds of the 'labyrinth' coalesce, and are produced into the moderately long and deep 'ethmoturbinal' *a*: the 'nasoturbinal,' *b*, deepest behind, is longer and more pointed

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[1] XLIV. p. 557.

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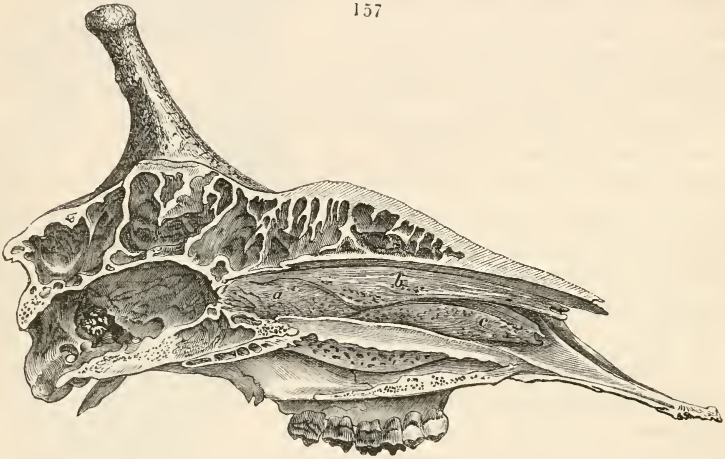

Left half of nasal cavity and turbinals, exposed in section of cranium; Giraffe. XCVII'

anteriorly than in other Ruminants; the 'maxilloturbinal,' *c*, is large and deep, finely reticulate or perforate; it is crossed by part of the vomer in fig. 157. The extent to which the air-sinuses communicating with the nasal chamber are extended is shown in this section, and noted in vol. ii. pp. 477, 478. The nasopalatine nerve entering the chamber below the fore-end of the ethmoturbinal receives some part of the olfactory filaments converging toward that end, then sends upward and forward a small branch to the nasoturbinal; a larger branch downward and outward to the chamber-wall and its lining; the main part being expanded on the long nasoturbinal.

In the Ruminants a gradation may be traced in the extent of the glandular and, in health, moist part of the skin of the external nose, from the Sheep, where it is a mere linear tract from the mid-furrow of the upper lip bifurcating to each oblique nostril, through the Roebuck, Fallow-deer, Red-deer, to the Ox, where it constitutes the broad naked muzzle.[1]

The organ of smell in *Carnivora* mainly differs from that of hoofed *Herbivora* in the greater relative size and strength of the ethmoturbinal, the shorter, deeper, more massive and much more subdivided 'maxilloturbinal.' In the Lion the ethmoturbinal is of a pyramidal form, its broad base continued from the short labyrinthic part attached to the cribriform plate, its apex terminating forward, between the naso- and maxillo-turbinal. The mesial surface of the ethmoturbinal shows numerous furrows, two of which are longitudinal and parallel with the upper margin of the bone, the others radiating from the lower part of the attached base: the lateral or outer surface is less complex and extensive; but, on removing the outer layer, a series of concentric curved folds are exposed. The 'nasoturbinal,' holding as in Ungulates the highest position, is an elongate cone, coextensive with the roof of the nasal cavity and with its base opposite to the frontal sinus: the mesial surface shows a series of deep arched folds; the lateral one seems more even, but when the peripheral lamella is removed a series of longitudinal folds of the bone is brought into view, beneath which are concentric folds arched or curved in the opposite direction to those in the ethmoturbinal. The maxilloturbinal is fusiform; the hind end is attached to the outer wall of the nasal chamber below the middle of the nasoturbinal; whence the bone rises and expands, crossing the anterior end of the ethmoturbinal, and again diminishing to its anterior and upper attachment behind the external bony nostril. From its position, therefore, the odorous atoms, in inspiration, must first impinge upon this bone, and the pituitary membrane is thicker and more vascular than on the other turbinals. Its mesial or septal surface presents one curved groove, parallel with and near to the lower margin of the bone: the outer surface has a like character. The more glandular part of the pituitary membrane is at the fore part of the floor of the nasal chamber, not occupying so deep a fossa as in Ungulates.

The sources and distribution of the nervous supply corresponds with that noted in the Giraffe: the septal branches of the olfactory curve down toward the thickened base of the partition. In the Dog, the longitudinal folds of the 'labyrinth' are about four, fewer in number but larger than in the Sheep: the æthmoturbinal is continued from the undermost and curves upward slightly to the nasoturbinal as it advances: the maxilloturbinal is shorter, relatively broader and deeper, and much more extensively folded than in the Lion. This is the part of the olfactory organ that reaches the extreme of turbinal development in the Seal-tribe. In the large species dissected for the preparation, No. 1557, the maxilloturbinal is attached by its contracted extremities, the intervening enormously swollen mass is divided by a deep longitudinal furrow into two parts; the free surface of which is singularly complicated by folds, radiating from both extremities of the bone and subdividing dichotomously.[1] These turbinals seem to block up the entry of the nasal respiratory passages, and must warm the air in arctic latitudes as well as arrest every indication from the effluvia of alimentary substances or prey. The nasoturbinals, in some *Otariæ*, extend backward, with the nasal chamber, above the long rhinencephalic compartment of the cranium.

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[1] This was pointed out to me by the estimable and justly famed water-colour artist and animal painter, Robert Hills, F.L.S.

In the *Quadrumana* the nasal chamber loses length and gains, but in less proportion, depth and breadth, from the Lemurs up to the Apes: the maxilloturbinal ceases to be suspended by its extremities, and acquires a linear longitudinal attachment externally to a ridge on the maxillary wall of the nasal chamber. This turbinal is divided into two chief parts lengthwise, in *Lemuridæ*, where it is longest: the nostrils are here terminal, the anterior expansion of the septal cartilage curves outward and downward on each side, and, with a corresponding degree of curvation of the principal alar cartilage, gives a subconvolute form of nostril to most Strepsirhines. In the Aye-aye they describe a semicircle; and the nasal chamber by its shortness, depth, and predominance of the ethmo- over the maxillo-turbinals exemplifies the quadrumanous affinities of the species.[2] In Platyrhine monkeys, the septal cartilage is remarkable for the transverse extent of its anterior terminal expansion between the nostrils, pushing them and their alar cartilages outward. In Catarrhines this expansion is much reduced; and the nostrils are obliquely approximated. In both groups the nostrils cease to be terminal; in a Bornean Douc (*Semnopithecus nasicus*), the nostrils are produced upon an ill-shapen prominent subcylindrical nose. In the Gorilla each nostril is surmounted by a broad prominence, arching outward from a lower part impressed by a median furrow; a deeper indent divides the nasal ala from the cheek: the aspect of the nostrils is forward and a little outward. The septal cartilage extends to the tip of the interalar prominence.

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[1] xx. vol. iii. p. 100.

[2] CII′. p. 18, pl. viii. fig. 6.

In Man the number of olfactory nerves varies from fifteen to twenty: after traversing the cribriform plate, they divide into two chief sets, 'septal' and 'turbinal,' and ramify between the periosteum and the pituitary membrane before terminating on the latter. The septal nerves, fig. 158, *a*, are about twelve in number, are quickly resolved into brushes of filaments, which unite together to form plexuses, and send off branches forming finer plexuses, traceable to near the base of the septum. The posterior fourth of the septal membrane is chiefly supplied by the nasopalatine nerve, *b*. The 'turbinal' or labyrinthic olfactory nerves are more numerous, rather smaller, and more plainly anastomotic in their course over the upper and middle turbinals, lying in grooves of the former, and extended chiefly upon the inner and lower front of the midturbinal; a few combine with that part of the nasopalatine which supplies the lower part of the middle turbinal. The lower turbinal is almost exclusively supplied by a branch of the 'nasopalatine.' The main characteristic of the human organ of smell is the prominence of the fore-part of the chamber, having the nostrils on its lower surface, and constituting the feature emphatically called the 'nose,' figs. 159, 161. The formative fold of integument is supported by eleven cartilages, of which one is medial, the others lateral, in five pairs. The medial or 'septal' cartilage, fig. 160, is usually triangular, with three unequally curved margins: the upper one,

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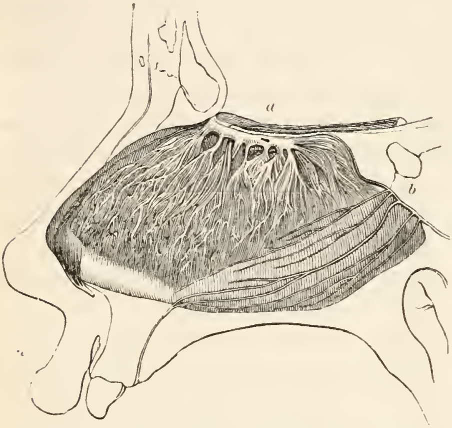

Branches of the olfactory and nasopalatine nerves on the septum of the nose. XCIV″.

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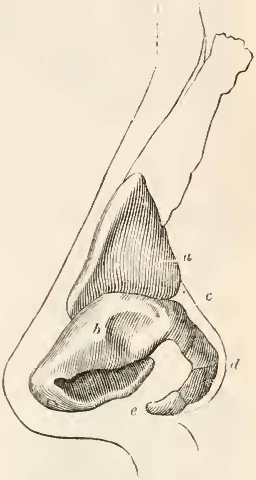

Alar cartilages, human nose. XCIV″.

a, is fixed in the groove of the 'perpendicular plate of the ethmoid,' the lower border, *b*, fits into the front groove of the vomer; the anterior border, *c*, extends from the nasal bones, where it is thickest, as at 2, *d*, and grows thinner down toward the apex of the nose. The varying proportions and form of the septal cartilage mainly govern the shape and prominence of the nose: it is least developed but thickest in the Negro and Papuan races. The lateral cartilages vary in size and shape, the upper one, fig. 159, *a*, is triangular, continuous in front with its fellow, where they are closely connected with the upper half of the anterior border, fig. 160, *c*, of the septal cartilage. The largest of the 'alar' or 'pinnate' cartilages, fig. 159, *b*, is bent upon itself, almost surrounding and governing the shape of the nostril: it is movably connected with the lower and outer part of *a*. To the outer and hinder apex of the cartilage *b*, is joined the first of the three small cartilages, *c*, *d*, *e*, which support the posterior convex part of the 'ala' or wing of the nose. The flexible fibrous tissue connecting these elastic cartilages allow of the movements of the parts to be readily produced, and the muscles are accordingly feeble. The 'pyramidalis nasi,' fig. 161, *c*, is continued from the medial portion of the 'frontalis,' fig. 28, *f*, which descends over the upper part of the nose to the cellular tissue covering the cartilage, *a*, and thence onward to combine with fibres of the 'triangularis nasi,' fig. 161, *e*, and fig. 29, *n*. The 'levator labii superioris alæque nasi' is shown at *d d*, fig. 161; in the degree in which the alar is distinct from the labial portion, or has been distinctly exercised, the wings of the nose can be ex-

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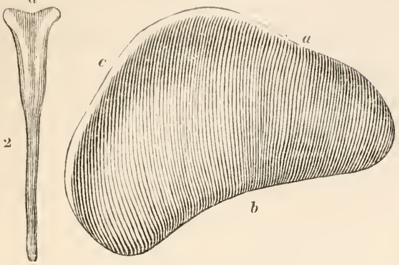

Septal cartilage. xciv″.

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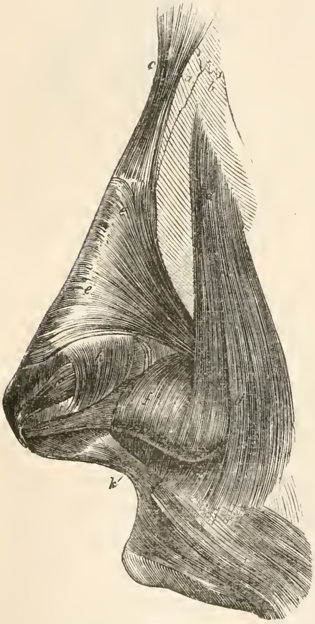

Muscles of human nose. xciv″.

panded independently of any other movement of the face. The 'depressor alæ nasi,' ib. *f*, arises from the outer border of the sockets of the canine and contiguous incisor: the fibres ascend to the alæ, many of them arching over the outer and back prominence of the nostril. The 'depressor septi,' ib. *k*, is detached from the upper part of the 'orbicularis oris,' fig. 29, *o o*, the fibres converging from each side toward the nasal septum. The small triangular patch of pale fibres, fig. 161, *g*, is the 'compressor narium minor:' the larger quadrilateral muscle, *h*, is the 'levator alæ proprius.' In races, like the Mincopies of the Andaman Islands[1] who scent the ripeness of indigenous fruits, moving the thick alæ of their squab nose, as they explore their dark forests for this purpose, the nasal muscles may be expected to be well and instructively developed.

§ 216. *Organ of Hearing.*—The advance in this sense-organ in the mammalian class is seen in the extension of the cochlea, fig. 162, *f*, into coils suggesting the name; in the greater proportion of the perilymph; in the ossification of the cartilages between the stapes and tympanum forming the 'malleus,' and commonly also the 'incus;' and in the presence, save in most swimmers and burrowers, of an external ear or conch, served by muscles for various movements to catch the sound. Besides the cochlea, the labyrinth, fig. 162, includes, as in other Vertebrates, the semicircular canals, *c*, *d*, *e*, and the intermediate space or 'vestibule,' *a*, by which they now communicate with the cochlea. The semicircular canals form a smaller proportion of the labyrinth in Mammals than in lower Vertebrates; they retain, however, their posterior position to the vestibule and cochlea.

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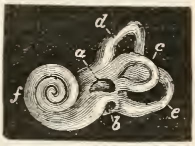

Osseous labyrinth of the left side. Human, nat size.

The larger opening in the bony wall of the labyrinth is called, from its shape in Man, the 'foramen ovale,' or, from its situation in the labyrinth, 'fenestra vestibuli,' fig. 162, *a*: it is closed by the base of the stapes. A smaller 'round aperture,' ib. *b*, is called 'fenestra cochleæ,' because it forms the terminal orifice by which one of the turns of that part, 'scala tympani,' would open into the tympanum, were it not naturally closed by membrane.

A depression in the petrosal or bony case of the labyrinth receives the facial and acoustic nerves, and terminates in a cul-de-sac, one division of which gives passage to the facial, fig. 165, *k*; the others receive divisions of the acoustic nerve, and transmit them, by sieve-like plates, to the labyrinth; an anterior main one, ib. *r*, going to the cochlea, and posterior ones, ib. *g*, *m*, supplying the vestibule and semicircular canals.

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[1] xxxvii″.

The labyrinth is lined by a delicate membrane closing, as it passes, the fenestra tympani, whence it is plainly continued into the cochlea, and completes the spiral septum of that part: continued over the vestibule, the lining membrane is applied to the base of the stapes which closes the 'fenestra vestibuli,' and it lines the semicircular canals. This membrane also extends along two very narrow canals continued from the labyrinth to the exterior of the petrosal, where it passes into the periosteum or dura mater of that part. One of the canals commences at the vestibule, at *p*, fig. 163; the other from the tympanic 'scala' of the cochlea, at *v*: the serous fluid of the labyrinth passes through these canals to the general arachnoid receptacle of the cerebral serosity, and they were accordingly termed 'aqueducts,' and distinguished as 'vestibular' and 'cochlear.' Minute blood-vessels are continued along both canals; but their constancy and their relation as the intercommunicating medium between the acoustic and cranial serosity indicate a function which justifies the precision with which they have been described by Cotugno.[1] The anthropotomical 'aqueducts' show the last trace of that community, so extensive in fishes (vol. i. fig. 227), in the differentiation of the cranial from the otocranial cavities.

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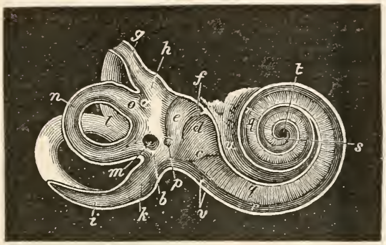

The labyrinthic cavity of the right side, magnified two diameters, Human. XCVII''.

The mammalian cochlea consists of a spiral tube, fig. 163, *d*, *r*, *t*, usually describing two turns and a half, and narrowing toward the apex, the vaulted roof of which forms the 'cupola,' fig. 164, *c*. The internal wall of the cochlear spire and the space it includes form the 'modiolus,' 'columella,' or hollow central pillar, ib. 1, 2, which, from the wider sweep taken by the first turn, is broadest below. Here enters the trunk, ib. *a*, *a*, of the cochlear division of the acoustic nerve, and the foramina by which its fibrils penetrate the spiral canal extend along a part of the modiolus called 'tractus spiralis foraminulentus.' The tube of the cochlea is divided into two passages or 'scalæ' by a delicate plate of bone, fig. 163, *q*, *q*, attached to the inner or modiolar wall of the turns, and projecting freely into their cavity toward the outer wall: the lining membrane extends from this plate to the outer wall, fig. 164, *d, e,* and completes the separation of the two scalæ. The attachment of the base of the 'lamina spiralis' is not solid, but indicates its constitution by two confluent layers, which here separate and intercept the minute channel called 'canalis spiralis modioli.' Towards the apex of the cochlea the spiral plate becomes free, and forms the part called 'hamulus,' fig. 164, 7. Here the two scalæ intercommunicate, as shown by the bristle in fig. 164, which emerges above at the opening termed 'helicotrema,' ib. 8: the apical part of the spiral lamina is formed by an onward extension of the lining membrane of the cochlea, bounding the upper part of the columellar canal called 'infundibulum,' ib. 2. In the section here exhibited the lower, 5, is the tympanic, the upper, *c,* the vestibular, division of the whorl divided by the partition, *b, e,* which is thus seen to be formed by the osseous plate supporting the nerve-filaments, *b,* the layer of membrane lining the tympanic scala, 5, and that lining the vestibular scala, 6; the two coalescing beyond the bone, and becoming thickened at *e,* where they again pass into the parietal lining. The cochlea is essentially a development of the petrosal capsule immediately related to the bone of the head and its vibrations. The membranous labyrinth, fig. 165, retains, in Mammals, its common vertebrate character, extending through the semicircular canals and vestibule, but not beyond the part of the latter whence the cochlea is prolonged to its mammalian extent: the sacculus, ib. *f,* retains the homologue of the otolite of that part in fishes and reptiles; the second otolite, *e,* is also commonly present in the body of the vestibule: both are in

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[1] XCV''.

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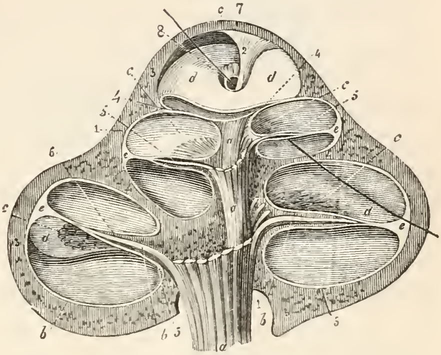

Section of Cochlea, parallel with its axis, magn. XCVI′′.

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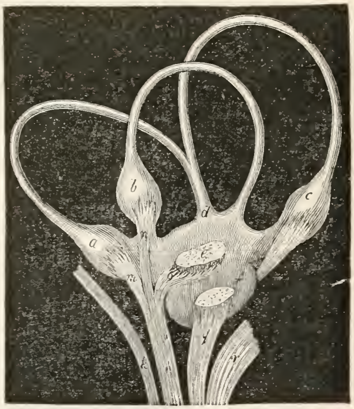

Membranous labyrinth, with nerves. Magnified. XCVI′′.

the condition of pulverulent aggregates of combined carbonate and phosphate of lime, the latter in greater proportion in Mammals than in Fishes: the particles are held together by a mucous tissue. The membranous labyrinth has a ciliate inner surface, and contains a thinner ‘endolymph’ than in fishes: it is suspended in the common serosity of the bony labyrinth, which is distinguished as ‘perilymph.’

Taking a retrospect of the course of the ear-organ, the primitive, constant, and essential element is the ‘sacculus,’ fig. 165, *e*, *f*, with its otolites, which receive the proportion of the nerve-supply not resolved into the pulpy lining of their bag: this simple condition obtains in Cephalopods.[1] In the Myxine something like one bent canal, and in the Lamprey two, are continued from the sacculus: in all higher Vertebrates the three semicircular canals are established; but in most fishes they float, as shown in vol. i. p. 342, fig. 227, in the common serosity of the cranium; their special bony cases, intercepting so much of the arachnoid fluid as now forms the ‘perilymph,’ are subsequently developed: finally is added the complex cochlea, into which the primitive membranous labyrinth is not extended.

In fishes, where the acoustic nerves are affected by vibrations of the endolymph propagated from the cranium or the body generally, the otolites are large, and usually of crystalline density. In air-breathers the sonorous vibrations of the atmosphere are more directly received: they first strike upon a membrane set in a frame and stretched across the opening of an air-chamber, like a drum. In Mammals the ‘membrana tympani’ is more delicate than in Reptiles, and, with few exceptions, is concave outwardly. Sound is usually collected into a conch, the hollow of which can be directed to its source. The medium of acoustic communication between the drum-membrane and the labyrinth undergoes also, in Mammals, that instructive course of ossification and development which converts the avian columella and its cartilages into the chain of little bones called ‘otosteals.’ These, after the external ear, are the seat of the chief modifications of the organ in the present class. They retain, in *Mammalia*, the names suggested by their shape in Man, viz. ‘stapes,’ fig. 166, C, ‘incus,’ B, and ‘malleus,’ A: a small epiphysis between B *e* and C *a*, when separate, is the ‘orbiculare’

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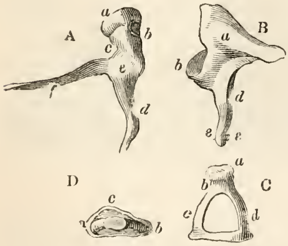

Human otosteals, magn. xcvii".

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[1] civ. p. 294, and *note*. ccxlix. p. 619.

or ‘lenticular’ ossicle. To maintain an equable pressure on both sides of the membrana tympani, and facilitate the movements of the otosteals on each other, atmospheric air is admitted into the cavity, as in other air-breathers, by the tube called ‘eustachian,’ fig. 167, *c*, continued from the back of the nose or mouth to the tympanum. In passing through this tube the air is warmed, and a proper atmosphere maintained in front of the membranous parts of the walls of the labyrinth.

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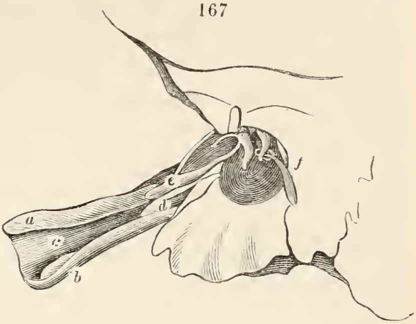

Tympanum and eustachian tube. Human, nat. size. xcviii''.

The structure of the ear-organ in *Cetacea* is highly suggestive and interesting: it is, as Hunter remarks, ‘upon the same principle as in the quadruped;’ yet the outer opening and passage leading therefrom to the tympanum can rarely be affected by sonorous vibrations of the atmosphere, and indeed they are reduced, or have degenerated, to a degree which makes it difficult to conceive how such vibrations can be propagated to the ear-drum during the brief moments in which the opening may be raised above the water. In a full-sized Cachalot it is a longitudinal slit one inch in length, admitting with difficulty the end of the fore-finger. In our common porpoises and dolphins this opening is so small as to require search in detecting, fig. 168, *a*: it leads to a flexible membranous canal capable of receiving, in

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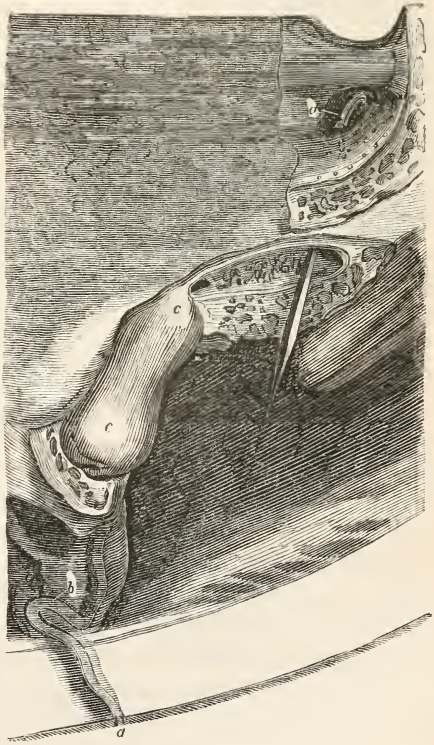

Organ of hearing, Delphinus, nat. size. xx.

Delphinus tursio, a hog's bristle: having passed through the skin and blubber, it makes a sudden bend upon itself, at *b,* and is then continued by a course of about an inch and a half to the ear-drum, where it rather suddenly expands: in the subcutaneous part of its course the walls are strengthened by a few longitudinal cartilages with elastic connections, allowing of slight changes in length and disposition; but the walls are in contact throughout most of the narrow part of the tube. The ear-drum is concave externally in *Delphinidæ* and *Physeteridæ*; but in a *Balænoptera* Hunter found it projecting with an unusual degree of convexity into the dilated inner termination of the meatus.

The density of the osseous tissue of the tympanic bone, ib. *c,* recalls that of the large otolites of fishes, and the almost free suspension of this singularly shaped subconvolute mass suggests that it may be affected, like those otolites, by the sonorous vibrations which are propagated through the water and strike upon the outer surface of the head of the *Cetacea.* Howsoever the ear-drum may be agitated, whether by a possible entry and propagation of air-vibrations through the meatus, *a, b,* or by an affection of the dense and massive bone, fig. 169, *a,* supporting it, the vibrations are conducted by a triangular plate of fibrous tissue, ib. *f,* to the handle of the malleus, *g,* one margin of the transmitting plate being attached to about three-fourths of the long axis of the inner surface of the ear-drum; but this is extended at *e* beyond the circumference of the inner termination of the bony meatus. The malleus articulates in the usual mammalian way with the incus, *h,* and the inner crus of this with the stapes, *i,* the thick, marginally rounded, elliptical base of which is deeply sunk into the 'fenestra ovalis:' there it is arrested by and presses against the continuation of the lining membrane of the vestibule, which, like the drum-membrane, is affected by the movements of the attached ossicle: these are due to a 'stapideus' muscle, fig. 169, *o,* inserted into the neck of the stapes so as to pull it at

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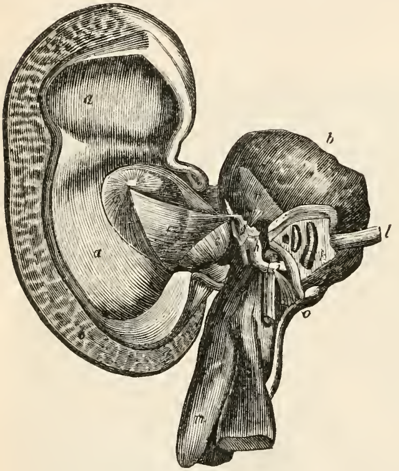

Tympanum and labyrinth, Balæna. XCIV.

an angle of 45° with the plane of the base: and, by depressing this into the 'fenestra,' to make tense the closing curtain and set in motion the perilymph. The muscle, ib. *n*, which seems to answer to the 'tensor tympani,' degenerates, in most *Cetacea*, into tissue which becomes ossified and fixes the malleus to the wall of the tympanum. In all *Cetacea* the otosteals are dense and massive. In *Delphinus leucas* the stapes is imperforate, as in the Walrus, fig. 170, C: in *Phocæna communis*, ib. B, there is a small hole. From the inner or mesial and anterior end of the tympanum the Eustachian canal is continued, which terminates, as shown by the probe, *d*, in fig. 168, in the fauces above the posterior part of the bony palate which has been cut away to expose it, the parts being displayed from below. The tube is membranous throughout, not traversing any bony canal. In the porpoise its inner surface is provided with folds like valves, with the free margin directed to the nasal outlet of the tube: this part communicates with sinuses, some leading to a cellular structure, others compared by Hunter 'to the large bag on the basis of the skull of the horse.'[1] The cetacean labyrinth is excavated in a petrosal capsule, fig. 169, *b*, *m*, of the same dense kind of bone as the tympanic, but of an irregular shape, and attached by a short, thin, easily fractured plate to the tympanic. The usual mammalian characters here prevail: the cochlea, *k*, is indeed relatively larger, compared with the semicircular canals, than in other Mammals, and differs, in *Delphinidæ*, in the greater extent and form of the 'scala vestibuli,' which more resembles a complete tube than the half of such divided in the direction of its axis: it also describes an oblique sigmoid curve on leaving the vestibule before it commences its spiral turns, which are two and a half in number, and rather more depressed than usual. The aqueductus cochleæ is large in *Delphinidæ*. The fenestra ovalis is bordered by a rim for the stapes. The fenestra rotunda is relatively large, and is divided, the lower canal passing along the wall of the scala vestibuli and conveying a part of the cochlear nerve. The acoustic nerve is large.

In Man it has been found that the fall of a drop of water on that with which the meatus has been filled affects the air in the tympanum, so as to produce a sensible impression of sound.[2] The membrane closing the fenestra cochleæ transmits its vibrations to the fluid filling the corresponding cone or 'scala,' which would be propagated at the apical communication along the other cone to the vestibule: the *Cetacea*, with their meatus and ear-drum in a like condition, would thus be affected by any sonorous vibrations that might be propagated to the tympanic cavity; and the share which the cochlea would take in their application to the acoustic nerves may explain the large proportional size of that part of the labyrinth and of the foramen rotundum.

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[1] xciv. p. 382 (1787).

[2] See Carlisle's experiment in cii″, p. 207.

In *Sirenia* the acoustic capsule is small, but dense in structure; it coalesces with the tympanic and mastoid, and the compound ear-bone is partly lodged in a large hemispheric cavity of the squamosal, and partly projects into the wide vacuity between that bone, the basisphenoid, and basioccipital. The otosteals are relatively large, especially the stapes, fig. 170, E (*Manatus*), which forms a massive, elongate, conical, subcompressed ossicle, truncate atop and obliquely perforated above its oval convex base: the incus is a much smaller bone with one crus thick, the other short and styliform: the malleus has a large irregularly globose head and a handle terminated by an abrupt point. The massiveness of the malleus of the Porpoise, ib. B, and Walrus, ib. C, has already been referred to: in the Seal, ib. D, the bone has lost less of the character of the mammalian stapes. In the *Ornithorhynchus* the avian type, ib. A, is retained, and the prolongation of the column has not developed the processes marking out the incus, as in the marsupial, fig. 171.

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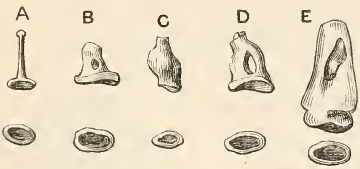


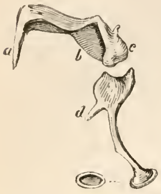
Stapes of aquatic mammals.
A. Ornithorhynchus. B. Porpoise. C. Walrus. D. Seal. E. Manatee.

In *Monotremata* the acoustic nerve is expended upon a labyrinth remarkable for the small relative size of the semicircular canals and the free projection of their bony wall into the cranial cavity. The cochlea is wide, but not high; it is bent in two turns, divided as usual into a vestibular and tympanic scala. The foramen ovale is nearly circular and opens into the wide but shallow tympanic cavity. It is closed by the base of the columelliform stapes, fig. 170, A; the incus being represented by a prolongation and expansion of the handle or neck of the columella, as in Birds. In this class such incudial expansion is joined to an obtuse angled triangular plate of cartilage, the longest side of which is attached to the membrana tympani. In the *Ornithorhynchus* the homologue of this cartilage is ossified, forming a bent plate which performs the office of the manubrium of the malleus and also contributes to the frame of the membrana tympani. This membrane is concave externally, and forms the inner extremity of a long and narrow meatus auditorius externus, which is strengthened by a cartilaginous incomplete cylinder, protected by a valve, but not provided with an external conch. This is equally wanting in the Echidna, in which the external aperture of the auditory canal presents the form of a vertical slit, shaped like the italic *ſ*, one inch and a half in length: the margins of the slit are tumid, and support a row of bristles which protect and cover the orifice when recumbent. The meatus is remarkably long; the tube is strengthened in this Monotreme by a series of incomplete cartilaginous hoops, connected together by a narrow longitudinal cartilaginous band, so that its structure closely resembles that of a trachea, fig. 301, *a*, *a*. The tympanic fossa is almost entirely encircled with a slender hoop of bone, vol. ii. fig. 197, 28, consisting of the anchylosed tympanic bone and malleus. The portion which represents the tympanic bone, ib. *a*, and which can be separated from the malleus in the young subject, is a slender osseous filament bent into three-fourths of a circle, and placed upon the inner margin of the tympanic fossa, its concavity looking outward: this concavity is impressed with a fine groove for the insertion of the membrana tympani: the posterior part of the hoop passes across the commencement of the Eustachian canal, and terminates in a free point upon the posterior wall of the tympanic fossa: the anterior end of the hoop is applied to and usually anchylosed with the longitudinal bar of the malleus.

Only a small portion of this ossicle is contained within the cavity of the tympanum; the principal portion, ib. *o*, forms the external and part of the posterior boundary of the bony meatus auditorius, and is then continued forward in the form of a slender pointed process; the bone slightly expands as it extends backward, and its broadest part is abruptly bent inward until it nearly meets the posterior end of the tympanic hoop. From the extremity of this inflected portion a slender compressed process, *c*, extends to the centre of the space encircled by the bony hoop; it is attached by its whole length to the membrana tympani, and represents the handle of the malleus. At the posterior margin of the broad incurved part of the malleus there are two minute ossifications in an incudial cartilage: the short and simple columelliform stapes, ib. *d*, ascends vertically from the innermost of these tubercles, with the upper surface of which it is articulated; its opposite extremity closes the foramen ovale in the form of an expanded plate. The membrana tympani is concave outwardly at its middle part.

In *Marsupialia* the chief instruction from the ear-organ is afforded by the successive steps by which the ordinary mammalian condition of the otosteals is attained. In most, as in *Perameles*, the stapes is still columelliform, fig. 171, *e*: its base oval, supported on an imperforate stem; its apex more expanded than in *Monotremes*, sending off the process, *d*, and developing the articular cup for the malleus, *a–c*. This representation of 'incus' begins, as in *Echidna*, by a separate ossification. In *Macropus*, it more commonly retains its individuality, and the stapes, fig. 172, is minutely perforate above the disc: however, in some instances, it also shows the process, *d*. The resemblance of the malleus, fig. 171, to the 'cartilago columellæ' of birds is instructively close in most marsupials: but the parts called the 'head,' *c*, 'body,' *b*, and 'handle,' *a*, are definable. The largest proportional external ears are those of the *Perameles lagotis*, the shortest those of the Wombat. The tympanic cavity in *Perameles* is very extensive, but is formed by the sphenoid and petrosal bones; the tympanic bone is limited to the function of supporting the ear-drum, and forming the internal commencement of the meatus auditorius externus. The internal extremity of the tympanic cylinder projects obliquely into the posterior and outer part of the sphenoidal bulla. In many other marsupials the tympanic is prolonged into a bony support of more or less of the external ear-passage, the extent and direction of which are noted in vol. ii. p. 340: the species in which the tympanic cavity is supplemented by excavations in the squamosal are also there mentioned.

171



Otosteals, Perameles.

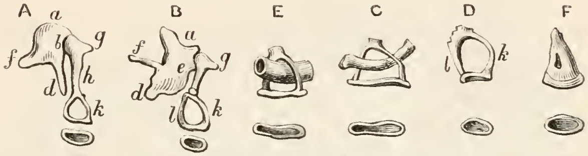
172

Stapes, Kangaroo.

It is interesting to find, in some Bats, a retention of the columelliform confluence of stapes and incus, as in fig. 173, A (*Vespertilio noctula*). All insectivorous *Cheiroptera* likewise show the semicircular canals projecting from the rest of the acoustic bony capsule, which is relatively large and free. The cochlea, however, departs far from the Bird-type, being of unusual relative size, and in some species describing more than three turns: divided as usual into the two scalæ, of which the tympanic one, as in Whales, is much the largest. The divisions of the meatus internus for the cochlear and vestibular branches of the nerve are unusually deep and distinct. The tympanic is here mainly subservient to the support of the drum-membrane: it is deeply sunk into the tympanic cavity, and very concave outwardly. One branch of the stapes is thicker than the other; the two crura of the incus are wide apart, and the articular one is the longest. The ear-conchs are large, delicate; in some genera of Bats enormously expanded: they have been noticed, together with their vibratory movements, under the 'Organ of Touch.' In the frugivorous kinds the conch is small; but with tragus and antitragus very distinct. A large and expanded malleus obtains in *Pteropus fuscus*, with the process and handle of almost equal length. The stapes is narrower in proportion to its length than in true Bats.

In most *Insectivora* the bony semicircular canals project from the petrosal capsule within the cranium, and conspicuously so in the mole, in which the petrosal is large and cellular. Part of the osseous wall of the labyrinth conducts a vessel and nerve through the opening of the stapes, as shown in fig. 173, C. The base of this ossicle is very thin at the middle; it has a wide opening: the malleus has an elongate tuberous head. The ear-conch does not project. In Shrews it is generally broad, thin, naked, and complex, rounded, and but little projecting. In *Sorex fodiens*, Pall., the free margin is folded and concealed by the surrounding hair: in the Water-Shrews the protecting hairs are longer; there are two folds within the conch; the upper one has a marginal row of hairs; the lower one—a kind of antitragus—can be folded over the auditory canal. When the outer margin of the conch is unfolded it reaches to the level of the top of the head. In the great groove-toothed shrew (*Solenodon*) the auricle is shaped as above, has the free margin unfolded, has fine short hairs on both surfaces; and the protecting folds of the meatus at the bottom of the conch are relatively small, but complex.

173



Stapes in *Lissencephala*.

A. Bat. B. Shrew. C. Mole. D. Hedgehog. E. Marmot. F. Sloth.

The lamelliform type of malleus prevails in all Shrews: it is figured from *Sorex araneus*, in fig. 173, B, *a*, *d*. In the Hedgehog the oval and round apertures of the labyrinth are approximate: the cochlea makes a slight projection into the tympanic cavity. The basisphenoid enters, as in Marsupials, into the formation of the tympanic cavity, and the tympanic bone retains its freedom and is almost restricted to the support of the drum-membrane: the stapes, fig 173, D, has slender, unequal crura, and a wide aperture; it is as large as the incus, the attached crus of which is short, its free one long: the malleus equals both bones, and its head and body, as in Shrews, are unusually expanded. In *Centetes* it is less broad, with a longer process and shorter and thicker handle. The membrana tympani is almost horizontal; there is no bony meatus externus. The ear-conch is short, broad, and rounded: two of its muscles are derived from the strongly developed dorsal panniculus carnosus, fig. 7. In the Tenrec the tympanic extends into a short 'meatus externus.'

In the Rat (*Mus decumanus*) the orifices for the cochlear and vestibular divisions of the acoustic nerve open separately on the petrosal surface, not into a common 'meatus internus.' In sections of the cranium of some Rodents I observed that the tympanic cavity was divided by a horizontal partition into an upper and lower compartment, intercommunicating, in the Porcupine, posteriorly above the membrana tympani; this is situated in the lower compartment, the external meatus terminating in a narrow oblique slit at its upper part. In the beaver the upper compartment of the tympanum is much smaller; the bony meatus contracts to a transverse slit as it approaches the membrana tympani, the plane of which is almost parallel with that of the meatus itself: from the membrane the bony meatus extends outward and curves forward and a little upward.[1] In the Paca (*Cœlogenys*) the horizontal septum divides only the anterior half of the tympanic bulla into an upper and lower compartment, the meatus terminating, as usual, in the latter. The tympanic cavity is remarkably developed in most members of the present active timid order: it is enormous in *Ctenomys*.[2] In the Chinchilla (*Lagotis*) the mastoid portion rises to the upper surface of the cranium, where it is girt by a slender band of the combined superoccipital and squamosal: the petrosal part of the tympanic bulla describes a curve downward and backward circumscribing a large foramen which opens into the bulla beneath the meatus auditorius externus. This is long, wide, funnel-shaped, with the outlet obliquely truncate and directed upward and a little backward. In the Capybara the bony meatus externus is unusually contracted, is cleft below, and bounded there by two small tuberosities. In the Hare the meatal part of the tympanic is long and ascends obliquely backward from the frame of the drum-membrane. This is a long ellipse; the handle of the malleus extends from above down its long axis to about one-fourth from the lower border; the fibres of the 'membrana propria,' diverging from nearly the

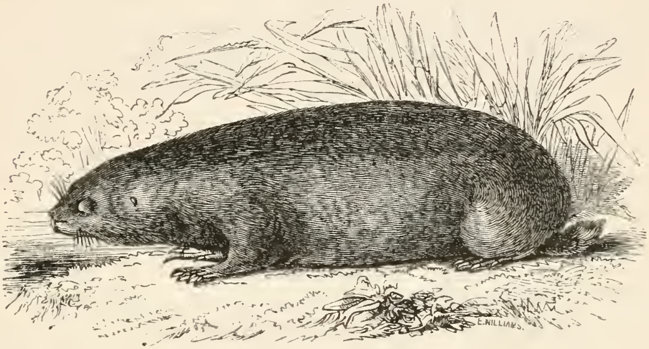
[1] XLIV. Nos. 2044, 2093, 2166.

[2] XLIV. p. 365, no. 2012.

whole length of the handle, affect, for the most part, a transverse course. The stapes has a wide vacuity and slender crura, and in many Rodents (Squirrels, Cavies, Marmots, fig. 173, E) it is traversed, as in Moles, by the bony canal of a vessel and nerve. The ear-conch shows a wide range of variety, from some swimmers (*Castor*) and burrowers (Mole-rat, fig. 174) where it is hardly visible, to the Flying Squirrels (vol. ii. fig. 154), Jerboas and Hares, where the ears are conspicuous appendages to the head.

The Sloths contrast with the Rodents in the degree in which they enjoy the sense of hearing: the conch is rudimental; there is no bony meatus; the tympanic is reduced to its function as the frame of the drum-head, and long retains its individuality. The stapes is small and imperforate, in the two-toed species, fig. 173, F. The crura of the incus are thick, of equal length, very divergent. The handle of the malleus is bent at the middle; it is short, as is also its process. The tympanic cavity extends into the squamosal and pterygoid.

174

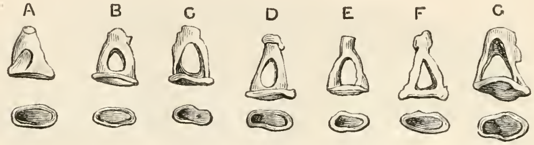


Bathyergus maritimus.

In the Armadillos (*Dasypus*) the meatus internus is subspiral; the cochlea projects into the tympanic cavity: this is large, but owes little to the tympanic bone. The malleus is bent, almost as in Monotremes, completing the circle for the drum-membrane, and expanding for its attachment thereto: the part articulated with the incus is very broad and flat. The ear-conch is contracted and tubular at its base; but expands to a length of nearly two inches and a breadth of one inch in *Dasypus Peba,* in which the apex is rounded off. In *Orycteropus,* also, the external ears are very large for a burrower. In the true anteaters (*Myrmecophaga*) they are much smaller: the tympanic bone retains its freedom and is chiefly subservient to the support of the drum-membrane, which is placed very obliquely. In the pangolins (*Manis*) the ear-conch is presented by a small scale-like fold of thin integument.

In the Elephant the petrosal is small in proportion to the size of the animal: its apex is grooved by the entocarotid. The post-tympanic part of the mastoid meets the postglenoid process below and circumscribes the outer auditory aperture: the tympanic contributes the lower wall of the meatus, internal to which it expands into a 'bulla,' which unites with the petrosal. The tympanic cavity communicates with the air-sinuses so extensively developed in the cranium, fig. 154. The stapes, fig. 175, G, has a thin convexo-concave base; its branches are of unequal length; the incus and malleus are large in proportion: the drum-membrane is a full oval, the radiating fibres of its proper tunic diverge from the end and sides of the handle of the malleus, which, terminating near the great end of the oval, causes a corresponding difference in the length of these fibres. The ear-conch is large, prodigiously so in the African species, and extremely mobile in both kinds.

175



Stapes, in *Ungulata*.

A. Hippopotamus. B. Hog. C. Musk Ox. D. Horse. E. Tapir. F. Rhinoceros. G. Elephant.

In the Hippopotamus the free part of the petrosal is of a compressed pyriform figure; the tympanic is expanded, at the cavity, and prolonged obliquely and almost vertically upward into a meatal tube, which becomes almost concealed between the zygomatic and paroccipital in the old animal. The otosteals are small and massive; the stapes has a very small perforation, fig. 175, A; the handle of the malleus is short: the conch is very small and little prominent.

The petrosal is small and rounded in the Hog-tribe; it retains its primitive individuality in the Babyroussa; not coalescing with the independently developed mastoid or other elements of the otocrane. The tympanic contains air-cells and is produced into a long and narrow auditory canal obliquely upward and backward, with an external orifice smaller than the frame of the ear-drum. Both the base and aperture of the stapes are small, fig. 175, B, and both the handle and body of the malleus are short.

The conch is small and erect in the Wild-hogs, larger and pendant in the domestic breeds.

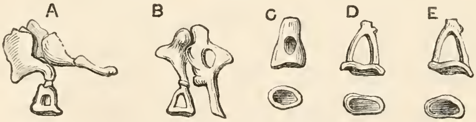
In the Anoplothere the bony outer aperture of the ear was round and horizontal, the passage directed from the tympanum backward. The diameter of the semicircular canals, as in most other Ungulates, is relatively less than in most small Lissencephalous Unguiculates. The lower ridge of the petrosal is less marked in Camels than in true Ruminants. In these the stapes is usually arched, widely open, with thickish crura, grooved internally, fig. 175, C, *Bubalus*, the base a long oval. In the Ox the membrana tympani is oval; the handle of the malleus extends from above obliquely downward and forward to one-fourth of the long diameter from the small end, and lies near the anterior part of the circumference; consequently the posterior fibres diverging from the handle are longest: in the stapideus muscle is imbedded at the passage of the carneous into the tendinous part, a roundish ossicle, about three-fourths of a line in long diameter, and one-third of a line in short diameter. The tympanic bone is compressed and produced into a long auditory canal with a trenchant lower border, and the outlet almost horizontal. The ear-conch in Ruminants is commonly characterised by three vertical rows of hairs longer than the rest on the inner surface.

The external ears of the Horse, fig. 156, are most expressive appendages, in their extensive, rapid and various movements. The tympanic bulla is divided by an unusually regular series of radiating plates. The stapes, fig. 175, D, is an elongate triangle, with crura of unequal thickness, a produced cervix, and narrow oblong base. Both the stapideus and tensor tympani have thick fleshy portions: in the stapideus of the Horse there is an ossicle, smaller than in the Ox, and of a longish shape, thicker in the middle. The auditory chamber of the Tapir is small: the tympanic does not develope a meatus externus: the part supporting the membrane early coalesces with the squamosal and the post-tympanic part of the mastoid. The base of the stapes is elongate, fig. 179, E: the head of the malleus is compressed, its handle is bent. In the Rhinoceros, also, the tympanic, which is reduced to the frame of the membrane, is indistinguishable from the mastoid and squamosal with which it early becomes fused. The petrosal is very small. The stapes is triangular, with a moderate vacuity, and thick crura, ib. F: the crura of the incus are very short: the head of the malleus is bifid, its handle much curved. The conch is pedunculate, and expands into a moderate elliptical chamber, from the upper part of the head. The tympanic of *Hyrax* is swollen and continued into a short horizontal auditory tube: the base of the stapes is rarely ossified beyond the circumference: the crura of the incus are subequal and very divergent: the malleus has a long handle. The ear-conch is short and round.

This appendage, in *Carnivora*, enlarges and elongates progressively from the eared-seals and bears to the hyenas; exception being made for the aquatic *Mustelidæ* (*Lutra* and *Enhydra*) which are seal-like in its smallness, and for the Fennecs which show the opposite extreme; the character expressed by the subgeneric name *Megalotis* makes the Nubian species conspicuous in the old Egyptian frescos.

The seals offer a great contrast to the manatees in the relative size of the stapes, fig. 176, A, which is much smaller than the incus or malleus; but it presents a similar massive character, with inequality of thickness of the crura and a small perforation, ib. and fig. 170, D. In the walrus, ib. C, the stapes is imperforate. In all *Phocidæ*, the body of the incus is tumid with short subequal branches: the body of the malleus expanded, compressed, and its handle short. The tympanic is large and dilated: it coalesces with the petrosal and mastoid, and together they occupy a large interspace between the basisphenoid, basioccipital and squamosal. It is interesting and suggestive to find that with proportions and powers of the pinniform limbs that enable the Seals of the southern ocean to raise and move the trunk better than in most northern kinds, the ear-conch begins to be visible, whence the name '*Otaria*' for such sea-bears and sea-lions.

176



Stapes of *Carnivora*.

A. Seal. B. Otter. C. Bear. D. Dog. E. Tiger.

In Bears (*Ursus*) it has but a moderate perforation, fig. 176, C, showing the affinity to the Seals: the crura of the incus are of unequal length: the head of the malleus is subcompressed: its handle of moderate length, and its process short.

In the badger (*Meles*) the stapes is small, wlth an elliptic base and moderate vacuity; the crura of the incus are of unequal length: the malleus is large with a subcompressed head, and the handle terminally expanded. The tympanic is large and moderately inflated. The stapes of the kinkajou has a larger base and wider opening than in the badger: the incus is relatively small. In the wolverine (*Gulo*) the malleus is perforated near the origin of the process; repeating a character presented in some birds by its cartilaginous homologue. In the otter (*Lutra vulgaris*) the malleus, fig. 176, B, is similarly perforated; the stapes is small, but adheres to the musteline type of the bone and is more widely open than in Seals. In the civets the stapes is triangular, its base oval, the branches thick and grooved on the inner side: the crura of the incus are short and very divergent. In *Canis* the stapes, ib. D, is subelongate, with the apex small, the base oval: the intercrural space is large. The handle of the malleus is grooved lengthwise. The stapes of the hyæna has a slightly convex and longish oval base; the crura of the incus are short: the malleus is rather curved, with a short subcompressed handle. The ear-conch is large and long, without any fold of the external border: the tympanic is less inflated than in *Felis*. The cochlea is longer and more prominent in the dog than in the cat. In this type-genus of *Carnivora* the acoustic capsule and labyrinth are small, especially in the large species; but the tympanic cavity is expanded in all felines into a notable 'bulla' at the base of the skull, formed chiefly by the tympanic, which, after framing the drum-membrane, forms an oval external orifice, deeply seated in the narrow space between the mastoid and zygoma. The stapes is a longish triangle, widely open, with the apex truncate and the base oblong, fig. 176, E, Tiger; it is shorter in the small Felines. The crura of the incus are short and subequal; the body of the malleus is broad and long; its handle of moderate length, and, in some, terminally expanded. The conch is short, usually rounded, broad and widely open; relatively largest in the smaller species; and distinguished in the lynxes by the apical tuft of long hairs.

The otosteals in *Quadrumana*, fig. 177, quickly approximate to the characters of those in Man, ib., *Homo*: the stapes in *Chiromys* has a shorter and broader summit; its base is firmly wedged into the foramen ovale. With the other otosteals it is proportionally larger than in true lemurs, bearing relation to the great development of the outer ears. These are large in all *Lemuridæ*: the tragus and antitragus are well marked in *Stenops*, but instead of anthelix there are two prominent and subparallel plates. The vestibule is shorter, and the cochlea closer to the semicircular canals in the Aye-aye than in Man. In the *Lemuridæ* the commencement of the cochlea is wide, and its axis is parallel with a line drawn from the fore end of the ampulla of the upper semicircular canal, and meeting the latter just before its junction with the hinder semicircular canal. The stapes in lemurs is a more equilateral triangle, and the perforation is less than in monkeys: the incus has a longer and larger body in proportion to its crura: the malleus has a shorter process, fig. 177, A.

In *Cebidæ*, ib. B, the stapes gains in length, but not much in vacuity: the crura of the incus are still short, and the extensions of the malleus are short in proportion to the mass articulating with the incus. The tympanum is large; the external meatus short and very wide. In catarrhine monkeys, ib. C (*Cercopithecus sabæus*) and in apes a nearer approach is made to the proportions and shapes of the human otosteals.

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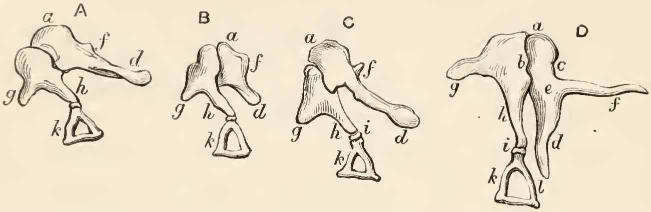

Lemur. Cebus. Cercopithecus. Homo.

Otosteals, Quadrumana and Man.

There is a wider range of diversity in the external ear than in the more essential parts of the organ. In the nocturnal Aye-aye, in which the conch is relatively largest, there is a beginning of the helix above the meatal fossa, but the rest of the margin is thin and unfolded: the tragus is not very prominent, the antitragus is better marked: a low fold represents the 'lower crus' of the anthelix, the upper one and the rest of that fold are wanting. It is only in the orangs and chimpanzees that the parts defined in the human auricle are represented. The free margin is reflected to form a 'helix,' but not to the same degree as in Man: the 'anthelix,' beginning above with both 'upper' and 'lower' crus, is continued to the antitragus; both scaphoid navicular fossæ are defined, as well as the cavity of the concha and the tragus: the lobulus is not pendant as in Man. In the chimpanzee (*Troglodytes niger*) the external ear is larger absolutely than in the great gorilla (*Troglodytes Gorilla*).

In all the figures of the otosteals previously given the stapes is drawn at right angles to its natural position, in which only a foreshortened view of the bone could be had, as in fig. 178, where it is shown with its base *a* applied to the 'fenestra' of the vestibule.

Of the three semicircular canals the shortest, *c*, has a nearly horizontal position: the other two are more vertical: the upper one rises at the convexity of its curve, *d*, above the level of the upper surface of the petrosal: it is that which, with its arch-area, is most free in many lower Mammals. The lower vertical canal, *e*, unites by its upper extremity with the contiguous one at *l*; the common opening of which is shown at *m*, fig. 163. Each of the semicircular canals expands at one extremity; but this is more marked in the membranous canals, fig. 165, where the dilatations, *a*, *b*, *c*, are termed 'ampullæ:' the bony canals are wider in proportion to the membranous ones in Man than in most Mammals, and consequently the perilymph is more abundant. This is seen in fig. 179, which represents the osseous labyrinth laid open, with the membranous labyrinth in situ of the human ear. Of the latter the part occupying the vestibule is divided into the 'common sinus,' *i*, and the 'sacculus,' *l*; each contains a mass of otolithic powder, *k*, *m*, receiving filaments of the acoustic nerve: other brushes of nerve filaments go to the ampullary ends of the semicircular canals: the opposite non-dilated ends communicate with the 'common sinus' either singly, at *h*, or by the conjoint termination *g*. The different positions of the three canals and the different directions in which their

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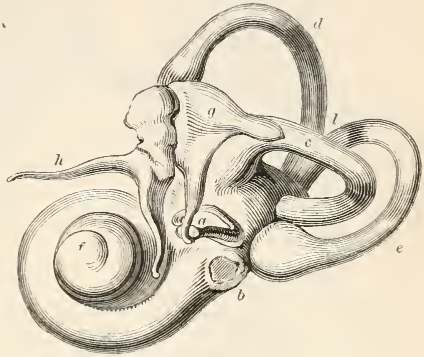
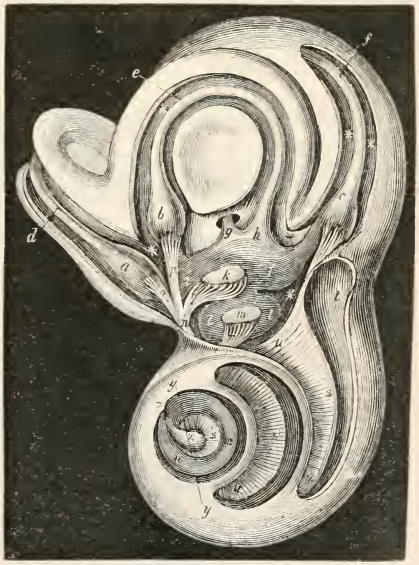


Osseous labyrinth and otosteals, Human; magn. XCVIII″.

179



Left osseous labyrinth laid open, with membranous labyrinth and nerves; magnified. Human. XCVII″.

respective waves of sound must strike upon the rich supply of nerves at the ampullary ends, may have relation to the power of appreciating the locality of the source of sound, or the direction in which it arrives. The branch, fig. 180, *g*, to the 'common sinus' spreads thereon in a radiated expanse: the branches, *o*, *p*, to the ampullæ of the upper, *a*, and horizontal, *b*, canals, form a bifurcate enlargement, *p*, upon their outer surface. When the ampulla is laid open, as in fig. 181, the nervous fork is seen to protrude and push in a slightly curved eminence of the membrane, ib. A, upon which and the adjacent part of the ampulla the delicate nervous fibres resolve themselves into a kind of retinal pulp, ib. C.

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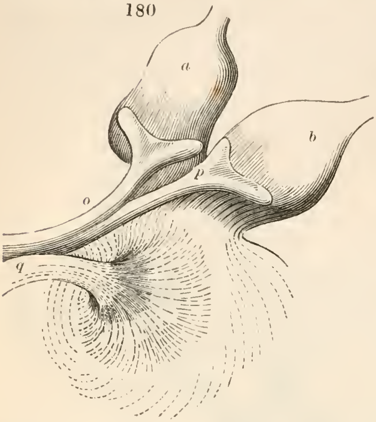
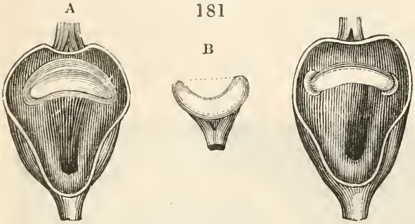


Nerves of ampullæ and 'sinus communis;' magn. Human. XCIX''.

181



Terminations of nerves in ampullæ, magn. Human. XCIX''.

The septal plate of the cochlea has lent itself to a more favourable or distinct view of the termination of the acoustic fibrils. Fig. 182 shows the cochlear nerve, isolated. If a small bit of the spiral plate, fig. 183, A, be magnified, as at B, the filaments, *b*, are seen, as they diverge upon the osseous part, to subside or flatten on approaching the middle tract, and there to anastomose in loops, *c*; the neurilemma, *d*, being continued on to blend with the membranous part of the spiral plate.

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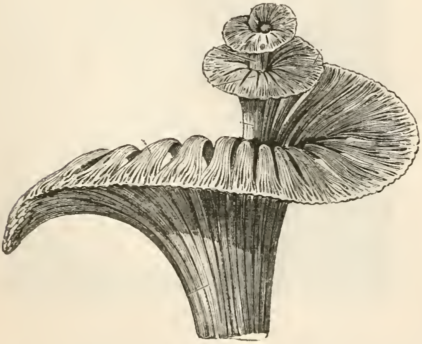

The cochlear nerve, magn. XCVI''

The human tympanic cavity, fig. 184, is formed by the petrosal, the mastoid, and the tympanic bone: in the dry skull it communicates with the labyrinth by the foramen ovale, *b*, and foramen rotundum, *c*; with the exterior of the cranium by the foramen auditorium externum: but all these apertures are closed by membrane in the recent state. The other communications are with the breathing passage, back of the nose, or pharynx, by the eustachian tube, fig. 167, *a*, *b*, *c*, whereby air is conveyed into the tympanum, and thence passes into the mastoid cells. On the petrosal wall of the tympanic cavity is specified the 'promontory,' *a*, between the openings, *b*, *c*, the pyramid, *d*, the eminence of the 'fallopian aqueduct,' *e*, and the groove, *f*, for the internal ligament of the malleus.

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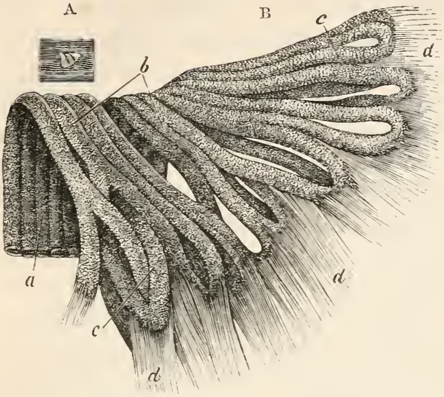

Termination of cochlear nerve, more highly magn. (A. nat. size). XCVI''.

The movements of the membrane closing the foramen ovale, *b*, are brought into relation with those of the membrane closing the outer auditory opening by the chain of ossicles called 'otosteals.' The 'membrana tympani' is fixed in a groove of a bony frame which is so far ossified as to form an incomplete ring, at the third month of human fœtal life; at the sixth month it begins to coalesce with the squamosal, fig. 185, and then to grow outward, forming the wall of the bottom of the auditory meatus, fig. 188, *g*, the lower part of which is the last to be completed. The drum, fig. 186, consists of a 'proper membrane,' with an inner layer

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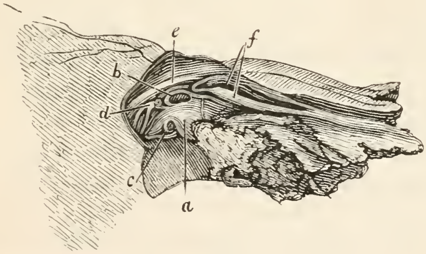

The inner wall of the tympanum. XCVII''.

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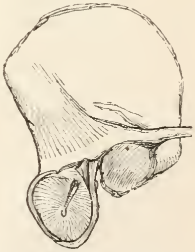

Squamosal and tympanic bone with the membrane. Human fœtus. XCVII''.

contributed by the lining of the tympanum, and an outer layer by that of the auditory passage. The proper membrane, moreover, is divisible into two layers, an outer one consisting of fibres radiating from near the centre, and an inner, thicker, less distinctly fibrous layer, but indicative of a contrary disposition of such fibres. The conspicuous radiating fibres pass from the circumference of the membrane to be fixed to the handle of the malleus. They show no characters of voluntary muscular fibre.

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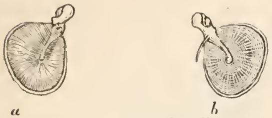

Membrana tympani and malleus, nat. size; Human. *a* outer, *b* inner view.

Anthropotomy distinguishes the following parts of the otosteals: — in the hammer, ‘malleus,’ fig. 166, A; *a*, head; *b*, articular surface (adapted to *b* of the incus); *c*, neck; *d*, handle; *e*, short process; *f*, long process: this latter is the most constant, and is called simply the ‘process’ in comparative anatomy; sometimes also ‘Rau’s process,’ from the describer of its true shape and flattened end in Man: in the anvil, ‘incus,’ B; *a*, body; *b*, articular surface; *c*, short crus; *d*, long crus; *e*, lenticular process, epiphysis, or ossicle: in the stirrup, ‘stapes,’ D; *a*, head; *b*, neck; *c*, anterior crus; *d*, posterior crus; D, the base. The head of the malleus is lodged in the roof of the tympanum above the upper margin of the membrane, and sends its ‘handle’ down to near its centre, as seen from without at *a*, from within at *b*, fig. 186. The body of the incus lies in the upper and back part of the tympanum; its articular surface is directed forward, the joint with the malleus being a synovial one, with articular cartilage and a fibrous capsule: the short crus is directed backward towards the mastoid cells; the long crus descends almost parallel with the handle of the malleus, to articulate by means of the lenticular process with the head of the stapes, fig. 178.

Savart’s experiments[1] show that the malleus participates in the oscillations of the tympanic membrane; that they are propagated to the incus and stapes, and thus to the membrane of the fenestra ovalis. Two muscles, probably subserving volitional impulse through their proper nervous supply, act upon the otosteals; and from vibrations of the drum-membrane to which those bones are attached, they may be excited to act, also, automatically. The ‘musculus internus mallei,’ or ‘tensor tympani,’ fig. 167, *e*, arises from the eustachian process of the alisphenoid, and from a groove in the bony part of the eustachian tube, and passing backward forms a slender tendon, which enters the tympanum, bending at nearly a right angle, and is inserted into the handle of the malleus below the long process. By the action of this muscle the handle is drawn inward and forward, and the membrane attached to the handle is also drawn inward and is stretched. Besides the tension to which the membrana tympani is thus subjected, the base of the stapes is forced against the vestibular fenestra in consequence of the movement communicated by the head of the malleus to the incus, which tends to press inward the long extremity of the latter. The second muscle is the 'stapideus,' fig. 167, *f*: it arises from a groove in the 'pyramid,' fig. 184, *d*: it is inserted into the posterior and upper part of the head of the stapes by a slender tendon, which issues by the aperture in the summit of the pyramid, and proceeds downward and forward to its termination.

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[1] c″.

The first effect of the action of this muscle will be to press the posterior part of the base of the stapes against the vestibular fenestra: at the same time the long branch of the incus will be drawn backward and inward, and the head of the malleus being, by this movement of the incus, pressed forward and outward, its handle will be carried inward, and the membrana tympani thus put on the stretch. On the other hand, the contraction of the 'tensor tympani' depresses the stapes and increases the tension of the fenestral membrane. The cessation of muscular action restores all the vibratile membranes to their state of indifference. The incus, by its firm connection with the mastoid cells, its intermediate position, and having no muscle inserted into it, must be more limited in motion than the other two bones.

The stapideus muscle receives a nervous filament from the facial nerve. The tendinous insertion of the stapes is usually the seat of ossification. These muscles have no homologues in Vertebrates devoid of tympanum and tympanic membrane: they are as purely independent and superadded parts of the mechanism of that advance of the auditory organ, in Mammals, as are the ossicles they move.

The cartilage described by Meckel, and representing the mandibular hæmal arch in the embryo-skull, from the fibrous sheath of which are developed the 'tympanic' at the upper and outer part and the mandible at the lower and outer part, has no such relation of a mould to the malleus. This ossicle, starting as a wart-like prominence from the wall of the tympanic cavity, is precociously developed on the inner side of Meckel's cartilage, early showing its long process above and quite distinct from that cartilage or its capsule. The short crus of the 'incus' has the same accidental relation to the embryonal, cartilaginous, hyoidean, hæmal arch described by Huschke[1] as extending from the mastoid or petro-mastoid to the upper or short horn of the hyoid (cerato-hyal), and from the outer part of the capsule of which cartilage the styloid process (stylo-hyal) is ossified. The stapes first appears as a compressed pyramidal wart from the petrosal or inner wall of the tympanum, projecting from a depression the bottom of which becomes the fenestra vestibuli: the malleus, according to Rathké and Valentin,[2] projects, somewhat earlier, as a small wart from the back wall of the tympanum. Ossification begins first in the malleal wart by a point at the head, and by a second at the root of the long process. According to Meckel, the rudiment of the stapes has grown, at the third month of the human fœtus, to a cartilage representing both stapes and incus, like the columella of *Ovipara*: as such it is ossified in the Ornithorhynchus. The ossification of the columella begins first in the 'incudeal' part, extending along the long crus toward the stapes, which is subsequently ossified, according to Rathké,[3] from three nuclei, one for each crus and one for the base. As regards the vacuity, it does not exist in the cartilage, but is produced by the modelling absorption in the course of the ossification, transitorily representing the characters shown in the porpoise, seal, and bear. Abnormal arrests of development of the stapes in the human subject have been found to represent the imperforate avian columella and most of the above-cited mammalian conditions of the stapes.

The membrane lining the tympanum, fig. 187, *a*, invests the small bones and the tendons of their muscles where they run free in the cavity. A fold of it fills up the space bounded by the crura and base of the stapes. The chorda tympani, also, in its passage across the tympanum, is enveloped by it. Lastly, it forms the inner borrowed layer of the membrana tympani, covering and adhering closely to the handle of the malleus.

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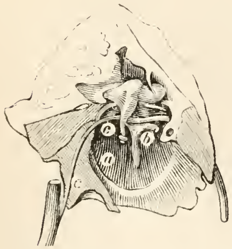

Tympanum, otosteals and 'chorda tympani;' Human. XCVIII''.

The nerve called 'chorda tympani,' fig. 187, *c*, is continuous, as shown at p. 157, fig. 132, with the facial and superficial petrosal nerves: it leaves the facial before the exit of the latter by the stylo-mastoid foramen, ascends in its own osseous canal, enters the tympanic cavity, crossing the inner side of the tympanic bone, as in birds, advances between the handle of the malleus and

[1] CIV''.

[2] CXLII'', p. 211.

[3] CXLIII'', p. 120.

long crus of the incus, and descending to the 'fissura Glasseri,' makes its exit by the contiguous canal and foramen, descending mesiad of the ascending mandibular ramus to join the lingual nerve. Within the tympanum it receives filaments from the tympanic branch of the trigeminal. The facial nerve gives a branch to the stapideus muscle. From a ganglion of the pneumogastric is sent off the 'ramus auricularis,' which is joined by a filament from the glosso-pharyngeal, and is conducted by a groove in the jugular fossa to the 'aqueduct of Fallopius:' here filaments are sent to join the facial, and one to the nerves of the meatus and ear-conch. The tympanic nerve derived from the 'petrous' and 'otic' ganglia, enters the tympanum near the anterior margin of the 'fenestra rotunda,' traverses the groove on the promontory, and, near the 'fenestra vestibuli,' enters the osseous canal which leads to the surface of the petrosal in front of the 'hiatus Fallopii,' and passes to the otic ganglion. From this ganglion a nerve is sent to the tensor tympani.

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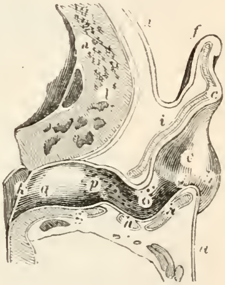

Horizontal section of the auditory passage (meatus auditorius externus). XCVIII''.

The 'meatus auditorius externus,' fig. 188, is formed by bone, *g*, for a short extent from the drum-membrane, *k*, is chiefly cartilaginous in the rest of its extent, but is membranous above and behind, and there perforated by the orifices of the ceruminous follicles, *o*, *p*. The canal has an oval area, is about an inch and a quarter in length, and is lined by a continuation of the skin of the auricle. This skin becomes more delicate as it approaches the osseous part of the passage — extremely so where it is continued on the outer surface of the membrana tympani. The skin of the auditory passage is covered with fine hairs, and these become developed at the outlet into long defensive cilia or ear-lashes. The 'glandulæ ceruminosæ' are small round or oval bodies of a brownish-yellow colour, and very vascular. They are imbedded in the areolæ presented by the dense cellular tissue which connects the skin of the auditory passage to the subjacent cartilage or bone. The ear-wax, *cerumen*, is, as is known, a thick orange-coloured or yellowish-brown viscid substance, of an extremely bitter taste, and somewhat aromatic odour. When first secreted, it is a thin, yellowish, milky fluid. It is an accessory defence against the entry of insects into the meatus. The ear-drum closes the meatus obliquely from above downward and inward; the bony part, *q*, of the meatus forms a gentle curve, convex upward: the membrano-cartilaginous continuation, *p, o, h*, describes a stronger curve, concave upward, and this expands into the concha, *c*, of the 'pinna,' auricle, or external ear. Of this it will be only requisite to indicate the parts which have received names in anthropotomy, since extended to anatomy generally. The fold or reflected outer margin, fig. 189, *a—e*, is the 'helix;' the subparallel eminence within, *h, k*, is the 'anthelix:' it is formed by the junction, at *h*, of the 'upper ridge,' *f*, and the lower ridge, *g*, intercepting the 'navicular fossa,' *o*. The prominence, *m*, which might be viewed as the lower end of the anthelix, is called 'antitragus,' being opposite the projection called 'tragus,' *l*, which more directly defends the entry, *r*, to the meatus: *q* is the 'conch' proper, or cavity of the concha: finally is the appendage called 'lobule,' *n*. With the exception of the latter, all the other parts of the auricle are more or less formed by cartilage, figs. 191, 192, in which, besides the prominences already named, there may be observed the fissure, *e*, between the tragus and the beginning of the meatal cartilage. The skin covering the cartilage of the ear adheres intimately to its sculptured surface, less so to its back and circumference: the lower part of the hem-like fold of the helix is formed entirely by it; also the lobule, as has been already said. The skin of the auricle contains a number of sebaceous follicles, particularly in the concha and around the entrance of the auditory passage. Toward this the channels and inequalities of the ear tend ultimately to convey the vibrations of sound.

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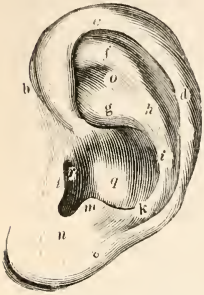

Left ear, auricle, or 'pinna,' Human. XCVIII''.

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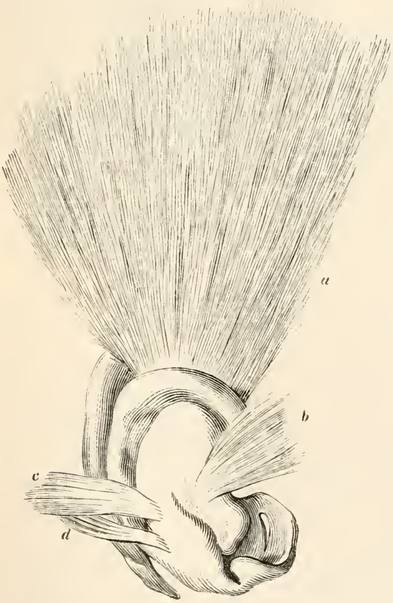

Auricular cartilage from behind, and extrinsic muscles. XXVIII''.

But pale and feeble representatives of the auricular muscles are met with in the dissection of Europeans. The ‘attollens auriculæ’ is the largest, fig. 190, *a*, arising from the epicranial aponeurosis; its fibres converge to be inserted in the surface of the ear-cartilage next the head. The ‘retrahens auriculæ,’ ib. *c*, *d*, consists of two or three fascicles arising from the mastoid and inserted into the back of the conch. The ‘attrahens auriculæ,’ ib. *b*, arises from the zygoma, and is inserted by a broad but short tendon into the helix near the tragus. Five groups of fibres have been made out in the auricle itself, and are described as the ‘intrinsic muscles.’ The ‘helicalis major,’ fig. 191, *a*; the ‘helicalis minor,’ ib. *c*; the ‘tragicus,’ ib. *d*; the antitragicus,’ ib. *e*, and the ‘transversalis auriculæ,’ fig. 192, *a*.

All these muscles of the human external ear exemplify the Lamarckian law of degeneration from disuse. In the primitive men of the ‘stone-period,’ they probably existed in normal size and force.

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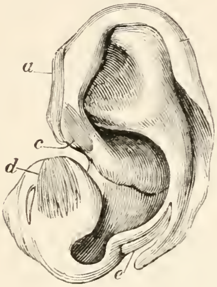

Front view of auricular cartilage, and intrinsic muscles. XCVIII″.

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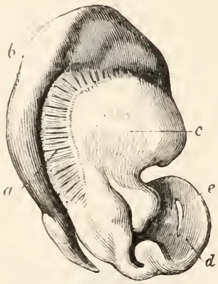

Back view of auricular cartilage and transversalis muscle. XCVIII″.

In thus concluding the comparative anatomy of the organ of hearing, it has to be owned that, hitherto, the experiments of the accomplished and ingenious physicists and physiologists to that end have failed to demonstrate the relations of the various exquisite structures to sound, in the satisfactory way in which those of the eye are understood to relate to light. The vestibular part of the labyrinth may be inferred to detect the presence and intensity of sound, especially as conveyed through the external ear and tympanum. It has been conjectured and argued that the semicircular canals are concerned in forming a judgment of the direction of sounds. The cochlea receives those sounds which are propagated through the bones of the head, and is conjectured to be the medium of the perception of the pitch of notes, and of the *timbre* or quality of sounds. The tympanum affords a non-reciprocating cavity for the free vibration of its membrane and of the otosteals: it also renders the labyrinth independent of atmospheric vicissitudes. The otosteals conduct vibrations from the tympanic membrane to the vestibular one, and, under the influence of the muscles, regulate the tension of both these and of the cochlear fenestra, so as to protect the ear against the effects of sounds of great intensity. The external ear and meatus are collectors and conductors of vibrations, and the former assists in enabling us to judge of the direction of sounds.

§ 217. *Organ of Sight.*—A. *Eyeball.* The organ of sight, like that of smell, is wanting in a few Mammals, the eyeball being reduced to the size and condition of the 'ocellus' in Amblyopsis, and to its simple primitive office of taking cognisance of light, a filament of the fifth aiding the remnant of a proper optic nerve. The moles, especially the Italian kind, *Talpa cæca,* and mole-rats, exemplify this condition, in which, as in *Spalax typhlus,* the skin passes over the ocellus without any palpebral opening, or loss of hair. The eyeballs are very small in the allied genus *Bathyergus,* fig. 174, and other rodent burrowers: they acquire the largest absolute and proportional size in the Ruminant order. In no Mammal is bone developed in the sclerotic: in most a special cavity, called 'orbit,' is fashioned in the facial part of the skull to give lodgment to the eye-ball. One sees least indication of it in the blind quadrupeds above noted and in the ant-eaters: it is deepest, best defined, and most completely walled in Man.

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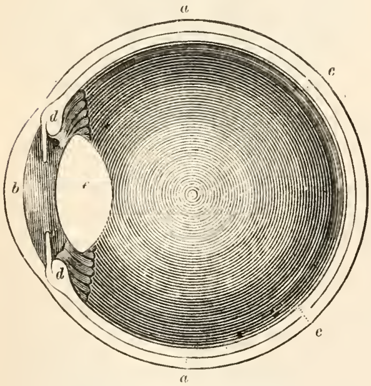

Diagrammatic section of Mammalian eye. cv''.

In all Mammals with the eye developed for sight, properly so called, we recognise, as in the diagrammatic section, fig. 193, the fibrous capsule, *a,* called 'sclerotic coat,' the transparent fore part, *b,* called 'cornea;' the vascular tunic, *c,* called 'choroid coat,' becoming thickened, at *d,* by the so-called 'ciliary ligament,' from which the 'ciliary processes' are, as it were, reflected backward upon the capsule of the lens, *f*: while the movable curtain, or 'iris,' is continued onward into the space between *b* and *f,* leaving a central opening, called 'pupil,' for the admission of light. The choroid, *c*, is lined by the expansion of the optic nerve called 'retina,' which extends to the 'ciliary processes,' and is kept outstretched by the 'vitreous humour' contained in the cells of the delicate membrane called 'hyaloid,' which restrains its forward advance beyond the 'crystalline humour' or lens, *f*. The space in front of this body is occupied by the 'aqueous humour,' and is divided by the iris into an 'anterior' and 'posterior chamber.'

The rays of light admitted by the cornea and pupil are slightly refracted in traversing the aqueous humour, and are subject to a greater degree of convergence in passing through the denser lens, fig. 194; when, striking the retina at the back of the globe, they there depict the image of the visual object, inverted.

194

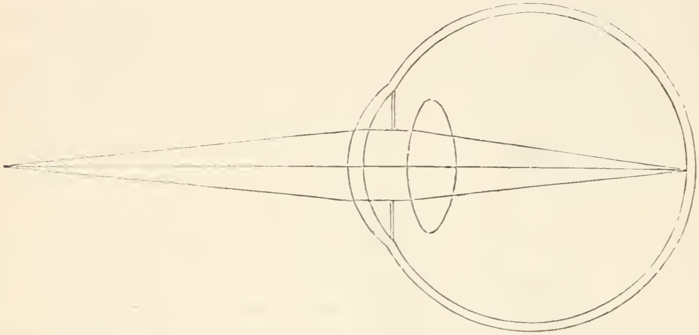

Diagram of course of luminous rays in traversing the humours of the eye.

In crepuscular and nocturnal Mammals (*Pteromys*, Aye-aye, Lemur) the cornea gains in size and convexity and the iris in breadth; the latter being capable of admitting many rays through a very wide pupil, which also it can completely close against the glare of noontide. The convexity of the lens is concomitantly increased, and it approaches the spherical form most nearly, in bats and nocturnal rodents. The vitreous humour is less in proportion to the crystalline and aqueous humours in such eyes. In aquatic Mammals, on the contrary, the cornea hardly projects (seals, whales), and there is little aqueous humour; here, also, the convexity of the lens is in excess, fig. 195, *d*. In most diurnal and terrestrial mammals, the eyeball is subspherical, the cornea slightly projecting at the fore part, as forming part of a smaller sphere than the rest of the globe. The lens retains much of the proportions shown in fig. 194.

In the *Ornithorhynchus* the eyeball is small and spherical; the sclerotic fibro-cartilaginous, the cornea flabby, the retina thick: there is no trace of pecten or marsupium: the lens is two lines in transverse diameter, one line in antero-posterior diameter; the anterior surface is nearly flat, the posterior very convex. The choroid is black, without a tapetum lucidum; the pupil is circular.

The anatomy of the eye offers no peculiarity illustrative of the affinities of the Marsupialia or of any other speciality in their economy save the nocturnal habits of the majority of the order. It is in relation to these habits that the lens is large and convex, the iris broad, the pupil round and very dilatable, and the cornea correspondingly large. The eye is relatively large in the swift-moving, far-ranging Kangaroos: I found the dark pigment on both the inside and outside of the choroid; the ciliary processes are long: the lens is proportionally large. In the dead Kangaroo the radiated muscle of the iris is much contracted, and the pupil widely open. The eye is small in *Didelphis virginiana*; the pupil is round: the lens very convex.

The *Insectivora* have small eyes: the moles least of all. In a great pipe-toothed shrew (*Solenodon*) one foot in length, exclusive of tail, the palpebral opening does not exceed three lines, and there is no distinction between orbit and temporal fossa. Bats have the smallest eyes of all volant Vertebrates. In Rodents the size of the eyeball bears relation to the extent and swiftness of locomotion, and is greatest in *Jerboidæ* and *Leporidæ*. The position of the eyes is always lateral, and by the prominence of the cornea they are susceptible in these timid quadrupeds of receiving the image of a pursuer. In the hare and other rodents the retina seems to expand from the divisions of a cleft termination of the optic nerve, within the eyeball. The pupil is round in most Rodents: in a dead Agouti it was a horizontal ellipse. In the squirrel the ante-retral diameter of the eyeball is to the transverse as 11 to 12: in the hare it is as 23 to 25.[1] In all the order *Bruta* the eyes are relatively small: in the sloths the contracted pupil is a vertical slit.

In *Cetacea* the eyes are small, especially in relation to the bulk of the larger kinds: and the essential part of the organ is still less, owing to the thickness of the sclerotic, fig. 195, *a*, *a*, and this increases from the cornea, *b*, backward to the long, infundibular canal for the optic nerve, *f*. Outwardly the eyeball is subspherical; but, in the section figured, the contour of the cavity containing the vitreous humour, *e*, and lens, *d*, presents an ellipse, with the long axis transverse: in a *Balænoptera* of 65 feet in length, this axis measured $2\frac{1}{3}$ inches, and the shorter axis 2 inches: the posterior curve is regular; but, toward the cornea, the sclerotic turns in quickly, *c*, flattening the fore part of the eye: the distance between the fore part of the sclerotic and the bottom of the eye being but $1\frac{1}{4}$ inches. In shape the cornea is a longer ellipse than the eyeball, and the upper border is more curved than the lower: it is thinner at the centre than the circumference, and is soft and flaccid in the dead whale. The choroid has a silvery or bluish white hue on the inner surface: the darker pigment is limited to the ciliary processes and back of the iris. In a mysticete whale (*Balæna*) the cellulosity connecting the choroid with the sclerotic was of a light brown hue: the darker pigment extends from the ciliary processes a little way upon the choroid: and in both kinds of whale is so disposed as to absorb the rays of light and prevent them being a second time reflected so as to disturb the spectrum on the back of the retina. Of the numerous minute folds which constitute the ciliary zone every third, fourth, or fifth is enlarged, and produced forward to form a wrinkled corrugated process about three lines long, compressed and terminating obtusely: the intermediate shorter processes are of varying length; the long ciliary processes are about seventy in number, in *Balænoptera*. The peripheral radiated contractile fibres of the iris, and the central circular ones, are conspicuous on the back part of that curtain in whales: the front surface shows the wavy vessels radiating from arterial canals which surround the margin of the pupil which is transversely elliptical. Four equidistant canals in the thick sclerotic give passage to the long ciliary arteries and the vorticose veins: the two arteries which advance in the direction of the long axis of the pupil terminate in a canal bordering the pupil a little way from its margin: the wavy branches radiate from this canal, and are prominent on the

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[1] A table of these dimensions of the eye in different Vertebrates will be found in XII. iii. p. 390; also in CVI″.

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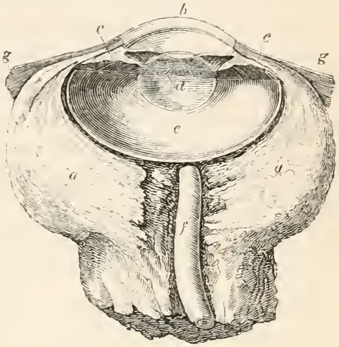

Section of the eye of a Whale.

anterior surface of the iris. The quantity of the aqueous humour is small: the lens, *d*, is subspherical, flatter in front than behind. The nucleus is seen in the posterior half and the surrounding laminæ are reflected inward and backward toward the middle of the anterior surface of the nucleus, leaving a funnel-shaped cavity in front of it which is filled by less dense substance. In *Hyperoödon* the pupil is transversely oblong with a moderate projection of the upper margin, reminding one of the skate's pupillary curtain (vol. i. p. 334). In the Grampus the choroid presents a greenish tinge: in the Porpoise it is a bluish white. In both, the pupil resembles that of *Hyperoödon*. The retina is thick.

In the Seals the sclerotic is chiefly remarkable for the sudden thinning at the part corresponding with the ciliary zone; it is moderately thick both in front and behind: the cornea is thin and flabby. The muscles of the eye-ball being inserted into the anterior part of the sclerotic may shorten the axis of the eye and bring the lens nearer to the back of the globe, thus adapting it to vision in air and water. In the *Sirenia* the eye is very small. In a *Rhytina* of 25 feet in length the eye-ball was but 1¼ inch in diameter: it is about 1 inch in diameter in the Dugong: the pupil is circular.

The eye of the Elephant is about 2 inches in diameter, reminding one of that in the Whale by its small relative size: there is likewise an unusual thickness of fibrous or sclerotic substance at the entry of the optic nerve, and a similar extent of light-coloured tapetum within the choroid, which tapetum presents the fibrous type of structure: the pupil is round, the cornea is larger and more convex than in *Cetacea*.

In the Rhinoceros the eyeballs are of small comparative size; in the Indian species which I dissected,[1] each measured in antero-posterior diameter one inch five lines, and in transverse diameter one inch three lines. Some dark-brown pigment lies under the conjunctiva for the extent of about a line from the circumference of the cornea: the same kind of pigment is also deposited upon the outside of the nictitating eyelid, and over a great part of the inner surface of the same part, covered of course by a reflection of the conjunctiva. The trunks of the venæ vorticosæ perforate the sclerotica half-way between the entry of the optic nerve and the edge of the cornea: their disposition, with the flocculent but somewhat firm connecting tissue of their radiating branches, presented that structure which most nearly resembled the figures given by Mr. Thomas of the parts he

[1] v″, p. 56.

describes as 'processes having a muscular appearance, with the fibres running forwards in a radiated direction.'[1] On removing the anterior part of the sclerotica, whilst the eye was suspended in spirit, both the vitreous humour and the lens rolled out; and the capsule of the lens showed no particular mark of the insertion or fixation of the ciliary processes; their impressions, in remains of pigmental matter, were perceptible on the anterior part of the 'canal of Petit.' The transverse diameter of the lens was six lines, the antero-posterior diameter four lines. The pigment was not confined to the inside of the choroid; but in both Rhinoceroses dissected by me, I found on the outside of the chorion much loose cellular tissue, with dark pigment: this coloured flocculent tissue concealed at first the venæ vorticosæ, even when injected. The sclerotica is one line thick at the back part of the eyeball; and is thinnest near the middle of the ball, becoming thicker towards the cornea, which is two lines thick. The choroid adheres pretty strongly to the back part of the sclerotic, around the entry of the optic nerve, both by the entering vessels and by the tenacity of its outer flocculent coat, especially where the vessels penetrate the sclerotica. There is no tapetum lucidum. The lower eyelid has a special depressor muscle.[2]

The Tapir has a proportionally small eyeball. Of the Perissodactyle group the Horse has the largest eyes, in relation to its greater powers of locomotion. They are lateral, prominent, capable of directing against any object in the rear, without turn of the head, the outkick of the hind-leg. The cornea inclines to an oval figure, the larger end being toward the nose. The tapetum is of a light blue colour, and fibrous structure: the ciliary processes are long; more numerous than in the ox: the pupil is transversely oblong, rather wider on the nasal side, with a few processes from the upper margin.

In the Hog-tribe the cornea is oval, with the large end internal, or toward the nose; the sclerotic is thin; the pupil is round; the eyeball rather larger than the palpebral opening would indicate; the inner figure of the choroid is of a shining chocolate colour in the common Hog, but much darker in the Babyroussa. The eyes in Ruminants are large, lateral; the transverse exceeds the fore-and-aft diameter of the eyeball. In the Ox the latter is to the transverse diameter as 43 to 49; in the sheep as 32 to 35. The ciliary processes are short in most, especially in some Antelopes: the retina extends far forward.

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[1] cvi″, p. 157, pl. x., figs. 1–3.

[2] v″, p. 56.

The tapetal layer is fibrous, extensive, of almost metallic brightness; in most of a fine green colour; in a few of a bluish tint, with certain portions, generally toward the bottom of the eye, white: in the Ox the tapetum occupies a broad transverse tract of the choroid. The pupil is transversely oblong, with the upper border somewhat festooned in the Camel, Ox, and Sheep.

In the Carnivora the relative size of the eyes increases from the Bears to the Cats. The tapetal layer exists in most, and consists of obscurely nucleated cells. In the nocturnal Badger it is silvery white; in the Dog and Wolf whitish, edged with blue; in most felines of an amber, or golden, or greenish hue, with a lighter tract of crescentic form, curving round the lower part of the entry of the optic nerve. In the Lion, the greater extent of tapetum is below the nerve; only a small portion above: the general form of the whole tapetum is broadly crescentic in Felines. In the small crepuscular Cats the pupil contracts to a vertical slit; in the larger diurnal felines it is circular. The optic nerve penetrates more nearly the axis of the eyeball in Carnivores than in Ruminants: the ciliary folds are long, especially in the Lynx, in which the retina does not reach the meridian of the eyeball: it is also very thin.

In the nocturnal Quadrumana the main modifications of the eyeball have been noted; the large and prominent cornea, the unusually convex lens, the broad iris and circular pupil, and the patch of tapetum, are well exemplified in the dissection of the eyes of *Stenops gracilis*, in XX, vol. iii. p. 158, no. 1706. I found also a delicate tapetum at the back of the eye in *Chiromys*; but the light is less brightly reflected from the living eyes of the Aye-aye than from those of the slow Lemurs. The lens is almost spherical in *Perodicticus*. In no Lemurine has the retinal spot been found; but there seems to be a minute fold or crease in its place. This spot, fig. 201, A, due to a thinning there of the retina, defined by a yellowish border, accompanied, usually, in the dead eye, with a slight crease, and situated in or very near the axis of vision, exists in the catarrhine *Quadrumana* as in Man. The sclerotic seems, in most, to be somewhat thinner than in Man and to take more readily the stain of the choroidal pigment after death. In no *Quadrumana* above the Lemurs is there a tapetum.

The human eyeball is in some individuals a sphere; in most the antero-posterior is rather less than the transverse diameter.[1] The sclerotic, or 'tunica albuginea,' is of a fibrous structure, and so much as is visible at the fore-part of the globe forms the 'white of the eye:' being thinner here than behind, the dark choroid appearing through it sometimes gives it a bluish tint; it resumes thickness near the cornea. This, fig. 193, *b*, forms the segment of a smaller sphere than the rest of the eyeball; it is perfectly transparent in the living eye, and consists of a proper tunic, a most delicate continuation of conjunctive membrane, fig. 207, *g*, over the outer surface, and an elastic layer on the inner surface with which the membrane of the aqueous humour is blended: the proper tunic is laminated. It is intimately connected with the sclerotic; the elastic layer is continued beneath the sclerotic, 'as if slipped between it and the ciliary ligament,' fig. 193, *d*. The choroid is the vascular tunic of the eye and is stained, in Man, within and without with a deep brown or black pigment: the outer surface is flocculent, through the attachment to the cellulosity uniting it with the sclerotic: the inner surface is smooth, highly and minutely vascular: this surface, artificially separated from the outer surface supporting, as in fig. 196, the trunks and larger branches of the vessels and nerves, was termed the 'tunica Ruyschiana.' The arteries supplying the choroid are the 'short ciliary:' the 'long ciliary' arteries are chiefly distributed to the iris, and also give anterior branches to the sclerotic. The veins of the choroid converge in arches to four or five trunks which pierce the sclerotic at equal distance from each other behind the middle of the eyeball: from this disposition, shown in fig. 196, they are termed 'venæ vorticosæ.' The choroid receives minute branches from the ciliary nerves in their passage to the iris. On the outer part and anterior border of the choroid is a circle of grey softish substance, applied, like a band, round the margin of the aperture into which the iris is fitted: it adheres closely to the sclerotic at the line of the attachment of the cornea. The ciliary nerves penetrate and subdivide in this zone, which is termed 'ciliary ligament,' fig. 197, *a*. On the inner surface of the anterior border of the choroid is a circle of longitudinal folds of that membrane, called 'ciliary processes,'

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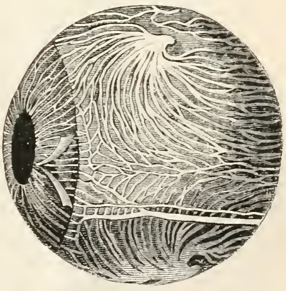

Outer surface of choroid and iris; Man, magnified. CVII″.

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[1] According to the careful admeasurements in CVI″.

collectively 'ciliary zone,' or '*corpus ciliare*,' fig. 198. Of these folds, in Man, there are from sixty to seventy, about two lines in length, but alternately a little longer and shorter. The free central or internal border of the fold sinks into the contiguous hyaloid membrane, round the circumference of the crystalline lens, the anterior ends of the processes project into the posterior chamber of the aqueous humour, touching the iris, and bounding peripherally that chamber. The circular screen or curtain attached at its periphery to the ciliary ligament, and interposed between the cornea and lens is called the 'iris;' its aperture is the 'pupil,' which is nearly in the centre of the disc, but a little toward the nasal side. The anterior surface of the iris, fig. 199, presents linear elevations, irregular in size and number, converging to a circular one about $\frac{1}{20}$th of an inch from the margin of the pupil: from the 'circle' numerous minute striæ converge to the margin itself. The anterior surface is the seat of that variety of colour, to which, in common parlance, the colour of the eye itself is attributed. The posterior surface of the iris is covered by a thick layer of black pigment which when removed exposes a number of lines converging from the ciliary folds to

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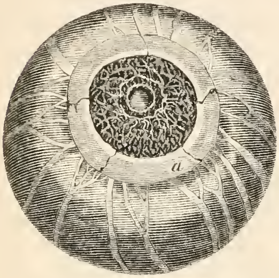
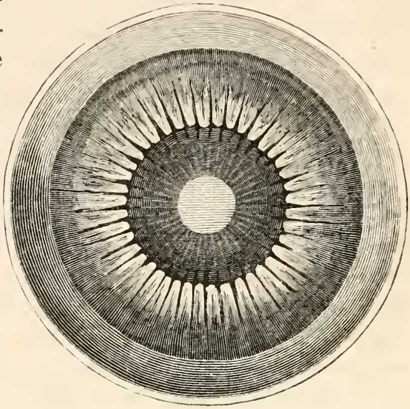


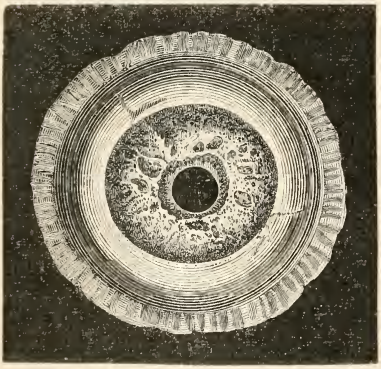
Ciliary ligament and iris. CV″.

198



Ciliary zone, iris, and pupil, from within; Human, magn. CVI″.

199



Anterior surface of iris. CV″.

within a short distance of the pupil; this is immediately encircled by a band, $\frac{1}{20}$th inch in breadth, which is the orbicular or sphincter muscle. The radiating lines, by analogy with the eye of the Whale and Giraffe, indicate the 'dilator fibres' of the pupil. The peculiar contractile office or muscular character of the iris calls for the large supply of nerves; it is also highly vascular. The two long ciliary arteries which penetrate the sclerotic posteriorly, advance horizontally, about the middle of the eyeball, between that membrane and the choroid, to the iris, where each divides into two branches, which proceed round the circumference and inosculate with each other, thus forming an arterial circle, from which numberless branches converge to the pupil. The nerves are derived from the third and fifth pairs, with communications from the sympathetic, and consequently having connections with the sixth. They penetrate the sclerotic posteriorly, and advance towards the iris between the sclerotic and choroid, about fifteen or twenty in number: arrived at the ciliary ligament, they divide at acute angles, as in fig. 197, and may be traced through this structure until they are finally lost in the iris. The optic nerve, on entering the orbit, bends a little forward and enters the eye about an eighth of an inch below and internal to the axis of the globe: it undergoes a constriction, as in fig. 200, *a*, just before piercing the sclerotic: on entering the cavity of the eyeball the neurine forms a slight prominence, before expanding into the sheet called 'retina.' The branch of the ophthalmic artery which penetrates the optic nerve before it reaches the eye, emerges from the centre of the terminal prominence by the 'porus opticus,' and ramifies, as 'arteria centralis retinæ,' upon the vascular layer adherent to the hyaloid membrane of the vitreous humour. The microscopic character of the retina itself is given in vol. i. p. 332. It is covered externally by a delicate transparent membrane, by which the retina is connected with the Ruyschian layer of the choroid. In the Horse, Ox, and Sheep, this membrane is more easily demonstrated than in Man, where it is obscured by the black pigment: the

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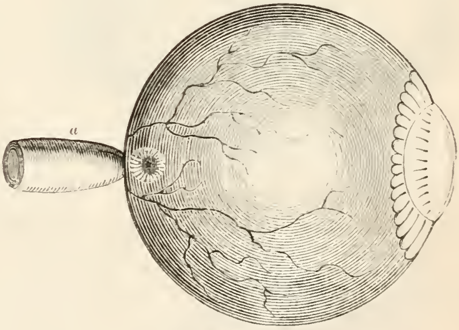

Optic nerve and retina. v''.

subjoined cut (fig. 201, B) gives Dr. Jacob's illustration of this membrane as partly reflected from the back of the retina. In the centre of the retina and axis of vision is a speck which retains its transparency when the rest of the nervous expansion has become opaque after death; this speck is margined by a yellowish tint; and in the dead eye one or more short delicate folds pucker the contiguous retina. It was regarded as a natural perforation by its discoverer, and has been called the 'foramen of Soemmerring:' it is a modification of the retina. The relative position of the 'macula centralis' to the termination of the optic nerve, whence the branches of the arteria centralis diverge, is shown in fig. 201, A. The retinal neurine terminates at the posterior margin of the ciliary body. The vitreous humour, which mainly maintains the sphericity of the eye, consists of water, 98·40; chloride of sodium with a little extractive matter, 1·42; albumen, 0·16; a substance soluble in water, 0·02. It is lodged in the cells of the hyaloid membrane, receives in an anterior depression the crystalline lens, fig. 202, *a*, from the circumference of which it is extended to the anterior extremities of the ciliary processes, shows their impressions at *c*, and bounds the posterior chamber of the aqueous humour. The cellular structure of the part of the hyaloid at the circumference of the lens when demonstrated by inflation or injection, produces the appearance shown at *b*, called by its describer Petit, 'canal godronné:' the folds of the hyaloid in relation to the ciliary processes form the 'corona ciliaris,' ib. *c*. In the human crystalline lens the anterior is to the posterior convexity as 4 to 3: the transverse diameter is from 4 to 4½ lines, the thickness or axis is about 2 lines. The degrees of convexity of both surfaces vary at different periods of life. In fig. 203, A shows the lens of a six-months' fœtus, B, of a child of six years, C, of an adult of middle age: after fifty

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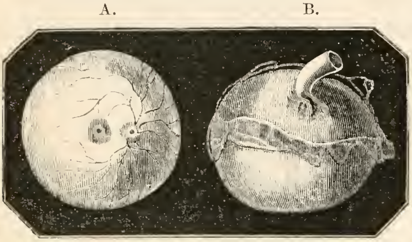
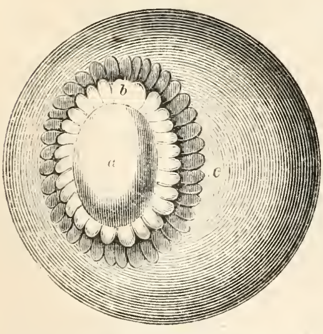


A. Back of retina, showing macula centralis and porus opticus.
B. 'Jacob's membrane' reflected from the retina. CV''.

202



Vitreous humour with hyaloid membrane and lens, showing the 'canal of Petit' and corona ciliaris; magn. CV''.

it becomes rather flatter and also firmer in texture. The density of the lens is not the same throughout, the surface being nearly fluid, while the centre scarcely yields to the pressure of the finger and thumb, especially in advanced life. The eye is thus rendered achromatic. The specific gravity of the lens to water is as 10024 to 10000: the refractive power of the centre of the lens is to that of water as 18 to 7. Brewster found the following to be the refractive powers of the different humours of the human eye, the ray of light being incident upon them from the eye: 'aqueous humour, 1·336; crystalline, surface 1·3767, centre 1·3990, mean 1·3839; vitreous humour, 1·3394. But as the rays refracted by the aqueous humour pass into the crystalline, and those from the crystalline into the vitreous humour, the indices of refraction of the separating surface of these humours will be, from the aqueous humour to the outer coat of the crystalline, 1·0466; from the aqueous humour to the crystalline, using the mean index, 1·0353; from the vitreous to the outer coat of the crystalline, 1·0445; from the vitreous to the crystalline, using the mean index, 1·0332.' If the lens with the capsule attached to the hyaloid membrane be placed in water, the following day it is found slightly opaque or opaline, and split into several portions by fissures extending from the centre to the circumference, as in fig. 204, B. If allowed to remain some days in water, it continues to expand and unfold itself; and if then transferred to spirit and hardened, it may be unravelled by dissection, fig. 204, C, and its fibrous structure demonstrated.

203

Crystalline lens, human, at different ages; nat. size. CV″.

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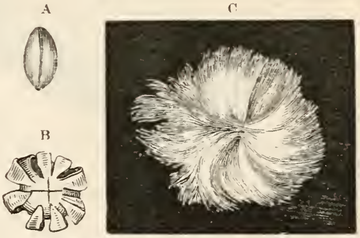

A, Crystalline lens, natural state; B, peripheral softer portion fissured by action of water; C, resolution of nucleus into fibres, magnified. CV″.

In Man and Mammals generally three septa diverge from each pole of the lens at angles of 120°, the septa of the posterior surface bisecting the angles formed by the septa of the anterior surface: the fibres diverge from these septa as shown in fig. 205. The denticulated structure by which the fibres are laterally united, or interlock, is shown in vol. i. p. 333, fig. 217, in the crystalline lens of a cod. The human lens is inclosed in a transparent, firm, elastic capsule. A branch of the 'arteria centralis retinæ' attains the back part of the capsule, and ramifies richly thereon, in the fœtus.

The aqueous humour lodged in the chamber between *b* and *f*, fig. 193, has a refractive power very little higher than that of water; 100 parts consisting of 98·10 of water, 1·15 of chloride of sodium, and 0·75 of extractive matter soluble in water, with the merest trace of albumen: it is secreted by the membrane lining the chamber.

B. *Appendages of the Eye.*—The muscles moving the human eyeball are the four straight and two oblique ones. In lower *Quadrumana* a few fibres seem to be detached from the inner part of the origin of the recti to be inserted into the sclerotic nearer the entry of the optic nerve. This is the remnant of a stronger muscle, which in other Mammals, with few exceptions, surrounds the optic nerve, expanding, funnel-wise, as it approaches the back of the eyeball: it is called the 'choanoid muscle,' or *suspensor oculi*, and is supplied by a branch of the sixth cerebral nerve. In *Cetacea* it is divided into four short muscles, paralleling the longer recti, but of greater breadth and almost continuous: they are inserted into the sclerotic behind the transverse axis of the eye-ball. The narrower and longer recti muscles expand to be inserted anterior to that axis. The superior oblique arising, with them, above the foramen opticum, has the course of its fibres changed, as usual, by a pulley at the upper and fore part of the orbit, but in passing through the substance which serves as the trochlea, the muscle is only partially tendinous and little diminished in diameter. The inferior oblique is long, and broad at its insertion.

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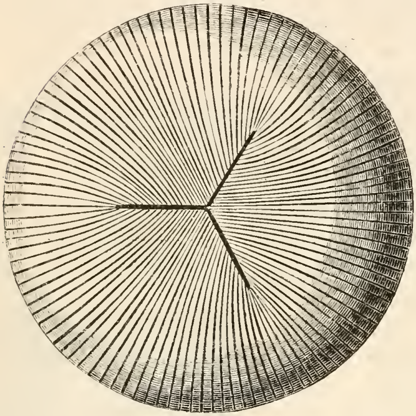

Arrangement of fibres of lens, Mammal. CCXIII.

In the Rhinoceros the fasciculi of the choanoid muscles have coalesced into two masses: in most quadrupeds they form a single 'infundibular suspensor.' The cellular tissue is more or less condensed between the insertions of the choanoid and the fleshy parts of the recti muscles, and in Man between these and the eyeball, the recti perforating this layer or sheath before expanding to their insertions. The upper one, 'rectus superior,' directs the cornea upward, the 'rectus inferior' downward, the 'rectus externus' outward, the 'rectus internus' inward or toward the nose; the 'recti' antagonising, or combining with, each other in all the degrees required to make the cornea assume any intermediate direction: they can thus produce the movements analogous to the 'circumduction' of a limb; in doing which the centre of the cornea describes a circle. For 'rotation' of the eyeball, in which this corneal centre remains fixed as the fore end of an axis, the two muscles called 'oblique' are added.

In Mammals the 'superior oblique' arises from the back part of the orbit with the recti, advances to the upper part of the rim, glides there through a tendinous pulley, returns toward the eyeball, is reflected backward and outward beneath the rectus superior, and is inserted into the sclerotic between this muscle and the rectus externus. The inferior oblique takes its origin, in advance of the eyeball, from the orbital plate of the maxillary; passes outward and backward beneath the 'rectus inferior,' and is inserted into the outer and back part of the sclerotic. The two oblique are so disposed as to act, when antagonising each other, in rotating the eyeball on its antero-posterior axis: when combining in action they tend to draw forward the eye, and thus antagonise the recti muscles collectively. The trochlear arrangement of the superior oblique is peculiar to the present class.

As habitually antagonistic muscles have nerves from distinct sources, the rectus abductor is supplied by the 'sixth' nerve, the rectus adductor by the 'third.' The superior oblique, which opposes the inferior one in most movements, is supplied by the 'fourth' nerve. As the depression of the eyeball can be performed by the superior oblique if the downward motion be directed by the lateral muscles, it suffices that it should have the same separate nerve (fourth) for that motion as for antagonising the inferior oblique, which, like the upper, lower, and inner recti, is supplied by the 'third nerve.'[1]

In *Cetacea* the eyelids are represented by a continuous circular fold of the skin, leaving a round opening in front of the eye with a narrow margin unprovided with eyelashes. This 'palpebral' opening is closed by an orbicular muscle or sphincter, and is expanded by four broad, thin, almost continuous muscles (in the Porpoise). The 'tunica conjunctiva,' fig. 195, *g*, lines the circular eyelid, and is reflected upon the eyeball, near its middle. At the line of reflection are the orifices of a zone of 'Meibomian' follicles: an aggregate of somewhat more complex ones at the inner side of the eyeball represents a 'Harderian' gland. There is no true lacrymal gland, nor any 'third' or nictitating lid. The presence of this eyelid distinguishes the *Sirenia* from the *Cetacea*;[1] and the Harderian gland is more distinctly developed. In Seals the circular eyelid is supplied by four dilators and a sphincter, as in Whales; but an external groove at the inner canthus indicates the division of the horizontal eyelids: the nictitating membrane is well developed and the Harderian gland at its base is large. In the Elephant the 'third' or vertical eyelid is supported by a flat, slightly curved cartilage, which becomes thinner as it is attached to the concave free margin: the Harderian is continued as in Cetacea, from a group of smaller mucous glands, which have many excretory orifices upon the margin of the third eyelid, but its principal duct terminates upon the inner surface near the base of that lid. There is a special 'nictitator' muscle, the fibres of which pass at first over the base of the membrane in a curve, then form an angle to include the extremity of the nictitating cartilage, which is consequently moved in the diagonal of the contracting forces, and pushed forward and outward over the front of the eyeball. In the Rhinoceros the lower eyelid has a depressor muscle. The Harderian gland is large in the Hog-tribe; its duct opens upon the lower part of the inner surface of the membrane: it co-exists with a 'caruncula lacrymalis.' There is a small lacrymal gland the duct of which opens upon the inner surface of the upper eyelid: the margin of this is provided with a row of stiff, unequal cilia, beneath which are orifices of the 'Meibomian glands.' In most Ungulates the base of the third eyelid is buried in a fatty and fibrous substance. In the Sheep a large 'caruncula' co-exists with the Harderian and lacrymal glands. The upper eyelid has cilia in all Ruminants. The margins of the lids and the conjunctiva are charged with black pigment in the Giraffe; and the cilia of the upper lid are very long.

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[1] For Hunter's excellent remarks on 'the use of the Oblique Muscles,' see XCIV. p. 24.

The eye is protected, in the Ornithorhynchus, by a cartilaginous plate continued from the upper part of the orbit, comparable with the palpebral plates in the crocodile. Both the water Monotreme and the Echidna have a well developed membrana nictitans: there are also an upper and a lower eyelid, each of which has its proper apertor muscle. In Marsupials, the

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[1] CXVII''. p. 28.

Harderian gland and the retractor oculi co-exist, as usual, with the nictitating eyelid. This is largely developed, and the conjunctiva covering its free margin is stained black. Beneath the upper eyelid, in the Kangaroo, there is a cartilaginous ridge having the conjunctiva reflected over it. There are no palpebral cilia in *Didelphis.*

The Harderian gland subserves the movements of the third or nictitating lid, and with the choanoid muscle, are present in all quadrupeds up to the *Quadrumana.* In these, as in Man, the third lid is reduced to a small fold, fig. 206, *g*, at the inner canthus, within and projecting a little beyond the vascular protuberance called 'caruncula lacrymalis,' ib. *f*: the Harderian gland ceases to be developed: the true lacrymal gland at the upper and outer part of the orbit, fig. 209, *k*, *l*, is large. In fig. 206 the orifices of the 'tarsal' or 'meibomian' glands are shown at *a*, *a*. In Man and Quadrumana the upper of the two horizontal lids is the largest and most movable, contrary to the case in most lower Mammals. The fibrous tissue within that fold of skin is now condensed to form a 'tarsal cartilage,' largest and most conspicuous in the upper lid, of which it forms the basis: its straight and thick border constitutes the ciliary margin. In the lower lid the so-called 'cartilage' is hardly more developed than it is in both lids of quadrupeds. The meibomian follicles extend into the fibrous (lower lid) or fibrocartilaginous (upper lid) tissue. The muscle closing the lids is the 'orbicularis palpebrarum,' fig. 29, *o*. The upper lid is raised by a special muscle, 'levator palpebræ superioris,' which extends from the upper border of the optic foramen, to the tarsal fibro-cartilage. The lower lid on the relaxation of the 'orbicularis' which draws it up, falls down by its own elasticity: rarely in Mammals has it a proper

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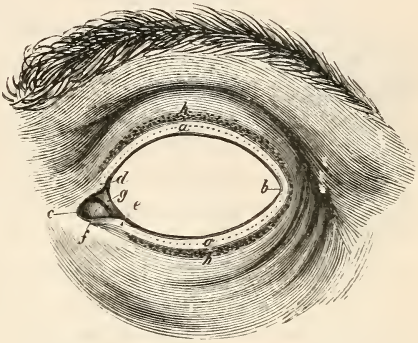

The eyelids of the left side opened. XCVIII''.

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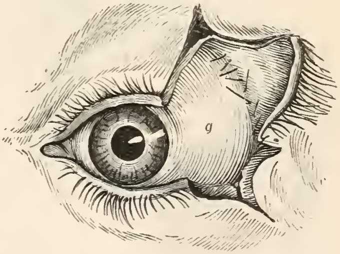

Section of eyelids showing extent of conjunctive membrane and ducts of lacrymal gland. CX''.

depressor. The outer border of the ciliary margin of both lids is provided, in Man, with eye-lashes, fig. 207, the orifices of which, when plucked out, are shown at *h*, fig. 206. In this figure *b* is the 'outer canthus,' *c* the 'inner canthus,' *d* lacrymal papilla or 'punctum' of the upper lid; *e*, the same of the lower lid; *f*, the lacrymal caruncle; *g*, the semilunar fold representing the 'third eyelid,' and now forming the bottom of the 'lacus lacrymalis' within the fissure of the inner canthus; *i*, the eyebrow. In the section of the outer parts of the eyelids, in fig. 207, is shown the line of reflection of the conjunctive membrane upon the eyeball, *g*, at the upper and outer part of which line open the 9 to 12 orifices of the ducts of the lacrymal gland, into which bristles have been inserted.

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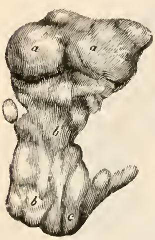

Lacrymal gland, left side. cx″.

The gland, fig. 208, consists of an upper portion *a*, *a*, which is lodged in the shallow depression at the outer side of the roof of the orbit, and a lower thinner portion, *b*, *b*, which is a looser aggregate of lobules extending into the substance of the upper eyelid. The fluid contributed by the lacrymal and meibomian glands to the conjunctival cavity, after being spread by the winking movements of the lids over the front of the eyeball, is carried along the groove formed by the margins of the closed lids to the inner canthus, and is there imbibed by the 'puncta lacrymalia,' fig. 209, *a*, *a*. From each of these orifices a canal is continued, ascending in the upper, descending in the lower lid; in both, then, bending at an acute angle and converging to a long dilated receptacle, *f*, *g*, called 'lacrymal sac.' The large blind end, *e*, is directed upward; the sac gradually contracts, *h*, to the 'nasal duct,' *i*, which opens into the inferior meatus, fig. 152, *k*, of the nose. In all Mammals with divided or horizontal eyelids there is a similar provision for carrying off the waste lubricating fluid of the eyeball. In Man, in whom the true lacrymal gland is relatively largest, its peculiar secretion — the tears — when emotionally secreted in excess, overflows the palpebral groove.

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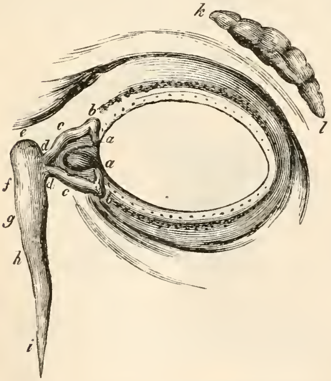

Lacrymal apparatus, Human. cx″.

C. *Parallel between eye and ear.*—The author of the excellent articles, XCVII″ and CX″ has drawn a parallel between the eye and ear which, in the main, appears to me to express justly the 'serial homologies' of the parts of those sense-organs. I include, however, the consideration of the cavities in which they are respectively lodged. The 'otocrane' parallels the 'orbit.' The homology is masked by the deeper situation of the former, its communication rather with the interior than with the exterior of the cranium, and its more frequent coalescence with the fixed bony sense-capsule which it includes. In some Mammals, however, that capsule retains its primitive and typical distinctness, and can be removed from the otocrane.[1] This is, then, seen to be formed by the exoccipital and alisphenoid, the mastoid, the tympanic, and, in Mammals, the expanded and intercalated squamosal. The primitive bony nuclei of the capsule which appear round the fenestra rotunda, on the outer end of the upper vertical semicircular canal, and on the middle of the hinder vertical semicircular canal, extend to form the bony labyrinth, and are wholly independent of the centres from which the ossification of the mastoid or other otocranial bones begins. The addition of bony matter envelopes in various degrees the first formed part of the capsule, called 'bony labyrinth,' and constitutes, therewith, the 'petrosal.' This capsule of the ear corresponds with the sclerotic in the eye; which, in many Vertebrates, becomes the seat of ossification, and in some (*Cetacea*, e.g., fig. 195, *a*) is thickened as much out of proportion to the nervous and vascular parts of the essential organ it contains, as is the petrosal. The orifice by which the optic nerve enters the eye-bulb answers to the foramen auditorium internum. The membranous labyrinth answers to the parts of the eyeball within the sclerotic. The delicate vascular external tissue of the labyrinth, frequently exhibiting pigment-specks, answers to the choroid, the expansions of the acoustic nerves to the retina, the endolymph to the vitreous humour. The fluid in the space between the sclerotic and choroid, including the aqueous humour, represents the perilymph. Wharton Jones compares the 'lens' to the 'otolites.'[2]

If we compare the conjunctival space in front of the eyeball with the tympanic cavity, and the duct therefrom leading to the nose with the eustachian tube, then the anterior opening of the sclerotic will answer to the fenestra vestibuli, and the membrane closing it, or cornea, to that which closes the fenestra. In mammals the open movable eyelids seem very remote analogues to the external membrane closing the tympanum: but they are superadded developments to the true serial homologue of the tympanic membrane, shown in Reptilia, vol. i. p. 338, 339, fig. 220; and which disappears or blends with the later added developments of integument with special cartilages, muscles, and glandules, and which truly parallel the 'pinna' of the ear. In the eyelids, the meibomian follicles repeat the ceruminous ones, and the eyelashes, the cilia which guard the entry to the meatus auditorius. Wharton Jones compares the muscles of the eyeball to those of the otosteals, and I concur, with him, in accepting the opinion of Weber as to the special relation of both to their respective Organs of Sense, and as to their being parts superadded to the elements of the vertebral skeleton. But I believe that the divergence of functions so governs the development of special motive organs and ossicles as to remove the ground for safely or usefully homologising such parts, and I refrain from going beyond the serial repetitions in the eye and ear which are above indicated.

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[1] XLIV. p. 557.

[2] XCVII″. p. 562.

CHAPTER XXIX.

DENTAL SYSTEM OF MAMMALIA.

§ 218. *General characters of the Teeth.*—The present class includes a few genera and species that are devoid of teeth; the true ant-eaters (*Myrmecophaga*), the scaly ant-eaters (*Manis*), and the spiny monotrematous ant-eater (*Echidna*), are examples of strictly edentulous Mammals: *Ornithorhynchus* has horny teeth; the whales (*Balæna*, *Balænoptera*) have transitory embryonic calcified teeth, fig. 219, succeeded by whalebone substitutes, fig. 217, in the upper jaw. The female Narwhal seems to be edentulous, but has the germs of two tusks in the substance of the upper jaw-bones: one of these so remains; the other becomes developed into a large horn-like weapon in the male Narwhal, fig. 220, A, and suggested to Linnæus the name, for its genus, of *Monodon*: but the tusk is never median, like the truly single tooth on the palate of the Myxine; and occasionally both tusks are developed. In *Hyperoödon* the teeth are reduced in the adult to two in number, whence the specific name, *H. bidens*; but they are very small and confined to the lower jaw. *Ziphius* has two teeth of functional size and shape, one in each ramus of the lower jaw; and this is perhaps a sexual character. The *Delphinus griseus* has five teeth on each side of the lower jaw: but they soon become reduced to two. The Marsupial genus *Tarsipes* is remarkable for the paucity as well as minuteness of its teeth. The Elephant has never more than one entire molar, or parts of two, in use on each side of the upper and lower jaws, to which are added two tusks, more or less developed, in the upper jaw. Some Rodents, *Hydromys*, e. g., have two grinders on each side of both jaws, which, added to the four cutting teeth in front, make twelve in all; the common number of teeth in this order is twenty; but the hares and rabbits have twenty-eight teeth. The sloth has eighteen teeth. The number of teeth, thirty-two, which characterises man, the apes of the Old World, and the true Ruminants, is the average one of the class Mammalia; but the typical number is forty-four. The examples of excessive number of teeth are presented, in the order *Bruta*, by the Priodont

Armadillo, which has ninety-eight teeth; and in the Cetaceous order by the Cachalot, which has upwards of sixty teeth, though most of them are confined to the lower jaw; by the common porpoise, which has between eighty and ninety teeth; by the Gangetic dolphin, which has one hundred and twenty teeth; and by the true dolphins (*Delphinus*), which have from one hundred to one hundred and ninety teeth, yielding the maximum number in the class *Mammalia*.

Where the teeth are in excessive number, as in the species above cited, they are small, equal, or sub-equal, and of a simple conical form; pointed, and slightly recurved in the common dolphin; with a broad and flattened base in the Gangetic dolphin; with the crown compressed and expanded in the porpoise; compressed, but truncate, and equal with the fang, in *Priodon*. The compressed triangular teeth become coarsely notched or dentated at the hinder part of the series in the great extinct cetaceous *Zeuglodon*. The simple dentition of the smaller Armadillos, of the Orycterope, and of the three-toed Sloth, presents a difference in the size, but little variety in the shape of the teeth, which are subcylindrical with broad triturating surfaces; in the two-toed Sloth, the two anterior teeth of the upper jaw are longer and larger than the rest, and adapted for piercing and tearing, fig. 215.

Teeth are fixed, as a general rule, in all Vertebrates. In Mammals the movements of the teeth depend on those of the jaw-bones supporting them, but appear to be independent in the ratio of the size of the tooth to the bone to which it is attached: the seemingly individual movements of divarication and approximation observable in the large lower incisors of the *Bathyergus* and *Macropus*,[1] are due entirely to the yielding nature of the symphysis uniting the two rami of the lower jaw, in which those incisors are deeply and firmly implanted.

In Man, where the premaxillaries early coalesce with the maxillary bones, where the jaws are very short, and the crowns of the teeth are of equal length, there is no interspace or ‘diastema’ in the dental series of either jaw, and the teeth derive some additional fixity by their close apposition and mutual pressure. No inferior Mammal now presents this character; but its importance, as associated with the peculiar attributes of the human organisation, has been somewhat diminished by the discovery of a like contiguous arrangement of the teeth in the jaws of a few extinct quadrupeds; e.g., *Anoplotherium*, *Nesodon*, and *Dichodon*.[2]

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[1] xxvii. vol. i. p. 285.

[2] clxxx. fig. 130.

The teeth in Mammals, as in the foregoing classes, are formed by superaddition of the hardening salts to pre-existing moulds of animal pulp or membrane, organised so as to insure the arrangement of the earthy particles according to that pattern which characterises each constituent texture of the tooth, together with a course of vitalising plasma through its tissue.

The complexity of the primordial basis, or 'matrix,' corresponds, therefore, with that of the fully-formed tooth, and is least remarkable in those conical teeth which consist only of dentine and cement. The primary pulp, fig. 129, *i**, which first appears as a papilla rising from the free surface of the alveolar gum, is the part of the matrix which, by its calcification, constitutes the dentine. In simple teeth, the secondary, or enamel pulp, covers the dentinal pulp like a cap; in complex teeth it sends processes into depressions of the coronal part of the dentinal pulp, which vary in depth, breadth, direction, and number, in the different groups of the herbivorous and omnivorous quadrupeds. The dentinal pulp, thus penetrated, offers corresponding complications of form; and, as the capsule follows the enamel pulp in all its folds and processes, the external cavities or interspaces of the dentine become occupied by enamel and cement—the cement, like the capsule which formed it, being the outermost substance, fig. 237, *c*, and the enamel, ib. *e*, being interposed between it and the dentine, ib. *d*. The dental matrix presents the most extensive interdigitation of the dentinal and enamel pulps in the Wart-hog, Capybara, and Elephant.

The matrix of the mammalian tooth sinks into a furrow, and soon becomes inclosed in a cell in the substance of the jaw-bone, from which the crown of the growing tooth extricates itself by exciting the absorbent process, whilst the cell is deepened by the same process, and by the growth of the jaw, into an alveolus for the root of the tooth. Where the formative parts of the tooth are reproduced indefinitely, to repair, by their progressive calcification, the waste to which the working surface of the crown of the tooth has been subject, the alveolus is of unusual depth, and of the same form and diameter throughout, figs. 215 and 216, except in the immature animal, when it widens to its bottom or base. In teeth of limited growth, the dentinal pulp is reproduced in progressively decreasing quantity after the completion of the exterior wall of the crown, and forms, by its calcification, one or more roots or fangs, which taper to their free extremity. The alveolus is closely moulded upon the implanted part of the tooth; and it is worthy of special remark, that the complicated form of socket, fig. 256, which results from the development of two or more fangs, is peculiar to animals of the class *Mammalia.*

In the formation of a single fang, the activity of the reproductive process becomes enfeebled at the circumference, and is progressively contracted within narrower limits in relation to a single centre, until it ceases at the completion of the apex of the fang, which, though for a long time perforated for the admission of the vessels and nerves to the interior of the tooth, is, in many cases, finally closed by the ossification of the remaining part of the capsule.

When a tooth is destined to be implanted by two or more fangs, the reproduction of the pulp is restricted to two or more parts of the base of the coronal portion of the pulp, around the centre of which parts the sphere of its reproductive activity is progressively contracted. The intervening parts of the base of the coronal pulp adhere to the capsule, which is simultaneously calcified with them, covering those parts of the base of the crown of the tooth with a layer of cement. The ossification of the surrounding jaw, being governed by the changes in the soft but highly organised dental matrix, fills up the spaces unoccupied by the contracted and divided pulp, and affords, by its periosteum, a surface for the adhesion of the cement or ossified capsule covering the completed part of the tooth.

The matrix of certain teeth does not give rise, during any period of their formation, to the germ of a second tooth, destined to succeed the first. This, therefore, when completed and worn down, is not replaced; all the true *Cetacea* are limited to this simple provision of teeth. In the Armadillos, Megatherioids, and Sloths, the want of germinative power, as it may be called, in the matrix, is compensated by its persistence, and the consequent uninterrupted growth of the teeth. In most other Mammals, the matrix of certain of the first developed teeth gives origin to the germ of a second tooth, which displaces its predecessor and parent. All those teeth which are so displaced are called temporary, deciduous, or milk teeth, fig. 293, *d i, d* 1–4. The mode and direction in which they are displaced and succeeded, namely from below upward in the lower jaw, in both jaws vertically, are the same as in the crocodile; but the process is never repeated more than once in the present class. A considerable proportion of the dental series is thus changed; the second, or permanent teeth, ib. *i* 1–*p*, 2–4, having a size and form as suitable to the jaws of the adult as the displaced temporary teeth were adapted to those of the young animal. Those permanent teeth, ib. *m* 1–*m* 3, which assume places not previously occupied by deciduous ones, may be regarded as a continuation of that series, and are posterior in their position; they are generally the most complex in their form. The successors of the deciduous incisors and canines differ from them chiefly in size. The successors of the deciduous molars may differ likewise in shape, in which case they have less complex crowns than their predecessors. The 'bicuspids' in Anthropotomy, fig. 258, *p* 3, *p* 4, and the corresponding teeth called 'premolars' in lower mammals, fig. 293, *p* 2–4, illustrate this law.

The Mammalian class might be divided, in regard to the succession of the teeth, into two groups—the *Monophyodonts*, or those that generate, as a rule, one set of teeth, and the *Diphyodonts*, or those that generate two sets of teeth.[1] The Monophyodonts include the *Monotremata*, *Cetacea* and *Bruta*; all the other orders are Diphyodonts.

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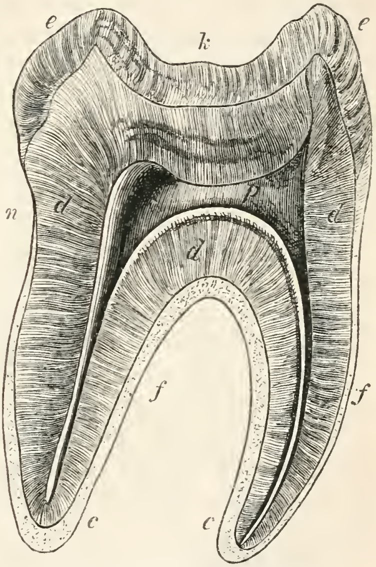

Section of human molar tooth, magn.

The teeth of *Mammalia*, especially of the Diphyodonts, have usually so much more definite and complex a form than those of fishes and reptiles, that three parts are recognised in them: the fang or root (*radix*, fig. 210, *f*) is the inserted part; the crown (*corona*, ib. *k*) is the exposed part; and the constriction which divides these is called the neck (*cervix*, ib. *n*). The term 'fang' is properly given only to the implanted part of a tooth of restricted growth, which fang gradually tapers to its extremity. Those teeth which grow uninterruptedly, fig. 236, have not their exposed part separated by a neck from their implanted part, and this generally maintains to its extremity the same shape and size as the crown.

It is peculiar to the class Mammalia to have teeth implanted in sockets by two or more fangs, figs. 256, 293; but this can only happen to teeth of limited growth, and generally characterises the molars and premolars: perpetually growing teeth require the base to be kept simple and widely excavated for the persistent pulp, figs. 215 and 216. In no mammiferous animal does anchylosis of the tooth with the jaw constitute a normal mode of attachment. Each tooth has its particular socket, to which it firmly adheres by the close co-adaptation of their opposed surfaces, and by the firm adhesion of the alveolar periosteum to the organised cement which invests the fang or fangs of the tooth.

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[1] Vol. ii. p. 268.

True teeth implanted in sockets are confined to the maxillary, premaxillary, and mandibular or lower maxillary bones, and form a single row in each. They may project only from the premaxillary, as in the Narwhal, or only from the lower maxillary as in the Ziphius; or be apparent only in the lower jaw, as in the Cachalot; or be limited to the superior and inferior maxillaries, and not present in the premaxillaries, as in the true Ruminants and most *Bruta.*

Mammalian teeth usually consist of hard unvascular dentine, fig. 210, *d,* defended at the crown by an investment of enamel, ib. *e,* and everywhere surrounded by a coat of cement, ib. *c.* The coronal cement is of extreme tenuity in Man, Quadrumana, and terrestrial Carnivora; it is thicker in the Herbivora, especially in the complex grinders of the Elephant, fig. 289, and is thickest in the teeth of the Sloth, Megatherium, Dugong, Walrus, and Cachalot. Vertical folds of enamel and cement penetrate the crown of the tooth in most Rodents and Ungulates, characterising by their various forms the genera; but these folds never converge from equidistant points of the circumference of the crown towards its centre. The teeth of *Bruta* have no true enamel; this is absent likewise in the molars of the Dugong and of the fully developed teeth of the Cachalot. The tusks of the Narwhal, Walrus, Dinothere, Mastodon, and Elephant, consist of modified dentine, which, in the last two great proboscidian animals, is properly called 'ivory,' and is covered by cement.

The Dolphins and Armadillos present little variety in the shape of the teeth in the same animal, and this sameness of form is characteristic of Monophyodonts; subject, like the successional character, to such exceptions as are exemplified in *Cholœpus didactylus,* fig. 215, and in *Dasypus 9-cinctus,* the milk-teeth of which are figured in CXXXII″, p. 254.

In most other Mammals particular teeth have special forms for special uses: thus the front teeth, from being commonly adapted to effect the first coarse division of the food, have been called cutters or *incisors*; and the back teeth, which complete its comminution, grinders or *molars*: large conical teeth, situated behind the incisors, and adapted by being nearer the insertion of the biting muscles, to act with greater force, are called holders, tearers, laniaries, or more commonly *canine* teeth, from being well developed in the dog and other Carnivora, although they are given, likewise, to many vegetable feeders for defence or combat; e. g., Musk-deer. Molar teeth, which are adapted for mastication, have either tuberculate, or ridged, or flat summits, and usually are either surrounded by a ridge of enamel, or are traversed by similar ridges arranged in various patterns. Certain molars in the Dugong, the Mylodon, and the Zeuglodon, are so deeply indented laterally by opposite longitudinal grooves, as to appear, when abraded, to be composed of two cylindrical teeth cemented together, and the transverse section of the crown is bilobed. The teeth of the *Glyptodon* were fluted by two analogous grooves on each side, fig. 214. The large molars of the Capybara and Elephant have the crown cleft into a numerous series of compressed transverse plates, cemented together side by side. The modifications of the crown of the molar teeth are those that are most intimately related to the kind of food of the animal possessing them. Thus, in the purely carnivorous mammals, the principal molars are simple, trenchant, and play upon each other like scissor-blades. In the mixed feeding species, the working surface of the molars becomes broader and tuberculated; in the insectivorous species it is bristled with sharp points; and in the purely herbivorous kinds, the flat grinding surface of the teeth is complicated by folds and ridges of the enamel entering the substance of the tooth, the most complex forms being presented by the Elephants.

§ 219. *Teeth of Monophyodonts.* A. *Monotremata.*—The substances serving for teeth in the Ornithorhynchus are of a horny texture, consisting of close-set, vertical hollow tubes, resembling the outer compact tissue of baleen or 'whalebone.' They are eight in number, four in the upper, and as many in the under jaw. The anterior tooth of the upper jaw is extended from behind forward, but is low, very narrow, and four-sided. The corresponding tooth in the lower jaw, fig. 211, *b*, is rather narrower, and retains longer its trenchant edge. At a distance from the anterior tooth, equal to its own length, is situated the horny molar, ib. *c*, which consists of a flattened plate of an oblong subquadrate figure. The corresponding tooth in the lower jaw is

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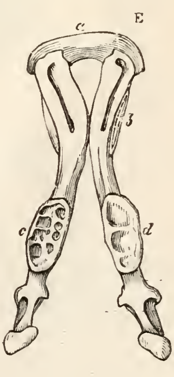

Mandible and teeth, Ornithorhynchus.

somewhat narrower, but of simple form. Each division or tubercle of the molar is separately developed, and they become confluent in the course of growth. According to the analysis of Lassaigne, 99·5 parts of the dental tissue of the Ornithorhynchus have the composition of horn; this is hardened by 0·3 parts of phosphate of lime.

The notice of the dental apparatus of the Monotremes ought to include mention of the two short and thick conical processes, fig. 212, *g*, *g*, which project from the forepart of the raised intermolar portion of the tongue, in the *Ornithorhynchus*; and like the more numerous spines on the corresponding part of the tongue of the Echidna, represent, in these low-organised mammals, the lingual teeth of fishes.

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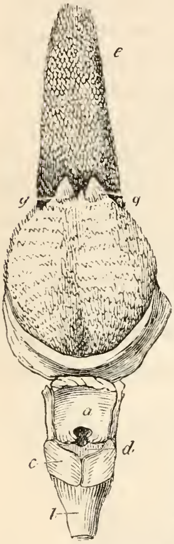

Tongue, lingual teeth, and larynx of the Ornithorhynchus.

B. *Bruta.*—The teeth of the Orycterope, or Cape Ant-eater, are of a simple form, but peculiar structure; their common number in the mature animal is $\frac{7}{6}:\frac{7}{6}=26$, and they all belong to the molar series. The first and smallest is soon lost. The proportions of the persistent teeth, the depth of their sockets, and their structure, as viewed in longitudinal section with the naked eye, are shown in fig. 213. The teeth are continued, solid, and of the same dimensions, to the bottom of the socket, and terminate in a truncate and undivided base. If each be viewed as an aggregate of teeth, as partially shown in fig. 247, vol. i., p. 396, it will be found that the component denticle has its base excavated by a conical pulp-cavity, as in other animals, and which is persistent, as in the rest of the order *Bruta.* The wide inferior apertures of these pulp-cavities constitute the pores observable on the base of the compound tooth of the Orycterope, and give to that part a close resemblance to the section of a cane. The canals to which these pores lead are the centres of radiation of the dentinal

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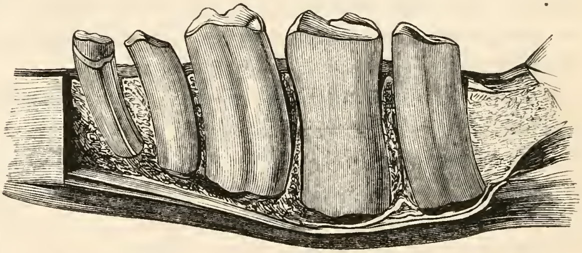

Section of lower jaw and teeth of the Orycteropus. Nat. size tubes; such denticles are cemented together laterally, ib. *c*, slightly decreasing in diameter, and occasionally bifurcating as they approach the grinding surface of the tooth. The substance of the entire tooth thus resembles the teeth of the *Myliobates* and *Chimæroids* among fishes, rather than any in the Mammalian class, in which it offers a transitional step from the horny dental substitutes, above described, to the true teeth.

The teeth of the *Orycteropus*, when rightly understood, offer, however, no anomaly in their mode of formation. Each denticle is developed according to the same laws, and by as simple a matrix, as those larger teeth in other mammals which consist only of dentine and cement. The dentine is formed by calcification of the pulp, the cement by ossification of the capsule; both pulp and capsule continue to be reproduced at the bottom of the alveolus, *pari passu* with the attrition of the exposed crown; and the mode and time of growth being alike in each denticle, the whole compound tooth is maintained thoughout the life of the animal. The augmentation in the size of the whole tooth, during the growth of the jaw, is effected by the development of new denticles, and a slight increase of size in the old ones, at the base of the growing tooth, which, in the progress of attrition and growth, becomes its grinding surface.

The teeth of the Armadillo-tribe are harder than those of other species of *Bruta*, the unvascular dentine being present in greatest proportion, and forming the main body of the tooth; it includes a small central axis of vascular dentine, and is surrounded by an extremely thin coating of cement. The numerous teeth in *Priodon* are of very small size and simple form, and are all referable to the molar series. They vary in number from twenty-four to twenty-six in each upper jaw, and from twenty-two to twenty-four on each side of the lower jaw, amounting to from ninety-four to one hundred in total number. The Armadillos of the sub-genus *Euphractus*, Wagler, are distinguished by having the anterior tooth, which is shaped like the succeeding molar, implanted in the premaxillary bone. The two anterior teeth of the lower jaw being in advance of the premaxillary tooth, are, with it, arbitrarily held to be incisors.

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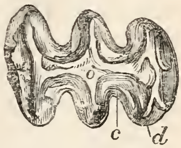

Crown of tooth of great extinct Armadillo (*Glyptodon clavipes*).

Some species of the extinct loricate genus, *Glyptodon*, surpassed the Rhinoceros in size, and the dentition was more complicated, and more adapted to a vegetable diet, than that of the small existing Armadillos. The osteo-dentine, fig. 214, *o*, occupied a larger proportion of the centre of the tooth, and being harder than the dentine, *d*, or cement, *c*, rose upon the grinding surface, in the form of a ridge extending along the middle of the long axis of that surface, and in three shorter ridges at right angles to the preceding, at the middle of each of the three rhomboidal divisions of the tooth.

Of the leaf-eating species of the order *Bruta*, very few, and these the most diminutive of the tribe, now exist. The following are the characters of their dentition, both recent and extinct:—Teeth implanted in the maxillary and mandibular bones, few in number, not exceeding $\frac{5}{4}:\frac{5}{4}$; composed of a large central axis of vaso-dentine, with a thin investment of hard dentine, and a thick outer coating of cement: to these add the dental characters common to the order *Bruta*, viz., uninterrupted growth, and concomitant implantation by a simple, deeply-excavated base.

In the two-toed sloth (*Cholœpus didactylus*, Illig.) the teeth, fig. 215, offer a greater inequality of size than has yet been observed in any other genus of *Bruta*; the first of each series, 1, in both jaws, which in the rest of the order is the smallest, here so much exceeds the others as, with its peculiar form, to have received the name of a canine. This tooth is separated by a marked interval from the other teeth, 2–5, especially in the upper jaw, so that 1–1 above play upon the anterior part of those below, contrary to the relative position and mutual action of the true canine teeth in the *Quadrumana* and *Carnivora*.

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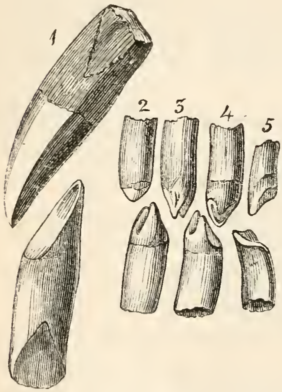

Teeth of the two-toed Sloth (*Chalœpus didactylus*).

The teeth of the *Megatherium*, the most gigantic of the extinct quadrupeds of the Sloth tribe, are five in number on each side of the upper jaw, fig. 216, and four on each side of the lower jaw. They are deeply implanted with narrow intervals: each is excavated by an unusually extensive pulp-cavity, ib. *p*, from the apex of which a fissure is continued to the middle depression of the grinding surface of the tooth. The central axis of vaso-dentine, *v*, is surrounded by a thin layer of hard or unvascular dentine, *d*, and this is coated by the cement, *c*, which is of great thickness on the anterior and posterior surfaces, but is thin where it covers the outer and inner sides of the tooth. The vaso-dentine, *v*, fig. 238, vol. i. p. 361, is traversed throughout by medullary canals, measuring $\frac{1}{1500}$ of an inch in diameter, continued from the pulp-cavity, and anastomosing in pairs by a loop, the convexity of which is turned towards the origin of the tubes of the hard dentine, *t*.

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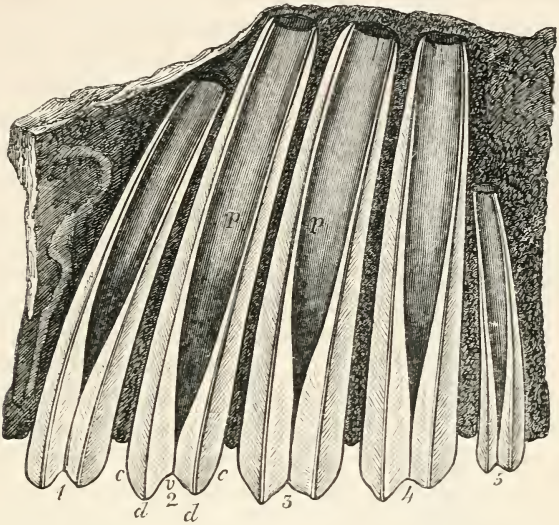

Section of upper jaw and teeth of the Megatherium. One-third nat. size.

The cement, ib. *c*, is characterised by the size, number, and regularity of the vascular canals which traverse it in a direction slightly inclined from the transverse axis toward the crown of the tooth, running parallel to each other, and anastomose in loops, the convexity of which is directed toward the hard dentine.

The tooth of the Megatherium offers an unequivocal example of a course of nutriment from the dentine to the cement, and reciprocally. All the constituents of the blood freely circulated through the vascular dentine and the cement, and the vessels of each substance, intercommunicated by a few canals, continued across the hard or unvascular dentine. The minuter tubes, which pervade every part of the tooth, characterising by their difference of length and course the three constituent substances, form one continuous and freely intercommunicating system of strengthening and reparative vessels, by which the plasma of the blood was distributed throughout the entire tooth, for its nutrition and maintenance in a healthy state.

The grinding surface of the close-set molars of the Megatherium differs on account of the greater thickness of the cement on their anterior and posterior surfaces, from those of all the smaller Megatherioids, in presenting two transverse ridges, fig. 216, *d*; one of the sloping sides of each ridge being formed by the cement, *c*, the other by the vascular dentine, *v*, whilst the unvascular dentine, *d*, as the hardest constituent, forms the summit of the ridge like the plate of enamel between the dentine and cement in the Elephant's grinder. The great length of the teeth, and concomitant depth of the jaws, the close-set series of the teeth, and the narrow palate, are also strong features of resemblance between the Megatherium and Elephant in their dental and maxillary organisation. In both these gigantic phyllophagous quadrupeds provision has likewise been made for the maintenance of the grinding machinery in working order throughout their prolonged existence: but the fertility of the creative resources is well displayed by the different modes in which this provision has been effected: in the Elephant, it is by the formation of new teeth to supply the place of the old when worn out; in the Megatherium, by the constant repair of the teeth in use, to the base of which new matter is added in proportion as the old is worn away from the crown. Thus, the extinct Megatherioids had both the same structure and mode of growth and renovation of their teeth as are manifested in the present day by the diminutive Sloths.

C. *Cetacea.* Those Mammals which are properly called 'Whales' have no teeth, but horny substitutes in the form of plates, terminating or fringed by bristles. Of these plates, called 'baleen' and 'whalebone,' fig. 217, *b*, the largest, which are of an inequilateral triangular form, are arranged in a single longitudinal series on each side of the upper jaw, situated pretty close to each other, depending vertically from the maxillary bones, with their flat surfaces looking backward and forward, and their unattached margins outward and inward, the direction of their interspaces

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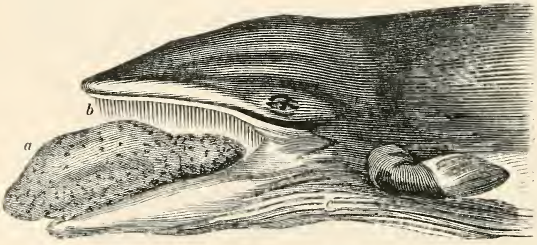

Baleen-plates and Tongue of Piked Whale (*Balænoptera*) being nearly transverse to the axis of the skull. The subsidiary plates are arranged in oblique series internal to the marginal ones. Thus, if the upper jaw of one side of the skull of a Whale were bisected transversely, the flat surface of a series of the baleen-plates would be exposed, as in fig. 218, in which *a* is the superior maxillary bone, *b* the ligamentous gum, giving attachment to *c* the horny base and body of the chief baleen-plate, which terminates in *d*, the fringe of bristles; *e* marks the smaller baleen-plates.

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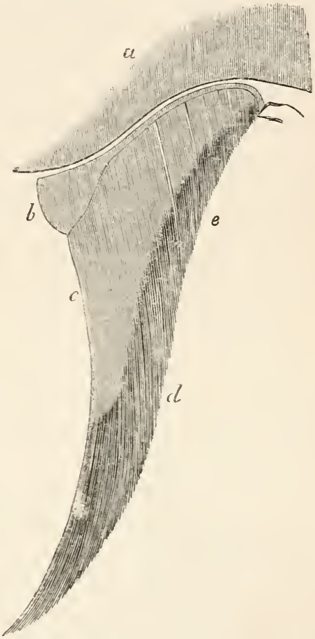

Section of Upper Jaw, with Baleen-plates, of a Whale (*Balænoptera*).

The base of each plate is hollow, and is fixed upon a pulp developed from a vascular gum, which is attached to a broad and shallow depression occupying the whole of the palatal surface of the maxillary and of the anterior part of the palatine bones, the Whale being thus, like the Echidna, an example of a mammalian animal, which may be said to have palatal teeth. The base of each plate is unequally imbedded in a compact sub-elastic substance, *b*, which is so much deeper on the outer than on the inner side, as, in the new-born whale, to include more than one half of the outer margin of the baleen-plate. This margin is shown at *c*, fig. 218, and is continued down in a line dropped nearly vertically from the outer border of the jaws. The inner margin of each plate, *d*, slopes obliquely outward from the base to the extremity of the preceding margin; the smaller plates decrease in length to the middle line of the palate, so that the form of the baleen-clad roof of the mouth is that of a transverse arch or vault, against which the convex dorsum of the thick and large tongue, fig. 217, *a*, is applied when the mouth is closed. Each plate sends off from its inner and oblique margin the fringe of moderately stiff but flexible hairs, which project into the mouth. These present an obstacle to the escape of the small marine animals,[1] for the prehension and detention of which this singular modification of the dental system is especially adapted. The baleen-pulp is situated in a cavity at the base of the plate, like the pulp of a true tooth; whilst the external cementing material maintains, both with respect to this pulp and to the portion of the baleen-plate which it develops, the same relations as the dental capsule bears to the tooth. According to these analogies, it must follow, that only the central fibrous or tubular portion of the baleen-plate is formed, like the dentine, by the basal pulp, and that the base of the plate is not only fixed in its place by the cementing substance or capsule, but must also receive an accession of horny material from it answering to the cement of true teeth.

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[1] *Clio borealis*, *Limacina arctica*, and small pelagic Crustacea.

In *Balæna mysticetus* there are about 200 large marginal plates on each side, from 10 to 14, rarely 15, feet in length, and about 1 foot in breadth at their base; these plates are overlapped and concealed by the under lip when the mouth is shut. In the *Balænopteræ* or fin-backed whales, figs. 217, 218, the baleen-processes, *e*, internal to the marginal plates, are fewer and smaller than in the *Balænæ*; the marginal plates, *c*, are more numerous, exceeding 300 on each side; they are broader in proportion to their length, and much smaller in proportion to the entire animal; they are also more bent in the direction transverse to their long axis.

A thin transverse section of baleen, viewed with a low magnifying power, demonstrates that the coarse fibres, as they seem to the naked eye, which form the central substance, are hollow tubes with concentric laminated walls. When a high magnifying power is applied to such a section, the concentric lines are shown not to be uniform, but interrupted here and there by minute elliptical dilatations, which are commonly more opaque than the surrounding substance, and which, like the radiated cells of true bone, are probably remains of the primitive cells of the formative substance; similar long elliptical opaque bodies or cells are dispersed irregularly through the straight parallel fibres of the dense outer laminæ of the baleen-plate. The chemical basis of baleen is albumen hardened by a small proportion of phosphate of lime.

The *Balænidæ*, before they acquire their peculiar array of baleen-plates, manifest in their fœtal age a transitory condition of a true dental system, abortive and functionless, but homologous with that which is normal and persistent in the majority of the order. In an open groove which extends along the alveolar border of both the upper and the lower jaws, there is a series of minute, conical, acute or obtuse, single or double, denticles, fig. 219, with hollow bases inclosing the uncalcified remains of a vascular pulp. In the fœtus of a *Balænoptera,* the jaws of which were about four inches in length, the groove of the upper jaw contained twenty-eight such teeth, that of the lower jaw forty-two: these disappear before birth. The fœtal Whale exemplifies the earliest stage of dental development in the higher Mammals, retaining the open fissure which in them is rapidly closed.

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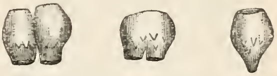

Transitory denticles of Fœtal Whale
Nat. size.

The great Bottle-nose or bident Whale offers a transitional grade between the true Whales and the typical *Delphinidæ.* The fœtal denticles do not all perish, but two or three of the anterior pairs acquire a large size as compared with their transitory representatives in the *Balænidæ*—and one of these pairs is long retained in the lower jaw, though functionless, and hidden by the gum.

In the Narwhal (*Monodon monoceros*), two of the primitive dental germs at the forepart of the upper jaw proceed in their development to a greater extent than do those in the lower jaw of the *Hyperoödon*; but every other trace of teeth is soon lost. The two persistent matrices rapidly elongate, but in the retrograde direction, forming a long fang rather than a crown; each tooth sinks into a horizontal alveolus of the premaxillary bone, or, rather, at the junction of the premaxillary with the maxillary, and soon, by the forward growth of these bones, becomes wholly inclosed, fig. 220, *a,* like the germs of the teeth of higher Mammals at their second stage of development. In the female Narwhal, the pulp is here exhausted, the cavity of the tooth is obliterated by its ossification, further development ceases, and the two teeth remain concealed as abortive germs in the substance of the jaws for the rest of life. In the male, the matrix of the tooth in the left premaxillary, ib. *b,* continues to enlarge; fresh pulp-material is progressively added, which by its calcification elongates the base, protrudes the apex from the socket, and the tusk continues to grow until it acquires the length of nine or ten feet, with a basal diameter of four inches. This is that famous 'horn' which figures on the forehead of the heraldic unicorn, and so long excited the curiosity and conjectures of the older naturalists, until Olaus Wormius made an end of the fabulous 'monocerologies' by the discovery of the true nature of their subject.[1]

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[1] CLX''. Linnæus has embalmed the old idea of this weapon in the binomial *Monodon monoceros,* under which the Narwhal is entered in the *Systema Naturæ.*

The exterior of the long tusk is marked by spiral ridges, which wind from within forward, upward, and to the left. About fourteen inches is implanted in the socket; it tapers gradually from the base to the apex. The pulp-cavity, as shown in the longitudinal section of the tusk, in fig. 220, is continued nearly to the extreme point, but is of variable width: at the base it forms a short and wide cone; it is then continued forward, as a narrow canal, along the centre of the implanted part of the tooth, beyond which the cavity again expands to a width equalling half the diameter of the tooth; and finally, but gradually, contracts to a linear fissure near the apex. Thus, the most solid and weighty part of the tooth is that which is implanted in the jaw, and nearest the centre of support, whilst the long projecting part is kept as light as might be compatible with the uses of the tusk as a weapon of attack and defence. The portion of pulp, in which the process of the calcification has been arrested, receives its vessels and nerves by the fissure continued from the basal expansion of the pulp-cavity. In a few instances, both tusks have been seen to project from the jaw.

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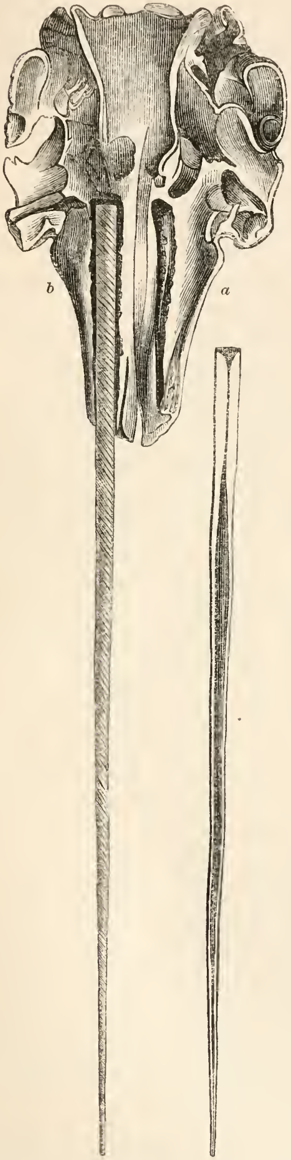

Base of skull of male Narwhal, with a section of the Tusk.

In *Delphinus griseus* the dentition of the upper jaw is transitory, as in *Hyperoödon*, but at least six pairs of teeth rise above the gum and acquire a full development at the forepart of the lower jaw. The crowns of these teeth soon become obtuse, and their duration is limited: aged individuals of this species have been taken with the dentition reduced to two teeth in the lower jaw.

The outward and visible dentition of the great Sperm-whale or Cachalot (*Physeter macrocephalus*) is confined to the lower jaw. The series consists in each ramus of about twenty-seven teeth. In the young they are conical and pointed; usage renders them obtuse, whilst progressive growth expands and elongates the base into a fang, which then contracts, and is finally solidified and terminated obtusely. The teeth are separated by intervals as broad as themselves. The mode of implantation is intermediate between that of the teeth of the *Ichthyosaurus*, and of those of *Delphinus*. They are lodged in a wide and moderately deep groove, imperfectly divided into sockets, the septa of which reach only about half-way from the bottom of the groove. These sockets are both too wide and too shallow to retain the teeth independently of the soft parts, so that it commonly happens, when the dense semi-ligamentous gum dries upon the bone, and is stripped off in that state, that it brings away with it the whole series of the teeth like a row of wedges half-driven through a strip of board. A firmer implantation would seem unnecessary for teeth which have no opponents to strike against, but which enter depressions in the opposite gum when the mouth is closed. That gum, however, conceals a few persistent specimens of the primitive fœtal series of teeth; these are always much smaller and more curved than the functional teeth of the lower jaw, of which a section is given in fig. 239, vol. i. p. 362. In the small snub-nosed Cachalot (*Physeter simus*) the first tooth of this series is exposed in the front of the upper jaw.[1]

The first-formed extremity of the tooth in the young Cachalot is tipped with enamel: when the summit of the crown has been abraded, the tooth consists of a hollow cone of dentine, ib. *d*, coated by cement, *c*, and more or less filled up by the ossified pulp, *o*. Irregular masses of this fourth substance have been found loose in the pulp-cavity of large teeth. The external cement is thickest at the junction of the crown and base, which are not divided by a neck.

The permanent or mature dentition of the Beluga (*Delphinus leucas*, Pall.), though scanty, is more normal than in the Physeter, nine functional teeth being retained on each side of the upper jaw, and eight in each ramus of the lower jaw. They present the form of straight subcompressed obtuse cones.

The most formidable dentition is that of the predaceous Grampus (*Phocæna orca*), whose laniariform teeth are as large in proportion to the length of the jaws as in the crocodile; they are in number $\frac{13}{12}:\frac{13}{12}=50$; all fixed in deep and distinct sockets, separated by interspaces which admit of the close interlocking of the upper and lower teeth when the mouth is closed; the longest and largest teeth are at the middle of the series, and they gradually decrease in size as they approach the ends, especially the posterior one.

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[1] xcix′. p. 42, pl. 12.

In the common Dolphin the number of teeth amount to 190, arranged in equal numbers above and below, and there is a pair of teeth in the premaxillaries which are toothless in the other *Cetacea.* They have slender, sharp, conical, slightly incurved crowns, and diminish in size to the two extremes of the dental series; the acute apices are longer preserved than in the foregoing species.

The Gangetic Dolphin (*Platanista gangetica*) differs from the rest of the *Delphinidæ* scarcely less in the form of its teeth than in that of the jaws. Both the upper and lower maxillary bones are much elongated and compressed; the symphysis of the lower jaw is coextensive with the long dental series, and the teeth rise so close to it that those of one side touch the others by their bases, except at the posterior part of the jaw. The lateral series of teeth are similarly approximated in the upper jaw at the median line of union, which line is compelled, by the alternate position of the teeth, to take a wavy course. There are thirty teeth on each side of the upper jaw, and thirty-two on each side of the lower jaw. In the young animal they are all slender, compressed, straight, and sharp-pointed, the anterior being longer than the posterior ones, and recurved. Contrary to the rule in ordinary Dolphins, the anterior teeth retain their prehensile structure, while the posterior ones soon have their summits worn down to their broad bases: in the progress of their growth the implanted base is elongated antero-posteriorly, its outer surface augmented by longitudinal folds analogous to those in the teeth of the Sauroid fishes. Sometimes the posterior tooth of *Platanista* has the base divided into two short fangs, the sole example of such a structure which I have met with in the existing carnivorous Cetacea. In the Dolphins of the South American rivers (*Inia*) the inner side of the tooth expands into a crushing tubercle.

The primitive seat of the development of the tooth-matrix is maintained longer in the *Cetacea* than in other *Mammalia*; a greater portion of the tooth is also developed before the matrix sinks into, or is surrounded by, a bony alveolus; and, with the exception of the rudimental tusks in the Narwhal, is at no period entirely closed in a bony cell, in which respect the *Cetacea* offer an interesting analogy to true fishes.

§ 220. *Teeth of Diphyodonts.* A. *Sirenia.*—Two marks of inferiority in the dental system of the carnivorous Cetacea, which they have in common with many of the order *Bruta*, viz. a general uniformity of shape in the whole series of teeth, and no succession and displacement by a second or permanent set, disappear when we commence the examination of the dentition of those apodal pachyderms which were called by Cuvier the Herbivorous Cetacea.

In the Dugong (*Halicore*), for example, we find incisors distinguished by their configuration as well as position from the molars, and the incisive tusk is deciduous, displaced vertically, and succeeded by a permanent tusk; both these characters are shown in fig. 160, vol. ii. p. 281. Of the incisors of the Dugong, only the superior ones project from the gum in the male sex, and neither upper nor lower ones are visible in the female. The superior incisors, ib. *i*, are two in number in both sexes. In the male they are moderately long, subtriedral, of the same diameter from the base to near the apex, which is obliquely bevelled off to a sharp edge, like the scalpriform teeth of the *Rodentia.* Only the extremity of this tusk projects from the jaw, at least seven-eighths of its extent being lodged in the socket, the parietes of which are entire. In the female Dugong the growth of the permanent incisive tusks of the upper jaw is arrested before they cut the gum, and they remain throughout life concealed in the premaxillary bones; the tusk in this sex is solid, is about an inch shorter and less bent than that of the male; it is also irregularly cylindrical, longitudinally indented, and it gradually diminishes to an obtuse rugged point; the base is suddenly expanded, bent obliquely outwards, and presents a shallow excavation. The deciduous incisors of the upper jaw, *i*, *d*, are much smaller than the permanent tusks of the female, and are loosely inserted by one extremity in conical sockets immediately anterior to those of the permanent tusks, adhering by their opposite ends to their tegumentary gum, which presents no outward indication of their presence. Not more than twenty-four molar teeth are developed in the Australian Dugong (*Halicore Australis*), or more than twenty molar teeth in the Malayan Dugong, viz., in the latter, five on each side of both upper and lower jaws, ib. 1–5, but these are never simultaneously in use, the first being shed before the last has cut the gum.

The molar teeth of the Dugong consist of a large body of dentine, a small central part of osteo-dentine, and a thick external investment of cement, *c*, fig. 242, vol. i. p. 365. In the female

Dugong the whole of the smaller extremity of the tusk is surrounded by a thin coat of true enamel, which is covered by a thinner stratum of cement. In the male's tusk the enamel, though it may originally have capped the extremity, as in the female's, yet, in the body of the tusk, it is laid only upon the anterior convex, and on the lateral surfaces, but not upon the posterior concave side of the tusk, which is thickly coated with cement. This side, accordingly, is worn away obliquely when the tusk comes into use, whilst the enamel maintains a sharp chisel-like edge upon the anterior part of the protruded end of the tusk.

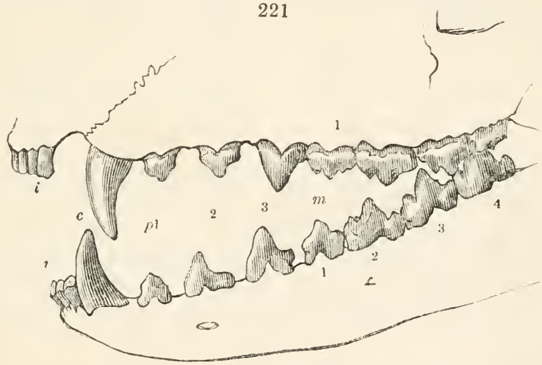
The presence of abortive teeth concealed in the sockets of the deflected part of the lower jaw of the Dugong, fig. 160, *a*, *i*, *d* (vol. ii.), offers an analogy with the rudimental dentition of the upper jaw in the Cachalot, and of both jaws in the fœtal Whales. The arrested growth and concealment of the upper tusks in the female Dugong, and the persistent pulp-cavity and projection of the corresponding tusks in the male, are equally interesting repetitions of the phenomena manifested on a larger scale in the dental system of the Narwhal. The simple implantation of the molar teeth and their composition are paralleled in the teeth of the Cachalot; their difference of form, and the more complex shape of the hindmost tooth, ib. *b*, are repetitions of characters which were present in the dentition of the extinct *Zeuglodon*. The coexistence of incisive tusks with molar teeth, and the successive displacement of the smaller and more simple anterior ones by the advance of larger and more complex grinders into the field of attrition, already seem to sketch out peculiarities of dentition which become established and attain their maximum in the Proboscidian family (Elephants and Mastodons) of the Ungulates.

The molars of the American Manatee are thirty-eight in number, ten on each side of the upper jaw, and nine, at least, on each side of the lower jaw; but they are never simultaneously in place and use. The first in both jaws is small and simple. Beyond the second, the crowns in the upper jaw are square, and support two transverse ridges with tri-tuberculate summits, having also an anterior and posterior basal ridge; each tooth is implanted by three diverging roots, one on the inner and two on the outer side: they increase in size very gradually, from the foremost to the last. The crowns of the four or five anterior molars of the lower jaw resemble those above, but the rest have a large posterior tubercle; they are all implanted by two fangs which enlarge as they descend, and bifurcate at the extremity; the crowns are of moderate height, and project only a few lines above the sockets. The molars consist of a body of dentine, a coronal covering of enamel, and a general investment of cement, very thin upon the crown, and a little thicker upon the fangs.

B. *Marsupialia.* In the Marsupial order, the typical number of the teeth in the molar series is seven on each side of both jaws, the first three of which are ‘premolars,’ fig. 221, *p*, 1, 2, 3, the last displacing, in some, a calcified predecessor, fig. 296, *d* 3, and giving the extent of the theoretical deciduous series. Incisors, fig. 221, *i*, are present in all the species, but are variable in number, in some genera exceeding that of the Mammalian type. Canines, ib. *c*, are large in the Dasyures, are feebly represented in the Phalangers and Petaurists, are absent in the lower jaw of the Potoroos and Koala (fig. 221, vol. ii), and in both jaws of the Kangaroos, fig. 231, and Wombats, fig. 232.

The Dasyures and Thylacine offer the carnivorous type of the dental system, but differ from the corresponding group of the placental Mammals in having the molars of a more uniform and simple structure, and the incisors in greater number: the dental formula of the Dog-headed Opossum, *Thylacinus*, is—

221



Dentition of Thylacine.

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{4.4}{4.4} = 46,\text{ fig. 221.}$$

The canine teeth are long, strong, curved, and pointed; the points of the lower canines are received in hollows of the premaxillary palatal plate when the mouth is closed, and do not project, as in the carnivorous placentals, beyond the margins of the maxillary bones. The premolars, *p*, present a simple compressed conical crown, with a posterior tubercle, which is most developed on the hindmost. The molars, *m*, in the upper jaw are unequally triangular, the last being much smaller than the rest;

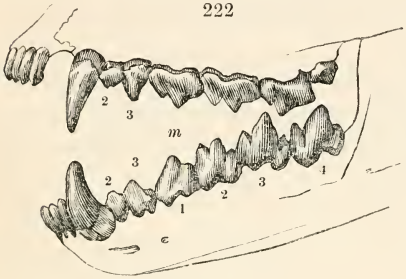
the exterior part of the crown is raised into one large pointed middle cusp and two smaller cusps; a small strong obtuse lobe projects from the inner side. The molars of the lower jaw are compressed and tricuspidate; the middle cusp being the longest, especially in the two last molars, which resemble the feline carnassials.

The dental formula of the genus *Dasyurus* is—

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{4.4}{4.4} = 42, \text{fig. 222.}$$

The eight incisors of the upper jaw, fig. 222, are of the same length and simple structure, and are arranged in a regular semicircle. The premolars, *p* 2 and 3, answer to the two last in *Thylacinus*, and have simple crowns. The upper true molars, *m*, have triangular crowns; the first presents four sharp cusps; the second and third each five; the fourth, which is the smallest, only three. In the lower jaw, the last molar is nearly of equal size with the penultimate one, and is bristled with four cusps, the external one being the longest. The second and third molars have five cusps, three on the inner and two on the outer side; the first molar has four cusps. The carnivorous character of the above dentition is most strongly marked in the Ursine Dasyure, or *Devil* of the Tasmanian colonists, the largest existing species of the genus.

222

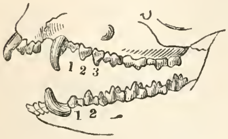


Dentition of Ursine Dasyure.

In some of the smaller species the canines lose their great relative size, and the molars present a surface more cuspidated than sectorial; there is also an increased number of teeth, and as a consequence of their equable development, they have fewer and shorter interspaces. The subgenus *Phascogale* is characterised by—

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{4.4}{4.4} = 46, \text{fig. 223.}$$

223



Dentition of Phascogale.

In this formula may be discerned a step in the transition from the Dasyures to the Opossums, not only in the increased number of spurious molars, but also in the shape and proportions of the incisors.

The general character of the dentition of these small predatory

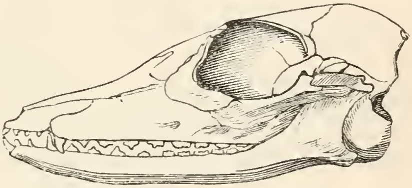
Marsupials approximates to the insectivorous type, and leads thereto from the flesh-feeding genera.

Myrmecobius is characterised by the following remarkable dental formula:—

$$i\,\frac{4.4}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{6.6}{6.6} = 54, \text{fig. } 224.$$

The number of true and false molars, eighteen in both jaws, exceeds that of any other known existing Marsupial. The molars are multicuspid, and both the true and false ones possess two separate fangs. The inferior molars are directed obliquely inward, and the whole dental series describes a slight sigmoid curve, fig. 225. The premolars present the usual compressed triangular form, with the apex slightly recurved, and the base more or less obscurely notched before and behind. The canines are very little longer than the false molars. The incisors are minute, slightly compressed, and pointed; they are separated from each other and the canines by wide intervals.

224



Dentition of Myrmecobius.

The extinct genus *Amphitherium* is founded on fossil remains of lower jaws and teeth discovered in the oolitic slate at Stonesfield, in Oxfordshire, and it receives elucidation from the dental characters of the previous genus, but is remarkable for having a still greater number of molar teeth. The dental formula is as follows:—

$$i\,\frac{?.?}{3.3};\ c\,\frac{?.?}{1.1};\ p\,\frac{?.?}{6.6};\ m\,\frac{?.?}{6.6}.$$

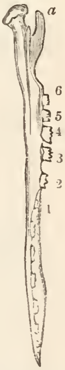
There being thus thirty-two teeth in the lower jaw, and probably as many in the upper jaw.

The following dental formula—

$$i\,\frac{5.5}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{4.4}{4.4} = 48,$$

characterises a number of Marsupials commonly known in Australia by the name of *Bandicoots*, fig. 226. The teeth which offer the greatest range of variation in the present genus (*Perameles*) are the external or posterior incisors and the canines: the molars, also, which originally are quinque-cuspidate, have their points worn away, and present a smooth and oblique grinding surface in some species (fig. 222, *m*, vol. ii.) sooner than in others.

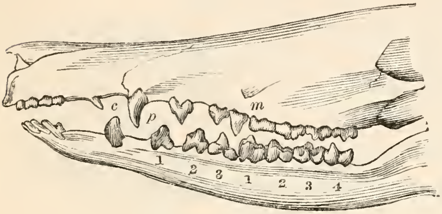
225



Mandibular teeth, Myrmecobius.

The Bandicoots which approach nearest to the *Myrmecobius* in the condition of the incisive and canine teeth, are the *Perameles obesula* and *P. Gunnii.* There is a slight interval between the first and second incisor, and the outer or fifth incisor of the upper jaw is separated from the rest by an interspace equal to twice its own breadth, and moreover presents the triangular pointed canine-like crown which characterises all the incisors of *Myrmecobius* ; but the four anterior incisors are placed close together and have compressed, quadrate, true incisive crowns. From these incisors the canine is very remote, the interspace being equally divided by the fifth pointed incisor, which the canine very slightly exceeds in size. In *Peram. nasuta,* fig. 226, the incisors present the same general condition, but the canines are relatively larger.

226



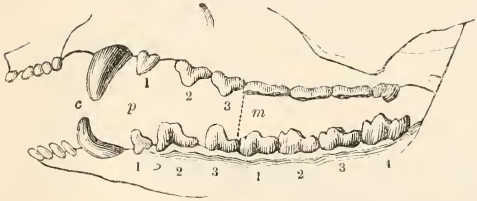
Dentition of Perameles.

The dental formula of the genus *Didelphys* is—

$$i\,\frac{5.5}{4.4};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{4.4}{4.4} = 50, \text{ fig. } 227.$$

The Opossums resemble in their dentition the Bandicoots more than the Dasyures; but they closely resemble the latter in the tuberculous structure of the molars; the two middle incisors of the upper jaw are more produced than the others, from which they are also separated by a short interspace. The canines still exhibit a superior development in both jaws adapted for the destruction of living prey, but the molars have a conformation different from that which characterises the true flesh-feeders, and the Opossums consequently subsist on a mixed diet, or prey upon the lower organised animals.

227



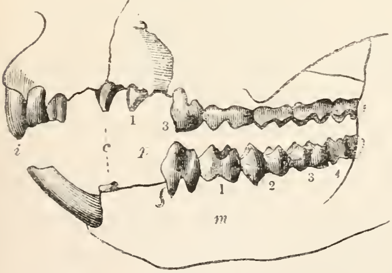
Dentition of Opossum. (*Didelphys*)

The smaller species of *Didelphys*, which are the most numerous, fulfil in South America the office of the insectivorous Shrews of the old continent. The larger Opossums resemble in their habits, as in their dentition, the carnivorous Dasyures, and prey upon the smaller quadrupeds and birds; but they have a more omnivorous diet, feeding on reptiles and insects, and even fruits. One large species (*Did. cancrivora*) prowls about the sea-shore, and lives, as its name implies, on crabs and other crustaceous animals. Another species, the Yapock, frequents the fresh water, and preys almost exclusively on fish: it has the habits of the Otter, but the dentition does not differ from that of ordinary Opossums.

In the genus *Tarsipes* the molars soon begin to fall; the small canines are also deciduous; the two procumbent incisors of the lower jaw remain the longest. The inferior incisors are opposed to six minute incisors above, which are succeeded by a small canine and some small molars; but these are reduced in some, perhaps old, individuals, to a single tooth on each side.

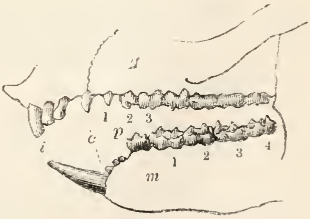
The Phalangers, being provided with hinder hands and prehensile tails, are strictly arboreal animals, and have a close external resemblance to the Opossums. They differ chiefly in their dentition, and in accordance therewith their diet is more decidedly of a vegetable kind. The interspace between the functionally developed incisors and molars in both jaws always contains teeth of small size and little functional importance, and variable not only in their proportions but their number. The constant teeth are the $\frac{4-4}{4-4}$ true molars, and the $\frac{3-3}{1-1}$ incisors. The canines, *c*, fig. 228, are constant in regard to their presence, but variable in size; they are always very small in the lower jaw: the functional premolars, *p* 3, are always in contact with the molars and their crowns reach to the same grinding level; sometimes the second premolar is similarly developed in the upper jaw, as in the *Phal. Cookii*, *p* 2, fig. 229, but it is commonly absent; the first premolar, *p* 1, is a very minute tooth, shaped

228



Dentition of Phalangista vulpina.

229



Dentition of Cook's Phalanger.

like a canine: thus, in the upper jaw, between the posterior or functional premolar, *p* 3, and the incisors, *i*, we may find three teeth, as in *Phal. Cookii*, or two teeth as in *Phal. vulpina*, the first being the canine, *c*. In the lower jaw similar varieties occur in these small and unimportant teeth: e. g. there may be between the procumbent incisors and the posterior premolar, either three teeth, as in *Phal. Cookii*; or two, as in *Phal. ursina*; or one, as in *Phal. vulpina.* The most important modification is presented by the little *Phal. gliriformis* and *Petaurus* (*Acrobates*) *pygmæus*, fig. 219, vol. ii., which have only three true molars on each side of each jaw. These minor modifications are unaccompanied by any change of general structure or of habit, whilst those teeth which most influence the diet are constant.

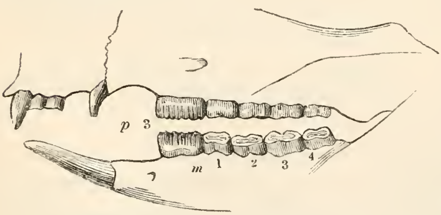
The absence of functionless premolars and of lower canines is constant in the Koala (*Phascolarctos*, fig. 221, vol. ii.). The molars are proportionally larger than in the Phalangers: each is beset with four three-sided cusps, the outer series in the upper teeth being the first to wear down; those in the lower jaw are narrower than in the upper; there is also the rudiment of a 'cingulum.' The premolars are compressed, and terminate in a cutting edge. The small canine is situated close to the premaxillary suture.

The dental formula of the Potoroos (*Hypsiprymnus*) is—

$$i\,\frac{3.3}{1.1};\ c\,\frac{1.1}{0.0};\ p\,\frac{1.1}{1\ 1};\ m\,\frac{4.4}{4.4} = 30, \text{ fig. } 230.$$

The anterior of the upper incisors are longer and more curved than the lateral ones, and their pulps are persistent. The canine is larger than in the Koala; it is similarly situated. In the large *Hypsiprymnus ursinus* the canines are relatively smaller than in the other Potoroos, a structure which indicates the transition from the Potoroo to the Kangaroo genus. The single premolar, *p* 3, has a peculiar trenchant form; its maximum of development is attained in the arboreal Potoroos of New Guinea; in *Hypsiprymnus dorcocephalus*, e.g. its antero-posterior extent nearly equals that of the three succeeding molar teeth. In all the Potoroos, the trenchant spurious molar is indented, especially on the outer side and in young teeth, by many small vertical grooves. The true molars, *m* 1, 2, 3, 4, have large

230



Dentition of Hypsiprymnus murinus.

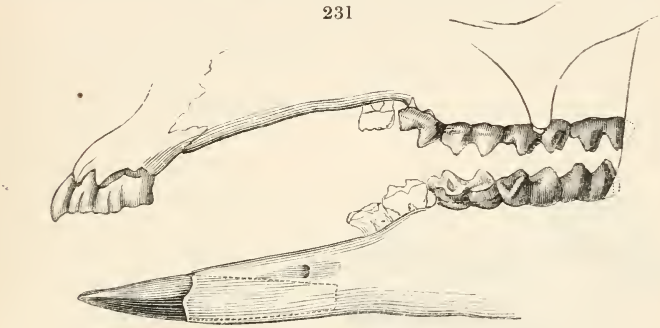
subquadrate crowns; each presents four three-sided pyramidal cusps; but the internal angles of the two opposite cusps are continued into each other across the tooth, forming two angular or concave tranverse ridges. In the old animal these cusps and ridges disappear, and the grinding surface is worn quite flat.

In the genus *Macropus*, fig. 231, the normal condition of the permanent teeth may be expressed as follows:—

$$i\,\frac{3.3}{1.1};\ c\,\frac{0.0}{0.0};\ p\,\frac{1.1}{1.1};\ m\,\frac{4.4}{4.4} = 28.$$

The main difference, as compared with *Hypsiprymnus*, lies in the absence of the upper canines as functional teeth; but the germs of these teeth are to be found in the young mammary fœtus of the *Macropus major*, and may be detected of very small size, concealed by the gum, in the adults of some small species of Kangaroos, as, e. g., *Macropus rufiventer*, Ogilby, and *Macr. psilopus*, Gould. The crown of the true molars supports two principal transverse ridges, with a broad anterior talon and a narrow hinder one. In most species a spur is continued from the hinder to the fore ridge, and another from the fore ridge to the front talon.

231



Dentition of Macropus major, one-third nat. size.

