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composition of hornpipes flourished chiefly in the last century, and even Handel did not disdain to use the characteristic rhythm. The hornpipe may be written in $\frac{3}{2}$ or in common time, and is always of a lively nature.

HORROCKS, JEREMIAH (1619–1641), an astronomer of extraordinary promise blighted by a premature death, was born in 1619 at Toxteth Park, near Liverpool. Of the circumstances of his family little is known, further than that they were poor; but the register of Emmanuel College, Cambridge, testifies to his entry as sizar, May 18, 1632. Isolated in his scientific tastes, and painfully straitened in means, he pursued amid innumerable difficulties his purpose of self-education. His university career lasted three years, and on his return to Lancashire he devoted to astronomical observations the brief intervals of leisure snatched from the harassing occupations of a laborious life. In 1636 he met with a congenial spirit in William Crabtree, a draper of Broughton, near Manchester; and encouraged by his advice he exchanged the guidance of Lansberg, a pretentious but inaccurate Belgian astronomer, for that of Kepler. He now set himself to the revision of the Rudolphine Tables (published by Kepler in 1627), and in the progress of his task became convinced that a transit of Venus overlooked by Kepler would nevertheless occur on the 24th of November (O.S.) 1639. He was at this time curate of Hoole, near Preston, having recently taken orders in the Church of England, although, according to the received accounts, he had not attained the canonical age. The 24th of November falling on a Sunday, his clerical duties threatened fatally to clash with his astronomical observations; he was, however, released just in time to witness the punctual verification of his forecast, and carefully noted the progress of the phenomenon during half an hour before sunset (3.15 to 3.45). This transit of Venus is remarkable as the first ever observed, that of 1631 predicted by Kepler having been invisible in Europe. Notwithstanding the rude character of the apparatus at his disposal, Horrocks was enabled by his observation of it to introduce some important corrections into the elements of the planet's orbit, and to reduce to its exact value the received estimate of its apparent diameter.

After a year spent at Hoole, he returned to Toxteth, and there, on the eve of a long-promised visit to his friend Crabtree, unexpectedly expired, January 3, 1641, in the twenty-second year of his age. It is difficult to overestimate the services which, had his life been prolonged, this singularly gifted youth might have rendered to astronomical science. To the inventive activity of the discoverer he already united the patient skill of the observer and the practical sagacity of the experimentalist. Before he was twenty he had afforded a specimen of his powers by an important contribution to the lunar theory. He first brought the revolutions of our satellite within the domain of Kepler's laws, pointing out that her apparent irregularities could be completely accounted for by supposing her to move in an ellipse with a variable eccentricity and directly rotatory major axis, of which the earth occupied one focus. These precise conditions were afterwards demonstrated by Newton to follow necessarily from the law of gravitation.

In his speculations as to the physical cause of the celestial motions, his mind, though not as yet wholly emancipated from the tyranny of gratuitous assumptions, was working steadily towards the light. He clearly perceived the significant analogy between terrestrial gravity and the force exerted in the solar system, and used an ingenious experiment to illustrate the composite character of the planetary movements. He also reduced the solar parallax to 14″ (less than a quarter of Kepler's estimate), corrected the sun's semi-diameter to 15′ 45″, recommended decimal notation, and was the first to make tidal observations.

Only a remnant of the papers left by Horrocks was preserved by the care of William Crabtree. After his death (which occurred soon after that of his friend), these were purchased by Dr Worthington, of Cambridge; and from his hands the treatise *Venus in sole visa* passed into those of Hevelius, and was published by him in 1662 with his own observations on a transit of Mercury. The remaining fragments were, under the directions of the Royal Society, reduced by Dr Wallis to a compact form, with the heading *Astronomia Kepleriana defensa et promota*, and published with numerous extracts from the letters of Horrocks to Crabtree, in a volume entitled *Jeremiæ Horroccii Opera Posthuma*, London, 1672. A memoir of his life by the Rev. Arundell Blount Whatton, prefixed to a translation of the *Venus in sole visa*, appeared at London in 1859.

HORSE

PART I.—ZOOLOGY AND ANATOMY.

ZOOLOGY.

THE horse and its near allies, the several species of asses and zebras, constitute the genus *Equus* of Linnæus, a small group of animals of the class *Mammalia*, so distinct in their organization from all other existing members of the class that in many of the older zoological systems they were placed in an order apart, under the name of *Solidungula* or *Monodactyla*.

Investigations in comparative anatomy have, however, demonstrated that their structure, at first sight so singular and exceptional, is really but a modification of the same general plan upon which the tapirs and rhinoceroses are formed, and the discovery and restoration of the characters of extinct species, inaugurated by Cuvier during his fruitful researches into the fauna of the Paris basin, continued in various European localities by Kaup, Rütimeyer, Gervais, Gaudry, Huxley, and others, and recently conducted on a more ample scale in the prolific fossiliferous strata of North America by Leidy, Marsh, and Cope, have revealed numerous intermediate stages through which the existing horses appear to have passed in their modification from a very different ancestral form.

We shall best understand what a horse really is if we first consider its origin and lineage; and this we are in a better position to do than with almost any other animal, as it is one of the few whose history (if the evidence afforded by palæontology can be relied upon) can be traced back through an almost unbroken chain of links as far as the earliest Tertiary age.

We have as yet no cognizance of the history of any mammals of the group to which the horse belongs before the dawn of the Eocene period. Of where they lived and what they were like, from what earlier forms and by what stages of modifications descended, our actual knowledge is an absolute blank. Conjecture helps us but little, and why none of their remains have not ere this been discovered is a palæontological mystery. We have, however, certain knowledge that when the land which formed the bottom of the great cretaceous ocean which flowed over a considerable part of the present continents of Europe and North America was lifted above the level of the water and became fitted for the habitation of terrestrial animals, it was very soon the abode of vast numbers of herbivorous mammals belonging to the group now called *Ungulata* or "hoofed animals." Wherever they came from, they had existed sufficiently long to have become already completely differentiated into two

principal forms, separated from each other by many distinct points in their organization, among which one of the most externally conspicuous was the structure of their feet. From this character the one form has received the name of *Artiodactyla* or "even-toed," the other *Perissodactyla* or "odd-toed." It is only of the latter that we shall have to speak in this article.

Perhaps the best notion of a perissodactyle ungulate of the Eocene age can be derived from the tapir of the present day, an animal which has changed less from the primitive and generalized type of the group of that time than any other existing member of the order. These early forms had all the complete number of teeth found in so many of the mammals of that period of various orders, arranged according to the well-known formula—*incisors* $\frac{3}{3}$, *canines* $\frac{1}{1}$, *premolars* $\frac{4}{4}$, *molars* $\frac{3}{3} = \frac{11}{11}$ on each side, or 44 in all. The molar teeth had very short square crowns, with transverse or oblique ridges on the grinding surface. In the fore limbs the radius and ulna, and in the hind limbs the tibia and fibula, were distinct and well-developed bones. Whatever the number of toes on each foot, the one corresponding to the middle or third digit of the generalized pentadactyle limb was the longest; its ungual phalanx was symmetrical in itself, and it formed the centre of the foot, on each side of which the other toes were arranged in complete or partial symmetry according to the stage of development. In the hind foot in all known cases the symmetry was complete, only one toe on each side of the middle digit being present (fig. 3, *c*); but in the fore foot the primitive symmetry, formed by the presence of two toes on each side of the middle toe, had been lost in nearly all, by the disappearance of one of the outer toes (the first), the condition still retained by the tapirs (fig. 3, *a*); or it had been replaced by the second stage of symmetry, in which both outer toes are absent, and only three remain, as in the modern rhinoceros (fig. 3, *c*). By no animal of this period had the third, or most highly specialized stage of symmetry, that which, as we shall see, characterizes the modern horses (fig. 3, *e*), been attained.

