XX. *Description of the* Lepidosiren annectens. *By* Richard Owen, *Esq., F.R.S. F.L.S. F.G.S., Hunterian Professor in the Royal College of Surgeons, London.*

Read April 2nd, 1839.

THE animal about to be described belongs to a genus founded and referred to the class *Amphibia* by Fitzinger*, for the reception of an allied species discovered by Dr. Natterer in the river Amazon, and of which a brief account has been given by that excellent naturalist in the Annals of the Museum of Vienna† under the name of *Lepidosiren paradoxa*, a new genus of the family of Fish-like or Perennibranchiate Reptiles, with the following characters:

"Corpus anguillæforme totum squamatum. Pedes quatuor, valde distantes, adactyli."

In these and most of the other characteristics detailed in the text of Dr. Natterer the present species closely agrees with the *Lepidosiren paradoxa*; the principal differences occur in the relative proportions of the head, trunk and rudimental filamentary extremities.

The whole length of the *Lepidosiren paradoxa* includes eleven lengths of the head, measured from the end of the mouth to the gill-openings; in the present species the total length of the animal includes little more than six lengths of the head. In the *L. paradoxa* the length of the body anterior to the commencement of the dorsal fin includes four and a half lengths of the head: in the *L. annectens* there are only two lengths of the head before the dorsal fin commences. The length of the anterior extremity is one-twelfth that of the entire body in the *L. paradoxa*: it is only one-sixth of the same length in *L. annectens*. This species is therefore distinguished from the *Lepidosiren paradoxa* by the shorter relative length of the trunk as

* Frorieps Notizen, vol. 1. p. 90; and Wiegmann's Archiv., 1837. p. 232.

† "*Lepidosiren paradoxa*, eine neue Gattung, aus der Familie der Fischähnlichen Reptilien, von Johann Natterer, Annalen des Wiener Museums der Naturgeschichte, 1837, ii. p. 165."

compared with the head and the extremities,—a difference which is quite independent of age or growth; and the character, "pedes valde distantes," which Dr. Natterer has founded on the length of the trunk, must be restricted as a specific application to the *Lepidosiren paradoxa*.

Dr. Natterer obtained two specimens of his species; one of these, which measured upwards of three feet in length, was found in a swamp on the left bank of the Amazon, above Villa Nuova; the other, which was nearly two feet long, was taken in a pond near Borba, on the river Madeira, a tributary of the Amazon. The specimen about to be described, though differing apparently from the *L. paradoxa* only in certain proportions of its outward form, is a native of a different continent, and was taken in the river Gambia*. It is a female, with the ovaria well-developed, and measures twelve inches, eight lines in length: its greatest circumference is four inches and a half†. The head commences by an obtuse muzzle, and gradually enlarges in all its dimensions to the gill-openings, which are situated immediately anterior to the base of the pectoral extremities: the length of the head from the snout to the gill-opening is one inch, eleven lines; the trunk, from the pectoral to the ventral filamentary fins, is five inches, five lines. The anus, or rather the cloacal vent, is a small elliptical aperture marked with radiating lines, which is situated three lines behind the ventral filaments, and offers the same peculiarity as does that of the *Lepidosiren paradoxa* in not being situated on the median plane: in the present specimen it was on the right side of a longitudinal fold of integument which occupied the middle line. The distance from the vent to the end of the tail is five inches. The trunk gives a wide elliptical transverse section‡, and maintains a pretty uniform size, slightly decreasing in breadth to the ventral filaments. Beyond these the tail becomes more rapidly compressed, and, after a short distance, diminishes also in vertical dimension, till it ends in a thin point.

A membranous dorsal fin commences at the distance of four inches from

* It was presented to the Royal College of Surgeons, June 1837, by Thomas C. B. Weir, Esq., together with a smaller dried specimen inclosed in indurated clay, baked hard by the sun. Several species of insects, peculiar to the Gambia, or African forms, accompanied these specimens. It is here described and figured by permission of the Museum Committee of the College.