Remains of Kangaroos, larger than any living species, have been discovered in the same caves in Australia which contained the teeth and jaws of the extinct *Dasyurus laniarius*, and they probably formed the prey of that species and of its contemporary the Thylacine which no longer exists in the continent of Australia.[1]

A gigantic extinct herbivorous Australian Marsupial (*Diprotodon*), the bulk of which may be surmised from the length of the skull, which equals three feet, manifests a dentition which makes the nearest approach to that of the Kangaroos; but the anterior or median pair of upper incisors present the condition of large, curved, scalpriform, ever-growing tusks, which work against a similar but straight procumbent pair of incisive tusks below; thus presenting a transitional feature between the Kangaroos and the Rodent form of Marsupial called Wombat (*Phascolomys*).[1] In this genus, the dental system presents the extreme degree of that degradation of the teeth, intermediate between the front incisors and true molars, which has been traced from the Opossum to the Kangaroos; not only have the functionless premolars and canines now totally disappeared, but also the posterior incisors of the upper jaw, which we have seen in the Koala and Potoroo to exhibit a feeble degree of development as compared with the anterior pair; these, in fact, are alone retained in the dentition of *Phascolomys*. The dental formula of the Wombat is thus reduced, both in number and kind, to that of *Rodentia*, viz.—

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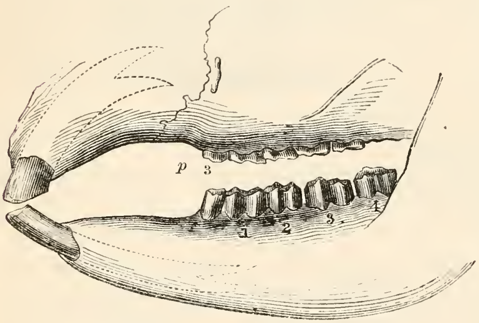
[1] CXVIII″, vol. ii.

$$i\,\frac{2}{2};\ c\,\frac{0}{0};\ p\,\frac{1.1}{1.1};\ m\,\frac{4.4}{4.4} = 24, \text{ fig. 232.}$$

232



Dentition, Phascolomys fuscus, ½ nat. size.

The incisors, *i*, moreover, are 'dentes scalprarii,' but are inferior, especially in the lower jaw, in their relative length and curvature to those of the placental *Glires*; they present a subtriedral figure, and are traversed by a shallow groove on their mesial surface. The premolars, *p*, 3, present no trace of that compressed structure which characterises them in the Koala and Kangaroos, but have a wide oval transverse section; those of the upper jaw being traversed, on the inner side, by a longitudinal groove. The true molars, *m* 1–4, are double the size of the premolars; the superior ones are also traversed by an internal longitudinal groove; but this is so deep and wide that it divides the whole tooth into two prismatic portions, with one of the angles directed inward. The inferior molars are in like manner divided into two triedral portions; but the intervening groove is external, and one of the facets of each prism is turned inward. All the grinders are curved, and describe about a quarter of a circle. In the upper jaw the concavity of the curve is directed outward; in the lower jaw, inward. The false and true molars, like the incisors, have persistent pulps, and are, consequently, devoid of true fangs, in which respect the Wombat differs from all other Marsupials, and resembles the extinct *Toxodon*, the dentigerous *Bruta*, and herbivorous *Rodentia*.

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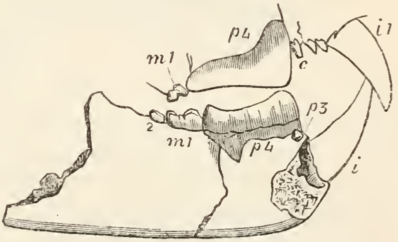
[1] CLXXX, p. 431.

A retrospect of the modifications of marsupial dentition shows them to be divisible into two classes: one 'polyprotodont,' or characterised by several pairs of mandibular incisors; the other 'diprotodont,' or by a single pair: these are large, more or less procumbent, and ever-growing; the incisors of the first group are small, and of the usual limited growth. The polyprotodont type prevails in the American genera: the diprotodont obtains in the majority of the Australasian marsupials, and is associated usually with vegetarian or promiscuous diet. There did exist, however, coeval with *Diprotodon*, *Nototherium*, &c., in a tertiary age in Australia, a carnivorous marsupial equalling the Lion in size, with the diprotodont type of dentition adaptively modified for preying on the huger contemporaneous *Herbivora*.

233



Dentition of *Thylacoleo.*

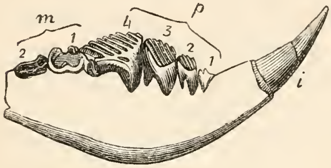
The pair of incisors in the lower jaw, fig. 233, *i*, and their homotypes above, *i* 1, were 'canines' in size and shape: a single tooth of the molar series on each side of both jaws, ib. *p* 4, was concomitantly modified to act as a 'sectorial' or flesh-cutting tooth; the crown being narrow or 'compressed,' long antero-posteriorly, with the sides marked by vertical folds or grooves, and converging to a rather oblique cutting edge, that of the upper blade playing on the outside of the lower one. These 'sectorials' were larger than in the Lion or Tiger, and were even more 'carnassial' as wanting the 'tubercle,' and consisting wholly of the 'blade.' Behind the upper sectorial is one small tubercular, *m* 1, of the relative proportion of that in *Felis*: the lower sectorial is followed by two small teeth with subtuberculate crowns, *m* 1, *m* 2. The teeth between the carnassials and laniary incisors are too small for definite use. So far as present fossils show, the dentition of *Thylacoleo* was:—

$$i\,\frac{3.3}{1.1};\ c\,\frac{1.1}{0.0};\ p\,\frac{2.2}{2.2};\ m\,\frac{1.1}{2.2} = 24.$$

The chief business of the teeth was delegated to the tusks and carnassials; development was concentrated on these at the cost of the rest of the normal or typical dental series. The foremost teeth seized, pierced, lacerated or killed, the carnassials divided the nutritive fibres of the prey.

Thylacoleo exemplifies the simplest and most effective dental machinery for predatory life known in the Mammalian class. It is the extreme modification, to this end, of the diprotodont type of *Marsupialia.* The skull exhibits all the concomitant carnivorous modifications, in a like extreme degree.[1]

234



Dentition of lower jaw, *Plagiaulax.*

It is interesting to note that, just as the exceptional modification of the polyprotodont type, in the modern *Myrmecobius*, was manifested by *Amphitherium* in Oolitic times, so likewise was the zoophagous diprotodont modification; but on a smaller scale than in *Thylacoleo.* The lower incisor in *Plagiaulax*, fig. 234, *i*, was a large, upcurved, pointed tusk: the carnassial, p. 4, was of great fore-and-aft length, coupled with narrowness, and an oblique cutting edge, rendered sub-serrate by the better-marked and more oblique lateral grooves, than in *Thylacoleo.* Anterior to the carnassial, *p*, 4, there are two or three similar and smaller sectorial premolars, in *Plagiaulax*, more of the general diphyodont type being retained in the older zoophagous diprotodont. Behind the carnassial are two small tuberculate molars, *m* 1, *m* 2, as in *Thylacoleo.* Some Palæontologists, neglecting Cuvier's guide-post of the true molar as the light-giving tooth, have been led astray in regard to the affinities of *Plagiaulax*, referring it to the 'poephagous Potoroos and Kangaroos,' which combine with a single trenchant and grooved premolar, four large and massive grinders, of quadricuspid or transversely ridged structure.

C. *Rodentia.*—In different orders of the placental as in the marsupial diphyodonts there are instances in which the ordinary number of incisors is diminished, and their growing power transferred to a single pair of tusks projecting from the forepart of the upper or the lower jaw, or of both. The Dinotheres, Toxodons, Mastodons, and Elephants, among the *Ungulata*, the Dugong in the *Sirenia*, the Aye-aye in the *Quadrumana*, are instances of this modification, which reaches its extreme in the latter mammal and the elephants. In numerous *Lissencephala* a single pair of large curved ever-growing incisors, in each jaw, is combined with so many peculiarities of structure, as to have led to their association into one order[1] called by Linnæus *Glires* and by Cuvier 'Rongeurs' or 'Eroders,' from the gnawing power and habit resulting from such dental modification.

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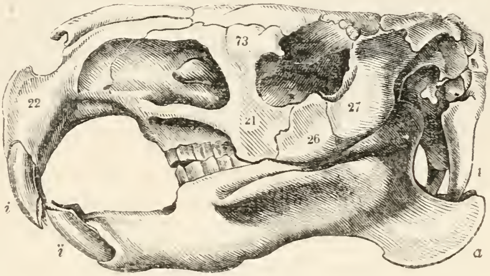
[1] cxix″.

The incisors, fig. 235, *i*, *ï*, are separated by a wide interval from the molars: the upper pair, ib. *i*, describe a larger segment of a smaller circle, the lower ones, ib. *ï*, a smaller segment of a larger circle; these are the longest incisors, and usually have their alveoli extended below, or on the inner side of, those of the molars, to the back part of the lower jaw, fig. 129: but in the Hare they reach only midway toward the angle. As in all teeth of unlimited growth, the implanted part of the incisors, besides its length, retains the form and size of the exposed part or crown, to the widely open base, which contains a long conical persistent dentinal pulp, ib. *a*, and is surrounded by the capsule in a progressive state of ossification, as it approaches the crown; an enamel-pulp is attached to the inner side of that part of the capsule which covers the convex surface of the curved incisor.

235



Dentition of the Capybara.

The calcification of the dentinal pulp, the deposition of the earthy salts in the cells of the enamel-pulp, and the ossification of the capsule, proceed contemporaneously; fresh materials being added to the base of the vascular matrix as its several constituents are progressively converted into the dental tissues in the more advanced part of the socket. The tooth, thence projecting, consists of a body of compact dentine, sometimes with a few short medullary canals continued into it from the persistent pulp-cavity, with a plate of enamel laid upon its anterior surface, and a general investment of cement, which is very thin upon the enamel, but less thin, in some Rodents, upon the posterior and lateral parts of the incisor. The substances of the incisor diminish in hardness from the front to the back part of the tooth, not only in so far as the enamel is harder than the dentine, but because the enamel consists of two layers, of which the anterior and external is denser than the posterior layer, and the posterior half of the dentine is rendered by a modified number and arrangement of the dentinal tubes less dense than the anterior half.

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[1] Vol. ii. p. 276.

The abrasion resulting from the reciprocal action of the upper and lower incisors produces, accordingly, an oblique surface, sloping from a sharp anterior margin formed by the dense enamel, like that which slopes from the sharp edge formed by the plate of hard steel laid on the back of a chisel; whence the name 'scalpriform,' 'dentes scalprarii,' given to the incisors of the *Rodentia.* In *Leporidæ* the enamel is traceable to the back of the incisors: with this exception, the varieties to which these incisors are subject in the different Rodents are limited to their proportional size, and to the colour and sculpturing of the anterior surface. Thus in the Guinea-pig, Jerboa, and Squirrel, the breadth of the incisors is not half so great as that of the molars: whilst in the Coypu they are as broad as the molars, and in the Cape Mole-rats (*Bathyergus* and *Orycteromys*) are even broader. In the Coypu, Beaver, Agouti, and some other Rodents, the enamelled surface of the incisors is of a bright orange or reddish-brown colour. In some genera of Rodents, as *Orycteromys, Otomys, Meriones, Hydrochœrus, Lepus,* and *Lagomys,* the anterior surface is indented by a deep longitudinal groove. This character seems not to influence the food or habits of the species: it is present in one genus and absent in another of the same natural family. In most Rodents the anterior enamelled surface of the scalpriform teeth is smooth and uniform.

The molar teeth are always few in number, obliquely implanted and obliquely abraded, the series on each side converging anteriorly in both jaws; but they present a striking contrast to the incisors in the range of their varieties, which are so numerous that they typify almost all the modifications of form and structure which are met with in the molar teeth of the omnivorous and herbivorous genera of other orders of mammalia. In some Rodents—e.g. Cavies, the molar teeth, fig. 236, *p, m,* are rootless; others—e.g. the Agouti, have short roots, tardily developed like the molars of the Horse and Elephant; others, again—e.g. the Rat and the Porcupine, soon acquire roots of the ordinary proportional length.

The differences in the mode of implantation of the molar teeth relate to the differences of diet. The Rodents, which subsist on mixed food, and which betray a tendency to carnivorous habits, as, e.g., the true Rats, or which subsist on the softer and more nutritious vegetable substances, such as the oily kernels of nuts, suffer less rapid abrasion of the molar teeth ; a minor depth of the crown is therefore needed to perform the office of mastication during the brief period of existence allotted to these active little Mammals: and as the economy of nature is manifested in the smallest particulars as well as in her grandest operations, no more dental substance is developed after the crown is formed, than is requisite for the firm fixation of the tooth in the jaw.

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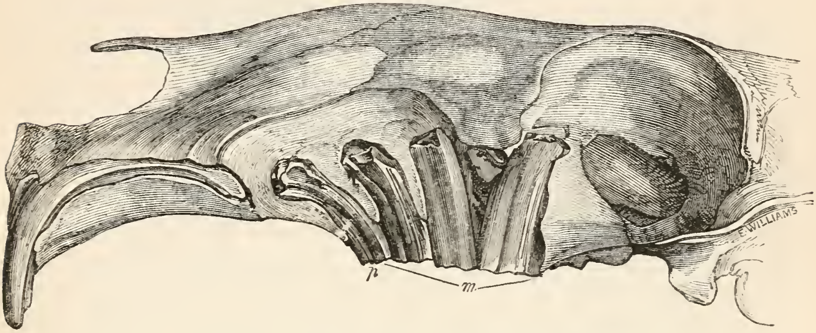

Cranium and upper teeth of the Patagonian Cavy (*Dolichotis*).

Rodents that exclusively subsist on vegetable substances, especially the coarser and less nutritious kinds, as herbage, foliage, the bark and wood of trees, wear away more rapidly the grinding surface of the molar teeth ; the crowns are therefore larger, and their growth continues by reproduction of the formative matrix at their base in proportion as its calcified constituents, forming the exposed working part of the tooth, are worn away. So long as this reproductive force is active, the molar tooth is implanted, like the incisor, by a long undivided continuation of the crown. The rootless and perpetually growing molars are always more or less curved, fig. 236, *p*, *m* ; they derive from this form the same advantage as the incisors, in the relief of the delicate tissues of the active vascular matrix from the effects of the pressure which would otherwise have been transmitted more directly from the grinding surface to the growing base.

The complexity of the structure of the crown of the molar teeth, and the quantity of enamel and cement interblended with the dentine, are greatest in the rootless molars of the strictly herbivorous Rodents. The crowns of the rooted molars of the omnivorous rats and mice are at first tuberculate. When the summits of the tubercles are worn off the inequality of the grinding surface is for a time maintained by the deeper transverse folds of enamel, the margins of which are separated by alternate valleys of dentine and cement; but these folds, sinking only to a slight depth, are in time obliterated, and the grinding surface is reduced to a smooth field of dentine, with a simple border of enamel. Examples of various forms assumed by the inflected folds of enamel in the molars of the *Rodentia* are given in the works of the Cuviers and other naturalists.[1] These folds have a general tendency to a transverse direction across the crown of the tooth (vol. ii. fig. 236, p. 370): the joint of the lower jaw almost restricts it to horizontal movements to and fro, in the direction of the axis of the head, during the act of mastication. When the folds of enamel dip in vertically from the summit to a greater or less depth into the substance of the crown of the tooth, as in those molars which have roots, the configuration of the grinding surface varies with the degree of abrasion; but in the rootless molars, where the folds of enamel extend inward from the entire length of the sides of the tooth, the characteristic configuration of the grinding surface is maintained without variation, as in the Guinea-pig, the Capybara, and the Patagonian Cavy.

The whole exterior of the molar teeth of the *Rodentia* is covered by cement, and the external interspaces of the enamel-folds are filled with the same substance. In the *Chinchillidæ* and the Capybara, where the folds of enamel extend quite across the body of the tooth, and insulate as many plates of dentine, these detached portions are held together by the cement. Such folds of enamel are usually parallel, as in the large posterior lower molar of the Capybara, which, in shape and structure, offers a very close and interesting resemblance to the molars of the Asiatic Elephant. The modification observed in the Voles (*Arvicola*) calls to mind the molars of the African Elephant. The partial folds and islands of enamel in the molars of the Porcupine and Agouti foreshow the structure of the teeth of the Rhinoceros. The opposite lateral inflections of enamel in the molars of the Gerbille and Cape Mole-rat, represent the structure of the molars of the Hippopotamus. The double crescentic folds in the Jerboa sketch out, as it were, the characteristic structure of the molars of the Anoplothere and Ruminants, &c.

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[1] CXX″. and CXXI″.

The transverse section of the molar of the Water-vole, fig. 237, shows that modification of the grinding surface in which the folds of enamel, *e*, extend like promontories, some outward, the others inward, into the substance of the crown; a like section of the Beaver's molar exhibits islands with a promontory of enamel. The transverse section of the crown of the molar of *Lagostomus* displays not fewer than five islands of enamel, which hard substance is so thick that it enters more abundantly into the composition of the tooth than the dentine itself. The pulp, after the formation of a certain thickness of tubular dentine, becomes converted into osteo-dentine in both the rooted and rootless molars of the Rodents. This fourth substance is exhibited at *o*, fig. 237, which shows the four different dental tissues, viz. cement, *c*, enamel, *e*, dentine, *d*, and osteo-dentine, *o*, entering in more equal proportions into the formation of the crown than in other Mammalian teeth. When the crown is worn by mastication down to the place of the section figured, the four substances appear in the same proportions on the grinding surface, contributing to its efficiency as a triturating organ by the inequalities consequent on their various degrees of density and resistance to the abrading forces.

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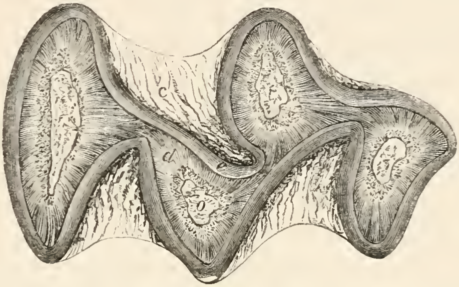

Structure of the molar of the Water-vole (*Arvicola amphibia*), magnified.

The molars are not numerous in any Rodent; the Hare and Rabbit (*Lepus*) have $\frac{6}{5}$:$\frac{6}{5}$, i.e. six molars on each side of the upper jaw, fig. 238, and five on each side of the lower jaw, vol. ii. fig. 233. The Pika (*Lagomys*) has $\frac{5}{5}$:$\frac{5}{5}$. The Squirrels have $\frac{5}{4}$:$\frac{5}{4}$. The families of the Dormice, the Porcupines, the Spring-rats (*Echimyidæ*), the Octodonts, the Chinchillas, and the Cavies, figs. 235, 236, have $\frac{4}{4}$:$\frac{4}{4}$ molars. In the great family of Rats (*Muridæ* the normal number of molars is $\frac{3}{3}:\frac{3}{3}$; but the Australian Water-rat (*Hydromys*) has but $\frac{2}{2}:\frac{2}{2}$ molars, making, with the incisors, twelve teeth, which is the smallest number in the Rodent order. The greatest number of teeth in the present order is twenty-eight, which is exemplified in the Hare and Rabbit; but forty teeth are developed in these species, ten molars and two incisors being deciduous.

The first or anterior of the molar series, whether the number be 2–2, 3–3, or 4–4, is a premolar; it has displaced a deciduous predecessor in the vertical direction. When the series extends to 5–5 or 6–6, the additions are to the fore part, and are premolars. This it is which constitutes the essential distinction between the dentition of the marsupial and the placental Rodent; the latter, like the placental *Carnivora*, *Quadrumana*, and *Ungulata*, having never more than three true molars. Thus the Rodents which have the molar formula of $\frac{4}{4}:\frac{4}{4}$, shed the first tooth in each series, and this is succeeded by a permanent premolar, which comes into place later than the true molars—later at least than the first and second, even when the deciduous molar is shed before birth, as was observed by Cuvier in the Guinea-pig. In the Hare and Rabbit, three anterior teeth in the upper jaw, fig 238, *p*, succeed and displace three deciduous predecessors, ib. *d*, coming into place after the first and second true molars, ib. *m*, are in use, and contemporaneously with the last molar. It does not appear that the scalpriform incisors, ib. *i*, are preceded by milk teeth, or, like the premolars of the Guinea-pig, by uterine teeth; but the second incisor, ib. *i*, 2, is so preceded —e.g. by the tooth marked *d*, *i*, 2, at which period of dentition six incisors are present in the upper jaw. This condition is interesting both as a transitory manifestation of the normal number of incisive teeth in the mammalian series, and as it elucidates the disputed nature of the great anterior scalpriform teeth of the Rodentia. It has been contended that they are canines, because those of the upper jaw extended their fang backward into the maxillary bone, which lodged part of their hollow base and matrix. But the scalpriform teeth are confined exclusively to the premaxillary bones at the beginning of their formation, and the smaller incisors which are developed behind them, in our anomalous native Rodents, the Hare and

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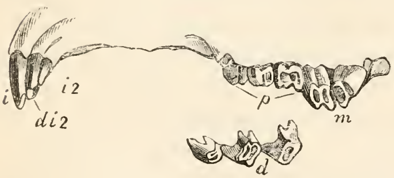

Upper deciduous and permanent teeth of the Hare.

Rabbit, retain their usual relations with the premaxillaries, thus proving, *à fortiori*, that the tooth which projects anterior to them must also be an incisor.

The law of the unlimited growth of the scalpriform incisors is unconditional; and constant exercise and abrasion are required to maintain the normal and serviceable form and proportions of these teeth. When, by accident, an opposing incisor is lost, or when, by the distorted union of a broken jaw, the lower incisors no longer meet the upper ones, as sometimes happens to a wounded hare, the incisors continue to grow until they project like the tusks of the elephant, and their extremities, in the poor animal's painful attempts to acquire food, also become pointed like tusks. Following the curve prescribed to their growth by the form of their socket, their points often return against some part of the head, are pressed through the skin, then cause absorption of the jaw-bone, and again enter the mouth, rendering mastication impracticable and causing death by starvation. I have seen a lower jaw of a beaver, in which the scalpriform incisor has, by unchecked growth, described a complete circle. The point had pierced the masseter muscle, and entered the back of the mouth, passing between the condyloid and coronoid processes of the lower jaw, descending to the back part of the molar teeth, in the advance of the part of its own alveolus, which contains its hollow root. The upper jaw of a Rabbit, with an analogous abnormal growth of the scalpriform and accessory incisors, is shown in fig. 239.

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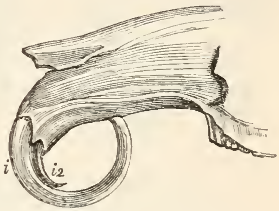

Forepart of upper jaw of a Rabbit, with incisors of abnormal growth.

D. *Insectivora.*—The dental system in this order is remarkable for the many varieties and even anomalies which it presents—almost the only characteristic predicable of it being the presence of sharp points or cusps upon the crowns of the molar teeth, which are always broader in the upper than in the lower jaw. The teeth that intervene between these and the incisors are most variable in form and size, but are never absent; the incisors differ in number, size, and shape, in different species, the anterior ones approximating in some species to the character of the scalpriform teeth of the Rodents. They may be wholly absent in the upper jaw, fig. 242, A.

The Chrysochlore, or iridescent Mole of the Cape, makes the nearest approach, by the number of its molar teeth, fig. 240, to that remarkable condition which a solitary genus (*Myrmecobius*) of existing Marsupials also presents, and which was more abundantly manifested in the extinct *Amphitheria* and *Spalacotheria* of the Oolitic period. At least $\frac{6}{5}:\frac{6}{5}$ true molars may be assigned to the Chrysochlore according to their form—the only character, in the absence of the known order of their vertical displacement and succession, by which the true and false molars can at present be defined in this species. In the upper jaw, *ib.* 1, the anterior large laniariform tooth, and the two succeeding small teeth, are incisors, by virtue of their position in the premaxillary bones; the next small tooth, with a simple compressed tricuspid crown, may be regarded either as a canine or a premolar. The crowns of the true molars are thin plates, narrowed from before backward, with two notches on the working edge, and a longitudinal groove along the outer and thicker margin. Another anomaly, more remarkable than that of the shape of the true molars, is their separation from each other by vacant intervals, as in many Reptiles.

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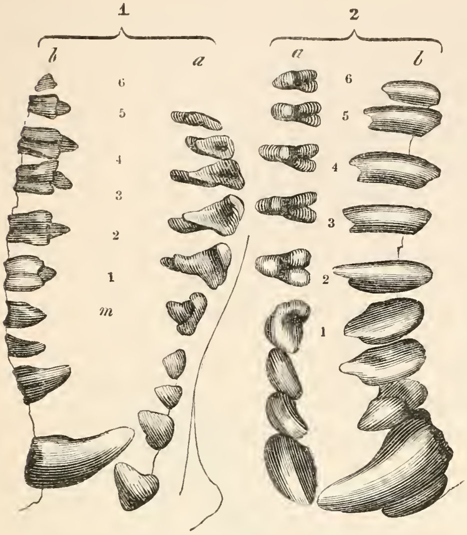

Dentition of Chrysochlore, magn.
1. Upper jaw, *b* side view, *a* grinding surface.
2. Lower jaw, *a* grinding surface, *b* side view.

The crowns of the five lower true molars, ib. 2, 2...6, are compressed antero-posteriorly, but are of unusual length, and have the thicker margin turned inward; the summit of the outer border is pointed and most prominent; the inner division is subdivided into two points. The anterior incisor is small and procumbent; the second has a larger laniariform crown; the third is small, and resembles the two premolars which intervene between this and the first large tricuspid molar. The lower molars are separated by wider intervals than those above; the crowns of the opposing series enter reciprocally the interspaces, and interlock; in mastication, the anterior margin of the lower tooth works upon the posterior margin of the opposite upper tooth.

The views of the nature of these teeth, as given in the foregoing description, are expressed by the following formula:—

$$i\,\frac{3.3}{3.3};\ p\,\frac{1.1}{2.2};\ m\,\frac{6.6}{5.5} = 40.$$

The small insectivorous mammal, called *Spalacotherium*, which has left its fossil remains in the upper Oolite of Purbeck, had ten molar teeth on each side of the lower jaw, of which six at least presented a tricuspid crown with proportions very similar to those of the Chrysochlore.

In the Shrew-moles of America (*Scalops*) the dentition makes an important step towards the normal mammalian condition, by the restriction of the characters of the true molar teeth to the three posterior ones in each lateral series. Between these and the large scalpriform incisor, in the upper jaw, there are six teeth, the first two of which must also be regarded, by the analogy of the Chrysochlore, as incisors; the next tooth might pass for a canine; and the remaining three for premolars: of these the last is the largest, and has a triedral pointed crown. The true molars have large crowns, each with six cusps, four on the outer, and two on the inner part of the grinding surface. In the lower jaw the first incisor is small and procumbent, and the second large and laniariform; the third is absent, and a vacant space separates the incisors from the three premolars, and the crown of each true molar consists of two parallel three-sided prisms, each terminated by three cusps, and having one of the angles turned outward, and one of the faces inward. The dental formula of this genus, according to the above description, is—

$$i\,\frac{3.3}{2.2};\ c\,\frac{1.1}{0.0};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 36.$$

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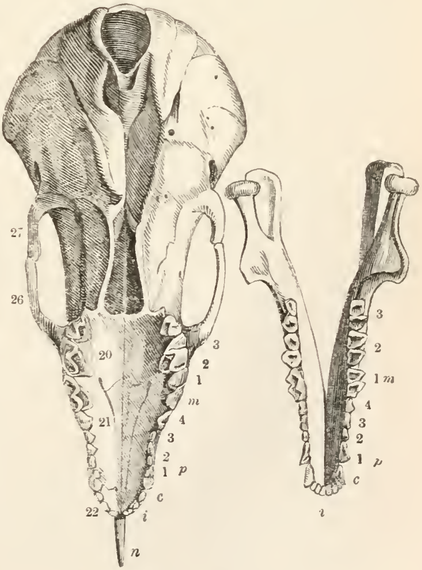

Dentition of Mole (*Talpa*).

The dentition of the common Mole (*Talpa europœa*), fig. 241, includes eleven teeth on each side of both upper and lower jaws. The first three, *i*, in the upper jaw are very small, with simple incisive crowns, and are each implanted by a long and slender fang in the premaxillary, 22: these teeth are incisors. The next tooth, *c*, by the size and shape of the crown, represents a canine, but it is implanted by two fangs, like the succeeding premolar teeth. Three of these teeth, *p* 1, 2, 3, are of small size, with compressed conical crowns; the fourth premolar, *p* 4, has a larger three-sided conical crown, supported by three fangs: the crowns of the true molars, *m* 1, 2, 3, are multicuspid; the middle one the largest, with five points, and usually supported by four fangs, the hindmost the smallest, with a tricuspid crown and three fangs. In the lower jaw the first four teeth on each side are small, simple, and single-fanged, like the three incisors above, but the outermost, *c*, is the largest; the fifth tooth has a large laniariform crown, supported by two fangs, being very similar to, but shorter than, the two-fanged canine above. As it passes behind that tooth when the mouth is shut, we must regard it as a premolar, *p* 1: it is the first and largest of the series of four premolars, each of which has a small posterior talon at the base of the compressed conical crown. The three true molars, *m* 1, 2, 3, are each implanted by two fangs, and have quinque-cuspid crowns, the middle molar being the largest.

According to this homology, the dental formula of the genus *Talpa* is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{3.3}{3.3} = 44.$$

The teeth are equal in number, and alike in both jaws; the true molars are reduced to the normal quantity in the placental series, and the entire dentition is the least anomalous of any which is manifested in the family *Talpidæ*.

The transition from the Moles to the Shrews seems to be made by the Water-moles (*Mygale*) and the *Solenodon*. The latter insectivore combines the form of a gigantic Shrew, with a dentition resembling that of the Chrysochlore. Each premaxillary bone contains three incisors, the first large, canine-shaped, grooved anteriorly, with the point inclined backward; the other two incisors small, with simple conical crowns; these are succeeded by seven teeth, the two anterior having three-sided conical crowns, the other five bearing, in addition, an external tuberculate basal ridge. In the lower jaw, the anterior incisor is very small, and the second large and laniariform, as in *Scalops*, but it is remarkable for a deep longitudinal excavation upon its inner side; the third lower incisor is small and simple. Of the seven succeeding teeth, the four last have multicuspid crowns like true molars. *Potamogale*[1] has—

$$i\,\frac{3.3}{3.3};\ c\,\frac{0.0}{0.0};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 36.^{2}$$

In this large otter-like piscivorous shrew the anterior tooth of the premolar series, in the above formula, may be homologous with the canine in fig. 242; the double fang of the upper one would not bar such determination. The posterior incisors and the premolars have triangular trenchant crowns like the teeth of some sharks: the anterior upper, and the second lower, incisors are large and prehensile, as in *Solenodon.*

The typical Shrews always manifest their rodent analogy by the great preponderance of the anterior pair of incisors in both upper and lower jaws (vol. ii. p. 277, fig. 155[3]). In the lower jaw the great incisor, ib. 2, *i*, is uniformly succeeded by two small, *p* 3, 4, and three large, *m* 1, 2, 3, multicuspid molars; but in the upper jaw the number of small premolars varies. The last true molar is commonly of small size. The subgenera of Shrews are chiefly based upon the form of the large incisors and the numerical variations of the dentition of the upper jaw. In the common Shrew (*Sorex araneus*, Linn.) there are three true molars and four small teeth between these and the anterior incisor; this tooth, ib. 1, *i*, has a pointed tubercle at the back of the base of the crown. The long procumbent incisor of the lower jaw has the trenchant superior margin entire. In the *Sorex* (*Amphisorex*) *tetragonurus,* the upper edge of the lower incisor is notched; the large upper incisor appears bifurcate from the great development of the posterior talon; five small teeth, progressively decreasing in size, intervene between the upper large incisor and the true molars. In the *Sorex* (*Hydrosorex*) *Hermanni,* the trenchant edge of the lower procumbent incisor is entire; there are four small teeth between the large anterior incisor and the true molars in the upper jaw, as in the great *Sorex indicus*; but the three first are subequal, and the fourth very minute; there is a fourth small true molar above. The enamelled tips of the teeth of the species of *Amphisorex* and *Hydrosorex* are stained of a bright brown colour; the teeth of *Sorex* proper, as the common Shrew (*S. araneus*), are not so stained.[4]

In the progress of the formation of the large notched incisors, the summits of the tubercles are first formed as detached points, supported upon the common pulp, and do not become united until the centripetal calcification has converted this into a common dentinal base. Some anatomists have regarded the large incisor so formed as an aggregate of two or three teeth; but in *Sorex* proper and *Hydrosorex*, the calcification of the lower incisor spreads from a single point, and the interpretation of the notched incisor of the *Amphisorex*, as the representative of these incisors, might, by parity of reasoning, be applied to the human incisor teeth, the dentated margins of which are likewise originally three or four separate tubercles.

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[1] Du Chaillu, XIII″, and CLXVI″, p. 353.

[2] CLXV″, p. 6.

[3] In this figure the tooth marked *p* 1, being at the suture of the premaxillary with the maxillary, should be the canine, *c* 1.

[4] CLXVII″, p. 6.

The determination of the small teeth between the large anterior incisors and the multicuspid molars depends upon the extent of the early anchylosed premaxillaries; the incisors being defined by their implantation in those bones, the succeeding small and simple-crowned molars must be regarded as premolars, not any of them having the development or office of a canine tooth; their homotypes in the lower jaw are implanted by two roots.

The thickness of the enamel, in proportion to the body of dentine, is unusually great in these small insectivores, and the sharp points of the teeth long retain their fitness for the office of cracking and crushing the hard or tough teguments of insects. The enamel-pulp of the lower incisors is so large as to overlap, in the young Shrew, the growing margin of the socket, so as to encase with enamel not only the crown of the tooth, but also the contiguous part of the jawbone: the roots of these teeth also become anchylosed to the jawbone, a reptilian character offered by the *Soricidæ* alone in the Mammalian class.

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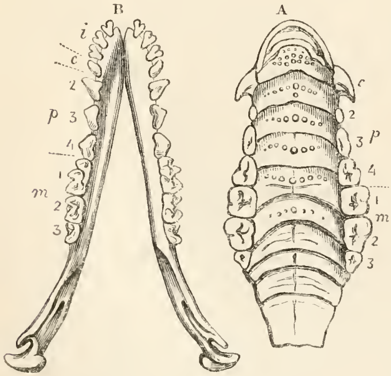

Dentition of *Rhynchocyon*. LXXXIV′.

In a large long-legged and long-snouted African Shrew (*Rhynchocyon*, Peters[1]) the lower incisors are bilobed; the upper ones absent, giving the following dental formula, fig. 242 :—

$$i\,\frac{0.0}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 34.$$

The premaxillaries terminate in a trenchant edentulous border, A, as in the true ruminant: to the hard gum covering it are opposed the crowns of the six lower incisors, ib. B, *i*; a canine, *c*, with a similar-sized but simple crown, seems part of the semi-circular incisive series, as in ruminants, and is separated by a slight interval from the premolar, 2. The canine above, A, *c*, has a long compressed pointed crown, with a sharp hind border: its root is deeply implanted and divided into two fangs: it descends outside the lower teeth and their alveoli, reminding one of the canines in the small Musk-deer. The upper premolars, A, *p*, 2, 3, 4, have compressed pointed crowns increasing in size as they approach the molars: the hind border of the second has one notch, that of the third two notches, and a low sub-bilobed inner portion. The molars decrease in size to the third: the first and second above have two outer cusps more produced than the two inner ones: the third molar has the hind pair blended into one cusp. The first lower premolar has a longer but thinner crown than the last. The first and second lower molars are 4-cuspid; the third, 3-cuspid; and the first has an anterior talon.

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[1] LXXXIV′, p. 106.

Macroscelides and *Petrodromus*, also South African Insectivora with long hind-limbs and a long snout, have similar 4-cuspid molar teeth, the last molar the smallest and with the outer and inner cusps of the hind pair blended into one. The last premolar above has a low beginning of the inner cusps, which are the lowest in the true molars. In the lower jaw of *Macroscelides fuscus* the type series is preserved, viz.:—*i* 3, *c* 1, *p* 4, *m* 3; but *p* 1 is undeveloped above; and *p* 1 is wanting, both above and below, in *Petrodromus*, as in *Rhynchocyon*.

Bdeogale crassicauda (Peters), with the following formula:—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 40,$$

is remarkable for the large proportional size of the upper outer incisor, which almost equals the canine.

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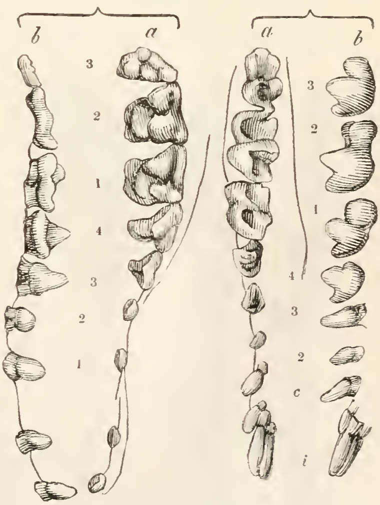

Dentition of *Tupaia*.
1. Upper jaw, *b* side view, *a* working surface
2. Lower jaw, *a* working surface, *b* side view.

In the dentition of the Tupaias (*Glisorex*, fig. 243) we trace characters intermediate between those of Shrews and Hedgehogs. The dental formula of *Glisorex tana* is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 36.$$

The upper incisors are small, simple, and wide apart in the upper jaw, 1; the anterior incisor in the lower jaw, 2, is long and procumbent, but relatively smaller than in the Shrews; the canines are small in both jaws; the premolars, 2, 3, 4, increase in size and complexity as they approach the true molars, 1, 2, 3.

In *Gymnura* each premaxillary bone contains three teeth; the next has the form and size of a canine in both upper and lower jaws, but has two roots in the upper jaw; this is followed by four premolars, the last of which, in the upper jaw, is large and quadricuspid: the first and second of the true molars have square multicuspid crowns; the last molar is smaller and triangular. In the lower jaw the fourth premolar has a compressed tricuspid crown. The dental formula of *Gymnura* is typical, viz.:—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{3.3}{3.3} = 44.$$

The dentition of our common Hedgehog (*Erinaceus europæus*) shows greater inequality in the upper and lower jaws, the formula being—

$$i\,\frac{3.3}{3.3};\ \ c\,\frac{1.1}{0.0};\ p\,\frac{3.3}{2.2};\ m\,\frac{3.3}{3.3} = 36,\ \text{fig. } 244.$$

The first incisor in both upper and lower jaws is larger and longer than the rest, and is very deeply implanted in the jaw; the tooth which follows the incisors is small in both jaws, but especially so in the lower; it may be called a canine with two roots in the upper jaw, *p* 1. The last premolar is the largest in both jaws; above it has a quadricuspid crown with three fangs; below, a subcompressed tricuspid crown with two fangs. The true molars decrease in size from the first to the third in both jaws, the first and second have subquadrate four-pointed crowns above; below, they are narrower, and the anterior and inner angle is produced into a fifth cusp.

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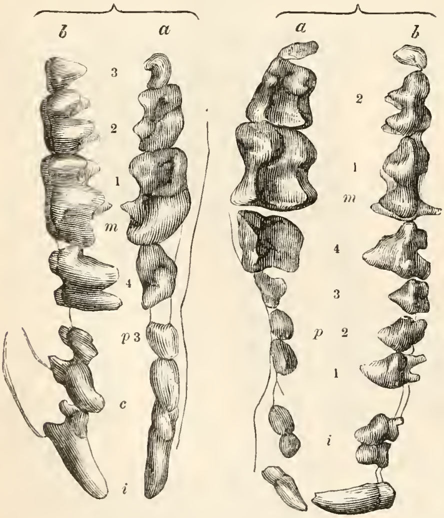

Dentition of Hedgehog.
1. Lower jaw, *b* side view, *a* working surface.
2. Upper jaw, *a* working surface, *b* side view.

The true molars of the tropical Hedgehogs, forming the subgenera *Echinops* and *Ericulus*, are more simple, and approach the form of those in the Chrysochlore, being compressed from before backward, with two outer cusps and one inner cusp in the upper jaw, and with one outer and two inner cusps in the lower jaw. The number of incisors is $\frac{2}{2}:\frac{2}{2}$ in both subgenera, which are followed by $\frac{2}{2}:\frac{2}{2}$ small and simple premolars; but *Ericulus* has $\frac{5}{5}:\frac{5}{5}$ compressed tricuspid molars, and *Echinops* only $\frac{4}{4}:\frac{4}{4}$.

The large Tenrecs or tailless Hedgehogs of Madagascar, combine the simple molars of *Ericulus* with the most formidably developed canines which are to be met with in the whole order *Insectivora*. The incisors are two in number in the upper jaw, but three in the lower jaw; very small and sub-equal in both; the canines are long and large, compressed, trenchant, sharp-pointed, recurved, and single-fanged, thus presenting all the typical characters of those teeth in the *Carnivora*. They are separated in both jaws by a wide space from the premolars; the first above is compressed, unicuspid with a hinder talon, and two-fanged; the second has a larger prismatic tricuspid crown and three fangs; of the four posterior teeth, which by their antero-posterior compression may be regarded as true molars, the first three have tricuspid crowns as in the *Echinops*, and have three fangs; the fourth is smaller, is tricuspid, and has two fangs; all the lower molars have two fangs.

The teeth of *Insectivora* consist of a basis of hard dentine, with a thick coronal investment of enamel, and an outer covering of cement, very recognisable in the interspaces of the coronal cusps in microscopic sections of the molars of the larger species, as the Tenrecs and Macroscelids, and always thick when it closes the extremity of the fangs. Here the cement is commonly more highly organised, is traversed by medullary canals, generally presenting concentric walls; it thus assumes the character of true bone, and, in the *Soricidæ*, is frequently continued into the substance of the jaw itself.

The small proportion of dentine, in comparison with the thick layer of enamel, has been already alluded to in the Shrews, yet the dentinal tubuli are at their commencement very little inferior in diameter to those of the human incisors; the trunks are very short, and are resolved into radiated penicilli of undulating branches, which quickly subdivide, interlace and anastomose together near the boundary line between the dentine and enamel. In most of the *Insectivora*, the secondary branches of the dentinal tubes are unusually conspicuous, especially in the dentine forming the fangs. The dentinal compartments (vol. i. fig. 237) are rarely well defined; in the large canines of the *Centetes* they are subhexagonal.

The deciduous teeth of the Moles and Shrews are uterine, i.e., are developed and disappear before birth. They are extremely small, and are all of the most simple form. In the fetal *Sorex araneus* calcification of the papillary exposed pulps of the teeth, which are succeeded by the first and second premolars, proceeds to a very slight extent, and these microscopic rudiments appear to be absorbed rather than shed. The deciduous incisors are further advanced before their displacement, and present the form of equal-sized dentinal spicula, tipped with enamel, attached by the opposite end to the gum, and not exceeding $\frac{1}{40}$th of an inch in length; the number of the uterine series of teeth is $\frac{4}{3}:\frac{4}{3}$.

In the volant *Insectivora*, or Bats, the canines are always present in both jaws, of the normal form, and with slightly variable proportions. The molar series never exceeds $\frac{6}{6}:\frac{6}{6}$, and is divisible into premolars and true molars; the latter are bristled with sharp points in the great bulk of the *Cheiroptera*. The incisors are the most variable teeth; they may be entirely wanting, or be present in the numbers of $\frac{1.1 \text{ or } 2.2}{1.1 \text{ to } 3.3}$; they are always very small, and, in the upper jaw, commonly unequal, and separated by a wide median vacancy. In the genus *Chilonycteris*, the mid-incisors above and the outer ones below have the crown notched; the mid-incisors below have two notches, producing three lobes on the cutting border. Taking the common simple-nosed Bat (*Vespertilio murinus*) as a type of this Insectivorous group, we find its dental formula to be—

$$i\,\frac{2.2}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 38.$$

In the leaf-nosed Bats (*Phyllostoma*, fig. 245) the incisors are $\frac{2}{2}:\frac{2}{2}$, the mid pair above being large and laniariform; the canines are well-developed in both jaws. The second premolar above has a large, triedral, pointed crown. The first and second molars have two large external, and three small internal cusps.

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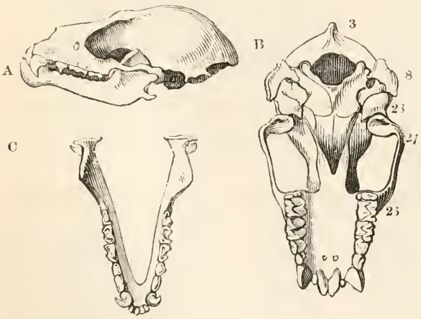

Dentition of leaf-nosed Bat (*Phyllostoma*).

The dentition of the blood-sucking Bats deviates, as might be anticipated, in a remarkable degree from that of the insectivorous kinds. The crushing instruments required for the food of the latter are not needed; and the true molars, with their bristled crowns, are entirely absent in the Vampires (*Desmodus*), fig. 246. The teeth, at the fore-part of the mouth, are especially developed, and fashioned for the infliction of a deep and clean triangular puncture, like that made by a leech. The incisors are two in number above, closely approximated, one in each premaxillary bone, with a very large, compressed, curved, and sharp-pointed crown, implanted by a strong fang which extends into the maxillary bone. The upper canines have similar large lancet-shaped crowns, and their bases touch those of the incisors. In the lower jaw the incisors are two in number on each side, much smaller than the upper pair, and with bilobed crowns. The lower canines are nearly equal in size to those above, and have similar piercing trenchant crowns. The molar series is reduced above to two very small teeth, each with a simple compressed conical crown, implanted by a single fang. The first two molars below resemble those above; but they are followed by a third, which has a larger compressed and bilobed crown, implanted by two fangs. This tooth corresponds with the last premolar in the more normal genera. The dental formula of the true *Desmodus* is thus reduced to—

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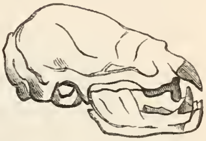


Skull and Teeth of the Vampire-Bat (*Desmodus Vampirus*).

$$i\,\frac{1.1}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{3.3} = 20.$$

The opposite extreme which the aberrant varieties of the Cheiropterous dentition attain is manifested in the great frugivorous Bats: these constitute the genus *Pteropus*; their dental formula is—

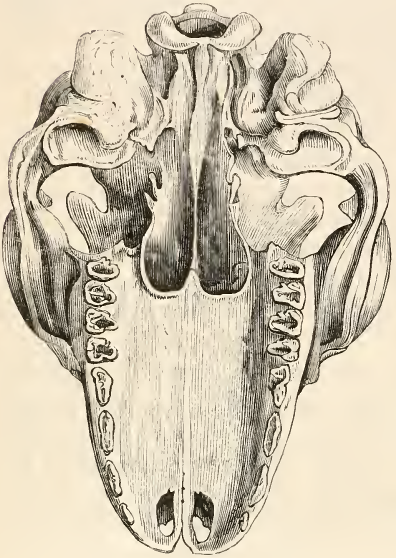
$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{3.3};\ m\,\frac{3.3}{3.3} = 34.$$

(vol. ii. p. 388, fig. 252): their molars have broad flat crowns. In some African *Pteropi* (*Pt. macrocephalus* and *Pt. Whitei*) the last small molar would seem to be wanting in both upper and lower jaws. The deciduous teeth make their appearance above the gum in Bats, as in Shrews, before birth; but they attain a more completely developed state, and are retained until a short time after birth, when they are shed.

The Colugos (*Galeopithecus*) resemble the Bats in the great expanse of their parachute, formed by the fold of integument extending on each side from the fore to the hind extremity, and in the incompleteness of the rim of the orbit (vol. ii. p. 388, fig. 253, A). The dental formula of the genus is—

$$i\,\frac{2.2}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 34, \text{ figs. } 247, 248.$$

247



Upper jaw and teeth, *Galeopithecus.*

The two anterior incisors of the upper jaw are separated by a wide interspace. In the Philippine Colugo they are very small, with simple sub-bilobed crowns; but in the common Colugo (*Lemur volans,* Linn.; *Galeopithecus Temminckii,* Wat.) their crown is an expanded plate with three or four tubercles; the second upper incisor presents the peculiarity of an insertion by two fangs in both species of *Galeopithecus.*

In the lower jaw the crowns of the first two incisors, *i*, present the form of a comb, and are in this respect unique in the class *Mammalia.* Fig. 249 shows a section of one of these teeth magnified. This singular form of tooth is produced by the deeper extension of the marginal notches on the crown, analogous to those on the edge of the new-formed human incisor, and of those of certain Shrews, the notches being more numerous as well as deeper.

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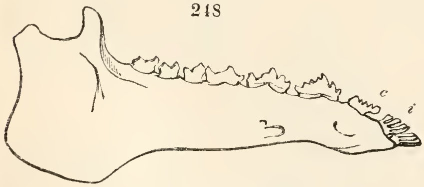
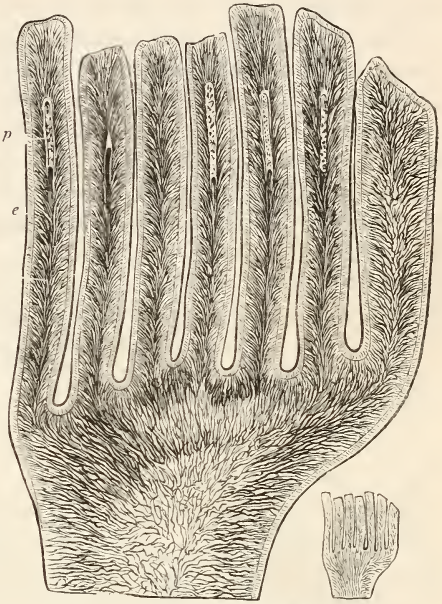


Lower jaw and teeth, *Galeopithecus.*

Each of these broad pectinated teeth is implanted by a single conical fang, and is excavated by a pulp-cavity, which divides into as many canals as there are divisions of the crown, one being continued up the centre of each to within a short distance of its apical extremity. The medullary canal or branch of the pulp-cavity is shown in some of the divisions of the crown, at *p*. Each division has its proper investment of enamel, *e*, which substance is continued for a short distance upon the common base.

The deciduous teeth appear not to cut the gum before birth, as they do in the true Bats. In a fœtus of *Galeopithecus Temminckii*, with a head one inch and a half in length, I found the calcification of the first incisor just commenced in the closed alveolus, the second incisor and the rest of the deciduous series being represented by the vascular uncalcified matrices. The upper milk teeth consist of two incisors, a canine, and two molars, which latter are displaced and succeeded by the two premolars. The deciduous teeth are six in number in the lower jaw, the incisors being pectinated, but much smaller than their successors. The true molars are developed and in place before the deciduous teeth are shed.

249



Section of lower incisor, *Galeopithecus*, magnified. v.

E. *Quadrumana.* — In entering upon the dentition of the Quadrumanous order, we pass from that of the *Insectivora* by the Colugo, and seem to quit the *Rodentia* by the Aye-aye (*Chiromys*). In this genus of the Lemurine animals, as in *Phascolomys* amongst the Marsupials, *Desmodus* amongst the Bats, and *Sorex* amongst the Insectivores, the dentition is modified in analogical conformity with the Rodent type, to which, in the present instant, it makes a very close approximation, the canines being absent, and a wide vacancy separating the single pair of large curved scalpriform incisors in each jaw from the short series of molars.

The upper incisors (vol. ii. p. 513, fig. 343, 22) are curved in the segment of a circle, and deeply implanted. The short exserted crowns touch one another, their simple widely excavated fangs diverging as they penetrate the substance of the jaw. These crowns also project obliquely forward, and do not extend vertically downward, as in the true *Rodentia.* The lower incisors are more depressed, and of greater breadth from before backward, than the upper ones. They are more curved than in the *Rodentia*, describing a semicircle, three-fourths of which are lodged in the socket, which extends backward beyond the last molar tooth to the base of the coronoid process. The most important character by which the incisors of this anomalous Lemur differ from those of the *Rodentia* is the entire investment of enamel, which is, however, thicker upon the front than upon the back part of the tooth. The molar teeth are four on each side of the upper jaw, and three on each side of the lower jaw, implanted vertically and in parallel lines. The molars are of simple structure, with a continuous outer coat of enamel, and a flat subelliptic grinding surface. The upper ones are of unequal size, the first being the smallest, and the second the largest. In the lower jaw the inequality is less, and the last molar is the least. The first and last molars above have but one root; the second and third have each three roots. The first lower molar has two roots; the second and third have each a single root. The adult dental formula is—

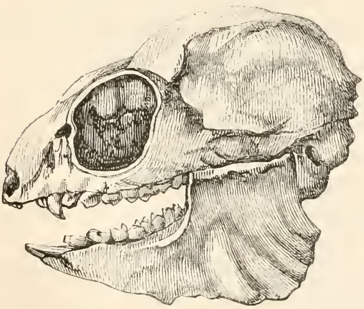
$$i\,\frac{1.1}{1.1};\ c\,\frac{0}{0};\ p\,\frac{1.1}{0.0};\ m\,\frac{3.3}{3.3} = 18.$$

The deciduous dentition is—

$$i\,\frac{2.2}{1.1};\ c\,\frac{1.1}{0.0};\ dm\,\frac{1.1}{1.1} = 12.$$

The second upper incisor and canine, and the lower milk-molar, all which are very minute, are not replaced; the first true or permanent molar follows so speedily the deciduous one that, being 'in place' therewith, it has been reckoned with the milk-dentition.[1] The lower jaw is modified to give strength to the muscles wielding the enormous and powerful incisors by the low position of the condyle, analogous to that in *Plagiaulax* and other carnivorous Mammals, contrasting with its high position in true Rodents and Kangaroos.

250



Dentition of Woolley Lemur.

The Avahi, or woolley Lemur (*Lichanotus laniger*, fig. 250), has the incisors of the lower jaw large and limited to a single pair, but far from showing the proportions of those in *Chiromys*: the upper incisors are in two pairs, as in the milk-dentition in *Chiromys*, and are small.

The dental formula in the Slow Lemurs (*Stenops, Tarsius*) is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 36.$$

The first upper incisor is larger than the second.

---

[1] CXXII″.

Otolicnus and *Lemur* have the same number and kinds of teeth. In the upper jaw the incisors are small and vertical; the two on the right side are separated by a wide space from the two on the left. The lower canines are compressed and procumbent like the incisors, but are a little larger. The upper canine is long, curved, compressed, sharp-edged, and pointed. The three upper premolars have the outer part of the crown prolonged into a compressed pointed lobe, whilst the inner part forms a tubercle, which is largest in the third. In the true molars the inner division of the crown is so increased as to give it a quadrate form, the outer division being divided into two pointed lobes. The premolars below are long, and the molars 4-cuspid in *Otolicnus*.

All the American Quadrumana are distinguished from the Apes and Monkeys of the Old World by the superior number of the premolars, and, by this resemblance to the Lemurs, they show their inferior position in the zoological scale. The small 'Marmosets,' however, forming the genera *Hapale* and *Midas*, have but two true molar teeth on each side of both jaws, their dental formula being—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{2.2}{2.2} = 32.$$

The lemurine character of the long, narrow, inferior incisors continues to be manifested by the Sakis (*Pithecia* Ill.), which, like the larger species of Platyrhines called Howlers, Capuchins, and Spider-Monkeys, have the normal number of true molar teeth in the Quadrumanous order, their dental formula being—

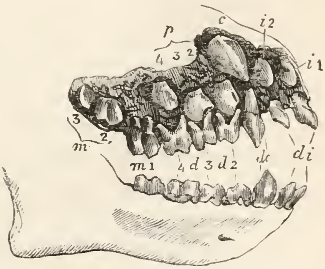
$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 36.$$

The Capuchin Monkeys (*Cebus*, vol. ii. fig. 349) have the four lower incisors broad, thick, and wedge-shaped—a form which these teeth retain, with slight modifications, throughout the Quadrumanous order. The canines are sufficiently developed to inflict severe wounds. The first three of the molar series, *p*, 2, 3, 4, are bicuspid premolars; the rest, *m*, 1, 2, 3, are quadricuspid true molars. The deciduous formula is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 24.$$

Fig. 251 shows the deciduous series,

251



Deciduous and permanent teeth of a young *Cebus Apella*. CLXXII''.

d i. ... *d* 4, in place, together with the first of the permanent true molars, *m*, 1; the germs of the rest of the permanent teeth are exposed in the upper jaw.

In the Catarhine division of the order, the first or deciduous dentition consists of—

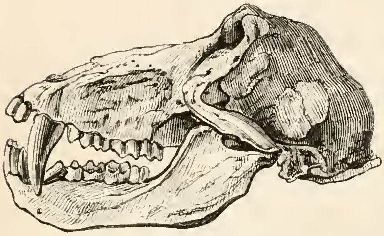
$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ m\,\frac{2.2}{2.2}=20.$$

The two milk molars are displaced and succeeded vertically by the two bicuspid premolars, and are followed horizontally by three true molars on each side of both upper and lower jaws. The permanent formula in all the Old World *Quadrumana* is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3}=32,\ \text{fig. 252.}$$

The incisors have always a shape conformable to their name, but are very thick and strong; in the upper jaw the middle are larger than the lateral ones, and both are larger than those below. The canines are conical, pointed, with trenchant posterior margins, always longer than the adjoining teeth, and acquiring, in the males of the great Baboons and Orangs, the proportions of those teeth in the *Carnivora*. The Mandrills *Papio maimon* (fig. 252) have these dental weapons most formidable for their size and shape; especially the upper pair, which descend behind the crowns of the lower canines, and along the outside of the first lower premolars, the crowns of which seem as if bent back by the action of the upper canines; the anterior longitudinal groove of these teeth is very deep, their posterior margin very sharp. A long diastema divides the upper canine from the incisors, a short one separates it from the premolars; these and the three true molars are arranged in a straight line.

252

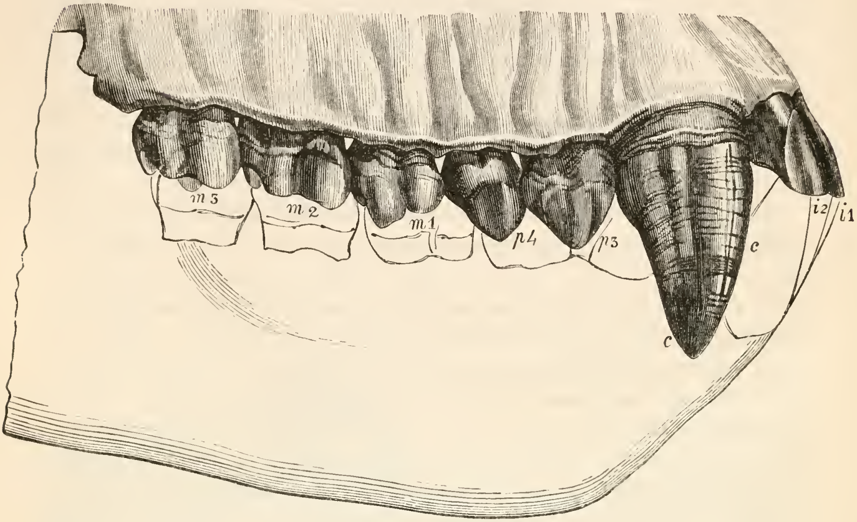


Catarhine dentition (*Papio*).

In the Orang-utan (*Pithecus Wurmbii*), vol. ii. p. 534, fig. 355, the thickness of the base of the crown of the upper middle incisors equals the breadth of the same; and they are double the size of the lateral incisors. The abraded surface of the front incisors in the old Orang forms a broad tract extending obliquely from the cutting edge to the back part of the base of the crown; the lateral incisors are more pointed, the outer angle being obliquely truncated; a vacant space of their own breadth divides them from the canines. These, in the male Orang, have a long and strong slightly-curved crown, extending below the alveolar border of the under jaw when the mouth is shut, with a moderately sharp posterior margin, but without an anterior groove. In the female Orang the canines are smaller; the crowns extend only a short distance beyond the level of the adjoining molars. In the upper jaw both premolars and molars are implanted by three diverging roots, two external and one internal; in the lower jaw the corresponding teeth have two strong diverging roots; the series of grinders forms a straight line on each side of both jaws.

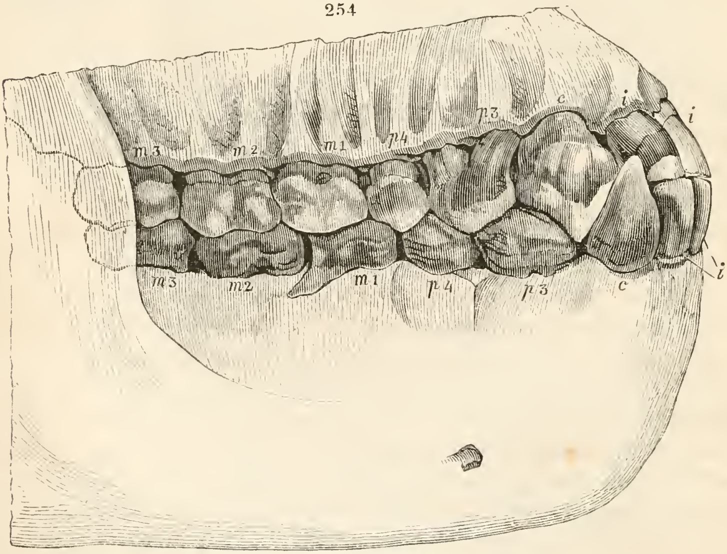
As the precise characteristics and ordinal distinction of the human dentition are best demonstrated by comparison with that brute species which is most nearly allied to man, the details of such a comparison will here be given and illustrated more fully, as manifested in the Gorilla (*Troglodytes Gorilla*). Fig. 253 gives a side view of the teeth of a male full-grown, but not aged, specimen of this species. In the upper jaw the middle incisors are smaller, the lateral ones *i*, 2, larger than those of the Orang; they are thus more nearly equal to each other; nevertheless the proportional superiority of the middle pair is much greater than in Man, and the proportional size of the four incisors both to the entire skull and to the other teeth is greater. Each incisor has a prominent posterior basal ridge, and the outer angle of the lateral incisors *i*, 2, is rounded off as in the Orang. The incisors incline forward from the vertical line as much as in the Orang. Thus the characteristics of the human incisors are, in addition to their true incisive wedge-like form, their near equality of size, their vertical or nearly vertical position, and small relative size to the other teeth and to the entire skull. The diastema between the incisors and the canine on each side is as well marked in the male Gorilla as in the male Orang. The crown of the canine, fig. 253, *c*, passing outside the interspace between the lower canine and premolar, *p* 3, extends in the male *Troglodytes Gorilla* a little below the alveolar border of the under jaw when the mouth is shut; the upper canine of the male *Troglodytes niger* likewise projects a little below that border. In the male of the Chimpanzee (*Troglodytes niger*), the upper canine is conical, pointed, but more compressed than in the Orang, and with a sharper posterior edge; convex anteriorly, becoming flatter at the posterior half of the outer surface, and concave on the corresponding part of the inner surface, which is traversed by a shallow longitudinal impression; a feeble longitudinal rising and a second linear impression divide this from the convex anterior surface, which also bears a longitudinal groove at the base of the crown. The canine is rather more than twice the size of that

253


m 3
m 2
m 1
p 4
p 3
c
c
i 2
i 1

Dentition of an adult male *Troglodytes Gorilla*, nat. size. CIII′.

254


m 3
m 2
m 1
p 4
p 3
c
i
i
m 3
m 2
m 1
p 4
p 3
c
i

Dentition of an adult female Gorilla, nat. size. CIII′.

in the female. In the male *Gorilla* the canine is more inclined outward; the anterior groove on the inner surface of the crown is deeper, the posterior groove is continued lower down upon the fang, and the ridge between the two grooves is more prominent than in the *Troglodytes niger.* Both premolars,

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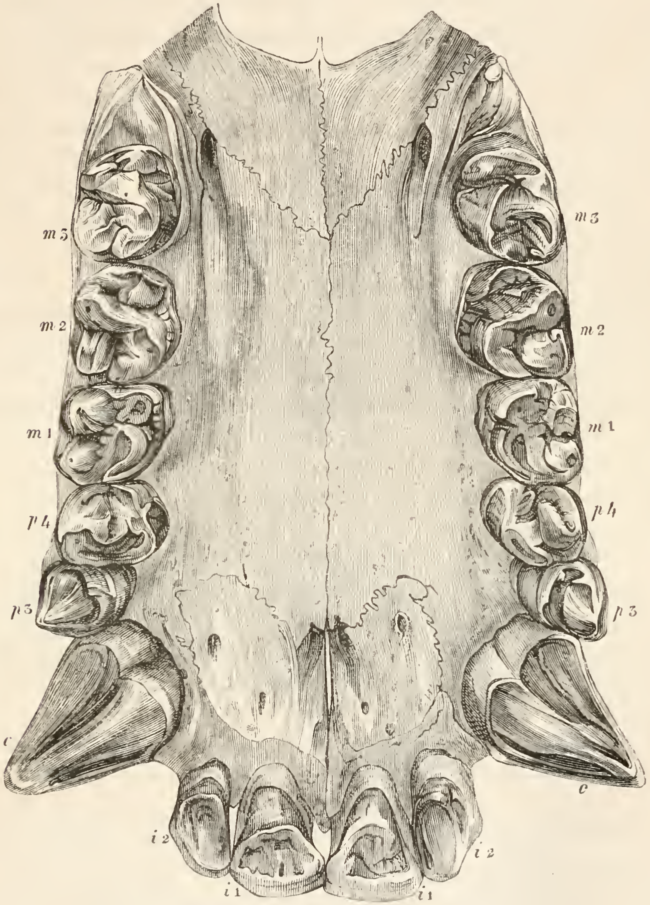

Dentition of upper jaw, male *Troglodytes Gorilla*, nat. size. CIII′.

fig. 255, *p* 3, and *p* 4, are bicuspid; the outer cusp of the first, and the inner cusp of the second being the largest, and the first premolar, *p* 3, consequently appearing the largest on an external view. The difference is well marked in the female, fig. 254, *p* 3. The anterior external angle of the first premolar is not produced as in the Orang, which in this respect makes a marked approach to the lower *Quadrumana*. In Man, where the outer curve of the premolar part of the dental series is greater than the inner one, the outer cusps of both premolars are the largest; the alternating superiority of size in the Gorilla accords with the straight line which the canine and premolars form with the true molars. In fig. 255, *m* 1, *m* 2, *m* 3, are quadricuspid, relatively larger in comparison with the bicuspids than in the Orang. In the first and second molars of both species of *Troglodytes* a low ridge connects the antero-internal with the postero-external cusp, crossing the crown obliquely, as in Man. There is a feeble indication of the same ridge in the unworn molars of the Orang; but the four principal cusps are much less distinct, and the whole grinding surface is flatter and more wrinkled. In *Troglodytes niger* the last molar is the smallest, owing to the inferior development of the two hinder cusps, and the oblique connecting ridge is feebly marked. In *Troglodytes Gorilla* this ridge is as well developed as in the other molars, but is more transverse in position; and the crown of *m* 3 is equal in size to that of *m* 1 or *m* 2, having the posterior outer cusp, and particularly the posterior inner cusp, more distinctly developed than in *Troglodytes niger*. The repetition of the strong sigmoid curves which the unworn prominences of the first and second true molars present in Man, is a very significant indication of the near affinity of the Gorilla as compared with the approach made by the Orangs or any of the inferior *Quadrumana*, in which the four cusps of the true molars rise distinct and independently of each other. A low ridge girts the base of the antero-internal cusp of each of the upper true molars in the male Chimpanzees; it is less marked in the female. The premolars as well as molars are severally implanted by one internal and two external fangs. In no variety of the human species are the premolars normally implanted by three fangs; at most the root is bifid, and the outer and inner divisions of the root are commonly connate. It is only in the black varieties, and more particularly that race inhabiting Australia, that I have found the 'wisdom-tooth,' fig. 257, *m* 3, with three fangs as a general rule; and the two outer ones are more or less confluent. The lower canine of the male (figs 253, 256, *c*), shows the same relative superiority of size as the upper one, compared with that in the female, in both species of *Troglodytes*. The canine almost touches the incisor, but is separated by a diastema one line and a half broad from the first premolar. This tooth *p* 3, is larger externally than the second premolar, and is three times the size of the human first premolar, fig. 257, *p* 3; it has a subtriedral crown, with the anterior and outer angle produced forward, slightly indicating the peculiar features of the same tooth in the

Baboons, but in a less degree than in the Orang. The summit of the crown of *p* 3 terminates in two sharp triedral cusps—the outer one rising highest and the second cusp being feebly indicated on the ridge extending from the inner side of the first; the crown has also a thick ridge at the inner and posterior part of its base. The second premolar, *p* 4, has a subquadrate crown, with the two cusps developed from its anterior half, and a third smaller one from the inner angle of the posterior ridge. Each lower premolar is implanted by two antero-posteriorly compressed divergent fangs, one in front of the other, the anterior fang being the largest.

The three true molars are nearly equal in size in the *Troglodytes Gorilla*, the last being a little larger than the first: in the *Troglodytes niger*, fig. 256, the first, *m* 1, is a little larger than the last, *m* 3, which is the only molar in the smaller Chimpanzee as large as the corresponding tooth in the black varieties of the human subject, in most of which, especially the Australians, fig. 257, the true molars attain larger dimensions than in the yellow or white races. The four principal cusps, especially the two inner ones of the first molar of both species of *Troglodytes*, are more pointed and prolonged than in Man; a fifth small cusp is developed behind the outer pair, as in the Orangs and the Gibbons, but is less than that in Man. The same additional cusp is present in the second molar, which is seldom seen in Man. The crucial groove on the grinding surface is much less distinct than in Man, not being continued across the ridge connecting the anterior pair of cusps in the Chimpanzee. The crown of the third molar is longer antero-posteriorly from the greater development of the fifth posterior cusp, which, however, is rudimental in comparison with that in the Semnopitheques and Macaques. All

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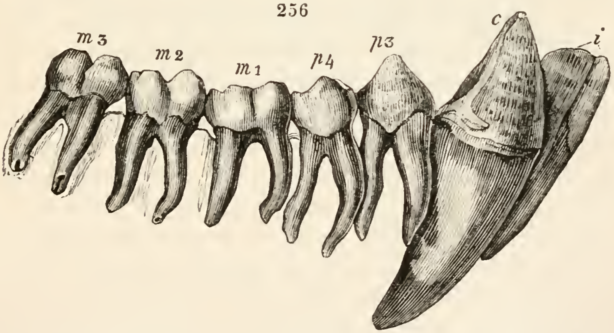

Teeth of right side, lower jaw, of adult male Chimpanzee, (*Troglodytes niger*), nat. size.

the three true molars are supported by two distinct and well-developed antero-posteriorly compressed divergent fangs; in the white and yellow races of the human subject these fangs are usually connate in *m* 3; and sometimes also in *m* 2. The molar series in both species of *Troglodytes* forms a straight line, with a slight tendency, in the upper jaw, to bend in the opposite direction to the well-marked curve which the same series describes in the human subject.

This difference of arrangement, with the more complex implantation of the premolars, the proportionally larger size of the incisors as compared with the molars; the still greater relative magnitude of the canines; and, above all, the sexual distinction in that respect illustrated by figs. 253 and 254, stamp the Gorillas and Chimpanzees, fig. 256, most decisively with not merely specific but generic distinctive characters as compared with Man. For the teeth are fashioned in their shape and proportions in the dark recesses of their closed formative alveoli, and do not come into the sphere of operation of external modifying causes until the full size of the crowns has been acquired. The formidable natural weapons of the males of both species of *Troglodytes*, form the compensation for the want of that psychical capacity to forge or fashion destructive instruments which has been reserved, as his exclusive prerogative, for Man. Both Chimpanzees and Orangs differ from the human subject in the order of the development of the permanent series of teeth; the second molar, *m* 2, comes into place before either of the premolars has cut the gum, and the last molar, *m* 3, is acquired before the canine. We may well suppose that the larger grinders are earlier required by the frugivorous Chimpanzees and Orangs than by the higher organised omnivorous and longer nursed Bimanal, with more numerous and varied resources, and probably one main condition of the earlier development of the canines and premolars in Man may be their smaller relative size.

F. *Bimana.* Having reached, in the Gorilla, the highest step in the series of the brute creation, our succeeding survey of the dental system, cleared and expanded by retrospective comparison, becomes fraught with peculiar interest, since every difference so detected establishes the true and essential characteristics of that part of man's frame.

The human teeth are the same in number and in kind as those of the catarhine Quadrumana. The bimanal dental formula is therefore—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3}=32;$$

that is to say, there are on each side of the jaw, both above and below, two incisors, one canine, two premolars, and three true molars.

They are more equal in size than in the *Quadrumana*. No tooth surpasses another in the depth of its crown ; and the entire series, which describes in both jaws a regular parabolic curve, is uninterrupted by any vacant space (vol. ii., fig. 182). The most marked distinction between the bimanal dentition and that of the highest Quadrumanals, is the absence of the interval between the upper lateral incisor and the canine, and the comparatively small size of the latter tooth ; but its true character is indicated by the conical form of the crown, which terminates in an obtuse point, is convex outward, and flat or sub-concave within, at the base of which surface there is a feeble prominence. The conical form is best expressed in the Melanian races, especially the Australian, fig. 257, *c*. The canine is more deeply implanted, and by a stronger fang than the incisors ; but the contrast with the Chimpanzee is sufficiently manifest, as is shown in fig. 256, *c*. There is no sexual superiority of size either of the canine or any other single tooth in the human subject.[1]

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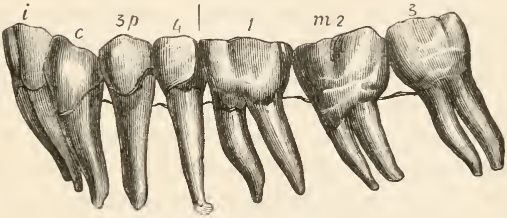

Dentition, lower jaw, of male Australian.

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[1] In honest argument as to Man's place in Nature, his zoological characters are to be compared with those of the brute that comes nearest to him ; the differences so established should be contrasted with those between such brute, the gorilla, e.g., and the next step in the scale, the chimpanzee, e.g.; and so on, step by step, through the order which Zoology forms of the series of species so gradually differentiated. No doubt a gorilla differs more in its dentition from a lemur, and still more from a mole or a mouse, than it differs from Man. Take another character—the hinder or lower limbs, e.g.; contrast the Negro in this respect with the gorilla, and, next, that ape with any other quadrumanal. Much as the aye-aye differs as a whole, from the gorilla, it does resemble it more in such quadrumanal structure than the gorilla resembles Man. Between the two extremes of the four-handed series there is greater organic conformity in the main ordinal character than exists between the highest ape and the lowest man. Or take the cerebral test. Man's place in the Natural System is to be judged, not by the degree of difference between the brain of an ape and that of a mammal one hundred links removed ; but by the degree of difference between the human brain and that of the brute which comes nearest to him, as contrasted with the degree of difference between the brains of the gorilla and chimpanzee, or between those of any other two conterminous species constituting links in the quadrumanous chain. The difference between figs. 147 and 148–9 may be greater than between 149

Both upper and lower premolars, fig. 257, *p* 3 and 4, are bicuspid; they are smaller in proportion to the true molars than in the Chimpanzee and Orang. In the upper premolars a deep straight fissure at the middle of the crown divides the outer and larger from the inner and smaller cusp; in the lower premolars the boundary groove describes a curve concave towards the outer cusp, and is sometimes obliterated in the middle by the extension of a ridge from the outer to the inner cusp, which cusp is smaller in proportion than in the upper premolars. These teeth in both jaws are apparently implanted each by a single, long, subcompressed, conical fang; but that of the upper premolars is shown by the bifurcated pulp-cavity to be essentially two fangs, connate, and which, in some instances, are separated at their extremities.

The crowns of the true molars, fig. 257, *m* 1, 2, 3, are larger in proportion to the jaws, are a little larger in proportion to the bicuspids, and still more so in proportion to the canine and incisor teeth, than in the Chimpanzees and Orangs. The contour of the grinding surface is more rounded, and the angles of the crown are less marked in the higher than in the lower *Quadrumana*. The first and second true molars of the upper jaw support four triedral cusps; the internal and anterior one is the largest, and is connected with the external and posterior cusp by a low ridge extending obliquely across the grinding surface, with a deep depression on each side of it; the anterior groove extending to the middle of the outer surface, the posterior one to the inner surface. The enamel is first worn away by mastication from the anterior and internal or largest tubercle; a line of enamel extending from the outside to the middle of the crown is the last to be removed before the grinding surface is reduced to a field of dentine with a simple ring of enamel. It is worthy of remark, that by the time when the permanent teeth have come into place, the first true molar in both jaws is more worn, as compared with the second and third molars, than it is in the Chimpanzee or Orang, owing to the slow attainment of maturity characteristic of the human species, and the longer interval which elapses between the acquisition of the first and the last true molars, than in the highest *Quadrumana*. In the last true molar, called from its late appearance the 'dens sapientiæ,' or wisdom-tooth, the two inner tubercles are blended together, and a fissure extends in many

and 150 (vol. ii.); but truth compels the remark that the lemur and ape are separated by numerous gradational species; whilst between the ape and man there is no known connecting or intermediate link. Logicians have long ago exposed and branded the sophism which has of late been propounded to persuade men that they are of the order of apes.

instances, especially in the Melanian varieties, from the middle of the grinding surface, at right angles to that dividing the two outer cusps, to the posterior border of the tooth.

The first upper molar is always implanted by three diverging fangs, two external and one internal. The second molar is usually similarly implanted, but the two outer fangs are less divergent, are sometimes parallel, and occasionally connate; this variety appears to be more common in the Caucasian than in the Melanian races; and in the Australian skulls the wisdom tooth usually presents the same three-fanged implantation as in the Chimpanzee and Orang.

The crowns of the inferior true molars are quinque-cuspid, the fifth cusp being posterior and connected with the second outer cusp: it is occasionally obsolete in the second molar. The four normal cusps are defined by a crucial impression, the posterior branch of which bifurcates to include the fifth cusp; this bifurcation being most marked in the last molar where the fifth cusp is most developed. In the first molar a fold of enamel, extending from the inner surface to the middle of the crown, is the last to disappear from the grinding surface in the course of abrasion. The wisdom-tooth, fig. 257, *m* 3, is the smallest of the three molars in both jaws, but the difference is less in the Melanian than in the Caucasian races. Each of the three lower molars is inserted by two sub-compressed fangs, grooved along the side, turned towards each other. This double implantation appears to be constant in the Melanians, especially the Australian race, in which the true molars are relatively larger than in other blacks. In Europeans it is not unusual to find the two fangs in both the second and third molars connate along a great part or the whole of their extent.

With respect to the reciprocal apposition of the teeth of the upper and under jaw, it is interesting to observe that the crown of the lower canine is, as usual, in advance of that above, and fits into the shallow notch between that and the lateral incisor. The inferior incisors are so small that their anterior surface rests against the posterior surface of the upper ones when the mouth is closed; the other teeth are opposed crown to crown, the upper teeth extending a little more outwardly than the lower ones.

The deciduous series of teeth in the human subject, fig. 258, consists of—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ m\,\frac{2.2}{2.2} = 20.$$

The upper milk incisors of the Chimpanzee are relatively larger than in Man, especially the middle pair; but the disproportionate size of these is still more manifest and characteristic of the Orang. The crown of the canine is longer and more pointed in the Chimpanzee than in Man; still more so, and further apart from the incisor in the Orang. The first milk-molar, fig. 258, *d* 3, in the human subject is more similar in shape and size to the second, *d* 4, than it is in either the Chimpanzee or Gorilla: in which it is relatively smaller, showing in the lower jaw a subcompressed triangular crown. The eruption of the human milk-teeth usually begins in the infant of seven months old, and is completed about the end of the second year; those of the lower jaw preceding the upper. The average periods of the appearance of both deciduous and permanent teeth are as follows:—

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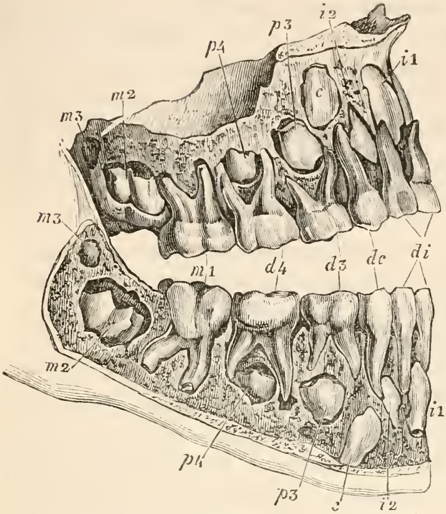

Deciduous and permanent teeth, Human Child: æt. 6½.

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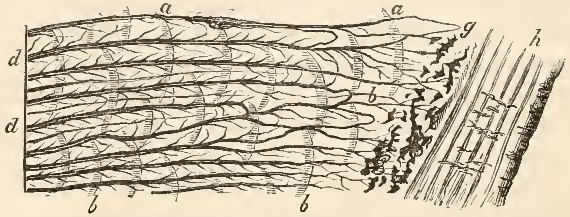

Highly-magnified section of dentine and cement, from the fang of a Human molar. v, pl. 123.

Deciduous teeth.	*Permanent teeth.*
7th month, mid-incisor, *d i* 1.	6½ years, first molar. *m* 1, (fig. 258).
ib. to 10th month, lat.-incisor, *d i* 2.	7th year, mid-incisor, *i* 1.
12th to 14th month, first molar, *d* 3.	8th year, lat.-incisor, *i* 2.
14th to 20th month, canine, *d c*.	9th year, first bicuspid, *p* 3.
18th to 36th month, second molar, *d* 4.	10th year, second bicuspid, *p* 4.
	11th to 12th year, canine, *c*.
	12th to 13th year, second molar, *m* 2.
	17th to 21st year, third molar, *m* 3.

The structure of human dentine is exemplified in fig. 259.

The dentinal tubes, *d, d,* send off ramuli into the inter-tubular tissue, and terminate either by anastomotic loops, or in the irregular vacuities or cells at the periphery of the dentine. The dentinal compartments, or indications of the original cells of the dentinal pulp, are shown at *a, b*; the modified peripheral layer of the dentine, remarkable for its superior sensibility, at *g*. The layer of cement, *h,* which covers the dentine of the fang, is seldom so thick as to show a bone-cell, in human teeth. The structure of the dentine relates, in regard to the curvilinear compartments, *a, b,* to the steps in its formation; and, in regard to its tubular columns, to the strength of the tooth and its vitality; the latter important property depending on the percolation of the plasma through the delicate cellular sructure of the filamentary prolongations of the pulp, so far as they may extend along the tubuli. The sensibility of the dentine is due to concomitant productions of neurine; but the distinct tubules are not large enough to admit capillary vessels with red particles of blood, and the tissue above described has consequently been termed 'unvascular dentine.'

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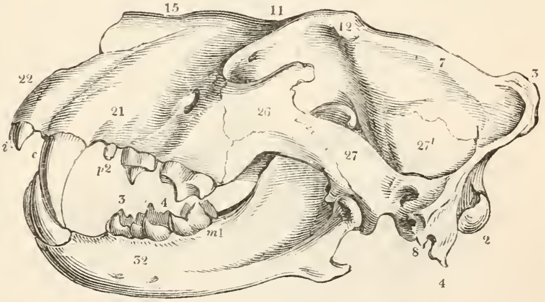

Dentition of Lion.

G. *Carnivora.*—The feline dentition is the best for flesh-food. The canines, fig. 260, *c,* are of great strength, deeply implanted in the jaw, with the fangs thicker and longer than the enamelled crown; this part is conical, slightly recurved, sharp-pointed, convex in front, with one or two longitudinal grooves on the outer side, almost flat on the inner side, and with a sharp edge behind. The lower canines pass in front of the upper ones when the mouth is closed. The incisors, six in number on both jaws, form a transverse row; the outermost above, ib. *i,* is the longest, resembling a small canine; the intermediate ones have broad and thick crowns indented by a transverse cleft. The first upper premolar, *p* 2, is rudimental; there is no answerable tooth in the lower jaw. The second, *p* 3, in both jaws, has a strong conical crown supported on two fangs. The third upper tooth, *p* 4, has a cutting or trenchant crown divided into three lobes, the last being the largest, and with a flat inner side, against which the cutting tooth, *m* 1, in the lower jaw works obliquely. Behind, and on the inner side of the upper tooth, *p* 4, there is a small tubercular tooth. The feline dental formula is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{2.2};\ m\,\frac{1.1}{1.1} = 30.$$

A glance at the long sub-compressed, trenchant, and sharp-pointed canines, suffices to appreciate their peculiar adaptation to seize, to hold, to pierce, and lacerate a struggling prey. The co-adaptations of jaws and skull are given in vol. ii. p. 505. The use of the small pincer-shaped incisor teeth is to gnaw the soft, gristly ends of the bones, and to tear and scrape off the tendinous attachments of the muscles and periosteum. The compressed trenchant blades of the sectorial teeth play vertically upon each other's sides like the blades of scissors, serving to cut and coarsely divide the flesh; and the form of the joint of the lower jaw almost restricts its movement to the vertical direction, up and down. The wide and deep zygomatic arches, fig. 260, 27, and the high crests of bone upon the skull, ib. 3, 7, concur in completing the carnivorous physiognomy of this most formidable existing species of the feline tribe.

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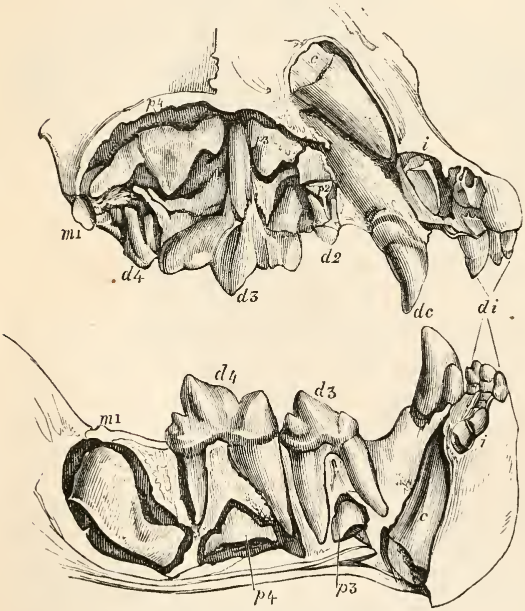

Deciduous dentition, Young Lion.

The penultimate tooth in the upper jaw, fig. 260, *p* 4, and the last tooth in the lower jaw, ib. *m* 1, were denominated by F. Cuvier 'dent carnassière,' which has been rendered 'dens sectorius,' the 'sectorial,' or scissor-tooth. It preserves its characteristic form only in the strictly flesh-feeding genera, in which is seen the part called the 'blade,' and that called the 'hump' or tubercle. In *Felis* the lower sectorial (fig. 261, *m* 1) consists exclusively of the blade, and plays upon the inside of that of the upper 'sectorial.' This tooth, fig. 261, *p* 4, above, succeeds and displaces a deciduous tubercular molar, ib. *d* 4, in all Carnivores, and is therefore a 'premolar;' the lower sectorial, ib. *m* 1, comes up behind the deciduous series, *d* 3, *d* 4, and has no immediate predecessor; it is, therefore, a true molar, and the first of that class. By these criteria the sectorial teeth may always be distinguished under every transitional variety of form which they present in the carnivorous series, from *Machairodus*, fig. 293, IV., in which the crown consists exclusively of the 'blade' in both jaws, to *Ursus*, ib. II., in which it is totally tubercular; the development of the tubercle bearing an inverse relation to the carnivorous propensities of the species.

The dentition of the hyæna resembles the feline in the reduction of the tubercular molars to a single minute tooth on each side of the upper jaw, and in the inferior molars being all conical or sectorial teeth; but the molar teeth in both jaws are larger and stronger, and the canines smaller in proportion, than in Felines, from the formula of which the dentition of the hyæna differs numerically only in the retention of an additional premolar tooth, *p* 1 above and *p* 2 below, on each side of both jaws: it is—

$$i\,\frac{3.3}{3.3};\; c\,\frac{1.1}{1.1};\; p\,\frac{4.4}{3.3};\; m\,\frac{1.1}{1.1} = 34.$$

The crowns of the incisors form almost a straight transverse line in both jaws, the exterior ones, above, being much larger than the four middle ones, and extending their long and thick inserted base further back; the crown of the upper and outer incisor is strong, conical, recurved, like that of a small canine. The four intermediate small incisors have their crown divided by a transverse cleft into a strong anterior, conical lobe, and a posterior ridge, which is notched vertically; giving the crown the figure of a trefoil. The lower incisors gradually increase in size from the first to the third; this and the second have the crown indented externally; but they have not the posterior notched ridge like the small upper incisors; the apex of their conical crown fits into the interspace of the three lobes of the incisor above. The canines have a smooth convex exterior surface; the inner surface is almost flat and of less relative extent in the inferior canines. The first premolar above is very small, with a low, thick, conical crown; the second presents a sudden increase of size, and an addition of a posterior and internal basal ridge to the strong cone. The third premolar exhibits the same form on a still larger scale, and is remarkable for its great strength. The posterior part of the cone of each of these premolars is traversed by a longitudinal ridge. The fourth premolar above is the carnassial tooth, and has its long blade divided by two notches into three lobes, the first a small thick cone, the second a long and compressed cone, the third a horizontal, sinuous, trenchant plate; a strong triedral tubercle, *t*, is developed from the inner side of the base of the anterior part of the crown. The single true molar of the upper jaw is a tubercular tooth of small size. The first premolar of the lower jaw fits into the interspace between the first and second premolars above, and answers, therefore, to the second lower premolar in the *Viverridæ.* The second is the largest of the lower premolars; its crown forms chiefly a strong rounded cone, girt by a basal ridge, and might serve as the model of a hammer for breaking stones. The last lower tooth is the sectorial,' as in *Felis.* The deciduous teeth consist of—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 28.$$

The permanent dentition of the *Hyæna* assumes those characteristics which adapt it for the peculiar food and habits of the adult: of these the chief is the great size and strength of the molars as compared with the canines, and more especially the thick and strong conical crowns of the second and third premolars in both jaws, the base of the cone being belted by a strong ridge which defends the subjacent gum. This form of tooth is especially adapted for gnawing and breaking bones, and the whole cranium has its shape modified by the enormous development of the muscles which work the jaws and teeth in this operation. Adapted to obtain its food from the coarser parts of animals which are left by the nobler beasts of prey, the hyæna chiefly seeks the dead carcass, and bears the same relation to the lion which the vulture does to the eagle.

The family *Viverridæ,* which comprehends the Civets, Genets, Ichneumons, Musangs, Surikates, and Mangues, is characterised, with few exceptions, by the following formula:—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{2.2} = 40.$$

It differs from that of the genus *Canis* by the absence of a tubercular tooth, *m* 3, on each side of the lower jaw; but, in thus making a nearer step to the feline dentition, the *Viverridæ,* on the other hand, recede from it by the less trenchant and more tubercular character of the sectorial teeth.

The canines are more feeble, and their crowns are almost smooth; the premolars, however, assume a formidable size and shape in some aquatic species, as those of the sub-genus *Cynogale*, in which their crowns are large, compressed, triangular, sharp-pointed, with trenchant and serrated edges, like the teeth of certain sharks (whence the name *Squalodon*, proposed for one of the species), and well adapted to the exigencies of quadrupeds subsisting principally on fish; the opposite or obtuse, thick form of the premolars is manifested by some of the Musangs, e.g. *Paradoxurus auratus*. The deciduous dentition consists, in the Viverrine family, of—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 28.$$

The interlocking of the crowns of the teeth of the upper and lower jaws, which is their general relative position in the Carnivora, is well-marked in regard to the premolars of the *Viverridæ*; as the lower canine is in front of the upper, so the first lower premolar rises into the space between the upper canine and first upper premolar; the fourth lower premolar in like manner fills the space between the third upper premolar and the sectorial tooth, playing upon the anterior lobe of the blade of that tooth which indicates by its position, as by its mode of succession, that it is the fourth premolar of the upper jaw. The first true molar below, modified as usual in the *Carnivora* to form the lower sectorial, sends the three tubercles of its anterior part to fill the space between the sectorial and the first true molar above. In the Musangs, the lower sectorial is in more direct opposition to its true homotype—the first tubercular molar in the upper jaw; and these Indian *Viverridæ* (*Paradoxuri*) are the least carnivorous of their family, their chief food consisting of the fruit of palm-trees, whence they have been called 'Palm-cats.'

The normal dental formula of the genus *Canis* is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{3.3} = 42 \text{ (fig. 293, III.)}$$

The incisors increase in size from the first to the third; the trenchant margin of the crown is divided by two notches into a large middle and two small lateral lobes. The canines, *c*, are curved, sub-compressed; the enamelled pointed crown forms nearly half the length of the tooth, and is smooth, without any groove. The premolars, fig. 293, *p* 1-4, have strong sub-compressed conical crowns gradually enlarging from the first to the third, *p* 3, in the upper jaw, and to the fourth, *p* 4, in the lower jaw, and acquiring one or two accessory posterior tubercles as they increase in size. The fourth upper premolar, *p* 4, presents a sudden increase of size, with its sectorial form; its blade is divided into two cones by a wide notch, the anterior cone being the strongest and most produced; the tubercle is developed from the inner side of the base of this lobe. The first and second upper molars, *m* 1 and 2, are tuberculate; but the second is very small, less than half the size of the first molar. The first true molar below, *m* 1, is modified to form the opposing blade to the sectorial tooth above; retaining the tuberculate character at its posterior half. The blade is divided by a vertical linear fissure into two cones, behind which the base of the crown extends into a broad trituberculate talon. The second molar, *m* 2, has two anterior cusps on the same transverse line, and a posterior broad flat talon; the last lower molar, *m* 3, is the smallest of all the teeth.

The absence of a tuberculate molar in the lower jaw of the immature Dog, brings the character of the deciduous dentition of the genus *Canis*, fig. 262, closer to the permanent dentition of stricter carnivores, and affords an interesting illustration of the law that unity of organisation is manifested directly as the proximity of the animal to the commencement of its development. The succession of two tubercular molar teeth behind the permanent sectorial tooth in the permanent dentition of the lower jaw contributes to adapt the Dog for a greater variety of climates, of food, and of other circumstances, all of which tend, in an important

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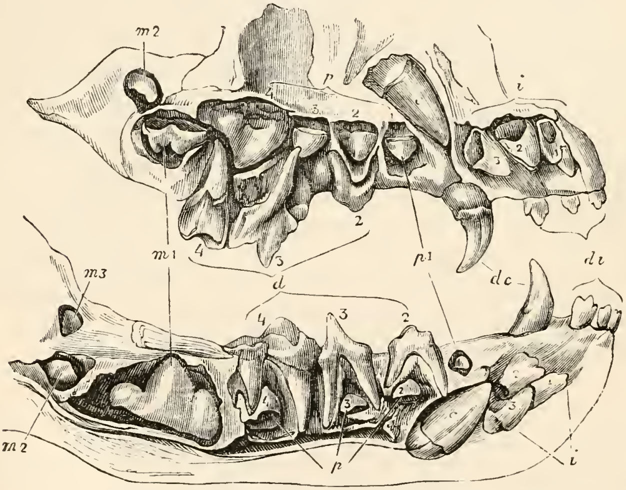

Deciduous and permanent teeth in the Dog (*Canis*).

degree, to fit that animal for the performance of its valuable services to man. In no other genus of quadruped are the jaws so well or so variously armed with dental organs; notwithstanding the extent of the series, the vacancies are only sufficient to allow the interlocking of the strong canines. These are efficient and formidable weapons for seizing, slaying, and lacerating a living prey; the incisors are well adapted, by their shape and advanced position, for biting and gnawing; the premolars, and especially the sectorials, are made for cutting and coarsely dividing the fibres of animal tissues, and the tuberculate molars are as admirably adapted for cracking, crushing, and completing the comminution of the food, whether of animal or vegetable nature.

The dentition of the Weasel tribe (*Mustelidæ*) is illustrated in fig. 293 IV., *Mustela*: the dental formula is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{3.3};\ m\,\frac{1.1}{2.2} = 36.$$

The first premolar, *p* 1, in the upper jaw, which is absent in the Polecat and Weasel, is retained in the Otter, and is placed on the inner side of the canine; the sectorial premolar, *p* 4, has its inner lobe much more developed in *Lutra* than in *Putorius*, and the tubercular molar, *m* 1, is relatively larger. Similar modifications of these teeth distinguish the dentition of the lower jaw of the Otter, which agrees in the number and kind of teeth with that of the Polecat. The increased grinding surface relates to the inferior and coarser nature of the animal diet of the Otter, the back teeth being thus adapted for crushing the bones of fishes before they are swallowed.

In the Martin cats (*Mustela*), the little homotype of *p* 1 above is present in the lower jaw; in the bloodthirsty Stoats and Weasels, *p* 1 is absent in both jaws; as it is likewise in the great Sea-otter (*Enhydra*), in which also the two middle incisors are wanting in the lower jaw. In this animal the second premolar, *p* 3, has a strong obtuse conical crown, double the size of that of *p* 2; the third premolar, *p* 4, is more than twice the size of *p* 3, and represents the upper carnassial or sectorial strangely modified; the two lobes of the blade being hemispheric tubercles. The last tooth, *m* 1, has a larger crown than the sectorial, and is of a similar broad crushing form.

In the family *Melidæ* is comprised the European (*Meles*), the Indian (*Arctonyx*), and the American (*Taxidea*) Badgers, which, with respect to their dentition, stand at the opposite extreme of the *Mustelidæ* to that occupied by the predaceous Weasel, and manifest the most tuberculate and omnivorous character of the teeth. The formula is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{4.4};\ m\,\frac{1.1}{2.2} = 36.$$

The canines are strongly developed, well pointed, with a posterior trenchant edge; they are more compressed in *Arctonyx* than in *Meles.* The first lower premolar is very small, single-fanged, and, generally, soon lost. The first above, corresponding with the second in the Dog, is also small, and implanted by two connate fangs. The second upper premolar, *p* 3, has a larger, but simple, sub-compressed conical crown, and is implanted by two fangs. The third repeats the form of the second on a larger scale, with a better developed posterior talon, and with the addition of a trituberculate low flat lobe, which is supported by a third fang; the outer pointed and more produced part of this tooth represents the blade of the sectorial tooth and the entire crown of the antecedent premolars. The true molar in *Meles* is of enormous size compared with that of any of the preceding *Carnivora*; it has three external tubercles, and an extensive horizontal surface traversed longitudinally by a low ridge, and bounded by an internal belt, or 'cingulum.'

In other allied genera, which, like the badgers, have been grouped, on account of the plantigrade structure of their feet, with the bears, a progressive approximation is made to the type of the dentition of the Ursine species. The first true molar below soon loses all its sectorial modification, and acquires its true tubercular character; and the last premolar above becomes more directly and completely opposed to its homotype in the lower jaw. The Racoon (*Procyon*), and the Coati (*Nasua*), present good examples of these transitional modifications; they have the complete number of premolar teeth, the dental formula being—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{2.2} = 40.$$

That of the Benturong (*Arctictis*) and Kinkajou (*Cercoleptes*) is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{2.2}{2.2} = 36.$$

The lower canine of *Nasua* has a deep longitudinal groove on the inner side of the crown. In *Ailurus* both upper and lower canines present two longitudinal grooves. In *Cercoleptes* a longitudinal ridge divides the two grooves on the canines. A fossil canine tooth from the eocene sand at Kyson presents a still greater number of grooves and ridges, whence the name *Pricynodon.*

The essential characteristic of the dentition of the Bears, fig.

340, vol. ii. (*Ursus*) is the development, in the lower jaw, of the true molar teeth to their typical number in the placental *Mammalia,* and their general manifestation, in both jaws, of a tuberculate grinding surface; the premolar teeth are much reduced both in size and number. In the frugivorous Bears of India and the Indian Archipelago, the four premolars (*p* 1–4) are commonly retained longer than in the fiercer species of the northern latitudes. In these the second lower premolar is soon lost. The first true molar, *m* 1, has a longer and narrower crown than the one above. The second true molar, *m* 2, has a narrow, oblong, subquadrate, tubercular crown, which, like that of the first true molar, is supported by two fangs. The crown of the third lower molar, *m* 3, is contracted posteriorly, and supported by two connate fangs; it is relatively smallest in the Sun-bears, and largest in the great *Ursus spelæus.* The dental formula of the genus Ursus is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{3.3} = 42 \text{ (fig. 293, II. } \textit{Ursus}\text{).}$$

It is essentially the same both in number and kind of teeth as in the genus *Canis,* but the individual or specific varieties, which in the Dog affect the true molar teeth, are confined in the Bears to the premolars. It would seem in the genus *Ursus* as if the preponderating size of the large tubercular true molars had tended to blight the development of the premolars.

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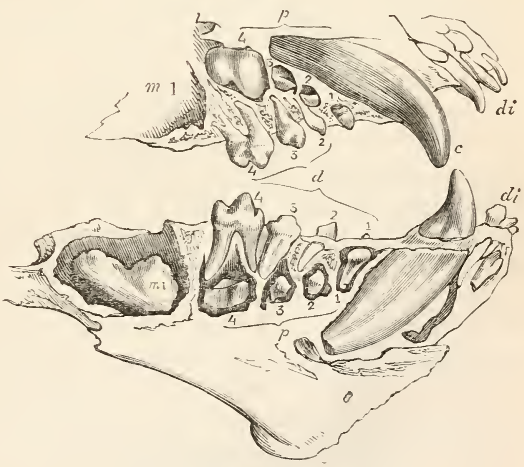

Deciduous dentition, Bear (*Ursus*).

In fig. 263 the deciduous teeth and their successors are given as displayed by the removal of the outer wall of their sockets. The milk-molars, four in number on each side of both jaws, progressively increase from the first to the fourth. The characteristic relative position to them of the premolars is shown at *p* 2, 3, and 4. Behind these is shown the large formative cell of the first, *m* 1, of the true molar series.

A tendency to deviate from the ferine number of the incisors is seen in the most aquatic and piscivorous of the Musteline quadrupeds, viz., the Sea-otter (*Enhydra*), in which species the two middle incisors of the lower jaw are not developed in the permanent dentition. In the family of true Seals the incisive formula is further reduced, in some species even to zero in the lower jaw, and it never exceeds $\frac{3}{2}$:$\frac{3}{2}$. All the *Phocidæ* possess powerful canines; only in the aberrant Walrus, fig. 265, are they absent in the lower jaw, but this is compensated by the singular excess of development which they manifest in the upper jaw. The molar series, fig. 264, *m*, usually includes five, rarely six, teeth on each side of the upper jaw, and five on each side of the lower jaw; with crowns which vary little in size or form in the same individual. They are supported in some genera, as the Eared Seals (*Otariæ*) and Elephant Seals (*Cystophora*), by a single fang; in other genera by two fangs, which are usually connate in the first or second teeth; the fang or fangs of both incisors, canines, and molars, are always remarkable for their thickness, which commonly surpasses the longest diameter of the crown. The crowns are most commonly compressed, conical, more or less pointed, with the 'cingulum' and the anterior and posterior basal tubercles more or less developed; in a few of the largest species they are simple and obtuse, and particularly so in the Walrus, in which the molar teeth are reduced to a smaller number than in the true Seals. In these the line of demarcation between the true and false molars is very indefinitely indicated by characters of form or position; but, according to the instances in which a deciduous dentition has been observed, the first three permanent molars in both jaws succeed and displace the same number of milk-molars, and are consequently, 'premolars;' occasionally, in the seals with two-rooted molars, the more simple character of the premolar teeth is manifested by their fangs being connate, and in the *Stenorhynchus serridens* the more complex character of the true molars is manifested in the crown. There is no special modification of the crown of any tooth by which it can merit the name of a 'sectorial' or 'carnassial;' but we may point with certainty to the third molar above and the fourth

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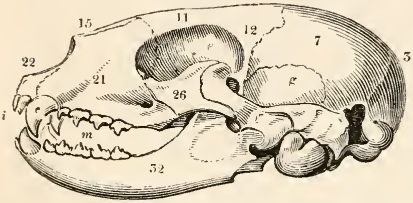

Dentition of Seal (*Phoca*).

below, as answering to those teeth which manifest the sectorial character in the terrestrial Carnivora. The coadaptation of the crowns of the upper and lower teeth is completely alternate, the lower tooth always passing into the interspace anterior to its fellow in the upper jaw.

In the genus *Phoca* proper (*Calocephalus*, Cuv.) typified by the common seal (*Ph. vitulina*), the dental formula is—

$$i\,\frac{3.3}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{1.1}{1.1}=34.$$

The Sterrincks with double-rooted molars (*Pelagius*, *Stenorhynchus*) have four incisors above as well as below, i. e. $\frac{2}{2}{:}\frac{2}{2}$.

In the Saw-tooth Sterrinck (*Stenorhynchus serridens*), the three anterior molars on each side of both jaws are four-lobed, there being one anterior and two posterior accessory lobes; the remaining posterior molars (true molars) are five-lobed, the principal cusp having one small lobe in front, and three developed from its posterior margin; the summits of the lobes are obtuse, and the posterior ones are recurved like the principal lobe.

The allied sub-genus (*Ommatophoca*) of Seals of the southern hemisphere has six molar teeth on each side of the upper, and five on each side of the lower jaw, with the principal lobe of the crown more incurved.

In the genus *Otaria* the dental formula is—

$$i\,\frac{3.3}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{2.2}{1.1}=36.$$

The two middle incisors are small, sub-compressed, with the crown transversely notched; the simple crowns of the four incisors below fit into these notches; the outer incisors above are much larger, with a long-pointed conical crown, like a small canine. The true canine is twice as large as the adjoining incisor, and is rather less recurved. The molars have each a single fang. In *Stemmatopus* the last upper molar has two divergent fangs, at least in the young state.

In the great proboscidian and hooded Seals (*Cystophora*), the incisors and canines still more predominate in size over the molars; but the incisors are reduced in number, the formula here is—

$$i\,\frac{2.2}{1.1};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{1.1}{1.1}=30.^{1}$$

The molars are single-rooted, and the incisors laniariform. The two middle incisors above and the two below are nearly equal;

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[1] cxxiii″. p. 38.

the outer incisors above are larger. The canines are still more formidable, especially in the males; the curved root is thick and subquadrate. The crowns of the molar teeth are short, sub-compressed, obtuse; sometimes terminated by a knob and defined by a constriction or neck from the fang; the last is the smallest.

In the Walrus (*Trichechus rosmarus*, fig. 265) the normal incisive formula is transitorily represented in the very young animal, which has three teeth in each premaxillary and two on each side of the fore-part of the lower jaw; they soon disappear, except the outer pair above, which remain close to the maxillary suture, on the inner side of the sockets of the enormous canines, and seem to commence the series of small and simple molars which they resemble in size and form. In the adult there are usually three such molars on each side, behind the permanent incisor, and four similar teeth on each side of the lower jaw; the anterior one passing into the interspace between the upper incisor and the first molar. The crowns of these teeth must be almost on a level with the gum in the recent head; they are very obtuse, and worn obliquely from above down to the inner border of their base. The molars of the lower jaw are rather narrower from side to side than those above, and are convex or worn upon their outer side. Each molar has a short, thick, simple and solid root.

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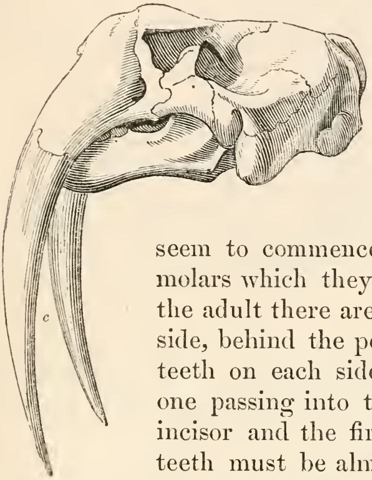

Skull and Teeth of the Walrus.

The upper canines are of enormous size, descending and projecting from the mouth, like tusks, fig. 265, *c*, slightly inclined outward and bent backward; they present an oval transverse section, with a shallow longitudinal groove along the inner side, and one or two narrower longitudinal impressions upon the outer side; the base of the canine is widely open, its growth being uninterrupted. Their homotype below retains the size and shape of the succeeding molars.

The food of the Walrus consists of sea-weed and bivalves; the molars are well adapted to break and crush shells; and fragments of a species of *Mya* have been found, with pounded sea-weed, in the stomach. The canine tusks serve as weapons of offence and defence, and to aid the animal in mounting and clambering over blocks of ice.

A large extinct carnivorous animal (*Machairodus*, fig. 293, VI.), had the upper canine teeth, *c*, developed to almost the same disproportionate length as in the Walrus, whereby they were also compelled to pass outside the lower jaw when the mouth was shut. But these teeth were shaped after the type of the feline canines, only with more compressed and trenchant crowns; and they were associated with other teeth in number and kind demonstrating the feline affinity of the genus *Machairodus*. Its remains occur in newer tertiary deposits and in caves.[1]

In older tertiary formations, remains of carnivorous Mammals have been found with the three true molar teeth as expressly modified for the division of flesh, and as worthy the term of 'sectorials' as the teeth so called in the lion. These teeth were associated with conical premolars, long canines, and short incisors, so as to exemplify the typical formula, e.g.—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{4.4};\ m\,\frac{3.3}{3.3} = 44.$$

The extinct *Hyænodon* and *Pterodon* of the upper eocene formations of Hampshire and of France, manifest this interesting and instructive character of dentition.

A reduced view of the lower jaw of the *Hyænodon Requieni* is given in fig. 266. After the canines, *c*, come four successively enlarging conical compressed premolars, *p* 1–4; then, instead of a single carnassial representing the first true molar, there are three of these singularly modified teeth—the first, *m* 1, being of suddenly small size, as compared with the antecedent premolar, and obviously illustrating its true nature as a continuation of the deciduous series, with which, doubtless, it agreed in size. It became a permanent tooth only because there was no premolar developed beneath it, so as to displace it. The succeeding carnassial true molars, *m* 2 and 3, progressively increase in size. The symbols in fig. 266 denote the homologies of the teeth. The marks of abrasion on the lower teeth in the *Hyænodon* prove the upper series to have been the same in number.

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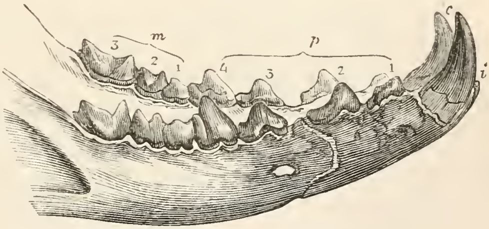

Dentition, lower jaw, of *Hyænodon*.

A second form of equally ancient Carnivore was a mixed-feeding animal, allied to the viverrine and canine families, the true molars presenting the tuberculate modification, and the typical number and kinds of teeth being functionally developed, as in the *Hyænodon*. The series in the upper jaw are shown in fig. 267. The term 'tubercular' is as applicable to the three true molars of the *Amphicyon*, *m* 1, 2, 3, as the term 'carnassial' is to those of the *Hyænodon*.

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[1] Kent's Hole, Devonshire, e. g.; CXVI″. p. 174.

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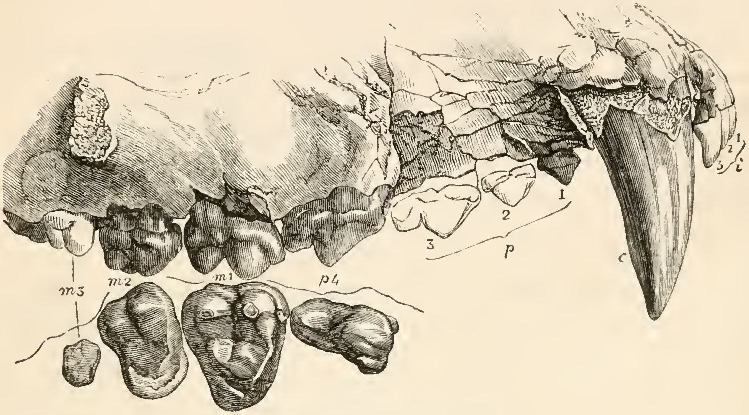

Dentition, upper jaw, *Amphicyon*.

§ 221. *Teeth of Ungulata.*—The most common characteristic of this dentition is the large size, cuboid shape, and complex structure of the crowns of the grinding teeth. The enamel not only incloses but dips or penetrates into the substance of the dentinal body, and the cement, which is thick, accompanies the enamel. Thus the massive grinding organ is made up of substances of different densities, and the working surface is irregular by the projections of the harder material, as in the mineral 'grit' that is thereby suitable as a millstone.

A. *Homologies of the parts of the grinding surface.*—The pattern of the grinding surface, especially of the upper molars, varies in each genus of Ungulata, and is eminently characteristic thereof. Nevertheless, two leading types may be recognised. One, of unsymmetrical character, was early shown in *Palæotherium*, and is traceable in secondary modifications characteristic of *Paloplotherium*, *Hipparion*, *Equus*, *Hyrax*, and *Rhinoceros*. A second was as early manifested in *Anoplotherium* and *Dichodon*; it is more symmetrical in pattern, and is traceable, with modifications, in *Dicotyles*, *Sus*, *Hippopotamus*, and *Ruminants*. Indications of a more generalised type of molar have been obtained from tertiary deposits antecedent in time to those characterised by *Palæo-* or *Anoplo-therium*: they are afforded by *Pliolophus*,[1] and *Coryphodon*.[2] The answerable parts of the grinding surface will first be illustrated in the unsymmetrical series. In *Palæotherium*, e. g. fig. 268, the tract of dentine, *a*, *b*, extending along the outer side of the crown, has two indents, *f*, *f*, whereby it is divided into two lobes, an anterior or 'ant-external lobe,' *a*, and a posterior or 'post-external lobe,' *b*. The tract of dentine along the inner side of the crown is also divided by two deeper and more oblique clefts or valleys into an 'ant-internal lobe,' *c*, *m*, and a 'post-internal lobe,' *d*: these lobes extend obliquely inward and backward from the outer ones, of which they are direct continuations. The anterior of the two inner clefts, *e*, *i*, extends from the middle of the inner surface of the crown obliquely outward and forward: the posterior one, *g*, *h*, enters at the posterior side of the crown, and extends nearly parallel with *e*, *i*: both valleys expand and deepen at their blind ends. At an early period of the attrition of the crown they intercommunicate, and extend to the anterior side of the crown, at *l*, as in the younger molar of *Paloplotherium*, fig. 269. But the shallow communicating passages between *h* and *i*, *i* and *l*, are soon obliterated, the dentine of lobe *d* becoming continuous with *b*; and that marked *e* with *a*. In *Paloplotherium* a branch valley, also, extends from *e* *i*, to the anterior side of the crown, *k*, cutting off the part of the ant-internal lobe *m* from the rest of *c*; but, by continued abrasion, this valley is also obliterated, and the tooth assumes more of the palæotherian pattern. In *Equus*, fig. 270, the valleys are of less equal depth than in *Palæotherium*, and are

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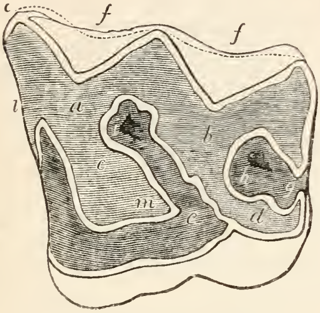

Upper molar (*m* 2): *Palæotherium magnum*.

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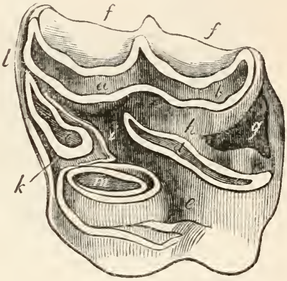

Upper molar (*m* 2): *Paloplotherium*.

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[1] cxv″. p. 54.

[2] cxvi″. p. 299.

so shallow midway that, at an early stage of attrition, the entry of the posterior valley, *g*, is separated from its termination, *h*; and that of the internal valley, *e*, from its termination *i*; the blind ends of both valleys, moreover, are more extended and irregular, than in *Palæotherium*, with the tendency to curve, so as to produce the crescentic form of the islands, *i*, *h*, in fig. 270. The obliteration of the mid-part of the accessory valley, *k*, unites the dentinal tract, *m*, to the rest of the lobe, *c*, as in *Palæotherium*, fig. 268: but it long remains separate in *Hipparion*, as in *Paloplotherium*, fig. 269.

The *Rhinoceros* and *Hyrax* more closely adhere to the Palæotherium type: but the outer indents, *f*, *f*, are less marked. The horse approaches nearest to the symmetrical type of the Ruminants, in which the homologous parts of the crown can, mostly, be well defined.

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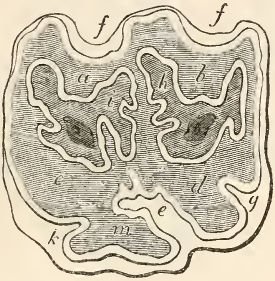

Upper molar (*m* 2), *Equus caballus*.

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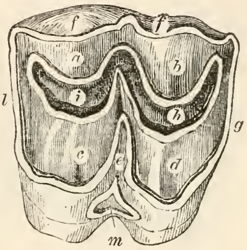

Upper molar (*m* 2). *Megaceros*.

In the unworn crown of the Ruminant molar, fig. 271, the valley, *g*, *h*, extends across the crown more parallel with the long axis of the jaw, than in fig. 268, curving with the concavity outward: it communicates with the valley, *i*; and, as in *Paloplotherium*, this is continued to the foreside of the crown, as at *l*, fig. 269, severing the lobe *c* from *a*. In Ruminants, both the anterior and posterior entries to this antero-posterior double-curved cleft are so shallow that they are soon obliterated, and the lobe *b* is continued by a tract of dentine, with *d*, along the hind part of the crown: as the lobe *a* is continued into lobe *c* at the fore part, as seen in the worn molar of the deer, fig. 271: the middle of valley, *e*, is separated from the end *i*, as in the horse: but the course of this valley is more transverse, and more directly bisects the antero-posterior valley, *h*, *i*: thus the inner lobes *c* and *d* are more parallel with and similar to the outer lobes *a, b.* Whether the accessory lobule *m,* be a homologue of the end, so marked, of lobe *c* in *Palæotherium, Paloplotherium,* and *Equus,* or a special development at the entry of valley *e* may be doubtful.

In the Hippopotamus, fig. 272, the valley commencing at the inner side of the crown at *e,* extends straight across the tooth to *n,* bisecting the crown transversely: it is also bisected, antero-posteriorly, by a shallower valley, answering to *h, i,* fig. 271. At the stage of attrition shown in fig. 272, the remnant of the latter valley is seen at *h* and *i*: the deeper transverse valley, *e, n,* remains: the shorter indents, *f, f, g, k,* give the trefoil character to the two chief divisions of the crown characteristic of *Hippopotamus.*

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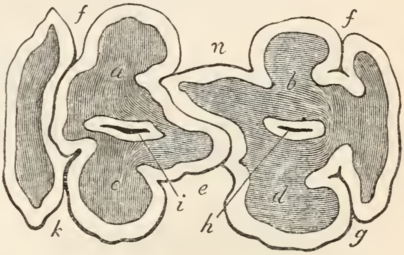


Upper molar ($m\ 2$), *Hippopotamus*

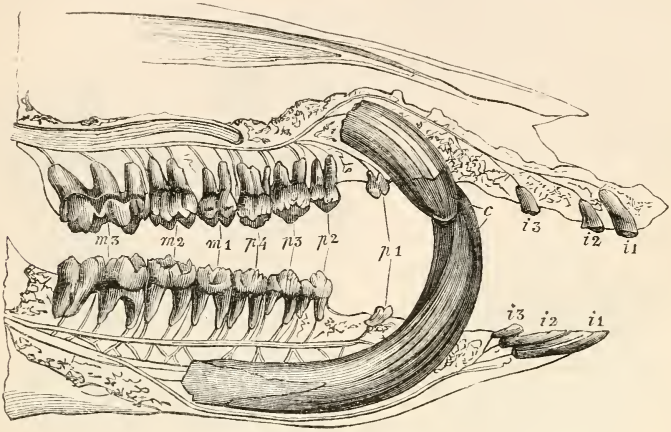
Another exposition of the homologous parts of the complex crowns of the Ungulate molars assumes the crucial division into four quarters or lobes to be the primitive modification. The fore-and-aft cleft has already begun to be filled by the mid-lobules in *Pliolophus*: the arrest of the outer end of the transverse cleft produces the continuity of *a* with *b*: that of its mid-part, of *d* with *e*: the obliteration of both ends of the antero-posterior cleft insulates that cleft, as in the Ruminant. The obliteration of the middle of the transverse cleft produces the continuation of *a, b,* with *d, c*; while the oblique continuation of *e* with *i,* and the retention of the continuity of *g* with *h,* leads to the type of *Palæotherium* and *Rhinoceros.*

A sub-type of grinding surface is produced by the existence of a transverse without an antero-posterior valley, dividing the crown into a pair of transverse ridges; as in the *Tapir*; which, however, is mainly the greater development, and more transverse disposition, of the tracts *b, d,* and *a, c,* in *Palæotherium,* fig. 268. The 'bilophodont' sub-type becomes more marked in *Dinotherium,* fig. 288, and in the anterior small molar of *Mastodon*: the successive multiplication of the transverse ridges completes the transition into the molar character of *Elephas.*

B. *Artiodactyla.* The extinct *Chæropotamus, Anthracotherium, Hyopotamus* and *Hippohyus,* had the typical dental formula, and this is preserved in the existing representative of the same section of non-ruminant Artiodactyles, the Hog. The permanent dental formula of the genus *Sus* is illustrated in fig. 273.

The upper incisors decrease in size from the first, *i* 1, to the third, *i* 3, receding from each other in the same degree; the first is relatively larger in the *Sus larvatus* than in the *Sus scrofa*; the basal line of the enamel is irregular; that substance extends more than an inch upon the outer side of the tooth, but only two or three lines on the inner side. The lower incisors are long, subcompressed, nearly straight; the second is rather larger than the first; the third is the smallest, as in the upper jaw.

273



Dentition of Boar (*Sus*).

The upper canines, in the Wild Boar, fig. 273, *c*, curve forward, outward, and upward; their sockets inclining in the same direction, and being strengthened above by a ridge of bone, which is extraordinarily developed in the Masked Boar of Africa. The enamel covering the convex inferior side of this tusk is longitudinally ribbed, but is not limited to that part; a narrow strip of the same hard substance is laid upon the anterior part, and another upon the posterior concave angle forming the point of the tusk, which is worn obliquely upwards from before, and backwards from that point. In the Sow the canines are much smaller than in the Boar. Castration arrests the development of the tusks in the male.

The teeth of the molar series progressively increase in size from the first to the last. The first premolar, ib. *p* 1, has a simple, compressed, conical crown, thickest behind, and has two fangs. The second, *p* 2, has a broader crown with a hind-lobe, having a depression on its inner surface, and each fang begins to be subdivided. The third, *p* 3, has a similar but broader crown implanted by four fangs. The fourth, *p* 4, has two principal tubercles and some irregular vertical pits on the inner half of the crown. The first true molar, *m* 1, when the permanent dentition is completed, exhibits the effects of its early development in a more marked degree than in most other mammals, and in the Wild Boar has its tubercles worn down, and a smooth field of dentine exposed by the time the last molar has come into place; it originally bears four primary cones, with smaller subdivisions formed by the wrinkled enamel, and an anterior and posterior ridge. The four cones produced by the crucial impression, of which the transverse part is the deepest, are repeated on the second true molar *m* 2, with more complex shallow divisions, and a larger tuberculate posterior ridge. The greater extent of the last molar, *m* 3, is chiefly produced by the development of the back ridge into a cluster of tubercles; the four primary cones being distinguishable on the anterior main body of the tooth. The crowns of the lower molars are very similar to those above but are rather narrower, and the outer and inner basal tubercles are much smaller, or are wanting; the grinding surface of the last is shown in fig. 274.

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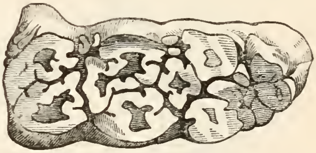

Grinding surface, (*m* 3) *Sus*.

The first or deciduous dentition of the Hog consists of—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 28 \text{ (fig. 294).}$$

The canines are feeble, and have their normal direction in both jaws, the upper ones descending according to the general type, which is not departed from until at a later period of life. The first deciduous molar is not succeeded by a premolar, but holds the place of such some time after the other deciduous molars are shed.

The dentition of the Wart-hogs is reduced by the suppression of certain incisors and of the first two premolars—the tooth-forming energy being, as it were, transferred to the last true molar, fig. 275, *m* 3, which is even more remarkable than in the common hog for its size and complexity in both jaws: it is perhaps the most peculiar and complex tooth in the whole class of *Mammalia*. The surface of the crown presents three series of enamel-islands, in the direction of the long axis of the grinding surface; the eight or nine islands of the middle row are elliptic and simple; those of the other rows are equal in number, but are sometimes subdivided into smaller islands. These islands or lobes are the abraded ends of long and slender columns of dentine, encased by thick enamel, and the whole blended into a coherent crown by abundant cement, which fills up all the interspaces, and forms a thick exterior investment of the entire complex tooth.

The milk-molars are $\frac{3}{2}:\frac{3}{2}$ in number; but only the two last are succeeded by premolars. These are small, and, after the wearing out of the first true molar, are shed, leaving the remnant of the second true molar, fig. 275, *m* 2, with the last large one, *m* 3, to which the work of mastication is confined in old Wart-hogs. This interesting modification, as to order and number, in the change of the dentition, has thrown important light on the more anomalous dentition of the Elephant.[1]

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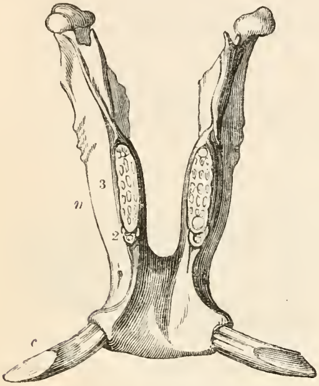

Dentition, lower jaw, old Wart-hog (*Phacochoerus*).

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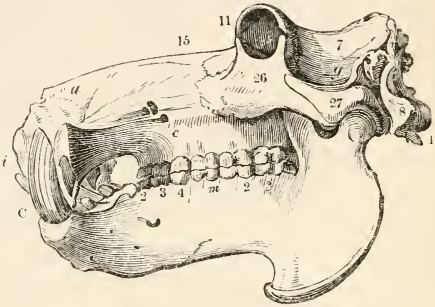

Dentition of Hippopotamus.

The tendency to excessive development which characterises the canine teeth in the *Suidæ,* affects both these and the incisors in the genus *Hippopotamus.* The two median inferior incisive tusks, fig. 276, *i,* are cylindrical, of great size and length; the two outer incisors are likewise cylindrical and straight, but much smaller. The upper canines curve downward and outward; their exposed part is very short, and is worn obliquely at the forepart; they are three-sided, with a wide and deep longitudinal groove behind. The lower canines, ib. *c,* are massive, curved in the arc of a circle, subtriedral, the angle rounded off between the two anterior sides, which are convex and thickly enamelled, the posterior side of the crown being almost wholly occupied by the oblique abraded surface opposed to that on the upper canine. The implanted base of each of these incisive and canine teeth is simple, and excavated for a large persistent matrix, contributing to their perennial growth by constantly reproducing the dental matter to replace the abraded extremities. The direction of the abraded surface is in part provided for by the partial disposition of the enamel. The molar series consists of—

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[1] CLXXIII'', p. 495.

$$p\,\frac{4.4}{4.4};\ m\,\frac{3.3}{3.3} = 28.$$

The first premolar is small, far in advance of the second, and is soon shed: the others (fig. 276, 2, 3, 4) form a continuous series with the true molars (*m*, 2, 3). These have the double trefoil character shown in fig. 272. The crown of the last, in the lower jaw, is lengthened by a fifth cusp developed behind the normal pairs. The large tusks, fig. 276, *c*, exhibit the maximum of density in their component tissues. The enamel 'strikes fire' with steel like flint. The compact dentine has a high commercial value, especially for the fabrication of artificial teeth. It differs from true ivory by showing, in transverse section, the simple concentric instead of the 'engine-turned' or curvilinear decussating lines.[1]

The affinities of the Hippopotamus are clearly manifested by the character of its deciduous dentition; and if this be compared with the dentition at a like immature period in other *Ungulata*, it will be seen, by its closer correspondence with that of Artiodactyles, and more especially the Phacochere, that the Hippopotamus is essentially a gigantic Hog.

The formula of the teeth which are shed and replaced, is—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3.3} = 24.$$

If the small and simple tooth, which is developed anterior to the deciduous molars, and which has no successor, be regarded, from its early loss in the existing Hippopotamus, as the first of the deciduous series, we must then reckon with Cuvier four milk-molars on each side of both jaws.

The incisors in both jaws are simply conical and subequal, with an entire cap of enamel on the crown. The deciduous canines scarcely surpass them in size in the upper jaw, and not at all in the lower. Projecting forward, here, from the angles of the broad and straight symphysis, they appear like an additional pair of incisors; and this character of equality of development was retained by the ancient form of Hippopotamus with the more typical number of incisors, $\frac{3}{3}:\frac{3}{3}$, which formerly inhabited India.

The first true deciduous molar, *d* 2, has a conical crown and two fangs in both jaws. That above has also a conical crown with one strong posterior and two anterior ridges. The second deciduous molar, *d* 3, has a large trilobate crown, the first lobe small, with an anterior basal ridge; the second large, conical, with three longitudinal indentations; the third lobe still larger, and cleft into two half-cones by an antero-posterior fissure assuming the normal pattern of the true molars. The third deciduous molar, *d* 4, above more closely resembles the ordinary upper true molar; but its second pair of demi-cones are relatively larger. In the lower jaw the last deciduous molar, *d* 4, has a more complex crown than that of any other teeth of the permanent or deciduous dentition. It has three pairs of demi-cones, progressively increasing in size, from before backward, with an anterior and posterior basal ridge and tubercles. Like the last trilobate deciduous lower molar of the Hog, it increases in thickness posteriorly, instead of diminishing here, like the last true molar of the lower jaw of the adult Hippopotamus.

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[1] In v. is described (p. 569) and figured (pl. 142), the lower tusk of a Hippopotamus which, after fracture, had been united again by a mass of 'osteodentine.'

The upper incisors, and the first premolar of both jaws, are not developed in the typical Ruminants, rarely the upper canines: the dental formula being:—

$$i\,\frac{0.0}{3.3};\ c\,\frac{0.0}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3} = 32 \text{ (vol. ii. p. 474, fig. 324).}$$

The gazelle, the sheep, the ox—respectively representing the families *Antilopidæ*, *Ovidæ*, and *Bovidæ*, which are collectively designated the 'hollow-horned ruminants'—all present this formula. It likewise characterises many of the solid-horned ruminants, or the deer tribe (*Cervidæ*), the exceptions having canine teeth in the upper jaw of the male sex, and sometimes also in the females, though they are always smaller in these.

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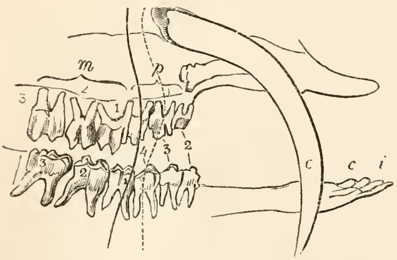

Dentition, Moschus moschiferus.[1]

The upper canines attain their greatest length in the Muntjac (vol. ii. p. 478, fig. 328, *a a*) and the small Musk-deer, and especially in the typical species (*Moschus moschiferus*, fig. 277.) These teeth, indeed, in the male Musk, ib. *c*, present proportions intermediate between those of the upper canines of the Machairodus and of the Morse. The inverse relationship in the development of teeth and horns, exemplified by the total absence of canines in the Ruminants with persistent frontal weapons, by their first appearance in the periodically hornless deer, and by their larger size in the absolutely hornless Musks, is further illustrated by the presence not only of canines, but of a pair of laniariform incisors, fig. 278, *i*, in the upper jaw of the *Camelidæ*.

---

[1] The line traverses the Cuvierian 'dents carnassières'; the interrupted line traverses the Blainvillian 'dents principales'.

In the Camel and Dromedary the upper canines, fig. 278, *c*, are formidable for their size and shape, but do not project beyond the lips like the tusks of the Musk-deer; they are more feeble in the Llamas and Vicugnas, and are always of smaller size in the females than in the males. The inferior canines, *o*, moreover, retain their laniariform shape in the *Camelidæ*, and are more erect in position than in the ordinary Ruminants. They are separated by a short diastema from the incisors in the *Aucheniæ*.

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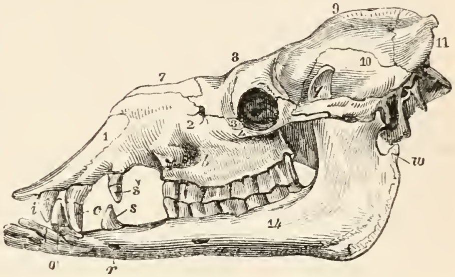

Dentition of Camel (*Camelus bactrianus*).

The true nature of the corresponding canines in the ordinary Ruminants, in which they are procumbent, and form part of the same series with the incisors, is always indicated by the lateness of their development, and often by some peculiarity of form. Thus in the *Moschus*, fig. 277, *c*, they are smaller and more pointed than the incisors; in the Giraffe they have a much larger crown, which is bilobed. The laniariform tooth in the premaxillary bone of the *Camelidæ*, fig. 278, 1, which represents the upper and outer incisor, *i*, is smaller than the true canine, *c*, which is placed behind it in the Camel and Dromedary; but in the Vicugna it is as large as, or larger than, the true canine.

Most of the deciduous molars of the Ruminants resemble in form the true molars; the last milk-molar, for example, fig. 279, *d* 4, in the lower jaw, has three lobes like the last lower true molar, *m* 3. The deciduous molars in existing true Ruminants are three in number on each side, and, being succeeded by as many premolars, the ordinary permanent molar formula is—

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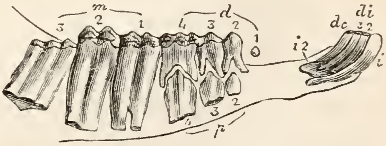

Deciduous and permanent teeth of a Sheep.

$$p\,\frac{3.3}{3.3},\ m\,\frac{3.3}{3.3};$$

but there is a rudiment of *d* 1 in the embryo Fallow-deer, and in one of the most ancient of the extinct Ruminants (*Dorcatherium*, Kaup) the normal number of premolars was fully developed.

The characteristic complexity of the Ruminant grinder, fig. 271, is seen, in the permanent series, only in the three posterior teeth of both upper and lower jaws, which are the true molars; the three first, or premolars, having more simple crowns than those which they displace. The complexity in question is the result of peculiar plications of the formative capsule, some of which are longitudinal, or project inward from the sides of the capsule, and form peninsular folds of enamel upon the grinding surface of the tooth, whilst others depend vertically from the summit of the matrix into the body of the tooth, and form islands of enamel when the crown begins to be worn. Of the longitudinal folds, two in the upper true molars are external, broad, but shallow, and often sinuous, and one is internal, narrow, and deep, extending quite across the summit of the crown of the tooth, and decreasing in depth toward the base of the crown. The corresponding fold of enamel in the completed tooth, accordingly, extends more or less across the crown, from within outward, as the tooth is less or more worn. The whole circumference of this complex molar is also invested by a coat of enamel and a thinner layer of cement. In some Ruminants, e.g. Ox, Deer, and Giraffe, a small vertical column, fig. 271, *m*, is developed at the internal interspace of the two lobes of one or more of the upper true molars, varying in height, and rarely reaching the summit of the new-formed crown, but longest in the *Bovidæ*. Different genera of Ruminants also differ in the depth and sinuosity of the two outer longitudinal folds, *f*, and in the depth and complexity of the two vertical folds, *h*, *i*, which likewise are united in some species by a longer common base than in others, producing thereby a continuity of the enamel, and complete antero-posterior bisection of the grinding surface during a longer period of attrition. The molars of the Camel present the most simple condition of the Ruminant type of these teeth; the transverse fold dividing the crown being short, the dentine of the two lobes soon forms a continuous tract. The common base of the crescentic vertical folds of the capsule being likewise short, the enamel islands are soon separated from each other. They include a shallow or narrow crescentic cavity, with a simple but slightly sinuous contour. The two outer shallow longitudinal depressions of the crown have no middle rising; and there is no columnar process at the interspace of the two inner convexities.

The lower molars are like the upper ones reversed. The single median longitudinal fold is external, and divides the convex outer sides of the two lobes. The base of the fold extends, in some species, across the molar for some distance before it contracts in breadth, retreating toward the outer side, and the two lobes of the crown accordingly continue to be completely divided for a longer period, as in the Elk and Giraffe. The inner surface of the molar is gently sinuous, the concavities being rarely so deep as those of the outer surface of the upper molars. The lower molars are always thinner, in proportion to their breadth, than those above, and the crescentic islands are narrower and less bowed. The differences which the lower molars present in different genera of Ruminants are analogous to those in the upper molars, but are less marked. The accessory small column, when present, as in *Bos, Urus, Megaceros,* and *Alces,* is situated at the outer interspace of the convex lobes, and nearer the base in the *Cervidæ* than in the *Bovidæ.* It is not developed in the Antelopes, Sheep, or Camel, and is wanting in most of the smaller species of Deer. The last true molar of the lower jaw is characterised in all Ruminants by the addition of a third posterior lobe. This is very small and simple in the Camel and the Gnu, is relatively larger in the *Bovidæ* and *Cervidæ,* and presents, in the *Megaceros* and *Sivatherium,* a deeper central enamel island or fold, which also characterises the smaller third lobe in the Giraffe. The lower molars of the genus *Auchenia* are peculiarly distinguished by the vertical ridge at the forepart of the anterior lobe, which does not exist in the Camels of the Old World.

In all Ruminants, the outer contour of the entire molar series is slightly zigzag, the anterior and outer angle of one tooth projecting beyond the posterior and outer angle of the next in advance. All the three lower premolars have compressed, subtrenchant, and pointed crowns in the small Musk-deer (*Tragulus*). The true Musk (*Moschus*) more resembles the ordinary Deer in its premolars. The aberrant *Camelidæ* deviate most from ruminant type in the position, shape, and number of the premolars: the anterior one, fig. 278, *s*, is laniariform in both jaws.

As phenomena of dentition serve to determine, or indicate, the age of Hoofed beasts, a table is subjoined in which the characteristic teeth are indicated by the symbols adopted in my 'Odontography' (v), and illustrated in figs. 279 and 294, with reference to those domesticated varieties raised for food, which are usually exhibited, in competition, of prescribed ages, at the great cattle shows. The range of variety, for which allowance may be made, is noted in the Ox and Sheep.

Table of the Times of Appearance of the Permanent Teeth in the Ox, Sheep, and Hog.

Symbols.	OX.				SHEEP.				HOG.	
	Early.		Late.		Early.		Late.			
	Year.	Month.	Year.	Month.	Year.	Month	Year.	Month.	Year.	Month.
i 1	1	9	2	3	1	0	1	4 to 8	1	0
i 2	2	3	2	9	1	6	2	0 to 4	1	6
i 3	2	9	3	3	2	3	2	9 to 12	0	9
c	3	3	3	9	3	0	3	6	0	9
m 1	0	4	0	6	0	3	0	6	0	6
m 2	1	3	1	8	0	9	1	0	0	10
m 3	2	0	2	3	1	6	2	0	1	6
d or *p* 1	0	0	0	0	0	0	0	0	0	6
p 2	2	6	2	8	2	0	2	6	1	0
p 3	2	6	2	8	2	0	2	6	1	0
p 4	2	8	3	0	2	3	2	6	1	3

c. *Perissodactyla.*—The Horse is selected as the first example of the dentition of the hoofed Quadrupeds with toes in uneven number, because it offers in this part of its organisation some transitional features between those of the dental characters of the typical members of the artiodactyle and of those of the perissodactyle *Ungulata.*

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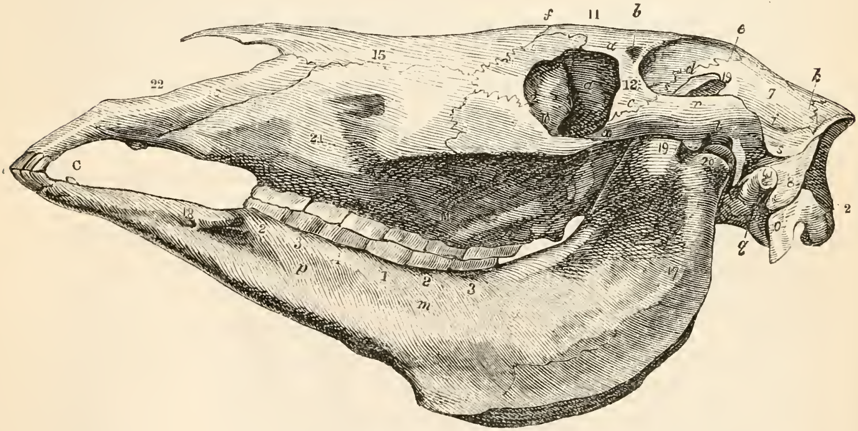

Dentition of Horse (*Equus*).

All the kinds of teeth are retained, in nearly normal numbers, in both jaws, and with almost as little unequal or excessive development as in the Anoplothere; but the prolongation of the slender jaws carries the canines, figs. 280, *c*, and incisors, ib. *i*, to some distance from the molars, and creates a long diastema, as in the Ruminants and Tapirs. The first deciduous molar is very minute and is not succeeded by a premolar; yet, remaining longer in place than the larger deciduous molars behind, it represents the first premolar, and completes the typical number of that division of the grinding series. If the dental formula of the genus *Equus* be restricted to the functionally developed permanent teeth, it will be—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{3.3}{3.3};\ m\,\frac{3.3}{3.3};\ = 40.$$

The outer side of the upper molar of the Horse (*Equus Caballus*, fig. 269) is impressed, as in the Palæothere, fig. 267, by two wide longitudinal channels: the other evidences of the perissodactyle type of grinding surface, and the modifications thereof, are given at p. 341. In the lower jaw, the teeth, as usual, are narrower transversely than in the upper jaw; they are divided externally into two convex lobes by a median longitudinal fissure, and on the inner side they present three principal unequal convex ridges, and an anterior and posterior narrower ridge; but the crown of the molar is penetrated from the inner side by deeper and more complex folds than in the Rhinoceros or Palæothere.

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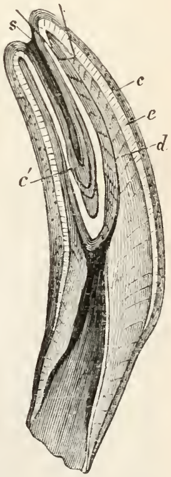

Section of incisor Horse.

The incisors, figs. 280, 285, *i*, are arranged close together in the arc of a circle at the extremity of both jaws. They are slightly curved, longitudinally grooved, with long simple subtrihedral fangs tapering to their extremity, fig. 280. The crowns are broad, thick, and short. The contour of the biting surface, before it is much worn, approaches an ellipse. These teeth, if found detached, recent or fossil, are distinguishable from those of the Ruminants by their greater curvature, and from those of all other animals by the fold of enamel (ib. *c′*), which penetrates the body of the crown from its broad flat summit, like the inverted finger of a glove. When the tooth begins to be worn, the fold forms an island of enamel inclosing a cavity, *s*, partly filled by cement and partly by the discoloured substances of the food; this is called by horse-dealers the ‘mark.’ In aged horses the incisors are worn down below the extent of the fold, and the mark disappears. The cavity is usually obliterated in the first or mid-incisors at the sixth year, in the second incisors at the seventh year, and in the third or outer incisors at the eighth year, in the lower jaw. It remains longer in those of the upper jaw, and in both the place of the 'mark' continues for some years to be indicated by the dark-coloured cement or osteo-dentine.

The canines are small in the stallion, less in the gelding, and rudimental in the mare. The unworn crown is remarkable for the folding in of the anterior and posterior margins of enamel, which here includes an extremely thin layer of dentine. The upper canine is situated in the middle of the long interspace between the incisors and molars: the lower canine, fig. 280, *c*, is close to the outer incisor, as in the Ruminants, but is better distinguished by its cuspidate form.

The most obvious character by which the horse's molars may be distinguished from the complex teeth of other *Herbivora* corresponding with them in size, is the great length of the tooth before it divides into fangs. This division, indeed, does not begin to take place until much of the crown has been worn away; and thus, except in old horses, a considerable portion of the whole of the molar is implanted in the socket by an undivided base. This is slightly curved in the upper molars. It provides for mastication during a longer life than in the cow.

The following is the average course of development and succession of the teeth in the *Equus Caballus*:—The summits of the first functional deciduous molar[1] ('first grinder' of veterinary authors) are usually apparent at birth; the succeeding grinder[2] sometimes rises a day or two later, sometimes together with the first. Their appearance is speedily followed by that of the first deciduous incisor, fig. 282, *d* 1 ('centre nipper' of veterinarians), which usually cuts the gum between the third and sixth days; but occasionally protrudes at birth. The second deciduous incisor, ib. *d* 2, appears between the twentieth and fortieth days, and about this time the rudimental molar,[3] comes into place, and the last deciduous molar[4] begins to cut the gum. About the sixth month the inferior lateral or third incisors, ib. *d* 3, with the deciduous canine make their appearance. The lower minute canine is shed about the time that the contiguous incisor is in

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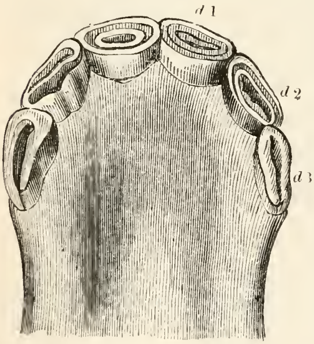

Deciduous incisors of 1-year old Colt. Lower jaw.

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[1] The homologue of *d* fig,2 . 287.

[2] Ib. *d* 3.

[3] Ib. *d* 1.

[4] Ib. *d* 4.

place. The upper deciduous canine is shed in the course of the second year. The rise to working level of the third deciduous incisors or ‘corner nippers’ completes the stage of dentition called the ‘colt’s mouth’ by veterinary authors, fig. 282. The deciduous incisors are not only smaller than the permanent ones, but are whiter, have a better marked ‘neck,’ the fang more slender and pointed, and are devoid of the median longitudinal groove. The first permanent

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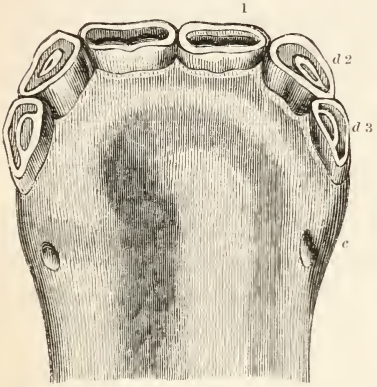

Incisive dentition of 3-year old Colt.
Lower jaw.

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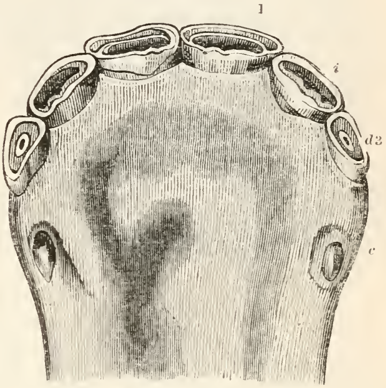

Incisive dentition of 4-year old Colt.
Lower jaw.

molar, *m* 1, appears between the eleventh and fourteenth months. The ‘second’ molar, *m* 2, follows at the twentieth month or the second year. The first functional premolar, *p* 2, displaces the deciduous molar, *d* 2, at from two years to two years and a half old.[1] The first permanent incisor, fig. 283, *i* 1, displaces *d* 3, and protrudes from the gum at between two years and a half and three years. At the same period the second or penultimate premolar, *p* 3, pushes out the penultimate milk-molar, and the penultimate true molar, *m* 2, comes into place. The last premolar, *p* 4, displaces the last deciduous molar at between three years and a half and four years; the appearance above the gum of the last true molar, *m* 3, is usually somewhat earlier. The second incisor, fig. 284, *i* 2, pushes out its deciduous predecessor at about three years and eight months. The permanent canine or ‘tusk,’ *c*, next follows; its appearance indicates the age of four years and a half; but it sometimes comes earlier. The third, or outer incisor, fig. 285, *i* 3, pushes out the deciduous incisor, *d* 3, about the fifth year, but is seldom in full place before the horse is five years and a half old; the last premolar is then usually on a level with the other grinders. Upon the rising of the third permanent incisor, or 'corner nipper,' the 'colt' becomes a 'horse,' and the 'filly' a 'mare,' in the language of the horse-dealers; after the disappearance of the 'mark' in the incisors, at the eighth or ninth year, the horse becomes 'aged.'

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[1] The homologous teeth in the young Hyrax, fig. 287, are indicated by the same symbols, and the sole developmental difference from the Horse is the displacement of *d* 1 by a *p* 1 of functional size.

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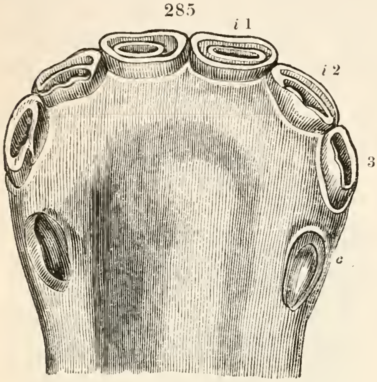

Incisive dentition, 5-year old Horse. Lower jaw.

The modifications which the upper molars of *Hyrax*, fig. 286, present, as compared with those of *Paleotherium*, will be readily understood by the remarks in the section on the homologies of the grinding surface, as illustrated by figs. 268–270. The present genus is a miniature form of the family, and, like the primitive eo- and miocene hornless rhinoceros (*Acerotherium*), retains large incisors, with a type molar series, e.g.

$$i\,\frac{1.1}{1.1};\ c\,\frac{0.0}{0.0};\ p\,\frac{4.4}{4.4};\ m\,\frac{3.3}{3.3} = 32.$$

There are no canines. As to the incisors in *Hyrax* or *Rhinoceros* the species vary, not only in regard to their form and proportions, but also their existence; and in the varieties of these teeth we may discern the same inverse relation to the development of the horns which is manifested by the canines of the Ruminants. Thus, the two-horned Rhinoceroses of Africa, which are remarkable for the great length of one (*Rh. bicornis*, *Rh. simus*) or both (*Rh. Keitloa*) of the nasal weapons, have no incisors in their adult dentition; neither had that great extinct two-horned species (*Rh. tichorinus*), the prodigious development of whose horns is indicated by the singular modifications of the vomerine, nasal, and premaxillary bones, in relation to the firm support of those weapons. The Sumatran bicorn Rhinoceros combines, with comparatively small horns, moderately developed incisors in both jaws. The incisors are of larger size in the unicorn Rhinoceroses (*Rh. Indicus* and *Rh. Sondaicus*); still larger, relatively, in the hornless Acerotherium and Hyrax, figs. 286, 287, *i*.

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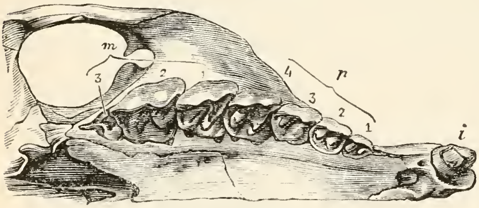

Dentition, upper jaw (*Hyrax*).

The deciduous molars of the Rhinoceros are, in number as well as in shape, similar to those in *Hyrax*, which bears the same relation to the great Rhinoceros as the small existing Sloth does to the extinct Megatherium. The change of dentition of the *Rhinocerotidæ* is, therefore, here illustrated by the young *Hyrax capensis*, fig. 287.

The four premolars, *p* 1, 2, 3, 4, are exposed above the four deciduous molars, *d* 1, 2, 3, 4, which they push out; the first true molar, *m* 1, is in place; the second, *m* 2, and third, *m* 3, molars are in different states of forwardness. The first premolar differs from the rest only by a graduated inferiority of size, which, in the last premolar, *p* 4, ceases to be a distinction between it and the true molars.

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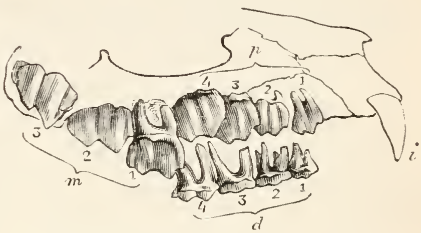

Deciduous and permanent teeth, *Hyrax*. Nat. size.

The dental formula of the Tapir is—

$$i\,\frac{3.3}{3.3};\ c\,\frac{1.1}{1.1};\ p\,\frac{4.4}{3.3};\ m\,\frac{3.3}{3.3} = 42 \text{ (vol. ii. p. 449, fig. 300, immature).}$$

The median incisors above have a broad trenchant crown, *k*, separated by a transverse channel from a large basal ridge; the wedge-shaped crowns of the opposite pair below fit into the channel, and have no basal ridge; the outer incisors above are very large and like canines; those below are unusually small. The canines, *l*, have crowns much shorter than their roots, and not projecting, like tusks, beyond the lips; they are pointed, with an outer convex, separated by sharp edges from an inner, less convex, surface. The lower canines form part of the same semicircular series with the incisors. The first three premolars above have the outer part of the crown composed of two half-cones, the posterior one having a basal ridge; the anterior basal ridge rises into a small cusp in the second premolar, which increases in size in the third and fourth; in this tooth the transverse depression divides at the base of the anterior and outer demicone, and the posterior division is continued into the interspace of the two demicones; these, therefore, now become in *m* 1 and *m* 2 the outer ends of the two transverse wedge-shaped eminences, giving their summits a curve whose concavity is turned backward; the last molar, *m* 3, may be known by the shorter and more curved posterior eminence. In the dentition of the lower jaw the double transverse ridged structure prevails throughout the molar series, the anterior talon being most produced and compressed in the first tooth, *p* 2.

Certain huge fossil bilophodont grinders, which seemed to indicate a gigantic Tapir, are now known, by the discovery of the cranium, and the enormous tusks of the lower jaw, fig. 288, *i*, to belong to a genus connecting the tapiroid with the proboscidian families.

The permanent dentition of the genus *Dinotherium* is—

$$i\,\frac{0.0}{1.1};\ c\,\frac{0.0}{0.0};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 22.$$

The two deciduous molars *in situ* on each side of the fragment of the upper jaw of the young *Dinotherium*, which Professor Kaup[1] has figured, answer to the third and fourth of the typical series. The crown of the anterior milk-molar supports two transverse ridges with an anterior and posterior basal ridge; its contour is almost square; the last milk-molar has a greater antero-posterior extent, and supports three transverse eminences with an anterior and posterior basal ridge, the anterior ridge being developed into a pointed tubercle at its outer end. The two premolars, fig. 288, *p* 3 and 4, conform to the general rule in being more simple than the teeth which they displace and succeed. The transverse diameter of the second premolar exceeds the antero-posterior one, the proportions being the reverse of those of the deciduous molar, which it displaces. The first true molar, *m* 1, repeats the structure of the hindmost deciduous molar, its crown

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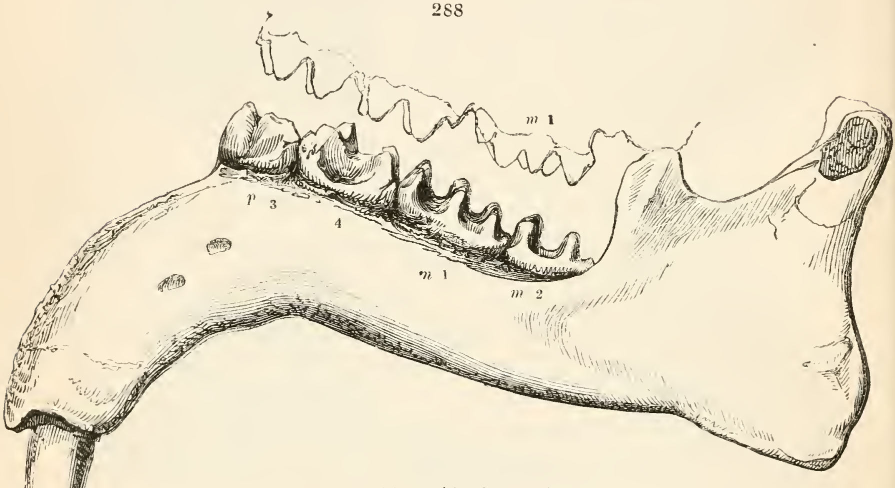

Dentition of Dinotherium (Kaup).

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[1] CLXIX″, p. 401; and CXIII″. Tab. I.

having a disproportionate antero-posterior extent, and supporting three transverse eminences, with an anterior, posterior, and internal basal ridge. The Dinothere resumes the tapiroid character, and differs from the Mastodon, inasmuch as the posterior molars, *m* 2 and 3, instead of having an increased antero-posterior extent and more complex crowns, increase only in thickness, and support two instead of three transverse eminences; they have also an anterior and a posterior basal ridge. In the lower jaw the first premolar, *p* 3, is implanted, like that above, by two fangs; but it has a smaller and simpler crown, which is narrower in proportion to its antero-posterior extent, and is almost entirely occupied by the antero-posterior ridge, only the posterior of the two inner tubercles being developed; thus the crown presents more of a trenchant than of a grinding character; the second premolar, *p* 4, supports two transverse ridges. The third of the permanent series, which is the first true molar, *m* 1, has three transverse ridges, like the one above, but is relatively narrower; the second, *m* 2, and third, *m* 3, true molars have each large square crowns, with two transverse ridges, and an anterior and posterior talon, the latter being more developed than in the corresponding molars of the upper jaw.

The generic peculiarity of the *Dinotherium* is most strongly manifested in its tusks. These, fig. 288, *i*, are two in number, implanted in the prolonged and deflected symphysis of the lower jaw, in close contiguity with each other, and having their exserted crown directed downward and bent backward, gradually decreasing to the pointed extremity. In jaws with molar teeth of equal size, the symphysis and its tusks offer two sizes; the larger ones, which have been found four feet in length, with tusks of two feet, may be attributed to the male Dinothere; the smaller specimens, with tusks of half size, to the female. The ivory of these tusks presents the fine concentric structure of those of the Hippopotamus, not the decussating curvilinear character which characterises the ivory of the Elephant and Mastodon. No corresponding tusks, nor the germs of such, have yet been discovered in the upper jaw of the *Dinotherium*.

D. *Proboscidia.*—The dentition of the genus *Elephas*, the sole existing modification of the once numerous and varied Proboscidian family, includes two long tusks, fig. 289, one, *i*, in each of the premaxillary bones, and large and complex molars, ib., *d* 4, *m* 1, *m* 2, in both jaws: of the latter there is never more than one wholly, or two partially, in place and use on each side at any given time, the series being continually in progress of formation and destruction, of shedding and replacement: and all the grinders succeed one another, like true molars, horizontally, from behind forwards.

The total number of teeth developed in the elephant appears to be $i\,\frac{2-2}{0-0}, m\,\frac{6-6}{6-6} = 28$: the two large permanent tusks being preceded by two small deciduous ones, and the number of molar teeth which follow one another on each side of both jaws being not less than six, of which the last three answer to the true molars of other mammals.

The deciduous tusk appears beyond the gum between the fifth and seventh month; it rarely exceeds two inches in length, and is shed between the first and second year.

The permanent tusks cut the gum when about an inch in length, a month or two usually after the milk-tusks are shed. Their widely open base is fixed upon a conical pulp, which, with the capsule surrounding the base of the tusk and the socket, continues to increase in size and depth, obliterating all vestiges of that of the deciduous tusk, and finally extending its base close to the nasal aperture, fig. 289, *n*. The tusk, being subject to no attrition from an opposed tooth, but being worn only by the occasional uses to which it is applied, arrives at an extraordinary length, following the curve originally impressed upon it by the form of the socket, and gradually widening from the projecting

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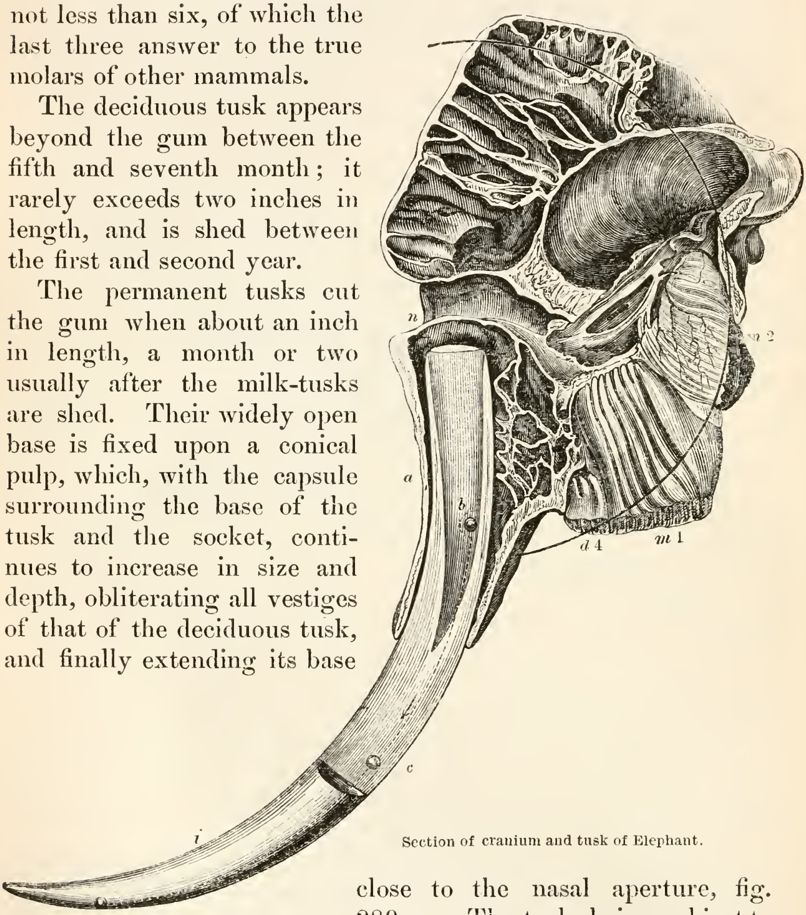

Section of cranium and tusk of Elephant.

apex to that part which was formed when the matrix and the socket had reached their full size.

These incisive teeth of the elephant not only surpass other teeth in size, as belonging to a quadruped so enormous, but they are the largest of all teeth in proportion to the size of the body; representing in a natural state those monstrous incisors of the rodents, which are the result of accidental suppression of the wearing force of the opposite teeth, fig. 239.

The tusks of the elephant, like those of the mastodon, consist chiefly of that modification of dentine which is called 'ivory,' and which shows, on transverse fractures or sections, striæ proceeding in the arc of a circle from the centre to the circumference in opposite directions, and forming by their decussations curvilinear lozenges. This character is peculiar to the tusks of the Proboscidian Pachyderms.

In the Indian Elephant the tusks are always short and straight in the female, and less deeply implanted than in the male: she thus retaining, as usual, more of the characters of the immature state. In the male they have been known to acquire a length of nine feet, with a basal diameter of eight inches, and to weigh one hundred and fifty pounds: but these dimensions are rare in the Asiatic species.

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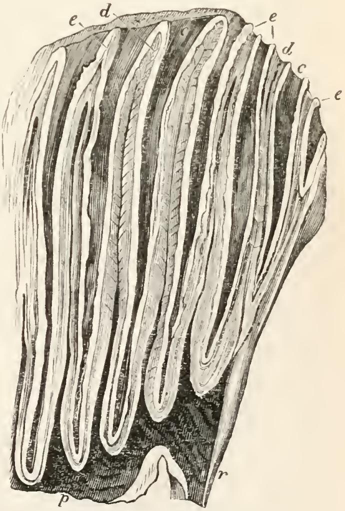

Section of molar, Elephant.

The elephant of Africa, at least in certain localities, has large tusks in both sexes; and the ivory is most esteemed by the manufacturer for its density and whiteness.

The molar teeth of the elephant are remarkable for their great size, and extreme complexity of their structure, fig. 290. The crown, of which a great proportion is buried in the socket, and very little more than the grinding surface appears above the gum, is deeply divided into a number of transverse perpendicular plates, consisting each of a body of dentine, *d*, coated by a layer of enamel ib., *e*, and this again by the cement, ib., *c*, which fills the interspaces of the enamelled plates, and here more especially merits its name, since it binds together the several divisions of the crown before they are fully formed and united by the confluence of their bases into a common body of dentine. As the growth of each plate begins at the summit, they remain detached and like so many separate teeth or denticules, until their base is completed, when it becomes blended with the bases of contiguous plates to form the common body of the crown of the complex tooth from which the roots are next developed.

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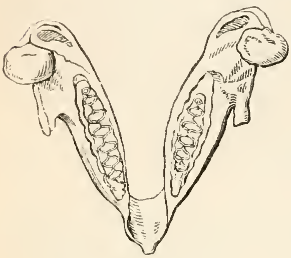

Molars, African Elephant.

The plates of the molar teeth of the Siberian Mammoth (*Elephas primigenius*) are thinner in proportion to their breadth, and more numerous in proportion to the size of the crown than in the existing species of Asiatic Elephant. In the African Elephant, fig. 291, the lamellar divisions of the crown are fewer and thicker, and they expand more uniformly from the margins to the centre, yielding a lozenge-form when cut or worn transversely, as in mastication. From this modification the gradation is close in the many extinct species to the three-ridged Mastodons and two-ridged Dinotheres.

The first molars of the Asiatic Elephant include four plates, are in place and use at three months, and are shed when the elephant is about two years old.

The eight or nine plates of the second molar are formed in the closed alveolus, behind the first molar by the time this cuts the gum, and they are united with the body of the tooth, and most of them are in use, when the first molar is shed.

The third molar has the crown divided into from eleven to thirteen plates; it averages four inches in length, and two inches in breadth, and has a small anterior, and a very large posterior root; it begins to appear above the gum about the end of the second year, is in its most complete state and extensive use during the fifth year, and is worn out and shed in the ninth year. Its remains about this period are shown in fig. 289, *d* 4. The three preceding teeth answer to the deciduous molars, *d* 2, *d* 3, and *d* 4, in the Hyrax, fig. 287, and Hog, fig. 294.

The fourth molar, figs. 289 and 292, *m* 1, presents a marked superiority of size over the third, and a somewhat different form: the anterior angle is more obliquely abraded, giving a pentagonal figure to the tooth in the upper jaw. The number of plates in the crown of this tooth is fifteen or sixteen: its length between seven and eight inches; its breadth three inches. The fore-part of the grinding surface of this tooth begins to protrude through the gum at the sixth year: it is in full use and place at the fifteenth year (fig. 289, *m* 1): the tooth is worn away, and its last remnant shed, about the twentieth or twenty-fifth year. It is the homologue of the first true molar of *Hyrax*, fig. 287, *m* 1.

The fifth molar, ib., *m* 2, with a crown of from seventeen to twenty plates, measures between nine and ten inches in length, and about three inches and a half in breadth. It begins to appear above the gum about the twentieth year: its duration has not been ascertained by observation.

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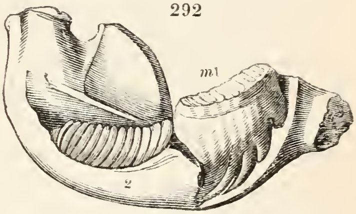

Molars, lower jaw, Indian Elephant. Æt. 15 years.

The sixth molar is the last, and has from twenty-two to twenty-seven plates; its length, or antero-posterior extent, following the curvature, is from twelve to fifteen inches: the breadth of the grinding surface rarely exceeds three inches and a half.[1]

The molar teeth succeed each other from behind forward, moving in the arc of a circle, shown by the curved line in fig. 289. The position of the growing tooth in the closed alveolus, *m* 2, is almost at right angles with that in use, the grinding surface being at first directed backward in the upper jaw, forward in the lower jaw, and brought, by the revolving course, into a horizontal line in both jaws, so that they oppose each other, when developed for use. The imaginary pivot on which the grinders revolve is next their root in the upper jaw, and is next the grinding surface in the lower jaw; in both, towards the frontal surface of the skull. Viewing both upper and lower molars as one complex whole, subject to the same revolving movement, the section dividing such whole into upper and lower portion runs parallel to the curve described by that movement, the upper being the central portion, or that nearest the pivot, the lower, the peripheral portion: the grinding surface of the upper molars is consequently convex from behind forward, and that of the lower molars concave: the upper molars are always broader than the lower ones.

The bony plate forming the sockets of the growing teeth is more than usually distinct from the body of the maxillary, and participates in this revolving course, advancing forward with the teeth. The partition between the tooth in use and its successor is perforated near the middle; and, in its progress forward, that part next the grinding surface is first absorbed; the rest disappearing with the absorption of the roots of the preceding grinder.

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[1] In my 'Odontography' I was led to conjecture that 'this molar, if it makes its appearance about the fiftieth year, would, from its superior depth and length, continue to do the work of mastication until the ponderous Pachyderm had passed the century of its existence:' but I would now merely suggest, to all who may have the opportunity, the desirability of making and recording observations supplementary to those in the text made on captive Asiatic elephants in European menageries.

There are few examples of organs that manifest a more striking adaptation of a complex structure to the exigencies of the animal endowed with it, than the grinding teeth of the elephant. We perceive, for example, that the jaw is not encumbered with the whole weight of the massive tooth at once, but that it is formed by degrees as it is required; the division of the crown into a number of successive plates, and the subdivision of these into cylindrical processes, presenting the conditions most favourable to progressive formation. The fore and most abraded part of the tooth is fitted for the first coarse crushing of the branches of a tree: the transverse enamel ridges of the succeeding part of the tooth divide it into smaller fragments, and the posterior islands and tubercles of enamel pound it to the pulp fit for deglutition. The structure and progressive development of the tooth not only give to the elephant's grinder the advantage of the uneven surface which adapts the millstone for its office, but, at the same time, secure the constant presence of the most efficient arrangement for the finer comminution of the food, at the part of the mouth which is nearest the fauces.

The central part of the tusk especially near the base of such as have reached their full size, is occupied by a slender cylindrical tract of modified ivory, perforated by a few vascular canals, which is continued to the apex of the tusk. It is not uncommon to find processes of osteo-dentine or imperfect bone-like ivory, projecting in a stalactitic form into the interior of the pulp-cavity, apparently the consequence of the partial inflammation of the vascular pulp.

The musket-balls and other foreign bodies which are occasionally found in ivory, are immediately surrounded by osteo-dentine in greater or less quantity. It has often been a matter of wonder how such bodies should become completely imbedded in the substance of the tusk, sometimes without any visible aperture, or how leaden bullets may have become lodged in the solid centre of a very large tusk without having been flattened. The explanation is as follows:—A musket-ball, aimed at the head of an elephant, may penetrate, at *a*, fig. 289, the thin bony socket and the thinner ivory parietes of the wide conical pulp-cavity occupying the inserted base of the tusk; if the projectile force be there spent, the ball will gravitate to the opposite and lower side of the pulp-cavity, as indicated in fig. 289, *b*. The hole *a* is soon healed and filled up by ossification of the periosteum of the socket, and of the pulp next the thin wall of ivory which has been perforated. The ball sinks below the level of this cicatrix, and the presence of the foreign body exciting inflammation of the pulp, an irregular course of calcification ensues, which results in the deposition around the ball of a certain thickness of osteo-dentine. The pulp then resuming its healthy function, coats the surface of the osteo-dentine inclosing the ball, together with the rest of the conical cavity into which that mass projects, with layers of normal ivory.

By the continued progress of growth, the ball so inclosed is carried forward, in the course indicated by the arrow in fig. 289, to the middle of the solidified exserted part of the tusk, *c*. Should the ball have penetrated the base of the tusk of a young elephant, it may be carried on, by the uninterrupted growth and wear of the tusk, until that base has become the apex, and be finally exposed and discharged by the continual abrasion to which the apex of the tusk is subjected.

Yet none of these phenomena prove the absolute nonvascularity of the tusk, but only the low degree of its vascularity. Blood circulates, slowly no doubt, through the prolongations of the pulp into the minute vascular canals which are continued through the centre of the ivory to the very apex of the tusk: and it is from this source that the fine tubular structure of the ivory obtains the correspondingly minute villi carrying the plasmatic colourless fluid by which its low vitality is maintained.[1]

The modification of dentine called 'ivory,' is characterised partly by the minute size of the tubes, which, at their origin from the pulp cavity, do not exceed $\frac{1}{15000}$th of an inch in diameter, in their close arrangement at intervals scarcely exceeding the breadth of a single tube, and, above all, on their strong and almost angular gyrations, which are much greater than the secondary curvatures of the tubes of ordinary dentine.

The dentinal tubes of ivory, as they radiate from the pulp-cavity, incline obliquely towards the pointed end of the tusk, and describe two slight primary curves, the first convex towards that end, the second and shorter one concave: these curves in narrow sections from near the open base of the tusk are almost obscured by the strong angular parallel secondary gyrations. The tubes divide dichotomously, at acute angles, and gradually decrease in size as they approach the periphery of the tusk.

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[1] I had the tusk and pulp of an elephant at the Zoological Gardens longitudinally divided, soon after the death of that animal in the summer of 1847. Although the pulp could be easily detached from the inner surface of the pulp-cavity, it was not without a certain resistance; and when the edges of a co-adapted pulp and tooth were examined by a strong lens, the filamentary processes from the outer surface of the pulp could be seen stretching as they were withdrawn from the dentinal tubes before they broke. They are so minute that, to the naked eye, the detached surface of the pulp seems to be entire, and Cuvier was thus deceived in concluding that there was no organic connection between the pulp and the ivory. CXXXIX. Ed. 1834, tom. i, p. 535.

The characteristic appearance of decussating curved striæ, with oblique rhomboidal spaces, so conspicuous on transverse sections or fractures of ivory, is due to the refraction of light caused by the parallel secondary gyrations of the tubes above described. The strong contour lines observed in longitudinal sections of ivory, parallel with the cone of the pulp-cavity, and which are circular and concentric when viewed in transverse slices of the tusk, are commonly caused by strata of minute opaque cellules, which are unusually numerous in the interspaces of the tubes throughout the substance of the ivory, and by their very great abundance and larger size in the peripheral layers of cement. The decomposition of the fossil tusks into superimposed conical layers takes place along the strata of the opaque cellules, and directly across the course of the gyrating dentinal tubes.

By the minuteness and close arrangement of the tubes, and especially by their strongly undulating secondary curves, a tougher and more elastic tissue is produced than results from their disposition in ordinary dentine; and the modification which distinguishes 'ivory' is doubtless essential to the due degree of coherence of so large a mass as the elephant's tusk, projecting so far from the supporting socket; and to be frequently applied in dealing hard blows and thrusts.

§ 222. *Homologies of Teeth.*—In Histology tissues differ according to the kinds and degrees of force which they exercise in the living body: some, the nervous and muscular, e.g. are 'active;' others, with lower endowments of elasticity, adhesiveness, hardness, &c., may be called 'passive,' and the classes of these tissues are less definite and distinct. In considering the homology of a tooth, in reference to its class of tissue, our view of it must not be restricted to its ordinary conditions in mammalia, where a central pulp-canal radiates a single system of dentinal tubes like the lacunal tubes from a Haversian canal, but should be extended to those less specialised states of tooth in which the body of dentine is traversed by several pulp-canals, either dichotomising, as in the molar of *Orycteropus*, vol. i. p. 369, fig. 247, or ramifying throughout the dentine, as in the laniariform tooth of *Lamna* (vol. i. p. 364, fig. 241).

A vascular matrix buds out in the shark from the membrane covering the jaw, as in the deer from that covering the cranium, and the blood-vessels, ramifying through such matrix, convey the phosphate of lime which hardens it; each ultimate ramification that radiates a system of dentinal tubes in the shark's tooth, corresponds with the same ramification of the artery radiating lacunal tubes in the matrix of the deer's antler.

After the tooth of the shark has been worn by the uses for which it was calcified, it is shed like the antler, and is succeeded by another. There is merely a difference in the place of succession, the new tooth rising close to, but not, as in the antler, directly under, the base of the old.

But the basis from which the matrix of both tooth and antler grows is homologically the same. In both instances the gum, or corium, is pushed out by the growing matrix: in the deer it forms the 'velvet' which peels away from the ossified matrix, in the shark it is hardened into the enamel-like layer covering the matrix.

These are the differences that can be predicated in reference to the histological homology of the parts in question, and the shark's tooth answers to the deer's antler, *plus* the outer enamel-like covering, in mode of development, structure, growth, shedding, and succession. They correspond, alike, with osseous texture; and, under a less genus, with the parts of the dermo-skeleton.

But the tooth of a shark is homologous with that of a porpoise; therefore, teeth are referable to the dermo- or entero-skeletal parts of the osseous system.

Descending to the special homologies, we find that the idea of a recognition of answerable teeth in different animals has prevailed, more or less vaguely, in Anatomy, from an early period of the science.

When 'incisors,' 'canines,' and 'molars' were predicated of the dentition in different species, homologous teeth were recognised so far as the characters of those classes of teeth were defined and understood.

The Cuviers[1] went a step further, and distinguished the molar teeth into 'false' and 'true,' into 'carnassial' and 'tubercular.' De Blainville pointed out a particular tooth by the name of 'principal,' which he believed himself able to trace from species to species.[2]

The first step in this inquiry is the elimination of those classes of *Vertebrata* and orders of *Mammalia* in which homology cannot be predicated of individual teeth. This limits the work to the group of mammals here termed 'Diphyodonts.'

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[1] CXX″. and CXXI″.

[2] The line 'Blainville' runs through that tooth in fig. 293.

Only in the Mammalian orders with two sets of teeth do those organs acquire fixed individual characters, supporting the application of special denominations; and this individualisation of the teeth is significative of the high grade of organisation of the animals manifesting it.

Originally, indeed, the name ‘incisors,’ ‘laniaries’ or ‘canines,’ ‘molars,’ ‘tuberculars,’ were given to the teeth in Man and certain Mammals, as in Reptiles, in reference merely to the shape and offices so indicated; but names of teeth can now be used as arbitrary signs, in a more fixed and determinate sense. In some *Carnivora*, e.g., the front teeth have tuberculate summits, adapted for nipping and bruising, while the principal back teeth are shaped for cutting, and work upon each other like the blades of scissors. The front teeth in the Elephant project from the upper jaw in the form, size, and direction of long pointed horns. In short, shape and size are the least constant of dental characters; and the homologous teeth are determined, like other parts, by their relative position, by their connections, and by their development.

Those teeth which are implanted in the premaxillary bones, and in the corresponding part of the lower jaw, are called ‘incisors,’ whatever be their shape or size. The tooth in the maxillary bone, which is situated at, or near to, the suture with the premaxillary, is the ‘canine,’ as is also that tooth in the lower jaw which, in opposing it, passes in front of its crown when the mouth is closed. The other teeth of the first set are the ‘deciduous molars;’ the teeth which displace and succeed them vertically are the ‘premolars;’ the more posterior teeth, which are not displaced by vertical successors, are the ‘molars,’ properly so called.

The premolars must displace deciduous molars in order to rise into place; the molars are a continuation, backward, of the primary or ‘milk’ series. It will be observed in fig. 294 that the last deciduous molar, *d* 4, has the same relative superiority of size to *d* 3 and *d* 2 which *m* 3 bears to *m* 2 and *m* 1; and that the crowns of *p* 3 and *p* 4 are of a more simple form than those of the milk-teeth which they are to succeed: this, however, is not a constant character (see fig. 287, *Hyrax*). Teeth of each of the kinds arbitrarily termed ‘incisors,’ ‘canines,’ ‘false molars,’ and ‘molars,’ have received other special names, having reference to certain peculiarities of form or other property. The premolars in the human subject have been called ‘bicuspids.’ The last upper premolar and the first true molar in the *Carnivora* are termed 'sectorials,' or 'molaires carnassières.' Teeth of an elongated conical form, projecting considerably beyond the rest, and of uninterrupted growth, are called 'tusks;' such, for example, are the incisors of the elephant, narwhal, dinotherium, and dugong, the canines of the boar, walrus, and hippopotamus. The long and large incisors of the rodents have been termed, from the shape and structure of their cutting edge, scalpriform teeth, chisel teeth, 'dentes scalprarii.' The lower incisors of the colugos (*Galeopithecus*), with the crown deeply notched like a comb, are termed 'dentes pectinati.' The canines of the baboons, which are deeply grooved in front like the poison-fangs of some snakes, are 'dentes canaliculati.' The compressed crowns of the teeth of short-clawed seals (*Stenorhynchus*) and of the extinct *Zeuglodon*, being divided into points like a saw, are 'dentes serrati,' &c. But a true knowledge of nature, a right appreciation of what is essential in her phenomena, tends to explode needless terms of art invented for unimportant varieties, and to establish those names that are the signs of true species of things.