By various and gradually progressing deviations from the common original type, these animals began at a very early period to break up into several groups, some of which (as *Macrauchenia*), after undergoing a considerable degree of specialization, have become extinct without leaving successors; but three of these modified types, already distinct at the close of the Eocene period, have continued up to the present day, gradually, as time advanced, becoming more and more divergent from each other. These are now represented by the three families of the rhinoceroses, the tapirs, and the horses. Great as may be the differences between these animals as we see them now, we can trace their history step by step, as revealed by the fragments preserved from former ages, further and further back in time, their differences continually becoming less marked, and ultimately blending together, if not into one common ancestor, at all events into forms so closely alike in all essentials that no reasonable doubt can be held as to their common origin.

Leaving out of further consideration the two collateral branches, it will be our purpose now to follow the history of the special subject of this article.

The remains of the earliest known animals to which it is possible to trace back the modern horse by a series of successive modifications are found in the lowest strata of the great lacustrine formations assigned to the Eocene period, spread over considerable portions of the present territories of New Mexico, Wyoming, and Utah in North America. That similar animals may have existed in other parts of the world is extremely probable. Negative evidence in such cases is of little value, as may be judged by the fact that it is only within a very few years that the existence of these deposits teeming with fossil remains of previously unsuspected forms has been brought to light, and their systematic exploration has scarcely yet commenced. A little animal, not larger than a fox, *Eohippus* of Marsh, presented the most generalized form of the perissodactyle type as yet discovered, as besides the four well-developed toes of the fore foot, found in so many others, it had at least a rudiment of a fifth. All analogy leads to the supposition that this must in its turn have been represented at a still earlier period by another form with all five toes complete, but direct evidence of this is at present wanting.

The transition from this horse-like animal of the early period to the horses of modern times has been accompanied by a gradual increase in size. The diminutive Eocene *Eohippus* and *Orohippus* were succeeded in the Miocene period by other forms to which the names of *Anchitherium* and *Miohippus* have been given, of the size of sheep; these again in Pliocene times by *Hipparion* and *Pliohippus*, as large as the modern donkeys; and it is only in the Pleistocene period that *Equidæ* appeared which approached in size the existing horse. Important structural modifications have also taken place, with corresponding changes in the mode of life of the animal. The neck has become elongated, the skull altered in form, the teeth greatly modified, and the limbs have undergone remarkable changes. The last two require to be described more in detail.

The teeth in the Eocene forms had, as mentioned above, the characteristic number of forty-four. This number has been retained throughout the series, at least theoretically; but one tooth on each side of each jaw, the anterior premolar, which in all the Eocene and Miocene species was a well-developed tooth, persisting through the life time of the animal, is in all modern horses rudimentary, functionless, and generally lost at an early period of life, evidently passing through a stage which must soon lead to its complete disappearance. The canines have also greatly diminished in size, and are rarely present in the female sex, so that practically a very large number of adult horses of the present day have eight teeth less than the number possessed by their predecessors. The diastema or interval between the incisor and premolar teeth, of essential importance in the domesticated horse to his master, as without it there could be no room for inserting the special instrument of subjugation to his commands, the bit, already existed in the earliest known forms, but has gradually increased in length. The incisors have undergone in comparatively recent times that curious change producing the structure which will be more fully described hereafter, and which distinguishes the horse's incisors from those of all other known animals. Lastly, the molars have undergone a remarkable series of modifications, much resembling in principle those that have taken place in several other groups of herbivorous animals. Distinctions in form which existed between the premolars, at least the anterior members of the series, and the true molars have gradually disappeared, the teeth becoming all very uniform in the shape and structure of their grinding surface. The crowns of all these teeth in the early forms were very short (see fig. 2, *a*); there was a distinct constriction, the neck, between the crown and roots; and when the tooth was developing, as soon as the neck once rose fairly above the alveolar margin, the tooth remained permanently in this position. The term "brachyodont" expresses this condition of teeth, the mode of growth of which may be illustrated by those of man. The free surface had two nearly transverse curved ridges, with valleys between (fig. 2, *a*); but the valleys were shallow and had no deposit of cementum filling them, the whole exposed surface of the unworn tooth being formed of enamel. When the ridges became worn down the dentine of the interior was exposed, forming islands surrounded by enamel. With the progress of time

the crowns of the teeth gradually become longer, the valleys deeper, and the ridges not only more elevated but more curved and complex in arrangement. To give support to these high ridges and save them from breaking in use, the valleys or cavities between them became filled up to the top with cementum, and as the crown wore down an admirable grinding surface consisting of patches and islands of the two

FIG. 1.—*a*, Grinding surface of unworn molar tooth of *Anchitherium*; *b*, corresponding surface of unworn molar of young horse; *c*, the same tooth after it has been some time in use. The uncoloured portions are the dentine or ivory, the shaded parts the cementum filling the cavities and surrounding the exterior. The black line separating these two structures is the enamel or hardest constituent of the tooth

softer substances, dentine and cement, separated by variously reduplicated and contorted lines of intensely hard enamel, resulted (fig. 2, *c*). The crown continued lengthening until in the modern horses it has assumed the form called "hypsidont" (fig. 2, *b*). Instead of contracting into a neck, and forming roots, its sides continue parallel for a considerable depth in the socket, and as the surface wears away, the whole tooth slowly pushes up, and maintains the grinding edge constantly at the same level above the alveolus, much as in the perpetually growing rodent's teeth. But in existing horses there is still a limit to the growth of the molar. After a length is attained which in normal conditions supplies sufficient grinding surface for the lifetime of the animal, a neck and roots are formed, and the tooth is reduced to the condition of that of the brachyodont ancestor. It is perfectly clear that this lengthening of the crown adds greatly to the power of the teeth as organs of mastication, and enables the animals in which it has taken place to find their sustenance among the comparatively dry and harsh herbage of the open plains, instead of being limited to the more succulent vegetable productions of the marshes and forests in which their predecessors mainly dwelt.

FIG. 2.—*a*, Side view of second upper molar tooth of *Anchitherium* (brachyodont form); *b*, corresponding tooth of horse (hypsidont form).

The modifications of the limbs which took place *pari passu* with those of the teeth must have been associated with increased speed, especially over firm and unyielding ground. Short, stout legs, and broad feet, with numerous toes, spreading apart from each other when the weight of the creature is borne on them, are sufficiently well adapted for plodding deliberately over marshy and yielding surfaces, and the tapirs and the rhinoceroses, which in the structure of the limbs have altered but little from the primitive Eocene forms, still haunt the borders of streams and lakes and the shady depths of the forests, as was probably the habit of their ancient representatives, while the horses are all inhabitants of the open plains, for life upon which their whole organization is in the most eminent degree adapted. The length and mobility of the neck, position of the eye and ear, and great development of the organ of smell, give them ample means of becoming aware of the approach of enemies, while the length of their limbs, the angles the different segments form with each other, and especially the combination of firmness, stability, and lightness in the reduction of all the toes to a single one, upon which the whole weight of the body and all the muscular power are concentrated, give them speed and endurance surpassing that of almost any other animal. When surprised, however, they are by no means helpless, both fore and hind feet becoming at need powerful weapons of defence.