† Tab. XXIII. figs. 1. & 2. ‡ Ib. fig. 3.

the snout, and gradually increasing to the height of five lines, is thus continued into the caudal membranous expansion. This fin is supported by numerous soft, elastic, transparent rays articulated to the extremities of the superior and inferior peripheral spines of the caudal vertebræ: the under part of the caudal fin commences about one inch behind the vent.

The entire body is covered with cycloid scales*, which are relatively larger, but have the same general structure and disposition as in the *Lepidosiren paradoxa*. They present a subcircular form, with a diameter of about three lines; their posterior margin adheres to the strong cuticle, with which they are removed as in other fishes: the anterior margin lies freely in a corresponding groove of the chorion. When viewed with a low magnifying power they present a series of canals, radiating somewhat irregularly from a centre near the posterior edge of the scales, and maintaining a uniform diameter. These canals are united together by cross canals, which do not form regular concentric lines. The meshes formed by this reticulation are small and of a subquadrate form at the anterior part of the scale, but are more elongated in the middle of the scale: they are, again, smaller and shorter at the circumference. With a magnifying power of 150 linear diameters the interspaces of the larger canals are seen to be occupied by a finer network of apparent tubes, and from an angle of each of these spaces a short obtuse process, projecting slightly backwards, is developed on the external surface of the scale: the internal surface is quite smooth. There are three or four faint concentric lines of growth at the circumference of the scale, but this body is evidently one continuous organized whole. The subcuticular tissue of the scale is a kind of dense elastic cartilage, not yielding any gas-bubbles on the application of acid. The scales are continued upon the base of the caudal natatory fold of integument.

The disposition of the mucous pores and ducts upon the head is very similar in the two species of *Lepidosiren*, judging from the figure given by Dr. Natterer. A linear series of mucous pores encircles each eye, and from the posterior angle of this series the lateral line commences. This line extends backwards, nearly parallel with the dorsal line, situated a little more than one-fourth of the vertical diameter of the body from that line, until it nearly

* See the magnified view of one of these scales, Tab. XXVII. fig. 1.

reaches the ventral extremities, where it bends down to midway between the dorsal and ventral margins, and so continues to the end of the tail.

The rudimental filamentary fins, the analogues of the four ordinary extremities in the Vertebrata, permanently represent in the present singular animal the earliest embryonic condition of the pectoral and pelvic members. They are round, filiform, gradually attenuated to an undivided point, resembling tentacles or feelers rather than fins or legs, and doubtless restricted to their tactile functions. Each filiform member is supported by a single-jointed, soft, or cartilaginous ray. The pectoral tentacles* are somewhat shorter and more slender than the ventral ones†; the former are two inches, the latter two inches, four lines in length.

The branchial apertures are narrow vertical slits, four lines in extent.

The eyes appear externally as two small round flat spots, of a lighter colour than the surrounding integument; they are situated seven lines from the end of the snout, and nearly the same distance apart from one another. Each of these simple visual organs measures one line and a half in diameter; it is not defended by any palpebral folds of the skin; the cornea is thin, sufficiently transparent to allow the lens to be visible even in the specimen preserved in spirits. The nostrils are situated at the under part of the upper lip, within the opening of the mouth. They appear as two small perforations leading to blind sacs afterwards to be described‡. The opening of the mouth§ is wide, and defended by well-developed fleshy lips. The skin at the angles of the mouth is thinner than at the rest of its circumference, and the upper lip folds over the lower one from the angle to near the fore part of the mouth; here the lips are thick, smooth and rounded; the lower lip is the thickest.

About a line behind the lower lip, between it and the teeth, there project six soft papillose processes, of a triangular form; two of these, which are situated in the middle line, consist of a transverse row of papillæ; the posterior ones are membranous, and the papillæ are confined to their margin and outer surface: they occupy the notches of the broad and strong dental plate.

* Tab. XXIII. fig. 2, *a*. † Ib. *b*.

‡ In the Siren as well as in the Proteus, Cuvier expressly states, that the nasal cavities communicate with the mouth; and attributes to the ingenious naturalist Oken his attention to this circumstance as a distinguishing character between Fishes and Reptiles.—See Ossemens Fossiles, 8vo., 1837, tom. x. p. 339.