As most zoologists have adopted the Cuvierian system of nomenclature and homology of the teeth in Mammalia, it may not be superfluous to explain what is objectionable in that system. In it the molar series of teeth, or those that follow the canines, are divided, according to their form, into three kinds, 'false molars,' 'carnassials,' and 'tubercular molars,' and the generic dental characters of the Mammalia are formulised according to this system. Thus, the genus *Felis* has—'fausses molaires' $\frac{2}{2}:\frac{2}{2}$, 'carnassières' $\frac{1}{1}:\frac{1}{1}$, 'tuberculeuses' $\frac{1}{0}:\frac{1}{0}=\frac{8}{6}$. This seems a natural way of expressing the homotypal teeth, or the answerable teeth in the upper and lower jaws. But to illustrate its error, the subjoined diagram, fig. 293, is appended, in which the dental system of the Cat-tribe (*Felis* v.) is associated with that of other Mammals, and in which the line marked '*Cuvier*' intersects the teeth in each jaw, called 'carnassières,' those anterior to them being the teeth called 'fausses molaires;' those behind—a single tooth in the upper jaw of *Felis*—being the 'tuberculeuses.' In this genus the tooth, *p* 4, above chiefly plays upon the tooth, *m* 1, below, which has a similar sectorial or carnassial modification of form; they fit, indeed, almost as Cuvier describes, like the blades of a pair of scissors. The two teeth in advance of the carnassial in the upper jaw, *p* 3, *p* 2, in like manner are opposed to the same number of 'fausses molaires' in the under jaw, and the canine, *c*, above plays upon the canine below:

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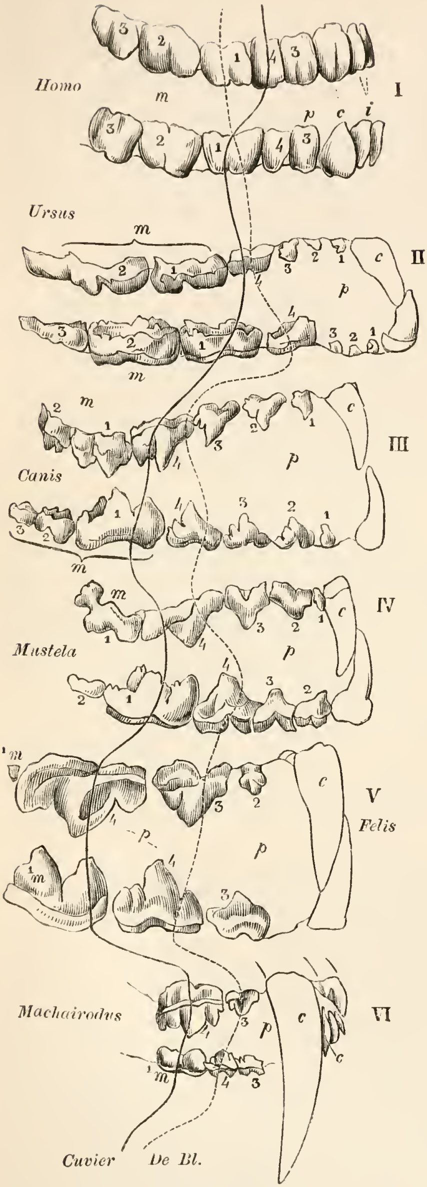

Homologies of Teeth.

all seems fitting and symmetrical, save that the little tubercular, *m* 1, above has no opponent in the lower jaw. And, perhaps, the close observer might notice that, whilst the upper canine, *c*, glides behind its homotype below, the first upper false molar, *p* 2, passes anterior to the crown of the first false molar, *p* 3, below; and that the second false molar, *p* 3, and carnassial, *p* 4, of the upper jaw are also a little in advance of those teeth, *p* 4, *m* 1, in the under jaw, when the mouth is shut.

In passing to the dentition of the Dog, ib. III. *Canis*, formulised by Cuvier as 'fausses molaires $\frac{6}{8}$, carnassières $\frac{2}{2}$, tuberculeuses $\frac{4}{4}=\frac{1\ 2}{1\ 4}$,'[1] it will be observed that here the first upper false molar, *p* 1, differs from the first, *p* 2, in *Felis*, inasmuch as, when the mouth is shut, it preserves the same relative position to its opponent below, *p* 1, in III., which the upper canine does to the lower canine, and that the same may be said of the second and the third false molars; but that, with regard to the carnassial above, *p* 4, this tooth repeats the same relative position in regard to the fourth false molar below, *p* 4, and not to that tooth, *m* 1, which Cuvier regarded as the lower homotype of the carnassial; and, indeed, the more backward position of the lower carnassial is so slight that its significance might well be overlooked, more especially as the two succeeding tubercular teeth above were opposed to two similar tuberculars below.

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[1] cxxi″. p. 95.

How unimportant size and shape are, and how significant relative position is, in the determination of the homologies of teeth as of other parts, may be learnt before quitting the natural order of *Carnivora*; e. g. by the condition of the dental system in the Bear, ib. II. *Ursus*. Here the lower tooth, *m* 1, instead of presenting the carnassial character, and resembling in form the upper tooth, *p* 4, which is the homologue of the upper carnassial in the dog, has a tubercular crown, and corresponds in size as well as shape with the upper tooth, *m* 1, to which it is almost wholly opposed, and with the same slight advance of position which we observe in the lower canine as compared with the upper one, and in the four lower premolars, *p* 1, *p* 2, *p* 3, *p* 4, as compared with their veritable homotypes above. F. Cuvier divides the molar series of the genus *Ursus* into 'fausses molaires $\frac{6}{8}$, carnassières $\frac{2}{2}$, tuberculeuses $\frac{4}{4}=\frac{1}{1}\frac{2}{4}$.'[1] The tendency in every thinker to generalise and to recognise Nature's harmonies, has led him here to use the term 'carnassière' in an arbitrary sense, and to apply it to a tooth above (II. *p* 4), which he owns has such a shape and diminished size as would have led him to regard it as merely a false molar, but that the upper carnassial would then have entirely disappeared; and it has also led him to give the name 'carnassière' to a tooth below, *m* 1, which he, nevertheless, describes as having a tubercular and not a trenchant crown. In so natural a group as the true *Carnivora*, it was impossible to overlook the homologues of the trenchant carnassials of the lion, even when they had become tubercular in the omnivorous bear; and Cuvier, therefore, having determined and defined the teeth so called in the feline genus, felt compelled to distinguish them by the same names after they had lost their formal specific character. And if, indeed, he had succeeded in discovering the teeth which were truly answerable or homotypal in the upper and lower jaws, the term 'carnassial' might have been retained as an arbitrary one for such teeth, and have been applied to their homologues in Man and other diphyodonts, where they are as certainly determinable as in those aberrant Carnivores, in which they have equally lost their sectorial shape.

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[1] CXXI″. p. 109.

But the inconvenience of names indicative of such specialties of form will be very obvious when the term 'tuberculeuses' comes to be applied to the three hindmost teeth in the *Hyænodon* (fig. 266), which teeth answer to the broad crushing teeth, *m* 1, *m* 2, and *m* 3, in the bear and some other existing *Carnivora*. The analogous term 'molar' having a less direct or descriptive meaning, is therefore so much the better, as the requisite arbitrary name of a determinate species of teeth.

Had Cuvier been guided in his determinations of the teeth by their mutual opposition in the closed mouth, and had studied them with this view in the *Carnivora* with the dentition most nearly approaching to the typical formula, viz. the Bear, he could then have seen that the three small and inconstant lower premolars, *p* 1, *p* 2, *p* 3, were the homotypes of the three small and similarly inconstant premolars above; that the fourth false molar, *p* 4 below, which, as he observes, 'alone has the normal form,'[1] was truly the homotype of the tooth above, *p* 4, which he found himself compelled to reject from the class of 'fausses molaires,' notwithstanding it presented their normal form; that the tubercular tooth, *m* 1, which he calls 'carnassière' in the lower jaw, was the veritable homotype of his first 'molaire tuberculeuse' above, *m* 1, and that the tooth in the inferior series, which had no answerable one above, was his second 'tuberculeuse,' *m* 3, in the present work. The true second tubercular above, *m* 2, is, however, so much developed in the Bear as to oppose both *m* 2 and *m* 3 in the lower jaw, and it might seem to include the homotypes of both those teeth coalesced. One sees with an interest such as only these homological researches could excite, that they were distinctly developed in the ancient *Amphicyon*, fig. 267, which accordingly presents the typical formula.

Thus the study of the relative position of the teeth of the Bear might have led to the recognition of their real nature and homologies, and have helped to raise the mask of the extreme formal modifications, by which they are adapted to the habits of the more blood-thirsty *Carnivora*. But the truth is plainly revealed when we come to trace the course of development and succession of these teeth. As the question only concerns the molar series, the remarks will be confined to those teeth. In the jaws of the young Bear, fig. 263, the first premolar is the only one of the permanent series in place; the other grinders in use are the deciduous molars, *d* 2, *d* 3, and *d* 4; *d* 2 will be displaced by *p* 2, *d* 3 by *p* 3, and *d* 4 by the tooth *p* 4, which, notwithstanding its size and shape, Cuvier felt himself compelled to discard from the series of false molars, but which we now see is proved by its developmental relations to *d* 4, as well as by its relative position and similarity to *p* 4 in the lower jaw, fig. 292, II., *Ursus*, to be veritably the last of the premolar series, and to agree not in shape only, but in every essential character, with the three preceding teeth called by Cuvier 'fausses molaires.' So, likewise, in the lower jaw, it is seen that the primitive deciduous series, fig. 263, *d* 1, *d* 2, *d* 3, and *d* 4, will be displaced by the corresponding premolars, *p* 1, *p* 2, *p* 3, *p* 4; and that the tooth *m* 1, called carnassière by Cuvier, in the lower jaw, differs essentially from that, *p* 4, so called in the upper jaw, by being developed without any vertical predecessor or deciduous tooth.

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[1] CXXI″. p. 111.

The same law of development and succession prevails in the genus *Canis* as may be readily seen in the jaws of a dog of ten months' age. Although the tooth, *m* 1, III. fig. 293, in the lower jaw has exchanged the tubercular for the carnassial form, it is still developed, as in the Bear, behind the deciduous series, and independently of any vertical predecessor, fig. 262, *m* 1; and the tooth, ib. *p* 4, above, although acquiring a relative superiority of size to its homologue in the Bear, and more decidedly a carnassial form, is not the homotype of the permanent carnassial below, but of that premolar, *p* 4, which displaces the deciduous carnassial, *d* 4. The symbols in fig. 293, III., sufficiently indicate the relations of the other teeth, and the conclusions that are to be drawn from them as to their homologies.

In the genus *Felis*, fig. 260, the small permanent tubercular molar of the upper jaw, *m* 1, has cut the gum before *d* 4 has been shed; but though analogous in function, this tooth is not homologous with, or the precedent tooth to *m* 1, but precedes the great carnassially modified premolar, *p* 4. In the lower jaw the tooth, *m* 1, which is functionally analogous to the carnassial above, is also, as in the Dog, the first of the true molar series, and the homotype of the little tubercular tooth, *m* 1, above. And the homologues of the permanent teeth, *p* 4 and *m* 1 below, fig. 293, V., with those so symbolised in the Dog, ib. III., teach us that the teeth which are wanting in the feline, in order to equal the number of those in the canine dentition, are *m* 2 in the upper jaw, *m* 2 and *m* 3 in the lower jaw; *p* 1 in the upper jaw, *p* 1 and *p* 2 in the lower jaw; thus illustrating the rule, that, when the molar series falls short of the typical number, it is from opposite extremes of such series that the teeth are taken, and that so much of the series as is retained is thus preserved unbroken.

In the great extinct sabre-toothed Tiger, *Machairodus*, fig. 293, VII., the series is still further reduced by the loss of *p* 2, in the upper jaw.

In the common Cat, the deciduous incisors, *d i*, begin to appear between two and three weeks old; the canines, *d c*, next, and then the molars, *d m*, follow, the whole being in place before the sixth week. After the seventh month they begin to fall in the same order; but the lower sectorial molar, *m* 1, and its tubercular homotype above, *m* 1, appear before *d* 2, *d* 3, and *d* 4 fall. The longitudinal grooves are very faintly marked in the deciduous canines. The first deciduous molar, *m* 2, in the upper jaw is a very small and simple one-fanged tooth; it is succeeded by the corresponding tooth of the permanent series, which answers to the second premolar, *p* 2, of the Hyæna and Dog. The second deciduous molar, *m* 3, is the sectorial tooth; its blade is trilobate, but both the anterior and posterior smaller lobes are notched, and the internal tubercle, which is relatively larger than in the permanent sectorial, is continued from the base of the middle lobe, as in the deciduous sectorial of the Dog and Hyæna; it thus typifies the form of the upper sectorial, which is retained in the permanent dentition of several Viverrine and Musteline species. The third or internal fang of the deciduous sectorial is continued from the inner tubercle, and is opposite the interspace of the two outer fangs. The Musteline type is further adhered to by the young Feline in the large proportional size of its deciduous tubercular tooth, *d* 4. In the lower jaw, the first milk-molar, *d* 3, is succeeded by a tooth, *p* 3, which answers to the third lower premolar in the Dog and Civet. The deciduous sectorial, *d* 4, which is succeeded by the premolar, *p* 4, answering to the fourth in the Dog, has a smaller proportional anterior lobe, and a larger posterior talon, which is usually notched; thereby approaching the form of the permanent lower sectorial tooth in the *Mustelidæ*.

When the premolars and the molars are below their typical number, the absent teeth, as a rule,[1] are missing from the forepart of the premolar series and from the back-part of the molar series. The most constant teeth are the fourth premolar and the first true molar; and these being known by their order and mode of development, the homologies of the remaining molars and premolars are determined by counting the molars from before backwards, e.g. ‘one,’ ‘two,’ ‘three’; and the premolars from behind forwards, ‘four,’ ‘three,’ ‘two,’ ‘one.’

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[1] In some instances the first premolar or first milk-molar remains, of small size, when *p* 2 and *p* 3 are lost.

Examples of the typical diphyodont dentition are exceptions in the actual creation; but it was the rule in the earlier forms of placental Mammalia, whether the teeth were modified for animal or vegetable food.

Not only the *Hyænodon*, fig. 266, and *Amphicyon*, fig. 267, but the *Dichodon, Anoplotherium, Palæotherium, Chæropotamus, Anthracotherium, Hyopotamus, Pliolophus, Hyracotherium,* and many other ancient (eocene and miocene) tertiary Mammalian genera presented the forty-four teeth, in number and kind according to that which is here propounded as the typical or normal dentition of the placental diphyodonts. When the clue is afforded to their homologies, it infallibly conducts to the true knowledge of the nature both of the teeth which are retained, and of those which are wanting to complete the typical number. Thus may be deciphered the much modified dentition of the genus *Felis;* and the same clue will guide to the knowledge of the precise homologies of the teeth in our own species.

The known limits of the premaxillary in Man leads to the determination of the incisors, which are reduced to two on each side of both jaws; the contiguous tooth shows by its shape as well as position that it is the canine; and the characters of size and shape have also served to divide the remaining five teeth in each lateral series into two bicuspids and three molars. In this instance the secondary characters conform with the essential ones, as exhibited in the dissection of the jaws of a child of about six years of age, fig. 258. The two incisors on each side, *d i*, are followed by a canine, *c*, and this by three teeth having crowns resembling those of the three molar teeth of the adult. In fact, the last of the three is the first of the permanent molars; it has pushed through the gum, like the two molars which are in advance of it, without displacing any previous tooth, and the substance of the jaw contains no germ of any tooth destined to displace it; it is therefore, by this character of its development, a true molar, and the germs of the permanent teeth, which are exposed in the substance of the jaw between the diverging fangs of the molars, *d* 3 and *d* 4, prove them to be temporary, destined to be replaced, and prove also that the teeth about to displace them are premolars. According, therefore, to the rule previously laid down, we count the permanent molar in place the first of its series, *m* 1, and the adjoining premolar as the last of its series, and consequently the fourth of the typical dentition, *p* 4.

We are thus enabled, with the same scientific certainty as that whereby we recognise in the middle toe of our foot the homologue of that great digit which forms the whole foot, and is encased by the hoof, in the horse, to point to *p* 4, or the second bicuspid in the upper jaw, and to *m* 1, or the first molar in the lower jaw, of Man, fig. 293, I., as the homologues of the great carnassial teeth of the Lion, *p* 4, *m* 1, ib. V. We also conclude that the teeth which are wanting in Man to complete the typical molar series, are the first and second premolars, the homologues of those marked *p* 1 and *p* 2 in the Bear, ib. II. The characteristic shortening of the maxillary bones required this diminution of the number of their teeth, as well as of their size, and of the canines more especially; and the still greater curtailment of the premaxillary bone is attended with a diminished number and an altered position of the incisors.

The homologous teeth being thus determinable, they may be severally signified by a symbol as well as by a name. The incisors, e.g., are represented in the present work by their initial letter *i*, and individually by an added number, *i* 1, *i* 2, and *i* 3, counting from the medial line outwards; the canines by the letter *c*; the premolars by the letter *p*; and the molars by the letter *m*; these also being differentiated by added numerals. Thus, the number of these teeth, on each side of both jaws, in any given species, Man, e.g., may be expressed by the following brief formula:—

$$i\,\frac{2.2}{2.2};\ c\,\frac{1.1}{1.1};\ p\,\frac{2.2}{2.2};\ m\,\frac{3.3}{3.3} = 32;$$

and the homologies of the individual teeth, in relation to the typical formula, may be signified by *i* 1, *i* 2; *c*; *p* 3, *p* 4; *m* 1, *m* 2, *m* 3; the suppressed teeth being *i* 3, *p* 1, and *p* 2.

The soundness of the foregoing conclusions as to the nature of the teeth absent in the reduced dental formula of Man, is exemplified by the mode in which the type is progressively resumed in descending from Man through the order most nearly allied to our own.

Through a considerable part of the Quadrumanous series, the same number and kinds of teeth are present as in Man, the first deviation being the sexual disproportionate size of the canines and the concomitant break or 'diastema' in the dental series for the reception of their crowns when the mouth is shut. This is manifested in Gorillas, Chimpanzees and Orangs, together with the sexual difference in the proportions of the canine teeth. Then comes the added premolar in the New World Monkeys, fig. 251, *p* 2, and the further additions in lower quadrupeds, until in the Hog genus we see the old primitive type of diphyodont dentition resumed or retained.

In the genus *Sus*, fig. 293 illustrates the phenomena of development which distinguish the premolars from the molars. At the stage exemplified the first premolar,[1] *p* 1, and the first molar, *m* 1, are in place and use, together with the three deciduous molars, *d* 2, *d* 3, and *d* 4; the second molar, *m* 2, has just begun to cut the gum; *p* 2, *p* 3, and *p* 4, together with *m* 3, are more or less incomplete and concealed in their closed alveoli.

The premolars displace deciduous molars in order to rise into place; the molars have no such relations; it will be observed, that the last deciduous molar, *d* 4, has the same relative superiority of size to *d* 3 and *d* 2 which *m* 3 bears to *m* 2 and *m* 1; and the crowns of *p* 3 and *p* 4 are of a more simple form than those of the milk-teeth which they are destined to succeed.

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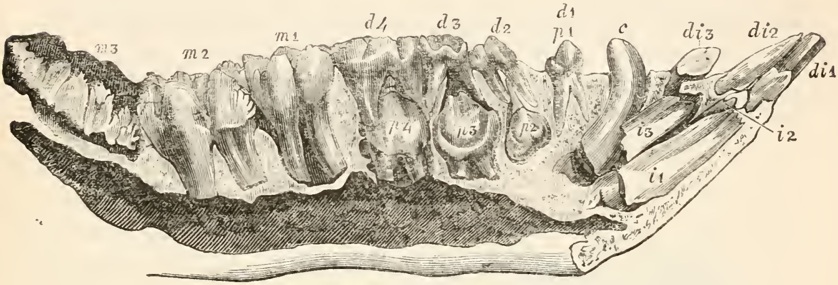

Deciduous and permanent teeth (*Sus*). Lower jaw

The premolars have a more simple structure as well as smaller size, than the true molars, in all Artiodactyles. In the Ruminants they represent only the moiety of the true molars, or one of the two semi-cylindrical lobes of which those teeth consist, with, at most, a rudiment of the second lobe. The Perissodactyles are distinguished by the size and complexity of more or less of the premolars. In *Equus*, *p* 2, *p* 3 and *p* 4, even exceed in size *m* 1, *m* 2 and *m* 3. In *Rhinoceros* and *Palæotherium* the proportions of the molars and premolars are reversed; but the structure is the same. In *Lophiodon*, *Coryphodon* and *Pliolophus* the premolars become more simplified as well as diminished, approaching to a common Ungulate type. In the Proboscidian group, the oldest species indicate retentions of type unknown in the dentition of existing Elephants. A premolar, fig. 295, *p* 3, displaces vertically the second deciduous grinder, *d* 3, in some Mastodons: and, that the third molar in the order of appearance, *d* 4, is also the last of the deciduous series, is indicated by the contrasted superiority of size of the tooth, *m* 1, that follows. The great extent and activity of the processes of dental development required for the preparation of the large and complex true molar teeth, would seem to exhaust the power in Proboscidians, which, in ordinary Pachyderms, is expended in developing the vertical successors of the deciduous teeth. In the miocene Mastodon above cited, this normal exercise of the reproductive force was not, however, wholly exhausted; and one premolar, fig. 295, *p* 3, of more simple form than its deciduous predecessor, was developed on each side of both jaws. Another mark of adhesion to the archetype was shown by the development of two incisors in the lower jaw in the young of some Mastodons, by the retention and development of one of these inferior tusks in the male of the *Mastodon giganteus* of North America, and by the retention of both in the European *Mastodon longirostris*, Kaup. No trace of these inferior homotypes of the premaxillary tusks have been detected in the fœtus or young of the existing elephants. In the gigantic *Dinotherium*, the upper incisors were suppressed, and the lower incisors were developed into huge tusks, which curved down from the symphysis of the massive lower jaw.

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[1] If this tooth have not displaced a minute milk-molar, it may be reckoned a *d* 1, which is longer retained than the rest of the deciduous molars; in this degree the type-dentition is departed from.

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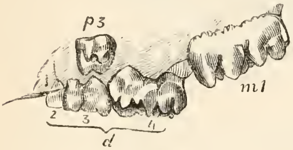

Deciduous teeth, Mastodon.

The chief modifications of the marsupial dentition have already been described and illustrated. The observed phenomena of the development and change of the teeth led to the generalisation that the marsupial differed from the placental Diphyodont mammals in having four true molars, i. e., $m\ \frac{4}{4}:\frac{4}{4}$ instead of $m\ \frac{3}{3}:\frac{3}{3}$; and also that they differed in having only three premolars, i. e. $p\ \frac{3}{3}:\frac{3}{3}$ instead of $p\ \frac{4}{4}:\frac{4}{4}$; the typical number of the grinding series, $\frac{7}{7}:\frac{7}{7}$, being the same; and it was convenient for comparison to symbolise them accordingly, in figs. 221–230. Since, however, there is reason to conclude that *m* 1 in the placental Diphyodonts, as, e. g., figs. 259 and 294, is a continuation of the deciduous series of molars, which might be symbolised as *d* 5, and only becomes a permanent molar because there is no premolar developed above it, so we may regard the tooth marked *m* 1 in figs. 221–230 as being an antecedent tooth of the deciduous series, rendered permanent by a like reason, the suppression, viz. of *p* 4. In other words, that *m* 1 in fig. 227 is the homologue of *d* 4 in fig. 294, and that the true homologue of *p* 4 is not developed in the *Marsupialia.*

The homologies of the teeth of the Kangaroo are illustrated in fig. 296, according to this idea of them; the dental formula of both the *Macropodidæ* and *Hypsiprymnidæ* being—

$$i\,\frac{3.3}{1.1};\ c\,\frac{1.1}{0.0};\ p\,\frac{1.1}{1.1};\ d\,\frac{1.1}{1.1};\ m\,\frac{3.3}{3{\cdot}3} = 30:$$

instead of—

$$i\,\frac{3.3}{1.1};\ c\,\frac{1.1}{0.0};\ p\,\frac{1.1}{1.1};\ m\,\frac{4.4}{4.4} = 30.$$

The canines, which are confined to the upper jaw, are small or minute when retained; and disappear after being represented ‘en germe’ in most of the true Kangaroos.

In the deciduous dentition of the great Kangaroo (*Macropus major*) the canines are rudimental, and are absorbed rather than shed. No other of the deciduous series is calcified, save the molars *d* 2 and *d* 3, fig. 296, unless the permanent incisors be developed and retained milk-teeth. When the young animal finally quits the pouch the dentition is—

$$d\,i\,\frac{1.1}{1.1};\ d\,m\,\frac{2.2}{2.2} = 12;$$

the upper incisors being *i* 1, the molars *d* 2 and *d* 3 of the typical dentition. This stage is exemplified in the lower jaw at A (fig. 296). The next stage shows the acquisition of *i* 2 in the upper jaw, and *d* 4 in both jaws, and the formula is—

$$d\,i\,\frac{2.2}{1.1};\ d\,m\,\frac{3.3}{3.3} = 18,\ \text{ib. B.}$$

At one year old, the dentition is—

$$d\,i\,\frac{3.3}{1.1};\ d\,m\,\frac{3.3}{3.3};\ m\,\frac{1.1}{1.1} = 24;$$

the additional teeth being *i* 3 and *m* 1 (ib. C), in which the demonstration of the true deciduous character of *d* 2 and *d* 3 is shown by the germ of their vertical successor *p* 3, which is exposed in the substance of the jaw. The next stage is the shedding of *d* 2, and the acquisition of *m* 2 (ib. D). Then *d* 3 is shed by

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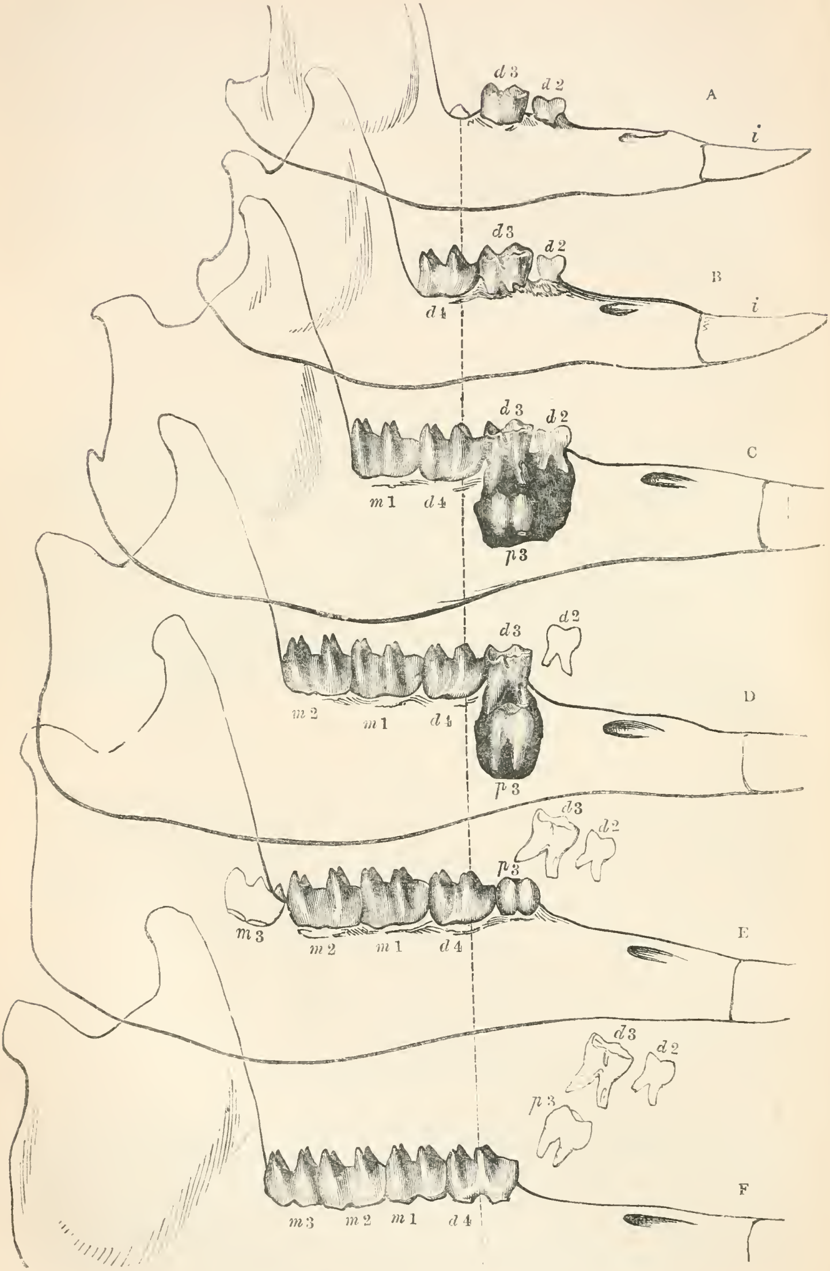
d 3
d 2
A
i
d 3
d 2
B
d 4
i
d 3
d 2
C
m 1
d 4
p 3
d 2
d 3
D
m 2
m 1
d 4
p 3
d 3
d 2
p 3
E
m 3
m 2
m 1
d 4
d 3
d 2
p 3
F
m 3
m 2
m 1
d 4

Development and succession of the molar series, Kangaroo.

the ascent of *p* 3 into its place (ib. E). Afterwards *m* 3 is acquired; and in the *Macropus gigas*, *p* 3, simultaneously pushed out (ib. F).

Thus, four individuals of this species may be found to have the same number of molars, i. e. $\frac{4}{4}:\frac{4}{4}$; two of these individuals may seem, on a cursory comparison, to have them of the same shape, e. g., as in C and E, or as in D and F, fig. 296. In fact, to determine the identity or difference in such instances, it requires that the substance of the jaws be examined, to see if the germs of successional teeth are present, as at *p* 3, C and D, or at *m* 3, E. The result of such examination may be to show that not one of the four Kangaroos with the *m* $\frac{4}{4}:\frac{4}{4}$ had the same or homologous teeth.

The four grinders, e. g. may be—*d* 2, *d* 3, *d* 4, *m* 1; as in C; or *d* 3, *d* 4, *m* 1, *m* 2; as in D; or *p* 3, *d* 4, *m* 1, *m* 2; as in E; or *d* 4, *m* 1, *m* 2, and *m* 3; as in F.

The changes, however, do not end here. As age advances, *d* 4 is shed, and the molar series is reduced numerically to the condition of B; but, instead of *d* 2, *d* 3, and *d* 4, it consists of *m* 1, *m* 2, *m* 3.

Finally, *m* 1 is shed, and the dentition is reduced to the same numerical state as at A; the teeth, however, being *m* 2 and *m* 3.

The symbols used, it is hoped, are so plain and simple as to have formed no obstacle to the full and easy comprehension of the facts explained by means of them. If these facts, in the manifold diversities of Mammalian dentition, were to be described in the ordinary way, by verbal definitions, e. g., 'the second deciduous molar representing the third in the typical dentition,' instead of *d* 3, and so on, the description of dental development would continue to occupy much unnecessary space, and would levy such a tax upon the attention and memory as must tend to enfeeble the judgment and impair the power of seizing and appreciating the results of the comparison.

Each year's experience has strengthened the writer's conviction that the rapid and successful progress of the knowledge of animal structures, and of the generalisations deducible therefrom, will be mainly influenced by the determination of the homology of parts and organs, and by the concomitant power of condensing the propositions relating to them, and of attaching to them signs or symbols equivalent to their single substantive names. In the writer's Works, CXL, CXLI, CXLIV, he has denoted most of the bones by simple numerals. The symbols of the teeth are fewer in number, are easily understood and remembered, and, if generally adopted, might take the place of names. They would then render unnecessary the repetition of phrases, harmonise conflicting synonyms, serve as a universal language, and at the same time express the expositor's meaning in the fewest and clearest terms. The entomologist has long found the advantage of such signs as ☿ and ♀, in reference to the sexes of insects, and the like; and it is hoped that the time is now come when the anatomist may avail himself of this powerful instrument of thought, instruction, and discovery, from which the chemist, the astronomer, and the geometrician have obtained such important results.

CHAPTER XXX.

ALIMENTARY CANAL AND APPENDAGES OF MAMMALS.

§ 223. *Mouth.*—Fleshy lips form the main characteristic of the mammalian mouth. But they are wanting in the Monotremes, with other significant shortcomings of mammalian excellence. Lips are, here, transitorily manifested, it is true, at the suckling period; but soon degenerate into the pergameneous border of the beak in *Platypus*, and are reduced, in *Echidna*, to the scarcely movable margin of the small terminal oral orifice of the adult. The *Cetacea* show the greatest extremes within the limits of a natural group in the development of the lips. They are barely represented in the Porpoise, fig. 297, and other *Delphinidæ* by the low, firm, ridge of integument, supported by adipo-fibrous tissue with scarce a trace of 'orbicularis oris': while in the Whale (*Balæna*) the upper lip falls down like a thick curtain some feet in depth concealing the baleen, and overlapping the

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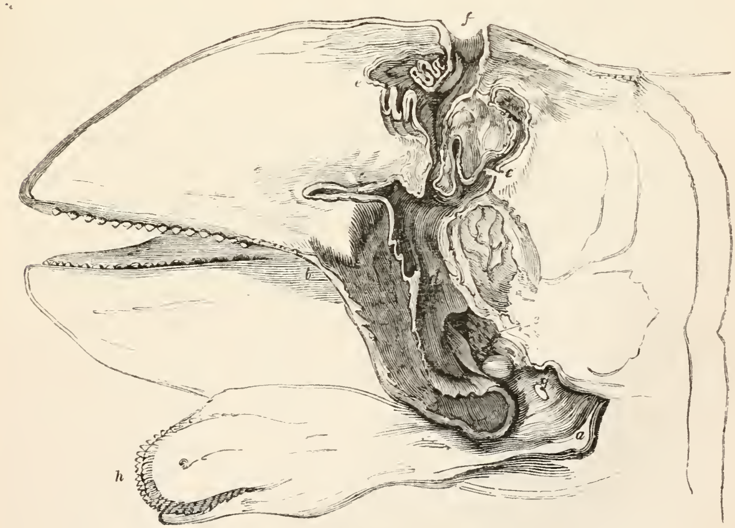

Section of mouth and nose, Porpoise.

mandible when the mouth is closed. The side-walls of the mouth are not dilatable and contractile so as to vary the capacity of the buccal cavity, like the 'cheeks' in most other mammals. As a rule, in the present class, the mouth is terminal: when not so, a rostral production, analogous to that in Sharks, makes the opening inferior, as in the Tapir, fig. 155. In the Chrysochlore the mouth is a small triradiate slit, like that of a leech, on the under surface of the muzzle: it has a like inferior position, but is more deeply cleft in Shrews, in which the groove that runs along the mid-line of the under surface of the snout represents the third ray of the closed mouth. The remoteness of the mouth from the end of the muzzle is in the ratio of the length of the latter: consequently, among the Shrews, it is greater in those (*Petrodromus*, *Rhynchocyon*, fig. 298) which, from the production of the snout, have been called 'Elephant Mice': still more so in the Elephant itself, vol. ii. fig. 162.

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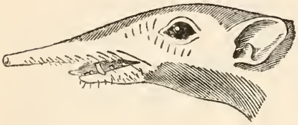

Head of Rhynchocyon. LXXXIV'.

The Ornithorhynchus subsists on aquatic insects, larvæ, mollusks, and other small invertebrates which conceal themselves in the mud and banks of rivers, and is provided with a mouth nearly resembling the flat and sensitive bill of a lamellirostral bird. The jaw-bones are invested by a smooth coriaceous integument, vol. ii. fig. 199, A, E, *a*, devoid of hair, but perforated by innumerable minute foramina. At the base of the jaws this integument is produced into a free fold, which overlaps the hairy covering of the cranium immediately behind it. The integument covering the upper mandible extends beyond the margins of the bone, and forms a tumid, smooth, and highly sensible border; the narrower and shorter under jaw is more closely invested: the oral or upper surface of the lateral part of the under jaw supports a series of about twenty nearly transverse folds, increasing in breadth as they approach the angle of the jaw: the corresponding surface of the upper jaw is smooth. On the outside of the posterior part of each molar in the lower jaw, is the orifice of an oblong cheek-pouch, fig. 3, F, F, about two inches in length, and half an inch in diameter: the pouch is continued backward, and is lined with a hard dry cuticle. The raised posterior lobe of the tongue, fig. 212, *f*, with the projecting horny bodies, *g*, *g*, can impede the passage of unmasticated food to the pharynx, and direct it on each side into the cheek-pouches; whence the Ornithorhynchus may transfer its store at leisure to the molar teeth, and complete its preparation for deglutition. An air-breathing warm-blooded animal, which obtains its food, while submerged, by the capture of small aquatic animals, must derive great advantage from the structure which enables it to transfer them quickly to a temporary receptacle, whence they may be extracted and masticated while the animal is floating on the surface or at rest in its burrow. The soft palate is thick, broad, and divided posteriorly into three fimbriated lobes. The pharynx is narrow, and is encompassed by two posterior processes of the thyroid cartilage, fig. 212, *c*, *c*. The long tubular mouth in *Echidna*, like that in the Anteaters, is remarkable for its small orifice, fig. 302. The palate is armed with six or seven transverse rows of strong, sharp, but short retroverted spines. The tongue is long and slender, as in the true Anteaters; its dorsum is broad, flat, callous, and beset with hard papillæ, and the insects are doubtless crushed between these and the palatal spines. As, however, the food undergoes less comminution in the mouth of this Monotreme than in that of the Ornithorhynchus, the pharynx is wider.

The jaws of the *Marsupialia* are covered by well-developed fleshy lips; the upper one is partially cleft in the Kangaroos, as in some Rodents; the muzzle is clad with hair in *Macropus major* and a few other species; but in most Marsupials it is naked, and generally red from the vascularity of the integument. The palate is sculptured with transverse ridges. These are most numerous in the Bandicoots, being fourteen in the *Perameles nasuta*, and are slightly curved forwards: the roughness thus produced must aid the tongue in retaining small insects. In a few species of Marsupials I have detected cheek-pouches. In the Koala they are wide and shallow, situated one on each side of the upper lip; the orifice is opposite the first superior premolar, and leads forward above a horizontal fold of the mucous membrane which attaches the upper lip to the side of the premaxillary bone, separating this part of the cheek-pouch from the mouth. In the *Perameles lagotis* there are also two small fossæ, one on the inside of each cheek, about four lines in diameter, and lined by a very distinct white epithelium. The aquatic Opossum (*Didelphys Yapock*) has large cheek-pouches, extending far back into the mouth, in which, like the Ornithorhynchus, it may stow away fresh-water insects, crustacea, &c. The fauces are wide in the zoophagous, but narrow in the entomophagous and phytophagous Marsupials. The tonsils are represented by a pair of small glandular cavities.[1]

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[1] xx. vol. iii. p. 81.

In *Rodentia* the scalpriform incisors are commonly more or less exposed in front of the mouth; and, as their office is to reduce the food to small bits, the mouth is small. A groove running thereto from the nostrils divides the upper lip, conspicuously so in the species which has suggested for this modification in other animals the name 'hare-lip.' But in a few Rodents, e.g. Mole-rats (*Orycteropus, Spalax*), the undivided upper lip surrounds the bases of the huge pair of incisors by a kind of hairy sheath, and the lower lip is similarly modified in relation to the prominent lower incisors. The hairy integument is continued or reflected within the mouth in some degree in most Rodents. In the Paca (*Cœlogenys*) it is continued along the inside of the cheeks, with an accession of glandular follicles; then, losing the hair, it lines a large cavity formed by the singular expansion of the zygomatic process of the maxillary and by the malar bone, vol. ii. fig. 237, 21, 26. Some Rodents have duplicatures of the buccal membrane, outside the zygomata, and capable of expansion, for storage and conveyance of alimentary substances. Fig. 299 shows these 'cheek-pouches' in *Geomys bursarius*, everted and inflated: a more natural view of this buccal appendage is given in the dissection, fig. 300, of the head of an African pouched rat. In this species (*Saccostomus lapidarius*, Peters) an orifice at the angle of the mouth leads to the pouch, widening from the orbit to the lower border of the mandible, and reaching back as far as beneath the ear. In the Hamster (*Cricetus*) the wide orifice of the pouch is just within the commissure of the short lips: the bag itself extends along the side of the head to the neck. The orifice has a sphincter, and from this there diverge longitudinal fasciculi backward over the wall of the cavity, which is also provided with fibres from the dorso-lateral panniculus carnosus: these tending to retract the pouch-walls, while the others draw them forward, and both combining to empty the pouch. *Saccomys* and *Spermophilus*

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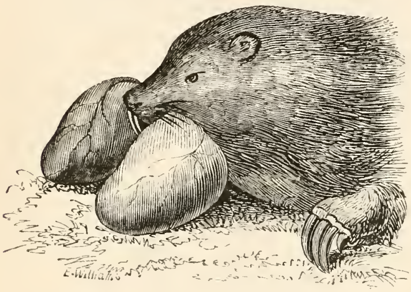

Cheek-pouches of the Canada Rat (*Geomys bursarius*).

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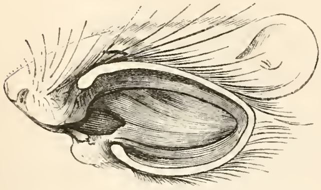

Cheek-pouch (*Saccostomus*). LXXXIV."

have similar cheek-pouches. The roof of the mouth between the incisors and molars is narrow and ridge-like: as it expands posteriorly it is commonly beset with two rows of hard oblique ridges. In no mammalian order is the food so much reduced by mastication as in Rodents, and many of them show concomitant modifications of the fauces; such as the constriction of the soft palate in the *Capybara*, reducing the communication between the mouth and pharynx to a small aperture. In *Capromys* the upper lip is furrowed longitudinally, but not bifid. On the middle line of the palate, between the incisors and molars, are three distinct hard white tubercles: the first, the largest and most prominent, is situated about half-an-inch behind the incisors; the second, which is the smallest of the three, is at a distance of three lines from the former; and immediately behind it is the third. On each side of the first tubercle there is a softer one situated on the margins of the upper lip.

The gape of the mouth is wide in insectivorous *Cheiroptera*. Some bats have a modification of the integument for an analogous office to the cheek-pouches in a part of the body remote from the mouth: the skin extended from the hind-legs to the incurved tail (interfemoral membrane) forms a bag into which flies are beaten, inclosed, and stored. The frugivorous kinds have not this structure.

In *Nycteris* two converging ridges of the lower lip inclose a triangular prominence of the upper lip. In *Otoöps* the upper lip is transversely grooved. In *Noctilio* it is dependent. The palate is transversely ridged, the hinder ones usually divided by a medial cleft. The tongue can be protruded far in *Cheiroptera*; and, when retracted, usually shows transverse (*Mormoöps*) or oblique foldings of the dorsum: the minuteness or absence of incisors permits protrusion even when the molars are in a state of apposition. Bats use the tongue in lapping; also in licking off the juice of fruits, as e.g. in the tropical *Phyllonycteris*. The tip of the tongue is spinulose in *Rhinopoma*. In the Vampire (*Desmodus*, *Phyllostoma*) the terminal papillæ resemble wart-like elevations, so arranged as to form a circular suctorial disk when they are brought into lateral contact by the action of a set of muscular fibres thereto adapted. Some bats (*Saccolaimus*) have a gular pouch: in *Molossus* this seems to be sexual, and is peculiar to the male.

In the order *Bruta*, the mouth is remarkably short in the Sloths, and attains its maximum of length and narrowness in the Ant-eaters in which it seems to be mainly a sheath for the retracted tongue. The buccal orifice, fig. 9, *a*, is little wider than is needed for the protrusile and retractile movements of that slender organ, so singularly modified for the prehension of the Termites which form the staple food of the so-called 'anteaters.' The tongue in *Myrmecophaga jubata*, ib. *b*, is covered by a smooth shining epithelium, which begins to present a softer, more vascular or mucous character fourteen inches from the apex, but the only papillæ anywhere visible are two fossulate ones, two lines apart, situated on the dorsum, about two inches in advance of the termination of the frænum. A linear groove, commencing two inches from the base of the tongue, extends along the dorsum to within four inches of the apex. The muscular substance of the free part of the tongue is formed by the intrinsic fibres, or 'linguales,' and by the lingual portions of the sterno-glossi, genio-glossi, and epihyo-glossi (p. 23). The buccal membrane is smooth, perforated at its lateral and inferior parts, and also superiorly beyond the bony palate, by innumerable very minute orifices, from a quarter of a line to one line apart, by which the secretion of a thin glandular stratum behind the membrane enters the mouth. Four inches in advance of the angle of the jaw, near the lower border of the ramus, a longitudinal ridge or low fold of the buccal membrane begins to rise, increasing in depth and assuming a callous hardness as it extends forward and upward: this ridge is about two lines in breadth, and bends down so as to leave a groove between it and the lower membrane of the mouth. Introduced termites may be crushed by the action of the tongue against these two callous ridges, which seem to occupy the place of teeth on each side of the mouth. In the two-toed Anteater they take the form of a horny molar plate on each side of both jaws. The cavity of the mouth quickly expands as it passes backward, and acquires its greatest breadth opposite the base of the tongue, ib. *g*, *g*, having there, in *Myrmecophaga jubata*, a diameter of from four to five inches. The thin membrane, over which the diverging fasciculi of the sterno-glossi and hyo-glossi spread, is capable of considerable dilatation: it serves as a sheath for the spirally retracted tongue, and may also form a temporary receptacle for the Termites, there blended with the more alkaline and solvent salivary secretion of the parotids, after being pounded by the tongue against the callous ridges, before they are finally swallowed: the singular backward extension of the fauces and nasal passages appears to relate, in part, to the presence and function of this receptacle. The buccal cavity gradually contracts beyond the receptacle to the hyoid bone, immediately in advance of which, nineteen inches from the aperture of the mouth, are situated the tonsils, each tonsil being an oval patch of a thin layer of muco-glandular substance with a finely reticulate surface. Behind the tonsils, and between them and the basi-hyal, a pouch of the gular membrane, fig. 9, *s*, descends between the epi-hyals; it is one inch and a half in depth, by one inch in width. The posterior margin of the soft palate terminates by a low angular projection, like the rudiment of a uvula, opposite the base of the epiglottis. From the sides of this uvula the membrane arches backward, and gradually subsides upon the beginning of the œsophagus. The whole length of the nasal passages is twenty-two inches in the full-grown *Myr. jubata*. The first inch is surrounded by the cartilaginous part of the nose: the next thirteen inches is inclosed by bone: the last eight inches of the canal has musculo-membranous walls, and is an enormously developed homologue of the 'palatum molle' in Man. The canal of the posterior nares is continued far back beyond the base of the skull, and the homologues of the 'constrictor pharyngis' act upon this canal before they embrace the proper pharynx. They consist of several distinct muscles. The most anterior one (*cerato-pharyngeus*) comes off from an extent of more than an inch of the middle part of the cerato-hyal. It is a thin, broad layer, the fasciculi of which diverge to spread upon the sides of the postcranial continuation of the nasal passage, interlacing with the constrictor fibres which spread over the back part of that passage. The second muscle (*epi-pharyngeus*) has a thicker origin, of ten lines in extent, from the back part of the inner end of the cerato-hyal, and from the joint between this and the epi-hyal. The fasciculi diverge and spread over the sides of the posterior part of the soft nasal canal, partly overlapping the preceding muscle anteriorly, and being themselves slightly overlapped by the next portion behind. The third constrictor (*hyo-pharyngeus*) has an origin three lines in extent from the thyro-hyal and contiguous part of the basi-hyal: the fibres diverge upon the sides of the end of the nasal canal and the beginning of the pharynx, the anterior fibres overlapping and then blending with the posterior fibres of the preceding muscle. The fourth constrictor (*thyro-pharyngeus*) comes off from the outer margin of the thyroid cartilage, having an origin of nine lines in extent. The fibres pass transversely round the pharynx, partially overlapping the preceding muscle, and slightly expanding at the back of the pharynx. The posterior continuation of this portion, which might be regarded as a fifth muscle (*crico-pharyngeus*), arises from the posterior and outer prolongation of the cricoid, behind the three upper rings of the trachea. The *retractor pharyngis* is a slender longitudinal muscle, arising from a fascia connected with the origin of the scalenus, runs along the outer side of a long slender gland, and then passes forward to the outer side of the crico-pharyngeus, where it bends backward, slightly expands, and appears to blend with the contiguous fibres of the *crico-* and *thyro- pharyngei.* In the Armadillo (*Dasypus* 9-*cinctus*) the epiglottis projects through the arch of the soft palate, in the middle of which there is a thickened part like a rudimental uvula.

The mouth is remarkable for its small relative size in the Manatee. In a specimen with a head eighteen inches long and fifteen inches deep, the oral opening was only three inches from angle to angle. The anterior border of the premaxillaries, covered by a callous gum, projects beneath the thick upper lip, and the horn-clad symphysis of the mandible makes a similar projection above the under lip.

The mouth is relatively small in the Elephant; the under lip alone is free, and is produced into a pointed form; the upper lip blends with the nose, and is, therewith, produced into the remarkable prehensile appendage characteristic of the proboscidian order. As it chiefly ministers to the mouth, conveying thereto the aliment, it will be described in the present section.

The proboscis of the full-grown Elephant forms an elongated cone of four or five feet in length, gradually tapering from the root towards the point, which is terminated by a kind of thumb-like appendage which is endowed with exquisite sensibility, so as to be useful in picking up the smallest objects. It is perforated lengthwise, by a double tube, formed by a strong tendinous membrane, lubricated by the secretion of innumerable mucous crypts. The membranous tubes are continued upward as far as the bony nostrils; but, a little before their junction with the latter, they form two curves, the nasal passages being closed at this point by a cartilaginous elastic valve, which may be opened at the will of the animal, but closes by its own elasticity when the muscles which open it cease to act. The interval between the membranous tubes and the skin of the proboscis is filled up with a thick layer of muscular substance composed of several sets of fibres, and with sclerous tissue.

The nasal passages may be observed to be not in the centre of the trunk, but nearer the anterior surface: the muscles before them pass in a radiating direction to the circumference of the proboscis; those which are immediately behind the nasal passages are disposed in a straight line from side to side; external and posterior to these again the muscular fibres resume the radiated course. The second series of muscles tend to diminish, but cannot close, the areæ of the nasal passages; the first and third series contract the diameter of the trunk without affecting that of the canals. All the muscles are distinct, and terminate at both extremities in slender tendons: they are imbedded in a cellular texture occupied by a white homogeneous substance.

The other muscles of the proboscis are disposed longitudinally, in a multitude of fasciculi, dispersed in short curves, so that the two extremities of each fasciculus are implanted into the membranous tubes, while the convexity of the arch is adherent to the external aponeurosis. These fasciculi surround the whole trunk, throughout its length; their effect being to shorten it from end to end or in any part, and by partial contractions, on one side or the other, to bend the trunk in any direction. The longitudinal fasciculi are derivations from four great muscles, which, though almost blended together in the trunk itself, have distinct origins. Of these the two anterior arise from the whole breadth of the frontal bone above the ossa nasi, while the two lateral muscles take their origins from the superior maxillary bones beneath and in front of the orbit, answering to those in the Tapir, fig. 155, *a*. The posterior surface of the basal part of the proboscis is supplied with fibres which seem to be continuations of a muscle answering to the *orbicularis oris* of the Tapir, ib. *d*, *d*, and which run obliquely downward and inward so as to meet their fellows from the opposite side at an acute angle. With such a structure it is evident that the nasal prolongation of the proboscidian Pachyderms is able to move in every needful direction, and perform all the duties of a lithe and flexible arm.

In the Horse, the callous roof of the mouth is disposed into about sixteen curved ridges, with their convexities forward. Many mucous crypts perforate the membrane, above which, as in other Ungulates, is a remarkable plexus of veins and nerves. The pharynx is capacious and communicates with the pair of large sacculi at the ends of the eustachian tubes. The muscle which represents the *middle constrictor* descends from the pterygoid and palate bones, along the sides of the pharynx, around which the fibres wind obliquely, uniting in the middle line upon its posterior surface, where they form a thick muscular layer. The *inferior constrictor* is equally broad and strong, its fleshy fibres taking nearly the same direction as they proceed towards the back of the pharynx, where they join by a median raphe. In addition to the above, there is a *crico-pharyngeus,* arising from the posterior and inferior margin of the cricoid cartilage, whence its fibres extend obliquely upwards along the sides of the pharynx. The homologue of the *stylo-pharyngeus* is a cylindrical muscle, arising from the stylohyal, and, running from behind forward upon the sides and upper part of the pharynx, mixing its fibres with those of the superior constrictor: its action is to raise the commencement of the pharyngeal sac, which it at the same time dilates and draws backward. There is likewise a small muscle derived from the middle part of the stylo-hyal, the fibres of which run backward and inward, so as to meet those of the muscle last mentioned. Lastly, there are two other muscles, the fibres of which take a longitudinal direction. One of these, the *pharyngeus proprius,* arises from the tendinous middle line that extends from below the insertion of the stylo-pharyngei, and is prolonged downward along the posterior and lateral walls of the œsophagus: the other, the *aryteno-pharyngeus,* is a small muscular band proceeding from the back part of each arytenoid cartilage, and running down the front of the œsophagus towards the stomach.

The mouth of the Hog-tribe is served by the uprooting modification of the upper lip and nose, forming the 'snout.' The palate is ridged. In the Babyroussa Vrolik[1] found a small pouch at the back part of the commencement of the œsophagus: a pair of air-sacs continued from the posterior nostrils communicate with the back part of the pharynx.

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Buccal papillæ of the Bactrian Camel.

The mouth of the Ruminants is chiefly remarkable for the callous pad covering the edentulous borders of the premaxillaries, and for the number of hard, commonly retroverted papillæ, developed from extensive tracts of the buccal membrane: those on the inside of the lower lip are large and pointed; interspersed with groups of mucous follicles. Along the roof of the mouth they are flattened, and disposed in parallel transverse rows with retroverted denticulate margins: the papillæ usually attain their greatest size inside the cheeks, opposite the masticating line of the molars. In the Camel they are aggregated and obtuse, fig. 301. In the Giraffe they are close-set, strong, retroverted, pointed, some of them half-an-inch in length, and giving off secondary papillæ. In the act of rumination the regurgitated bolus is driven into the mouth with great force; and the use of these papillæ as mechanical obstacles to its escape, and their tendency to confine the soft slimy comminuted vegetable substances to the molar region during the second mastication, appear to be offices of sufficient importance to found upon their presence an argument of adaptation. Neither the Hog nor the Horse have such buccal papillæ; but the front part of the mouth is closed by teeth both above and below, and the food is not regurgitated for the purpose of undergoing a lengthened remastication.

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[1] CLIV''. p. 31, pl. iii.

The mouth of the Camel seems formed to save for the animal every drop of the fluid excretions of the nose: a channel leads from each nostril to the mid-fissure dividing the upper lip, which is continued down into the mouth. In the non-division and extensibility of the hair-clad upper lip, the Giraffe resembles the Elk, but differs widely from that and every other ruminant in the elegant tapering form of the muzzle.

The Giraffe possesses great extensibility, flexibility, and extraordinary command and power over the movements of its tongue, fig. 144; its muscles are in number and kind as in other Ruminants. The principal difference obtains in the greater extent of the organ, anterior to the insertion of the *genio-glossus*; and as this free and active part consists entirely of a firm muscular tissue, invested by a thin but dense and very closely adhering integument, there is a corresponding increase in the bulk of the intrinsic as compared with those of the extrinsic muscles. Of these the *stylo-glossi*, which are the principal retractors of the free anterior part of the tongue, are relatively stronger than in other Ruminants; they arise by a tendon from near the lower extremity of the stylo-hyal, and run forward, below the lateral margins of the tongue, to which they are braced by a thin sheet of fibres, descending obliquely forward from the sides of the *linguales* to the upper margin of the *stylo-glossi*. The *lingualis inferior* is a broad thin sheet of muscular fibres which comes off from the condensed cellular tissue at the under part of the root of the tongue and runs forward parallel with the fibres of the *stylo-glossi*, with which it becomes blended anterior to the *hyo-glossi*; these accessory fibres cross the inner surface of the *hyo-glossus* muscle, which is thus inclosed between the two layers of longitudinal retractors. The arteries and veins of the tongue of the Giraffe are not connected with a reservoir of blood, or with any erectile tissue, as has been alleged.[1] The movements of the tongue are due to muscular action. Any physiologist who has felt the firm but regulated grasp of the tongue of the Giraffe, when twined round the finger, must have recognised the difference of the action from the fitful force arising from vascular or erectile injection. The muscular fibres in the free and flexible part of the tongue present an arrangement adequate to all its movements. The *stylo-glossi* and inferior *linguales* expand into a layer of longitudinal fibres, about a line in thickness, covering the whole of the inferior surface of the free portion of the tongue, and becoming continuous at the sides, with a corresponding but thicker stratum of longitudinal fibres on the upper surface of the tongue; these longitudinal muscles inclose a mass of fibres, which run in the transverse direction. The action of the transverse, combined with that of several short vertical, fibres near the margins, and of those forming the thin circular stratum surrounding the *stylo-glossi* at the middle part of the tongue, serves to attenuate or diminish the transverse diameter of the tongue and increase its length; while thus rigidly extended the apex of the tongue can be curved upward or downward by the superficial longitudinal fibres, which are less intermingled with the transverse fibres than in the tongues of most other Mammals: the contraction of the longitudinal fibres taking place with the relaxation of the transverse ones produces the retraction of the whole organ. The nerves of the tongue present the same disposition as those in ordinary Ruminants, but the ninth pair is relatively larger than the branch from the fifth pair; the nerve which runs along the inner or under surface of the *stylo-glossi* toward the free extremity of the tongue is remarkable for its beautifully wavy course, by which it is accommodated to the variations which occur in the length of the organ in the living animal.

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[1] cxiv''. p. 85.

The back of the mouth appears to be as completely closed in the Giraffe as in the Capybara; but, instead of contracting, like a funnel, to a small circular depression, it terminates by a transverse slit, through which projects the broad upper margin of the epiglottis, which is folded upon itself. The faucial membrane is coarsely corrugated.[1] The velum palati descends to the interspace between the epiglottis and the large arytenoid cartilages; and there is an uvular process from the middle of the inferior margin. The tonsils are well-developed glands of a flattened oval form, having each a short duct communicating by one wide opening with the fauces.

[1] xcvii'. pl. xlii, fig. 3.

The back of the mouth, in Ruminants, presents its chief modifications in the Camel-tribe. A broad pendulous flap hangs down from the fore part of the soft palate and usually rests upon the dorsum of the tongue. The velum palati extends beyond this process, some way down the pharynx and terminates by a concave border. The pharynx behind the velum dilates into a sac. In the rutting male the palatal flap is greatly enlarged. I have found it extending ten inches down the pharynx, passing below the margin of the soft palate and the opening of the larynx, into the œsophagus: in the living animal it is, at this season, occasionally protruded, with a belching noise, from the mouth. Its surface shows the pores of innumerable mucous crypts, and in the ordinary state, in both sexes, the flap may apply its own secretion, and water regurgitated from the storage-cells of the stomach, to the extended surface of the pharynx and root of the tongue, so as to allay the feeling of thirst and help the animal to endure the long remissions of drinking to which it is liable in traversing the desert.

The mouth in *Carnivora* is characterised by the width of its gape, and the mobility, dilatability, and contractility of its muscular and membranous walls. Cheek-pouches have not been found in any species. The great extent of faucial membrane between the back of the tongue and the larynx, with the coextensive soft palate in the Lion and some other large Felines, has been adverted to (p. 198); also the retroverted spines, and the lytta of the tongue in connection with the work of the mouth, in certain *Carnivora*. In the Hyæna the tonsils are relatively larger than in the Lion. The palatal gum is transversely ridged in most *Carnivora*. The provision for the lubricating mucus at the back of the mouth and fauces is much less in the present than in the hoofed group of Mammals.

In *Quadrumana* the *Cercopitheci*, *Macaci*, and *Cynocephali* have cheek-pouches, the slit-like orifices of which are a little within the labial commissure; the cavity extends outside and below the mandibular rami, where it is occasionally seen much distended with food. The *Semnopitheci* and *Colobi*, remarkable for their large sacculated stomachs, have not such cheek-pouches: they are wanting also in *Lemuridæ*, *Platyrhines*, and tailless Apes.

The *Lemuridæ* have the palatal gum ridged. In the Aye-aye[1] there are three curved transverse ridges anteriorly, convex forward, followed by four transverse pairs of similar ridges. In other *Lemuridæ* the palatal ridges are similarly curved, but usually undivided, from five (*Potto*) to eight or nine (*Galago*) in number: between the two anterior ridges are the orifices of canals leading from the palate to the nose.

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[1] cii′. p. 41, pl. xii, fig. 6.

The uvula is represented in the Aye-aye and some other *Lemuridæ* by a medial longitudinal fold from the back of the soft palate close to the margin, but does not project so as to divide the fauces into two arches: this form of soft palate begins to appear in Platyrhines: in the Baboons the uvula is thick and short: in the Apes it approaches nearer the proportions of that appendage in Man.

In the higher Quadrumana the palate is smooth, or unridged, as in Man.

§ 224. *Salivary Glands.*—Fluids of different properties are poured into the mouth in aid of its various functions of receiving, retaining, comminuting, softening or dissolving, tasting, and transmitting throatward, the food. For the preparation of these fluids corresponding modifications of glandular parts exist, from the simple mucous follicle to aggregates of three or of more complex follicles, with further multiplication and compaction of secerning surfaces, in groups and bodies, forming glands and ducts with definite names.

As the function of the mouth is simplified so is the condition of such ministering glands. In the piscivorous *Cetacea*, which bolt their food like fishes, the parotids and submaxillaries are not present: the latter are represented with the sublinguals, in a diffused form in whalebone whales. The parotids are large in *Sirenia*;[1] their ducts open in the Manatee on two papillæ, one on each side the fore part of the palate: in the Dugong the parotids are situated immediately behind the ascending mandibular rami: there is a thick layer of mucous glands above the membrane covering the hard palate.

In the Ornithorhynchus the parotid, fig. 3, E, is divided into flat portions or lobes thinly applied to the fundus of the cheek-pouch and anterior to the long meatus auditorius. The submaxillary, ib. D, is a moderately-sized, oval, compact body, situated behind and below the meatus auditorius. The duct passes under the omo-mylo-hyoideus, ib. 10, and then, contrary to the usual mode, begins to be disposed in a series of about twelve close transverse folds, and terminates by a simple aperture at the frænum linguæ. In the *Echidna* the submaxillary gland, fig. 302, *b*, is of unusual dimensions: it extends from the meatus auditorius along the neck, and upon the anterior part of the thorax: it is a broad, flat, oblong lobulated body, narrowest at its anterior extremity, from which the wide duct emerges. When the duct has reached the interspace of the lower jaw, it dilates, and then divides into eight or ten undulating branches, which subdivide and ultimately terminate by numerous orifices upon the mem-

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[1] cxvii″. p. 29.

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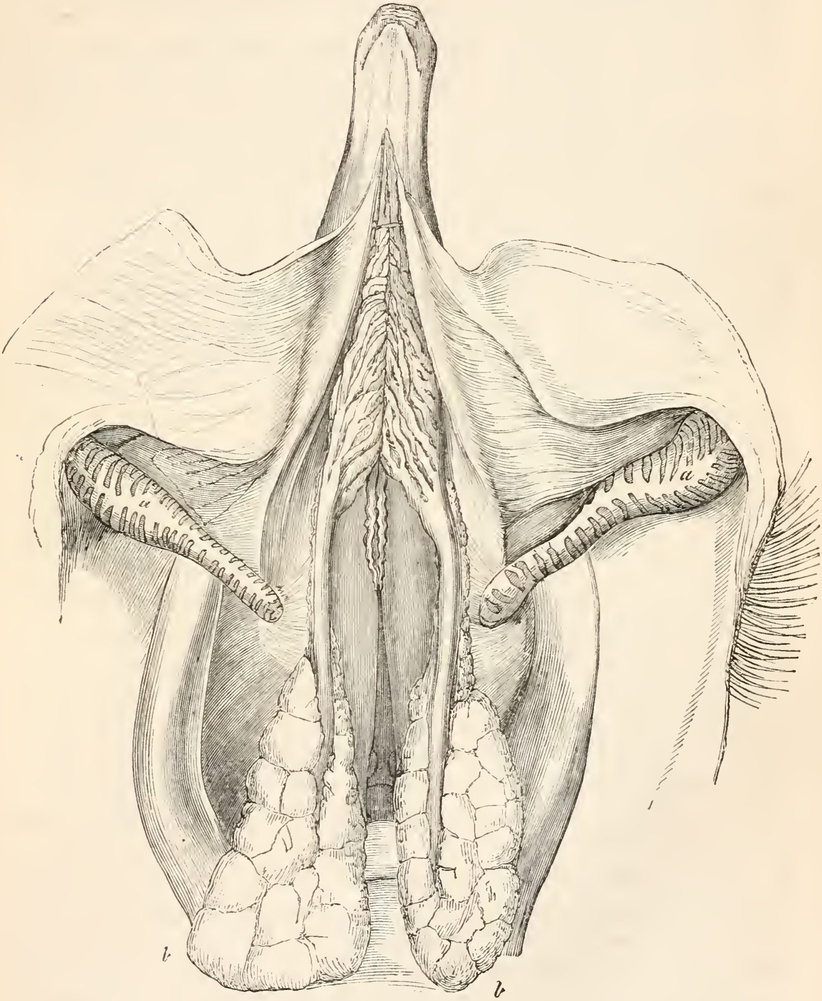

Submaxillary glands, Echidna setosa; nat. size.

branous floor of the mouth. This modification of 'Wharton's duct' appears to be unique. The large size of the glands and the mode in which the secretion is spread over the floor of the mouth relate to the lubrification of the long, slender, and extensible tongue, and to its fitness as an instrument for obtaining the insect food of the spiny Monotreme.

The salivary glands in the carnivorous Dasyures consist of a small parotid and a large submaxillary gland on each side. They do not agree with the dogs in having the zygomatic glands. The submaxillary is placed in front of the neck, so that its duct passes on the dermal side of the tendon of the biventer maxillæ, and terminates half an inch from the symphysis menti. There is a thick row of labial glands along the lower lip. The Opossums and Bandicoots present a similar salivary system. In the *Phalangista vulpina* there is a sublingual gland on each side of a firm texture, about one inch in length and three lines broad; a roundish submaxillary gland about the size of a hazel-nut; and a broad and flat parotid, larger than in the entomophagous or sarcophagous Marsupials. The parotid glands are relatively larger in the Koala, in which the duct takes the usual course over the masseter and enters the mouth opposite the third true molar, counting backwards. In the Wombat I found the parotid glands very thin, situated upon both the outer and inner side of the broad posterior portion of the lower jaw; the duct passed directly upwards and outwards to the insertion of the sterno-cleido-mastoideus; here it was buried in the cellular substance anterior to that muscle, then turned over the ramus of the jaw, and, pursuing a somewhat tortuous course over the masseter, entered the mouth just anterior to the edge of the buccinator. The submaxillary glands were each about the size of a walnut; their ducts terminated as usual on each side of the frænum linguæ. In the great Kangaroo the parotid is very large, extending from below the auditory meatus three or four inches down the neck: In the Potoroos it reaches as far as the clavicle. In both genera this gland is separated from the submaxillary gland by the submaxillary vein. The sublingual glands are elongate, but of moderate size. The tonsils are small in all the Marsupials, but are not represented in the carnivorous species, as in the placental Feræ, by simple glandular pouches at the sides of the fauces; for example, they consist of an oblong glandular body on each side in the *Dasyurus macrurus*.

In Rodents, as in Marsupials, the proportions of the parotid and submaxillary differ according to the nature of the food. In the omnivorous rats with ferine tendencies, the submaxillaries are in excess: in most other Rodents which subsist mainly or exclusively on vegetable products the parotids are the largest. They are enormous in the Beaver, extending from before the ears forward and downward to contact with the submaxillaries, which are about one-twentieth their size; the whole forming a sort of glandular collar: the buccal glands are numerous. In *Leporidæ* the parotids partly inclose the base of the ear-conch and also descend to meet the submaxillaries: the parotid duct crosses the upper part of the masseter and terminates opposite the last upper molar tooth. The submaxillary duct terminates at the side of the frænum linguæ: the submaxillaries are thin and long: the chief mass of the molar follicles is near the upper molars. The submaxillary glands are almost as large as the parotids in the Paca (*Cœlogenys*): both glands are large: the latter present a compact reddish tissue. There is also a large zygomatic salivary gland, which exists, of smaller relative dimensions, in the Guinea-pig (*Aperea*). In the Hamster the parotids are elongate, narrow, and applied, as in the Ornithorhynchus, to the back of the cheek-pouches: there is also an accessory lobe, beneath the masseter. The submaxillaries are large, round, and of a reddish colour. The sublinguals are small, subglobular. In *Bathyergus* the salivary glands are smaller than in most other Rodents.

Amongst *Insectivora* the hedgehog is remarkable for a zygomatic gland which seems to be a development of the homologue of the 'molar' glands in Marsupials. The parotids are larger than the submaxillaries; but both are well-developed. The sublingual follicles are in two series, the larger one next the mandibular ramus. The mole has large parotids and submaxillaries, the former oblong, the latter subdivided into roundish masses: the sublingual is placed very near the mandible: there is no zygomatic gland. In shrews the maxillary exceeds the parotid gland in size: the latter follows the auditory meatus in its inferior position. The same proportions hold in the insectivorous bats: but in the fruit-eating Pteropines the parotids are the larger glands.

Great is the diversity of the salivary system in the order *Bruta*, as the difference of food and ways of getting it might indicate. The parotids are somewhat less than the submaxillaries even in the phyllophagous Sloths, and are much the smallest in the insectivorous families. In the Armadillos the parotid gland is small: its duct opens into the mouth near the angle of the lips. The submaxillary glands are very large, subcervical in position, extending from the angle of the jaw to the anterior border of the pectoralis major, where they meet at the middle line, under-lapping the sterno-hyoidei. The gland, fig. 303, *c*,[1] is lobular, and sends its secretion by three or four short ducts, *d*, *d*, into a pyriform bladder, *e*, situated at the fore part of the gland, from the apex of which the duct, *f*, is continued forward to terminate by a minute orifice on the sublingual membrane of the mouth, immediately behind the symphysis menti. The saliva which the bladder contains is tenacious, the serous part being probably absorbed during its detention. Thus prepared and accumulated it is expelled at the fore and under part of the mouth, in order to lubricate the tongue.

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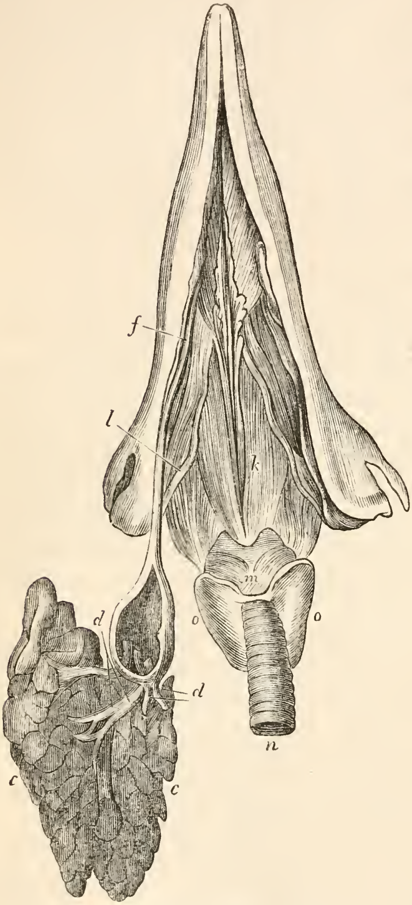

Salivary gland and bladder, Armadillo.

In the great Anteater the submaxillary salivary gland is a bilobed body, sixteen inches in length, two inches in greatest thickness at the posterior part where the two glands blend together.[2] From this confluent base they diverge, extending outward and forward, and form, each, a flattened triangular mass, from four to five inches in breadth and two inches thick posteriorly, and becoming thinner towards the outer and anterior border, where the apex is prolonged into a slender process. The isthmus, or base of the combined glands, overlies the anterior half of the thorax; the base of each lateral lobe is notched by the prominence of the shoulder-joint, round which its outer border extends; the contracting anterior prolongations of the gland pass forward along the sides of the neck, external to the sterno-maxillaries, and terminate a little in advance of the angle of the jaw.

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[1] cxxvii″. p. 144. The preparations which exemplify this modification of the salivary system are Nos. 772 l, and m, in xx, vol. i. p. 238 (1831). Prof. Rapp, in cxxix″. (1843), refers, for this structure, to Winker, Dissert. sistens observationes anatomicas de Tatu novemcincto. Tubing. 1826, pp. 10, 11: Rapp, præses; who adds:—'Nachdem Prof. Jäger, in Stuttgart, sie schon vorher bemerkt hatte.' This inaugural Thesis I had not seen at the date of viii″, and I became aware of its existence only through the reference thereto in Prof. Rapp's work.

[2] viii″. pl. 40.

The two packets of ducts, which indicate the essential doubleness of the gland, emerge from the inner and posterior part of the lateral lobes, five or six inches in a straight line from the posterior border of the isthmus, and nine or ten inches from the anterior attenuated extremity of the gland. After a short course, the ducts dilate and form a small reservoir on each side; they are here so closely covered and connected by elastic cellular tissue as to seem a single reservoir; they maintain, however, their distinctness, and continue, contracted, from each dilatation, as three closely united attenuated ducts, which at length unite into one long and slender duct. The dilated portion is surrounded by a compressor muscle (*constrictor salivaris*). The gland is conglomerate, the primary lobes being for the most part oblong, subcompressed, from about three to nine lines in diameter. The closely united ducts, after quitting the reservoir, are continued forward covered by the extraordinarily extended *mylohyoideus*, and, after their union, the common duct terminates at the symphysis of the lower jaw.

The parotid gland is small in proportion to the animal: it is situated in front and below the root of the ear, is of a triangular form, two inches four lines in length, one inch two lines in breadth, with the duct continued from the outer side of the anterior apex of the gland, which apex terminates at the posterior end of the origin of the masseter muscle. The duct extends forward along the outside of the masseter near its origin, passes along the buccinator near its upper border and beneath the tendons of three of the retractors of the mouth, then dips under the orbicularis oris, and terminates near the opening of the mouth. The length of the duct is eleven inches, its diameter scarcely half a line. This is perhaps the longest duct, in proportion to the size of the gland, in the animal kingdom: as the submaxillary is the largest gland outside a visceral cavity in the vertebrate series. The depressor auris, which arises from the angle of the jaw, perforates the parotid gland. A chain of lymphatic glands is continued backward from beneath the parotid on the side of the neck.

The representative of the 'sublingual gland' forms a thin layer, divided for the most part into narrow elongated lobes or groups of follicles, attached to and spread over the inferior buccal membrane for an extent of twelve inches: the greatest breadth of this layer is two and a half inches, and is opposite the angle of the jaw.

There is a small elongated 'labial gland,' lying upon the fore part of the buccinator, near its lower border, and sending its secretion into the side of the fore part of the mouth; apparently to lubricate that contracted aperture during the frequent and rapid protrusive and retractile movements of the tongue. The 'buccal glands' form a very extensive but extremely thin stratum of muco-glandular follicles, closely attached to the thin membrane of the mouth; they are chiefly developed at the lower and lateral parts, and along the middle of the upper surface of that part of the mouth which is prolonged backward, below the similarly prolonged nasal canal, beyond the bony palate. These glands terminate by innumerable very minute orifices upon the smooth inner surface of the buccal membrane, which they serve to lubricate. They are continuous with the better-marked series of follicles extending along the sides of the under surface of the mouth, beneath the lower jaw, which represent the 'sublinguales.' But the glands that pour out the abundant viscid secretion which lubricates the tongue and is mainly subservient to its peculiar prehensile function in the Great Anteater, are those conjoined or interblended pair that answer to the submaxillary salivary glands in other animals; which glands are most modified and developed, for a like function, in other species of *Myrmecophaga*, and, as we have seen, in the Armadillos (*Dasypus*), and in the Echidna.

In the little scansorial *Myrmecophaga didactyla*, the homologues of the submaxillary glands are subcervical and blended together, as in the larger species; and a slender process is continued from them to the labial gland. The duct commences by three tubes continued on each side from the main body of the gland; and these tubes dilate into a small reservoir, provided with a compressor muscle, before the long and slender single duct is continued, covered by the mylohyoideus, to the symphysis of the jaw. The parotid gland is of very small relative size; and this striking difference in the proportions of the two chief salivary glands indicates the difference in their functions and in the quality of their respective secretions. The labial glands are relatively larger in the *Myrmecophaga didactyla* than in the *Myrmecophaga* *jubata*; and there is a superadded aggregate of mucous follicles behind the eyeball, in the shallow orbit of the smaller species, the secretion of which enters near the angle of the mouth.

In the Hyrax the parotid exceeds the submaxillary in size, and is of a redder colour: the sublingual is almost as large as the latter. In the Horse the parotid forms a considerable mass extending from its normal position behind the masseter, upward to the ear-conch, the base of which it embraces, and downward to the larynx, where it meets its fellow. Three ducts quit the mass at different points of its lower half, converge and unite as they pass downward and forward; the common duct, which curves down beneath the lower border of the masseter, rises in front of that muscle to pierce the buccal membrane at a papilla opposite the last upper premolar. The submaxillaries are about one-fourth the size of the parotids, by which they are covered: the gland extends from the transverse process of the atlas to the angle of the jaw. The duct terminates on a valvular papilla anterior to the frænum linguæ. The sublingual glands, beneath the sides of the frænum, are elongate, as large as the submaxillary, and communicate with the mouth by several orifices. The buccal glands form large tracts of lenticular follicles along the upper maxillary bone, ascending to beneath the zygoma.

In the Hog-tribe the parotids have a large proportional size: the duct follows the lower border of the masseter, curves upward, and opens into the mouth opposite the last premolar: there is a small patch of buccal glands near its termination. In the Babyroussa and Wart-hog the parotid extends from its normal position, downward and backward, to the shoulder-joint and, mesiad, to the sterno-thyroids: resembling in size, shape, and proportion, the submaxillary of the Armadillo: its duct crosses the upper part of the masseter. As in the Hog, there are two sublingual glands; one, which is very long and narrow, accompanies the duct of the submaxillary gland, and is composed of small lobes of a pale reddish colour; the orifice of its excretory duct is near that of the maxillary. The second sublingual gland is placed in front of the former, and is of a square form; it discharges its secretion through eight or ten short ducts, which pierce the mucous membrane of the mouth. Dr. Ward has given an illustration, fig. 304, from a preparation by Quekett, of the distribution of the capillaries in the parotid of a Pig. The arteries penetrate the areolar tissue at different points of the surface, and are conducted, as it were, by this tissue through the interlobular spaces as far as the primary aggregations of the vesicles, where they form a network, which is distributed over the elementary parts of the gland.

The parotids are large in all Ruminants. In the Ox the parotid is vertically extended behind the long ascending mandibular ramus from the lower border of the ear-conch to the angle: the duct, as in the Horse and Hog, follows the lower contour of the masseter, and penetrates the mouth opposite the first upper true molar.

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Capillaries of Parotid of Pig, magn. CXXV″.

The submaxillary lies behind and upon the angle of the jaw: it is relatively larger than in the horse; its duct traverses the sublingual gland in passing to its termination below the fringed fore part of the frænum. In the Giraffe its opening is similarly protected by a small valvular papillose fold. There are three small elongate masses of buccal glands, over the alveoli of both upper and lower molar series: opening upon the angle of reflection of the gum-membrane upon the cheeks or lips.

In the Carnivorous order the salivary system is least developed in the Seal-tribe: they have the parotid either very small or wanting: and have no zygomatic glands. In the Dog the parotid, fig. 305, *a*, is comparatively small, flat externally, with the duct continued from near the lower end, and traversing the masseter, in an almost straight course, at an equal distance from the upper and lower borders of the muscle: it terminates opposite the upper carnassial, ib. *b*. The submaxillary, ib. *c*, is a large globose gland, beneath and partly covered by the parotid behind the angle of the jaw: its duct terminates at *d′*. The sublingual, ib. *e*, is more posteriorly placed than in Ungulates, and is in contact with the submaxillary, of which it seems an accessory lobe: its duct, *f*, has a similar termination at the fore part of the frænum linguæ. The zygomatic gland, ib. *g*, seems to be a special development of part of the buccal system: its duct, *h*, terminates behind that of the parotid, opposite the interval between the penultimate and last molars. The parotid is relatively larger in the Cat, and more so in the Bear-tribe.

In the Aye-aye the parotid, of a subtriangular flattened form, extends from its usual position to beneath the mandible where it is in contact with the submaxillary gland. The duct leaves the parotid about three lines above the lower margin of the mandible, crosses the masseter, and penetrates the buccal membrane close to the angle of the mouth. The submaxillary is smaller, thicker, more globose and compact in texture.[1] These forms and proportions of the two main salivary glands obtain in all *Lemuridæ*: in *Stenops* the authors of CXXIV″ describe and figure[2] the ducts of the submaxillaries as uniting, beneath the middle of the tongue, into a common duct which passes backward to terminate upon the mucous membrane of the mouth a little above the hyoid. In the Potto the submaxillary ducts open in the usual position, upon the free margin of the sublingual. In the higher *Quadrumana* the salivary system accords, in the main, with that in Man. The situation of the submaxillary agrees with the name of the gland. The buccal follicles are more numerous in the cheek-pouched monkeys, and the parotids are relatively larger in the more exclusive vegetarians.

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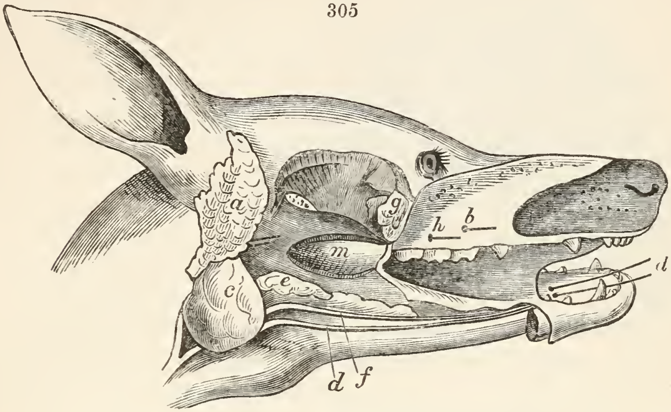

Salivary glands of Dog. IV″.

The human parotid is a depressed, three-sided pyramid: its base forms the exterior surface, and the apex sinks deep to the stylo-hyal and its muscles, penetrating between them and the internal pterygoid muscle, as far as the pharynx. A dense fascia separates it from the submaxillary: that which covers its base is called 'parotid fascia:' and the gland is attached by similar tissue, posteriorly, to the cartilage of the meatus auditorius. A portion of the gland which extends from the part overlapping the masseter, forward below the zygoma, is called 'socia parotidis;' and in some cases it sends its secretion by one or two small tributary canals into the main duct. This crosses the masseter, perforates the buccinator, glides between that muscle and the mucous membrane of the mouth, which it finally perforates opposite the penultimate upper molar, *m* 2. The parotid derives its arterial supply from the ectocarotid, directly and through the medium of branches; the disposition of the terminal capillaries resembles that shown in fig. 304. The nerves are derived from the facial, the anterior auricular, and the external carotid plexus. The submaxillary gland, much smaller than the parotid and larger than the sublingual, is situated in the anterior portion of the digastric space. It is irregularly oblong in form, and is enclosed in a loose investment of areolar tissue more delicate than that covering the parotid. Its long axis is directed from before backward, and is about an inch and a half in extent. Its external or maxillary surface is slightly concave, is lodged in a groove in the bone, and is in immediate contact with the mylo-hyoid nerve. The anterior extremity is the smallest, and from the part represented by the confluence of the inner and outer surfaces above, generally proceeds a process, longer than the gland itself, and passing along the upper surface of the mylo-hyoid muscle in company with the excretory duct, but above it, as far as the sublingual gland in front, with which it is occasionally incorporated. This process may be regarded as analogous to the accessory gland of the parotid, and like it varies considerably in size and relation to the body of the gland. A quarter of an inch below the base of the process appears the commencement of the excretory duct. It accompanies the gustatory nerve toward the tip of the tongue between the sublingual gland and the genio-hyo-glossus muscle to the side of the frænum linguæ: in the terminal part of its course it is directed forward and inward, fig. 306, *b*, lies immediately beneath the mucous membrane, and opens by a very narrow orifice into the mouth, in the centre of a papilla of mucous membrane which projects from the side of the frænum. The duct is about two inches in length, its coats are more delicate and extensible than those of the parotid. Its calibre exceeds that of the parotid duct, and, like it, its narrowest portion is that immediately beneath the mucous membrane, and this gradually contracts more and more, so that the terminal orifice becomes so small as scarcely to be visible by the naked eye. The primary lobes of the submaxillary gland are much larger than those of the parotid, and the lobules have an irregularly triangular arrangement. The arteries and veins that supply the submaxillary gland, are derived from the facial and lingual. The nerves are from the mylo-hyoid branch of the dental, and the gustatory, but chiefly from the submaxillary ganglion.

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[1] CII′. p. 43.

[2] p. 52, pl. I, fig. 5.

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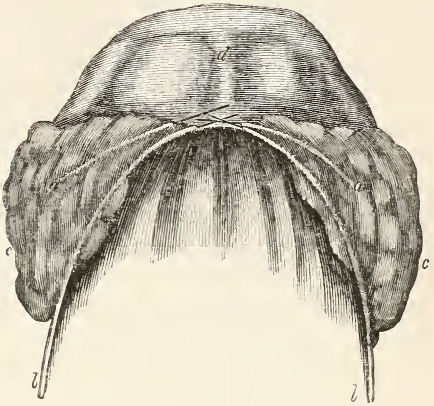


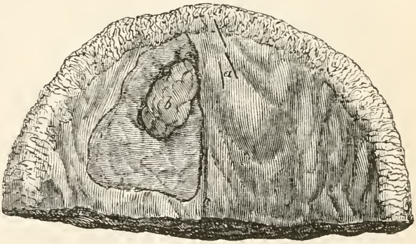
Sublingual glands, Human, nat. size. cxxv″.

The sublingual gland forms a distinct eminence underneath the anterior part of the tongue by the side of the frænum. Its shape and position are shown in fig. 305, *c*, *c*: its lobules are smaller, firmer, and more distinct than those of either the parotid or maxillary: its ducts are numerous, their orifices conspicuous along the ridge of mucous membrane behind the terminal papilla of the duct of the submaxillary. Occasionally one duct is longer and larger than the rest: it is named, after the anatomist who first drew attention to it, ‘Bartholin's duct,’ fig. 306, *a*. For a like reason, Anthropotomy calls the duct of the submaxillary, ib. *b*, ‘Wharton's,’ that of the parotid ‘Steno's,’ and the short ducts of the sublingual ‘Rivinus's.’ The secretion of the latter gland is more viscid than true saliva: and it may be considered as the best defined of the subsidiary glands of the salivary system. The posterior part of the sublingual is occasionally represented by one or more distinct glands in juxtaposition, each furnished with a very short excretory duct. The anterior lingual glands, fig. 307, *b*, are situate below the apex of the tongue, between the lower longitudinal and transverse muscular fibres, and emit their secretion during the movements of that organ upon the mucous membrane beneath the tip, by delicate ducts indicated by bristles in the figure.

The labial glands form a series of closely packed small, dense, spheroidal crypts, situated in the areolar tissue between the mucous membrane of the mouth and the orbicularis oris muscle; their excretory ducts open upon the posterior or free surface of the labial mucous membrane. They are not visible to the eye when the lips are in their natural lax position, but when the latter are everted, they appear as prominences upon the tense mucous membrane.

The buccal are smaller than the labial glands, but resemble them in form and position, being irregularly spheroidal, and placed between the buccinator and mucous membrane; they open by the orifices of distinct ducts upon the free surface of the latter. The molar glands are placed between the buccinator and masseter muscles. They are larger and more dense than the buccal, being composed of several lobes. The ducts open upon the mucous membrane at the posterior part of the cheek. The palatine glands are very numerous and small, and situated partly between the mucous membrane and the palatine arch, and partly between the mucous and muscular layers of the soft palate. The former are situated on either side of the median line, and form a thick layer, being more closely aggregated together in the front and behind than in the middle, opening on to the mucous membrane by distinct orifices. The latter, smaller than the former, exist both on the upper and lower surface of the velum, and are continuous below, where they are more numerous than above, with the glands of the hard palate. The aggregate follicles opening near the fossulate papillæ at the back part of the tongue are sometimes specified as the 'posterior lingual glands.' Like the other subsidiary glands their secretion is more mucous and lubricating than solvent: and the homologues of most of these glands are maximised in herbivorous Mammals in relation to the movements and mastication of their coarse vegetable food.

307



Anterior lingual gland, Human, nat. size. CXXV″.

The diversion of the parotid secretion from the mouth of a horse, during mastication of oats, was followed by dryness of the interior of the bolus and an exterior envelope of tenacious mucus, which was as abundant as before the division of Steno's ducts; the experiment[1] indicating that the secretion of the parotid is of the more fluid saliva which moistens, in ordinary mastication, the whole mass; and that the submaxillary and sublingual, like the more diffused tributary glands, provide the secretion of the slimy lubricating saliva. Further experiments showed[2] that the flows from the parotid, submaxillary and sublingual glands are respectively regulated by conditions special to each. Thus, the quantity of saliva secreted

[1] CXXVI″.

[2] Ib.

by the parotid of a horse is in direct ratio to the dryness of the food and the difficulty experienced in its mechanical division. The mastication of straw and hay causes a greater flow than does that of oats and farinaceous matters; the mastication of moist forms of food hardly excites any. The saliva from the sublingual and submaxillary ducts flows nearly in equal abundance whether mastication be exerted on dry or moist forms of food; and, owing to its comparative tenacity, it is not easily imbibed into the centre of the masticated material, but is gathered round the surface of the mass, thus favouring its passage along the alimentary canal.

The comparative anatomy of the salivary system supports the conclusions of experimental physiology: thus, the parotids are relatively largest in mammals that masticate most; the submaxillaries are largest in those that need the greatest amount of viscid lubricating secretion. In the anteaters, hairy or spiny, the parotid is so small as to have escaped the notice of Cuvier and his continuators:[1] the submaxillary attains its maximum of size. In many long-tongued Edentates (*Myrmecophaga* and *Dasypus*) a bladder is superadded to the submaxillary gland both for storage of a quantity of secretion needed in a sudden excess of outflow, and also for adding to the tenacity of the secretion so poured out to lubricate the tongue. In *Echidna* the end is gained by subdivision with enlargement of Wharton's ducts.

Most analyses of saliva have been made on that from the human mouth which is the combination of the secretions of the various glands above described. The peculiar animal principle called 'ptyalin' is a nearly solid matter, adhesive, of a yellowish colour: it is neither acid nor alkaline, is readily soluble in ether, alcohol, and essential oils, but more sparingly soluble in water. It appears to give the peculiar odour to saliva: when pure it may be kept long at a moderate temperature without undergoing decomposition.

Dr. Wright's analysis of human saliva[2] is as follows:—

Water	988·1
Ptyalin	1·8
Fatty acid	·5
Chlorides of potassium and sodium	1·4
Albumen combined with soda	·9
Phosphate of lime	·6
Albuminate of soda	·8
Lactates of potash and soda	·7
Sulphocyanide of potassium	·9
Soda	·5
Mucus, with some ptyalin	2·6

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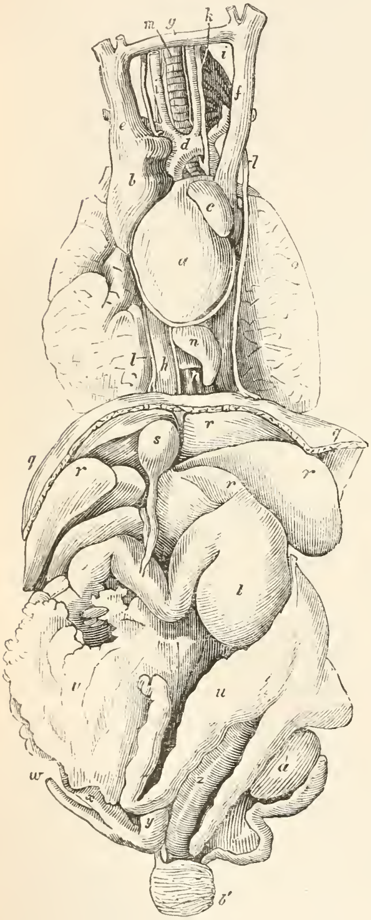
[1] 'Lorsqu'il n'y a point de parotides, comme cela a lieu dans *l'échidné* et le *fourmilier*, la proportion des maxillaires augmente considérablement.' XII. vol. IV. p. 421.

[2] CXX″. p. 417.

Pure saliva obtained from the parotids and submaxillaries of a dog, and from the parotids of a horse, is incompetent to effect the saccharine transformation of starch: but the secretion of the mucous and subsidiary glands of the mouth reacts upon either starch or sugar in the way of producing lactic acid.

§ 225. *Alimentary canal, Lyencephala.*—In the Ornithorhynchus the œsophagus becomes slightly dilated near the diaphragm, extends a little way into the abdomen, and expands into a moderate-sized membranous stomach, fig. 308, *t*, which is chiefly remarkable for the close approximation of the cardiac and pyloric orifices. The intestinal canal is moderately wide, five feet three inches and a half in length, and provided, at a distance of four feet three inches from the pylorus, with a small and slender cæcum, ib. *w*. The small intestines are chiefly remarkable for the extent of the mucous coat, which is disposed in numerous folds or valvulæ conniventes: these are transverse at the beginning of the duodenum, but are placed more or less obliquely in the rest of the small intestine; they are about two lines broad, are close together in the duodenum, but diminish in breadth and number as they approach the cæcum coli. There are about fifteen longitudinal folds in the first half of the colon; the remainder of the intestine has a smooth inner surface. There is no valvula coli. The rectum, ib. *z*, terminates at the anterior and dorsal part of the vestibular compartment of the cloaca.

308



Thoracic and abdominal viscera, Ornithorhynchus. LXXXI′.

As the food undergoes less comminution in the mouth of the Echidna than in that of the Ornithorhynchus, the pharynx and œsophagus are wider, and a dense epithelium lines the inner surface of the latter tube: it is continued over the capacious stomach to the pylorus, near which orifice it is developed into numerous horny and sharp papillæ. The subjacent mucous membrane is smooth; the tunics of the stomach are thin, to near the pylorus, where the muscular coat assumes something of the gizzard-character, and the inner coat forms a prominent protuberance in the duodenum. The intestinal canal of the Echidna is seven times the length of the body; the mucous membrane is not raised into valvular folds; a small vermiform and glandular cæcum divides the small from the large intestines; the rectum terminates as in the Ornithorhynchus.

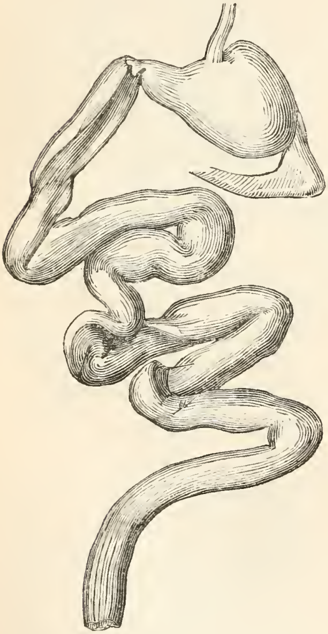
The various modes of locomotion, resulting from the different modifications of the osseous and muscular systems observable in the several families of *Marsupialia*, relate to the acquisition of as various kinds of alimentary substances, which necessarily require for their assimilation as many adaptations of the digestive organs. Food—means of obtaining it—instruments for preparing and mechanically dividing it—cavities, canals, and glands for chemically reducing and animalising it—form a closely connected chain of relationships and interdependencies. The preparatory instruments have been described in previous sections. In all Marsupials the œsophagus in passing through the chest recedes from the spine as it approaches the diaphragm, and is loosely connected with the bodies of the dorsal vertebræ by a broad duplicature of the posterior mediastinum. In the Phalangers the œsophagus terminates in the stomach almost as soon as it has pierced the diaphragm; in the Opossums it is continued some way into the abdomen; in the *Didelphys virginiana*, for example, for the extent of an inch and a half; in *Did. brachyura*, for half an inch. In the Kangaroos the abdominal portion of the œsophagus is of still greater extent; I have observed it five inches long in a male *Macropus major*.

The inner surface of the œsophagus is generally smooth, or disposed in fine longitudinal plaits; but in the Virginian Opossum the terminal part of the œsophagus presents many transverse folds of the lining membrane analogous to, but relatively larger than, those in the Lion and other *Felines*. I have not met with a like structure in the Phalangers, nor in any other genus of Marsupials; what is more remarkable is that the transverse œsophageal rugæ are not developed in the carnivorous *Dasyures* or *Phascogales*, where analogy would lead one to expect them, rather than in the insectivorous Opossums.

The *stomach* presents three leading modifications of structure in the Marsupialia; it is either simple, as in the Zoophagous, Entomophagous, and Carpophagous tribes; or is provided with a cardiac glandular apparatus, as in the Koala and Wombat; or is complicated by sacculi, as in the Poephagans.

It might have been expected that the stomach would have exhibited some modifications in the development of the left or cardiac extremity corresponding with the differences of food and dentition observable in the large proportion of the Marsupial order, in which this viscus presents its simple condition; but this is not the case: the form of the stomach is essentially the same in the carnivorous Dasyure, the insectivorous Bandicoot, and the leaf-eating Phalangers. It presents a full, round, ovate, or subtriangular figure, with the right extremity projecting beyond and below the pylorus; the longitudinal diameter seldom exceeds the vertical or transverse by more than one-third; often, as in *Phascogale* and *Dasyurus viverrinus*, by only one-fourth of its own extent; and the œsophagus enters at the middle of the lesser curvature, or sometimes nearer the pylorus, but always leaves a large hemispherical cul-de-sac on the left side. Daubenton[1] has given illustrations of this characteristic form of the stomach in different species of *Didelphys*; it is here figured as it exists in the *Phascogale*, fig. 309. The stomach is relatively much more capacious in the carnivorous Marsupials than in the carnivorous Placentals. Some slight modifications occur in the disposition of the lining membrane; in the *Phascogale* a series of very thick rugæ radiate from the middle of the upper part of the cæcal end of the stomach, some of which were continued along the lesser curvature to the pylorus. In the *Perameles nasuta* the internal surface of the left cul-de-sac is smooth; the right half of the stomach has rugæ, running chiefly in a longitudinal direction, and particularly numerous towards the pylorus.

309



Alimentary canal, Phascogale flavipes.

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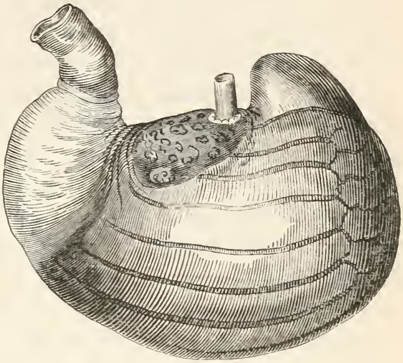
[1] cxxii″, tom. x, pl. 48, fig. 1.

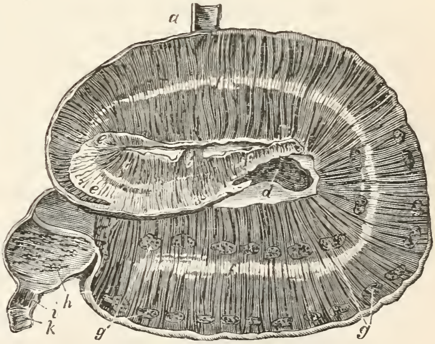
The stomach in the Wombat and Koala does not materially differ in external figure from that of the above-cited Marsupials; the œsophagus terminates nearly midway between the right and left extremities, but further from the pylorus in the Wombat than in the Koala. The conglomerate gastric gland is of a flattened ovate form, relatively larger in the Wombat than in the Koala, situated to the left of the cardiac orifice, at the lesser curvature of the stomach, fig. 310. The gastric gland has a similar position in the Beaver, but in this animal the excretory orifices of the gland are arranged in three longitudinal rows, while in the Wombat and Koala they are scattered irregularly; in the Wombat they are about thirty in number, and the bottoms of the larger depressions are subdivided into smaller cells. In the partially contracted state the inner membrane of the stomach of the Wombat is disposed in longitudinal rugæ, which gradually subside towards the pylorus; but when the stomach is distended these folds disappear, and the left extremity presents a full globular form.

310



Stomach of the Wombat, inverted.

311



Stomach of the Kangaroo.

The sacculated stomach of the Kangaroo, which offers the extreme modification of this organ in the Marsupial order, resembles the human colon both in its longitudinal extent, structure, and disposition in the abdomen. In a full-grown female Kangaroo (*Macropus major*) I found the abdominal œsophagus, fig. 311, *a*, four inches long, and terminating at six inches distance from the left extremity of the stomach: this was folded forward and to the right in front of the œsophagus; from the basis of the left cul-de-sac the stomach continued to expand, and descended into the left lumbar and iliac regions, whence it stretched upward and to the right side obliquely across the abdomen, to the right hypochondrium, where it became contracted and finally bent downward and backward to terminate in the duodenum. The whole length of the stomach, following its curvatures, was three feet six inches, equalling that of the animal itself from the muzzle to the vent.

The cavity may be regarded as consisting of a left, a middle, and a right or pyloric division. The left extremity of the stomach is bifid, and terminates in two round cul-de-sacs. The sacculi of the stomach are produced, like those of the colon, by three narrow longitudinal bands of muscular fibres, which gradually disappear, together with the sacculi at the pyloric division. One of the longitudinal bands runs along the greater curvature, at the line of attachment of the gastro-colic omentum; the others commence at the base of the left terminal pouches, and run, one along the anterior, the other along the posterior side of the stomach: the interspace, between these bands, forming the lesser curvature of the stomach, is not sacculated. The largest of the two terminal sacculi, *d*, fig. 310, is lined with an insulated patch of vascular mucous membrane, which is continued for the extent of five inches into the cardiac cavity; the thick epithelium is continued from the œsophagus in one direction into the nearest and smallest sacculus, *c*, and extends in a sharp-pointed form for a considerable distance in the opposite direction into a series of sacculi in the middle compartment of the stomach, ib. *e*: this epithelium is quite smooth. The vascular mucous surface recommences by a point at the great curvature, near the beginning of the middle compartment, and gradually expands until it forms the lining of the whole inner surface of the right half of the stomach. Three rows of clusters of mucous follicles, ib. *g*, *g*, are developed in the mucous membrane of the pyloric half of the middle compartment; they are placed parallel with the longitudinal muscular bands: about fifteen patches are situated along the greater curvature, and there are nine in each of the anterior and posterior rows. These glandular patches disappear altogether in the pyloric compartment of the stomach, where the lining membrane is thickened, and finely corrugated; but immediately beyond the pylorus there is a circular mucous gland three-fourths of an inch broad: the non-sacculated pyloric division of the stomach was five inches in length.

In the smaller species of Kangaroo the stomach is less complicated than in the *Macropus major*; the number of sacculi is fewer: in *Macropus parryi*, e. g., the third longitudinal band at the great curvature of the stomach is almost obsolete: in the

Brush-tailed or Rock Kangaroo (*Macropus penicillatus*) the cardiac extremity terminates in a single subclavate cul-de-sac: the œsophagus opens into the middle division of the stomach, close to the produced crescentic fold which separates it from the cardiac compartment. In the great Kangaroo a second slighter fold is continued from the right side of the cardiac orifice parallel with the preceding, and forming with it a canal, somewhat analogous to that in the true ruminating stomachs, and along which fluids, or solid food not requiring previous preparation in the cardiac cavity, might be conducted into the middle compartment.

I have more than once observed the act of rumination in the Kangaroos kept in the vivarium of the Zoological Society. It does not take place while they are recumbent, but when the animal is erect upon the tripod of the hind legs and tail. The abdominal muscles are in violent action for a few seconds, the head is then a little depressed, and the cud is masticated by a rapid rotatory motion of the jaws. This act is by no means repeated in the Kangaroos with the same frequency or regularity as in the true Ruminants. A fact may, however, be noticed as an additional analogy between them; balls of hair, cemented by mucus, adpressed and arranged in the same direction, are occasionally formed in the stomach, of which I have met with two, of an oval shape, in the *Macropus parryi*.

In the genus *Hypsiprymnus* the stomach is as singularly complicated as in the Kangaroos, and the complication is essentially the same in both; arising from the sacculation of the parietes of a very long canal by a partial disposition of shorter bands of longitudinal fibres; but in the Potoroos this sacculation is confined to that part of the stomach which lies to the left of the œsophagus, while the right division of the cavity has the ordinary form and structure of the pyloric moiety of a simple stomach. The left or cardiac division is enormously developed; in relative proportion, indeed, it is surpassed only by the true ruminant stomachs, in which both the rumen and reticulum are expansions of the corresponding or cardiac moiety of the stomach. The relation of the stomach of a Potoroo to that of a Kangaroo may be concisely expressed by stating that the termination of the œsophagus in the former is removed from the commencement, or left, of the middle sacculated compartment to its termination.

When fluid is injected into the stomach of a dead Potoroo, it distends first the pyloric division; it is probably by a kind of antiperistaltic action that the aliment is propelled into the long sacculated cæcum to the left of the œsophagus.

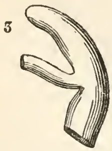
Having seen that, with the exception of the Potoroos and Kangaroos, the stomach is simple in the *Marsupialia,* presenting only some additional mucous glands in the Koala and Wombat, it is to the succeeding parts of the alimentary canal that we have to look for those modifications which should correspond with a vegetable, a mixed, or an animal diet; and never perhaps was a physiological problem more clearly illustrated by comparative anatomy than is the use of the cæcum coli by the varying conditions which it presents in the present group of Mammalia.

In the most purely carnivorous group of the Marsupial order the stomach presents in the magnitude of the left cul-de-sac a structure better adapted for the retention of food than we find in the stomachs of the corresponding group in the placental series. In the most strictly carnivorous *Feræ,* as the cat-tribe, there is a cæcum, though it is simple and short; but in the Marsupial Sarcophaga[1] this part is entirely wanting, and the intestinal canal, short and wide, is continued, like the intestine of a reptile, along the margin of a single and simple mesentery from the pylorus to the rectum. The jejunum, in the Thylacine, has a diameter of two inches and a half.

In the entomophagous[1] Marsupials, some of which are suspected with reason to have a mixed diet, the intestinal canal is relatively longer; the distinction of small and large intestine is established; and the latter division commences with a simple, moderate-sized, subclavate cæcum, fig. 312.

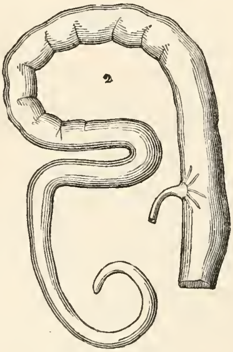
In the carpophagous[1] Phalangers, whose stomach resembles that of the predatory Dasyure, the compensation is made by a longer intestine, but principally by the extraordinary length of the cæcum, which in some species is twice that of the body itself.

312



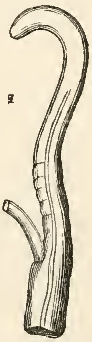
Cæcum of the Opossum.

313



Cæcum of the Kaola.

314



Cæcum of the Kangaroo.

Lastly, in the Koala, which is, perhaps, a more strictly vegetable feeder than the Petaurists or Phalangers, the cæcum, fig. 313, is more than three times the length of the animal, and its essential part, the inner secreting membrane, is further augmented by about a dozen longitudinal parallel, or nearly parallel, plaits, which are continued from the colon three-fourths of the way towards the blind extremity. When we reflect that the Sloth, which has the same diet and corresponding habits with the Koala, has a singularly complicated stomach, but no cæcum, the vicarious office of this lower blind production of the digestive tube as a subsidiary stomach is still more strikingly exemplified. In the Marsupials with sacculated stomachs the cæcum coli is comparatively short and simple. In the Potoroos, which scratch up the soil in search of larvæ and farinaceous roots, it is shorter than in the great Kangaroos which browze on grass. There is a slight tendency to sacculation at the commencement of the cæcum in the latter Marsupials, by the development of two longitudinal bands, fig. 314. In the Wombat the cæcum is extremely short, but wide; it is remarkable for being provided with a vermiform appendage, fig. 315. In this animal, however, the colon is relatively longer, larger, and it is puckered up into sacculi by two broad longitudinal bands. In the specimen dissected by me, one of these sacculi was so much longer than the rest as to almost merit special notice as a second cæcum.

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[1] LXXIV′ and LXXX′, p. 330.

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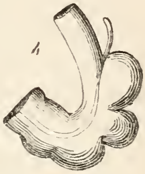

Cæcum of the Wombat.

The most interesting peculiarity which the Zoophagous Marsupials exhibit in the disposition of their simple intestinal canal, consists in its being suspended from the very commencement of the duodenum on a simple and continuous mesentery, like the intestine of a carnivorous reptile. The duodenum makes the ordinary fold on the right side, but it is not tied to the spine at its termination; the commencement of the jejunum may, however, be distinguished by a slight twist of the mesentery, and a fold of peritoneum is continued from the lowest curve of the loop of the duodenum to the right iliac region, as in the Kangaroos. The intestine is a little narrower at its middle part than at its two extremes; the tunics increase in thickness towards the rectum. There is a zone of glands at the commencement of the duodenum.

In the Entomophagans[1] the duodenum is tightly connected to the spine, where it crosses to be continued into the jejunum: from this part the mesentery is continued uninterruptedly along the small intestines and colon to the rectum; so that although the cæcum is generally found on the right side, its connections are sufficiently loose to admit of a change of position. In the Carpophagans[1] the pygmy Petaurist (*Acrobates*) shows the duodenum attached to the spine as in the opossums, but it is not tied down to the right iliac region by a fold of peritoneum continued from the convexity of its depending curve. The cæcum is disposed in a spiral curve in the left lumbar region; the colon ascends a little way in front of the stomach, receiving a branch of the superior mesenteric artery, and is then continued straight down to the anus; again exemplifying the oviparous character by the shortness of the large intestine. In the *Pet. taguanoides* the duodenum is tied down to the iliac region, as in the Dasyure; the cæcum is four inches long, and the colon is relatively longer than in *Acrobates*; it makes the tour of the abdomen much as in Man, but is continued into the rectum without forming a sigmoid flexure. In the Phalangers the duodenum winds round the root of the mesentery, descending pretty low down on the right side, and becoming a loose intestine or jejunum on the left side. The long cæcum is suspended by a broad duplicature of peritoneum continued from the mesocolon; and the colon is closely attached at its transverse arch to the duodenum and root of the mesentery. In the Koala the cæcum and large intestines arrive at their maximum of development. The duodenum commences with a small pyriform sacculus nearly an inch in breadth, and soon contracts to a diameter of five lines, which is the general calibre of the small intestines. The large intestines, where the ileum terminates, have a diameter of two inches. The end of the ileum, fig. 316, *a*, protrudes for the extent of a quarter of an inch within the cæcum, forming a very effectual valve: near this part there are two wide and deep glandular fossæ: the longitudinal valvulæ conniventes of the large intestines have already been noticed.

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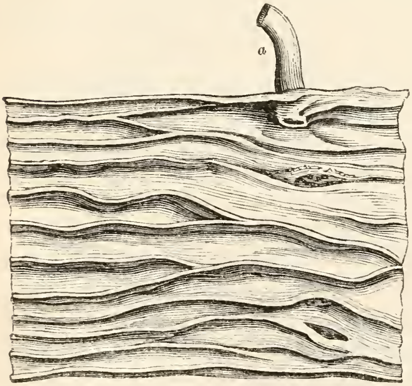
[1] See LXXIV′, for characters of these families of *Marsupialia*.

316



Ileo-cæcal valve, Koala. Half its natural size.

In the Potoroos the small intestines are disposed nearly as in the Phalangers: the short and wide cæcum lies in the right hypogastrium: the colon makes the usual tour of the abdomen, but is disposed in long convolutions through its whole course, being suspended on a broad mesocolon. The diameter of both small and large intestines is nearly the same: in *Hyps. setosus* I found this to be half-an-inch.

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[1] LXXIV'.

In the great Kangaroo the descending portion of the duodenum is attached posteriorly, by means of a thin peritoneal duplicature, to the spine, and anteriorly to the ascending colon: it makes an abrupt turn upon itself, and a fold of peritoneum is continued from the convexity of the curve to the right iliac region. The small intestines are strung in short folds on a rather narrow mesentery. The cæcum is in part suspended from the same mesenteric fold. The colon, besides its posterior connections with a mesocolon, is attached, as before observed, to the duodenum; and also, by means of the great omentum, pretty closely to the stomach, whence it passes down, forming many large and loose convolutions, to the rectum, being attached by a broad mesocolon to the left hypochondriac region.

The zone of glands at the commencement of the duodenum has been already noticed; they are present in other Marsupials, even in the most carnivorous species. The villi of the small intestines in the Kangaroo are of moderate length, compressed and close-set. Glandulæ aggregatæ are arranged in narrow patches in the ileum. There are seven groups of similar follicles in the cæcum; and a few long and narrow patches of glands occur in the colon intermingled with numerous glandulæ solitariæ; the surface of the rest of the lining membrane of the large intestine is disposed in a very fine net-work.

Two faint longitudinal bands extend along the first ten inches of the colon and are continued along two-thirds of the cæcum: the sacculi produced by these bands are but very feebly marked. The contents of the cæcum in the great Kangaroo are of a pultaceous consistence, and the mass continues undivided along the first two feet of the colon, gradually becoming less fluid and then beginning to be separated into cubical fæces about an inch square. The diameter of the large intestine in this species exceeds very little that of the small intestines.

In all the Marsupials two sebaceous follicles open into the termination of the rectum. The anus has its proper sphincter, but is also surrounded, in common with the genital outlet, by a larger one. When the penis is retracted, the fæcal, urinary, and genital canals all terminate within a common external outlet; so that in the literal sense the Marsupials are monotrematous.

The following is a table of the length of the intestinal canal, and its parts, as compared with the body, in a few species of the different families of Marsupialia:—

SPECIES.	Body from snout to vent.		Intestinal canal with cæcum.		Small intestines.		Large intestines.		Cæcum.	
	ft.	inch.	ft.	inch.	ft.	inch.	ft.	inch.	ft.	inch.
Thylacinus Harrisii	3	4	9	8						
Phascogale flavipes	0	5	0	14						
Dasyurus macrurus	1	4	5	0						
Perameles nasuta	1	4	3	5	2	5	0	9	0	3
Didelphys Philander	0	9	3	5	1	11	1	$2\frac{1}{2}$	0	4
Petaurus pygmæus	0	$2\frac{1}{2}$	0	$6\frac{2}{3}$	0	5	0	$0\frac{2}{3}$	0	1
Phalangista vulpina	1	8	24	10	11	0	9	0	4	10
Ditto	1	7	18	8	9	9	6	10	2	1
Phascolarctos fuscus	1	11	24	0	7	8	10	5	6	5
Hypsiprymnus setosus	1	0	5	0	2	5	2	6	0	2
Macropus major	3	3	32	0	22	0	9	0	1	8
Phascolomys Vombatus	2	6	25	6	11	3	14	2	0	1

§ 226. *Alimentary canal of Rodentia.*—In relation to the degree of comminution of the food and in continuation of the character of the fauces the œsophagus is narrow in all Rodents and is usually continued a short way into the abdomen before opening into the stomach. The position of the cardia is at or near to the middle of the upper curvature (fig. 317, *f*, Rat, fig. 318, *f*, *g*, Vole) as in Marsupials, and the modifications of the alimentary canal in relation to the nature of the food are, also, manifested chiefly in the cæcum. The left end of the stomach commonly projects beyond the pylorus, fig. 317, *d*, fig. 318, *b*: and it is not unusual to find both 'blind sacs' marked off by transverse constrictions from the mid-part of the cavity, fig. 317, *b*. The œsophageal epithelium is usually continued upon the inner surface of the cardiac compartment, ib. *a*. In the Porcupine, which shows well this tripartite type of stomach,

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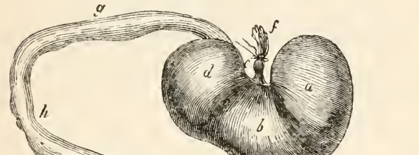

Intestinal canal, with proper and supplementary stomachs (*Mus Rattus*). CXXII'.

the pyloric aperture is much larger than the cardiac one and is bounded toward the left side by a valvular ridge.

In the Squirrels (*Sciurus*) the stomach is of a pyriform or oval shape, quickly contracting to a conical or cylindrical portion, which is bent upon the small curve and terminates in the pylorus. The cardiac compartment, which projects far to left beyond the œsophagus, is lined with a thick epidermis, which forms two oval lips, as it is prolonged around the opening into the second compartment, the lining membrane of which is gastro-mucous.

In the Hamsters (*Cricetus*) the stomach is divided into two pouches, separated by a deep constriction; the left pouch is cylindrical, the right globular. The cardiac orifice is situated in the constriction, so that food can pass at once into the pyloric compartment and be antiperistaltically moved and stored in the cardiac division.

In the Rat (*Mus decumanus*) the abdominal part of the gullet, fig. 317, *f*, is 1½ inches long, and carries forward a fold of peritoneum. The cardiac compartment, ib. *a*, has thin coats and is lined by an epithelium which usually gives it a whiter colour than the rest of the organ. At the midpart, ib. *b*, there is a tendinous patch from which muscular fibres radiate, as in the bird's stomach: the muscular coats of the pyloric division, *d*, are thicker, as is also the gastro-vascular lining membrane.

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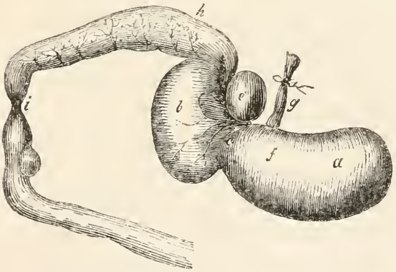

Stomach of the Water-vole. CXXII′.

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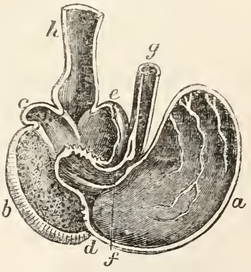

Stomach of the Lemming, inner surface. CXXXIII″.

In the Water-vole (*Arvicola amphibius*) the cardiac and middle compartments form one elongated cavity, fig. 318, *a*, *f*, separated by a constriction from the pyloric portion, *b*. This swells out in two directions, above into a small sacculus, *e*, the coats of which are thin, like those of *f*, and below into the true digestive pyloric part, with a thicker muscular tunic and gastro-vascular lining membrane. The epithelial lining of *a*, *f*, terminates by a fringed margin. The Lemmings have a similar type of stomach, complicated with a slight subdivision, fig. 319, *c*, of the right compartment, near the pylorus, where the thicker glandular lining graduates into the thin smooth mucous membrane of the suprapyloric sac, *e*. From the cardiac orifice a pair of ridges curve toward the pyloric division, defining a groove or canal, *f*, analogous to that which will be shown in the Ruminants; the border of the epithelium of the cardiac half is well-defined and sometimes fringed. The gastric tubes of the compartment, *b*, are so complex as to give the character of a gland to the lining membrane.

In the Beaver (*Castor*) the stomach is transverse and elongated in that direction, the right portion being larger than that which is situated to the left of the cardia; the œsophagus is inserted into the first third of its anterior margin by a narrow opening, surrounded with pointed processes, which are analogous to the fringes formed by the epithelium in many other Rodents. On the right of the œsophagus, at the lesser curvature of the stomach, is a gastric gland composed of numerous branched follicles, the blind ends of which, when exposed by removal of the muscular coat, give the gland a lobulated surface: the orifices of the glands are arranged on slight ridges in three longitudinal rows on a flat tract of the inner surface. On the right of these orifices commences the pyloric portion, the termination of which is indicated by an external constriction, and by an internal thickened ring: the pylorus is approximated to the cardiac orifice. This pyloric portion, which is more muscular than the rest, is sometimes dilated into a distinct pouch, separated by a constriction from the pyloric cul-de-sac. The internal membrane presents everywhere the same appearance, except that in the pyloric portion it appears to be more smooth, and its folds take a different direction. On the right of the cardia there is a very thick fold, separating the left from the right compartment. In the Dormouse (*Myoxus glis*) and Muscardine (*M. avellanarius*) similar follicular glands are aggregated round a dilated termination of the œsophagus, or cardiac commencement of the stomach, like the 'proventriculus' of birds.[1] We have here a repetition of the structure noted in the Wombat.

In the Cape Mole (*Bathyergus*) the abdominal œsophagus is an inch in length and terminates midway between the two ends of the stomach. The right compartment is of enormous size, elongated and pierced at its base by the cardiac orifice; the left compartment is of smaller dimensions, of a globular form, and separated from the preceding, both by an external constriction and an internal fold of the mucous membrane. There are, moreover, two additional folds nearer to the pylorus, which seem to form a third compartment. The Oryctere (*Orycterus*) has its stomach slightly different: its position is more longitudinal, so that the left compartment is anterior, and the right posterior; the pyloric portion is short, cylindrical, and directed forward.

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[1] xx. vol. i. p. 181, No. 590 A.

In *Capromys Fournieri* the œsophagus, after a short course in the abdomen, terminates in a stomach six inches long, about 2¼ inches from the left end: a pouch of the same extent is continued from the right of the pylorus, which is situated 1½ inches to the right of the cardia.

In the Coypu (*Myopotamus*) the stomach closely resembles that of *Capromys*, being of an oblong figure, both extremities having pretty nearly the same volume; the cardiac extremity projects three inches beyond the entrance of the narrow œsophagus, and the pyloric sacculus, a little more than two beyond the pyloric orifice. The stomach, measured in a straight line from end to end, is 7¾ inches; its greatest depth 4½ inches.

In the Agouti (*Dasyprocta agouti*), with a stomach 5½ inches long, the constriction dividing it into cardiac and pyloric portions is deep: the latter bulges out on each side the pylorus so as to make the duodenum commence from a central depression. The Paca (*Coelogenys*) shows the same structure. In an Acouchi the gastric constriction was not present or had relaxed. In the Capybara the abdominal œsophagus is two inches in extent: the greater curvature of the stomach is sometimes found puckered into sacculi by contraction of a band of longitudinal fibres.

In the Rabbit and Hare (*Lepus*, Lin.) the stomach is roundish, bent in a quick curve, with the œsophagus entering nearer the left or great end than the pyloric end: the left end adheres to part of the abdominal œsophagus: it is usually found partially constricted into two compartments, the pyloric being the thickest and most muscular. The sides of this division have a well-marked tendinous patch.

The intestinal canal usually, in Rodents, begins by a well-marked dilatation, and the whole duodenum is more continuously and loosely suspended than in most higher Mammals. In the Dormice (*Myoxus*) which hybernate like the bear, there is no cæcum. In the common Mouse and Rat (*Mus*, fig. 317) the cæcum, *k*, *l*, is short, wide, and bent; the colon, *p*, reduced to the calibre of the ileum, leaves the cæcum, like the duodenum quitting the stomach. The fæces begin to be divided in the colon, by constrictions of the gut, as in the figure: the rectum runs some way along the base of the tail before terminating. The small intestines are five times the length of the body, the large intestines once that length. In the Mole-rat (*Bathyergus*) the cæcum makes a close spiral turn, and its inner membrane is augmented by many transverse folds. The cæcum is of greater length in the *Sciuridæ*: in the common Squirrel it is curved, fig. 320, *c*, and divided from the colon, *e*, by a constriction close to the termination of the ileum. The colon is wider at its commencement than in the Rats, and the whole intestinal canal is longer. In *Sciurus griseus* the small intestines are seven times, the large intestines twice, the length of the body; the cæcum is half that length. In the Hamster the colon describes two direct and two reflected spiral coils at its commencement, decreasing in calibre, and then proceeds, of nearly the same diameter as the ileum, to terminate in the rectum.[1] In the Marmots (*Arctomys*) the duodenum passes loosely down the right side until its attachment, by a mesentery from its concavity, to the first bend of the colon, behind which it winds to the left; and after an attachment to the descending colon by serous layers from its convexity, becomes jejunum. The long and large cæcum has a mesentery; its inner surface is multiplied by circular folds, indicated outwardly by constrictions which led Hunter to compare it 'to a quilted petticoat.'[2] The indication of the low grade or affinities yielded by the termination of the intestines, is thus noted in the present Lissencephalan:—'The rectum cannot be said to terminate at the verge of the anus; but about three-quarters of an inch higher up, that lower part seems common to the anus and to a glandular apparatus whose ducts open into it. It is something like the common vagina to the bladder and uterus in fowls.'[3] In *Capromys* the ileum

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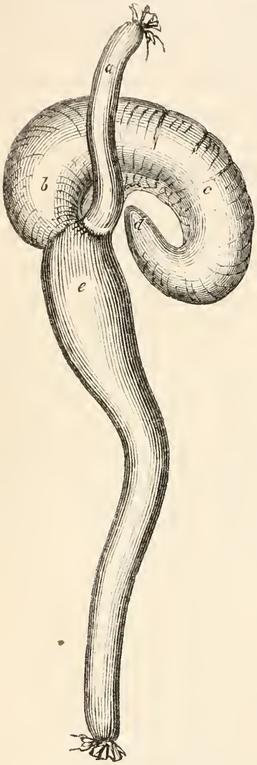

Cæcum of the Squirrel. CXXII'.

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[1] CXXII''. XXIII. p. 134, pl. XV.

[2] CCXXXVI. vol. ii. p. 242.

[3] Ib. p. 243.

applies an expanded termination to a much smaller orifice at the side of the cæcum: the part so included forming the valve. The length of the cæcum is thirteen inches: its widest circumference six inches: its parietes are puckered up by two longitudinal muscular bands, one of which is continued a short way upon the colon. The cæcum is marked off from the colon by a valvular structure similar to that at the end of the ileum; the two orifices of the blind gut being analogous to the cardia and pylorus of the stomach.[1]

In the Coypu the duodenum commences with so large a dilatation that it projects toward the œsophagus like a cæcum; its circumference here was 4½ inches; the decrease is gradual, and where the biliary duct enters the circumference is three inches, and a little distance below this 2½. The length of the small intestines is sixteen feet, their mean circumference 1¾ inches. The cæcum is large, making a circular turn at its base and gradually diminishing in volume: it is puckered into sacculi by two muscular bands, less defined toward the basal part: its length is one foot ten inches, its greatest circumference eight inches. The ileum terminates in a sort of sacculus at the base of the cæcum, close to the colon. This gut begins large, but gradually becomes narrow: it is slightly sacculated for a short distance: its mean circumference 2¾ inches. The colon makes an abrupt turn from the cæcum, and after a course of one foot five inches suddenly folds upon itself, the reflected length running down for the distance of eleven inches, when it turns as suddenly back again, but does not adhere so closely to the previous fold as that to the first length; it then contracts and soon proceeds to constitute the rectum. Near the end of the first loose fold, as in *Capromys*, the fæces begin to assume a solid form in separate oval masses. The total length of the large intestines was four feet four inches. The enormous cæcum of the Capybara occupies almost the posterior half of the abdomen.

The parallel course of the arteries along the coats of the colon in *Hystricidæ*, *Chinchillidæ*, and *Ctenomyidæ*, connected at distant intervals by transverse branches, without other ramification, is worthy of remark.[2] In the Porcupine the cæcal sacculi are puckered upon three longitudinal bands, two of which are continued some way along the colon. In the Chinchilla the sacculi project alternately from opposite sides of the cæcum. The above-defined general form of large intestines in vegetarian rodents is exemplified in fig. 321, from the Water-vole. Here the ileum terminates at the base of the sacculate cæcum, *n*; the slender termination, *q*, simulates a vermiform appendage: the colon begins by a pair of large sacculi, *r*, but quickly contracts to the calibre shown at *s*. Two oval patches are here, as usual, situated on either side of the ileo-cæcal valve. In the *Leporidæ* they are lodged in a special pouch, fig. 322, *f*: the vascular mucous membrane of the cæcum, in these herbivorous rodents, is augmented by being produced into a broad fold, disposed spirally to near the slender termination of the cæcum, *d*, *b*, which is glandular, like the vermiform appendage in Man. Three longitudinal bands extend upon the colon; but two of these become blended together as that gut contracts, and the sacculi project from one side only, in which the fæcal contents begin to be moulded into the pellet-shaped excrement. After the colon has completed its first long fold, returning to near its commencement, the sacculi disappear.

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[1] cxxx″. p. 70, *et seq.* for further details of the alimentary canal of this rare rodent.

[2] xx. vol. i. p. 215, No. 723, c. cxxxi″. p. 22, pl. i.

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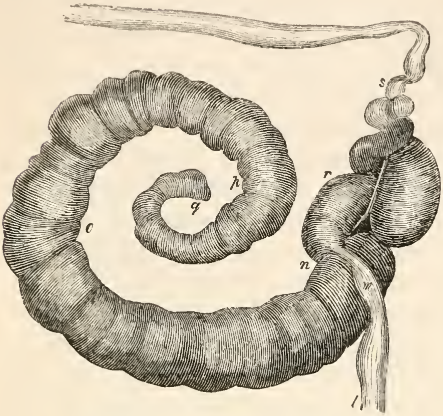
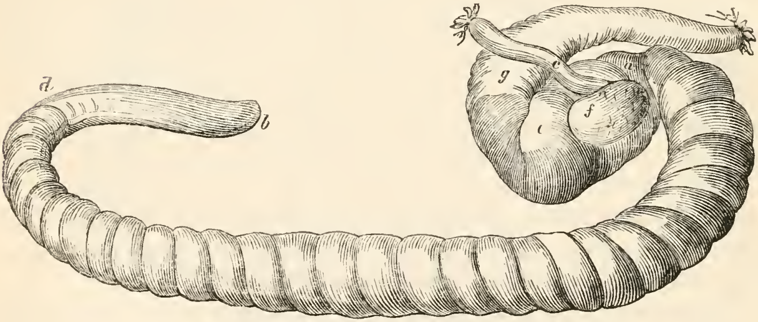


Cæcum of the Arvicola amphibius. CXXII′.

322



Cæcum of the Hare. CXXII′.

Besides the analogy already noted between the orifices of the cæcum and those of the stomach, that of the different diameters of the entering and out-going tubes may be observed. Comparative anatomy concurs with results of undesigned experiments, as in cases where artificial openings have been established in the human intestinal canal, in showing that a change to gastric digestion is repeated upon the food in the cæcum: chemistry has, also, shown that the chyme here again becomes acidified, after having been neutralised by bile in the small intestines.

§ 327. *Alimentary canal of Insectivora.*—In this, as in preceding orders, the œsophagus is usually prolonged some way into the abdomen before its termination. My examinations of the stomach in the different insectivorous genera lead me to generalise an approximate, rather than a remote, relative position of the cardiac and pyloric orifices:[1] the form of this viscus, in most, accords with that in Ornithorhynchus, fig. 308, *b*. In a Proboscis-shrew, e.g. (*Rhynchocyon*, Peters), the depth, or diameter of the stomach in the axis of the abdomen, exceeds the length, or transverse diameter: the cardiac end does not bulge out to the left of the gullet so much as in *Rodentia*; but there is usually an expansion beyond and to the right of the pylorus, and the proximity of that orifice to the cardia leaves but a short tract answering to the 'lesser curvature' of the stomach, fig. 323, *s*. The form of this viscus in *Solenodon*, *Amphisorex*, *Hydrosorex fodiens*, and *Cladobates*, is very similar to that in *Rhynchocyon*: in all *Insectivora* the duodenum expands to much more than the diameter of the œsophagus. In our small native Shrews the shape of the stomach depends much upon the quantity it happens to hold, and the transverse extent prevails most in the empty state. In *Sorex araneus* the cardiac sac projects moderately beyond the œsophagus; in *S. leucodon*, *Hydrosorex hermanni* and *Amphisorex tetragonurus*, the cardiac sac assumes almost rodent proportions: in many Shrews the contracted pyloric part of the stomach is much prolonged.

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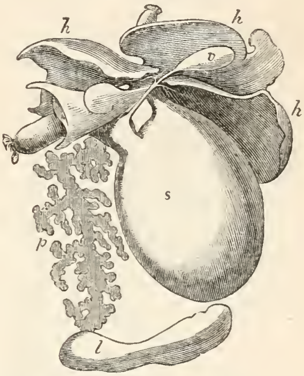

Stomach, liver, &c., Rhynchocyon. LXXXIV′

In the Hedgehog the transverse length of the stomach prevails over the depth: the blind end to the left is less produced than in the above-named Shrews: the coats of the narrow pyloric end are thick.[2]

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[1] 'Il est généralement disposé en travers, plus ou moins alongé dans ce sens, avec les orifices distants.' XII. tome iv. p. 34. See also LXIII″. p. 1002.

[2] Hunter notes that he found in the stomachs of Hedgehogs, in April, grubs, with a little unchewed grass; in May, June, July, and August, 'the insects of the season,' and caterpillars of the cabbage (*Pieris Brassicæ*); in September and October,

In the Mole the abdominal œsophagus is long and enters the stomach midway between the two ends: the cavity, when distended with the worms and grubs devoured by this voracious burrower, 'fills nearly half of the abdomen.'[1] In the Tenrecs (*Centetes*) the cardia and pylorus are further apart than in most *Insectivora*: the cardiac sac is less prominent; the pyloric end is bent upon itself.

As a rule the intestinal canal is uniform in diameter, and devoid of cæcum in the present order: it is loosely suspended on one continued peritoneal fold from the beginning of the duodenum to the rectum. In the common Shrews, fig. 359, the intestine is about four times the length of the body; in the Hedgehog about six times, in the Mole seven times, that length. The Tupaias and some of the snouted-shrews are exceptions: in the former (*Cladobates*) the cæcum is simple, straight, about an inch in length, not wider than the major part of the colon; and but little wider than the ileum. *Macroscelides* has a long, slender, pedunculate cæcum. In *Rhynchocyon*, the cæcum, fig. 324, *c*, is about 3 inches long, and is twice the width of the ileum, ib. *i*. The colon, of similar diameter with the cæcum, forms a short double bend, *r*, *r*, returning upon itself, before it is continued on into the narrow portion ending in the rectum.

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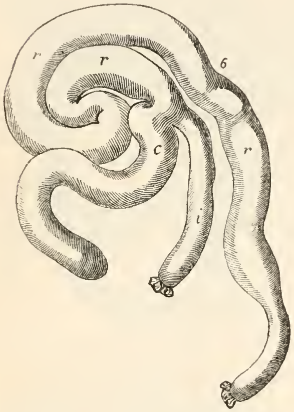

Cæcum and colon, Proboscidian Shrew. LXXXIV'.

The lining membrane of the Mole's intestine is disposed, along part of the canal, in close-set longitudinal folds; but is remarkable for its smoothness and absence of visible villi. The mucous membrane of the Hedgehog's intestine is beset with minute flat, conical villi, changing toward the end of the canal into a fine reticulate surface.

§ 328. *Alimentary canal of Cheiroptera.*—The Cheiroptera present three forms of stomach; one relating to vegetable diet, another to the times of taking the food and to the quantity taken, a third to the ordinary capture of insects during flight. The latter relation, which prevails in the order, is associated with a form of

elytræ, wings and legs of insects, including those of the *Scarabæus* and of *Geotrupes stercorarius*; from November onward to March—the hybernating season—there was no food in the stomach, only a little creamy mucus. CCXXXVI. vol. ii. p. 193.

[1] Ib. p. 187.

stomach, resembling that in the common Shrew. In fig. 325, the cavity has been inverted, showing the rugæ and the glandular character of the gastric membrane at the pyloric end. The difference in the diameters of the œsophagus and duodenum are also shown. In the Noctule a small part of the right end of the stomach projects beyond the pylorus. In *Plecotus communis* the left end of the stomach becomes somewhat attenuated and bent up. In the Vampires (*Desmodus*) the cardiac portion is produced into a long intestiniform reservoir,[1] in which the blood is stored up, that may have been sucked during a night's adventure, and transported for digestion in the place of repose. In the Pteropines the left end of the stomach, fig. 326, is much produced, but in a far less degree, than in *Desmodus*. It is sometimes found, in the partially distended state, divided into two dilatations: the extreme one smooth; the other, nearer the cardia, showing rugæ longitudinally disposed: the œsophagus in these frugivorous Bats is wide and expands near its termination. To the right of this expansion the stomach is long and narrow, bent upon itself, and produced into a cæcal pouch beyond the pylorus, which is extremely small. The intestinal canal is usually devoid of cæcum; but the colon begins with one about a quarter of an inch in length, in *Rhinopoma Hardwickii* and *Megaderma spasma*. The whole intestine is barely thrice the length of the body in *Vespertilio murinus*: in a *Pteropus* it is nearly seven times that length. The intestinal villi in some Bats are close-set foliaceous processes, and form extremely beautiful microscopic objects when injected. In *Rhinolophus* the lining membrane presents fine transverse folds.

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Stomach inverted of common Bat (*Vespertilio murinus*).

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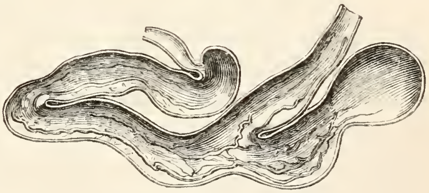

Stomach of Pteropus. XXVIII.

The low position of the volant and terrestrial *Insectivora*, as of Rodents and Marsupials in the Mammalian series, is shown by the loose and simple mode of suspension of the intestinal canal.

§ 329. *Alimentary canal of Quadrumana.*—The *Galeopitheci* indicate their lemurine affinities by their long and large cæcum. The œsophagus opens on the cardiac side of the middle of the small curvature; but leaves a well-marked semi-oval pouch to the left: the pyloric end loses in calibre and gains in thickness of its coats, the inner one projecting in wavy longitudinal folds: the pylorus is a small constriction. In a male *Galeopithecus Temminckii,* measuring from the apex of the nose to the root of the tail 1 foot 4 inches, the small intestines were 4 feet 4 inches, the cæcum 1 inch, the large intestines 7 feet 7 inches.[1]

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[1] A good figure of this modification, first observed by Peters, will be found in cxxxvi″. p. 388.

In the Aye-aye the œsophagus has a course of about a third of an inch in the abdomen before terminating at the cardiac orifice. This is situated, as in most Lemurs, nearer the pylorus than the cardiac end. The stomach is of a full, subglobular form: the pyloric end projects about half an inch below and to the right of the pylorus. A narrow glistening tract of fine aponeurotic fibres runs parallel with, and a little below, the short curvature between the cardiac and pyloric orifices, and from this tract the fibres of the outer muscular layer radiate. A narrow but well-marked crescentic fold projects into the cavity from the lesser curvature, four lines to the right of the cardia, subsiding about an inch down the fore and hind walls: this fold appears even when the cavity is fully distended, and it marks out internally the division between the cardiac and pyloric compartments. The pylorus is a subcircular aperture, above which projects a short thick longitudinal prominence. The duodenum, after its usual curve, crosses the spine below the root of the mesentery, then turns up the left side to commence the three principal folds of the small intestine, on the border of the mesentery, by which, with the cæcum, they are freely suspended. A duplicature of peritoneum is continued from the end of the duodenum, and from the lower part of the beginning of the colon, to the first lumbar vertebra, attaching them thereto. The colon, after a course of 3 or 4 inches, forms a long narrow fold, 5 inches in length, then passes to the left, above and behind the root of the mesentery, and descends along the left lumbar and hypogastric regions to form the rectum.

The small intestines are rather more than three times the length of the body: the cæcum is about one-fifth that length; measuring 2 inches 7 lines: for the first inch it is 10 lines in diameter, but suddenly contracts to a diameter of 3 lines; terminating rather obtusely, and resembling an appendix vermiformis; but this is not marked off by any valvular structure from the wider part of the cæcum, and it is continued, as in the human fœtus, directly from the end of the wider part, or cæcum proper. The large intestines are about 1 foot 10 inches in length. The colon, moderately distended, is 1 inch 2 lines in diameter at its commencement, and gradually decreases in width. Beyond the first enlargements it is not sacculated, but is slightly puckered on a longitudinal band, which may be traced a few inches from the beginning of the gut, where two or three pouch-like protrusions appear on inflation. The ileo-colic aperture is slit-shaped, bounded by two low ridges, that next the cæcum being most produced.[1]

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[1] 'In several shot on the hills at Pinang, the stomach contained vegetable matter, but no remains of insects. In confinement plantains constitute the favourite food.' LXXXII″. p. 8.

This type of cæcum is repeated in *Stenops javanicus* with a longer and narrower 'vermiform' termination:[2] in *Stenops tardigradus* this part is shorter:[3] in *Tarsius*,[4] *Perodicticus*,[5] *Otolicnus*,[6] and the Galagos,[7] it is wanting, and a moderately long and wide cæcum terminates obtusely, without contracting: in *Galago calabariensis* it is comparatively short:[8] in *Galago moholi*, with a more efficient form of molars for mastication, the cæcum is more than twice the length in proportion to its calibre, and it is puckered by a mesenteriole into five or six short folds, fig. 327. The cardiac part of the stomach is large in all Lemurines, fig. 328, *a*: but the pyloric part rarely protrudes to the right of the pylorus, below the beginning of the gut. The duodenum is rather shorter in true

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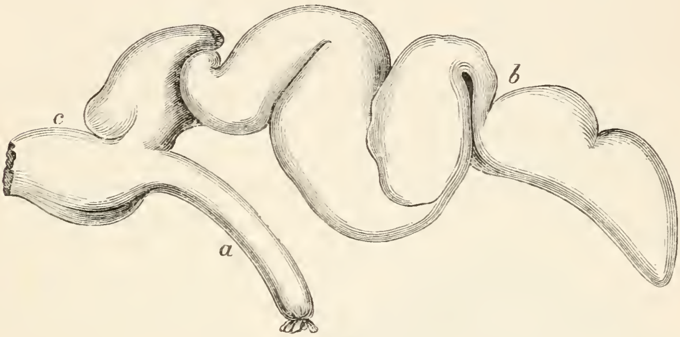

Cæcum of *Galago Moholi*, nat. size.

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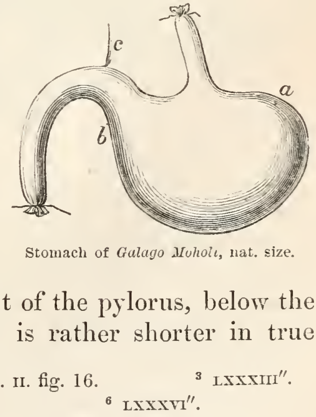

Stomach of *Galago Moholi*, nat. size.

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[1] CII′. p. 42, pl. xiv.
[2] CXXIV″. p. 50, pl. II. fig. 16.
[3] LXXXIII″.
[4] LXXXIV″.
[5] LXXXV″.
[6] LXXXVI″.
[7] LXXXVIII″. pl. xi. fig. 1.
[8] CXXXIV″. and CXXXV″. p. 329, fig. 9.

Lemurs than in Galagos: the cæcum was 7 inches long in a *Lemur Mongoz*; it was loosely suspended, as in other *Lemuridæ.*

In the small Platyrhines (*Midas, Jacchus*) the œsophagus is continued a short way into the abdomen, and the stomach resembles that in *Lemuridæ*: the duodenum becomes free in passing to the left. The cæcum is of moderate length, cylindrical, curved: two longitudinal bands are continued from it along the colon. In *Jacchus vulgaris* the small intestines are twice the length of the body, the large intestines once that length. The cardiac sac of the stomach is large in all Platyrhines, but the cardia and pylorus are less approximate in the larger kinds. In *Ateles* and *Mycetes* Cuvier notes a tendency to sacculation along the great curvature. The cæcum is 4 inches long and 1 inch broad in *Cebus*; in *Ateles* it is subconical, the base being next the colon. In *Mycetes* the cæcum is proportionally shorter, but retains the simple unsacculated character.

In *Cercopithecus* the œsophagus, with a short abdominal course, opens into the stomach midway between the left and right ends: in *Macacus* and *Cynocephalus* the left sac is relatively less: the chief modification is presented by the Doucs, or those tailed monkeys which have a fifth tubercle on the last lower molar, and are without cheek-pouches. In a *Semnopithecus entellus* which measured 1 foot 8 inches from the mouth to the vent, I found the stomach, fig. 329, 2 feet 7 inches along the greater curvature, and 1 foot along the lesser curvature. To the left of the cardia it forms a large and sub-bifid pouch: the middle and widest part of the stomach is puckered up into several large sacculi: the pyloric portion is long, narrow, curved and sacculated along the line of the greater curvature to within one-third of the distance from the pylorus, where it is simple and gradually contracts to that orifice: the vascularity and structure of the lining membrane of the third division indicates it as the chief

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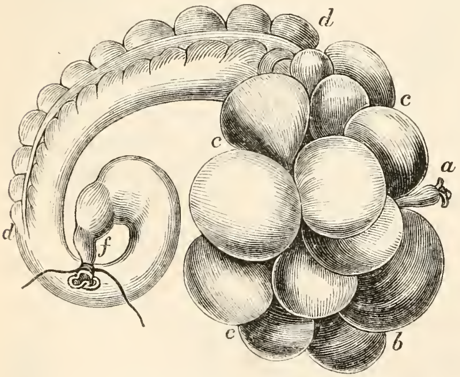

Stomach, distended; *Semnopithecus Entellus*. CXXXIX″.

seat of true digestion; the wider sacculated divisions have mainly a preparatory and a receptacular function: a firm epithelium is not continued into them from the œsophagus: the greatest circumference of the dilated stomach is 1 foot. The stomach of the *Semnopithecus fascicularis* is similarly complex but proportionally smaller: as are also those of *Nasalis larvatus* and *Colobus ursinus*; in which, as in the *Semnopitheci*, a narrow band of longitudinal fibres, continued from the left end along the greater curve, puckers up the tunics into the larger sacculi, a second band along the lesser curvature contributing in a minor degree to this complexity.[1] Evidence of the accumulation and detention of vegetable food is afforded here, as in Ruminants, by occasional 'bezoar' concretions.

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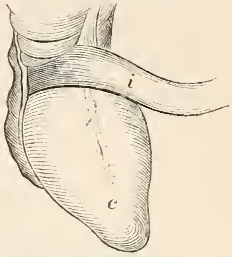

Cæcum, *Cercopithecus sabæus*. CXXII

The stomach resumes its simple form in tailless apes: in which the left end is less prominent than in *Macaci*, and the lesser curvature is of greater extent; the pyloric division is longer, and the entire form less globular: in the Orang the pyloric division shows a rather abrupt bend. The lining membrane of the stomach when in a moderately distended state is devoid of rugæ in all Apes; and the small intestines are without transverse folds of the mucous membrane. The cæcum in Catarhines is always shorter than in Platyrhines, is usually wider and more or less sacculated. In some species of *Cercopithecus* it is puckered up by four longitudinal bands, of which three are continued along the colon: in most the cæcum is more conical in shape than in *Macacus*, the apex being narrower and more prolonged, e.g. *Cerc. Sabæus*, fig. 330. In *Hylobates*, fig. 331, the vermiform appendage reappears; it is terminal, and in some species short; but is more

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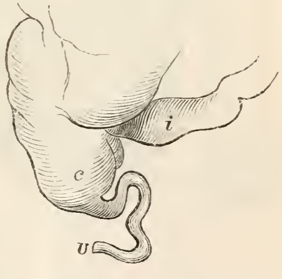

Cæcum and vermiform appendage, *Hylobates*. CXXII′.

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[1] This type of quadrumanous stomach was discovered in an undetermined kind of monkey by Wurmb, in 1785; and, independently, by Otto, in a supposed *Cercopithecus* in 1824, and described in CXXXVII″: it was determined to be characteristic of the natural group, including the genera *Semnopithecus*, *Nasalis*, and *Colobus*, in CXXXVIII″, CXXXIX″, CXL″, and CXLI″.

differentiated as such by its glandular tunic and marked commencement than in *Lemuridæ*: the appendix is terminal, but is long and convolute in the Orangs (*Pithecus*): in the Chimpanzees (*Troglodytes*) there is a more marked constriction between the appendix and the cæcum. The colon is sacculated and moderately long in all Catarhines: it is loosely suspended by a broad mesocolon, and only in tailless apes does the cæcum begin to adhere, through an incomplete peritoneal investment, to the right hypogastric region.

§ 330. *Alimentary canal of Bimana.*—The chief characters of the canal in this order are the termination of the gullet almost as soon as it has entered the abdomen; the more extensive and closer adhesion of parts of the alimentary canal, as the duodenum, cæcum, beginning and end of colon, to the abdominal walls, which relates to the erect posture; the more definite and finished character of the several parts of the canal; and the modification of the lining membrane of the small intestines, called 'valvulæ conniventes,' for a more complete and efficient extraction of nutritious matter from the chyme.

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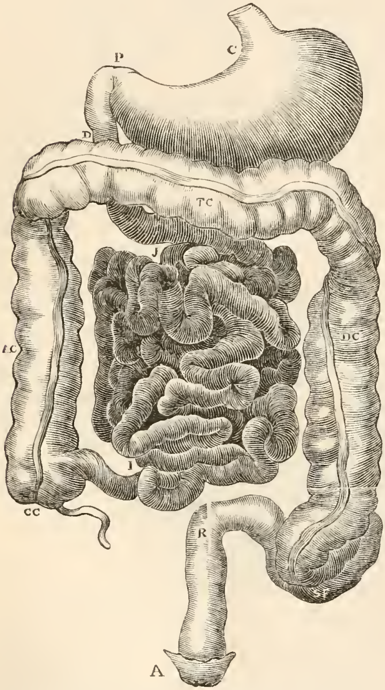

Stomach and intestinal canal of the adult Human subject. CXLVIII''.

The stomach presents a greater extent transversely to the abdomen than in *Quadrumana*, and the blind left end ('saccus cæcus,' Haller) is less extended and expanded than in Monkeys and Lemurs, the œsophagus opening more to the left, and leaving a more extensive 'lesser curvature,' fig. 332, C, P. Anthropotomy distinguishes the 'cardiac orifice,' fig. 333, *a*, *g*; the 'cardiac pouch' or 'blind sac,' ib. *g*, *d*; the 'lesser curvature,' ib. *a*, *e*, *b*; the 'greater curvature,' ib. *g*, *d*, *f*, *c*, *h*; the 'pyloric portion,' ib. *e*, *b*, *b*, *c*; and its orifice or 'pylorus,' ib. *b*, *b*. In a state of moderate distension the length of the stomach averages from thirteen to fifteen inches; its widest diameter five inches; its capacity five pints. It extends almost transversely across the upper (in Man) part of the abdomen from the left toward the right side, the pylorus entering the region called 'right hypochondrium:' as the stomach becomes distended, it gently rotates the great curvature forward. The outer or 'serous' coat is continued from the lesser curvature and contributes with the end of the gullet and beginning of the gut to suspend or attach the bag: from the curve *d*, *f*, *c*, the serous coat extends down to form the 'great omentum,' fig. 388; thus provision is made for the digestive cavity to encroach upon the interspace of the two serous layers during expansion. The muscular coat of the stomach is in three layers which, from the general course of the fibres, are termed 'longitudinal,' 'transverse,' and 'oblique:' the latter or innermost layer, fig. 333, *g*, *d*, *f*, *c*, is partial: the other two are complete. The longitudinal layer, like that of the gullet, is the outermost; and the fibres radiate from the cardia, becoming thinner as they diverge, spreading and decussating with the other fibres, and hardly traceable continuously to the pylorus, save along the lesser curvature. The transverse fibres, which lie immediately beneath the longitudinal, form a thicker and more uniform stratum: in the inverted stomach, from which the mucous membrane has been dissected, in fig. 333, they are the innermost at the pyloric end, *c*, *e*, *b*: at the cardiac end they are lined by the layer of 'oblique' fibres. The transverse layer increases in thickness to the pylorus, fig. 334, the circular fibres or sphincter occupying the valvular fold of the mucous membrane,

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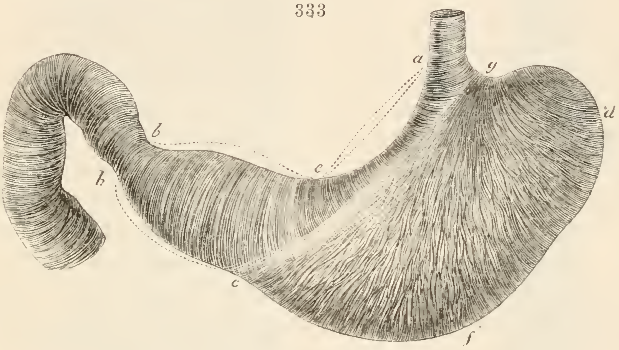

Muscular coat, Human stomach, inverted. CXLVIII''.

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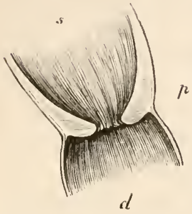

Longitudinal section of the pylorus. CXLVIII''.

ib. *p*. This membrane is usually of a pale pink colour, deeper tinted at the pyloric than at the cardiac portion, and produced into numerous wrinkled folds or 'rugæ,' which are not so soon effaced, under distension, as in the quadrumanous stomach. The 'basal' part of the membrane is areolar or cellular tissue, connecting it to the muscular coat; it also supports the vessels and nerves, forms the cylinders of the gastric tubules, and is covered by a delicate epithelial layer of the columnar kind. The gastric tubules, fig. 337, are cylinders of the basal membrane, packed vertically side by side, and filled by cells: their inserted end, *d*, is closed: they expand slightly before reaching the free surface of the membrane, where their margins become continuous with each other, so as to form a series of low ridges, the height and width of which vary somewhat in different parts of the stomach. The length of these tubes is about $\frac{1}{25}$th of an inch at the middle of the organ, almost double that length at the pyloric portion, and half that length at the cardiac region,—a difference causing the different thickness of the mucous membrane in these parts of the cavity. Their diameter is about $\frac{1}{450}$th of an inch, and is a little increased in the pyloric ones: in some of these, blind processes are continued from the inserted end; as commonly seen in the Dog, fig. 349. Toward the outlet the tubule is occupied by 'columnar epithelial cells,' fig. 337, *c*: the deeper portion is filled by oval nucleate cells, attaining in some cases $\frac{1}{1200}$th of an inch in diameter, ib. *b*. The tubules are connected together by a finely fibrous form of areolar tissue, in which their blind ends, or branches, are imbedded.

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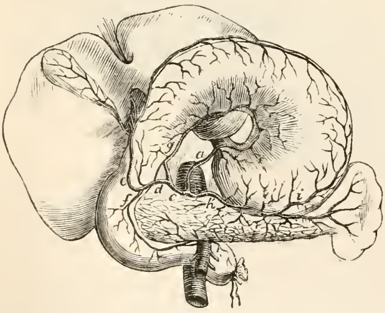

Arteries of the stomach, as seen by raising it CXLVIII''.

The principal arteries of the stomach, derived from the 'cœliac axis,' are the 'arteria coronaria ventriculi,' fig. 335, *a*, which courses along the lesser curvature; the 'gastro-duodenalis,' *d*, which gives off the 'arteria pylorica,' *g*; the 'gastro-epiploica,' 'dextra,' *e*, and 'sinistra,' *i*. The branches of all these arteries have a tortuous course and freely inosculate; their ramuli perforate the muscular coat and form, with the veins, an expanse of network, fig. 336, *e*, in the loose submucous areolar tissue: the capillaries, ib. *a*, penetrate the gastro-mucous coat, their ultimate branches, of from $\frac{1}{1500}$th to $\frac{1}{1800}$th of an inch in diam., ib. *d*, passing vertically along or between the walls of the gastric tubes to their outlets, where they form a fine superficial network, *b*: from this the veins commence, and return by the vertical canals, *c*, *c*, to the submucous network, *e*.

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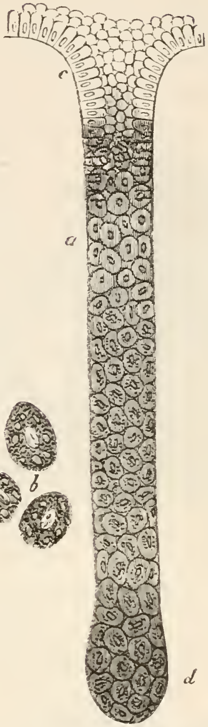

Gastric tubule, from the middle of the Human stomach; magn. 140 diam. CXLVIII″.

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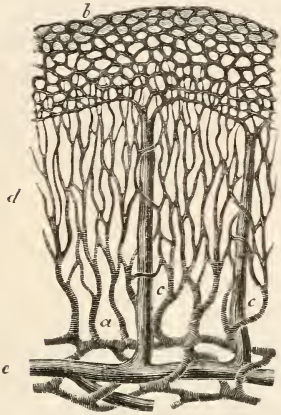

Capillaries of the gastro-mucous membrane. CXLVIII″.

The product of the tubules, called 'gastric juice,' is a limpid fluid of a pale straw colour, acidulated by hydrochloric acid, and also by lactic acid (unless this be a secondary result of analysis): its peculiar organic principle, called 'pepsin,' contains about two per cent. more nitrogen than the ordinary proteine compounds. If dilute hydrochloric acid be added to a solution of pepsin in cold water, the liquid exercises solvent powers over organic substances, especially animal ones, and a kind of artificial gastric juice is thus produced. The natural gastric juice exercises a coagulative and alterative as well as solvent power upon the food, and 'digests' or converts it into chyme.

The canal which receives the chyme, called 'small intestine,' extends from the pylorus, fig. 332, P, to the cæcum, C C: it is about 20 feet in length and $1\frac{1}{4}$ inches in diameter.[1] Its beginning, fig. 335, *f*, curves outward and backward to the under surface of the right lobe of the liver, and has an entire investment of peritoneum: the gut descends along the inner border of the right kidney, where the posterior wall is left uncovered by the peritoneum, and is attached by cellular tissue to the subjacent parts: it then crosses below the pancreas, behind the stomach, to the left, having a partial covering of peritoneum, and only regains the entire serous coat where it emerges to form the beginning of the next part of the small intestine. This is termed 'jejunum,' fig. 332, J, from its usual emptiness, and the rest of the tube is 'ileum,' ib. I: these convolutions are suspended upon the duplicature of peritoneum called 'mesentery.' The muscular tunic of the intestine consists of an outer longitudinal and an inner transverse or circular stratum; both layers being somewhat stronger in the duodenum. The mucous membrane begins, in the second portion of the duodenum, to be disposed in transverse folds called by the old Anthropotomists 'valvulæ conniventes,' fig. 338, as tending to impede, while, at the same time, conniving at, the passage of the chyme; but, in truth, extending the surface to which the chyme adheres in the process of elimination of the chyle: their direction at right angles to the course of peristalsis not only checks the passage but insures the admixture of the various constituents of the chyme. The alterative and absorbent surface of the small intestine is further augmented, as in most Mammals, by the minute filamentary processes which, giving the free surface a velvety character, are termed 'villi.' In the magnified section of the intestinal tunics, fig. 339, *a* are the villi, *c* the submucous areolar tissue, *e* transverse fibres, *f* longitudinal fibres of the

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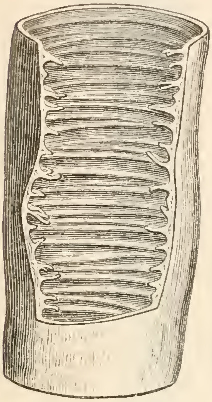

Valvulæ conniventes,' Human small intestine. CXLVIII″.

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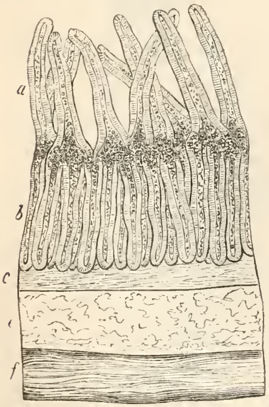

Section of Human jejunum: magn. 50 diam. CXLVIII″.

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[1] The length of the body from the vertex to the vent, not to the heel, is that which should be taken for comparison of proportionate length of the intestines in Man with those of brutes recorded in the 'Tables' of XII, tome iv. pp. 182–208.

muscular coat; in fig. 341 the serous coat is marked *g*. In the interspaces of the villi minute pores may be seen by the aid of the lens: they are the outlets of the 'intestinal tubules,' figs. 339, 341, *b*. Like those of the stomach they are hollow cylinders, fig. 340, closed at the ends, *e*, which are buried in the areolo-fibrous tissue: their length is about five times their width, which averages $\frac{1}{300}$th of an inch: their proper wall consists of nucleated columnar cells, *a*, *b*; their mouths *d*, open into the area of the gut: their contents are a clear fluid and minute granules. Each villus is covered by an epithelium of columnar cells inclosing a parenchyme, with traces of unstriped muscular fibre, the commencement of the lacteal absorbents, and a rich supply of capillary vessels. From the analogy of the gastric tubules it may be concluded that the intestinal ones continue the solvent and alterative operations on the chyme. Other arrangements of secreting surface relate to the furnishing of lubricating mucus for accessory offices: these are noted as the 'follicles.' They are either 'solitary,' fig. 341, *i*, or in groups, termed 'agminate,' fig. 342, and such patches appear to be bare of villi. The size and structure of the follicles are the same under both arrangements: they are considerably larger than the intestinal tubules, fig. 341, *b*; the follicle, *h*, expands as it sinks into the submucous tissue, *d*, and its broad base is usually applied to the muscular coat, *e*. The follicles are filled with an albumino-mucous pulp. Fig. 342 gives a moderately magnified view of a patch of 'agminate follicles,' of which patches about a

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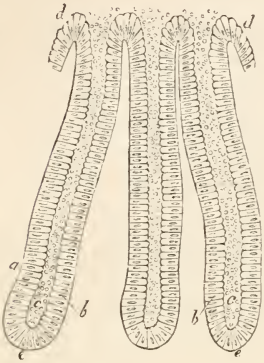

Intestinal tubes from the jejunum magn. 80 diam. CXLVIII''.

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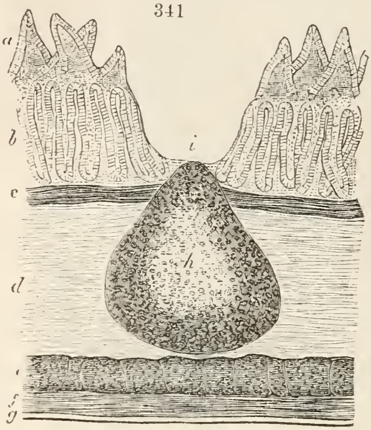

Intestinal follicle in vertical section; magn. 40 diam. CXLVIII''.

score may be found in the tract of the small intestine, situated opposite the line of attachment of the mesentery, and most numerous in the ileum, where the intestinal contents become less dilute: rarely are any seen in the duodenum. Viewed with a higher power, as in fig. 343, the follicular orifice, *a*, is surrounded by a circle of pores of the 'intestinal tubules:' and in the interspaces of the clustered follicles project short obtuse conical villi, *b*, of so much smaller size than the ordinary ones as to make the patch appear bare. The looped capillaries of the follicle come off from vessels encircling their capsule.

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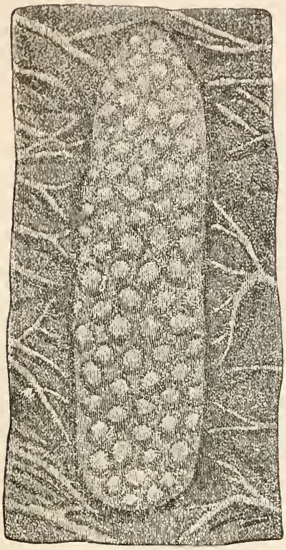

Patch of agminate follicles, magn. 5 diam. CXLVIII''.

The 'racemose glands,' fig. 343, *c*, are peculiar to the duodenum, and most numerous at its commencement where they form a circular layer just beyond the pylorus. Here each gland is about $\frac{1}{118}$th of an inch in diameter. The duct at the areolo-fibrous base of the intestinal glands, fig. 344, *a*, divides and subdivides in the thick submucous tissue, and ultimately terminates, or receives the secretion of numerous subglobular or polyhedral follicles, averaging $\frac{1}{300}$th of an inch in diameter: these answer to what are termed the 'acini' in larger glands: the nature of their secretion has not been determined: it, probably, resembles the pancreatic from analogy of structure.

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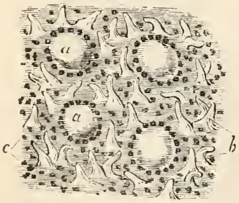

Portion of patch of agminate follicles, magn. 12 diam. CXLVIII''.

The ileum terminates in the side of the beginning of the large intestine leaving a short and wide sacculated 'cæcum' from near the end of which is sent off a slender 'vermiform appendage,' fig. 332, C C. The human cæcum is further characterised by its fixed position; having only a partial covering of peritoneum, which passing off from its fore part binds it down to the 'iliacus internus' muscle to which its non-serous surface is connected by areolar tissue and fascia. The intestine, as it rises from the cæcum, is called 'colon' or 'ascending colon,' ib. A C, and continues, as it passes the right kidney and 'quadratus lumborum,' to be attached thereto by a progressively decreasing breadth of non-serous wall: the gut then resumes a complete serous coat, which passes off into the progressively widening duplicature of peritoneum, forming the ‘mesocolon:’ nearing the duodenum it arches across to the left, TC, at the line between the ‘umbilical’ and ‘epigastric’ regions of Anthropotomy: then, descending ventrad of the left kidney and ‘quadratus lumborum,’ it becomes attached thereto by areolar tissue: it next forms the folds called ‘sigmoid flexure;’ ib. S F; and, bending to the mid line, contracts and passes as the ‘rectum,’ R, to the vent. Save at this terminal portion, the longitudinal fibres of the large intestine are specially aggregated along three nearly equidistant tracts, one of which runs along the line of attachment of the mesocolon: these ‘bands’ are nearly one-half shorter than the entire gut, and consequently pucker it up into sacculi. They commence at the setting on of the vermiform appendage and diverge therefrom to their positions on the cæcum and colon: at the sigmoid flexure they begin to expand and form, with added fibres, a strong continuous longitudinal stratum upon the rectum. The circular fibres, uniformly thin and feeble upon the colon, are thickened round the rectum. The human ‘vermiform appendage,’ fig. 345, *g*, is commonly from 4 to 5 inches in length: its diameter is about $\frac{1}{3}$ of an inch: the follicular glands are so numerous as to constitute sometimes a continuous layer. The ileum, ib. *a*, opens by a transverse slit into the inner or mesial side of the cæcum, *c*: the opening being defended by a pair

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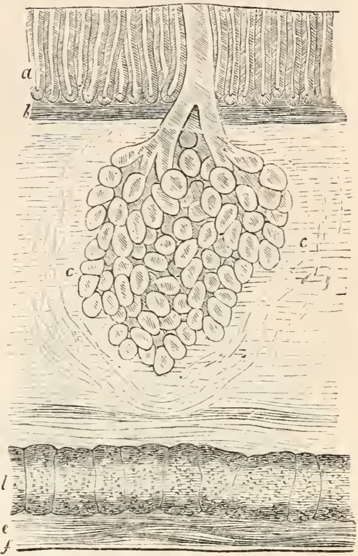

Racemose gland; Human duodenum; magn. 40 diam. CXLVIII″.

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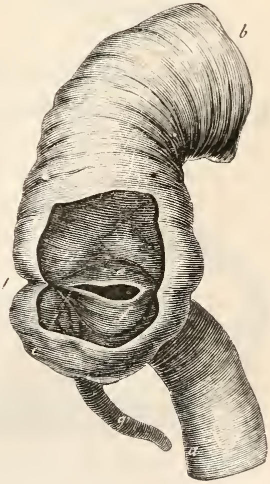

Cæcum and ileo-cæcal valve, CXLVIII′

of semilunar valvular folds, of which the lower, *f*, is the 'ileo-cæcal,' the upper, *e*, the 'ileo-colic' valve. A transverse constriction, *d*, usually marks the boundary between cæcum and colon. In the apes and all lower quadrumana the ileo-cæcal orifice and valve are circular. The mucous membrane of the cæcum and colon is the seat of both intestinal tubules and follicles: the latter are chiefly present in that of the rectum, which is disposed in numerous folds. Although this gut appears straight in a front view, it follows, in Man, the curve of the pelvic cavity, through which it passes, as shown in the side view, fig. 346. The peritoneum is reflected from its upper third, forming the 'recto vesical' pouch, ib. *r*, *v*; and the rest of the gut is attached by the ordinary areolar tissue to the surrounding part. Anthropotomy accordingly distinguishes, in the rectum, an upper or 'oblique segment,' *s*, *r* 1: a middle or 'arcuate segment,' *r* 2, and a 'terminal portion,' *r* 3: inclosed at the end by the 'sphincter ani,' *q*, *n*.

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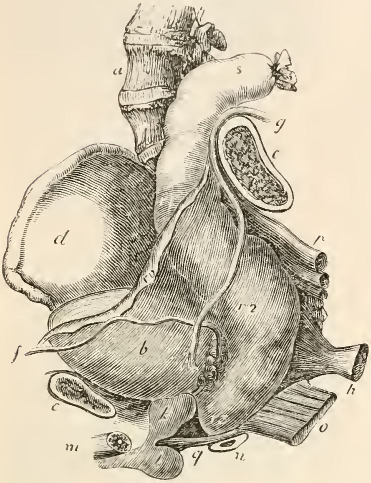

Section of Human pelvis, showing course of rectum.
CXLVIII″.

§ 331. *Alimentary canal of Carnivora.*—In this group the digestive system is adapted, as a rule, exclusively for animal diet. The œsophagus is usually wide. The muscular fibres are arranged in an external longitudinal and an internal transverse layer: but, in the Lion, a third layer of longitudinal fibres is applied to the inner side of the circular ones at the terminal part of the tube: they are separated from the circular fibres by loose areolar tissue; and are closely attached to the lining membrane of the œsophagus, which they, here, pucker up into numerous narrow alternating

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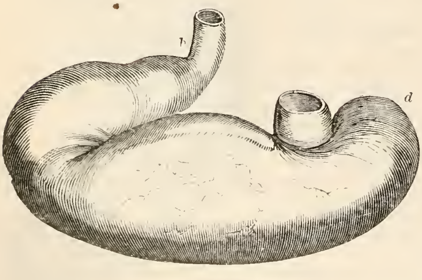

Stomach of the Lion.

transverse rugæ. The stomach of the Lion, fig. 347, shows its common form in the order: it is chiefly elongated from right to left; but lies less transversely to the abdomen than in Man: the cardia, *a*, and pylorus, *b*, are wide apart: there is but a small extent of 'blind sac,' *d*, to the left of the cardia, and the pyloric end, *e*, *b*, is bent abruptly and closely upon the middle of the stomach. The longitudinal fibres of the muscular coat form a strong band along the lesser curvature: the rugæ of the inner coat affect a longitudinal course: the pyloric valve is less prominent than in man. The branches from the 'arteria coronaria ventriculi' pass some way down the front wall before penetrating the gastric coats; not entering at the lesser curvature, as in Man. In all *Felidæ* the pylorus is suspended by a duplicature of peritoneum, and the duodenum has the same loose attachment, to its termination, which becomes more closely tied to the vertebral body. The mesentery again expands to suspend the rest of the small intestines. In a full grown Lion these measured 18 feet, with a uniform circumference of 2½ inches. The cæcum was 2 inches long: it is simple and conical, fig. 348: the length of the large intestines was 2 feet 10 inches; the colon soon gains a circumference of 4 inches. The muscular coat of the intestines is thick throughout. The terminal orifice of the ileum is circular, and situated on a valvular prominence of the same form. The apex of the cæcum is a cluster of intestinal follicles.

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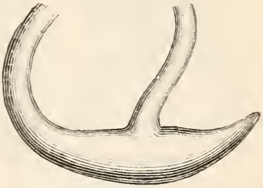

Cæcum of the Lion

The lining membrane of the small intestine has fine and close-set villi in the Lion; they are longer and coarser in the Bear, and seem to be rather flattened than cylindrical. In contracted parts of the tube the lining membrane is thrown into longitudinal rugæ: the agminate follicles form long longitudinal tracts in the Lion. In the Hyæna the cæcum is about twice the length of that in the Lion, relatively.

In the Dog the gullet extends about two inches beyond the diaphragm before terminating in the stomach. The duodenum is loosely suspended by a mesentery, except at its transit across the vertebræ to become jejunum. The cæcum is relatively longer than in the Hyæna, and after a short course is folded or curved. The intestinal canal is longer and narrower in the Dog than in the Wolf, and the cæcum in the latter is curved from its origin: it has three coils in the Fox.

The rugæ of the gastric membrane are numerous and well-marked in the contracted stomach of the Dog. Microscopic investigation of the gastro-mucous coat has shown the tubules to be more commonly subdivided at their blind ends than in Man. In fig. 349, A is a tubule from the cardiac half, and B one from the pyloric portion, of a Dog's stomach: *a*, *b* the columnar epithelium; *c* the sub-sacculate branches of the pyloric tubules.

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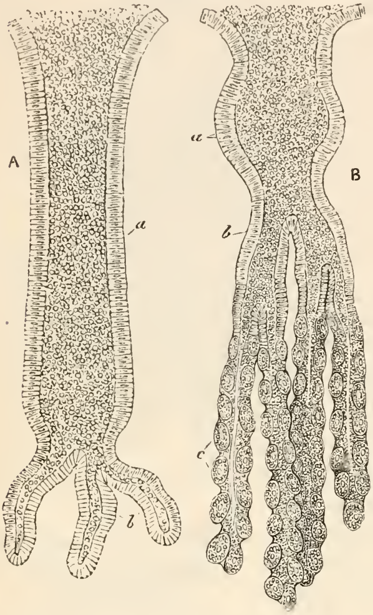

Gastric tubules, Dog's stomach, magn. 60 diam. CXLVIII″.

The intestinal mucous membrane is finely villous. Fig. 350 shows a magnified view of one of the villi, *b*, from which the columnar epithelium, *a*, *c*, is partly detached: *d*, *e*, are columnar cells, more magnified, showing the nucleus.

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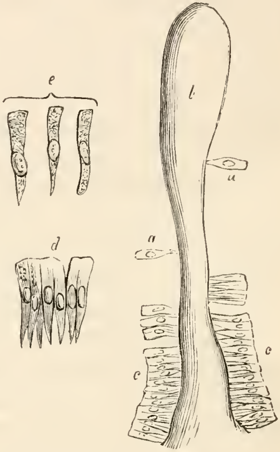

Villus of the ileum of a Dog, magn. 40 diam. CXLVIII″.

Some of the Civet tribe have a stomach of a fuller form. In the Suricate (*Ryzæna tetradactyla*) the œsophagus, fig. 351, *a*, runs half an inch into the abdomen before ending in the stomach, about half an inch from the left end, ib, *b*. The epithelial lining of the gullet terminates abruptly, as in all *Carnivora*, at the cardiac orifice. The stomach is of a full oval shape, maintaining much

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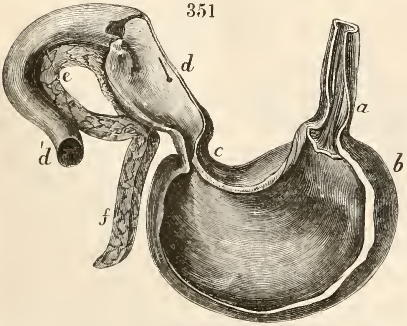

Stomach, duodenum, and pancreas, Suricate ½ nat. size width to near the pyloric end, *c*, which is too short to be bent. The duodenum, *d, d*, makes a large curve, and is a loose intestine, with a meso-duodenum which becomes shorter as it approaches the spine at the lower end of the curve: it is continued into the jejunum before crossing the spine. The biliary and pancreatic ducts, *d*, terminate about an inch from the pylorus. The length of the small intestines is 3 feet 2 inches, with a general circumference of one inch. The cæcum, fig. 352, *c*, is an inch in length, rather contracted at the neck, with an obtuse blind end: this is occupied by a patch of agminate follicles: a larger patch is at the end of the ileum, ib. *a*: the ileo-colic orifice and valve, *b*, are circular. The colon, *d*, is continued almost straight to the vent, *e*: the length of the large intestine was but 6 inches.

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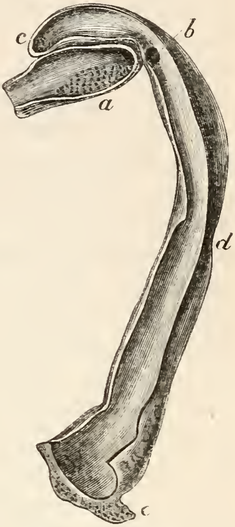

Large intestine, Suricate, half nat. size.

The Musteline, Subursine and Ursine *Carnivora* are, as a rule, devoid of cæcum. In the Martin (*Mustela martes*) the intestinal canal is three and a half times the length of the body. In the Otter the great and small curves of the stomach appear angular through the abruptness of the bend of the pyloric upon the cardiac part. The intestinal canal is relatively longer in *Enhydra* than in *Lutra*. In the Racoon the beginning of the colon is indicated by a slight enlargement and circular fold of the lining membrane, not produced so as to form a valve. In a Benturong (*Ictides*) I found a cæcal projection of half an inch in length at the beginning of a large intestine two feet in length: the small intestines were seven feet long; the length of the animal, exclusive of tail, was two feet. The stomach of *Ailurus* is subglobular, with terminal orifices; the narrow termination of the pyloric part has a thick mucous membrane. In the Bear there is a more marked blind sac at the left end; both muscular and mucous coats are thick. The villi of the small intestine are longer and coarser than in the Lion. In *Ursidæ* the entire intestines are about twelve times the length of the body; in *Felidæ* from three to four times; in *Viverridæ* from four to six times: the longest in this family being in the frugivorous Palm-cats (*Paradoxurus*.)

In the common Seal (*Phoca vitulina, L.*) the œsophagus opens widely into the left end of the stomach, leaving no blind sac there: the pyloric end is bent acutely on the rest of the cavity: the pylorus is very small and is defended above by a valvular prominence, giving the opening a crescentic form; the diameter of the pylorus is ½ an inch, while that of the cardia is 1½ inch. The duodenum descends abruptly from the pylorus, and is connected by a continuation of peritoneum with the pyloric end of the stomach. It is contracted at its origin, but soon dilates, and a sacculus is formed between its muscular and mucous coats for the reception of the biliary and pancreatic secretions, which afterwards are conducted through a narrow passage into the intestine. Having descended as far as the right kidney, the duodenum turns to the left in the usual manner, but has a complete investment of peritoneum through its whole course: at the left side of the abdomen it carries forward this process of peritoneum, which forms the mesentery in the usual manner. The small intestines do not exceed 1½ inch in circumference, but their deficiency in this part of their dimension is compensated by their great length. The large intestines commence by a short round cæcum, which, in two instances, was situated close to the pyloric end of the stomach: the greatest circumference of the colon was 4 inches. The Walrus has a similar cæcum. The interior of the stomach is smooth and without rugæ; the intestines have the same character. In a Seal measuring 3 feet from the snout to the end of the hind flippers, the small intestines were 40 feet long, the large intestines 2 feet, with a cæcum of nearly one inch in length. The agminate glands run in long narrow strips.