If we were not so habituated to the sight of the horse as hardly ever to consider its structure, we should greatly marvel at being told of a mammal so strangely constructed that it had but a single toe on each extremity, on the end of the nail of which it walked or galloped. Such a formation is without a parallel in the vertebrate series, and is one of the most remarkable instances of specialization, or deviation from the usual type, in accordance with special conditions of life. It can be demonstrated, both by the structure of the foot itself, and also by an examination of the intermediate forms, that this toe corresponds to the middle or third of the complete typical or pentadactyle foot, the "ring finger" of man; and there is very strong evidence to show that by a gradual concentration of all the power of the limb upon this toe, and the concurrent dwindling away and final disappearance of all the others, the present condition of the horse's foot has been produced.

The small horse-like animals of the Eocene period with four, or rudiments at least of five, toes on the fore feet have been already mentioned. In the early Miocene period the animal most like an existing horse was the *Anchitherium*, the remains of which are found in a fossil state both in Europe and in America. In this genus there were three well-developed toes reaching the ground on each foot, and

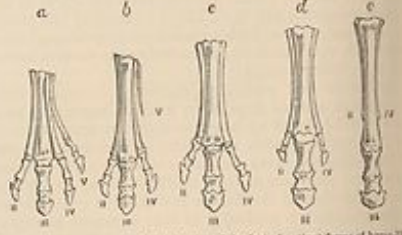

FIG. 3.—Successive stages of modification of the feet of extinct forms of horse-like animals (chiefly from Marsh), showing gradual reduction of the outer and enlargement of the middle toe (III). *a*, *Orohippus* (Eocene); *b*, *Mesohippus* (Early Miocene); *c*, *Miohippus* and *Anchitherium* (Late Miocene); *d* *Hipparion* and *Pliohippus* (Pliocene); *e*, *Equus* (Pleistocene).

the radius and ulna, and the tibia and fibula of the hind leg, were complete and distinct. This was succeeded on the European and Asiatic continent by *Hipparion* and in America by *Pliohippus*, perhaps more directly in the line of descent, as *Hipparion* has some special characters of its own in the teeth and skull, which make it probable that it is a collateral branch which became extinct without leaving descendants. In these and other forms which flourished at this period, the lateral toes, though containing the full number of bones, were much reduced in size, and did not reach the ground, but were suspended to the outside of and rather behind the large middle one, like the rudimentary outer toes of the deer, or the short first digit ("dew-claw") of the dog. Horses, or rather horse-like creatures, with this structure of feet were no longer met with in the Pleistocene period, but then for the first time appeared the true horse in its development exactly or very nearly as we know it now. The outer toes were reduced to rudiments of the metacarpals or metatarsals only, the so-called "splint bones" entirely concealed beneath the skin (fig. 3, *e*, II. and IV.), the middle

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toe (III.) greatly elongated, and with its ungual phalanx and hoof expanded, and the stability of the forearm and leg increased by the complete subordination of the ulna and fibula to the larger bones, the radius and tibia, which alone are concerned in the formation of the wrist and ankle joint.

Fossil remains of true horses, differing but very slightly from the smaller and inferior breeds of those now existing, are found abundantly in deposits of the most recent geological age, in almost every part of America, from Escholz Bay in the north to Patagonia in the south. In that continent, however, they became quite extinct, and no horses, either wild or domesticated, existed there at the time of the Spanish conquest, which is the more remarkable as, when introduced from Europe, the horses that ran wild proved by their rapid multiplication in the plains of South America and Texas that the climate, food, and other circumstances were highly favourable for their existence. The former great abundance of *Equidæ* in America, their complete extinction, and their perfect acclimatization when reintroduced by man, form curious but as yet unsolved problems in geographical distribution.

The existing species of the genus *Equus* are the following:—

(1.) The Horse, *Equus caballus*, Linn., is distinguished from the others by the long hairs of the tail being more abundant and growing quite from the base as well as the end and sides, and also by possessing a small bare callosity on the inner side of the hind leg, just below the "hock" or heel joint, in addition to the one on the inner side of the forearm above the carpus, common to all the genus. The mane is also longer and more flowing, and the ears shorter, the limbs longer, and the head smaller.

Though the existing horses are usually not marked in any definite manner, or only irregularly dappled, or spotted with light surrounded by a darker ring, many examples are met with showing a dark median dorsal streak like that found in all the other members of the genus, and even with dark stripes on the shoulders and legs indicating "the probability of the descent of all the existing races from a single dun-coloured, more or less striped, primitive stock, to which our horses still occasionally revert."[1]

In Europe wild horses were extremely abundant in the Neolithic or polished-stone period. Judging from the quantity of their remains found associated with those of the men of that time, the chase of these animals must have been among his chief occupations, and they must have furnished him with one of his most important food supplies. The characters of the bones preserved, and certain rude but graphic representations carved on bones or reindeers' antlers, enable us to know that they were rather small in size, and heavy in build, with large heads and rough shaggy manes and tails, much like, in fact, the present wild horses of the steppes of the south of Russia. These horses were domesticated by the inhabitants of Europe before the dawn of history, but it is doubtful whether the majority of the animals now existing on the Continent are derived directly from them, as it is more probable that they are descendants from horses imported though Greece and Italy from Asia, derived from a still earlier domestication, followed by gradual improvement through long-continued attention bestowed on their breeding and training. Horses are now diffused by the agency of man throughout almost the whole of the inhabited parts of the globe, and the great modifications they have undergone in consequence of domestication and selective breeding are well exemplified by comparing such extreme forms as the Shetland pony, dwarfed by uncongenial climate, the thoroughbred racer, and the London dray-horse. In Australia, as in America, horses imported by the European settlers have escaped into the unreclaimed lands, and multiplied to a prodigious extent, roaming in vast herds over the plains where no hoofed animal ever trod before.

(2.) *Equus asinus*, Linn.—The Domestic Ass is nearly as widely diffused and useful to man as the horse. It was known in Egypt long before the horse, and is probably of African origin, indeed its close resemblance to the existing wild ass of Abyssinia, *E. taeniopus*, Heuglin, leaves little doubt as to its identity with that species.

(3.) The Asiatic Wild Asses, which roam in small herds in the open plains of Syria, of many parts of Persia, of the north-west of India, and the highlands of Tartary and Tibet from the shores of the Caspian to the frontiers of China, differ from the last in being of a more rufous or isabelline colour, instead of pure grey, in wanting the dark streak across the shoulder, and having smaller ears. They have all a dark-coloured median dorsal stripe. Though it is considered probable by many zoologists that they form but a single species (*E. hemionus*, Pallas), they present such marked variations in size and form that they have commonly been divided into three—the Syrian Wild Ass (*E. hemippus*, Geoff.), the Onager (*E. onager*, Pall.) from Persia, the Punjab, Scinde and the desert of Cutch, and the Kiang or Dzeggetai (*E. hemionus*, Pallas) of the high table-lands of Tibet, where it is usually met with at an elevation of 15,000 feet and upwards above the sea-level. The last is considerably larger than either of the others, and differs from them in external appearance, having more the aspect of the horse. They are all remarkably swift, having been known to outstrip the fleetest horse in speed.

Lastly, there are three striped species, all inhabitants of South Africa. These constitute the genus *Hippotigris* of Hamilton Smith, but they are not separable except by their coloration from the true asses, and one of them (4), the Quagga (*E. quagga*, Gmel.), may be considered as intermediate. This animal has the dark stripes limited to the head, neck, and shoulders, upon a brown ground. In (5) the Dauw or Burchell's Zebra (*E. burchellii*, Gray), the ground colour is white, and the stripes cover the body and upper part of the limbs. This is the commonest species in the great plains of South Africa, where it roams in large herds, often in company with the quagga and numerous species of antelope. It ranges from the Orange River to the confines of Abyssinia. In (6) the Mountain Zebra (*E. zebra*, Linn.) the contrast between the clear white of the ground and the black of the stripes is most marked, and the latter extend quite down to the hoofs. This is, consequently, the most beautiful species of the group as regards colour, if the horse may bear the palm in elegance of form. It frequents mountainous districts rather than the open plains which are the dwelling-places of the other two species, and as it appears to be limited to the southern portion of the continent, within the confines of the Cape Colony, its numbers are rapidly diminishing under the encroachments of European civilization.