§ Tab. XXVII. fig. 2.

Behind the upper lip there are eight similar papillose processes, four on each side; the mesial placed one line behind, or within the margin of the lip; the outermost three lines from the same part: immediately anterior to the interspace of the two outer lamellæ is the orifice of the nostril, which is elliptical, and one line in the long diameter; the olfactory cavity* itself is three lines in the long diameter, and its closed posterior part is occupied with two rows of small transverse lamellæ, about twenty in a row, divided by a transverse line.

There are two small slender, conical, sharp-pointed and slightly recurved teeth†, which project downwards from the intermaxillary bone, to which they are attached by ligaments; and the alveolar border of both the upper and lower maxillaries is armed with a strong trenchant dental plate‡ anchylosed to the bone, and divided at the middle line so as to form four distinct pieces, two above and two below; each of these teeth or dental plates is impressed on its outer side with two broad angular notches, extending almost through the whole breadth of the plate, and dividing it into three angular processes§, which, from the direction of the notches, appear to radiate from the inner and posterior angle of the tooth: the two anterior divisions in both the upper and lower jaws are the most produced in the vertical direction, and are pointed so as to be adapted for piercing: the posterior divisions are most extended in breadth, and least in height, and terminate in a sharp trenchant edge; the middle divisions present an intermediate structure. These teeth, in their paucity, relative size and mode of fixation to the maxillæ, resemble those of the Chimæra and some of the extinct cartilaginous fishes, as *Cochliodus* and *Ceratodus*; but they are unlike these in their microscopic structure, and differ from any known dental apparatus in the class of Fishes in the modifications of the working surface which at once adapt them for piercing, cutting and crushing. The strength of the jaws and the size of the muscles which work them are proportionate to the size and formidable character of the maxillary dental plates.

There are no lingual, palatine, pterygoid, vomerine or pharyngeal teeth.

The general colour of the specimen was a mixed tint of dark olive-green and brown, growing lighter towards the belly, with irregular dark spots, as

* Tab. XXVII. fig. 2, e, e'.

‡ Tab. XXIII. fig. 4, β, γ. Tab. XXV. fig. 4.

† Tab. XXIII. fig. 4, α. Tab. XXVII. fig. 2, α.

§ Tab. XXVII. fig. 2, b & c.

big as the largest scales, chiefly confined to the tail: the mucous pores and lines were black.

Such are the general external characters of the *Lepidosiren annectens*, in most of which it agrees with the *Lepidosiren paradoxa*. It is not, however, a whit less paradoxical than its earlier described congener; and it may be truly said, that since the discovery of the *Ornithorhynchus paradoxus* there has not been submitted to naturalists an animal which proves more forcibly than the *Lepidosiren* the necessity of a knowledge of its whole organization, both external and internal, in order to arrive at a correct view of its real nature and affinities.

It was the reluctance to bring before the notice of zoologists an incomplete description of this form, which has prevented my being the original proposer of the genus, having recorded its principal characters as the type of a new genus of abdominal malacopterygious Fishes in the MS. Catalogue of the Museum of the College of Surgeons, in June 1837, under the name of '*Protopterus*,' in reference to the rudimental or embryonic condition of the fins, and with the specific name of *anguilliformis* as indicative of its forming a transition from the abdominal to the apodal orders. The subsequent reception of Dr. Natterer's memoir in February 1838, rendered it necessary to substitute another generic and specific name, since the species described by that enterprising and scientific traveller presented still more eel-like proportions.

The anatomical details which form the subject of the remaining part of the present memoir, while they confirm the propriety of referring the genus *Lepidosiren* to the class of Fishes, lead to more enlarged and juster views of its affinities both to the members of that class and to the higher Vertebrate animals. To the description of these details I now proceed.

*Osseous System**.

The skeleton of the *Lepidosiren* is partly cartilaginous, partly bony; the ossified portions are of a green colour, like those of the Gar-pike (*Belone vulgaris*). The bodies of the vertebræ retain the primitive condition of a continuous cylindrical gelatinous chord, with an external ligamentous sheath†, except in the caudal region, where they present a cartilaginous firmness, with

* Tab. XXIII. figs. 4, 5, 6, 7.