§ 332. *Alimentary canal of Bruta.*—After exceptional instances in the Marsupial (*Macropus*) and Quadrumanous (*Semnopithecus*) orders, we now begin to find complex conditions of the gastric organ to predominate; the main characteristic of which in the present order is, that, when a laminate epithelium covers the lining membrane so thickly as to be comparable with cuticle, its most constant position is at the pyloric division of the stomach. There are, however, gradations, and the Armadillos retain most of the preceding more simple conditions of the alimentary tube. In *Dasypus peba*[1] the œsophagus, after the course of an inch in the abdomen, terminates in a stomach of a subglobular form about 1½ inch from the left end: its epithelial lining ends at the cardia. The lining membrane of the stomach is villous, becoming smoother toward the pylorus; to that part a few longitudinal rugæ at the middle of the cavity converge. The muscular coat is thin at the wide cardiac end, but attains a thickness of 2 lines near the pylorus, and here on each side there is a tendinous spot externally. A semilunar ridge defines the lower part of the pylorus; from the upper part depends a protuberance: this valvular structure resembles that in the Seal. Beyond the pylorus is a well-marked zone of racemose glands. In *Dasypus* 6-cinctus I found a greater proportion of the stomach to the left of the cardia: the other characters were repeated. The duodenum is dilated at its commencement and is suspended on a fold of peritoneum which becomes narrower as the gut descends: after crossing the spine the fold again expands to form the mesentery of the rest of the intestine. After a length of from 12 to 18 feet the gut suddenly expands, and here, in *D. peba*, the small intestine seems to enter, forming a narrow circular fold within, the larger intestine. The former are smooth internally, the latter shows a few longitudinal rugæ. In Dasypus 6-cinctus the large intestine expands into a pair of short, wide pouches, one on each side the insertion of the ileum. The terminal orifice of the ileum is a slit with tumid margins on the middle of the ridge between the two cæca. The length of the intestinal canal is 10 feet.[1]

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[1] CXXVII″. p. 142.

In Orycteropus the lining membrane of the œsophagus is smooth: the tube terminates at the middle of the lesser curvature of the stomach: the lining membrane of the large cardiac sac is disposed in coarse reticulate folds, which become longitudinal toward the pyloric end: this is pyriform, with a muscular coat increasing to a thickness of 8 lines: the mucous coat showing strong rugæ, with an epithelium. The small intestines are of unwonted length in the present genus, about 37 feet: the lining membrane is without folds, but is beset with long and fine villi, and shows five or six elliptic patches of agminate glands in the ileum. The cæcum is between 4 and 5 inches in length; the colon about 8 feet long, and about 4 inches in circumference at the commencement.[2]

In the Pangolins (*Manis*) the distinction between the cardiac and pyloric portions of the stomach is still more marked: the latter has acquired a greater accession of muscular fibres, and their tendinous centres are externally more conspicuous: the structure is made the more gizzard-like by its thick papillose cuticular lining. At the middle of the great curvature is a mass of complex glandular follicles, the ducts of which intercommunicate and terminate by a common orifice in the cavity of the stomach.[3] The valvular protuberance above the pylorus is large.

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[1] CXXVIII″. p. 155.

[2] CXLIX″. p. 16.

[3] CXLVII″. p. 182, No. 590 c.

There is no cæcum. In the great Ant-eater (*Myrmecophaga jubata*) the stomach, fig. 353, presents a spherical form, of about 8 inches diameter, with a smaller subglobular appendage, as it seems, ib. *h*, *h*, of about 3 inches diameter, intervening between the main cavity, *c*, *c*, and the intestine, *d*. The œsophagus, *a*, terminates near the middle of the upper surface of the main, or cardiac, portion. On the middle of both the anterior and posterior surfaces of the stomach is a sheet of tendon, which extends from the large to the small division of the organ, expanding upon both divisions, but acquiring upon the latter its greatest thickness and whitest colour. The cardiac cavity, *c*, *c*, has a vascular secreting surface, the lining membrane being disposed in very numerous small wavy rugæ: the larger and apparently more permanent folds converge toward the aperture, *f*, of the pyloric cavity. The cardiac orifice has the form of a narrow, slightly bent crescentic slit. It is situated about 3½ inches from the similarly shaped aperture of communication between the cardiac and the pyloric cavities: but the margin of this latter aperture is indented, as it were, by the ends of the converging folds of the lining membrane, which are continued into the pyloric cavity. The pyloric division is remarkable for the thickness of its muscular tunic and the density of its epithelial lining, which convert it into a veritable gizzard. The muscular coat, ib. *h*, *h*, varies from 1 inch to ½ an inch in thickness; at the middle of the cavity it is separated from the lining membrane by an unusual accumulation of the elastic submucous areolar tissue, *i*, which is most abundant in the upper wall of the cavity. A very small proportion only of food can enter at one time into this cavity, to be subjected to the triturating force of its parietes, operating, with the aid of swallowed particles of sand, in the comminution of the unmasticated or imperfectly masticated Termites. The area of the pyloric cavity, as exposed

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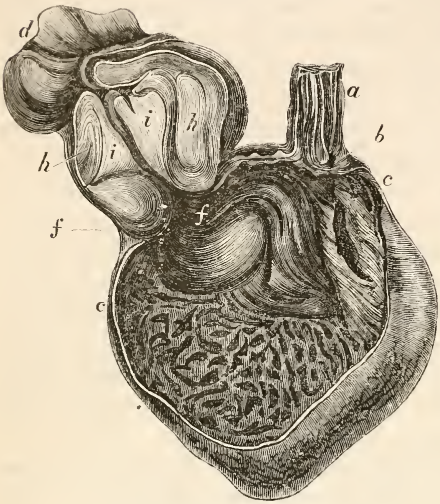

Stomach of Great Anteater.

by the vertical longitudinal section in fig. 352, appears a mere linear, slightly sinuous, tract, with a dilatation near the pylorus, due to the valvular protuberance of the upper wall projecting toward that aperture. But, when the pyloric cavity is bisected transversely, its area presents a crescentic figure, owing to the protuberance formed by the thicker muscular tunic, *h*, and the more abundant submucous elastic tissue, *i*, in the upper parietes. The lower longitudinal plicæ, which commence on the cardiac side of the intercommunicating aperture, give a longitudinally ridged character to the inner surface of the cavity.

This character is changed near the pylorus for a reticular rugosity: the pylorus, when viewed from the duodenal side, presents a crescentic form, with the horns of the crescent directed upward. The lining membrane of the duodenum soon becomes smooth. This intestine is suspended on a broad fold of peritoneum, and is continued into the jejunum without being tied by a contraction of the mesentery to the vertebral bodies. The ileum dilates rapidly into the colon which commences without a cæcal projection. The greatest circumference of the duodenum is 2½ inches: the calibre of the intestinal canal gradually contracts to a circumference of 1 inch 9 lines at the jejunum, and recovers a circumference of 3 inches near the end of the ileum. The colon, within 3 inches of the ileum, has a circumference of 9½ inches; and has decreased to a circumference of 6 inches, where it forms the rectum, about 9 inches from the anus.

The inner surface of the duodenum and jejunum is smooth, offering no villi to the naked eye. A few short and narrow longitudinal folds of the lining membrane, not parallel to but following one another, begin to appear in the ileum: these are succeeded by one or two longer longitudinal folds, which are soon followed by one extending continuously throughout the rest of the ileum, along the side of the gut opposite the attachment of the mesentery: this fold is from 2 to 3 lines in breadth, is narrowest where the canal has been most distended, but is not obliterated by the utmost dilatation of the gut: it is a permanent single longitudinal production of the vascular lining membrane, and forms the chief characteristic of the lower half of the small intestines in the *Myrmecophaga jubata*. In this part of the canal there are patches of glandulæ agminatæ from 1 to 2 inches long, and with intervals of about 1 foot. The transition of the ileum into the colon is effected by a rapid increase of diameter, viz. from 1 inch to 2½ inches; by a slight thickening of the muscular coat; by the appearance of a few transverse ridges or very low folds of the mucous membrane at the beginning of the colon, and not extending round the circumference of the gut: but the boundary of the ileum is not defined by any ileo-colic valve nor by any appreciable alteration in the vascularity or other structure of the mucous membrane in the two divisions of the intestinal canal. The inner surface of the colon is smooth, finely reticulate, with a few very narrow transverse folds, from 1 inch to half an inch apart, subsiding for the most part before reaching the attached line of the gut; these folds are not obliterated when the canal is fully distended; they commence about 18 inches from the ileum, gradually become shorter and narrower, and disappear about a foot from the rectum. The longitudinal folds of the rectum extend to the margin of the anus, where a little dark pigment is developed under the epithelium. The soft epithelial-covered integument extends from the fore part of the anus to the vulva, which is distant about half an inch. The longitudinal muscular fasciculi of the rectum and rectal end of the cloaca are strongly marked, and are from one line to one line and a half in breadth. The specimen dissected[1] measured 4 feet 7 inches from the snout to the vent: the intestinal canal was 34 feet in length, the large intestines being but 4 feet of that extent.

In the little two-toed Anteater the double cæcum reappears:[2] but each is relatively rather longer than in the six-banded Armadillo.

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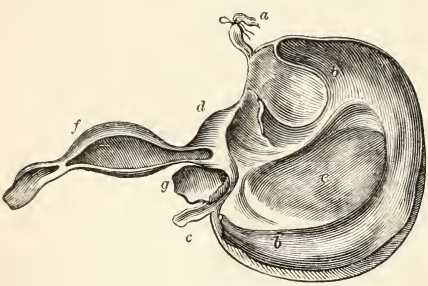

Stomach of two-toed Sloth. CXXII″.

In the two-toed Sloth (*Cholœpus*) the œsophagus is lined by a dense epithelium disposed in longitudinal folds: it communicates with both the first and the second compartments of the cardiac division of the stomach, fig. 354. The first compartment is the largest, and is subdivided into a left and right portion; the left, *b*, terminating below in a short cæcal appendage, *c*: its inner surface is minutely villous and vascular. The right compartment of the paunch is partially subdivided into a larger left and a smaller right cavity, *d*, both of which are lined by a continuation of the thick epithelium of the œsophagus, the inner surface of which is minutely wrinkled, but not villous: the thick epithelium terminates in a free, minutely jagged border. A groove or canal is continued from the cardia along the right side of the incomplete septum dividing the right compartment of the paunch, *d*, and curves downward to communicate by a moderately wide crescentic aperture with the second or middle division of the stomach, *g*. This division presents the ordinary form of a simple stomach, but in a reversed position, i.e. with the great curvature turned toward the diaphragm: it communicates with the right compartment of the cardiac division by the right extremity of the crescentic œsophageal aperture, and with the third or pyloric division of the stomach by the left extremity of the same canal: a fold formed by the lower end of the left wall of the œsophageal groove divides these two communications. In the character of its lining membrane the second division resembles the right compartment of the cardiac division, and should be regarded, physiologically, as a third subdivision of it. The third, or pyloric cavity, *f*, has also the form of the ordinary simple stomach, but with the great end next the pylorus; the smaller or left end swells out about half an inch to the left of the crescentic aperture by which both the second cavity and the œsophageal groove communicate with it. The thick epithelium is continued over the inner surface of the third cavity to the pylorus, increasing in thickness toward that part, and taking on a coarse villous character. The thick epithelium is absent from an oval patch at the great curvature, *e*, the surface of which is vascular and minutely villous; about half an inch to the left of the free epithelial border of the mucous patch, there is the apex of a gland, lodged in a circular fossa, 1 line in diameter, and closely resembling one of the 'fossulate papillæ' of the tongue.

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[1] VIII″. p. 121, pls. li, lii, and liii.

[2] 'There are two cæca, as in birds,' CCXXXVI. vol. ii. p. 181.

The leading character of the stomach in *Bruta* is one tending to compensate for the poor masticating machinery in the mouth, indicated by Cuvier's name of the order. It is, of course, least conspicuous in the toothed families: but even in these the musculo-tendinous structures at the pyloric portion, and the thick epithelium continued over the inner surface of that part in the Phyllophagous species, significantly indicate a community of type under the mask of the most complex modifications of the digestive cavity. The great expanse and subdivision by broad and permanent folds of the cardiac cavity, in fig. 354, simulates the ruminant stomach: but the position of the vasculo-villous part of the lining membrane is similar to that of the more special glandular part in the Manis.[1] In all Sloths the duodenum is loosely suspended, and is continued without constriction of mesentery into the rest of the small intestines, which is disposed in many short convolutions, and enters a short and straight colon, without a cæcum. The anus is not distinct from the vulva.

§ 333. *Alimentary canal of Cetacea.*—The first peculiarity to be noted in this order is the small area of the gullet in the largest species, especially in the great Whale-bone Whale (*Balæna mysticetus*): its lining membrane is here disposed in longitudinal folds which close the area of the tube in the contracted state: they are coated by a thick irregularly rugous epithelium, and are connected with the strong muscular coat by a deep layer of elastic cellular substance. The stomach is complex, divided into several cavities, in all true *Cetacea.* In the Porpoise (*Phocæna communis*), fig. 355, the first cavity is continued in the same line with the œsophagus, having the same structure, and not being divided from it by any sensible constriction; its commencement is indicated by the orifice leading into the second stomach, beyond which orifice it is continued in the form of a dilated ovate cavity, ib. *a*, *a*. It is lined with a cuticle, or thick laminated epithelium, and its inner surface is

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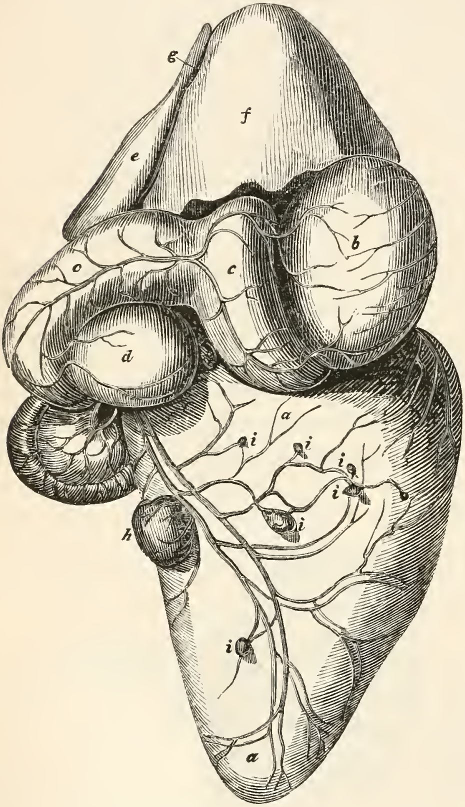

Stomach, liver, and spleens, of the Porpoise. cxliv″. (From a drawing by R. O. the prep. dry, is in Mus. Coll. Chir.)

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[1] The fig. 354 has been taken by the writer of cl″. from cxxii′. vol. xiii. pl. iii., fig. 2. The foregoing description is from dissection of the specimen of *Cholœpus didactylus* which died at the London Zoological Gardens, in 1851, and in which the arteries were previously injected. See cxlvii″. p. 167, No. 553 c.

beset with small rugæ. A number of large irregular projections surround the aperture leading to the second cavity, and are calculated to prevent the passage therein of any substances save such as are of very small size. Notwithstanding the nature of the lining membrane the digestive processes are considerably advanced in the first cavity, which does not act simply as a reservoir. It is probable that the secretion of the second stomach regurgitates into the first and assists in producing the dissolution of the fishes, the remains of which are usually found in it. The thick epithelial lining terminates abruptly at the small orifice leading into the second stomach, ib. *b*. The interior of this cavity presents a series of close-set longitudinal wavy rugæ, laterally indented into one another. The internal layer is thick, and mainly consists of unusually long gastric tubes perpendicular to the two membranes which enclose them. The membrane next the cavity of the stomach is smooth; the one external to the fibres is a vascular and cellular tunic, and is invested by the layer of muscular fibres, continued from the preceding cavity. The communication with the third stomach is near the lower end of cavity, *b*. The third compartment is a small round vascular cavity, into which the second opens obliquely: it is lined by a smooth and simple villous tunic: it is not visible exteriorly, and does not exceed an inch in length in the Porpoise, but in the *Hyperoödon* is about 5 inches long. The fourth cavity, ib. *c, c*, is long and narrow, and passes in a serpentine course almost like an intestine; the internal surface is smooth and even, but villous. It opens on the right side into the duodenum, ib. *d*, which is much dilated. The pylorus is a smaller opening than that between the third and fourth cavities.[1]

In *Balænoptera* the œsophagus enters obliquely at the back part a little beyond the upper end of the first cavity: the second cavity is larger and longer, in proportion to the first, than in *Phocæna*: the rugæ are longitudinal, very deep, and here and there united by cross bands. The third cavity is very small, and, as in the Porpoise, appears only to be a passage between the second and the fourth. The latter is more definitely divided into two successive cavities.

The duodenum commences in all *Cetacea*, by so considerable a dilatation that it has been reckoned among the divisions of the complex stomach. In the Porpoise it soon contracts to the ordinary diameter of the small intestines — about 1 inch: these are continued for between 40 and 50 feet to the vent. Broad and well-marked longitudinal folds of the lining membrane extend along the major part of this course: and the same character obtains in other *Delphinidæ*. In *Balænoptera* the longitudinal folds are wavy, run into each other, and are connected by smaller oblique or transverse folds: the submucous areolar tissue is very loose and abundant. In *Hyperoödon* the complexity is carried out to such a degree as to occasion a sacculated structure of the mucous coat through nearly the whole tract of the intestinal canal. The orifices of the larger pouches are directed vent-ward: their cavity is divided into smaller cells. They begin gradually in the duodenum near its last abrupt bend, and subside near the anus.

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[1] xx. vol. i. p. 175, no. 569 c. This description I appended, together with the other paragraphs between brackets, to the Art. *Cetacea* (CLI″), the translation of which was confided to me by the Editor.

In *Balænoptera* the ileum opens in a valvular way into a comparatively short colon, leaving a cæcum of about 7 inches in length, and of a simple conical form: in the specimen 17 feet long, of *Bal. rostrata*, dissected by Hunter, he records the length of the small intestine at 28½ yards, of the large intestine 2¾ yards;[1] and notes that he 'never found air in the intestines of this tribe.'[2]

The complicated stomach and long intestinal canal of such carnivorous *Cetacea* as the Grampus have other relations than to the nature of the food: they are necessitated in the present order by the amount of nutriment which must be had from it. In no other carnivorous mammals is so great a quantity of blood and fat to be obtained from the raw alimentary material: in none are such active and extensive molecular changes concerned in the production and maintenance, under adverse external conditions, of so high a temperature of the body. The digestive system and processes are therefore perfected in these warm-blooded marine air-breathers to meet the contingencies of their aquatic life.

§ 334. *Alimentary canal of Sirenia.*—In these more slothful, tropical, or sub-tropical marine mammals, although the food is of a low vegetable kind, the digestive and assimilative tract differs from that of the carnivorous Cetaceans rather by a minor than a major degree of complexity. The stomach, it is true, shows appended sacculi, special glands, and a subdivision of the general cavity, not only through constriction, but by a difference of structure in the lining membrane. It is of considerable length, and nearly equally divided into a cardiac and pyloric portion. In the Manatee the œsophagus terminates at the middle of the cardiac portion, the left end of which is produced into an elongate obtuse glandular pouch, communicating with the gastric cavity by an oblique slit serving for the passage of the secretion. A fold of the lining membrane continued from the right of the cardia partially subdivides the cardiac chamber. A pair of oblong, slightly bent, obtusely terminated, subpedunculate pouches open near each other into the narrow beginning of the pyloric cavity, which, after a moderate expansion, gradually contracts to the pylorus.[1]

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[1] CCXXXVI, vol. ii. p. 115.

[2] XCIV. p. 361.

In the Dugong the œsophagus, fig. 356, *f*, terminates nearer the left end of the cardiac portion, from the extremity of which the glandular pouch, ib. *e*, projects, but to a less extent and in a more conical form than in the Manatee: its gastric end or base projects into the stomach as a low circular protuberance with an oblique crescentic orifice, which leads to a flattened winding sinus, formed by a broad membrane spirally disposed in about eight or ten turns, having both surfaces covered with the orifices of follicles; and their interspaces filled by the cream-like secretion.[2] The muscular coat covering the spiral gland is 2 lines thick: but it quickly increases, as it spreads over the cardiac cavity, ib. *a*, to a thickness of 8 lines, again becoming thinner near the pyloric portion. In order to defend the cardiac orifice against

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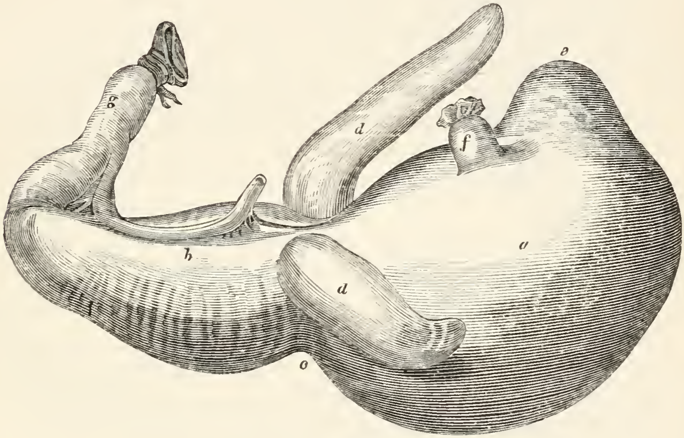

Stomach of the Dugong. XXVIII.

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[1] The stomach of the now extinct boreal *Rhytina* appears from the record left by Steller to have much resembled that in the Manatee: he was struck by its surprising size, ‘ 6 feet in length and 5 feet in breadth,’ distended with masticated sea-weed.

[2] CXVII″. p. 30. A peculiar species of Nematoid worm (*Ascaris Halicoris*, Ow.) was found in this spiral gland.

the pressure of the contents of the stomach, when acted upon by the powerful muscular coat, the œsophagus enters in a valvular manner, and is surrounded at its termination by a great accession of muscular fibres, forming a coat of an inch or more in thickness: the outermost of these fibres run longitudinally; the middle ones decussate each other obliquely; the innermost are circular and form a sphincter round the cardia. The diameter of the canal so surrounded is but 3 lines and its inner membrane is gathered into irregular transverse rugæ. That of the cardiac compartment is puckered up around the cardia, whence a few small irregular rugæ extend along the lesser curvature and about the constriction leading to the pyloric compartment: over the rest of the surface the membrane was not folded and was finely reticulate. At the constriction, ib. *c*, there is an accession of circular muscular fibres and a valvular production of the inner membrane about 3 lines broad. Immediately beyond this circular fold are the orifices of the two cæcal appendages, ib. *d*, *d*: they are relatively narrower than in the Manatee: their lining membrane is minutely rugous: there were comminuted fuci in both; their muscular coat is 1½ lines thick: they are, in some Dugongs, of unequal length. The pyloric stomach, ib. *b*, is long and narrow, and extends a foot beyond the cæcal appendages before terminating in the pylorus, ib. *g*: the inner membrane presented a few rugæ: the cavity is bent upon itself, and the terminal part, *g*, is intestiniform, but with thick walls. The small intestines, in a half-grown Dugong, presented a length of 27 feet and a uniform diameter of 1 inch: they have a similar uniformity in the Manatee. In the Dugong the mucous membrane, beyond the pylorus, is for a few inches slightly rugous, and then becomes disposed in transverse wavy folds: at 5 inches from the pylorus the duodenum receives the biliary and pancreatic secretions on a mammillary eminence. Beyond this part the transverse rugæ are crossed by longitudinal ones, and the surface becomes sub-reticulate: this disposition extends along about 6 feet of the gut, when the transverse disposition subsides, and the longitudinal folding prevails throughout the rest of the small intestine. The muscular coat is 2½ lines thick, the external longitudinal layer being about half a line. The orifices of intestinal follicles are arranged in a zig-zag line, thus .˙.˙.˙.˙.˙ upon the mucous surface along the side of the intestine next the mesentery, all the way to the cæcum, fig. 357. Where the ileum, ib. *a*, enters that cavity it is surrounded by a sphincter as thick as that at the cardia. The cæcum is conical; in my half-grown subject it was 6 inches long, with a basal diameter of 4 inches. The muscular coat rapidly increases toward the apex to a thickness of one inch: the inner surface is smooth, its capacity trifling as compared with the area of the rest of the large intestine, to which it may be said to act as a kind of heart, giving a first powerful impulse to the long column of vegetable ‘magma’ usually distending the colon. There is no constriction between this gut, *c*, and the cæcum, *b*. The parietes of the colon are thinner than those of the small intestine, the inner membrane is generally smooth. At the wider terminal part of the colon there are a few irregular folds: for about an inch within the anus it is of a dark leaden colour, the pigmentum being continued so far beneath the rectal epithelium.

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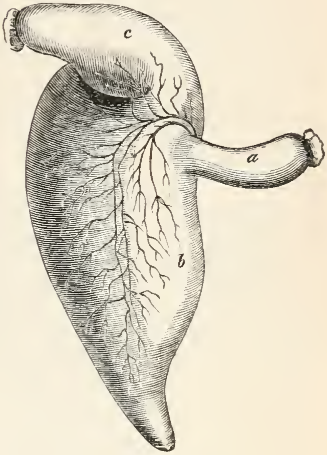

Cæcum of Dugong. XXVIII.

The cæcum of the Manatee is bifid: and the colon at its commencement is sub-sacculate.

§ 335. *Alimentary canal of Proboscidia.*—In the Elephant the stomach presents a simple exterior, but is longer than usual, with the cardiac sac much produced and conical: the lining membrane of this part is produced into twelve or fourteen broad transverse folds which ‘do not go quite round.’[1] The duodenum is at first loosely suspended and convolute, as in some rodents: it is more closely attached at its termination. The mucous coat of the jejunum is thrown into small irregular folds, both transverse and longitudinal. There are oblong patches of agminate follicles. The termination of the ileum projects as a conical valve into the cæcum. The longitudinal layer of muscular fibres is continued directly from the ileum upon the cæcum: but the circular layer accompanies the valvular production of the mucous membrane, and is there thicker than on the free gut. The large cæcum is sacculated on three longitudinal bands, which are continued some way along the colon. In a young Indian Elephant, about 7 feet high at the shoulder, the following were the dimensions of the intestinal canal:—

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[1] CCXXXVI. vol. ii. p. 171.

	ft.	in.
Length of the small intestines	38	0
Circumference of ditto	2	0
Length of cæcum	1	6
Circumference of cæcum	5	0
Circumference of colon	6	0
Length of colon and rectum together	20	0
Total length of intestinal canal, exclusive of the cæcum	58	6

§ 336. *Alimentary canal of Perissodactyla.*—In all this order the stomach has the ordinary simple outward form; the cæcum and large intestine are capacious and sacculate. In the Tapir[1] the œsophagus ends about one third from the left end of the stomach: its thick epithelium is continued for the extent of 3 inches to the left of the cardia, and for that of 7 inches to the right, toward the pylorus: the rest of the stomach has a compact villous surface with a few narrow well-defined rugæ: the gastro-mucous membrane increases in thickness, through lengthening of the gastric tubules, as it nears the pylorus. The stomach of the Sumatran Tapir presents a similar disposition and proportion of the cuticular lining. The pyloric part of the stomach shows a tendinous lustre on each side. In one subject the length of the stomach in a right line, was 1 foot 8 inches. In the duodenum of the American Tapir, the mucous coat is raised into transverse folds, along an extent of gut of about 5 inches: in the rest of the small intestines it is smooth and even. In the Sumatran species the valvulæ conniventes are continued along a greater extent of the beginning of the small intestine, and reappear toward the cæcum. The length of this cavity is 1 foot, and its greatest breadth the same: it is honeycombed internally, and its lining membrane developes short obtuse processes. The length of the small intestines in the Sumatran Tapir is 69 feet: in the American species 45 feet: the length of the large intestines in the Sumatran Tapir is 20 feet, but in the American kind only 10 feet. The comparative shortness of the intestinal canal in the American Tapir is a specific difference not explicable on any observed or known difference of food or habits.

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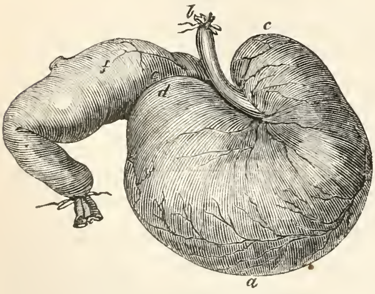

Stomach of the Horse. cxxii′.

In all the *Equidæ* the stomach is simple, differing from that in Man by the pyloric part, fig. 358, *d*, being less contracted and produced beyond the cardiac part: and this distinction is maintained by more important characters of internal structure. The œsophagus, *b,* is inserted at an acute angle into the smaller curvature, which rather resembles a deep cleft.[1] The cardiac cul-de-sac, *c,* is very capacious, and is lined throughout internally with a thick cuticular layer continuous with the lining of the œsophagus, and extends toward the pylorus as far as the middle of the cavity, where it terminates abruptly by a prominent indented edge: the interior of the pyloric half of the viscus, *a, d,* presents the usual villous mucous surface. The muscular coat of the stomach consists of several superimposed layers of fibres that cross each other in different directions, some of them being appa-

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[1] The species dissected were the common one (*Tapirus Americanus*, Gmelin), clii″. p. 161, and the *Tapirus Sumatranus*.

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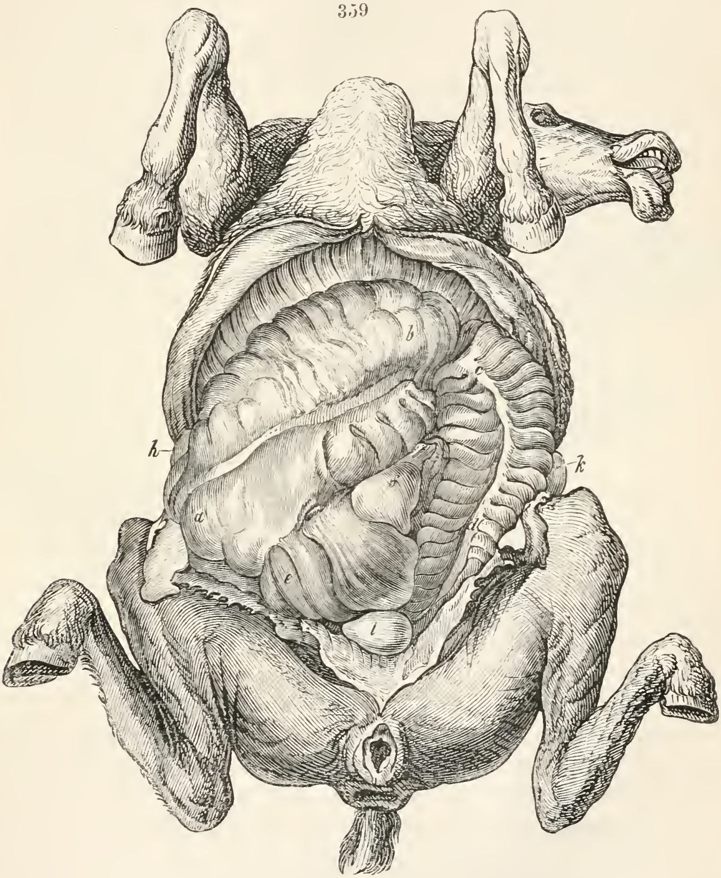

Colon of the Mare in situ. CXXII′.

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[1] Vomiting is rare and difficult; but has been observed in sea-sick horses slung on board transport-vessels.

rently derivations from the muscular bands of the œsophagus.[1] The alimentary canal is short in comparison with that of the Ruminants; but this want of length, together with the simplicity of the stomach, is compensated by the enormous capacity of the large intestine, which seems of itself to occupy the whole of the abdominal cavity, fig. 359.[2]

Commencing from the pylorus, the duodenum, fig. 358, *f*, is considerably dilated; but its diameter soon contracts, and the rest of the tract of the small intestines is of pretty equable dimensions throughout, or if it presents constrictions here and there, they disappear when the gut is distended. The ileum, fig. 360, *d*, terminates in a cæcum of enormous bulk, ib. *a*, *b*, *c*, *e*, *f*, which is separated from the commencement of the colon by a deep constriction, *g*: the cæcum near its termination contracts to an obtuse end, *b*, which is usually turned toward the diaphragm. It has four longitudinal bands. The colon itself is throughout its entire extent proportionately voluminous: commencing in the right flank, its ample folds, fig. 359, *a*, *b*, mount upward as far as the diaphragm, whence they descend to the left iliac region, where, becoming gradually contracted, the great gut terminates in the rectum. The ascending portion of the colon, *a*, *b*, is separated from the descending part, *c*, *d*, by a constriction; and the latter forms a third remarkable dilatation before it ends in the rectum. The whole colon is puckered up into huge sacculi by three longitudinal muscular bands, which toward the end of the colon are reduced to two; and these expand and coalesce at the beginning of the rectum, of which they form the strong outer muscular layer. The small intestines are about 56 feet in length: the cæcum is 2½ feet in length and about 2 feet in circumference. The colon maintains the same circumference to near its termination, save that, about a yard from the cæcum, it becomes much dilated: its length is 21 feet.

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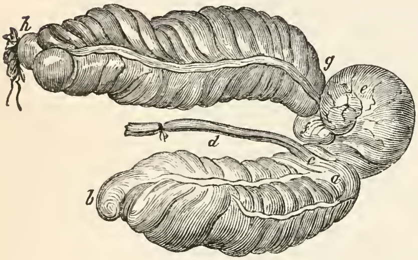

Cæcum of the Horse. CXXII′.

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[1] At certain seasons the stomach of the Horse is infested with the larvæ of a gad-fly (*Œstrus equi*). Daubenton figures the cavity in this state. CXXI′. pl. v, fig. 2.

[2] CXXII′. vol. iv. pls. IV–V.

In dissecting the Rhinoceros[1] I was struck by the general resemblance of the abdominal anatomy to that in the Horse. The epiploön was not observable when that cavity was exposed, the viscera which presented themselves being in immediate contact with the sustaining parietes. A single but enormous fold of the colon, not less than 2 feet in breadth, formed more than one half of the exposed surface of the abdominal viscera: it passed obliquely across the middle of the cavity, from the right hypochondriac to the left hypogastric or iliac region; immediately below this was a smaller fold of colon running parallel with the preceding; below this was a second fold; and, occupying the right iliac region, a part of the smooth parietes of the cæcum appeared. The colon was not displaced without considerable difficulty, owing to the weight of its contents, and the strength of the duplicatures of the peritoneum attaching it to the spine and contiguous parts. Behind and above the great oblique folds of colon lay a short, thin and corrugated epiploön, devoid of fat; and behind and below them were several coils of the small intestines. The length of the great fold of the colon taken in a straight line as it lay first exposed was 6 feet 6 inches: some idea of its capacity may be formed from the fact that the portion of the fold next the cæcum could easily contain a man, with ample room for him to turn about in it.

The œsophagus extends about 6 inches into the abdomen, and terminates at the cardiac orifice about 1 foot 5 inches from the left extremity of the stomach. This obtuse sac expands to the cardiac orifice, opposite to which the stomach, as in the Horse, presents its greatest circumference; it gradually contracts to near the pylorus, on the cardiac side of which the stomach shows its smallest circumference: it then expands into a blind end, of a hemispheric form, beyond the pylorus. The length of the stomach in a straight line was, in the male, 4 feet; its diameter from the cardia to the opposite part of the great curvature was 1 foot 10 inches. The small curvature between the cardia and pylorus was 1 foot 9 inches. There is a glistening aponeurotic sheet upon the anterior and posterior surfaces of the contracted pyloric end of the stomach. A sheet of white thick epithelium, continued from the œsophagus, spreads from the cardia over the inner surface of the cardiac portion of the stomach, about 1 foot 4 inches along the lesser curvature. This epithelial layer is 1 line thick, smooth, or with very fine rugæ on its inner surface, and terminates by a well-defined border, near which it is perforated by numerous orifices of mucous follicles. The rest of the inner surface of the stomach presents the usual vascular structure, with the minute orifices of gastric tubules. There is no crescentic fold or valve at the cardia, as in the horse: nor is there any valvular protuberance on the gastric side of the pylorus, as in the cow and most ruminants: the thickened rim of the pylorus is slightly produced into the duodenum.

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[1] A male and a female of *Rhinoceros indicus*, Cv., v″.

The outer layer of the muscular tunic is one-fourth the thickness of the inner layer, and becomes thinner over the pyloric end of the stomach. The areolo-vascular tunic begins to increase in thickness near the termination of the thick epithelium in relation to the lodgment of the gastric tubules.

	Rhinoceros indicus.	
	Female.	Male.
The length of the small intestines was . .	50 feet.	65 feet.
The circumference of the duodenum . .	8 inches.	10 inches.
The circumference of jejunum . . .	6 inches.	8 inches.
The circumference of ileum	7 inches.	9 inches.

The lining membrane of the duodenum, at the beginning of that gut, is puckered up into small irregular rugæ: flattened triangular processes begin to make their appearance about 6 inches from the pylorus; in the jejunum three or four of these processes are often supported on a common base; as they approach the ileum they begin to lose breadth, and gain in length, until they assume the appearance, near the end of the ileum, of vermiform processes, like tags of worsted, from two-thirds of an inch to an inch in length. Intestinal follicles are scattered here and there; a conspicuous reticular agminate patch was situated close to the end of the ileum. The small intestines have nearly the same disposition as in the Horse; they are suspended by a short mesentery, in which the anastomosing arteries form only one series of arches. The mucous membrane of the ileum projects in the form of a circular fold within the cæcum; but it seems inefficient as a valve for preventing regurgitation of at least fluid matters from the large intestines. The length of the cæcum from this orifice to its blind extremity in the male Rhinoceros was 3 feet, and its greatest circumference was 4½ feet. In the female Rhinoceros the length of the cæcum was 2 feet; its circumference 2 feet 6 inches; these proportions to the colon and the rest of the intestinal canal being rather less than in the Horse. The anterior surface of the cæcum is traversed longitudinally by a fibrous band, 4 inches broad, upon which it is slightly sacculated: a second band appears, nearer the colon. Its lining membrane is puckered up into innumerable irregular small transverse rugæ, which appear, however, to be but temporary foldings of the mucous membrane, and are easily obliterated when this is stretched. The colon for the first 4 feet of its extent is puckered up upon three longitudinal bands into sacculi, each about 5 inches long: it is here suddenly bent upon itself, forming the long and large fold, the two parts of which are very closely connected to each other; and here it dilates into the very wide portion which forms the most prominent object on laying open the abdomen; the beginning of this dilatation is also closely adherent by its posterior surface to the opposite surface of the beginning of the cæcum. The circumference of this part of the colon (which, if its capacity was not due to accidental accumulation of alimentary matter, might be regarded as representing a second cæcum or reservoir) is 5 feet: beyond this fold the colon becomes gradually narrower, its smallest circumference being 20 inches, where it passes into the rectum, which forms several short convolutions before its termination.

	Rhinoceros indicus.	
	Female.	Male.
The entire length of the colon was . . .	19 feet.	25 feet.
The entire length of the rectum . . .	3 feet.	5 feet.

The total length of the intestinal canal, including the cæcum, was in the female 73 feet; in the male 96 feet, or eight times the length of the entire animal. The circumference of the rectum was 10 inches in the female, and 16 inches in the male; but it widens toward the anus. The masses in which the fæces are discharged from the immense receptacles formed by the large intestine, are greater than in the Elephant, and are softer and more amorphous. The longitudinal muscular fibres of the rectum are developed into powerful fasciculi. The contrast between these fibres and those of the external sphincter is well marked, the latter presenting the striated character of voluntary muscles.

In the little *Hyrax*, as in the Rhinoceros, the chief feature of the abdominal viscera is due to what Pallas justly calls ‘insignis crassorum intestinorum apparatus:’ but there are complexities of the large gut superadded to those in other Perissodactyles. The œsophagus has a course of 2 inches in the abdomen: it terminates in the same relative position to the stomach as in the Rhinoceros. Two-thirds of the cavity are lined by a thick, white, wrinkled epithelium: the stomach is bent upon itself where this lining ceases.

The duodenum is not so loosely connected with the back part of the abdomen as in most *Rodentia*; but it has throughout its course an entire investment of peritoneum. It descends in front of the right kidney for 4 inches, and then suddenly returns upon itself, passing behind the ascending colon, and runs along the middle of the spine as high as the stomach, where it becomes a loose intestine, or jejunum. The small intestines are about 8 lines in diameter, and present, internally, a series of about twelve small pouches, distant from 3 to 5 inches from each other, about 3 lines in diameter and the same in depth, their orifices pointing toward the cæcum. These pouches make no projection externally, being situated wholly beneath the muscular coat. They consist of duplicatures of the mucous membrane, and are surrounded by the agminate follicles, which open into them by numerous orifices. Their use would appear to be to prevent the secretion of these glands being mixed as soon as formed with the chyme, but, by retaining it, to alter its qualities in some degree.[1] The rest of the inner surface of the small intestines is beset with long and fine villi. For the extent of about a foot from the commencement of the small intestines I found that many of these villi terminated in a black point. The length of the small intestines is 4 feet 6 inches.

The cæcum is sacculated, and in form like that of the Tapir, its magnitude arising more from its breadth than its length. Its length from the orifice of the ileum is 3 inches, its circumference 8 inches. The colon gradually diminishes as it leaves the cæcum, 4 inches from which its diameter is nearly that of the small intestines: the dilated part of the colon is bent in a sigmoid form, and the remainder is convoluted on a broad mesocolon, and at a distance of 2 feet from the dilated part (when unravelled) terminates between two conical cæca in a second dilated intestine. Each of these lower cæca is an inch and a half in diameter at its base, and gradually contracts till it terminates in a glandular vermiform appendage about half an inch long, and 2 lines in diameter. The intestine continued from these is 3 inches in diameter, but also gradually contracts, so that at a distance of 6 inches it also becomes as small as the small intestines. The whole length of this intestine, or second colon, is 2 feet 6 inches; making the length of the whole intestinal canal, exclusive of the cæca, 9 feet 4 inches, or about six times the length of the animal. Notwithstanding the complexity of the intestinal canal, it is suspended from a single continuous duplicature of the peritoneum advancing from the bodies of the vertebræ and extending from the beginning of the jejunum to the rectum.

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[1] CLIII″. p. 203.

§ 337. *Alimentary canal of Artiodactyla.*—In this order the stomach is the usual seat of complication; the cæcum is simple. The Hogs (*Sus*) present the least complex form of stomach. The epithelium continued from the œsophagus into the cardiac end is unusually dense: and the part to the left of the gullet is more distinct and pouch-like than in the ordinary simple stomachs; the remaining and larger portion of the stomach has its soft and vascular lining membrane thrown into many rugæ. 'Where the œsophagus enters there is a doubling of the stomach on the left which would seem as if designed to conduct the food toward the pylorus: and there is another doubling of the great end, at that surface where the œsophagus enters, as it were, dividing the great end from the rest of the stomach.'[1] In short, one may plainly discern the initial steps in the modifications for affecting the course of the food which culminate in the ruminants. On the left side of the cardia the hard epithelium extends as far as a ridge which partially divides the general cavity of the stomach from the small blind pouch at that end: on the right side the cuticle terminates at the ridge formed by the angle between the cardiac and pyloric portions of the cavity: the muscular tunic of the latter portion is very thick. The pylorus is defended by an oval protuberance.

In the Babyroussa the cardiac portion to the left of the gullet is much more extensive than in the common Hog: and develops a more distinct blind pouch, curved and of smaller calibre than the rest of the cardiac end. The epithelium of the margin of the cardiac orifice gives off small processes, and these also appear as tubercles in the cardiac pouch. The pyloric part of the stomach is marked by the thickness of its walls: its mucous surface is reticulate. In the Peccary (*Dicotyles torquatus*) the stomach is divided into three compartments by the inward production of two broad ridges, which are situated, one to the left, and the other to the right of the cardiac orifice, like the narrower ones in the stomach of the Hog. The cardiac division of the stomach is greatly extended in the transverse direction, and terminates in two moderately elongated blind pouches. This division communicates with the middle compartment by a broad circular aperture. The œsophagus opens into the middle compartment, which is of less extent than the preceding, and communicates by a smaller transverse aperture with the pyloric division. The whole of the middle compartment is lined with laminate epithelium continued from the œsophagus, and this is extended a short way into both the cardiac and pyloric divisions. But the greater part of the cardiac cavity, with the two *cul-de-sacs*, being lined by a vascular and villous membrane, proves that it has a greater share in the digestive processes than as a mere preparatory receptacle. Both muscular and gastro-mucous coats of the pyloric cavity are remarkably thick; and the pyloric valvular protuberance is well defined.

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[1] ccxxxvi. vol. ii. p. 120.

Daubenton [1] has left the following record of the structure of the stomach in a fœtal Hippopotamus. Externally it appeared to be composed of three parts; the principal portion, extending from the cardiac extremity to the pylorus, was much elongated, resembling more a portion of intestine than an ordinary gastric receptacle. Besides this central part, extending from the œsophagus to the pyloric valve, were two long appendages like two cæcums, one arising on the right side of the cardia and running along the exterior of the stomach throughout almost its entire length, and then folding backward, the other and shorter *cul-de-sac* issuing from the posterior aspect of the cardiac extremity of the stomach and projecting toward the right side. The interior of this stomach is so divided by septa, that food coming into this viscus through the œsophagus may pass by different channels, either into the central portion, which seems properly entitled to the name of stomach, or into either of the great diverticula appended to it. The inferior walls of the central stomach have nine or ten cavities in them, something like those of the Camel and Dromedary. The lining membrane both of the stomach and diverticula is granular and wrinkled except near the pylorus, where the parietes become smooth and folded into numerous plicæ somewhat resembling those of the third stomach of a ruminant.

Professor Vrolik [2] received from the Cape of Good Hope drawings of the viscera of a half-grown Hippopotamus, and states that they showed two pouches on each side of the cardia, which communicate with a large pouch the cavity of which is divided transversely by numerous folds, like valves: between that large cavity and the pylorus there is a narrow appendage which opens at the pylorus: this latter appendage is not indicated in Daubenton's figures or description. Thus, the stomach resembles that of the Peccary, with the exception of the greater length and transverse ridges in the middle portion of the cavity. I long ago expected the opportunity of testing and supplementing these descriptions by dissection of the stomach of the full-grown animal: but the Hippopotamus received at the Zoological Gardens in 1850 still lives, in good health (1867), to the credit of that noble and well-administered establishment.

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[1] CXXII′. tom. xii, p. 55, pl. iv.

[2] CLIV″. p. 86.

The stomach of ruminant Artiodactyles is divided into cavities so distinct in boundary, structure, and function, that they have received special names. The first, called 'rumen,' or 'paunch,'[1] is the largest, forming a capacious reservoir; its inner surface is commonly villous: that of the second cavity, called 'reticulum,'[2] is divided into small compartments or cells, mostly hexagonal in form: the third cavity is occupied by broad longitudinal folds, like the leaves of a book, whence the name 'psalterium';[3] it is the least constant of the divisions: the fourth and last cavity, 'abomasus,'[4] has the usual structure of the true digestive stomach, with a vascular and finely tubular gastro-mucous inner coat.

In a pigmy Musk-Deer (*Tragulus Kanchil*), the paunch is of a subglobular form, partially divided into three chambers by the folding inwards of the parietes, forming prominent ridges: the inner surface is beset with filamentary villi, covered by dense epithelium. The second cavity, or reticulum, is less distinctly separated from the rumen than usual: the cells are very shallow, and are lined by dense epithelium. The passage leading from the œsophagus to the third cavity is bounded by two low parallel ridges: the longitudinal lamellæ which are characteristic of this cavity in other ruminants are wanting, but as it possesses the dense epithelium, it may be regarded as a rudimentary form of 'psalterium:' it is partially separated from the fourth cavity by a semilunar fold. This cavity has a smooth gastro-mucous membrane: the muscular tunic is thickest at the pyloric end, where a small valvular protuberance projects above the orifice leading to the intestine. This least complex condition of the true ruminant stomach represents a stage in its development in the larger species.

The next modification is more simple than the true ruminant stomach in some essential characters, but more complex in accessory particulars: it is presented by the *Camelidæ,* and will be first described as it appears in the stomach of a fœtal Llama (*Auchenia Glama,* Desm.). Like the stomach of *Tragulus,* the psalterium is less distinctly separated from the abomasus, and at this early period of existence it exhibits in the Llama a similar deficiency of the characteristic longitudinal laminæ; but it is also devoid of the dense epithelium. The reticulum, however, is much more complex, each of the larger alveoli being developed into many smaller ones,—a structure partially indicated in the reticulum of the Goat, and more strongly marked in that of the Ox. There are, moreover, two groups of cells developed from distant parts of the rumen, which differ from those of the reticulum in being shallower and being visible from without, giving a sacculated character to those parts of the paunch. The rumen has the dense epithelial lining, but is destitute of the villi which characterise it in the horned ruminants. It is partially divided into two compartments by a strong fasciculus of muscular fibres, which, commencing on the left side of the cardiac orifice, traverses the paunch longitudinally. On the right side of this ridge, about fourteen smaller muscular fasciculi pass off at right angles, and these ridges are connected by still smaller fasciculi, running transversely between them, at definite distances from each other; the quadrangular spaces which result from the above arrangement of fasciculi are partly closed by a production of the lining membrane, leaving a circular aperture in the centre of each square for the passage of liquids into the cells beneath. The compartment of the paunch, to the left of the great longitudinal ridge, terminates in two sacculi, at what may be considered the cardiac extremity. The sacculus nearest the œsophagus is simple; the one farthest from it is developed into a series of cells, of a smaller size, but of precisely similar construction to those on the opposite side of the paunch,—a series of smaller muscular bands passing off at right angles from the larger one which separates the two sacculi, and these lesser bands being connected by transverse fasciculi, in the intervals of which the cells are developed. The reticulum or water-bag, shows that the cells are situated between a series of parallel muscular fasciculi, as in the rumen; but their further subdivision is carried to a greater extent, and their orifices are not guarded by membranous productions. The dense epithelium is not continued into this cavity: its muscular coat is so disposed that the exterior is smooth and uniform, and the cells are scarcely visible from without. A muscular ridge, longitudinal at the end of the œsophagus, winds round the upper part of the reticulum to terminate at the orifice of the psalterium. By the contraction of this fasciculus, all communication between the first two cavities and the œsophagus is cut off, and food is conducted into the third cavity. A slighter degree of contraction cuts off the communication with the rumen, and allows the passage of fluids direct into the reticulum or water-bag, which probably takes place when the Camel or Llama drinks. A free communication, however, subsists between the water-bag and paunch. The oblique canal leading to the third cavity, forms, in the Camel, a small sacculus, distinct from, and intervening between, the reticulum and psalterium: it is not so distinct in the Llama; but on a close inspection, the inner membrane nearest the orifice above mentioned may be seen to be produced into ridges, which are arranged in a reticulate or alveolar form; and as a similar structure is more distinctly observable in the Camel, this cavity was considered by Daubenton as the homologue of the reticulum, and the water-bag as a peculiar superaddition. The remainder of the stomach, in the fœtal Llama, may be seen to form one elongated continuous cavity, bent upon itself at its lower third, without rugæ or laminæ; the latter being afterwards developed at the cardiac half of this cavity. The pylorus is a small transverse aperture, protected above by a large oval protuberance. The duodenum is considerably dilated at its commencement.

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[1] Syn. 'penula,' 'l'herbier,' 'la double,' (fig. 362, *b*.)

[2] Syn. 'bonnet,' 'réseau,' 'honey-comb-bag,' 'water-bag,' (ib. *c*.)

[3] Syn. 'centipellis,' 'maniplus,' 'le feuillet,' 'omasus,' (ib. *d*.)

[4] Syn. 'la caillette,' 'rennet-bag,' (ib. *e*.)

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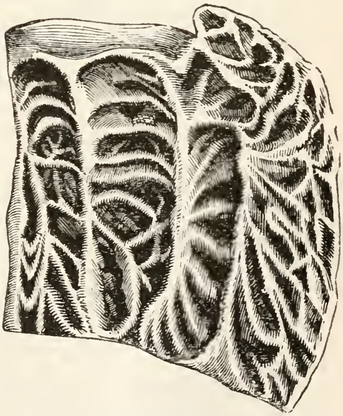

Water-cells from the paunch of the Came CXXII′.

The cuticular villi are not developed in the paunch at any age or in any species of the *Camelidæ*; but the appended pouches, fig. 361, augment in relative size. They are arranged, as in *Auchenia*, in two groups—one on the right, the other on the left side; the former being the larger, and in the adult Dromedary measuring about one foot and a half in length, and six inches in breadth. The cells of each group are disposed in parallel rows, separated from one another by strong muscular bundles, given off from a single large band of fibres which commences at the cardiac extremity of the rumen, and proceeds in a longitudinal direction, dividing the entire cavity into two compartments. The muscular fasciculi are arranged transversely, and give off secondary bundles at right angles and regular intervals, so that the orifice of each sacculus, of a square-shape when not contracted, is guarded by a powerful sphincter. Some of the cells are more complicated than others, being subdivided into numerous loculi by folds of the lining membrane. The largest of the reservoirs in the adult Dromedary, when dilated, have a depth and width of about three inches. The second cavity, or reticulum, has not the dense epithelial lining in either Dromedary or Camel: the muscular longitudinal fasciculi forming the principal ridges between the cells are less thick than the corresponding ones of the paunch-cells: the middle fibres in each become tendinous in the Llama; but the transverse fasciculi continue muscular, and spread over the circumference of the cells, continuously with the general muscular tunic of the cavity. In the Camel the tendinous character is not obvious in the fasciculi which close the primary cells of the reticulum. This cavity and the paunch freely intercommunicate, and both have the same relation to the œsophagus, as in true ruminants. The muscular channel also exists for conveying the ruminated or remasticated food past them, to a small third unlaminated cavity in the Camel, through which it passes to the last or true stomach. This, however, is divided by a modification of the lining membrane into two parts: in the first the membrane is produced into many parallel longitudinal folds, not covered by laminate epithelium, and gradually subsiding into the ordinary rugæ of the lining membrane of the rest or pyloric part of the true stomach: there may be a slight constriction between the parts of the stomach above modified. The pyloric protuberance exists in the Camels.

The experiments of Clift[1] proved the direct transit of water drunk by the Camel into the reticulum, where it was found 'pure,' and also into the appended cells of the rumen, where it was discoloured: while the concurrent testimonies of travellers in the arid regions traversed by this animal establish its power of there retaining water, as in a reservoir, for some days.

In true or ordinary Ruminants the muscular fibres of the œsophagus are disposed on two layers of spirals, taking reverse directions, which decussate at one or other of two opposite longitudinal lines: the outer layer contains more muscular and less cellular tissue than the inner one: the fibres of both are of the striated kind; and, as is usual where such are in more habitual and energetic action, they have a redder colour than in non-ruminating mammals. In the Giraffe the outer layer is more transversely disposed than the opposite spirals of the inner layer. The mucous membrane of the œsophagus is thick and firm; it is lined by a smooth and dense epithelium, and is connected to the muscular coat by a very lax cellular membrane. The entire tube in the Giraffe is remarkable for its length, and well displays in the living animal the rapidity with which the bolus is shot upward to be remasticated.

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[1] xxvii. vol. i.

The food when first gathered into the mouth is subject in all Ruminants to a coarse and brief mastication, and is swallowed without interruption of the act of grazing or browsing: the coarse bolus pushes open the lips of the groove, *g*, fig. 362, and at once enters the first cavity of the stomach, ib. *b*; water that may be drank finds its way mainly, as in the Camel, into the cells of the second cavity, *c*. The paunch is most capacious, is usually bifid, and the thick epithelium is continued over its inner surface, which is multiplied by close-set villiform processes. In the Giraffe, though varying at some parts of the paunch, they are, in the main, more regular and uniform in their size and shape than in the Ox; they are relatively narrower and longer; their margins are thickened but entire, not notched, and they become expanded and rounded at their free extremity, instead of tapering to a point, as in many parts of the paunch of the Ox: they resemble more those of the Reindeer. In the Sheep the villi are flattened and expanded at the end: in the Reindeer they are longitudinally plicated: they are larger and coarser in the Bison

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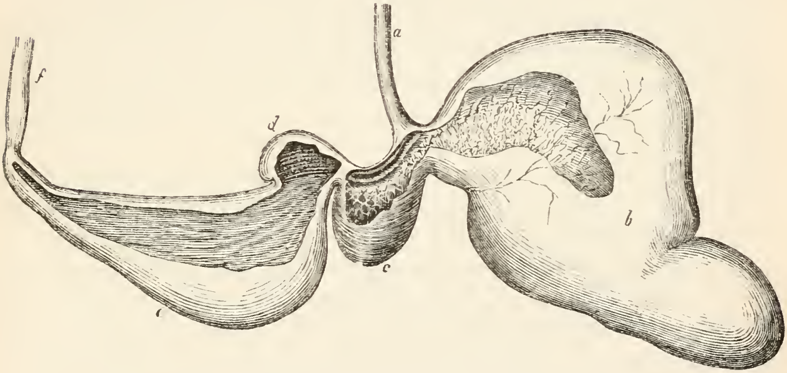

Ruminant stomach of the Sheep. CCXXII″

than in the Ox: in the Goat they are elongate and spatulate, but become shorter as they approach the reticulum.

There is more variety, however, among the horned Ruminants, in the form and depth of the cells of the reticulum, fig. 362, *c*, and these modifications mainly relate to differences in the power of retaining fluids. The structure of the Reindeer's stomach exemplifies this relation: the snow which must be swallowed with the lichens through a great part of the year would render any reservoir for water unnecessary, and the cells in the reticulum are remarkably shallow. The same structure also obtains in the Giraffe sustained by juicy leaves and buds: the cells are not, however, as has been stated, entirely wanting; but their hexagonal boundaries appear as mere raised lines supporting a row of pyramidal papillæ larger than those in the interspaces: for any imaginable use they might have been arranged in any other, even the most irregular, forms; but that pattern is closely adhered to, which grouping together a number of cells in the least possible space renders necessary in other Ruminants, and which is almost universal in nature. In the Goat some of the hexagonal cells are divided into smaller cells. In the Ox the deep cells are chiefly disposed between broad parallel septa: and these are also divided into smaller cells.

The food is subject to a rotatory movement in the paunch,[1] and is brought, successively, in this course, to be moistened by the fluid of the reticulum. If a Ruminant be alarmed in his pasture or browsing ground, it can transport the mass of hastily swallowed food in the paunch, as in a receptacle, to a place of safety and concealment, and there, the animal, at rest, can complete the act of digestion. This is done by the abstraction of the softer portion of the macerated food, successively brought within the grasp of the muscular walls of the groove, *g*, fig. 362, where it is moulded into a bolus and transferred by an antiperistaltic action of the muscular coat of the œsophagus to the mouth. It is there subjected to a longer and better process of mastication than at first; and, being mixed more thoroughly with the saliva and other fluids of the mouth, it is a second time swallowed. The soft mass is now less fit to push its way out of the œsophageal groove; but, the muscular walls being stimulated to contract, they close the entry to the first and second cavities, and, drawing that of the psalterium, ib. *d*, nearer to the gullet, conduct the remasticated bolus into the third cavity, the deep parallel crescentic folds of the lining membrane of which occupy almost its whole area: the thick epithelium is continued upon these folds. In the psalterium of the Giraffe, between each two narrow folds there is alternately one of great and one of moderate breadth, as in the Ox:[1] these lamellæ are beset with short pyriform papillæ. The bolus is squeezed into the interspaces, deprived of the superfluous alkaline fluid, and is passed on in a less dilute state to undergo the action of the true digestive acid secretion of the fourth and last compartment, ib. *e*. The communication between this cavity and the psalterium is wider than between the latter and the œsophageal groove: but the distinction is marked by the abrupt termination of the thick epithelium. The vascular and finely villous lining of the abomasus is usually thrown into large oblique wavy rugæ; which subside toward the pylorus. In the Giraffe these rugæ are slightly developed and chiefly longitudinal: the pylorus is protected by a valvular protuberance placed above it, as in other Ruminants, just within the stomach; this protuberance is relatively smaller than in the Llama.

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[1] The arrangement of the outer hairs in the agglutinated masses called 'ægagropiles,' occasionally found in the paunch, is the effect of this movement: the peculiar concretions called 'bezoars' are most commonly found in the paunch of Antelopes; and are probably due to the long sojourn in recesses of that receptacle of parts of the gummy shrubs on which they browse.

When the Giraffe ruminates, it masticates the bolus for about fifty seconds, applying to it from forty to fifty movements of the lower jaw, and then swallows it: after an interval of three or four seconds a second bolus is regurgitated. A slight contraction of the abdominal parietes accompanies the action of the stomach by which the regurgitation is commenced. This action of the abdominal parietes in rumination is much stronger in the Camel. The Camelidæ differ from the true Ruminants in the mode in which the cud is chewed; it is ground alternately in opposite directions from side to side: in Oxen, Sheep, Antelopes, and Deer, the lower jaw is ground against the upper by a uniform rotatory motion: the movements may be from right to left, or from left to right, but they are never regularly alternate throughout the masticatory process as in the Camels.

In the sucking Ruminants the first and second cavities of the stomach are relatively small, collapsed, and the milk flows almost wholly, at once, into the psalterium and abomasus. The laminæ of the psalterium are early developed in the fœtal calf.

In all Artiodactyles the duodenum is dilated at its commencement: it there forms a distinct pouch in the Camel. The gut is loosely suspended. In the Hog it adheres to the back part of the ascending colon before bending forward to become jejunum: the small intestines form numerous short convolutions: their lining membrane is not produced into folds. Hunter found them twenty times the length of the body of the domestic Hog: they are much shorter in the Wild Boar. The cæcum is about four inches in length and an inch in diameter, lying loose, but attached by a peritoneal fold to the ileum. The colon in part of its course is disposed in five spiral coils 'like a screw, coming nearer the centre; at the end of which it is bent back upon itself, passing between the former turns as far as the first, but in this retrograde course it gets nearer the centre of the screw, so that it is entirely hid at last, then makes a quick turn upward, as high as the first spiral turn: thence it crosses the spine before the mesentery, adhering to the lower surface of the pancreas, and, as it were, inclosing the fore part of the root of the mesentery: then passes down before the duodenum, gets behind the bladder and forms the rectum.'[1]

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[1] In this ruminant Daubenton counted 24 large folds, and each interspace included one middle sized and two small folds, ninety-six in all. CCXXII″, tome iv. p. 494.

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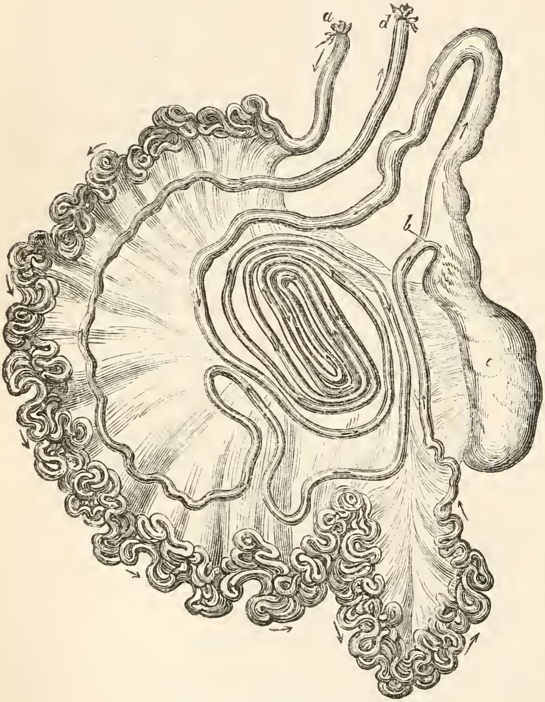

Intestines of the Sheep. XCVI'

The spiral turns of the colon, above described, form one of the characteristics of the Artiodactyle order: they are represented, as they appear in the Sheep, in fig. 363. The ileo-cæcal valve consists of two semilunar folds in the Hog. The cæcum of the Babyroussa consists of an expanded, sub-bisacculate part and a narrower short straight obtusely terminated part. The cæcum of the peccary is similar but less capacious, and more pointed at the end.

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[1] ccxxxvi. ii. p. 121.

In Ruminants the small intestines, of almost uniform calibre, are suspended in short convolutions upon a broad mesentery, fig. 363, *a, b*. In many species the agminate follicles are lodged, as in *Hyrax*, in fossæ of the mucous membrane,[1] fig. 364. The cæcum, fig. 363, *c*, is of a simple oblong form: a patch of follicles, usually lodged in a pouched recess,[2] is situated near the ileo-cæcal orifice. This is surrounded by a circular ridge; the cæcum is less dilated in the Vicugna than in the Sheep. In the Giraffe, also, the cæcum is a simple cylindrical gut: it is about two feet in length and six inches in circumference: it extends downward from where the ileum enters, and its blind end appears on the left side above the pelvis; but this position might be accidental as its connections are loose. The ileum terminates by a circular tumid lip within the cæcum,[3] fig. 365, *a*; the contiguous glandular cavity is sacculate. The disposition of the colon resembles that of the Deer. The extent of this intestine, before it begins to make the spiral turns, is about eight feet; it becomes narrower where it takes on this characteristic disposition, and the separation of the fæces into pellets begins at the end of this part. The spiral coils are situated to the left of the root of the mesentery, which, with the small intestines, must be turned to the right in order to bring them into view: there are four complete gyrations in one direction, and four reverse coils in the interspaces of the preceding, the gut being bent back upon itself: the length of this part of the intestine when unravelled is about fourteen feet. The spiral coils are not on the same plane, but form a depressed and oblique cone, whose concavity is next the mesentery. The colon, emerging from its coils, passes to the right, behind the root of the mesentery, becomes connected with the duodenum and the

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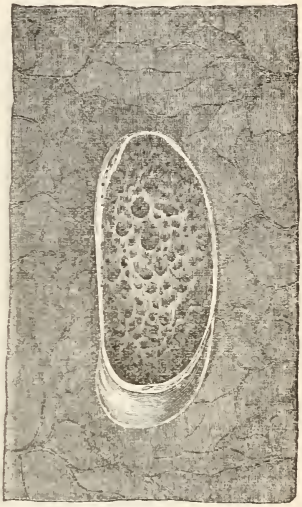

Pouched disposition of agminate follicles, Giraffe. XCVII″.

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[1] CXLVII″. vol. i. 2nd ed. (1852) p. 229, No. 760 A, and No. 760 D (*Camelus*).

[2] CXLVII″. vol. i. p. 220, Nos. 726 C (*Vicugna*) 726 D (Llama) p. 221.

[3] XCVII′. p. 227.

first part of its own course, then winds round to the left of the mesentery, and finally recedes backward and descends to form the rectum. In those *Ruminants,* as the Ox, which have soft undivided fæces, the coils are less numerous and regular; the cæcum is between two and three feet long in the Ox; it is subbifid at the end in the Buffalo: the colon is shorter and wider in both, than in the Giraffe, Deer, Sheep and Goat tribes, where the fæces are expelled in small pellets. In such Ruminants the anus is a more contracted aperture than in the Bovines or in Perissodactyles.

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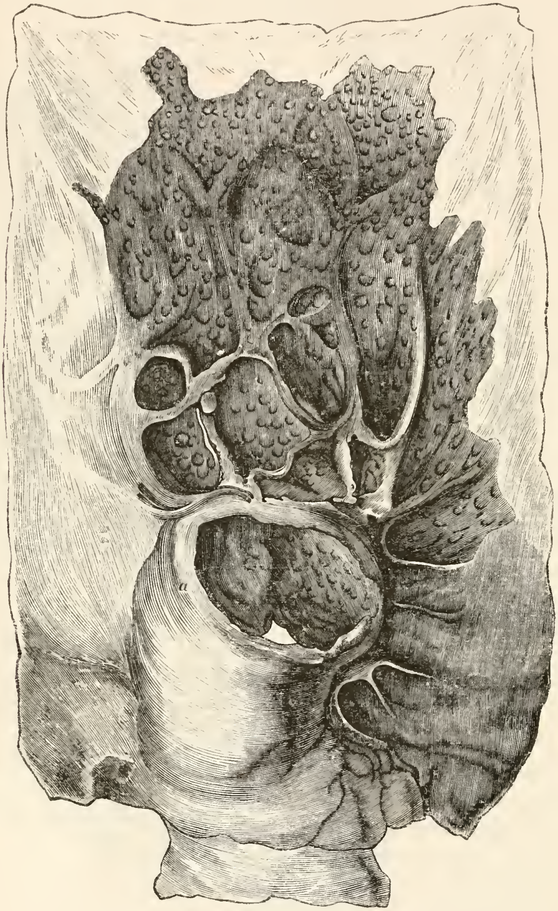

Ileo-cæcal valve and contiguous agminate follicles, Giraffe. XCVI'.

The herbivorous Mammals differ from the carnivorous more in the character of their large than of their small intestines. The less putrefactive nature of their food renders it susceptible of a longer retention in the body; and the receptacular and sacculate structures, and convolute extension, of the large intestines seem especially designed to retard the course of the alimentary substances. In the anomalous instance in a Human body, recorded by Abernethy, of a reduction of the length of the small intestine to about two feet, the compensation was effected by an unusual length and size of the colon. The condition of the subject 'showed that nutrition was not scantily supplied.'[1] Dupuytren noticed in a patient who had an artifical anus near the end of the small intestines, that the vegetable parts of the food thence ejected were undigested. Dr. Beaumont also observed that the vegetable substances underwent much less change than the animal substances in the stomach of the man (Alexis) with the fistulous opening into the stomach. That organ in the Artiodactyles (Peccary, Hippopotamus, and Ruminants) is rendered specially complex for overcoming the difficulty, and the cæcum and colon are comparatively small: but in the Perissodactyles (Horse, Tapir, Rhinoceros) the more simple stomach is compensated by the increased capacity and complexity of the large intestines. The subdivided stomach in the Sloths is in some respects, as e. g. the glandular appendage, and vascular secerning surface of the paunch, more complex than that of Ruminants: and here accordingly we find the cæcum absent and the colon undefined. The Dormouse and other hybernating Rodents are far from being the sole exceptions to the presence of a proportionally large cæcum in herbivorous quadrupeds; such receptacle is only found in those species, in which, through the necessity of a correlation with other circumstances than that of the nature of the food, the stomach retains the simple form and moderate size of that of the carnivorous or omnivorous mammals. Comparative Anatomy demonstrates that neither a complex stomach nor a large cæcum is essential to the digestion of vegetable food: but it teaches that a capacious and complex alimentary canal, as a whole, is related to that purpose, at least in the Mammalia. Either a highly-developed and concentrated glandular apparatus must be added to the stomach, as in the Dormouse, Wombat and Beaver; or the stomach must be amplified, subdivided or sacculated, as in the Ruminants and herbivorous Marsupials; or both complexities must be combined, as in the Sloths, Dugongs and Manatees; or, if a simple condition of stomach is retained, it must be compensated by a large sacculated colon and cæcum.

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[1] CXLVI″. p. 63.

§ 338. *Liver of Mammalia.*—The liver, as a rule, is divided into a greater number of lobes in the present than in the preceding classes, the body being more flexuous at the seat of the viscus. In the stiff-trunked Whales and erectly-moving Man the organ is more compact: and it is least subdivided in the purely herbivorous Ungulates where a minor degree of hydrocarbonates has to be eliminated. Thus, in a full-sized Giraffe, the liver weighed but 6 lbs. 11oz. avoirdupois; it was of a flattened, wedge-like form, consisting of one lobe, with a small posterior Spigelian process; its greatest breadth was 12 inches; its dorso-ventral diameter, 8 inches. The postcaval vein passed through a notch at the posterior edge of the liver, and did not perforate it. In all Ruminants the liver is confined to the right hypochondriac and epigastric regions. In most, two lateral lobes are indicated by a small fissure at the entry of the suspensory ligament. In the Ox, the main part to the right is partially subdivided into two, with the ‘ Spigelian ’ process from the back part of the right subdivision: with a breadth of 13 inches and a dorso-ventral diameter of 10 inches, the greatest thickness does not exceed 3 inches. In the *Camelidæ* the under surface of the liver is subdivided into many polygonal lobules of small but varying size: the fissures between some of which extend to the convex surface.

In *Cetacea* the liver more resembles that of the human subject, but is not so thick at its base nor so sharp at the front or ventral edge. The right lobe, *e*, fig. 355, is the largest and thickest; the falciform ligament is broad, and there is a deep fissure, *g*, between the two lobes, into which the round ligament passes. The left lobe, *f*, is extensively and firmly attached to the stomach, the small omentum being a thick substance.

In *Sirenia* the liver is flatter and more transversely extended. In the Dugong the liver is a transversely oblong viscus, divided into three lobes with a fourth small process at the root of the left lobe, representing the lobulus Spigelii. It is as usual convex toward the diaphragm, but rather flattened than concave toward the viscera, the anterior margin is thick and rounded. Of the three larger lobes the middle one is the smallest, of a square shape, projecting forward, and as it were over-hanging the gall-bladder, which is lodged in the middle of the inferior surface. The ligamentum suspensorium is continued upon the middle lobe, immediately above the gall-bladder, the anterior margin of this lobe being notched to receive it, and the remains of the umbilical vein enter the liver an inch above the fundus of the gall-bladder. The two lateral lobes are more than double the size of the cystic lobe, and of these the left is the largest. Both these lobes are concave toward the small middle lobe, which they thus surround and conceal. The lobulus Spigelii is of a flattened and square shape, measuring 1¼ inch in length. The Manatee has a gall-bladder.

In the Hog-tribe the liver begins to encroach more upon the left hypochondrium; and the mass to the right of the suspensory fissure is subdivided into a 'cystic' and a right lobe, besides the spigelian lobule.

The Perissodactyles in general have a larger and more subdivided liver than the Artiodactyles, especially than the Ruminants: no species has the gall-bladder. In the Horse this viscus extends as far to the left as the right: the suspensory ligament enters the fissure which defines the left lobe: the mass to the right is divided by a second fissure, answering to the 'cystic' in beasts with the gall-bladder; and a fourth small lobe is defined by fissures on the under surface of the right lobe. In the Rhinoceros the liver is of a dark colour, and has the usual flattened form in Ungulates; its greatest thickness not exceeding 6 inches in a liver weighing 44 lbs.: it consists of a middle portion with the suspensory fissure, answering to the 'cystic' lobe, of a smaller left lobe, and a still smaller right, or posterior, or spigelian lobule. The hepatic duct, ½ inch in diameter, receives the duct of the larger portion of pancreas as it passes between the coats of the duodenum, and such common duct opens upon a protuberance of the mucous membrane.[1] In the Hyrax the homology of the cystic lobe is better marked by the presence of a cystic notch, although without the bladder, to the right of the suspensory fissure: the left and right lobes have the same relative proportions as in the Rhinoceros. The duct from each lobe dilates on quitting it,[2] and the united capacities of these receptacles equal an ordinary-sized gall-bladder; the common duct continued therefrom is 3 lines in diameter, contracts gradually to the intestine, and opens therein 9 lines from the pylorus.

In the Elephant the liver is divided into two lobes, the right being the largest: the suspensory fissure is the boundary. There is no gall-bladder. The hepatic duct, fig. 366, *f*, *g*, is wide and very long: it has a reticulate inner surface: it expands, between the coats of the duodenum, into an oval receptacle, ib. *o*, irregularly divided into compartments: the first pancreatic duct, ib. *i*, also pours its secretion into this receptacle, which contracts and is surrounded by a sphincter of the circular layer of fibres, before penetrating the muscular coat, which here protrudes, as a mammillary eminence, traversed by the probe, *q*, *r*.

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[1] v″. pl. 14, fig. i. *p*, *h*.

[2] CLIII″, p. 205. In the largest of these dilatations I found a *Distoma*. Daubenton found (April) a species of the same genus in the bile-ducts of an Ass, CXII″, tome iv. p. 419.

In a female Giraffe I found a large gall-bladder, bifid at its

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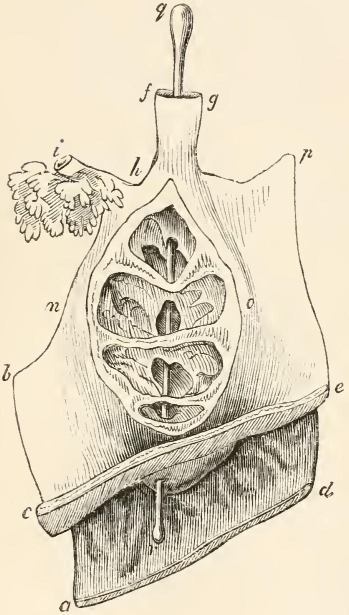

Terminal bile-pouch, Elephant.

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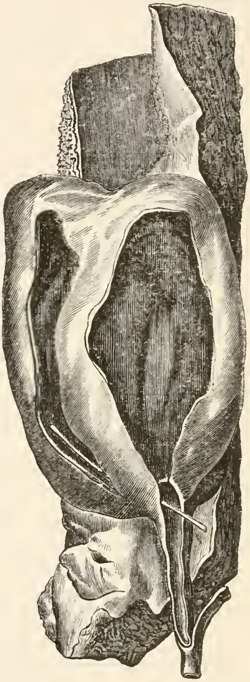

Double gall-bladder of a Giraffe

fundus. It was attached in the usual position to the under part of the undivided liver, having a covering of peritoneum over three-fourths of its surface. It was divided throughout its length by a middle vertical septum, fig. 367. The lining membrane of each chamber was smooth; they communicated with the commencement of a single cystic duct, the terminal orifices admitting freely the blunt end of a common probe and being protected by a valvular fold. In two males, subsequently dissected, there was not a vestige of a gall-bladder, but the bile was conveyed by a rather wide hepatic duct to the duodenum. I conclude, therefore, that the absence of the gall-bladder is the rule, or normal condition; and that the Giraffe in this respect, as in the structure of its horns, has a nearer affinity to the Deer than to the Antelopes. In these and all hollow-horned Ruminants, a gall-bladder is present; as it is, also, in *Moschus* and *Tragulus*. In the *Camelidæ* the gall-bladder is absent as in the *Cervidæ*. A like absence characterises all Perissodactyles, and suggests some relationship with the small capacity and simple structure of the stomach compared with the quantity of food taken, and with the rapid and continuous transit of the gastric contents through the small intestines to the enormous cæcal and colonic receptacles where digestion is finally completed. But the somewhat capricious appearance of the gall-bladder in vegetarian Mammals discourages such attempts to physiologise. Thus the Hog, e.g. with the simple stomach has the gall-bladder, while the Peccary, with a complex one, has it not.

The liver, fig. 308, *r*, *r*, closely retains the mammalian type of the organ in Monotremes. Four lobes may be distinguished in the Echidna: the principal or cystic lobe receives the suspensory ligament in a fissure; the large gall-bladder is placed a little to the right of this; the left lobe occupies the left hypochondrium; the Spigelian lobule is of moderate size; it is an appendage of the right lobe. The liver presents nearly the same form in the Ornithorhynchus, which has likewise a large gall-bladder, ib. *s*. There are three hepatic ducts in the Echidna which join the cystic, and the common canal terminates in the duodenum rather more than an inch from the pylorus. In the Ornithorhynchus the two chief hepatic ducts join the cystic near the neck of the bladder; the third hepatic joins a more distant part of the cystic; the ductus choledochus receives the pancreatic duct about 9 lines before its termination, as in the Marsupials, where its coats are thickened and glandular, and opens into the duodenum about 8 lines from the pylorus.

The liver is subdivided into many lobes in all the Marsupial genera. It is relatively largest in the burrowing Wombat and carnivorous Dasyure; relatively smallest in the graminivorous Kangaroo, in which it is situated, as in the placental Ruminants, entirely to the right of the mesial plane. The small or Spigelian lobe, which fits into the lesser curve of the stomach, is given off from the left lobe of the liver in the Kangaroos, but from the right in most other Marsupials; the difference just noticed in the Kangaroo depends on the peculiar disposition of its remarkable stomach. In the Koala the under-surface of the liver, fig. 368, is subdivided into thirty or forty lobules: this condition is presented in a minor degree in the Ursine Dasyure. In a long-tailed Dasyure, which weighed 3 lbs. 8¼ oz., the liver weighed 3½ oz. avoirdupois. The suspensory fold in *Lyencephala* shows hardly a trace of 'ligamentum rotundum.'

The gall-bladder is present in all Marsupials, is of large size, and loosely lodged in a deep cleft of the cystic lobe. In the Opossum it generally perforates that lobe, and the fundus appears at a round opening on the convex surface of the liver. I have observed a cæcal process from the cystic duct, like the beginning of a second gall-bladder.[1] The coats of the ductus choledochus are thickened toward its termination, and become the seat of numerous mucous cysts which open into the interior of the duct. In the Phalangers the terminal half-inch of the ductus choledochus is similarly enlarged and glandular. The biliary and pancreatic ducts generally unite together before perforating the duodenum: in the Virginian Opossum, the long-nosed Bandicoot, and the long-tailed Dasyure, they pour their secretions into the gut an inch from the pylorus: in the great Kangaroo the glandular ductus choledochus is joined by the pancreatic duct, and terminates in the duodenum 5 inches from the pylorus.

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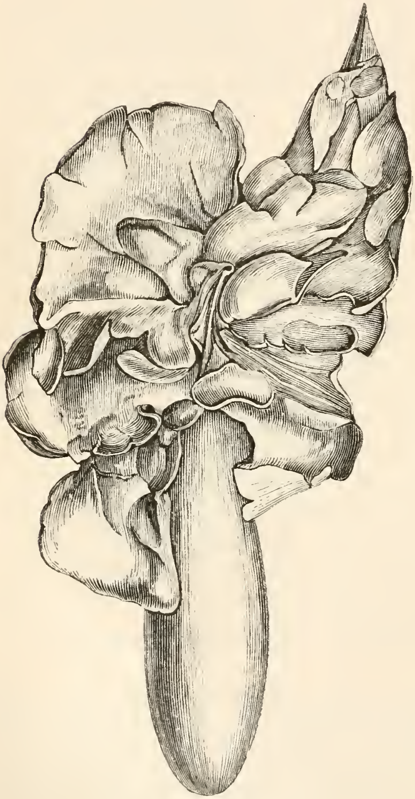

Liver and gall-bladder, Koala.

The answerable parts of the liver under its various degrees of division are indicated by the suspensory fold or ligament, which enters a fissure called 'suspensory,' and by the gall-bladder, which occupies a depression, fissure or canal, called 'cystic,' to the right of the suspensory one. The cystic fissure is the less constant character; the suspensory fold is almost obsolete in some Bats, which pass the greater part of their time head downward.

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[1] CXLVII″. p. 247.

In the more simple or entire forms of liver, as the human and cetacean, fig. 255, *e, f,* the suspensory fissure, ib. *g,* and fig. 369, 3, divides the left, ib. 1, from the right lobe, ib. 16, 18: the process sent off from the under and back part of the gland to the lesser curvature of the stomach, in Man, being the 'Spigelian lobule,' ib. 20. In the majority of Mammals a lobe is more definitely marked off by a deeper cleft to the left of the suspensory fissure, and a right portion is similarly defined by a cleft to the right of the cystic fissure. These two superadded clefts thus define a middle, commonly the largest, portion of the liver, which is characterised by the 'suspensory' and 'cystic' fissures. It is the 'cystic' or gall-lobe,[1] and is the homologue of the right portion of the left lobe and the left portion of the right lobe, including the cystic fossa, of the human liver.[2] The portion of the gland to the right of the cystic lobe, in most quadrupeds, is subdivided into two or more lobules; the lobe to the left more commonly remains single. The transverse depression usually about the middle of the under-surface of the liver, or of the cystic lobe, by which the portal vein enters the gland, is the 'portal' fissure, ib. 7. Another groove or canal is called 'postcaval,' being traversed by the vein, ib. 13, of that name.

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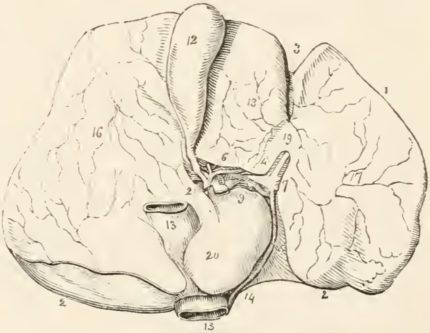

The under-surface of the human liver.

In the large Shrew, fig. 323, and in most *Insectivora,* the more subdivided condition of the liver, *h, h,* exists: the cystic lobe is marked by the gall-bladder, *v*, and by the suspensory notch to its left; beyond this is the left lobe, and, on the opposite side, are subdivisions of the right lobe. The liver of the Tupaia adheres to this type, showing four lobes, the gall-bladder presenting its fundus at the upper part of the cystic fissure, 'as if in a hole.'[3] The gall-bladder is for the most part of considerable size. In the Hedgehog its fundus appears beyond the free margin of the liver, and is supported by a process of falciform ligament. In the Tenrec, on the contrary, it is as it were incrusted by the substance of the right portion of the principal lobe.

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[1] 'The "gall-lobe" is the largest.' Anat. of Capybara, CCXXXVI. vol. ii. p. 213.

[2] I do not regard the whole human liver as the homologue of the 'cystic lobe' in quadrupeds, and the 'right and left lobes' in them as superadded parts, as in the following view:—'Il faut considérer le foie de l'*homme* comme composé d'un seul lobe, que nous appelons "lobe principal" avec un rudiment de lobule droit, celui de Spigelius. Nous verrons successivement un lobe gauche et un lobe droit s'ajouter à gauche et à droite du "lobe principal," puis un lobule droit et un lobule gauche,' XII. tom. IV. deuxième partie, p. 432. The homologue of the 'Spigelian lobule' is shown by its relation to the lesser curvature of the stomach. Fissures, rather than lobes are added to the liver of quadrupeds.

[3] Ib. p. 197.

The liver of Bats is very little divided: occasionally a small lobe is marked off to the left of the suspensory limit of the cystic lobe: still more rarely is there a right lobe. All Bats, with the Roussettes and Colugos, have the gall-bladder.

The liver of the two-toed Sloth is confined to the right hypochondrium, and consists chiefly of a very large cystic lobe, receiving the suspensory ligament: sometimes a small left lobe is marked off, and there is always a smaller Spigelian lobe behind. In the Ai (*Bradypus, 3-dactylus*) the left lobe is not present, and the posterior lobule is less defined; but there are one or two fissures at this part. This Sloth has no gall-bladder: the two-toed kind possesses one. Hunter describes its cystic duct as passing 'down through the substance of the liver and emerging at the aorta, like the ductus hepaticus;' it then joined that duct, and the common canal entered the duodenum about 4 inches from the pylorus.[1]

The cystic lobe is the largest in the Armadillos: there are two small lobes to the right, as well as one to the left: all the species have the gall-bladder. I found it more deeply imbedded in *Dasypus sexcinctus* than in *D. Peba.*[2]

The liver in *Orycteropus* differs in the non-division of the right lobe. In the specimen dissected by Jaeger,[3] the gall-bladder was double, the two being closely connected by cellular tissue, and having a common covering of peritoneum: the two cystic ducts soon unite into one, which is joined by three hepatic ducts: the common duct terminating about an inch from the pylorus. The liver of *Myrmecophaga* shows, likewise, a cystic, a left, and a right lobe, and extends from the right to the left hypochondrium: the fundus of the gall-bladder protrudes through a subcircular notch at the convex side of the gland in *Myrm. jubata.*

In the *Rodentia* the cystic lobe has the usual characters, is the largest, and is often so deeply cleft by its characteristic fissures as to present the appearance of three distinct lobes, the left lobe is sometimes divided, and the right more commonly so, the clefts affecting an oblique course. The most noteworthy modification in the Rodent order is that presented by the liver of *Capromys*. Five primary divisions or lobes are indicated by the usual characters; but each of these undergoes a subdivision 'into almost innumerable angular lobules, varying in size from 3 to 5 lines: though closely in contact they are quite detached from each other, being appended by their apices to the larger branches of the vena portæ and hepatic arteries and veins. Each of the lobules is partially subdivided into still smaller ones, the whole structure approximating to a complete natural unravelling of this conglomerate gland to its component acini.'[1] The gall-bladder was large; its contents limpid and of a greyish green colour. The genera *Mus*, *Cricetus*, *Lemmus*, *Echimys*, *Erethizon*, *Synetheres*, as a rule, are without the gall-bladder. Cuvier did not find it in *Sciurus maximus* and in a species of *Pteromys*: but in that dissected by Hunter (*Pt. volucella*) it was present, as also in *Sciurus cinereus* and the common Squirrel. The Porcupine (*Hystrix*) has a small gall-bladder, and the common Jerboa (*Dipus sagitta*) has one of the usual size: the Cape Jerboa (*Helamys*) has it not. In all other Rodents the gall-bladder is present. In the Guinea-pig (*Cavia porcellus*) Hunter remarks, that the common duct, on reaching the duodenum, 'makes a turn and passes with the gut for more than one-third of an inch, where it becomes larger, and then it enters the gut. This looks as if this duct must make a turn somewhere, as it did not do it at the gall-bladder.'[2] The bile in Rodents is thin and transparent, yellow or greenish.

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[1] CCXXXVI. vol. ii. p. 177.

[2] CXXVIII'', p. 154.

[3] CXLIX''. p. 19.

All *Carnivora* have a liver with a left, a cystic, and a right lobe, the latter usually subdivided into two or three lobules: in some the left and the cystic are of equal size; in others the left is the largest lobe. In the Lion the cystic lobe is deeply cleft by the suspensory fissure and the part to the left of that has been counted as a smaller left lobe: there is a larger one to the left of this, and two small lobes to the right of the part of the cystic lodging the gall-bladder. In the Walrus the liver is divided into seven lobes, each of which is more or less notched at the under-surface. Comparing this liver with the more simple forms in *Carnivora*, we recognise the homologue of the right lobe, here divided into two, the right division being the smallest. The part answering to the cystic lobe is deeply cleft into three subequal lobules, between the two right of which, at the base of the cleft, lies the long pyriform gall-bladder. The homologue of the left lobe is of a broad and rounded figure: it is attached by a band of hepatic substance, one inch broad, to the base of the cystic lobe, this band bridging over the portal vessels. The lobulus Spigelii, so constant in its position behind the small omentum in Mammals, here forms the seventh portion of the liver. The gall-bladder is three and a half inches long, and one and a half inch in diameter: a duplicature of peritoneum, one inch broad, extends from the cervix vesicæ and the cystic duct to the duodenum. The fundus of the bladder is attached by shorter folds of peritoneum to the two walls of the cystic fissure; it has an entire serous investment.

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[1] CXXX″. p. 70. The preparation is No. 8108, in XX. vol. i. (1833), p. 238. It appears to be a normal structure in the Houtias, being described in XII. tome IV. (1835) p. 454; also by SAY in the Rodent called *Isodon*, which appears to be identical with *Capromys*. CLV″. (1826).

[2] CCXXXVI. vol. ii. p. 209.

The liver of the Seal (*Phoca vitulina*) differs chiefly in the greater elongation and more pointed form of its divisions: viewed from below or behind, the left lobe, fig. 370, *a*, retains most of the normal shape; in the cystic lobe, *b*, *b*, the suspensory fissure is marked by the round ligament, *c*, the cystic one, *d*, by the gall-bladder, *e*; *f* is the larger, and *g* the smaller divisions of the right lobe, *h* being the Spigelian lobule or process; *i* is the portal vein entering the fissure so called; *k* is the post-caval, perforating the liver to combine with the hepatic veins in forming the capacious sinus, *l*, *l*, from which the trunk, again contracted, *m*, is continued to perforate the diaphragm, before terminating in the heart. The hepatic veins in the Seal have an outer coat of circular fibres.[1] The accumulation of blood in the sinus of the hepatic veins during the act of diving indicates the need of a muscular power to propel the blood onward to the heart.

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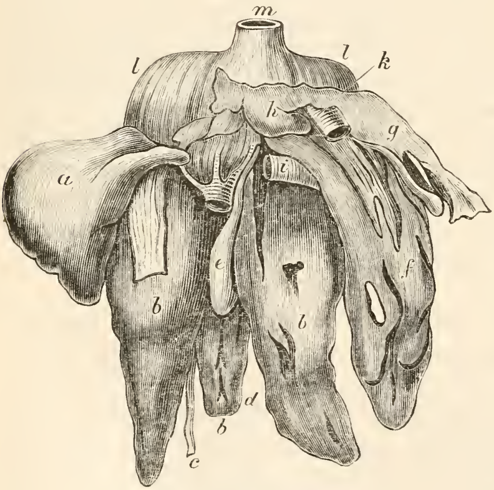

Liver of Seal, from behind.

The under surface of most of the lobes shows small notches or fissures; and these are still more marked in *Otaria*. Two hepatocystic ducts entered the gall-bladder in the seal I dissected.[1] The cystic duct was joined by a small hepatic duct about half an inch from the gall-bladder; and a little lower down was joined by a larger hepatic duct, which was formed by the junction of two other ducts, each of which was also formed by the union of two ducts, coming distinctly from four lobes of the liver. The ductus communis was one and a half inch long; it was joined by the pancreatic duct, as it terminated in a dilated sacculus within the duodenal coats.

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[1] CLVII″. p. 738, pl. xxiii, fig. 2.

The inner surface of the gall-bladder is minutely rugous and villous, the rugæ becoming longitudinal at the cervix, and subsiding in the duct. This character obtains in other *Carnivora*, in all species of which the alterative reservoir of the bile is present. In the Felines the valvular or impeding twist of the cystic duct is well marked.

Domestic Carnivora, obtaining more food, and more regularly, than wild ones, have a corresponding increase of the digestive apparatus: not only is the intestinal canal longer, but the liver is larger: there are more hydro-carbonates to be eliminated, more chyle to be made.[2]

In the Aye-aye neither left nor right lobe of the liver are subdivided; but, as in other Lemurs, both are distinct from the cystic lobe, which shows the usual cystic and suspensory fissures, and the left lobe is the largest. All the clefts are more transverse, less oblique than in the usually more subdivided liver of Rodents.[3] In many Platyrhines the right lobe, in some the left lobe also, are subdivided. In most Catarhines the same degree of hepatic division obtains as in Strepsirhines; but in some Doucs, in Gibbons, Orangs, and Chimpanzees, both right and left lobes have blended with the cystic, and the suspensory notch becomes, as in Man, the boundary between the two masses termed 'right' and 'left' lobes in Anthropotomy. The 'Spigelian' lobule is a process of the left posterior angle of the right lobe: it is partly defined by the post-caval vein, fig. 369, 13: the part of the cystic lobe between the cystic and suspensory fissures is the 'lobulus quadratus,' ib. 18, of Anthropotomy.

The lobes of the liver in its several grades of natural subdivision in the Mammalian class are invested by a delicate fibrous coat which is continuous with the similar looser investment of the vessels in the portal fissure called 'Glisson's capsule.' The serous accompanies and closely adheres to the fibrous coat, save at the portal fissure and along the suspensory and other folds, called 'ligaments,' where the serous coat is reflected from the gland. The resolution of the lobes and lobules of the liver into the ultimate subdivisions or 'acini,' is naturally shown in *Capromys*: as a rule they require section or maceration.

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[1] CLVII″. p. 152.

[2] So Daubenton:—'Le foie du chat domestique étoit plus gros, plus ferme, et d'une couleur rougeâtre beaucoup plus foncée que le foie du chat sauvage.' CXXII′. tome vi. p. 29.

[3] CII′. p. 43.

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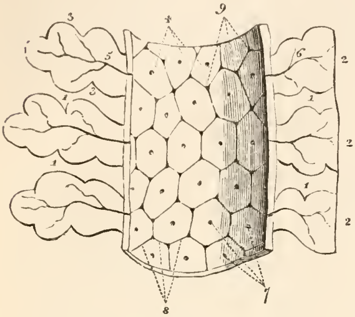

A longitudinal section of a sub-lobular vein. CLVII″.

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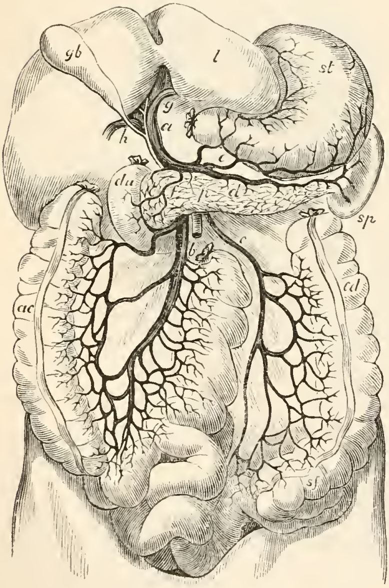

Branches of the portal vein, Human. CXLVIII″.

As the anatomist[1] to whom we are indebted for a knowledge of their structure has applied to these 'acini' the term usually given to such secondary divisions as the 'lobulus Spigelii,' and has founded his nomenclature thereon, it will be retained. Kiernan's 'lobules' range in size from $\frac{1}{20}$th to $\frac{1}{10}$th inch in diameter, present a foliated contour in longitudinal section, fig. 371, 1, 3, a polygonal one in transverse, fig. 378: a venule issuing from their centre, fig. 371, 5 and 7, connects them with the initial or 'sublobular' branches of the hepatic vein (laid open in fig. 371): the rest of their surface is attached by similar beginnings of hepatic ducts and absorbents, by terminal branches of the hepatic artery and portal vein, and by nerves, to the thin stratum of areolar tissue connecting one lobule with others. Each is composed of ramifications of its suspensory 'intralobular' venule, of arterial capillaries, of a plexus of portal capillaries, a plexus of biliary passages, of nerves, lymphatics, and intermediate cell-substance—the essential part of the gland which the other structures subserve. The section magnified of a ‘sublobular venule,’ fig. 371, shows the commonly hexagonal outline of the flattened bases of the lobules 4, the terminations of the ‘intralobular’ venules 7, the interlobular fissures 8, and the ‘interlobular spaces’ 9, at their angles: these are continued into the intervals between the more or less rounded lateral surfaces of the closely packed lobules. The ramification of the intralobular venule 5 is seen in the longitudinal section of the lobules, 1, 3. In the Seal the intralobular veins at their exit from the lobules enter hepatic-venous canals, where they unite into branches, which are connected by a fine cellular tissue, forming a sheath round the hepatic veins.[1]

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[1] CLVII″.

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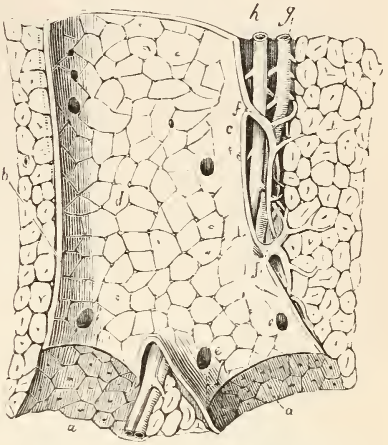

Longitudinal section of a small portal vein and canal. CLVII″.

The portal vein, in Mammals, fig. 372, is formed by the superior, *b*, and inferior, *c*, mesenteric veins, by the splenic vein, *d*, by the gastro-epiploic, *e*, and pancreatic, *f*, veins: the trunk, *a*, entering the portal fissure, divides into a right, *h*, and left, *g*, branch: these penetrate their respective divisions of the liver, ramify and subdivide therein, along tracts termed ‘portal canals,’ fig. 373, *a*, *a*; but which likewise lodge branches of the hepatic artery, *g*, and duct, *h*. As all these are connected together by a prolongation of the areolar tissue of ‘Glisson’s capsule,’ branches continued from the portal vein, *e*, and forming a plexus in that tissue, are termed ‘vaginal,’ from which, as well as directly from the portal vein, as at *f*, venules enter the interlobular spaces, are called ‘interlobular venules,’ fig. 374, *a*, *a*, penetrate the lobule, *b*, and form a capillary plexus therein, most richly at the periphery, but from which the ‘intralobular vein,’ *c*, begins. The hepatic artery has a similar

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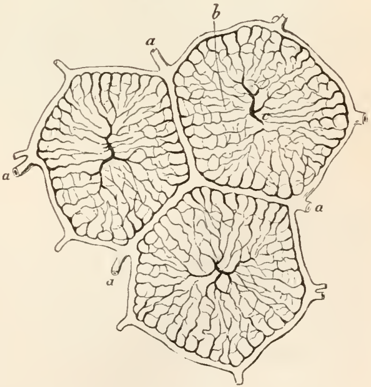

Lobules showing the portal venous plexus CLVII″.

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[1] CLVII″. p. 738.

distribution through the portal canal, fig. 373, *g*, where the minute branches form 'vaginal plexuses,' sending off interlobular branches which terminate in the lobule by a capillary plexus communicating and localised with the portal one. The meshes of the radially arranged plexuses, fig. 375, are occupied by organites which subsist by endosmotic intussusception and assimilation of blood-elements, modify them by interchange of other elementary combinations, then perish by rupture or solution of their walls. These bodies, called 'hepatic cells,' much exceed in size the monads of infusoria,[1] being about $\frac{1}{2000}$th inch in diameter; but, like them, they have a hyaline granulated nucleus, which contrasts by its refractive brightness with the tawny yellow of the minuter granules of the main contents of the cell, in which also float oil-globules. These contents, exuded or set free, fill the intervals of the 'nucleated cells,' and form the 'bile,' or brief equivalent of 'bile vesicles without proper walls.'[2] When an epithelium is discernible, separating them from the capillaries,[3] the bile-ducts may be said to commence. The inductive figure given by Kiernan of the intralobular or initial bile-conduits, fig. 375, receives support from the recent careful researches of Hering in the liver of the rabbit: he describes them as forming a plexus with polygonal meshes[4] from which the canals are continued to form the interlobular ducts, *a*, *a*; from these are continued the 'vaginal branches,' fig. 373, *h*, which progressively unite to form the hepatic ducts. These, in Man, emerge, two in number, at the portal fissure: in more divided livers the liberated ducts are more numerous; but all unite, as a rule in Mammals, into one trunk, which, in those having a gall-bladder, joins the cystic duct to form the 'ductus communis choledochus.' This duct, fig. 376, *a*, penetrates the duodenum distinctly from the pancreatic duct, *b*, both run obliquely between the several

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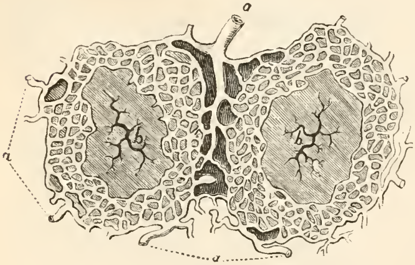

Lobular biliary plexus. CLVII.″

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[1] Such, e.g. as the *Monas atomus*, $\frac{1}{2000}$th line in diameter.

[2] 'Ein Gallencapillarystem ohne eigene Wandung.' CLIX″. p. 241.

[3] The 'when' or 'where' such 'epithelial walls' are gained, forming a beginning of proper conduits for carrying off the bile from the interspaces of the formative cells, may long be debateable ground with Micrographers; as now between Beale, Budge, and Hering. CLIX″. p. 241.

[4] 'Ein Netz mit polygonalen Maschen,' CLIX″, p. 241. Kiernan obtained a view of anastomosing biliary ducts in part of a lateral ligament of the human liver; CLVII″. p. 769, pl. XXIV. fig. 4.

tunics, *c*, *d*, *e*, of the gut, in Man, to the extent shown in fig. 376, before uniting to form the common receptacle within the terminal prominence.

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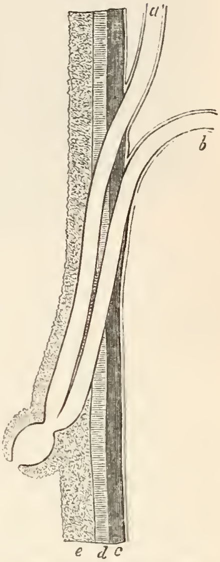

Hepato-pancreatic ampulla human : magn.

The 'carrying arrangements' of the bile are, thus, on a more concentrated plan in the present than in lower classes of Vertebrates. The human cystic duct shows a series of crescentic folds of the lining membrane, directed obliquely round the canal, and so arranged as to give the appearance of a spiral valve. Numerous minute follicles, either branched or clustered, open upon the mucous tract of the bile-ducts: in the smaller branches their orifices are in two opposite longitudinal rows.

From the arrangement and localisation in the 'lobule' of the capillaries of the two systems of veins, determined, together with most that is of importance in hepatic structure, by the admirable research, skill, and patience of KIERNAN, an explanation has been afforded of appearances otherwise unintelligible or misleading.[1] When the capillaries of the hepatic vein are gorged, as is usual in an early stage of congestion, the flattened surfaces of the lobules on the superficies of the liver present the appearance in fig. 377. When the portal capillaries are congested, the peripheral parts of the lobules present the deeper colour, as in fig. 378. So, in examining portions of the

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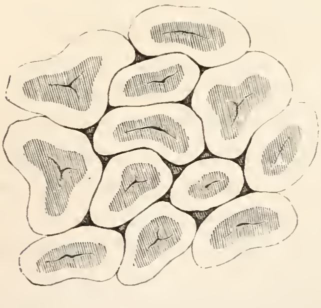

Lobules of liver with congested hepatic veins. CLVII''.

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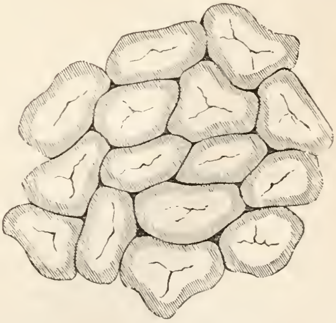

Lobules of liver with congested porta veins. CLVII''.

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[1] As e.g. the supposed distinction of 'cortical' and 'medullary' substances of some authors; of 'red' and 'yellow' substances of others. See CLVII''. p. 763.

liver of lower Mammals, as in that of the squirrel figured by J. Müller,[1] fig. 379, the uncongested pale peripheral portions of the lobules, nearest the interlobular fissures, *e*, *e*, may suggest an arrangement of ultimate or initial biliary ducts, which is merely due to partial congestion.[2] The structure of the liver is the same throughout the class; the form of the gland varies, governed mainly by relations of package with adjoining abdominal viscera, and by the degree in which it may be affected by inflections of the trunk.

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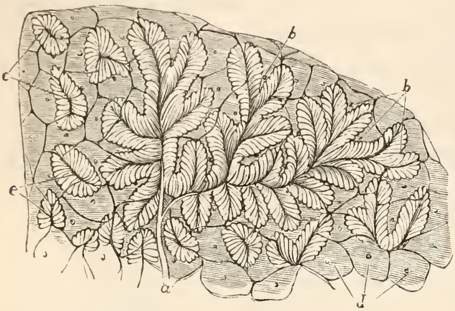

Congested hepatic veins, liver of Squirrel. CXXII.

§ 339. *Pancreas of Mammalia.*—This conglomerate gland here differs chiefly from that in birds by the progressive development of a part more or less distinct from that which is lodged within the loop or fold of the duodenum: such added part may be represented by that freely projecting end of a fold of the bird's duodenal pancreas (vol. ii. p. 175, fig. 87, *q*), which stretches towards the spleen, but there is no transverse part of the gland extending at right angles from the duodenal portion, like that which forms the splenic or transverse pancreas in the Mammalian class, and which ultimately becomes the main part or body of the gland in them. In most Mammals the pancreas is of a pale flesh colour, but usually less pink or of less decided tint than in birds: it is firmer in texture, and shows more plainly its conglomerate structure.

The pancreas in the Ornithorhynchus is a thin, somewhat ramified gland bent upon itself; the left and larger portion descends by the side of the left lobe of the spleen. The pancreas is thicker in the Echidna, and enlarges considerably towards the duodenum. The principal difference occurs in the place of termination of the pancreatic duct, which, in the Ornithorhynchus, joins the ductus choledochus, but in the Echidna terminates separately in the duodenum and nearer the pylorus than does the ductus choledochus. The arrangement of the hepatic and pancreatic ducts is thus conformable to the Mammalian type, and the Ornithorhynchus, in the place of the junction of these ducts near the commencement of the ductus choledochus, manifests its affinity to the Marsupials. In these the pancreas extends as usual from the duodenum to the spleen, behind the stomach; it is characterised by a process sent off at right angles, or nearly so, to the main lobe at or near its left extremity. Small and thin processes branch out into the duodenal mesentery (in a Phalanger); and similar but still more numerous processes, in the peritoneal attaching, or omental, fold to the left, give the organ a dendritic appearance in the Kangaroo; but the splenic process seems to be constant. The pancreatic duct usually opens into the glandular dilatation of the ductus choledochus, and the secretions enter the intestine further from the pylorus than usual.

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[1] CXXII. pl. xi. fig. 11.

[2] Well explained in CLVIII", p. 185.

The same low type of gland prevails in the *Rodentia*, and is well shown by Hyde Salter in the rat (*Mus decumanus*, fig. 380, the main part of the gland being that which extends from the end of the duodenal fold to the left into the gastrosplenic omentum, *o*, where it ramifies: the chief part of the duodenal pancreas follows the curve of the gut, but ramifies in its wide messentery, *d*. In the Cavy, where the duodenal loop is longer and narrower than in the Rat, the included portion of pancreas reminds one of the disposition of that in the Bird. In the Capybara the resemblance is less because the duodenum is shorter, and the corresponding part of the pancreas is small: the transverse and larger part of the gland is also more compact than in most Rodents. In the Porcupine the duct of the larger part of the pancreas enters the duodenum far from the pylorus. In the Beaver the pancreas is of considerable extent, measuring in length nearly 2 feet, and following the course of the duodenum down to the iliac region and up again as far as the umbilical, being attached to the intestine by a process of mesentery: it is thin and narrow, and has one small branch or process lying parallel with its body where it passes behind the liver, and a few others at the curvature of the duodenum. Its duct, somewhat larger than a crow-quill, enters the small intestine at the extremity of the gland, 1 foot and 9 inches from the pylorus, and 1 foot and 6 inches from the termination of the ductus choledochus.[2] This is the extreme of distance from the pylorus and bile-conduits of the entry of the pancreatic secretion into the intestinal tract, which has been observed in Mammals: the character prevails in the Rodent order, and Physiologists have availed themselves of it in the Rabbit in

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[1] CCXXXI, p. 98.

[2] CLXI''. p. 19.

experimental research on the action of the bile in the intestine before its admixture with the pancreatic secretion. Most *Insectivora* also show the flattened branched form of the pancreas in the broad membranes suspending contiguous organs: it is shown in a large snouted Shrew, in fig. 323, *p*. In the Hedgehog one of the duodenal branches hangs freely from the mesentery with an entire investment of peritoneum.[1]

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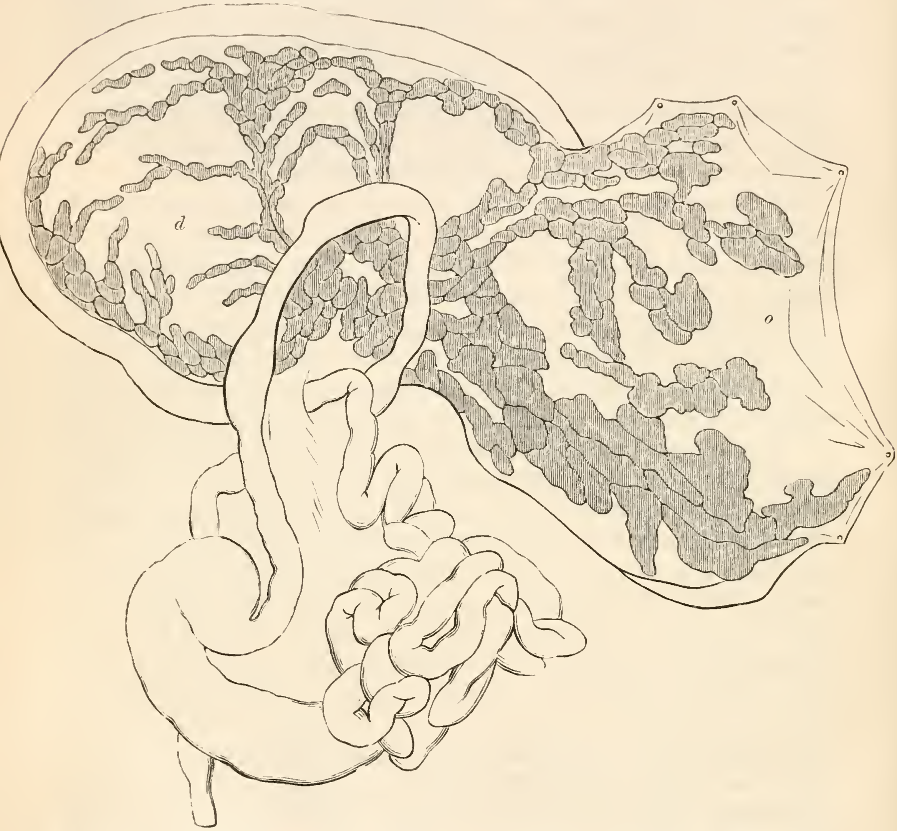

Pancreas of the Rat (natural size), shown by throwing up the duodenum and duodenal mesentery. ccxxxi.

In the Sloth the left end of the splenic portion of the pancreas has an entire serous coat, and is somewhat loosely suspended from the back of the epiploön: the duodenal portion is narrower. In *Myrmecophaga* the transverse or splenic portion is long and narrow, connected with both epiploön and stomach: the duodenal part follows the curve of the gut.

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[1] cxlvii″. p. 236, No. 780 a.

In Cetacea the pancreas, like the liver, becomes more compact in form: it is unusually long, flat, rather narrow but thick, with its left end near the spleen, and attached to the first gastric cavity: it crosses the spine at the root of the mesentery, behind the second and third stomachs, to the right, following, or expanding at, the curve of the duodenum, to which it adheres, and sending its duct to join the hepatic near the entry into the dilated part of the duodenum.

In a half-grown Dugong I found the splenic part of the pancreas seven inches in length, thick and obtuse at the left, and where its diameter was two inches, and gradually diminishing toward the duodenal part: the duct is wide, and terminates on the same prominence with the bile-duct, and at a greater distance from the pylorus than in *Cetacea.* The pancreas of the elephant shows more of the rodent than of the ungulate type of the gland. It consists of several masses not very closely connected with each other, from which separate ducts are given off, which unite into two conduits: one of these pours the secretion into the upper compartment of the biliary pouch, fig. 366, where it is mixed up with the bile therein contained preparatory to its introduction into the intestine, while the other opens into the duodenum about two inches lower down. In the Rhinoceros the transverse or splenic part of the pancreas is the largest, in length nearly two feet: the duodenal part, about half that length, extended at a right angle, chiefly backward (sacrad) expanding within the process of the peritoneum, connecting the duodenum to the enormous cæcum. The duct of the splenic portion entered the duodenal fossa common to it and the hepatic duct; the duct of the smaller portion terminated about two inches from the other, but at the same distance from the pylorus. The pancreas in the Hyæna and Tapir resembles that in the Rhinoceros; nor is there any material modification in the Horse: the descending duodenal portion is relatively broader, and lies over the right kidney. In the Hog the duodenal part is narrower, but longer: the splenic part is broad and bifurcate, sending downward, or sacrad, a process as far as the left emulgent vein. In Ruminants the divisions of the broad and flat pancreas are less defined: the descending process comes off rather from the duodenal side of the gland. In the Giraffe the duodenum receives the combined biliary and pancreatic secretions about ten inches from the pylorus.

The pancreas in *Carnivora* is long and narrow, but continues of a more definite and compact form than in *Ly-* or *Liss-encephala*: its duodenal and splenic divisions are, however, well marked and subequal: the former usually describes a circle, as in fig. 351, *e*, following that of the comparatively long and loose duodenum; the latter, ib. *f*, is straight and transverse in course: both portions are triedral, and have an entire, or nearly entire, serous coat; and in some species this is continued from one of the angles as a narrow suspensory fold of the gland, from the posterior part of the great omentum in the splenic portion.[1] In the Lion and most Felines, the duct of the annular part sometimes communicates with that of the splenic part at two points, and the main duct communicates with the bile-duct, before entering the intestine. In the Dog the duodenal portion follows the descending course of that gut, and is longer than the splenic division, which it joins at a right angle: the ducts of each part unite between the duodenal coats, before joining the bile-duct, which is distinct external to the duodenum, and can be separately tied. Cuvier notes, as a rare structure or anomaly, a lateral reservoir for the pancreatic secretion in the Cat: its duct, about an inch and a half in length, communicated with the common duct formed by those of the two parts of the pancreas, which joins the bile-duct, as in the Lion. The dilatation or sac between the tunics of the duodenum in the Seal-tribe is common to the pancreatic and biliary secretions.

In the Aye-aye the pancreas is a broad thin gland, extending and expanding from near the spleen to the duodenum, and thence continued, as the 'small pancreas,' a little way beyond the entry of the duct, which is close to that of the gall-duct: here the gland sends off some short narrow processes into the fold of the mesentery: it is, however, more compact, less ramified and diffused, than in Rodents. The duodenum being relatively shorter and less loosely suspended in both the Aye-aye and Lemurs, the part corresponding to the 'small pancreas' is less developed than in *Lissencephala*: but it is more developed than in the true *Quadrumana*, in which the duodenum becomes still more confined in position. The left end of the pancreas is rather loosely suspended in both Lemurs and Platyrhines: in Catarhines it has only a partial covering from the epiploön, and the gland acquires its fixedness and compactness of form which characterise it in them. Here the duodenal or small pancreas, fig. 381, *h*, is reduced to an enlargement called the 'head,' and which occasionally follows in a short curve the bend of the duodenum: it more rarely repeats the detached condition which prevails in some lower mammals : the splenic portion, ib. *pa*, contracts near the spleen, *sp*. The thick upper border receives in a groove or canal the splenic artery and vein. The main duct traverses the substance of the gland nearer the lower than the upper border; it is commonly joined near its end by the duct from the lesser pancreas, or 'head,' *h*: but the homology of this with the duodenal pancreas of lower mammals and birds is sometimes instructively exemplified by the independent entry of its duct into the duodenum, as in fig. 382, B, *c*. In the ordinary arrangement the duct ot the larger, *b*, unites with that of the lesser pancreas, and the common pancreatic duct penetrating the duodenal tunics joins the common bile-duct at the ampulla, before entering the intestine, as shown in fig. 376. In the variety B, the duct of the larger pancreas, *b*, alone has this relation with the gall-duct, *a*: in a rarer variety, C, the common duct of the pancreas, *b*, opens distinctly from the common bile-duct, *a*: in a still rarer anomaly, D, the duct of the lesser pancreas receives tributaries from the larger pancreas, becoming a tube of equal size, and the two, *b*, *c*, unite, before the usual junction with the bile-duct, *a*. The proper coat of the pancreatic duct is a firm tissue of interwoven, mainly longitudinal, fibres; with an outer loose areolar covering and an epithelial lining. This, in the minute beginnings of the carrying system, consists of columnar cells so packed that their ends next the duct-cavity present a penta- or hexa-gonal pavement, fig. 383. The initial ductlets arise from the interspaces of the follicular or cell-structure of the

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[1] XLVII''. p. 132. (Cheetah.)

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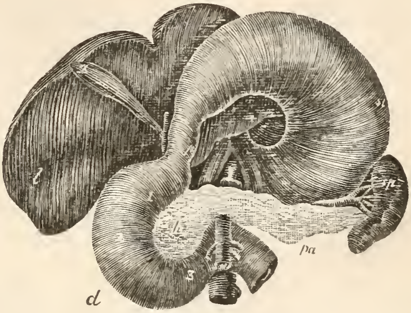
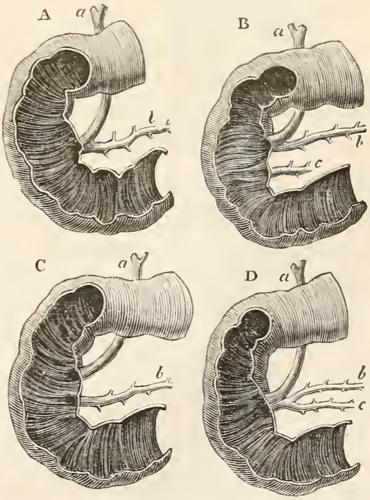


Pancreas, exposed by raising the stomach ; Human. CXLVIII''.

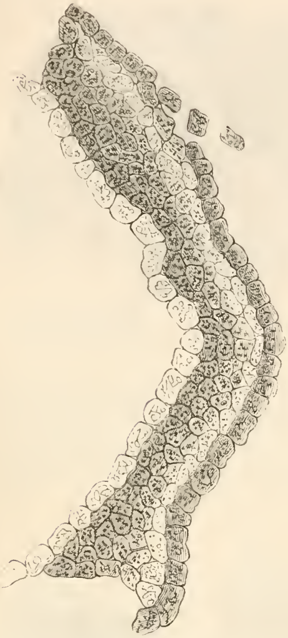
382



Varieties in the termination of the pancreatic duct Man. CCXXXI.

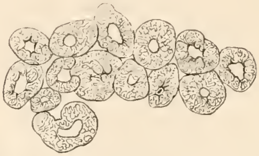
gland, receiving the contents of the cells, which, as in the liver, are the agents operating upon the blood-constituents so as to convert them into 'pancreatic juice.' Hyde Salter, who found in the thin ramified plates of the Rodents' pancreas the best conditions for microscopic scrutiny, has given the following amongst other illustrations of the ultimate structure of this gland. Fig. 384 shows a group of follicles from the pancreas of a Rat, viewed so as to bring their central cavity into focus. The average size of a pancreatic follicle is $\frac{1}{500}$ of an inch: they are commonly arranged in groups of very various numbers.

383



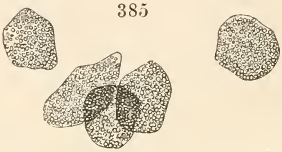
Portion of epithelium lining a small duct 1·400th of an inch in diameter. From a Rabbit. Mag. 300 diam. CCXXXI.

384



Pancreatic follicles; Rat. Magn. 150 diam. CCXXXI.

385



Selective cells from the pancreatic follicles of the Rat. Magn. 400 diam. CCXXXI.

In the follicles proteine matter is formified or developed as selective cells, of from $\frac{1}{1500}$ to $\frac{1}{2000}$ of an inch

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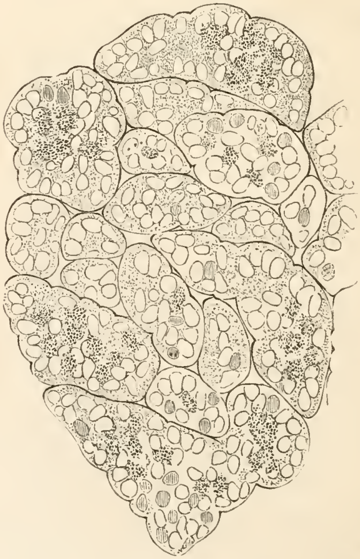

Ultimate lobule or acinus of the pancreas of a Mouse. Magn. 180 diam. CCXXXI.

in diameter, subcompressed, rounded or polygonal in shape; which escape by rupture of the follicle. These cells slightly increase and become filled by opaque granules, fig. 385, resembling the granular contents of the free secretion, which granules appear to be liberated by the solution and disappearance of the cell-wall.

The spaces containing both follicles and cells are circumscribed by productions of a basilemma defining the ultimate lobules or 'acini' of the pancreas: in one of these, fig. 386, may be seen a group of follicles containing two results of formifaction, called 'stages of selective or epithelial cells.'[1]

The following are among the later and more exact analyses of the pancreatic secretion from a carnivorous and a herbivorous species of mammal:—

Pancreatic juice of dog (Schmidt).[2]

Water	900·76
Solid residue	99·24
Organic matter	90·38
Inorganic	8·86

Pancreatic juice of ass (Frerichs).[3]

Water	986·40
Solid residue	13·60
Fat	0·26
Alcohol extract	0·15
Water extract	3·09
Soluble salts	8·90
Insoluble salts	1·20

Frerichs' 'water-extract' and Schmidt's 'organic matter' signify a substance resembling albumen and casein, but not identical with ptyalin. The pancreatic secretion differs from the salivary in containing more than double the amount of solid residuum, in which albumen and casein are abundant; while they exist in very small quantity in saliva. Saliva is neutral, or contains a little alkaline carbonate: the pancreatic secretion contains a little free acid. Saliva contains sulpho-cyanide of potassium; in the pancreatic fluid there is none.

This fluid completes the process of converting amylaceous matters into sugar, which was commenced by the saliva. Bernard maintains that it also exercises the more important office of emulsifying or saponifying the neutral fatty matters contained in the food, by decomposing them into glycerine and their respective fatty acids, and so rendering them absorbable.[1] But the latest experimenters are agreed only in regard to the first result, and the chief office of the pancreatic secretion in digestion still awaits determination.

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[1] In using the terms 'cell' and 'nucleate cell' I would not be understood as implying that such are progeny of previous cells, owing their origin to a genetic process inherited from 'one primordial form into which life was first breathed (ccxiii″. p. 484).' The cell is one of the forms in which proteine matter in solution may be aggregated, with limitation of size and definition of shape; such forms differing from crystals in being rounded instead of angular, as shown in the instructive experiments of Rainey (ccix″. p. 9.) Accordingly, to express this act, I use, instead of 'crystallise,' the word 'formify,' for crystallisation 'formifaction,' for crystallising 'formifying': such terms imply, simply, the fact of the assumption of the forms called 'granule,' 'corpuscle,' monad,' 'globule,' 'disc,' 'cell,' 'nucleus,' 'nucleate cell,' &c. 'Formified particles' cling, like crystals, to the free surface of the cavity containing the solution, and are then termed 'epithelial cells': such surface seems favourable to the initiation of the formifying process: but a large proportion of the results of such process is manifested in the free state, like the fine crystals that follow concussion of water cooled gradually and quietly below the freezing point.

[2] clxii″. [3] clxiii″.

§ 340. *Peritoneum and appendages in Mammalia.*—The abdomen, as a definite and circumscribed visceral chamber, is peculiar to the present class: the heart and other thoracic viscera are shut out by the complete transverse septum or 'diaphragm' from the major part of the trunk-cavity, to which the term 'abdomen' is now restricted. The serous membrane called 'peritoneum,' which lines this cavity, is reflected from the walls upon the principal abdominal viscera to some of which it gives a complete, to others a partial, investment. In the human subject the peritoneum, as in the section shown in fig. 387, passes over the fore part of the abdominal aorta, *i*, the postcaval, *h*, and the kidneys, *k*, *k*; but is reflected so as to inclose the liver, stomach, spleen, and major part of the intestinal canal: it is continued from the transverse fissure of the liver upon the lesser curvature of the stomach to form the gastrohepatic omentum. At the level of the section figured, one part, *f*, is seen passing forward from the left kidney to enclose the spleen, *b*, and the stomach, *a*: the opposite border, *e*, is the part of the lesser omentum inclosing the hepatic duct and vessels, *c*. Another fold of peritoneum is reflected from the upper and fore part of the abdomen upon the umbilical vein of the fœtus, which afterwards degenerates into the 'round ligament,' *d*; the supporting fold, *g*, being continued into the suspensory fissure of the liver, and forming its 'falciform' ligament: other folds continued from the diaphragm upon the opposed convexity of the liver are its 'coronary' and 'triangular' ligaments. The lesser omentum, more properly the 'mesogaster,' or peritoneal fold which mainly suspends the stomach and conveys thereto its vessels, also covers and suspends the spleen; and this part of the mesogaster is termed the 'gastrosplenic omentum,' of which, in Man, only the left or outer layer forms

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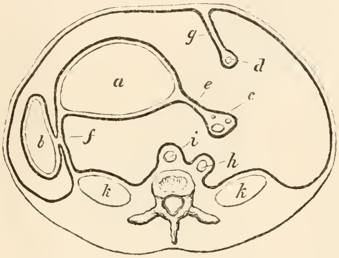

Transverse section of abdomen through the first lumbar vertebra; Human. CCXXXV.

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[1] CLXIV″.

the splenic covering. Both layers recede to include the stomach, fig. 388, *b*, whence they are continued from the line of the greater curvature over the fore part of the abdomen, and are folded back to the colon, in the form of a large flap or apron, including vessels and more or less fat, forming the ‘great omentum,’ ib. *o*, *o*: it is peculiar to the *Mammalia*, coexists with the diaphragm, and may have useful relations as insulating the peristaltically winding intestines from the constant respiratory movements of the abdominal walls. The posterior returning folds of the omentum meet the transverse arch of the colon, recede and embrace that intestine, as the anterior or descending folds had embraced the stomach; the colonic folds are continued back as a suspensory ‘mesocolon;’ the upper layer of the fold passes over the fore part of the duodenum and pancreas to the posterior abdominal walls, the lower layer is continued a short way down those walls, and is again reflected forward to the small intestines as the anterior or upper layer of their suspending fold called ‘mesentery.’ The relations of the peritoneum to the pelvic viscera show no class-specialities. Large omental processes with accumulated fat are never continued from the urinary bladder, and rarely from the pelvic or other regions of the abdominal walls, as they are in most *Reptilia*:[1] small ones from the serous coat of the large intestine are developed in many Ungulates, and are called ‘appendices epiploicæ’ in the human subject. The serous sac of the abdomen communicates with the mucous canal of the oviducts or ‘fallopian tubes,’ but is elsewhere closed in the female, and is a shut sac in the male mammal. Productions of this sac, however, accompany the testes into the scrotum; but are insulated by obliteration of the canal of the spermatic cord in Man.

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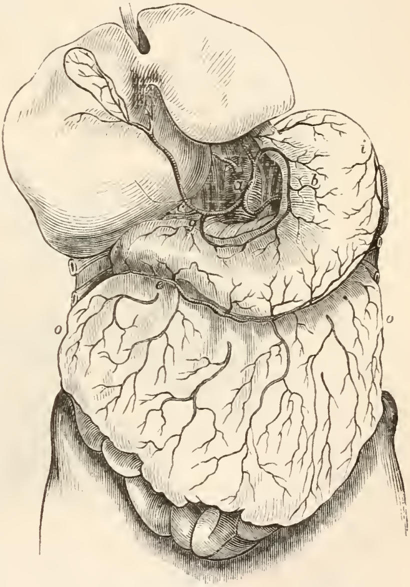

Liver raised to show the stomach and great omentum, Human. CXLVIII″.

The above leading features in the disposition of the peritoneum offer modifications in the present class. In the insectivorous species of the Ly- and Liss-encephala, with little or no cæcal distinction of the intestines, the suspensory fold of the abdominal alimentary canal may be almost as simple as in lizards; e. g., in the Shrews, fig. 389, *m*. The omentum is restricted to a very small duplicature from the spleen, *s*, supporting some processes of the ramified pancreas. When the cæcum and large intestines are more developed, then the peritoneum, reflected from the back of the abdomen, appears to make a half twist, fig. 380, *c*, to form the mesocolon, behind which the duodenum passes to become the loose jejunum, which, with the ileum, is suspended on the mesentery. The meso-duodenum, continued partly from the upper layer of the mesocolon, is here of a size characteristic of the peritoneum in many Mammals, but is reduced in *Quadrumana*, and is almost lost in Man. The great omentum or epiploön is larger in Rodents than in Shrews; but is transparent, and with little or no fat: it includes, in Rodents, pancreatic processes,

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[1] xx. vol. iii. pt. ii. p. 221.

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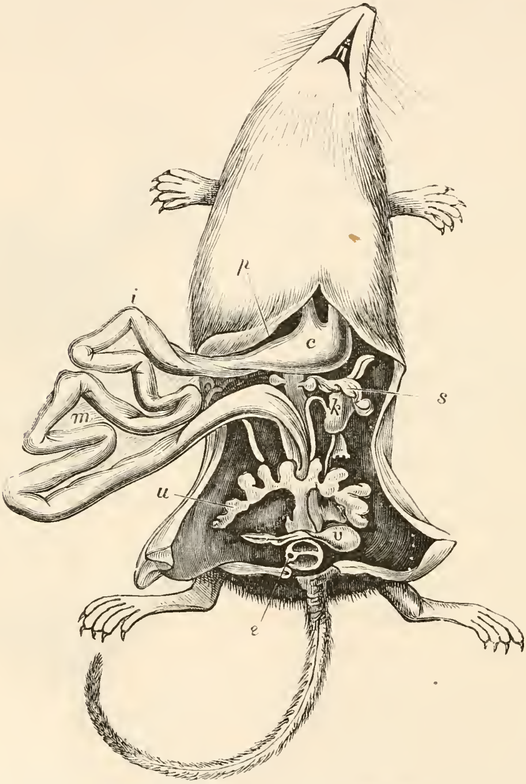

Abdominal cavity, and mesentery. *Hydrosorex Hermanni*, nat. size. CLXVII″.

ib. *o*, with the spleen. In the Kangaroo it is of moderate size, continued loosely from the stomach to the transverse colon, but not extended beyond that part. The posterior layer lies between the stomach and the intestines, and exemplifies one of the uses of the epiploön, as it prevents these parts from interfering with each other's motions. The anterior layer generally contains more or less fat. In the Petaurus the epiploön is continued from the great curvature of the stomach and the commencement of the duodenum. In the Phalangers it is of considerable extent and is usually loaded with fat. In the Opossums I have found it generally devoid of fat, when this substance has been accumulated in other parts. In the Phascogales and Dasyures the epiploön is of moderate size, and contains little or no fat. The epiploön is attached to the lower arches of the several divisions of the stomach in *Cetacea*, is always devoid of fat, and is of limited extent: the subdivided spleens, fig. 355, *h*, *i*, are scattered in it, as in a net: it is in parts reticulate. The epiploön is small and does not cover the intestines in *Sirenia*, *Proboscidia*, and *Perissodactyla.* It is, also, of limited extent in the Hog-tribe. In fatted Sheep it is larger and is reticulated with adipose matter. It is attached, in Ruminants, to the right side of the left division of the rumen, and along its anterior or ventral convexity, passing from the right of this to the abomasus and the beginning of the duodenum: it does not cover the intestines, and is commonly found crumpled up beneath the paunch. The reticulate structure of the great omentum appears to be natural and pretty constant in the Dog and some other *Carnivora*: in the Seal the omental fold is thin and devoid of fat.

The peritoneum lining the elastic ventral wall of the abdomen in the Elephant and Rhinoceros is of unusual thickness and strength, the areolar tissue connecting it to adjacent structures presents an aponeurotic firmness: the free surface of the serous membrane I found to be white and opaque:[1] it is generally transparent and opaline or colourless. In some hibernating Rodents a fold of peritoneum extends forward from each lumbar region, covering the lateral convolutions of the intestine as far as the umbilicus, and towards the beginning of winter becoming the seat of an abdominal deposit of fat: they may serve with the ordinary omentum the double purpose of nonconductors of heat and a store of nutriment.

[Since Sheets T–DD were printed off, the excellent Paper CLXXXVI″ has appeared, showing that the deciduous teeth of the mole, though too minute to seem of use, are not shed until after birth. In other respects Mr. Spence Bate confirms the talpine formula given at p. 304.]

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[1] v″. p. 37.

CHAPTER XXXI.

ABSORBENT SYSTEM OF MAMMALIA.

§ 341. *Lacteals.*—In Mammalia the intestinal villi constitute a modification of surface intimately related to the formation and more especially to the absorption, of chyle. Such villi, e.g. of a calf killed after being fed with milk, exhibit, when magnified as in fig. 390, a central canal, dilating towards its end, *c,* white or opaque with chyle: it appears to be an excavation in the substance of the villus, and the only definite tunic is the limitary membrane, *a* ; from which the epithelium (shown in fig. 350, *o*) has been removed. The columnar cells of which this epithelium is composed are the direct agents of absorption. Each cell becomes gradually filled by a clear globule of refractive fluid, like oil. The scattered cells which are first filled, cause parts of the surface of the villus to glisten, as in fig. 391, in contrast with the darker tracts of unfilled cells. The oil-like globule next undergoes changes, represented in the cell-series, fig. 392, which mainly consist in a subdivision or reduction of the globule, *d,* to the granular state in *a,* the nucleus of the columnar cell remaining unchanged. These granules, or molecules, escape by rupture or solution of the cell-wall, penetrate the limitary membrane, become aggregated in the basal tissue of the villus, and finally enter the lacteal canal. Dead animal membrane does

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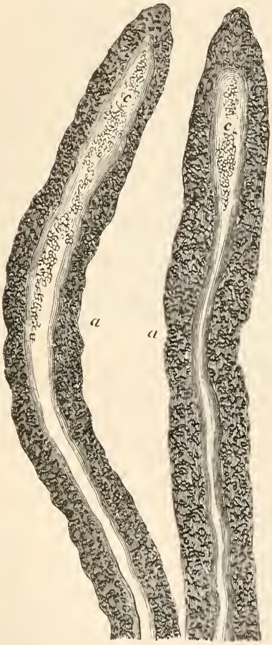

Intestinal villi with lacteal canal, Calf, magn. CLXXVIII″.

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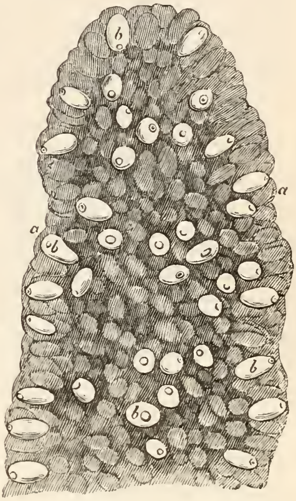

Intestinal villus, Dog, magn. 400 diam two hours after feeding. CXLVIII″

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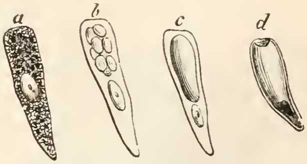

Epithelial cells of a villus, during absorption of fat, magn. 350 diam. CXLVIII″.

not prevent the effects of the ever-present, ever-active force which manifests itself, e.g., in the combination of an alkaline solution with a less alkaline fatty emulsion previously separated by such membrane: and the cell-wall would offer much less physical resistance to the diffusive interchange than the membrane used, e.g., in Matteucci's experiments.[1] But, besides the act of physical imbibition, with which the intussusception of aliment by monads or nucleate cells is closely related if not identical, there are also assimilative changes effected by these organites. Viewed by the microscopic aids of the last century they were thought to be orifices by which the chyle was sucked up and then conveyed by beginnings of the lacteal absorbents to the central space or 'trunk,' of which Cruikshank saw 'but one in each villus' of a female who had died suddenly a few hours after a full meal (CLXXVIII″): occasionally two have been seen with looped unions in one villus: in Mammals with broader villi the chyle-cavity is reticulate. These trunks are, however, the first definite absorbent channel, and, acquiring proper walls, unite together at the roots of the villi to form a network at the areolar basis of the mucous membrane, whence branches proceed to perforate the muscular coat, and take a transverse course to the line of attachment of the mesenteric layers. There are, also, superficial absorbents of the serous coat, which affect a longitudinal course and unite with the lacteals in their passage to the areolar interval of the layers of the mesentery: here they traverse the mesenteric glands, and progressively unite into a plexus surrounding the superior mesenteric artery. The lacteals and lymphatics from the cæcum and colon, which also traverse absorbent ganglions or glands, ultimately join the mesenteric lacteals, and the contents of the whole intestinal system of absorbents are carried by a few trunks to a 'chyle-receptacle,' fig. 399, II, at the root of the mesentery, whence are continued the beginnings of the 'thoracic duct.'

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[1] CLXXVII″. p. 104.

§ 342. *Lymphatics.*—These differ from the lacteals only in the nature of their contents, and even this is a temporary or contingent difference, for the lacteals convey a clear lymph, when the function of chylification is suspended. The gastric absorbents accompanying the right gastro-epiploic vessels communicate behind the beginning of the duodenum with 'lacteals' and absorbents from the liver: the gastric absorbents from the lesser curvature join those of the liver descending 'Glisson's capsule:' the absorbents accompanying the left gastro-epiploic vessels unite with those from the spleen. The pancreatic absorbents communicate partly with the splenic ones, partly with the duodenal lacteals. The deep-seated absorbents of the liver, continued from the initial plexuses already adverted to in the portal fissures, fig. 373, emerge with the hepatic ducts, and are joined by those of the gall-bladder and by many of the superficial absorbents: they traverse glands in 'Glisson's capsule.' Some of the superficial absorbents ascend along the coronary and lateral 'ligaments' and enter the thorax, independently of the trunks of the deeper-seated ones. They combine with the absorbents of the heart and lungs and those accompanying the 'internal mammary' vessels to form three or four trunks communicating with the thoracic duct. The direct work of taking up waste tissues is done by independent organites: the earliest recognition of absorbents is as intercellular spaces or areolæ (vol. i. p. 455), or serous cavities; the canals continued from which, when filled by injected fluid, resemble a 'plexus,' such as Breschet has delineated in figure 393: such plexiform beginnings are commonly superficial, as beneath the skin and the serous surface of organs: in the substance of organs and tissues the origins are 'lacunar': in both forms the free surface shows nucleate scale-cells. When a distinct wall can be defined, the lymphatics of Mammals are seen to be more numerous, minute, and 'highly finished' than in lower Vertebrates. And, though remarkable for their almost transparent delicacy, their walls are strong, and in them may be distinguished fibrous layers

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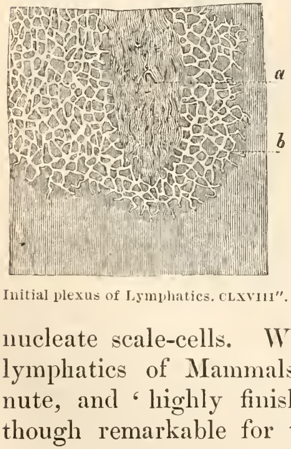

Initial plexus of Lymphatics. CLXVIII″.

and a lining membrane: the latter consists of flat and nucleate epithelial cells, adherent to a reticulate subfibrous membraniform basis: it presents a smooth surface, like that of a serous membrane, to the naked eye. The fibres of the middle tunic affect a circular arrangement, are contractile like other fibres of the 'smooth system,' and are also elastic. An outer tunic may be defined by the longitudinal course of the fibres of the condensed areolar tissue mainly forming it. In the thoracic duct longitudinal fibres of the 'smooth' kind are distinctly superadded to the outer coat, and a reticulate membrane has been detected between the inner and fibrous tunics. In the present class, the inner tunic is folded to form many and efficient valves, of the 'semilunar' form, and commonly in pairs, fig. 394, rarely single: it is reflected from the fibrous coat half-way across the area of the vessel and then folds back upon itself to return to the wall, which it continues to line until it forms the next valve. The two layers of the fold firmly adhere, and offer great resistance to any pressure upon their concavity. In figure 395, *a* shows a side-view, *b* an oblique, and *c* an end-view of the usual disposition of the valves in pairs in distended lymphatics, when their free margins meet and close the area of the vessel to prevent the lymph flowing back. Mr. Lane has figured three varieties in the valves of lymphatics, fig. 396, near their entry into the conglobate bodies called 'glands.' In A, one fold, *b*, was less than the other *b*, and the margins of the outstretched folds did not meet or perfectly

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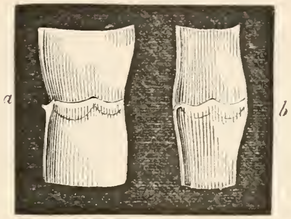

Valves of Lymphatics, *a*, horse; *b*, human; magn. CLXVIII″.

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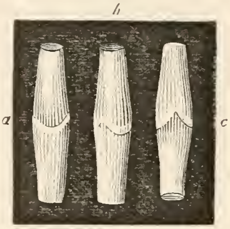

Valves of Lymphatics. CLXVIII″.

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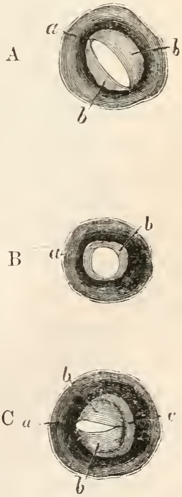

Varieties of valves of Lymphatics. CLXX″.

close the vessel, the inner surface of which is shown at *a*: in B the folds were continuous forming a subcircular valve, and contained both fibrous and serous tissues: in C, besides the ordinary pair of semilunar valves, *b*, *b*, there was a subcircular fold, *c*.

§ 343. *Absorbent ganglions.*—These bodies, also called lymphatic or lacteal 'conglobate glands,' are much more numerous in Mammals than in other Vertebrates. In the limbs they are chiefly situated at the flexures of the joints; and, being connected by a looser tissue to surrounding parts, elude pressure by the freedom of motion so allowed. They occur in the neck and head external to the cranial cavity: in the thorax at the anterior and posterior 'mediastina,' and at the bronchial trunks where they are usually discoloured by black carbonaceous matter. In the abdomen they are found in the mesentery, near the spleen, and along the side of the aorta, post-caval, and iliac vessels. In the neighbourhood of the liver and gall-bladder post-mortem exudation tinges them yellow: as a rule, they are of a pinkish grey tint. The absorbents which enter the gland, fig. 397, B, *a*, *a*, are commonly smaller and more numerous than those that quit it, ib. *e*: the former, or 'vasa inferentia' divide into small branches previous to entering. They then finely ramify, lose their proper tunics, and become continuous with those lacunar channels or 'vacuoles' which appear in the cell-mass of the developing glands.[1] The preponderance of the fibrous tissue left, as it were, in the peripheral part of the gland gives ground for the distinction of a 'cortical' from a 'central' portion. But there is no definite boundary-line: septa extend from the 'cavernous' capsule, at first lamelliform in the cortical part and becoming cord-like or 'trabecular' in the central part. In the latter, the lymph-channels become larger, especially in the mesenteric glands, and have been termed 'loculi:' they are large in the mesenteric glands of the *Cetacea*, though not in the degree, or with the anatomical relations, described in CLXXIV″, p. 27. They are paved by the flat nucleate cells, and usually contain a whitish pulpy matter: minute plexiform vessels, surrounding the 'loculi,' form the beginnings of most of the 'vasa efferentia,' ib. *e*; a few are direct continuations of the inferent vessels.

§ 344. *Disposition of Lymphatics.*—In the Mammalian class the anatomical disposition of the lymphatic system has been most completely traced out in the human subject. Successfully injected, the superficial lymphatics of the lower limb present the general arrangement shown on the fore-part of the leg, in Mascagni's magnificent work (CLXXI″), from which fig. 398 is reduced. On the inner side they tend to converge about the vena saphena, and, with the deeper-seated ones, mainly unite into trunks which again subdivide to enter the 'inguinal glands,' fig. 399, I, 2. Their efferent trunks affect the course of the iliac vessels, converging toward and uniting by cross branches with those of the opposite side, and communicating with the lacteal system, at the 're-ceptaculum chyli,' II, whence proceed the origins of the thoracic duct. This, in Man and most Mammals, enters the thorax between the aorta and vena azygos, and lies behind the œsophagus in the posterior mediastinum. It is frequently tortuous and rarely single throughout. It often splits into two or more branches, which after a longer or shorter course reunite; this division and reunion may be two or three times repeated. The principal canal, in Man, fig. 400, *a*, *a*, mounts into the cervical region in front of the vertebral artery and vein to the level of the seventh cervical vertebra, opposite to which it begins to form a curve, first forward and outward, then downward

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[1] CLXXVI″. p. 152.

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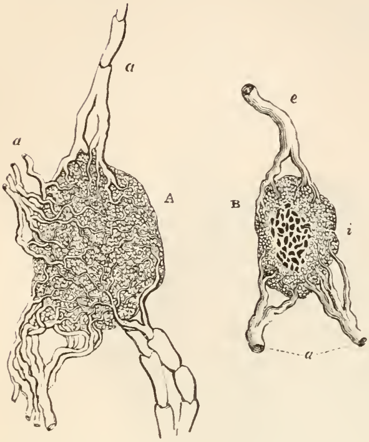
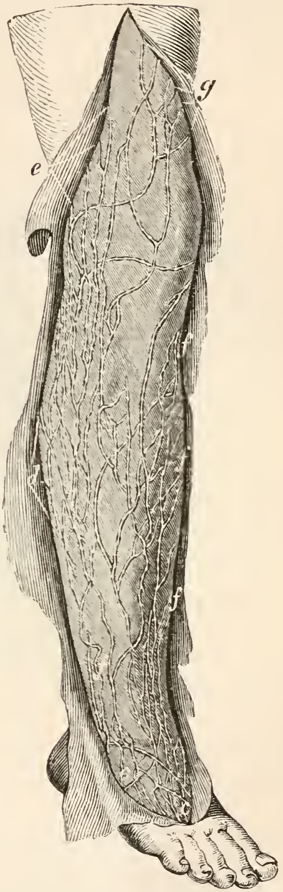


Lymphatic glands injected with mercury. CLXXI″.

398



Superficial lymphatics of the lower extremity. CLXXI″.

and inward, over the subclavian artery to reach the angle of union between the left subclavian, *s*, and internal jugular, *j*, veins, at which point it empties itself into the venous system by one or more branches. The corresponding veins on the right side also

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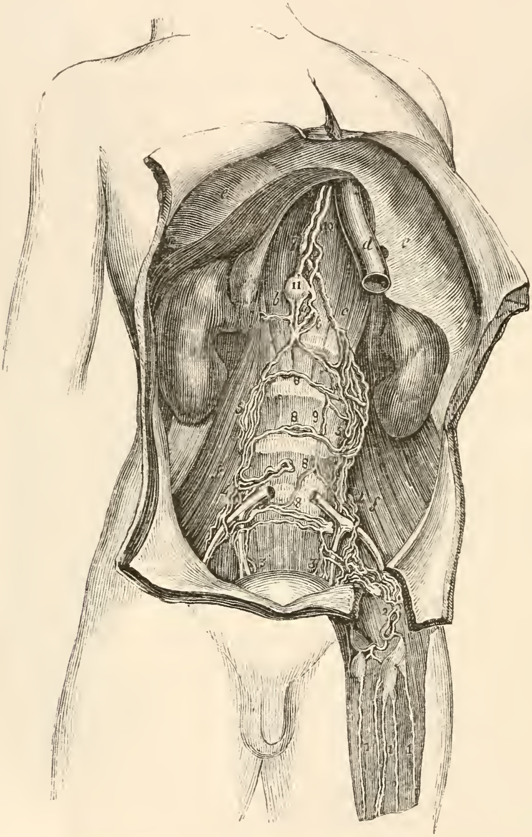
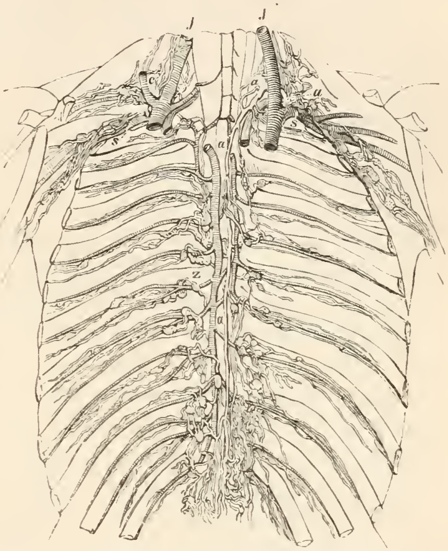


Absorbent trunks of inguinal and lumbar regions, with receptaculum chyli ; Human. CLXX '

receive lymph, but usually by a short trunk, ib. *c*. There have been observed, in Man, varieties which are more constant in some lower Mammals, as, e.g., a double 'thoracic duct,' one terminating in the left, the other in the right subclavian vein; a bifurcation of the duct at a higher or lower level, one branch terminating in the angle of union of the subclavian and internal jugular veins of the left side, the other emptying itself either into the corresponding point on the right side or joining the right lymphatic trunk, close to its termination; a single trunk terminating altogether on the right side of the conflux of the internal jugular and subclavian veins, in which case a short lymphatic trunk is found on the left side similar to that which usually exists on the right, constituting a partial lateral inversion or transposition confined to the trunks of the lymphatic system. The right lymphatic trunk nearly equals the thoracic duct in diameter; it is, however, not more than half an inch in length. Its situation is in the neck at the level of the lower edge of the seventh cervical vertebra, lying close to the inner edge of the 'scalenus anticus,' and opposite to the union of the subclavian and internal jugular veins, at which point it terminates in the venous system. It receives the lymphatics of the right upper extremity and of the right side of the head and neck, those from the right lung and right side of the heart, some few from the right lobe of the liver, and from the exterior and interior of the right upper half of the body. Sometimes the trunk of the cervical lymphatics, fig. 400, *c*, enters separately the jugular vein, *j*.

400



The thoracic duct and right lymphatic trunk; Human CLXX″.

§ 345. *Mammalian modifications.*—The lacteals in *Dasyurus viverrinus* converge to two subelongate, dark-coloured mesenteric glands; one of them situated near the pylorus, at the end of the pancreas. The cysterna chyli is plexiform in the Marsupials which I have examined; in the Kangaroo it lies upon the crura of the diaphragm, and extends upon the right side above the diaphragm into the thorax. Two thoracic ducts are continued from the cysterna, one along the left, the other along the right side of the bodies of the dorsal vertebræ. The right duct crosses the seventh vertebra and joins the left, which again divides and reunites, forming a slight plexus, before finally terminating at the confluence of the left subclavian and jugular veins. The double thoracic duct has been observed, with a similar arrangement, in the Dog and Sea-otter. In most *Carnivora* the mesenteric glands are aggregated in one mass, known to the old anatomists as the 'pancreas Asellii:' in the Weasel it is in two masses, and in the Cat, Ichneumon, and Seal has been found more subdivided. In these, however, there is one principal gland or 'vasoganglion,' the efferent vessels of which quickly unite into a trunk grooving its dorsal surface in the Seal, from which two main canals proceed to the thorax. In *Ungulata* and *Quadrumana* the mesenteric glands are numerous. I have noticed a large one in the mesocolon of the Echidna, near the rectum. The chyle-receptacle is large and cavernous, sometimes bilocular, in the Horse: the thoracic duct has shown varieties like those above described in Man, but it always terminates in the precaval vein at the union therewith of the two jugulars. In the Ox the lymphatic trunk perforates the diaphragm by an aperture distinct from that of the aorta: it usually bifurcates, sometimes becomes plexiform, in the thorax: the two divisions diverging to the right and left innominate veins formed by the junction of the jugulars and axillaries. In the Hog the thoracic duct has been observed to terminate in the azygos vein. The orifice of communication with the venous system is usually defended by a pair of semilunar valves; but varieties have been noted, and, after death, blood has been observed in the thoracic duct of the Horse.

Independent movements of contraction and dilatation have been witnessed in the chyle-receptacle and lacteals of the Ox;[1] but no rhythmically pulsating sacs have been detected in the absorbent system of Mammalia, nor have other points of communication with the venous system been uncontrovertibly determined, save those above described.

[1] CLXXV'.

CHAPTER XXXII.

CIRCULATING SYSTEM OF MAMMALIA.

§ 346. *Blood of Mammals.* The blood in this class is hot and red, with a proportion of organic matters to the water as great as in Birds, and more abounding in blood-discs, which, as a rule, are of a circular form, and of smaller size than in *Ovipara*, consisting of viscous hematosine without a cell-wall (vol. i. fig. 8, *a*, *b*). Besides the ordinary red discs there occur pale or granulated vesicles, the appearances of which, in the blood of a *Perameles* examined by me in 1838, 'suggested the idea that such blood-disc was undergoing a spontaneous subdivision into smaller vesicles.'[1]

The existence of a capsule, or rather a difference between the peripheral and central parts, in ordinary mammalian blood-discs, seems to be demonstrated by submitting them to a solution of magenta, when the contents become a faint rose colour, with a more deeply tinted outline, at least in part of their circumference: occasionally a definite part, like a nucleus, is recognisable.

In the highest class of Vertebrates the several tissues of the body are best defined and, so to speak, most highly finished: the condition of organic matter by and through which the acts of addition and subtraction are performed in relation to the growth, maintenance, and renovation of such tissues is the formified proteine substance, or organite. It would seem that mere fluid would not serve the purpose: the more solid particles, called blood-discs, added to the 'liquor sanguinis,' move in single file along the terminal capillaries of the circulating system and here come into the requisite contact with the tissues for the interchanges in question. One visible result of the giving and taking through attracting and repelling forces, usually defined as 'vital,'[1] is the change of colour which here takes place, viz., from florid to modena, in the general system, and the reverse in the respiratory one. Agreeably with this view of the function of the blood-discs we find them, in relation to the grade of histological development in the class, to be the most numerous and most minute relatively to the bulk of the body, in the present: in other words, the collective circulating surface effecting organic interchange is greatest in the blood of Mammals.

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[1] CLXXIX", p. 474. This idea has received confirmation in various degrees; e.g., by Quekett ('Med. Gazette,' January, 1840), by Martin Barry ('Philos. Trans.' 1840, p. 595), by Wharton Jones (ib. 1846); and more recently by Dr. Roberts, of Manchester, in his instructive researches, aided by the effects of a solution of magenta on the blood. 'The pale corpuscles were more strongly tinted than the red; and their nuclei were displayed with great clearness, dyed of a magnificent carbuncle-red. A number of the nuclei were seen in the process of division, more or less advanced, and in some cells' (my 'granulate vesicles') 'the partition had issued in the production of two, three, or four distinct secondary nuclei. There was evidence that these secondary nuclei were set free in the blood, and, by subsequent enlargement and change of form and chemical constitution, developed into red blood-discs.'—Proceedings of the Lit. and Phil. Society of Manchester, 1866.

The blood-discs are squeezed in the narrowest tract of the capillaries, and by their elasticity resume their shape in the wider part: they are not constantly separated by plasma from the capillary wall, and the thickness of that wall is very inferior to that of the membrane which experiments have shown to allow of endosmotic transit of matters. The mammalian blood-corpuscle, as a general rule, is a circular disc; and, instead of being swollen in the centre by a nuclear part, is there thinner; the disc is consequently slightly biconcave: it consists of the albuminoid coloured matter, insoluble in serum, called hematosine, the particles of which have aggregated, according to their formifying forces, into the discoid shape. The colour of the individual blood-disc is yellow; lighter in the middle where it is thinnest, deepening to a red tint only when light is reflected from a thickness resulting from an aggregate of many discs: the quantity of the disc-substance similarly affects transmitted light.

The average diameter of the human blood-disc is $\frac{1}{3500}$th of an inch (vol. i, fig. 8, *a*). I early availed myself of the menagerie of the London Zoological Society to test the characters of size in the Mammalian class, and communicated the two extremes, observed, e. g., in the Elephant and Pygmy Musk (ib. *b*), with some other instances from different orders, including Marsupials and Monotremes, so far as to determine the class-characteristic afforded by the size of the blood-discs.[1] In every individual a certain range of size was presented, and the two extremes and the average were recorded: thus, in the Indian Elephant, the largest blood-discs were twice the size of the human, and the smallest was not less than $\frac{1}{3500}$th, the average being $\frac{1}{2500}$th of an inch.[2] In the Chevrotain (*Tragulus Kanchil*) the average diameter of the blood-disc was $\frac{1}{12800}$th inch. In the Giraffe the average size of the blood-discs was $\frac{1}{4500}$th inch, or nearly one-third smaller than those of Man; the two extremes were $\frac{1}{4000}$th (few in number), $\frac{1}{4800}$th of an inch (more in number). 'The result of the examination of the blood of the largest of the ruminating tribe indicates that the size of the blood-discs relates to the condition of the whole organisation rather than to the bulk of the species. It would appear from the examination of the blood-discs in the goat, sheep, and ox, that an unusually small size of the blood-discs was associated with the peculiarities of the ruminant structure.'[3] This generalisation has not been affected by later observations. MANDL[4] had discovered in the Dromedary that the blood-discs were elliptic. I confirmed the fact, giving the long diameter of the average-sized discs as $\frac{1}{3800}$th inch, the short diameter $\frac{1}{6500}$th inch; but I remarked that among the elliptical discs were a few of a circular form. Extending the observation to the smaller South American species of the aberrant ruminant family, I found the elliptical form to prevail in the blood-discs of both Llama and Vicugna.[5] In the latter the average dimensions were, in long diameter $\frac{1}{3443}$, short diameter $\frac{1}{3619}$. Mr. Wharton Jones subsequently observed blood-discs of a circular form with the more numerous elliptic ones in the Llama.[6] These exceptional instances to the Mammalian form of blood-disc are not associated with any other approximation to the oviparous type: the oval kind are equally non-nucleate with the ordinary circular blood-discs, and adhere to the ruminant characteristic of minuteness of size. Within the limits of that natural group, it will be observed that there is a ratio between the size of the blood-disc and that of the animal. But such ratio is quite inapplicable to the Mammalian class generally. If the *Camelidæ* repeat a reptilian shape of blood-disc, the Sloths have the largest blood-discs in proportion to the body: but neither one nor the other character occurs in the Monotremes and Marsupials which combine the greatest proportion of oviparous characteristics in their Mammalian organisation. In the Echidna and Ornithorhynchus the blood-discs are circular and average $\frac{1}{3600}$th inch in diam.: being larger in proportion than in Man, though less than in the Sloths. The numerous and insignificant gradations of size of Mammalian blood-discs between the two extremes noted in CLXXIX″ have been recorded, decimally, in CCXXXIX, vol. i. p. 84.

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[1] 'Tous les faits les mieux constatés me semblent montrer que les globules du sang ne sont pas de simples concrétions inertes de matière animale résultant d'une sorte de précipitation ou de coagulation sphéroïdale; que ce sont au contraire des parties vivantes;' ccxxxix. p. 80. Nevertheless if, as Acherson thought he observed, (clxxxiii″) the white or granular globules should be a result of reaction of oil-like particles on proteine-matters in plasma, their manifestation of forces, though called 'vital,' would not be valid against an observed mode of 'spontaneous generation' or 'formifaction' of such globules.

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[1] CLXXIX''.

[2] Ib. p. 284.

[3] Ib. p. 284.

[4] CLXXXII'', p. 1060.

[5] Ib. p. 475.

[6] CLXXXI''. p. 73.

§ 347. *Heart of Mammalia.*—In Mammals, as in other Hæmatothermals, the venous and arterial parts of the vascular system have no communication, beyond the heart, save at the peripheral capillaries.

The right auricle is less definitely divided into 'sinus' and 'auricle' proper than in Birds, and the intervening valves, always less efficient against reflux from the auricle into the sinus, gradually disappear. The right auriculo-ventricular valve resembles in structure the left, as being membranous and attached by tendinous threads to muscle. Other differences between the circulating systems of the two hot-blooded classes are shown by blood-vessels.

The heart, with its bag, or pericardium, is exclusively located in the thorax, and in many Mammals is more or less separated by a lobe of the lung, fig. 308, *n*, from the diaphragm, *q*.

A. *Heart of Lyencephala.*—In the Ornithorhynchus, fig. 308, *a. b, c,* it presents a rounded oblong, scarcely conical, form; it is situated in the middle of the fore part of the chest, parallel with the axis of the cavity, inclosed in a thin subtransparent but strong pericardium. The right auricle, *b*, is larger and longer than the left; its appendix is free and is slightly bifid. It receives the venous blood by three great veins; the left precaval, *f*, descending behind the left auricle, *c*, to join the termination of the postcaval, *h*; to the right of which the coronary vein also terminates in the auricle. The right precaval, *e*, is joined to the left by a transverse branch, *g*. There is a deep but closed fossa ovalis near the upper extremity of the septum of the auricles; indicating that the intra-uterine existence of the young was of longer duration than in the Marsupials. The right ventricle, *a*, is capacious, with thin parietes. The tricuspid valve consists of two membranous and two fleshy portions: the smallest of the latter is situated nearest the origin of the pulmonary artery, and corresponds with the lesser fleshy valve in the heart of certain Birds (vol. ii. p. 188, fig. 92, *m*): it is attached to the whole of the side of the first or adjoining membranous portion. The second fleshy portion answers to the larger muscular valve (ib. fig. 92, *l*). The two edges of the lower half of the second fleshy portion of the valve in the Ornithorhynchus are free; but those of the upper half are attached to the two membranous portions of the tricuspid valve; the margin of the membranous part of the valve is attached to the fixed wall of the ventricle by two small chordæ tendineæ; and the structure of the valve thus offers an interesting transitional state between that of the Mammal and that of the Bird. The origin of the pulmonary artery is provided with the three usual sigmoid valves. The left ventricle has very thick parietes, which form the apex of the heart; the mitral valve is membranous; the larger flap is attached to two strong columnæ carneæ; the smaller flap also receives tendons from some smaller columnæ. The left auricle, *c*, receives two pulmonary veins. In the Echidna the free appendix of the right auricle is slightly indented. The terminal orifice of the right precaval is protected by a membranous semilunar valve, extending from its left side. The musculi pectinati diverge from a strong fasciculus which extends from the appendix to the orifice of the inferior cava; this fasciculus bounds the left side of a wide fossa ovalis, which is imperforate. The postcaval is protected by a large membranous Eustachian valve; the left precaval terminates by a distinct aperture to the left of the preceding, and is also defended by a process of the Eustachian valve. The inner surface of the right ventricle is more irregular than in the Ornithorhynchus; the free wall is attached to the fixed one by several columnæ carneæ and short chordæ tendineæ: the tricuspid valve is membranous, and consists of one principal portion attached to the exterior circumference, and a smaller portion closing the outer angle; the free margin of the valve is attached to the extremity of a large fleshy column, arising by different roots from both the fixed and the free walls of the ventricle; a short fleshy column is attached to the left extremity of the valve; some chordæ tendineæ are fixed to its right angle.

The heart of Marsupials offers no peculiarity in its general outward form. The apex is less obtuse in some species, as the Phalanger and Wombat, than in others, as the Kangaroo. The serous layer of the pericardium is reflected upon the large vessels near to the heart. The fibrous layer of the pericardium adheres to the sternum. The appendix of the right auricle is always divided into two angular processes, *a*, *a*, figs. 401 and 402, one in front and the other behind the trunk of the aorta, *o*. The right auricle presents the following marsupial conditions:—There is no trace of a 'fossa ovalis' or an 'annulus ovalis,'[1] and the absence of these structures, which are present in the heart of all the placental Mammalia, relates to the very brief period during which the auricles intercommunicate in the Marsupials, and to the minute size, and in other respects incompletely developed state, at which the young marsupial animal respires air by the lungs, and has the mature condition of the pulmonary circulation established. The right and left auricles intercommunicate by an oblique fissure in the uterine embryo of the Kangaroo when two-thirds of the period of gestation is past, but every trace of this fœtal structure is obliterated in the subsequent growth of the heart; so that in the mature animal the wide terminal orifice of the postcaval, ib. *d*, is separated from that of the right precaval, ib. *b*, by a simple crescentic ridge, ib. *e*, which forms a salient angle of the parietes of the auricle between these apertures. The orifice of the left precaval, ib. *c*, is close to that of the postcaval, in a position analogous to that of the coronary vein in Man, which here opens into the left precaval. The right auriculo-ventricular valve is membranous, and its free margin is attached by fine 'chordæ tendineæ' to three mammillary 'columnæ carneæ;' these

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[1] xx. vol. ii. p. 52.

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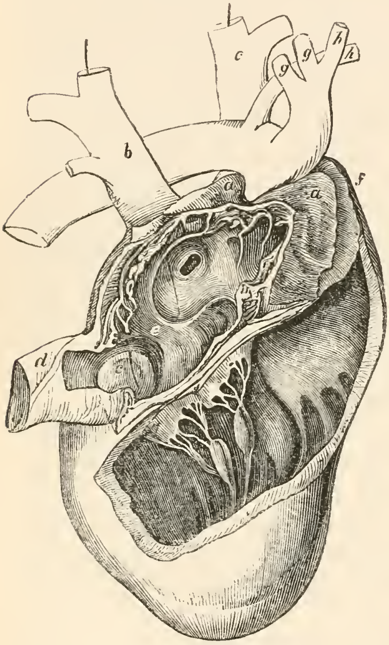
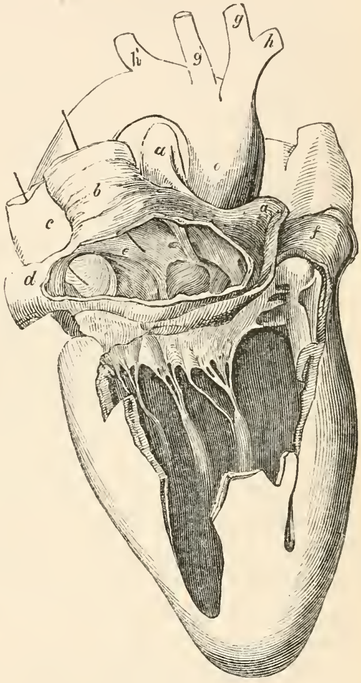


Heart of the Kangaroo.

402



Heart of the Wombat.

in the Kangaroo, fig. 401, arise from the septum of the ventricles, but in the Wombat, fig. 402, the base of two of the 'columnæ' is situated at the angle between the septum and the thin outer wall of the ventricle. The right ventricle extends nearly to the apex of the heart in the Wombat, but falls short of that part in the Kangaroo. The ventricle is continued in a conical form, somewhat resembling a 'bulbus arteriosus,' to the origin of the pulmonary artery, *f*, figs. 401 and 402, and projects beyond the general surface of the heart further than in ordinary Mammalia. The appendix of the left auricle is notched in the Kangaroo to receive the apex of this process, but not in the Wombat. Two pulmonary veins, *i*, fig. 403, terminate close together, or by a single trunk, at the upper and dextral angle of this auricle. The mitral valve is regulated by two short and thick mammillary columnæ, ib. *k*, *k*, which send their tendinous chords to the margin and ventricular surface of the valve.

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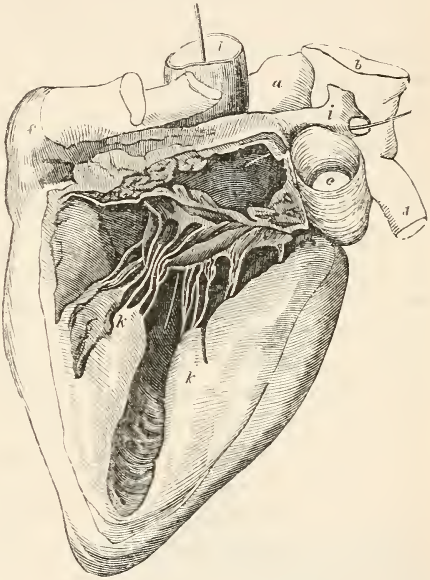

Heart of the Wombat.

The ventricles and auricles present the usual Mammalian proportions and relative thickness of the parietes. Three sigmoid valves are situated at the origin of the pulmonary artery, and the same number at that of the aorta.

B. *Heart of Lissencephala.*—In most species of this subclass[1] the right auricle shows the modifications resulting from the return of the blood thereto, as in *Lyencephala*, by two distinct precavals, of which the left opens alongside the postcaval into the lower (sacral) part of the auricle, as in figs. 401, 402. In the Porcupine a large 'Eustachian' fold is on the auricular side of the postcaval aperture, and a slight ridge indicates the remains of the upper fold, forming the boundary of the 'sinus venosus.' In the great Anteater I observed that the resemblance to the auricular valve in Reptiles was rather closer:—the entry of the postcaval was guarded as usual by the Eustachian valve, or homologue of the lower of the two semilunar valves between the sinus and the auricle in the Crocodile (vol. i. fig. 339): and here there was also a narrower valvular fold or ridge on the opposite side of the postcaval orifice, answering to the second valve (ib.): a ridge is continued from both valves toward the opening of the precaval. In the Elephant, also, which shows its rodent affinity in the two precavals, there is, besides the 'Eustachian' between the orifices of the postcaval and left precaval, a remnant of the upper valve extending from the posterior side of the orifice of the right precaval.

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[1] *Capromys* is an exception, among the Rodents: at least in the specimen I dissected, the blood from the head and fore-limbs entered the auricle by a single precaval vein. cxxx″. p. 72.

The inner surface of the right ventricle is smooth and even, little broken by trabeculæ, in Rodents and other *Lissencephala.* Two or three slender 'mammillary columns' send tendinous chords to the tricuspid valve in the Porcupine and Hare. The apex of the heart is sub-bifid in the Hare and Acouchi: it is simple and obtuse, with the ventricles broader and rather flattened from before backward, in the Beaver: it is relatively longer and less obtuse in the Water-vole: in neither of the aquatic Rodents are the foramen ovale or ductus arteriosus kept patent. In most Rodents the right ventricle reaches to the apex: in *Helamys* it even descends lower than the left ventricle. The heart is short and obtuse in the Sloths: the auricles almost cover the basal part of the ventricles: the pericardium adheres to the diaphragm by loose cellular tissue, and the thoracic part of the postcaval is short. The pericardium is not so attached in the Armadillos, and the heart is more oblong in shape, with the apex more sinistrad: the lower third forming the apex is due wholly to the left ventricle, from the basal part of which the right ventricle projects, like an appendage, in *Dasypus Peba.* *Orycteropus* has the Eustachian, but not the Thebesian, valve: the muscular walls of the left ventricle are four times thicker than those of the right; but are almost smooth internally. With an unusual thoracic convexity of the diaphragm, in the Mole, is associated a less symmetrical position of the heart than in other Lissencephalans.[1] The tenuity of the pericardium is a characteristic of many *Insectivora*: notably of the Hedgehog.

C. *Heart of Cetacea.*—In these marine and fish-like Mammals the heart, like the brain, shows higher characters than in the preceding subclasses. The pericardium extends down upon the abdominal muscles to reach the diaphragm, which has a like low position anteriorly, to which it adheres broadly: and the precavals unite and terminate in the auricle by one orifice: the thoracic part of the postcaval is very short. The musculi pectinati are well developed in the right auricle, and the appendix is distinct, but undivided. The fossa ovalis is feebly marked in the Cachalot, is deeper in some Delphinidæ, but in all *Cetacea* it is closed: there are neither Eustachian nor coronary valves. In the Cachalots and Whales the ventricular mass is subdepressed and semicircular, the apex being rounded or rather flattened, and sometimes indented: for the right ventricle is coextensive with and sometimes terminates, as in the Mammalian embryo, distinctly from the left. In *Phocæna* and most *Delphinidæ*, the apex of the ventricle is simple and better marked. The movable wall of the right ventricle has about half the thickness of that of the left, showing the exercise of greater force in propelling the blood through the lung, than in land Mammals. The tendons of the tricuspid valve go to three short and thick columns in most *Cetacea*; but the rest of the inner surface is broken by strong trabecular bands. Hunter notes the soft yielding substance of the semilunar valves in the *Hyperoödon* he dissected, suggesting that they were naturally less strong than in land Mammals.[1] The left auricle is less than the right, with many well-defined muscular columns on the inner surface, and a distinct appendix; but is less fleshy than the right auricle. In the left ventricle both trabecular and mammillary forms of muscular processes of the inner surface are numerous.

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[1] cxxii'. tom. iv. p. 486.

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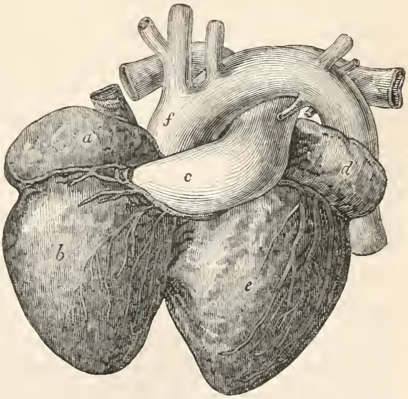

Heart of the Dugong.

The most striking feature in the anatomy of Whales is the vast size of their several organs: the heart may be more than a yard in transverse diameter, and not much less in length.

D. *Heart of Sirenia.*—The outward division of the ventricles indicated in some *Cetacea* is carried to an extent very characteristic of the present group: but in *Rhytina* and *Manatus* the cleft is not quite so deep as in the heart of *Halicore*, fig. 404.

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[1] CCXXVI. ii. p. 111.

In half-grown specimens of Dugong[1] I found the foramen ovale completely closed, and the ductus arteriosus reduced to a thick ligamentous chord, permeable only for a short distance by an eye-probe from the aorta, where a crescentic slit still represented the original communication. In the smoothness and evenness of their exterior, and their general form, the auricles of the Dugong, ib. *a*, *d*, resemble those of the Turtle (*Chelone*, vol. i. fig. 335): the appendix can hardly be said to exist in either. The right auricle, *a*, is but little larger than the left, *e*: the musculi pectinati are well developed, especially in the left: they are irregularly branched, and with many of the small round fasciculi attached only by their two extremities to the auricular parietes. There is but one precaval and one postcaval orifice in the right auricle, with a smaller coronary inlet. The pulmonary veins terminate in the left auricle by a common trunk one inch in length. The free wall of the right ventricle scarcely exceeds at any part a line in thickness, and is in many places even less. The tricuspid valve is attached to three fleshy columns by chordæ tendineæ given off from the sides and not the extremities of those columns, both of which extremities are implanted, as trabeculæ, in the walls of the ventricles. There are several other columnæ carneæ passing freely from one part of the ventricle to another, like the musculi pectinati of the auricles, and which have no connection with the tricuspid valve. The mitral valve is adjusted to its office by attachments to two short and transversely extended mammillary columnæ. The thickness of the parietes of the left ventricle varies from half an inch to an inch. The valves at the origins of the great arteries, *c*, *f*, present the usual structure.

E. *Heart of Ungulata.*—In all hoofed beasts the ventricles are conical; the apex being longer and sharper in Ruminants than in most other Mammals. The auricles are relatively smaller to the ventricles than in the preceding groups. The three parts of the tricuspid valves are distinct from their confluent bases, and are pointed at the apex: the basal union of the two parts of the mitral valve is of a greater extent, forming there an annular valve about the left auriculo-ventricular opening. The smooth inner surface of the ventricles is but little interrupted by fleshy columns. The Horse resembles the Ruminant in the general shape and structure of the heart: but in the Tapir[2] it is shorter and broader, as it is in the Rhinoceros[3] and Elephant. The right auricle in the *Rhinoceros*, as in most Ungulates, has but one precaval orifice, and shows no valve at the termination of either the postcaval or coronary veins: the contrast presented by the Elephant, in this respect, is significant. The strong chordæ tendineæ of the tricuspid connect it, in most Ungulates, with three obtuse and transversely oblong carneæ columnæ: one rising from the movable wall, a second from the septum, and a third smaller one from the anterior interspace between the fixed and movable walls: the tendons diverge from each column to the two contiguous moieties of the divisions of the tricuspid—a provision ensuring the simultaneous action and outstretching of the three portions of the valve. Two smaller columns placed opposite to each other, one on the free, the other on the fixed wall, are connected in the Rhinoceros and many other Ungulates, by a single strong tendon passing across the cavity from the apex of one to the other.[1] In the Hog some of the tricuspid tendons pass to a thick short 'column' projecting from the free wall, others pass directly into the smooth convex fixed wall of the ventricle.

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[1] CXVII″. p. 35. [2] CLII″. [3] V″. p. 46.

In most Ruminants, especially the larger kinds, there is a bent bone at the base of the heart, on the septal side of the origin of the aorta, and imbedded in the tendinous circle which gives attachment to muscular fibres of the ventricle; in the Giraffe this bone was two-thirds of an inch in length. Two such ossifications of the sclerous tissue have here been met with in Oxen and Red-deer: an ossified and an unossified piece of fibro-cartilage are more commonly observed: in the Horse these bodies at the septal side of the aortic ring are rarely ossified until extreme age.