There are thus at least six modifications of the horse type at present existing, sufficiently distinct to be reckoned as species by all zoologists, and easily recognized by their external characters. They are, however, all so closely allied that each will, at least in a state of domestication or captivity, breed with perfect freedom with any of the others. Cases of fertile union are recorded between the horse and the quagga, the horse and the dauw or Burchell's zebra, the horse and the hemionus or Asiatic wild ass, the common ass and the zebra, the common ass and the dauw, the common ass and the hemionus, the hemionus and the zebra, and the hemionus and the dauw. The two species which are perhaps the farthest removed in general structure, the horse and the ass, produce, as is well known, hybrids or

[1] Darwin, *Variation of Animals and Plants under Domestication*, 1868, vol. i., chap. ii.

mules, which in some qualities useful to man excel both their progenitors, and in some countries and for certain kinds of work are in greater requisition than either. Although occasional instances have been recorded of female mules breeding with the males of one or other of the pure species, it is doubtful if any case has occurred of their breeding *inter se*, although the opportunities of doing so must have been great, as mules have been reared in immense numbers for at least several thousands of years. We may therefore consider it settled that the different species of the group are now in that degree of physiological differentiation which enables them to produce offspring with each other, but does not permit of the progeny continuing the race, at all events unless reinforced by the aid of one of the pure forms.

The several members of the group show mental differences quite as striking as those exhibited by their external form, and more than perhaps might be expected from the similarity of their cerebral organization. The patience of the ass, the high spirit of the horse, the obstinacy of the mule, have long been proverbial. It is very remarkable that, out of so many species, two only should have shown any aptitude for domestication, and that these two should have been from time immemorial the universal and most useful companions and servants of man, while all the others remain in their native freedom to this day. It is, however, still a question whether this really arises from a different mental constitution causing a natural capacity for entering into relations with man, or whether it may not be owing to their having been brought gradually into this condition by long continued and persevering efforts when the need of their services was keenly felt. It is quite possible that one reason why most of the attempts to add new species to the list of our domestic animals in modern times have ended in failure is that it does not answer to do so in cases in which existing species supply all the principal purposes to which the new ones might be put. It can hardly be expected that zebras and quaggas fresh from their native mountains and plains can be brought into competition as beasts of burden and draught with horses and asses, whose naturally useful qualities have been augmented by the training of thousands of generations of progenitors.

Not unfrequently instances occur of domestic horses being produced with a small additional toe with complete hoof, usually on the inside of the principal toe, and, though far more rarely, three or more toes may be present. These malformations are often cited as instances of reversion to the condition of some of the earlier forms of equine animals previously mentioned. Such explanations, however plausible they appear at first sight, are nevertheless very doubtful. All the feet of polydactyle horses which we have examined bear little resemblance to those of the extinct *Hipparion* or *Anchitherium*, but look rather as if due to that tendency to reduplication of parts which occurs so frequently as a teratological condition, especially among domestic animals, and which, whatever its origin, certainly cannot in many instances, as the cases of entire limbs superadded, or of six digits in man, be attributed to reversion.

Anatomy.

The anatomical structure of the horse has been described in great detail in several works devoted to the subject, which will be mentioned in the bibliography, though these have generally been written from the point of view of the veterinarian rather than of the comparative anatomist. The limits of the present article will only admit of the most salient points being indicated, particularly those in which the horse differs from the other *Ungulata*. Unless otherwise specified, it must be understood that all that is stated here, although mostly derived from observation upon the horse, applies equally well to the other existing members of the group.

Skeleton.—The skull as a whole is greatly elongated, chiefly in consequence of the immense size of the face as compared with the hinder or true cranial portion. The basal line of the cranium from the lower border of the foramen magnum to the incisor border of the palate is very nearly straight. The orbit, of nearly circular form, though small in proportion to the size of the whole skull, is distinctly marked, being completely surrounded by a strong ring of bone with prominent edges. Behind it, and freely communicating with it beneath the osseous bridge (the post-orbital process of the frontal) forming the boundary between them, is the small temporal fossa occupying the whole of the side of the cranium proper, and in front is the great flattened expanse of the "cheek," formed chiefly by the superior maxilla, giving support to the long row of molar teeth, and having a prominent ridge running forward from below the orbit for the attachment of the masseter muscle. The lacrymal occupies a considerable space on the flat surface of the cheek in front of the orbit, and below it the malar does the same. The latter sends a horizontal or slightly ascending process backwards below the orbit to join the

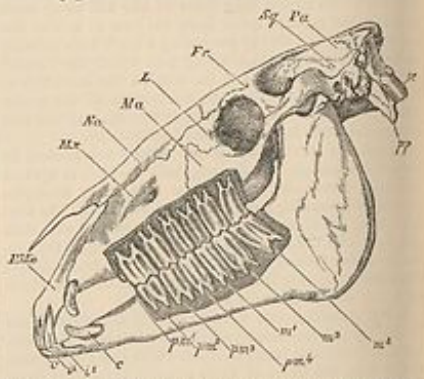

FIG. 4.—Side view of skull of horse, with the bone removed so as to expose the whole of the teeth. *PMx*, premaxilla; *Mx*, maxilla; *Na*, nasal bone; *Ma*, malar bone; *L*, lacrymal bone; *Fr*, frontal bone; *Sq*, squamosal bone; *Pa*, parietal bone; *oc*, occipital condyle; *pp*, paroccipital process; i^1, i^2, and i^3, the three incisor teeth; *c*, the canine teeth; $p.m.^1$, the situation of the rudimentary first premolar, which has been lost in the lower, but is present in the upper jaw; $p.m.^2$, $p.m.^3$, and $p.m.^4$, the three fully-developed premolar teeth; m^1, m^2, and m^3, the three true molar teeth.

under surface of the zygomatic process of the squamosal, which is remarkably large, and instead of ending as usual behind the orbit, runs forwards to join the greatly developed post-orbital process of the frontal, and even forms part of the posterior and inferior boundary of the orbit, an arrangement not met with in other mammals. The closure of the orbit behind distinguishes the skull of the horse from that of its allies the rhinoceros and tapir, and also from all of the perissodactyles of the Eocene period. In front of the cerebral cavity, the great tubular nasal cavities are provided with well-developed turbinal bones, and are roofed over by very large nasals, broad behind, and ending in front by a narrow decurved point. The opening of the anterior nares is prolonged backwards on each side of the face between the nasals and the elongated slender premaxillæ. The latter expand in front, and are curved downwards to form the semicircular alveolar border which supports the large incisor teeth. The palate is narrow in the interval between the incisor and molar teeth, in which are situated the large anterior palatine foramina. Between the molar teeth it is