† Tab. XXIV. fig. 2, *a*.

imperfect divisions corresponding in number with the upper and lower spines. The neurapophyses, or laminæ protecting the spinal chord, are ossified, as are also the neural spines and the hæmapophyses and hæmal spines* in the caudal region.

The neurapophyses of the atlas are slightly expanded at their lower extremities, and almost meet below the foramen magnum, where they rest upon the anterior pointed extremity of the gelatinous chord; as they ascend, they are bent at an open angle, with the upper ends meeting above the foramen magnum: these extremities are disunited, and a short spine is attached to them by a ligament. The neurapophyses of the second cervical vertebræ have their bases expanded so as to meet below the spinal marrow and above the gelatinous chord; they are disunited above, as are the rest of the neurapophyses†. The basis of these vertebral elements, besides being developed inwards, are expanded in the antero-posterior direction so as almost to touch each other; they become gradually narrower as they approach the caudal region. The neural spines‡ increase in length from the atlas to the fourth vertebra, and are continued of the same length, viz. between four and five lines, to the middle of the caudal region, whence they progressively diminish to the end of the vertebral column. The supernumerary or dermal spines§ are rather shorter than the true vertebral spines, to the upper end of which they are attached by ligaments, as in other fishes. In the caudal region they are expanded and compressed, and give attachment to the horny transparent filaments which support the membrane of the caudal fin: the inferior corresponding appendages‖ of the hæmal spines¶ present a similar form, and, like the upper ones, have the same bony structure and green colour as the ossified parts of the true endo-skeleton. The hæmapophyses** are relatively longer and more slender than the neurapophyses.

The capsule of the anterior extremity of the gelatinous chord is ossified at its inferior and lateral parts, where it forms the base of the cranium; and the bodies of the occipital and posterior and anterior sphenoidal vertebræ are represented by a single elongated sub-triangular plate of bone††. The base

* The explanation of these terms, and of the vertebral elements to which they are applied, will be found in my paper on the *Plesiosaurus macrocephalus*, Geol. Trans., 1838.

† Tab. XXIII. fig. 4, *b. b.* ‡ Ib. *c. c.* § Ib. *d. d.* ‖ Ib. *g.* ¶ Ib. *f.*

** Ib. *e.* †† Ib. *h.* fig. 6; and Tab. XXIV. fig. 2, *c.*

of this plate is turned forwards, the apex expands into an oblique elliptical plate, having a shallow depression, which receives the pointed anterior extremity of the gelatinous chord. The fibrous capsule of the chord is attached to the margin of the basi-occipital depression, and supports the neurapophyses of the atlas, anterior to which are the corresponding elements of the occipital vertebra itself. These exoccipitals* present the form of thin expanded plates, of a subquadrate figure, concave towards the medulla oblongata, which they defend and embrace, their anterior and inferior extremities being extended into the upper part of the capsule of the fibrous chord, as far as the middle line, like the bases of the ordinary neurapophyses: their upper extremities meet above by an extended superior margin. The basi-occipital is notched below the base of each exoccipital, leaving a foramen for the transmission of a large nerve. The limits of the basi-occipital and sphenoid bones are indicated by a transverse groove. The basi-sphenoid sends upwards, near its outer margin, two low longitudinal vertical plates, which give attachment to the cartilaginous alæ of the sphenoid forming the lateral parietes of the cranial cavity†. Between these alæ and the ex-occipital bony plates is interposed on each side the large and thick cartilaginous capsule of the organ of hearing‡, which is extended upwards to the parietal bone, and represents the petrous and squamous elements of the temporal bone. There is no distinct supra-occipital bone or spine, but its place is occupied by the posterior extremity of the parietal§. This is a single symmetrical, lozenge-shaped bone, from the middle line of whose upper surface a longitudinal stout spine is developed, augmenting the surface of attachment of the strong temporal muscles. This spine is continued upon the frontal bone‖ as far as its anterior extremity. Both the parietal and frontal bones are ossified, and were anchylosed together in the larger specimen: the limits of the cranial vertebræ are thus effaced above as they are by the confluence of the occipital and sphenoids below. The anterior part of the frontal is deeply notched on each side. There are no distinct ossified anterior frontals, but the posterior frontals¶ are enormously developed, and extend backwards over the frontal and parietal bones as far as the occiput, forming a second bony shield to the skull, analogous to the osseous plates in the