F. *Heart of Carnivora.*—In the present group the heart is more obtuse at the apex, and the left ventricle forms a greater share thereof, than in Ungulates. The Eustachian valve is wanting in most *Carnivora*; where indicated, its remains have been found in the smaller kinds, as the Weasel, Polecat, Ichneumon, which by their size resemble the immature of the larger species. The inner surface of the ventricles, especially the right, is more fasciculated, and the number of carneæ columnæ is greater than in Ruminants. A condensation of the sclerous tissue of the aortic ring in the Lion and Tiger, at two points, indicates the homologues of the heart-bones in Ungulates. In these and other Felines the mammillary columns are continued from the septal end of a strong trabecular tract between the 'fixed' and 'free' walls of the right ventricle. The heart in *Phocidæ* is broad and somewhat flattened, with an obtuse apex: the appendix of the right auricle is bifid, one process covering the origin of the pulmonary artery, the other lying upon the right ventricle. The auricular septum seems to be formed by an extension of the left part of the wall of the anterior cava, terminating in an arch to the right of the postcaval orifice, which thus seems to open (as it did in the embryo) into the left auricle. In the younger of two Seals, (*Phoca vitulina*), which I dissected,[1] the valve that cuts off this original communication between the auricles was incomplete, and left a large 'foramen ovale:' in the older Seal, not full grown, the 'valvula foraminis ovalis' was complete as to its extent, and the margins were adherent, save at the upper part where an oblique aperture, admitting a goose-quill, remained. In a young Walrus,[2] the entire margin of the valve was adherent, and there was no intercommunication between the right and left sides of the heart. A broad crescentic fold, looking downward, divides the sinus, or fossa, receiving the precaval vein from the larger and deeper one receiving the postcaval one: this fold answers to the upper border of the 'fossa ovalis' in the human heart; there is no orifice in the 'fossa' communicating with the left auricle. There is a small semilunar valve at the coronary orifice, but no Eustachian valve. The appendix of the auricle, in *Trichechus*, extends in front of the base of the aorta as far as the pulmonary artery, gradually contracting to an obtuse point: in *Cystophora proboscidea* the auricular appendix is short, broad, and bifid; in both it is occupied by a reticular arrangement of carneæ columnæ. The ventricles are broader in proportion to their length, and the apex is not produced in *Trichechus*, as in *Cystophora proboscidea*: the tendinous cords of the anterior division of the tricuspid valve, and a few of those of the right or external division, are attached to a short and thick fleshy column from the free wall of the ventricle; this column is connected by a short and thick 'trabecula' with the septum: most of the other tendinous cords are attached to the septum, and a few to trabeculæ connecting that fixed wall with the free wall of the ventricle. The pulmonary artery presents no peculiarity; it is connected by the ligamentous remnant of the 'ductus arteriosus,' which is 10 lines long and 5 lines in diameter, to the under part of the aortic arch, just beyond the origin of the left subclavian; its cavity is obliterated, but a short, thick, semilunar fold of the lining membrane of the aorta, with its concavity turned toward the end of the arch, indicates the place of the former fœtal communicating channel.

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[1] I have not found, in Ruminants, so exclusive an origin of the mammillary columns from the 'free' or external wall, as described in CCXXXIX. t. III. p. 502, after CLXXXV″.

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[1] CLVI″. p. 152.

[2] CXCI″. p. 104.

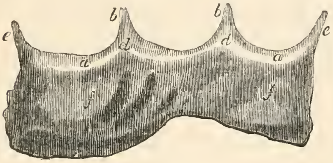
G. *Heart of Quadrumana.*—In the Aye-aye, as in other *Lemuridæ,* the heart is rounded, subdepressed, with a very obtuse apex; much resembling that of the four-months fœtus in Man: the right auricle is much larger than the left: it receives the blood by a single precaval, by the postcaval and coronary veins. There are both Eustachian and Thebesian valves, and a well-marked fossa and annulus ovalis. These also characterise the right auricle in higher *Quadrumana.* The carneæ columnæ and chordæ tendineæ are more numerous in the right ventricle of Monkeys and Baboons, relatively, than in Man: the divisions of the tricuspid terminate in a broad and rounded margin; that next the orifice of the pulmonary artery being, as usual, the largest. In the left ventricle the columnæ carneæ are numerous and small, giving a strongly reticulate character to the inner surface.

The pericardium, which has a limited adhesion to the diaphragm, opposite the apex of the heart, in Lemurs, progressively becomes less perpendicular in the thorax as the *Quadrumana* rise in the scale, with concomitant shortness of the thoracic post-cava, and increasing extent of adhesion of the pericardium to the diaphragm: but in none is the heart so broad at the base, so flattened, or so extensively supported by the diaphragm, as in Man.

H. *Heart of Bimana.*—In the prone trunk of quadrupeds the pericardium adheres to the sternum, rarely to the diaphragm; in erect bipeds the connections are reversed: no Mammal has so large a proportion of the heart resting upon the diaphragm as Man, where the central aponeurosis is concomitantly expanded for the attachment of the intervening part of the pericardium. Here the heart lies obliquely, not, as in most Mammals, parallel with the mesial plane: the apex, less acute than in Ruminants, and less obtuse than in aquatic Mammals, is directed downward, forward, and to the left, notching the anterior margin of the left lung, and beating across the interval between the cartilages of the fifth and sixth left ribs. The appendix of the right auricle has one undivided apex, extending over the origin of the aorta to that of the pulmonary artery. The single precaval terminates at the upper part of the auricle on a plane anterior to that of the postcaval, which is at the lower part: from the anterior margin of this orifice is continued the valvular fold called 'Eustachian,' which is often reduced in substance to a filmy network, or may be wanting: between the postcaval orifice and that leading to the ventricle is the opening of the coronary vein, with its valve: above the Eustachian valve is the depression, 'fossa ovalis,' indicative of the closed oval intercommunicating vacuity in the septum of the fœtal auricles; bounded above by the prominent crescentic border, or 'annulus ovalis.' The opening into the ventricle is bordered by a sclerous oval ring, to which muscular fibres of both auricle and ventricle are attached; the ring being thicker for the latter.

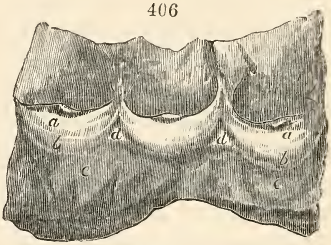
In the Human right ventricle the portion of the tricuspid valve nearest the orifice of the pulmonary artery is the largest, and is divided by deeper notches from the two smaller portions than these are from each other: the chordæ tendineæ from each columna carnea are inserted, generally into the contiguous borders of two portions of the valve: the muscular prominences of the inner surface of the ventricle have either their inner or central surfaces free, or are free in the circumference of their middle part but attached at both ends, like beams (trabeculæ), or they project freely in a conical form, as 'columnæ mammillares:' they are least developed in the conical prolongation of the cavity, (infundibulum, conus arteriosus), from the apex of which the pulmonary artery arises. The arterial orifice of the ventricle is formed by sclerous tissue, which a dissector may define as a ring, fig. 405, disposed in three crescentic curves, with the convexities, *a, a,* toward the ventricle, and the blended horns, *d, b,* projecting toward the artery: the ring is represented as cut through at one of these points of confluence, *e, e,* in order to its being spread out. Muscular fibres of the right ventricle, *f, f,* are attached to the convexities of the ring; the fibrous coat of the artery is attached to the outer margin, the sigmoid valves, fig. 406, *a, a,* to the inner margin, of the upper or arterial surface of the concavities which owe their definition to the junction of the endocardium to such valvular attachments. The right ventricle continues to show, in Man as in other Mammals, the same relation, as an appendage to the left, which is illustrated in the section of the Bird's heart, vol. ii., fig. 92, forming, as so seen, a concave parabolic section of a cone, applied to the more perfect cone of the left

405



Annulus arteriosus, with attached fibres of right ventricle. CLXXXVII''.

406

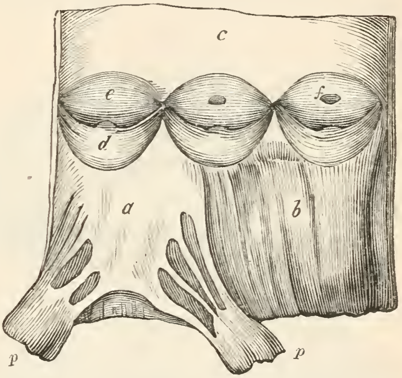


Sigmoid valves, right ventricle. CLXXXVII''.

ventricle: but the walls are relatively thicker to those of the left ventricle than in Birds.

The left auricle, figs. 408 and 409, LA, lies to the left and back part of the base of the heart, is transversely oblong and subquadrate behind; its auricular appendage comes forward into view curving to the right, upon the base of the pulmonary artery. The walls of the 'sinus venosus' are thicker than those in the right auricle: the terminal orifices of the pulmonary veins, usually one on each side, sometimes two on the right and one on the left, are undefended by valves: on the septum, the fœtal foramen is feebly indicated by a crescentic depression. The opening into the left ventricle is smaller than the right auriculo-ventricular one: it is defended by the pair of triangular folds of endocardium, called the 'bicuspid' or 'mitral' valve. Of these the largest, fig. 407, *a*, hangs between the auricular and aortic orifices, and is in part reflected from the sclerous ring of the latter: a small fold commonly also projects at each angle of junction of the larger folds. The chief conical 'columnæ' are two in number, and larger than those of the right ventricle; their apices are shown at fig. 407, *p*, *p*, each contributing tendinous cords to the portion of the mitral valve, *a*. The distribution of the chordæ tendineæ, from each column to contiguous borders of the two parts of the mitral, obviously illustrates the adaptation to bring those margins together in the contraction of the ventricle. The semilunar valves at the aortic orifice, ib. *d*, are thicker than those of the pulmonary artery, the 'Valsalval sinuses,' *e*, are deeper, and the 'corpora arantii' larger: the muscular walls of the left ventricle are about three times thicker than those of the right: some of the inner longitudinal fibres, ib. *b*, are attached to that part of the aortic ring, not preoccupied by the larger mitral fold, *a*. The left ventricle is longer and narrower than the right and alone forms the apex: the two large mammillary columns occupy the lower three-fourths of the cavity, rising in its axis: the fibres radiate from their base and wind round the axis, being progressively

407



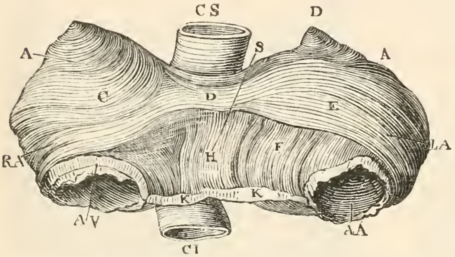
Semilunar valves and portion of mitral valve, left ventricle. CLXXXVII″.

sent off, so that few reach the apex of the column: but the moulding of the ventricle about these is not the cause of the conical figure of the heart, since this obtains where no such mammillary columns are present. (Vol. i. figs. 334–340.)

The heart is lined by a membrane, 'endocardium,' rather thicker and more opaque in the left than in the right cavities, especially in the auricle: thinnest on the muscular projections, both pectinate and columnate. The chief layer consists of a close network of elastic fibres, lined by a stratum of polygonal epithelial scales, constituting the free surface; and attached by an areolar tissue to the muscular coat. This is covered by the reflected serous layer of the heart-bag, called 'ectocardium.'

The disposition of the intervening muscular fibres has been best illustrated in relation to the human heart. Those of the auricles form a superficial layer, fig. 408, common to both cavities, and also a deep layer, fig. 409, proper to each.

408

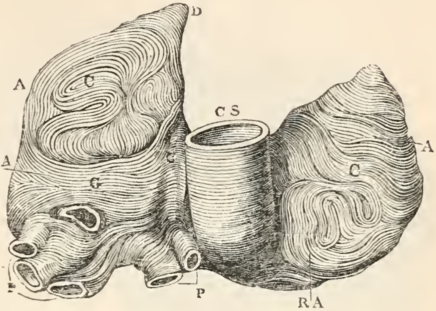


Muscular coat of auricles. CLXXXVIII″.

The superficial layer includes the transverse band of fibres, fig. 408, D, expanding as it passes to the right, RA, and left, LA, auricles. The deeper fibres appear at the parts not covered by the superficial ones. Some, H, arising from the 'annulus aorticus,' K, K, arch over the auricle, beneath D, contributing some fibres to the septum, at S: other arched or 'looped' fibres, F, curve over the auricles and are attached by both extremities to the auriculo-ventricular rings AV and AA: a third series, C, surround the auricular appendages, AA, and encircle the terminations of the superior, CS, and inferior, CI, venæ cavæ.

The winding or convolute disposition of these so-called 'annular fibres' is exemplified in fig. 409. The superficial and deep-seated fibres are, however, continuous, at parts of their course: those marked E, fig. 408, of the former series, wind round the left auricle LA, and are continuous, with some intervening attachment to the aortic root K, with the ascending band F: a posterior band is shown at G, fig. 409, passing over the left auricle LA, and along the posterior border of the appendix A: some of the fibres, on reaching the anterior border, quit the band G, to join the fibres *d* forming the apex: other detachments from the band *g*, encompass the terminations of the pulmonary veins, P, *p*. Like the muscular fibres of the tongue, those of the heart are not visibly connected together by areolar tissue; such connective medium, in the degree in which it may exist, can only be inferred through the help to unravelling gained by boiling the heart. The more obvious mode of connection is, as in the tongue, by reciprocal decussation or interlocking. In the ventricles the longer external fibres, e. g., wind upward round the apex and bend downward from the auricular and arterial rings at the base, to become internal, and so inclose, and, at the same time contribute to form, the shorter, interposed loops; these, likewise, having similar relations to the layers of fibres which they successively inclose. Evidence of a stratified disposition is, however, progressively narrowed, or shown by smaller tracts of conformable course of fibres, as these are removed in dissection from without inward.

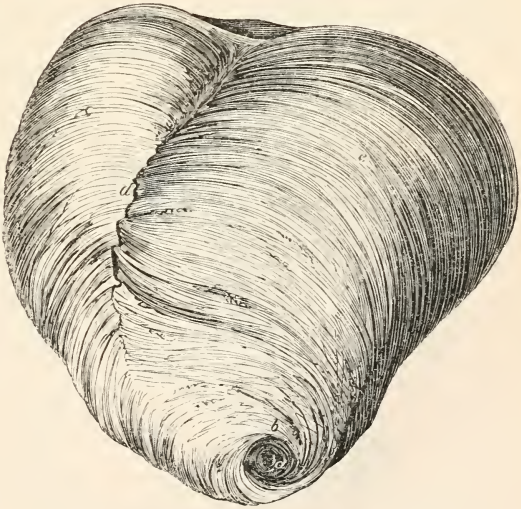
409



Superficial auricular fibres. CLXXXVIII″.

In the superficial ventricular layer they have a subspiral course, descending, in the fore part of the ventricles, fig. 410, to the left, and on the back part to the right, being partially interrupted at the interventricular grooves, of which the anterior is shown at *d*. Those which cross the groove bridge over the coronary vessels; those which penetrate it curve upward and contribute to the right layer of the septum, and so help to encompass the right ventricle. The super-

410

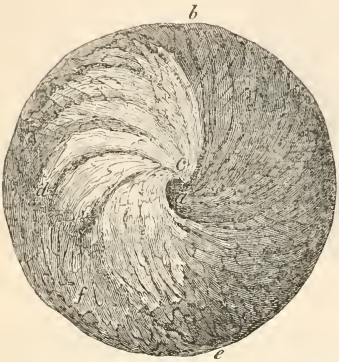


Superficial ventricular fibres; front view. CLXXXVII″.

ficial layer gains in thickness as it approaches the apex, *a*, where the course of the fibres to the inner surface of the ventricles is well expressed by the term 'whorl' or 'vortex,' fig. 411.

Those from the fore-part of the heart, *d*, *e*, *f*, enter the apex posteriorly: those from the back part of the heart, *b*, enter it anteriorly, at *a*. The curved margin of the entering anterior fibres, *c*, is left entire in successive sections of the apex of the left ventricle, until that of the right ventricle is reached, when a more complex arrangement appears. Most of the entering fasciculi form the innermost layer of almost longitudinal fibres of the ventricular cavities; others are continued into the trabecular and mammillary processes.

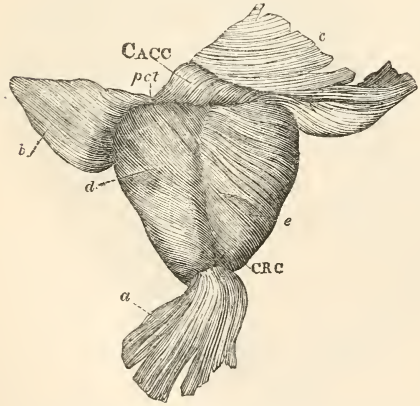
411



Apical or vortical fibres, Human heart. CLXXXVII''.

By reflecting the superficial layer to its attachments or points of inflection at the apex, *a*, and at the base, *b*, fig. 412, the second layer is exposed; which is partly formed by fibres ascending from the interior of the right ventricle, CACC, emerging at the posterior coronary tract, *pct*, and receiving accessions from the aortic and auricular rings. The fibres of this layer, *d*, take an opposite course from those of the first, *b*, *c*. A third layer repeats the general disposition of the superficial one; but a larger proportion of the fibres serve a single ventricle, especially at the apex, CRC. Many fibres of this layer are derived from, or are continued into, the middle layer of the septum, from which, as at fig. 413, *b*, the layer has been cut, and reflected, at *a* 2, CRC, exposing the distribution of the internal layers, about each ventricle exclusively, as at *rv* and *l*, fig. 413.

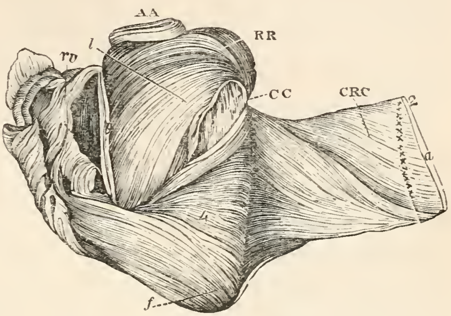
412



Mid-layers of heart fibres; back view. CLXXXVIII''.

The interruption of such deep layers is frequent, both by change of direction, as at 4; and by the decussation of fibres to form the great mammillary columns, as shown in the section of such at CC, fig. 413. The right layer of septal fibres, though continuous mainly with the parietal fibres of the right ventricle, curve with their concavity toward the left ventricle, and aid in its compression.[1]

413

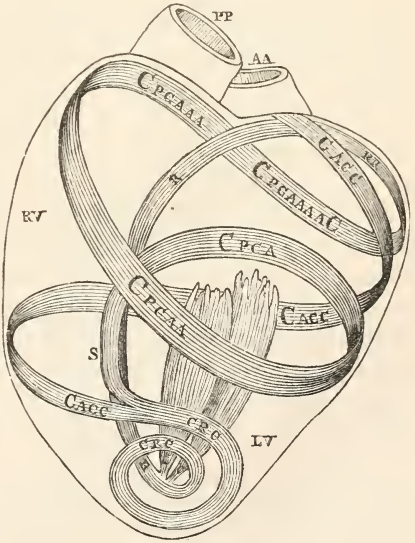


Inner layers of heart-fibres. CXLXXXVIII″.

A conception of the plan of arrangement of the muscular fibres of the ventricles may be helped by the diagram, fig. 414.

The course of the superficial fibres, round both ventricles, is indicated by the band, CPCAAA, from the arterial rings over the fore part of the ventricles, and by the band CACC, over the back part: both combine to form the whorl CRC and R, and gain the interior of the ventricles forming the septum, S, and the carneæ columnæ, CC: the deeper layers surrounding the left ventricle, LV, are indicated at RR, CPCAAAAC, and CPCA. Traced from within outward, the fibres from the funicular fasciculus or 'rope,' R, combine with others continued from the two great carneæ columnæ, CC, of the left ventricle, LV, to form the inner series, CRC, which, twining round the apex, close the ventricular cavity, and become superficial: then sweeping spirally from left to right divide into two bands: the longer one first encircles the left ven-

414



Ideal type of arrangement of ventricular fibres; Human heart. CXLXXVIII″.

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[1] The fibres of the heart have attachments to fixed points in parts of their course, rather than at definite beginnings or endings: and variations of description may be

tricle, as Cpca; then describes a second circle round both ventricles, Cpcaa. The band Cacc passing down from the aorta, aa, winds over the lower half of the right ventricle, rv, combines with the apical spirals, whence it can be traced obliquely round the left ventricle to terminate at the aortic circle near the anterior coronary tract. The septum ventriculorum consists of three strata, the left and middle belonging to the left ventricle, the right layer exclusively to the right.

The contraction of the heart-fibres is called ‘systole,’ their relaxation ‘diastole.’ The parts of the muscular walls of the heart have different degrees of motion: the inner wall or ‘septum’ loses length and breadth, but gains in thickness, during the systole: the outer wall changes these dimensions in a greater degree, with changing relative position to the heart's centre: hence it has been termed the ‘movable’ wall, and the septum the ‘fixed’ one. The mammillary processes become shorter and thicker cones, and in the degree in which the blood in the ventricles is compressed during ‘systole,’ the valves are held by the tendinous cords attached to their free borders and expanding upon their ventricular surface more firmly against eversion, with reflux of blood, into the auricles. The position of the semilunar valves, on the contrary, invites the flow of the blood into the arteries, and forbids return. The ‘trabeculæ’ passing from the ‘fixed’ to the ‘movable’ walls have an analogous function as adding to the resistance of the latter against internal pressure, whence they have been termed ‘moderator bands.’[1]

§ 348. *Arteries of Mammalia.*—The walls of the arterial tube are so strong as to maintain that form when cut across; and so elastic as, then, to retract some way within the areolar or connective tissue, which surrounds the vessel like a sheath. On the inner surface of the tube amyline formifies[2] as elliptical or irregularly polygonal scales, more or less of which show a further stage of condensation, expressed by the term ‘nucleate epithelial cell,’ fig. 424. The tissue so lined consists of a thin continuous

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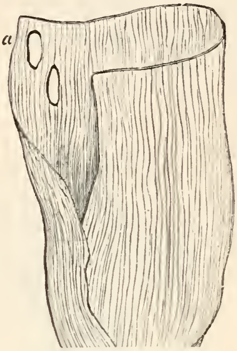
proffered indefinitely as the observers arbitrarily select such attachments under the names of ‘origins’ and ‘insertions.’ The general conformity of muscular arrangement in the heart of the sheep is shown in clxxxix″, with that previously demonstrated in the human heart, by the author of clxxxvii″ and clxxxviii″; especially in regard to the continuity of certain external with internal fibres.

[1] clxxxv″. p. 123.

[2] I use this term as the correlative of ‘crystallises,’ signifying thereby the tendency in dissolved proteine, amyline, or other albuminoid atoms to assume defined size and shape, under given conditions, both in and out of the living body; Rainey has shown how such tendency or property effects the superinduction of organic form upon crystal in the formation of shell (ccix″); and its effects are demonstrated more at large in ccx″.

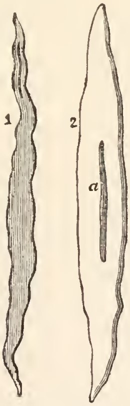
sheet of pellucid membrane, to which are adherent fine reticulate fibres, mostly affecting a longitudinal direction. It is also frequently perforated with small holes, fig. 415, *a*, *a*, from which circumstance it is called 'fenestrate.' This homogeneous membrane has the property of rolling itself up in the form of a scroll, somewhat like the elastic laminæ of the cornea. It is strengthened in many parts by longitudinal anastomosing fibres of elastic tissue; and together with the epithelial deposit forms the 'inner coat' of the artery. The 'middle coat' consists of a fibrous tissue, circularly disposed, in layers more numerous as may be the size of the artery and thickness of the coat, fenestrate tissue intervening; of a reddish-yellow, clearer when fresh than yellow elastic tissue: it consists of bundles of slender fusiform filaments, commonly nucleate, with fine elastic fibres traversing them in a reticulate manner. Acetic acid dissolves the chief substance of the filament, and demonstrates the long staff-shaped nucleus, fig. 416, *a*, and the 'cell-wall.' This 'muscular tissue' predominates in the smaller arteries; of which, when treated by soluble reagents, the coats present the appearance shown in the portion of a splenic arteriole, fig. 417, where *c* is the outer coat with the sheath of areolar tissue, *e* the elastic inner coat, and *d* the dissolved middle

415



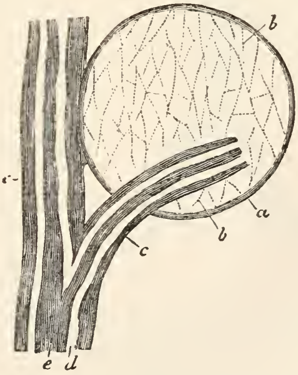
Fenestrate membrane.

416



Fusiform nucleate filaments, or 'muscular fibre-cells.' 1. Natural. 2. Treated with acetic acid. ccviii″.

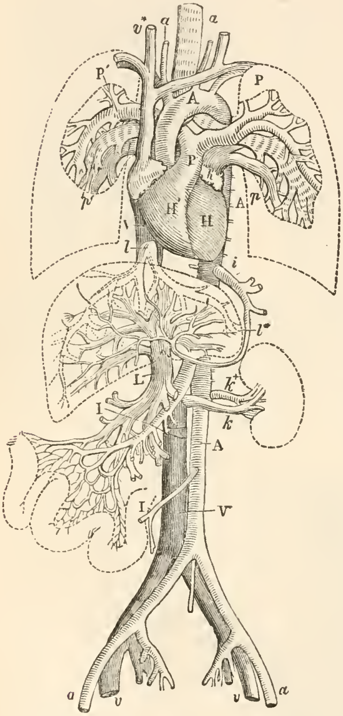
417



Small artery with appended corpuscle, from the spleen of a Pig; treated with soda, and magn. 250 diam. ccviii″.

or muscular coat. The external coat consists of an inner stratum of elastic fibres, and an outer one of the same, blended with a large proportion of closely-fitted bundles of white fibres, identical with those of the areolar tissue of the arterial sheath. By virtue of the above-described structures arteries possess not only elasticity, but an allied power of slow and long-enduring contraction, excitable by stimulus of touch, cold, and electricity during life; and lost after death.

418

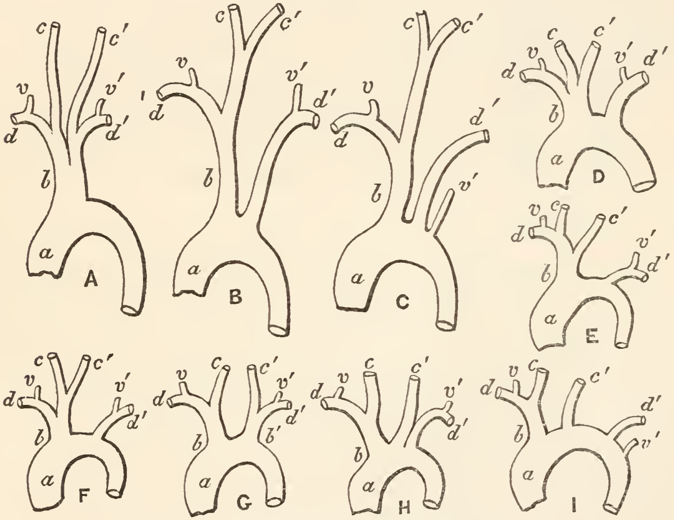


Central organs of circulation in Man. CCLXVII.

In the Mammalian class the aorta, fig. 418, A, bends over the left, not over the right bronchial tube. The chief primary branches of the arch are given off, not immediately after, but at a little distance from, its origin; and there is less constancy in the order of their origin than in birds: the phrenic arteries, the cœliac axis, and the superior mesenteric artery are branches of the abdominal aorta, which terminates, save in *Mutilata*, by dividing beyond the kidneys into the iliac arteries, from which usually spring both the femoral, *a*, and ischiadic branches: the caudal or sacromedian artery, which, in *Mutilata* and long-tailed quadrupeds, assumes the character of the continued trunk of the aorta, never distributes arteries to the kidneys, rarely to the legs, as it does in birds. After the arteries to the heart ('coronaries') the aortic arch sends off those to the head ('carotids') and to the pectoral limbs ('brachials'). I use, with Barclay, the latter term in preference to those by which Anthropotomy designates for surgical purposes parts of the same artery, as where it passes beneath a clavicle (as 'subclavian'), or sinks into the arm-pit (as 'axillary') before reaching the arm. The principal varieties in the origins of the large primary branches of the aortic arch, characteristic of Mammalian genera or families, are given in the order of their complexity in fig. 419.

In Tapirine, Equine, Bovine, and most ruminant Ungulates, the aorta sends off a large common trunk, A, *b* (the 'anterior aorta' of Veterinarians), which divides into two brachio-carotids, each subdividing after a longer or shorter course into the brachial *d* or *d′*, and the carotid *c* or *c′* of its respective side: the vertebral artery, *v*, is given off by the brachial. The arch of the aorta, diminished after dismissing *b*, is the 'posterior aorta' of Hippotomy; and, indeed, in this variety the trunk of the arterial system appears to bifurcate shortly after its origin. In the Rhinoceros the 'anterior aorta' sends off the two internal thoracics, the two brachials, and a common trunk subdividing into the two carotids.[1] In *Auchenia*, fig. 419, B, the left brachial, *d′*,

419



Origins of arteries from aortic arch in Mammals.
A, Ox. B, Lama. C, Giraffe. D, Lion. E, Otter. F, Gibbon. G, Hedgehog. H, Man. I. Dugong.

comes off close to, but distinct from, the innominate trunk, *b*; which, after dismissing the right brachial, *d*, sends onward a long common bi-carotid trunk, dividing into *c*, *c′*. A similar arrangement obtains in the Giraffe,[2] ib. C; but the bi-carotid is still longer before its division, and the left internal thoracic, *v′*, has a distinct origin from the aorta, *a*, beyond that of the left brachial, *d′*. In *Suidæ* a longish innominata gives off the right brachial and both carotids, almost at the same terminal point: the left brachial rises close to the innominata. In the Elephant I found a short innominata giving off the right brachial and both carotids, the left brachial having a distinct origin, but more remote than in the Hog and Giraffe.[1] A like condition prevails in the order *Carnivora*, ib. D. In the Otter a longer interval divides the origin of the left brachial, *d′*, from the innominata, *b*; which, after sending off the left carotid, *c′*, is continued as a brachio-carotid trunk a short way before dividing into the right carotid, *c*, and right brachial, *d*.[2] In the *Quadrumana*, from the Aye-aye up to and including *Hylobates*[3] and *Pithecus*,[4] the innominata, ib. F, *b*, gives off, first the right brachial, *d*, and then a short bi-carotid trunk. In the Hedgehogs, Moles, and Bats, there are usually two symmetrical brachio-cephalics, G, *b*, *b′*. Cuvier ascribes a like condition to *Delphinus*; but in *Phocæna* the otter-type, E, is repeated, only with relatively smaller brachials and larger carotids. Hyperoödon and Whales, the Seals, Beavers, Rats and most claviculate Rodents, the Ornithorhynchus and Chimpanzees partake, with Man, of the mode of origin shown in H: the innominata *b* being the common trunk of the right carotid *c* and brachial *d*. The same pattern obtains essentially in *Sirenia*, but with wider intervals between *b*, *c′*, and *d′*, and with a distinct origin of the left internal thoracic artery, *v′*.

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[1] V″. p. 47.

[2] XCVIII″. p. 229.

These varieties, pretty constant in the groups they characterise, are to be distinguished from the anomalies which are exceptional in species. Both, and especially the latter, are explicable by reference to modified or arrested stages of development; and an embryonal phase, exemplified in fig. 420, affords a ground-plan on which most Mammalian arrangements of the aortic arch and branches can be laid down, or from which they can be picked out.

In the rare mammalian anomaly of a double aorta bending, one over the right, the other over the left bronchus, before uniting to form the descending trunk, the second of the three pairs of similar vessels by which the blood passes from the heart to the dorsal vessel in the embryo is retained, and such persistent aortæ answer to the vessels A, A′, D, fig. 420 (in Saurians). When a single aorta is found bending over the right bronchus, the primitive vascular arch A′ is retained, and A D is obliterated, as in Birds: this arrangement is a rare anomaly, the rule in mammals being to retain the left of the mid-pair of primitive vascular arches, A, D, with complete obliteration of the right arch A′.[5] In the variety A, fig. 419, characteristic of the Horse and Ox, the common trunk of the foremost pair of vascular arches, fig. 420, *a*, is retained and lengthened, the arches being modified into brachials, fig. 419, *d d′*, and carotids, *c c′*, and the communications with the succeeding arches obliterated: in most of the other varieties the communication of the left of the second pair with that of the first pair of primitive arches, as at fig. 420, D, persists and becomes the distinct origin of the left brachial, *a**, the intermediate part of the first left arch being obliterated as far as the artery to the head, or the trunk transmitting such. But this way of explanation has its limits. Most of the varieties in fig. 419 bear relation to the breadth of the chest, with which that of the heart and aortic arch, in a measure, coincides. Thus, in the non-claviculate narrow-chested Ungulates the varieties A, B, C, are met with, that of A prevailing: in non-claviculate, but broader-chested Unguiculates, with flexile and rotatory fore limbs, the separate origin of the left brachial is more constant and remote from the innominata: the same is better marked in the broader-chested Swimmers (*Lutra*, *Phocæna*, E), and in the claviculate *Quadrumana*, F: in many *Insectivora* G, an analogous but other arrangement prevails. In the broad-chested species illustrating the variety H, the head and pectoral limbs are supplied by three primary trunks: in the still broader and flatter-chested *Sirenia*, I, the heart itself is able to expand laterally, even to a partial severance of the ventricles, the aortic arch shows its widest span, the intervals between the innominata, *b*, the left carotid, *c′*, and the left brachial, *d′*, are longer, and the left internal thoracic artery has likewise an independent origin.

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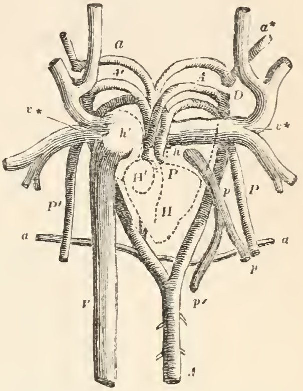
[1] CXCV. p. 61. Cuvier seems to have found the right as well as left brachial rising separately, and between them the carotids by a common trunk, XII. tom. VI. p. 112.

[2] CXCV. p. 16. [3] Ib. p. 15. [4] CXCII″. p. 5.

[5] I have failed to find in any embryo of bird or mammal more than three pairs of primitive vascular arches, conveying the blood, in that form, from the heart to the dorsal aorta. In the exceptional minority of Vertebrates, in which branchiæ are deve-

420



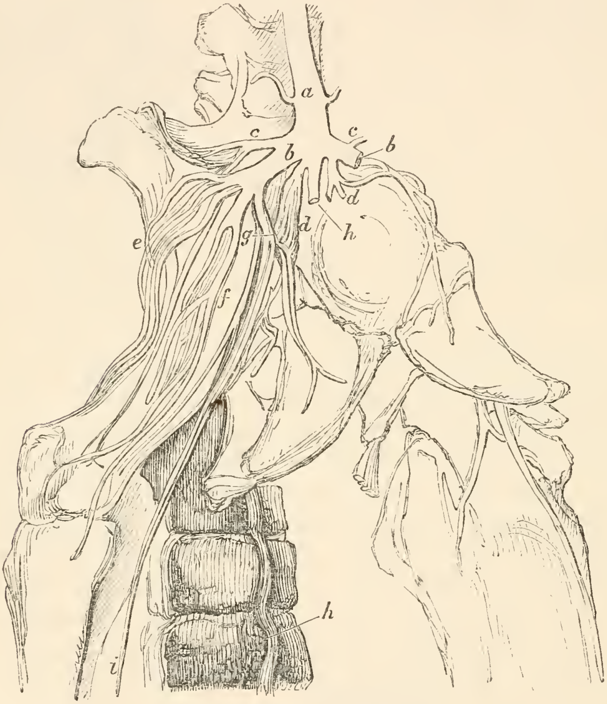
Primitive vascular arches, as retained in Saurians.

I have not met with an instance of a double aorta, or of a single one arching over the right bronchus, or of the origin of the right brachial from the termination of the arch, in any mammal below Man: but such rare anomalies may, perhaps, be found when as many individuals of the brute have been anatomised as those of the human kind.

loped from the primitive arches, four or more of these may exist. But the notion of the human embryo having gills and gill-slits tickles the fancy; and so the term 'branchial' may long continue to be misapplied to the hæmal vascular arches and blastemal folds of the fœtal mammal, bird and reptile.

Proceeding with the mammalian modifications of other parts of the arterial system, I find that in all *Lyencephala* the carotids are relatively smaller than in the better-brained groups: and that the vertebral arteries give the main supply of arterial blood to the brain. In the Monotremes the brachial artery emerges from the thorax above the first rib, and passes between it and the coracoid: the trunk is speedily reduced by the number of small branches given off, and, with some of these, perforates the distal end of the humerus nearly midway between the condyles. The phrenic, cœliac, and mesenteric arteries are given off from the abdominal aorta; the renal artery is short, wide, and single; there is no inferior mesenteric artery, but the abdominal aorta, fig. 421, *a*, terminates by dividing into the two common iliac, ib. *b*, and the caudal, ib. *h*, arteries. The iliac trunks are unusually short: they give off a ‘circumflex,’ *c*, which soon is resolved into a plexus bending over the ilium to supply the muscles on the back of the pelvis: on the opposite side of the origin of the iliac is sent off

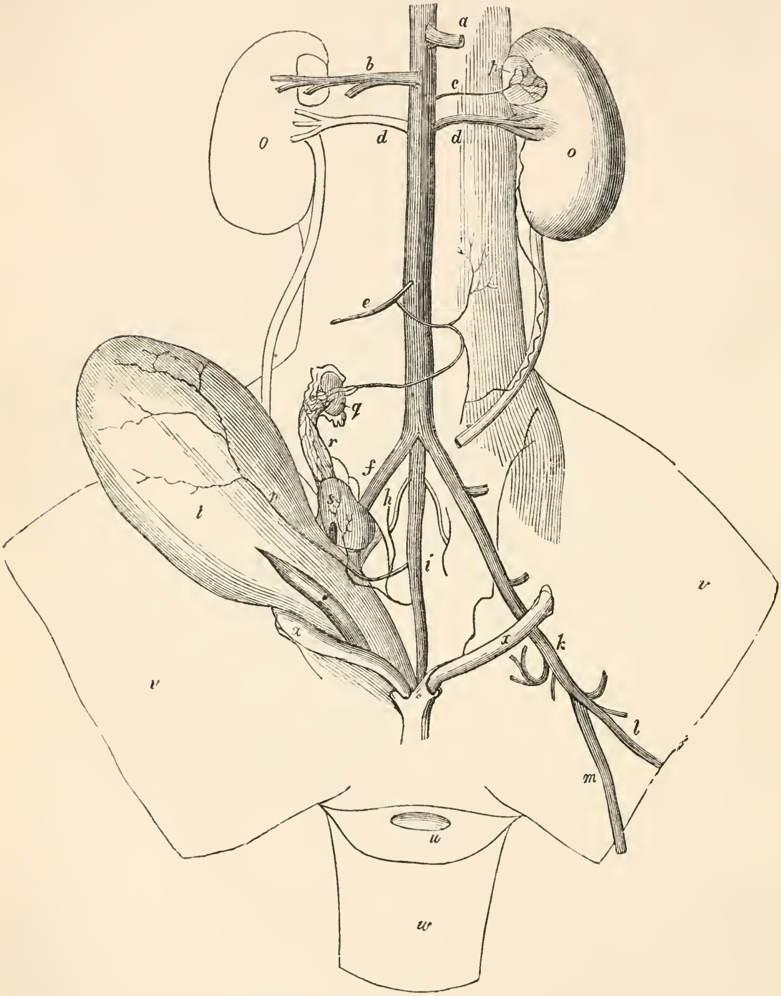
421



Femoral plexuses. *Ornithorhynchus.*

the marsupial artery, *d*, which is similarly resolved: most of the branches coursing to the back part of the marsupial bones and bending upward or forward upon the abdominal muscles attached thereto, in a course analogous to that of the so-called ‘epigastric’ artery in Man. The iliac trunk, *b*, is then continued a short way, and resolves itself into the short trunks of three plexuses: the outermost, *e*, take a course obliquely to the outer side of the thigh, analogous to that of the ‘external circumflex’ branch of the femoral in Man, the middle division representing the femoral trunk has a course of three lines before its resolution into the ‘femoral plexus,’ *f*, which continues the usual course to the ham: the third short trunk, representing the ‘internal iliac,’ *g*, resolves itself into a plexus distributed to the parts supplied, in Man, by the sciatic, gluteal, and pudic arteries; but one branch is continued superficially down the back part of the hind leg, *i*, to the tarsal bone supporting, in the male, the spur: it accompanies the duct of the spur-gland in the lower half of its course. The arterial system in *Echidna* is similarly characterised by the subdivided plexiform disposition of many of the arteries. The caudal artery, ib. *h*, pursues a wavy course beneath the broad caudal vertebra, in *Ornithorhynchus*. In *Marsupialia*, after the coronary arteries, the primary branches from the arch of the aorta rise in some species by three, in others by two trunks. The broad-chested Marsupials, the Koala and Wombat, for instance, are those in which the left carotid, *g′*, fig. 402, and subclavian, *h′*, arise separately from the arch; the arteria innominata dividing into the right subclavian and carotid, ib. *g*, *h*, as in Man. In most Marsupials the innominata gives off both carotids, *g*, *g*, fig. 401, as well as the right subclavian, *h*. The common carotid in the Kangaroo gives off the thyroid artery, and divides opposite the transverse process of the atlas into the ecto- and ento-carotids. The latter describes a sharp curve at its origin, passes along the groove between the occipital condyle and the paroccipital to the basisphenoid which it pierces. The vertebral arteries are given off by the subclavians, and pass to the skull, as usual, through the cervical vertebrarterial foramina. They unite beneath the medulla oblongata to form the basilar artery, which sends off at right angles to the cerebellum two branches as large as itself: it divides opposite the anterior margin of the pons Varolii, and the diverging branches are connected by two straight transverse canals, before they anastomose with the smaller ento-carotids to form the circle of Willis. The brachial artery divides early into ulnar and radial branches: in the Koala, Wombat, Kangaroos, Potoroos, most Phalangers (*Phal. Cookii* is an exception), most Petaurists (*Pet. Sciureus* is an exception), the Opossums, Bandicoots, and Phascogales, the ulnar and larger division of the brachial perforates the internal condyle of the humerus; it passes over that condyle, impressing it with a more or less deep groove in the Dasyures and Thylacine.

422



Branches of the abdominal aorta, Kangaroo.

In the abdomen, the primary branches of the aorta are sent off in the same order as in most Mammalia, with the exception of the constant absence of an inferior mesenteric artery. This modification probably relates to the simplicity of the mesenteric attachment of the intestines above described. A more marked repetition of an oviparous arterial character occurs in the mode of origin of the great arteries of the posterior extremities. In most Mammalia these are derived from a single trunk on each side — the common iliac artery; in Birds from two primary branches of the aorta, one corresponding with the external iliac and femoral, the other with the internal iliac and ischiadic arteries. In the Kangaroo and vulpine Phalanger the aorta gives off, opposite the interspace of the two last lumbar vertebræ, the iliac arteries, fig. 422, *f*; but these are afterwards resolved into the ordinary branches of the external iliac of the placental Mammals, with the addition of the ilio-lumbar artery. The trunk of the aorta, much diminished in size, maintains its usual course for a very short distance, and then gives off the two internal iliacs, ib. *h*, and is continued as the 'arteria sacra media,' *i*, to the tail. The transitional character of this part of the marsupial sanguiferous system between the oviparous and placental types, is manifested in the large size of the external iliacs as compared with the internal iliacs, their greater share in the supply of blood to the hinder extremities, and the brevity of the aortic trunk between their origins. In most Birds the femorals or external iliacs (vol. ii. p. 190, fig. 98, 23) are smaller than the ischiadic or internal iliac (ib. 26) arteries subsequently given off. At the upper part of the thigh the femoral artery divides, in the Kangaroo, into two equal branches; the one which corresponds with the radial artery in the fore leg, *m*, fig. 419, principally supplies the foot; it passes along the back of the tibia, between the gastrocnemius internus and tibialis posticus, and divides a little above the internal malleolus. The smaller division, ib. *l*, which follows the ordinary course of the femoral along the popliteal space, is lost upon the inner and posterior part of the tarsus; the larger branch winds over the malleolus to the front of the tarsus, sends off the anterior tarsal artery, and is then continued along the inner and afterwards the under part of the metatarsal bone of the long and strong toe.

In fig. 422, *a* is the trunk of the cœliac artery; *b* that of the superior and inferior mesenteric arteries; *c* is the adrenal artery of the left side; *d*, *d*, the renal arteries; *e* the spermatic artery, of which the left branch is shown continued to the left ovarium, *q*, which, with the uterus, *r*, vagina; *s*, and bladder, *t*, is drawn to the right side; the spermatic arteries arise close together but separately in the male vulpine Phalanger: *k* is the femoral artery; *l* the external, *m* the internal branch; *i* is the caudal artery, which here corresponds in size with the development and functional importance of the tail, and is very small in the tail-less or nearly tail-less Marsupials, such as the Chœropus, Koala, and Wombat.

The proportions in which the vertebral and entocarotid arteries supply the brain continues to characterise the *Lissencephala*, and relates rather to the restricted development of the cerebrum than to any special proneness to hybernation or torpidity. The artery, moreover, which, entering the basis cranii, represents the entocarotid, supplies parts usually served by the ectocarotid, in *Gyrencephala*. Thus, in the Hedgehog, a branch of the carotid, after sending off twigs to the occipital muscles, penetrates the petrosal bulla, and there divides: one branch, traversing the stapes, gives off the middle meningeal artery, and is continued forward by the orbitosphenoid fissure into the orbit: the other branch, truly representing the entocarotid, passes into the cranial cavity, and joins the 'circle of Willis,' which is mainly formed by the vertebral arteries. Evidence of this condition of cephalic arteries in other *Insectivora* and in *Rodentia* is given in fig. 173, C and E, as regards the passage of the petro-tympanic branch through the arch of the stapes. In the Hare the division of the carotid which sends off the entocarotid pierces the petro-tympanic bulla, as in the Hedgehog: in the Capybara it grooves the basisphenoid. In the Hedgehog each carotid gives off, near its origin, the inferior thyroid: in the Anteater, the inferior thyroids have a common origin from the innominate trunk. In most Rodents which have the entocondyloid perforation of the humerus (vol. ii. pp. 382–384) the brachial or ulnar artery accompanies the median nerve through that hole: in *Myrmecophaga* the nerve only so passes. In Bats the brachial bifurcates about the middle of the humerus: the deeper-seated division supplies the extensors of the fore-arm.

The most remarkable modification of the brachial artery is that which was discovered by Carlise,[1] in the Sloths and Slow-lemur, and which is repeated in the femoral of the same animals. The divers interpretations, leading to controversy, on these peculiarities of the arterial system in CXIV″, CXV″, CXVI″, called for special care and attention to the subjects afforded to me by the London Zoological Society, in respect to the arterial system.

In the Ai (*Bradypus tridactylus*) the arch of the aorta, opposite

[1] CXLIII″. p. 17.

the fifth pair of ribs, gives off a very short trunk, which divides into the right brachio-carotid and the left carotid; the aorta then sends off the left brachial artery which has a long course in the chest before it attains and bends over the first left rib. The brachio-carotid has a course of an inch before dividing. The carotids do not divide until they have passed the atlas, and the ectocarotid is larger than the entocarotid: small plexuses are formed in the orbits and temporal fossæ. The brachial, after bending over the first rib and traversing the axilla, suddenly sends off and seems to break up into a fasciculus of minute longitudinal branches, which surround and conceal the main-trunk. This, however, exists in the middle of the plexus, contracted at first, but gradually resuming its more normal dimension as the brachial artery, and that not by the reception of any of the previous ramuscules. It begins to diminish again at the elbow, and thence gradually contracts until it forms the radial side of the palmar arch and the chief origin of the two digital arteries that go, one to each interspace between the middle and the two lateral fingers: the ulnar side of the palmar arch is formed by a continuation of one of the branches sent off from the axillary, and the rest of that plexus is distributed progressively to the muscles and other parts of the limb, eight or ten of the branches quitting the main trunk at the bend of the elbow to perforate the interosseous space or to supply the deep-seated muscles of the fore-arm.

Thus, the arterial stream is propelled directly by the main trunk to the digits; the force being broken by the sudden dispersion of the current in the score of branches sent off from nearly the same part of the circumference of the axillary artery.

The vertebral artery is sent off at the brim of the thorax on both sides. The phrenic pierces the diaphragm with the aortic trunk, winds round the right of the œsophageal aperture, and soon divides. The gastric artery is as large as the superior mesenteric. The renal artery gives off the spermatic. The abdominal aorta bifurcates opposite the last lumbar vertebræ. The left iliac, in my subject, sent off, at its origin, the arteria sacra media and the two epigastric arteries: the former soon resolves into a plexus. The right iliac also sends a few branches to the sacral plexus; but this is formed chiefly by branches sent off around the origin of the sacromedian trunk. The internal iliac is represented by a plexus coming off by three or four quickly-dividing branches from the common iliac before it passes over the brim of the pelvis: at this part, also, the femoral plexus begins to be given off by one or two branches which subdivide; not, as in axilla, by many ramuscules from one point. Other branches are sent off from the commencement of the femoral artery, which rapidly subdivide and conceal the whole course of the femoral trunk as far as the ham. Some branches from the internal iliac plexus pass over the brim of the pelvis and anastomose with arteries of the femoral plexus; but there is no re-entering of any of the members of the plexus into the main trunk. They are distributed, successively quitting the plexus, to the femoral muscles: a numerous fasciculus perforates the proximal part of the interosseous space, between the heads of the gastrocnemius; the remaining branches accompany the main trunk down the back of the leg, some as far as behind the inner malleolus, whence the main trunk passes to the scapho-calcaneal joint and divides into the two digital arteries for the interspaces of the three toes. The continuation of the trunk may be thus explained:—The foot and hand being the first segments developed in their respective limb, the artery supplying them is first established; the subsequently formed segments are supplied by branches sent off from this.

In the Unau (*Bradypus didactylus*) the aorta sends off the right brachial and both carotids by a common trunk, half an inch long: the left brachial has a course of more than an inch in the thorax. Each brachial sends off, after winding over the first rib, many arteries: the main trunk perforates the entocondyloid hole of the humerus, as does likewise part of the brachial plexus. The continued trunk forms no palmar arch, but terminates by bifurcating at the interspace of the two digits. The abdominal aorta gives off the common iliacs opposite the last lumbar vertebræ; and then sends off the last pair of lumbar arteries and the 'sacra media:' this distributes a pair at each sacral vertebræ until it is resolved into a pencil of arterioles at the fourth vertebra. The iliacs send off, first, the epigastrics; then the internal iliac plexus; after which the external iliac trunk, bending over the brim of the pelvis, sends off the arterioles of the plexus, which conceals the continuation of the femoral trunk; this plexus supplies the femoral muscles, and also a large proportion to the interosseous space of the leg. The main trunk passes down the back of the leg, and divides at the middle of the sole into two branches for the interspaces of the three toes of the hind foot.

A closely similar disposition of the arteries, but with less numerous arterioles, obtains in the Anteaters[1] and Armadillos[2]: and the analogy of this with the arterial system of the Monotremes is worthy of note.

[1] CXCV″. [2] CXCIX″.

A closer resemblance to the plexiform limb-arteries of the Sloths is shown by the Slow Lemurs, as exemplified in the arm of *Stenops tardigradus* in fig. 423, *c.*[1]

Cuvier first indicated the analogous division into numerous branches of the brachial artery of the Porpoise;[2] the plexuses afterwards receiving a more detailed account, with a figure, from V. Baer,[3] who also found a similar arrangement in the pectoral fin of the Manatee,[4] and, with a minor degree of subdivision, in that of the Walrus.[5] V. Baer associates the speedy subdivision of the main artery with the restricted degree of movement of fin-shaped fore-limbs: but the extent and freedom of motion of the long prehensile limbs of the Sloths and Lemurs point to other conditions.

The extreme degree of plexiform multiplication of the arterial system in the intercostal and other vertebral branches, in the *Cetacea*, more plainly relates

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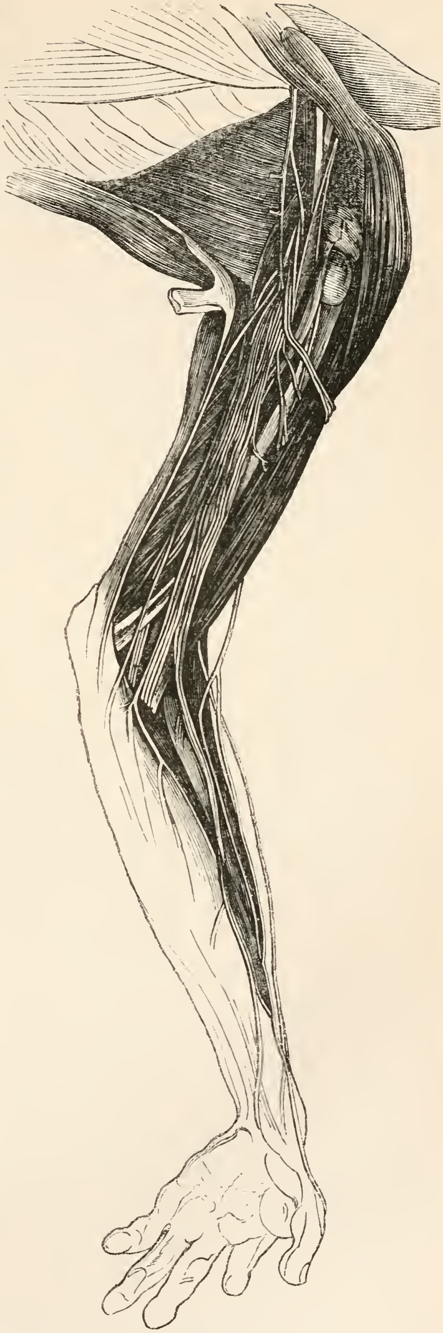

Plexiform branches of brachial artery; *Stenops tardigradus*. LXIX′.

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[1] Vrolik remarks of these plexuses, 'they consist not only of arteries, but also of veins; and that, by dividing in branches, these ramifications become smaller and smaller, and composed of a less number of vessels.' LXIX′. p. 219.

[2] XII. (1805, tom. 4).

[3] CXCVI″. fig. I.

[4] Ib. fig. II.

[5] Ib. fig. III.

to the provision of a reservoir of arterial blood, especially in behoof of the brain.

In the Porpoise the aorta, after giving off the two coronary arteries, forms the usual arch from the convexity of which are sent off three primary trunks: the first is the largest, and gives off, first, the 'posterior thoracic,' then the right carotid, and afterwards divides into the right brachial and internal mammary arteries. The second trunk sends off the left carotid, left brachial, and internal mammary arteries. The third primary branch is the left posterior thoracic artery.[1] The common carotid sends off an inferior thyroid before dividing into external and internal carotids: the subordinate branches of both these vessels form the plexuses in various parts of the head, especially at the basis cranii and around the optic nerve. The posterior thoracic, on each side, bends down and gives off branches to the five anterior intercostal spaces: the succeeding ones derive their arteries directly from the thoracic aorta, and some of them by a short common trunk, which bifurcates. The intercostals send off the dorsal branch, and that which accompanies the rib: but they also, and chiefly, divide into a vast number of branches, forming by their close tortuous interlacement a thick substance, compared by Tyson to a gland,[2] and, more truly, by Hunter, to the plexiform mass of the spermatic artery in the bull.[3] This arterial structure lines the sides of the thorax from the ninth or tenth pair of ribs, forwards, penetrating between the ribs near their joints and behind the costal ligaments, and there anastomosing with corresponding productions from contiguous intercostal spaces: branches pass therefrom into the neural canal, surrounding the myelon with a similar plexus, increasing in thickness near the skull and about the macromyelon, and anastomosing freely with the myelonal meningeal arteries. Thus the neural axis can receive its appropriate stimulus of oxygenated blood during the periods of long submersion and consequent interruption of respiration, to which the *Cetacea* are subject. Any convoluted intercostal artery, contributing to this reservoir, can be unravelled and traced to a great length, without sending off branches or changing its calibre. In the Piked Whale (*Balænoptera*), the external thoracics and internal mammaries combine with the intercostals in supplying this huge and singular plexiform reservoir. The brachial trunk gives off an external thoracic to the pectoral muscles, a subscapular artery, one to the supraspinal fossa and a circumflex branch: these supply the muscles of the fin. The trunk then divides into two, each of which subdivides, and forms plexuses upon the humerus, mainly expended in nourishing the bones, their ligaments, and the enveloping integument.[1] The caudal prolongation of the aorta is surrounded by layers of plexiform arterioles, as by a sheath, in its course along the wide hæmal canal.[2]

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[1] xciv. p. 365, note (1837). See also cxcviii″. (1841), p. 383.

[2] xciv. p. 365.

[3] xciv. p. 365.

The littoral and herbivorous *Sirenia*, which never go so deep or stay so long submerged as the Whales, seem not to possess the intercostal and myelonal arterial plexuses: at least I found them not in the Dugong.[3]

Amongst the minor degrees of plexiform multiplication of arterial canals is that oldest recorded instance[4] of the intracranial 'rete mirabile' at the base of the skull in Ruminants: it is large in grazers, is less in browsers, and least in the Giraffe which habitually feeds with the head raised. In *Bovidæ*, where the 'rete' is most extensive, it is situated at the sides and back of the sella turcica, in the sclerous venous receptacle called 'cavernous sinus.' There is no definite bifurcation of the cephalic arterial trunk into an ecto- and ento-carotid, in Ruminants: a small branch of the carotid, perforating the cranium at, or behind, the foramen ovale, represents the 'middle meningeal artery,' and joins the 'rete mirabile'; but this is mainly formed, in advance, by branches of the internal maxillary, which enter the fissura lacera anterior, subdivide and anastomose reticularly, and are continued backward, on each side of the 'sella,' as a 'rete mirabile': three or four transverse portions bring the main lateral 'retia' into union with each other; while, posteriorly, are sent off a median and two lateral narrow plexiform extensions: the latter diverge to anastomose with the precondyloid arteries; then the middle portion is continued to join the converging cerebral branches of the vertebral arteries. These, in the Ox, enter the neural canal between the axis and third cervical, are united together by oblique cross-branches, as they advance; each bifurcates in the neural canal of the atlas, sending one branch out through the anterior perforation of the neurapophysis, while the other converges towards its fellow, to terminate by anastomosing with the median production of the 'rete' from the 'circle of Willis,' and also with a division of each precondyloid artery.

In the Hog (*Sus scrofa*), a larger proportion of the comparatively small 'rete mirabile' is formed by the vessel entering the cranium through the posterior 'fissura lacera,' representing an 'entocarotid.' A common efferent vessel, piercing the inner layer of the dura mater, carries the blood from the 'rete' to the brain, supplying principally the prosencephalon. Another instance of plexiform disposition in the arteries of Artiodactyles has been observed in the gastric branch of the cœliac axis of the Hog, prior to its ramification in the dorsal parietes of the stomach.[1]

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[1] xciv. p. 366 (note).

[2] cxcviii″.

[3] cxvii″. p. 35. The trace observed by Stannius in the Manatee does not support a functional inference, as in the true whales.

[4] cc″.

The Perissodactyles have a recognisable entocarotid which, however, has no proper bony canal, but enters the cranium by the posterior fissura lacera: it forms strong bends as it converges towards its fellow, with which it is united, behind the 'sella,' by an external flexuous 'ramus communicans'; then, piercing the dura mater, the entocarotids are again united by the internal 'ramus communicans,' which completes the circle of Willis behind and also receives the 'arteria basilaris.' A rudiment of the 'rete mirabile' of Artiodactyles is represented by small plexiform vessels given off from the hinder part of 'Willis's circle.'

The entocarotid deeply grooves the apex of the petrosal in the Elephant. Branches of the ectocarotid form a remarkable plexus internal to the cheek-gland which opens between the eye and ear in this animal.

In most *Carnivora* the entocarotid traverses a curved canal in the petrosal and makes a bend on emerging, which protrudes at the foramen lacerum before entering the cranial cavity: the bend, so exposed externally, receives in *Canidæ* and *Viverridæ* (*Herpestes*) a branch of the ectocarotid; and, as it advances alongside the 'sella,' also anastomoses with branches of the internal maxillary and ophthalmic arteries. In *Ursidæ* a smaller portion of the loop projects into the cartilage occupying the 'foramen lacerum.' The entocarotid and its bony canal are smallest in Felines and the Hyæna. In these a maxillary plexus is formed which supplies the internal maxillary, ciliary, ethmoidal, ophthalmic, and anterior meningeal arteries.

The condition of the mesenteric arteries in Man renders them, in a degree, reservoirs as well as conveyers of blood: it facilitates a more continuous or less interrupted supply to the intestinal membrane. The fewer anastomotic arches in the *Carnivora* favour a more rapid and direct supply of blood when the presence of chyme in the intestines gives stimulus to such supply. The human condition relates to the more regular and frequently repeated supplies of food; to the more constant and continuous presence of chyme upon the villous surface of the gut. In the Dog, and more especially in wild *Carnivora*, the gorging of prey is followed by fasting, by long intermission of the supply of chyme; consequently the provision for the arterial supply is simplified, and at the same time adapted to the more rapid assimilation which the hungry or famished frame requires.

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[1] ccı''. p. 614, pl. 28, fig. 4.

Modifications of the arterial supply of the mammary glands, exemplified by large epigastric and subcutaneous abdominal branches, anastomosing with the internal and thoracic-mammary arteries, accompany the position and extension of the mammary glands from the thoracic to the inguinal regions in many quadrupeds.

The ultimate capillaries of the arterial ramifications either open directly into venous capillaries, or into sinuses, as in erectile and uterine structures, whence the venous capillaries begin. In exceptional cases, as in the Bat's wing, arteries of the second and third order of branches have been observed to pass into veins of corresponding size, without the intermedium of capillaries.[1]

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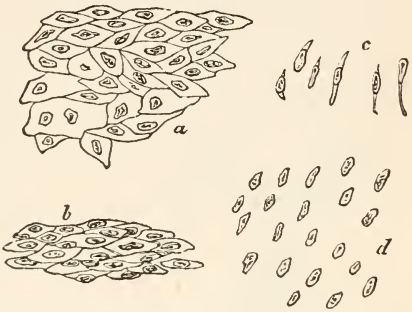

Epithelium from vena cava of Sheep. CCIII″.

§ 349. *Veins of Mammalia.*—The delicate structureless coat of the capillaries present, as the venules enlarge, an epithelial lining of flat, usually rhomboid, nucleate scales, fig. 424. The middle tissue of the vein includes sparing delicate unstriped fibres in an abundant bed of connective or areolar tissue, in which may be distinguished an internal stratum of wavy longitudinal fibres, fig. 425 *a*, a middle stratum of intermixed circular and longitudinal fibres of elastic tissue, imbedded in a nidus of white or contractile fibres, *b*, and these degenerating into an

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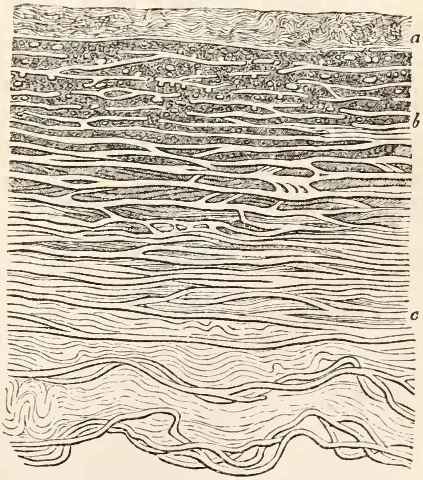

Longitudinal vertical section of wall of subclavian vein of an Ox: magn. 200 diam. CCIII″.

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[1] CXCVII″. p. 968.

outer mass of areolar tissue, in which such fibres as can be traced run lengthwise, *c*. This forms the greatest proportion of the venous coat, and the transition to the mid-stratum, *b*, is closer than that between *b* and the thinnest layer, *a*, which is lined by the epithelial tissue.

The elastic tissue is never so developed as to give the yellow colour which characterises the middle coat of arteries, or to maintain the tubular form in the empty vein. The valves are not confined to the place of union of the venous trunks with the heart, as is the case with arteries, but occur, usually in pairs, fig. 426, in the major part of the venous system after the vessels have gained, in returning from the capillary area, a conspicuous size. They 'consist,' as Harvey described, 'of raised or loose portions of the inner membrane of these vessels, of extreme delicacy, and a sigmoid or semilunar shape. They are situate at different distances from one another, and diversely in different individuals; they are connate at the sides of the veins; they are directed upward or toward the trunks of the veins; the two—for there are, for the most part, two together—regard each other, mutually touch, and are so ready to come into contact by their edges, that if anything attempt to pass from the trunks into the branches of the veins, or from the greater veins into less, they completely prevent it; they are further so arranged, that the horns of those that succeed are opposite the middle of the convexity of those that precede, and so on alternately.' He further writes, 'In many places two valves are so placed and fitted, that, when raised, they come exactly together in the middle of the vein, and are there united by the contact of their margins; and so accurate is the adaptation, that neither by the eye, nor by any other means, can the slightest chink along the line of contact be perceived. But if

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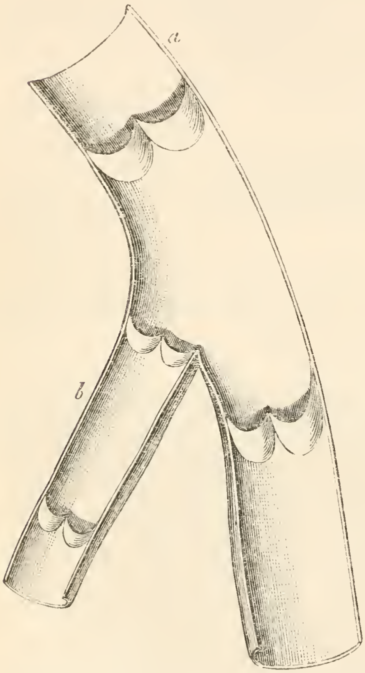

Venous valves, *a*, femoral vein: *b*, saphena interna, Human. CCVI″.

the probe be now introduced from the extreme towards the more central parts, the valves, like the floodgates of a river, give way, and are most readily pushed aside.'[1]

The most conspicuous tissue in these valves is of the white fibrous kind, having a general direction parallel with the free border of the valve and remarkable for their minute and equal undulations in this course. The epithelial lining is feebly indicated by scattered nuclei, especially at the extreme margin of the valve. As a general rule the cerebral and myelonal veins, those of the heart, lungs, kidneys, uterus, and liver, both portal and hepatic, have no valves: there are few valves in the external jugular; none in the internal jugular: valves abound in the veins of the pectoral limb, including the axillary, but are not present in the subclavian or precavals. The postcaval and iliac veins have no valves, but they abound in those of the pelvic limb. The spermatic veins have valves, but not the ovarian veins; they are few and incomplete where they have been found in the azygos veins.

The varieties in the disposition of the veins exemplify, in mammals, a greater degree of repetition of primary or embryonal steps than do those of the arteries. The cardinal veins, which persist in great proportion in Lizards, fig. 420, unite at $v^{\times}$ with the brachio-jugulars to form a short 'precaval' trunk[2] on each side. That of the left receives the blood from the coronary vein before terminating in the right auricle *h*. A smaller proportion of blood is returned by the persistent venæ cardinales, *z*, *z*, in mammals; but with this exception, the disposition of the great trunks returning the blood from the head, trunk, and pectoral limbs, is essentially such in *Lyencephala* and most *Lissencephala* as is exemplified in Saurians. The blood from the left side of the trunk (intercostal or intervertebral spaces) is carried, in the ascending series of Mammals, by progressively increasing anastomosing channels from the left into the right cardinal vein: and, to such an extent in Man, that the right cardinal vein was noted for its want of symmetry as the 'vena azygos,' while the remnant of the left cardinal was called 'hemi-azygos.' With this change goes on an enlargement of an anastomosing vein between the right and left precavals at the upper and fore part of the chest, ultimately diverting the blood from the left precaval into the right, as the blood of the left cardinal had been attracted to the right cardinal vein. This is accompanied by obliteration of the left precaval trunk, of which a remnant, recognisable by the developmental anatomist, becomes the ‘coronary sinus’ of Anthropotomy, or the dilated portion of the heart-vein, with well-marked fibrous tunic, receiving the ‘oblique auricular vein’ representing the left ‘ductus Cuvieri,’ and terminating by the wide valvular opening in the right auricle.[1]

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[1] CCIV''.

[2] Called by some 'ductus Cuvieri.'

In the Monotremes each precaval, fig. 308, *e*, *f*, receives the azygos vein of its respective side: they are united by the characteristically mammalian transverse canal, *g*, which becomes the ‘vena innominata’ in Man. The postcaval has a long course in the thorax; before entering which it is greatly dilated, within the liver, in the Ornithorhynchus, as it is in the placental divers. The vena portæ is constituted as in other Mammalia. The veins of the kidney are continued from the renal artery, and communicate solely with the postcaval. In the Marsupials, also, the iliac veins combine to form the postcaval trunk, as in the rest of the Mammalia, without conveying any part of their blood to the kidneys: in the Kangaroo they both pass on the central aspect of the iliac arteries. The renal veins, in like manner, directly communicate with the abdominal cava, and do not contribute any share in the formation of the portal vein. This great secerning trunk of the hepatic organ presents the strictly mammalian condition, being formed by the reunion of the gastric, intestinal, pancreatic, and splenic veins. ‘The primitive veins of the animal system of organs, commonly called “azygos,” retain their original separation and symmetry; the left “azygos” bends over the left bronchus to communicate with the left precaval, and the right azygos over the right bronchus to join the right precaval.’[2] This vein, *b*, returns the blood from the right side of the head and the right anterior extremity; the corresponding vein on the left side, *c*, passes down in all the Marsupials, in front of the root of the left lung, as in Birds and Reptiles, behind the left auricle, and, after receiving the coronary vein, joins the postcaval, *d*, immediately before its expansion into the auricle. The anterior anastomosing vein between the two precavals exists.

Where the pelvic extremities are less or not larger than the pectoral ones, as in the Ursine Dasyure and Wombat, the postcaval is somewhat less than the left precaval, figs. 402 and 403, and they appear to terminate by separate apertures in the auricle; but in the Kangaroo, fig. 401, the proportions of the two veins are reversed, and the postcaval more obviously receives the left precaval before it terminates: these two veins meet at a very acute angle, and are separated by a crescentic ridge similar to, but thinner than, that which divides their common orifice from the orifice of the right precaval. In most *Lissencephala* the left precaval descends behind the auricle to terminate with or near to the postcaval: the left vena azygos communicates with the left precaval in the Hedgehog and many others, and is larger than the right: opposite proportions prevail in *Leporidæ* and some other Rodents, as in Squirrels, the left azygos being small or wanting. In the Bats the venules of the wing-membrane, owing to their comparatively wide communications with the arterioles, manifest the impulse of the heart's action.

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[1] ccvii″. (1848.)

[2] lxxx′. (1842) p. 308.

In *Cetacea* the left cardinal and precaval veins are reduced to the condition of a coronary sinus which is large; the blood from the head and fins is returned by the right precaval trunk to the auricle. The definition of any distinct right or left azygos trunks is obscured by the characteristic expansion and plexiform multiplication of the veins at the back of the thoracic-abdominal cavity, fig. 427; and indeed the precaval system is chiefly brought into communication with the postcaval one by the continuity of the vast venous sinuses surrounding the neural axis and receiving the intercostal and lumbar veins, ultimately opening into the precaval by a short trunk which penetrates the posterior and right part of the chest. In fig. 427, the postcaval vein is cut across at *p*, where it lies in the interspace of the two masses of depressor muscles of the tail. Veins, *m*, *m*, which seem to answer to the iliacs of quadrupeds, return from the side-muscles of the tail; the caudal vein is represented by a plexus, *f*, and occupies much of the hæmapophysial canal. A plexus from the intestine, G, terminates in the right iliac vein, and thus establishes a communication between it and the portal system. A hypogastric plexus terminates at *i*. The peritoneal plexus is shown at *l*; it becomes more considerable at the season of sexual excitement: but the chief abdominal reservoir of venous blood is formed by the vast psoadic plexus, *k*, which extends from behind the hinder end of the kidney, E, to the hinder end of the abdomen. In the Porpoise it forms a mass of reticulate veins upwards of an inch in thickness: it is fed by the caudal veins, *a*, *b*, *c*, *d*, behind, and laterally by from five or seven veins which, returning blood from the dorsal and lateral parietes of the abdomen, pierce the lateral abdominal muscles to join the plexus at *e*, *e*. At the mesial margin the psoadic plexus communicates by many and wide apertures with the iliac vein; and anteriorly with veins of the diaphragm or 'phrenic plexuses' which converge to terminate at *o*, *o*, in the postcaval trunk. The non-valvular structure of the veins in *Cetacea*, and the pressure on

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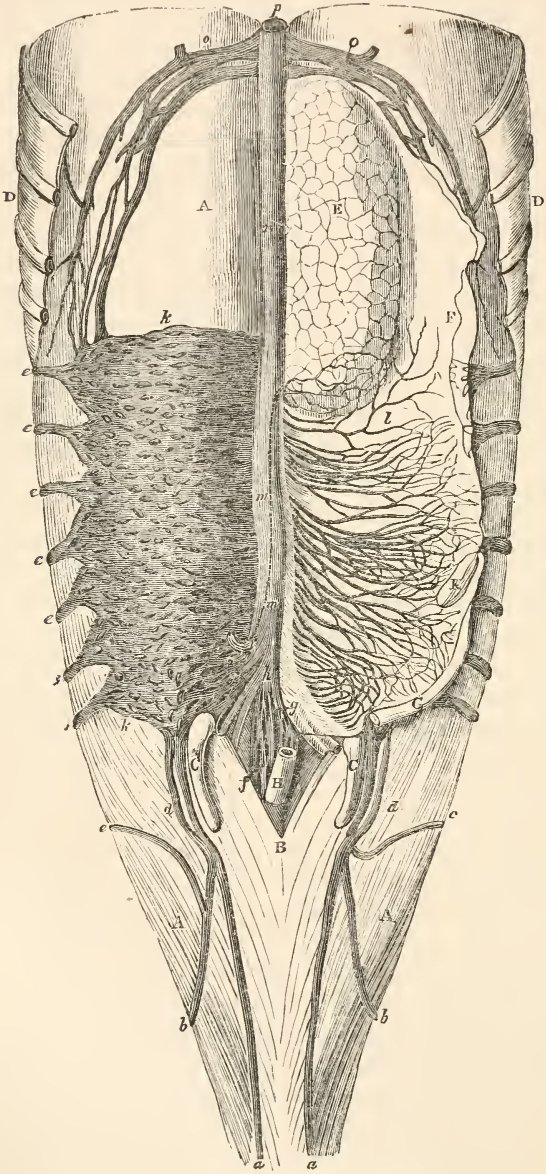
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Abdominal venous plexus and kidney of the Porpoise.

these reservoirs of blood at the depths to which they retreat when harpooned, explain the profuse and lethal hæmorrhage which follows a wound that, in other Mammalia, would not be fatal.

In the Ungulates a left azygos co-exists with a single (right) precaval. In the Hog the azygos trunk passes forward, left of the aorta, crossing that vessel below the arch and curving over the left auricle, and enters the right. Hunter notices its attachment to the left auricle and its analogy, in both the Hog and Fallow-deer, to the left precaval in Birds.[1] In the Corinne Antelope (*A. Dorcas*) Hunter observed 'two azygos veins, the left being the larger';[2] a right azygos exists in the Ox, and is larger in the Horse, receiving blood from several of the left intercostal spaces. The oblique vein at the back of the left auricle is large in the Dromedary and Tapir, and represents the remnant of a left azygos. The portal vein shows valves in some Ruminants. In the Rhinoceros the right precaval receives the right or common azygos close to its termination at the upper part of the right auricle: two inches above this it receives the right vertebral vein which is about half an inch in diameter; two inches above this it is formed by the junction of the left brachiocephalic. At the concavity of the great vein formed by this junction, the bronchial veins and some small pericardial veins enter. The upper part of the precaval receives the two large jugular veins close together, so that a proper 'vena innominata' can scarcely be said to be formed. The left vena azygos, which is formed by the union of a few intercostal veins of the same side, terminates in the left subclavian vein, which receives separately the left vertebral vein from the neck. The right or principal azygos receives the intercostal veins of both sides as far forwards as its entry into the precaval vein: the Rhinoceros in this structure agrees with the Horse. The coronary vein receives a small pericardial vein, which descends along the back of the left auricle, before it terminates with the inferior cava, at the base of the right auricle.

With the relatively long and narrow thorax of the hoofed and most other Mammals the pre- and post-caval trunks are correspondingly longer than in Man; the length of the thoracic part of the post-caval being as is the distance of the right auricle from the diaphragm, and also from the dorsal region: the base of the heart being further from the back as well as from the midriff than in Man.

In *Carnivora*, *Quadrumana*, and *Bimana* the blood from the head and pectoral limbs, and intercostal spaces is poured by a single precaval into the auricle. The lower intercostal veins of the left side unite to form a hemi-azygos which joins the right or main azygos vein. The plexiform disposition of the veins continues in those surrounding the myelon up to and including Man. The diploic plexuses are the networks of veins which exist in and among the cancellated tissue of the bones. In those of the cranium they form large irregular meshes of ampullated veins. These vessels are very unequal in size, are subject to dilatations, and frequently end in *culs-de-sac*. In the looser texture of the vertebral centrums a vertical section, as in fig. 428, exposes the anterior, *a*, and posterior, *b*, portions of the myelonal plexus; the transverse channel of anastomosis, *c*, with the 'sinus centri,' *d*, which bifurcates to unite with the 'vena superficialis centri,' *e*. Many veins within the cranium are included in spaces formed by the separation of the laminæ of the dura mater, and do not admit of being dilated beyond a certain size: these 'sinuses' empty themselves, in Marsupials and Ruminants and some other quadrupeds, into temporal veins, as well as into the internal jugulars; but in *Carnivora*, *Quadrumana*, and Man, almost wholly into the internal jugular vein.

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[1] ccxxxvi. vol. ii. pp. 124, 140.

[2] Ib. p. 147.

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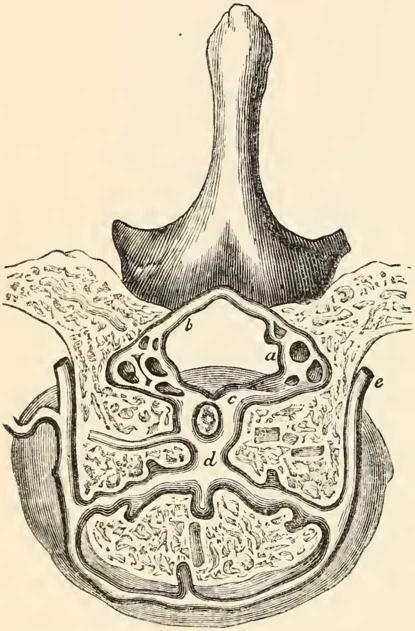
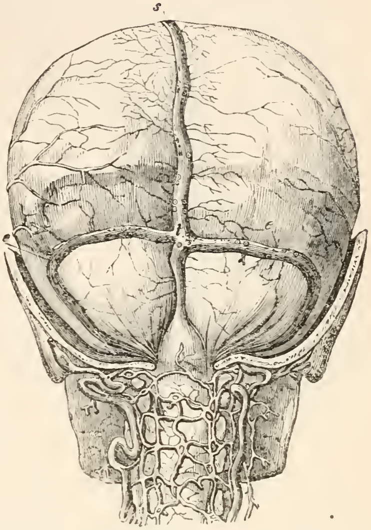


Myelonal and diploic venous plexus and sinus: Human lumbar vertebra.

In all Mammals may be found the 'superior longitudinal sinus,' fig. 429, *s*, uniting at *t*, the 'torcular Herophili' with the lateral sinuses, *e*. Besides these are the smaller 'petrosal sinuses,' superior and inferior, and the 'cavernous sinuses' which are reservoirs of venous blood on each side of the sella turcica, crossed by interlacing sclerous fibres. The cavernous sinuses communicate with each other by the 'circular sinus,' and also with the petrosal ones by the 'transverse sinus.' All the sinuses are devoid of valves, and, by their freedom of intercommunication, and hindrance to dilatation, prevent any local congestion of blood pressing upon the brain.

429



Venous sinuses of dura mater, from behind, Human.

§ 350. *Spleen of Mammalia.*—As with the absorbents, so with the bloodvessels, some change their tubular for a lacunar or cellular form in certain parts, where the blood undergoes, or receives elements of, change; such parts, resembling 'glands,' are so called, with the qualifying epithets of 'vascular' or 'ductless.' Of these 'vasoganglions' the chief is the spleen.

In Mammals this organ is relatively larger than in lower Vertebrates: it is mainly appended to the artery that supplies the pancreas, with the left end of which gland it is in close connection, and consequently lies to the left or behind the stomach, to which it is attached by the fold of peritoneum noted at p. 500. This membrane covers the whole spleen, except the 'hilus,' where its two folds support the splenic vessels and form the 'gastro-splenic' ligament. The serous tunic is less intimately adherent to the fibrous or proper capsule in most lower Mammals (Ruminants, e.g.) than in Man; where the separation only takes place at the hilus. The proper coat consists mainly, and in Man wholly, of white and yellow fibres, the former arranged in bands, the latter in an irregular network. With these are blended, in some lower Mammals (Dog, Pig, e.g.), filamentary fusiform bodies with a nucleus, fig. 430, *a*, called 'fibre-cells of unstriped muscle' in ccviii″. The fibrous tunic is reflected into the interior at the hilus, in the form of sheaths accompanying the vessels, most complete in the human spleen: from the exterior of which sheaths, and more abundantly from the inner surface of the proper capsule, are sent off white elastic 'trabecular' bands, which form a reticular bed for

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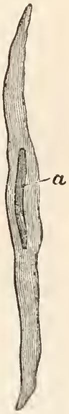

Nucleate filament or 'muscle-cell,' from tunica propria of the spleen of a dog: magnified 350 diam. ccviii″.

the proper tissue, throughout the whole organ. This tissue consists of the 'lienine' or spleen-substance and of 'splenic corpuscles.' If a portion of the trabecular tissue be treated with acetic acid, muscular fibre-cells may be seen, as at *a′*, with their nuclei *b*, intermixed with the yellow elastic fibres *c*, fig. 431. The demonstration is easiest in the most delicate plates of the trabecular tissue, especially in quadrupeds. The splenic corpuscles, fig. 432, *c*, *c*, are whitish spherical bodies imbedded in the 'lienine;' most constant and conspicuous in ruminant, equine, and some other quadrupeds; less conspicuous, or wanting, in adult human spleens, especially after lethal disease. They are elliptical, averaging one-sixth of a line in diameter, and are attached by short peduncles to splenic arterioles *a*, *b*, the peduncles being continuous with the sheaths accompanying those vessels. Treated with a little dilute alkali, the proper wall of the corpuscle, fig. 417, *a*, is rendered more distinct, and the elastic fibres of the same, *b*, may be seen, in connection with the branch of the arteriole *c*, to which it is appended. The corpuscular capsule is filled by a semi-fluid greyish mass, including nucleated corpuscles, fig. 433. They have suggested

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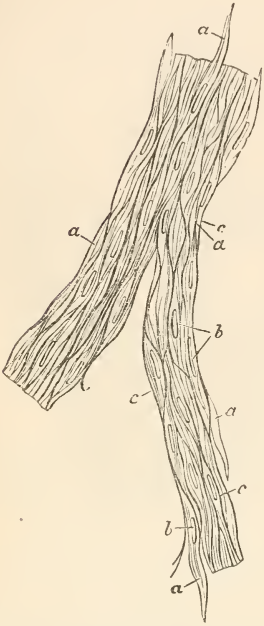

Trabecula from the spleen of a Pig: magn. 350 diam. CCVIII″.

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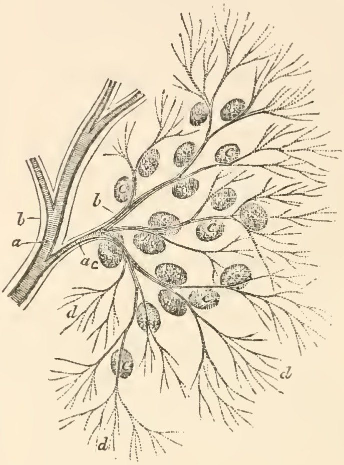

Splenic or 'Malpighian' corpuscles, on branches of an arteriole: from the spleen of the Pig, magn. 10 diam. CCVIII″.

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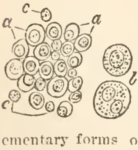

Elementary forms of substance in splenic corpuscle, Ox, magn. 350 diam. CCVIII″.

many hypotheses, their comparison, by Kölliker, to the cells in the sinuses of lymphatic ganglions, appearing to be most acceptable. The 'lienine' is a soft mass, in colour passing from reddish-brown to bright red on exposure to air, filling up all the interstices between the larger partitions and vessels. It consists of fine bloodvessels, lienine cells, delicate fibres or bands, and blood in various states. The lienine cells, fig. 434, vary in size from $\frac{3}{1000}$th to $\frac{5}{1000}$th of a line, are pale in colour, with a dark nucleus: with them are cells with smaller corpuscles, caudate corpuscles, and free nuclei; all exemplifying the size-limiting or shape-inducing property of the viscid materials, proteine and myeline, under the reaction of albumino-serous solution: fallaciously suggesting the 'continuous process of cell-growth by which new cells are formed around nuclei, and old ones disappear;'[1] as also the 'development of blood-discs within cells.'[2] The figures 433 and 434 merely exemplify some among the manifold forms under which colloid elements aggregate in definite spaces, under such influences as the spongy reservoir of the spleen affords.

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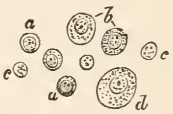

Elementary forms of substance in lienine, Ox; mag. 350 diam. CCVIII″.

The splenic artery, especially when the 'pancreatica magna' and other branches to the pancreas are not called upon to supply materials for the energetic and fitful action of that gland, must pour more blood into the splenic reservoir than is needed for the mere nutrition of the organ, and consequently the blood must there undergo change. But the spleen receives too small a proportion of the circulating mass to have any definite influence on the manufacture or general condition of blood. Such changes as are effected in the splenic locality more probably relate to the functions of the gland to which the altered blood is exclusively carried: and it is to be noted that the splenic vein is the largest of the constituent channels of the portal one.[3] The most significant fact in the Comparative Anatomy of the spleen is its correlative development with the pancreas and its reception of blood from the termination of the artery mainly supplying the pancreas in its course to the spleen.

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[1] CCVIII″. p. 781.

[2] Ib. p. 782, figs. 531, 532. These, and the figures 529, 530, represent nothing specifically distinct from the results of formifaction under similar conditions in other localities both in and out of the living body.

[3] The supply of the colouring matter of the bile from hæmatin set free in the spleen has been suggested. Extirpation of the spleen chiefly affects the biliary secretion. The condition of the spleen in *Hæmatocrya* negatives its being the seat of the manufacture of blood-corpuscles.

In the Ornithorhynchus, the spleen, fig. 308, *u*, *u*, is relatively large, and consists of two lobes bent upon each other at an acute angle: the anterior and right lobe is four inches long, the posterior and left lobe two inches and a half; the right lobe is bent upon itself. The artery of the pancreas is continued from the left end of that gland into the base of the spleen before its bifurcation. In the Echidna, besides the two lobes which are continued forwards from the left side, there is a third shorter descending appendage. The lobes are thin and moderately broad in both Monotremes. The Marsupialia repeat the bent or bilobed character of the spleen as shown in that appended to the left end of the stomach of the Phascogale, fig. 309. In the great Kangaroo (*Macropus major*) I found the main body of the spleen ten inches long, and the rectangular process six inches; both parts were narrow and thin.

In *Lissencephala* the spleen presents a more simple form, oblong, flattened, fig. 323, *l* (*Rhynchocyon*), with one end in contact, and having the usual vascular relation with the pancreas, ib. *p*. The spleen is relatively longer and narrower in the Mole and Hedgehog: it is a thin elongate body, loosely suspended, in the Squirrel, where it lies to the left of the epiploön, as in the Marmot: it follows, similarly suspended, the great curve of the stomach in the Mole-rat (*Bathyergus*), being thickest at the left and upper end: in the common Rat the spleen has an oblong triangular form: in the Vole it is broader at the lower than at the upper end: in *Capromys* it has an elongate trihedral form, broadest at the lower end: in *Lagostomus* the spleen is triangular, with the upper and anterior angle most produced.[1] It varies from the round to the oblong shape in the Porcupines and Agoutis, and occasionally a small detached spleen is added, in the epiploic suspending duplicature. Hunter notes, in the Capybara, the close resemblance of the spleen in shape to that of Man;[2] and it is less elongate than usual in the Guinea-pig. In *Leporidæ* it resumes its narrow elongated figure. In *Dasypus Peba* the spleen is elongate and three-sided; I found it 2½ inches in length; in contact with the pancreas: in *Das. 6-cinctus* the spleen is broader and flatter, and there was a small supplemental spleen in my subject.[3] In the three-toed Sloth the spleen is an inch in length, oblong, thickest at the lower end, suspended in the epiploön: in the two-toed Sloth it is almost round, flat, and thin, and closely attached to the second compartment of the stomach, but in contact with the pancreas. In some *Cetacea* the spleen is remarkable for its subdivisions; the largest in the Porpoise, fig. 354, equals a walnut, *h*; the others, to the number of four, five, or six, ib. *i, i,* are of much smaller size: in the Whales (*Balænoptera*) the spleen is, usually, single, but smaller relatively. In *Sirenia* it appears to be always undivided; presenting an oval form in the Dugong, and measuring 4½ inches in length and 1½ inch in breadth.

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[1] ccxii″. p. 176.

[2] ccxxxvi. vol. ii. p. 213.

[3] cxxviii″. pp. 143, 157.

In the Elephant the spleen is long and flat; it measured in a half-grown Indian kind 3 feet 10 inches, its extreme breadth being 8 inches.

In the Hyrax the spleen is broad, flattened, semilunar, with occasionally a narrow process from its middle, like a handle: its length is 2 inches, its breadth 1 inch. In the Rhinoceros the spleen is elongate, subtrihedral: in my male subject it measured in length 3 feet 6 inches, and 1 foot 4 inches in greatest breadth.[1] The spleen is elongate, and flattened in the Horse, broadest at the upper end. In the Wart-hog (*Phacochœrus*) the spleen is a long flattened ellipsoid body, 11 inches in length, and 2½ inches across its broadest part, which is at the middle.[2] The spleen has a similar form in the Babyroussa (*Sus Babyrussa*): in the common Hog it is elongate and trihedral. The spleen is elongate and flattened in all Ruminants; the inner edge is sometimes attached to the crura of the diaphragm: it is broader, at one end, in the Cow, Reindeer, and Giraffe, than in other Ruminants. In one Giraffe the spleen was 10 inches long, and 7½ inches broad: in another of the same stature it was 9 inches long, and 5 inches broad: in both of an oval form, and not more than 1⅔ inches at the thickest part.[3]

If a spleen be injected with alcohol and hardened therein previous to section, the intertrabecular spaces are seen to be larger in *Ungulata* than in *Carnivora*. In the Horse such spaces are then seen to intercommunicate by circular apertures.

In a Seal (*Phoca vitulina*) I found the spleen a flattened body with an irregular notched margin, measured 5½ inches in length. It was attached to the epiploön in such a manner that it could be drawn away for some distance from the stomach, and in the intervening membrane were situated a number of small dark glandular bodies from the size of a horse-bean to that of a pea, resembling the omental splenules in the Porpoise: these were not found in a second specimen.

In a setter-dog the spleen was oblong, 10 inches long by 3 inches at the broadest part: its serous coat, as in most quadrupeds, is derived from both layers of the epiploön, which are reflected from one margin to the stomach, and by the opposite to the dorsal abdominal walls. In the Felines the spleen commonly presents an elongate trihedral form, attached to the stomach by the duplicature extended from the angle formed by the meeting of the two lesser sides.

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[1] v″. p. 44.
[2] ccxiii″. p. 68.
[3] xcvii″. p. 228.

In the Aye-aye the spleen is an elongate, trihedral body, bent at nearly a right angle upon itself, the lower portion being nearly half the length of the upper one; it is suspended in the epiploön at the left and lower curve of the stomach. The spleen presents a like shape and position in the Lemurs: but is less bent in *Lemur Mongoz.* The spleen is elongate and straight in Platyrhine Monkeys; it becomes broader and thicker in Catarhines: it shows a subtriangular form in the Baboon (*Papio porcarius*), where one angle is attached to the stomach, another to the kidney, and a third projects freely into the epiploön: in tailless Apes the spleen more resembles in shape, attachments, and in the source of its serous investment, that of Man.

The loose nature of the suspension of the spleen somewhat affects the value of the remarks on its various positions in Mammalia, given in XII. tom. iv. pl. ii. p. 617, where it is said to be near the pyloric end of the stomach in a Nyctinome and a Noctilio, a Phyllostome and a Megaderm among Bats, while in other species of these genera it was found nearer the cardia: in a *Vespertilio* and *Rhinolophus* it was observed to be bent round the great curvature of the stomach. In *Pteropus* and *Galeopithecus* the spleen retains its common position applied to the cardia: it is relatively smaller in frugivorous than in insectivorous and sanguivorous Bats, but is generally long and narrow: it is triangular in *Galeopithecus.* In *Insectivora* the spleen is loosely suspended in the epiploön from the cardiac cul-de-sac; it is relatively largest in the more carnivorous of the order, e.g., the Tenrecs.

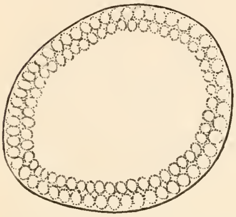
The spleen is larger in the omnivorous and quasi-carnivorous Rodents, e.g., the Rats, than in the vegetarian majority of the order: it is relatively larger in *Carnivora* than in *Ungulata.* The amount of hydro-carbonates to be eliminated by the liver would seem to influence the capacity of the alterative receptacle of the great proportion of the blood which is supplied to the bile-making organ. With reference to the hypothesis of sanguifaction it may be remarked that in no Mammalian order is the mass of blood so great, or so full of blood-discs, as in the *Cetacea*; yet in them the spleen has its least relative size.

§ 351. *Thyroid of Mammalia.*—The representative beginnings of the vasoganglion commonly known as the 'thyroid gland' are noticed in vol. i. p. 564 (Fishes, Reptiles), and in vol. ii. p. 230 (Birds): but this organ is recognisable, without ambiguity, only in the present class. Here it is locally related to the windpipe, and has received its name from its proximity to the shield-shaped cartilage of the larynx in the human subject. It consists of a pair of oblong, rounded masses; in some, especially higher gyrencephalous Mammals, united as in Man by a transverse band of like substance crossing the sternal aspect of the air-tube.

The proper tunic of the thyroid is a thin layer of condensed areolar tissue, from the inner surface of which proceed septal or trabecular processes, partitioning its substance into lobules, and ultimately into minute bags of vesicles. The analogy to the structure of the spleen is close, but the frame-work is much less dense and fibrous: and the vesicular structure, instead of receiving the blood directly, is filled with a solution of fibro-albuminoid, proteine, or myeline substance derived therefrom. The quantity of blood sent to the thyroid is much more than would be needed for mere nutrition: it is derived from arteries, not constantly rising just beyond the points where the arteries to the brain are given off from the large trunks, but varying according as the length of the neck in Mammals may affect the relative position of the thyroid to those trunks: thus in the Giraffe and most Ungulates the arteries supplying the thyroids come off from the contiguous part of the carotids. There may be two or three branches from the common carotid (*Lutra*); and the distinction between 'lower thyroid arteries' from the subclavian, and 'upper thyroid arteries' from the ectocarotid, hardly begins to be established before the Quadrumanous order is reached. The ultimate ramifications of these arteries form close-meshed plexuses upon the limitary membrane or capsule of the vesicles; such capillaries present a diameter of from $\frac{1}{2000}$th to $\frac{1}{3000}$th of an inch. The blood is returned by veins joining in most Mammals the external jugular; and in *Quadrumana* and Man the internal jugular: but with varieties in this respect.

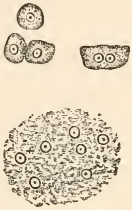
The effect of 'formifaction,' or assumption of shape and definable size, by the 'colloid,' 'proteine,' or 'myeline' elements of the solution filling the thyroid vesicles, is shown in the sections of such from the Hedgehog, fig. 435, and the Bullock, fig. 437, and in portions of such lining, or adherent formed matter, from the thyroid vesicles of a Rabbit, fig. 436. In these instances the forms have been described as ‘an epithelial stratum, consisting usually of nuclei set closely together in a scanty basis substance, fig. 435, which is either feebly granular or of a somewhat oily aspect:’ ‘their nucleoli are not always visible, and vary in number from one to four or five. The nuclei are always vesicular, bounded by a strongly marked envelope, and have a mean diameter of $\frac{1}{3000}$th inch.’[1] But the formed lining substance often presents, as in figs. 435 and 437, the condition of delicate vesicles, without nucleus, with contents mostly pellucid, sometimes faintly granular. Dr. Jones observes:—‘I am inclined to believe that they originate in the nuclei, which undergo a kind of expansion, at the same time losing their nucleoli.’ Emancipating himself for a moment from the ‘generative’ theory in reference to the ‘progress of the nucleus from its primitive condition to a further stage of cell-development,’ he candidly admits it to be ‘worth remarking that it’ (the stage) ‘may be artificially produced by adding to the specimen some coagulating reagent, which speedily solidifies a film of albuminous plasma around the nuclei, and thus produces very good imitations of cells.’[2]

435



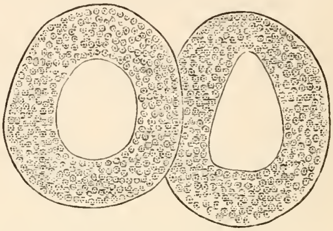
Formified proteine, lining a vesicle of the thyroid, Hedgehog. CCCXXIX.

436



Ib. Rabbit

437



Formified proteine, lining thyroid vesicles, Bullock. CCCXXIX.

Analyses of the contents of the thyroid have shown or rendered it very probable that they are albuminoid, yet not in the state of ordinary fluid albumen, and that gelatine is sometimes an ingredient: among the salts are chloride of sodium and a trace of alkaline sulphate: crystals of triple phosphate and of oxalate of lime occur in the cavities.[3]

In the *Ornithorhynchus* two bodies, extending between the scapula and humerus, covered by the panniculus carnosus and the trapezius, present a reddish colour, a lobulated structure, and pretty firm texture, and seem to represent the thyroids. These are in more constant relation to the windpipe, in Marsupials: they are two disunited bodies in the Dasyures; each presenting the size of a horse-bean in the *Das. macrurus.* They were of the same size in a *Phalangista fuliginosa*, but were united by a filamentary strip passing between their lower extremity, across the first tracheal ring. In the Wombat I found two elongated thyroid bodies of a dark colour reaching from the thyroid cartilage to the seventh tracheal ring on each side. In the Koala they were situated lower down, extending from the fourth to the ninth or tenth tracheal ring.

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[1] CCLXXIX. p. 1104.

[2] Ib. p. 1105. For the conditions and degree in which this and most other phenomena of so-called ‘cell-development’ may be artificially manifested, see CCIX″ and CCX″, especially the latter important contribution to the philosophy of physiology.

[3] CCLXIX. p. 1106.

The thyroid is relatively small in the Kangaroo. It presents more normal proportions in Rodents, but is connected by very lax areolar tissue to the trachea. Each body is elongate and almost cylindrical, but expanding at the lower end, where they are joined by a thin band, in the Hare and Rabbit. The uniting band is thicker and rounded in Rats and Marmots; but appears to be wanting in *Geomys* and *Bathyergus.* The thyroid bodies are commonly ununited in *Cheiroptera.* They lie, similarly detached, but low down, opposite the sixth and seventh tracheal rings, in the Elephant. They are also separate and more remote from the larynx in *Delphinidæ.* Cuvier notes them as rounded and separate in the *Hyrax.*[1] In the Rhinoceros I found them joined together by a very thin and narrow strip continued between their hinder ends, obliquely across the trachea. Each body was elongate, subtriangular, extending from the sides of the larynx to the fourth tracheal ring, and diminishing as they descended: a small compact yellow body was attached to the thyroid at the point of emergence of the vein. In the Horse, also, I find the thyroids connected by a slender band crossing the second tracheal ring:[2] each body is egg-shaped and united about one-third from the lower end. The thyroids are relatively smaller in the Ass, but are similarly united to each other.

In the Llamas (*Auchenia*) the thyroids are oval, with the great end downward, extending from the side of the thyroid cartilage to the third tracheal ring, where they are connected together by a filamentary band: this band is relatively broader in the true Ruminants, in most of which the thyroids have a more elongate form. In Bears the thyroids are joined by a long slender band at their lower ends. In Felines the uniting band appears to become longer and more slender by age, and sometimes disappears. Cuvier notes three distinct connecting bands in a Civet-cat,[1] and two such bands in a Marmoset monkey. In the Aye-aye the thyroid bodies, elongate, triangular, and flattened, lie upon the sides of the second to the seventh tracheal rings inclusive, and are devoid of connecting transverse strip.[2] In most *Quadrumana* the thyroids are united, but by a longer and narrower band or 'isthmus' than in Man. In him the thyroid bodies are not only relatively large, but are united by an 'isthmus' so broad as to usually extend across two or more upper rings of the trachea; moreover, a process extends from the upper part of the isthmus, as the 'pyramid' or 'mesial column,' which in some subjects reaches to the hyoid bone. Many varieties have been noted in the human thyroid. Sometimes the isthmus is absent, as normally in certain lower Mammalia; and sometimes there is more than one pyramidal or ascending process.

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[1] I regret that I omitted to note the condition of the thyroid in CLIII".

[2] Cuvier describes them as 'entièrement séparés, et situés bien au-dessous du larynx.' XII. tom. viii. p. 677.

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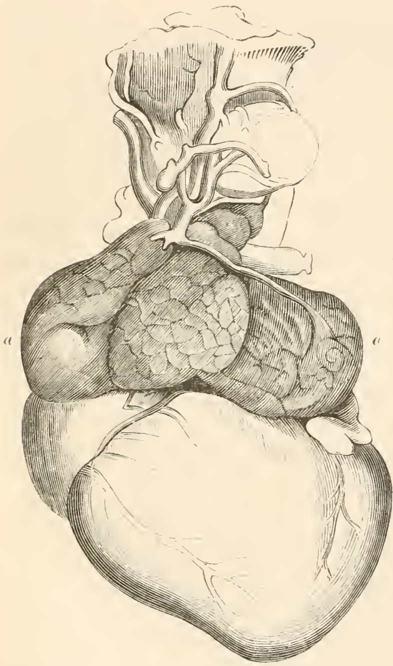

Thymus and heart of child at birth. ccxvi″.

§ 352. *Thymus.*—This body is distinguished from the thyroid by its wide central cavity, and by its diminution of volume or disappearance after early age. In the Human subject, e.g., at birth the thymus, fig. 438, *a, a,* may weigh 240 grains, and increase to 270 grains in the infant of one year; but, with the development and exercise of the muscular system, it wastes away, and may be reduced at twenty-one years of age to a remnant weighing only forty grains. After twenty-five it is rare, or difficult, to discover any of its structure left in the areolar tissue of the mediastinum. At birth the bulk of the gland lies behind the manubrium, descending to near the middle of the sternum, and ascending upon the fore and lateral parts of the trachea to the thyroid. By dissection the thymus can be separated into two lateral portions, which are naturally distinct at an earlier phase of development; each lateral part being a narrow elongated body, folded upon itself, and further resolvable into lobules and acini, like those of a true conglomerate gland: but all the acinal cavities communicate with a central reservoir, fig. 439, occupied by a milk-like solution of albuminoid or proteine principles. Formifaction here produces 'corpuscles, very closely resembling (in fact identical with) the nuclei of glandular cells;'[1] but presenting more numerous nucleoli: their form being for the most part spherical. 'Mingled with these I have found in the thymus of a Calf, as well as in that of a young Guinea-pig, a few larger corpuscles, about double the size of the former, of spherical form, filled either with a granular matter alone, or containing also a nucleus, or larger vesicular body.'[2]

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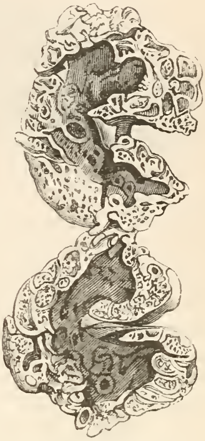
[1] xii. tom. viii, p. 675.

[2] cii′. p. 44. Peters confirms this, in ccxiii″. p. 95, Taf. 4, fig. 5, *gl*.

439



Section of Thymus, showing the central reservoir. CCXVI″.

The thymus in Monotremes lies between the episternum and the beginnings of the vessels from the aortic arch. In a Kangaroo from the pouch Simon found the thymus on the pericardium with a medial lobe besides the two lateral ones.[3] In Rodents the thymus consists of two long lobes extending from the base of the heart, parallel with each other, forward, to the root of the neck. Bodies extending from this position to the posterior mediastinum and forward along the cervical vessels to near the mandible, but consisting, according to Simon, of aggregates of fat-vesicles, undergo periodical increase, in the Marmots, prior to hibernation. In a Bat dissected in March, Dr. H. Jones could not detect any certain homologue of a thymus; but found on each side of the root of the neck a yellowish lobulated mass consisting of conical lobes defined by limitary membrane: the lobes were hollow and 'filled by aggregations of celloid particles, which were not manifestly nucleated, nor provided with an envelope,[4] but consisted of aggregations of oil-drops and molecules. In the subjoined view, fig. 440, of a portion of this body, magnified, only the peripheral row was visible, the rest of the mass being opaque. In terrestrial *Insectivora* the thymus is less ambiguous, and consists of two nearly equal lobes lying on the base of the heart and beginnings of the great vessels. In the Hedgehog were found 'two roundish masses almost precisely similar to those in the same situation in the Bat, and two broader and thinner ones lying in the axilla.'[1] 'The celloid particles were more loaded with oil than in the Bat, and in some parts they were more or less broken up and the oily matter diffused in the cavity.'[2] In both cases these lobulated masses may be well-marked modifications of the adipose tissue. In *Cetacea* a thymus has been recognised in *Balæna mysticetus,* the right lobe extending over the aortic arch to the trachea, where it terminates in two small cornua, the left lobe being of smaller size. 'In the fœtal Dolphin these are two large median portions, pericardiac and tracheal, with deep-seated lateral cornua.'[3] In a fœtal Elephant the thymus is a flat mass beneath the anterior part of the pericardium, with a short forward prolongation of the right lobe. In the Rhinoceros the thymus holds a like position, and encroaches but a little way upon the neck. In the Artiodactyles, whether ruminant (Ox, Deer) or non-ruminant (Peccari), the cervical portions of the thymus are more developed, often extending to the mandibular angles. The thymus of the Calf is very large and affords a good subject for investigating the structure of this body. In *Carnivora* the thymus has the usual position in the thorax, to which it is limited; it soon shrinks, and in Felines disappears. At its fullest phase of development in the Cat, the thymus is thick from before backward, and its right and left lobes closely interdigitate. In a young Seal, Simon found it in two symmetrical, broad, thickish lobes, extending to the root of the neck, and 'abruptly terminated by clubbed extremities, which are deeply grooved in front by the left vena innominata.'[4] In most *Quadrumana,* especially the Catarhine group, the thymus presents the same general shape and relations as in the human subject.

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[1] CCXIV″. p. 1093. [2] Ib. [3] CCXV″. [4] CCXIV″. p. 1096.

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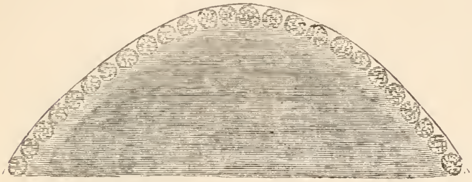

Convexity of lobe of cervical thymus-like body, Bat. XCIV″.

§ 253. *Adrenals.*—These bodies are best developed in Mammalia; and, in the Bimanous order, they repeat, though in a minor degree, the relation of largest relative size to the immature period. They are subtriangular, flattened, with their base excavated and resting, in Man, upon the upper end of the kidney, whence they have been termed 'supra-renal capsules:' in lower Mammals they are more commonly mesiad of the upper end of the kidney, and not always in contact therewith: at the base of the part is a fissure giving issue to the large adrenal vein. The substance of the body is distinguished by, usually conspicuous, differences of colour into 'cortical' and 'medullary;' the former, in Man, being yellowish-brown, the latter reddish-brown: the cortical substance is also firmer than the medullary, which receives more blood, and appears soon to dissolve after death, occasioning the cavity there usually found. The proper areolar capsule sends incurved processes, localising the tissue into lobes and lobules: the ultimate texture of the cortical substance being minutely vesicular, the vesicles varying in size, but affecting an arrangement in rows. The vesicles are smallest at the limits of the medullary substance, and here inclose spaces in which the usual results of formifaction more especially are met with; such as fine granules, globules, nuclei, and nuclear structures, affording ample ground for misinterpretation as 'transitions to cell-development' and 'metamorphosis to the cell-form,' &c.

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[1] CCXIV″. p. 1096. [2] Ib. [3] CCXV″. [4] Ib.

Ecker has delineated some of the evidences of size-limiting, form-giving forces, analogous to those of crystallisation, in fig. 441, where *a* is a 'nucleus,' *b* 'nucleus enwrapped in a fine granular mass,' *c* 'cell,' *d* 'nuclear vesicle of an embryo,' *e* 'two gland-vesicles with their contents.' With these are mixed oil-globules; in greater abundance in the adrenals of *Lissencephala* and *Carnivora* than in those of Man, and more or less obscuring the 'nuclei' and 'gland-vesicles.' These, in the Horse, are smaller and more spherical at the periphery, larger and more oval toward the centre, of the cortical substance, there offering the linear arrangement. Gland-vesicles also occur in the medullary substance of the Horse's adrenals. In the Ox the trabecular tissue of the cortical substance defining the lobules is firm and well-marked: the fatty globules are fewer than in Man. The gland-vesicles are distinct in the adrenals of the Hedgehog. In

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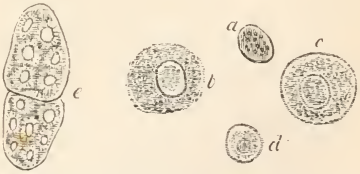
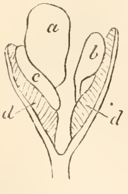


Forms assumed by proteine matters, in solution within the cellular spaces of the adrenal; Man CCLXXXVII.

the Mole the adrenals have the form of a three-sided pyramid. In the Coypu they are long and rounded, of a greyish-yellow externally; their medullary structure like soft liver. Their length was one inch: their situation mesiad of the upper extremity of each kidney. They have a similar cylindrical figure, and large relative size in the Porcupine and many other Rodents: they are shorter in the *Muridæ*; are roundish and somewhat flattened in *Leporidæ*. In a young Sloth I found the adrenal surpassing the kidney in size, and showing distinctly the cortical and medullary substances. In the *Cetacea* there is an interesting analogy between the adrenal, in regard to its lobulated exterior, and the multilobate kidney. In the Elephant the adrenal is a depressed cone, with the base bilobed. In the Rhinoceros the adrenal bodies, like the kidneys, differed from each other in form; they were elongated and nearly cylindrical. The right had one extremity bent at a right angle: its length in a female Rhinoceros was three and a half inches; its breadth across the bent extremity two inches: the left was simply elongated, three and a half inches long, one and a half broad, and one inch thick. In section they presented an external greyish-yellow fibrous cortex, from one-fourth to one-third of an inch thick, enclosing a fleshy-coloured substance, in the middle of which there was a semilunar portion of the grey fibrous matter: there was no trace of a central cavity. Both suprarenal bodies adhered closely to the contiguous large veins.[1] In the Horse the adrenals are flattened and triangular. In the Ox they somewhat resemble the kidney itself in shape: in the Reindeer they are a full oval: in the Sheep they are more elongate. In the Seal, as in the Whale, they resemble the kidney in their finely lobulate exterior: in the Dog they are longish and cylindrical: in the Cat roundish and somewhat flattened. In the Aye-aye the adrenals are subtriangular, elongate, depressed, and relatively larger than in the higher *Quadrumana*, in which the adrenals progressively approach the shape and proportions presented in the human subject.

442



Urogenital organs. from Human embryo, eight lines long. CCXVII''.

In the fœtus the adrenal, like the kidney, shows a lobulated exterior: at an early period of the development of these bodies the adrenal, fig. 442, *a*, exceeds the kidney, *b*, in size: both are preceded by the deciduous or Wolffian kidneys, *d*, *d*. In the embryo of the twelfth week the kidneys and adrenals are of equal size: in the sixth month the kidneys have gained in weight so as to be as five to two: and at birth they are as three to one: after this time the adrenals diminish so as in the adult to be only $\frac{1}{28}$th the size of the kidney. Occasionally they entirely waste away.

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[1] CII''. p. 45, pl. XII, fig. 1, *n*, *n*.

The large proportional supply of nerves to the mammalian adrenals from the contiguous plexuses (cœliac and renal) of the sympathetic system is worthy of note.

CHAPTER XXXIII.

RESPIRATORY SYSTEM OF MAMMALIA.

§354. *Lungs of Mammalia.*—The class-characteristic afforded by these organs is defined in vol. ii. p. 266, and exemplified in fig. 139, ib. In all Mammals each lung, ib. *lg*, is conical, with the base resting upon the diaphragm, ib. *d*, and the apex reaching to the root of the neck: the shape, and especially the degree of subdivision, of the pulmonary cone offer many varieties in the class. The most common quadrupedal difference from the bimanal type is the lobe, called 'azygos' or 'impar,' detached from the right lung to occupy the space between the heart and diaphragm, as at *n*, fig. 308 (*Ornithorhynchus*). The outer surface of the lung is smooth, being covered by a serous membrane, reflected from the great blood- and air-vessels forming its 'root' upon the walls of the thorax; thus constituting a shut sac, called 'pleural,' distinct from that of the opposite lung. The portions of the pleuræ passing respectively from the pulmonary roots to the back and fore parts of the thoracic cavity, are called 'mediastinal,' and intercept the pericardium, great vessels, thymus, gullet, and other parts intervening between the two lungs: the regions of such thoracic septum being defined, in Anthropotomy, as 'anterior,' 'posterior,' and 'middle mediastina.' The pleural serous sacs are peculiar to *Mammalia*: they facilitate the movements of the lung upon the thoracic walls during respiration.

The wind-pipe bifurcates to supply each lung, fig. 418, P, P·, with air, as does the pulmonary artery conveying the blood to be affected thereby; the pulmonary veins, ib. *p*, return the blood so changed to the heart. Besides these three main constituents of the 'root' of the lung, it includes the 'bronchial' or nutritive arteries and veins, absorbents and nerves, with their connective tissue, and the enveloping pleural sheath. Beneath the serous covering of the lung is a layer of combined areolar and elastic tissues, the latter predominating in the denser 'sub-serous' coat of the lungs of the larger carnivorous and ungulate mammals: in Cetacea the smooth contractile fibre is therewith intermixed.

The trachea is kept patent by cartilaginous hoops, the ends of which, in most mammals, do not coalesce, but either overlap, meet, or, more commonly, fail to meet by about one-fourth, or less, of their circumference, fig. 453, *b*. The slit or interval, which is usually at the back, or gular surface, of the windpipe, is completed by a musculo-membranous sheet. The hoops themselves are connected together by a strong elastic membrane occupying their intervals and also extended over both their outer and inner surfaces. The entire tube is invested by loose areolar tissue, and is lined by a mucous membrane with a ciliated free surface.

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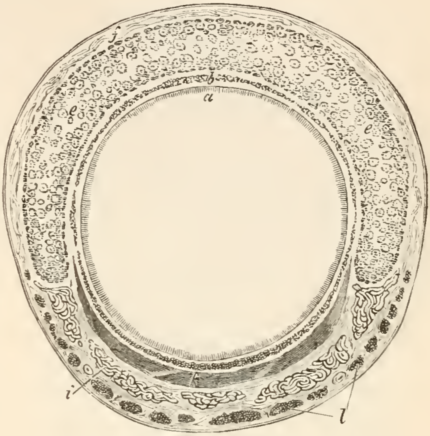

Transverse section of trachea through a cartilaginous hoop, *e*. CCLXVIII.

The tracheal cartilage, fig. 443, *e*, consists of a fibrous basis, charged with nucleate cells. Unstriped muscular fibres extend between the ends of the hoop, having their attachment to the inner surface, some short way from the end itself, as at *k*, fig. 443, others pass obliquely between contiguous hoops. On the inner surface of the tracheal cartilages and muscles is a stratum of elastic, chiefly longitudinal, fibres, ib. *i*: their fasciculi are most conspicuous, extending in a serpentine course along the back part of the tube. The mucous membrane consists of a basilemma, fig. 444, *a*, and of finer areolar tissue, *b*, forming a bed of numerous nucleate cells, *c*, *d*, the innermost, *e*, or those next the inner surface of the air-tube, being clavate, and supporting on their base, each from about twenty to fifty vibratile cilia, so acting as to direct throat-ward the matters with which they are in contact. The mucus lubricating the ciliate surface and entangling any foreign particles admitted with the air, is the secretion of small, for the

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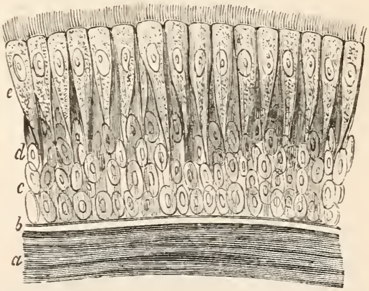

Section of tracheal ciliate mucous membrane, magn CCLXVIII.

most part racemose, glands, most conspicuous at the gular part of the wall, fig. 443, *l*, with longish ducts opening upon the ciliate surface. The trachea bifurcates into the ‘bronchi,’ which, before they penetrate their respective lung, resemble their trunk-tube in structure: after penetration, or when ‘intra-pulmonary,’ the incomplete hooped form of cartilage is exchanged for a series of irregular curved pieces, expanded so as to encase the whole circumference of the several bronchial ramifications to near the terminal ones, where the cartilages become thinner, smaller, more remote from one another, and ultimately cease; when the fibro-membranous walls owe their patency to the expansive force of the contained air. The muscular fibres affect, for the most part, a circular disposition, but some run along the bronchial ramifications, thus serving both to contract the area and diminish the length of the tube. With the longitudinal muscle are blended elastic fibres, and in large proportion in the terminal branches, fig. 447, *a*, *a*: the transverse muscles, ib. *b*, *c*, have no terminal tendons as in the trachea.

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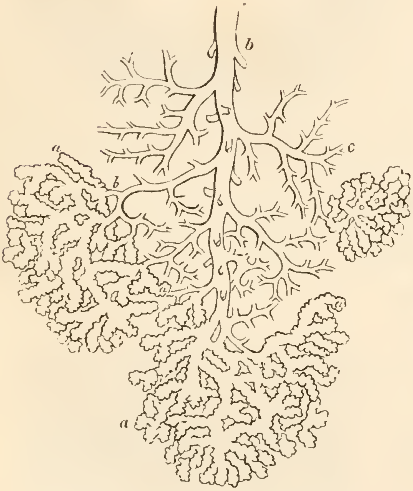

Transition of ultimate bronchial branches, *b*, into intercellular passages, *a*. CCLXVIII.

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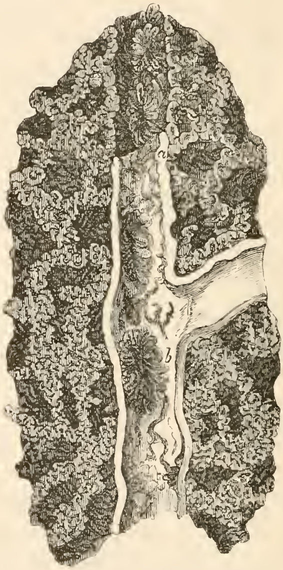

Section of terminal bronchial tube: magn. XLV′.

The ultimate portions of lung to which the bronchi are distributed are called ‘lobules,’ on entering which, as in fig. 445, the air-tube divides and subdivides, its branches diverging at less and less acute angles; and, after the fourth or further division, according to the size of the lobule, they maintain an ultimate diameter of about $\frac{1}{40}$th of an inch: then the cylindrical form is lost, and the air-tube becomes an intercellular passage, beset with dilatations, or ‘air-cells,’ aggregated at the periphery of the lobule into groups. The ciliate mucous membrane terminates abruptly, where the bronchial tube becomes, as at *a* and *b*, fig. 446, an intercellular passage; but formifaction shows its results, as ‘nuclei’ and ‘pavement cells’ upon the free surface of the air-cells. The intercellular passages intercommunicate, as in fig. 445, *a*, the bronchial ramifications, ib. *b*, *c*, do not: in fig. 446 is shown the abrupt transition from the terminal bronchial tube, *a*, to the intercellular passage, with its appended air-cells, *b*, *e*.

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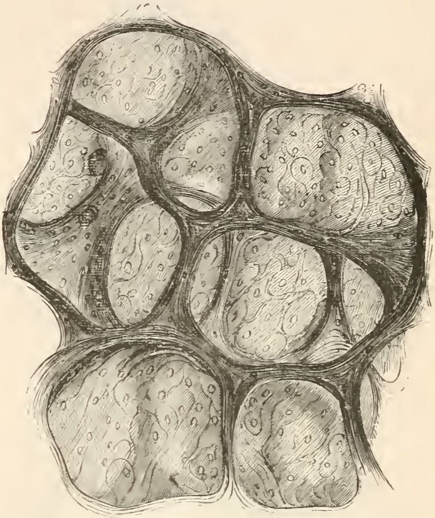

Pulmonary cells, showing trabecular’ fibres, and epithelia precipitate: magn. CCLXVIII″.

The openings of the air-cells are strengthened or defined by fibres of yellow elastic tissue, fig. 447, minute filaments of which have been traced over the wall of the cell. The branches of the pulmonary artery accompany those of the bronchi to the intercellular passages, as at fig. 448, *a*, and are there resolved into the arterioles, *b*, *b*, encompassing the orifices of the air-cells, where they pass into the capillary network, *d*, *e*; whence the aerated or arterialised blood is received into the beginning of the pulmonary vein *c*.

On a general comparison of the lung-structure in the two warm-blooded classes, it may be affirmed, of mammals, that the secondary and tertiary bronchi, instead of a ‘central’ hold a ‘peripheral’ course; have arborescent, not pinnatifid divisions; and more gradually decrease in size: moreover they terminate in cells on the parietes of which the pulmonary capillaries offer only one side to the respiratory medium, instead of being wholly immersed in the extrabronchial air, as in birds.

In the Ornithorhynchus the tracheal tube, fig. 308, *m*, is wide;

the cartilaginous rings, fifteen in number, are broad, entire, and slightly overlap each other: the bronchial annuli are bony, and are continued of that texture through a great part of the lungs. The right lung is divided into three lobes, of which the smallest, ib. *n*, fills the interspace between the heart and diaphragm: the left lung, *o*, is undivided.

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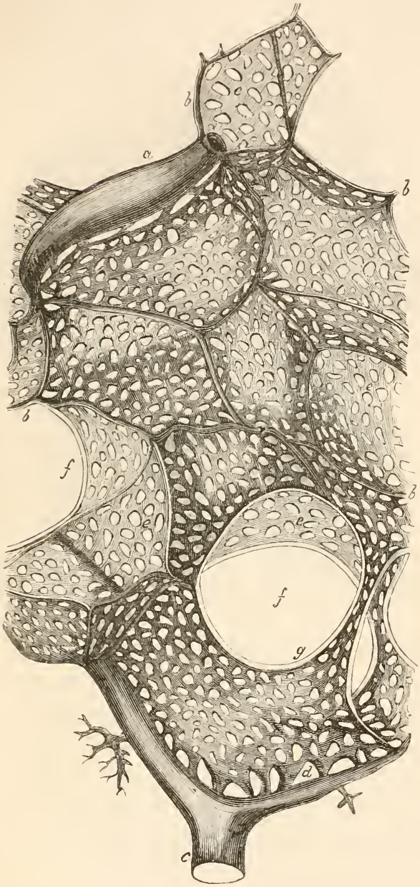

Capillaries of the air-cells; lung of Cow; magn. CCLXVIII.

In the Echidna the trachea is narrower: there are twenty-two tracheal hoops, which are disunited behind; very firm cartilaginous annuli are continued along the larger branches of the bronchus for some way into the lung.

In the condition and structure of the respiratory organs all the marsupial species adhere to the mammalian type; the only tendency to the Ovipara is in the entireness of the tracheal rings in certain species. In the *Phalangista fuliginosa*, where I counted twenty-nine rings, the first four-and-twenty were entire; below these they were divided posteriorly, the interspace growing wider to the twenty-ninth ring. In the *Dasyurus macrurus* the rings of the trachea are twenty-three in number, and are incomplete or rather ununited behind. In the *Perameles* the tracheal rings are divided posteriorly by a fissure. The lungs in the Wombat consist of a single lobe on both the right and left sides, with a small lobulus 'impar' extending from the right lung to the interspace between the heart and diaphragm. In *Macropus major* the right lung has two notches on the anterior margin, the left lung is undivided. In *Macropus Parryi* both lungs had one or two notches. In another Kangaroo I found the right lung divided into four lobes, the left into two. The azygos lobe is large in consequence of the length of the chest in the Kangaroos, and the distance of the heart from the diaphragm: it is three-sided, one side convex, the second concave and applied to the pericardium, the third side concave, and in contact with the diaphragm. In the Potoroo the left lung is unilobate with a fissure on the anterior or upper edge; the right lung has two or three deep fissures; the azygos lobe is elongated, pointed, and trihedral, as in the Kangaroo. In the Petaurists and Phalangers the right lung is trilobate, the left bilobate; there is also a lobulus azygos. The Koala has the lungs similarly divided, and not simple as in the Wombat. In the Opossums, Dasyures, and Perameles the right lung is usually trilobate (bilobate in *Didelphys brachyura*), and with the usual azygous appendage: the left lung is commonly divided into two, but is sometimes entire, as in the *Perameles* and *Didelph. brachyura*. In all the marsupials the right lung is the largest, owing to the oblique inclination of the heart to the left side.

In the order *Rodentia* a tracheal structure, recalling the early division of the tube in Reptiles, is present in the Cape Jerboa (*Helamys*): the windpipe is divided a little beyond the larynx into two canals by a median septum, as if the bronchi there began, and were continued, adhering, some way before diverging to the lungs. In the Coipu (*Myopotamus*) the extrapulmonary bronchi are each one-third the length of the undivided trachea. The right lung has four lobes, the left three: the same division obtains in *Dasyprocta*: in *Cœlogenys* the lungs have been seen to be still more divided. In *Orycterus capensis* the left lung is undivided, the right has four lobes. In the Water Vole (*Arvicola*) the left lung has two lobes, the right four. In the Porcupine the right lung has four lobes besides the azygous lobule. In the Hare the right lung has four lobes, the left two.

The thoracic cavity and the lungs are comparatively large in the Mole: in this Insectivore, as in the Hedgehog and Shrews, the right lung has four lobes, the left one lobe: in the Chrysochlore the left lung has two lobes. In true Bats the lungs are large, and with one or two shallow fissures: in *Pteropus* the right lung has three lobes, the lower one extending to the place of the azygous lobule; the left lung is bilobate: in this genus, as in *Galeopithecus*, a few upper rings of the trachea are entire, fig. 460: the ends of the slit ones meet behind.

In *Dasypus Peba* the right lung has three lobes, the left two:

in *Dasypus* 6-*cinctus* both lungs have three lobes: the azygous lobule is represented in all Armadillos by a small process of the right lowest lobe. A repetition of a reptilian character of trachea is again manifested in the Lissencephalous group by the Ai, the windpipe being convoluted, as in the Crocodiles (vol. i. p. 530). The trachea, fig. 449, *a*, goes along the right of the descending aorta to the diaphragm; then abruptly bends upon itself, *b*, and returns anterior to the first part to *e*, and again bends downward and forward, a short way before dividing into the bronchi, of which the right is shown at *h*. The right lung, *d*, gives off a small azygous lobe, *f*; the left lung, *g*, is undivided. In the Unau (*Bradypus didactylus*) the azygous lobule is almost obsolete, and both lungs are undivided.

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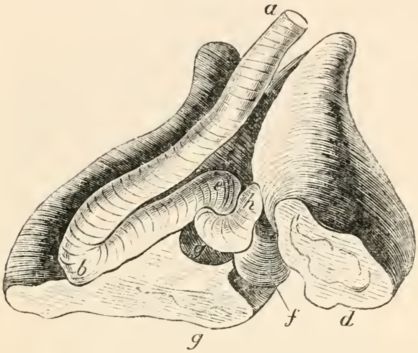

Lungs, from behind, with convolution of trachea, *Bradypus tridactylus*. CXXII'.

The chest and abdomen are more nearly coextensive lengthwise in *Cetacea* than in any other Mammals, and the lungs extend far back: they are flattened, broad, and pointed anteriorly; not divided into lobes: their tissue is highly elastic, 'so as to squeeze out any air that may be thrown into them, and to become almost at once a solid mass.'[1] The cartilaginous rings of the trachea, at least near the termination of the tube, are entire; where not so the deficiency is at their fore part, and this is considerable in the upper tracheal rings, in *Balænidæ*: the windpipe is very short in all Cetacea; its width is great in proportion to its length, but not to the bulk of the lungs or of the body. The rings of the bronchi are more rounded than flattened, and are continued to their extreme ramifications. The pulmonary cells are relatively smaller than in quadrupeds, and the extent and degree of intercommunication of the non-ciliate intercellular passages are such as that, 'by blowing into one branch of the trachea, not only the part to which it immediately goes, but the whole lungs are filled.'[2] Great force being required to expand the chest in the dense medium of sea-water, especially when it is to be filled with the rarer atmosphere, the inspiratory muscles, and especially the diaphragm, are very strong. The yellow fibres of the elastic tissue are abundant and conspicuous on the walls of the pulmonary air-cells in the Whales, as shown by V. der Kolk, in *Balænoptera*, fig. 450, *a*, *b*; in which figure a portion of the injected capillary web is represented at *c*. The elasticity of the lungs with the pressure on the surface of the body, makes expiration very easy, and the current strong when force is exerted, as e. g., to clear the naso-palatine breathing passages, fig. 297, *f*, *d*: the pulmonary vapour so expelled mainly forms the 'spout' of the Whale.

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[1] XCIV. p. 369.

[2] Ib. p. 369.

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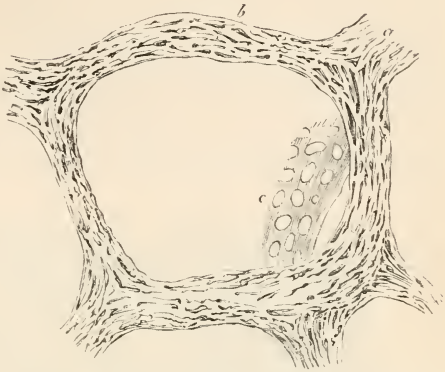

Elastic tissue of air-cells, magn. *Balænoptera*. CCLXVIII.

In *Sirenia* the lungs resemble in shape and position those of *Chelone*, but are loosely suspended at the back part of an elongated thorax, defined by an oblique diaphragm from the abdomen. This resemblance is further exemplified in the shortness of the trachea, the completeness of its cartilaginous rings, the length of the bronchi, and the extent to which their cartilages are continued into the substance of the lungs. These are convex on the dorsal aspect, flattened on the opposite surface along which the principal branches of the bronchi can be seen through the pleura pulmonalis. The fore end of each lung is thick and obtuse but narrow: they soon become flattened as they recede and broaden. In the Manatee their anterior or outer margin is crenately notched.

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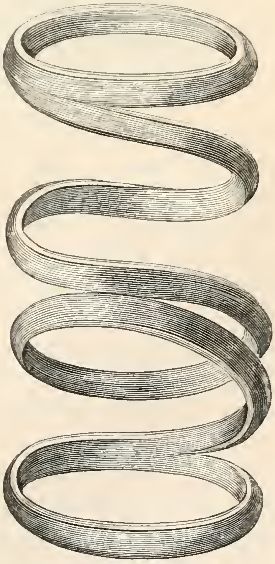

Bronchial cartilages of the Dugong.

There are but three rings in the trachea of the Dugong, the first being the largest. The tube is somewhat flattened from before backward: I found it, in a specimen 8 feet long, 5 inches in circumference and 1 inch in antero-posterior diameter. In older specimens the rings have been found bony. The cartilages of the bronchial tubes are continued spirally into one another, fig. 451 : the pulmonary artery lies to the outer side of the bronchus and is deeper seated, the pulmonary vein to the inner side and superficially. The principal branch of the bronchus, *b*, fig. 452, runs down near the inner margin of the lung, and continues distinct to within four inches of the end; it then divides into smaller branches; the larger ramifications are given off from its outer side, *c*, *c*. In all the branches the cartilaginous rings continue distinct and strong till their diameter is contracted to one or two lines; the rings passing irregularly into each other as in the main trunks. The lining membrane of the air-tubes is thrown into longitudinal rugæ, indicating their dilatability. The superficial air-cells, ib. *a*, are six times larger than in the Porpoise. The 'pleura costalis' is dense in both *Cetacea* and *Sirenia*, as is the subserous tissue of the 'pleura pulmonalis.'

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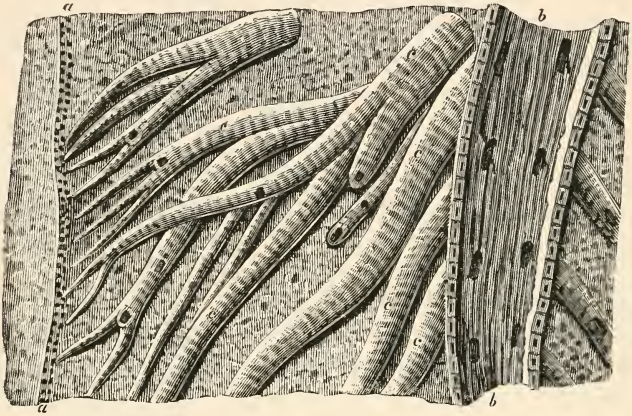

Section of terminal part of lung, Dugong.

In the Elephant the right lung sends a lobular process, behind the thoracic postcava, into the space between the heart and diaphragm, but both this and the left lung are undivided. The trachea has thirty rings, many of which are partially cleft.

In the Rhinoceros (*Rh. indicus*) the trachea has thirty-one rings: they are close-set, cleft behind, the ends meeting: the lining membrane is longitudinally rugous, as is that of the bronchial ramifications for some way into the lung. Each lung is divided into a small upper and a large lower lobe; the right lung also gives off a transversely elongated narrow azygous lobule: the upper lobe has numerous deep marginal notches. In the Horse the trachea has fifty-two posteriorly incomplete cartilaginous rings, the ends of which are flattened, expanded, and overlap each other: the tracheal muscles are attached to their inner surface at the angle where the free ends are bent inwards. The lungs are, as in *Rhinoceros*, each somewhat notched where they embrace the pericardium. The left lung, in the Tapir, has, besides the fissure opposite the base of the heart, a second nearer the apex. The right lung is more definitely three-lobed, the lower one forming the azygous process. The tracheal rings are thick and broad, as in the Rhinoceros.

In *Suidæ* and *Camelidæ* the left lung is rarely cleft so as to show two lobes: the right is more commonly so, with the 'lobulus impar' as a process of the lower lobe. In the Wart-Hog (*Phacochœrus*) and *Hippopotamus* an upper lobe is distinguishable from a lower one, in the left lung, and the right shows three lobes, besides the lobulus impar. In the Ruminants it is more common to find three lobes on the left side and four, including the azygos one, on the right. The chief peculiarity of the respiratory system in the Ruminant group relates to the length of the neck, with which the windpipe is made to agree by the number not the length of its rings: thus the Camel may have upwards of 100 rings, the Giraffe upwards of 90, the Llama 80, while the shorter-necked Musks have not more than 50 tracheal rings. In some Ruminants the right bronchus bifurcates at its origin, and the left seems a third tube. The tracheal rings are cleft posteriorly, with the ends touching or overlapping.

In certain pinnigrade *Carnivora* the tracheal rings are entire for some way down the tube, and in the cleft rings the ends overlap. *Phoca vitulina* has upwards of 70 rings. I found the left lung in this Seal rather larger than the right, and both divided into two lobes: Hunter noted three lobes on the left side 'united by a loose cellular texture.'[1] In the Ursine Plantigrades the left lung has two lobes, the right three and the lobulus impar. The tracheal rings are thickest anteriorly, thinning off to their edges at the posterior cleft: there is a slight alternate overlapping, or interlocking, both in successive rings, and at the fore and back parts of the same ring.

The Ratel, Wolverine, and Carcajou, agree with the Bears in the pulmonary divisions: the Mydaus has three lobes to the lung; and the lobulus impar of the right lung is large and notched. In the Otter the left lung has two lobes and the right four lobes including the lobulus impar: the ends of the cleft tracheal rings are thinned off and overlap more closely than in terrestrial *Carnivora*. The tracheal tube is wide in most of the order, the number of rings ranges from 40 to 60. In Digitigrades as a rule the right lung has four lobes: in some (Lion, Tiger, e. g.) the left has two lobes; in others (Dog, Hyæna) three lobes.

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[1] CCXXXVI. vol. ii. p. 96.

In *Chiromys*, as in most *Quadrumana*, the lobulus impar is superadded to the three ordinary lobes of the right lung: the left lung is bilobed: all the lobes are distinct from each other throughout. The tracheal rings, 26 in number in *Chiromys*, are cleft behind, with the ends in contact, but not overlapping. The bronchi have shown dilatations in some *Lemuridæ*. In a *Lemur Macaco* and a *Tarsius* the left lung was trilobed: as also in a Baboon, in which, as in other Catarhines, the lobulus impar is small: it is represented as a process of the right lower lobe in *Hylobates*. In a *Simia Satyrus* I found both right and left lung undivided.[1] In *Troglodytes* the right lungs has three lobes, the left two lobes, as is the rule in the Bimanous order.

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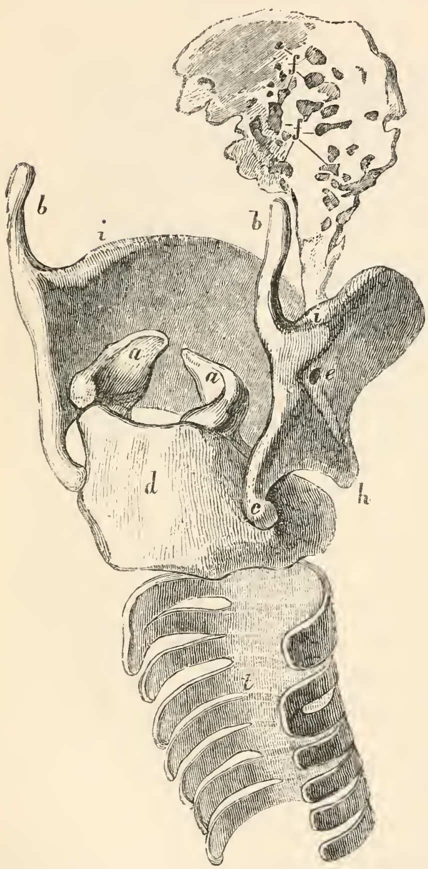

Cartilages of the Larynx, and of the upper part of the windpipe; Man, nat. size. CCXVII″.

§ 355. *Larynx of Mammalia.* — The vocal organ appended to the respiratory system in Mammals is a larynx answering to the upper one in Birds. It consists of cartilages, sometimes ossified, joined by ligaments, forming the framework of a tube or case (*pixis cava*, Anthropotomy), lined by mucous membrane, which may be produced into 'folds' and 'sacs' and reflected over elastic, sclerous, and muscular fibres. The larynx communicates below (or behind) with the trachea, fig. 453, *t*, and above with the pharynx. The chief or constant cartilages are the 'cricoid,' ib. *d*, the thyroid, ib. *h*, *i*, the ‘arytenoid,’ ib. *a*, *a*, and the epiglottis, ib. *f*.

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[1] xxxiv″. p. 8.

The more immediate impressors of ‘sonorous vibrations’ upon the air transversing the larynx are the elastic fibres stretched between the arytenoid and the thyroid cartilages, thence termed ‘chordæ vocales,’ and ‘thyro-arytenoid ligaments;’ of which one is distinguished as the ‘upper,’ fig. 454, *l*, the other as the ‘lower vocal cord,’ ib. *k*. They intercept a space *n*, where the lining membrane bulges outward, and in Man backward, forming the ‘laryngeal sac’ or ‘ventricle.’ In this section are shown the hyo-epiglottic ligament *b*, the thyro-hyoid ligaments *c*, the glosso-epiglottic ligament *e*, the crico-thyroid ligament *f*, and its junction with the lateral crico-thyroid ligament at *g*, *i*, and with the base of the arytenoid cartilage at *n′*.

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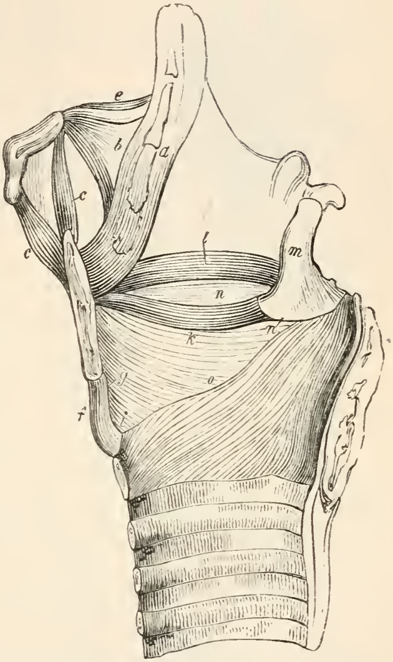

A longitudinal section of the larynx; Man. CCXVII″.

With this brief indication of the chief parts of the larynx in Man, its comparative anatomy may be better followed.

In the Monotremes the superior larynx presents some remarkable modifications in the Ornithorhynchus. The thyroid cartilage, fig. 455, *c*, in this animal is very broad; its middle part is prominent and acuminate: the lateral alæ are bony, and each of them divides, and sends one of the processes to the posterior part of the pharynx, ib., where it becomes cartilaginous, and is confluent with the corresponding process of the opposite side. The cricoid cartilage, ib. *d*, is ossified at its middle anterior part. The arytenoid cartilages, ib. *e*, *e*, present the usual triangular form, and are of large size. The epiglottis, ib. *a*, is broad, with an acuminate and notched apex.

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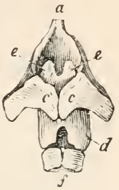

Larynx of Ornithorhynchus. LXXXI′.

On slitting up the larynx posteriorly, and divaricating the thyroid process, *f*, *f*, fig. 456, the superior vocal cords are shown at *b*, *b*, the inferior ones at *c*, *c*: they are short, feeble, with a shallow linear interspace: a sulcus, *d*, lies between the upper cord and the cricoid cartilage. Both sexes emit a feeble squeak.

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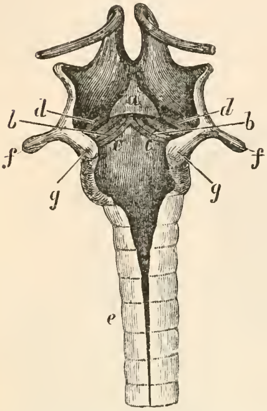

Larynx opened from behind, *Ornithorhynchus*, magn. CCCXX.

The epiglottis, in Marsupials, is remarkable for its large size, and generally for its emarginate apex. There is no muscle passing from the epiglottis to the tongue; its base is connected in the Kangaroo by a triangular fascia to the body of the os hyoides and the greater cornua; and a small muscle passes from the middle part of the body of the os hyoides to the dorsum linguæ. In *Didelphis Opossum* the epiglottis, fig. 456, *f*, is entire, the thyroid, ib. *a*, short, anteroposteriorly produced, and bifurcating into upper and lower cornua behind: the cricoid, *b*, *c*, is broad behind and notched below. In the Phalangers the epiglottis is broad and short, and with a bifid apex. In *Perameles* and *Phascogale* the sides of the broad and short epiglottis are attached to the apices of the arytenoid cartilages, retaining thus much of its early condition, which will be adverted to in the account of the peculiarities of the mammary fœtus. In the *Perameles lagotis* I found on the base of the tongue in front of the epiglottis a small sacculus of mucous membrane, which communicated by a regular symmetrical crescentic aperture situated between the body of the os hyoides and the thyroid cartilage, and was continued down in front of the thyroid cartilage: the surface of the cavity was smooth and lubricated, and it seemed to be for the purpose of facilitating a hinge-like motion between the thyroid cartilage and the body of the os hyoides. The thyroid cartilage is convex externally and protuberant in the Phalangers and Koala. The base of the arytenoid cartilages is broad in the antero-posterior direction. The chordæ vocales are represented by short and slight folds of the membrane, wanting the 'ligaments,' and not susceptible of being stretched, in

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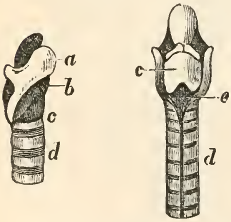
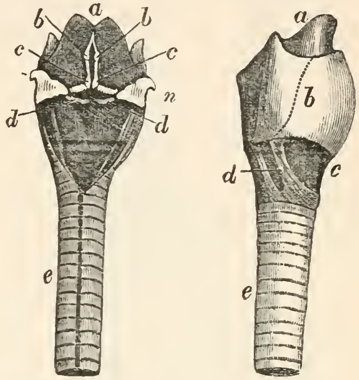


Larynx of the Opossum. CCCXX.

the Kangaroos and Phalangers. The Opossums have the lower ligament, above which is a small 'ventricle': they can squeak and also 'purr.' As a rule the Marsupials have little or no voice: the Wombat emits a guttural hissing sound: the *Dasyurus Ursinus* a snarling growl or whine: the Thylacine is described as uttering a short guttural cry. I have never heard a vocal note of any kind from the Kangaroos, Potoroos, Petaurists, Phalangers, or Perameles. Bennett[1] states that the Kangaroo utters a moan when wounded and in pain.

458



Larynx of the Rabbit, laid open from behind, nat. size. CCCXX.

Larynx and upper part of trachea, Rabbit, nat. size.

The voice of Rodents is shrill and monotonous: the cry of the wounded Hare is loud and piteous. The alæ of the thyroid, fig. 458, *b*, are quadrate, convex, and united at an obtuse angle; the posterior margins are oblique and parallel. The cricoid, ib. *d*, is short or narrow anteriorly, leaving a wide space for the crico-thyroid ligament, ib. *c*. The arytenoids, ib. *n*, *n*, are relatively large, with everted apices. The epiglottis, ib. *a*, is broad, with a bifid apex: at its base are small cartilaginous styliform bodies, separated by a triangular space: a vertical groove divides the insertions of the 'chordæ vocales' from *b* to *c*, fig. 458. The inferior tubercles, *c*, *c*, give attachment to the upper vocal cords; which they help to stretch, while they expand the ventricles, and afford freer motion to the lower vocal cords, *d*, *d*. In the Beaver the epiglottis is triangular, with a vertical raphé on its posterior surface, terminating in a sac bordered by the vocal ligaments. There is a blind sac at the base of the epiglottis in *Cœlogenys Paca*: in both Rodents the vocal cords are short and little salient, and the 'ventricles' are shallow: the voice is acute. In the Porcupines both the vocal cords and ventricles are wanting: they are mute, save at the rut, when the male emits a low grunt.

The *Insectivora* agree with other *Lyencephala* in the low development of the vocal organ and power. In the Hedgehog, fig. 459, besides the thyroid, cricoid, *c*, arytenoid, *d*, and epiglottal *a*, cartilages, there is a triangular cartilage, *f*, between the bases of the arytenoids and the cricoid, called 'interarticular' in ccxviii″, p 34. At the apex of the arytenoids are the confluent 'cartilages of Santorini,' ib. *b.* The cricoid, *c,* has a median longitudinal ridge behind. The vocal cords are short, and attached interiorly to the lobes of the base of the epiglottis, the lower chord is the strongest; the 'ventricle' is produced into a sac between the epiglottis and hyoid. The Hedgehog's squeak is seldom heard.

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[1] CXCII″.

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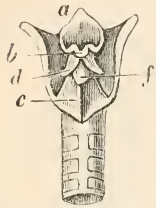
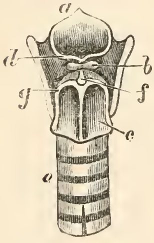


Larynx of Hedgehog.
cccxx.

The larynx of Shrews and Bats agrees in the main with that of the Hedgehog. In a large frugivorous bat (*Pteropus*)[1] the wings of the thyroid coalesce anteriorly for a short extent: the cricoid, fig. 460, *c,* has the posterior longitudinal ridge: the epiglottis is broad with an acute apex: besides the arytenoids and their apically confluent 'Santorinian cartilages,' *d,* there are the 'sesamoid cartilages,' *b,* and an 'intercellular cartilage,' *f,* narrower than in the hedgehog, and of an oblong form. The inferior vocal cord is sharply produced, but is short and narrow: the ventricle is not dilated into a sac.

460



Larynx of *Pteropus.*
cccxx.

In the Sloths the upper vocal cord is obsolete; the lower one is well defined but short; the ventricle is shallow. The voice of the Ai (*Bradypus tridactylus*) is feeble and plaintive; that of the *Cholœpus didactylus,* captive at the London Zoological Gardens, has never been heard there. The Armadillos, also, appear to be habitually mute: only the lower vocal cord is manifest: the ventricle is obsolete: the epiglottis is deeply notched at the apex.[2] In the great Anteater (*Myrmecophaga jubata*) the thyroid cartilage is ossified. The cricoid is cartilaginous. The arytenoids are low obtuse cartilages. The lower 'chordæ vocales' extend from the arytenoids forward, the fold containing them expanding as they advance. There is a shallow fossa beneath this fold and a deeper one representing the ventricle above it. A small 'interarticular' fibro-cartilage supports an obtuse prominence near the hinder ends of the epiglottidean folds, which are continued back to the arytenoids.

The larynx includes, in *Cetacea,* the usual Mammalian cartilages, much modified in shape and proportions. The thyroid in

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[1] Referred by Brandt to *Pteropus Vampirus,* in ccxviii″; and by Bishop, who copies the figure, to *Phyllostoma Spectrum,* cccxx, fig. 898.

[2] cxxvii″. p. 144.

Balænoptera is but little convex transversely; the wings unite at an open angle; the breadth much exceeds the length, but the lower angles are produced and continued down outside the cricoid: this is a thick cartilage, broad and flat posteriorly, with a thick upper margin and an irregular thinner lower one: it is incomplete at the fore-part, from which the lining membrane of the larynx protrudes and expands into a large sacculus. In *Phocæna* the thyroid, from the great extension of the inferior cornua, seems to consist of two semilunar cartilages united at their anterior extremities. The cricoid is incomplete at the fore part, but does not give passage to a laryngeal sac. The arytenoids, articulated to the cricoid by a broad base, are of unusual size and length, rising, in contact along their mesial borders, and becoming inclosed with the long epiglottis by a sheath of the pharyngeal mucous membrane, fig. 461, *b*, so as to form therewith a long pyramidal projection, with a slightly expanded apex, which is encircled, as it were grasped, by a sphincteric disposition of the muscles of the soft palate, ib. *e*. The opening of the glottis (through which passes the bristle, in fig. 461) is transversely semilunar in *Delphinidæ*: it is triradiate with the posterior cleft extending backward between the arytenoid apices in *Balænidæ*. The epiglottis seems almost continuous, through its fibro-cartilaginous union, with the upper margin of the thyroid: it is elongated, and curved toward the arytenoids to which its lateral margins are attached, completing the apical third of the laryngeal tube in *Delphinidæ*: in *Balænidæ* the epiglottis and arytenoids are relatively shorter, and are connected together by the membrane at their base, the apices being free and not expanded, as in *Delphinidæ*. The bases of the arytenoids extend from the cricoid forward to the thyroid, and

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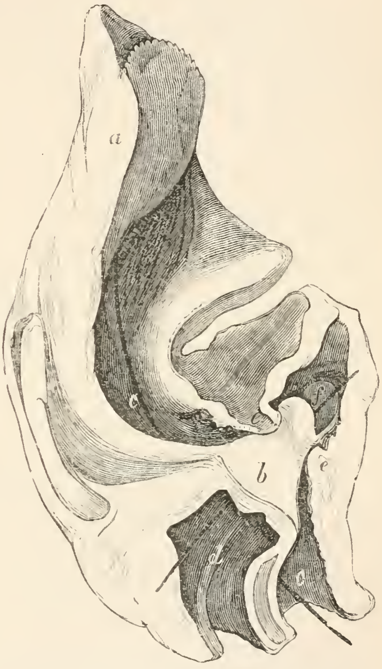

Section of the Tongue, Pharynx and Larynx of the Porpoise. CCCXX.

there are no 'vocal cords,' but between them and the base of the epiglottis are two lateral glandular fossæ, representing the 'ventricles': there are numerous orifices of mucous follicles along the fore part of the base of the larynx.

The external respiratory aperture, fig. 297, *f*, answering to the nostrils of other Mammals, is single in all *Cetacea*, save the Whales (*Balænidæ*), and is called the 'spout-' or 'blow-hole.' Where it is single it is a transverse slit; it is symmetrically situated, crescentic with the horns turned forward, in *Delphinidæ*; it is crescentic but oblique and to the left of the medial line in the small Cachalot (*Euphysetes*); it is similarly unsymmetrical, but of sigmoid shape in the great Cachalot (*Physeter*). The two nostrils in the Whale-tribe are longitudinal. In all *Cetacea* the 'spout-hole' is at the upper surface of the head, readily emerging for inspiration without unnecessary exposure of the animal. In the broad truncate muzzle of the great Cachalot it is advanced to near the anterior margin of that part: in other *Cetacea* it is mostly on the same transverse parallel as the eyes. The direction of the nasal passage is accordingly vertical: and as the lining or defining membranes descend through the mass of adipose tissue to the bony canal, the passage is dilated or produced into large irregularly plicated sinuses or sacculi, ib. *e*, *e*. The first, toward the fore part of the passage, is connected with the formation of the anterior valvular prominence in *Delphinidæ*, which fits into and closes the outer crescentic aperture, at the will of the animal: other muscles serve to open and dilate the spout-hole. The great Cachalot, when gasping in the death-throes, opens it widely: in the ordinary state it will admit, in the Whale, a man's arm. Lower down, in the Porpoise, larger lateral narial sacculi extend both forward and backward: the parietes of all these plicated expansions are invested by a layer of muscular fibres; whereby the water that may get access to them by the blow-hole, and to which they serve as diverticula, can be expelled along with the expired current of air. The number, size, and complexity of the narial sacculi vary in different genera: Hunter remarks that 'the Spermaceti Whale has the least of this structure.'[1] In *Delphinidæ* the nasal meatus divides on entering the osseous part of the passage, which is traversed by a medial prefrontal and vomerine 'septum narium,' fig. 297, *d*: below this the passages again intercommunicate and receive the swollen apex of the glottis. In the small Cachalot (*Euphysetes*) the bony narial septum exists, but the right meatus is so small that only the larger left one is traversed by the air-passage[1]: and in the great Cachalot it is this disproportionately enveloped 'bony nostril' which is described as the 'single canal' by Hunter.[2] In the *Balænidæ* the two narial canals are continued from the blow-holes; distinct from one another to the lower and hinder border of the bony septum. In all *Cetacea* a dark pigment is continued with the dense epithelial lining of the narial passages from the blow-hole down to the bony tract. The phenomenon described and figured as the 'spouting of the Whale' consists chiefly of the expired pulmonary vapour: it does not include water received into the pharynx from the mouth; but it may contain that which has been diverted from the nasal passage and accumulated in the sacculi: and the appearance of a fountain may be enhanced by superincumbent sea-water 'blown up' in the violent act of expiration, begun before the blow-hole itself had emerged.

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[1] xciv. p. 371.

Similarity of structure can as little be predicated of the beginning of the air-passage as of the digestive and circulating systems, in the herbivorous and the carnivorous marine apodal Mammals. The Dugong and Dolphin present opposite extremes, e. g. in the development of the epiglottis, which can hardly be said to exist in *Sirenia*.[3] The glottis is very small and ⊤-shaped, the upper transverse slit being crescentic, with the horns bent a little way outside the vertical slit: the epiglottis is not long enough to close or cover this, but makes an obtuse prominence in front of the glottis: the sides of the opening are formed by the membrane covering the thin convex borders of the arytenoids. The cartilaginous wings of the thyroid are not confluent, but are joined anteriorly, for a short way, by sclerous tissue, and below this by membrane and areolar tissue: the mesial cleft below is continued on as a fissure to the upper cleft of the thyroid: each wing is an irregular rhomboid, of which the foremost end is the point of junction with its fellow, while the opposite angle is produced into the 'inferior cornu,' and is similarly connected by sclerous fibres to a prominence on the side of the cricoid: the intermediate angle on the posterior margin of the thyroid feebly represents the 'superior cornu,' which is connected to the thyrohyal by ligament including a nuclear 'cartilage of Morgagni.' The cricoid is a larger cartilage, and forms a complete ring: its broad posterior surface offers three longitudinal facets—one medial, narrow but expanding above and below, and two lateral and broad: the lower border describes three straight lines: the upper border is very thick, and presents, on each side, an elliptical convex articular surface for the arytenoid: the anterior part of the cricoid is convex and notched above. Each arytenoid is an irregular three-sided pyramid, the inner surface flat, the antero-external surface convex, the postero-external surface concave, the base excavated to fit the cricoid articular tubercle, with which it is articulated by a synovial and fibrous capsule; the apex is compressed and extended in the antero-posterior direction, forming the convex lateral margin of the glottis. The short space between the arytenoid and thyroid cartilages is traversed by a thick fasciculus of dense elastic fibres representing the lower vocal cord, and covered by the lining membrane of the larynx: there is a small pit between the anterior insertions of the 'chordæ,' but no other indication of sacculus. The mucous membrane is smooth for a short extent below its reflection and over the arytenoid apices, and then begins suddenly to be disposed in numerous narrow plicæ which increase in breadth as they descend into the trachea: at the back part of the larynx are a few longitudinal rugæ. There is no true cartilage in the epiglottis: the small pyramidal prominence in front of the glottis includes yellowish and white fibrous tissue which degenerates gradually into the areolar substance occupying the interalar thyroid space: the other parts of the laryngeal framework have bony granules scattered through their gristly tissue. A 'hyo-epiglottideus' is continued from the fore part of the epiglottis to the base of the tongue. The 'arytenoidei obliqui' and 'transversi' are represented by a single pair of muscles, which derive a broad and extensive origin from the posterior and external ridges of the arytenoid cartilages, and converge to be inserted into a small round cartilage in the posterior interspace of the arytenoids. These muscles, through the advantage afforded them by this middle fixed fulcrum (which ought therefore to be regarded as their point of origin), act with great power upon the arytenoid cartilages, drawing them together, and thus forcibly closing the narrow glottis. They are directly opposed by strongly developed 'thyreo-arytenoidei,' which pass obliquely backward from the internal and interior part of each division of the thyroid cartilages to the posterior and outer part of the arytenoids, which they draw apart, and thus open the glottis. The 'crico-arytenoidei' arise from the anterior border of the cricoid, and are so inserted as to draw the arytenoidei forward as well as outward. The 'crico-thyroidei' cover the whole of the fore part of the cricoid cartilage. The 'sterno-thyroidei' and 'thyreo-hyoidei' are extremely powerful.[1]

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[1] XLIX′. p. 37, pl. 13, fig. 1, *ol.*

[2] Ibid.

[3] CXVII″. p. 30 (1838).

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[1] CXVII″. p. 32.

In the Elephant the alæ of the thyroid are externally convex and unite anteriorly at an obtuse angle; the upper cornua are short, the lower ones are notched anteriorly. The cricoid extends posteriorly over the first three tracheal rings. The arytenoids are long: the lower vocal cord is well-marked; the upper one indistinct. In the Rhinoceros the wings of the thyroid cartilage meet at a slightly obtuse angle: there is no notch at the upper margin of the anterior median line; but there is a considerable triangular vacancy below, filled up by dense elastic and aponeurotic membrane, to which yielding walls of the larynx some of the fibres of the thyreo-arytenoidei muscles adhere. The cricoid is nearly thrice as deep behind as in front, contributing to the extent of the crico-thyroid interspace. The arytenoid cartilages are relatively of large size: their base extends half-way across the aperture of the larynx, and from the anterior extremities of these produced bases, the upper and lower 'chordæ vocales' extend forward to the thyroid cartilage and base of the epiglottis. Only the anterior half, therefore, of the 'rima glottidis' is bounded by vibratile vocalising material, and the ordinary voice of the Rhinoceros is a feeble bleat like that of a calf. Between the upper and lower chordæ vocales is the opening of a large sacculus laryngis, which communicates anteriorly with a crescentic fossa under the base of the epiglottis. A fold of membrane extends on each side from a small semilunar fibro-cartilage at the inner and under side of the base of the epiglottis, downward, inward, and forward to the anterior termination of the chordæ vocales: these oblique folds form the inner or posterior walls of the anterior fossæ of the sacculi laryngis. The anterior or superior labia of the glottis form two broad, thick, slightly everted folds of mucous membrane. In the mass of muscles attached to and passing between the arytenoid cartilages, there are developed about twelve tendons which radiate to be inserted into a central sesamoid cartilage. The epiglottis is of a triangular figure, with the pointed apex curved forward, and having strong glosso-epiglottidei muscles attached to it.

In the Horse the wings of the thyroid meet at an acute angle, leaving a large inferior notch: the back part of the thyroid forms an almost acute angle with the cricoid: the cricoid has similar proportions to that in Rhinoceros: it has been vertically cleft behind and the moieties divaricated, in fig. 462, *i*, *i*. The arytenoids, ib. *f*, *f*, have their bases deflected from each other, keeping patent the 'rima glottidis': the 'cartilages of Santorini,' ib. *k*, *k*, are hook-shaped. The lower vocal cords, ib. *g*, *g*, are large and prominent; above them are the orifices, *e*, *e*, of the deep 'ventricles': the upper cords are barely definable. The epiglottis, ib. *a*, is a longish triangle with the apex entire and antroverted, the base medially cleft by the so-called 'sulcus,' ib. *d*; and produced into two processes ('cornua' of Casserius). Between the commissure of the lower cords, *g*, *g*, and the epiglottis is an oval cavity, *c*, above which is the 'semilunar ridge' or 'membrane,' *b*.

In the Ass, the wings of the thyroid unite anteriorly at a rather obtuse angle: the cricoid resembles that of the Horse: it is similarly cleft and divaricated in fig. 463. The crico-thyroid interspace is relatively less than in the Horse. The epiglottis, *a*, is a more equilateral triangle than in the Horse, with the apex less acute: it is perforated by two apertures, ib. *c*, *c*, leading to two 'sacculi' continued upon part of the inner surface of the thyroid. Between the apertures is the arched recess, ib. *b*, in which the lower vocal cords, *d*, *d*, are inserted; these arising behind from the bases of the arytenoids.

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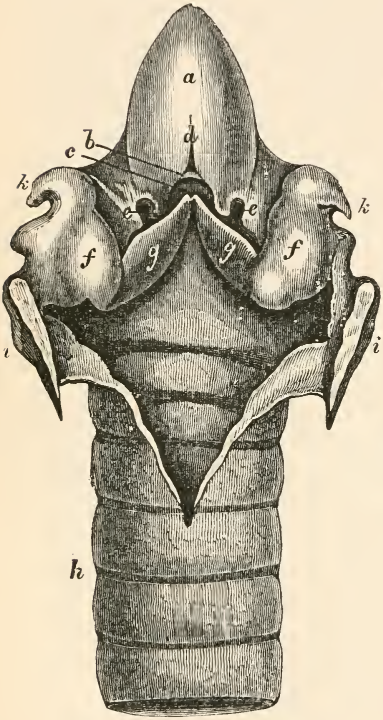
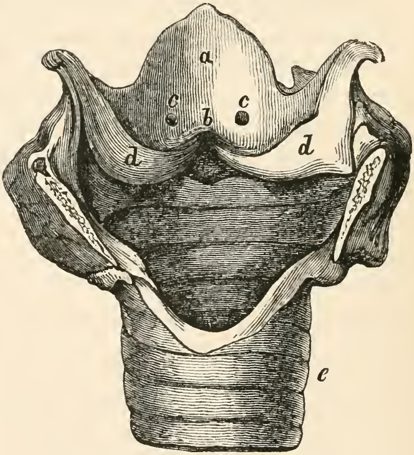


Larynx of the Horse laid open. CCCXX.

463



The Larynx of the Ass laid open. CCCXX.

The voice of the horse under sexual or other pleasurable excitement is due to movements of the vocal cords through forcibly expired air, but with short intervals or interruptions of the current, producing the shrill but tremulous or vibratory scale of notes, sinking to its close, and called the 'neigh.' It is peculiar to the group of *Equidæ* with callosities on both fore and hind legs and with flowing mane and tail; the species with callosities on the fore legs only, with stiff erect manes and naked terminally tufted tails, vibrate their vocal cords by currents of air in alternate opposite directions, produced by vigorous acts of inspiration and expiration, with the head and neck held in the position in which such currents can best act upon the larynx; the sounds so produced are termed the 'bray:' in some species the notes are long-drawn out, e. g. the ass; in others they are shortened to a kind of 'bark,' as in the S. African striped ass, called, on that account, 'couakka' or 'quagga.'

The thyroid of the Tapir is thicker than in the Horse or Ass, and lies more in the plane of the trachea: the cricoid is less than in them, and has no tubercle on the back part. The arytenoids resemble those of the Horse, but are less hollowed behind. A triangular fibro-cartilaginous mass represents the two cartilages of Santorini (fig. 462, *k*, *k*, Horse): a similar triangular fibro-cartilage at the anterior border of the arytenoid represents the cuneiform cartilage, and is continued at its apex into the lower vocal cord: this is well marked, sharp, and joins its fellow at an acute angle; the upper vocal cord is very short, but definable. The 'ventricle' is prolonged into a blind oval sac resting upon the inner surface of the thyroid. From the anterior confluence of the lower cords a membranous fold ascends toward the epiglottis, and divides into two semilunar folds which bound small follicular depressions. The epiglottis resembles that of the Ass; an opening at its base leads to a curved cavity on each side.

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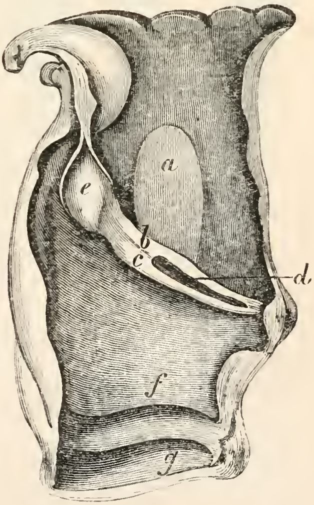

Mesial section of the Larynx of the Pig (Sus scrofa). CCCXX.

In Artiodactyles the wings of the thyroid unite at an acute angle. In the Hog there are no upper cornua: the cricoid, fig. 464, *f*, is broad and thick behind, with a tuberous process on each side. The arytenoids, *e*, are united at their apices by a 'santorinian cartilage;' both upper, *b*, and lower, *c*, vocal cords are well defined, and directed obliquely downward to be inserted into the thyroid about one-eighth of its length from the lower margin. The ventricle, commencing by the chink, *d*, is continued upward into an oblong flattened sacculus, *a*. The range of voice is considerable, from the low grunt to the loud discordant squeal.

In the Camel the wings of the thyroid meet at an almost right angle, and unite along the mid part, leaving an upper and an under notch. The upper cornu is represented by a slightly prominent tubercle; the lower cornu is more produced, overlapping obliquely the cricoid, and tied to a tubercle near its lower border by short ligamentous fibres. The cricoid is a deep and thick annular cartilage; the vertical extent anteriorly is about half of that behind; the upper border has an oval facet on each side for the arytenoids. The base of the arytenoid developes an external, fig. 465, *d*, and an internal process; the body is lamelliform, and expands above into a punctate softer cartilage which curves outward. The epiglottis, ib. *a*, has a median rising or tubercle, *h*, on the hinder surface; the lower cords, *c*, *c*, from the base of the arytenoids, are neatly defined, more linear in the Llama than in the Camel; the broad membranes, *b*, *b*, continued from the anterior border of the arytenoids to the base of the epiglottis, represent, by a slight thickening of their lower border, the upper cords; a slit-like aperture between these and the lower cords leads to moderately developed ventricles. The thyroid cartilage is perforated by a laryngeal nerve and by a vessel.

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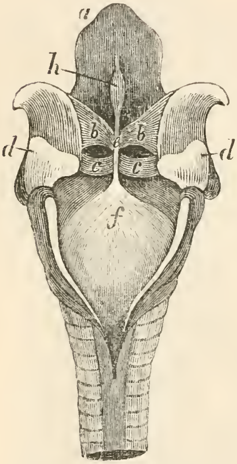


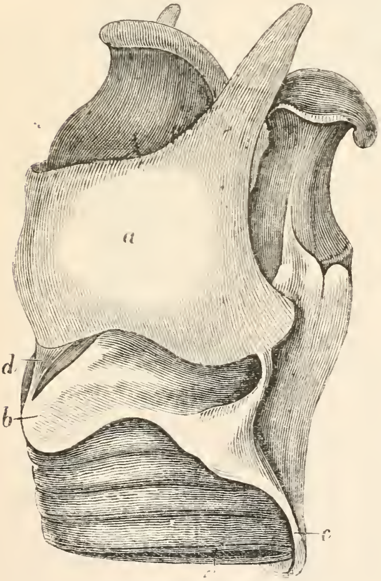
Larynx exposed from behind, Camel. CCCXX.

In the Ox the thyroid alæ are sub-equilateral, and united at an obtuse angle: the upper vocal cord is less marked than in the Camel; the lower one is rather longer, and vibrates so as to produce the bellowing roar of the bull and the sonorous lowing of the cow.

In the Elk (*Alces*), the upper cornu of the thyroid, fig. 466, *a*, is much produced; the lower one is obsolete, and the rounded angle there is connected by ligament with the cricoid tubercle. The cricoid is short anteriorly, ib. *b*, and connected there by the crico-thyroid ligament, *d*, crossing the wide space of that name, to the thyroid; the cricoid is expanded behind and thence produced downward, at *c*, so as to cross the five first tracheal rings. The upper cord is not defined: the lower one is inserted into the middle of the fore-part of the thyroid. In the Rein-deer a laryngeal sac protrudes below the base of the epiglottis.

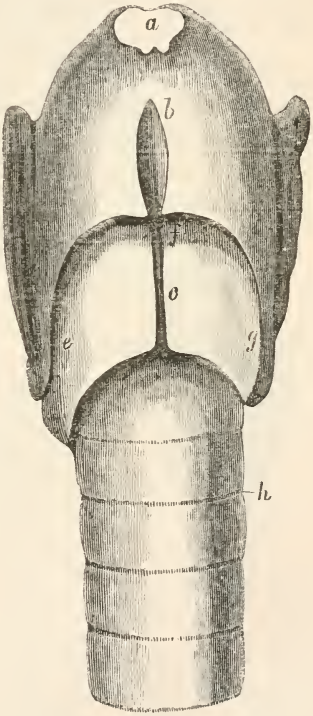
The Giraffe is mute, save at the sexual season. The larynx of the Deer, with the annexed vascular thyroid bodies, undergoes a periodical development, at the season of the rut, in the male, which then utters notes characteristic of the species: in the Red-deer it is termed 'belling' (*quasi* bellowing): in the Fallow-deer it is something between a belch and a bray: in the Roe-buck it is a shriller grunt.

466



Larynx of Alces. CCCXX.

467



Larynx, Ursus Malayanus. CCCXX.

In the Bear the thyroid is convex, the alæ meet at an obtuse angle, and unite along the upper half of their fore part, which developes a tubercle, fig. 467, *a*, to which the epiglottis is attached: the inferior cleft, ib. *b*, almost extends thereto in *Ursus arctos*: the upper cornua are short, the lower ones, ib. *g*, are very long. The cricoid is almost divided by an anterior cleft, *e*, and the lateral halves are connected chiefly by ligament. The arytenoids, fig. 468, are rhomboid: between them at the hind part of the rima glottidis are the sesamoid cartilages, ib. *d*, *d*, upon which a few muscular fibres act. Cuneiform and santorinian cartilages are also present. The lower vocal ligaments rise, as they advance, toward the upper ones. The epiglottis is broad, with an obtuse apex. In the Badger the laryngeal sacs are deep and bifid, one portion extending to beneath the root of the tongue, the other to between the thyroid and cricoid cartilages. In the Otter the anterior cleft of the cricoid, fig. 469, *c*, extends to near the upper border: the lower or hinder border of the thyroid, ib. *b*, is deeply emarginate: the middle of the upper border shows a rounded apex, like a process: the epiglottis *a* is oval.

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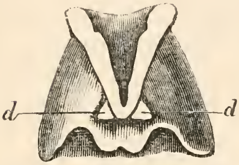

Rima glottidis, with arytenoid and sesamoid cartilages, Ursus Malayanus. CCCXX.

In the Dog the epiglottis is triangular, with a medial furrow at the base: the ventricles are deep: santorinian and cuneiform cartilages are present, superadded to the arytenoids which curve away from each other. In the Cat tribe the upper vocal cords, fig. 470, *c*, are unusually prominent, and by their vibration cause the 'purring' sound: the lower vocal cords, ib. *d*, are shorter and less prominent, and do not support any membranous appendages: the epiglottis, ib. *b*, is triangular with a subacute apex: in the Lion this is more obtuse. The ventricles form a sac between the vocal ligaments. The larynx of the Lion differs from that of the Cat chiefly in its more free suspension, allowing the strong vibrations of all the parts producing the terrific roar. In the Cat the upper cornua of the thyroid are closely connected through the medium of the thyro- and cerato-hyals, with the stylohyals: in the Lion a long ligament intervenes between the stylo- and cerato-hyals.

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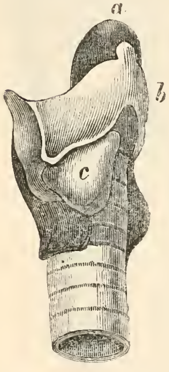

Larynx of Otter. CCCXX.

In the Aye-aye (*Chiromys*) the thyroid is like the prow of a boat, without keel, being laterally contracted and produced: the cricoid is notched at the middle of its broad back part: the cricothyroid interspace is narrow. The vocal cords are slender and well defined; between them and the epiglottis is a large and deep pouch, from which a median sacculus is produced between the back of the thyroid and the base of the epiglottis.[1] An interarticular cartilage lies between the arytenoids. I found both these cartilages partly ossified and the cricoid confluent with the upper two tracheal rings. The laryngeal cartilages are commonly more or less ossified in the Slow Lemurs.

In *Stenops gracilis* the lower cornua of the thyroid are produced over and beyond the cricoid to be connected with the first tracheal ring: the crico-thyroid interspace is narrow, but vertically wide: there are both santorinian and cuneiform cartilages. The upper vocal cords are rather thick and attached forward to the root of the epiglottis: the lower vocal cords are narrow, short, and attached to the thyroid: the ventricles are shallow, and are confluent beneath the epiglottis. This rises high and has its free border rounded and notched. The thyroid is prominent, with a median emargination above, in *Lemur Mongoz*: the back of the cricoid is ridged below, and above this is excavated. The arytenoids are rather large and high, having the santorinian bodies connected, but not confluent, with their apices. The vocal cords are well

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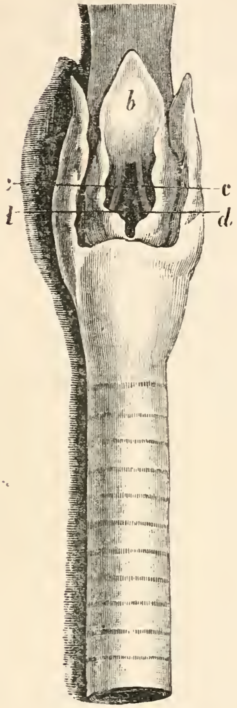
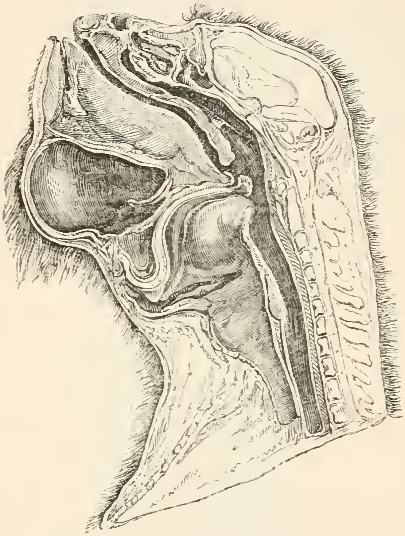


Larynx of Cat. CCCXX.

471



Vertical section of the head and neck, with the expanded basihyal and larynx, of Mycetes seniculus. LXIX′.

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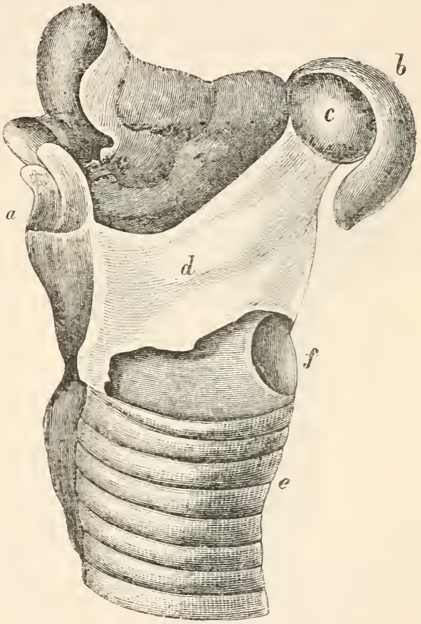
[1] CII′. p. 44, pl. 10, fig. 3.

defined, the upper ones are broad; above their epiglottidean attachments there is a widish sac: the intercordal ventricles are moderate.

Among Platyrrhine Quadrumana the larynx of *Hapale*, *Callithrix*, and *Cebus* retains the moderate proportions of that in *Lemuridæ*: it is relatively larger in the Spider-monkeys (*Ateles*) and attains, with the hyoid, an enormous size in the Howlers (*Mycetes*, fig. 471). In most the upper border of the thyroid is emarginate: but *Ateles arachnoides* and *Hapale rosalia* are exceptions; instead of the notch there is a median process, and a small sacculus projects from the crico-thyroid interspace: the santorinian cartilages are confluent at their apices, and distinct from the cuneiform cartilages, in *Cebus* and *Hapale*; but both are fibrous rather than gristly: they appear as processes of the upper vocal cords. These are attached to the thyroid like the lower cords, which there rather overlap them: the ventricles are moderate: the rima glottidis is ordinarily wide and almost perpendicular: the basihyal is not excavated. In *Ateles* the basihyal is quadrangular and excavated: the santorinian and cuneiform bodies coalesce with each other and with the epiglottis, of which they seem to be processes. In the Howler (*Mycetes*) the cricoid, though small in proportion to the rest of the larynx, is larger than in other Platyrrhines and remarkably thick and powerful, especially behind: it is ossified, and impressed on each side, near the lower posterior angle, by an articular cavity for the short obtuse lower horn of the thyroid. This cartilage shows a still larger relative size, which is thrice that of the human thyroid: it makes a strong anterior prominence, bulging out there to lodge a pair of sacculi continued from the fore part of the long intercordal cleft or ventricle. The arytenoids are small, with their uncinate apices continued into a large fibro-cartilaginous mass, representing vastly developed and confluent santorinian and cuneiform cartilages, connecting the arytenoids with the long sigmoid epiglottis, and including the scarcely distinguishable upper vocal cords. The lower ones are broad, but well defined. From the fore part of the intercordal space the pair of sacculi are developed which line or occupy the thyroid bulla. The epiglottis is more than 4 inches in length and 2 inches in breadth, with the sides bent down so as to form a kind of arch above the glottis. The 'rima' so covered consists of an anterior semilunar portion, from which a chink extends backward, dilating into an oval aperture. Between the glottis and the arytenoid cartilages are the orifices of a pair of pouches, continued rather from the pharyngeal than the laryngeal membrane, which extend forward and upward on each side of the epiglottis. From the upper part of the thyroid sacculi are continued a pair of ‘pyramidal oval’ sacculi, which occupy the sides of the interspace between the epiglottis and the hyoid: and from the fore part of the thyroid sac is continued the neck of the large ‘infundibular sac,’ which expands to occupy and line the huge ‘bulla’ or bony cave formed by the basihyal, and of which the section is shown in fig. 471. Travellers in the forests of tropical America testify to the astounding tones emitted by these far-heard ‘howling’ Monkeys.