broader, and it ends posteriorly in a rounded excavated border opposite the hinder border of the penultimate molar tooth. It is mainly formed by the maxillæ, as the palatines are very narrow. The pterygoids are delicate slender slips of bone attached to the hinder border of the palatines, and supported externally by, and generally ankylosed to, the rough pterygoid plates of the alisphenoid, with no pterygoid fossa between. They slope very obliquely forwards, and end in curved, compressed, hamular processes. There is a distinct alisphenoid canal for the passage of the internal maxillary artery. The base of the cranium is long and narrow; the alisphenoid is very obliquely perforated by the foramen rotundum, but the foramen ovale is confluent with the large foramen lacerum medium behind. The glenoid surface for the articulation of the mandible is greatly extended transversely, concave from side to side, convex from before backwards in front, and hollow behind, and is bounded posteriorly at its inner part by a prominent post-glenoid process. The squamosal enters considerably into the formation of the temporal fossa, and, besides sending the zygomatic process forwards, it sends down behind the meatus auditorius a post-tympanic process which aids to hold in place the otherwise loose tympano-periotic bone. Behind this the exoccipital gives off a very long paroccipital process. The periotic and tympanic are ankylosed together, but not with the squamosal. The former has a wide but shallow flocculer fossa on its inner side, and sends backwards a considerable "pars mastoidea," which appears on the outer surface of the skull between the post-tympanic process of the squamosal and the exoccipital. The tympanic forms a tubular meatus auditorius externus directed outwards and slightly backwards. It is not dilated into a distinct bulla, but ends in front in a pointed styliform process. It completely embraces the truncated cylindrical tympanohyal, which is of great size, corresponding with the large development of the whole anterior arch of the hyoid. This consists mainly of a long and compressed stylohyal, expanded at the upper end, where it sends off a triangular posterior process. The basi-hyal is remarkable for the long, median, pointed, compressed "glossohyal" process, which it sends forward from its anterior border into the base of the tongue. A similar but less developed process is found in the rhinoceros and tapir. The mandible is largely developed, especially the region of the angle, which is expanded and flattened, giving great surface for the attachment of the masseter muscle. The condyle is greatly elevated above the alveolar border; its articular surface is very wide transversely, and narrow and convex from before backwards. The coronoid process is slender, straight, and inclined backwards. The horizontal ramus, long, straight, and compressed, gradually narrows towards the symphysis, where it expands laterally to form with the ankylosed opposite ramus the wide, semicircular, shallow alveolar border for the incisor teeth.

The vertebral column consists of seven cervical, eighteen dorsal, six lumbar, five sacral, and fifteen to eighteen caudal vertebræ. There may be nineteen rib-bearing vertebræ, in which case five only will be reckoned as belonging to the lumbar series. The odontoid process of the atlas is wide, flat, and hollowed above, as in the ruminants. The bodies of the cervical vertebræ are elongated, strongly keeled, and markedly opisthocœlous, or concave behind and convex in front. The neural laminæ are very broad, the spines almost obsolete, except in the seventh, and the transverse processes not largely developed. In the trunk vertebræ the opisthocœlous character of the centrum gradually diminishes. The spinous processes of the anterior thoracic region are high and compressed. To these is attached the powerful elastic ligament, *ligamentum nuchæ*, or "paxwax," which passing forwards in the middle line of the neck above the neural arches of the cervical vertebræ, to which it is also connected, is attached to the occiput and supports the weight of the head. The transverse processes of the lumbar vertebræ are long, flattened, and project horizontally outwards or slightly forward from the arch. The metapophyses are moderately developed, and there are no anapophyses. The caudal vertebræ, except those quite at the base, are slender and cylindrical, without processes and without chevron bones beneath. The ribs are eighteen or nineteen in number on each side, flattened, and united to the sternum by short, stout, tolerably well ossified sternal ribs. The sternum consists of six pieces; the anterior or præsternum is extremely compressed, and projects forwards like the prow of a boat. The segments which follow gradually widen, and the hinder part of the sternum is broad and flat.

As in all other ungulates, there are no clavicles. The scapula is long and slender; the supra-scapular border is rounded, and slowly and imperfectly ossified. The spine is very slightly developed; rather above the middle its edge is thickened and somewhat turned backwards, but it gradually subsides at the lower extremity without forming any acromial process. The coracoid is a prominent rounded nodule. The humerus is stout and rather short. The ulna is quite rudimentary, being only represented by little more than the olecranon. The shaft gradually tapers below and is firmly ankylosed to the radius. The latter bone is of nearly equal width throughout. The three bones of the first row of the carpus (the scaphoid, lunar, and cuneiform) are subequal in size. The second row consists of a very broad and flat magnum, supporting the great third metacarpal, having to its radial side the trapezoid, and to its ulnar side the unciform, which are both small, and articulate distally with the rudimentary second and fourth metacarpals. The pisiform is large and prominent, flattened, and curved; it articulates partly with the cuneiform and partly with the lower end of the radius. The large metacarpal is called in veterinary anatomy "cannon bone"; the small lateral metacarpals, which gradually taper towards their lower extremities, and lie in close contact with the large one, are called "splint bones." The single digit consists of a moderate-sized proximal (*os suffraginis*, or large pastern), a very short middle (*os coronæ*, or small pastern), and a wide, semi-lunar, ungual phalanx (*os pedis*, or coffin bone). There is a pair of large nodular sesamoids behind the metacarpo-phalangeal articulation, and a single large transversely-extended sesamoid behind the joint between the second and third phalanx, called the "navicular bone."

The carpal joint, corresponding to the wrist of man, is commonly called the "knee" of the horse, the joint between the metacarpal and the first phalanx the "fetlock," that between the first and second phalanges the "pastern," and that between the second and third phalanges the "coffin joint."

In the hinder limb the femur is marked, as in all other known perissodactyles, by the presence of a "third trochanter," a flattened process, curving forwards, arising from the outer side of the bone, about one-third of the distance from the upper end. The fibula is reduced to a mere styliform rudiment of the upper end. The lower part is absent or completely fused with the tibia. The os calcis has a long and compressed calcaneal process. The astragalus has a large flat articular surface in front for the navicular, and a very small one for the cuboid. The navicular and the external cuneiform bones are very broad and flat. The cuboid is small, and the internal and middle cuneiform bones are small and united together. The metapodials and phalanges resemble very closely those of the fore limb, but the principal metatarsal is more laterally compressed at its upper end than is the corresponding metacarpal.

The joint between the femur and tibia, corresponding to the knee of man, is called the "stifle joint"; that between the tibia and tarsus, corresponding to the ankle of man, is called the "hock." The bones and joints of the foot have the same names as in the fore limb. The horse is eminently "digitigrade," standing on the extremity of the single digit of each foot, which is kept habitually in a position approaching to vertical.

The muscles of the limbs are modified from those of the ordinary mammalian type in accordance with the reduced condition of the bones and the simple requirements of flexion and extension of the joints, no such actions as pronation and supination, or opposition of digits, being possible or needed. The muscles therefore which perform these functions in other quadrupeds are absent or rudimentary.