* Tab. XXIII. fig. 4, *i*.
† These portions are distinguished by dots in Tab. XXIII. fig. 4.
‡ Tab. XXIV. fig. 2, *k*, *k*.
§ Tab. XXIII. figs. 4 & 5, *k*.
‖ Ib. *l*.
¶ Ib. *mm*.

Heterobranchus, or to the ossified temporal fascia in the *Cheloniæ*. These elongated post-frontals are of a triangular form, their narrow and irregular base is anterior, and is connected with the median frontal by a moveable ligamentous joint: a small longitudinal vertical crest or ridge is given off from the under surface.

The analogue of the conjoined nasal and intermaxillary bones* is a strong triangular plate of bone, with its rounded anterior apex forming the anterior extremity of the skull, and supporting at its under surface the two long and sharp intermaxillary teeth. It has a slight vertical movement, by means of its posterior ligamentous connexions, upon the frontal and ascending process of the maxillary bone. The maxillary bones, palatines and pterygoids are represented by a single piece of bone on each side. The dental portion of this bone presents three vertical ridges, with intervening notches, radiating from the posterior part of the mesial symphysis: the ridges are in the shape of compressed wedges, with the apex downwards, and are covered with a continuous dense dental substance with a corresponding cutting edge: an ascending triangular process of the maxillary rises above the two outer dental laminæ; its apex is directed backwards, and is joined by ligament to the frontal and intermaxillary bones: the external angle of the maxillary portion of the bone curves backwards and ends in a free point†. The pterygoid portion of the bone now described is indicated by its fulfilling the usual function of an abutment extended between the palatine portion of the upper jaw and the articular pedicle of the lower jaw: it is expanded and compressed as it extends downwards and outwards to support the inner surface of the articular pedicle, and terminates by a broad truncated margin‡.

The articular surface for the lower jaw presents a more complicated form than is usually observed in either fishes or reptiles: its general contour presents a very regular semicircular convexity, but the surface is sculptured by two parallel grooves with an intervening convex ridge, adapted to a corre-

* Tab. XXIII. fig. 4 & 5, *n n*. This bone may, under another point of view, be regarded as analogous to the rostral prolongation of the anterior part of the cranium in the Sturgeon and other *Chondropterygii*; and the true intermaxillaries may be supposed to be confluent with the maxillary, and enter into the formation of the superior dentigerous arch.

† Tab. XXIII. fig. 5, *β*.

‡ Ib. fig. 4 & 5, *o*.

sponding central groove and lateral ridges in the concave articular surface of the lower jaw. Moreover, this double articular trochlea is not bony but cartilaginous in both the pedicle and the lower jaw. The convex or upper part of the joint forms the termination of an elongated piece of cartilage continued from that which represents the squamo-temporal bone, downwards and forwards, between the expanded end of the pterygoid plate above-described, which forms its internal support, and an elongated plate of bone, which runs parallel with the cartilaginous pedicle and adheres to its outer side. This outer plate of bone may be regarded as a rudimental *os tympanicum**: its inferior extremity is regularly convex, and forms the outer edge of the mandibular articulation: above this part it becomes contracted, and, as it were, twisted, with the posterior edge turned outwards, so as to render its external surface concave; it then again becomes expanded and compressed, as it ascends obliquely backwards and terminates in a rounded edge, which gradually degenerates into cartilage.