472



Larynx of Baboon. (*Cynocephalus*). CCCXX.

In most Catarrhines the basihyal is expanded and excavated for the reception of a laryngeal sacculus, but in a far inferior degree to that in *Mycetes*. In the Baboons a section of the basihyal is shown at *b*, fig. 472,[1] to expose the sacculus, *c*, which is continued from below the root of the epiglottis; from this pouch the sacculi continued from the intercordal ventricles are distinct. The back part of the cricoid is traversed by a medial ridge. The upper and fore part of the thyroid, ib. *d*, is produced, and supports the hyoid sac: the wings of the thyroid coalesce at an obtuse angle. The crico-thyroid interspace, ib. *f*, is wide. The arytenoids, ib. *a*, resemble those of Man: the santorinian cartilages, therefrom continued, are not confluent with each other apically, as in Platyrrhines. The cuneiform fibro-cartilages are continued from the upper vocal cords, are large, and project from the aryteno-epiglottidean folds: the free border of the epiglottis is obtuse, in some species emarginate. The upper vocal cords are bent; the lower ones are rather thick: above the convergence of the upper cords is the longitudinal fissure leading to the hyoid sac.

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[1] This figure is taken from the preparation, No. 1173, xx. vol. ii. p. 110. (1834).

In the green Monkey (*Cercopithecus sabæus*), the structure of the larynx accords with that in *Macacus*[1] and *Cynocephalus*. In fig. 473, B shows the expanded and excavated basihyal, *f*, with the attached thyrohyals: in A, *a* is the epiglottis, *b* the basihyal, *c* the hyoid sac, *d* the thyroid cartilage, *e* the trachea.

No tailless Ape has the medial aperture and hyoid sac. In the Gibbons the larynx is relatively large, the vocal cords well defined, with deep intervening ventricles, from one of which is continued the sac projecting into the thyro-hyoid space. If *Mycetes* has the loudest cry, the Gibbons have the greatest range of notes; they alone, of brute Mammals, may be said to sing. I heard, with astonishment, the Wouwou (*Hylobates agilis*), captive at the Zoological Gardens, emit the rising and falling scale of semitones, throughout the octave, which Martin has accurately rendered in the musical notation given in CCXX″. In the Orangs the sacculi continued from the intercordal ventricles pass out between the thyroid and hyoid, and in the adult males extend over the fore part of the neck and upper part of the chest, being subdivided into several pouches, as in fig. 474, the lowest of which may be crossed by the pectoralis major. In the young Chimpanzee (*Troglodytes niger*), the laryngeal sacculi, fig. 475, *a*, *a*, produced from the ventricles extend upward and outward, the left, in the specimen dissected by me, being continued for-

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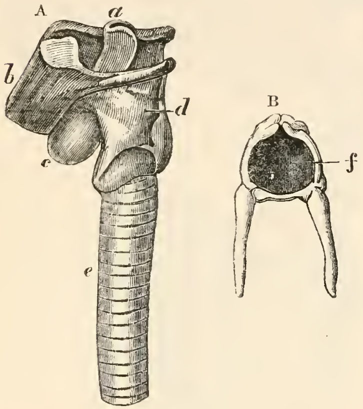
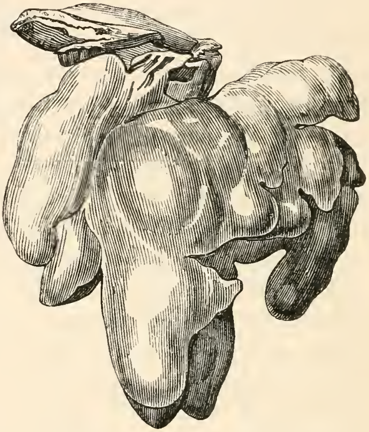


Larynx of Cercopithecus sabæus. CCCXX.

474



Laryngeal pouch of the adult Orang-utan.

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[1] xx. vol. ii. p. 110, fig. 1173 *c*.

[2] xx. vol. ii. No. 1173 A.

ward, ib. *c*, below the basihyal, ib. *b*, which was slightly expanded and excavated for its reception. In the larger species of *Troglodytes* (*Tr. Gorilla*), this sacculus is developed in the adult male to the degree which it presents in *Pithecus Satyrus*. The roar of the male Gorilla is loud, and may be heard far off in its native forests.

In Man there is no such excess of development of the laryngeal sacculi or other part of the vocal organ. The cords are long and well-defined, and all parts of the organ are in well-balanced proportion. The chief elements of the vocal organ have been already defined and exemplified in figures 453 and 454. The external muscles of the larynx, viz., the 'thyro-hyoidei,' 'sterno-thyroidei,' and 'crico-thyroidei,' operate (among other actions) in producing that rotation of the cricoid upon the thyroid which effects the important change in the angle of the vocal cords as it exists in ordinary breathing, when they are so inclined to each other as to have no vibratory motion, to the position in which their surfaces lie in the same plane, and when the breath excites their vibration; the 'thyro-arytenoidei,' fig. 477, *d*, *d′*, co-operate in putting the cords into this position. The quality of the vibration dependent upon the degrees of tension of the vocal cords, and the vocal tones due to degrees of patency of the 'rima glottidis,' are mainly influenced by muscles acting upon the cords, fig. 476, *c*, *c*, through the medium of the arytenoid cartilages, *b*, *b*. If the left wing of the thyroid be removed, the following muscles operating on the vocal cords through that medium may be demonstrated. To each arytenoid cartilage proceeds a pair of muscles; one, 'thyro-arytenoideus,' fig. 477, *d*, arises from the inner surface of the anterior part or angle of the thyroid *a*: the superior fibres, *d′*, pass horizontally backward and outward to be attached to the prominence on the outer side of the arytenoid, *l*; these, sometimes distinguished as the 'thyro-arytenoideus superior,'

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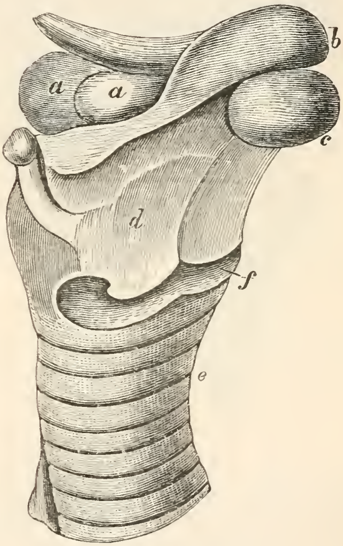
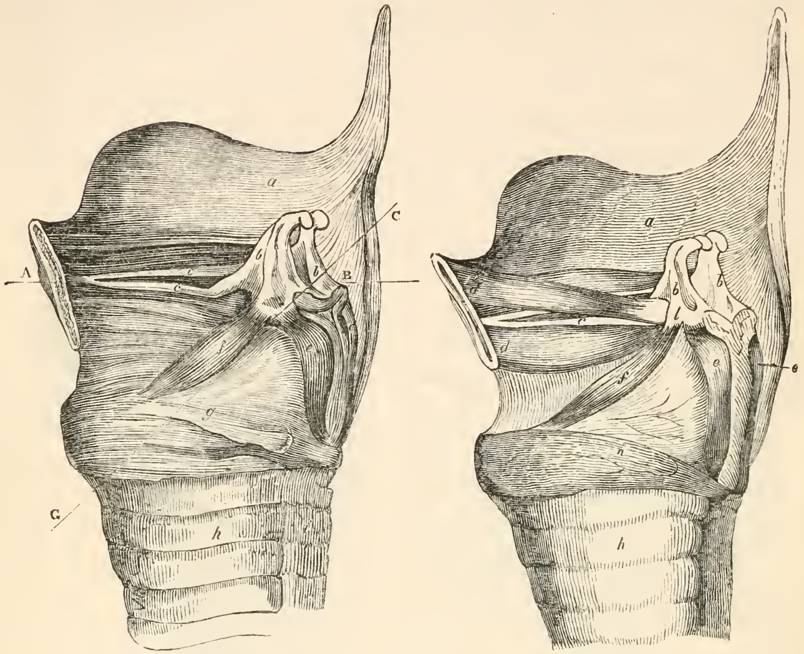


Larynx of Chimpanzee.

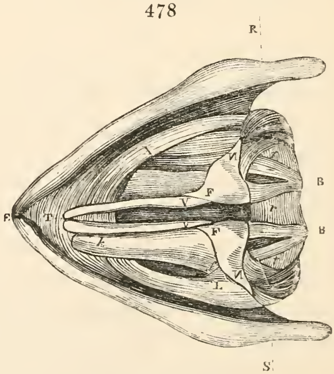
must be removed to give a full view of the vocal cords, as at *c*, *c*, fig. 476. The 'crico-arytenoidei postici,' figs. 476, and 477, *e*, *e*, arise from the back part of the cricoid, and are inserted into the outer and back part of the base of the arytenoid. The 'crico-arytenoideus lateralis,' ib. *f*, arises from the upper and fore margin of the cricoid, and passes upward and backward to be inserted, with the thyro-arytenoid, *d*, into the outer basal prominence, *l*, fig. 477. The line C G, fig. 476, is the vertical projection of the crico-arytenoid articular axis. The tendency of *e* and *f* to divaricate the arytenoids and open the glottis, is counteracted by muscular fibres passing from one arytenoid to the other, and which have received the names of 'arytenoidei obli-

476 477



Dissections of the Human larynx, from one side. CCXVII''.

478



Dissection of Human larynx, from above. CCXXIII''.

qui' and 'ar. transversi.' In fig. 478, the mucous membrane is removed to show the vocal cords, v, v, bounding the glottis: attached behind to the arytenoids at F, and in part to the thyroid at T. The ring of the cricoid cartilage is shown at X, L, which can be rotated on its axis R, S, by the crico-arytenoidei postici, and the crico-arytenoidei laterales.

In the louder tones of voice or song the vibrations extend from the cords to the contiguous elastic tissues, and even to the thyro-arytenoid muscles, ib. *k*. In the deeper notes the cords are relaxed by drawing the arytenoids toward the thyroid to the degree in which the air-current can put them into vibration, and according to the length of the cord that can be made to vibrate is the depth of the bass note. In the medium degree of tension, when the wrinkles of the rima glottidis are effaced, the ordinary tones of the voice and the middle notes of its compass in singing are produced. The higher notes depend on combined tension of the cords with narrowing of the glottis and strengthening of the currents of air. The vocal cords in men are about one-third longer than in women and boys. Castration arrests that prominent growth of the thyroid, &c., which accompanies the elongation of the cords.[1]

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[1] For the further and minor influences of the various combinations of the actions of the foregoing muscles on the vocal mechanism, reference should be made to CCCXX, CCXVII″, CCXXI″, CCXXII″, and especially to CCXXIII″.

CHAPTER XXXIV.

URINARY SYSTEM OF MAMMALS.

§ 356. *Kidneys of Mammals.*—These glands (fig. 422, *o*, *o*, and vol. ii. fig. 139, *k*) are characterised, in the present class, by being composed of two kinds of substance differing in colour; one 'cortical,' highly vascular, with tortuous secerning tubes, fig. 479, *c*; the other 'medullary,' less vascular, with straight secerning tubes, ib. *m*. They are preceded, in the development of Mammals, as of Birds, by the temporary embryonal bodies, noticed and figured in vol. ii. p. 226, fig. 103: but the persistent kidneys reach a higher grade of structure, differentiated as above. They have a more compact and definite form than in birds, and their vascular supply is more exclusively their own; the uriniferous tubules converge toward the interior, and do not spread to the exterior, of the gland; the ureter, moreover, is not directly continued from them, but receives, by a dilated beginning or pelvis, *p*, their terminations usually crowded upon a prominence called 'mammilla.' All mammals have the urinary bladder.

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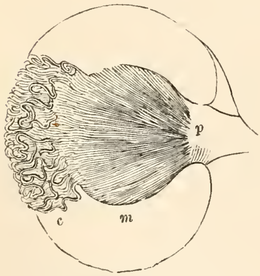
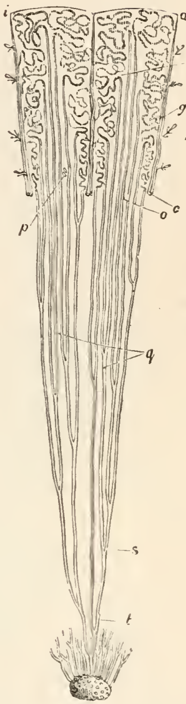


Type of Mammalian kidney.

In *Lyencephala*, *Lissencephala*, and most of the smaller species of *Gyrencephala*, the kidney offers its most simple mammalian condition, as exemplified in fig. 479. The cortical substance, of softer texture, and usually of a dull light-red colour, contains the malpighian bodies, fig. 481, *m*, *c* (vol. i. p. 538), and the reflected tortuous beginnings of the uriniferous tubes, ib. *t*: the medullary substance is firmer, of less uniform colour, conical in form, dark red at the base, lighter-coloured toward the apex in many Mammals; it is devoid of malpighian bodies, and is composed chiefly of the uriniferous tubes continued from the cortical part in a straighter course, uniting as at *q*, *s*, *t*, fig. 480, on the dichotomous plan, and converging to open upon the apex of the medullary cone.

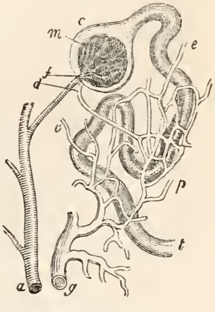
The membranous beginning of the ureter, reflected upon the apex of the cone (where this projects), is called 'calyx;' its contracting continuation to form the duct is the 'infundibulum;' the cavity of the gland which it lines, as at *p*, fig. 479, is the 'pelvis' of the kidney; the fissure from which it emerges is the 'hilum.' The renal artery, derived directly from the aorta, fig. 422, *d*, *d*, divides into two or three branches on entering the hilum, and, of the subdivisions of these in the medullary substance, the two principal, in the Kangaroo, anastomose to form an arch over the base of the cone, whence proceed the arterioles, fig. 481, *a*, to the cortical substance. Here the terminal twigs, ib. *f*, enter the malpighian body, *m*, to form the vascular brush or tuft; the returning vessel, *d*, combines, with those from other tufts, *e*, *e*, to form the capillary plexus, *p*, which surrounds the uriniferous tube, *t*. The capillaries unite to form venules, which on the surface of the human kidney have a stelliform disposition, and when congested give it a finely lobulated appearance. The veins from the centre of each 'star' dip into the renal substance, unite, and ultimately emerge at the 'hilus' anterior to or ventrad of the artery; but, in a few Mammals, they unite in an arborescent disposition (*Felis*, *Hyæna*) or form a network (*Phoca*) upon the surface of the kidney; in all, the venous trunk, fig. 418, *k*, terminates in the postcaval, ib. v. The uriniferous tubule commences in Mammals, as in lower Vertebrates (vol. ii. p. 538, fig. 356), from the malpighian corpuscle, fig. 481, *m*, *c*, and passes toward the surface of the kidney, before being reflected and convoluted in the cortical substance.

480



Tubuli uriniferi of cortical and medullary parts of kidney. CCLXXXVI.

481



Plan of the renal circulation in Mammalia. CXXXVII.

The chief modifications of the kidneys in Mammalia are seen in the shape or absence of the mammilla, and in their composition by a seeming multiplication of simple kidneys, either with or without a common cortical envelope. The first of these is presented by the Ornithorhynchus, fig. 502, *a*, in which the tubuli uriniferi terminate on the concave surface of a small and simple pelvis. The ureter, ib. *c*, *c*, takes the usual course to the contracted neck of the bladder, ib. *d*: but terminates, in the male, in the urogenital canal, below the vasa deferentia; and, in the female, fig. 534, *l*, *l*, beyond the uterine orifice, *m*, which thus intervenes between the ureter and the orifice of the urinary bladder. In all respects, save the place of termination of the excretory ducts and their relation to the reservoir of the secretion, the urinary system of the Monotremes adheres closely to the Mammalian type: in the Echidna the mammilla slightly projects. The circumstances in which they deviate from the higher Mammals approximate them to Reptiles; and it is to be observed that the deviation commences where the urinary system begins to be connected with the generative organs, in which the oviparous type of structure is especially manifested.

In the Marsupialia the tubuli uriniferi terminate on a mammilla which projects into the commencement of the ureter in the Opossums, but does not extend beyond the pelvis of the kidney in the Kangaroos. In the larger herbivorous Marsupials the medullary substance forms several lateral abutments to the base of the cone. In *Macropus Parryi* the kidneys are situated six inches above the brim of the pelvis, and lie in the same transverse line: they have the same relative position in other Poephaga. In the Koala the right kidney is higher by its whole length than the left. In *Dasyurus macrurus* and *D. viverrinus* the right kidney lies half an inch higher or in advance of the left; in this carnivorous genus a few branches of the renal veins are distributed upon the surface of the kidney, but not in the same proportion or with the beautiful arborescent disposition characteristic of the kidneys of the Cats, Suricates, and Hyæna. In a *Dasyurus macrurus* weighing three pounds eight ounces, the two kidneys weighed thirteen drachms. In a *Phalangista vulpina*, weighing five pounds three ounces, the two kidneys weighed only ten drachms. The ureters terminate, in all Marsupials, at the back of the neck of a large and pendulous urinary bladder, fig. 422, *l*.

In *Hyrax capensis* the tubuli uriniferi terminate in a prominent and pointed mammilla; in all the large Perissodactyles, e. g. Horse, Rhinoceros, Tapir, they open upon the concave surface of the renal pelvis, and can be readily injected from the ureter. Injection of the arteries of the Horse's kidney shows the terminal branch, fig. 482, *f*, dilating within the malpighian corpuscle, *d*, and there dividing into lobes or groups of capillaries, *l*, *i*; the returning or efferent vessel is shown at 2, *e*; and the continuation of the uriniferous tubule at 3, *t*, from the capsule of the corpuscle, *m*.[1] In the Rhinoceros the pelvis is represented by two longitudinal canals which converge and unite to form the ureter, of which they may be said to be the beginnings. The kidney is lobulated, or composed of numerous renules, each with its cortical and medullary part, but the tubes of the latter unite and converge to open into the longitudinal, *quasi* pelvic, canals without any valvular prominence.[2] The kidney of the Elephant differs chiefly in the termination of the tubuli of the lobes upon slight prominences; of these there is no appearance in the *Equidæ*. The tubular divisions of the pelvis are shorter in the Zebra than in the Horse or Ass, where they are continued nearer to the upper and lower ends of the kidneys. The ureters in these, as in the Tapir, terminate as usual in the neck of the bladder. But in *Hyrax*, concomitantly with an unusual length of loins, the ureters do not reach so far down, but open obliquely into the back part of the 'fundus vesicæ.'

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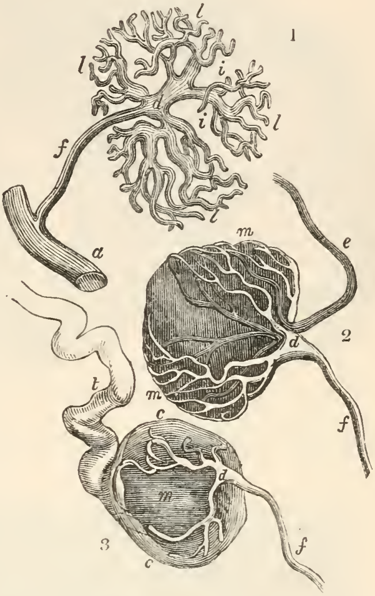

Malpighan tufts and corpuscle : Horse. CXXXVII.

In the Hog-tribe the kidney is simple; but the mammilla is somewhat extended at its free termination. In the Chevrotains and other small ruminants the kidney is simple as in *Lissencephala*; but in larger deer and antelopes the beginning of a more complex structure is seen in the aggregation of the tubuli uriniferi into several cones, distinct at their bases, but blending into a common elongate or ridge-like mammilla. This structure also obtains in the *Camelidæ*; but in the *Bovidæ* the cones are distinct, terminate by mammillæ in tubular productions of the renal pelvis, and are associated with some lobes or divisions of the cortical substance, such divisions sometimes including more than one cone.

In the Dugong the tubuli terminate in a single pelvis by several lateral ridges; but the exterior is undivided. In the Manatees, and in *Rhytina*, according to Steller, the kidney is lobulated. In the human kidney the tubuli are grouped into from twelve to fifteen conical bundles, the apices of which project into a common pelvis; but occasionally two cones combine to terminate by a common mammilla: in fig. 483 are shown three cones, in section, with the relative position thereto of the arteries, *a*, and the veins, *b*. In the fœtus the cortical part is subdivided like the medullary, but the clefts become obliterated in the growth of the kidney.

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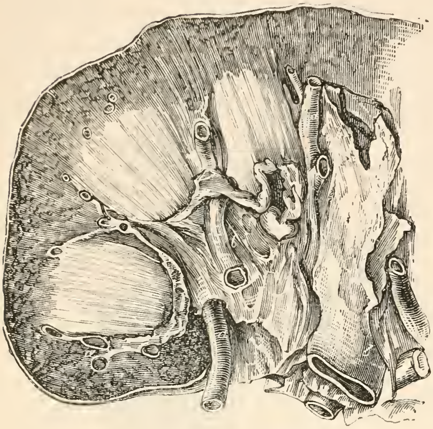
[1] CXXXVII.

[2] V″. p. 44, pl. 14, figs. 2 and 3.

483



Section of part of Human kidney: nat. size. CCLXXXVI.

Quadrumana have a single mammilla; but in the larger kinds it is extended, and the tubuli are partially grouped into bundles near the cortical substance. The kidney in the Suricate, Viverridæ, Hyænas, and Felines is chiefly remarkable for the arborescent disposition of the veins on or near the surface; the mammilla is single, as it is, also, in the *Mustelidæ*, *Canidæ*, and *Subursidæ*. In Bears, Seals, and Whales, the kidney is divided into numerous lobes or renules, in the Walrus amounting to three or four hundred, and in the Porpoise, fig. 427, E, to even a greater number. Each renule has its own capsule, which is removed at *a*, *a*, fig. 484; a section of the renule shows it to be composed of a cortical and medullary

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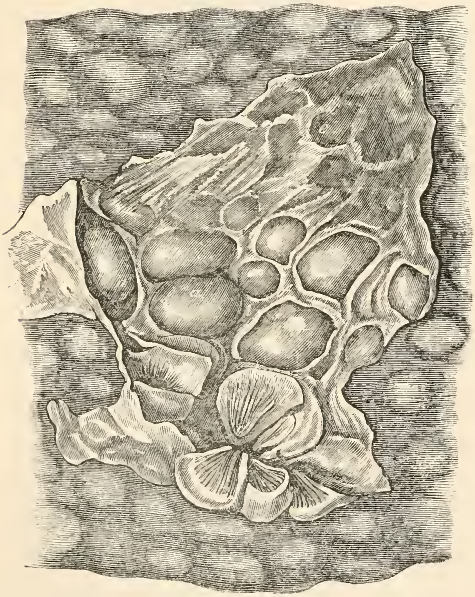

Portion of the kidney of a Porpoise. CCLXXXVI.

substance, ib. *b*, *c*; the tubuli terminate at the apex of a mammilla, *d*, which projects into an infundibulum. The infundibula are prolonged, and unite to form the ureter which comes out at the medial and hinder surface of the kidney and enters the neck of the urinary bladder.

In most quadrupeds this reservoir is more pendulous, has a more complete covering of peritoneum, than in Man. The oblique valvular course of the ureters through its coats is common to the Mammalian class. The monotremes are the sole exceptions; in them the ureters, fig. 485, *l*, 2, do not terminate in the bladder, *k*, but in the urogenital canal, *c*, the orifice of the spermduct or oviduct, *m*, intervening between that of the ureter and the bladder. The urine may dribble out with the fæces, or may pass by a retrograde course into the bladder; but, in either case, it is expelled *per cloacam* not *per urethram*: the penis in the male subserving the conveyance of the semen only. In all other mammals both urine and semen are carried out by the urethral canal in the male; and, in some *Insectivora* (Shrews, Moles) and *Quadrumana* (Slow Lemurs), the clitoris in the female is similarly traversed by a canal, which here, however, is exclusively for the urine. The vaginal orifice intervenes between the prominent and perforate clitoris, figs. 485, 546, *c*, and the anus.

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Clitoris, vagina and vent, Shrew.

CHAPTER XXXV.

TEGUMENTARY SYSTEM AND APPENDAGES OF MAMMALIA.

§ 357. *Derm.*—The main constituent of the skin of Mammals consists of an interlacement of fibres of the white or sclerous kind, fig. 486, *f*, continuous with those of the subjacent areolar tissue, *i*, but more or less abruptly defining a firm sheet of strong and tough fasciculate framework investing the body: the looser central or initial texture, *i*, includes, in its larger meshes, fat, sweat-glands, *h*, bulbs of hair, of bristles, or of spines, with sebaceous follicles, according to the species: it is traversed by the nerves of the sensitive or tactile papillæ, *d*, by sweat-ducts and by arteries, veins, and absorbents: it is covered by the epiderm, *c*, *a*. With the sclerous fibres of the derm are blended a varying proportion of the yellow elastic fibres, and of unstriped muscular tissue, especially in relation to the roots of the hairs or spines.

The texture of the derm is firmest at its periphery, where its surface is best defined: its thickness varies in relation to the bulk of the species and to other circumstances; it is such, e.g., in certain Perissodactyles and the Hippopotamus, as to have suggested the name of 'Pachyderm' for an artificial group of Ungulates in the Cuvierian system. In the full-grown Giraffe the corium hardly exceeds half an inch in thickness at any part: in the Indian Rhinoceros, of about the same weight, the average thickness of the derm is between two and three inches: it is thinner on the less exposed surfaces and at the bending of the joints. In the large specimen which I dissected the integument on the middle line of the abdomen presented a general thickness of three-fourths of an inch: on the inner side of the extremities, it was about one-fourth of an inch in thickness. It was connected to the abdominal parietes by a loose cellular tissue, and by a closer one to most of the other parts of the body; but the parts to which the stiff and ponderous hide most firmly adhered were the spinous processes of the posterior lumbar and sacral vertebræ, and the anterior extremities of the iliac bones, at which places the corium was blended with the periosteum, and was thin. The derm adhered over the jugal bones to a kind of movable fibro-cartilage; but its attachment along the median line of the fore part of the head was so firm as to require, especially beneath the horn, the use of a chisel in order to separate it from the skull.

Besides its attachment to subcutaneous cellular substance, fasciæ, elastic tissue, fibro-cartilages, and periosteum, the derm is connected with parts which are destined for its motions and adjustment upon the body. The 'panniculus carnosus' of the Rhinoceros is developed in certain parts to an extraordinary thickness; the permanent folds in the hide of the Indian species serving to afford, like the processes of bone, a firmer insertion to the aponeuroses of the cutaneous muscles than a plane surface of integument could have done. A sheet of these muscles situated on each side of the thoracic or scapular region sends its fascia into the interstice of the fold in front of the anterior extremities, the skin being bent upon itself, as it were, to grasp this fascia. Similar portions of panniculus carnosus send their aponeuroses into the posterior folds of the skin.

The derm, in *Cetacea*, is a somewhat gradual condensation of the close fibrous reticulation in the areolæ of which the oil is contained; the thickness of such subcutaneous tissue, called 'blubber,' being enormous in the large Whales: it is wanting at the fins, and here the derm is closely connected with the sclerous tissue covering the bony framework of the pectorals, and contributing mainly to form the dorsal and caudal fins: in the latter the subdermal fibres become assorted into three layers, the upper and under ones being longitudinal, the intermediate layer transverse, and the texture of the whole so compact that the traversing veins as well as the arteries preserve their open state when cut across. The fine lengthened papillæ or villi from the periphery of the derm are noticed at p. 188.

Certain *Rodentia* contrast with the Pachyderms in the thinness and lacerability of their derm, resembling birds in that respect. Another Lissencephalous family reproduces a crocodilian character, in the development of osseous scutes upon the peripheral part of the derm (vol. ii. p. 396, fig. 261). These scutes are small, mostly quadrilateral, and suturally united so as to form three principal groups: one protecting the trunk like an arched roof, a second forming a flatter shield or helm upon the head, the third encasing the tail, like a sheath. In most existing Armadillos the trunk-armour consists of an anterior thoracic buckler in which the ossicles form a kind of mosaic work; a middle 'annular' part in which they are disposed in transverse series movable upon each other; and a posterior lumbar buckler, like the thoracic one: by this modification of the dermal plates the little animal is enabled to roll itself into a ball, and protect its snout and legs beneath the trunk-armour. In the large extinct Armadillos (*Glyptodon*) the annular or banded modification of the armour was not present; and the whole of the dermal scutes of the trunk were united into one massive domed roof: the marginal scutes being generally triangular, the rest more or less regularly hexagonal. The inner surface of the scutes, imbedded in the derm, is smooth; the outer surface coated with epiderm is sculptured in a definite pattern, distinct for each species and characteristic thereof. The dermal plates of the caudal sheath in certain kinds of *Glyptodon* formed annular series of large conical tubercles: the first ring, in all, was distinct from the rest of the caudal sheath, to facilitate the movements of the tail.

In the Pangolins (*Manis*) the exterior of the derm is grooved, as in Lizards, for the lodgment of the bases of the large horny scales, which protect the body and tail by their imbricated overlapping arrangement (vol. ii. fig. 158). The muscular tissue enters in greater proportion than usual into the composition of the derm of this Mammal, in connection with the thick 'panniculus carnosus,' and in relation to the erection of the scales, when the integument is drawn defensively about the uprolled trunk and tail.

Productions or duplications of the derm, with included muscles, &c., form the peculiar mammalian oral appendages called 'lips:' an everted fold of skin forms the 'scrotum:' an inverted fold the marsupium and the cheek-pouch (p. 386, fig. 300): the derm is extended between the digits to form the 'web' in most aquatic quadrupeds, and also beyond the digits to augment the swimming surface in the Ornithorhynchus: a duplicature of integument forms the 'dewlap' in certain Bovines: it forms a broad fold on each side, continued from the fore to the hind limbs to form the parachute, in the Petaurists, Pteromyds (Vol. ii. fig. 156), and Flying Dormice (*Anomalurus*): in the Colugos (*Galeopithecus*) the dermal fold expands from the nape to the fore-feet, from these to the hind-feet, and thence to the tip of the tail, forming a triangular 'interfemoral' flap. But the most extraordinary developments of derm are presented by the Bat tribe (vol. ii. p. 278, fig. 156): the 'antibrachial fold' crosses the deep interspace between the humerus and radius; the 'digital fold,' which mainly forms the wing, occupies the interspaces of the long and attenuated digits; the 'flank-folds' extend from the fifth digit to the tarsus; the 'interfemoral fold' passes from leg to leg, intercepting more or less of the tail.

The wing-membrane is sometimes further developed, so as to be disposed at one part in the form of a pouch, as in the genus of Bat thence called *Saccopteryx*, in which the pouch is plicated, and its linear orifice is near the head of the humerus. The delicate organisation of these modifications of the derm has been noted at p. 189; and, as regards its vascular structure, at pp. 549 and 553. The conchal or auricular productions of the derm are considerable in all Bats: the two outer ears are confluent, or united by a transverse fold of skin, crossing the forehead, in *Nycteris* and *Megaderma*; in these and many other genera, e.g. *Rhinopoma*, *Rhinolophus*, *Phyllostoma*, the nose, also, is furnished with a crest or with foliaceous lamellæ.

The sudoriferous or sweat-glands, fig. 486, *i*, consist of a fine secerning tubule, coiled up into a ball, and situated at the under surface of the derm or in the subcutaneous tissue, *h*: the duct traverses the derm, at first in a wavy course, *g*, becoming straighter in the denser peripheral part, and spiral as it passes through the epiderm, *b*, to terminate at the sweat-pore. The sebaceous glands relate chiefly to the hairs, and mostly open into the hair-sheath or follicle, fig. 487, *h*. The movements of the derm are due either to intrinsic or extrinsic muscles: the former, ib. *g*, which are smooth as a rule, produce the shrinking called 'cutis anserina,' on account of the protrusion of the hair-sheaths, and the depression of the intervening part of the skin; the extrinsic muscles, which have striped fibres, move more or less of the integument, as when cattle after a shower, or a dog quitting the water, shake off the moisture, or when a fly or other irritant is sought to be dislodged.

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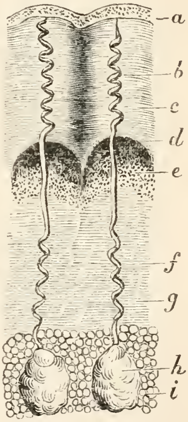

Section of Human skin, magn.[1]

§ 358. *Epiderm.*—Upon the papillose surface of the derm, in the embryo, albuminoid atoms in the solution exuding therefrom formify as cells, and between the outermost of these, condensed and dried by exposure after birth, and the derm, formifaction continues, throughout life, to produce a precipitate of cells. These, at first, are perpendicular to the derm, in one or more strata; then, as they are pushed off by newly formed cells, they assume a more rounded shape, lose their soft granular contents, afterwards their firmer nuclei, and, finally, become pressed into dry hard scales at the periphery of the epiderm. Many of the deepest-seated and first-formed cells contain coloured particles or pigment, constituting the 'rete mucosum,' or 'malpighian layer,' fig. 484, *d.* This pigment, combined with the cells constituting the hairs or spines, gives the characteristic colour of the quadruped, and seems to affect the derm itself. It rarely manifests, in Mammals, the bright and pure colours noticed in the skin of Birds (p. 231, vol. ii.); but to the face of certain baboons it may give a red, blue, or violet tint. In quadrupeds with circumscribed patches of black hair a deposition of dark pigmentum may be traced in the corium above the sheaths whence the black hairs grow. The darker-coloured skin and hair is, as a rule in Mammals, on the upper or more exposed surface of the body, and the lighter-coloured pelt is below. But in the Ratel and Skunk the ordinary arrangement of colours is reversed, the back being light and the belly dark: the white bands of hair in the Skunk are associated with a corresponding colour of the corium, and are seen on the inner side of the dried pelt. In the human subject the amount and colour of the subcuticular pigmental cells relate, but not absolutely as regards existing continents and peoples, to the degree of solar influence to which the skin is exposed. A fair complexion and light hair do not characterise any race indigenous to tropical and warmer temperate latitudes, but are limited to cooler temperate and cold climes, which, from the present excess of dry land in that hemisphere, are northern or arctic. The continent of Europe, if the complexions of its peoples be compared from Scandinavia to the Mediterranean, exemplifies the progressive deepening of the tints of skin, hair, and eyes, as the sun exerts more power. But the Asiatic part of the 'Old World' shows this relation in a minor degree. The aborigines of Northern Asia to Kamtschatka are, like the Japanese, of a brownish-yellow complexion: the same prevails through all the latitudes of the vast Chinese Empire; but the southern extensions of that people into Cochin-China, Siam, and Burma, do show a deeper brown. The Hindoos retain the same almost black tint over a range of twenty-six degrees of latitude and twenty-four degrees of longitude; but these are tropical, or nearly so. The Malays of the Indian Archipelago preserve the same deep brown tint over eighteen degrees of latitude, reckoned from the equator northward, and the tint would seem still to relate to such excess of solar influence; although the sway of other causes is exemplified by the darker Mincopies, Cingalese, and Hindoos, under similar influences. Still more strikingly is this shown by the blackness of the Melanian aborigines of New Guinea, Australia, and Tasmania, retained from the sixth to the forty-third degree of south latitude; and especially of those of the outlying islands in proximity with others inhabited by the olive-brown Polynesians, whose complexion prevails from lat. 12° S. to 46° S. (New Zealand). But the most instructive example of the closer relationship of tint to race than to climate is afforded by the aborigines of the New World, which hold nearly the same depth of copper-brown or reddish tint, latitudinally from Tierra del Fuego to Hudson's Bay, and longitudinally from the Atlantic to the Pacific. The contrast between the South American Indians and the African Negroes would seem to be decisive against the hypothesis of degrees of solar influence being the causes of degrees of darkness of complexion.

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[1] The derm, *f*, so magnified, is considerably thicker than here represented.

But there is an element in the problem which ought to be taken into consideration, viz. 'time.' If Africa be an older continent than South America, its aborigines may have been subjected to solar influences through a longer series of generations. We know not the extent of such series; some may deem that were the intertropical South American Indians subject to a vertical sun during the long ages of Africa's emersion, they would acquire a darker complexion.

Climate, however, depends on other influences than sunshine. Degrees of moisture, and whatever influences cause a contrast or gradation of seasons, &c., may have their effects upon complexion. Filthy habits, foul air, and bad food, affecting biliary and other secretions, have their share in darkening the skins or sallowing the complexions of the Esquimaux, Fins, and Laps, e.g. as compared with the cleanlier and more healthily living and better nourished Scandinavians residing some degrees further from the pole. But assuming, as the general result of the above survey of human complexions, that such complexions do, in the main, show a certain dependent relationship on solar light and heat, and postulating the effect of long periods of such subjection, we might then be led to conclude the darkest of the intertropical and warm temperate peoples to be the oldest; that the Melanians, scattered on islands to the east of the Indian Ocean, inhabit relics of a continent as old as, perhaps older than, Africa; and that the lighter-tinted races on intercalated or contiguous portions of dry land are subsequent immigrations or derivatives from lands less affected by solar influences. On this hypothesis it may be inferred that the deepest-tinted races existing in the islands of the Malayan Archipelago are the oldest inhabitants of such—those most entitled to be termed aborigines. The Hindoos, by the same pigmental test, would be deemed older than the Parsee or Mahometan natives of Hindostan, as history, indeed, testifies. In extra-tropical latitudes, human generations may have succeeded each other for the same duration of time as in tropical ones, without further deepening or development of pigment than such diminishing influence of the sun may effect. Such peoples, migrating to tropical countries, may long maintain their inherited complexions; just as the black races migrating to extra-tropical latitudes long retain the tint inherited from forefathers in whom it has been established primarily by the requisite continuance of exposure to extreme solar heat and light.

§ 359. *Callosities.*—The epiderm, besides forming the firm and more or less insensible outer protection of the derm, acquires unusual thickness at certain parts in different mammals. It forms callosities over the sternum of the Camel and Dromedary, and upon the parts of the joints (carpal and rotular) on which these useful beasts of burden kneel. It defends the broad back of the penultimate phalanges of the fingers of the knuckle-walking Apes, the ischial tuberosities of most lower Catarhines, and the prehensile surface of the tail in many Platyrhines.

In the *Equidæ* there are callosities on the inner surface of the limbs, which, however, are more dermal than epidermal. In the Horse, on the inner side of the fore-leg, a little above the carpus ('fore-knee' Hippotomy), and on the inner side of the hind-leg, a little below the 'tarsus' (hock-joint, Hippotomy), is a naked protuberance of a soft horny consistence, about the size of a chestnut, and called 'châtaigne' by the French veterinarians. Behind the metacarpo-phalangeal joint is a similar but smaller horny tubercle, called the 'ergot,' or spur. The Ass has not the 'châtaigne' on the hind-leg; but there is the vestige of one on the fore-leg, situated there as in the Horse; it consists of a patch of black skin devoid of hair, but not horny. There is a similar trace of the spur (ergot) behind the metacarpo- and metatarso-phalangeal joints. The Zebra resembles the Ass in these respects: the homologue of the fore-leg callosity is a patch of black naked skin about 3½ inches long and 3 inches broad; the callosities behind the metacarpo-tarso-phalangeal joints are like those of the Ass.

§ 360. *Hair.*—The cutaneous clothing characteristic of the Mammalian class is 'hair.' It consists of unbranched filaments of epidermal material, usually composed of 'pith' and 'crust,' and in which are distinguished the 'root,' the 'stem,' and the 'point.'

The root is softer and lighter in colour than the stem,[1] is contained in a canal of the skin or sheath, fig. 487, *e*, and expands at the implanted end into the 'knob.' This part during the growth of the hair has a conical cavity inclosing the 'bulb,' ib. *f*, which forms the 'pith;' from its base there is reflected upon the 'knob' a capsular layer of cells which forms the 'crust;' this layer is continued to near the outlet of the sheath; it consists of two or more layers of cells, the outermost of which have generally lost their 'nuclei.' The proper tunic of the sheath is 'derm,' lined by epiderm continuous with the cuticle, which accordingly, when shed, usually brings away the hairs. In the dermic part there is a vascular and a hyaline layer; the latter ceasing with the capsular part of the hair's matrix.

Two sebaceous glands, ib. *h*, usually open into the hair-sheath; and one or more delicate muscles, ib. *g*, of unstriped fibre, pass from the harder superficies of the derm to be inserted into the capsule beneath the glands; these are mainly concerned in raising the hairs.

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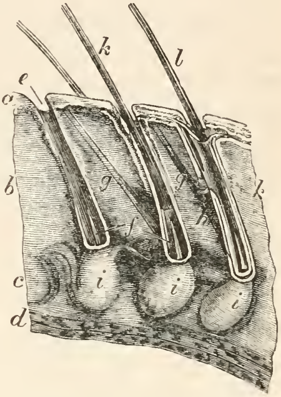

Section of skin with hair-matrices.

Hairs, like teeth, are of two kinds as regards growth; one temporary, the other persistent. The former are shed and succeeded by new hair, usually once a year; the latter have persistent bulbs and perennial growth. The body-hair of the Horse is an example of the first kind, the hair of the mane and tail of the second kind. In many Mammals there are two kinds of hair, according to form, length, and structure; one short, fine, more or less curled, and mostly hidden by the longer, coarser, and straighter kind, which is sometimes called the external coat, albeit the roots sink deeper into the derm than do those of the internal coat, usually called 'fur.'

These two kinds of hair—inner and outer—are most distinctly as well as abundantly shown in arctic and aquatic quadrupeds, (ermine, sable, beaver, and the seal-tribe), especially in the young state, when the heat-forming power is weak. In some species of

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[1] The contrast is striking in the hair of the Ornithorhynchus, in which the brown tint is confined to the expanded terminal part of the hair.

Seal the 'fur' gets scanty in the adult (*Otaria lobata*, e.g.); in others it continues abundant in quantity, and of fine quality (*Otaria ursina*, e.g.); hence a difference in the commercial value of the skins, whereby 'sealers' distinguish between the 'hair-seals' and the 'fur-seals.'

The term 'wool' is commonly understood to mean the modified hairs of domesticated breeds of sheep, which, through a finely imbricate arrangement of superficial serrated scales, and a curly disposition, have the property of mutual cohesion, called 'felting,' on which depends the value of wool in manufactures. The property is present in a minor degree in the longer, straighter, scantier fleece of such wild sheep as the Himalayan *Ovis Vignei*, the *Ovis Ammon* of Central Asia, and the *Ovis Musimon* of Sardinia. In the domesticated races the fleece has been modified and improved, in various degrees, by crossing the breeds, by choice of climate and pasture, and by careful attention and defence during its growth, until not only has the original coarse character of the product disappeared, but qualities of wool of different kinds and of different degrees of superiority have been obtained, generally divisible into two classes, one better adapted for 'carding,' the other for 'combing,' and both available for a great variety of useful and elegant textile fabrics.[1]

The fleece of the domesticated varieties of *Auchenia* (Llama Vicugna) has analogous properties rendering it useful for various manufactures. In all Ruminants the hair is shed annually: this would happen to the wool of Sheep were it not shorn. The Llamas form no exception: the fleece of one in the London Zoological Gardens became ragged and detached in masses in the month of July. Mammals living in cold climes develop a thick undercoat of fur or wool: this is seen in the Musk-bubale, and was the case with the primigenial Elephant[2] and Rhinoceros,[3] its former associates in high northern latitudes.

The muzzle, the inside of the ears, the sole of the paws, are defended by hair in arctic quadrupeds (e.g. *Ursus maritimus*). The sole of the foot in the Camel and Dromedary is defended by hair from the hot sand of the desert.[1] Nocturnal quadrupeds of hot climates, as, e.g., *Lemuridæ,* have the soft fur and the longer scantier kind of hair. The northern Wild Boar has an undercoat of fur besides the bristles: in most domestic Hogs the latter alone are developed; and a gland-like body partly surrounds the matrix of the bristle, fig. 485, *i*. Rhinoceroses and Elephants of tropical latitudes have but one kind of hair, most conspicuous in the young, especially in elevated localities, but almost wholly lost in the full-grown animal. The Hippopotamus, *Sirenia, Cetacea, Bimana,* are examples of naked Mammals; but on the limited localities where the skin develops such a covering, it is of the mammalian character—hair or bristle. The fœtal Whales show the latter on the lip, the adult Elephants and Rhinoceroses on the tail. Human hair, which continues to grow through more or less of life, has distinctions as to localities and length, characteristic of age and sex: it varies in colour from pale yellow to black, and in form from straight to crisp, resembling wool on the head of the Negro variety.

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[1] In judging of these qualities in wools, it is requisite to test the fineness and elasticity of the fibre, the degrees of imbrication of the scaled surface of the fibre as shown by the microscope, the quantity of fibre developed in a given space of the fleece, the comparative freedom of the fleece from extraneous matters, and the skill and care employed in preparatory processes; such, for example, as that termed 'scouring' the fleece, upon which depends its liability or otherwise to mat at the bottom of the staple. CCXXVIII″.

[2] CCXL″. p. 263.

[3] Ib. p. 351 (*Rhinoceros tichorhinus*).

The degree of imbrication of the scaly outer layer of the human hair is such that rubbing one between the thumb and finger pushes the root-end away. Beneath the scales the cortical part of the hair is minutely fibrous; it includes a cellular pith with pigment, upon which the colour of the hair mainly depends. In the minute hairs on the general surface of the body, the pith is wanting. I have observed the hair of the beard to be three-sided, with rounded angles, in transverse section; the hair of the head of the same individual being a full oval in such section.

The general direction of the minute and fine hairs on the human limbs accords with that of the medullary arteries of the long bones, viz. toward the elbow-joint and from the knee-joint.[2] A corresponding disposition prevails in the hairy clothing of the limbs of *Quadrumana*. In the attitude assumed by an Ape crouching beneath the pelting of a tropical shower, with close-bent limbs, thigh and fore-arm upward, arm and leg downward, the reverse directions of the hairs on the proximal and distal segments will be seen to be such as to act in both as a downward watershed.

The general direction of the hair in swift quadrupeds offers least impediment to forward motion. Some small burrowers, which move backward as well as forward in their long and narrow tunnels, would be inconvenienced by such unchangeable disposition of their fur. Accordingly in Moles, Shrews, and Platypi, e.g., the stem of the hair is filamentary, the end broad and flat, and the slender and expanded parts may alternate twice or oftener in the course of the hair, enabling the whole fur to assume any direction in which it may be stroked.

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[1] xx. vol. iii. p. 243.

[2] Eschricht has given ample details of the disposition of the hair in the human fœtus, in ccxxx″.

The heat-retaining property of the pilose covering is mainly due to the amount of air it is able to retain. The long curly character of the Sheep's and Llama's fleece is one modification to this end; the swifter Deer and Antelope are not so encumbered; but the hairs composing their thin but close and smooth pelt have a cellular structure which combines lightness with the requisite air-intercepting quality.

In the Horse there is a central point on each flank, whence the hair radiates in a somewhat spiral manner: the corresponding centre in the Giraffe is a little behind the middle of the abdomen, towards the lower part.[1]

The hide of the larger Ruminants which are exposed to the elements in the prolonged act of grazing is defended by the greasiness of the hair, as may be felt in the recently killed Red-deer or Fallow-deer. The amount of sebaceous matter excreted with the hair in some Antelopes is such as to have suggested a specific name in accordance therewith.[2]

The varieties of structure of hair are extreme: those of Deer seem almost wholly to consist of cellular pith, the cortex undefinable: the tail-hair of the Horse, and the Pig's bristle, offer the opposite extreme of thickness of cortex and minimum of pith. But these and other modifications demand a special micrography.[3] Hairs of some quadrupeds, the Racoon, e.g., in the filamentary productions of the cortical scales, recall the character of the immature down in Birds (vol. ii. p. 237). In some Rodents, the Hare, e.g., several fine hairs project from the mouth of the same sheath as the larger hair. In Mice and Shrews the margins of the cortical scales encompass the hair and project forward or rootward. This free projection is such in some bats that the hair presents the appearance of a succession of ensheathed funnels with their apices backward or outward. The hair of the Sloth is fluted, the crust appearing to be composed of several filaments confluent with a common central pith. In the Peccari the pith of the coarse body-hair is crossed by condensed cells like beams strengthening the cortex. The colour of the hair is lost by age in Man, and during the winter season in the annually renewed covering of many arctic Mammals: the endosmotic transfer of their contents from cell to cell of the pith effects this change. The hairs of the Cape-Mole are peculiar for the iridescent tints they reflect, whence its generic name, *Chrysochloris.*

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[1] The varieties in this respect merit more notice than they have hitherto received.

[2] Laurillard's *Antilope unctuosa* is probably the same species as *Kobus Sing-sing* of Ogilby.

[3] Brief immersion in sulphuric acid and cleansing with ether are requisite preliminaries for clear and satisfactory microscopic specimens of hairs.

The stiffer, thicker kinds of 'hair' are called 'bristles:' when these attain unusual length, grow from the lips, cheeks, and other parts of the head, and have the matrix supplied by unusually large nerves, endowing them with tactile or exploratory faculties, they are termed 'whiskers' or 'vibrissæ'[1]: those which beset the muzzle of the Walrus attain the thickness and stiffness of spines, and serve, also, mechanical uses.[2] The muscles moving vibrissæ have the striped fibre.

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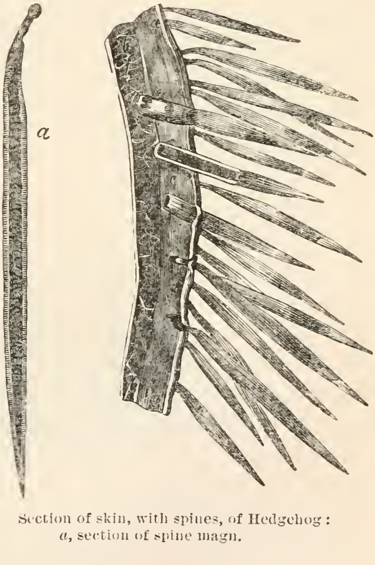

Section of skin, with spines, of Hedgehog: *a*, section of spine magn.

§ 361. *Spines.*—Over the major part, including the more exposed surfaces, of the skin of the Hedgehogs (*Erinaceus*, *Centetes*) spines are developed in such numbers and of such length as to conceal the hairs; they are nearly straight, terminate in a point, and, when fully formed, are smaller at the root than in the shaft. They have a thick, stiff, horny cortex, including a pith of cells arranged in transverse groups, fig. 488, *a*. The matrix is originally situated beneath the derm, in contact with the strong 'panniculus carnosus;' but section of the skin shows the roots and sheaths of the quills, extending to different depths according to the period of their growth: the newly formed ones are lodged deep, and terminate without contracting, the pulp being large and active, and the cavity containing it of corresponding size; but as the growth of the quill proceeds, the reflected integument forming the sheath gradually shortens and draws the quill nearer the surface; the pulp is at the same time progressively absorbed, and the base of the quill is contracted in diameter, until it adheres to the surface of the derm by a narrow neck, below which is a slightly expanded remnant of the matrix. The disposition of the dermal muscles subserving the spiny armour of *Erinaceus europæus*, is given at pp. 18, 19, figs. 7 and 8.

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[1] xx. vol. iii. p. 245.

[2] Ib. p. 246.

In the Porcupine (*Hystrix cristata*) the spines attain so great a length that they are called 'quills.' The formative pulp, fig. 489, *e*, is longitudinally furrowed; to it is due the cellular pith: the capsule or inner layer of the theca is reflected into, or fills, the pulp-grooves, and deposits therein, and continuously around the whole, the horny cortex: the consequent arrangement of crust and pith is such as in transverse section to give the figure, fig. 489. Beneath the matrix is a cavity like a minute 'bursa mucosa,' which allows much freedom of motion to the quill when acted upon by the muscle, *d*, of the sheath, *f*: a sebaceous gland, *h*, serves the quill opening into the sheath near the outlet. When the growth is completed, the matrix shrinks, and the same movement to the periphery of the derm takes place as in the spines of the Hedgehog. Thus it happens that when the quills of the Porcupine are violently shaken by the action of the cutaneous muscle, *c*, the adhesion of some old quills to the derm has been so reduced that they are thrown off.

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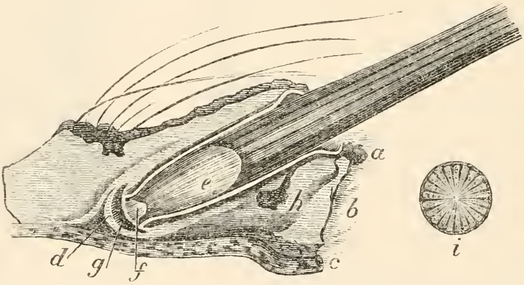

Section of skin, with matrix and root of quill: *i*, section of quill, Porcupine.

§ 362. *Scales.*—Only one genus of Mammal (*Manis*) offers a covering of scales; and with them are associated hairs. The scales are large, epidermal or horny in tissue, and imbricate or overlapping, with the free border turned backward, vol. ii. fig. 158. The external surface of the derm is raised into large rhomboidal processes, upon which the scales are moulded: beneath the derm is a thick 'panniculus carnosus,' adapted to draw the integument around the animal as a means of defence, and connected with muscular slips, which erect the scales.

A few other Mammals show partial deposits of scale-shaped cuticle. Thus, in the tail of the Beaver the epiderm is disposed in hard scale-like plates, the anterior margins of which project obliquely inwards, and develop small pointed processes which pass into corresponding depressions of the derm. In the great Flying Dormice of Africa (*Anomalurus*) there is a double row of alternate overlapping horny plates at the under part of the base of the tail, reminding one by their size and strength of the scales of *Manis.*

§ 363. *Nails, Claws, and Hoofs.*—The derm covering the ends of the digits, in Man, is closely connected or confluent with the perioste at the back of the last phalanx, and forms near its base a crescentic groove or 'nail-bed,' from the ridged and highly vascular surface of which a solution of epidermic material exudes, which material formifies as cells, at first vertical to the surface; then, when pushed off by a succeeding precipitate of cells, becoming flattened, and ultimately condensing or coalescing into the horny plate termed the 'nail.'

In the hoofed quadrupeds the ridged or laminate vascular derm or dermo-perioste extends over the fore and lateral parts of the last phalanx, and similarly provides it with a thick hard horny wall, in great part of which the primitive cells have condensed into fibres perpendicular to the plane by which the superincumbent weight is transferred to the ground. In the Horse the formative lamellæ are shown in fig. 17, at 17; the resulting hoof being turned off to expose the horny lamellæ, ib. 3, which interlock with the vascular lamellæ. From the greater part of the derm covering the under surface of the foot horny matter arranged as vertical fibres is also formed, completing, with the denser front and side walls, the case called 'hoof.' The fibrous epiderm on the sole of the bisulcate foot of the Ruminant is very thick, but less dense than in the soliped. Further particulars of the structure of the Horse's hoof are given at pp. 39–41.

In *Carnivora* the base of the last phalanx forms a 'nail-bed' much deeper than in Man, a plate of bone being reflected forward like a sheath for the base of the terminal, prominent, and pointed part of the phalanx. The dermo-perioste of this bed develops a very dense horny sheath covering the claw-core, and reciprocally received at its base within the 'bed' or sheath formed by that part of the ungual phalanx. For the form of such 'claw' in the Felines, and the muscular and elastic structures connected therewith, see pp. 69, 70, and fig. 36. The maximum of claw-development is, however, presented by the Armadillos (vol. ii. figs. 272, 276), the Sloths (ib. fig. 280), and the Anteaters (ib. fig. 263): in the gigantic extinct members of the order *Bruta* (*Megatherium*, fig. 279, e.g.) the claws and their core or supporting bone rivalled the horns of many Ruminants in bulk.

§ 364. *Horns.*—The horn of the Rhinoceros consists of a uniform compact agglutinate mass of epidermal fibres, the slightly concave base of which is attached to the dermo-perioste of as slightly elevated a rugous tract of bone: it is medial in position and symmetrical in shape.

The Asiatic continent and the Island of Java have the one-horned species called *Rhinoceros indicus* and *Rh. sondaicus* (vol. ii. p. 284, fig. 165): the same continent and the Island of Sumatra have the two-horned species (*Rh. sumatranus*): all the known kinds of *Rhinoceros*, four in number, of Africa are two-horned: in these one horn is behind the other in the same medial tract of the upper part of the skull.[1] The nasal bones support the constant or anterior horn: when a second is superadded it is attached to the frontals, and is, usually, shorter than the first;[2] in *Rhinoceros Oswellii* considerably shorter; but in *Rh. Ketloa* it is almost or quite as long as the first horn, but is straight. The horn or horns of the female Rhinoceros are usually shorter or smaller than in the male. In the young one-horned Rhinoceros living, from 1834 to 1849, at the Zoological Gardens, the new fibres of the growing horn were chiefly added to the front and sides, those at the back decaying, and by this direction of addition the horn preserved its relative position to the fore part of the growing head. This local decay and renovation became less conspicuous after the animal had gained its full size; and in the long horns of aged individuals the whole basal circumference presents the same smooth and polished surface, the reception of additional matter being then restricted to the completed area of the base.

Raise and prolong the bone covered by the vascular horn-forming tegument, and the next type of horn would result. In most Ruminants (Oxen, Antelopes, Goats, Sheep) a pair of processes extend from the frontal bones, the dermo-perioste of which develops a sheath composed of horny fibres: but the supporting process is long and conical, and the horn which sheaths it is correspondingly hollow, whence the Ruminants, so armed, are termed 'hollow-horned.' The bone is termed the 'core:' it has usually a rugous or grooved exterior: in *Bovidæ* and *Ovidæ* the frontal sinuses extend therein: in *Antilopidæ* the core is solid or but slightly excavated at the base. In an Indian species (*Antilope quadricornis*, fig. 491) two pairs of horn-cores are developed from the frontals; the same peculiarity characterised the gigantic extinct Antelopes (*Bramatherium* and *Sivatherium*, vol. ii. p. 473, fig. 322), and they also combined the branched character of the horn in the hinder pair, which is at present restricted to the single pair borne by the Prong-horn Antelope (*Antilocapra Americana*, fig. 492).

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[1] The nasals of the fossil *Rhinoceros minutus*, Cuv., show a transverse pair of small and smooth conical processes, which cannot confidently be inferred to have sustained horns: like the *Rhinoceros incisivus*, I believe it to have been hornless.

[2] There are reports, needing confirmation, of a small third horn, as a rare variety.

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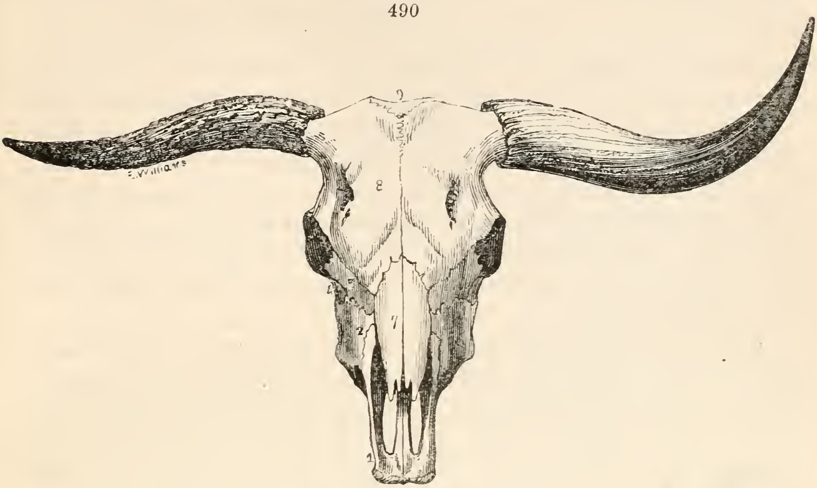
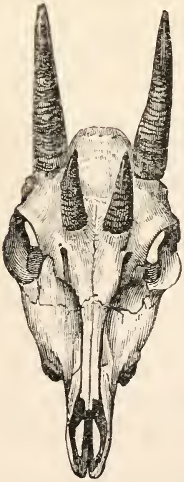


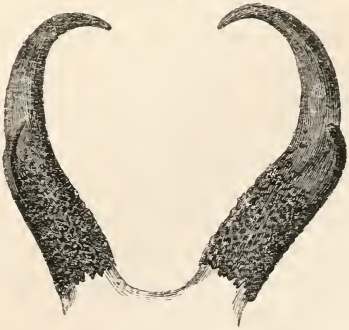
Skull of Ox with horn-core, *a*, and horn, *b*.

491



Skull of four-horned Antelope.

492

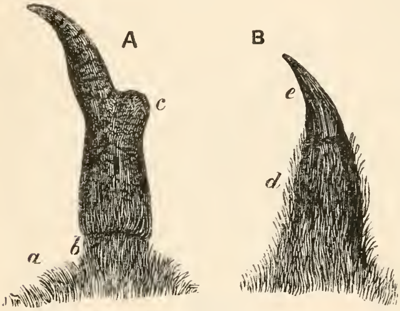


Branched horns of the Prong-horn.

In the true Oxen (*Bos*) the horn-cores spring from the posterior angles of the frontals, fig. 490: in the Bisons (*Bison*) their origin is a little in advance of these angles (vol. ii. fig. 320): in the Buffaloes and Bubaline Antelopes the horn-cores rise by broad and extended bases, meeting at the mid-line (*Bubalus Caffer*, *B. moschatus*, *B. Gnu*): in Antelopes the origin of the horns are more in advance. The shape, size, length and direction of the horns vary extremely in the hollow-horned Ruminants: in many they are transversely ridged or annulate; but several rings may be formed in one year: a periodical activity of growth is noticeable in most, as in the Ram and Goat, toward the period of the rut. Horns are usually present in both sexes; but in some genera of Antelopes (*Tragelaphus*, *Cervicapra*, *Cephalophus*, e.g.) only in the male. In *Antilocapra* the rudimental horns in the female are sometimes conspicuous, but are small, short, and simple, as in the yearling-buck.

The Prong-buck acquires its full-sized horns by progressive growth of the persistent core and by annual shedding and renewal of the extra-vascular sheath. The latter phenomena have been witnessed and recorded by two trustworthy observers. Mr. Bartlett noticed their fall in a young male at the Zoological Gardens, November 7th, 1865: the shed sheath was 8 in. long, and showed an obtuse beginning of the lower prong of the fork, fig. 493, A, *c*. The dermo-perioste of the core does not lose its vascularity: the shedding of the agglutinated fibres of the sheath, like that of the ordinary hair, is due to the obliteration of the matrices of these fibres and their extrusion from the dermo-perioste; which, in the meanwhile, has begun to develope a new coat of fibres, ib. *b*. These, on the shedding of the old mass, appear as an abundant covering of long, straight, silky and light-coloured hairs, ib. *d*, the growth of which mechanically uplifts and pushes off the old sheath. The new sheath, 4 inches long when so exposed, grew to 6 inches in the course of three weeks, at which time the fibres had begun to felt or agglutinate into a compact horn at the summit, fig. 493, B, *e*.[1]

493



Shedding and formation of horny sheath of horn, *Antilocapra Americana*. CCXXIV″.

Dr. Canfield observed in a young yearling male Prong-buck, which he had captive, at Monterey, California, the growth of the first pair of horns commencing in July (1855), and attaining the length of $\frac{3}{4}$ths of an inch and the form of a mammillary knob; the sheath was shed, early in December, leaving the core $\frac{1}{2}$ an inch long, and covered by fine silky hairs: in a week the agglutination of the summit into compact horn commenced. In October 1857, the animal being two years and a half old, the horns were 9 inches long, and the anterior prong was indicated by a protuberance, as in fig. 493, A, the agglutinate tip of which soon became confluent with that of the main stem. The phenomena noted between 1855 and 1857 indicated an annual shedding of the horn-core.[1] It is probable that such takes place, also, in the fully-formed horn and, in the month of November, as a rule.[2]

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[1] CCXXIV″. p. 719.

The Giraffe has a pair of small, short, cylindroid unbranched horns which consist of bone covered by hairy skin terminated by a tuft of coarser hair. The bones are not processes of the skull but are joined, like epiphyses, by 'synchondrosis' to both frontal and parietal bones, the base crossing the coronal suture. They are present in both sexes (vol. ii. p. 476, fig. 325); and the young is born with such horns, being the sole horned mammal that enters the world with these weapons.[3]

In Deer (*Cervidæ*) the horns consist wholly of bone which grows from the frontal, the periosteum and finely haired integument, called 'velvet,' co-extending therewith during the period of growth; at the end of which the formative envelope loses its vascularity, dries and is stript off, leaving the bone a hard insensible weapon. After some months' use, as such, the horns or more properly 'antlers,' having lost all vascular connection with the skull, and standing in relation thereto as dead appendages, are undermined by the absorbent process and shed; whereupon the growth of a succeeding pair commences. The shedding of the antlers coincides with that of the hair, and, with the renewal of the same, is annual.

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[1] ccxxv″. p. 108.

[2] Thus Dr. Canfield observes:—'In the month of December and January I have never killed a buck with large horns; and at that time of the year all the bucks appear to be young ones, because their horns are so small, whereas in the spring and summer months almost all the bucks appear to be old ones, for their horns are then large and noticeable.' He also remarks:—'In the summer months the line of demarcation is very apparent and abrupt between the horn and the skin from which it grows, but that in winter there is no demarcation, the horn being very soft at its base, passing insensibly into cuticular tissues, and the horny substance being covered thinly with hair.' Ib. p. 108.

[3] ccxxvi″. p. 25. A broad obtuse eminence formed by thickening of contiguous parts of the two frontals at the part of the frontal suture, the base of which eminence is often irregularly excavated or undermined by vessels, has been mistaken for a third horn, articulated to the frontals. See xcvii′. p. 219; and section through this part, vol. ii. fig. 326.

As a rule the antlers of deer are branched: their base expands into a series of dense osseous tubercles (vol. ii. fig. 327, *b*) called the 'burr;' this ridge defends the edge of the frontal skin and periosteum, which terminates abruptly beneath it, usually on a persistent process or 'pedicel:' the vessels co-extended with the 'velvet' during the growth of the antler, check the continuous development of the basal ridge, and leave it notched and perforated. The 'burr' is not the mechanical cause of the obliteration of the vessels. To suppose that the growth of the antler is stopped by sudden suppression of its supply of blood—by a sort of bony ligature of the arteries—exemplifies a shallow physiology:[1] the ebb of blood, like the flow or 'determination' to the periodically growing part, whether 'horn' or 'testicle,' is due to deeper constitutional conditions. As the vessels of the antler gradually diminish in size, the 'burr' encroaches upon their channels; but of these sufficient remains in the form of perforations and notches to allow blood enough to pass to the 'velvet,' if its entire deprivation of nourishment were not a pre-ordained condition, independent of the 'burr.'

The stem or body of the antler is termed the 'beam'; its branches are the 'tynes,' its branchlets the 'snags': the first or lowest branch is the 'brow-tyne,' as projecting from the forepart of the base, forward, fig. 494, *m*; the second is the 'beze' or 'bez-tyne,' ib. *n*; the third is the 'royal,' ib. *o*; the upper ones, which are more or less clustered on an expansion or 'crown' of the beam, are the 'sur-royals,' ib. *p*. When a branch is sent off from the hind part of the beam, as in *Megaceros*,[2] it is a 'back-tyne:' this is long and subpalmate in the Chinese *C. davidianus*.[3]

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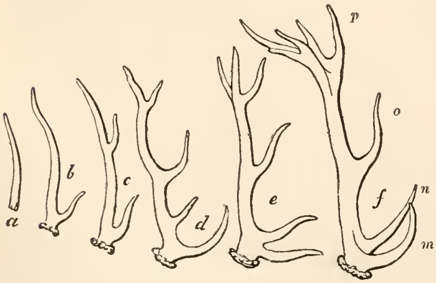

Antler-series, Red Deer. CXXXIX.

In the Red-deer (*Cervus elaphus*), as in all other species, the first pair of antlers which the young male developes in the spring of the year after his birth, consist of beam only, fig. 494, *a*; they are called 'dags,' and the animal carrying them is a 'brocket:' the next year's pair develope the 'brow-tyne,' *b*, and characterise the 'spayad,' but occasionally a 'royal' also appears, as at *c*: the bez-tyne, a 'royal' and short 'sur-royal,' characterise the antlers, ib. *d*, of the 'staggard' or male of the fourth year: in the fifth year the antlers assume the type of *e*, and the animal is a 'stag.' They go on increasing in size, length of tynes, and number of those diverging from the expanded crown, ib. *f*, *p*, until the male becomes a 'great Hart', and may be 'summed of from 10 to 16 points.' Rarely, however does a Red-deer of the restricted 'forests' of Britain or France, now become a 'Cerf de dix cours.'[1] But, with a range affording choice of favourite food, and under other conditions of constitutional vigour, among which may be reckoned the absence of that irritation of nerves caused by the dread and persecution of man, the bony sexual appendages of the skull have attained grand proportions. The largest which I have personally examined are of a Red-deer, killed some centuries ago in Wallachia. The length of each antler from burr to extreme tip, following the curve of the beam is 5 feet 8 inches: the crown divides into four primary tynes, the subdivisions or snags of which, included with the ordinary tynes, give a total of upwards of 20 points: the weight of the pair is 74 lbs. avoird. These antlers are now in the possession of Earl Powerscourt, by whom I have been favoured with the opportunity of inspecting them.

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[1] XCVI′. p. 518. [2] XVII′. p. 456. [3] CCXL″, p. 27, pl. 4.

In the Fallow-deer the yearling fawn 'puts up' a conical, commonly slender dag, fig. 495, *a*; so long as it is carried the animal is a 'pricket': the antler of the following year is longer, and sends off two tynes, ib. *b*; such antlers characterise the 'sorel': the third pair, increasing in size, show, in addition to the two anterior tynes, an expansion of the beam with two or more short snags, ib. *c*; they characterise the 'sore' or buck of the fourth year: in the fifth the antlers assume the form characteristic of the species, ib. *d*; and the animal is a 'buck of the first head.' In the seventh year the antlers have acquired their full size and their best

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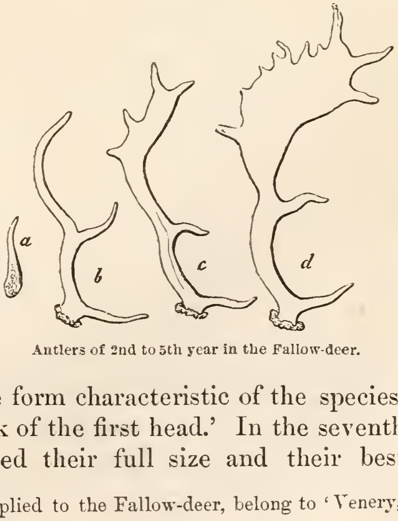

Antlers of 2nd to 5th year in the Fallow-deer.

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[1] The foregoing terms, with those applied to the Fallow-deer, belong to 'Venery,' or the Art of the Chase.

condition, in regard to length and sharpness of snags, for weapons of combat: the buck is now 'full-headed.' After the seventh year the antlers are thicker, heavier, more obtuse, becoming shorter in the beam, and especially in the branches. The antlers of the Fallow-deer are shed in May; their growth is complete in August; they are 'burnished,' or the formative covering is stripped or rubbed off, early in September; prior to this they are said to be 'in velvet', the fine hairs clothing the temporary skin resembling the pile of velvet. In the Red-deer these annual phenomena occur about a month earlier. Soon after burnishing, the combative instincts of the males arise; and, when the swelling of the throat and the 'belling' challenge announce the 'rut,' the combats ensue *à l'outrance*: thereupon the coincidence of the perfection of the antlers with the acquisition of maturity of strength and wind, enabling the male to wield them in the most efficient manner, gives him the command of the field, and he drives off every younger and less favoured antagonist from his chosen seraglio of hinds or does. The antlers of an older buck or stag, though more massive, are more obtuse; the addition to the bulk of the body is then due to other matters than working muscle, and the animal is sooner 'out of wind.' Consequently the male that has been the victor of one year is conquered by the younger one, now in his prime, who ventured into combat with him and was beaten the previous year. Thus is provision made for the propagation of the race by the best and strongest. It may further be remarked, that the fawns are 'dropped' at a time when the paternal antlers are shed; and the males, which are vicious, are thus deprived of the power of injuring the young during their more tender period of life.

The Rein-deer (*Cervus tarandus*) is one of the very few *Cervidæ* in which antlers are developed by the female: they are shed and renewed as in the male, but are much smaller. In the male they are remarkable for the length and forward curvature of the beam, and for the length and broad terminal snagged expanse of the tynes, especially of the brow-tynes, which also converge with occasional decussation of snags; whence Cæsar was led to describe the Rein-deer haunting Germany and the South of France, in his day, as having a third horn growing out of the middle of the forehead.[1] The opposite extreme is seen in *C. davidianus*, in which the brow-tynes are wanting. In the Elk (*Alces*) they are represented by the lower tynes of the generally expanded antler. Species of deer of small size, e.g. the Roe (*C. capreolus*) and the South American *C. rufus, C. simplicicornis*, have antlers more or less in the condition of 'dags' at all ages.

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[1] CCXLII''.

If a Fallow-buck, with antlers, be castrated, they are shed earlier than usual, and by a more active absorbent process, which leaves an irregular concavity at the base: the antlers that are subsequently developed are small, seldom branched, retain the 'velvet' longer than usual, and become thickened by irregular tuberculate masses of bone. If a young buck be castrated before it has 'put up' antlers, it does, afterwards, in some instances, develope them, but of reduced size and abnormal shape, retaining them, with their formative covering, longer than usual. Occasionally, though rarely, they are shed and renewed: but such shed antlers of a 'heavier' or castrate deer are characterised by the excavation of their base.[1] The normally shed antlers of perfect males have the base flat or convex, and almost smooth. A rare instance of the sexual relation of antlers, the coincidence, viz. of a small one with a diseased ovary of the same size, in a fallow-doe, has been recorded.[2]

In most deer the antlers are supported on permanent processes, or 'pedicels,' varying in length in different species, and attaining their greatest in the Muntjac (*Cervus Muntjac*, vol. ii. p. 478, fig. 328), which thus seems to shed only half its horns. The persistent integument of such pedicels is always defended by the burr (ib. *b*), below which the absorbent process takes place at the shedding period.

Thus Deer are the only Ungulates that annually shed their horns: the Prong-buck is the only known hollow-horned Ruminant that annually sheds the extravascular part of the horn, called the 'sheath.' The horns of Ungulates may be summarised as consisting either of horn only (*Rhinoceros*), of bone only (*Cervus*), of horn and bone (*Bos*), or of skin and bone (*Camelopardalis*).

[1] Redi's dictum:—'Si cervus juvenis castretur, nondum emissis cornubus, cornua nunquam emittit: si castretur jam emissis cornubus, cornua nunquam mutat; sed quæ dum castratur habet, castratus semper retinet' (CCXXVII″. p. 162):—is adopted by Buffon:—'Si l'on fait cette operation dans le temps qu'il a mis bas sa tête, il ne s'en forme pas une nouvelle; et si on ne la fait au contraire que dans le temps qu'il a refait sa tête, elle ne tombe plus; l'animal, en un mot, reste pour toute sa vie dans l'état où il était lorsqu'il a subi la castration,' CXXII′. tom. VI. p. 81.

The experiments (XLIV. pp. 590, 591), which Sir Philip de M. Grey Egerton, Bart., was so kind as to have made, at my suggestion, on Fallow-deer, in Oulton Park, yielded in the main the results given in the text. It is desirable that similar experiments should be repeated in the Red-deer. Two males of Rein-deer, said to be castrates, at the Zoological Gardens, and which have never shown sign of rut, have shed and reproduced antlers of normal form, and nearly full size during three consecutive years.

[2] CCXLIII″, p. 356.

CHAPTER XXXVI.

PECULIAR GLANDS OF MAMMALIA.

Most species of the Mammalian class have their peculiar odour, whereby, mainly, the individuals of such recognise each other; and, in the gregarious kinds, a stray one may be guided to the herd by scenting the secretion which has been left upon their track. Such odours are commonly due to follicles or glands opening upon some parts of the skin; but there are, likewise, glands subserving other uses, peculiar to certain species.

§ 365. *Opening upon the head.*—In many Ruminants and some hogs, a depression or inverted fold of skin, near and usually anterior to or below the orbit, is perforated by the ducts of numerous more or less developed sebaceous follicles, discharging their secretion into the cavity. As this is often placed so as to receive an overflow of the lacrymal secretion, and as a corresponding depression is usually present in the large facial plate of the lacrymal bone, it has been termed by French naturalists 'larmier:' by English writers, the tegumentary sac, with its glands and muscles, is called 'suborbital pit or sinus.' In the Indian Antelope (*Antilope cervicapra*), it is large and deep: a few short hairs project between the glandular orifices at the bottom of the sac: its circumference is entire and provided with radiating and circular strata of muscular fibres on the surface next the depression of bone in which it lies: by these muscles the tegumentary pit can be expanded, contracted, protruded, and partially everted, whereby the glandular surface may be brought into contact with and rubbed against foreign bodies: the follicles are multilocular and numerous in this species. The odour of the secretion, inclining to musky, may be recognised by a stray individual of a herd, or by the doe, which might thereby be guided to her mate. The gland seems most nearly to relate to the sexual function: it is usually larger in the male than the female, and its development is checked by castration. It is present, but small, in most goats and sheep; also in many deer,[1] in which it appears as a simple fissure continued from near the lacrymal angle of the eye. A similar pit occurs in a more advanced position in some antelopes; such 'maxillary pits' sometimes co-exist with the suborbital ones, sometimes replace them. A third position of the cutaneous gland-pit is more rare, viz. behind the base of the ear, as in the Chamois (*Antilope rupicapra*). With a view to test the relation of these organs to the habitats, and gregarious or solitary habits of the *Antilopidæ*, I drew up the subjoined table[2]:—

Suborbital and maxillary pits.	Inguinal pits.	*Antilope Sumatrensis.*	Hab. hilly forests; habits of the *Goat.*
		quadriscopa.	Senegal.
		cervicapra.	Open plains of India; gregarious.
Suborbital pits large.		*melampus.*	Open plains of Caffraria; flocks of six or eight.
		picta.	Dense forests of India; small herds.
		scoparia.	Open plains of S. Africa; subgregarious.
		tragulus.	Stony plains and valleys of S. Africa; in pairs.
		melanotis.	Plains, hides in underwood; in pairs.
		Dorcas.	Borders of the desert; gregarious.
		Kevella.	Stony plains, Senegal; gregarious.
		subgutturosa.	Plains, Central Asia; gregarious.
		Bennettii.	Rocky hills of Deccan; not gregarious.
		Arabica.	Stony hills of Arabia; sub-gregarious.
		Sœmmerringii.	Hills in Abyssinia; not gregarious.
		Euchore.	Dry plains of S. Africa; gregarious.
		pygarga.	Plains S. Africa; gregarious.
		Mhorr.	Deserts of Morocco.
		ruficollis.	Deserts of Nubia; gregarious.
small.		*Antilope colus.*	Vicinity of lakes; gregarious, migratory.
		gutturosa.	Arid deserts, Asia; periodically gregarious.
Suborbital pits.	No inguinal pits.	*Antilope Saltiana.*	Mountainous districts, Abyssinia; in pairs.
		Oreotragus.	Mountains of the Cape; sub-gregarious.
		Thar.	Hills of Nepaul; not gregarious.
		Gazella.	Senegal.
Suborbital pits.		*Antilope Babalus.*	Mountains and deserts, Tripoli; gregarious.
		Caama.	Plains of S. Africa; gregarious.
		lunata.	S. Africa; gregarious.
		Gnu.	Karroos of S. Africa; gregarious.
		taurina and *Gorgon.*	S. Africa; gregarious.
Maxillary pits.	Inguinal pits.	*Antilope silvicultrix.*	Thickets and underwood, Africa; ?
		mergens.	Forests and underwood, S. Africa; in pairs.
		Grimmia.	Guinea.
		Burchellii;	S. Africa, in pairs.
		perspisilla.	Bushes, S. Africa; in pairs.
		Maxwellii.	Ib. ib.
		pygmæa.	

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[1] xx. vol. iii. p. 272, no. 2101 (*Cervus tarandus*).

[2] CCXXXIII″. p. 37.

No suborbital, or maxillary pits.	Inguinal pits.	*Antilope Strepsiceros.*	Woods and banks of rivers, Caffraria; subgregarious.
		sylvatica.	Woods, Caffraria; in pairs.
		scripta.	
		Koba.	Senegal.
		Kob.	Senegal.
		Eleotragus.	Reedy banks, Cape; subgregarious.
		redunca.	Goree.
		capreolus.	Underwood, S. Africa; subgregarious.
		Landiana.	Underwood, S. Africa; subgregarious.
Post auditory pits.		*Antilope Rupicapra.*	Mountains, Europe; subgregarious.
No suborbital, or maxillary pits.	No inguinal pits.	*Antilope Addax.*	Deserts, N. Africa; in pairs.
		leucoryx.	Acacia groves, N. Africa; gregarious.
		Oryx.	Woods and plains, S. Africa; subgregarious.
		leucophæa.	Open plains, S. Africa; subgregarious.
		barbata.	Open plains, S. Africa; in pairs.
		equina.	Plains, S. Africa; gregarious.
		elypsiprymnus.	S. Africa.
		Oreas.	Open plains, S. Africa; gregarious.
		Canna.	Desert, Cape; gregarious.
		Goral.	Elevated plains, Himmalay; gregarious.

From the foregoing summary it may be inferred that the scented secretion of the suborbital sinus serves rather to attract or guide the female, than a stray individual of a herd. In the African Water-hogs a naso-maxillary pit opens between the eye and snout, rather nearer the eye.

In the Elephant a large gland of a flattened form and multilobate structure, lies beneath the skin of the face, in the temporal region: the secretion exudes from a small orifice, situated about half way between the eye and ear. The gland enlarges, in the male, at the rutting season, and the secretion then has a strong musky odour.

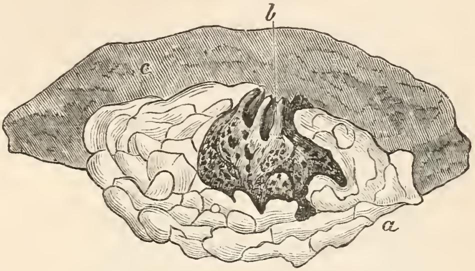
§ 366. *Opening upon the trunk.*—In certain tropical bats (*Cheiromeles torquatus*, *Cheir. caudatus*, e.g.) a glandular sac exudes upon the forepart of the breast, near the axilla, a brownish sebaceous secretion of a penetrating submusky odour.

In many Shrews two longitudinal series or groups of glandular tubes, open upon the flanks, at a part surrounded by short hairs; the tubes are tortuous and closely conglomerated at their blind ends, but become straighter near their termination. The peculiar odour, more or less musky, of *Soricidæ*, is due to the secretion of these glands, and makes the shrew-mouse unacceptable as food to the cat that may have killed it.

In the Peccari, a large gland, fig. 496, consisting of many lobes, exudes its secretion by an orifice, ib. *b*, on the midline toward the hinder part of the back. The resemblance of this orifice to the navel on the opposite part of the trunk suggested to Linneus the term *Dicotyles*, for this genus of S. American porcine animals.

In many Antelopes there are situated in the groin, external to the nipples in the females, glandular depressions of the skin, or pouches, sometimes of large size, as in *Antilope corinna*, e.g., in which the secretion is yellow, like cerumen.[1] The presence or absence of the groin-pits in the different species of Antelopes is noticed in the table, p. 633.

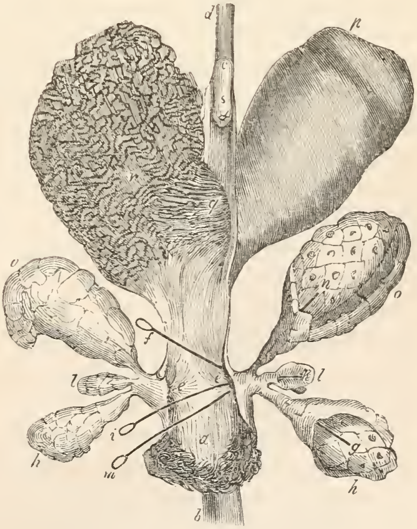
496



Dorsal scent-gland, Peccari; one-third nat. size.

The most notable development of scent-glands and bags, at the groin, are those which open into the prepuce of the small Ruminant, called on account of the odour of the secretion 'Musk-deer' (*Moschus moschiferus*). The fully developed gland at the fundus of the sac may be three inches in diameter and one inch at its thickest part; the moist secretion accumulates in the cavity of the tegumentary pouch, and constitutes, when dried, the costly medicament or perfume, 'musk.'

497



Preputial and glands of the Beaver.

The analogous carminative or antispasmodic substance 'castoreum' is the secretion of glands, fig. 497, exuding into the preputial and ano-preputial passage of the beaver. They present the appearance of two large masses, with a common muscular investment on each side the dorsal tract, which is unusually prolonged beyond the pelvis for their accommodation in that rodent. On removing the muscular layer, each mass has its capsule: on dissecting this away, the upper mass is seen to be a large pyriform bag, fig. 497, *p*, with a corrugated glandular lining membrane, *r*; the pair terminates by a common orifice, *q*, in the ano-preputial passage, *q*, *e*, *a*: the other mass may be separated into three rather compact glands, *o*, *l*, *h*, with short ducts, ending by a common orifice, *e*, *e*, on the same passage, nearer the anus, *a*. The secretion of these latter glands is yellow, viscid, and musky; that of the upper bags, *p*, *r*, is greyish-coloured and more offensive: both secretions appear to be mixed in the dried 'castoreum' of commerce, of which that from the *Castor fiber* of Europe and Asia has a higher value than the 'New England castor,' obtained from the American beaver.

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[1] ccxxxvi. vol. ii. p. 146.

Homologues of the glands, *o*, *h*, of smaller size and simpler structure exist in many Rodents, and are reckoned as 'anal:' they are shown in the Agouti, at *r*, *s*, fig. 506; in the water-vole, at *t*, fig. 510; in the male hare, at *k*, *l*, fig. 505; and in the female hare at *q*, fig. 539. In *Lepus* the follicles open into a deep glandular fossa occupying the interspace between the rectum and prepuce, on each side. Hunter, after noting in a male *Helamys capensis* the position of the vent 'about two inches from the tail,' proceeds to state:—'About half-an-inch farther between the legs is another opening, similar to the anus, passing in the same direction between the two crura of the os pubis, and leading to, or terminating in, two blind ends, between the rectum and the bulbous part of the urethra. These two ends are glandular, or secrete a whitish mucus; they are lined with a cuticle, are white and silky, having a good deal of short white hair.'[1] On each side of the termination of the rectum in the cloaca of the *Ornithorhynchus* there is an oblong glandular prominence, about four lines in length and two in breadth, on which there are about ten orifices of follicles which secrete a scented sebaceous matter. In all Marsupials two similar cavities with sebaceous follicles open into, or near to the termination of the rectum. The short vestibular or cloacal passage in the two-toed Sloth shows many orifices of such follicles. A pair of small anal bags exude their secretion near the verge of the anus in the Armadillos.

The anal gland-bags are most constant and best developed, as a rule, in the Carnivorous order: they are each provided with a muscular capsule, fig. 498, *a*, and present a smooth surface when this is removed, as at *b*: they are, also, commonly smooth within, and lined by a dense epithelium: the glandular stratum is sometimes limited in extent, and usually thickest toward the orifice of the bag which is just within the verge of the vent. The glandular stratum is thick and continuous in the Otters and Skunks, and in the latter, at least at certain seasons, secretes the intolerable, penetrating and long-enduring odour for which these quadrupeds are proverbial, and from which they derive some means of defence against foes: the orifice from which the secretion is ejected is situated on a mammillary prominence (*Mephitis*, *Mydaus*).

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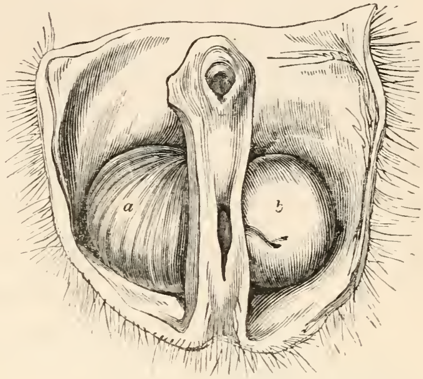
[1] ccxxxvi. vol. ii. p. 239.

498



Anal gland-bags, Skunk.[1]

In the Hyæna the anal glands are thickest and largest; they are two in number on each side and open into a wide transverse depression or sinus extending across and above the anus.[2] In the Civets (*Viverra civetta*, *V. genetta*) the two lateral gland-bags intercommunicate sooner, before forming the common canal opening into the transverse sinus; which, moreover, crosses between the vent and prepuce in the male, and between the vent and vulva in the female. The modified musky odour of the secretion has made it sought for and vendible, under the name of 'civet.' In the Suricate and Ichneumon a glandular glossa surrounds the anus.

In *Chiromys* and some other *Lemuridæ*, the anal glands are reduced to two shallow cutaneous pits at the sides and upper part of the vent: in higher *Quadrumana* this trace disappears.

§ 367. *Opening on the tail.*—In certain large Shrews (*Myogalea*, *Macroscelides*) the under part of the base of the tail is tumid, through the development of glandular follicles: these open there in a double row in the species which, from the odour of their secretion, is termed *Myogalea moschata*.

The caudal scent-gland in the Fox is elliptical, about an inch in length; it is minutely lobulate; each lobule consisting of clusters of spherical follicles terminating by a short duct; the orifices of these ducts are on a linear tract, indicated by hairs of a different colour from the rest.[3]

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[1] xx. vol. iv. p. 183, No. 2803.

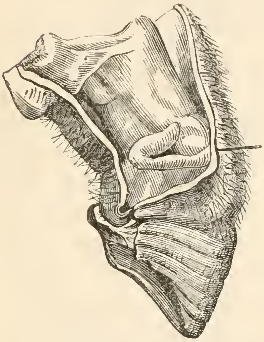
[2] Ib. p. 181, Nos. 2797, 2798.

[3] ccxxxii″. p. 309, tab. viii.

§ 368. *Opening on the limbs.*—In certain Bats (*Emballonura*, e. g.) a glandular cutaneous sac, exuding a reddish mal-odorous secretion, opens upon the anterior border of the wing, near the head of the humerus. In *Saccopteryx* (at least in the male) a larger sac, with a plicate internal surface situated on the under part of the wing, near the ulna, opens by a fissure on the upper surface of the limb.

In the one-horned Rhinoceros (*Rh. indicus,* and probably in other species) there is a glandular orifice at the back part of each foot, situated about three inches above the callous sole: it is concealed in the middle of the transverse fold that runs parallel to the interspace between the carpus and metacarpus, and between the tarsus and metatarsus. The gland is of a compressed ovate figure, measuring one inch and a half in length, and one inch in breadth: it is hollow, with parietes from two to three lines in thickness, consisting of a compact congeries of follicles, surrounded externally by a muscular and tendinous capsule. The external orifice may be expanded to a width of eight lines.[1]

499



Interungulate gland, Sheep.[2]

In most bisulcate Ungulates a similar gland exudes its lubricating sebaceous secretion from an orifice at the upper and fore part of the cleft between the principal hoofs. In the sheep, fig. 499, the gland is elongate and bent forward at an acute angle upon its duct, (indicated by the bristle in the figure and preparation). These post-digital and interdigital glands, in ungulate quadrupeds, seem to relate to lubricating or greasing the hoofs.

The most remarkable of the 'peculiar glands' in the Mammalian class, and one that relates most closely to sex, is that which in the mature male Monotremes sends its duct to terminate in the hollow spur projecting from the heel. The character is not manifested in the young animal. A small spur concealed in a cavity or socket of the integument covering the heel, the bottom of which closely adheres to the accessory tarsal ossicle, exists in the immature of both sexes.[3] As the young animal advances to maturity the cutaneous socket increases in width and depth in the female, but without any corresponding growth of the rudimentary spur, of which in aged females no trace remains. In the male Ornithorhynchus the tarsal spur soon begins to rise above the socket, and finally attains a length of ten lines with a basal breadth of five lines, apparently everting the tegumentary socket in the progress of its growth. The spur, fig. 500, *e*, consists of a firm semitransparent horn-like substance; it is conical, slightly bent, and terminated by a sharp point; its base is expanded, and notched at the margin for the implantation of the ligaments which connect the spur with the accessory flat tarsal bone (vol. ii. fig. 199 *k*, *d*.) The base of the spur is covered by a thin vascular integument. The spur is traversed by a canal which commences at the centre of the base and terminates by a fine longitudinal slit, about one line distant from the point, closely resembling in this respect the canal that traverses the poison-fang of the venomous snake. Like that weapon the spur of the male Monotreme is subservient to the transmission into the wound it may inflict of the secretion of a peculiar gland.

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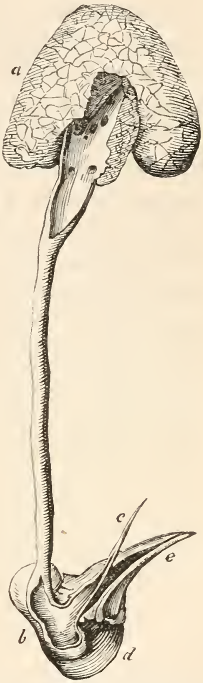
[1] v″, p. 34, pl. ix. figs. 1 and 2.

[2] xx. vol. iii. No. 2152 B.

[3] A magnified view of the part in the young male is given in LXXVIII′. pl. 32, figs. 1 & 5.

500



Crural gland and spur, male Ornithorhynchus. LXXXI′.

This gland, fig. 500, *a*, is situated at the back part of the thigh, between the femur and the long olecranoid process from the head of the fibula, covered by the integument and the cutaneous muscle. It is triangular, convex above, concave below, or toward the leg, from twelve to fourteen lines in length, seven or eight lines broad, and three or four lines thick, with a smooth exterior, invested by a thin capsule, on the removal of which the gland may be divided into a number of small lobes. Its intimate structure, as displayed by a successful injection of mercury, is minutely cellular; the excretory duct is continued from the concave side of the gland, and small clusters of vesicles are developed from parts of its expanded commencement. The duct, which is about a line in width and with pretty strong tunics, descends straight down the back of the leg, covered by the flexor muscles, to the posterior part of the tarsus, where it suddenly expands into a vesicle, ib. *b*, applied to the base of the spur, and a minute duct, ib. *c*, is continued from it into the canal which traverses the spur.

The tarsal perforated spur and its glandular apparatus are both relatively smaller in the male Echidna than in the Ornithorhynchus. The gland is situated lower down, in the popliteal region, between the insertions of the deep-seated fasciculi of the adductor femoris and the origins of the gastrocnemius ; it is of subspherical form, about the size of a pea, with a smooth exterior ; the excretory duct, wide at the commencement, soon contracts into a filamentary canal, which again enlarges to form a small reservoir for the secretion just above the base of the spur. The duct is accompanied and partly covered by the posterior tibial nerve.

The spur is a round, curved, sharp-pointed cone, traversed by a canal, continued from the reservoir, and opening on the convex side of the spur a little way below the pointed extremity.

The true nature and use of this apparatus has not yet been determined. Its close analogy with the poison-apparatus in other animals suggests a corresponding function ; but no well authenticated case of symptoms of poisoning consequent upon a wound inflicted by the spur has been recorded: it seems on the contrary that the Ornithorhynchus possesses not the instinct of availing itself, when attacked or annoyed, of a weapon so formidable as, upon this theory, the spur must be.[1]

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[1] CCXXXIV″. p. 236.

CHAPTER XXXVII.

GENERATIVE ORGANS OF MAMMALIA.

OUTWARD characters of sex are least marked in *Lissencephala*. To distinguish the male from the female Mole, Shrew, Hedgehog, Sloth, Rodent, requires close scrutiny, if not dissection. The male Monotreme is known by his heel-spur; the female Marsupial by her pouch and by her smaller (in Kangaroos much smaller) size. Among *Cetacea* the tusk distinguishes the male Narwhal, and the larger head the male Cachalot: in Seals the canines are usually larger in the male. External parts of generation are conspicuous in other *Gyrencephala*. Besides these, most Ruminants have sexual characters in the horns, either by their presence or greater size; the Stallion and Boar have the tusks: these by their greater length distinguish the male Elephant, especially the Indian kind. In the *Carnivora* the male is the strongest: the Lion is dignified by his grand mane. The larger canines, with greater general size, mark the male sex in most *Quadrumana* up to and including the Gorilla. Besides some differences in size and proportions of body, developments of hair are the outward marks of sex in *Bimana*.

A. MALE ORGANS.

In the Mammalian class the testes attain their most compact form, with most definiteness and finish of parts, in unravelling which anatomy has surpassed itself, chiefly upon the glands as they exist in Man, from which type of testicular structure there is no essential departure in the lower orders. The peritoneum adds a serous layer to the proper sclerous covering of the gland: and when this passes, as in the majority of Mammals, out of the abdomen, it pushes before it another portion of peritoneum, which becomes reflected after the manner of serous membranes, to form the 'tunica vaginalis testis.' This, however, is an accidental adjunct, dependent upon the 'descent of the testis.' The constant and proper covering, 'tunica albuginea,' consists chiefly of the white sclerous tissue: the spermatic vessels ramify therein, especially the veins, so locally as to facilitate the separation of the tunic into an outer dense protective layer, and an inner laxer layer, the seat of the minuter subdivisions of the arteries proceeding to, and of the venules returning from, the essential parts of the gland. Processes of the inner layer, resolving into areolar tissue, convey the vessels into the gland-substance, and partition that substance into lobes: a denser layer is continued from the line of the albugineal tunic perforated by the testicular vessels, and projects some way into the gland: it is called ‘corpus Highmori,’ or ‘mediastinum testis,’ and varies in longitudinal extent, and depth of position, in different Mammals: in Man it is limited to the tract, fig. 501, *b*, along which the reticulate ducts emerge or become ‘efferent.’ The cavities in which the sperm-cells are developed, fig. 514, have the form of tubes, of a diameter of from $\frac{1}{150}$ to $\frac{1}{200}$ of an inch, minutely and extensively convoluted: from two to five of such tubes, averaging two feet in length in the human testis, are packed into a long pyramidal lobule, invested by a process of the inner albugineal tunic: and the sum of these lobules or packets of seminiferous tubules forms the glandular part of the testis, fig. 501, *a*, *a*. The reticulate intercommunication manifested in the wider spermogenous tracts of the milt of fish (vol. i. p. 569, fig. 379), prevails in the more finished and thick-coated seminal tubules of Mammals: and, where such become free, they have blind ends. From the lobules the tubules converge, anastomosing, but with straighter course, to the mediastinum, and there form the plexus called ‘rete testis,’ ib. *b*. From this the ‘vasa efferentia,’ ib. *c*, *c*, emerge, and enter the upper end of the appended body called ‘epididymis,’ ib. *d*, *g*. Here the convoluted disposition of the tubule is resumed, and from ten to twenty groups, called ‘coni vasculosi,’ resembling, save in the greater width and less length of the tubuli, the lobes of the testis, combine to form the head or ‘globus major,’ *d*, of the epididymis. By repeated anastomoses there, a single tube results, the trans-

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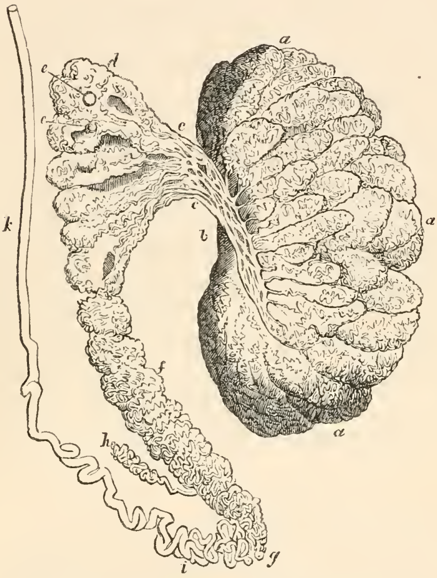
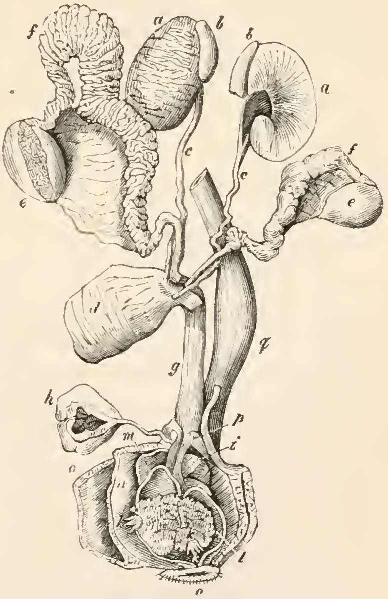


Glandular structure of Human testis, as shown by mercurial injection, nat. size. CCLXXII″.

versely disposed convolutions of which, *f*, form the rest of the epididymis: at its lower part the tube naturally untwists, and increasing in size, ib. *g*, *i*, becomes the spermduct or 'vas deferens,' *k*. In Man and many lower Mammals another feature of the spermogenous tract is commonly shown in the epididymis by the offset and blind termination of one or more tubules, as at *h*, fig. 501.

The epididymis varies in relative size and position to the testis in different Mammals. In all, the semen is conducted, *in coitu*, by a single intromittent organ traversed by a complete canal, which may bifurcate at its termination in the lowest members of the class. Accessory secretions are added to the semen at the beginning of the urethro-seminal canal, by glands called 'vesicular,' 'prostatic,' and 'Cowperian.' But these do not coexist in every species, and the varieties in regard to their presence and development, as well as in the structure and muscles of the intromittent organ, are the chief elements in the comparative anatomy of the Mammalian male generative organs.

502



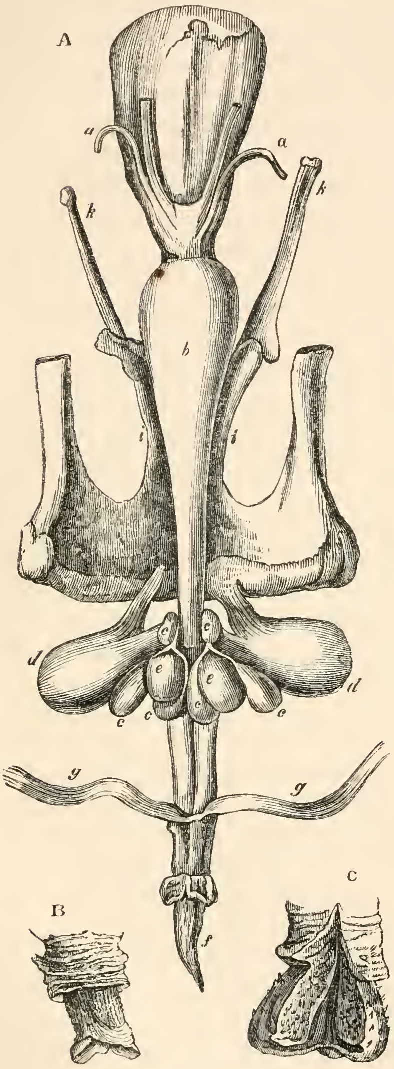
Male organs, Ornithorhynchus. LXXXI'.

§ 369. *In Monotremata.*—These are true 'testiconda:' each testicle, fig. 502, *e*, *e*, is situated immediately below, or sacrad of, the kidney, ib. *a*, and is suspended to that gland by a fold of peritoneum; the same fold is continued to the neck of the bladder, inclosing the vas deferens, fig. 308, *a*, which appears to be thick and simple, but when injected and dissected, as at *f*, fig. 502, is seen to be slender and disposed in a series of close transverse folds. In neither *Ornithorhynchus* nor *Echidna* is there any disparity of size between the right and left testicle. The vas deferens emerges from the upper and inner part of the testis *e*; and, from the peculiar extent of its transversely folded disposition, seems to prolong the epididymis nearly to the neck of the bladder; the folds gradually diminish, and the duct itself enlarges, as it approaches its papillary termination, which is in the beginning of the urogenital canal, *g*. This canal is continued through the pelvis and terminates in the vestibular passage, anterior to the orifice of the rectum, *q*. The vascular tissue of the penis commences at the termination of the urogenital canal; it is separated by a median septum into two lateral moieties, and both are inclosed by a common dense fibrous sheath. The whole penis in its collapsed and retracted state is about fifteen lines in length in *Echidna*, and is concealed in a large preputial sheath. The terminal half of the penis is formed by the glans, which, in *Ornithorhynchus*, presents a quadrilateral form, *l*, and is traversed by a median longitudinal furrow upon both the upper and the under surface. Its exterior is beset with numerous short and hard epidermal spines: its extremity is bifurcate, and each lobe is directed outward, and terminates in three or four spines, ib. *k*, *k*, much larger, but softer, than the rest, and which are usually retracted in a depression. A longitudinal azygos 'levator' muscle runs along the upper surface of the penis; it arises by two lateral slips from the internal stratum, ib. *n*, of the protrusive sphincter, *o*. Another longitudinal, but longer and more slender muscle, the 'retractor penis,' ib. *p*, arises from the base of the coccyx, and is inserted into the origin of the penis near the termination of the urogenital canal. The urethral canal of the penis begins by a small orifice at its root, communicating with the termination of the urogenital passage, and by the combined action of the last described muscle with the 'sphincter cloacæ' it can be brought into contact with the terminal papillæ of the spermducts. Such temporary continuation of the urethral and seminal passages takes place during the vigorous muscular and vascular actions of the parts *in coitu*, the semen being then propelled from the one along the other without escaping into the cloaca. Under ordinary circumstances, as when the urine is transmitted along the urogenital passage, that fluid escapes into the vestibule, and may there be blended, as in the Bird, with the rectal excrement. The seminal urethra, commencing by the distinct aperture above described, is about a line in diameter, and continues single to the middle of the glans, where it divides into two canals; each branch runs along the middle of the bifurcation of the glans, and, when arrived at the base of the large papillæ, subdivides into smaller channels corresponding with the number of the smaller ones, and opening upon their apices. If the canal of the penis were slit open along its under part, and thus converted into a groove, the male organs of the Ornithorhynchus would be like those of a Tortoise; and although the Mammalian type of intromittent organ is manifested by the completeness of the urethral canal, a resemblance to that of Lizards is evinced in its bifurcation, corresponding with that of the glans itself. That the existence of a penis is essentially related to the sexual organs and not to the renal, is singularly illustrated by the complete separation of the uro-urethral from the semino-urethral passages in *Monotremata.* The modifications by which the male organs in the Echidna differ from those of the Ornithorhynchus, are confined to the glans penis, which divides into four mammilloid processes, roughened by minute papillæ, and terminated by a depression in which is the branch of the seminal canal that traverses each process. Cowper's glands, fig. 3, *k*, *k*, and fig. 502, *h*, are of large relative size; they are situated between the base of the penis, the arch of the ischium, and internal part of the thigh: their secretion is carried by a long and slender duct, ib. *m*, into the seminal urethra. The physiological relation of these glands to such a canal is clearly illustrated by their presence in the Monotremes, and by their absence in the oviparous animals which have merely a seminal groove. There are neither prostatic nor vesicular glands. It is probable that the spurs, in the male Monotreme, fig. 500, *e*, may relate to the sexual act, as holders or stimulators.

§ 370. *In Marsupialia.*—In these *Lyencephala* the testes, which are still abdominal at the time of birth, descend, soon after the fœtus is transferred to the pouch, into the external pedunculate prepenial scrotum; the canal of communication between the abdominal cavity and the tunica vaginalis is long and narrow, but always remains pervious. The tubuli testis are relatively smaller than in Monotremes, but the corpus Highmori is near the surface and upper part, not at the centre, of the gland. The epididymis is large, and generally loosely attached to the testis. The spermatozoa of the Perameles have a single barb at the base of the head, which is sub-elongate and compressed; in other respects, as in size and proportion of the filamentary tail, they resemble those of the Rabbit. Neither in the Kangaroo, Phalanger, nor Dasyure do the spermatozoa present a spiral head or any noticeable deviation from the characters of the spermatozoa in the smaller placental quadrupeds: those of the Dasyure have a node at the base of the head. The spermduct passes along the infundibular muscular sheath formed by the cremaster as far as the abdominal ring, then bends downward and backward, external to the ureter, and terminates, fig. 503, *a*, at the commencement of the urethra, at the side of a longitudinal verumontanal ridge. There are no vesicular glands.

As the part of the urethral canal immediately succeeding the

503



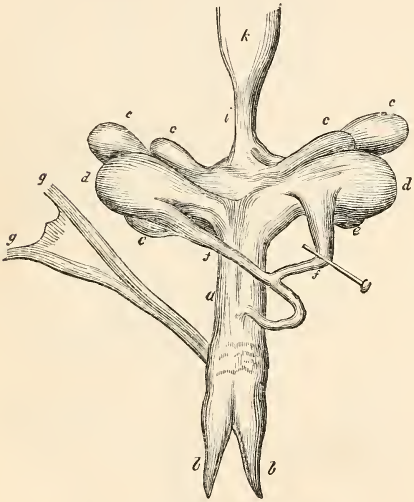
Male organs.
A, *Hypsiprymnus.* B, *Phascolarctus.* C. *Phascolomys.*

termination of the spermducts is the homotype of the vagina some modification of this part might be anticipated in the male corresponding with the extraordinary form and development which characterise the vagina in the female: accordingly we find that the prostatic tract of the urethra, ib. *b*, is proportionally longer and wider in the Marsupial than in any other Mammal. It swells out immediately beyond the neck of the bladder, and then gradually tapers to its junction with the spongy part of the urethra. Its walls are thick, formed by an external thin stratum of nearly transverse muscular fibres, and by a thick glandular layer, the secretion of which exudes by innumerable pores upon the lining membrane of this part of the urethra. In a male Kangaroo I found that a glairy mucus followed compression of this musculo-prostatic tract of the urethra: the canal itself is but slightly dilated. Three pairs of Cowperian glands, ib. *c*, *c*, *c*, pour their secretion into the bulbous part of the urethra: the upper or proximal pair are not half the size of the two other pairs in the Kangaroo, but are relatively larger in the Koala and other Marsupials: the two lower pairs are situated, one on each side the lateral division, *e*, *e*, of the bulb of the urethra; their ducts meet and join, above this part, with the duct of the smaller gland: each gland is enclosed by a muscular capsule. The penis consists of a cavernous and a spongy portion, each of which commences by two distinct bodies. The separate origin of each lateral half of the spongy body constitutes a double bulb of the urethra, ib. *e*, *e*, and the 'accelerator urinæ,' as it is termed, undergoes a similar division into two separate muscles, each of which is appropriated to compress its particular bulb. The two bulbous processes of the corpus spongiosum soon unite to surround the urethra, but again bifurcate to form a double glans penis in the multiparous Marsupials, in which most of the ova are impregnated in both ovaria, as e.g. in the Phalangers, Perameles, Opossums, &c., *b*, *b*, fig. 504. In the uniparous Marsupials, as the Kangaroo, the glans penis, fig. 503, *f*, is single.

The intermediate structures of the glans between the two extremes above instanced are presented by the Ursine Dasyure, Koala, and Wombat. In the Koala, fig. 503, B, the glans penis terminates in two semicircular lobes, and the urethra is continued by a bifurcated groove along the mesial surface of each lobe. In the Wombat, ib. C, there is a similar expansion of the urethra into two divergent terminal grooves, but the glans is larger, cylindrical, and partially divided into four lobes: the chief peculiarity in this part of the Wombat is the callous external membrane of the glans, and its armature of small recurved, scattered horny spines. The small retroverted papillæ on the infundibuliform glans of the Koala and on the bifurcate glans of the Phalangers and Petaurists are not horny. In the *Perameles lagotis* not only is the glans bifurcate, but each division is perforated, and the urethral canal is divided by a vertical septum for about half an inch before it reaches the forked glans: from the septum to the bladder the canal is simple, as in other Marsupials. The divisions of the glans in the Opossums, fig. 504, *b*, and Phalangers are simply grooved.

The corpus cavernosum penis commences by two crura, figs. 503, 504, *d*, *d*, neither of which have any immediate attachment to the pelvis. In the Kangaroo these crura, and the two bulbs of the corpus spongiosum, soon unite to form a single cylindrical body, the blended cavernous and spongy structures forming the parietes of a canal which nearly follows the direction of the axis of the penis, and contains or constitutes the urethra: a transverse section of the corpus cavernoso-spongiosum thus resembles a ring; but the lateral erectile tracts are separated by two vertical septa which extend from the central canal, the one to the dorsum penis, the other to the inferior wall: in this case there is no definite commencement of the glans penis; its termination is that of the corpus cavernosum, the urethra, with a corpus spongiosum, projecting and opening beneath the apex. In *Perameles, Didelphys, Phascolarctus,* and *Phascolomys,* the corpus spongiosum maintains its character for a greater extent, and may be more distinctly recognised as forming the proper wall of the urethral canal, which sooner becomes superficial, and the glans penis is better defined. In the Kangaroo and Potoroo, the ' erectores penis,' fig. 503, *d, d,* arise by a thin fascia from near the lower part of the symphysis pubis, soon become fleshy, and increase in thickness as they pass outward: each muscle then returns upon itself, at an acute bend, to grasp the crus penis, and terminates in a strong tendinous expansion at the junction of the cavernous with the bulbous structures. The ' retractor penis,' figs. 503, 504, *g, g,* arises in the Kangaroo from the middle of the sacrum, and divides into two muscles, behind the rectum, opposite the dilated commencement of the musculo-prostatic part of the urethra; each division diverges to the side of the rectum, then passes to the interspace between the rectum and roots of the penis, converging along the lateral and posterior part of the penis, to be inserted with the opposite muscle at the base of the glans. In the Opossum and those Marsupials which, having a bifid glans, enjoy, as it were, a double *coitus,* there is a ' levator penis,' fig. 504, *f, f,* which is not present in the Kangaroo. Each portion of this muscle takes its origin from the fascia covering the crus penis, converges towards its fellow above the dorsum penis, diminishing as it converges, and terminates in a common tendon inserted into the upper part of the base of the glans. There is another powerful muscle which, though not immediately attached to the penis, must exert in all Marsupials an important influence upon its erection. This is the external ' sphincter cloacæ: ' it is an inch and a half in breadth in the Kangaroo, and half an inch in thickness; from the back of the termination of the rectum it passes over the anal glands and sides

504

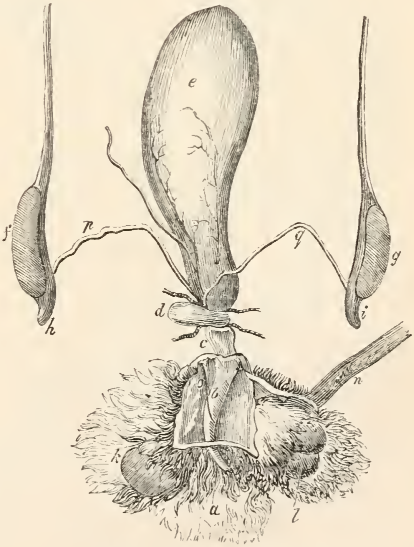


Male organs, Opossum. CCXXXV″.

of the base of the penis, inclosing the two bulbs with Cowper's glands and their muscles, and terminates anteriorly in a strong fascia above the dorsum penis, so as to compress against that part the venæ dorsales. In all Marsupials the penis is bent upon itself when passive and retracted; with the glans concealed just within the cloacal aperture, from which it emerges, as in oviparous Vertebrates, when the penis is turgid and erect.

§ 371. *In Rodentia.*—Here, likewise, the penis is habitually retracted out of view, being strongly bent, in many (e. g. *Sciurus, Castor*) in a sigmoid curve, with the glans directed backward, fig. 497, *s*, within a prepuce, which opens into, or forms part of, the common passage, ib. *g*, *e*, *a*, in which the rectum, ib. *b*, terminates. The testes undergo a periodical increase of size and change of position, passing from the abdomen into a sessile scrotum, and being again retracted, after the rut (except, perhaps, in *Leporidæ*) within the abdomen. Besides Cowperian there are prostatic and vesicular glands, usually large: but, again, the *Leporidæ* show their exceptional character in the Order by the absence of the latter. In the Hare (*Lepus timidus*) the testes make a more conspicuous prominence than in other Rodents, in their scrotal bags, one on each side the cloacal vent, fig. 505, *a*. The tunica vaginalis retains an opening wide enough for the repassage of the testis into the abdomen, but it adheres to the bottom of the sac, the serous membrane of which is there reflected by a fold upon the epididymis, fig. 505, *h*, *i*, and beginning of the vas deferens, ib. *p*, *q*. The testes, *f*, *g*, in this figure, have been dissected from the scrotum and tunica vaginalis. The epididymis is extended beyond the testis, as at *h*, *i*, before being reduced and reflected as 'vas deferens:' the sperm-ducts enlarge at their termination between the urinary, *e*, and protometral, *d*, bladders, into the latter of which they open, very near

505



Male organs, Hare. CXXII′.

its communication with the urethra. The protometra,[1] *d*, has thin walls, except at its terminal neck, where it seems thickened by the adhesion of prostatic follicles, opening by distinct ducts into the urethra. The Cowperian glands lie at the sides of the muscular tract of the urethra, and open into it. The penis is short, consisting chiefly of a pyramidal pointed glans; it is exposed at *b*, in its prepuce, which opens into the subanal fossa, *a*, into which the preputial or ano-preputial glands, *k*, *l*, exude their firm sebaceous secretion. The 'erectores penis' arise from both pubis and ischium, and are inserted chiefly into the outer side of the 'crura corporis cavernosi:' the 'levator penis' arises from the symphysis pubis, and is inserted into the glans by a small tendon, passing along the dorsum penis, over the convex bend, which it straightens when the penis is extended in erection. The Rabbit differs from the Hare chiefly in the larger relative size of the protometral vesicle, which also more commonly shows a bilobation of the base: its terminal orifice, in the urethra, is transverse and crescentic 'as if bent round the swellings of the verumontanum.'[2] *Lagomys* resembles *Lepus* in its male generative organs.

The vesicular glands are present, but small, in the Sciurine family. In the grey Squirrel they are slender, somewhat elongated bodies, bent upon the base of the prostate, through the substance of which their comparatively long ducts pass, together with the vasa deferentia. The prostate is a relatively large elongated compact body, loosely attached to the posterior part of the neck of the bladder and muscular part of the urethra. Cowper's glands are also relatively of large size; they are situated at the sides of the rectum, of a rounded conical form with the base bent forward upon the apex, from which a long, thick duct, with glandular parietes, is continued into the bulb of the urethra. The diminutive size of the so-called 'vesiculæ seminales' is not compensated by a dilatation of the vasa deferentia, as might have been expected had their office been to serve as a reservoir for the secretion of the testes, but by the magnitude of the other glands, viz. the prostate and Cowper's, the admitted function of which is to add some accessory fluids to the semen; and the Squirrels do not differ in the mode or duration of the act of copulation from other Rodents in which the vesicular glands are largely developed.

In the Porcupine (*Hystrix cristata*) the 'tunica vaginalis testis' adheres to the scrotum and abdominal ring by so much and so lax areolar tissue that its inversion with return of the testis to the abdomen is easy. The epididymis, after quitting the testis, recedes, and is connected therewith for the rest of its extent by a fold of serous membrane. The prostatic glands are large and ramified, one on each side the muscular part of the urethra, with which they communicate close to the verumontanum: the terminal orifices of the vesicular glands are wider. The levator penis is inserted into an ossicle in the glans. The penial bone is strong in the Capybara: the vesicular glands in that Rodent are long and large, slightly branched: the prostatic glands are short, broad, and thick, consisting of numerous slender ramified cæca.

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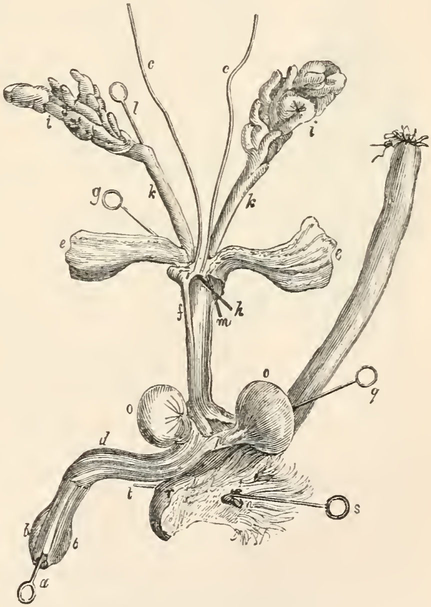
[1] CCXXXVI, vol. ii. p. 167 (note). 'Uterus masculinus,' CCXXXVIII″. passim. 'Corpusculum Weberianum,' 'Vesicula prostatica,' 'Sinus prostaticus,' CCXXXIX″. p. 1415.

[2] CCXXXIX″. p. 1419.

In the Agouti and Acuchi (*Dasyprocta*) the testes, during the rut, lie in the perinæum, one on each side the retroverted bend of the penis; the cremaster is a sacciform development of the inferior fibres of the obliquus internus abdominis, which is inverted when the testes return to the abdomen. Adipose appendages extend from the spermatic cords. The vasa deferentia, fig. 506, *c*, *c*, have usually a tortuous course behind the bladder: they terminate in the urethra distinct from the ducts of the vesicular glands, ib. *k*, *k*: these bodies, *i*, *i*, are long and ramified; the style, *l*, *m*, indicates the urethral end of the duct. The prostatic glands, *e*, *e*, are shorter, and consist of a fascicule of slender cæca, which unite and form the short duct through which the style, *g*, *k*, passes. The Cowperian glands, ib. *o*, *o*, are of a compact oval form, and send their secretion by a short duct, traversed by *p*, *q*, into the bulbous part of the urethra. The bulb is compressed by its ‘acceleratores:’ the cavernous crura of the penis by the ‘erectores:’ the ‘levatores penis,’ which unbend the organ during erection and compress the ‘venæ dorsales penis,’ rise from the symphysis pubis, and send their tendon along the dorsum to be inserted into the ossicle of the glans. This part is provided with a pair of lateral dentate horny plates, ib. *b*, *b*.

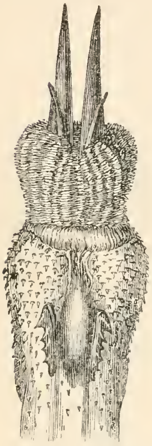
506



Male organs, Agouti. CXXII′.

In the Guinea-pig (*Cavia cobaya*), the 'os penis' is a flat and slightly curved bone imbedded in the upper part, and reaching as far as the extremity of the glans above the canal of the urethra. Behind and below the termination of the urethral canal is a wide pouch, in the bottom of which are lodged two horny styles. This pouch, during erection, is everted, so that the horns protrude externally. Two tendons are connected with the bottom of this pouch, which run along the penis inferiorly, and come from a thin layer of muscular fibres, derived from the erectores: they invert the pouch and draw it back again within the glans. The surface of the glans is beset with corneous scales. This singular armature of the intromittent organ is maximised in the spotted Cavy (*Cœlogenys subfuscus*), of which, fig. 507 shows the glans beset with short spines, the long terminal horny spikes, and the lateral horny plates, with marginal retroverted serrations.

507



Glans penis of the spotted Cavy.[1]

In *Capromys* I found a large adipose appendage attached to the epididymis. The ducts of the seminal, vesicular and prostatic glands terminate by distinct orifices; the fossa receiving those of the right side being divided by the verumontanum from the left one. The protometra is reduced to a small cul-de-sac behind the neck of the bladder; it seems like a blind backward continuation of the urethra separated by a transverse ridge from the orifice of the bladder. The vesicular glands present a white and glistening exterior; they are of an elongated form, with thin parietes, and send off, on one side principally, from fifteen to twenty obtuse cæcal processes. The prostate gland consists of four principal masses or lobes, each composed of a number of flattened tubular cæca, with thin and easily lacerable parietes, compacted together by cellular tissue. The muscular part of the urethra is closely embraced by a thick stratum of muscular fibres, diverging in a double oblique or penniform manner from a middle longitudinal inferior raphe: the 'acceleratores urinæ' have the usual relations to a large bulb of the urethra: the crura penis are embraced by short but strong 'erectores;' the 'levatores' muscles, or 'compressores venæ dorsalis,' terminate in a single tendon, passing along the dorsum penis, to be inserted into an elongated flattened ossicle in the glans, which, in this genus, is unprovided with the horny armature which gives it so remarkable a character in the Cavies.

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[1] xx. vol. iv. p. 75. Nos. 2495, 2496.

In the Beaver (*Castor canadensis*) I have usually found the testes, fig, 508, *r*, *s*, though small in proportion to the bulk of the animal, lodged in subcutaneous depressions between the castor-bags; but with the usual wide opening of the 'tunica vaginalis,' permitting easy return of the gland into the abdomen. The tortuous disposition of the vasa deferentia would favour such periodical movements of the testes: the terminal portion of the ducts, fig. 508, *a*, is dilated, or enlarged by glandular thickening of the walls, the inner surface of which is multiplicate. The vesicular glands are (for Rodents) moderate sized convoluted bags, fig. 508, *o*, *p*: the duct, fig. 509, *d*, sometimes communicates with, sometimes terminates distinctly from, the contiguous vas deferens, ib. *a*. The prostatic glands, ib. *c*, *c*, are a cluster of shorter pyriform sacs, the long slender ducts of which intercommunicate before terminating in the urethra. The protometra, ib. *b*, *b*, soon divides, after its communication with the urethra, into two long 'cornua,' which lie on the peritoneal fold behind the neck of the bladder, mesiad of the vasa deferentia, the course of which they follow till they become too attenuated for distinction. The Cowperian glands, fig. 508, *m*, *n*, are of a compact oval form, situated between the 'erectores' and 'acceleratores' muscles; and opening into the bulb of the urethra. The maximised preputial glands, ib. *e*, *f*, and ano-preputial glands, *g*, *k*, *h*, *i*, have already been described.

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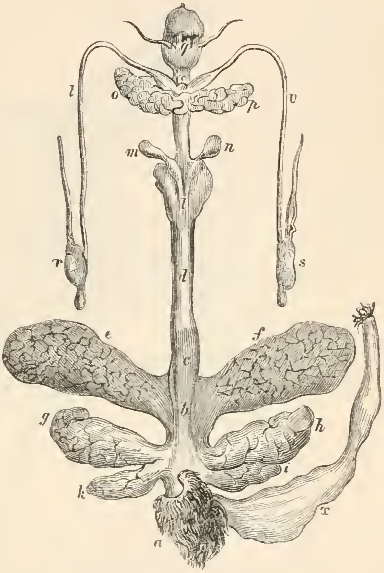
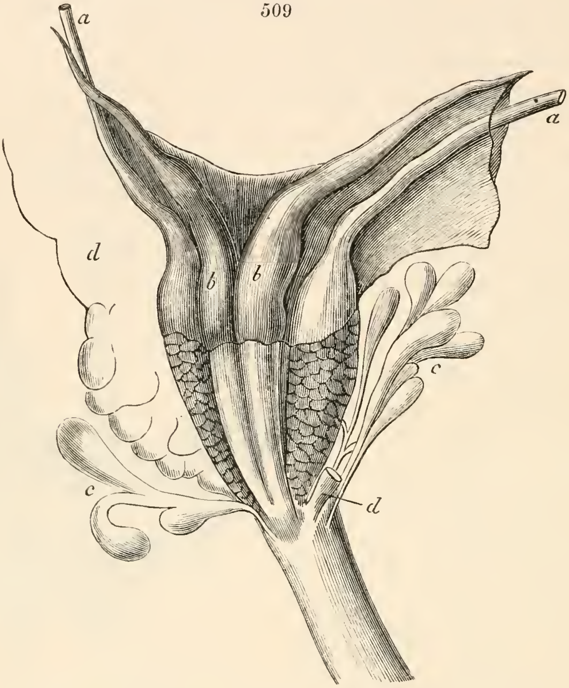


Male organs, Beaver. CXXI''.

In the Water-vole (*Arvicola amphibia*) the epididymis, fig. 510, *f*, *g*, is connected by longer 'vasa efferentia' than usual with the testes, ib. *c*, *d*. The vesicular glands, ib. *k*, *l*, relatively larger than in *Castor*, are bent upon themselves, and subdivided along one border: each prostate consists of three lobes, ib. *m*—*r*, or aggregate groups of cæca. The Cowperian glands resemble those of *Castor.* A pair of long thin glandular bodies opening into the prepuce, on each side the glans, ib. *a*, answer to the chief castor-bags, *c, f*, fig. 607, in the Beaver: the homologues of *g—k*, fig. 508, are confluent and surround the termination, fig. 510, *v*, of the rectum *s*, and exude their opaque whitish secretion near the anus.

509

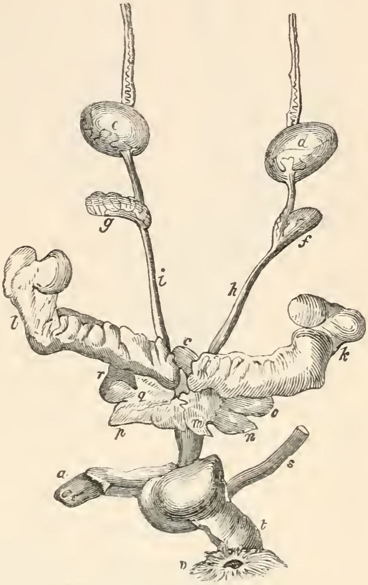


Protometra and prostates, Beaver. (Part of Pl. vi. ccxxxviii″.)

In the Marmots (*Arctomys*) the preputial orifice is more distinct than in most Rodents from that of the rectum: in the Alpine marmot the space of an inch intervenes. The prostates form a considerable mass, aggregated into two roundish lobes. The mesorchial accumulation of fat is considerable at the commencement of hibernation. The vesicular glands of the Jerboa (*Dipus sagitta*) resemble those of the Vole, but are less notched. In *Helamys capensis*, they consist of slightly sacculate pendulous bags, with thin walls: the prostatic follicles are numerous, short, and thick: the glans penis becomes singularly expanded, and forms a hollow disc in the centre of which opens the urethra.

In the Rat and Mouse the periodical enlargement of the testes, fig. 511, C, is considerable[1]: the globus major of the epididymis lies in the cremasteric pouch, which is inverted when the reduced testis returns into the abdomen. The vasa deferentia, ib. *f*, receive at their termination the secretion of the small glands with a granulated exterior, *e*: the 'vesicular glands,' ib. *a*, *a*, are large, lobulate, and exude a hardish cheese-like secretion. The prostatic glands, *b*, *c*, are masses of slender subconvolute tubes. The Cowperian glands, of the usual compact form, lie one on each side of the rectum and send their long ducts to the large 'foramen cæcum' at the urethral bulb. The penis has its 'levator' muscle and ossicle: the prepuce is served by a pair of glands secreting a whitish mucus.

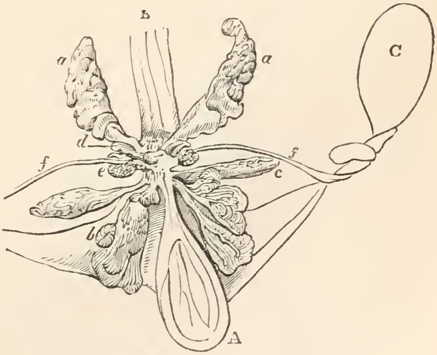
510



Male organs, Water-vole. CXXII'.

The spermatozoa of the *Muridæ* have the 'body' shaped like the bent blade of a knife, when viewed in profile, fig. 512, A, B; the vibratile 'tail' is very long: in the Squirrel (fig. 513) the body is lamelliform, with the surfaces subbiconcave, and the margin thickened anteriorly: the 'tail' is of moderate length. It is relatively shorter to the body in the Guinea-pig, fig. 514, *d*: in this figure a portion of a tubule of the testis is magnified 300 diameters, showing the basilemma *a*, *a*, its lining (precipitate) of nucleate corpuscles and granules, *b*: with the developed nuclei of detached cells, forming the spermatozoa, *a*.

511



Male organs, Rat.

§ 372. *In Insectivora.* — The periodical enlargement and

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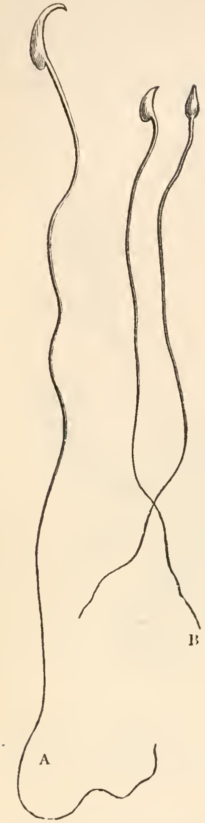
[1] As in birds; see vol. ii. p. 243, and xx. vol. iv. p. 79.

'descent' of the testes are better marked, perhaps, in some *Insectivora* than in *Rodentia*. In December the testes of the Mole lie on each side of the urinary bladder, with the inverted cremasteric pouch attached to the great end of the epididymis: in March they are protruded into serous sacs, which look like a continuation of the abdominal cavity beneath the base of the tail. The prostatic glands, which begin to increase in February, acquire an enormous size and conceal the urinary bladder towards the latter end of March. The Cowperian glands lie beneath the integument above the root of the tail, and send their duct to terminate in the urethral bulb. The penis, bent backward upon itself, terminates in a very long conical glans with an ossicle, lodged in a preputial sheath, which projects freely, a short distance below the anus. In a Cape-mole (*Chrysochloris*) I found the testes near the kidneys; but the convolute course of the vasa deferentia indicated their periodical movements. The accessory glands are better differentiated into 'vesicular' and 'prostatic' than in *Talpa*.

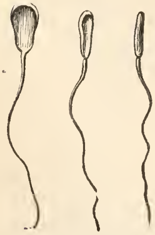
512



Spermatozoa, A, of the Rat: B, of the Mouse: magn. CCCVI.

In the Hedge-hog the vesicular glands, which become enormous at the rut, lie mainly behind the urinary bladder; the flattened mass of prostatic glands rises in front: they are supported by folds of peritoneum. The Cowperian glands, as in the Mole, are extra-pelvic, behind the ischia, and accordingly reach the urethral bulb by very long ducts. The penis is long and bent when at rest. There are two 'levatores' which rise from the ischial tuberosities behind the 'erectores:' passing along the sides of the penis, their tendons meet upon the 'dorsum' near the reflection of the long prepuce, crossing the 'vena dorsalis' and inserted into the 'ossiculum glandis': the urethra opens upon a special process which projects beyond the main body of the glans. In the Shrews, temporary receptacles in the perinæum receive the enlarged testes during the rut: but do not project, as a scrotum. The epididymis

513

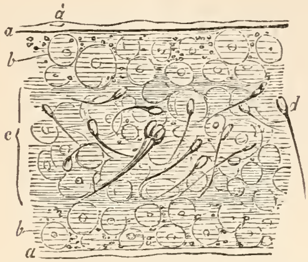


Spermatozoa, Squirrel: magn. CCCVI.

extends round two-thirds the circumference of the testis. The terminal half of the sperm-duct is dilated, like a uterine horn.

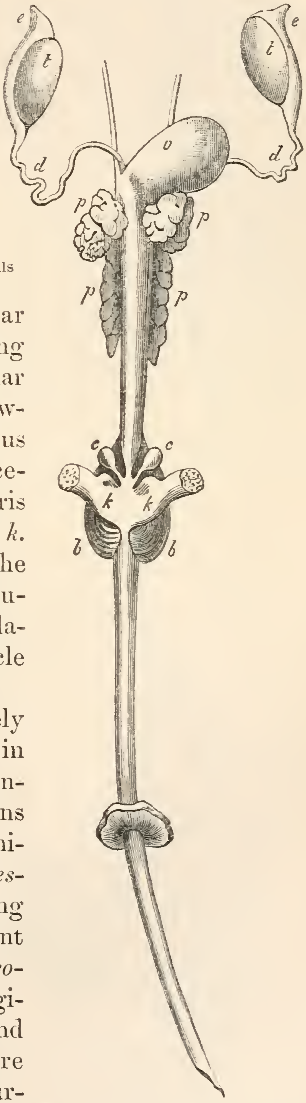
In a proboscis-shrew (*Rhynchocyon*) the testes, fig. 515, *t*, have a long epididymis, *e*, terminating in the usual convoluted vas deferens, *d*: large conglomerate vesicular and prostatic glands, *p*, *p*, extend along the upper half of the elongate muscular part of the urethra: a pair of small Cowperian glands, *e*, *e*, open into the bulbous part: this is grasped by a strong 'accelerator,' *b*, *b*. Above the 'crura corporis cavernosi' are the 'levatores penis,' *k*, *k*. The glans is nearly half the length of the penis; its termination is suddenly attenuated, with a crenate border and a filamentary appendage: there is no ossicle in this or other shrews.

514



A portion of a tubule of the testis, Guinea-pig, with sperm-cells and spermatozoa. CCXC. Magnified 300 diameters.

515

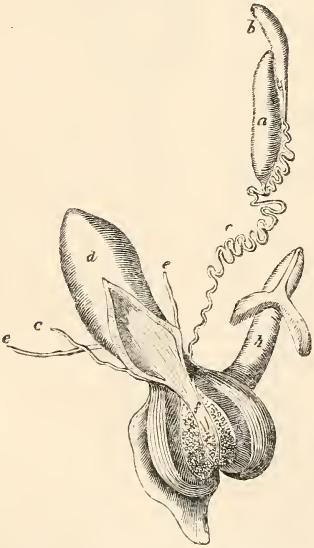


Male organs, *Rhynchocyon*. LXXXIV'

In the Bats the prepuce is relatively longer in its freely projecting part than in Moles and Shrews, and the penis is pendulous. The glans offers odd modifications in some species: a lateral pair of prominences extend its upper surface in *Vespertilio scrotinus*, the lower surface being carinate and produced into a hirsute point upon which the urethra opens. In *Galeopithecus* the glans shows two lateral longitudinal prominences which do not extend to the pointed urethral termination. There is an ossiculum penis in *Pteropus*: these frugivorous bats have large vesicular glands.

§ 373. *In Bruta.*—A long epididymis characterises the testicle in the Armadillo: the tubuli testis are relatively large and disposed in narrow oblique folds beneath the tunica albuginea. The testes lie above the brim of the pelvis: they appear not to pass out of the abdomen, for the vasa deferentia are short and unconvolute: these, converging behind the bladder, penetrate a compact triangular prostate (or protometra?): there are no vesicular glands. The Cowperian glands are situated behind the urethral bulb: each has its muscular capsule. Two 'levatores' arise from the symphysis pubis and send a common tendon to the glans penis. The preputial sheath is of great extent, and the reflected membrane is coloured by a dark pigment. The penis has a disproportionate length, in relation to the mechanical obstacles to coition presented by the body-armour. The testes are constantly abdominal in the Anteaters and Sloths. Hunter notes that the ducts of the vesicular glands of the Anteater open into 'the urethra by a separate sulcus from the common canal.'[1] There are no vesicular or prostatic glands in the Sloth. 'The penis is a short flat body inclosed in a prepuce which is within the verge of the anus. It is not above two-tenths of an inch in length, and terminates in an obtuse point. It has a groove which runs along its under surface, and which makes the point somewhat forked.'[2]

516



Male organs, *Delphinus*. XII.

§ 374. *In Cetacea.*—Here the testes are abdominal, situated at the hinder part of the cavity between the great depressor muscle of the tail and the transversalis abdominis: they greatly augment in size at the rut, but do not change in position: in their quiescent state they assume an elongate form, fig. 516, *a*, and the epididymis, *b*, extends unusually far in advance of the gland itself. The vas deferens, *c*, has a short tract, but is convolute. There are no vesicular glands. The prostatic part of the urethra, ib. *k*, *k*, is surrounded by a thick capsule of muscular fibres. The protometra is reduced to a small, elongate cæcum, fig. 517, *a*, concealed in the prostate, and opening by the usual transverse crescentic slit, ib. *c*, into the urethra, between and a little beyond the terminal orifices, ib. *b, b*, of the sperm-ducts.

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[1] CCXXXVII. vol. ii. p. 182

[2] Ib. vol. ii. p. 180.

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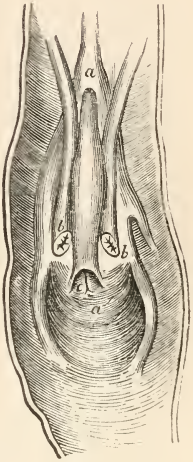

Protometra of Narwhal. CCXXXIX″.

The penis commences by two cavernous crura inclosed in strong ‘ erectores,’ arising each from the loosely suspended ischial ossicle of the same side. The crura coalesce into a single cavernous body surrounded by a very thick sclerous sheath. After the junction of the crura the penis, in *Delphinidæ*, describes a close sigmoid curvature, before terminating in the long, straight, gradually tapering glans. The corpus spongiosum commences by a bulbous expansion, fig. 518, *l*, embraced by the ‘ accelerator fibres,’ *g*; but degenerates into little more than a close venous plexus as it penetrates, in the Porpoise, the corpus cavernosum; it then emerges and extends along the under part of the corpus cavernosum, to re-expand into the venous plexus surrounding the tuberous basis of the glans. The upper part, or dorsum, of the cavernous body is grooved for the lodgment of the plexiform vena dorsalis. In the unexcited state the penis is withdrawn and concealed in the long prepuce, the orifice of which is considerably in advance of the vent. The retraction is effected by a pair of muscles, *m*, arising from the aponeurotic commissure anterior to the sphincter ani *e*, and running along the under or urethral side of the penis to be inserted into the sclerous basis of the glans. The protrusion of the organ is aided by the transverse fibres of the ‘ panniculus carnosus ’ surrounding the preputial sheath. The section of the penis of a *Balænoptera* preserved by Hunter shows a single corpus cavernosum grooved above for the

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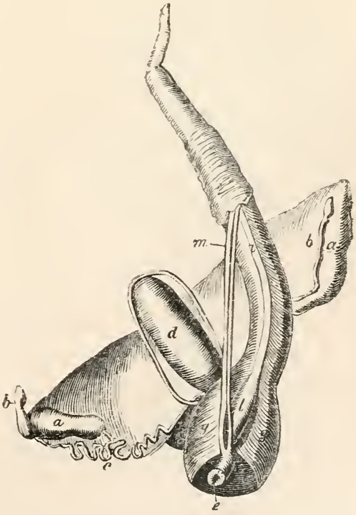

Male organs, *Phocæna*. XII.

vena dorsalis, and more deeply excavated below for the corpus spongiosum urethræ.[1]

§ 375. *In Sirenia.*—These mutilate Mammals are also 'testiconda,' but differ from the *Cetacea* in having vesicular glands, a penis with a 'septum corporis cavernosi,' and provided with a pair of 'levatores,' which unite to form a tendon upon the 'dorsum.' In the Dugong (*Halicore*), the glans consists of two semilunar side-lobes, including the conical process, on the apex of which the urethra opens. In a half-grown male the vesicular glands were four inches long and two inches across the fundus, where their glandular parietes were thickest; the internal surface was reticulate. The vasa deferentia were irregularly convoluted: they communicated with the duct of the vesicular gland, the common opening being into the dilated beginning of the urethra, which describes a curve below the vesical orifice: according to Leuckart, it receives the opening of a bottle-shaped protometra, about an inch in length.[2]

§ 376. *In Proboscidia.*—The testes retain in the Elephant the situation in which they were developed, viz. below or beyond the kidneys. Their ducts have the same minor degree of density as in *Sirenia* and other 'testiconda;' they describe a tortuous course to between the urinary bladder and vesicular gland, where they terminate on a papillary eminence at the fundus of a true seminal bladder, of a pyriform shape, with thin walls and a smooth internal surface. These terminal reservoirs are in contact and adherent: they open into the beginning of the urethra distinctly from the orifices of the vesicular glands. These are elongated and rather contracted toward the closed end, which is divided by a constriction or septum from the general cavity, with which it communicates by a small canal. The glandular parietes are thickest at the closed end, and the inner surface is broken by decussating columnar processes projecting into the cavity; their interspaces extend in many parts, like sinuses, deep into the substance of the vesicular walls: towards the urethra these walls become smoother. Each vesicle has a special muscular investment, for expulsion of its secretion into the urethra. The prostatic glands are two on each side, external to the vesicular ones, and of much smaller size: they are also provided with a partial muscular covering. A cæcal rudiment of the protometra extends from the base of the verumontanal cul-de-sac. The corpora cavernosa penis are divided by a thick sclerous vertical partition, and in transverse section present a reniform figure, with the corpus spongiosum and urethra occupying the concavity. The veins of the corpus cavernosum are surrounded by a soft tissue of unstriped muscular fibre. The glans penis is elongate, subcylindric at the base, becoming rather depressed at the end, which is obtuse and rounded. Besides the ordinary muscles, there are a pair of 'levatores penis,' arising from the pubis, sending their tendons into the dorsum, where they coalesce above the vena dorsalis, and run along a sheath of the thick sclerous wall to the glans.

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[1] xii. vol. iv. p. 87, No. 2527.

[2] ccxxxix″. p. 1429.

§ 377. *In Perissodactyla.*—In the Rhinoceros the testes are inguinal, in close contact with the abdominal rings. The tunica vaginalis communicates freely with the peritoneal cavity. The testis is surrounded by a strong and thick 'tunica albuginea:' the 'corpus Highmorianum' is continued in the form of a moderately thick white band, from the end where the efferent vessels pass out to form the 'caput epididymidis,' along the whole longitudinal axis of the gland. From this band or centre of the cellular framework of the gland, the septal layers diverge to all parts of the external tunic, forming the compartments in which the lobes of aggregated 'tubuli seminiferi' are lodged. The branches of the spermatic artery, on penetrating the tunica albuginea, pass directly to the corpus Highmorianum, and their ramifications diverge thence, supported by the radiating septa, and form a rich network upon the inner or vascular layer of the capsule of the testis. The vas deferens in the inguinal canal is surrounded by the vessels and especially by the plexiform veins of the spermatic chord; on entering the abdomen it is received in a peritoneal fold, and is conducted to the side and then to the back part of the urinary bladder, passing between the bladder and the ureter: having got to the inner side of the termination of the ureter, fig. 519, *u*, the vasa deferentia, ib. *vd*, descend straight, slightly converging, to the middle of the back part of the prostate, *p*: they penetrate that gland, together with the ducts of the vesicular glands, *vs*, lying to the inner side of these; and, communicating with them, the common duct

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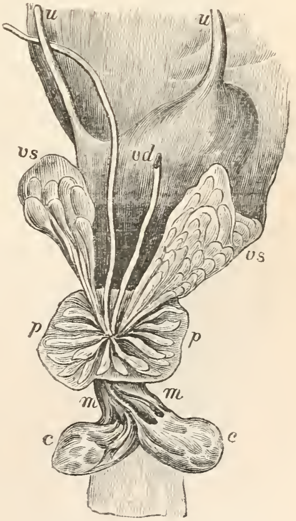

Accessory glands, male organs. Rhinoceros.

on each side finally terminates by a minute pore upon the crucial verumontanum. The vasa deferentia are thickened to about thrice their ordinary diameter in the last three inches of their course; but their canal or area is not proportionally dilated; it is, on the contrary, rather contracted, by the thickness of the cellulo-glandular parietes to which the enlargement of the duct is due. The vesicular glands, ib. *vs*, present an elongate subcompressed pyriform shape, eight inches in length, and three inches and a half across the broadest part of the fundus. They have a lobulated exterior, and a structure very similar to that of the same bodies in Man. The prostate, ib. *p*, resembles that of many Rodents, being composed of an aggregate of long slender cæcal tubes with glandular walls converging to the ducts of the vesiculæ and vasa deferentia, and opening by numerous minute apertures on the verumontanum. The breadth of the prostate is six inches; its antero-posterior extent four inches: it does not quite surround the beginning of the urethra, but is closely applied to the back and sides of that canal. The muscular part of the urethra extends about three inches from the prostate before it joins the bulbous and cavernous portions, close to which are situated two large subcompressed oval Cowperian glands, ib. *c*, *c*. Each of these measures three inches and a half by two inches and a half. The great plexus of veins above the dorsum penis, near its root, is enveloped in a mass of elastic tissue, like the ‘dartos’ of the human scrotum.

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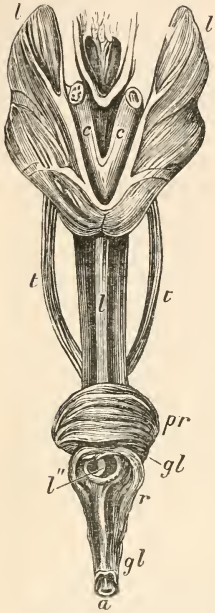

Penis and muscles, Rhinoceros.

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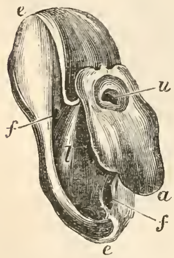

Apex of glans, penis, Rhinoceros.

The fleshy part of the ‘levatores penis,’ fig. 520, *l*, *l*, measures fourteen inches in length, five inches across their basal origin, and between one and two inches in thickness. Their oblique origin is extended over the space of one foot from the ento-pelvic part of the pubis down to the ischium. The tendinous part of the muscle commences where the pubic portion joins the ischial one at the inner and under border of the fleshy part:

it is half an inch thick at its commencement, but expands as it extends along the muscle, the fleshy fasciculi of which are inserted into the tendon in an obliquely converging, or semipenniform manner. As the tendon augments in breadth, it diminishes in thickness, converging towards its fellow, which it meets and joins two inches before the anterior termination of the fleshy portion. The two united flattened tendons beyond are gradually converted into a round chord of ligamentous substance an inch in diameter. This chord, ib. *l*, *l''*, glides through a strong slightly elastic aponeurotic sheath, along the median groove of the dorsum penis; it is connected with the inner surface of the sheath by a highly elastic cellular tissue; the chord maintains its ropelike character along the basal third of the glans, then subsides, expanding laterally, and is finally lost upon the firm capsule of the glans. There is no 'os penis.' A pair of 'retractores penis,' fig. 520, *t*, *t*, are inserted into the under part of the base of the glans. The nerves of the dorsum penis, the arteries, and trunks of two large plexuses of veins, pass beneath the bridge formed by the confluence of the tendinous and muscular parts of the 'levatores penis' and between the two suspensory ligaments of the penis. These ligaments are an inch in breadth, and one-third of an inch in thickness at their origin from the ischio-pubic arch a little in advance of the ligamentous attachments of the crura corporis cavernosi. The total length of the undistended penis is three feet nine inches; the circumference of the prepuce is one foot five inches. The preputial orifice is two feet ten inches from the vent. The substance of the large reflected preputial fold of soft integument, fig. 520, *p*, *r*, is from half an inch to two-thirds of an inch in thickness, and consists of a moderately compact cellular corium, with a delicate epiderm, minutely rugose, in the transverse direction, and perforate or punctate with the pores of the mucous follicles which are very regularly dispersed at intervals of about a quarter of an inch. The glans penis, ib. *gl*, is a long and slender subcompressed cone with a truncate apex; in its flaccid undistended state, it is one foot in length: the prepuce is reflected upon its base at the same transverse or circular line, and there is no frænum. The apex, ib. *a*, is not simple, but resembles a mushroom on a thick peduncle, fig. 521, *l*, projecting from an excavation at the end of the glans with a thin wall or border, ib. *e*, *e*, like a second prepuce; but this is of the same structure as the rest of the firm surface of the glans. On each side of the base of the glans, and rather towards its under part, there is a longitudinal thick oblong ridge or lobe, fig. 520, *r*, three inches and a half in length, and eight lines in basal thickness: the thick rounded free border of each lobe inclines downwards. A narrow ridge commences in the median space of the 'dorsum glandis,' which increases in height as it advances forwards, and then subsides two inches from the border of the terminal or apical fossa. The projecting border of this fossa describes a compressed oval, and is attached to the pedunculated appendage, fig. 521, *a*, by a process, like a frænum, continued upon the middle line of both the upper and under surfaces, ib. *f*, of the thick peduncle: the fossa between this peduncle and the free external border is two inches in depth. The stem, *l*, of the terminal expanded discoid appendage is subcompressed with an oval section: the disc is ovate, one inch eight lines long by one inch across its broader inferior part, where it extends farthest from the supporting stem. The urethra, *u*, terminates in the middle line of the disc between its middle and upper third.

In the Sumatran Tapir the base of the glans has an upper lobe as well as one on each side, beyond which it is continued forward contracting, but terminates in a truncate surface on the middle of which the urethra opens. In the American Tapir the orifice is nearer the lower margin of the disc. The testes are inguinal, in a slightly indurated sessile scrotum, about 6 inches below the vent. The accessory glands resemble those of the Rhinoceros.

The testes were abdominal, below or beyond the kidneys, in the Hyrax (*H. capensis*) dissected by me: the vasa deferentia are convoluted, like a second epididymis, behind the urinary bladder: they terminate near to, but distinct from, the ducts of the vesicular glands, at the lower end of the unusually elongated muscular tract of the urethra: the vesicular glands extend on each side of this canal, their closed ends just reaching the bladder. Two prostates, of a tubular structure, are near the duct-ends of the vesiculæ. Two small flattened Cowperian glands communicate by long ducts with the wide cavity of the bulb of the urethra. The penis is bent abruptly backward, and the glans has a truncate termination. Besides the 'erectores' and 'acceleratores,' there is a pair of 'levatores,' arising from the symphysis pubis, and terminating by a single tendon, as in the Rhinoceros.

In the Horse the scrotum, fig. 522, *a*, is suspended between the thighs at a distance of about nine inches beneath the anus, whence it is prolonged forward, to terminate in the prepuce, ib. *f*, *e*. The testis, ib. *g*, is of a subcompressed ovoid form, the epididymis, *h*, *l*, rather closely attached to the testis and not longer than the gland. The vas deferens, *m*, enlarges at its terminal part, ib. *o*, *o*, and fig. 523, *a*, *a*, by the development of its inner tunic into numerous close-set transverse glandular lamellæ. The vesicular glands, fig. 522, *x*, *x*, fig. 523, *b*, *b*, are simple bladders with thin walls. In the transverse fold of peritoneum connecting together the enlarged parts of the sperm-ducts is situated the protometra, fig. 523, *c*, in form of a slender elongate tube, bifurcate, in the Zebra and Ass, at its blind end.[1] The prostates are parenchymatous, and open into the upper or vesical end of the muscular tract of the urethra: at the lower end of this part are the Cowperian glands, fig. 522, *y*, *y*, which open into the bulb of the urethra.

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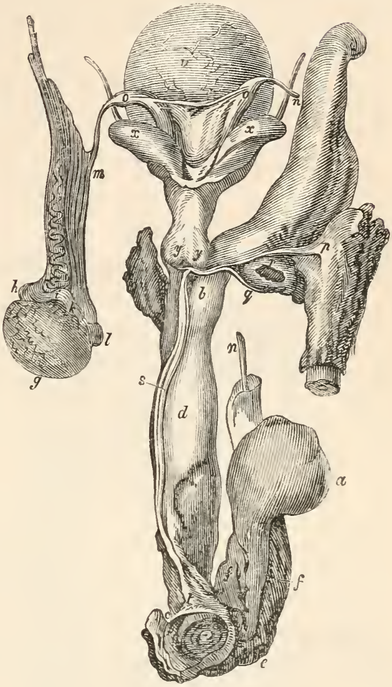

Male organs, Horse.

The corpus cavernosum penis is formed by confluence of that of the two crura, into one body, without vertical septum, ‘the parts composing its cells appear muscular to the eye, and in a Horse just killed they contract on being stimulated.’[2] The fibrous tissue here noticed lies between the vascular and sclerous parts of the cells. The glans has two lateral semilunar lobes, and at its apex a central pyramidal process on which the urethra opens. The ‘crura penis’ are surrounded by thick ‘erectores,’ having an extensive origin, fig. 524, *d*: two strong suspensory ligaments, ib. *a*, pass from the symphysis pubis to the dorsum. Besides the ordinary muscles, there is a pair of small ‘levatores,’ ib. *b*, *c*, serving mainly as compressors of the vena dorsalis penis, ib. *e*: there is also a pair of 'retractores' arising from the os coccygis, fig. 522, *p*, *q*, passing on each side the sphincter ani, *r*, then converging to run together along the urethral side of the penis, *s*, to the base of the prepuce. In the castrate horse these usually degenerate into elastic sclerous tissue.

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[1] xx. vol. iv. p. 93.

[2] xciv. p. 30.

§ 378. *In Artiodactyla.*—The male organs of the *Suidæ* are chiefly remarkable for the enormous development of the Cowperian glands. The testes are perinæal: the scrotum slightly projects; it is not pendulous. The vesicular glands are large, lobulated, with parenchymatous walls, their ducts terminate distinctly from those of the testes. The prostates are small, near the cervix of the vesiculæ. The muscular part of the urethra is of great length and the Cowperian glands are co-extended therewith: each presents an elongate subtrihedral form, invested by a muscular capsule; the glandular parietes are very thick:

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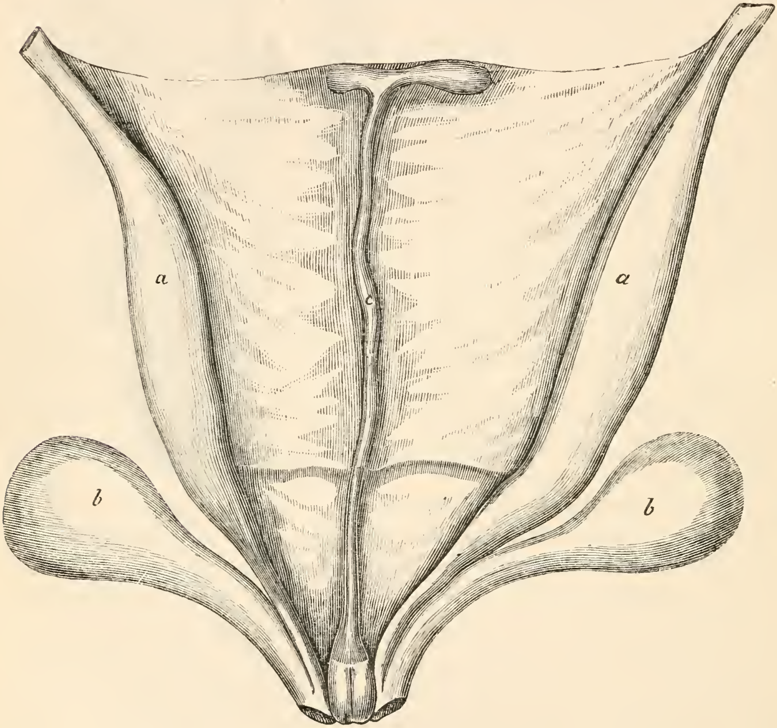
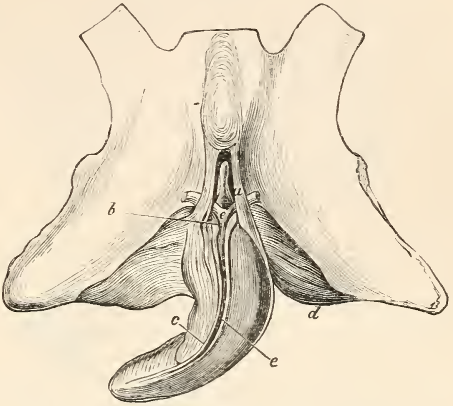


Protometra, &c. of the Ass. CCXXXIV″.

the terminal duct opens beyond a transverse valvular fold separating the bulbous from the muscular part of the urethral canal. The penis shows a sigmoid flexure, and has a pair of 'retractores,' arising from the hollow of the caudal end of the sacrum, and inserted at the end of the bend next the glans. This is triquetral, elongate and pointed. The spongy part of the urethra, between glans and bulb, is reduced to a few veins. The preputial opening is near the navel.

524



Suspensory ligaments and muscles of penis, Horse.

The Ruminant Artiodactyles are devoid of vesicular glands; their testes pass into a pedunculate scrotum. The spermatic arteries form, by their close and numerous convolutions, a plexiform mass, which is specially notable in the Bull. The vasa deferentia slightly enlarge at their termination in the Camel, but are not there different in structure from the rest of the sperm-ducts: they terminate upon a broad wrinkled verumontanum. The prostate is a transversely oblong compact body with a smooth exterior, the secretion passes by several orifices into the depressions at the sides of the verumontanum. Cowper's glands are of moderate size, subcircular, compact in structure, with a thick muscular capsule. The corpus spongiosum commences by a plexus of veins affecting a parallel course around the membranous part of the urethra, but convolute in diverse directions to form the bulbous expansion; advancing from which the veins become reduced to two or three in number, running parallel with each other and the urethra. The cavernous part of the penis forms a slender cylinder, it extends forward beneath the linea alba, closely connected therewith, making a ridge along that part of the abdominal surface; then becoming free and receiving a reflected covering of skin, or 'prepuce,' anterior to which usually depends a tuft of hair. The glans, in the Camel, is long, pointed, with its apex continued beyond the urethral opening and bent back.

In the Goat, fig. 525, the dilated terminal parts of the sperm-ducts, *a*, *a*, have a glandular thickening of the inner tunic. The prostates, *b*, *b*, have each a small central cavity; whence the duct is continued to terminate near the sperm-duct, in an oblong depression by the side of the verumontanum: on a small fold of this part is the orifice of the protometra which is continued, at *c*, between the dilated sperm-ducts, closely attached thereto by areolar tissue; then dividing into two horns diverging and closely apposed to the sperm-ducts, *a*, *a*, as far as the epididymis, in which they are lost. The Cowperian glands, two on each side, open upon the margin of a fold at the bulb of the urethra. The prostatic glands in the Deer, fig. 526, *b*, *b*, are more slender in proportion to their length than in the Goat. The protometra, *c*, is reduced to a hardly distinguishable trace; and its cavity, which exists in the embryo, is obliterated at birth.

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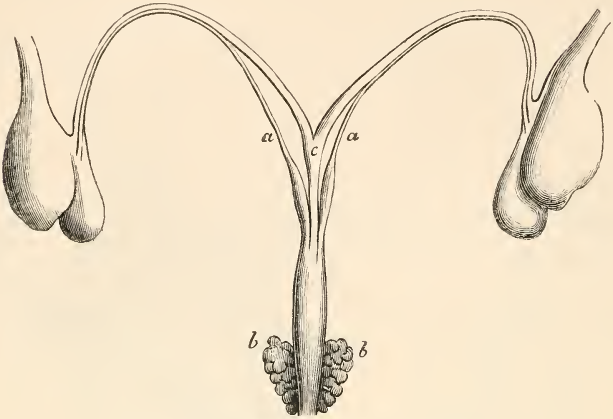
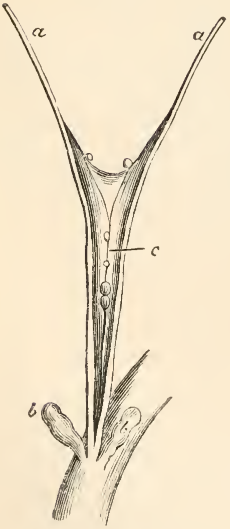


Testes, prostates and protometra, Goat. CCXXXIX″.

526



Prostates and protometra, Deer. CCXXXIX″.

In the Bull the narrow elongate prostates are irregularly contorted. The 'erectores' and 'acceleratores' are powerful muscles. The slender 'retractores' arise from the anterior commissure of the sphincter ani. There are preputial follicles in most Ruminants, especially the Antelopes; but only in the Muskdeer do they attain the size and structure described in the preceding chapter. In no hoofed Mammal is there an 'os penis.'

§ 379. *In Carnivora.*—The outward indications of the male sex are hardly distinguishable in the Seal tribe. Here, the testes, when extra-abdominal, make no scrotal projection: they are imbedded in areolar tissue, between the pubis and the thighs: the tunica vaginalis communicates freely with the abdomen: the sperm-ducts take the usual course. There are no vesicular glands; there is but a small subbilobed prostate. The penis makes no outward projection: the preputial opening, about six inches in advance of the vent, is inconspicuous. The glans penis is pointed, supported by a bone about half an inch long, in *Phoca vitulina*, into which are inserted a pair of 'retractores,' arising from the anterior commissure of the anal sphincter. The remnant of the protometra in *Ph. vitulina*, is but two lines in length; the orifice behind the verumontanum is rarely patent. The os penis of the Walrus is a massive subcylindrical bone, sometimes two feet in length, expanded at one end, where the cancellous structure prevails.[1]

The testes lie under the skin of the groin in otters, under that of the perinæum in civets. The scrotum, where best developed in *Carnivora*, is hairy and less pendulous than in Ruminants. As in these, the vesicular glands are absent[2]; the prostatic glands are small and compact. The penis, save in *Canidæ*, *Viverridæ*, and *Hyæna*, has a bone.

In the Bear the sperm-ducts are enlarged and in close contact at their terminations, with thick follicular walls: beyond this glandular part they retain their width, but contract to open upon the verumontanum.[3] A thin layer of prostatic substance surrounds the beginning of the urethra. The os penis in *Ursus arctos* may be 6 inches in length.[4] In the Subursine genus *Meles* a remnant of the protometra, fig. 527, *a*, rises between the glandular ends of the sperm-ducts, *b, b*: its cornua are reduced to mere filaments, *c*: the prostate is better developed than in Ursines, especially in the Racoon, in which it is in advance of the neck of the bladder. In the Kinkajou the os penis is sub-bifurcate at the distal end, which is covered, as in most Subursines and Mustelines, by the membranes of large dila-

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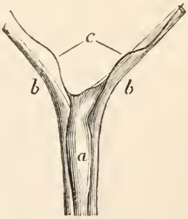

Protometra, *a*, nat. size, Badger. CCXXXIX″.

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[1] XLIV. p. 638, No. 3919.

[2] 'Les vésicules séminales existent dans les coatis,' XII. tom. viii. p. 160. Hunter, however, expressly affirms of his 'Swash,' which I determined by the skull (No. 4669, XLIV.) to be a young Coatimondi, that 'it has no vesiculæ seminales.' CCXXXVI. vol. ii. p. 90. The same result has been had from subsequent dissections at the Zoological Gardens. CCLXXIII″.

[3] CCXXXVI. vol. ii. p. 92, *note* 3.

[4] A fossil specimen of this bone, in *Ursus spelæus*, measured nine inches.

table sinuses, and projects beyond the proper erectile tissue of the glans. Besides the usual muscles of the penis there is, in Plantigrades, a pair arising from the sacrum diverging to include the sphincter ani, and then continued on to the dorsum penis as far as the bone. In the Otter the sperm-ducts have glandular terminations. 'Between the two there is a small body or canal which enters the urethra at the caput gallinaginis, but not with the vasa deferentia:'[1] in this remnant of the protometra the cornua are filamentary, as in *Meles.* In *Mustela martes,* also, Hunter observes:—'There is a small cavity between the two vasa deferentia, at their entrance into the urethra, which will admit the small end of a small blow-pipe; but I could not find any natural opening into the urethra.'[2]

In the Dog-tribe the scrotum is more prominent than in Mustelines or Plantigrades. The prostates form a protuberant body, and exude the secretion by several pores at the sides of the verumontanum. The spongy tissue of the urethra expands suddenly and considerably at the base of the glans, which has an ossicle: the blood is thence returned by two 'venæ dorsales penis': these are compressed by the action of 'levatores,' arising from the first caudal vertebra, passing one on each side of the anal sphincter, then converging to gain the dorsum penis, crossing the veins, and terminating at the base of the bulbous part of the glans. As long as the 'levatores' retain the stimulus to contract, after coition, the distended glans forms a mechanical impediment to retraction of the penis from the vagina.[3] The ossicle is grooved for the urethra.

The prostates are moderately large and lobulate in the Ichneumons, in which Cowperian glands also exist. In the Suricate (*Rhyzæna tetradactyla*) the scrotum is as little marked as in Mustelines: there are neither vesicular nor prostatic glands; but there is a pair of very large Cowperian glands, with the usual muscular capsule, and with unusually long ducts, through which the secretion is propelled to a dilatation near the distal end of the urethra: behind their orifices a semilunar fold opposes the retrograde passage of the secretion into the long tract of urethra intervening between it and the neck of the bladder. In the Zibet (*Viverra Zibetha*) there is a small prostate: beyond which the muscular tract of the urethra extends far before its combination with the erectile parts of the penis: here, behind the bulb, is a pair of large Cowperian glands. The penis is continued from the junction of the crura, forward, in front of the pubis to a small prepuce at the fore part of the enlargement caused by the scent-glands. The glans penis is pointed and bent downward: it has no bone. This is wanting also in the Musangs, in which the prostate is large, but surpassed by Cowper's glands: the preputial scent-follicles open upon a tract distinct from the anal glands. In the Hyæna the prostates fig. 528, *c*, *c*, are large and reniform, partially confluent behind: there is a minute flash-shaped protometra, ib. *a*, in the usual position between the ends of the sperm-ducts, *b*, *b*: these are less dilated and glandular than in most Carnivores. The Cowperian glands, *d*, *d*, are elongate and pyriform: their ducts open far forward, nearer the glans penis than the vesical orifice. There is no ossicle: 'the penis is easily pulled out of the prepuce, and the prepuce then seems to be continued all along the penis to the end, and much of the same colour. This is not the same as in a dog,'[1] in which the covering of the glans is more distinct in texture and attachment.

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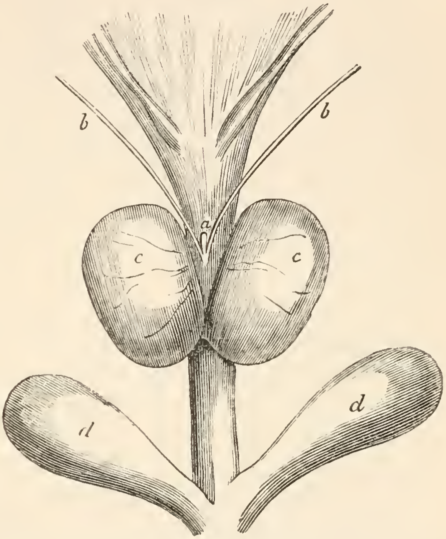
[1] CCXXXVI. vol. ii. p. 74. See also CCXLI''. p. 49.

[2] Ib. ib. p. 67.

[3] 'I laid bare the penis of a dog, almost through its whole length; traced the two veins that came from the glans and separated them from the arteries by dissection, that I might be able to compress them without affecting the arteries. I then compressed the two veins, and found the glans and large bulb became full and extended.' XCIV. p. 32.

528



Accessory male glands and protometra of *Hyæna Striata*, half nat. size. CCXXXIX″.

In the Cat the glans penis is beset with callous retroverted papillæ: they are less numerous and conspicuous in the Tiger and Lion. In all Felines there is a small prostate, limited to the back part of the neck of the bladder: the muscular part of the urethra is long. Cowper's glands are large, and derive their muscular covering from a modification of the 'acceleratores,' of which an external may be distinguished from an internal portion. The 'erectores' arise each by a broad tendon from the pubis: anterior to this the 'compressores venæ dorsalis' take their origin, and converge to unite, at the symphysis pubis, in a strong common tendon, which passes over the 'vena dorsalis penis.' Two slender fasciculi derived from the 'retractor ani' pass along the bulb and under side of the urethra to the line of reflection of the prepuce, where they are lost in the skin of the glans: they bend back that part, in the unerect state, and cause the felines to be 'retromingent.'

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[1] ccxxxiv. vol. ii. p. 58.

§ 380. *In Quadrumana.*—The testes of the Aye-aye (*Chiromys*) occupy a sessile scrotum: the tunica vaginalis communicates with the peritoneal cavity, but by too contracted a canal to permit any return there of the testes, offering a notable difference from Rodents. There are no vesicular glands; but a moderate sized compact prostate, and a pair of flattened oval Cowperian glands, the ducts of which penetrate the urethral bulb. Besides the 'erectores' and 'acceleratores,' there is a pair of strong 'levatores penis' arising from a fascia below the symphysis pubis, crossing the vena dorsalis, and inserted by a common tendon into an 'ossiculum penis.' The penis, of a subconical form, projects about an inch, in the unerect state, it is covered by the thin naked skin of the prepuce, which has a transverse orifice.

In the Slow Lemurs (*Stenops Tarsius, Otolicnus, Perodicticus*) there are vesicular glands in the form of oval subcompressed bags, with a plicate or honeycombed inner surface: their ducts terminate distinctly from those of the testes. The prostate has a bifid base and compact structure. The Cowperian glands are relatively large. The short penis has an ossicle, and projects, or hangs conspicuously as in *Chiromys*: the ossicle ends in a terminal process of the glans.[1] In the Makis (*Lemur*) the vesicular glands consist each of an elongate cæcal tube, bent inward and downward at their free end, with thin walls and a minutely rugous inner surface: in other respects the male organs resemble those of *Chiromys*. Each 'levator penis' arises from the upper part of the crus: they converge above the two 'venæ dorsales' to a common tendon which runs along the dorsum penis to the ossicle. The glans is large and expands to a free truncate end with the urethra opening near the centre of the disc; the sides of the glans are beset with small callous papillæ.

The scrotum is more pendent in Platyrhine and higher *Quadrumana*: the vesicular glands have thicker parietes and a more lobulated or ramified form: the prostate is more compact: the Cowperian glands become reduced in size. The penis is prominent or pendulous in all. The glans terminates by a large expansion in *Ateles*. In *Cebus capucinus* Cuvier found no median septum dividing the corpus cavernosum: it is present in all *Catarhines*, but degenerates into a 'pectiniform' partition anteriorly. In *Macacus Cynomolgus* the vesicular gland, fig. 529, *e*, is large and lobulate, its duct is long and unites with that of the testis, *c*, some way before the latter terminates in the urethra. The prostate, *d*, is large and compact. The remnant of the protometra, *b*, resembles the 'sinus prostaticus' or third lobe of the prostate in Man. Cowper's glands are applied to the back part of the urethral bulb. The acceleratores muscles surrounding the bulb do not advance between the erectores penis: these arise from the sclerous covering of the crura corporis cavernosi, not from the ischia. Two small 'levatores penis,' after the usual disposition for compressing the 'vena dorsalis,' terminate in a tendon inserted into a small 'os penis.' In the Mandril (*Papio*) the vesicular glands are so large as to appear, invested with peritoneum, in the pelvis: they consist of numerous cæca which terminate the subdivisions of branches given off by one main central tube or duct. The prostate, also, is partially subdivided into lobules. The testes, larger than in Man, slightly project, one on each side the base of the penis. In Apes as well as Monkeys, the 'frænum preputii' is absent, and an ossiculum penis present. Crisp found it one-third of an inch long, but gristly at both ends, in the Chimpanzee.[1]

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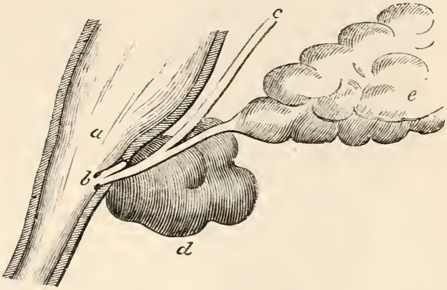
[1] xx. vol. iv. p. 101.

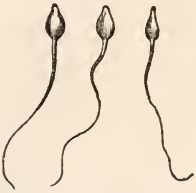
529



Accessory glands and protometra, *Macacus Cynomolgus*. CCXXXIX″.

§ 381. *In Bimana*.—Here the testes pass, two or three months before birth, into a pendulous scrotum; the serous canal of communication becomes obliterated, and the tunica vaginalis is an independent short serous sac. All the accessory glands are well developed and differentiated, but of moderate proportions. The penis is pendulous and without a bone: the prepuce has a 'frænum.' The spermatozoa, fig. 530, have an ovoid or almond-shaped body, subcompressed, viewed sideways, with a filamentary vibratile appendage, averag-

530



Spermatozoa of Man, magn. 300 diam.

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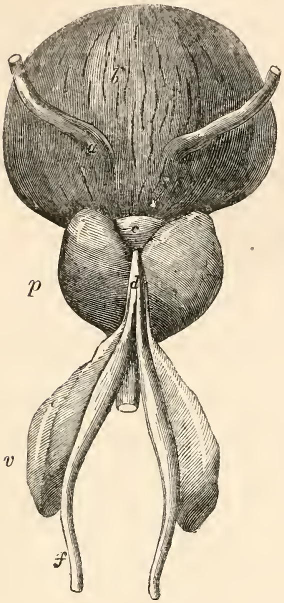
[1] CCLXXIV″, p. 48.

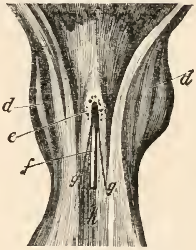
531



A posterior view of the human bladder and prostate : the spermducts and vesiculæ are reflected downward ; half natural size. XXVIII.

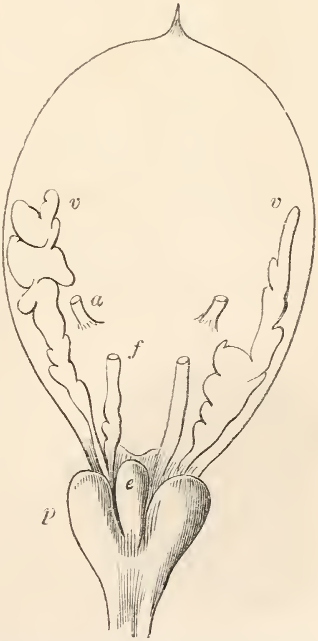
ing from $\frac{1}{500}$ to $\frac{1}{600}$ of an inch in length. They are conveyed, with the fluid in which they move, by the spermducts to the beginning of the urethra. The ducts are slightly enlarged, chiefly through thickening of their walls, near their termination, fig. 531, *f*, as they pass along the inner sides of the vesicular glands, *v*; they again contract to communicate, each with the duct of the gland of its own side, at *d*. The vesicular gland is a fusiform multilocular bag about two inches in length and three quarters of an inch in greatest breadth. The lower attenuated end penetrates the prostate between the lateral, *p*, and medial, *c*, lobes, and after joining the vas deferens, the common duct terminates at the side of the urethral depression called ‘sinus pocularis,’ fig. 532, *g*, *g*. Each ‘vesicula’ is invested by a fascia, on removal of which, with some maceration and dissection, it is shown to consist of a main tube with, commonly, three or four cæcal diverticular appendages. This tube has a much smaller calibre for a short distance from its junction with the vas deferens than elsewhere. The narrow portion is straight, and is commonly called the duct. The vesicular glands are found to contain a glairy mucus, deepening to a brownish colour soon after death, and containing stray spermatozoa. The prostate, figs. 531, 533, *p*, is a more compact glandular body surrounding the neck of the bladder and beginning of the urethra, deriving its name from its position in front of the vesicular glands. It is surrounded by a dense fascia, which adheres firmly to the glandular substance. This is of a lightish brown colour, and very firm texture. It forms two lateral lobes, of an ovoid shape, between which is a small middle lobe. It is composed of minute canals with blind follicular beginnings, which unite together to form ducts, opening in an oblique manner on the prostatic portion of the urethra. Their orifices are situated around the most elevated portion of the verumontanum, in the form of a crescent, fig. 532, *e*. The depression, or ‘sinus,’ in front of this valvular fold receives the combined vesicular and seminal ducts, *g*, *g*. A small style passed into it, as at *f*, penetrates a pyriform sac in the middle lobe of the prostate, which is the remnant of the protometra: it is exposed by removal of the glandular covering, at *e*, fig. 533. Cowper's glands are rounded bodies, about the size of an ordinary pea; of a solid texture, a palish red colour, and conglomerate. The lobules are connected together by areolar tissue, and are surrounded by a fibrous capsule: they are composed of elongate follicles, from the fiftieth to the twenty-fifth of a line in length, and about the thirty-sixth of a line in breadth. Their slender ducts, of about the eighteenth or sixteenth of a line in diameter, usually coalesce into a single excretory duct. The ducts of each gland run parallel for the distance of half an inch beneath the mucous membrane of the bulb, and approaching each other, they pierce the urethra by two exceedingly minute orifices.