Below the carpal and tarsal joints, the fore and hind limbs correspond almost exactly in structure as well as function. On the anterior or extensor surface of the limb a powerful tendon (7 in fig. 5), that of the anterior extensor

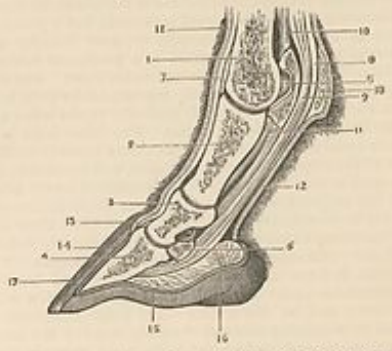

FIG. 5.—Section of foot of horse. 1, metacarpal bone; 2, first phalanx (*os suffraginis*); 3, second phalanx (*os coronæ*); 4, third or ungual phalanx (*os pedis*, or coffin bone); 5, one of the upper sesamoid bones; 6, lower sesamoid or navicular bone; 7, tendon of anterior extensor of the phalanges; 8, tendon of superficial flexor (*f. perforatus*); 9, tendon of deep flexor (*f. perforans*); 10, suspensory ligament of fetlock; 11, inferior or short sesamoid ligament; 12, derma or skin of the foot, covered with hair, and continued into 13, the coronary cushion, 14, the podophyllous or laminar membrane, and 15, the keratogenous membrane of the sole; 16, plantar cushion; 17, hoof; 18, fatty cushion of fetlock.

of the phalanges (corresponding to the *extensor communis digitorum* of the arm and *extensor longus digitorum* of the foot of man) passes down over the metacarpal bone and phalanges, to be inserted mainly into the upper edge of the anterior surface of the last phalanx or pedal bone. There is also a much smaller second extensor on the outer side of this in each limb, the lateral extensor of the phalanges. In the fore leg the tendon of this muscle (which corresponds with the *extensor minimi digiti* of man) receives a slip from that of the principal extensor, and is inserted into the first phalanx. In the hind leg (where it is the homologue apparently of the *peroneus brevis* of man) the tendon becomes blended with that of the large extensor.

A very strong ligamentous band behind the metapodium, arising from near the upper extremity of its posterior surface, divides into two at its lower end, and each division, being first connected with one of the paired upper sesamoid bones, passes by the side of the first phalanx to join the extensor tendon of the phalanges. This is called in veterinary anatomy the "suspensory ligament of the sesamoids," or of the "fetlock" (10 in fig. 5); but its attachments and relations, as well as the occasional presence of muscular fibres in its substance, show that it is the homologue of the interosseous muscles of other mammals, curiously modified both in structure and function, to suit the requirements of the horse's foot. Behind or superficial to this are placed the two strong tendons of the flexor muscles, the most superficial, or *flexor perforatus* (8), dividing to allow the other to pass through, and then inserted into the middle phalanx. The *flexor perforans* (9) is as usual inserted into the terminal phalanx. In the fore leg these muscles correspond with those similarly named in man. In the hind leg, the perforated tendon is a continuation of that of the plantaris, passing pulley-wise over the tuberosity of the os calcis. The perforating tendon is derived from the muscle corresponding with the long flexor of man, and the smaller tendon of the oblique flexor (*tibialis porticus* of man) is united with it.

The hoof of the horse corresponds to the nail or claw of other mammals, but is so constructed as to form a complete and very solid case to the expanded termination of the toe, giving a firm basis of support formed of a non-sensitive substance, which is continually renewed by the addition of material from within, as its surface wears away by friction against the ground. The terminal phalanx of the toe is greatly enlarged and modified in form to support this hoof, and the size of the internal framework of the foot is further increased by a pair of lateral fibro-cartilaginous masses attached on each side to the hinder edges of the bone, and by a fibro-cellular and adipose plantar cushion in the median part. These structures are all enclosed in the keratogenous membrane or "subcorneous integument," a continuation of the ordinary derma of the limb, but extremely vascular, and having its superficial extent greatly increased by being developed into papillæ or laminæ. From this the horny material which constitutes the hoof is exuded. A thickened ring encircling the upper part, called coronary cushion (13), and the sole (15), are covered with numerous thickly-set papillæ or villi, and take the greatest share in the formation of the hoof; the intermediate part constituting the front and side of the foot (14), corresponding with the wall of the hoof, is covered with parallel, fine longitudinal laminæ, which fit into corresponding depressions in the inner side of the horny hoof.

The horny hoof is divided into a wall or crust consisting of the front and sides, the flattened or concave sole, and the frog, a triangular median prominence, notched posteriorly, with the apex turned forwards, situated in the hinder part of the sole. It is formed of pavement epithelial cells, which are mainly grouped in a concentric manner around the vascular papillæ of the keratogenous membrane, so that a section near the base of the hoof, cut transversely to the long axis of these papillæ, shows a number of small circular or oval orifices, with cells arranged concentrically round them. The nearer the surface of the hoof, or further removed from the seat of growth, the more indistinct the structure becomes.

Small round or oval plates of horny epithelium called "chestnuts," growing like the hoof from enlarged papillæ of the skin, are found on the inner face of the fore arm, above the carpal joint in all species of *Equidæ*, and in the horse (*E. caballus*) similar formations occur near the upper extremity of the inner face of the metatarsus. Their use is unknown.

Dentition.—The dentition of the horse, when all the teeth are in place, is, as stated before, expressed by the formula $i.\frac{3}{3}, c.\frac{1}{1}, p.\frac{4}{4}, m.\frac{3}{3} = 44$. The incisors of each jaw are placed in close contact, forming a semicircle. The crowns are broad, somewhat awl-shaped, and of nearly equal size. They have all the great peculiarity, not found in the teeth of any other mammal, and only in the *Equidæ* of comparatively recent geological periods, of an involution of the external surface of the tooth (see fig. 6), by which what should properly be the apex is carried deeply into the interior of the crown, forming a fossa or pit, the bottom

of which becomes partially filled up with crusta petrosa or cementum. As the tooth wears, the surface, besides the external enamel layer as in an ordinary simple tooth, shows in addition a second inner ring of the same hard substance surrounding the pit, which of course adds greatly to the efficiency of the tooth as an organ for biting tough, fibrous substances. This pit, generally filled in the living animal with particles of food, is conspicuous from its dark colour, and constitutes the "mark" by which the age of the horse is judged, as in consequence of its only extending to a certain depth in the crown it becomes obliterated as the crown wears away, and then the tooth assumes the character of that of an ordinary incisor, consisting only of a core of dentine, surrounded by the external enamel layer. It is not quite so deep in the lower as in the upper teeth.

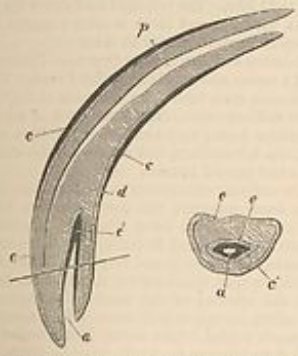

FIG. 6.—Longitudinal and transverse section of upper incisor of horse. *p*, pulp cavity; *d*, dentine or ivory; *e*, enamel; *c*, outer layer of cementum or crusta petrosa; *c'*, inner layer of cementum, lining *a*, the pit or cavity of the crown of the tooth.

The canines are either quite rudimentary or entirely absent in the female. In the male they are compressed, pointed, and smaller than the incisors, from which they are separated by a slight interval. The teeth of the molar series are all in contact with each other, but separated from the canines by a considerable toothless space. The anterior premolars are quite rudimentary, sometimes not developed at all, and generally fall by the time the animal attains maturity, so that there are but six functional grinding teeth,—three that have predecessors in the milk dentition, and hence are considered as premolars, and three true molars, but otherwise, except the first and last of the series, not distinguishable in form or structure. These teeth in both upper and lower jaws are extremely long-crowned or hypsidont, successive portions being pushed out as the surface wears away, a process which continues until the animal becomes advanced in age. The enamelled surface is infolded in a complex manner (a modification of that found in other perissodactyles), the folds extending quite to the base of the crown, and the interstices being filled and the surface covered with a considerable mass of cement, which binds together and strengthens the whole tooth. As the teeth wear, the folded enamel, being harder than the other constituents, the dentine and cement, forms projecting ridges on the surface arranged in a definite pattern, which give it great efficiency as a grinding instrument (see fig. 1, *b* and *c*). The free surfaces of the upper teeth are quadrate, except the first and last, which are nearly triangular. The lower teeth are much narrower than the upper.