Each ramus of the lower jaw is composed of an articular or post-mandibular† and a dentary piece‡, as in most osseous fishes. The articular piece is an elongated compressed bone, concave posteriorly where it forms the outer margin of the articular surface, and extending forwards in a groove on the outer and near the lower part of the dentary piece; it ends in a point near the symphysis. The cartilage, which forms the principal part of the articular concavity, extends forwards on the inner side of the postmandibular bone half-way towards the symphysis. The dentary elements are anchylosed to each other at the symphysis, and each is deeply notched behind for the reception of the apex of the postmandibular bone. Their masticating or upper surface is modified in correspondence with the dental surface of the opposed jaw; three trenchant ridges radiate from the symphysis, the anterior being like that in the upper jaw the shortest and thickest, and with the external angle most pointed and produced, adapted for piercing and tearing; the posterior one is the thinnest, and best fitted for cutting: the two anterior dentary ridges in each ramus of the lower jaw work into the notches between the ridges of the jaw above.

Behind, and nearly parallel with the *os tympanicum*, is placed an elongated slender trihedral bone, pointed at both ends, having a slight sigmoid curva-

* Tab. XXIII. fig. 4, *p*. † Ib. *q*. ‡ Ib. *r*.

ture, and with the external facet concave: this I regard as the analogue of the preopercular bone*: it gives attachment to the membranous and muscular outer wall of the branchial cavity in which the dermal bones of the operculum are developed in ordinary fishes.

A strong cylindrical and almost straight *styloid* bone† is articulated by a somewhat compressed and expanded upper extremity to the cartilaginous petrous element of the temporal; it extends downwards and forwards, parallel with the *os tympanicum*, and is articulated to the upper part of the expanded posterior extremity of the cerato-hyoid bone‡. The opposite extremity of the hyoid is united by ligament to the corresponding bone of the other side, and thus completes the hyoidean arch: there is no representative, bony or cartilaginous, of the body of the *os hyoides*. The slender cartilaginous arches of the gills are merely attached to and supported by the membrane of the cavity of the mouth.

The *scapular* or pectoral, like the hyoidean arch, is simply composed of a pair of elongated incurved bones, representing the anchylosed scapula and coracoid§, on each side. The coracoids meet below the pericardium, and their inferior extremities are united by strong ligaments; the scapular part, as it bends upwards toward the occipital region of the skull, is expanded, compressed, and concave towards the internal and posterior aspects, where it affords origin to the lateral series of muscles below the lateral line.

The cartilaginous basis of the rudimental pectoral fin or anterior extremity‖ is articulated to a very regular cartilaginous cavity at the posterior and near the upper end of the scapular arch. About thirty joints may be counted in the single soft ray which represents the skeleton of the pectoral member.

The ribs¶ are thirty-six pairs, all simple, slightly curved, slender styles, attached to the lower and lateral part of the fibrous capsule of the gelatinous vertebral chord by an upper obtuse extremity, and pointed at the opposite end, which projects into the intermuscular space, and from which the intermuscular ligament is continued. They are all of nearly the same length, viz. about five lines; the posterior pairs become straighter and incline towards each other; the thirty-seventh pair of corresponding appendages meet at their inferior ex-

* Tab. XXIII. fig. 4 & 5, *s. s.* † Ib. *t.* ‡ Ib. *u.*
§ Ib. *v.* ‖ Ib. fig. 4, *w.* ¶ Ib. *x.* Tab. XXIV. fig. 2, *n. n.*

tremities, and are more elongated, forming the first of the caudal series of vascular arches already described.

The pelvic arch is represented by a single piece of cartilage of a crucial form *; the transverse pieces curve slightly upwards, and we may suppose them to represent the iliac elements of the *os innominatum*: the articular surface for the basis of the posterior extremity is near the anterior part of the cartilage. This support of the rudimental ventral fin consists of a single-jointed soft ray†, similar to that of the anterior extremity, but thicker; about forty joints may be counted in this ray, in many of the larger of which there were ossific deposits.

In reviewing the principal characters above noticed of the skeleton of the *Lepidosiren*, we obtain good evidence of its ichthyic nature. If, indeed, the species had been known only by its skeleton, no one could have hesitated in referring it to the class of Fishes; but in that class it would have offered a most singular and interesting combination of the cartilaginous and osseous types.