532



Verumontanum, Man.

533



Vesicular and prostatic glands, with protometra, Human; half nat. size. CCLXVIII″.

The penis consists of the erectile tissues called 'corpora cavernosa' and 'corpus spongiosum,' the latter inclosing the urethra and expanding at its hind end into the 'bulb' and at its fore end into the 'glans.' The 'corpus cavernosum' forms in Man more than two-thirds of the bulk of the penis: it is a lengthened subdepressed cylinder, with a median groove both above and below; the upper groove lodging the dorsal vein, arteries, and nerves, and the under one the corpus spongiosum. Anteriorly the corpus cavernosum terminates in an oblong and rounded extremity, which is received into a depression on the posterior surface of the glans; posteriorly it is attached to the ischiopubic rami by its two crura; and above it is connected to the symphysis pubis by means of a strong triangular fascia, the 'ligamentum suspensorium penis.'

The 'corpus cavernosum' is composed of a cellular structure enclosed in a strong sclerous tunic, from the inner surface of which are given off numerous bands, 'trabeculæ,' which converge towards the middle line of the inferior wall; they are most abundant in the middle line of the organ, where they form a septum between the two lateral halves of the corpus cavernosum: but this becomes incomplete or 'pectinate' anteriorly. The so-called cellular structure of the corpus cavernosum consists of a plexus of dilated and freely intercommunicating veins, the interspaces of which are occupied by contractile tissue: the fibres being unstriped and with a general arrangement transversely to the axis of the penis.

Besides the 'erectores penis' and 'acceleratores urinæ,' there is a remnant of the 'levatores penis' reduced to the function of 'compressores venæ dorsalis;' and occasionally a small fan-shaped muscle, 'ischio-bulbosus,' may be defined in the interspace between the bulb and crura penis, having a slender attachment to each ischium, and expanding upon the bulb. The prepuce is connected to the glans on its under part by means of a narrow fold, with some sclerous tissue, termed the 'frænum præputii.' At the base of the prepuce, where it is reflected over the glans, open the small lenticular representatives, called 'glandulæ odoriferæ,' of the preputial follicles of lower Mammals.

B. FEMALE ORGANS OF MAMMALS.

The ovaries retain, as in lower Vertebrates, their abdominal position; but are relatively small in Mammalia, and consist of a dense areolar 'stroma,' which, with the ovisacs therein developed, is inclosed in a firm sclerous 'tunica albuginea,' fig. 534, *a*. The abdominal aperture of the oviduct is wide, and, as a rule, 'fimbriate;' but the canal quickly contracts, usually to a diameter like that of the spermduct, and, after a certain course, suddenly expands, or opens, into a 'uterus.' This may remain distinct from its fellow; but a prevalent mammalian characteristic is a blending of the uteri, to terminate by one valvular orifice in a 'vagina;' the confluence extending, by degrees, in different species, until a single uterus results. The vagina, as a rule, is single, and usually

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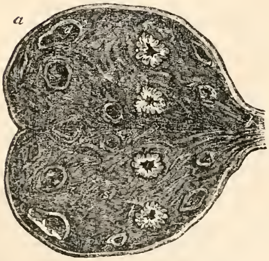

Section of Human Ovarium; nat. size. CCXLVI''.

terminates by a ‘ vulva ’ distinct from the vent. The ‘ clitoris ’ is single. The variations in the efferent and subordinate parts of the female organs are greater and more numerous in Mammals than in other Vertebrates, and with female sexual organs are associated functional mammary glands: marsupial pouches are superadded in most *Lyencephala.*

§ 382. *In Monotremata.*—The female organs here consist of two ovaria, the right much smaller than the left, two oviducts, two uteri, an urogenital passage, and a clitoris.

The ovaria correspond in situation and surrounding attachments with the testes in the male; and the oviducts and uteri exhibit in their closely convoluted disposition an analogy with the spermducts.

The left ovary, fig. 535, *f*, is an irregular, semi-elliptical, flattened body, with a wrinkled and granulate surface in the unexcited state; but becomes thicker, with the surface studded by elevations formed by the ovisacs in different stages of development, at the season of sexual excitement. At this period usually two ovisacs, as in the figure, are conspicuously larger than the rest, and present each a diameter of about two lines. The right ovary, *f′*, is a narrow, thin, generally elongated body; sometimes broader, with a finely granulated surface. It is often scarcely to be distinguished from the ovarian ligament to which it is attached. This ligament, *i*, *i*, arises from the posterior parietes of the abdomen, behind and a little on the outer side of the kidney, and passes along the edge of the broad ligament to the fallopian extremity of the oviduct, where it divides into two; one portion is attached to the side of the ovary, the other to the posterior margin of the fallopian orifice: after a course of an inch they again unite, and the ligament is continued along the anterior part of the uterus to its cervix, where it is insensibly lost. The two separated portions of the ligament support a large pouch of peritoneum, which forms the ovarian capsule; the wide anterior orifice of the oviduct is also, by means of this ligament, prevented from being drawn away from the ovary.

The efferent canal of the ovarian products is divisible into an oviduct or fallopian tube, *d′*, and an uterus, *d*. The size of the latter is nearly equal on both sides, but the right oviduct is much shorter than the left, and corresponds with the abortive condition of the ovary. The external serous coat of the oviduct is loosely connected to the muscular coat by filamentary processes of areolar tissue, among which numerous tortuous vessels ramify. The muscular coat is thin and compact, and is most readily demonstrable

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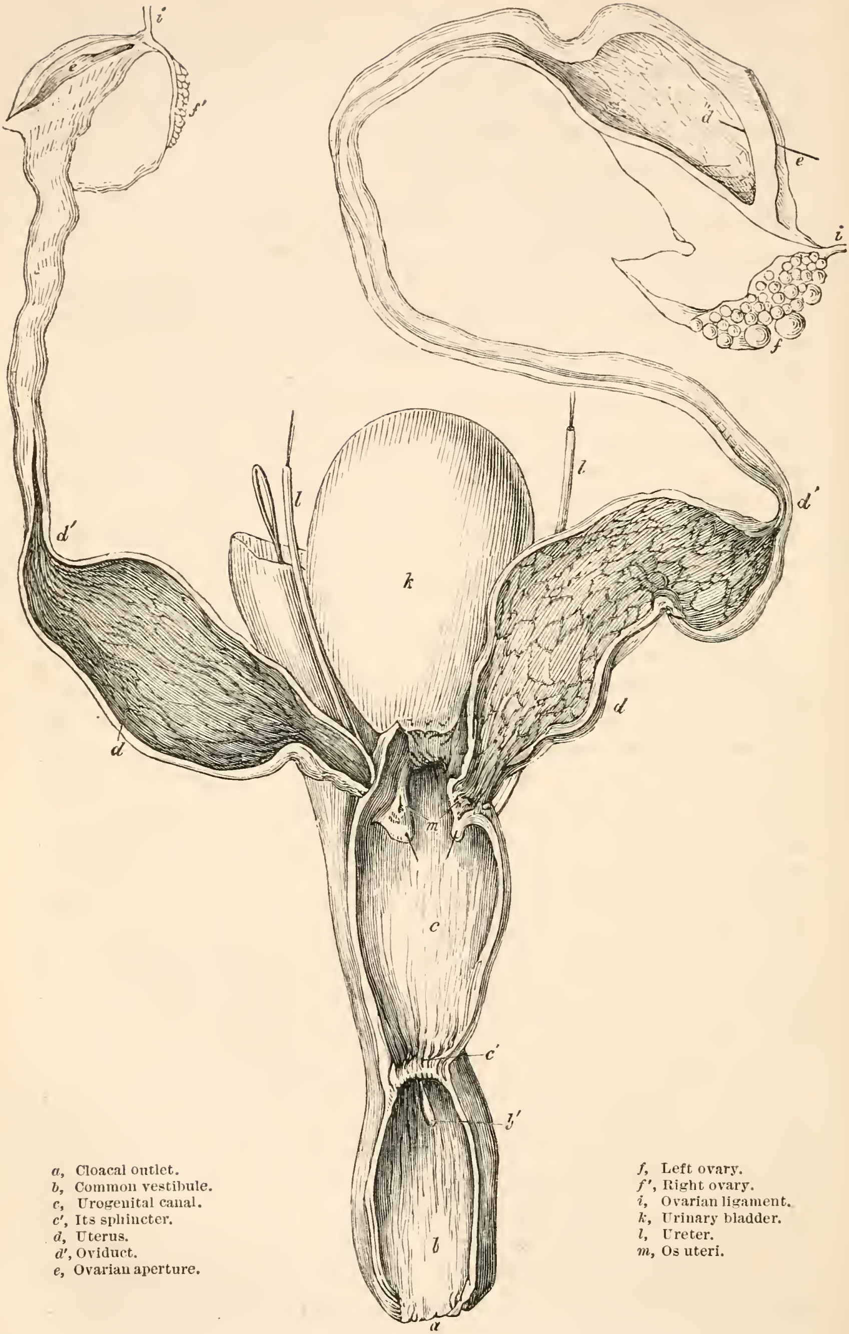


a, Cloacal outlet.
b, Common vestibule.
c, Urogenital canal.
c', Its sphincter.
d, Uterus.
d', Oviduct.
e, Ovarian aperture.

f, Left ovary.
f', Right ovary.
i, Ovarian ligament.
k, Urinary bladder.
l, Ureter.
m, Os uteri.

Female organs of generation, natural size, Ornithorhynchus. LXXVI.

in the uterus. The mucous coat is thin and smooth in the oviduct; it is thick, soft, plicated, but not villous, in the uterus.

The left uterus in a female with a large ovary, shot in the month of September, was two inches long, from four to five lines in diameter, and about a line thick in its parietes; it became suddenly contracted and thinner in its coats to form the oviduct, which presented a diameter of about two lines, slightly enlarging to within an inch of the extremity, which forms a wide membranous pouch, *d″* opening into the capsule of the ovary by an oblong orifice or slit, *e*, of eight lines in extent. The edges of this orifice were entire as in the oviducts of Reptiles, not indented as in the fimbriated extremity of the Fallopian tube in higher Mammals. The entire length of the oviduct and uterine tube, when detached from their connections with the mesometry, was nine inches. The right uterus and oviduct of the same specimen exhibited similar differences in diameter and structure, but was shorter, measuring only six inches in length.

The thickened parietes of the uterine tube depends chiefly on an increase of the inner membrane, which, at the cervix uteri, presents deep and close-set furrows: these, as the canal widens, are gradually lost, and the surface becomes more or less smooth. In the oviduct, the inner surface is smooth on leaving the uterus, then becomes finely reticulate, and in the terminal dilated part becomes again smooth. The cervix uteri makes a valvular projection analogous to an os tincæ on each side of the commencement of the urogenital canal, just beyond the orifice of the urinary bladder. There are two orifices on each of these prominences: the lower one is the termination of the ureter—a bristle is represented as passing through it in fig. 535; the upper or anterior orifice is the os uteri, *m*. In young or virgin Ornithorhynchi this orifice forms scarcely any projection into the urogenital canal, and it is divided by a narrow septum. The urogenital canal, *c*, is one inch and a half long, and three or four lines in diameter, but capable of being dilated to as great an extent probably as the pelvis will admit of; the diameter of the bony passage being seven-tenths of an inch. It is invested with a muscular coat, the external fibres of which are longitudinal; the internal, circular. The inner membrane of this part is disposed in longitudinal rugæ more or less marked, but presents as little the character of a secreting membrane as that of the vestibule, being smooth and shining; the orifices of a few minute follicles are situated in the interstices of the rugæ near the orifice of the urinary bladder.

The common vestibule, *b*, is about one inch four lines in length, and varies from half an inch to an inch in diameter: it is lined by a dark-coloured epithelium. The rectum opens freely into it posteriorly, as indicated by the probe *b′*. On the sternal aspect of the vestibule there are a series of longitudinal fibres, which extend from its external orifice to that of the urogenital cavity, the office of which is to approximate these orifices; and in this action certain oblique fibres assist, while at the same time they close the rectum.

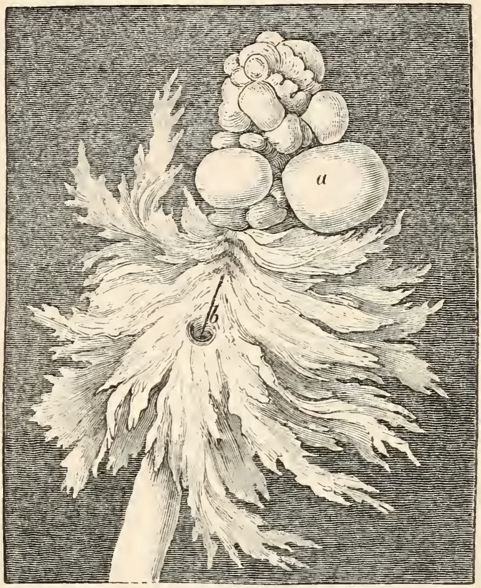
On the sternal aspect of the urogenital canal, and close to where it joins the vestibule, the clitoris is situated, which is consequently about an inch and a half distant from the external orifice of the vestibule. It is inclosed in a sheath upwards of an inch in length, and about two lines in diameter, of a white fibrous texture, and with a smooth internal surface, and this sheath communicates with the vestibule about a line from the external aperture. The clitoris itself is a little flattened body shaped like a heart on playing cards; it is about three lines long, and two lines in diameter at its dilated extremity, where the mesial notch indicates its correspondence of form with the bifurcated penis of the male.

At the base of the clitoris are two small round flattened glands, the homotypes of Cowper's glands in the male, which open into the sheath or preputium clitoridis.

§ 383. *In Marsupialia.*—In this order the female organs consist of two ovaries, two oviducts or fallopian tubes, two uteri, two vaginæ, an urogenital canal, and a clitoris.

The ovaries are small and simple in the uniparous Kangaroos, fig. 538, *a*, *a′*; tuberculate and relatively larger in the multiparous Opossums, presenting the largest size and most complicated form in the Wombat, fig. 536. In *Macropus* they are lodged within the expanded orifice of the oviduct, or 'pavilion,' near the upper or anterior extremities of its two principal lobes. These are of considerable extent, and their internal surface, which is highly vascular, is beset with rugæ and papillæ. In the Dasyures and Petaurists the ovaries are elliptical, subcompressed, and smooth. In the Virginian Opossum the ovary consists of a lax stroma remarkable for the number of ovisacs imbedded in it, the largest of which are the most superficial, and give rise to the tubercular projections on the surface. In the Wombat, fig. 536, each ovary, besides being lodged in the pavilion, as in the Kangaroo, is inclosed with the pavilion in a peritoneal capsule: it is botryoidal in form, resembling the ovarium of the bird. Numerous ovisacs in different stages of growth project from the surface, the largest presenting a diameter of eight lines, fig. 536, *a*; but the structure of these ovisacs, the character of the stroma in which they are imbedded, and the dense albugineous tunic by which they are inclosed, bespeak their strictly mammalian type. The oviducts contract, beyond the pavilion, *b*, to a greater degree than in Monotremes, and both by their slenderness and the thickness of their coats more nearly resemble the spermducts; they have, also, usually a more or less tortuous course, as shown in the Opossum, fig. 537, and Kangaroo, fig. 538, *b, b*. Their expansion into 'uteri' is more gradual than in higher Mammals. The uteri are fusiform, relatively longer in multiparous, fig. 537, than in uniparous, fig. 538, species. The muscular coat is of moderate thickness, exceeded by the innermost, owing to the abundance of lax areolar and vascular tissue which supports the smooth delicate lining membrane, which is usually thrown into many folds. Each uterus communicates with its own vagina by a valvular prominence, or 'os tincæ.' The vaginæ are of remarkable length in *Marsupialia*, and folded or otherwise developed, so as to adapt these passages to detain the fœtus after it has been expelled from the uterus for a longer period than in other *Mammalia*.

536

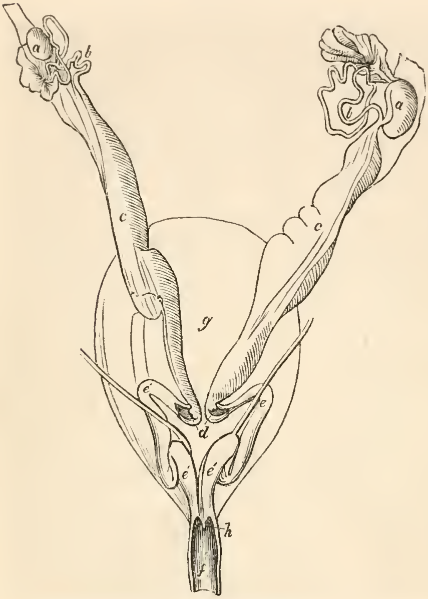


Ovarium and pavilion, Wombat. Natural size.

These complications vary considerably in the different marsupial genera. On a comparison of the female organs in *Didelphys dorsigera*, *Petaurus pygmæus*, *Petaurus taguanoides*, *Dasyurus viverrinus*, *Didelphys Virginiana*, *Macropus major*, and *Hypsiprymnus murinus*, I find that the relative capacity which the uteri bear to the vaginæ diminishes in the order in which the above-named species follow, while the size of the external pouch increases in the same ratio.

In *Didelphys dorsigera* the uteri, fig. 537, *c*, *c*, rather exceed the unfolded vaginæ in length. Each vaginal tube, *e*, *e′*, after embracing the os tincæ, *d*, is immediately continued upward and outward, then bends downward and inward, and, after a second bend upward, descends by the side of the opposite tube to terminate parallel with the urethra, *h*, in the common or urogenital passage, *f*.[1] In *Petaurus* the vaginæ, when unfolded, are a little longer than the uteri: they descend close together half-way toward the urogenital passage, and there terminate blindly without intercommunication. From the upper part of these culs-de-sac the vaginæ are continued upward and outward, forming a curve, like the handles of a vase, then descend, converge, and terminate close together, as in the preceding example.[2] In *Dasyurus viverrinus* and *Didelphys Virginiana* the mesial culs-de-sac of the vaginæ descend to the urogenital passage, and are connected to it, but do not communicate with it or with one another: each canal is, then, continued outward from the upper end of the cul-de-sac, and, forming the usual curve, terminates parallel to the orifice of the urethra. The vaginæ in the Dasyures are smaller in proportion to the uteri than in the Virginian Opossum, but of a similar form.[3]

537



Female organs, Didelphys dorsigera. LXXV′.

In the Wombat (*Phascolomys*) each uterus communicates with a separate and large vaginal cul-de-sac, the lining membrane of which is increased by irregular rugæ and papillæ: the terminal portion of each lateral canal has a thick muscular coat. The urogenital canal is lined by a thick epithelium, and its surface is broken up into countless oblique rugæ and coarse papillæ, betraying a certain regularity in their arrangement: the surface immediately around the urethral orifice is comparatively smooth.

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[1] xx. vol. iv. p. 151, no. 2734 c.

[2] xx. vol. iv. p. 152, no. 2734 E.

[3] xx. vol. iv. p. 154, no. 2738 A.

In *Macropus major* the vaginæ, fig. 538, *e*, *e′*, preponderate in size greatly over the uteri *c*, *c′*; and, the septum, *e″*, of the descending cul-de-sac being always more or less incomplete, a single cavity, *e*, is thus formed, into which both uteri open; but however imperfect the septum may be, it always intervenes and preserves its original relations to the uterine orifices, *d*, *d*. In the specimen examined by me, this part of the vagina was not continuous by means of its proper tissue with the urogenital canal, but was connected thereto by areolar tissue.[1] In *Halmaturus Bennettii* I found an aperture of communication between the median cul-de-sac and the urogenital canal;[2] and, as the same structure has been observed in two other specimens,[3] it is doubtless normal, at least, after parturition. The fact, however, does not justify the conclusion that the lateral vaginal canals convey exclusively the semen for impregnation, and that the median canals, which, as a rule, are closed and distinct from each other, serve only to transmit the fœtus to the urogenital passage. In *Hypsiprymnus murinus* the type of construction is the same as in the great Kangaroo, but the mesial cul-de-sac of the vagina attains a still greater development: it not only reaches downward to the urogenital passage, but also expands upward and outward, dilating into a large chamber, which extends beyond the uteri in every direction. From the sides of this chamber the separated portions of the vagina continue downward, to terminate, as usual, in the urogenital canal.

In *Perameles obesula* the uteri are wider in proportion to their length than in the Kangaroos. Each communicates with a vagina, expanding into a cæcum with semitransparent walls, and greatly surpassing the uteri in size: the cæca suddenly contract near the ora tincæ, to form long and slender vaginal canals, which converge, but terminate separately near the vulva. The urethra is of corresponding length and tenuity; its orifice is near those of the vagina, the urogenital passage having the least extent in this genus of *Marsupialia*.

In all, the structure of the uteri is distinct from that of the vaginæ. The muscular tunic of the uteri is thicker, and consists of an outer stratum of longitudinal fibres, and an inner one of

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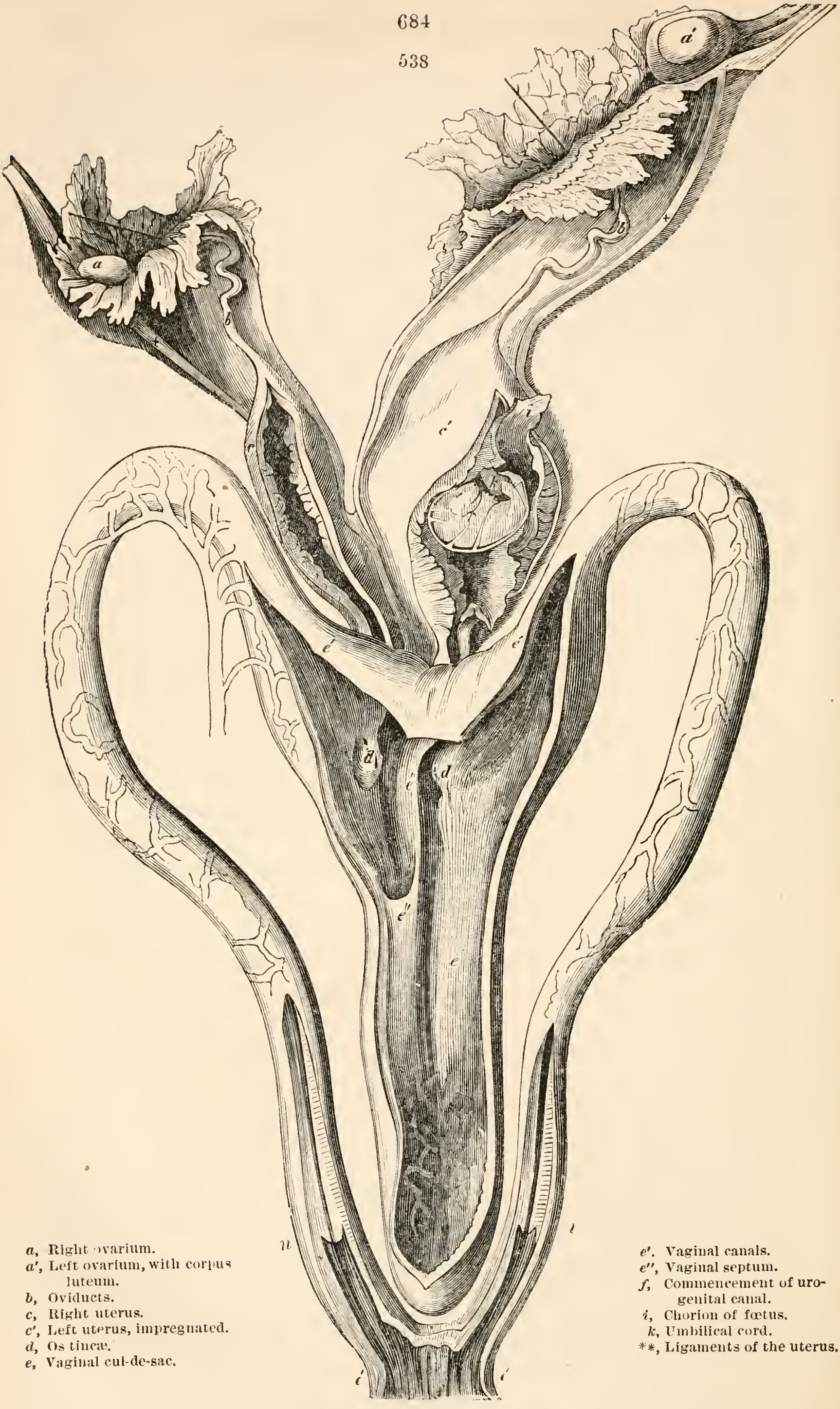
[1] Removed by dissection in the preparation, xx. vol. iv. p. 157, No. 2740 c, as in that from which fig. 538 was taken.

[2] CCXLIII″. p. 106.

[3] CCXLIV″. p. 599, and CCXLV″. p. 146.

538



a, Right ovarium.
a', Left ovarium, with corpus luteum.
b, Oviducts.
c, Right uterus.
c', Left uterus, impregnated.
d, Os tincæ.
e, Vaginal cul-de-sac.
e'. Vaginal canals.
e'', Vaginal septum.
f, Commencement of urogenital canal.
i, Chorion of fœtus.
k, Umbilical cord.
**, Ligaments of the uterus.

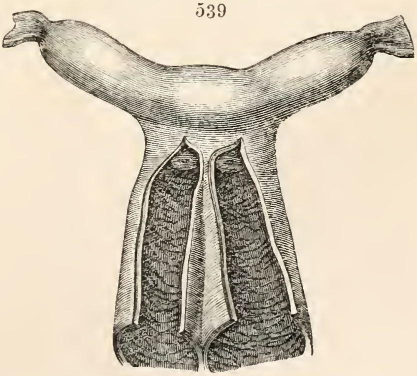
Female organs, *Macropus Major*. XXV'.

circular fibres. The lining is well organised, not deciduous: it is soft, and disposed in many irregular folds, but, when these are effaced, has a smooth surface: this is a distinct but delicate layer with minute pores, and is connected to the muscular coat by an abundant tissue, consisting of fine lamellæ stretched transversely between the muscular layer and the smooth membrane, the whole being of a pulpy consistence and highly vascular, especially in the impregnated state. The vaginæ are lined with a layer of epithelium, which is readily detachable, even from the middle cul-de-sac. The inner surface of the culs-de-sac in the Opossum is smooth, but in the lower part of the single cavity in the Kangaroo and Potoroo it presents a reticulate structure. The lining membrane in the lateral canals in all the genera is disposed in regular longitudinal folds, a disposition which characterises the true vagina in most. In the Kangaroo, as in the other Marsupialia, the lateral canals communicate with the common or urethro-sexual cavity without making a projection; but at the distance of three-fourths of an inch from their termination there is a sudden contraction, with a small valvular projection in each, fig. 538, *n*, *n*. By those who consider the cul-de-sac and lateral canals as a modification of the corpus uteri, these projections may be regarded as severally representing an os tincæ; but they do not exist in the Opossums and Petaurists, in which there is simply a contraction of the vaginal canals at the corresponding part; and in both these and the Kangaroo, the true uteri open in the characteristic valvular manner, *d*,*d*, without the slightest appearance of a gradual blending with the median cul-de-sac.

The clitoris is situated in a preputial recess near the outlet of the urogenital passage: it is simple in those Marsupials that have a simple 'glans penis,' but is bifid in those which have the glans divided: and in the Opossum each division of the 'glans clitoridis' is grooved.

The marsupial type is repeated in one of the rarer anomalies of the female organs in the Human species: in which not only the uterine cavities are distinct, but the 'os tincæ' of each opens into its own vagina, fig. 539.

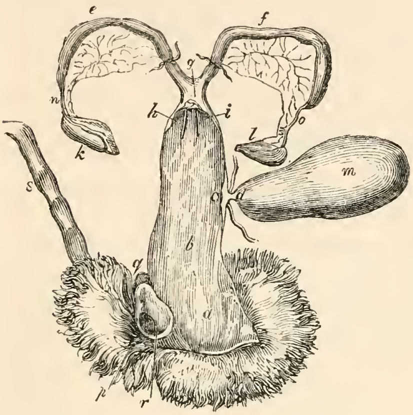
539



Double uterus and vagina, Human anomaly. CCXLVI''.

§ 384. *In Rodentia.*—This order offers transitional steps from the foregoing type to the more common 'uterus bicornis,' with single os tincæ and vagina. In the Biscachia (*Lagostomus trichodactylus*) the two uteri are distinct, and each opens into a separate canal formed by a longitudinal septum continued about one-third down the vagina.[1] In the Capybara, *Sciuridæ* and *Leporidæ*, the two ora tincæ of the separate uteri open into the fundus of a common vagina, fig. 540, *h, i.* In the Beaver there is one large prominence, like an 'os tincæ,' but the uteri terminate thereon by separate orifices. In *Muridæ*, the Aguti, the Paca, the two uteri blend into a short common cavity, with one opening into the vagina: they are connected together for some extent beyond the confluent cavities, or true 'corpus uteri.' The ovaries, which are elongated, subcompressed, and with an even exterior, in the unexcited state, fig. 540, *k, l,* become botryoidal when the ovisacs are developed with ripe ova, fig. 772, A, *a, a′.*

540



Female organs, Hare. CXXI′.

In the Beaver the 'pavilions' are small and simple: upon these the oviducts are obliquely folded; the uteri are long, straight, and of uniform slender diameter when unimpregnated. The os tincæ is followed by a series of irregular flat processes, which project from the fore part of the vagina, gradually becoming smaller. The urethra communicates with the vagina near its distal end: the clitoris projects from a notch just beyond the urethra; and in front of the clitoris is the wide aperture common to the two large preputial or 'castor' bags: there are also smaller lobulated masses beyond the bags. In the Rabbit the aperture of the pavilion, ib. *b′*, is more fimbriate and plicate than in the Beaver: it is continued along the border of a shallow peritoneal capsule extending from the further side of the ovary to the border of the broad ligament. From the ovary the remnant of the ligament of the primordial kidney ascends to the diaphragm. The oviduct, ib. *c*, *c′*, passes outward a short way beyond the ovary, then suddenly bends back toward the uterus, *f*: it is unravelled in fig. 772, A. The natural disposition of the efferent canals in the unimpregnated state are shown in fig. 540. The uterine tubes, *e*, *f*, are united for a short distance by areolar and serous tissue at *g*; but open separately into the vagina, as shown by the styles, *h*, *i*. The longitudinal and circular layers of the muscular coat are as well marked as in Marsupials; but the inner coat has a different and lower structure: it is more homogeneous, and adheres closely to the muscular coat: its inner surface is more or less wrinkled, and is minutely porous, the orifices being those of the irregular canals called 'utricular glands,' exuding fluid, and lined by the formified particles or 'cells,' which likewise adhere to the free surface of the uterine lining. This, when injected, presents a fine reticulate structure, with a similar disposition of the superficial capillaries. Near the distal end of the true vagina are two small semilunar folds, with their concavity directed toward the urogenital passage. This is long in *Leporidæ* and a few other Rodents: its commencement is indicated, where valvular limits are wanting, by the opening of the urethra, ib. *d*: it terminates close to the vent in all Rodents; and, in the Hare, on the same nude patch of skin on each side of which is the glandular bag, *q*. The 'preputium clitoridis' opens just within the verge of the urogenital outlet: the clitoris commences by two crura, and terminates by a flattened bifid glans. In the Capybara the urethra terminates close to the vulva, and a groove is continued to the preputium clitoridis, which projects externally. In many Rodents (*Arvicola*, *Lagostomus*, *Bathyergus*) the clitoris is perforated by the urethral canal. In the Squirrel the vulva is a longitudinal slit upon a conical prominence or 'peak:' in the Porcupine the vulva is a thick semilunar prominence, puckered up internally into longitudinal folds, and opening immediately below the vent. The urethra and preputium clitoridis are close to the vaginal outlet.

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[1] CCXII″. p. 177.

The human uterus repeats, as an anomaly, the grade of concentrative development attained by those Rodents in which a short common cavity or 'corpus' intervenes between the cornua and the vagina, as in the instance, fig. 541, given by ARTHUR FARRE in his masterly Article 'On the Uterus and its Appendages.[1]

§ 385. *In Insectivora.*—In some of these *Lissencephala*, as in some *Rodentia*, the clitoris projects externally to the vulva, and is perforated by the urethral canal. The Mole, which exemplifies this structure, fig. 542, *c*, also shows a complete closure of the vaginal orifice in the virgin state, ib. 1,[1] the vulva afterwards, ib. 2, intervening, at *n*, between the clitoris, *c*, and the prominent vent, below the letter *n*. The canals, severally continued from these apertures, viz. rectum, vagina, and urethra, are all anterior to the pubic bones, consequently outside the pelvis. There is no valvular or other distinction between the vagina and corpus uteri: a long, somewhat tortuous, subdepressed utero-vaginal canal extends into the abdomen to terminate in the cornua uteri: these are cylindrical tubes, and describe three abrupt curves, on quitting the corpus uteri, at right angles therewith. The ovaries are commonly found with a tuberculate exterior, and are inclosed in an almost complete peritoneal capsule. The oviduct pursues a wavy course along this capsule to the uterine 'horn.' The ovarian ligament, commencing near the diaphragm, descends external to the kidney, carrying before it a peritoneal fold. The uterine ligament is continued from the end of the 'cornu,' and runs along the posterior edge of a continuation of the same fold, or 'mesometry,' to the part answering to the abdominal ring in the male.

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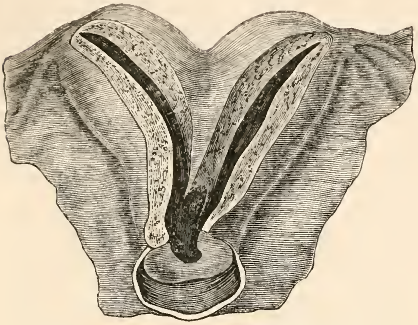
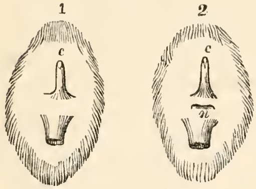
[1] CCXLVI″. p. 680.

541



Uterus bicornis, Human Anomaly. CCXLVI''.

542



External parts, female Mole. LXIII''.

The Shrews closely resemble the Moles in their female organs: there is the same absence of os tincæ and a corresponding length of utero-vaginal canal from which the cornua, fig. 389, *u*, arch away at a right angle. In the impregnated specimen figured, the commencing embryos were lodged in cæcal dilatations of the cornua. In the great-snouted Shrew (*Rhynchocyon*), the ovaria, fig. 543, *x*, are placed each near the orifice, *o*, of a large peritoneal capsule, bordered by the oviduct, *t*, which slightly enlarges towards the uterus. This commences by a bifid expansion, and is continued without constriction or distinction into a wide vagina with interlocking transverse folds at its uterine half. In *Tupaia* the clitoris is long but is merely grooved, the groove being continued to the urethral opening just within the vulva. The uterine cornua are short. In the Hedgehog the clitoris projects from a prepuce into a urogenital passage of an inch in length, midway between the vulva and the urethra: here a slight constriction marks the boundary of the proper vagina. This canal soon becomes rugous; the rugæ are nearly transverse, increasing in breadth, and interlocking near the os tincæ, which seems to terminate the series. The body of the uterus is about half an inch in length; the cornua not much more. The ovary is tuberculate and furrowed; its peritoneal capsule is large, with a small orifice near the termination of the oviduct in the uterus. The ovaria are large and clustered, and the uterine cornua long, in the multiparous Tenrec (*Centetes*);[1] the vagina has the transverse alternating folds at the uterine half of the canal.

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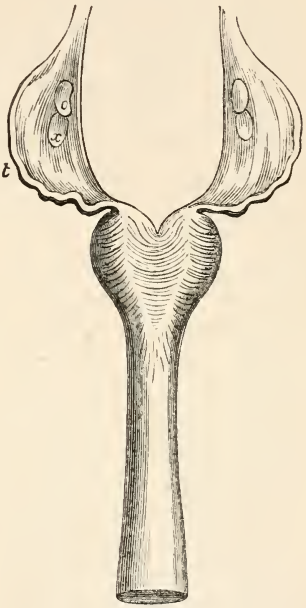
[1] According to LXIII''. p. 1006.

543



Female organs, *Rhynchocyon*. CXXXIV'.

In the Bats the uterus has two very short horns: the long corpus uteri opens by an os tincæ into the vagina: in *Pteropus* the vagina extends into a cul-de-sac beyond the os tincæ.

§ 386. *In Bruta.*—The absence of the valvular or mechanical limit between uterus and vagina, noticed in certain *Insectivora*, is an inferior character repeated in the present order of *Lissencephala*. In the Armadillos (*Dasypus Peba*, e.g.) the uterine walls gradually become thinner, the epithelium denser and smoother, and longitudinal furrows finally denote the vagina, which opens into a wide urethra about an inch from the end of the clitoris, the groove of which is continued from the urethra. The usual subordinate relations of urethral and vaginal canals are here reversed. The clitoris in *Dasypus* 6-*cinctus* is longer than in the 9-banded species, measuring nine lines in the unerect state: it is of a pointed form, covered with a leaden-coloured integument, and situated an inch anterior to the anus: the vulva is placed on an eminence. From this orifice the urogenital canal extends eight lines, receiving the vagina by a transverse semilunar slit, and being then continued for five lines further without any diminution of diameter, and terminating in the form of a cul-de-sac, into which the urethra opens by a very small orifice. In *Das. Peba*, the urogenital cavity is not separated by a corresponding contraction from the urinary bladder, but is a more direct continuation of it. In this Armadillo the uterus is undivided; it expands to the fundus, which again contracts to a point, the oviducts being continued from the sides of the fundus: in *Dasypus* 6-*cinctus* the uterus is triangular, the fundus expanding into slightly produced angles, from which the oviducts are continued. These, in both species, wind round the peritoneal capsules of the ovaries, become tortuous, and terminate by fimbriate expanded openings directed toward the ovary, which was subelongate and smooth in both the dissected specimens.

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[1] Of the two specimens of *Centetes setosus* transmitted to me by the Hon. W. R. Rawson, Treasurer of the Mauritius, one had brought forth twenty young: he had known an instance of twenty-two at a birth, the more usual number being twelve to eighteen. I added dissections of the fœtus to the Hunterian Series under the No. 3577, A, to show the close analogy in form and structure of the male and female organs at that period.

In the Ai (*Bradypus tridactylus*) the uterus is like that of *Dasypus* 6-*cinctus*, the oviducts being continued from the angles of the fundus: between the uterus and vagina there is as little distinction; and the elongate common canal communicates (in the young Sloth) by two apertures with a short and wide urogenital passage. The ovaria are smooth elliptic bodies, with a greater proportion of stroma than in multiparous *Lissencephala*: the oviducts, commencing by fimbriate apertures upon the anterior edge of the capsule, pursue a serpentine course in that peritoneal fold to the fundus uteri. The ovarian ligaments are continued each along the margin of a peritoneal fold upward to the diaphragm, and downward to an oval 'parovarium,' or remnant—of unusual size—of the 'Wolffian body': the unobliterated termination of its duct opens, as in most *Lissencephala*, on each side the urogenital passage, here very short. In the Unau (*Bradypus didactylus*) the rudiment of an uterine septum appears as a longitudinal ridge from the inner surface of the anterior wall in the unimpregnated state: in this species, also, the utero-vaginal canal communicates in the virgin animal by two distinct orifices with the short urogenital tract, the outlet of which is common with the vent. The clitoris is short, and does not project beyond the cloacal aperture. In the great Anteater (*Myrmecophaga jubata*) the vulva and vent have likewise a common external cloacal outlet.

§ 387. *In Cetacea.*—The ovaria are narrow and elongate, with the surface frequently fissured so as to appear convoluted: the orifice of the 'pavilion' is rarely fimbriate, but the lining membrane is produced into numerous folds, which sometimes project like a short fringe. The uterus is 'bicorn' with a short body: the lining of the 'cornua' is longitudinally plicate: the os tincæ is prominent: the surface of the vagina has many complex transverse folds. The vulva is a longitudinal fissure, fig. 608, *a*, anterior to the vent, ib. *b*: its labia are composed of soft and yielding integument not loaded with oil: a short urogenital tract is marked off by the entry of the urethra upon a longitudinal ridge of the vagina: anterior to the urethra are two folds, like the 'labia minora,' between which is the clitoris: at the sides of the urogenital passage are the orifices of 'Malpighian canals.' In *Balænoptera* the peritoneal fold forms a wide and shallow sac beneath the ovary: the oviduct dilates at first, then contracts, and after a short wavy course is continued straight to the corresponding horn of the uterus. The lining membrane of this part is longitudinally plicate; the folds subside at the beginning of the 'corpus uteri,' but again reappear, and are continued upon broader transverse or circular productions of the lining. The third of these, progressively increasing in depth, represents the 'os tincæ:' just beyond this, at the beginning of the vagina, is a semicircular fold, also multiplicate longitudinally: it is followed by four other transverse folds progressively increasing in width: beyond these the longitudinal plicæ gradually subside. In *Hyperoodon* about ten oblong processes surround the entry of the oviduct into the uterine horn, into which they project: the uterine body presents a few large smooth ridges and obtuse processes. The 'os tincæ' is divided into five tubercles: about six inches intervene between these and the first transverse fold of the vagina: between these folds the membrane is produced into smaller wavy and longitudinal rugæ. In *Delphinus delphis* and in *Phocæna* the entry of the oviduct into the uterine horn is not defended by processes of the lining membrane. The longitudinal and transverse productions of the uterine and vaginal inner surfaces resemble those of the Whale. The 'larger folds of the vagina appear like a succession of ora tincæ.'[1]

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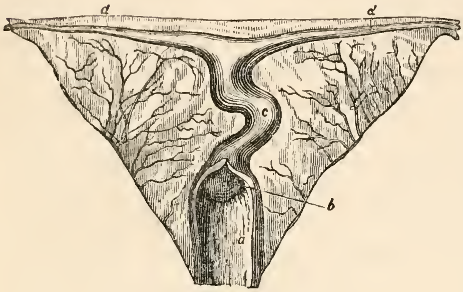
[1] xx. vol. iv. p. 175.

§ 388. *In Sirenia.*—In both *Halicore* and *Rhytina* the vagina, fig. 544, *o*, is characterised by longitudinal rugæ: the body of the uterus, *c*, is relatively longer than in *Cetacea*, and, in the young unimpregnated Dugong, is wavy: the cornua diverge at right angles, are more slender, and less arched: there is a well-developed 'os tincæ.' The vulva is situated further in advance of the vent. In *Rhytina* Steller describes the clitoris as of a hard texture, an inch and a half long, situated at the anterior broader part of the vulva, which is eight inches anterior to the anus.

544



Uterus of Dugong. CCXLVIII''.

§ 389. *In Proboscidia.*—In a half-grown female Elephant (*Elephas Indicus*, Cuv.), the ovaria are small oblong bodies, with an irregular tuberculated exterior and large proportion of stroma: the ovarian apertures of the oviducts are provided with numerous long and slender branched processes, like a loose tassel. Each tube makes a long bend upon itself around a deep and narrow ovarian capsule, and maintains a slightly tortuous course to the uterus. The body of the uterus is very short; the cornua are long and wide; their inner surface is broken by a few slight transverse puckerings on the concave side. The body of the uterus presents two large semilunar folds, and the os tincæ is represented by three similar successive and alternate folds, which form the boundary between the uterus and vagina: the latter is divided from the urogenital canal by a constriction, in which, viewed from the urogenital side, there appear three small apertures: the middle one leads to the vagina; the lateral ones to the mucous sinuses, called 'canals of Malpighi.' The internal surface of the vagina presents a few slight and irregular rugæ; those of the urethro-sexual canal affect a more regular, and in some places a penniform, arrangement: the urethra terminates immediately beyond the constriction. The clitoris measures fifteen inches in length. The two crura are attached to the rami of the os pubis: they are of a dense cavernous texture, and are joined together to form the body of the clitoris: this is inclosed in a strong ligamentous capsule. After the junction of the crura the clitoris descends along the perineum, with its under or posterior surface applied to the urogenital canal; two muscles, answering to the levatores penis in the male, converge and unite upon the upper or anterior part of the clitoris, and send their common tendon through a sheath to terminate near the glans: this is composed of a vascular corpus spongiosum.

§ 390. *In Perissodactyla.*—The ovaria, in *Rhinoceros Indicus*, are included within a large peritoneal sac, communicating with the general abdominal cavity: they are compact, oblong and subcompressed. The oviducts commence by wide orifices, having a richly fimbriated margin: their diameter at the expanded end equals two-thirds of an inch, but they gradually diminish in size as they pass in a slightly tortuous course along the parietes of the ovarian capsule towards the uterus: just before they enter the cornu their diameter does not exceed one-third of a line. They terminate in the extremity of the cornu upon a valvular protuberance about the size of a pea, which is divided into four or five processes. The 'cornua uteri' are each seventeen inches in length: the 'corpus uteri' only an inch and a half. The cornua are occupied by close-set longitudinal folds: the inner surface of the corpus is smooth. The vagina, about sixteen inches in length, is divided by a constriction from the urogenital tract, which is three inches long. The upper or uterine third of the vagina is occupied by broad transverse folds, the lowest of which is most extensive. About an inch above this fold, or nearer the uterus, a second and smaller fold is formed, which also descends from the upper and lateral parietes of the vagina, but passes across in an oblique direction: then follow in quick succession a series of shorter but equally broad semilunar folds, which become alternate in their relative position as they approach the uterus, so as to cause the cavity of the vagina to assume a spiral course: as these valvular folds also assume a thicker, softer, and more vascular texture, it is by no means easy to determine where the vagina ends or the uterus begins.[1] The structure resembles that in the Tenrec and some other *Lissencephala*. The urethra opens into the urogenital passage just beyond the vaginal constriction. The lateral apertures of the 'Malpighian canals' are about an inch and a half from the vulva. These canals expand, and then divide and subdivide, terminating in blind ends near the beginning of the vagina.[2] The 'preputium clitoridis' and urogenital canal open externally by distinct but approximate narrow elongate orifices: the vulva opens about five inches from the vent.

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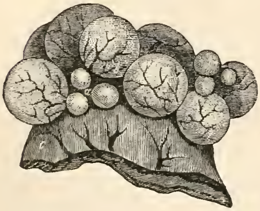
[1] v″. p. 52, pl. 18.

[2] Ib. *m, m.*

In the Tapir the ovaria are small subcompressed oval bodies, in a widely open peritoneal pouch; the oviducts have a tortuous course along the pouch near its margin to the uterine horns, which are long, and longitudinally multiplicate within: the body of the uterus is but two inches long, the 'os tincæ' not very prominent: the vagina is long; a constriction divides it from the urogenital passage, which is short. The clitoris and Malpighian canals resemble those of the Rhinoceros.

In the Mare the ovaries, of an elongate reniform figure, are inclosed and concealed in large peritoneal sacculi, fig. 574, *z*, to the mouths of which the fimbriated extremities of the oviducts are attached. The inner surface of the pavilions are characterised by numerous narrow, close-set, minutely plicated laminæ. The oviducts have a wavy course to the horns of the uterus, which are a little longer than the body or common cavity; short oblique wavy folds of the lining membrane, much developed in the impregnated state, fig. 575, *t*, project into the interior: a few similar folds are present in the body of the uterus, together with others which are broader and disposed more longitudinally at the cervix. The os uteri, ib. *l*, is denoted by the sphincteric thickening of the muscular coat and the contraction of the canal; but there is little or no valvular projection into the vagina. Of this canal, *k*, the inner surface is increased by numerous irregular longitudinal folds: a constriction defines the vagina from the urogenital passage, ib. *d*; the urethra, ib. *e*, opens near the constriction, behind a rugous prominence or flap, ib. *f*. The orifices of many follicles are dispersed over the comparatively smooth surface of the urogenital passage. The trilobate 'glans clitoridis,' ib. *a*, projects from its preputium close to the anterior margin of the vulva. It is provided with 'erectores' muscles and a 'plexus retiformis': the sphincter of the urogenital passage is very powerful. In the Filly the communication of the vagina with the urogenital canal is divided by a longitudinal septum or 'hymen.' The Zebra and Ass closely agree with the Mare in the structure of the female organs.

545



Ovarium of Sow; nat. size.

§ 391. *In Artiodactyla.*—The ovaria of the Sow, fig. 545, are large oblong bodies with an irregular and tuberculate surface: when the ovisacs enlarge, the stroma is scanty in proportion. Each ovarium is inclosed within a peritoneal sac, near the aperture of which it has a pedunculate attachment. The posterior wall of the sac appears to be formed by the wide and deep pavilion, the margin of the abdominal opening of which is almost entire; the inner surface of the pavilion is augmented by many long but narrow and highly vascular folds, which radiate from the beginning of the contracted part of the oviduct upon the expanded pavilion. The uterine cornua are long. The numerous and irregular processes and wrinkles which characterise the inner surface of the horns of the uterus gradually subside in the body as this approaches the vagina, and pass into two or three series of thick and soft ridges of the lining tissue. The os uteri is denoted by a series of close-set, narrow, longitudinal folds, but there is no valvular projection or 'os tincæ.' In the true vagina the longitudinal folds become fewer, and gradually subside toward the line of separation between the vagina and urogenital passage. The urethra opens between two longitudinal ridges, but the surface both of these and other similar projections in the urogenital passage is broken by numerous fine, wavy, and oblique furrows. The clitoris projects from the anterior angle of the vulval labia. In the Peccari the vaginal folds toward the uterine end are so arranged as to give a spiral curve to the canal, like that in the Tenrec and Rhinoceros. Usually one ovisac enlarges, at the heat, in each ovary, or there may be two in one ovary, the Peccary producing not more than two at a birth.

In the uniparous Camel the ovary is a comparatively small subcompressed oval body with a smooth and even exterior: it becomes furrowed and subtuberculate in older specimens, or at the heat. The greater part of the capsula ovarii appears to be formed by the fimbriate aperture of the oviduct, which is of very large size, and is supported by a broad fold of peritoneum; the pavilion as it approaches the contracted part of the duct has its inner surface provided with many broad parallel folds: the oviduct is disposed in a series of four oblique festoons, and is then continued in an unconvoluted course toward the uterus.

The cornua are of moderate length, and describe each a regular semicircular curve: they have a smooth internal surface, beset with utricular pores, without trace of cotyledonal processes. The corpus uteri is short: the cervix is occupied with a series of oblique but nearly transverse folds, which do not quite complete a circle. Three of these folds are seen from the vagina concentrically disposed around the beginning of the uterus, which has no defined 'os tincæ.' The commencement of the wide vagina presents a smooth and even internal surface. The clitoris commences by two crura, and is continued in a tortuous and somewhat spiral course to the preputium clitoridis, to one side of which it is adherent: the extremity of the preputium forms a conical prominence external to the anterior margin of the urogenital canal. The 'plexus retiformis' forms two large bodies.

In the Pigmy Musks or Chevrotains (*Tragulus*) the ovaria are smooth oblong bodies with a somewhat angular contour. The oviducts pursue a scalloped course along the edge of the broad ligament, and terminate in an expanded elongated pavilion at the outer part of the circumference of the capsula ovarii. I found the cornua of the uterus are unequal in size; the right was the largest in the specimen examined; its inner surface was smooth, the utricular pores generally diffused, without any appearance of cotyledonal processes, implying an uniform and stunted villosity of the fœtal chorion, as in the Camel tribe.[1] The inner surface of the vagina has many parallel longitudinal folds, the abrupt termination of which indicates the beginning of the uterus, there being no os tincæ. The vulva is close to the vent.

In horned Ruminants the lining of the cornua uteri shows smooth prominences, devoid of utricular pores, called 'caruncles' or cotyledonal processes, fig. 546, *e*, *e*, increasing in number with the size of the species. In *Cervus rufus* and *C. capreolus* there may be from four to six in each cornu, longitudinally disposed: in the Giraffe there may be eighty. In the Cameline group we have seen that the greater part of the capsula ovarii is formed by the expanded fimbriated aperture of the oviduct itself, which is of very large size. In Deer, Antelopes, Bovines, and Ovines the ovarium, ib. *k*, is lodged in a depression or sacculus of the broad ligament, which is more or less deep, and has its apertures more or less contracted in different species. In the Giraffe this sacculus is wide and deep, and incloses almost the whole of the ovary. The fimbriated extremity of each oviduct is expanded upon the outer margin of the ovarian capsule, as in fig. 546, *i*, *i*; the inner surface of the pavilion is beset with numerous fine oblique striæ, and is further increased by narrow folds of laminæ converging toward the contracted opening of the duct. The oviduct forms three or four wavy folds, and is then continued along the walls of the wide ovarian capsule to the extremity of the uterine horn, which makes an abrupt curve to meet it. Each cornu becomes bent in a spiral form when distended with fluid: four longitudinal rows of compressed caruncles project from the inner surface. The cervix of the uterus is occupied by two circular series of close-set, longitudinal lamellar processes, with their free margins converging to the centre of the canal. Above these the inner membrane of the uterus sends off several thicker processes similarly arranged. The 'os tincæ' is a large transversely oval prominence, having the orifice of the uterus in the centre, and marked by numerous fine rugæ, which radiate from this orifice. The vulva or 'peak' in the Giraffe resembles that of the Deer, and the other horned Ruminants, in coming to a point below, within which is the clitoris. From the vulva to the orifice of the urethra, the passage is five inches long in the Giraffe: the proper vagina is lined with a smooth and polished membrane, which is disposed in numerous fine and small longitudinal rugæ.

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[1] ccxxxvi. vol. ii. p. 135, *Note*.

In the Bison (*Bison Americanus*) the ovaria are smaller than in the Giraffe, and the peritoneal sacculi, or capsules, are deeper, and have a more contracted aperture; they are situated wholly external to the ovary, with their apertures turned toward those bodies. The fimbriated pavilion is extended along the external border of the opening of the ovarian sac. The smooth caruncles of the uterus are softer, thicker, and more obtuse than in the Giraffe, and are less regularly disposed. Series of longitudinal laminæ are disposed on transverse folds in the cervix uteri; the uppermost are narrower and longer; other series of shorter, broader, and thicker folds intervene between them and the plicated os tincæ. The longitudinal folds of the vagina are also more developed than in the Giraffe.

In the Rein-deer (*Cervus Tarandus*), the ovaria are small, simple, smooth, ovate bodies, with the larger end attached to the fimbriated aperture of the oviduct; this is situated external to the ovary, between which and the rest of the oviduct the peritoneum is developed into a wide but shallow sac. The oviduct, after a few slight folds at its commencement, is continued straight to the uterus. The cornua are unconnected with each other for the first half of their extent: the first of the cotyledonal processes commences near the orifice of the oviduct, is in the form of a compressed elongated fold of the lining membrane, and extends in the direction of the cornu, with its lower extremity projecting free for the extent of half an inch; the succeeding caruncle, which begins where the other ends, is also elongated and flattened, but is shorter and broader; the third is much shorter, but thicker and broader; the fourth, which is at the commencement of the common uterus, is the smallest. The caruncles of three other rows have similar proportions. In the cervix uteri the lining membrane is produced into numerous close-set longitudinal laminæ, supported on six successively larger transverse processes, the two last of which project into the vagina, and form the os tincæ. The vagina exhibits at its commencement some longitudinal rugæ; but the rest of its inner surface is almost smooth.

The cornua uteri in the Goat and Sheep, fig. 546, *g*, are relatively longer, more tortuous, and expand more gradually from the ends of the oviducts than in the Deer and Cow; their point of confluence is marked by the style *f*. The structure of the corpus and cervix uteri resembles that in the Bison. The groups of laminæ there present the appearance of a number of successive ora tincæ, ib. *c*, *b*. In the virgin Ewe a filamentary band, crossing the constriction between the urogenital canal and vagina represents the 'hymen.' The canals of Malpighi open into the urogenital passage, near that constriction. The crura clitoridis are embraced by 'erectores:' the glans projects just within the 'peak' of the vulva.

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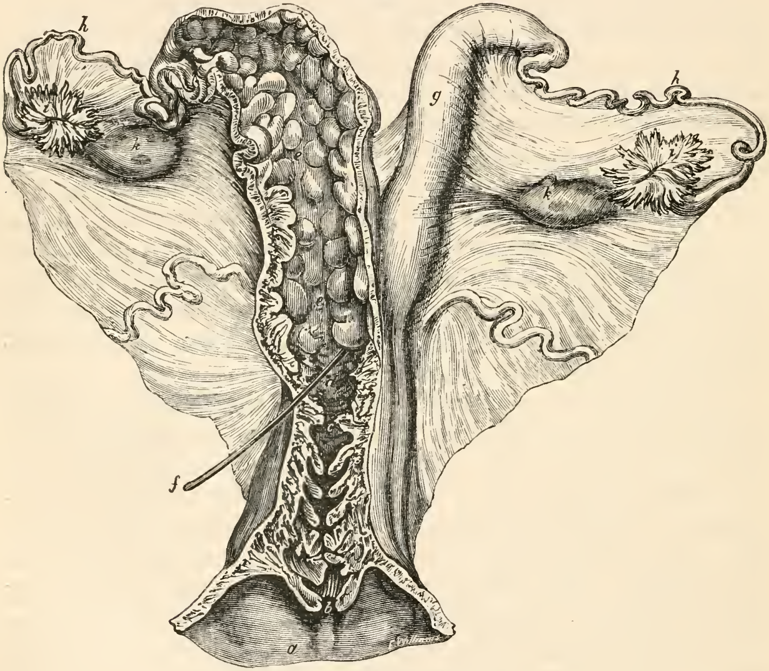

Ovaria, oviducts, and uterus, Sheep.

§ 392. *In Carnivora.*—In the Seal (*Phoca vitulina*) the ovaria are inclosed in the peritoneal capsules, situated close to the ends of the cornua uteri. The orifice of the capsule is chiefly formed by the fimbriate pavilion. The cornua continue distinct some way after they are externally joined together, the actual 'corpus uteri,' or common cavity, being very short. The inner surface of the cornua is beset with thick soft eminences, chiefly in the longitudinal direction, which fall into longitudinal ridges as they approach the corpus uteri. This part opens into the vagina on a well-developed round os tincæ. The vagina is lined by a loose usually longitudinally plicated membrane: it is separated, at the immature period, by a well-marked constriction from the urogenital canal. The urethra opens into the beginning of this canal upon a mammillary prominence. The clitoris projects from a small semilunar depression, just within the verge of the anterior part of the urethro-sexual canal: it has an ossicle. The rectum terminates close to the opposite side of the vulva, and a common cloacal sphincter muscle embraces both apertures.

In the White Bear (*Ursus maritimus*) the ovaria are completely inclosed in a reflected capsule of the peritoneal membrane, like the testes in the tunica vaginalis: a small opening, however, leads into the ovarian capsule at the part next the horn of the uterus. The fimbriated orifices of the oviducts are situated close to this aperture: the ducts pass round the capsule in a tortuous course to the uterus. The two cornua uteri communicate with a short and wide corpus uteri, between which and the vagina there appears to be no very distinct boundary: a broad transverse rugous projection of the lining membrane holds the place of the os tincæ. The vagina is separated from the urogenital canal by two transverse semilunar folds, continued one from each side of the longitudinal eminence upon which the urethra opens. The lining membrane of the urogenital canal is chiefly remarkable for its dark colour and sharply defined rugæ, which are mostly longitudinal, but in some places have an oblique or penniform arrangement. The clitoris lies concealed in a deep preputial cavity, attached through its whole length to the anterior or under part of the urethro-sexual canal: it has an ossicle. In *Ursus labiatus* the inner surface of the cornua uteri is marked by obtuse, depressed, irregular processes, on which are utricular pores. The body of the uterus offers a very contracted area; it terminates by a small circular papillose ridge in a short but wider canal, which traverses a similar but much larger prominence, or os tincæ: these valvular projections are minutely plicated. The lining membrane of the vagina presents many small, irregular, transverse rugæ at its commencement, but these gradually pass into the longitudinal direction at its termination in the urogenital canal, which is by a corrugated valvular fold.

In the Ratel (*Ratelus mellivorus*) the lining substance of the uterine horns is disposed in thick longitudinal and oblique folds. The os tincæ is a double circular prominence. The beginning of the vagina is beset with numerous minute obtuse rugæ, which become larger and more longitudinal as they approach the urogenital canal: into this the vagina opens by a bilobed valvular fold. The inner surface of the urogenital passage is smooth.

In the Bitch the capacious capsules of the ovaria have a small aperture at the part nearest the uterus. The fimbriated beginning of the oviduct is attached to the exterior boundary of this aperture opposite the ovarium; the tube itself passes in a wavy course round the anterior part of the capsule to the uterus. The cornua are long, slender, compressed tubes, with numerous flat eminences on the inner surface: they are joined together externally for nearly two inches before they communicate with the body of the uterus. The interior of this part presents a few smooth, longitudinal elevations of the lining membrane. The os tincæ is a smooth, thick, simple prominence. The true vagina is of considerable length, with longitudinal rugæ: the urethra opens between a small transverse fold and the triangular flattened clitoris, beyond which is a second transverse crescentic fold with its concavity opposite that of the preceding.

In the Civet (*Viverra Civetta*) the ovaria approach nearer to the globular form than usual. They are situated in shallow capsules, on one side of which the oviduct commences by a large elongated aperture. The cornua uteri are long, slender, compressed, straight canals. The corpus uteri is equally simple, but very short; the vagina is long, with a longitudinally rugous inner surface. The urogenital canal opens externally on a prominent vulva, above which there is a semilunar cutaneous depression, which receives the ducts of two large scent-glands.

In the Leopard (*Felis Leopardus*) the ovaria present an elongated, elliptical, flattened form, and are attached by one edge to the ovarian ligament: the peritoneal pouch is large and wide, with an opening extending its whole length. In the Hyæna the ovaria have a more compact oval form, and are more completely inclosed in the peritoneal capsules. The fimbriated aperture of the oviduct is extended in the Leopard along one side of the margin of the pouch; the ovary itself forms the opposite boundary. In the Hyæna the pavilion forms a smaller proportion of the margin of the capsule. The oviduct runs a short and tortuous course along the anterior part of the ovarian capsule to the horn of the uterus: both cornua present, in the unimpregnated Leopard, the form of simple, straight, narrow, flattened tubes, with a smooth and even internal surface, and they open into the common uterine cavity half-way between their external union and the vagina. The os tincæ is very prominent, and is beset with numerous short papillose processes: in the Hyæna it is not papillose. The vagina in the Leopard is a narrow canal, with a few smooth longitudinal rugæ internally, which terminate abruptly at the beginning of the urogenital passage: in the Hyæna the vagina is wider with more produced longitudinal folds. The internal surface of the urogenital passage is beset with coarse papillæ, the larger ones being aggregated in longitudinal groups; at its termination projects the clitoris: and at the sides of the passage, in the Leopard, are the orifices of two large glands. The prepuce has no ossicle or cartilage in the Viverrine or Feline *Carnivora.*

§ 393. *In Quadrumana.*—The reappearance of Lissencephalous characters of the female organs in the lowest members of the present group indicates their derivation and divergence from some antecedent common source. The smooth-brained *Lemuridæ* with gyrencephalous proportions of cerebrum show a common utero-vaginal elongate cavity, as in certain *Bruta,* and an external perforate clitoris, as in *Insectivora.*

In *Perodicticus, Lichanotus, Otolicnus, Tarsius* and *Stenops* (both *St. gracilis* and *St. tardigradus*), the ovaria are small oval bodies, in adults often presenting a granulate exterior; always suspended in a depression, which is a rudiment of the capsule of the broad peritoneal ligament. The oviducts commence by a fimbriated extremity exterior to the ovaries, and pass in front of those bodies in a tortuous course to the horns of the uterus. These are short and wide, and begin by large obtuse extremities; they are lined by a smooth, thick, and seemingly villous membrane. After the junction of the cornua the common uterine canal presents internally a smoother surface, but begins to fall into a number of fine longitudinal rugæ: it is continued into the vagina without any line or mark of distinction; the same embryonal character, as in *Dasypus* and *Bradypus,* being here persistent. The rugæ are more strongly developed in this canal, which terminates by a round opening, fig. 547, *b,* half an inch anterior to the rectum, ib. *a.* Immediately in front of the vagina is the clitoris, ib. *c*; it is a large and prominent body, perforated, like the penis in the male, by the urethral canal, which opens upon a glans cleft by a vertical fissure, and inclosed above and at the sides by a crescentic prepuce. The urethra is consequently of unusual length in these small *Quadrumana*, as it is in Moles and Shrews. When the cerebrum begins to show deep and definable gyrations a higher type of female organs is indicated. The uterus is differentiated from the vagina by an os tincæ in the Aye-aye, and the clitoris is distinct from the urethra. Moreover the vulva opens at about one and a half inch distance from the vent. The uterine horns are relatively longer than in most other *Lemuridæ*. The os tincæ appears trilobate through fission of the anterior valve or 'lip.' The vagina shows the usual provision for dilatation in the longitudinal folds. The urethral orifice defines a urogenital tract about one-third the length of the vagina: the preputium clitoridis opens by a transverse crescentic fossa anterior to the urogenital outlet: the crura clitoridis embrace the urogenital passage before uniting, on its fore wall, into the body of the clitoris: the glans is subbilobate.[1]

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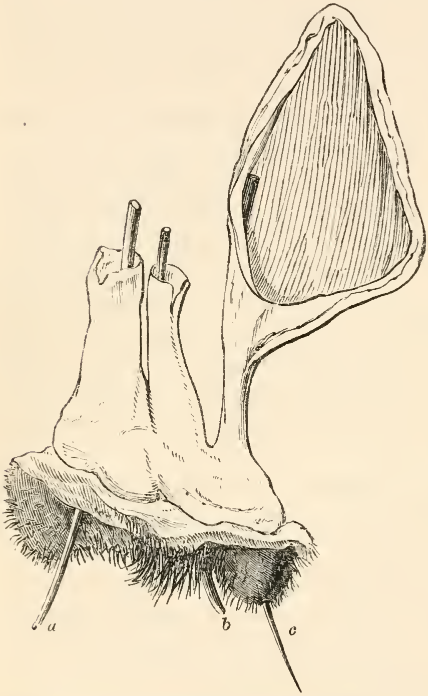

Rectum, vagina and urethra, Stenops tardigradus. LXIX′.

In the Mongoose and other species of true *Lemur*, the uterus communicates with the vagina upon a distinct valvular prominence or os tincæ; but the clitoris is situated more within the verge of the vulva than in *Chiromys*, and is perforated by the urethra. The rugæ of the vagina are well developed, and are of two kinds; the stronger ones are longitudinal, in the interspaces of which are smaller transverse or oblique folds: these assume a penniform arrangement near the outlet. The clitoris is inclosed in a large and thick internally plicated prepuce. The external labia are continued from the dorsum of the clitoris; within these there are two smaller folds, or 'labia minora,' continued from the sides of the clitoris to the opposite part of the vulva; and on the internal surface of each of these folds there is a thick longitudinal process of membrane projecting like the 'carunculæ myrtiformes,' into the cavity of the vagina.

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[1] CCXIII′. p. 97, tab. 3, figs. 2 and 3.

In Platyrhine Monkeys the uterus is long and narrow, with a truncate fundus, the angles of which are not produced into cornua: it begins to show thicker muscular walls. The os tincæ is bilabiate: the urogenital tract is relatively longer than in *Lemur*, equalling that of the vagina. The clitoris is of unwonted length, and is pendent outwardly, like the penis of the male, in the Spider-Monkeys (Ateles): it is not perforated by the urethra; this opens upon a longitudinal fold extending from the constricted limit of the proper vagina to the vulva.

In Catarhines the urogenital tract is always much shorter than the vagina, and the uterus is long and slender. In *Papio Mormon* the distended clitoris is three inches in length: the glans is smooth: the inner surface of the proper vagina is obliquely and transversely rugous: the external labia become much swollen at the heat. In both Baboons and Macacques the tunics of the uterus are thinnest at the fundus, the angles of which are slightly produced, like a last indication of cornua. At the cervix there are seen, besides the longitudinal folds, two bulbous processes of the lining membrane; below these a large os tincæ, with a remarkably irregular surface, projects into the vagina. This canal is lined by a dense epithelium, and presents a few large longitudinal, and numerous small, compressed, transverse and oblique rugæ, the margins of which are crenated. A transverse line divides the vagina from the urogenital canal, at the commencement of which is the termination of the urethra and also the orifices of the glandular sinuses, called canals of Gärtner or Malpighi. In *Macacus Silenus*, Hunter compares the constriction with a caruncular prominence at the beginning of the urogenital tract to the 'hymen': the 'glans clitoridis' is sub-bifurcate. In the Green-Monkey and other species of *Cercopithecus*, the ovaria are compressed, and approach the triangular form; the oviducts enter the angles of the fundus of a simple undivided uterus: the cervix uteri is occupied by several irregular longitudinal rugæ; the internal surface of the vagina presents a few oblique rugæ. The urethra, in *Cerc. Sabæus*, terminates two-thirds of an inch within the vulva, upon a longitudinal prominence, on each side of which there is a transverse ridge dividing the vagina from the urogenital passage: immediately beyond the constriction there are several small oblique plications of the lining membrane. The clitoris is imperforate; on each side of it there is a tumid process of integument, making a kind of prepuce. From these processes two ridges pass backward to the sides of the vulva, of which they constitute the labia, and between these there is a groove running from the clitoris to the urethro-sexual canal. In the tail-less Apes the fundus uteri acquires increased breadth; the general walls are thicker than in Monkeys; but the entire organ is longer and more slender than in the human subject.

§ 394. *In Bimana.*—The ovaria of the adult female are oval, subdepressed bodies, fig. 548, *f*, suspended by the layers of peritoneum continued from their surface to the 'broad ligament,' within which is a cord of sclerous tissue passing from the uterine end of the ovary to the womb, and called 'ligamentum ovarii,' ib. *h*: a process of the pavilion connecting these to the opposite end of the ovary is called 'tubo-ovarian ligament,' ib. *e*. The depression of the 'broad ligament' between ovarium, *f*, and oviduct, *c*, shown by raising the former, answers to the 'capsula ovarii' of lower Mammals. The anterior surface is less convex than the posterior one. The ovisacs expand in a dense tissue or 'stroma,' fig. 534, inclosed in a sclerous tunica albuginea: with the adventitious tunic which the ovisacs derive in their enlargement from the stroma, they form the cavities called 'Graafian vesicles.' In the young adult female the surface of the ovary is smooth: it afterwards becomes scarred by the cicatrices of ruptures caused by discharges

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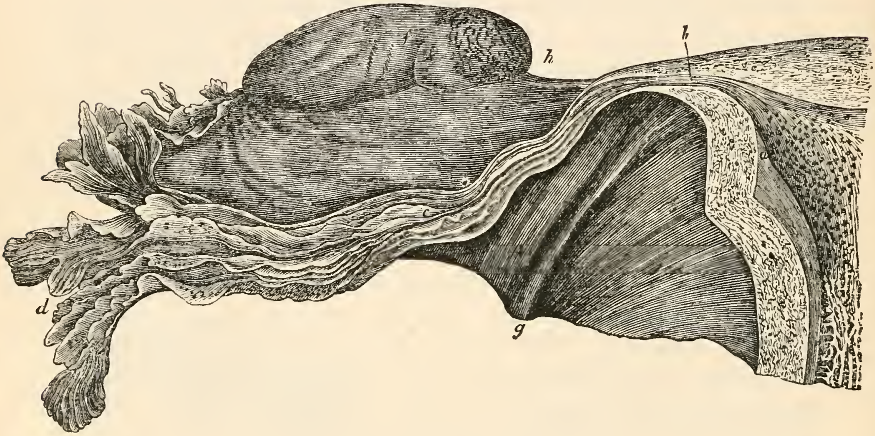

Ovary and oviduct, Human; nat. size. CCXLVI''.

of ova, of which a recent instance had occurred in the ovarium, fig. 549.

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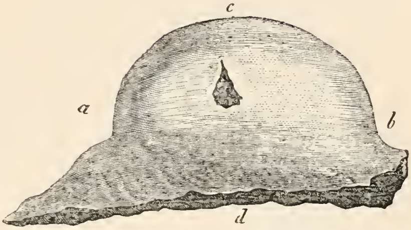

Ovary after recent discharge of unimpregnated ovum, Human; nat. size. CCXLVI″.

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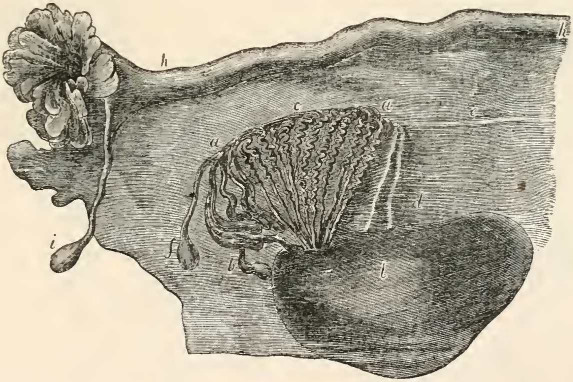

Ovarium and parovarium, Human; nat. size. CCXLVI″.

The remnant of the Wolffian body, noticeable in most lower Mammals in the form of a group of parallel wavy tubules extending from the ovary between the layers of the broad ligament, is constantly present in the human subject, and is termed 'parovarium,' fig. 550, *a*, *b*, *c*, *d*, the terminal cæcum becoming enlarged, as at *f*, to form the so-called 'hydatid' of the broad ligament: contiguous cæca, *b*, have a tendency to become dilated: those at the opposite end become atrophied, *d*, as does likewise the duct *e*, the terminal portion of which, known as 'Gärtner's canal' in lower Mammals, can seldom be recognised in the human female. The 'pavilion' or abdominal aperture of the oviduct ('Fallopian tube,' Anthr., fig. 548, *d*) is richly provided with a fringe of irregularly crenate folds radiating from the beginning of the canal: the duct dilates beyond this orifice, and then gradually contracts to almost capillary minuteness: the surface of the lining membrane of the tube is augmented by the folds continued from the fimbriæ, and chiefly longitudinal in direction; these subside about an inch from the uterus, where the oviduct again begins slightly to dilate: where it enters the uterus the longitudinal impressions terminate abruptly: the epithelium of the lining membrane is ciliate. Such is the structure of the human oviduct, as shown in the preparation, No. 2823, A, xx. vol. iv. p. 189; but there are varieties, as in fig. 550. A remnant of the primordial oviduct, or 'duct of Müller,' is constant, in the form of the pedunculate hydatid, fig. 550, *i*.

The human uterus, of the shape and dimensions shown in the sections, figs. 551 and 552, is more compact, more muscular, than in *Quadrumana*, has a broader and more convex fundus, a more marked constriction between the incubating and transmitting parts, and these are more distinct in their respective structures. The former, fig. 551, *uc*, which is analogous to and homologous with the 'cornua uteri' of brutes, is termed, in Anthropotomy, the 'body': the part, ib. *c c*, which answers to the 'corpus uteri' in brutes, fig. 546, *b*, *c*, *d*, is termed 'cervix uteri.' The relations above enunciated receive an interesting confirmation in the occasional anomaly of the human uterine structure shown in fig. 541.

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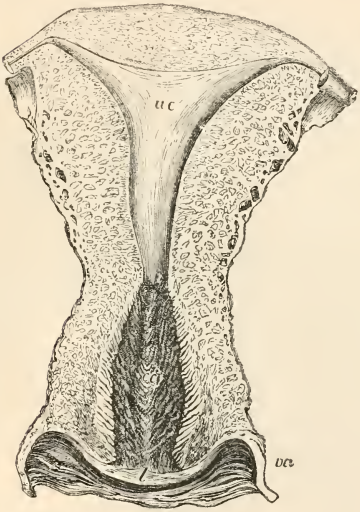

Cavity of unimpregnated uterus, Human; nat. size. CCXLVI".

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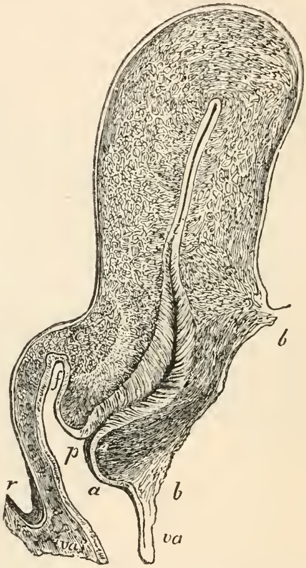

Cavity of uterus, as shown by longitudinal section from before backward, Human; nat. size. CCXLVI".

The enlargement for the lodgment of the fœtus and its appendages is limited to the incubatory part, the inner surface of which in the unimpregnated womb is smooth, and by contact closes the cavity, as at *i*, fig. 552. The cervix, *i*, *p*, has its inner surface increased by numerous plicate folds and furrows; in many instances diverging from an anterior and posterior medial longitudinal ridge; and here a slender fusiform cavity, occupied by secretion, is maintained.

What is called the 'lining membrane' of the uterus is a layer of substance, fig. 570, including formified corpuscles or 'nuclei,' fusiform fibres, and amorphous matter traversed by the irregular tortuous canals, called 'utricular glands or follicles,' and by capillary blood vessels, which form an angular network, fig. 553, on the surface, the 'utriculi' opening in the centre of the meshes. This substance is readily shed as 'decidua,' and renewed. At the 'cervix' a true 'lining membrane' becomes differentiated, composed of basilemma, fibrous and vascular tissues, follicles, and papillæ, the free surface showing a precipitate of tessellated epithelium. The 'os uteri' is a transversely elliptic convex protuberance, upon which the womb communicates with the vagina by a transverse fissure. It is directed obliquely backward, and when divided, as in fig. 552, presents an 'anterior lip,' *a*, and a 'posterior lip,' *p*. The posterior commencement of the vaginal canal, *f*, overarching the 'os uteri,' is called 'fornix.' The peritoneum is continued over this part as far as the line or reflection upon the rectum, *r*. Anteriorly, the peritoneum is reflected from the uterus at the beginning of the cervix, which, from *b* to *b*, is connected to the urinary bladder by areolar tissue. The round ligament of the uterus consists of fasciculi of unstriped fibres, continued from those of the angles of the 'fundus uteri,' fig. 548, *g*, inclosed by peritoneum, and continued to the internal inguinal ring: here it expands, and separates into an inner fasciculus lost in the tendons of the internal oblique and transversalis, a middle one in the upper column of the external abdominal ring, and an external one to the inferior column. It is a rudimental homotype of the cremaster of the male in its primitive inverted state. Anthropotomy extends the term 'ligament' to the different sheets or folds of peritoneum continued or reflected from the uterus. One of these incloses the ligament of the ovary continued upward into the remnant of that of the primordial kidney. The vagina is a subdepressed cylindrical canal, commencing as in fig. 552, and continued to near the vulval outlet, where it is bounded anteriorly by the prominence of the vestibule on which the urethra opens, fig. 554, *u*, and posteriorly by the usually crescentic fold, which more or less constricts the distal orifice of

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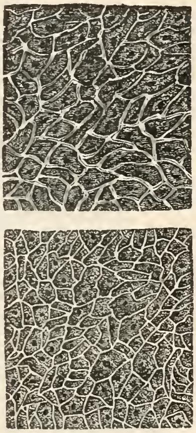

Capillaries on the surface of the lining substance, Human uterus. CCXLVI".

the vagina, ib. *va*. The inner surface of the vagina presents numerous close-set, transverse, often verrucose, rugæ, sometimes diverging from opposite longitudinal tracks, as 'columnæ rugarum,' on the fore and back parts of the walls: toward the vulval end of the canal the rugæ become broken up into shorter prominences, or 'leaflets.' This part of the vagina is surrounded by a 'constrictor' muscle, fig. 554, *b*, between which and the inner membrane, ib. *va*, there is, on each side, a gland, *g*, which sends its secretion by the duct, *d*, into the urogenital passage, between the hymen and nymphæ: it is called the 'vulvo-vaginal' gland, and answers to 'Cowper's' in the male. The urogenital passage rarely exceeds an inch in length: it includes the prominence or 'vestibule,' ib. *v*, upon which the urethra opens; the clitoris, *c*, with its preputium, *pc*; and the pair of highly vascular folds, *n*,[1] continued from the clitoris downward to the lower boundary of the passage. The vulva is chiefly composed by the 'labia,' ib. *l* (the right one has been removed in the figure), which are lateral folds of tegumentary and 'dartoid' tissue, including fibrous and adipose substance. The outer part is hairy skin, the inner layer is smooth, vascular, pinkish in colour, and furnished with many muciparous and sebaceous follicles. Above their upper commissure is an eminence of fibrous and adipose tissue, covered by integument which, at the age of puberty, becomes clothed with hair. The labia are homotypes of the scrotum: the clitoris is a miniature representation of the penis, and has its 'crura,' 'body,' 'glans,' 'suspensory ligament,' 'erectores muscles,' and closely conformable vascular structures, with the addition of large contiguous venous plexuses. Its nerves are equal in size to those of the penis.

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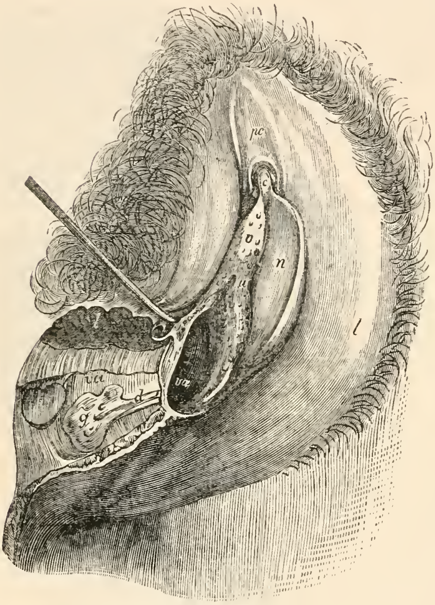

External female parts, Human. CCXLVII''.

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[1] These, called 'nymphæ,' are of unusual length in some low varieties (Hottentot, Boschismen) of the human species.

CHAPTER XXXVIII.

GENERATIVE PRODUCTS AND DEVELOPMENT OF MAMMALIA.

As the leading forms of the Mammalian spermatozoa have been already given, and as their development does not differ in any essential degree from the process described in Vol. I. pp. 589–592, I proceed to notice the correlative act which is truly characteristic of the present class.

§ 395. *Ovulation in Mammalia.*—The ovum in Mammals, characterised by its extreme minuteness, was recognised soon after the microscope came into use. De Graaf[1] (1672) discovered it in the oviduct of the Rabbit. Haller,[2] unsuccessful in this quest, lent his authority to discredit the statements of the Dutch anatomist; but Cruikshank[3] (1797) confirmed and established their accuracy. Nevertheless, up to 1824, the Mammalian ovum was known only as it appeared in the oviduct.

Prevost and Dumas, indeed, twice detected a less pellucid spherical corpuscle, a millimeter in diameter, in the ovarian or Graafian follicle, and deemed it very probable that thence was derived the oviducal ovule.[4] Von Baer (1827) raised the probability to scientific certainty by a series of observations of the ovarian ovum, made in the Bitch, Cow, Sow, Ewe, Rabbit, and also in the Human female. He deemed, however, this ovarian ovule to answer, not to the entire ovum of lower Vertebrates, but to the 'germinal vesicle' of such; the fluid of the Graafian vesicle he homologised with the 'yolk,' and its lining membrane with the 'membrana vitelli,' so that the 'Graafian vesicle' was still to Von Baer, as to Prevost and Dumas, the 'ovum of the ovary.'[5] Soon followed, however, an almost simultaneous series of observations[1] by which the 'germinal vesicle,' the 'germina spot,' the yolk, and yolk-membrane, were determined in the minute opaque sphere; and thus was the ovarian egg of the Mammal finally made known.

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[1] CCLVI″.
[2] CCLVII″.
[3] CCLVIII″.
[4] CCLIX″.

[5] '*Vesicula ergo Graafiana cum ad ovarium generatimque ad corpus maternum respiciamus, ovum sane est mammalium.* Sed evolutionem quod attinet, vehementer discrepat a reliquorum ovo animalium, quorum ovi nucleus integer ex ovario devehitur, fetui nascituro non sedem tantum præbiturus sed in ipsum potius fetum transformandus. In mammalibus vero *vesicula innata* vitellum magis excultum continet et *ratione ad fetum geniturum habita verum sese probat ovum. Ovo fetale dici possit in ovo materno.* Mammalia ergo habent ovum in ovo aut, si hac dicendi formula uti licet, ovum in secunda potentia.'—P. 32. 'Quapropter in vesicula Graafiana describenda

The ovisac and ovum appear later in the ovary than do the seminiferous tube and spermatoon in the testis. The first-formed elements in the fetal ovary are those called 'cells' and 'cell-nuclei': next appear roundish groups of such primary cells, rather more opaque than the rest of the previously uniform mass, fig. 555, A. A film soon condenses round these purposive groups, ib. B, upon the inner surface of which forms an epithelial precipitate from the fluid and granules of the interspaces of the contained primary cells: within the 'ovisac' thus formed a larger nucleate cell becomes visible, which is the beginning of the ovum. As the ovisac expands the proportion of fluid to the formified particles increases, and the latter are attracted to the contiguous surfaces, some to that of the ovisac, which thus becomes lined by a thicker layer of cells, others to the ovum, accumulating around it. With the enlargement of the ovisac, the 'stroma ovarii' condenses around its delicate membrane, fig. 556, *b*, to form the 'theca folliculi' of Baer. This vascular covering of the ovisac, ib. *a*, with the proper wall, ib. *b*, constitutes the 'Graafian vesicle or follicle.' The stratum of nucleate cells lining the ovisac is termed 'membrana

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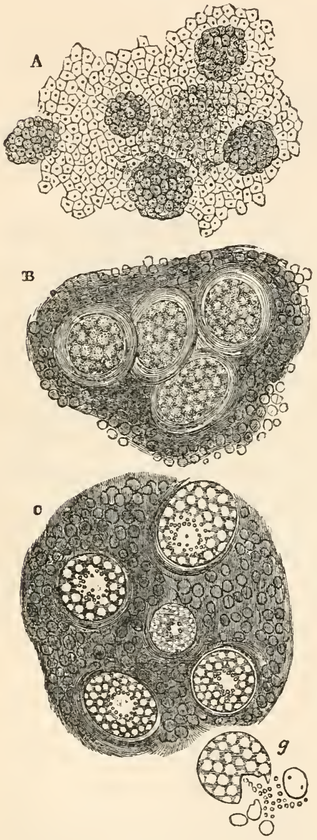

Formation of the ovisac, Dog. CCLXI″.

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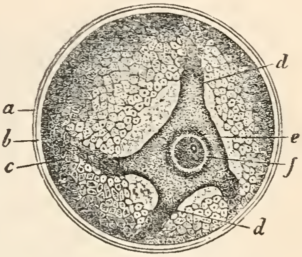
voce *ovuli* semper usus sum, quia vesicula Graafiana ipsa ovum refert, respecto ovario, ex ovulo autem, fit ovum fetale.' . . . ' Ex quo concludo: *quo diutius in corpore materno fetus foventur, eo magis jam primitus exculta videtur ovi vesicula innata,* quæ in *mammalibus eo pervenit ut omnes ovi virtutes in sese recipiat et reliquæ ovi partes parvi momenti extraneæ quasi fiant.*' CCXLIX″. p. 33. [The italics are V. Baer's.]

[1] CCL″. CCLI″. CCLII″.

granulosa,' those which surround the ovum itself form the 'proligerous disc,' ib. *e*, and the mass of cells thereto adhering is the 'cumulus.' The 'hyalinion,' or proper tunic of the ovum, thickens into the clear substance called 'zona pellucida,' *f*.[1] The cells immediately around the ovum, as it ripens, elongate and become pyriform, with the pointed end attached to the 'zona': those of the cumulus diverge irregularly into the fluid intervening between them and the 'membrana granulosa' of the ovisac: but the four groups, defined by Barry[2] as 'retinacula,' ib. *d*, and fig. 559, *g* 2, may be an exceptional disposition.

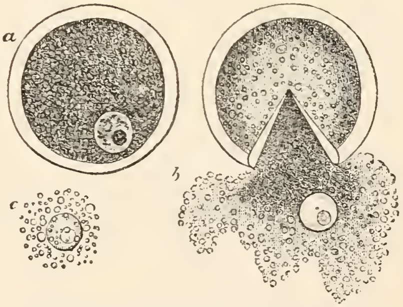
556



Graafian vesicle and ovum, Rabbit; magn. CIX.

The ripe ovarian ovum, freed from its cellular precipitate, fig. 557, is inclosed in the thick transparent structureless 'hyalinion,' *a*: its vitelline contents are opaque through the abundance of granular yolk-substance, *b*: in this is the 'germinal vesicle,' with its nucleus or 'macŭla,' ib. *c*: it is more readily seen when the yolk is discharged from the ruptured ovum under pressure, as at *b*.

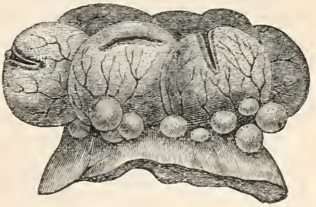
557



Mammalian ovarian ovum; magn. CCCVIII.

§ 396. *Ovipont.*—The maturation of ova occasions the 'rut' or 'heat': in many brutes it is annual; in the Ferret twice a year; in the domestic Rabbit, Cat, Hog, Bitch, it may recur three times a year or oftener: in the Human female it is menstrual. The number of ovisacs and ova which ripen at each rut varies according to the multiparity or uniparity of the species: in the Sow, e.g. fig. 558, there may be from four to six or more in each ovary; in the Ornithorhynchus, fig. 566, there are two only, and these limited to the left ovarium; in the Human female there is rarely more than one. The rut involves a determination of

558



Ovary, Sow, with ripe follicles burst; nat. size. CCLIII''.

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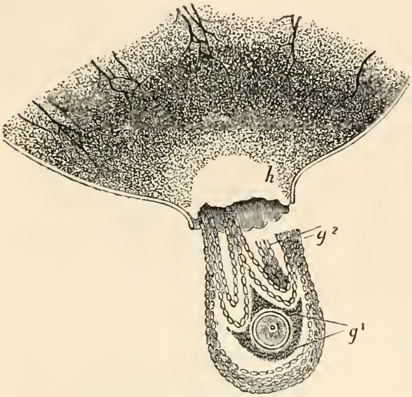
[1] As here shown it looks like a 'zone;' but is a bag, not a belt.

[2] CIX.

blood to the ovarium, and especially to the swollen ovisac and its adventitious coverings: a thinning of these takes place at the most prominent part, to which the ovum tends: blood is extravasated into the ovisac, which, partly by absorption, partly by pressure, yields and gives issue to the ovum, fig. 559. This happens whether the male have access to the female in heat or not. In the Human kind the ovipont concurs with and probably occasions the menstrual discharge.[1] The unimpregnated ovum may escape, as an impregnated one has sometimes done, into the abdominal cavity: but, save that it probably perishes in its normal progress outward, it might be said that a woman lays an egg every time she menstruates—an egg resembling in all essential structures that of the bird, but not exceeding $\frac{1}{180}$th of an inch in diameter.[2] Something like a sanguineous discharge has been observed in *Quadrumana*; but the more constant concomitant of the rut in that order is the swelling and vascularity of the external parts of generation. In the Mare an opaque white secretion is ejected *per vulvam* at the heat.

559



Ovum, with tunica granulosa, of the Rabbit, in the act of escaping from a ruptured Graafian follicle. cix′.

§ 397. *Corpus luteum.*—After the escape of the ovum, with other contents of the ovisac, the walls of that cavity become thickened and altered in colour: in most Mammals they are partially everted at the ruptured orifice, fig. 566, *b*, *b*. In the Cow and Sheep such altered 'Graafian follicle' assumes a brick-red colour; in the Sow a yellowish brown; and in the Woman the brighter colour led to its being called a 'corpus luteum.' In her the walls of the distended ovisac, compressed by the tunica albuginea and surrounding stroma, are thrown into delicate folds, fig. 560: the blood-clot which may have remained after the escape of the ovum is progressively absorbed. The plicated ovisac then contracts upon the cavity, and by the time the succeeding ovisac with the ripening ovum has begun to protrude from the surface of the ovary, the old ovisac has lost its yellow colour, with much of its size, and has retired inward. This movement, with the collapse of the wall, depresses the cicatrix of the aperture; and by these successive shrinkings and cicatrisations of the burst ovisacs, the ovary becomes marked by pits and furrows in advanced life. If the expelled ovum be not impregnated, the changes of the ovisac into the yellow convolute cavity, then into a small white stellate body, may occupy two months in the Human subject; but, if the maturation of successional ova be delayed by impregnation and its consequences, the first change goes on to a greater degree, and the 'corpus luteum' is not obliterated in less time than from thirteen to fourteen months: the inner coat, or original ovisac, is more thickened by a larger deposit of yellow oil-granules; it becomes more deeply plicated, is then compacted into a yellowish mass, and gains an adventitious white lining membrane, fig. 561. Rarely until after full gestation and delivery is the cavity obliterated: it is then represented by a stellate linear figure surrounded by the 'corpus luteum,' which is ultimately absorbed.

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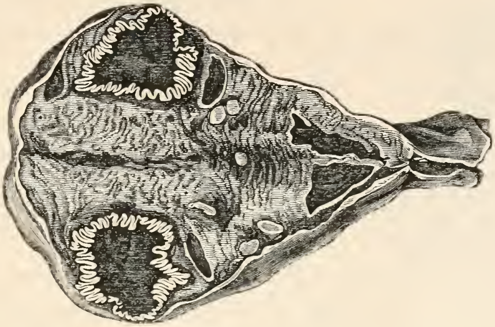
[1] ccliii″. ccliv″. cclv″.

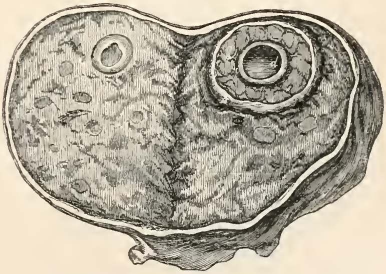
[2] In cccviii. the diameter of the mature ovarian ovum is given, as being, in man $\frac{1}{180}$, dog $\frac{1}{160}$, cat $\frac{1}{180}$, rabbit $\frac{1}{150}$, rat $\frac{1}{200}$, mouse $\frac{1}{220}$, pig $\frac{1}{200}$, cow $\frac{1}{250}$, guinea-pig $\frac{1}{240}$, of an inch.

560



Corpus luteum,' after escape of ovum, Human. CCXLVI''.

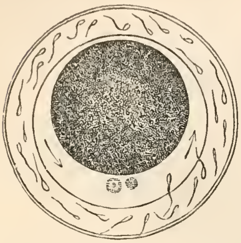
561



Section of Human ovary with 'corpus luteum,' after impregnation. CCXLVI''.

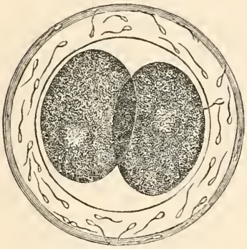
§ 398. *Impregnation.*—After coitus the spermatozoa find their way to the Fallopian tubes, or oviducts, and might come into contact with the ovarian ovum, through the opening in the ovisac, prior to its expulsion, but they have never been traced so far. They were first seen, by MARTIN BARRY, to have penetrated the 'zona pellucida,' in a Rabbit's oviducal ovum, fig. 562. No definite single pore or 'micropyle' for the entry of the spermatozoon has been detected in that delicate evanescent tunic of the Mammalian ovum. The 'germinal vesicle,' or 'germ-cell,' disappears as such. A somewhat more opaque 'embryonal cell' succeeds, which may be, or includes, a combination of the nuclear matter of the sperm-cell with that of the germ-cell. Then follow the initial steps, figs. 563-565, which Barry's capital discovery showed to be the same essentially in Mammals as in all lower animals; and the entire yolk undergoes the cleavage-process in its combination with the progeny of the embryonal cell. Most of these initial steps are taken in the course of the impregnated ovum through the oviduct.

562



Oviducal ovum of Rabbit, penetrated by spermatozoa; magn. 350 diam. (confirmed in CCLXI''.)

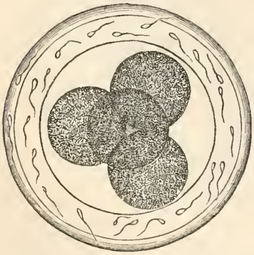
563



Ovum, more advanced in the oviduct, Rabbit; magn. 350 diam. CCLXI''.

While in this narrow tube the ova are rolled to and fro by its peristaltic actions in a transparent fluid more or less abounding with spermatozoa; and the more of these get access to the yolk the more certain and complete is its segmentation. With the formation of the embryo-cell the yolk becomes separated by fluid from the 'zona pellucida,' and begins to rotate therein, as indicated by the arrows in fig. 562; one or two minute granular or oil-like bodies may appear in the surrounding fluid.[1]

564



Ovum from the uterine half of the oviduct, Rabbit; magn. 350 diam. CCLXI''.

A division of the primary embryo-cell, with mutual repulsion of the two secondary ones, is followed by cleavage of the entire yolk, through attraction round each secondary cell, fig. 563, of the particles contiguous thereto. A repetition of this process issues in the four divisions of the germ-yolk, fig. 564; then in the eight, as in fig. 565; and so on until the whole is worked up into a mass of finely nucleate corpuscles; amongst which the qualities of the parent embryo-cell, due to impregnation, are thus equally distributed.

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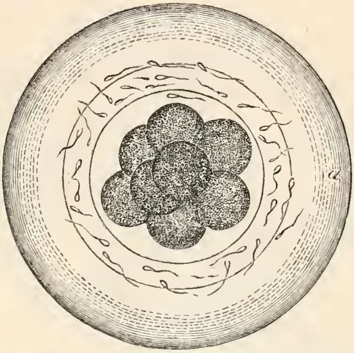
[1] CCLXI'', CCXLIX. for the same phenomena in Acephala (*Unio and Anodon*), p. 526; in Gastropods, p. 566.

The eight-fold cleavage of the yolk has been observed three days after impregnation in the Rabbit, four days in the Guinea-pig, and ten days in the Bitch: always in ova toward the uterine end of the Fallopian tube.

In the Bitch the smooth surface of the zona pellucida becomes irregularly flocculent, as if a granulo-mucous substance had been deposited thereon: in the Rabbit the ovum acquires a thick adventitious layer of albumen, fig. 565, *a*, before entering the uterus: in the Guinea-pig the zona continues smooth; and, after entering the uterus, on the fourth day, it grows fainter as the mulberry state of the yolk is there attained, and it disappears when the germ-mass is completed. The act of impregnation being thus consummated, ulterior changes with manifold modifications attend the development of the ovum in different Mammalia.

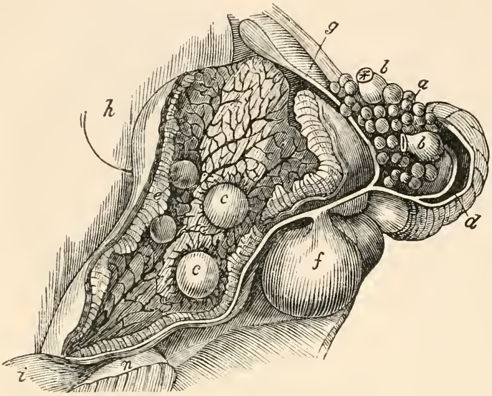
565



Ovum from uterine end of the oviduct, with the addition of a layer of albumen, Rabbit; magn. 350 diam. CCLXI''.

§ 399. *Development of Monotremata.*—The ripe ovarian ovum, though large in proportion to that in higher, especially placental, Mammals, is very much less than in Birds or Reptiles. Its external coat is thick, smooth, highly refracting—a true 'zona pellucida': the germinal vesicle is $\frac{1}{250}$th of an inch in diameter: the larger proportion of vitelline matter, rich in granules and oil globules, is the chief distinctive character of the monotrematous ovum as a Mammalian one. I found two ovisacs with such mature ova in the left ovary of a female Ornithorhynchus, killed in September. In a specimen killed on the 6th of October (Yas River, New South Wales), the left ovary presented two discharged and altered ovisacs. The ova from these were situated at the upper part of the left uterus, and at the distance of about a line from each other. Each was spherical, and measured two lines and a half in diameter; the germ-mass, originally pale, had deepened to a yellow colour in the preserving liquor. The outer tunic had received no adventitious covering, but retained its smooth and polished exterior, and had not contracted any adherence to the uterine parietes. Each ovum was imbedded in the soft, thick, plicated, smooth-surfaced, and well-organised lining membrane of the uterus. In a second Ornithorhynchus, shot in the same locality, on the 7th of October, the ova, fig. 566, *c*, *c*, from the two discharged ovisacs, ib. *b*, *b*, were situated a little below the middle of the left uterus; they were also spherical, each three lines in diameter, of a lighter colour than the preceding, specially at the upper part, from the subsidence of the contained vitelline or germinal mass: they were smooth, and rolled freely out of the position where they were lodged. In a third specimen, shot on the evening on which the first specimen was obtained, the uterine ovum had the same spherical form, smooth exterior surface, and freedom from connexion with the uterus; but was of a lighter colour, owing to the increased quantity of its fluid contents, to which its greater size was chiefly attributable. It measured three lines and a half in diameter, and was situated in a depression or cell a little below the middle of the left uterus. The lining membrane of the uterus was much thickened and highly vascular in each of the above specimens. In all these ova the contents were of two kinds, viz. a greyish sub-transparent fluid, and a yellowish denser mass, which varied in their relative proportions as above-mentioned: in the largest ovum, the yellow mass, germ or yolk, occupied about one-third of its cavity, while in the smallest it constituted four-fifths of the whole mass. The membrane, which may be the hyalinion or 'zona pellucida' of the ovarian ovum, but which I would still, as in 1834, call 'chorion,'[1] offers a moderate degree of resistance when torn open, and yields equally in every direction when separated from the yolk, the rent margins curling inwards like the coat of an hydatid. This membrane is of a dull greyish colour, inclining to brown, slightly transparent, and more polished upon its inner than upon its outer surface. The fluid,

566



Left uterus impregnated, Ornithorhynchus. LXXVII'.

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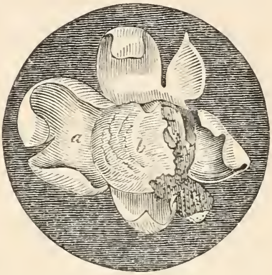
[1] This term signifies the 'outer tunic' of the uterine ovum: it may be 'zona' or something laid upon the zona, or something superseding the zona, such as the animal layer of the blastoderma, or the outer or vascular layer of the allantois.

answering to that which appears between the yolk and zona pellucida after impregnation in the Rabbit's ovum (fig. 562, marked by the arrows), occupies a situation analogous to that of the albumen in the egg of the fowl, but had not become coagulated by the action of the spirit in which it had been so long immersed: it divides the chorion, fig. 567, *a*, from the vitelline membrane, ib. *b*: this membrane, fig. 568, *a*, is thin, smooth, and transparent; adherent to parts of its inner surface was a thicker granular layer, answering to the 'blastoderm,' or germinal stratum, fig. 568, *b*. In each of the above impregnated Monotremes[1] the discharged ovisacs, fig. 566, *b*, *b*, were of an elongate flask-shaped form, about three lines in length, and two in diameter, with the margins of the orifice, through which the ovum and granular substance had passed, everted, with a slight contraction, resembling the neck of a flask, below the aperture. On compressing these ovisacs, small portions of coagulated substance escaped. When longitudinally divided, they were found to consist of the same parts as the ovisac before impregnation; but the theca, or innermost parietes of the sac, was much thickened, and encroached irregularly upon the empty space, so as to leave only a cylindrical passage to the external opening.

567



Uterine Ovum, magnified and dissected, Ornithorhynchus. LXXVII′.

568

Portion of the vitelline membrane and germinal stratum, Ornithorhynchus. LXXVII′.

On the 8th of December Dr. Bennett discovered in the subterranean nest of an Ornithorhynchus three living young, naked, not quite two inches in length, fig. 600. On the 12th of August (1864) a female *Echidna hystrix* was captured in the hollow of a prostrate 'cotton tree,' in Colac Forest, Victoria Province, Australia, having a young one, fig. 603, *e*, with its head buried in a mammary or marsupial fossa, ib. *c*. This young one was naked, of a bright red colour, and one inch two lines in length. Between the condition of the uterine ovum, as in fig. 567, and that of the (probably new-born, or recently born) young Monotremes, abovementioned, I have not hitherto received materials for further elucidating the development of the fœtus in this singular group of Mammals: whether cleavage of the yolk takes place prior to the entry of the ovum into the uterus still remains a matter for observation. The young of both *Ornithorhynchus* and *Echidna* will be described in the chapter on the Mammary organs.

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[1] LXXVII′. I was indebted to my old friend and fellow-student, GEORGE BENNETT, now F.R.S. for the above mentioned specimens.

§ 400. *Development of Marsupialia.*—On the 27th of August (1833), a female Kangaroo (*Macropus major*), captive in the Gardens of the London Zoological Society, received the male. She stood with her fore-paws off the ground; the male mounted, *more canino*, embracing her neck with his fore-paws, and retained his hold during a full quarter of an hour: during this period the coitus was repeated three times, and on the second occasion much fluid escaped from the vulva. The male was removed from the female in the evening of the same day, and was not afterwards admitted to her. On September the 2nd, six days after the coitus, I examined the pouch of the female; and this scrutiny was repeated every morning and evening until the birth of the young Kangaroo had taken place. It happened in the night of October 4, thirty-eight days after the coitus. On the morning of the 5th of October, I found the young in the pouch, pendant from the tip of the left upper nipple, of the size and shape shown in fig. 606: it will be described in a subsequent chapter.

The ovarian ovum, in the Kangaroo, agrees in all essential points with that of placental Mammalia: the main modification is the greater proportion of vitelline substance, and the smaller proportion of the surrounding fluid in the ovisac. In a female *Macropus Parryi*, the ovum from the largest ovisac of the left ovarium measured $\frac{1}{10}$th of a line in diameter, the germinal vesicle $\frac{1}{140}$th of a line in diameter. We are at present ignorant of the changes that take place in the development of the ovum between the period of impregnation until about the twentieth day of uterine gestation. At this time, in the great Kangaroo (*Macropus major*), the uterine fœtus, fig. 537, measures eight lines from the mouth to the root of the tail; the gape of the mouth is wide; the tongue large and protruded, fig. 569; the nostrils are small round apertures; the eyeball is not yet wholly defended by the palpebral folds; the visceral cleft reduced to the meatus auditorius externus is not provided with an auricle; a posterior cervical fissure was either unclosed, or the delicate cicatrix had given way in the manipulation of the fœtus. The fore-extremities are the largest and strongest; they are each terminated by five well-marked digits; those of the hind legs are not yet developed. The tail is two lines long, thick and strong at the commencement; impressions of the ribs are visible at the sides of the body: the membranous tube of the spinal marrow may be traced along the back between the ununited elements of the vertebral arches; posterior to the umbilical cord there is a small projecting penis, and behind that, on the same prominence, is the anus. This fœtus and its appendages were enveloped in a large chorion, ib. *i*, puckered up into numerous folds, some of which were insinuated between folds of the vascular lining membrane of the uterus, but the greater portion was collected into a wrinkled mass. The entire ovum was removed without any opposition from a placental or villous adhesion to the uterus. The chorion, fig. 567, *a*, *a*, was extremely thin and lacerable, and showed no trace of villi on the outer surface. The membrane, ib. *b.*, extending from the umbilicus to the inner surface of the chorion, was highly vascular. The fœtus was immediately enveloped in a transparent amnios. On turning the chorion away from the fœtus, it was found to adhere to the vascular membrane; but they could be separated from each other, without laceration, for the extent of an inch; at this distance from the umbilicus the adhesion was closer: and here the umbilical membrane terminated in a well-defined ridge, formed by the trunk of a blood-vessel. When spread out, as at *b*, *b*, fig. 569, its figure was that of a cone, of which the apex was the umbilical cord, and the base the 'vena terminalis.' Three vessels diverged from the umbilical cord and ramified over it. Two were continuations of the terminal or marginal vein: the third was the arterial trunk. The amnios, ib. *c*, was reflected from the umbilical cord, and formed, as usual, the immediate investment of the fœtus.

The umbilical cord measured two lines in length and one in diameter: besides the three vessels above-mentioned, it included a small loop of intestine; and from the extremity of the latter a filamentary process was continued to the vascular membrane. On tracing the contents of the cord into the abdomen, the two larger vessels, filled with coagulated blood, were found to unite; the common trunk then passed backward beneath the duodenum, and after being joined by the mesenteric vein, went to the under surface of the liver, where it penetrated that viscus: this was consequently an omphalo-mesenteric or vitelline vein. The artery was a branch of the mesenteric. The membrane, therefore, upon which they ramified answered to the vitellicle, i. e. the vascular and mucous layers of the germinal membrane, which spreads over the yolk in oviparous animals, and which constitutes the so called 'umbilical vesicle' of the embryo of placental Mammalia. The filamentary pedicle which connected this membrane to the intestine was given off near the end of the ileum.

At a later period of uterine development, when the fœtus, measured in a straight line from the mouth to the root of the tail, is ten lines in length, the urachus expands into a small allantois, fig. 569, *d*, of a flattened pyriform figure, and finely wrinkled external surface. This bag insinuates itself between the amnios and chorion, carrying along with it two small hypogastric arteries and a vein, but not establishing by their means an organised and vascular surface of the chorion by which a placental attachment is formed between the ovum and the womb. The

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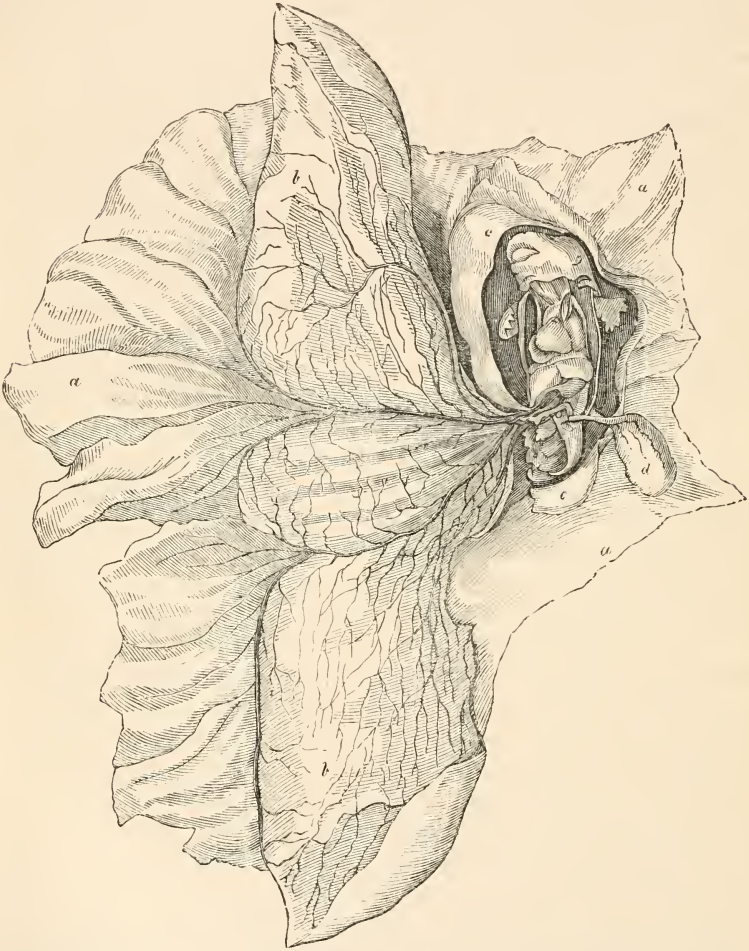

Uterine fœtus, membranes and appendages, *Macropus major*. (The fœtus is magnified twice the natural size.)

allantois depends freely from the end of the umbilical cord, and has no connection at any part of its circumference with the adjoining membrane. Its office, as in the *Batrachia*, is apparently limited to that of a receptacle of urine. The vitellicle or 'umbilical vesicle' presented the same large proportionate size and vascular structure as in the first described fœtus. The chorion which enveloped this fœtus and its appended sacs was adapted to the cavity of the uterus by being disposed in innumerable folds and wrinkles. It did not adhere at any part of its surface to the uterus, but presented a modification not present in the chorion of the earlier fœtus, in being partially organised by the extension of the omphalo-mesenteric vessels upon it from the adherent vitellicle. The digits of the hind legs were distinctly formed in this embryo.

In some smaller kinds of Kangaroo an ovum from each ovary may be impregnated, and two embryos be simultaneously developed.[1]

Rengger gives the following account of the generation of a species of Opossum (*Didelphis Azaræ*):—'The fœtuses are developed in the cornua uteri, and not in the lateral canals. Some days after impregnation they have the form of small round gelatinous corpuscles, which do not appear, even when examined with a lens, to have any communication with the mother, but a red line indicates the first commencement of development. Towards the end of gestation, when the fœtuses have attained the length of six lines, they are seen to be enveloped in a membrane and provided with an umbilical cord, which is united to the uterus' (chorion?) 'by the medium of many filaments. The head, the four extremities, and tail are recognisable with the naked eye, but those fœtuses which are nearest the Fallopian tubes are generally least advanced. In gestation they make the circuit of the lateral canals, in which they are found to be deprived of their fœtal envelopes, and to have no communication with the parent by means of the umbilical cord; whilst one fœtus was found in this situation, two others were still in the body of the uterus' (vaginal cul-de-sac?), 'from which the umbilical cords were not yet detached. At this period a slight enlargement of the uterus and lateral canals was the only change perceptible in them.'[1]

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[1] Two have not been found in the same uterus. Mr. Collie, Surgeon, R.N., states, 'I have just now procured gravid uteri (of the *Macropus Brunii*) in which two fœtuses seem to be arrived at, or very near to, the termination of the period of gestation. One of them, which was about one-half larger than the body of the common wasp, has protruded through an opening inadvertently made in the uterus, and is distinctly seen through its transparent membranes and the liquor amnii.'—'Zoological Journal,' vol. v. p. 240.

As accomplished Naturalists continued to believe and affirm that the young of the *Marsupialia* quitted the womb and were received into the pouch 'in the condition of a gelatinous ovum comparable to a Medusa,'[2] I deemed it requisite to anatomise the rare instance of the uterine fœtus of the Kangaroo, in order to demonstrate the conditions of the respiratory, circulating, digestive, and renal systems. 'From the cæcum, which was given off from the returning portion of the umbilical loop of the intestine, the large intestine passed backwards to the spine, and was then bent, at a right angle, to go straight down to the anus. The stomach did not present any appearance of the sacculated structure so remarkable in the adult, but had the simple form of a carnivorous stomach. The liver consisted of two large equal and symmetrically disposed lobes. The vena portæ was formed by the union of the vitelline with the mesenteric veins. The diaphragm was perfectly formed. The vena cava inferior was joined, above the diaphragm, by the left superior cava, just at its termination in a large right auricle. The ventricles of the heart were completely joined together, and bore the same proportions to each other as in the adult,—a perfection of structure which is not observed in the embryos of ordinary *Mammalia* at a corresponding period of development. The pulmonary artery and aorta were of nearly the same proportionate size as in the adult: the divisions of the pulmonary artery to the lungs were at least double the size of those observable in the embryo-sheep three inches in length: the ductus arteriosus, on the contrary, was remarkably small. The aorta, prior to forming the descending trunk, dilated into a bulb, from which the carotid and subclavian arteries were given off. The lungs were of equal size with the heart, being about a line in length, and nearly the same in breadth: they were of a spongy texture and of a red colour, like the veins, from the quantity of blood they contained. This precocious development of the thoracic viscera is an evident provision for the early or premature exercise of the lungs as respiratory organs in this animal: and on account of the simple condition of the alimentary canal, the chest at this period exceeds the abdomen in size. The kidneys had the same form and situation as in the adult. The supra-renal glands were half the size of the kidneys. The testes were situated below the kidneys, and were one-half larger than those glands, the superiority of size depending on their large epididymis, with the adherent remains of the Wolffian body. They continue within the abdomen for six weeks after uterine birth.'[1] The nervous system alone is embryonic, fig. 585.

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[1] From the Analysis of Rengger's 'Säugethiere von Paraguay' in the Bulletin des Sciences Nat. tom. xxi. p. 469.

[2] CCLXIV″. p. 342.

§ 401. *Development of Lissencephala.*—In *Lyencephala*, of which the uteri undergo least change of dimensions during the characteristic brief gestation, those tubes have the definitely organised and persistent lining membrane described, pp. 679, 685.

In the placental Mammals of which the uteri undergo wholly or locally great and rapid changes of size and capacity the lining of the incubatory part is less differentiated. In some it is but remotely allied to the class of membranes called 'mucous': canals so lined are habitually traversed by the matters they have to convey. The transmitting function of the womb is seldom exercised in the course of life, with long intervals of rest: its lining has a higher, organising, office: it differs from mucous membrane in the absence of 'submucous areolar tissue' (p. 439, fig. 361, *c*, *d*), or any such medium of connection with, or reception of, vessels from the muscular coat: it is a pulpy substance, in which corpuscles or nuclei abundantly, and fibre-cells more sparingly, formify: it receives directly from the fleshy substance of the womb its vascular supply; and is perforated by the minute canals, sparingly exuding fluid, termed 'uterine or utricular glands.' A ciliate epithelium may be distinguished on the free surface in most Mammals; non-ciliate cell-deposit occupies more or less of the 'utriculi.' These, in fig. 570, are indicated by the pale tortuous

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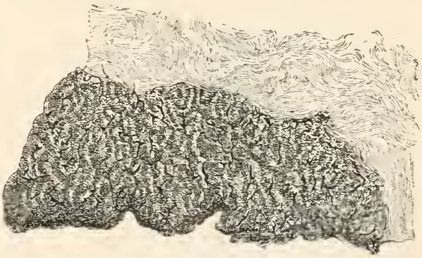

Section of lining substance, human uterus; nat. size. CCXLVI''.

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[1] LXXV'. p. 337 (1834). Such is the difficulty of giving up a strange or 'telling' statement, which has once gained currency, that we read:—'Les petits ne se développent pas comme d'ordinaire dans la poche utérine, mais sont promptement expulsés au dehors, et naissent dans un état d'imperfection telle qu'on ne peut les comparer qu'à des embryons à peine ébauchés. Ce sont des petits corps gélatineux, informes et incapables de mouvement, dont les divers organes ne sont pas encore distincts, et dont l'existence serait impossible si la nature n'avait assuré leur conservation par des moyens particuliers.' CCLXV''. Even M. Pouchet, usually so conscientiously accurate, writes:—'Le produit de la génération qui, en arrivant là (*the pouch*), n'est qu'un simple ovule encore baigné de fluides albumineux, se trouve posé sur les tétines.' (CCXCI''. p. 262, 1841). My observations on the Kangaroo were confirmed by those of Meigs on the Opossum (CCLXXVIII''. 1847).

lines *a b*; the dark fine lines represent injected capillaries, continued directly from the fibrous walls of the uterus, *a c*. Such pulpy vascular substance, compared by JOHN HUNTER to 'coagulable lymph,'[1] is rapidly formed, readily shed, speedily renewed: it grows with the needs of the growing embryo or fœtus, as the medium for bringing into requisite relation with the circulating system of such the mother's blood.

In the uterus with a non-caducous and well-organised lining membrane the chorion or outer coat of the ovum continues smooth and unvascular, at least, until the fœtus and appendages have advanced to the degree shown in fig. 569. But in the deciduate type of lining substance there is a reciprocal preparation of the chorion for intimate connection therewith in the form of villi, or long filamentary vascular processes, extending from more or less of its outer surface, fig. 571, *cho*.

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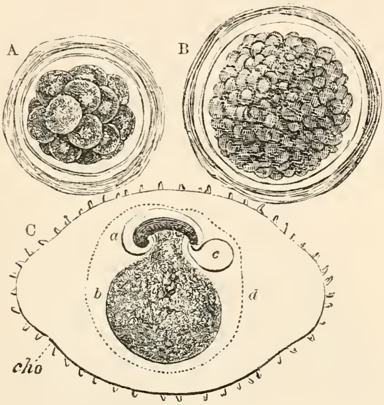

Uterine ova, Rabbit. CCCVIII.

In the very small proportion of the placental series in which the early phases of development *in utero* have been traced, so much diversity has been recognised as to warn against too hasty generalisations.

In the Rabbit, before the ovum enters the uterus, it has received from the oviduct additional layers, ib. A, B, which, either in combination with, or substitution for, the hyalinion, become the medium of applying the capillaries of the fœtus to those of the mother continued into the decidua. When the fœtal appendages have attained, in this Rodent, the stage they exhibit in the Marsupial, fig. 569—viz. the formation of the amniotic bag, fig. 571, *a*, the inclosure of the unconverted germ-mass, or yolk, by a vascular vitellicle, *b*, and the out-budding of a small allantois, *c*—the embryo is by no means so far advanced. The ventral parietes of the thoracic-abdominal cavity are not formed, the bilocular heart is

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[1] In the indication of the various definable parts of this deciduous substance a vocabulary of terms has been created; e. g. 'non-placental uterine mucous membrane,' 'uteroplacental mucous membrane,' 'persistent,' or 'non-deciduous serotina,' 'deciduous serotina,' 'fimbriæ of decidua serotina,' 'membrana decidua,' 'decidua reflexa,' 'rags,' 'tags,' &c.

exterior to it; neither lungs nor diaphragm have yet appeared; the parallel columns of the neural axis indicate the primary brain-vesicles, by receding from each other in the long cephalic expansion; a few pairs of protovertebræ show their beginnings at the sides of the myelon, and there is no trace whatever of limbs. The ovum has wholly sunk into a bed of the deciduously-developed lining substance of the womb. Before the Marsupial stage of the fœtus has been reached, changes have taken place in the environment of the embryo, and the growth of the abdominal parietes having reduced the wide aperture, shown in fig. 571, C, to a navel, the embryo with its amnios has sunk into the vitellicle, the trunks of the vitelline artery and veins becoming concomitantly elongated. The allantois comes in contact with that part of the chorion beyond the 'vena terminalis,' and, having fulfilled the main purport of its elongation by transporting thereto the allantoic or so-called 'umbilical' vessels,[1] it collapses, and leaves them to their work of organising the fœtal portion of the placenta. The maternal portion is developed upon a whitish area of the inner surface of the uterine horn at the side where the mesometry, fig. 572, *g*, *g*, is attached. The gravid uterus of the Rabbit, ten days after pregnancy, presents the appearance given in this figure: the fœtus in its chorion chiefly adheres to the preformed maternal disc at the mesometral side, as shown at *d*: it is not, however, lodged in a generally expanded segment of the uterine tube, but in a special dilatation thereof, appended, as it were, to the free side of the tube, *d*,[2] the normal canal of which continues mainly to subserve the lodgment of the placenta. This, in the Rabbit, is an oblong lobulated disc;[3] I have found it consisting of five lobes or cotyledons: in the Hare it is more compact and subcircular, and about two inches in diameter toward the close of gestation: the inner surface and margins are red, the rest yellowish with red spots, when uninjected: the outer surface is subconcave and uneven, the inner surface convex and tubercular. The navel-string, one inch in length, expands, after reflection of the amnios, and is lost in the

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[1] This is an ambiguous term, applied to different structures which are connected with the navel: e. g. to the vitellicle, as 'umbilical sac;' its vessels being distinguished by the Greek term for navel. I shall here, as in Vol. II. (p. 263), call the omphalo-mesenteric vessels 'vitelline' and the umbilical vessels 'allantoic,' in reference to the two primitive bags with which they are respectively connected.

[2] This is characteristic of most multiparous *Lissencephala*, e. g. Shrew, fig. 389, *u*; Rat, xx. vol. v. p. 117, nos. 3466, 3467; Guinea-pig, CCLXII''. tab. v. fig. 10, in which the normal canal of the uterus is obliterated by the accumulated deciduous substance:—'Später, wenn die Flächen und Ränder des Schleimhautschwulstes bereits miteinander verschmolzen, die Höhle des Uterus mit der sich durch sie hindurchziehenden Epithelialröhre verschwunden ist.' ib. p. 30.

[3] xx. vol. v. p. 168, no. 3472.

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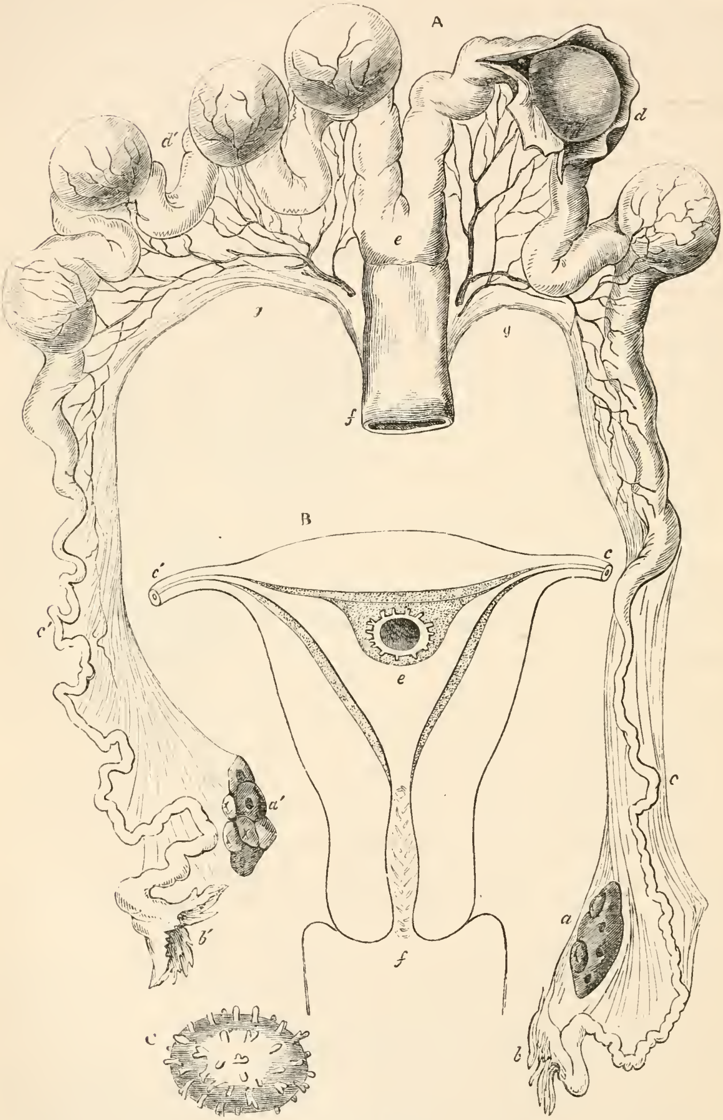

Gravid uterus, A, multiparous; D, uniparous, Mammal; C, early uterine ovum. CCCVIII.

allantois, which reaches the circumference of the placenta: folds of the allantois are reflected from the main trunks of the allantoic vessels, and partially divide its cavity. The chorion receives vessels from the vitellicle as well as from the allantois. Gestation in both Hare and Rabbit is 30 or 31 days: but the new-born Hare is more advanced, the eyes being open. The Rabbit is born blind.

In the Guinea pig (*Cavia Cobaya*, L.) the uterine ovum, when the subdivisions due to cleavage-process have coalesced into the germ-mass, has lost the hyalinion, and is surrounded by the cells, nuclei, molecules, so-called 'epithelium,' &c., formified from the fluid of the amorphous lining matter of the womb, from which the impregnated germ-mass is scarcely, if at all, distinguishable (5th or 6th day): fluid accumulates in the centre of the germ-mass, which now assumes the form of a cylinder with obtuse ends, and may be said to be lodged in an 'utricular canal' of the decidua. When this substance has filled the part of the uterine horn containing the cylindroid ovum, the end of this, next the mesometral side, begins to receive vessels from the decidua, and to be attached to such commencement of the maternal placenta: the opposite or free end of the ovum is the seat of the initial steps in the formation of the embryo.

The cylinder expands into a sphere (12th day), the remaining germ-mass forming the wall of which has become differentiated into a serous or 'animal' layer toward the centre or cavity of the ovum, and into a peripheral, 'vegetal' layer;[1] both expanding to form the tunic of the ovum, everywhere in contact with the thick surrounding bed of decidua. The fundamental structures of the embryo rise from the part of the serous layer next the free side of the uterine horn, and project into the cavity of the ovum, toward which the dorsum of the embryo is turned. A vascular layer is developed between the serous and the inner side of the vegetal layers, the normal relations of the primitive germinal strata being thus reversed. Bloodvessels extend from the widely open abdomen or ventral surface of the embryo upon the vascular layer of the ovum; and, as the growing abdominal walls contract to an 'umbilicus,' the embryo sinks into, or enters, the cavity of the ovum, with which it is in communication by vitelline vessels, fig. 573, *b*, defining a vitellicle by the 'vena terminalis,' ib. *c*, (14th day). Very early a knob of nucleate cells, which seem to form the caudal end of the embryo, are developed into an allantois, which conveys allantoic vessels to the attached mesometral side of the ovum, to ramify in the maternal placenta, ib. *f*, there formed out of the accumulated decidual substance (15th day): after fulfilling that office the allantois disappears, or is represented by the delicate sheath inclosing the trunks of the allantoic arteries and veins, ib. *d*. The amnios, *a*, in the meanwhile, has been completed: and the embryo, so inclosed, is suspended freely within the cavity of the vitellicle, which, by disappearance of the primitive vegetal layer, is now directly surrounded by a deposit of decidua, fig. 573, *i*, becoming thinner as the fœtus and its vitellicular membrane expands (17th day). Through this order of development it seems that the relative position of the embryo to its appendages is the reverse of that in the Rabbit, fig. 571. The mesometral mass of decidua forms a well-defined thick circular placenta, ib. *f*, lobulated on the inner free surface by furrows affecting a radiate but anastomosing disposition, to the centre of which pass the allantoic vessels. These, however, began on reaching the decidua, to organise a distinct placental mass, ib. *e*, which might be termed the fœtal portion: it, however, receives maternal vessels from the larger and first formed decidual placenta, ib. *f*. The proportions of these placentæ become reversed as the fœtus grows. The uterine veins, before quitting the placenta, form an annular sinus around the portion *e*, and then penetrate the decidual parts, *f*, *g*, and the uterus. The allantoic vessels also ramify not only in *e*, but also in *f*, between the lobules of which the larger branches pass to gain the periphery.

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[1] The microscopic characters of these two layers are given in figures 36 and 37, tab. iii. CCLXII''.

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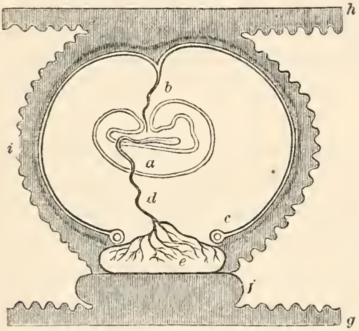

Diagrammatic section of embryo of Guinea-pig, with its vitelline and decidual membranes and placentæ. CCLXII″.

As the fœtus approaches its term the decidual covering of the ovum disappears, or is reduced to mere shreds at the circumference of the placental enlargement, *f*, which is now much reduced in size: it receives into a cavity a mammilloid process from the centre of the fœtal placenta, to which process converge the uterine vessels from without and the fœtal vessels from within, before they ramify to the periphery. The vitellicle still represents the chorion: its arteries form a peripheral ‘circulus arteriosus,’ parallel with the vena terminalis or ‘circulus venosus,’ and in the interspace of these vascular circles, fimbriate processes grow out richly supplied by vitelline vessels and constituting a third kind of placenta more exclusively related to the nutrition of the fœtus. For this grows so quickly and becomes so large,[1] that the allantoic placenta, serving both for respiration and nutrition, needs the help it obtains through absorption, by the vitelline fringes, of the uterine nutrient matter in which they are bathed. The umbilical cord, as in most Rodents, is very short and thick.

In the Aguti the decidual placenta is still more reduced, little more than the originally traversing maternal vessels remaining on their passage to the later allantoic placenta, which they seem to suspend by a central part, opposite to which, on the other side of the placenta, the fœtal vessels proceed. In the Rat the maternal or decidual placenta is cotyloid, and is adapted to a small convex process of the centre of the uterine surface of the button-shaped fœtal placenta;[2] and, as in the Guinea-pig, the allantois, after laying the foundation of the latter, speedily disappears. The like happens in the Water-vole, in which the fœtal placenta is small and circular, convex toward the uterus and flat toward the vitelline chorion, which has its attachment limited to the central part of the placental disc.

In the Mole and Shrew the vitellicle is large, and supplies the outer envelope of the ovum with vessels, coalesces with, and seems, indeed, to form it. The allantois, bending to the dorsal aspect of the embryo, carries its vessels to that part of the amorphous mass of decidua enveloping the ovum. The early embryo in its amnios thus appears to be suspended by opposite poles formed respectively by the vitelline and allantoic trunks. The allantoic vessels organise the fine villi of the fœtal placenta in a small proportion of the thick deciduous mass: this in the growth of the embryo becomes reduced to a subcircular maternal disc, larger than the fœtal one, which is imbedded in its central concave surface. The area on the peripheral convex surface affording the maternal supply of blood, is small in proportion to the placental disc. The terms 'fœtal' and 'maternal' relate to the source of the main part of the vascular supply of such divisions of the discoid placenta. The maternal vessels, the orifices of the veins being conspicuous on the area of placental detachment, are continued into the allantoic or fœtal button, and the villi of this part extend into the decidual part of the maternal placenta. Beyond this the decidual substance becomes reduced to a very thin layer, traceable over part of the chorion. The convexity of the maternal placenta is continued with the lining of the uterus. Such lining is homologous in tissue with the substance lining the human uterus, but is firmer, and to no part can the term 'mucous membrane' be correctly applied. The placental disc in the Tenrec is subcircular, thickest at the periphery; in all other essential points it agrees with the rest of its order. The main peculiarity of *Centetes* is its multiparity.[1] From four to six fœtuses may be brought forth by the Hedgehog: from twelve to twenty by the Tenrec. The shape of the placenta changes in the course of utero-gestation in Insectivora. When the embryo Hedgehog is from half an inch to an inch in length, it is enclosed in a cup-shaped placenta, as in a nest: this is subsequently spread out and flattened by the growth of the fœtus, and converted into a thin, shallow discoid plate, with its concavity applied to the back of the embryo, and with the central part of its convex surface attached to the uterus: the 'button' lies flat upon the maternal portion, and is attached by a wider surface than in the Guinea-pig. In the Mole the placenta is a circular disc at the early period of gestation, and subsequently becomes an oblong flat band, with its long axis parallel to that of the fœtus: the linear tract of the uterine surface to which the placenta is attached shows a fine areolar structure, penetrated by the fœtal placentary filaments, which are often brought away, as in the Rat, distinct from the maternal structure, like the fœtal cotyledon in the Cow.[2] In the Bat (*Vespertilio noctula*), the placenta has the form of an obtuse cone. In all the foregoing insectivorous mammals the vitellicle is large. But, in a frugivorous Bat (*Pteropus medius*, TEMMINCK), I found the vitellicle shrunk to a reniform, compactly folded body, which lay in the concavity of the placenta, between it and the allantois: the placenta was subcircular, discoid, slightly concave towards the fœtus, proportionally more convex towards the uterus. The fœtal villi are long, delicate, and branched, giving a flocculent appearance to the small portion of the centre of the disc by which the fœtal placenta is attached to the womb.

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[1] Calling in the Guinea-pig for the special expansion of the pelvis shown in Vol. II. p. 380, fig. 246.

[2] xx. vol. v. p. 117, no. 3467.

Volant *Insectivora*, in relation to the exigencies of flight, are commonly uniparous. The uterus of *Vespertilio emarginatus*, killed June 20, had a single fœtus, half an inch in length. A female of *Vespertilio noctula* produced, on the 23rd June, a young one, with an umbilical cord two inches in length.[1] Judging from observed dates of pairing, the gestation seems to be about forty days. The chief difference from *Insectivora* is in the larger proportion of the placenta formed by the long arborescent villi organised by the allantoic vessels: the reduced decidua beyond the maternal cake may be traced over a great part of the chorion, which receives, as in other *Lissencephala*, vitelline vessels.[2]

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[1] The chief of the alleged 'points of difference' of the Tenrec's placental structures from those of other *Insectivora*, in 'the absence of a yelk-sac, of the allantois as a distinct sac, and of any membrane either decidual or chorionic, on the exterior of the amnios' (CCLXVII''. p. 291), depend (granting the competency of the observer) on the admitted state of decomposition of the specimen described (p. 287): the 'absence of a yelk-sac,' moreover, would point from, rather than toward, 'marsupial affinities,' inasmuch as the embryo of the Kangaroo is chiefly remarkable for the large size of such sac, or 'vitellicle.'

[2] This never happens in the quadrumanous placenta; and the difference is not affected by showing that, prior to severance, the fœtal placenta is combined with maternal vessels in the Rat, Mole, &c.

According to Carus,[3] the placenta of the Ai (*Bradypus tridactylus*) is divided into so many distinct lobes, as to resemble the cotyledonary condition of the placenta in most Ruminants: but there are no corresponding partial thickenings of the lining substance of the uterus like the maternal cotyledons shown in fig. 546. The so-called placentulæ, of an irregular oblong, subdepressed form, from 1½ to less than ½ an inch in diameter, and from 30 to 40 in number, project from the endochorion, or inner surface of the allantois, into the interior of that sac: they are richly supplied with allantoic vessels: their flattened outer surface applied, with the uniting layer of chorion, to the inner surface of the uterus, may receive therefrom a medium of ramification of maternal vessels, answering to a decidua scrotina. The probability indeed is, that maternal deciduous substance is interblended with such allantoic lobules of the Sloth, as is the case with the single thin oblong placental disc in *Dasypus*. The genus *Manis* offers a third instance of the extent to which the temporary structures developed for the behoof of the fœtus, and cast off at its birth, are diversified in both form and structure within the limits of a subordinate natural group of placental Mammals. According to Sharpey,[1] the outer surface of the chorion is reticularly ridged, like the inner surface of the human gall-bladder, but in a finer degree. The inner surface of the uterus exhibits fine low ridges or villi, not reticulating quite so much (qu. with more open meshes?). The chorion, also, presents a band, free from villi, running longitudinally along its concavity, and there is a corresponding bald space on the surface of the uterus. The ridges of the chorion start from the margins of the bald stripe, and run round the ovum. The vitellicle is fusiform.

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[1] The mother gnawed the cord across and ate the afterbirth.

[2] A critic of xx. vol. v. pp. 140–45, writes:—'The delicate arborescent appearance which is described in the placenta of *Pteropus* is due, in all likelihood, to the prolonged maceration in spirit,' &c. CCLXVII''. p. 310. The Hunterian preparation yielding, according to the Oxford Professor, the above description (No. 3579, Physiol. Series) is well placed for illustration of this alleged influence in the production of modifications of placental structure. Some of the specimens had been put into spirit in 1754, thirty years before the placenta of the *Pteropus* was so treated; and both, together with other Hunterian preparations of placentæ, have been since subject to eighty years of 'maceration in spirit!' But there was really no need to assume so special a behaviour of a Bat's afterbirth under maceration, in order to show that 'this placental peculiarity brings them, as Linnæus did bring them, into the same class as the *Primates*' (CCLXVII''. p. 310). No one, now, dreams of leaving Bats among birds. Perhaps, however, Dr. Rolleston may mean the same order in the mammalian class. But cerebral, circulating, osseous and generative characters, especially those of the male organs, were even the placental structures so similar to human ones as Dr. R. contends, would outweigh them, and I believe will guide all unprejudiced naturalists in juxtaposing the winged with the terrestrial *Insectivora*, and in relegating both to the low lissencephalous subclass.

[3] XLIII. p. 21, tab. ix. figs. 15–17.

The species of the order *Bruta* are uniparous as a rule: the fœtus attains a relatively large size, and the pelvis has a corresponding width.

§ 402. *Development of Mutilata.*—The Cetacea are uniparous, and still more remarkable for the large proportional size of the young, at birth: its membranes extend from the division of the uterus corresponding to the impregnated ovarium into that of the opposite side. A general short verrucose villosity of the chorion intus-suscepted by corresponding alveolar modifications through decidual outgrowths of the lining substance of the uterus performs the placental function: the structure is least developed at the terminal blind ends of the chorionic sac, which are almost smooth, and, in the degree in which the diffused placenta is thus interrupted at the poles, it may be said to be broadly zonular. The amniotic sheath of the umbilical cord is beset with small pedunculate corpuscles.[2] In flensing a female Whale (*Balæna mysticetus*), harpooned in the month of August, a fœtus escaped from the vulva: it measured 5 feet 4 inches in length; and was probably far from the full time. No bony pelvic cincture offers a mechanical obstacle to the birth: and the exigencies of a hot-blooded air-breathing animal sent from the warm womb into—it may be—an arctic sea, call for muscular powers equal to the evolutions needed for maintaining contact with the nipple, and coming to the surface to breathe.

Of the fœtal membranes of the *Sirenia* nothing is known.

§ 403. *Development of Ungulata.*—Here no envelope of the ovum is superadded to the hyalinion ('zona pellucida'). With this for the outer covering the ovum enters the uterus: it is impregnated in the oviduct, where it meets the spermatozoa; the first stages of cleavage go on there, and the germ-mass is completed in the uterus. In this process the hyalinion thins away, and finally disappears. A mass of albuminoid matter accumulates around the ovum, as in *Cavia*, but is whiter in colour. It affords material for imbibition, and the germ-mass becoming fluid at, or getting fluid in, the centre, expands into a hollow sphere, the parietes of which become differentiated into two layers: the outer one seems to answer to the corresponding lamina demonstrated by Hunter in the germinal area of the chick; the other to the inner lamina of the same area.[1] Both layers consist of coherent cells, with some difference as to size and proportion of oil-globules.

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[1] As quoted in CCLXX″. p. 112.

[2] XX. vol. v. p. 200.

The ovum now grows rapidly in length, its opposite poles being prolonged and attenuated. At the point where the two layers or 'membranes' cohere, the embryonal trace appears, its long axis extending at right angles to that of the ovum; the inner or 'mucous' layer is so continued from the margin of the abdominal depression as to 'appear of itself to form the intestine, existing prior to that part being visible.'[2] The cephalic expansion and incurvation seems relatively late in Ungulates. Before the amnios is complete, and when the back of the embryo is still covered by the peripheral part of the serous layer, when but three pairs of proto vertebral nuclei are formed, and the cephalic ends of the myelonal cords are only beginning to diverge, the opposite end of the embryo begins to bud out two processes at right angles to its axis, which soon expand into the allantois.[3] This vesicle rapidly extends between the serous or animal layer forming the outer coat of the ovum, on the one hand, and the embryo, amnion and vitellicle, on the other hand; carrying with it allantoic vessels, and becoming coextensive with the outer coat. With this expansion that outer coat disappears, and the chorion is now represented by the vascular layer of the allantois itself, which has become distinct from its inner or mucous layer. Meanwhile the vitellicle has shrunk to slender proportions, its communication with the intestine being reduced by growth of the abdominal walls, and drawn out into an omphalo-mesenteric duct. The vascular layer of the allantois, representing the chorion, effects its vascular intus-susceptive relations with the uterine lining in various ways. In most Perisso- and a few Artio- dactyles short villous processes bud out from a greater part of the superficies of the chorion, and a co-extensive minutely alveolar growth of the lining substance of the uterus receives them.

Fig. 574 represents the fœtal membranes and appendages

[1] xx. vol. v. p. 20, pl. 59, fig. 7. Later German Embryologists have called the one 'serous' or 'animal' layer, the other 'mucous,' 'vegetal' or 'organic' layer; but any of these terms can only be understood in an arbitrary sense. See Vol. II. p. 259, fig. 133.

[2] Ib. p. 20.

[3] CCLXIII''. p. 18 (in the Roe-buck).

attached to part of the abdominal parietes, *a, b,* with the urinary bladder, *q,* the female organs, *s, z,* and rectum, *p, o,* of an aborted foal. The membrane, *d, d,* is the amnios which was reflected from the umbilical cord to inclose the fœtus; the inner concave surface of the bag, turned toward the parts of the fœtus, is characterised by the finely waved disposition of the amniotic vessels. Minute filiform processes project from the serous surface of this part of the cord. The urachus, accompanying the umbilical vessels (one artery, two veins, *b*), opens, or expands, into the cavity of the mucous layer of the allantois at *e*: this cavity is laid open, showing the part of its wall reflected upon the exterior of the amnios, at *d d,* and the part continued over the interior of the vascular layer of the allantois, or chorion, at *g g*: a portion of its exterior surface is shown at *h.* The umbilical vessels, continued beyond the end of the urachus to the chorion, seem to form a prolongation of the navel-string, about two feet in length, *f,* between the amnios and the chorion, around which part of the

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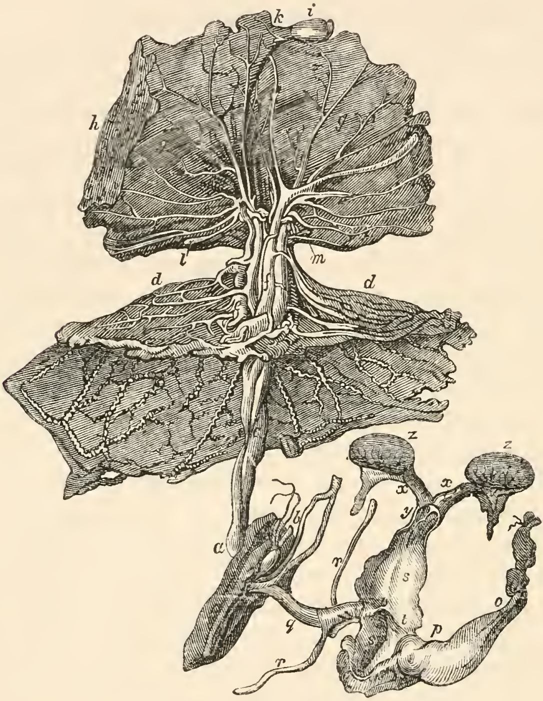

Fetal membranes, *Equus.* CXXII''.

cord the inner layer of the allantois is reflected. The vessels of the outer layer branch and spread themselves over it, becoming capillaries in the clusters of short villosities, and thereby brought into the requisite contact with the maternal capillaries in the similarly arranged decidual growths, for the interchange and reception of the materials and elements concerned in fœtal nutrition. The mucous layer of the allantois lines about half of the amnio-chorionic interspace. Towards the latter period of gestation, the renal excretion of the fœtus passing from the bladder along the urachus, deposits near the allantoic orifice of that tube a thick fluid of a reddish colour, of an urinous odour, and which contains uroerithrin and hippuric acid. The small oval masses, from the size of a pea to that of a hen's egg, *i*, sometimes loose in the allantoic cavity, sometimes adhering to its inner surface, are inspissated parts of the allantoic fluid; they have received a special attention from the fanciful import once assigned to them under the name 'hippomanes.'[1] The chorion, being moulded in great degree upon the uterine cavity, is produced into two 'cornua,' but they are not co-extensive with those of the uterus. The multiplication of the vascular surface of the chorionic cornua by fine and deep plicæ indicates the degree of the placentary function assigned to these prolongations. In fig. 575 the fœtus, *m*, at about the tenth month, is shown, enveloped in the amnios, *n n*: the entamniotic part of the navel-string, *o*, *p*, is continued to *q*, *r*, where the entallantoic part begins, and the allantois is reflected from its urachal pedicle. The endochorionic part of the allantois is seen at *s*, *s*; a portion of the exterior of the chorion at *t*: *y* is part of the left uterine horn; *z* is the ovary.

The gestation of the Mare is eleven months and a few days: she brings forth standing, and is fertile to the fifteenth year, rarely to the eighteenth. The horse is mature at the fourth year, and its average or usual term of life is thirty years, with fair usage. The Ass brings forth during the eleventh month of pregnancy. The milk appears at the tenth month: in very rare cases the ass may have twins. The Mare emits a whitish adhesive secretion, 'per vulvam,' during the period of heat. The temporary maternal modification of the uterine lining does not come away with the fœtal membranes at birth, but is either absorbed or passed off with the lochia. The usual smooth surface of the folds of the uterine lining is restored about six months after parturition.

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[1] The true nature and position of these bodies were made known by Daubenton, in ccxc″.

The outer surface of the chorion of the Tapir is beset with short linear series of small compressed foliate processes, dividing into from three to six leaflets, upon or within which the fœtal capillaries ramify: the inner surface, when the allantoic non-vascular layer or endochorion is removed, is reticulate through the division of the allantoic vessels, sending off the capillaries to the foliate villi.

The clustered arrangements of the placental capillaries is more marked in the Sow than in the Mare: when uninjected they appear as white subcircular spots scattered over the outer surface of the chorion: but when the allantoic veins are filled, these are seen to form plexules in the centre of each spot. The uterine veins have a corresponding arrangement. The uterine arterial capillaries form a fine network, the meshes receiving the villosities which carry the fœtal arterial capillaries; whence it might seem that the nutrition of the fœtus was effected principally at the points of contact of the fœtal with the maternal venules,

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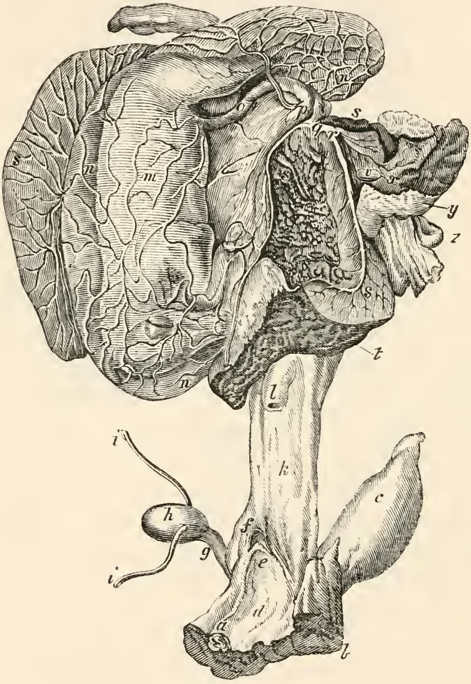

Impregnated uterus of Mare. CXXII'.

whilst the respiratory process took place at the surface of contact between the fœtal and maternal arterial capillaries. The period of gestation of the domestic Sow is about four months; the observed range of variation has been from 109 days to 123 days. The gestation of the Hippopotamus is 234 days. The pair at the Zoological Gardens at Amsterdam copulated December 1, and the young one was brought forth on July 29, next following.

Camelines and Chevrotains (*Tragulus*) have the diffused condition of the placenta as in the Mare and Sow, with some minor modifications of villi and capillaries: the vitellicle, as in other Ruminants, is relatively smaller than in Solipeds. The urachus dilates, beyond the amnios, into a narrow cylindrical sac transversely extended, or dividing into two slender cornua, entering those of the uterus; it consists of the mucous layer of the allantois, is usually found collapsed, and can hardly be inflated at the last month of pregnancy in the Cow. Laminated deposits from the allantoic fluid are occasionally present, like those called 'hippomanes' in the Mare. A much smaller proportion of the space between amnios and chorion is thus occupied in the Ruminants than in the *Equidæ,* and probably other Perissodactyles.

The villi of the chorion are developed in horned Ruminants on detached and limited localities, corresponding with the prominences of the lining substance of the uterus, fig. 546, from which the deciduous maternal parts of the placenta grow. The surface of these caruncles, previously smooth, now buds out into reticulate processes, moulding themselves upon the chorionic villi, and forming cavities or canals for their inter-susception. These outgrowths are homologous with the 'decidua serotina' of other Mammals,[1] but they gain a firmer texture, and usually remain attached to the uterus, allowing the fœtal villi to be withdrawn from them at birth: they are afterwards shed, or disappear, the caruncle resuming its smooth and even surface.[2] When the entire caruncle happens to come away, it is not reproduced; a smooth cicatrix remains upon the uterine surface.

Wherever there is placenta there is decidua. The special and temporary work of developments providing capillary superficies, whether on the part of the mother or fœtus, being ended, they go: they may not be thrown off together, and the maternal decidua may not be shed all at once, but in successive shreds or tags. The long gestation required to bring to due strength the young of the defenceless hoofed animals before birth, is the condition of the firmer texture, better organization, greater extent, and more persistent character of their ‘ deciduous ’ structures.

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[1] The student must not be seduced into accepting too absolutely Eschricht's dictum:—'quarum alteri placenta uterina caduca, alteri non caduca est.'

[2] In XCVI', the caruncles are called 'glandular protuberances' (p. 544); but it is precisely on that part of the uterine lining where the utricular glands are wanting; and the eminences and follicular depressions are peculiar to the period of gestation.

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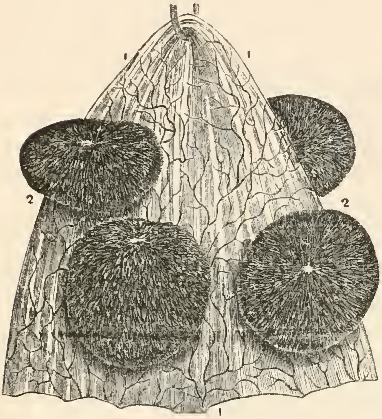

Portion of chorion with cotyledons, Cow. iv″.

The villi of the fœtal cotyledons offer varieties of form and mode of termination, beautifully illustrated by Clift in xxviii. vol. iii., tab. clxxi., and indicated by Home,[1] as follows :—

‘ *Bos*—terminales ramosæ :
Cervus ,, indivisæ filiformes :
Ovis ,, ,, villosæ :
Capra ,, ,, pilosæ :’

terms which, though not strictly accurate, indicate the degree and way in which generic variety manifests itself in the cotyledonal modification of placental structure.

About eighty cotyledons are developed from the chorion of the Cow ; the surface of the large uterine caruncles is usually flat or slightly concave. The gestation of the Cow is about nine months (286 days), with a range of variety of about twenty days.

In the Red-deer (*Cervus elaphus*) gestation is eight months and a few days: the rut is usually in the last three weeks of September ; the birth in May or early in June. The fœtus is long confined to one uterine horn: the mucous layer of the allantois forms a crescentic bag, the horns being prolonged into both those of the uterus and ending obtusely: it contains a milky fluid, depositing a sediment. The cotyledons are relatively smaller, more oblong, and much fewer than in the Cow. The same may be said of the Fallow-deer, the gestation of which is eight months. Both species of *Cervus* are uniparous, as a rule. The little Roe-deer usually brings forth twins : sometimes both come from one ovary, more often one from each. The gestation here is about nine months (280 days). The rut is in July and beginning of August : impregnation and the cleavage-process goes on as usual, and the ovum, with completed germ-mass, has been found *in utero* August 16:[1] here it lies with uncoated hyalinion until the latter half or end of December: the germ-mass remaining four months in a quasi-torpid state. Development is then resumed, and the young are brought forth at the end of April or beginning of May. The contiguous ends of the two elongated ova overlap each other, and as gestation advances the contiguous parts of the exochorion blend together; but each fœtus retains its own unvascular allantoic bag and amnios.

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[1] xxviii. iii. p. 560.

In the Giraffe there are two kinds of fœtal cotyledons: the larger or normal ones are in longitudinal rows corresponding with the disposition of the uterine caruncles: they have mostly a reniform figure, attached to the chorion by a contracted base: the terminal branches of the component villi are finer than those in the Cow, and more resemble those in the Deer. The smaller cotyledons, of irregular form and varying size, project from the outer surface of the chorion in the interspaces of the rows of the larger ones: their villi are proportionally shorter, and in the smallest ones simple and unbranched, indicating a transitional step to the diffused villosity in the small Musk-deer. I counted 180 cotyledons, large and small, on the chorion of the Giraffe: the umbilical cord is above a yard in length.

A male and female Giraffe paired, April 1, 1838, and again on the following day, after which the female lost the disposition to receive the male; on June 10, 1839, the udder began to enlarge, and on June 19 the young (a male) was born, 444 days after the second coitus. The same Giraffes paired on March 12, 1840, and after a gestation of 431 days a young male was born. In each case the female stood during parturition: the fore-legs of the fœtus first appeared, the head and body followed, the mother stooped behind to deposit her burthen safely. In half an hour the young one made efforts to rise, and in an hour after birth it stood upright. It was born with horns in structure and relative size like those of the dam,[2] and is the only horned ruminant that acquires these weapons before birth. Concomitantly with the long period of gestation is the unusually large size of the new-born young, which measured from the muzzle to the root of the tail six feet ten inches; from the base of the scapula to the end of the fore-hoof five feet. The enemies to which such a young Mammal might fall a prey in its native African wilds indicate the conditions of the unusual strength acquired during the long gestation.

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[1] CCLXIII″. p. 10, tab. I., fig. 8.

[2] CCXXVI″. pl. 1.

The varieties of placental structures and modifications in the Ungulate group are not yet exhausted. The chorion of the Elephant, fig. 577, *a*, *a′*, *d*, at about the middle of the period of gestation, forms a transversely oblong sac, 2 feet 6 inches in long diameter, and 1 foot 4 inches in short diameter, encompassed at its middle part by an annular placenta, ib. *b*, *b*, 2 feet 6 inches in circumference, varying from 3 to 5 inches in breadth, and from 1 to 2 inches in thickness: it is partially divided by opposite constrictions into two moieties; it presents the same spongy texture as does the annular placenta of the *Carnivora*; but the laminate villosities enclosing the fœtal filaments enter into its formation in a larger proportion, and are of a relatively coarser character. The greater part of the outer convex surface of the placenta is smooth; the rough part separated from the serotine portion occupied a narrow tract, *c*, *c*. A thin brown deciduous layer is continued from the borders of the placenta, for a distance varying from 1 to 3 inches, upon the outer surface of the chorion. Flattened folds of a similar substance could be raised from some parts of the surface of the placenta; at other parts the substance formed irregular fibrous bands, the fibres extending in the direction of the circumference of the placental ring. The outer surface of the chorion is for the most part smooth; but at each of the obtuse extremities of the sac there was a villous and vascular subcircular patch, *d*, *d*, the villi being short and graniform, $\frac{1}{6}$th of a line in diameter, or less. Thus the chief points of attachment of the chorion to the uterus are, at the equator, by the annular placenta,

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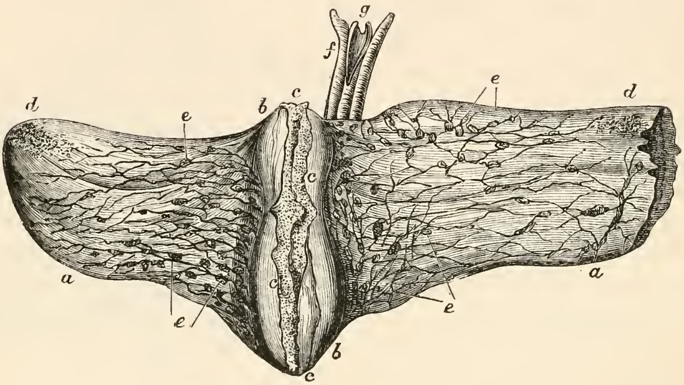

Fœtal membranes and placenta, Elephant.

and at each pole of the elongated sac, by the subcircular villous patch. The umbilical cord, *f*, formed by one venous and two arterial trunks, and by the slender neck of the allantois, *g*, with the connecting cellular tissue and the covering of amnios, is short and somewhat flattened. It measured about 6 inches in length, before the division of the vascular trunk, and about 3 inches in circumference. The inner surface of the amnios is roughened by brownish hemispherical granules, from 1 line to $\frac{1}{10}$th of a line in size, commonly about half a line; the outer surface is finely wrinkled, but smooth. The bag formed by the mucous or unvascular layer of the allantois is of considerable size, is continued from the base of the umbilical cord, so expanding between the chorion and amnios as to prevent any part of the amnios attaining the inner surface of the placenta. The allantois divides, where the amnios begins to be reflected upon it, into three sacculi: one extends over the inner surface of the annular placenta, and a little way into one end of the chorion: a second extends into the opposite end of the chorion, *a′*; it there bends round toward the placenta, and its apex adheres at that part to the first division of the allantois: the third prolongation subdivides into two smaller cavities, each terminating in a cul-de-sac, encompassing, and closely attached to, the primary divisions of the umbilical vessels. The line of adhesion of the amnios to the allantois, where it is reflected upon these cul-de-sacs, measures 3 feet 6 inches.

The primary branches of the umbilical arteries and vein diverge from the umbilical cord in four divisions: they reach, first, the borders of the placenta, and then ramify in its substance and upon the inner surface of the chorion, being supported there, and more or less surrounded, by the layer of the allantois called ‘endochorion.’ Upon the endochorionic vessels are developed a number of flattened, oval, or subcircular bodies, *e*, *e*, of a compact, structureless tissue, varying in diameter from an inch or more to half a line. On separating the chorion from the allantois, these bodies were found to belong entirely to the latter membrane: the vessels upon which they seem to be developed pass on their chorionic side, the bodies adhering to the allantoic side of the sheath of the vessel: they are most abundant near the placenta, and become wider apart as they approach the poles of the chorion: I counted 120: the smaller ones occur on the free duplicatures of the allantois continued from the umbilical trunks: in almost every case they are developed on the course of the large vessels, and are restricted, with few exceptions, to that part of the allantois which is in contact with the chorion. Their free surface is smooth and polished, not villous like the cotyledons of the *Ruminantia*; from which they likewise differ in projecting inward toward the cavity of the allantois, like the so-called cotyledons of the sloth: they are not mere precipitates of inspissated matters of the allantoic fluid, like the 'hippomanes' of the Mare.

A male and female Indian Elephant paired December 18, 1863, and at other times up to January 8, 1864, when they were kept apart. For twelve months there was no conspicuous increase of the abdomen: after that period it was obvious to close inspection, on the left side: then the mammary glands enlarged, with slight occasional oozing of milk; and on August 3, 1865, the young was born; it stood 2 feet 10 inches high, and weighed 175 lbs. Thus the period of gestation, reckoned from the date of first coitus, is 593 days.

The Hyrax has an annular placenta more subdivided than in the Elephant. The venous blood returns from it at three places, the centres of as many divisions of the belt, which, however, are continuous by thinner portions of placental substance. The villi are imbedded in decidual substance, and the surface of its attachment to that remaining on the uterus is less limited than in the Elephant. The placental zone seems relatively tighter, the ends of the chorion swelling out more, than in *Carnivora*. The perissodactyle number of ribs—twenty-two pairs, the simple stomach and complex cæcal structures, the hoofs of the unsymmetrically tetradactyle fore-foot and tridactyle hind-foot, as in a larger extinct hornless rhinoceros, the close repetition of dental characters in the diminutive existing species, not merely as to pattern of grinding surface of molars, but of kinds and manner of growth of all the teeth, the incisors being developed as in *Rhinoceros incisivus*,[1] demonstrate the low taxonomic value of the placental character, according to which the Hyrax, as well as the Elephant, would be classed with the *Carnivora*.

§ 404. *Development of Carnivora.*—In the fœtal Cat, about the middle of the period of gestation, the chorion, fig. 578, *a*, *a*, is a curved arc 6 inches in long diam., by 2 inches in short diam., with obtuse ends; it is girt in the middle by an annular placenta, *b*, 1½ inch broad: the zone is concave transversely within, of a mingled grey and red colour when uninjected: the chorion on each side of the placenta is slightly folded, and of a reddish colour. The fœtal surface of the placenta is lobulated:

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[1] He must have counted much upon the ignorance of his auditors or readers who could affirm that the 'HYRAX hangs by *Rhinoceros* mainly by the pattern of its molar teeth.' CCLXX″. p. 111.

the maternal placenta or serotine decidua is present, and can be separated as a distinct layer.[1] The mucous layer of the allantois expands from the uterine extremity of the umbilical cord upon the vascular layer (chorion or exochorion), forming broad duplicatures about the allantoic vessels outside; the trunks of these are in the free margins of the folds, and at the opposite margins the folds of the non-vascular layer of allantois recede and spread over the vascular layer or chorion, to which they cohere. The vitellicle, *d*, extends into the pointed horns, *f*, *f*, between amnion and placenta, at right angles to the latter: it is attached by a slender pedicle, *g*, to a loop of small intestine: it usually contains a yellowish liquid, with some small loose fimbriate precipitates. In the amniotic liquid crumbs of meconium occur toward the end of gestation. The navel-string is very short. The Cat is in heat, for about ten days, before she is a year old; and is prolific to the ninth year: bringing forth at least twice a year in the wild state, and three or four times in domesticity. The

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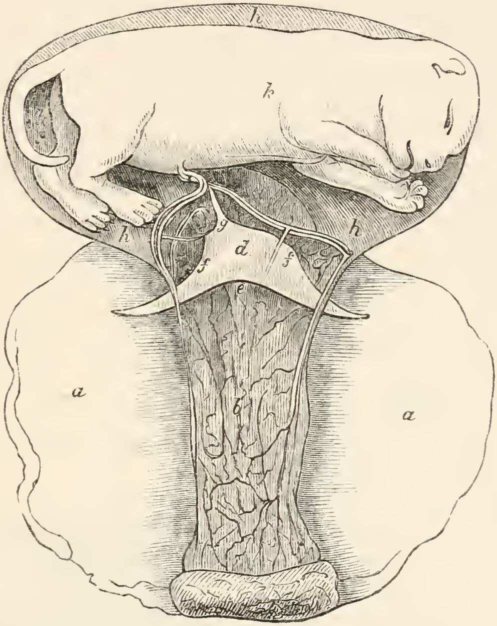

Fœtus with membrane and placenta, Cat. CXXII′.

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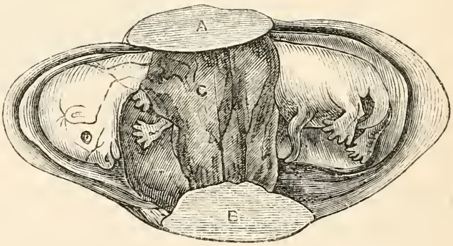
[1] xx. vol. v. p. 141, no. 3565.

gestation is fifty-five or fifty-six days; and she brings forth usually from four to six young.

In the Lioness the exterior of the placenta is marked by anfractuosities like those of the brain; the inner surface is divided into small irregular convex lobes by deep sulci. In the zonular placenta of the Dog the maternal portion cannot be defined and separated as in the Cat: the uterine surface to which the placenta adheres presents a finely reticulate substance, the meshes being formed by orifices of apparently utricular glands, aggregated in the interspaces of larger alveoli, scattered over the surface with intervals of between half a line and two lines. When the fœtus has attained a length of five or six inches, this alveolar decidua has acquired a thickness which makes it recognisable as the maternal portion of the placenta. The period of gestation of the Wolf, Jackal, and Dog is 63 days.

A modification of the annular placenta, analogous to that in the Elephant, obtains in some Carnivores, e. g. the Weasel tribe (fig. 579, *Putorius Furo*); two portions of a subcircular form, A, B, appear as a double placenta, but they are united by a much thinner tract, C, also receiving ramifications of the allantoic vessels. The umbilical cord, one-third of an inch in length, goes to one of the cotyledons, whence the vessels extend to the other. The omphalo-mesenteric duct expands into a pyriform vitellicle, five lines in length. The Ferret produces from five to eight young; she has usually eight teats; has a six-weeks' gestation, and produces twice a year. In the Martens the placenta is undivided (*Mustela martes*, *M. foina*, &c.); the decidua serotina sinks into its substance along a narrow tract at the middle of the outer surface of the zone, as in the Elephant: they bring forth, commonly, twice a year, but are less prolific than the Weasels. The navel-string is very short: the allantois is more elongated; a trace of vitellicle may be seen in a small bilobed yellowish patch, upon the inner surface of the placenta, where the navel-string ends.

579



Fœtus and Placenta. *Putorius Furo*. CXXII′.

In the Hyæna the deciduous substance becomes fused with the chorionic placental processes: it is moderately thick, spongy, tomatose, non-coherent: the fœtal processes penetrate cavities in the decidua apparently homologous with the utriculi of the human uterine lining, and having as little the structure of true follicular glands. The original deciduous capsule of the ovum is reduced to a very thin layer of mucous substance, exterior to the placental zone.

Seals have rarely more than two young, and more commonly but one, at a birth. In the latter case the fœtus and its membranes are limited to one horn of the uterus, not extending into the opposite horn, as in *Cetacea.* The placenta is zonular, in four or five continuous or connected divisions. In *Phoca vitulina* the diameter of the zone parallel with the long axis of the ovum is between two and three inches. In parturition the sclerous tissue of the symphysis pubis becomes relaxed, allowing divarication of that part of the pelvic arch, which, consistently with the reduced hind limbs, is smaller than in land Carnivores.

The gestation of the Bear (*U. americanus*) is seven months: the young, usually two in number, are born as well shaped as in other *Carnivora,* but are more naked: the eyelids are closed, and so continue for about four weeks. From some information I have received respecting the Badger, it would seem, like the Roe, to have a long gestation in proportion to its size. The young, as with the Bear, are blind at birth.

§ 405. *Development of Quadrumana.*—The Makis (*Lemur*) have sometimes one, commonly two, rarely three young at a birth. A pair of the *Lemur albifrons,* captive at the Jardin des Plantes, Paris, copulated December 23, and afterwards repeatedly for five or six days: the female brought forth April 13, after a gestation of fifteen weeks. The new-born young was covered with very short hairs, and had its eyes open.[1]

The Marmosets (*Hapale Jacchus*) resemble *Lemur* in the number of young: the gestation is three months: the young is naked at birth, except upon the head, and gets clothed in three or four weeks. In *Callithrix sciureus* the long twisted umbilical cord is chiefly in connection with a circular thick discoid placenta: but some of the branches of both the two arteries and two veins extend (as it seemed to Schroeder von der Kolk)[2] to a smaller and thinner circular villous tract, like a second placenta at the opposite end of the chorionic sac.

The Howler (*Mycetes seniculus*) has a single placenta, also circular, discoid, from which the fœtal blood is returned by two umbilical (allantoic) veins: the cord, as in *Callithrix*, is attached to the margin of the placental disc. *Hapale*, *Nocthora*, *Callithrix*, and other small kinds of Platyrhines are monogamous. Larger platyrhine Monkeys (*Mycetes*, *Cebus*, e.g.) are polygamous: three or four females are usually seen with one male. *Cebus* is usually uniparous: the gestation is five months: the placenta single, discoid, thick; the umbilical cord with two veins and two arteries: the maternal and fœtal portions of the placenta are expelled together, the fœtal villous part does not come away separately, as is sometimes the case in *Lissencephala*. The villous and cellular structures are still more intimately blended in old-world *Quadrumana*. In the tailed Catarhines, which, as a rule, are uniparous, the placenta is double, the two being distinct and apart, usually disposed upon the right and left sides of the uterus. In fig. 580, where they are exposed in the green Monkey (*Cercopithecus sabæus*) the following parts are indicate:—*a* peritoneal coat of uterus, *b b* muscular coat, *b′* thicker portion at the cervix uteri, *c os tincæ*, *d* glandular rugæ of cervix, *e* cavity between cervix and decidual lining of uterus, *f* decidua, *g* chorion, *h* amnios, *i* umbilical vessels associated in groups of two arteries and one vein, on their way to the cord, *k*, *k* amniotic surface of the two placentæ, *m n* amniotic sheath of cord, dissected to show the two arteries and one vein: *o* clitoris, *q* hair covering the labiæ, *r* diverging branches of umbilical vessels on the proximal placenta, *s*, *s* vessels extending to the distal placenta *t*, *v* interplacental area. In the pregnant *Macacus rhesus* dissected by Hunter[1] the two placentæ were contiguous, and each of more oblong form than in fig. 580. The placenta shows a combined cellular and filamentary villous structure. The filaments include the capillary loops of the fœtal vessels: but instead of lying freely in alveolar cavities of the maternal placenta, they are connected or entangled with the fine cellular structure which receives the blood from the uterine arteries: the uterine veins have stronger and more definite coats than in the human placenta: the decidua is also denser and more coherent, and the layer between the uterus and placenta is thicker. Each placenta consists of smaller lobes united at their edges: in the fissures lie the veins, or sinuses, from which the venous branches are continued.[2]

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[1] CCLXXVII″. p. 50.

[2] Ib. p. 55, pl. 6, fig. 1. Rudolphi found the placenta single in *Hapale Jacchus.*

In *Semnopithecus nasicus* the two placentæ are more remote than in *Cercopithecus*, and the distal one is smaller than that from which the umbilical cord is continued: this is divided into five lobes. Two placentæ have been observed in a species of *Hylobates*:

[1] xciv. p. 71.

[2] xx. vol. v. p. 145.

but in the Chimpanzee the placenta is single. In all old-world *Quadrumana* the umbilical vein is single, as in *Bimana*. Where any trace of vitellicle has been detected in *Quadrumana*, it has been very small.

§ 406. *Development of Bimana.*—The lining substance of the human uterus, when an ovum is impregnated, augments in thickness, fig. 570, and seems to degenerate into a pulpy spongy mass, into which the ovum sinks on entering the womb: its position is shown, diagrammatically, in fig. 572, B, *e*: but the special chamber in which, at first, it lies loosely, is exhibited in fig. 581: here, bristles are introduced at the orifices corresponding with those of the oviducts, and pass out at the beginning of the cervix uteri,

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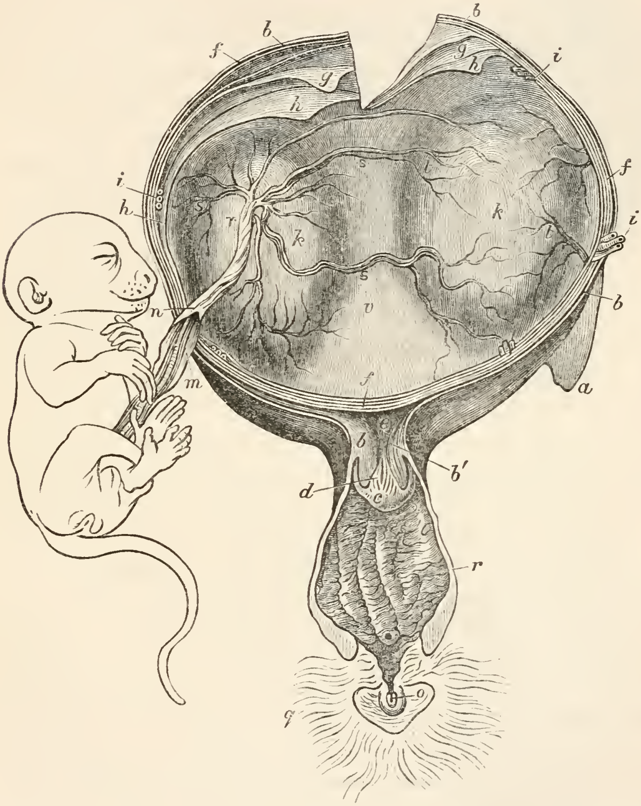
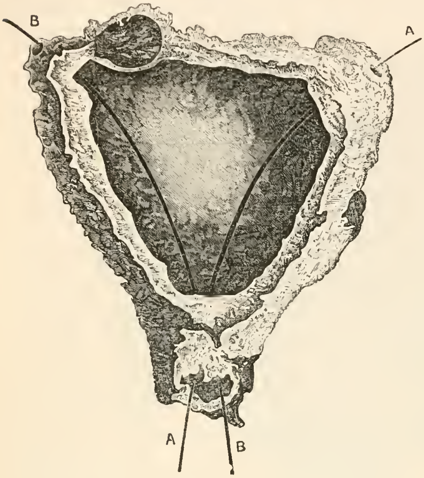


Impregnated uterus, placenta and fœtus, *Cercopithecus sabæus*. CCLXXVII″.

where the decidua ends. The utricular canals become dilated and tortuous, and are still lined (or formed) by epithelial cells: but formifaction is active in the production of diverse defined corpuscles from the 'granule' up to the colossal 'fibre-cells,' fig. 416.

At the fourth or fifth month the decidua becomes condensed to a thinner layer, and detached from the muscular wall of the uterus by a new, soft deposit, which takes on the utricular character of the original lining substance, and remains after parturition.

581

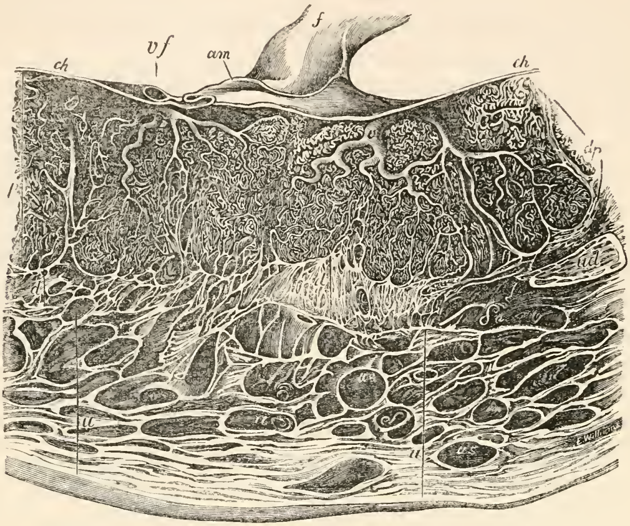


Decidual lining substance of human uterus, shed in abortion. CCXLVI''.

The primary changes of the impregnated human ovum have not been observed. It cannot be doubted that the germ-mass is due to the cleavage process. Whether the outer coat continues to be the hyalinion when the ovum passes into its deciduous nest; whether the hyalinion then gives place to an expanded 'animal' layer of the blastoderm; or whether this be superseded by the vascular layer of the allantois—are conjectural possibilities suggested by observed facts in lower Mammals, and awaiting proof. This is certain, that when the amnion is completed, the intestine formed, and the vacancy of the ventral walls contracted to an umbilicus, the remnant of the vitellicle is reduced to a crumpled yellowish subcircular corpuscle, 1½ line in diameter, adherent to the outside of the amnion, and connected with the intestine by a long filamentary omphalo-mesenteric pedicle, accompanied by a vitelline vein and arteries. The vascular layer of the allantois has formed, or organised, the chorion: its unvascular layer is disposed like a serous membrane between the amnion and chorion, and maintains a connection for a time with a filamentary urachus, expanding within the pelvis into a urinary bladder. The growing ovum pushes the free wall of its decidual chamber into the uterine cavity (traversed by the bristles in fig. 581), and, filling it, reduces it to a narrow 'hydroperionic space.' The layer of decidua so pushed in seems to be reflected upon the ovum, and is termed 'decidua reflexa' or 'decidua ovuli': the thicker layer lining the womb is the 'decidua vera,' or 'd. uteri.' Long and large villi extend from the chorion into the decidua, and at this period (latter half of the first month) there may be traced, upon its inner surface, orifices of canals that lead into the uterine sinuses. The maternal blood already flows freely into the maternal chamber, and, after passing everywhere among the villi, is returned into the uterine veins. Thus a temporary placenta is formed analogous to the diffused form described in *Cetacea* and certain *Ungulata.* But soon the villi increase in length and size on the side of the chorion next the uterine wall, and decrease on the opposite side, which becomes smooth or bald; this, pressing upon the hydroperionic space, finally obliterates it, and arrests the flow of blood to that part of the circumference of the chorion. On the other part, next the uterine wall, a circular space is left, like a meniscus, round the circumference of which decidual growths pass from the uterus to attach themselves to the chorion, and form the margin of the true placenta; then, as the uterus enlarges, concomitantly with the expansion of the ovum, a decidua, called 'serotina,' is reproduced to form the basis of the maternal placenta, from which septal processes extend grouping the developed villi of the chorion, or fœtal placenta, into lobes. With the further growth of the placenta these lobes become usually more and more confluent, the fœtal also becomes more blended with the maternal part, until a structure results, as exposed in the section of the placenta and placental area of the uterus, fig. 582.