The milk dentition consists of *i.* $\frac{6}{6}$, *c.* $\frac{0}{0}$, *m.* $\frac{3}{3} = 24$,—the canines and first or rudimentary premolars having apparently no predecessors. In form and structure they much resemble the permanent teeth, having the same characteristic enamel foldings. Their eruption commences a few days after birth, and is complete before the end of the first year, the upper teeth usually appearing somewhat earlier than those of the lower jaw. The first teeth which appear are the first and second milk molars (about five days), then the central incisor (from seven to ten days); this is followed by the second incisor (at one month), then the third molar, and finally the third incisor. Of the permanent teeth the first true molar appears a little after the end of the first year, followed by the second molar before the end of the second year. At about two and a half years the first premolar replaces its predecessor. Between two and a half and three years the first incisor appears. At three years the second and third premolars, and the third true molar have appeared, at from three and a half to four years the second incisor, at four to four and a half years the canine, and, finally, at five years, the third incisor, completing the permanent dentition. Up to this period the age of the horse is clearly shown by the condition of dentition, and for some time longer indications can be obtained from the wear of the incisor teeth, though this depends to a certain extent upon the hardness of the food or other accidental circumstances. As a general rule, the depression caused by the infolding of the surface of the incisor (the "mark") is obliterated in the first or central incisor at six years, in the second at seven years, and in the third at eight years. In the upper teeth, as the depressions are deeper, this obliteration does not take place until about two years later. After this period no certain indications can be obtained of the age of the horse from the teeth.

Digestive Organs.—The lips are flexible and prehensile. The membrane that lines them and the cheeks is quite smooth. The palate is long and narrow; its mucous surface has seventeen pairs of not very sharply defined oblique ridges, extending as far back as the last molar tooth, beyond which the velum palati extends for about 3 inches, having a soft corrugated surface, and ending posteriorly in an arched border without uvula. This embraces the base of the epiglottis, and, except while swallowing food, shuts off all communication between the cavity of the mouth and the pharynx, respiration being, under ordinary circumstances, exclusively through the nostrils. Between the mucous membrane and the bone of the hard palate is a dense vascular and nervous plexus. The membrane lining the fauces is soft and corrugated. An elongated raised glandular mass, 3 inches long and 1 inch from above downwards, extending backwards from the root of the tongue along the side of the fauces, with openings on the surface leading into crypts with glandular walls, represents the tonsil. The tongue, corresponding to the general form of the mouth, is long and narrow. It consists of a compressed intermolar portion with a flat upper surface, broad behind and becoming narrower in front, and of a depressed anterior part rather shorter than the former, and which is narrow behind and widens towards the evenly rounded apex. The dorsal surface generally is very soft and smooth. There are two large circumvallate papillæ near the base, rather irregular in form, about a quarter of an inch in diameter and half an inch apart. The conical papillæ are very small and close set, though longer and more filamentous on the intermolar portion. There are no fungiform papillæ on the dorsum, but a few not very conspicuous ones scattered along the sides of the organ.

Of the salivary glands the parotid is by far the largest, and elongated in the vertical direction, and narrower in the middle than at either upper or lower extremity. Its upper extremity embraces the lower surface of the cartilaginous ear-conch; its lower end reaches the level of the inferior margin of the mandible, along the posterior margin of which

it is placed. Its duct leaves the inferior anterior angle, at first descends a little, and runs forward under cover of the rounded inferior border of the mandibular ramus, then curves up along the anterior margin of the masseter muscle, becoming superficial, pierces the buccinator, and enters the mouth by a simple aperture opposite the middle of the crown of the third premolar tooth. It is not quite so thick as a goosequill when distended, and nearly a foot in length.

The submaxillary gland is of very similar texture to the last, but much smaller; it is placed deeper, and lies with its main axis horizontal. It is elongated and slender, and flattened from within outwards. Its posterior end rests against the anterior surface of the transverse process of the atlas, from which it extends forwards and downwards, slightly curved, to beneath the ramus of the jaw. The duct which runs along its upper and internal border passes forwards in the usual course, lying in the inner side of the sublingual gland, to open on the outer surface of a distinct papillæ, situated on the floor of the mouth, half an inch from the middle line, and midway between the lower incisor teeth and the attachment of the frænum linguæ. The sublingual is represented by a mass of glands lying just beneath the mucous membrane of the floor of the mouth on the side of the tongue, causing a distinct ridge, extending from the frænum backwards, the numerous ducts opening separately along the summit of the ridge. The buccal glands are arranged in two rows parallel with the molar teeth. The upper ones are the largest, and are continuous anteriorly with the labial glands, the ducts of which open on the mucous membrane of the upper lip.

The stomach of the horse is simple in its external form, with a largely developed right *cul de sac*, and is a good deal curved on itself, so that the cardiac and pyloric orifices are brought near together. The antrum pyloricum is small and not very distinctly marked off. The interior is divided by the character of the lining membrane into two very distinct portions, right and left. Over the latter the dense white smooth epithelial lining of the œsophagus is continued, terminating abruptly by a raised crenellated border. Over the right part (rather the larger portion) the mucous membrane has a greyish-red colour and a velvety appearance, and contains very numerous peptic glands, which are wanting in the cardiac portion. The œsophageal orifice is very small, and is guarded by a strong crescentic or rather horseshoe-like band of muscular fibres, which is supposed to be the cause of the difficulty of vomiting in the horse. The small intestine is of great length (80 to 90 feet), its mucous membrane being covered with numerous fine villi. The cæcum is of conical form, about 2 feet long and nearly a foot in diameter; its walls are sacculated, especially near the base, having four longitudinal muscular bands; and its capacity is about twice that of the stomach. It lies with its base near the lower part of the abdomen, and its apex directed towards the thorax. The colon is about one-third the length of the small intestine, and very capacious in the greater part of its course. As usual it may be divided into an ascending, transverse, and descending portion; but the middle or transverse portion is folded into a great loop, which descends as low as the pubis; so that the colon forms altogether four folds, generally parallel to the long axis of the body. The descending colon is much narrower than the rest, and not sacculated, and, being considerably longer than the distance it has to traverse, is thrown into numerous folds.

The liver is tolerably symmetrical in its general arrangement, being divided nearly equally into segments by a well-marked umbilical fissure. Each segment is again divided by lateral fissures, which do not extend quite to the posterior border of the organ; of the central lobes thus cut off, the right is rather the larger, and has two fissures in its free border subdividing it into lobules. The extent of these varies, however, in different individuals. The two lateral lobes are subtriangular in form. The Spigelian lobe is represented by a flat surface between the postal fissure and the posterior border, not distinctly marked off from the left lateral by a fissure of the ductus venosus, as this vessel is buried deep in the hepatic substance, but the caudate lobe is distinct and tongue-shaped, its free apex reaching nearly to the border of the right lateral lobe. In most works on the anatomy of the horse this has been confounded with the Spigelian lobe of man. There is no gall-bladder, and the biliary duct enters the duodenum about 6 inches from the pylorus. The pancreas has two lobes or branches, a long one passing to the left and reaching the spleen, and a shorter right lobe. The principal duct enters the duodenum with the bile-duct, and there is often a second small duct which opens separately near to this.

Circulatory and Respiratory Organs.—The heart has the form of a rather elongated and pointed cone. There is one anterior vena cava, formed by the union of the two jugular and two axillary veins. The aorta gives off a large branch (the anterior aorta) very near its origin, from which arise—first, the left axillary, and afterwards the right axillary and the two carotid arteries.