The central elements of the vertebral column,—the basis of the skeleton,—exhibit a persistence of its primitive embryonic condition, such as has hitherto been witnessed only in the Sturgeon and Cyclostomous fishes; but the superior arches and the spinous appendages, instead of retaining the cartilaginous state, are converted into the tough elastic fibrous texture characteristic of the skeleton of fishes. The cranium in like manner presents an extremely novel combination of the cartilaginous and bony states both as regards its partial ossification and the condition of the ossified parts. It is only in the higher cartilaginous fishes, *e.g.*, that the maxillary, palatine and pterygoid bones are blended together to form the simple superior dentigerous arch or upper jaw. The composition of the lower jaw corresponds with that which characterises most of the osseous fishes, and is more simple than in the Amphibia. The confluence of the cranial vertebræ reminds one of the condition of the skull in the Siren: but no vestige of a preopercular bone is present in any of the Perennibranchiates. The "sphenoideum basilare" as it exists in the Sturgeon is here seen in its fully ossified state. As the basis of the vertebral column presents a condition analogous to that which characterises the early embryonic periods of

* Tab. XXIII. fig. 4, *y*. † Ib. *z*.

the higher Vertebrata, so also the extremities retain their simple structure as when they first bud forth, and are devoid of any trace of digital divisions: still the march of development has begun, and we perceive by the numerous joints of the cartilaginous ray, that its direction is towards the ichthyic modification of the great vertebral plan.

*Muscular System**.

The muscles of the trunk of the *Lepidosiren* present all the simplicity and uniformity characteristic of the class of Fishes. They are divided by the lateral line into a dorsal and ventral series, each series consists of narrow subvertical plates of oblique fibres, separated by intermuscular fasciæ which afford on one side attachment to an anterior series, and on the opposite to a posterior series of muscular fibres: these fibres are directed upwards and backwards in the dorsal group, and downwards and backwards in the ventral one: the ventral series occupy the place of the true abdominal muscles which first begin to be developed in the strictly air-breathing Reptiles. The muscles of the mandibular, hyoidean, branchial and scapular arches are represented in Tab. XXIII, and will receive their necessary detailed description in the explanation of the figures in that plate. They resemble in some points the arrangement of the same muscles in the Perennibranchians, and in other points that in the true Fishes; but do not afford any sufficiently characteristic modifications to merit further notice here. It may be also observed, that although the muscles of the trunk are quite fish-like in their disposition, yet that the lower Perennibranchians and the larvæ of the higher Batrachia offer a similar agreement in this part of their organization to the class of Fishes.

Nervous System.

The brain consists of the following principal masses; viz. two elongated, oval, subcompressed cerebral lobes, a single elliptical optic lobe†, a medulla oblongata‡, and a transverse medullary fold continued across the anterior part of the widely open fourth ventricle, representing the cerebellum§. In the angle between the representative of the bigeminal bodies and the interspace of the hemispheres there is a well-developed pineal gland‖: on the inferior sur-

* Tab. XXVII. fig. 3 & 4, *a a*.
† Ib. fig. 3, *b*.
‡ Ib. fig. 4, *c*.
§ Ib. fig. 3, *d*.
‖ Ib. fig. 3, *e*.

face of the brain behind the hemispheres is an elongated bilobed tract corresponding to the base of the third ventricle*, and posterior to this a single subspherical corpus mammillare†.

The nerves given off from the brain are the olfactory; the optic, which arise close together from the mesial line, traversing the second basal mass; the fifth pair, which are of very large size; the auditory, and the eighth pair of nerves.

The brain bears a closer resemblance to that of the Perennibranchiate Reptiles than to the brain of any fish which has yet been described. Figures of the brains of the *Menopome*‡ and *Menobranchus*§ are added to the plate in order to illustrate this resemblance, which is very striking as regards the *Menobranchus* on account of the rudimental condition of its cerebellum. In the low development of this part of the brain, and in the large size of the pineal gland, the *Lepidosiren* deviates in a marked degree both from the osseous and cartilaginous fishes.