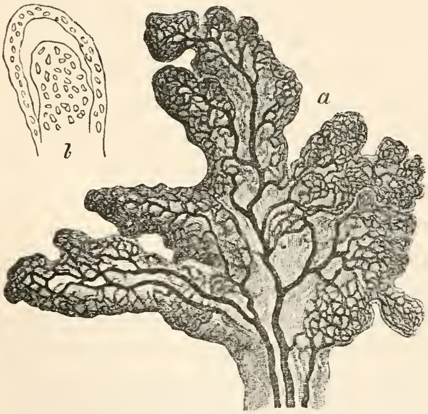
The line, *u, u,* indicates the extent of the uterine wall; *ud* is 'decidua serotina;' *dp* deciduous septa, *p* placenta, *ch* chorion, *am* amnion, *vf* fœtal blood-vessels, *v, v* villi, *us* uterine venous sinuses, *a, a* uterine 'curling arteries.' The two fœtal arteries (allantoic or umbilical) communicate by a cross branch near the placental end of the funis, beyond which they spread in large branches over a considerable part of the free surface of the placenta, and subdivide dichotomously in the chorion, two or three times, before they penetrate the placental substance to ramify in the villous processes called 'placental tufts.' The stems of these are rooted in the chorion, and are tough and fibrous. Each tuft consists of an outer coriaceous and an inner soft tissue: a distinction which is continued to the terminal villi, fig. 583, as shown in the end of one from a stale placenta in which the inner vascular substance had shrunk away from the outer epithelial sheath, ib. *b.* From the third to the sixth month the arteries of the villi terminate in a rich capillary plexus at their periphery, ib. *a.* The veins from the capillaries unite to accompany the arteries along the centre of the villi, emerge from the substance of the placenta, about sixteen in number, with a less tortuous course than the arteries, converging to the root of the funis and ultimately uniting to form a single umbilical vein. After the sixth month the capillaries of the villi begin to disappear. The uterine arteries, fig. 582, *a*, about the size of a crow-quill in the later months, have a tortuous or curly course, and they ultimately pour their blood into the large venous sinuses, ib. *us*. These are most numerous upon the inner side of the decidua constituting the uterine surface of the placenta, passing obliquely through that layer into the uterine wall; some extend into the decidual septa, and some lead to the marginal channel termed the 'circular sinus'.

582



Section of human uterus and attached placenta at 30th week of gestation. CCXLVI''.

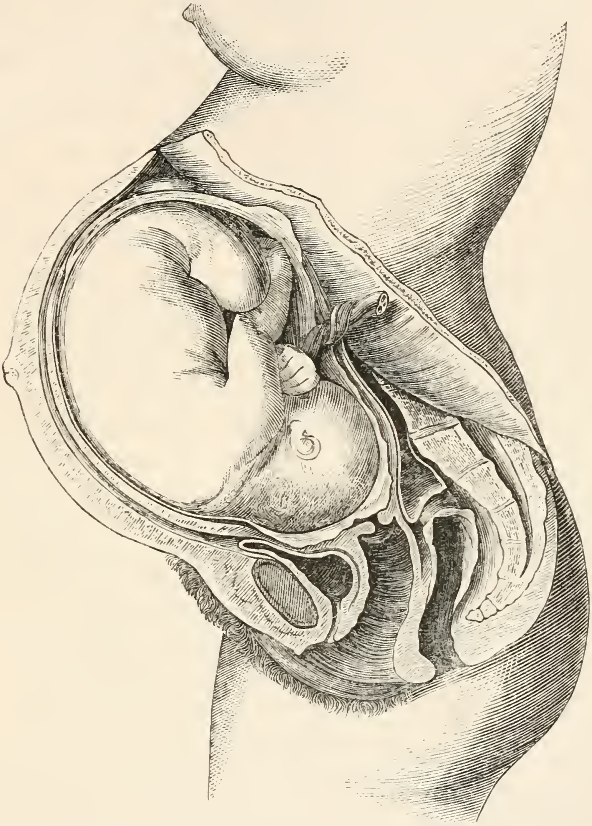
583



Villi of tuft of fœtal part of placenta, at six months; magn. CCXLVI''.

In *Bimana* the placenta is relatively thicker and smaller than in *Quadrumana,* and is attached to a relatively more contracted area of the womb than in the tailed kinds.

584



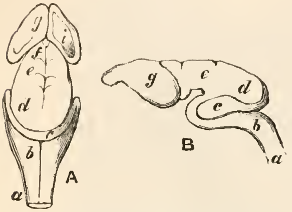
Fœtus in utero, at the end of gestation; Human. CCXLVI''.

At the end of pregnancy the fore part of the abdomen is occupied by the uterus, fig. 584, the fœtus being commonly carried in the position there represented.

Nine months is the usual period of gestation in *Bimana*; but occasionally birth occurs at the eighth or even the seventh month, and the infant has been reared.

§ 407. *Development of Mammalian Brain.*—Limitation of space compels me to conclude this chapter with a brief notice of some of the more specially mammalian modifications of fœtal formation.

585



Brain of new-born Kangaroo; magn. 5 times. LXXV'.

The initial steps in the development of the nervous system of the Mammal closely correspond with those of the Reptile and Bird (vol. II. figs. 39, 135). The brain of the Kangaroo, a fortnight after birth, fig. 585, A, B, has not advanced beyond the condition of that of the embryo chick at the fourth day of incubation. Hanging motionless from the teat, like a fœtus from the navel-string, its cerebellum, ib. A, *c*, has not transcended the filmy fold of the cold-blooded saurian type; but expansion has begun at the base, B, *c*, of what are destined to become the mammalian lateral lobes.[1] The mesencephalon constitutes the main part of the brain: it is a large oblong vesicle, in which the optic lobes, ib. *d*, begin to be faintly marked off from the 'thalamal' part, *e*, overlying the crura cerebri. No organ of the young air-breathing Marsupial offers a greater contrast to that in the new-born placental Mammal than the retarded brain. In form it has got no further than that in the six weeks embryo sheep, but it is firmer in texture: gradually advancing along the Mammalian route, its development stops at a certain point. The superincumbent mass of cerebellum expands, accommodating its ultimate sheet of grey matter to the cranial chamber by transverse folds; and the lateral lobes stretch out into appendicular lobes, fig. 74, *e*. The optic lobes, in their growth, show no disposition to special lateral expansion and divergence (as in the bird, vol. II. figs. 42, 44), but swell into a pair of closely united hemispheres: the special mammalian addition is due to growth of neurine in the fore part of the 'valvula vieussenii' between the 'processus a cerebello ad testes,' which proceeds in Marsupials and all higher Mammals to add a second pair of tubercles ('testes' of anthropotomy) to the optic lobes ('nates' ib.). Into the cavity of the small hemispheric vesicles, fig. 585, *g*, *i*, the 'corpora striata' first bulge, and are soon followed by the hippocampal protuberances: with the former appear the transverse fibres of the anterior commissure, with the latter those of the hippocampal commissure. In Marsupials this is the sole addition to the transverse connections of the hemispheres common to lower Vertebrates: in Placentals, development of the commissural system proceeds to establish the supraventricular mass called 'corpus callosum.' But this is not necessarily accompanied by increased development of the cerebral lobes: the *Lissencephala* retain the lyencephalous superficies and proportions of the superincumbent masses of the prosencephalon. In the *Gyrencephala* these extend backward over the mesencephalon, and more or less of the cerebellum: from the lissencephalous condition transitorily shown by the human fœtus, fig. 125, the middle lobes, *d*, progressively grow into posterior ones, finally extending in *Archencephala* above and beyond the cerebellum, and acquiring the proportions and conditions of the posterior horns of the lateral ventricles and 'hippocampi minores' peculiar to and characteristic of the human brain.

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[1] LXXV'. pl. vii. figs. 11, 12.

§ 408. *Development of Mammalian Skeleton.*—The notochord early begins to show a series of dilatations answering to the later intervertebral spaces.[1] In the embryo head the blastemal coverings of the piers of the anterior cephalic hæmal arch (maxillaries) project freely, and appear as processes of the second (mandibular) arch: only the proximal parts of the third (hyoidean) arch are indicated by indentations, and the piers do not project freely. The chief developmental mammalian modification arises from the proximity of the precociously and rapidly growing appendages of the acoustic sense-organ ('ossicula auditûs') peculiar to the class: accompanied with a reduction of the proximal part of the mandibular arch to the support of the tympanum, and with a slight forward dislocation of the distal part of the arch. In Monotremes the tympanic (vol. ii. fig. 197, 28), large and well-ossified in the blind and naked young, has its growth arrested and diverted by the rapid and excessive growth of the malleus, which becomes anchylosed to the tympanic by its long process, *o*, whilst its 'manubrium,' *c*, gives attachment to the radiating fibres of the muscle of the ear-drum. The incus, *b*, is represented by a small and early confluent epiphysis. The columelliform stapes *d* is relatively small as in other Mammals. The base of the mandible extends inwardly to join the tympanic, and its articular surface is also extended outward, as in the Bird: the conformity with the Chick in the relations of both tympanic and mandible to the primary and transitory cartilaginous hæmal arch, and the plain homology of the ossicle, *b*, with the better developed incus of higher Mammals, are decisive against the revival of Reichert's ill-founded conclusion as to the homology of the Mammalian incus with the os quadratum (tympanic) of Birds and Reptiles. In the mammary Kangaroo the tympanic, embracing by an upper bifurcation the hind part of 'Meckel's cartilage,' develops a convexity below adapted to the inner side of the ascending ramus of the mandible, and a smooth joint-like surface, fitting into the upper concavity of the inverted angle, answering to the persistent inner articular part of the condyle in birds.[1] The fourth hæmal arch is close to the occiput in the Ruminant, and retrogrades as the neck is lengthened out by vertebræ interposed between head and chest. It retains, in Cetaceans, almost the typical position exemplified in Fishes.

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[1] CCCXXIII″.

The common ossification of articular ends of bones from centres distinct from that of the shaft is a mammalian developmental characteristic. The ultimate confluence of the 'epiphyses' (vol. ii. p. 297) with the 'diaphysis' indicates maturity of growth: but in this relation there are differences in the same skeleton and in different species. In Man the epiphyses of the limb-bones toward which the 'arteriæ nutritiæ' run (p. 619) first coalesce with the shaft; those at the distal end of the humerus and proximal ends of the two antibrachials, e. g., at puberty, those at the opposite ends of the same bones at the twentieth year. The proximal epiphysis of the femur coalesces about the eighteenth year, the distal one at the twentieth; the proximal epiphysis of the tibia joins the shaft about the twenty-fifth year, the distal epiphysis five years earlier. The epiphyses of the vertebral bodies coalesce about the twenty-first year in *Bimana*, but they continue distinct for a much longer proportional period of life in *Cetacea*. Epiphyses and short bones of limbs, those of the carpus and tarsus, e. g., continue cartilaginous some time after the shafts of the long bones are ossified, as shown in fig. 586. This figure also exemplifies the early manifestation of ordinal characters; the inner digit of the pelvic limb, in the fœtal Monkey (*Cercopithecus sabæus*) already shows by its relative shortness and divergence from the others that it is destined to oppose them, and to terminate the member by a prehensile *hand*: while, from the earliest manifestation of the digits of the same limb in the human embryo, the 'hallux' by its proportions and parallelism with the other toes indicates the destination of the answerable part to become a plantigrade *foot*, perfected to sustain and move the body of an erect Biped.

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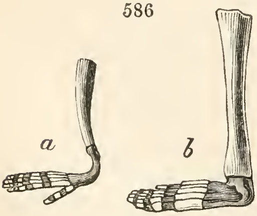

From fœtal lower limb; nat. size. *a*, Monkey. *b*, Man. CCLXXVII″.

§ 409. *Membrana pupillaris.*—The differences in degree of individual development attained at birth parallel, in Mammals, those in Birds expressed by the terms *altrices* and *præcoces* (vol. ii. p. 265). The hoofed quadruped enters the world with the use of all its senses; in a few hours can follow the dam, and keep pace with her if she sees cause for flight: the feline is born blind and helpless; some days elapse ere the commissure of the eyelids is unsealed. Corresponding steps in the human organ of vision are completed before birth. At the fifth month of fœtal life the pupillary aperture is very wide, and is occupied by a rich layer of looped capillaries supported by a production of the membrane of the aqueous humour, fig. 587, A. As the iris is developed the pupil contracts and the vessels of the pupillary membrane diminish in size and number; so that at the eighth month only a few vessels are seen crossing the transparent membrane, as at B. Shortly before birth, or for a week after, a mere shred of the membrane may be detected, as in C and D, and these are soon absorbed.

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[1] CCXCV″. p. 727.

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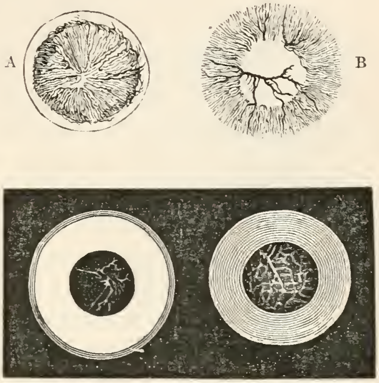

Membrana pupillaris, Human fœtus. CV″.

§ 410. *Fœtal circulation.*—The early stages in the development of the vascular system closely correspond, in Mammals, with those in Birds (vol. ii. p. 263, fig. 136): the steps in the establishment of the aortic arch, with their relations to conditions of primary branches characteristic of species, and to rare anomalies, have been explained at pp. 534–537; here, therefore, there only remain a few words to be said of the fœtal characters of the circulating system.

The blood of the fœtus, after passing through the ramifications of the allantoic arteries, fig. 588, U′, U, in the placenta, returns by the allantoic vein, *u*. This, on entering the abdomen, passes above and superficial to the duodenum, within the peritoneal fold called 'suspensory ligament' of the liver, to the great fissure of that organ, where it carries part of its blood directly, by the 'ductus venosus,' *d*, to the post-caval, V, and part is distributed by the branches of the portal vein, L, through the substance of the liver, and is then conveyed by the hepatic veins, *l*, into the general current of the returning blood. Thus, the right auricle of the heart, *h′*, receives not only the blood which has circulated through the body of the fœtus, but also that which has passed through the placenta, consequently a mixture of venous and arterial blood; — the blood in the precaval, *v**, being entirely venous, that in the post-caval, V, being mixed. A part of this blood so accumulated in the right auricle passes into the left auricle, *h*, by the 'foramen ovale,' *f*, in the septum auricularum, and it is chiefly the blood from the post-caval which takes that course. The rest of the blood entering the right auricle passes into the right ventricle, H′, and thence into the pulmonary artery: but very little blood is sent to the collapsed lungs, for a passage of communication continues from the pulmonary artery into the descending aorta by retention of part of the third primitive arch, fig. 420, forming the 'ductus arteriosus,' fig. 588, D; thus the greater mass of the blood, which in the adult would have proceeded to the lungs, is in the fœtus immediately transmitted to the aorta, A. This, after its origin from the left ventricle, delivers almost all the blood expelled by the contraction of that cavity into the carotid and subclavian arteries, while the ductus arteriosus passing between the trunk of the pulmonary artery and the descending aorta directs the blood which passes through the right ventricle to the lower regions of the body. In this manner the upper regions are supplied with the most arterialised part of the blood from the left side of the heart and aorta, while the purely venous blood is propelled from the right ventricle through the pulmonary artery and ductus arteriosus into the descending aorta, and consequently into the lower part of the body, and by the allantoic arteries to the placenta. The circulation in the fœtal Mammal thus offers a close and interesting analogy to that in adult Crocodilian Reptiles (vol. i. p. 512).

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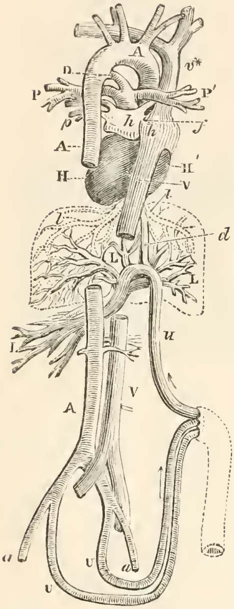

Fœtal circulation seen from behind.

The foramen ovale in the septum of the auricles, the ductus arteriosus passing from the pulmonary artery to the aorta, the ductus venosus leading from the allantoic vein to the post-caval, and the allantoic (umbilical) vein and arteries, are the structural peculiarities of the mammalian fœtal circulating organs. These passages are all closed up, and the allantoic vessels obliterated at the navel, after pulmonic respiration is established at birth.

§ 411. *Definition of Male and Female Organs.*—In the Mammalian as in other vertebrate embryos the urogenital parts, before showing distinction of sex, appear in a seemingly more complex or multiplex condition than when perfected at a later stage. As in fig. 589, we recognise the basis of the true or persistent kidneys, *a*, with their duct, *e*; the antecedent deciduous kidney, or 'Wolffian' body, *b*, is here on the wane, with its excretory duct, *f*; the beginning of the essential genital gland is marked *c*, the adrenals, *d*, and the tubes called 'ducts of Müller,' *g*.

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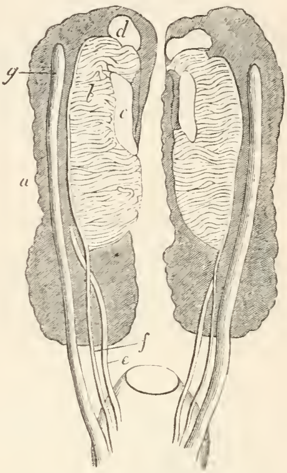

Urogenital parts of Embryo. LXXIV.

In the male Mammalian embryo the duct, *f*, becomes connected by a white granular process with a similar one from the gland, *c*, on the inner side of the Wolffian body: by the union of these offshoots is formed the epididymis, and the gland *c* can then be determined as the testis: the ducts, *g*, shrink and are metamorphosed into the protometra. In the female there are not such converging growths between the duct *f* and the gland *c*: the duct *f* shrinks with the Wolffian body, and is reduced to the remnant recognisable in the adult as a 'canal of Malpighi.' But the tube, *g*, rises above the Wolffian body, expands as at *e*, fig. 590, and afterwards opens at *f*. As the Wolffian body atrophies, the duct, *f*, fig. 589, begins to be tortuous in the male, and becomes 'spermduct'; while *g* shrinks: but, in the female, *g* widens, and becomes, as in fig. 591, oviduct, *c*, and uterine horn, *b*: but the distinction is late in the Ruminant embryo.

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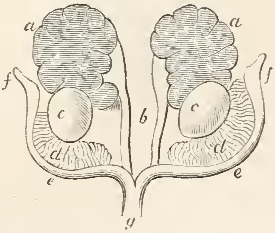

Urogenital organs, fœtal Sheep. CCCXXI''.

In the human embryo at three months, the lower or distal portions of *c*, *c*, fig. 592, have dilated and become fused into the uterus, *a*, which still shows the indent of its primitive division. The remnant of the Wolffian body, *e*, *e*, is long recognisable as the 'parovarium.' The ovaries, *d*, *d*, are smooth and elongate; the round ligaments, *b*, *b*, are relatively large.

In certain malformations more or less of the primitive conditions of the genital organs are retained, and give rise to 'hermaphrodite' states of the parts. In fig. 593, *a*, *a*, are the testes with which the ducts, *f*, in fig. 589, had effected their union, and become 'vasa deferentia,' fig. 593, *d*, *d*: *b* is a combination of epididymis with the abdominal ends of the 'mullerian ducts,' *g*, figs. 589, 593, here continuing closed and having become adherent to the mass including a remnant of the Wolffian body. Development of the mullerian ducts has, however, proceeded to a definition of the oviduct or fallopian tube, fig. 593, *g*, and of the uterine horn, *f*, *f*, with the body of the uterus and vagina, *e*: it is normally reduced to 'protometra,' in fig. 525, *c*.

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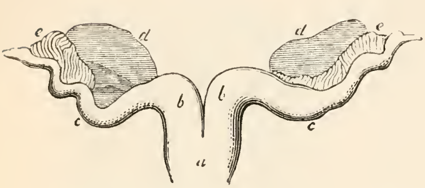

Female organs, fœtal Deer. CCCXXI''.

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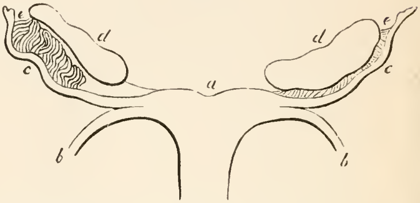

Female organs, Human fœtus of three months. CCCXXI''.

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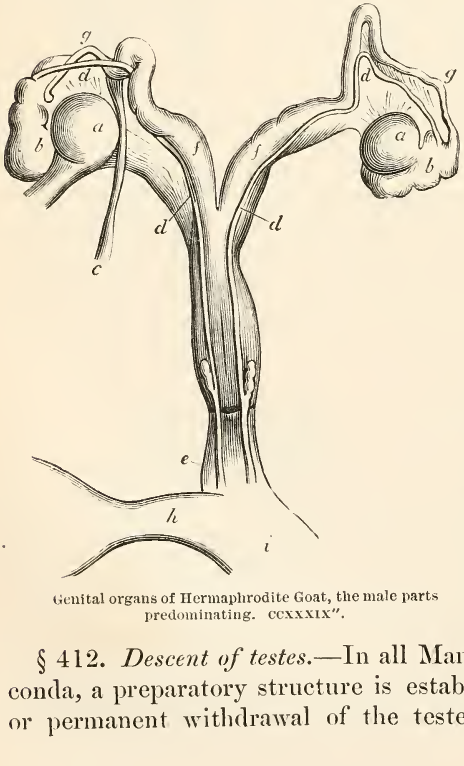

Genital organs of Hermaphrodite Goat, the male parts predominating. CCCXXXIX''.

§ 412. *Descent of testes.*—In all Mammals, save the true testiconda, a preparatory structure is established for either periodical or permanent withdrawal of the testes from out the abdomen.

In the human fœtus this structure, called 'gubernaculum testis,' fig. 594, consists of a central axis of soft gelatinous substance rife with nucleate cells and surrounded by fibrous tissue, which soon exhibits the striped characteristic of voluntary muscle. Some of these fibres rise from the bottom of the scrotum, 10, and traverse the abdominal ring, 6, here diagrammatically indicated in Curling's excellent article ccxlii″; by 'Poupart's ligament,' 7, 7: a second series of fibres, 9, arise from 'Poupart's ligament,' and, with the pubic fibres, 8, seem in many *Lissencephala* to be an inverted part of the internal oblique and transversales muscles: the whole, inclosed by aveolar tissue, and connected by a fold of peritoneum to the psoas muscle, extends to the testis, 2. This 'gubernaculum' shrinking or contracting, or both, between the fifth and six months of human gestation, draws the testis from below the kidney, 1, to the abdominal ring, 6, where it rests to the end of the seventh month. During the eighth month it traverses the inguinal canal, and by the end of the ninth month has reached the scrotum, where it is commonly found at birth, with the remnant of the scrotal part of the gubernaculum, fig. 595, 2. The iliac, 4, and the pubic, 5, portions of the muscular tissue have now become the 'cremaster': the bag of peritoneum, 3, 3, carried out with the testis, 1, is converted, by obliteration of the neck, into 'tunica vaginalis testis.' In scrotal Mammalia, as a rule, it remains pervious, and it communicates widely with the abdomen in periodical testiconda.

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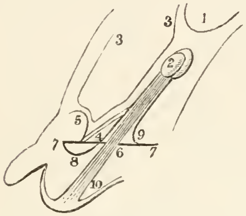

Diagram of the gubernaculum and testicle previous to its descent. ccxlii″.

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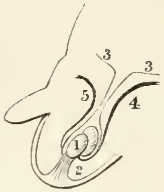

Diagram of the testicle immediately after its arrival in the scrotum. ccxlii″.

CHAPTER XXXIX.

MAMMARY AND MARSUPIAL ORGANS.

§ 413. *In Monotremata.*—In a female Ornithorhynchus, shot in December, and of which the 'corpora lutea' indicated that she had recently brought forth young, the mammary glands formed an oblong flattened mass on each side of the ventral parietes of the abdomen. Each gland was composed of between one hundred and two hundred elongated subcylindrical lobes, fig. 596, converging to a small oval areola, fig. 597, in the abdominal integument, situated between three and four inches from the cloaca, and about one inch from the medial line. The lobes are rounded and enlarged at their free extremities, and become narrower to about one-third from the point of insertion, where they end in slender ducts, fig. 596, *a*. Almost all the lobes are situated at the outer side of the areola, and consequently converge toward the mesial line of the abdomen: in fig. 596 they are exposed by reflecting outward the skin. Between the gland and the integument the panniculus carnosus is interposed, closely adhering to the latter, but connected with the gland by loose cellular membrane. This muscle is here a line in thickness, its fibres are longitudinal, and, separating, leave an elliptical space for the passage of the ducts of the gland to the areola. On the external surface of the skin, when the hair is removed, this areola can only be distinguished by the larger size of the orifices of the lacteal ducts, compared with those for the transmission of the hairs. The orifices of the ducts thus grouped together form an oval spot, five lines in the long and three in the short diameter. Neither in this nor any other of the many specimens in which I have dissected the mammary glands was the surface on which the ducts terminated raised in the slightest degree beyond the level of the surrounding integument.

In a full-grown female, killed in August, in which two enlarged ovisacs indicated the preparation of ova for impregnation, the mammary gland was reduced to the size given in fig. 598: diverging tracts of cellular sheaths with fat indicated a previous seasonal enlargement.

Mercury injected into the substance of a lobe diffused itself

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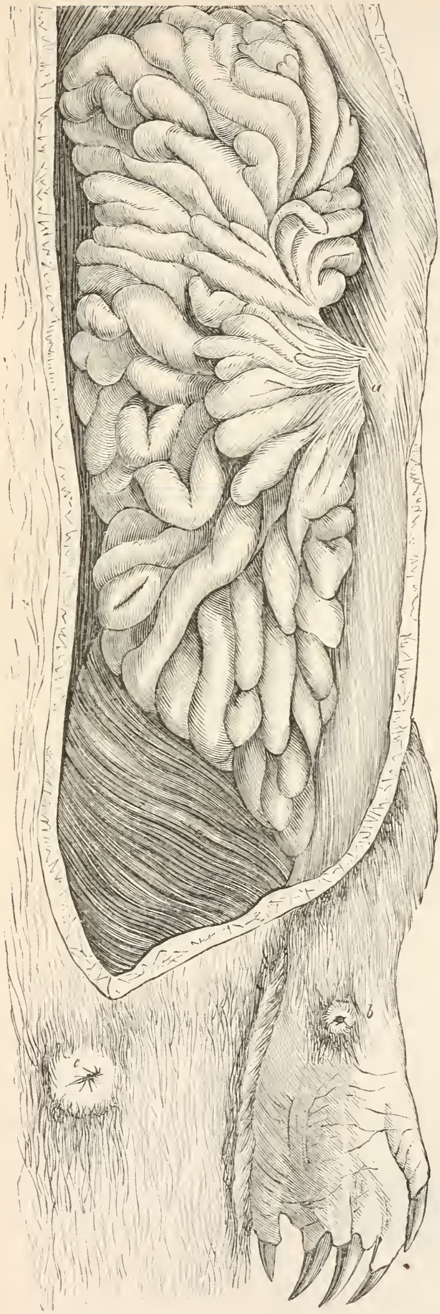
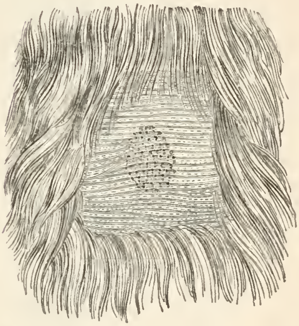


Mammary gland. Ornithorhynchus; nat. size. LXXXI′.

in minute globules through the parenchyma, and at a distance of an inch it entered a central duct, down which it freely ran to the areola, where it escaped externally from one of the minute orifices just described. This process was repeated on most of the lobes with similar results: the greater part of them terminated by a single duct opening exteriorly and distinct from the rest, but in a few instances the ducts of two contiguous lobules united into one, and in these cases the mercury returned by the anastomosing duct and penetrated the substance of the other lobe as freely as that into which the pipe had been inserted.

597



Mammary areola, Ornithorhynchus; nat. size. LXXVI′.

Some of the lobes injected by the reflux of the mercury through the duct, and of which it was more certain that the glandular structure

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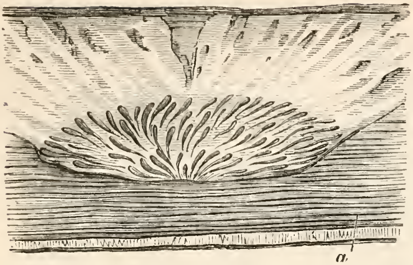
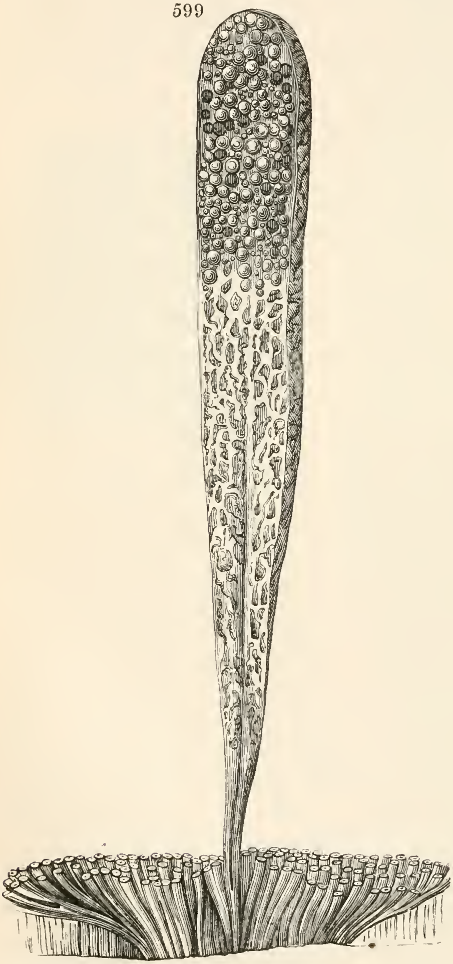


Mammary gland, Ornithorhynchus ; nat. size at non-breeding season. LXXVI′.

599



Terminal ducts, and lobe of mammary gland, injected ; twice nat. size. LXXVI′.

and not the cellular membrane was filled, were dried, and various sections were submitted to microscopical examination. At the greater extremity they are minutely cellular, the cells communicating with ducts elongating as the lobule grows narrower, dilating, and terminating in a larger central canal, or receptacle, from which the excretory duct is continued. On making a section of the corium through the middle of the areola the ducts are seen to converge to the external surface, but there is no inverted or concealed nipple at this part, as in the Kangaroo. Fig. 599 gives a magnified view of this section, with the section of one of the dried and injected lobules. On the first announcement, by MECKEL, of the existence of abdominal glands of the size and structure shown in fig. 596, it was objected, that they did not possess the characters of a true mammary gland, and that they resembled rather the clusters of elongated follicles situated on the flanks of Salamanders, and still more to the odoriferous scent-glands at the sides of the abdomen in Shrews, which are most active at the season of the rut.[1] I put this question to the test, first by showing the true structure of the mammary lobules, and next by comparing the relative size of the glands with the condition of the ovaria.[2] The abdominal scent-glands are present in both sexes, and become largest in the male Shrews: but, in the Ornithorhynchus the glands are confined to the female, and vary in degree of development at different periods in individuals of equal size, attaining an enormous development after gestation and being small at the rutting season. The secretion being conveyed outwardly by means of numerous long and narrow ducts indicates its fluid nature, and is contrary to the mode in which odorous substances are excreted. The excretory orifices are by no means extended over so wide a space, in proportion, as in the Shrew, but are collected into one which accords with the size of the mouth of the young animal, and this spot is situated in a part of the body convenient for the transmission of a lacteal secretion from the mother to her offspring.

Compared with an ordinary mammary gland, that of the Ornithorhynchus differs chiefly in the absence of the nipple, and, consequently, of the surrounding vascular structure necessary for its erection. But the remarkable modification of the mouth in the young Ornithorhynchus removes much of the difficulty which previously attached itself to the idea of the possibility of an animal with a beak obtaining its nutriment by suction. The width of the mouth in the smallest observed Ornithorhynchus, fig. 600, corresponds with the size of the mammary areola; and the broad tongue, extending to the apices of the broad, short, and soft jaws, fig. 601, with the fold of integument continued across the angle of the mouth, are all modifications which prepare us to admit such a co-adaptation of the mouth of the young to the mammary outlet of the parent as, with the combined actions of suction in the recipient, and compression of gland in the expellent, to effect this essentially Mammalian mode of nourishment.

The circumstances which first attract attention in these singular objects, fig. 600, are the absence of hair, the soft flexible condition of the mandibles, and the shortness of these parts in proportion to their breadth as compared with those of the adult. The integument with which the mandibles are covered is thinner than that which covers the rest of the body, and smoother, presenting under the lens a minutely granulated surface when the cuticle is removed, which, however, is extremely thin, and has none of the horny character which the claws at this period present. The margins of the upper beak are rounded, smooth, thick, and fleshy; the whole of the under mandible, fig. 601, *g*, is flexible, and bends down upon the neck when the mouth is attempted to be opened. The tongue, ib. *h*, which in the adult is lodged far back in the mouth, advances in the young animal close to the end of the lower mandible; all the increase of the jaws beyond the tip of the tongue, which in the adult gives rise to a form of the mouth so ill calculated for suction or application to a flattened surface, is peculiar to that period, and consequently forms no argument against the fitness of the animal to receive the mammary secretion at an earlier stage of existence. The breadth of the tongue in the larger of the young specimens was 3½ lines; in the adult it is only one line broader; and this disproportionate development is plainly indicative of the importance of the organ to the young animal, both in receiving and swallowing its food. The mandibles are surrounded at their base by a thin fold of integument, which extends the angle of the mouth from the base of the lower jaw to equal the breadth of the base of the upper one, and must increase the facility for receiving the milk ejected from the mammary areola of the mother. The oblique lines which characterise the sides of the lower mandible in the adult were faintly visible on the corresponding parts of the same jaw of the young animal: a minute ridge of the inner sides of these lines indicates the situations of the anterior horny teeth of the adult.

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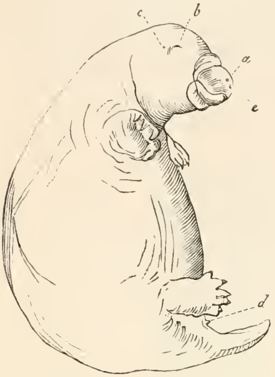
[1] XCVI''. p. 457.

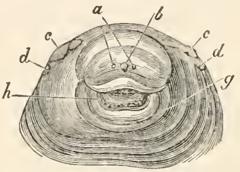
[2] LXXVI'.

600



Young Ornithorhynchus. LXXVIII′.

601



Head of young Ornithorhynchus. LXXVIII′.

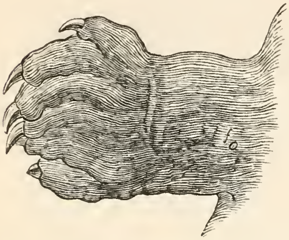
The exterior nostrils, ib. *a*, communicate with the mouth by the foramina incisiva, which are situated at nearly three lines distance from the end of the upper mandible, and are each guarded by a membranous fold extending from their anterior margin: the nasal cavity then extends backward, and terminates immediately above the larynx, the tip of the epiglottis extending into it, and resting upon the soft palate.

On the middle line of the upper mandible and a little anterior to the nostrils there is a minute fleshy eminence lodged in a slight depression, fig. 601, *b*. In the smaller specimen this is surrounded by a discontinuous margin of the epidermis, with which substance, therefore, and probably (from the circumstance of its being shed) thickened or horny, the caruncle had been covered. It is a structure of which the upper mandible of the adult presents no trace, and is obviously analogous to the horny knob which is observed on the upper mandible in the fœtus of aquatic and gallinaceous Birds. I do not, however, conceive that this structure is necessarily indicative of the mandible's having been applied, under the same circumstances, to overcome a resistance of precisely the same kind as that for which it is designed in the young Birds which possess it. The shell-breaking knob is found in only a part of the class; and although the similar caruncle in the Ornithorhynchus affords a curious additional affinity to the *Aves precoces*, yet, as all the known history of the ovum points strongly to its ovo-viviparous development, the balance of evidence is still in favour of the young being brought forth alive.

The situation of the eyes, ib. *c*, was indicated by the convergence of a few wrinkles to one point; but when, even in the larger of the two specimens, these were put upon the stretch, the integument was found entire, and completely shrouding or covering the eyeball anteriorly. The fact is of importance to the question of the mammiferous character of the Ornithorhynchus. For on the supposition of the young animal possessing locomotive faculties, which would enable it like the young gosling, immediately after birth or exclusion, to follow the parent in the water, and there to receive its nutriment (whether mucous or otherwise), the sense of vision ought certainly to be granted to it in order to direct its movements. The privation of this sense, on the contrary, implies a confinement to the nest, and a reception on land of the mammary secretion of the parent. The auditory orifices, ib. *d*, are situated about a line behind the eyes. The general form of the body and the cartilaginous condition of the bones of the extremities equally militate against the young Ornithorhynchus possessing, at this period of its existence, active powers of swimming or creeping. The head and tail are closely approximated on the ventral aspect, requiring force to pull the body out into a straight line; and the relative quantity of integument on the back and belly shows that the position necessary for the due progressive motions is unnatural at this stage of growth.

The toes on each of the four feet were completely formed, and terminated by curved, conical, horny claws; but the natatory fold of membrane of the fore foot had not the same proportional extent as in the adult, and the spur of the hind foot did not project beyond its socket in either specimen. In the smaller one, which was a male, it presented the form of an obtuse papilla; while in the larger specimen, although a female, it was more plainly developed and more pointed, fig. 602, *f*. This circumstance is in exact accordance with the known laws of the development of sexual distinctions, especially of those of secondary importance, such as beards, manes, plumes, horns, tusks, spurs, &c., which do not avail in distinguishing the sexes till towards the period of puberty.

602

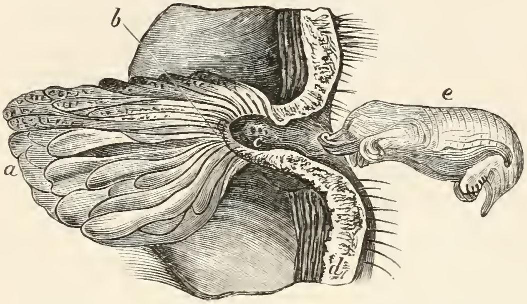


Hind-foot and spur, young female Ornithorhynchus; mag. LXXVIII′.

In the *Echidna hystrix* the mammary glands resemble in structure and position those of the *Ornithorhynchus*: but the ducts, when the gland is functionally developed, open into a small tegumentary pouch, fig. 603, *c*. The gland, ib. *a*, is of a flattened, subelliptic form. The lobules converge toward the mesial line, in their course to terminate in the fundus of the pouch. Each lobe is a solid parenchymatous body; the duct is more directly continued from a canal which may be traced about halfway toward the fundus of the lobule; the canal gives off numerous short branches from its circumference, which subdivide and terminate in clusters of subspherical 'acini' or secerning cellules. The structure is on the same general plan as that of the mammary glands in higher Mammals, but the cellules are proportionally larger. Each gland consists of about 100 long, narrow, flattened lobes, obtusely rounded at their free ends; they are surrounded by a loose capsule of cellular tissue, and lie between a thick 'panniculus carnosus,' adherent to the abdominal integument, ib. *d*, and the 'obliquus externus abdominis' muscle, on a plane exterior or 'lateral' to the pouch. On each side of the abdominal integument, about two inches in advance of the cloaca, and about three inches and a half from the base of the tail, is the aperture, which is longitudinal and directed towards the median line. The skin of the abdomen, where it begins to be inverted, loses thickness, and at the fundus of the pouch, ib. *c*, is only half as thick as where it overspreads the abdomen.

I have not hitherto met with any trace or beginning of such abdominal pouches in the various *Ornithorhynchi* in which I have had occasion to note different phases of the development of the ovaria and mammary glands. A warm-blooded air-breather, compelled to seek its food in water, could not safely carry the progeny it had brought forth in a pocket beneath its body during such quest: all observers have noted the nest-making instinct of the *Platypus*, and in such temporary and extraneous structures only have the young been hitherto found.

603



Mammary gland, pouch, and young. *Echidna Hystrix.* CCCXXII″.

The question remains, whether the marsupial pouches of the *Echidna* increase with the growth of the young? It is certain that they only commence with the growth or enlargement of the mammary glands preliminary to birth. In the young specimen of female *Echidna* in which the glands were first discovered[1] their ducts opened upon a plane surface of the abdominal integument. In a nearly full-grown unimpregnated female there was also a total absence of inflected folds of the integument where the mammary ducts terminate. Some movement, perhaps, of these ducts in connection with the enlargement of the mammary lobes, under the stimulus of preparation for a coming offspring, may, with associated growth of the abdominal integument surrounding the areola, be amongst the physical causes of the first formation of the pouch.

The young *Echidna*, ib. *e*, resembles the new-born Kangaroo in the proportions of the limbs to the body, in the inferior size and development of the digits of the hinder pair, and in the feeble indication of eyes or eyelids. But the mouth is proportionally wider, and has the form of a transverse slit; it is not circular. Upon the upper lip, in the midline between the two nostrils, is a small protuberance, corresponding to that in the young of the *Ornithorhynchus paradoxus,* and wanting the cuticle. The tongue is broad and flat, extending to the 'rictus oris,' but very short in proportion to that of the parent, and of a very different shape. The tail is much shorter than in the young Kangaroo, and shows as much proportional size as in the full-grown *Echidna,* in which it is a mere stump concealed by the quills and hair. The head is proportionally longer and more slender in the marsupial fœtus of the *Echidna* than in that of the Kangaroo, and already, at this early period, foreshows the characteristic elongation and attenuation of that part in the mature animal. The form of the mouth, as a transverse slit, is a good monotrematous character of the young at that period, since in all true or teated marsupials the mouth of the mammary fœtus has a peculiar circular and tubular shape. A scarcely visible linear cicatrix at the middle of the lower part of the abdomen is the sole trace of umbilicus. A bifid, obtuse rudiment of penis or clitoris projects from the fore part of the single urogenital or cloacal aperture, and in advance of the base of the tail-stump. Of the brain, the largest part is the mesencephalon, chiefly consisting of a vesicular condition of the optic lobes.

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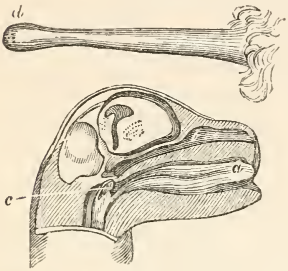
[1] CCCXXIII″. p. 179.

The fore limbs, in their shortness and breadth, foreshow the characteristics of those of the parent, which may be said, indeed, to retain in this respect the embryonic character with superinduced breadth and strength. The digits have already something of the adult proportions, the first or innermost of the five being the shortest, the others of nearly equal length, but graduating shorter from the third to the fifth; each digit is terminated by a claw: in the hind limb, the second is already the strongest and longest, the rest more rapidly shortening to the fifth than in the fore leg; the innermost, agreeably with the law of closer retention of type in the embryo, though the shortest of the five, is less disproportionally so than in the adult. The young nestles its head and fore-limbs within the marsupial fossa, clinging by its precocious fore claws to the skin or hairs of that part, and imbibing by its broad, slit-shaped mouth the nutritious secretion as it is pressed by the muscles acting upon the gland from the areolar outlets of the ducts.

§ 414. *In Marsupialia.*—In Marsupials the mammary glands have a more compact form and minutely conglomerate structure than in Monotremes. They are developed on each side the linea alba at the back of the marsupial depressions, or of the pouch; they are not fewer than two on each side (*Macropus, Hypsiprymnus, Phalangista, Petaurus, Phascolarctos, Phascolomys*); nor more than thirteen, six on each side and one midway (*Didelphys virginiana*). The follicles, from the inner surface of which the milk-cells are detached, are cylindrical in shape, $\frac{1}{30}$th in. in diameter; grouped in clusters of from ten to twenty on short, slender ducts, which enter the sides of larger canals, these uniting to form four or six conical dilatations, from the apices of which as many slender ducts pass to the apex of the nipple. This is peculiar for its length and slenderness when in use; but in the young and virgin Marsupial it is much shorter, and lies at the bottom of an inverted part of the skin of the back of the pouch, which becomes thin and is reflected over the end of the nipple, like the prepuce over the glans penis. The mammary glands enlarge after impregnation, and rapidly a day or two before uterine birth; when, partly from development of the nipple, partly from pressure of the enlarging gland, aided perhaps by the action of its compressor muscle, the sheath is everted and the nipple protruded. The preliminary infolding of the integument provides for the covering of the long nipple, which now is pendant at the back of the pouch. The compressor muscle arises from the ilium between or near to the lower attachment of the internal oblique and 'transversalis abdominis:' it passes out of the abdominal ring, bends round the marsupial bone, expands as it turns upward and inward behind the pouch to surround partly by carneous, partly by sclerous fibres, the mammary glands, dividing into as many insertions as there are glands of its own side. This muscle ('ileo-marsupialis' of Cuvier) is the homotype of the 'cremaster' in the male (p. 10); and the chief function of the ossification of the internal pillar of the abdominal ring (marsupial bone) is to add the power of the pulley to the compressor of the mammary gland, and effect the requisite change in the course of the contractile fibres. In the pouch of a young Marsupial the nipples are indicated by the inconspicuous orifices of the teat-sheaths. Once naturally protruded and the sheath everted, the nipples continue external. In the Kangaroo, after being some weeks in use, they present a slight terminal expansion, fig. 604, *d*. This part lies in a deep longitudinal fossa on the dorsum of the tongue, ib. *a*; and the originally wide mouth of the uterine fœtus is changed to a long tubular cavity, with a terminal sub-circular or triangular aperture, just large enough to admit the nipple, to which the young Marsupial thus very firmly adheres. In the new-born Opossum the oral pore is singularly minute, and the mother's nipple has an obtuse but not expanded termination.

In the Phascogale, in which the nipples are relatively larger than usual, and of a subcompressed clavate form, the young, when grown too large to be carried in the pouch, are dragged along by the mother, if she be pursued, hanging by the nipples.

604



Nipple, and head of Mammary Fœtus, Kangaroo.

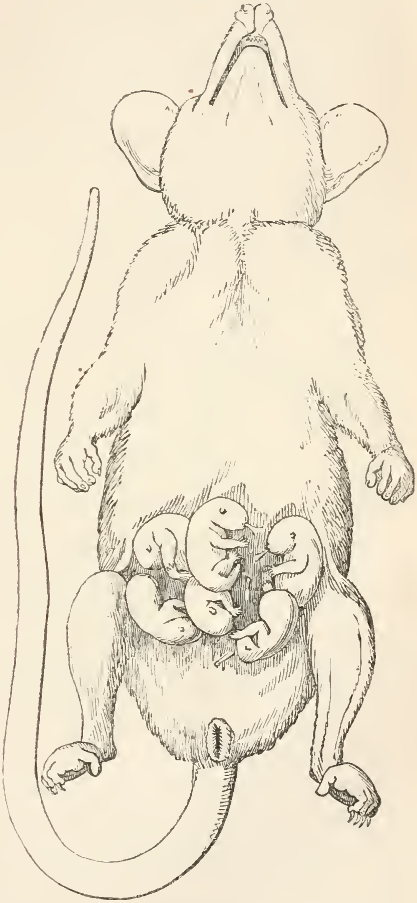
The number of nipples bears relation to that of the young brought forth at a birth; although, from the circumstance of the produce of two gestations being for a short time suckled simultaneously, the nipples are never so few. Thus the uniparous Kangaroo has four nipples, of which the two anterior are generally those in use: the Petaurists, which bring forth two young at a birth, have also four nipples; whilst the multiparous Virginian Opossum has thirteen nipples, six on each side and the thirteenth in the middle. In the *Didelphys Opossum* there are nine nipples, four on each side and one in the middle. The *Didelphys dorsigera* has the same number of nipples, although six is the usual number of young at a birth, fig. 605. In the *Phascogale penicillata* there are eight nipples arranged in a circle. The *Perameles nasuta* has the same number of nipples arranged in two slightly curved longitudinal rows; this Marsupial has three or four young at a birth. In all Marsupials the milk exudes from six to ten minute orifices arranged round the apex. The nipple increases in size with the growth of the mammary fœtus appended to it.

The development of the marsupial pouch is in an inverse ratio to that of the uteri and directly as that of the complicated vaginæ: thus it is rudimental in the Dorsigerous Opossum, which has the longest uteri and the simplest vaginæ: we may conclude therefore that the young undergo a greater amount of development in the womb in this and allied species; and here, if in any Marsupials, beginnings of a placental structure may be found. In the Kangaroos and Potoroos, which have the shortest uteri and longest vaginal tubes and cul-de-sac, the marsupial pouch is wide and deep. It is composed of a duplicature of the integument, of which the external fold is supported by longitudinal fasciculi of the panniculus carnosus converging below to be implanted in the symphysis pubis. The mouth of the sac is closed by a strong cutaneous sphincter muscle. The interior of the pouch is almost naked: a few hairs grow around the nipple: it is lubricated by a brown sebaceous secretion. The mouth of the pouch is directed forwards in most Marsupials: the reversed position in the Perameles, and Chæropus, where the mouth is directed towards the vulva, has been already noticed.

In the male Thylacine the rudimental marsupium is retained, in the form of a broad triangular depression or shallow inverted fold of the abdominal integument, from the middle of which the peduncle of the scrotum is continued. In the female the orifice of the capacious pouch is situated nearer the posterior than the anterior boundary of that receptacle.

From experiments and observations made at the London Zoological Gardens in 1833, I inferred that in the case of the Kangaroo the fore paws were not used for the transmission of the fœtus, but to keep open the pouch ready for its reception, the new-born animal being deposited therein by the mouth, and so held over a nipple until the mother had felt it grasping the sensitive extremity of the nipple.

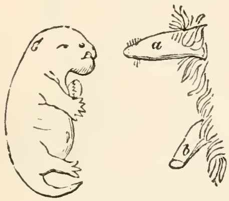
605



Female Didelphys dorsigera, with young and pouch.

This means of removal is consistent with analogy; dogs, cats, mice, all transport their young from place to place with the mouth. In the case of the Kangaroo, it may be supposed that the fœtus would be held by the lips only, not the teeth, on account of its delicate consistence. There is no internal passage from the uterus to the pouch:—the mouth of the vagina cannot be brought into contact with that of the pouch, either by muscular contraction in the living or by any force of stretching in the dead Kangaroo:—as the young was proved by the result of this experiment not to have the power of itself to regain the nipple, *à fortiori* we may conclude that it could not transfer itself from the vulva to the interior of the pouch and to the apex of the nipple:—the fore-paws of the Kangaroo would not so effectually protect the tender embryo from the external air as the mouth, nor so safely ensure its passage to the pouch, notwithstanding that they are adroitly used in grasping objects, being similar, in respect of the extent and freedom of motion of the digits, to the fore-paws of the Rodents.

606



New-born fœtus and left nipples, *Macropus major.*

The new-born Kangaroo (*Macropus major*, fig. 606), which I discovered in the pouch a few hours after uterine gestation, measured one inch from the mouth to the root of the tail, was quite naked, and covered by a thin semitransparent vascular integument; the place of attachment of the umbilical chord was obscurely indicated by a longitudinal linear cicatrix. The fore-legs were longer and stronger than the hind ones, and the digits were provided with claws; the toes were developed on the hind-legs; the body was bent forward; and the short tail tucked in between the hind-legs. This little animal breathed strongly, but slowly: no direct act of sucking could be perceived. Such, after a gestation of thirty-eight days, is the condition of the new-born young of a species of Kangaroo, of which the adult, when standing erect on his hind-feet and tail, can reach to the height of seven feet.

It has greater powers of action than the same sized embryo of the sheep; but less than has the new-born young of the rat. For, although it is enabled by the muscular powers of the 'orbicularis oris,' and those of the precociously-developed tongue, to grasp and adhere firmly to the nipple, it seems unable to draw all the needed sustenance therefrom unaided. And here the modified 'cremaster' comes into play, being adapted to inject the milk into the small feeble prematurely-born creature's mouth. One cannot suppose that its efforts at suction should always and exactly coincide with the mother's act of injection. And we find, in fact, provision for the required special relation of the larynx to the posterior nares. The epiglottis and arytenoid cartilages are elongated and approximated, and the rima glottidis is thus situated at the apex of a cone-shaped larynx, fig. 604, *c*, which projects into the posterior nares, where it is closely embraced by the muscles of the soft palate. The air-passage, *b*, is thus completely separated from the fauces, and the injected milk passes in a divided stream on either side the larynx to the œsophagus.

Thus aided and protected by modifications of structure, both in the system of the mother and its own, designed with especial reference to each other's peculiar condition, and affording, therefore, the most irrefragable evidence of creative foresight, the small offspring of the Kangaroo continues to increase, from sustenance exclusively derived from the mother, for a period of about eight months. During this period the hind-legs and tail assume a great part of their adult proportions; the muzzle elongates; the external ears and eyelids are completed; the hair begins to be developed at about the sixth month. At the eighth month the young Kangaroo may be seen frequently to protrude its head from the mouth of the pouch, and to crop the grass at the same time that the mother is browsing. Having thus acquired additional strength, it quits the pouch, and hops at first with a feeble and vacillating gait, but continues to return to the pouch for occasional shelter and supplies of food till it has attained the weight of ten pounds. After this it will occasionally insert its head for the purpose of sucking, notwithstanding another fœtus may have been deposited in the pouch; for the latter attaches itself to a different nipple from the one which had been used by its predecessor.

Dr. Meigs [1] reckons the utero-gestation of a female *Didelphys Virginiana*, which bred in captivity, as extending from the 18th February to the 7th March—a period of seventeen days [2]—when she brought forth thirteen young, which were found attached to as many nipples. The mammæ began to enlarge four days prior to birth. On the 6th March she was observed to lay on her side with her nose turned inward between her legs towards the belly, and took scarcely any notice of her keeper's hand when introduced into the box: the transit of the fœtuses was probably in preparation or operation at this time. The young, observed on the 7th, and which were certainly not in the pouch on the 5th, and probably not until the night of the 6th, were naked, of a rose tint, each 3½ grains in weight, and 8-10ths of an inch in length to the end of the tail: adhering strongly to the nipple, sucking actively, and clinging to the fur by the unguiculate digits of their fore-limbs, which they used freely. One survived separation from the nipple one hour and twenty-nine minutes, turned itself over and moved round the glass in various directions: respiring by the nostrils twenty-two times per minute, and ejecting bubbles of milk from mouth. The hind-limbs were each a mere bud, with feeble indications of toes, without claws. The tongue is very large—⅓ the entire weight of the head. The power of suction is such that the point of a pencil applied to the oral pore is held so strongly that the young can be partially lifted up by it. On March 14th the young weighed 12 grains, showing an increase of weight at the rate of 250 per cent. in seven days: it was now $1\frac{1}{10}$ inch long. On March 18th the weight was 18 grains: the claws appeared on the hind-toes: the testes had descended into a large scrotum. The eyelids were still sealed, but movements of the eyeball were visible beneath the skin. On May 22nd Dr. Meigs found one of the young crawling on the body of the dam; its weight was 42 grains; the eyes were open. This gave a term of marsupial gestation of 74 days. But the young return to the pouch for food and shelter until near the time for reception of a succeeding litter.

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[1] In a valuable memoir on the Reproduction of the Opossum. CCLXXVIII″.

[2] Dr. Barton computed the utero-gestation of the Virginian Opossum at from twenty-two to twenty-six days: his female brought forth seven young on the 21st of March; and had shortly before that time given suck to five young ones as large as rats. LXXX′. p. 320.

In *Thylacinus* the pouch opens backward, or vent-ward, as in *Perameles*; and shows four nipples.[1] In a female which carried there three young, each 1 foot in length from the snout to the end of the tail, the length of the pouch was 8 inches; its aperture was 3½ inches wide, and the bag expanded as it extended forward to a width of 6 inches. The teats were 4 inches long. The young were males: the testes had descended into a pendulous scrotum one inch in advance of the cloaca, from which the grooved but undivided penis projected: the eyelids were closed, but not adherent. The tongue presented a longitudinal rising, with a medial groove, the rising fitted into a depression on the roof of the mouth bounded by two, parallel, long and narrow palatal bones, recalling the condition of these bones in *Sauria*. In *Myrmecobius* 'the female is destitute of a pouch and has, apparently, eight nipples, arranged in a circle.'[2]

Besides the natural and portable nest, some Marsupials (*Didelphys, Phascogale, Chœropus, Perameles*) construct artificial ones. *Perameles myosurus*, e.g. 'makes a compact nest in a hollow of the ground, of grasses and other materials, which assimilate closely in colour and appearance to the surrounding herbage:'[1] the nest is generally inhabited by the pair, with three or four young, when these are so large as to quit the pouch.

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[1] CCLXXXI″. p. 148.

[2] CCLXXX″. p. 394.

§ 415. In *Lissencephala.*—The fertile and commonly multiparous species of the Rodent order have corresponding provision for the nourishment of the young in the number of nipples. A seeming exception is presented by the domesticated breed of S. American Cavy, called 'Guinea-pig.' The prolific power of this well-fed pet is proverbial: they begin to breed at two months old, and gestation may be repeated at intervals of two or three months. The first litter consists of four, the second of five or six; and, as full maturity is gained by the mother, she may bring forth eight, ten, and even twelve young: and yet she has only two nipples to serve them, turn and turn about. The teats are large and prominent, but lodged in a small shallow pouch, one on each side of the hind part of the belly. The mammary glands, however, attain a size more in accordance with the demands upon them: they are not pendant, like an udder, but flat and spread over the abdomen. The wild original (*Cavia aperea*, Linn.) breeds but once a year, and then has but one or two young. *Dolichotis* has but two young. *Echimys* appears to have but two teats, placed midway between fore and hind legs: Rennger found two young in the nest at the bottom of the burrow: they were blind The Paca (*Cœlogenys*), with commonly two young, has four teats; and this number is not surpassed in *Lagostomus*, *Cercolabes*, *Erithizon*, *Hystrix*, *Capromys*, *Helamys*, *Dipus*, and some species of *Sciurus* (*Sc. palmarum*). In the Biscacha the anterior pair of teats is 1½ inches behind the base of the fore-legs: the posterior pair 2 inches farther back. In the prehensile Porcupine the hind nipple is midway between the fore and hind leg, the front nipple midway between this and the base of the fore-leg. Both these species, the common and the Canadian Porcupines, have usually two at a birth. The mother *Coypu* usually carries her young upon the back in her frequent traverses of the river she frequents: her teats are easily reached by the young so transported, as they project from the flanks, nearer the back than the belly: the anterior pair are just behind the shoulders: the posterior pair anterior to the haunches. The nipples are rather less elevated than in the Coypu, in *Hydrochœrus*, which swims with the young on her back: they are also lateral in *Lagostomus*, *Octodon*, *Habrocoma*, and *Nelomys*.[2] In *Octodon* the foremost nipple is ½ inch behind the base of the fore-leg: the hindmost pair are inguinal. In the burrowing Mole-rat the anterior nipple is on the inside of the base of the fore-leg, the posterior one at the middle of the inner side of the thigh. There are six teats in *Bathyergus*, eight in *Loncheres*, *Octodon*, and *Dasyprocta*, ten in *Myoxus*, and *Lepus*; twelve in the Rat and Mouse: even fourteen are said to have been noted in the Agouti, but this is probably abnormal.

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[1] CCLXXIX''.

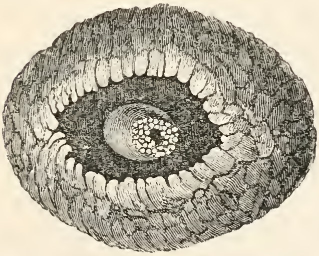
[2] CCLXXX''. p. 299.

The Insectivorous order yields the maximum number of nipples in the mammalian class; as many as twenty-two having been observed in the tropical Hedgehog called Tenrec (*Centetes*), and the number rarely falls below fourteen. In such multiplication of teats and lacteal glands they extend along the under surface of the body from the pectoral to the inguinal region; and, in some Shrews (*Sorex crassicaudatus*, e.g.), the last pair of teats projects from the under side of the thick base of the tail. In the common Hedgehog (*Erinaceus*) there are ten teats, three pairs thoracic and two pairs abdominal, ranging from the pectoral to the inguinal regions. The thin and flat mammary glands seem to form a continuous stratum. In Shrews and Moles the teats are from six to eight in number. In the volant Insectivora they are usually reduced to two, and are pectoral in position, whence Linnæus was led to avail himself of this, with another outward genital character, to unite Bats in the same order (*Primates*) with Apes and Man. But the Sloths have one pair of pectoral teats and mammary glands. Many Armadillos, likewise, have two pectoral teats; to which, in a few kinds (*D. novem-cinctus*, e.g.), a pair of inguinal teats are added. The two-toed Anteater has two pectoral and two ventral teats. The great Anteater (*Myrmecophaga jubata*) is limited to two pectoral mammæ. The young animal remains with the mother for the space of a year, and is carried on her back. In a species of *Phyllostoma* I have seen two pubic as well as two pectoral teats. The latter in all bats are almost laterally placed, and in *Pteropus* are axillary: the nipple when in use becomes long, compressed, and sub-pedunculate. The Colugo (*Galeopithecus volans*) has two nipples in each arm-pit: they become large during maternity, for the young cling long to them.

Among *Lissencephala* the Rodents are most remarkable for nidificatory instincts. The little Harvest-mouse (*Mus messorius*) builds a round nest, like a Tit's, and attaches it, high up from the ground, to the stems of full grown rye, barley, or other cereal. The nest of the Marsh Hare (*Lepus palustris*) is formed of a large kind of rush (*Juncus effusus*), cut into pieces about a foot in length, and is arched over; the foundation of the nest is usually a tussock surrounded by water, like a lake-dwelling: the number of young is from four to seven.

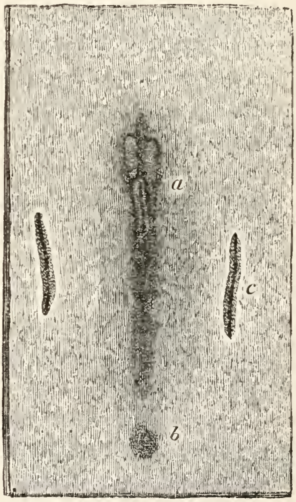
§ 416. In *Mutilata.*—In *Cetacea* the mammary glands, two in number, are oblong, narrow, flat bodies, lying between the dermal and abdominal muscles, with the subcutaneous blubber between them and the skin. The requisite mass of glandular substance at the suckling season is obtained by horizontal extent, not by thickness, so that they do not project, or interfere with the requisite shape of the natatory animal. Each gland has a principal duct running in the middle through the whole length of the gland, and collecting the smaller lateral ducts, which are made up of the still smaller ones. 'Some of these lateral branches enter the common trunk in the direction of the milk's passage, others in the contrary direction, especially those nearest to the termination of the trunk in the nipple. The trunk is large, and appears to serve as a reservoir for the milk:'[1] it is continued from the hinder end of the gland, and terminates in a nipple concealed in a cleft, fig. 608, *c*, one on each side of the vulva, *a*, and toward the vent, *b*.

607



Mammary cleft dilated, exhibiting the nipple and its orifices, Porpoise. CCLXXXIII''.

608



Position of mammary clefts, Porpoise. CCLXXXIII''.

The lateral portions of the cleft are composed of parts looser in texture than the common skin, which is probably to admit of the elongation or projection of the nipple. On the outside of this there is another small fissure, which gives greater facility to the movements of all these parts.

The nipple itself, shown by dilating the mammary fossa in fig. 607, is perforated by numerous lacteal ducts. Hunter thus alludes to the unusual circumstances under which the act of sucking must be performed in the present aquatic mammals:—'As either the mother or young one will be prevented from breathing at the time, their nostrils being in opposite directions, therefore the nose of one must be under water, and the time of sucking can only be between each respiration.' The considerable lacteal reservoir, and the quality of milk it contains,[1] relate to this difficulty.

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[1] XCIV. p. 392.

Some stress has been laid on the assistance which the muscles in contact with the mammary gland might afford by compressing the gland and ejecting the milk accumulated in the dilated receptacle; 'but,' as I remarked in CXLIV″. p. 594, 'when we consider how great the pressure of the surrounding water must be upon the extended surface of the mammary gland, we may readily conceive that when the nipple is grasped by the mouth of the young, and the pressure removed from it by the retraction of the tongue, the milk will be expelled in a copious stream by means of the surrounding pressure alone, independently of muscular aid.'

In *Sirenia* the mammary glands, also a pair, are pectoral in position; the teats are prominent and conspicuous at the suckling season. The mother has been seen holding her young to the breast, with one flipper, and maintaining both her own and her offspring's nostrils above water. The resemblance to a black woman and child has attracted attention, and the appearance of the tail-fin as she dived, has served to perpetuate the seaman's faith in the 'mermaid.'

§ 417. In *Ungulata.*—The Elephant resembles the Dugong in the number and position of the mammary glands and teats, which project between the fore-legs. The young animal compresses the gland with its proboscis as its sucks.

In the unimpregnated Rhinoceros the mammary glands, two in number, form a thin layer expanding forwards beneath the abdominal integument, between the dermal and abdominal muscles. The nipples are two in number and inguinal, are situated 14 inches in advance of the vulva, and $2\frac{1}{2}$ inches apart from one another. They are subcompressed, obtusely rounded at the extremity, and about 2 inches in length: about a dozen lactiferous ducts open upon the somewhat flattened summit of each nipple.

In the Mare and Ass the mammary glands, two in number, are situated between the thighs at a distance of about 9 inches in front of the vulva. The nipples project, one on each side of the mesial line, an inch and a half apart, near the base of the 'preputium clitoridis;' the lactiferous ducts open, above the base of the nipple, into a large reservoir, which is divided by an internal septum into two chambers, one situated in front, and the other behind; from each chamber a separate duct is derived, which passes along the nipple as far as its extremity, where it terminates. The orifices are one behind the other, about a line apart. The rudimental nipples, in the male *Equidæ*, are concealed within the prominent annular preputial fold of integument, and long escaped observation.[1]

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[1] 'The milk is probably very rich; for in that caught near Berkeley with its young one, the milk, which was tasted by Mr. Jenner, and Mr. Ludlow, surgeon, at Sodbury, was rich like cow's milk to which cream had been added.' XCIV. p. 392.

The Tapir has two inguinal nipples. The smaller and more prolific Perissodactyle, *Hyrax*, has four teats, all inguinal in position.[2]

In the Hippopotamus the two teats are inguinal, small, and round in the virgin female. The Peccari has four teats, two ventral, two inguinal. The Wart-hog (*Phacochœrus*) has six nipples; two inguinal, four ventral: the Water-hog (*Potamochœrus*) has eight nipples, and such is sometimes the number in the wild Sow; but in the domestic breeds the nipples are seldom below ten in number, distributed from the pectoral to the inguinal region.

All ruminants have the mammary glands compacted into a roundish mass, more or less pendulous when in full function; divisible into two glands, each remarkable for its large lacteal reservoir, from which the milk is conveyed to either one pair or two pairs of teats; these, when in use, are so elongated as to have received the special name of 'udders;' they are always inguinal in position, are hollow and have a contracted tubular terminal aperture.

Moschidæ, *Ovidæ*, many Antelopes, including the Gazelles, Bubalines, with *Bubalus moschatus*, have but two teats. *Antilope dama*, *A. strepsiceros*, *A. Oreas*, and their allies have four teats. All *Cervidæ*, from the great Elk to the little Roe, have four teats; as have also the Camels, Camelopard, and all Bovines. In some of our domestic cows a supernumerary pair is occasionally developed. Behind each teat, in the Gazelle, there is a pouch of skin, opening forward, about seven lines in depth, reminding one of the pair of marsupia in *Echidna*, save that the milk escapes in front of, and not into, the pouches.

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[1] *Solidungula mascula mammas non habent.* Rai, Synops. method. Anim. quad. &c. p. 64.

[2] SCHREBER found only this number in *Hyrax capensis*, as did EHRENBERG in *H. Syriacus*. DESMAREST adds a pectoral pair, but this needs confirmation.

§ 418. In *Carnivora.*—In the Seal-tribe, including the Walrus, the number of teats does not exceed four. In the Otters (*Enhydra, Lutra*) only two teats have been observed, ventral in position. The *Mustelidæ* have from four to six ventral teats. Six is the common number in *Ursidæ,* two being pectoral and four ventral. In *Cercoleptes* I found but two ventral teats. *Procyon, Meles, Taxidia, Nasua,* have six; *Ailurus* has eight teats. The palm-cats (*Paradoxurus*) and Ichneumons (*Herpestes*) have four ventral teats. They seem not to exceed that number in the Hyænas; but in the Civets two pectoral nipples are sometimes added to the four ventral ones. The felines have usually six nipples, four ventral, and two pectoral; but in the domestic cat eight have been seen. The *Canidæ,* wolf, dog, jackall, fox, have usually eight teats.

§ 419. In *Quadrumana.*—In the Aye-aye (*Chiromys*) there is but one pair of nipples, situated about an inch and a half in advance of the vulva, and one inch apart: they are sub-elongate, obtuse, with about a dozen terminal lacteal pores. To such a pair of inguinal nipples some *Lemuridæ* (*Stenops, Tarsius, Microcebus,* e.g.) add a pectoral pair; while in *Otolicnus* and some kinds of Maki (*Lemur catta,* e.g.)[1] two pairs of pectoral nipples have been found.

In platyrhine and catarhine *Quadrumana* the mammary glands and nipples are restricted, as a rule, to a single pair, and to the pectoral region. In the ordinary quadrupedal progression, the young, with its belly applied to that of the mother, clings back downward, by the fore and hind feet to her flanks, holding on by the mouth to the teat between her fore-legs. In the seated posture the mother ape holds her young to the nipple by the fore-limbs, in a very human fashion. The integument covering the mammary gland is not protruded by its enlargement in the form of a hemispheroid 'breast:' it is covered with hair, like the rest of the body, becomes conical and pendulous, with much elongation of the nipple, as the suckling period is prolonged. In an Orang-utan (*Pithecus satyrus*), I have observed an accessory nipple on the left side, below the normal one and of smaller size.[2] From ten to twelve lacteal ducts open upon the apex of the normal nipple in the Orang. Around the base of the nipple open the orifices of sebaceous ducts.

§ 420. In *Bimana* the mammary glands, two in number, are subdepressed circular bodies, thicker at the middle than at the circumference, which, with the connected sclerous, areolar, and adipose tissues, raise the pectoral integument, at puberty, in the form of two large hemispheres or 'breasts;' and, from a little below the centre or apex of each, projects the 'nipple.' The base of the 'breast' corresponds to the interval between the third and the sixth or seventh ribs. The gland is of a firm texture and pale reddish colour: the secerning follicles, when injected with mercury, are just visible to the naked eye. Magnified four times, they present the appearance shown in fig. 609. They are aggregated in clusters or 'glandules' of different sizes, suspended by the duct resulting from the union of those of the follicles. The short or stem-ducts open into a wide canal, and these, fig. 610, *c*, *d*, by successive unions, form dilated reservoirs of a conical form, ib. *b*, *b*, from the apices of which are continued the 'straight ducts,' *a*, *a*, of the nipple. The gland is enclosed in a sclerous capsule, fig. 611, *a*, *a*, firmest where it is attached to the derm, whence are continued processes into the substance of the

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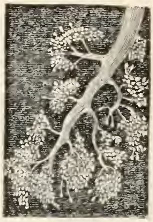
[1] xx. vol. v. p. 208, no. 3775 a.

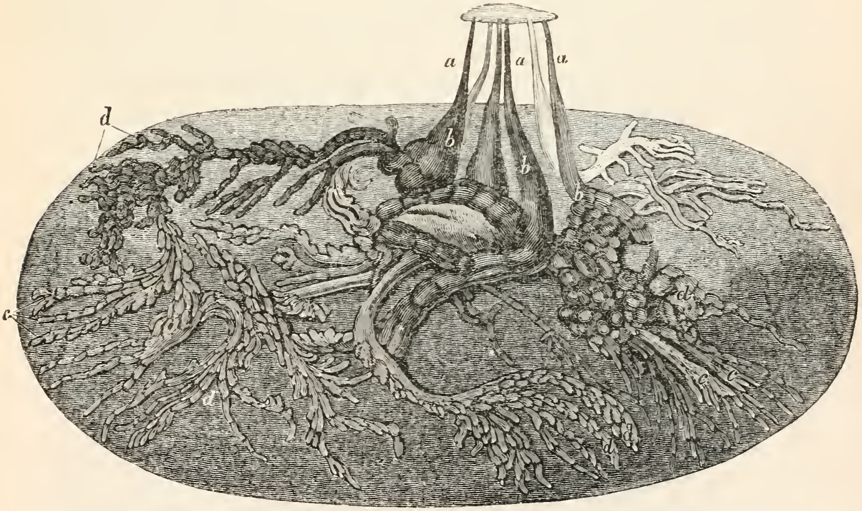
[2] Ibid. b.

609



Secerning follicles and ultimate lobules of Human Mammary gland, injected with mercury; magn. four times. CCLXXXIV″.

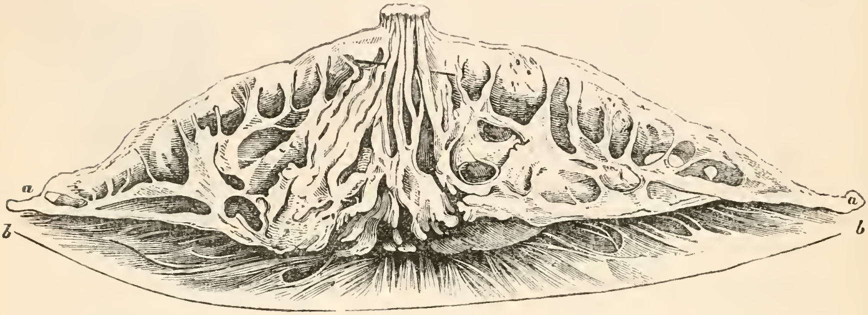
610



From a Cooperian preparation of parts of the Human mammary gland, injected from six terminal ducts, *a*, *a*, and dried. CCLXXXIV″.

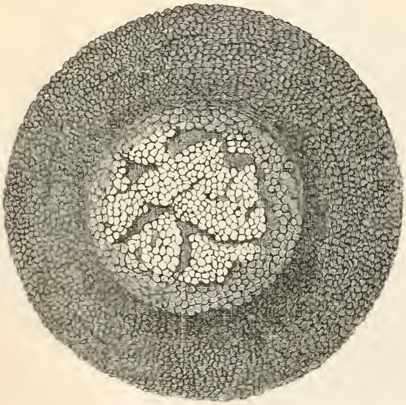
gland subdividing it, or defining its lobes; and which, from their connection with the tegument, are called 'suspensory' ligaments. Finer processes connect the opposite surface or base of the gland with the fascia of the pectoral muscle, *b, b*. The nipple in the virgin is a rounded cone and nearly smooth; at sixteen years it is slightly wrinkled; at seventeen it has small papillæ upon its surface; from twenty to forty years the papillæ are large; from forty to fifty the nipple becomes wrinkled; from fifty to sixty the nipple is elongated; and in old age it usually has a warty appearance. When in use its extremity expands and shows the circularly disposed conspicuous pores of the lacteal ducts. The papillæ of the nipple, fig. 612, are directed toward its apex. The coloured portion of skin around the base of the nipple is the 'areola:' it expands and changes from a reddish colour to a dark brown, after impregnation. Around the base of the nipple are orifices of complex sebaceous glands. The skin of the areola is covered with papillæ, like those of the nipple, but of smaller size; they are disposed in circles, directed toward the nipple, so that

611



From a Cooperian preparation of the sclerous framework and attachments of the Human mammary gland. A bristle is passed behind some of the straight or terminal lactiferous ducts. CCLXXXIV″.

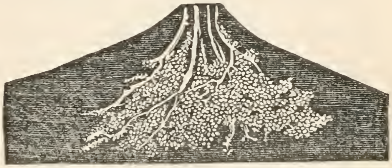
612



Sensitive papillæ of the Human nipple and areola; nat. size. CCLXXXIV″.

they also are opposed to the papillæ of the lips of the child: being highly vascular and nervous, they yield, when so grasped, a sensation which is followed by erection of the nipple through a fitting arrangement of its vascular tissue. The homotypal gland, in the male, varies from four lines to two inches in diameter. Astley Cooper succeeded in demonstrating its conformable structure to the functional gland in the female: fig. 613 is taken from his preparation. Under special circumstances and stimuli such gland may be developed so as to afford sustenance to the infant, of which more than one case has been recorded.

613



Secerning follicles and ducts of the male mammary gland, injected with quicksilver; nat. size. CCLXXXIV″.

The chief varieties in the female mammary organs relate to prolonged periods of lactation, as in those inferior races in whom the dugs become so extended as to permit the nipple to be thrown over the shoulder to the child carried on the mother's back. Cuvier noted an unusual breadth of the mammary areola in the 'Hottentot Venus.'[1]

Anomalies of supernumerary nipples and glands are rare.[2]

On a retrospect of the comparative anatomy of the mammary organs we see that the modifications of these persistent tributaries to the growth of the young mammal serve as little to characterise groups as do the deciduous nutritive organs at the uterine period of life. A pair of pectoral mammæ would associate together as heterogeneous an assemblage of species as does the diffused, or even the discoid, placenta. We may, however, discern in part, the uses of mammary modifications; whilst the teleological relations of a zonular, a cotyloid, or a cotyledonal afterbirth can, at best, be but very vaguely guessed at.

§ 421. *Adipose substances.*—These are common to all organisms, protozoa, plants, animals.[3] In *Mammalia* they exist under conditions which vary in the degree of temperature required for congelation, as 'oil,' 'marrow,' 'lard,' 'spermaceti,' 'suet.' The most solid fats when subject to pressure afford some fluid oil, termed 'elaine,' and when the fluid fats are cooled to about 32° they deposit a concrete element called 'stearine:' the temperatures of congelation indicate the varying proportions of elaine and stearine. Whether or not it be in relation to the degree of cold to which the hoofs of some ruminants are subject, in traversing the snows of arctic climes, the oil called 'neat's foot' owes its use in the arts to its maintaining its fluidity below the freezing point. Blubber-oil, which becomes lardy at 45° or 50° Fahr., and is fluid above 55°, most abounds in the thick subcutaneous tissue of the *Cetacea.* The fat of the hog-tribe, horse-tribe, most *Lissencephala, Carnivora, Quadrumana,* and *Bimana,* is in the state of 'lard.' It exists as suet and tallow in Ruminants. Spermaceti is peculiar to the Cachalot whales (*Physeter, Euphysetes*).

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[1] CCLXXXV″.

[2] In the instance narrated in CCLXXXVI″. the second nipple on each side was one-sixth the size of the normal one, and situated near the anterior margin of the axilla. When gently pressed, a milky fluid flowed from several ducts opening upon its extremity. When milk was drawn from the normal breasts, a small quantity usually escaped from the superadded nipples, but their flatness prevented the mother suckling her children by them.

[3] Hunter, who sometimes clothed his far-reaching thoughts in paradoxical language, writes:—'Fat is no part of an animal: for first, it is not animal substance; secondly, an animal is the same without it as with it,—it is to be considered as an adventitious matter; and thirdly, it is found both in vegetables and minerals, and, therefore, is a

Some Rodents, the Hare, e.g., show little or no fat; but it occasionally accumulates in the tame Rabbit. In many Rodents it is limited to the abdominal cavity and its special peritoneal processes. In the Seal-tribe and Whale-tribe, on the contrary, there is no fat in the abdomen, or in the mesenteric or omental duplicatures of the lining membrane. The subcutaneous areolar tissue to which it is limited in these aquatic mammals has a coarser reticulate structure in the Seals, the Grampus, and *Balænoptera,* than in the Porpoise, Sperm-whale, and *Balæna.* In all *Cetacea* the containing tissue is finer upon the trunk, and coarser toward the tail. Fat is subcutaneous in the Hog and human subject, but is also present in the great serous cavities, intermuscular spaces and joints, in variable degrees.

Fat is to the adult what milk is to the young—a source of nourishment when no other is available. Certain Bovines of the tropics, where during the rainy season luxuriant grasses abound on plains parched up in the dry season, accumulate fat and other assimilable substances in a dorsal hump at the period of plenty, and absorb its contents during that of drought. The Camels, when their food abounds, store up similar superabundant nutritious matters in one (*C. dromedarius*) or two (*C. bactrianus*) larger humps: whereby they are able to endure unusual fasts by re-

substance common to every class of matter.' xx. vol. iii. p. 209. The ternary compounds of carbon, hydrogen, and oxygen, discovered in the condition of petroleum and its allies, in mineral strata, are suspected, with good reason, to have originated in organic bodies.

absorbing those accumulations; concluding their journeys across the desert with the special stores of fat much reduced. Similarly, in other Mammals, when the digestive function and appetite are in abeyance, as in disease, or when food is withheld or scarce, the general fat is absorbed 'to support the actions of the machine.'[1] Hence the need of accumulations of this nutritive material in torpid mammals prior to their falling into that state, as in Marmots, Hedgehogs, &c. The subcutaneous fat, which forms a thick layer in October, becomes thin in March, yet remains after the fat of the abdomen, mesentery, and about the kidneys has quite disappeared; suggesting, as Jenner remarks, that the external fat also serves as a defence against cold.[2] The subcutaneous wrap of blubber in the naked *Cetacea*, serves as the non-conductor of heat, in place of hair.

In *Physeter* portions of spermaceti occur in the general subcutaneous blubber, but the main bulk is stored in the vast supracranial basin, in cells of areolar tissue, strengthened by aponeurotic partitions. The purest spermaceti lies in the smallest and most delicate cells: it is the stearic constituent in excess which crystallises on cooling. For economic purposes these masses are separated by pressure in woollen bags from the elaine, then washed with a weak solution of caustic potash, melted in boiling water, and strained. Thus prepared for commerce spermaceti appears as semi-transparent brittle masses of a foliate fracture, soapy to the touch, with a slight odour and greasy taste: its specific gravity is ·943; it fuses at about 114°; thep urified crystalline scales deposited from a solution in boiling alcohol, form 'cetine.' From the blubber of species of *Delphinus* a peculiar fatty principle called 'phocenine' is obtained. The characteristic colour of goats' fat is associated with a principle called 'hircin.'

With ordinary stearine a variable proportion of 'margarine' is always combined, and both these and 'elaine' are compounds of a distinct fatty acid with the sweet principle called 'glycerine.'

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[1] xx. vol. iii. p. 213.

[2] Ib. p. 216.

CHAPTER XL.

GENERAL CONCLUSIONS.

§ 422. *Biological Questions of* 1830.—At the close of my studies at the Jardin des Plantes, Paris, in 1831, I returned strongly moved to lines of research bearing upon the then prevailing phases of thought on some general biological questions.

The great Master in whose dissecting-rooms, as well as in the public galleries of Comparative Anatomy, I was privileged to work, held that 'species were not permanent:' and taught this great and fruitful truth, not doubtfully or hypothetically, but as a fact established inductively on a wide and well-laid basis of observation, by which, indeed, among other acquisitions to science, Comparative Osteology had been created. Camper[1] and Hunter[2] suspected that species might be transitory; but Cuvier, in defining the characters of his *Anoplotherium* and *Palæotherium*, &c., proved the fact.

In this truly scientific labour the law of the subordination of the different organic characters to the condition of the whole animal was first appreciated, clearly enunciated, and its application shown to the reconstruction of lost species from fragmentary remains. The importance of this generalisation may be paralleled with that of the principle of equivalents in chemical science.

Of the relations of past to present species, and the conditions of their succession, Cuvier had not an adequate basis for a decided opinion. Observation of changes in the relative position of land and sea suggested to him one condition of the advent of new species on an island or continent where old species had died out. This view he illustrates by a hypothetical case of such succession,[3] but expressly states:—'Je ne prétends pas qu'il ait fallu une création nouvelle pour produire les espèces aujourd'hui existantes, je dis seulement qu'elles n'existoient pas dans les mêmes lieux, et qu'elles ont dû y venir d'ailleurs.'[4]

Geoffroy Saint-Hilaire, whose discussions with his colleague in the 'Académie des Sciences' made its annals of 1830 memorable, equally rejecting the idea of new creations,[1] opposed to Cuvier's inductive treatment of the question the following expression of belief:—'Je ne doute pas que les animaux vivants aujourd'hui ne proviennent, par une suite de générations, et sans interruption, des animaux perdus du monde antédiluvien.'[2] But with regard to the demonstration of the proposition, of the truth of which he could not entertain a doubt, Geoffroy Saint-Hilaire expressly states:—'Je crois que les temps d'un savoir véritablement satisfaisant en géologie ne sont pas encore venus.'

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[1] ccxcii''.

[2] ccxciii''. and other authors cited in cxxxix. p. xlv.

[3] cxxxix. tom. i. p. lxiii.

[4] Ib.

The main collateral questions argued in these debates, to some of which I listened, and to all the reports and consequent pamphlets relating thereto devoted intense attention, appeared to me to be the following:—

Unity of Plan or Final purpose, as a governing condition of organic development?

Series of species, uninterrupted or broken by intervals?

Extinction, cataclysmal or regulated?

Development, by epigenesis or evolution?

Primary life, by miracle or secondary law?

On returning home and resuming office with additional duties at the Royal College of Surgeons, I was guided in all my work with the hope or endeavour to gain inductive ground for conclusions on these great questions.

§ 423. *Homology or Teleology?*—Cuvier held the work of organisation to be guided and governed by final purpose, or adaptation, expounding this principle under the terms 'conditions of existence' and 'correlations of structure.' Geoffroy denied the evidence of design, and protested against the deduction of a purpose as, e. g., from the coexistence of a valve with a definite course of fluid: he contended for the principle which he called 'unité de composition,' as the law of organisation. Most of his illustrations were open to the demonstration of inaccuracy, and his arguments to the refutation which they received from Cuvier in the debates in question: the logic, and, as it seemed, the facts, were on the side of teleology. The figurative language, moreover, in which contemporary anatomists had expressed their views of a principle akin to Geoffroy's was ill-calculated to enlist supporters. The expressions by which disciples of the school of Schelling illustrated, in the animal structures, the transcendental idea of 'the repetition of the whole in every part,' operated disadvantageously to the calm enquiry into the prime question at issue. To Cuvier this language seemed little better than mystical jargon, and he alluded to it with transparent contempt.[1] When he did extend inferences from comparative anatomy beyond the adaptation of structure to function, Cuvier went not beyond a recognition of what I have since termed 'special homologies': [2] and this lowest degree of correspondence he explained on the ground of the subserviency of such homologous parts to similar ends in different animals; [3] viewing them, in fact, in that relation which I express and contrast by the term 'analogies.' [4] With Cuvier answerable parts occurred in the zoological scale because they had to perform similar functions.

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[1] 'Or, cette proposition, déja contraire aux plus anciennes données historiques, répugne tout autant aux lumières de la raison naturelle qu'aux spéculations plus réfléchies des sciences physiques.'—CCLXXXVII″. p. 210.

[2] Also, more decisively:—'Les animaux perdus sont, par voie non interrompue de générations et de modifications successives, les ancêtres des animaux du monde actuel.' —CCLXXXVII″. p. 208.

Most of my fellow-students at the Garden of Plants, in 1830, and some subsequent fellow-labourers, Johannes Müller, Rud. Wagner, Milne-Edwards, Agassiz, implicitly accepted this explanation of the fact of answerable bones and other parts occurring in different species.

After the publication of the 'Memoir on the Pearly Nautilus,' and of those on Monotrematous and Marsupial generation, which subjects Cuvier had strongly recommended to my attention, the question of the condition or law of special homologies pressed itself upon me, more especially in connection with the task of arranging and cataloguing the osteological part of the Hunterian Museum.[5] As my observations and comparisons accumulated, with *pari passu* tests of observed phenomena of osteogeny, they enforced a reconsideration of Cuvier's conclusions to which I had previously yielded assent. To demonstrate the evidence of the community of organisation, I found that the artifice of an archetype vertebrate animal was as essential as that of the archetype plant had been to Goethe in expressing analogous ideas; and as the like reference to an 'ideal type' must be to all who undertake to make intelligible the 'unity in variety' pervading any group of organisms.[1] From the demonstration of this principle, which I then satisfied myself was associated with and dominated by that of 'adaptation to purpose,' the step was plain—to me inevitable—to the conception of the operation of a secondary cause of the entire series of species, whether of plants, or vertebrates, or other groups of organisms, such cause being the servant of predetermining intelligent Will.[2]

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[1] 'Quant à M. Oken, il déclare les pièces en question les parties écailleuses des temporaux, ou, selon son langage mystique, "la fourchette du membre supérieur de la tête."—Cet humérus de la tête de M. Oken devient pour M. Spix le pubis de cette même tête; ou, pour parler un langage intelligible, un des osselets de l'ouie, savoir le marteau.'—CXXXIX. tom. v. 2e partie, p. 85.

[2] CXL. p. 7.

[3] 'Ce n'est qu'un principe subordonné à un autre bien plus élevé et bien plus fécond, à celui des conditions d'existence, de la convenance des parties, de leur coordination pour le rôle que l'animal doit jouer dans la nature. Voilà le vrai principe philosophique d'où découlent la possibilité de certaines ressemblances.'—CCXCIV''. p. 9.

[4] CXL. p. 7.

[5] XLIV.

But, besides 'derivation' or 'filiation,' another principle influencing organisation became recognisable in the course of studies and researches on Invertebrate animals. To this principle, as more especially antagonistic to the theological idea, I gave the name of 'irrelative repetition;' sometimes also, as it prevailed most in plants and zoophytes, of 'vegetative repetition.'[3] The demonstrated constitution of the vertebrate endoskeleton, as a series of essentially similar segments, out of which, as corollary, came the power of enunciating not only 'special' but 'general' and 'serial' homologies, appeared to me to illustrate also the law of irrelative repetition. The recurrence of similar segments in the spinal column and of similar elements in a vertebral segment, struck me as analogous to the repetition of similar crystals as the result of polarizing force in the growth of an inorganic body.[4]

Accordingly, these results of extensive, patient, and unbiassed inductive research—or, if there were a bias, it was toward Cuvier—swayed with me in rejecting the principle of direct or miraculous creation, and in recognising a 'natural law or secondary cause' as operative in the production of species 'in orderly succession and progression.'[5]

§ 424. *Succession of Species, broken or linked?*—To the hypothesis that existing are modifications of extinct species Cuvier replied, that, in every mooted form of transmutation, the species were made to alter by small degrees, and that, therefore, traces of such gradual modifications were due from the fossil world:—'You ought,' he said, 'to be able to show, e. g., the intermediate forms between the Palæotherium and existing hoofed quadrupeds.'[6]

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[1] Such 'ideal type' must not be confounded with the so-called 'types' supposed to be exemplified by certain living species. Arguments against the latter vague and ill-defined ideas are of no weight against the former, and indicate a certain obtuseness of apprehension in the objector. See CCCXXVI″. p. 31.

[2] CXLI. (1849) p. 86.

[3] CCXLIX. p. 641 (1843); and vol. i. Preface, p. ix.

[4] CXL. p. 171.

[5] CXLI. loc. cit.

[6] 'Cependant on peut leur répondre, dans leur propre systême, que si les espèces ont changé par degrés, on devroit trouver des traces de ces modifications graduelles; qu'entre le palæotherium et les espèces d'aujourd'hui l'on devroit découvrir quelques formes intermédiaires, et que jusqu'à présent cela n'est point arrivé.'—CXXXIX., tom. i. p. lvii.

The progress of Palæontology since 1830 has brought to light many missing links unknown to the founder of the science. My own share in the labour led me, after a few years' research, to discern what I believed, and still hold, to be a tendency to a more generalised, or less specialised, organisation as species recede in date of existence from the present time.[1] Even instances which to some have appeared to oppose the rule, really exemplify it. The little marsupial carnivore, e. g., of the Purbeck beds, *Plagiaulax* (p. 294, fig. 234), retained the typical numbers of premolars (*p*. 1–4), all of them being carnassials: the more modified pliocene *Thylacoleo* had them reduced to the last (*p*. 4, fig. 233). So likewise in the later placental *Carnivora*, the eocene form *Hyænodon*, fig. 266, had the typical number of teeth, the three true molars here showing the carnassial form: in the existing Hyæna and Felines the carnassials are reduced to, or concentrated in, a single molar. The oolitic *Phascolotherium*, with the typical marsupial number of teeth, shows less differentiation in their form than in modern Opossums and Dasyures: the oolitic *Amphitheria* and *Palæotheria* manifest an earlier and more generalised type of dentition in the great number and similarity of character of their small molars. Both *Anoplotherium* and *Palæotherium*, with the majority of eocene placental Mammals, had the type-dentition of diphyodonts.[2]

The two notable examples of Cuvier's powers of restoration, viewed as Pachyderms, must have seemed widely different from any of the existing species of the order, and were so deemed. The *Anoplotherium* more especially, among its singular peculiarities, unexpectedly exemplified one dental character, previously known only in the human subject. These seeming anomalies, however, lost much of their import as evidence of insulated form, or special creation, when they came to be viewed by the light of the law of the 'more generalised character of extinct species.' Such law in its application to *Anoplotherium* also exemplifies the analogy between the earlier species of a class and the earlier stages of a fœtus. When, for example, the divided metapodials, the persistent upper incisors, and the hornless cranium of the Anoplothere were recognised as retentions of 'fœtal peculiarities' of existing ruminants,[1] that extinct species was seen to favour rather than oppose the idea of organisation by secondary law.

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[1] CCXLIX. Ed. 1843, pp. 129, 165; Ed. 1855, pp. 223, 332, 342. CLXXX. and XVII′. pp. 1, 361, *passim*. Agassiz had been struck by indications of the same law in fossil fishes, and expressed it by the analogy of fœtal and mature structures (CCCXXIX″. (1844) p. xxvi.), and this, in some degree, is true. The earlier forms of *Mammalia*, however, are not toothless, have rather an excess of teeth as compared with later and modern forms; but they exemplify, in the main, a more 'generalised' type.

[2] v. p. 524. CLXXX. p. 361.

The discovery of the remains of the *Hipparion*[2] supplied one of the links, required by Cuvier, between the *Palæotherium* and the Horse of the present day, and it is still more significant of the fact of filiation of species that the remains of such three-toed Horses are found only in deposits of that tertiary period which intervene between the older palæotherian one and the newer strata in which the modern Horse first appears to have lost its lateral hooflets. These relations I illustrated in my Lectures on Fossil Mammalia at the School of Mines (1857) by the diagram, fig. 614.

Other evidences of gradation, in the case in question, have been brought to light. The molar series of the Horse includes six large complex grinders, individually recognisable by developmental characters as they are symbolised in fig. 280, p. 352. The representative of the first premolar is minute and soon shed. Its homologue in *Palæotherium* is functionally developed and retained, the type-dentition being adhered to.[3] In *Hipparion, d* I is succeeded by a *p* I[4] smaller than in *Palæotherium*, but functional, with inflected folds of enamel on the grinding surface, and permanent. It exemplifies a condition intermediate to that in *Palæotherium* and *Equus*. It is not that the jaws of the Horse are too short to hold the full complement of grinders: on the contrary they are relatively longer than in the Palæothere, being specially produced between the grinders and cutters: the first grinder might seem, indeed, to have been taken away in order to add to the space for the application of the 'bit.' The transitory and singularly small and simple denticle, fig. 614, *p* I, compared with the large contiguous massive molar, *m* I, in the Horse, exemplifies the rudiment of an ancestral structure, in the same degree as does the hoofless 'splint-bones,' ib. *Equus*, II. IV.: just as the spurious hoofs dangling therefrom in *Hipparion*, ib. II. IV., are retained rudiments of the functionally developed lateral hoofs in the broader foot of *Palæotherium*, ib. II. IV.

Other missing links of this series of species have been supplied; as, e. g., by the *Paloplotherium*[5] of the newer eocene of Hordwell,

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[1] CLXXX. p. 367.

[2] CCCIII″. tom. ii. p. 25 (1832). Another species was discovered in the Miocene at Eppelsheim—the '*Hippotherium*,' of Kaup; a third in deposits of similar age on the Sewalik Hills; a fourth, *Hipparion prostylum*, Gv., at Vaucluse, in the south-east of France, in deposits 'peut-être plus récents que la mollasse dans ces localités.'—CCCXXX″. p. 432.

[3] v. Pl. 35, figs. 4, 5, 6.

[4] CCCII″. Pl. 19, figs. 1, 1 *a*.

[5] This modification, as the *Palæotherium ovinum*, Aymard, began to be shown, at

Hants., by the *Palæotherium aurelianense* from the 'molasse marine' of Orleans,[1] and by the *Palæotherium hippoïdes* of the lacustrine calcareous beds of Sansan, all which deposits are miocene, or are transitional between eocene and miocene. In the first-cited example, the swollen termination of the lobe of the molar, answering to *c*, *m*, fig. 268, remains longer as a detached column, *m*, fig. 269. In the two other Palæotherioids, the whole foot is longer and more slender, with a longer and thicker middle toe, than in the older eocene type-genus, whence the generic name *Anchitherium* applied to them by von Meyer.[2] It is interesting, also, to find that the transitional character is further marked by the smaller relative size of first premolar, whereby *Anchitherium* intervenes, as in the modification of the feet, between the *Palæotherium* and *Hipparion*.

Thus amply and satisfactorily has been fulfilled Cuvier's requisition of 1821:—'Entre le palæotherium et les espèces d'aujourd'hui l'on devrait decouvrir quelques formes intermédiaires.' How, then, is the origin of these intermediate gradations to be interpreted? One may first remark, that as *Palæotherium*, *Paloplotherium*, *Anchitherium*, *Hipparion*, and *Equus*, differ from each other in a greater degree than do the Horse, Zebra, and Ass, the difficulty of interbreeding would be greater, and the probability of fertility less, supposing those extinct genera to have co-existed. One cannot doubt, also, that every well-marked species of these genera paired within itself, and that they exemplified respectively the character of a 'group of individuals descended from common parents, or from such as resembled them as closely as they resembled each other.' They did not, however, exist as species, during the same periods of time, far less so 'from the beginning of things.' The single-hoofed Horse-family cannot be traced further back than the pliocene tertiary period: the tridactyle equine species have not been found in strata earlier than miocene, and disappear in the upper eocene: the heavier-bodied shorter-legged species with three functional hoofs to each foot belong to upper and middle eocenes. Furthermore, in the oldest eocene (London clay, super-cretaceous Conglomerates and Plastic clay at Meudon, Paris), we get evidence of Ungulates (*Pliolophus*, *Hyracotherium*, *Coryphodon*), in which the perisso- and artio-dactyle characters were less differentiated

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the upper eocene at Velay, e.g., ere *Palæotherium* proper had passed away. (Bulletin du Congrès Scientifique de France tenu à Puy, 1855.)

[1] Also in the upper eocene of the Basin of the Garonne, with *Acerotherium*.

[2] *Anchitherium* occurs, also, in the 'marine molasse,' or lower miocene, of St. Genies, Languedoc.

than in *Palæotherium* and *Anoplotherium*, affording additional significant evidence of progressive departure from generalised type. Thus, the succession in time accords with the gradational modifications by which *Palæotherium* is linked on to *Equus*.

With this additional knowledge the question, 'whether actual races may not be modifications of those ancient races which are exemplified by fossil remains?' presents itself under very different conditions from those under which it passed before the minds of Cuvier[1] and the Academicians of 1830. If the alternative—species by miracle or by law?—be applied to *Palæotherium*, *Paloplotherium*, *Anchitherium*, *Hipparion*, *Equus*, I accept the latter, without misgiving, and recognise such law as continuously operative throughout tertiary time.

In respect to its mode of operation, we may suppose Lamarck to say, 'as the surface of the earth consolidated, the larger and more produced mid-hoof of the old three-toed Pachyderms took a greater share in sustaining the animal's weight; and, more blood being required to meet the greater demand of the more active middle-toe, it grew; whilst the side-toes, losing their share of nourishment and becoming more and more withdrawn from use, shrank;' and so on, according to the hardening of the ground, until only the hidden rudiments of metapodials remained and one hoof became maximised for all the work. Mr. Darwin, I conceive, would modify this, like other Lamarckian instances, by saying that some individuals of *Palæotherium* happening to be born with a larger and longer middle-toe, and with shorter and smaller side-toes, such variety was better adapted to prevailing altered conditions of the earth's surface than the parental form; and so on, until finally the extreme equine modifications of foot came to be 'naturally selected.' But the hypotheses of appetency and volition, as of natural selection, are less applicable, less intelligible, in connection with the changes in the structure and proportion of the molar series of teeth, which we have seen also to be gradational from *Palæotherium* to *Equus*, fig. 614.

Any modification of Geoffroy's 'ambient medium,' affecting the density of the soil might so far relate to the changes of limb-structure, as that a foot with a pair of small hoofs dangling by the sides of the large one, like those behind the cloven hoof of the ox, would cause the foot of the Hipparion, e.g., and *à fortiori* the broader based three-hoofed foot of the Palæothere, to sink less deeply into swampy soil, and be more easily withdrawn, than the more concentratively simplified and specialised foot of the Horse.[1]

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[1] 'Pourquoi les races actuelles, me dirait-on, ne seraient-elles pas des modifications de ces races anciennes que l'on trouve parmi les fossiles?'—cxxxix. i. p. lvii.

Rhinoceroses and Zebras, however, tread together the arid plains of Africa in the present day: and the Horse has multiplied in that half of America where two or more kinds of Tapir still exist. That the continents of the eocene or miocene periods were less diversified in respect of swamp and sward, pampas or desert, than those of the pliocene period, has no support from observation or analogy.

Assuming, then, that *Palæotherium* did ultimately become *Equus,* I gain no conception of the operation of the effective force by personifying as 'Nature' the aggregate of beings which compose the universe, or the laws which govern these beings, by giving to my personification an attribute which can properly be predicated only of intelligence, and by saying, 'Nature has selected the mid-hoof and rejected the others.'

As some paragraphs in my 'Preface' have been misconceived,[2] I must further observe, to put my meaning beyond doubt, that, to say that *Palæotherium* has graduated into *Equus* by 'Natural Selection' is an explanation of the process of the same kind and value as that which has been proffered of the mystery of 'secretion.' For example, a particular mass of matter in a living animal takes certain elements out of the blood and rejects them as 'bile.' Attributes were given to the liver which can only be predicated of the whole animal: the 'appetency' of the liver, it was said, was for the elements of bile, and 'biliosity' or the 'hepatic sensation' guided the gland to their selection.[3]

Such figurative language, I need not say, explains absolutely nothing of the nature of bilification. One's surprise is that 'tropes' and 'personified acts' should not have died out, as explanatory devices, with the 'archeus faber,' the 'nisus formativus,' and other self-deceiving, world-beguiling simulacra of science, with the last century; and that a resuscitation should have had any success in the present. It is of interest as illustrating the 'alternation of generations.'

What, then, are the facts on which any reasonable or intelligible conception may be formed of the mode of operation of the derivative law exemplified in the series linking on *Palæotherium* to *Equus*? A very significant one is the following:—A modern horse occasionally comes into the world with the supplementary ancestral hoofs. From Valerius Maximus,[1] who attributes the variety to *Bucephalus*, downwards, such 'polydactyle' horses have been noted as monsters and marvels. In one of the latest examples,[2] the inner splint-bone, answering to the second metacarpal of the pentadactyle foot, supported phalanges and a terminal hoof, in position and proportion to the middle hoof, resembling the corresponding one in *Hipparion*, fig. 614, II.

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[1] xvii'. p. 397.

[2] Referring to my 'Anatomy of Vertebrates,' in the fourth edition of the 'Origin of Species by Natural Selection,' &c., the author asserts that 'he' (Professor Owen) 'at the same time admits that Natural Selection may have done something towards this end.' Mr. Darwin does not quote the passage or refer to the page on which he founds his assertion.—ccxiii'' (1866), Histor. Pref. p. xviii.

[3] cccxxviii''. vol. i. p. 268, and *passim.*

In relation to actual horses such specimens figure as 'monstra per excessum;'[3] but, in relation to miocene horses, they would be normal, and those of the present day would exemplify 'monstra per defectum.' The mother of a 'monstrous' tridactyle colt might repeat the anomaly and bring forth a tridactyle 'filly'; just as, at San Salvador, the parents of a family of six had two of the series born with defective brain and of dwarf size: they were 'male' and 'female;' and these strange little idiots are exhibited as 'Aztecs.' The pairing of the horses with the metapodials bearing, according to type, phalanges and hoofs, might restore the race of hipparions.

Now, the fact suggesting such possibility teaches that the change would be sudden and considerable: it opposes the idea that species are transmuted by minute and slow degrees. It also shows that a species might originate independently of the operation of any external influence; that change of structure would precede that of use and habit; that appetency, impulse, ambient medium, fortuitous fitness of surrounding circumstances, or a personified 'selecting Nature,' would have had no share in the transmutative act.

There is, however, one relation which I cannot shut out, for I hold it as strongly as when I explained it, and endeavoured to impress it upon the audience at my lectures of 1857: it is the fitness of the organisation of the Horse and Ass for the needs of mankind, and the coincidence of the origin of Ungulates having equine modifications of the perissodactyle structure with the period immediately preceding, or coincident with, the earliest evidence of the Human Race.

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[1] 'Exemplorum memorabilium Libri novem, &c. (De rebus mirificis.)'

[2] CCCIV''. p. 55, Pl. 1.

[3] Two such examples are described in LII. vol. ii., and one in CCCV''. p. 224, in which the left fore-foot had three subequal hoofs, and the right fore-foot two hoofs. But the application of an instructive and rightly discerned relation may be travestied and exaggerated: the two-tailed lizard and the double-headed snake do not reproduce to view normal ancestral forms. The essentially single mid-toe (fig. 193, iii) of the horse, occasionally bifid and terminated by a pair of ill-shapen hoofs, lends no support to the idea of the digit (iii) being homologous with the so-called cloven hoof (really the digits iii and iv, ib.) of Ruminants. It is a malformation akin to that of the partially double digit of the Dorking fowl.

Of all the quadrupedal servants of Man none have proved of more value to him, in peace or war, than the horse: none have cooperated with the advanced races more influentially in Man's destined mastery over the earth and its lower denizens. In all the modifications of the old palæotherian type to this end, the horse has acquired nobler proportions and higher faculties, more strength, more speed, with amenability to bit. No one can enter the 'saddling ground' at Epsom, before the start for the 'Derby,' without feeling that the glossy-coated, proudly-stepping creatures led out before him are the most perfect and beautiful of quadrupeds. As such, I believe the Horse to have been predestined and prepared for Man. It may be weakness; but, if so, it is a glorious one, to discern, however dimly, across our finite prison-wall, evidence of the 'Divinity that shapes our ends,' abuse the means as we may.

Thus, at the acquisition of facts adequate to test the moot question of links between past and present species, as at the close of that other series of researches proving the 'skeleton of all Vertebrates, and even of Man, to be the harmonised sum of a series of essentially similar segments,'[1] I have been led to recognise species as exemplifying the continuous operation of natural law, or secondary cause; and that, not only successively but progressively; 'from the first embodiment of the Vertebrate idea under its old Ichthyic vestment until it became arrayed in the glorious garb of the Human form.'[2]

The series of observations on the Ungulate group of Mammals yields insight, as above explained, into the mode of operation of the secondary law; and gives evidence of the amount of geological time intervening between the introduction and disappearance of generic or subgeneric modifications. According to the analogy of the mammalian *Hipparion* and *Equus*, we may expect the corresponding precedent form of the Papuan of the well-wooded and richly fruited islands representing a departed tropical or subtropical continent, to be exemplified by fossils in formations not earlier than middle tertiary. All species coexisting with the actual specific form of *Homo* will, with him, be immutable, or mutable only as he may be. To name such species, after comparing and determining their specific characters, will continue to be the Zoologist's staple task as long as his own specific intellectual character remains unchanged (Pref. p. xxxvi.). To suppose that coexisting differentiations and specialisations, such as *Equus* and *Rhinoceros*, or either of these and *Tapirus*, which have diverged to generic distinctions from an antecedent common form, to be transmutable one into another, would be as unscientific, not to say absurd, as the idea, which has been bolstered up by so many questionable illustrations, and foisted upon poor 'working men,' of their derivation from a Gorilla!

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[1] cxli. p. 119.

[2] Ib. p. 86. Even in his partial quotation from my work of 1849, the author of ccxiii″ (4th Ed. 1866) might have seen ground for apologising for his preposterous assertion, in 1859:—that 'Professor Owen maintained, often vehemently, the immutability of species' (p. 310), and for the question, as preposterous and unworthy: 'Does he really believe that at innumerable periods in the earth's history elemental atoms have been commanded suddenly to flash into living tissues?' (Ib. Ed. 1859, p. 483. In the Ed. of 1860, p. 111, the imputation is tacitly abandoned.) The significance of the concluding paragraphs of cxli was plain enough to Baden Powell, cccxxxiii″. p. 401 (1855), and drew down on me the hard epithets with which Theology usually assails the inbringer of unwelcome light, cii′. p. 61.

§ 425. *Extinction, cataclysmal or regulated?*—If, in place of recognising the series of the above-cited Perissodactyles as evidencing (preordained) departures from parental type, probably sudden and seemingly monstrous, but adapting the progeny inheriting such modifications to higher purposes, the theological notion be retained, and the species of Palæothere, Paloplothere, Anchithere, Hipparion, and Horse, be severally deemed due to remotely and successively repeated acts of direct creation, one is concomitantly led to suppose the successive going out of such species to have been as miraculous as their coming in. The destruction of one creation is the logical preordinance to a recurrence of 'genesis.' This nexus of ideas was too close not to have swayed with Cuvier: accordingly, in his famous 'Discours sur les Révolutions de la Surface du Globe,' we have a section of 'Preuves que ces Révolutions ont été nombreuses,'[1] and another section of 'Preuves que ces Révolutions ont été subites.'[2] Continued observations of Geologists, while establishing the fact of successive changes, have filled up the seeming chasms between such supposed 'revolutions,' as the discoveries of Palæontologists have supplied the links between the species held to have perished by the cataclysms. Each successive parcel of geological truth has tended to dissipate the belief in the unusually sudden and violent nature of the changes recognisable in the earth's surface. In specially directing my attention to this moot point, whilst engaged in investigations of fossil remains, and in the reconstruction of the species to which they belonged, I was, at length, led to recognise one cause of extinction as being due to defeat in the 'contest which as a living organised whole, the individual of each species had to maintain against the surrounding agencies which might militate against its existence.' (Pref. p. xxxiv.) This principle has received a large and most instructive accession of illustrations from the extensive knowledge and devoted labours of Charles Darwin: but he aims to apply it not only to the extinction but the origin of species.

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[1] cccxx″. p. 5.

[2] Ib. p. 8.

Although I fail to recognise proof of the latter bearing of the 'battle of life,' the concurrence of so much evidence in favour of 'extinction by law' is, in like measure, corroborative of the truth of the ascription of the origin of species to a secondary cause.[1]

[1] A critic of the first volume of the present work, switching over the pages of the 'Preface' with the speed they merited at his hands, caught sight of the words, 'contest of existence,' 'battle of life;' and thereupon dashed off with—'We would call attention to the following passage, and ask whether it is not actually an admission of the Darwinian Theory!' ('London Review,' April 28, 1866, p. 483); then pastes in the slip, beginning with 'the actual presence,' to 'fared better in the battle of life.' With the bulk of the two volumes before him, an able reviewer could hardly be expected to waste valuable time upon 'notes,' and so the fact escaped him that the 'admission' or 'adoption' was, in whatever degree it might relate to the D. T., an anticipation.

Oddly enough, another reviewer (if haply the same meritorious labourer may not have been doing this sort of work for both periodicals) makes the same transposition of dates, mistaking a quotation for text; e.g. 'Not the least important feature in the work before us is, that it contains a partial concurrence, on the part of the author, in the theory of *Natural Selection.*' And the same cutting does duty as 'pièce justificative,' viz., 'The actual presence,' &c. to 'battle of life.'—('Popular Science Review,' April, 1866, p. 212.)

Having regard to intelligent countrymen and countrywomen taking scientific sustenance from these weekly and monthly sources, and who might never see the pages of the work reviewed, I ventured to call attention to the omitted reference in the foot-note of my 'Preface,' viz., to the volume of 'Transactions of the Zoological Society,' 1850, in which my theory of the extinction and conservation of species appeared, including the passage quoted, with the obvious remark, that, 'if the difference between 1858 (date of the D. T. or "Natural Selection") and 1866 (date of vol. i. of Anat. of Vertebrates) puts the writer of the latter date in the subordinate relation of "admitter" or "adopter"—tacit or otherwise—to the author of the same theory at the earlier date, the writer of 1858 must stand in the same relation to the author of the same theory of 1850.'—(Letter to Ed. of 'London Review, May 1st, 1866.)

Of course, to every competent judge, the difference between a theory founded on the application of the principle of the contest for existence to the preservation or extinction of certain species, and that of a theory of the origin of all species partially based upon the same principle, must have been obvious; nor was any pretention advanced, in the letter rectifying the date of the 'idea,' to the ample and instructive degree in which it had been worked out, and doubtless as an original thought, by the accomplished author of ccxiii″.

I deeply regretted, therefore, to see in a 'Historical Sketch' of the Progress of Enquiry into the origin of species, prefixed to the fourth edition of that work (1866), that Mr. Darwin, after affirming, inaccurately and without evidence, that I 'admitted

§ 426. *How works the Derivative Law?*—The guesses made by those who have given the rein to the imaginative faculty in

Natural Selection to have done something toward that end,' to wit, the 'origin of species,' proceeds to remark: 'It is surprising that this admission should not have been made earlier, as Prof. Owen now believes that he promulgated the theory of Natural Selection in a passage read before the Zoological Society, in February, 1850 (Trans. vol. iv. p. 15).'

The reason assigned for this assertion is a paragraph in my letter to the 'London Review,' May 5, 1866, p. 516, which letter Mr. Darwin represents as an expression of my belief 'that I promulgated the theory of Natural Selection in a passage read before the Zoological Society, in February, 1850.' The passage which Mr. Darwin quotes is as follows:—"No naturalist can dissent from the truth of your perception of the essential identity of the passage cited with the basis of that (the so-called Darwinian) theory, the power, viz. of species to accommodate themselves or bow to the influences of surrounding circumstances." My ground for assuming the recognition of 'the power of species to accommodate themselves or bow to the influence of surrounding circumstances' to be the basis of the 'so-called Darwinian theory,' was, the definition of that theory given by the author in the title-page of the work 'On the Origin of Species by means of Natural Selection.' For, the words 'Natural Selection' not being likely, of themselves, to suggest the mode of origin of species, the author adds the following definition of his meaning: 'or, the preservation of favoured races in the struggle for life.'

Now, although in the perusal of the work so entitled I found many other previously propounded grounds of a belief as to the origin of species—as, e.g. 'volition or endeavour to act in a given way,' p. 184, 'homology,' p. 434, 'irrelative repetition,' p. 149, 'geological time,' p. 282, 'successive extinction of species,' p. 312, 'indications of older or earlier species having a more embryonal or generalised structure than their successors,' p. 338, &c.,—all of which had seemed to me to be better evidences of a genetic succession of species than the one ground set forth in the title-page—yet, being so set forth, it was due to the author to refer to it as 'the basis' of his theory. If reference be now made to the 'Zoological Transactions,' vol. iv. p. 15 (February, 1850), or to 'Preface' (vol. i.) p. xxxiv., it will be seen that I exemplify the principle of the preservation of the favoured race, in the circumstances of the struggle described, including seasonal extremes, adaptation to kinds of food, generative powers, introduction of enemies, &c., by such characters of species as those of size:—'If a dry season be gradually prolonged, the large Mammal will suffer from the drought sooner than the small one; if such alteration of climate affect the quantity of vegetable food, the bulky Herbivore will first feel the effects of stinted nourishment; if new enemies are introduced, the large and conspicuous quadruped or bird will fall a prey, whilst the smaller species conceal themselves and escape. Smaller animals are usually, also, more prolific than larger ones.' It will be admitted, I may believe, that, in view (in 1850) of the question of extinction by cataclysm, or by surrounding influences, not more extraordinary, for example, than extreme season (heat, cold, rain, drought, as part of the ordinary Laws of Climate), the operation of such influences in the preservation of some races and the extirpation of others could scarcely be more explicitly propounded. And this principle of victory or defeat in the 'contest with surrounding agencies' is set forth in Mr. Darwin's title-page as the basis of his theory of Natural Selection. Then, when a reviewer, ignorant of, or ignoring, the relative dates of promulgation of such basis, quotes me as adopting Mr. Darwin's theory, and when I point out the transposition of the dates of that theory and of my enunciation of its basis, Mr. Darwin turns upon me and writes, in 1866: 'Mr. Owen now believes that he promulgated the theory of Natural Selection,' and adds, 'this belief in Prof. Owen that he thus gave to the world the theory of Natural Selection will surprise all who are acquainted with the several passages of his works,' &c. (p. xviii.). But all that Mr. Darwin gives in support of this statement attempts to explain the mode of operation of the derivative law have mainly proved repellent to its study, and have raised the chief obstacles to its acceptance, by affording the most favourable opportunities of telling argument and caustic criticism to opponents of any recognition of such law in the abstract. Thus, De Maillet's conception of the conditions of transmutation[1] invited Cuvier's crushing exposition of its absurdity, which fell with the full weight of his great anatomical knowledge.[2] Lamarck

and comment, and I am very sure he quoted every word he could find to justify them, goes no further than to show that I had anticipated him in the basis of his theory, and in no way or degree supports his assumption that I accepted or had affirmed that I had promulgated (in 1850), the extraordinary superstructure which he has raised upon that basis, under the term 'Natural Selection.' In so asserting I should have merely deceived myself: no Naturalist cognisant of the history of the progress of the knowledge of the origin of species could be deceived for a moment by so gross an absurdity as would have been the statement of the belief, which statement Mr. Darwin endeavours to fasten upon me, of 'having promulgated the theory of "Natural Selection,"' or any other theory of the origin of species. It would have been a case of self-deception akin to that by which Mr. Darwin, having attempted and, as it seems to me, failed, to explain the origin of species on my basis of the 'struggle for life,' assumes to himself, or allows others to attribute to him the only reasonable and probable grounds for belief in the origin of species through a preordained continuously operating secondary law or cause. And here I take leave to remark, that certain facts having been pointed out, with their mode of operating in the origin of species, and the probabilities weighed for and against the miraculous origin of 'some one form into which life was first breathed' as contrasted with 'the normal origin of divers forms of sarcodal, single-celled, life' as hypothetical beginners of subsequent and higher forms, it is not honest to confound such 'derivative hypothesis of the origin of species' with the hypothesis of 'Natural Selection.'

[1] 'Car il peut arriver, comme nous sçavons qu'en effet il arrive assez souvent, que les poissons aîlés et volans chassant ou étant chassés dans la mer, emportés du désir de la proie ou de la crainte de la mort, ou bien poussés peut-être à quelques pas du rivage par les vagues qu'excitait une tempête, soient tombés dans des roseaux ou dans des herbages, d'où ensuite il ne leur fut pas possible de reprendre vers la mer, l'essort qui les en avait tirés, et qu'en cet état ils ayent contracté une plus grande faculté de voler. Alors leurs nageoires n'étant plus baignées des eaux de la mer, se fendirent et se déjettèrent par la sécheresse. Tandis qu'ils trouvèrent dans les roseaux et les herbages dans lesquels ils étaient tombés, quelques alimens pour se soutenir, les tuyaux de leurs nageoires séparés les uns des autres se prolongèrent et se revêtirent de barbes; ou, pour parler plus juste, les membranes qui auparavant les avaient tenus collés les uns aux autres, se métamorphoserent. La barbe formée de ces pellicules déjettées s'allongea elle-même; la peau de ces animaux se revêtit insensiblement d'un duvet de la même couleur dont elle était peinte et ce duvet grandit. Les petits ailerons qu'ils avaient sous le ventre et qui, comme leurs nageoires, leur avaient aidé à se promener dans la mer, devinrent des pieds, et leur servirent à marcher sur la terre. Il se fit encore d'autres petits changemens dans leur figure. Le bec et le col des uns s'allongèrent; ceux des autres se racourcirent: il en fut de même du reste du corps. Cependant la conformité de la première figure subsiste dans le total; et elle est et sera toujours aisée à reconnaître.' Telliamed, t. ii. p. 166 (1755).

[2] 'Des naturalistes, plus matériels dans leur idées, sont demeurés humbles sectateurs de Maillet. Voyant que le plus ou moins d'usage d'un membre en augmente ou en diminue quelquefois la force et le volume, ils se sont imaginé que des habitudes ou

gave occasion to many similar confutations, applied not always in good faith, and often by men without any anatomical or physiological qualifications for such criticism, to discredit veritable evidences of the operation of a secondary creative law. Subjoined, for example, is his hypothesis of the origin of the human species,[1] which, with similar illustrations from the web-footed, hoofed, and long-necked ruminant mammalia, have afforded topics of easy ridicule. So Lyell, asserting that 'orangs had been tamed by the savages of Borneo, and made to climb lofty trees and bring down the fruit,'[2] proceeds:—'It is for the Lamarckians to explain how it happens that these same savages of Borneo have not themselves acquired, by dint of longing, for many generations, for the power of climbing trees, the elongated arms of the orang, or even the prehensile tails of some American monkeys. Instead of being reduced to the necessity of subjugating stubborn and untractable brutes, we should naturally have anticipated "that their wants would have excited them to efforts, and that continued efforts would have given rise to new organs:" or, rather, to the reacquisition of organs, which in a manner irreconcileable with the principle of the "progressive" system, have grown obsolete in tribes of men which have such constant need of them.'[3]

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des influences extérieures, longtemps continués, ont pu changer par degrés les formes des animaux au point de les faire arriver successivement à toutes celles que montrent maintenant leurs différentes espèces. On y considère en quelque sorte les corps organisés comme une simple masse de pâte ou d'argile qui se laisserait mouler entre les doigts. Aussi du moment où ces auteurs ont voulu entrer dans le détail, ils sont tombés dans le ridicule. Quiconque ose avancer sérieusement qu'un poisson, à force de se tenir au sec, pourrait voir ses écailles se fendiller et se changer en plumes, et devenir lui-même un oiseau; ou qu'un quadrupède, à force de pénétrer dans des voies étroites, de se passer à la filière, pourrait se changer en un serpent, ne fait autre chose que prouver la plus profonde ignorance de l'anatomie. Quel rapport y a-t-il entre l'organisation compliquée et admirable de la plume, ses tuniques, ses vaisseaux, ses cupules transitoires sur lesquelles se moulent ses barbes, et dont il reste une partie dans son tuyeau, ses barbules de plusieurs ordres, toujours si bien adaptées à la nature de l'oiseau; quel rapport, dis-je, y a-t-il entre tout cela et une écaille qui se fendillerait? il y a mieux, c'est que l'écaille n'est pas même d'une texture qui lui permettre de se fendre ainsi en se dessèchant; et voilà cependant un échantillon de ce que nous proposent des auteurs vantés!'—xii. i. p. 100.

[1] 'Effectivement, si une race quelconque de *quadrumanes*, surtout la plus perfectionnée d'entre elles, perdoit, par la nécessité des circonstances ou par quelqu'autre cause, l'habitude de grimper sur les arbres et d'en empoigner les branches avec les pieds, comme avec les mains, pour s'y accrocher; et si les individus de cette race, pendant une suite de générations, étoient forcés de ne servir de leurs pieds que pour marcher, et cessoient d'employer leurs mains commes des pieds; il n'est douteux, d'après les observations exposées dans le chapitre précédant, que les quadrumanes ne fussent à la fin transformés en *bimanes*, et que les pouces de leurs pieds ne cessassent d'être écartés des doigts, ces pieds ne leur servant plus qu'à marcher.'—ccxcviii″. i. p. 349.

[2] ccc″. Ed. 1835, vol. ii. p. 463.

[3] Ib. p. 464.

An anatomist and physiologist competent to judge of the stable grounds of a derivative origin of species—unity of plan, geological epochs, successive species therein,—truly set forth by the great and philosophic naturalist, would have referred to him, bearing calmly and nobly an old age of blindness and poverty, in a more worthy spirit. From one destitute of qualifications for grappling with the difficulties of this profound genetic problem in physiology, silence would have been blameless. Vituperative condemnation by such a one of a given phase or an untenable ground of that problem is of no greater value than his extravagant commendation, with as little capacity for comprehending its weakness, of a subsequent attempt towards its solution.

Some of Lamarck's characteristic and assailable illustrations have indeed been adopted and further developed:—'Ceux des mammifères aquatiques qui contractèrent l'habitude de ne jamais sortir des eaux, et seulement de venir respirer à leur surface, donnèrent probablement lieu aux différens *Cetacées*. En effet, depuis l'énorme quantité de temps que ces animaux vivent dans le sein des mers, ne se servant jamais de leurs pieds postérieurs pour saisir les objets, ces pieds non employés ont tout-à-fait disparu, ainsi que leurs os, et même le bassin qui leur servoit de soutien et d'attache.'[1] As a fact, however, so much of the pelvis has been preserved in *Cetacea* as serves to give origin to certain muscles of the genitals; and, in the mysticete whale, even a rudiment of the attached limb remains (vol. ii. fig. 159, 63–66). But besides the influence of habitual sojourn in water, Mr. Darwin adds another consideration to account for the enormous head in *Cetacea*:—'In North America the black-bear was seen by Hearne swimming for hours with widely open mouth, thus catching, almost like a whale, insects in the water.[2] I see no difficulty in a race of bears being rendered by Natural Selection, more and more aquatic in their structure and habits, with larger and larger mouths, till a creature was produced as monstrous as a whale.'[3]

The idea which Mr. Darwin persuades himself that he originated in addition to Lamarck's 'influence des circonstances sur les actions et les habitudes des animaux et de celle des actions et des habitudes de ces corps vivans, comme causes qui modifient leur organisation et leurs parties' is most intelligibly illustrated in the Paper in which he first communicated his views to the Linnæan Society. It is by 'an imaginary example from changes in progress on an island':—'Let the organisation of a canine animal which preyed chiefly on rabbits, but sometimes on hares, become slightly plastic: let these same changes cause the number of rabbits very slowly to decrease, and the number of hares to increase: the effect of this would be that the fox or dog would be driven to try to catch more hares; his organisation, however, being slightly plastic, those individuals with the lightest forms, longest limbs, and best eyesight, let the differences be ever so small, would be slightly favoured, and would tend to live longer, and to survive during that time of the year when food was scarcest; they would also rear more young, which would tend to inherit those slight peculiarities. The less fleet ones would be rigidly destroyed. I can see no more reason to doubt that these causes in a thousand generations would produce a marked effect, and adapt the form of the fox or dog to the catching of hares instead of rabbits, than that greyhounds can be improved by selection and careful breeding.'[1] So Geoffroy Saint-Hilaire also wrote:—'Si ces modifications amènent des effets nuisibles, les animaux qui les éprouvent cessent d'exister, pour être remplacés par d'autres, avec des formes un peu changées, et changées à la convenance des nouvelles circonstances.'[2]

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[1] CCXCVIII″. ii. p. 461. [2] CCXIII″. p. 184, Ed. 1.

[3] This conclusion of the passage is omitted in later editions.

The modifications on which Geoffroy Saint-Hilaire laid chief stress were those assumed to have affected the ambient medium, the mode of operation of which in the origin of species he thus exemplifies:—'Mon Mémoire, traitant de l'influence des milieux ambians pour modifier les formes animales, montre comment la quantité décroissante de l'oxygène, relativement aux autres composans de l'atmosphère, a pu forcer les surfaces cutanées des embryons, premier et principal siége des actes respiratoires, à s'ouvrir davantage, à gagner, dans une raison inverse du volume existant de l'oxygène, plus de profondeur, au moyen de plus larges anfractuosités dans le tissu cellulaire, et à acquérir, par un accroissement dans l'intensité des effets, de plus en plus, le caractère d'ampoules et décidément de trachées, jusqu'à ce qu'enfin survienne dans le thorax une concentration des sinus respiratoires, et des arrangements de structure pour l'isolement des poches ou théâtres de respiration, appelés, suivant leurs qualités conditionnelles, *poumons* ou *branchies*.'—CCXCVII″. p. 82.

One should not be dealing fairly with this exposition of transmutative conditions if we were to take its terms in their literal or usual acceptation; else, the obvious objection that embryos are shut out from the influence of the atmosphere until their lungs are prepared for it, at once suggests itself. I assume, therefore, that the term is used, metaphorically, to signify the low and early embryo-like forms of living things. But it may then be remarked that if speculation be permitted on possible changes in the constitution of the atmosphere of this planet, during past geological æons, it is more probable that the proportion of the carbonic acid has been reduced than that of the oxygen. The prevalence of remains of cold-blooded slow-breathers in palæozoic and older mezozoic strata has more than once suggested such relation to the 'ambient medium.' I repeat, however, that the sole consequence of vague generalities, or figurative impersonations, propounded to show how transmutation may go on, has been to prejudice calm and sound judgments against any acceptance of, or favour toward, the grounds of a belief in secondary creational law. I have elsewhere tested the ideas of Lamarck and Darwin as to the mode of transmutation, by reference to the species *Chiromys Madagascariensis*:[1] I will now apply them, together with Geoffroy's, to another and lower degree of life.

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[1] CCCI. p. 49. But see the remarks on this in CLXXX. p. 434, and CII′. p. 65.

[2] CCXCIX″. p. 79.

What spectacle can be more beautiful, striking, and suggestive than that of the inhabitants of the calm expanse of water of an atoll, encircled by its vast ring of coral rock! Leaving the bright-tinted Chœtodonts, the Scari with adamantine jaws, the Holothurians and other locomotive frequenters of the calcareous basin out of the question, and restricting the test to the species cemented or otherwise confined to its area: we may first ask:—

Were the elements of the coriaceous and of the softer contractile and secreting tissues of the coral-polype suddenly combined and disposed so as to form the body-wall, inverted gastric-bag, produced tentacles, intermediate laminæ, generative plaits, vesicles and threads, with outer folds in arrangement and numbers such as to secrete the laminate calcareous polype-cell? Was the creature, so miraculously constituted, at the same time endowed with generative faculties to multiply and reproduce its kind for all time; the creative act henceforth and thereafter being dispensed with? Accepting, with the theologian, this view, it must then be applied to each of the more or less closely allied species associated in the same coral workhouse. The origin of such species thus dates back to the beginning of life on the globe.[2] The first created coral-polype included, potentially, the germs of its successors throughout all time.

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[1] CII″. pp. 64–66.

[2] I leave out of the question the subsequent lethal influence of the heavy and continuous rain added to the ocean in order to raise it above the highest mountains, according to the biblical flood.

Observation, however, shows that the species of existing *Anthozoa* cannot be traced very far back: those with a flexible, or with a branched, calcareous axis began only at the tertiary period; and, of the genera of eocene lamellate or stony corals, all the species are extinct, and have been superseded in their grand and useful operations by those now forming reefs and atolls. As we extend our researches back in time we find generic and family types of coral-polypes passing away: the prevalent pattern of stellate cups of rays of *six* or its multiples, has superseded a simpler pattern of *four* or its multiples. Of the *Cyathophyllidæ* of the palæozoic reefs which present a quadripartite character of their plaited polype-cells, not one such species now exists, or has been observed in any formation later than lower green-sand. Moreover, the filling up of abandoned cells in the course of growth of the polypary becomes changed from a more complex to a more simple method, as we recede in time in pursuing our comparisons.[1]

With this generalised result of observation of reef-building polypes we return to the initial question in a frame of mind inevitably other than that in which the creation of a coral-island is pondered on by one ignorant of the geological history of the class engaged in its construction. Was direct creation, after the dying out of its result as a 'rugose coral,' repeated to constitute the succeeding and superseding 'tabulate coral'? Must we, also, invoke the miraculous power to initiate every distinct species of both *Rugosa* and *Tabulata*? These grand old groups have had their day and are utterly gone. When we endeavour to conceive or realise such mode of origin, not of them only, but of their manifold successors, the miracle, by the very multiplication of its manifestations, becomes incredible—inconsistent with any worthy conception of an all-seeing, all-provident Omnipotence! It is not above, but against, reason; and I may assume the special primary creative hypothesis of the successive and coexisting species of *Anthozoa* to be not now held by the scientific naturalist.

Let us then test the propounded explanations of their origin by secondary law. That of 'appetency' subsides from the impotency of a coral-polype to exercise volition. The weak point of Lamarck's creative machinery is its limited applicability, viz., to creatures high enough in the scale to be able to 'want to do something:' for the determined laws of the 'reflex function' in the physiology of the nervous system and the necessity of the superadded cerebral mass for true sensation rigorously fix the limits of volitional faculties.

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[1] CLXXX, pp. 23-28.

We pass then to considerations of the 'ambient medium' and 'natural selection.' We have no evidence that the fabricators of the coral-reef of Wenlock-edge, or of those skirting the Cambrian slates and Devonshire 'killas,' or of those in the lofty limestone cliffs of Cheddar, worked in an ocean otherwise constituted than the present. What conceivable character of sea or of the air dissolved or diffused therein could have changed the loose aggregation of the individuals of composite *Rugosa* into the close combination, with intercommunicating pores, of those of the composite *Tabulata*? Or what possible external influence could have transmuted the comparatively simple massive mode of growth or deposition of carbonate of lime common to both *Rugosa* and *Tabulata* into the light and complex character of the polyparies of most existing lamelliferous *Anthozoa*? In the first mode the old polype-cell is successively partitioned off from the one in occupation by floor after floor crossing the cavity: in the other, radiating vertical partitions alone occupy the deserted cell and extend uninterruptedly from its bottom or beginning to the superficial inhabited chamber. The quadripartite pattern of the plaited cup of the palæozoic coral has changed into the sexpartite disposition of the radiating lamellæ of the polype-cells of tertiary and modern corals. But personifying the fact of such transmutations by the term 'natural selection' gives no more insight into the manner of the operations than we learn of that of the budding out of a new leg in a maimed newt, by being told that it is done by the 'nisus formativus' or by 'pangenesis'! Even were there evidence of changes in the composition of the atmosphere, their 'modus operandi' in effecting such structural differences would not be more conceivable.

I do not believe that a sexpartite type of coral was miraculously created to supersede a quadripartite one. If the grounds are good for admitting the continuous operation of a secondary cause of the specific forms of Vertebrate life, *à fortiori* it is admissible in the lower sphere of Radiate life. It is consistent with facts that a quadripartite coral might bud out, or otherwise generate, a variety with a greater number of radiating laminæ. Some varieties, like those expressed by the modern generic terms *Porites*, *Millepora*, especially the *M. complanata*, with its strong vertical plates, were better adapted to bear the brunt of the breakers, and flourish in the surf, under the protection of the coating Nullipore. But to how small an exception is this relation applicable! Of the 120 kinds of coral enumerated by Ehrenberg in the Red Sea,[1] 100, at least, exist under the same conditions. The majority of species, originating in uncalled-for, unstimulated, unselected departures from parental structure, establish themselves and flourish independently of external influences. All classes of animals exemplify this independence: the Cetaceans, under an extraordinary and nicely graduated range of generic and specific modifications; and the same may be said of most Fishes.[2]

So, being unable to accept the volitional hypothesis, or that of impulse from within, or the selective force exerted by outward circumstances, I deem an innate tendency to deviate from parental type, operating through periods of adequate duration, to be the most probable nature, or way of operation, of the secondary law, whereby species have been derived one from the other.

It operates, and has operated, in the surface-zones where the chambered cephalopods floated, and at the depths where the brachiopods were anchored, as in the more defined theatre in which the various polypes of the coral reef display their diversities of colour, size, shape, and structure, independently of outward influences. This tendency, moreover, is not exemplified in the ratio of the number, variety, or force of conceivable 'selective' surrounding influences, but is directly as the simplicity of the organism. In the *Foraminifera*, e. g., it is manifested in such degree that as many as fifteen genera defined by one given to—

> Intrigue with the specious chaos, and dispart
> Its most ambiguous atoms with sure art;
> Define their pettish limits, and estrange
> Their points of contact and swift counterchange,

have been found by his followers to be but varieties of a single type; and even this, too inconstant to come under the definition of a species given in p. 792. The departure from parental form, producing the beautiful varieties of perforate and imperforate Rhizopods, and which exemplify each group, respectively, under the Lagenine, Nummulinine, Globigerine, or under the Gromiine, Milioline, and Lituoline types, has effected its ends independently of inner volitions or of outer selections. Certain encrusting forms seem by the presence of siliceous spicula to have been derived from sponges; but no explanation presents itself for such transitional changes, save the fact of anomalous, monstrous births—as these varieties, and the whole assemblage of alternate-generative phenomena, would be called 'in high life.'

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[1] cccxix″. p. 46.

[2] xcix′. p. 44.

According to my derivative hypothesis, a change takes place first in the structure of the animal, and this, when sufficiently advanced, may lead to modifications of habits. But we have no evidence that the observed amount of change in *Porifera*, *Foraminifera*, and *Anthozoa*, &c. has been attended with any change in the way or power in which they extract from their ambient medium, and precipitate, silex and carbonate of lime, or in the performance of any other vital function. As species rise in the scale, the concomitant change of structure can and does lead to change of habits. But species owe as little to the accidental concurrence of environing circumstances as Kosmos depends on a fortuitous concourse of atoms. A purposive route of development and change, of correlation and interdependence, manifesting intelligent Will, is as determinable in the succession of races as in the development and organisation of the individual. Generations do not vary accidentally, in any and every direction; but in preordained, definite, and correlated courses.

If the survey of a series of siliceous polycystins and diatoms, of zoophytes, of brachiopods, of ammonites, excites pleasure by their beauty, and raises worship of the Power manifesting itself in such inconceivable and exhaustless variety, I accept the relation as one designed, and in His due time, fulfilled:—

To doubt the fairness were to want an eye;
To doubt the goodness were to want a heart!

'Derivation' holds that every species changes, in time, by virtue of inherent tendencies thereto. 'Natural Selection' holds that no such change can take place without the influence of altered external circumstances educing or selecting such change.

'Derivation' sees among the effects of the innate tendency to change, irrespective of altered surrounding circumstances, a manifestation of creative power in the variety and beauty of the results: and, in the ultimate forthcoming of a being susceptible of appreciating such beauty, evidence of the preordaining of such relation of power to the appreciation. 'Natural Selection' acknowledges that if ornament or beauty, in itself, should be a purpose in creation, it would be absolutely fatal to it as a hypothesis.

'Natural Selection' sees grandeur in the "view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one:"[1] 'Derivation' sees, therein, a narrow invocation of a special miracle and an unworthy limitation of creative power, the grandeur of which is manifested daily, hourly, in calling into life many forms, by conversion of physical and chemical into vital modes of force, under as many diversified conditions of the requisite elements to be so combined.

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[1] ccxiii″. Ed. 1860, p. 490.

'Natural Selection' leaves the subsequent origin and succession of species to the fortuitous concurrence of outward conditions: 'Derivation' recognises a purpose in the defined and preordained course, due to innate capacity or power of change, by which nomogenously-created protozoa have risen to the higher forms of plants and animals.

The hypothesis of 'derivation' rests upon conclusions from four great series of inductively established facts, together with a probable result of facts of a fifth class: the hypothesis of 'natural selection' totters on the extension of a conjectural condition, explanatory of extinction to the origination of species, inapplicable in that extension to the majority of organisms, and not known or observed to apply to the origin of any species.

§ 427. *Epigenesis or Evolution?*—The derivative origin of species, then, being, at present, the most admissible one, and the retrospective survey of such species showing convergence, as time recedes, to more simplified or generalised organisations, analogous to Von Baer's law of individual development, the result to which the suggested train of thought inevitably leads is very analogous in each instance. If to Kosmos or the mundane system has been allotted powers equivalent to the development of the several grades of life, may not the demonstrated series of conversions of force have also included that into the vital form?

In the last century, physiologists were divided as to the principle guiding the work of organic development.

The 'evolutionists' contended that the new being pre-existed in a complete state of formation needing only to be vivified by impregnation in order to commence the series of expansions, or disencasings, culminating in the independent individual.

The 'epigenesists' held that both the germ and its subsequent organs were built up of juxtaposed molecules according to the operation of a developmental force, or 'nisus formativus.'

Haller maintained the principle of 'evolution,' Buffon that of 'epigenesis.' Hunter, who surpassed all his contemporaries in observations on the formation of the chick, 'thought he could see both principles at work, together with a third.' However, as he limited the 'pre-existing entities' to 'the materia vitæ universalis' and the 'absorbent faculty,' he would now be classed with the 'epigenesists.' For, he reckoned among the parts newly built up, not evolved, 'the brain and heart, with their appendages, the nerves and vessels, and so on of all the other parts of the body which we do not find at first.'[1] His third principle is merely a modification of epigenesis, viz., 'change in form and action of pre-existing parts.'

At the present day the question may seem hardly worth the paper on which it is referred to.[2] Nevertheless, 'pre-existence of germs' and 'evolution' are logically inseparable from the idea of the origin of species by primary miraculously created individuals. Cuvier, therefore, maintained both, as firmly as did Haller.[3] It is, perhaps, one of the most remarkable instances of the degree in which a favourite theory may render us blind to facts which are opposed to our prepossessions. Hunter's demonstrations of the epigenetic development of the blastoderm and initial parts of the chick[4] were not known to Cuvier; but the analogous ones of Wolff[5] he had studied. To the phenomena of the blood-lakes and their union in order to constitute the 'circulus vasculosus' of the vitellicle, Cuvier opposes the following remark:—'Mais il faut nécessairement admettre qu'il y avait une pré existence de quelques chemins pour les pointes rouges; car en vertu de quelle force la figure veineuse serait-elle toujours composée des mêmes vaisseaux ayant la même direction? Comment ces vaisseaux aboutiraient-ils toujours au même point pour former un cœur? Tous ces phénomènes ne sont intelligibles qu'autant qu'on admet quelque pré-existence.'[6]

Haller, who had made some good observations on embryonal development, confessed that there was a stage in that of the chick in which the 'intestinal canal was not visible;' he would not admit, however, that it was not formed, or that it did not pre-exist; but affirmed that it was too minute to be perceived: not until the head and limb-buds of the chick appeared, was the intestine visibly 'evolved.'[7]

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[1] XX. vol. v. p. xiv.

[2] The encasement or imboxing ('emboitement') of germs was deemed, a century or more ago, to receive support from the evolution of buds and other parts of plants, and from Swammerdam's discoveries in the chrysalis, not only of the parts which afterwards form the butterfly, as wings, antennæ, &c., but also of the eggs which were to be laid in that phase of life. Bonnet drew an inference in favour of the same view from his discovery of the numerous successive generations of *Aphides*, which might be impregnated by a single copulation. (See, however, CXLII'. pp. 27, 39.)

[3] XXVIII''. [4] XX. vol. v. Pls. lxviii.–lxxviii. [5] CCCVI''.

[6] CCCVII''. tom. iv. p. 236.

[7] "Partes animalis non noviter formantur, sed transeunt ex statu obscuro in conspicuum."—XXVIII''. tom. viii. sectio 2da. p. 150–156. Also 'Mémoire II., sur la formation du Poulet,' p. 182.

To the beautiful demonstration of the steps in the successive building up and moulding of the intestinal canal, out of the 'mucous layer' of the blastoderm, Cuvier objects:—'Mais quand il serait vrai que l'intestin se forme comme Wolff croyait l'avoir observé, il n'en résulterait aucune preuve en faveur de l'êpigénèse; car le nombril, par lequel l'embryon tient à son placenta, est d'abord tout aussi large que l'animal lui-même; c'est en enveloppant la portion du jaune qui doit rester dans l'intérieur, que la peau finit par rétrécir de plus en plus cette ouverture, qui primitivement n'en était pas une, et par la réduire à l'ombilic tel qu'on le voit dans le poulet ou dans l'enfant naissant.'[1]

Geoffroy contended that the dogma of 'pre-existence of germs' owed its origin to a metaphysical explanation of ill-observed phenomena. To admit that a germ included within itself all the forms, in miniature, which were afterwards to be manifested, and to develope such theory by a matter so indefinable, was to multiply, at will, the most gratuitous suppositions.[2] His opponent's passages, above quoted, in defence of a doctrine now deemed by embryologists to be dead and buried, have hardly other than historical interest;[3] and I should not have recalled them, or their

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[1] CCCVII''. tom. iv. p. 277.

[2] Anat. Philos. vol. ii. p. 280.

[3] A polemical bishop, viewing with the mixed feelings of his kind the dawn of new light, which, in 1669, began to flood men's minds from the 'Essay on the Human Understanding,' commenced his attack by insinuating 'unsoundness' in the author; then called upon Locke 'to clear himself by declaring to the world, that he owned the doctrine of the Trinity, as it hath been received in the Christian Church.' (Bp. of Worcester's 'Answer to Locke's Second Letter,' p. 4.) Finally, he charged him with diffusing principles inconsistent with, and sapping the grounds of, belief in the following articles of the Christian faith: 'the Resurrection of the Body,' the 'Trinity,' and the 'Incarnation of Our Saviour.' It is in reference to the first article that the antagonism of 'evolution' and 'epigenesis' curiously comes in. Stillingfleet, contending for the dogma of the 'same body,' against the objection of the transitory state of its particles during life, affirmed that 'every seed had that body in little which is afterwards so much enlarged,' and in proof that 'it hath its proper organical parts, which makes it the same body with that which it grows up to, (Ib. p. 40), refers to 'certain most accurate observations whereby these seminal parts are discerned in them, which afterwards grow up to that body which we call corn.'

To which Locke replied: "If that could be so, and that the plant in its full growth at harvest, increased by a thousand or a million of times as much new matter added to it as it had, when it lay, in little, concealed in the grain that was sown, was the very same body; yet to say that every minute grain of the hundred grains contained in that little organised seminal plant is every one of them the very same with that grain which contains that whole little seminal plant, and all those invisible grains in it, is to say that one grain is the same with an hundred, and one hundred distinct grains the same with one; which I shall be able to assent to, when I can conceive that all the wheat in the world is but one grain." ('Second Reply to the Bp. of Worcester,' in CCCXXXVI''. vol. i. p. 658.)

The chief point of interest, here, is to note how the latest movement in Science is pressed into questions of theological dogma. The newly established 'Philosophical subject, were it not that ghosts of 'pre-existence' and 'evolution' still haunt some chambers of the physiological mansion, and even exercise, to many, perhaps, an unsuspected, sway over certain biological problems.

Although in the Debates of 1830, the question of 'Pre-existence of Germs,' was the sole one in which, as applied to Embryogeny, I held with Geoffroy Saint-Hilaire, I remained the thrall of that dogma in regard to the origin of single-celled organisms, whether in or out of body.[1] Every result of formifaction I believed, with most physiologists, to be the genetic outcome of a pre-existing 'cell.' The first was due to miraculous interposition and suspension of ordinary laws; it contained, potentially, all future possible cells. Cell-development exemplified evolution of pre-existing germs, the progeny of the primary cell. They propagated themselves by self-division, or by 'proliferation' of minute granules or atoms, which, when properly nourished, again multiplied by self-division, and grew to the likeness of the parent-cells.

Those who still hold by this rag of 'pre-existence of germs,' call all organic corpuscles or granules 'cell-gemmules,' and maintain that they are transmitted, sometimes becoming developed,

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Transactions' were, then, giving to the world the results of the improved Dutch magnifying glasses, some of which results—e.g. 'spermatozoa'—were interpreted in a way which seemed to help the Bishop's view of the resurrection and his interpretation of the texts, 1 Cor. xv. 37–40. I quote Locke's remark for its historical interest in Microscopic Anatomy:—'It does not appear, by any thing I can find in this text, that St. Paul here compared the body produced, with the seminal and organical parts contained in the grain it sprung from, but with the whole sensible grain that was sown. Microscopes had not then discovered the little embryo plant in the seed; and supposing it should have been revealed to St. Paul (though in the Scripture we find little revelation of natural philosophy), yet an argument taken from a thing perfectly unknown to the Corinthians, whom he writ to, could be of no manner of use to them, nor serve at all either to instruct or convince them. But granting that those St. Paul writ to knew as well as Mr. Lewenhocke; yet your Lordship thereby proves not the raising of the same body,' &c.

In fact Locke, having been driven by the Bishop to look into the Scriptural grounds of that article of a progressively developed theological summary or 'creed,' which he was charged by Stillingfleet with undermining, replied: 'I must not part with this article of the resurrection, without returning my thanks to your Lordship for making me take notice of a fault in my "Essay." When I writ that book, I took it for granted, as I doubt not but many others have done, that the Scripture had mentioned in express terms, "the resurrection of the body;" but upon the occasion your Lordship has given me in your last letter to look a little more narrowly into what revelation has declared concerning the resurrection, and finding no such express words in the Scripture, as that "the body shall rise or be raised, or the resurrection of the body," I shall in the next edition of it change these words of my book, "the dead bodies of men shall rise," into these of Scripture, "the dead shall rise."' (Essay, B. iv. c. 18, § 7, and cccxxxvi''. vol. i. p. 668.)

[1] ccxlix. cxlii.

sometimes lying dormant from generation to generation, independent, autonomous, pre-existing from their primal miraculous creation, as descendants, like all higher forms of life 'of that one form of "Natural Selection" into which life was first breathed.' Darwin grafts upon this modification of the old evolutional dogma[1] his provisional hypothesis of 'Pangenesis.' (CCCVIII″.)

In like manner the Evolutionists hold that every single-celled organism, torule, organic molecule, out of the body, arises from a pre-existent germ; and that such germs abound in the air, in the waters, or wherever any forms of living matter may happen to make their appearance.

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[1] Studying under this belief the phenomena described in CXLII., I was led to regard all 'cells' or organic units concerned in development and repair as the progeny of the primary germ-cell in the ovarium of the mother, and to be in that sense 'derivative.' Save in the case of the hypothetical primordial created unit, such primary ovarian cell in the *Aphis* and all sexual organisms I regarded as impregnated. The derivative cells or organic units propagated themselves independently of direct sexual intercourse; but, that they should not be remotely or indirectly related to the act by which their seat, the developed organism, came to be,—in which organism, or its parthenogenetically propagated offspring, the 'cells' subsequently were formed,—was to me inconceivable on the then accepted hypothesis of 'pre-existence of germs' or 'omnis cellula e cellulâ.' Mr. Darwin, however, opposes to the above view the remark, "My gemmules" (=my germ-cells) "are supposed to be formed quite independently of sexual intercourse, by each separate cell or unit throughout the body." (CCCVIII″. ii. p. 375.) Yet, his provisional hypothesis of 'pangenesis' assumes that they ('cells,' 'cell-gemmules,' 'units') "are transmitted from the parents to the offspring" (ib.). But how so (in sexual species), save as the progeny or outcome of the primary impregnated germ-cell in the mother, whence all subsequent development and cell-generation radiated? Take any case in CCCVIII″., which 'Pangenesis' is propounded to explain—and all the given instances of varieties, malformations, &c., are from sexual organisms—as e.g. 'when a stag is castrated the gemmules derived from the antlers of his progenitors quite fail to be developed.' (Ib. ii. p. 399): to each I should reply as to this case:—Such stag first existed as an impregnated unit in the oviducal ovum of the mother. By the 'spontaneous fission' or 'cleavage process' it must have existed as a mass of impregnated gemmules. Assuming, with Mr. Darwin, that some of these gemmules were derived from the antlers of its parent, yet they are not less the progeny of the primary germ-cell which was formed within the ovarium of the female and was fertilised by the male. It may be a defect of power; but I fail, after every endeavour, to appreciate the 'fundamental difference' between Mr. Darwin's cell-hypothesis of 1868 and mine of 1849 (CXLII. p. 5–8). Both of them I now regard as fundamentally erroneous; in so far as they are absolutely based on 'pre-existence'—or 'omnis cellula,' &c. No doubt, many cells or organic units are derived from pre-existing cells (vol. i. p. 625): the phenomenon of the pale or granulated blood-cells which suggested to me, in 1838, the idea of the genetic mode of formation of the ordinary blood-discs, is a true phenomenon: but such mode of formation is subordinate to a wider law. Under given conditions matter in solution aggregates and shows form; if inorganic as 'crystal,' if organic as 'spherule': in the one the process is termed 'crystallization,' in the other 'formifaction.' If the large 'pale cell' was first filled by fluid holding organic matter in solution, the smaller granules or atoms it subsequently discharged might be the result of 'formifaction': it is at least a more simple, and I believe truer, idea of their origin than that which ascribes such origin to a mysterious genetic act under the name of 'proliferation.'—(CCCVIII″. vol. ii. p. 374.)

§ 428. *Nomogeny*[1] *or Thaumatogeny?*[2]—The French Academy of Sciences was the field of discussion and debate, from 1861 to 1864, between the 'Evolutionists' holding the doctrine of primary life by miracle, and the 'Epigenesists' who try to show that the phenomena are due to the operation of existing law. The analogy of the discussion between Pasteur and Pouchet, and that between Cuvier and Geoffroy, is curiously close. Besides the superiority in fact and argument, Pasteur, like Cuvier, had the advantage of subserving the prepossessions of the 'party of order' and the needs of theology. The justice of Jamin's summary,[3] awarding to the chemist the palm of superior care and skill both in devising and performing the experiments, and exposing the inferiority of the physiologist in polemical ability and coolness of argumentation, cannot be denied. Nevertheless, Pouchet, is rapidly acquiring, in reference to the origin of monads, that position which Geoffroy Saint-Hilaire has taken in regard to the origin of species. It is a suggestive and instructive fact in the philosophy of mind and the history of progress.

Some rare instances, in every generation, are gifted with the faculty of discerning the light of truth through all obstruction: when its glimmer is of the feeblest their brain responsively vibrates through a barrier of beliefs, prepossessions, precise logic, across thickets of facts deemed to be rightly understood, athwart accepted 'laws' and principles, organised corps of the soldiers of science, public opinion, &c.; and these men never know when they are beaten and put out of court: happily, against all hindrance, they persist—'*'e pur si muove.*'

Pasteur by an ingeniously devised apparatus,[4] collected atoms in the atmosphere, and described and figured them as examples of 'organised corpuscles,' 'globules,' or the 'germs' of living things, there floating.[5] In a solution of organic matter, otherwise unfit for the development of life, the addition of some of these germs was followed by the appearance, in abundance, of its simple forms.

To the conclusion that the monads were the consequence, not merely the sequence, of the 'ensemencement,' it can be objected that the atmospheric atoms figured[6] are not like the observed formified corpuscles by which bacteriums have been seen to be built up; and, that the chemical treatment to which they had been subject, in their extraction from the atmosphere, would be likely to destroy the vitality of fecund germs, if any were present. To the alleged absence of any organisms in the experiments which were calculated to exclude extraneous germs, and to unfit the infusion for the development of any it might contain, the graver objection applies, that the microscopic power employed by Pasteur in their search was insufficient. Dr. Child,[1] in experiments which seem to be as exclusive as Pasteur's, does obtain bacteriums, discoverable, at first, by a power of 1,500 diameters, and, once so seen, afterwards recognisable by a power of 750 diameters: whereas Pasteur, in his quest, did not avail himself of a power exceeding 350 diameters, and consequently failed to detect the evidence of 'nomogeny,' under conditions as decisive as can be hoped in an attempt to prove a negative. Against 'panspermism,' or the dogma that animalcules of infusions come, invariably and exclusively, from pre-existing germs falling from the air, Pouchet records the results of experiments, conclusive or satisfactory from their simplicity and ease of repetition, and freedom from need of minute, ambiguous, manipulatory precautions.[2]

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[1] *νόμος*, law, *γένω*, root of *γίγνομαι*, to 'become,' or come into being.

[2] *θαῦμα*, miracle, *γένω*.

[3] cccxxxiv″. pp. 442, 443.

[4] cccix″. p. 25, Pl. I. fig. 1.

[5] Ib. Pl. I. figs. 2–9.

[6] Ib. "quelques corpuscles organisées."—p. 28, Pl. I. figs. 2, 3, 4:—"tout-à-fait semblables à des germes d'organismes inférieures."—p. 37. Of the various well-marked forms of ova or germs of lower organisms, I know not any recognisable in the figures above cited.

A glass tube containing a filtered infusion is placed in the middle of a glass dish containing the same infusion: this stands in a wider dish of water in which a bell-glass is placed covering the vessels with the infusion. At the end of four or five days the tube-infusion has a thick film abounding with ciliate infusoria: the dish-infusion has a thin reticulate film containing only bacteriums and other small non-ciliate 'microzoaires.' It is 'difficult to see how the germs of the one kind of creatures should have entered or become developed in the one vessel and entirely different kinds in the other.'[3]

I refer the reader to CCCXII″. and CCCXXXV″. for further analysis of the grounds of the disputants, and proceed to remark, that the illustrations of the process of development of a *Paramecium*[4] so closely resemble those of the ovarian ovum in Fish or Mammal, that either fig. 555 or fig. 416, vol. i. of the present work serves as well as those given by Pouchet, to exemplify it. The proligerous pellicle, due to the resolution into molecules of the primarily formified bacteriums and vibrios of infusions, answers to the molecular contents of the ovisac. In both instances the molecules or granules aggregate into groups forming spheroids more opake than the rest (as in fig. 555, A): as the aggregation and coalescence advances the sphere becomes more opake, more definite: then a clear line marks its inclusion within a membrane, analogous to a 'zona pellucida,' and proclaims its individualisation (as in ib. B). Next appears a clear nucleus, answering to the germinal vesicle (as in ib. C). Fission of the nucleus is followed by that of the monad, which may thus multiply itself within the primary envelope (*Chlamydomonas*, CCXLIX. fig. 29), like the cleavage-formation of the germ-mass: ciliary organs are acquired in both instances, rotating the germ-mass in the mammalian ovum, and extricating the monad from its proligerous bed; whereupon it revolves or darts along, a free animalcule, in the subjacent liquor of the infusion.

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[1] CCCXII″.

[2] CCCX″. pp, 122, 135.

[3] CCCXII″. p. 101: paraphrasing Pouchet:—'Si les œufs tombaient de l'atmosphère, comme le prétendent les panspermistes, il n'y aurait pas de raison au monde qui pût faire que, dans la même portion d'air, l'éprouvette en soit constamment remplie et la cuvette jamais. Celle-ci même, à cause de sa surface bien autrement étendue, devrait en récolter infiniment plus.'—CCCX″. p. 136.

[4] CCCX″. Pl. II. figs. 1–5, and CCCXI″. Pl. I. fig. 1.

In neither instance is there any support, from observation, of the derivation of germ-mass or of monad by evolution out of a pre-existing cell: in both instances have the processes of epigenesis or building up *ab initio* been repeatedly seen and traced.[1]

In the case of the ciliate infusory the following are the primary or preliminary steps in the formation of the proligerous pellicle, or 'Burdach's mucous layer.' In the clear filtered infusion a slightly opalescent appearance precedes the formation of the thin superficial film. This consists of molecules of various sizes, the most minute testing the highest powers of the microscope. These molecules I attribute to the act of formifaction, which in reference to organic matter in solution corresponds with the crystalline aggregation of mineral matter in solution. Solution of organic matter, such as clear serum from a blister, enclosed in 'goldbeater's' skin or other close membrane, and inserted beneath the integument of a living Mammal—even distilled water which so placed obtains the elements of formifaction by endosmosis—show its results in the form of granules, white blood-cells, pus-globules, &c. These experiments need repetition and modification mainly in reference to the objection that such 'leucocytes' might have wriggled their way, like *Abœmæ*, from without, through the close texture of the enclosing bag.[1] In the proligerous pellicle the larger molecules unite end to end, forming bacteriums, or less regularly into masses composing *Torulæ*: these send out parts which become jointed tubes, and may terminate in rows of sporules (*Penicillium*) or capsules of such (*Aspergillus*). The bacteriums may, by further union and confluence, form vibrios. There is much activity, allied in character to the Brunonian movements;[2] which, after a time, ceases, and the bacteriums, vibrios, &c. are decomposed to constitute the secondary series of molecules in and from which the development of the higher ciliate Infusory takes place. The formation of the proligerous pellicle or 'secondary histolytic mass of molecules'[3] by the primary developments and resolutions of the organic material, is analogous to the formation of the germ-mass, in ovo, by the successive spontaneous fissions, assimilations, and ultimate coalescence of the progeny of the original germinal cell.

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[1] CCCX''. pp. 352–388. CCCXI''. pp. 133–253. CCCXII''. pp. 121–129. CCCXIII''. p. 1046. CCCXIV''. p. 974. CCCXV'. p. 467: Mantegazza spent sixteen consecutive hours in observing this genesis.

To meet the inevitable question of 'Whence the first organic matter?' the Nomogenist is reduced to enumerate the existing elements into which the simplest living jelly (*Protogenes* of Hæckel) or sarcode (*Amœba*) is resolvable, and to contrast the degree of probability of such elements combining, under unknown conditions, as the first step in the resolution of other forces into vital force, with the degree of probability remaining, after the observations above recorded, of the interposition of a miraculous power associating those elements into living germs, or forms with powers of propagating their kind to all time, as the sole condition of their ubiquitous manifestation, in the absence of any secondary law thereto ordained.

In this, the last general summary of work which I am likely to find time to complete, the expression of belief on one or two points where proof is wanting may be condoned. The chance of its being a help, or encouragement, to any younger, more vigorous, mind, bent upon grappling with such problems, outweighs any anticipation of trouble consequent upon the avowal.

It seems to me, then, more consistent with the present phase of dynamical science and the observed gradations of living things, to suppose that sarcode or the 'protogenal' jelly-speck should be formable through concurrence of conditions favouring such combination of their elements and involving a change of force productive of their contractions and extensions, molecular attractions and repulsions—and that sarcode has so become, from the period when its irrelative repetitions resulted in the vast indefinite masses of 'eozoon,' exemplifying the earliest process of 'formifaction' or organic crystallisation—than that all existing sarcodes or '*protogenes*' are the result of genetic descent from a germ or cell due to a primary act of miraculous interposition.

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[1] ccxvii″.

[2] ccxviii″. p. 470, in all organic molecules, living or dead.

[3] cccxxxv″. p. 10.

Some, accepting the latter alternative, teach that, while generations of the first-created sarcode have descended to us unchanged from the period of the Laurentian limestone, other sarcodal offspring have developed and improved, or have been selected, into all higher forms of living beings. I prefer, however, while indulging in such speculations, to consider the various daily nomogeneously developed forms of protozoal or protistal jellies, sarcodes and single-celled organisms, to have been as many roots from which the higher grades have ramified, than that the origin of the whole organic creation is to be referred, as the Egyptian priests did that of the universe, to a single Egg.

Amber or steel when magnetised seem to exercise 'selection': they do not attract all substances alike. To the suitable ones at due distance they tend to move; but, through density of constitution, cannot outstretch thereto; so they draw the 'attracted' substance to themselves. If the amber be not rubbed, or the steel bar otherwise magnetised, they are 'dead' to such power. The movement of a free body to a magnet has always excited interest, often wonder, from its analogy to the self-motion so common and apparently peculiar to 'life.'

A speck of protogenal jelly or of sarcode, if alive, shows analogous relations to certain substances: but the soft yielding tissue allows the part next the attractive matter to move thereto, and then by retraction to draw such matter into the sarcodal mass, which overspreads, dissolves, and assimilates it. We say that the *Protogenes* or *Amœba* has extended a 'pseudopod,' has seized its prey, has drawn it in, swallowed, and digested it. No 'organs,' however, are recognisable; neither muscle, mouth, nor stomach.

If the portion of iron attracted by the magnet became blended with the substance of its attractor, the analogy thereto of the act of the abæma would be, perhaps, closer, more just, than that other analogy which is expressed by terms borrowed from the procedure of higher organisms.

From certain knowledge of the homogeneous, by some termed 'unorganised,' texture of *Protogenes* and *Abœma,* we cannot predicate of their having sensation or exercising volition. Given 'life' and suitable organic substance at due distances, the act of making contact seems as inevitable, as independent of any volition of the abæma, as in the case of amber or steel, given 'magnetisation' and attractable substances at due distance.

The term 'living,' in the one case, is correlative with the term 'magnetic' in the other. Devitalise the sarcode, unmagnetise the steel, and both cease to manifest their respective vital or magnetic phenomena. In that respect both are 'defunct.' Only the steel resists much longer the surrounding decomposing agencies.

A man perceives a ripe fruit: if he can and will, he stretches out his hand, plucks, brings to his mouth, masticates, swallows, and digests it.

The question then arises whether the difference between such series of actions in the man and the attractive and assimilative movements of the amæba, be less or greater, than the difference between these acts of the amæba and the attracting and retaining acts of the magnet.

More may be said on both questions than I have here space for; but, when all is said, the question, I think, may be put with some confidence as to the quality of the ultimate reply and the affinity to truth, and liberty to accept it, in the equal respondent, viz., whether the amæbal phenomena are so much more different, or so essentially different, from the magnetic phenomena than they are from the mammalian phenomena, as to necessitate the invocation of a special miracle for their manifestation?

Magnetic phenomena are sufficiently wonderful, exemplifying, as they do, one of those subtle, interchangeable, may we not say 'immaterial,' modes of force which endows the metal with the power of attracting, selecting, and making to move a substance extraneous to itself. It is analogically conceivable that the same CAUSE which has endowed His world with power convertible into magnetic, electric, thermotic and other forms or modes of force, has also added the conditions of conversion into the vital mode.

Nerve-force we know to be convertible into electric energy, and reciprocally: and from the electric force, so induced, magnetic and other modes have been derived (vol. i. p. 357). The direction, then, in which may be anticipated the replies to the ultimate question, will be toward an admission of the originating and vitalising of the primary jelly-speck or sarcode-granule, by the operation of a change of force forming part of the constitution of Kosmos; not contrary to its ordained laws, in the sense in which 'miracle' or the 'interposition of special creative act,' is rightly understood.

But from protozoa,[1] or protista, to plants and animals, the gradation is closer than from magnetised iron to vitalised sarcode. From reflex acts of the nervous system animals rise to sentient and volitional ones.

And with that ascent are associated brain-centres progressively increasing in size and complexity. Arrest the development of the human brain at the point it has reached in the 'Aztec,' and the faculty of generalising and giving expression to such generalisations is wanting. The Aztecs can articulate words, and apply the right noun to the thing, as e.g. 'bread,' 'chair;' but they cannot combine ideas into propositions and say 'give me bread,' 'set me the chair.'

For such advance in intellectual acts more brain is essential. Compared with the normal state of brains in the brutes best endowed, so much more cerebral substance is required, and in such position, as to make the great and sudden rise, in the lowest grades of man, which is referred to in p. 144.

Thought relates to the 'brain' of man as does electricity to the nervous 'battery' of the torpedo: both are forms of force, and the results of action of their respective organs.

Each sensation affects a cerebral fibre, and in so affecting it, gives it the faculty of repeating the action, wherein memory consists, and sensation in a dream.

A dog at the sight of a rabbit receives a sensation which induces a volition, and he barks with the excitement of the chase. He sleeps, and by suppressed barking and agitation of limbs reveals the fact that he dreams. Shall we obtain any further insight into the nature of the act or acts resulting in this sensation, memory, dreamy imagination, by saying that the perception of the rabbit reaches the 'soul' of the dog by the affection of its cerebral fibres? Is the 'soul' of the dog other than the personified sum of his psychological manifestations?

The 'sight' of the dog is its faculty of vision, the 'soul' of a dog is its power of knowing what it sees and determining accordingly: it may approach the object with every manifestation of sentiments of gladness and submissive affection: it may rush upon it with every sign of rage: it may pursue it with every mark of excited ardour.

And these mental activities can only go on for a time: the waste thereby occasioned of fibre and of power calls for renovation, and this for repose, of the mental organ. In sleep the eyes close and sight goes; what then happens to the brain-fibres we cannot see nor tell: but the sum of action called 'soul' ceases. Deep sleep is utter unconsciousness to Dog and Man. The initial steps, and partial resumptions, of brain-action are 'dreams'; the awakening one issuing, often suddenly, in the full blaze of consciousness.

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[1] This is the better as well as older term: ζῶον being understood as 'life' generically, and before development has differentiated its manifestations into unambiguous 'vegetal' and 'animal' modes.

I am most averse to travel beyond my proper province; but a general physiological conclusion from the phenomena of the nervous system inevitably brings on collision with a dogmatic affirmation or definition of the cause of the highest class of those phenomena instilled as an article of religious faith into fellow-Christians, and on which is based their mode of thought affecting dearest hopes and highest aspirations. It must be repugnant to any good man's feelings to say aught that may unsettle such mode of thought, though he knows that what he has to impart lends truer and better support to both the faith and the hope.

If the hypothesis that an abstract entity produces psychological phenomena by playing upon the brain as a musician upon his instrument, producing bad music when the fibres or cords are out of tune, be rejected, and these phenomena be held to be the result of cerebral actions, an objection is made that the latter view is 'materialistic' and adverse to the notion of an independent, indivisible, 'immaterial,' mental principle or soul.

What 'materialistic' means in the mind of the objector I nowhere find intelligibly laid down; but it is generally felt to be something objectionable, 'inconsistent with, or shaking the foundations of an article of faith,' as Stillingfleet would have said.

To this I repeat Locke's answer, that my faith in a future life and the resurrection of the dead rests on the grounds of their being parts of a divine revelation.

If I mistake not, present knowledge of the way in which we derive ideas of an outer world helps to a more intelligible conception of 'matter,' 'substance,' 'immateriality,' &c. than could be framed by patristic and mediæval theology. To make intelligible my own ideas in this subject, which the anticipated imputation draws from me, I would put a case and ask a question.

When Saul at Endor "perceived that it *was* Samuel,"[1] lines of force, as 'luminous undulations,' struck upon his retina. *Qu.* Were the centres whence they diverged to produce the idea of the dead Prophet 'material' or 'immaterial'?

Other lines of force, undulated in another manner, from centres, producing the ideas of the dead man's speech:—"Why hast thou disquieted me, to bring me up?"[1] *Qu.* Were the centres radiating these acoustic lines of force material or spiritual?

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[1] 1 Sam. xxviii. 14.

Substitute the living for the dead Prophet, and it will be said that the points whence the rays of light converged to produce his image in the beholder are 'material' because 'tangible;' in the case of the 'spirit of Samuel' not. Had Saul stretched forth his hand to grasp the vision it would have met no resistance. Let us, then, analyse the sensations from tangible lines of force. I stretch forth the sum of forces called 'hand,' and exercise part of them in a way and direction called 'pressure,' deriving the sense or idea of such act by my lines of force being opposed by other lines of force. To the extent to which my forces overcome the opposing forces, I have an idea of a something giving way; when my lines of force are overcome by the opposite lines of force, I have the idea of a hard or resisting surface. But all that I know, after ultimate analysis, is the meeting of opposite forces; of the centres respectively radiating such force I know nothing; and if I did or could know anything I cannot conceive that I should get a clearer idea of 'touch' than as a relation of certain lines of force acting from centres, which may as well be 'immaterial' as 'material' for any intelligible notion I can frame of those verbal sounds.

If a blade of metal could move itself to and fro in striving to cleave the space between excited electro-magnetic poles, and could tell us its sensations, they would be those of sawing its way through a substance like cheese; but there is no visible impediment: nor, were luminous undulations to vibrate from the hindrance as from the plane of force resisting the pressing finger, would the hindrance be less 'immaterial.' Similarly, if lines of thought-force were visible, the 'ghost' would not on that account be more 'material.'

The ideas excited by the act of pressure are those of the 'exertion of force' and the 'resistance of force;' if these ideas be analysed they include those of the direction of force in lines from centres or points. Further than this, my mind, or thinking faculty, cannot go; i. e. can have no clear ideas: I cannot feel that I know more about the matter by calling the 'centres of force' 'material atoms' or 'immaterial points,' and am resigned to rest at a point beyond which Faraday[2] did not see his way.

Having evidence of the opposing force acting in lines from centres distinct from and outside of those volitional centres called

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[1] 1 Sam. xxviii. 15.

[2] CCCXXXVII." p. 119.

'ego,' the sensation is sufficient for my belief that it is due to the reaction of lines of force from outside-centres upon lines of force put into action from inside-centres. But I have no ground for calling the one 'material,' and the other 'immaterial,' or either, or both. The same result has followed my attempts to analyse all sensations and volitions, i. e. I know of nothing outside myself of which I can have any clearer knowledge by calling it 'material,' than I have of that which originates force from within myself, by calling it an 'immaterial' entity, mental principle, or soul.

But, so it is; in the endeavour to clearly comprehend and explain the functions of the combination of forces called 'brain,' the physiologist is hindered and troubled by the views of the nature of those cerebral forces which the needs of dogmatic theology have imposed on mankind.

How long physiologists would have entertained the notion of a 'life,' or 'vital principle,' as a distinct entity, if freed from this baneful influence, may be questioned; but it can be truly affirmed that physiology has now established, and does accept, the truth of that statement of Locke—'the life, whether of a material or immaterial substance, is not the substance itself, but an affection of it.'[1] Religion, pure and undefiled, can best answer, how far it is righteous or just to charge a neighbour with being unsound in his principles who holds the term 'life' to be a sound

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[1] CCCXXXVI''. vol. i. p. 761. As the authority of a Physiologist and late President of the Royal Society may be cited for ascribing such vital phenomena to an invisible 'mental principle,' (a) I unwillingly refer to the remark by which Sir B. Brodie meets the obvious objection of the divisibility, without destruction, of acrite organisms:—'It is true that one of our most celebrated modern physiologists, from observing the multiplication of polypi by the mere division of the animal, has come to the conclusion that the mental principle, which to our conceptions presents itself as being so pre-eminently, above all other things in nature, one and indivisible, is nevertheless itself divisible, not less than the corporeal fabric with which it is appreciated.' (p. 115.) The reader, eager for new light and guidance toward truth, naturally here expects the facts and arguments exposing the weakness or fallacy of the inference deduced from the polype-phenomena. The sole remark is a charge of that kind called '*argumentum ad hominem*.' 'But it is to be observed' (proceeds Sir B. B.) 'that, great as is the authority of Müller generally in questions of physiology, in the present instance he is not quite an unprejudiced witness, inclined as he is to the pantheistic theory,' &c. (p. 116.) Now, the charge is untrue; and, were it otherwise, affects not the point in question. Johannes Müller was of the school of inductive physiologists, opposed to Oken and others of the school of Schelling. He would not accept even the 'vertebral theory of the skull,' or 'general homologies;' but adhered to the party of Cuvier: he lived and died a sincere member of the Roman Catholic Church. Brodie's notion of a 'mental principle' seems to be a combination of 'vital principle' and 'soul,' πνεῦμα and ψυχή.

(a) Brodie's, Sir B., 'Psychological Enquiries,' 12mo. 1854, pp. 103, 115, 167.

expressing the sum of living phenomena; and who maintains these phenomena to be modes of force into which other forms of force have passed, from potential to active states, and reciprocally, through the agency of these sums or combinations of forces impressing the mind with the ideas signified by the terms 'monad,' 'moss,' 'plant,' or 'animal.'

If the physiologist rejects the theological sense of the term 'life,' without giving cause for the charge of unsoundness in religious principles, does he lay himself more open to the charge, by rejecting, also, the theologian's meaning of the term 'spirit,' of the term 'soul,' of the term 'mind,' and we might add of 'sin' or 'death'? That is to say, arguments based upon scriptural expressions of thought-force may be drawn from the like personifications of the aberrations and cessation of such force. Both Poets and Painters have, in each case, endeavoured to realise and give shape to the abstractions.

When doubting Thomas obeyed the Lord's command, his fingers met resistance below what seemed to him the surface of the side, and, entering the wound, were opposed by a 'force' exceeding the 'force' they exercised.[1] The resulting idea was, that the 'matter' of our Lord was there, but wanting where the spear had penetrated; the fact was the opposition of a force by a force, and the sensation of that opposition. We know of nothing more 'material' than the 'centres of force.' Our ideas of things without as within the 'ego' are the action and reaction of forces, as 'material' or 'immaterial' as the ideas themselves.

In this view is avoided the alternative of 'idealism' with denial of an external world, or that of the personifying the sum of mental phenomena as an 'immaterial indestructible soul,' contradistinguished from other sums of forces which are as arbitrarily styled 'destructible matter.' Sleep, stimulants, drugs, disease, concur by their effects in testifying that the kinds and degrees of mental manifestations are the result of corresponding affections and changes of structure of the brain.

How the brain works in producing thought or soul is as much a mystery in Man as Brutes—is as little known as the way in which ganglions and nerves produce the reflex phenomena simulating sensation and volition.

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[1] cccxxxvi''. vol. i. p. 656. The whole of Locke's 'Second Reply' to Bishop Stillingfleet may be read, with profit, in relation to the undesigned testimony borne by Physiology to the clear good sense and affinity for truth in the Philosopher's remarks on the relation of the dogma of 'immateriality,' 'indestructibility,' and 'separability' of soul, to a Christian's faith in the resurrection of the dead as resting on the grounds of divine revelation.

But it is a gain to be delivered from the necessity of speculating where the 'soul' wanders when thought and self-consciousness are suspended: or how it is to be disposed of until the 'resurrection of the body,' glorified or otherwise; of which reintegrated sum of forces 'soul' will then, as now, be a parcel. If the Physiologist and Pathologist had done no more than demonstrate 'the universal law of our being',[1] which cuts away the foundations of 'purgatory' or other limbo, from the feet of those who trade thereon,[2] which makes 'judgment' follow death without consciousness of a moment's interval,[3] they would deserve the gratitude of the Christian world.

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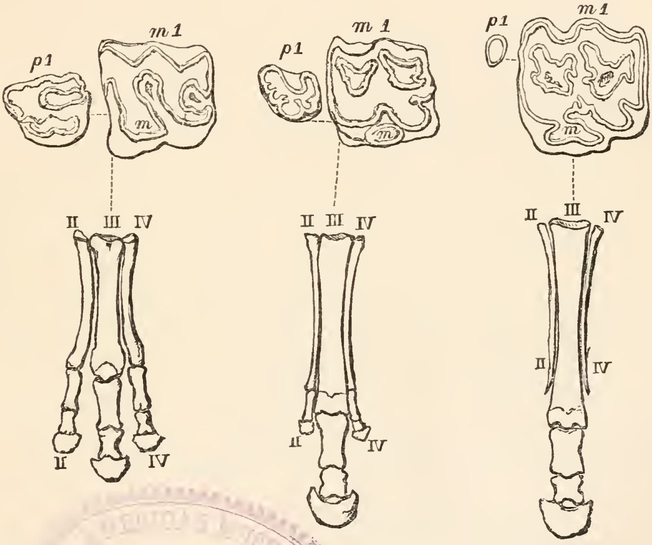

Paleothere. Hipparion. Horse.

Derivation of Equines.

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[1] cccxxxvii″. p. 306.

[2] Not to mention the kindred baser brood of 'Spiritualists and Spirit-Rappers.'

[3] For the importance of this conviction to 'practice,' see cccxxxvi″. vol. i. p. 156, § 63. 'In comparing present and future.'

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[1] This will subsequently be referred to as 'Trans. Zool. Soc.'

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