Under ordinary circumstances the horse breathes entirely by the nasal passages, the communication between the larynx and the mouth being closed by the velum palati. The nostrils are placed laterally, near the termination of the muzzle, and are large and very dilatable, being bordered by cartilages upon which several muscles act. Immediately within the opening of the nostril, the respiratory canal sends off on its upper and outer side a diverticulum or blind pouch (called "false nostril") of a conical form, and curved, 2 to 3 inches in depth, lying in the notch formed between the nasal and premaxillary bones. It is lined by mucous membrane continuous with that of the nasal passage, and its use is not apparent. It is longer in the ass than in the horse. Here may be mentioned the guttural pouches, large air sacs, diverticula from the Eustachian tubes, and lying behind the upper part of the pharynx, the function of which is also not clearly understood. The larynx has the lateral sacculi well developed, though entirely concealed within the alæ of the thyroid cartilage. The trachea divides into two bronchi, one for each lung.

Nervous System.—The brain differs little, except in details of arrangement of convolutions, from that of other ungulates. The cerebral hemispheres are rather elongated and subcylindrical, the olfactory lobes are large and project freely in front of the hemispheres, and the greater part of the cerebellum is uncovered. The eye is provided with a nictitating membrane or third eyelid, at the base of which the ducts of the Harderian gland open.

Reproductive System.—The testes are situated in a distinct sessile or slightly pedunculated scrotum, into which they descend from the sixth to the tenth month after birth. The accessory generative glands are the two vesiculæ seminales, with the median third vesicle, or *uterus masculinus*, lying between them, the single bilobed prostate, and a pair of globular Cowper's glands. The penis is very large, cylindrical, with a truncated, expanded, flattened termination. When in a state of repose it is retracted, by a muscle arising from the sacrum, within the prepuce, a cutaneous fold attached below the symphysis pubis.

The uterus is bicornuate. The vagina is often partially divided by a membraneous septum or hymen. The mammæ are two, inguinally placed. The surface of the chorion is covered evenly with minute villi, constituting a diffuse non-deciduate placenta. The period of gestation is eleven months.

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PART II.—HISTORY, MANAGEMENT, AND BREEDING.

From the evidence of philology it is plain that the horse was already known to the Aryans before the period of their dispersion.[1]

The first mention of the British horse occurs in the well-known passages in Cæsar (*B. G.*, iv. 24, 33; v. 15, 16; *cf.* Pomp. Mela, iii. 6), in which he mentions the native "essedarii" and the skill with which they handled their war chariots. We are left quite in the dark as to the character of the animal thus employed; but there would appear to be much probability in the surmise of Youatt, who conjectures the horse to have been, "then as ever, the creature of the country in which he lived. With short fare, and exposed to the rigour of the seasons, he was probably the little hardy thing we yet see him; but in the marshes of the Nen and the Witham, and on the borders of the Tees and the Clyde, there would be as much proportionate development of frame and strength as we find at the present day." After the occupation of the country by the Romans, it appears that the horses of their cavalry were crossed with the native mares, and thus there was infused into the breed new blood, consisting probably of strains from every quarter from which Roman remounts were procured. As to the effect of this cross we are not, however, in a position to judge. We are also quite uncertain as to the extent to which the Jutes and Saxons may in their turn have again introduced a new breed of horses into England; and even to the close of the Anglo-Saxon period of English history allusions to the horse are still very unfrequent. The *horsthegn* we know, however, was from an early period a high court official; and from such a law as that of Athelstan prohibiting the exportation of horses except as presents, it may be inferred that the English breed was not only much valued at home but also in great request abroad.[2]

The period of the Norman Conquest marks an important stage in the history of the British horse. William the Conqueror's own horse was of the Spanish breed, and others of the same kind were introduced by the barons on their estates. But the Norman horses included many varieties, and there is no doubt that to the Conquest the inhabitants of Britain were indebted for a decided improvement in the native horse, as well as for the introduction of several varieties previously unknown. According to Giraldus Cambrensis, Roger de Bellesme, a follower of William I., afterwards created earl of Shrewsbury, imported some stallions from Spain into England; their produce was celebrated by Drayton the poet. It is curious to notice that agriculture seems to be the last use to which the horse has been put. The earliest suggestion that horses were used in agriculture is derived from a piece of the Bayeux tapestry, where a horse is represented as drawing a harrow. This, however, must have been an exceptional case, for we know that oxen were used until a comparatively late time, and that in Wales a law existed forbidding horses to be used for ploughing.

In 1121 two Eastern horses are said to have been imported,—one of them remaining in England, and the other being sent as a present by King Alexander I. to the church of St Andrews, in Scotland. It has been alleged that these horses were Barbs from Morocco, but a still more likely theory is that they existed only in name, and never reached either England or Scotland. The crusades were probably the means of introducing fresh strains of blood into England, and of giving opportunity for fresh crossings. The Spanish jennet was brought over about 1182. King John gave great encouragement to horse-breeding: one of his earliest efforts was to import a hundred Flemish stallions, and, having thus paved the way for improving the breed of agricultural horses, he set about acquiring a valuable stud for his own use.

Edward III. was likewise an admirer of the horse; he procured fifty Spanish horses, probably jennets. At this time there was evidently a tendency to breed a somewhat lighter and speedier horse; but, while the introduction of a more active animal would soon have led to the displacement of the ponderous but powerful cavalry horse then in use, the substituted variety would have been unable to carry the weight of armour with which horse and rider were alike protected; and so in the end the old breed was kept up for a time. With the object of preserving to England whatever advantages might accrue from her care and skill in breeding an improved stamp of horses, Edward III. forbade their exportation; they consequently improved so rapidly in value that Richard II. compelled dealers to limit their prices to a fixed maximum. In the ninth year of his reign, Edward received from the king of Navarre a present of two running horses, supposed to have been valuable. The wars of 1346 checked the improvement of horses, and undid much of what had been previously accomplished, for we read that the cavalry taken into France by Edward III. were but

[1] Compare Sanscr., *açva*; Zendish and Old Persian, *açpa*; Lithuanian, *aszwà* (mare); Prussian, *aswinan* (mare's milk); Old High German, *ehu*; Anglo-Saxon, *eoh*; Icel., *jór*; Gothic, *aihvs*, *aihvus* (?); Old Irish, *ech*; Old Cambrian and Gaelic, *ep* (as in *Epona*, the horse goddess); Lat., *equus*; Gr., ἵππος or ἴκκος. The word seems, however, to have disappeared from the Slavonic languages. The root is probably *ak*, with the idea of sharpness or swiftness (ἄκρος, ὠκύς, *acer*, *acuo*). See Pott, *Etym. Forsch.*, ii. 256, and Hehn, *Kulturpflanzen u. Hausthiere in ihrem Uebergang aus Asien nach Griechenland u. Italien sowie in das übrige Europa* (3d ed., 1877), p. 38. The last-named author, who points out the absence of the horse from the Egyptian monuments prior to the beginning of the 18th century B.C., and the fact that the earliest references to this animal in Hebrew literature (Judg. v. 22, 28; *cf.* Josh. xi. 4) do not carry us any further back, is of opinion that the Semitic peoples as a whole were indebted for the horse to the lands of Iran. He also shows that literature affords no trace of the horse as indigenous to Arabia prior to about the beginning of the 5th century A.D., although references abound in the pre-Islamitic poetry. Horses were not numerous even in Mahomet's time (Sprenger, *Leb. Moh.*, iii. 139, 140). Compare Ignazio Guidi's paper "Della sede primitiva dei popoli Semitici" in the *Transactions* of the Accademia dei Lincei (1878-79).

[2] Some fragments of legislation relating to the horse about this period may be gleaned from *Ancient Laws and Institutes of England* (fol., London, 1840), and *Ancient Laws and Institutes of Wales* (fol., London, 1841).