The olfactory nerves‖ are more than twice the size of the optic; they pass forwards through foramina in the cartilaginous æthmoid, and expand upon the posterior surface of the nasal sacs, the pituitary membrane of which is disposed in two series of short transverse folds, about twenty in each, as before mentioned: these olfactory sacs have no communication with the buccal cavity.

The optic nerves¶ arise close together, as in the Skate, from the mesial line traversing the second basal mass; they do not decussate as in the osseous Fishes. They are remarkably small, in correspondence with the feebly-developed organs of vision. Each eyeball adheres to the skin, with which the flat cornea is on a perfect level: there is a small spherical lens, and a membranous sclerotic: there is no trace of the vascular body called, in osseous Fishes, the choroid gland. The diameter of the eyeball is about one line and a half: it has no special muscles, whence the absence of 3rd, 4th, and 6th cerebral nerves.

The organ of hearing consists of a large labyrinth excavated in a thick cartilaginous case, without other external communication than the foramina for

* Tab. XXVII. fig. 4, *f*.
† Ib. fig. 4, *g*.
‡ Ib. fig. 5.
§ Ib. fig. 6.
‖ Ib. fig. 3 & 4, *h h*.
¶ Ib. fig. 4, *i*.

the transmission of the acoustic nerve*. This nerve divides almost immediately into two branches, one of which is distributed over the sac of the lesser otolithe†, and sends a branch to the semicircular canals; the other is expended upon the sac of the greater otolithe‡. These sacs occupy the inferior part of the vestibule; the smaller one is internal, and about one sixth the size of the outer sac; both are of a spherical form, and are nearly filled with a white chalky substance, which here, as in the Cartilaginous Fishes, represents the hard otolithes of the Osseous Fishes. Above these sacs are three small semicircular canals §. There is not a vestige of tympanic cavity or Eustachian tube.

Of the fifth pair of nerves only the second and third divisions are present ‖.

The eighth pair of nerves supplies the branchial apparatus, sends a branch along the pharynx to the alimentary canal and air-sacs, and terminates in a large lateral nerve, which is continued backwards over the heads of the ribs to the middle of the caudal region, where it distributes its terminal branches to the muscles of the natatory membrane.

There is no modification worthy of notice, as bearing on the affinities of the *Lepidosiren*, in the spinal chord or nerves.

Digestive System.

The mouth ¶ is of moderate width, and is provided with fleshy lips, behind which are the papillose processes already described, and which are doubtless organs of delicate touch: the dental apparatus consists of the two long, moveable, piercing teeth descending from the intermaxillary bone, and the strong trenchant and crushing dental plates which incase the opposed margins of the upper and lower jaws.

Immediately behind the dental plate of the upper jaw there is a broad process of the palatal membrane beset with minute papillæ**, which it may be allowable, perhaps, to compare with the minute palatal teeth of the Siren, here represented in their uncalcified rudimental state. Behind the lower jaw there is a smooth transverse duplicature of the membrane of the mouth, covering the anterior extremities of the cerato-hyoids: this process is succeeded by a second trilobate, narrow, transverse fold††, minutely papillose and glandular.

* Tab. XXVII. fig. 4, *k*. † Ib. fig. 4, l. ‡ Ib. fig. 4, *m*. § Ib. fig. 3, *n*.
‖ Ib. fig. 4, *o*. ¶ Ib. fig. 2. ** Tab. XXIV. fig. 2, *g*. †† Tab. XXVI. fig. 1, *b*.

Beyond these rudiments of a gustatory organ the membrane of the mouth is smooth, slightly puckered into irregular longitudinal folds, and gradually contracting as it passes along the interspace of the branchial openings to the orifice of the pharynx. This orifice* is much smaller and more suddenly contracted than in Fishes generally, or the Perennibranchiate Reptiles: it is also defended by a semicircular valvular fold†, which closes it from below. The œsophagus‡ is scarcely an inch in length; its lining membrane is puckered longitudinally: about three lines from the pharyngeal orifice, at the lower part of the œsophagus, is the laryngeal fissure§, or the orifice of the *ductus pneumaticus*: the fissure is one line in length, and is pierced in the posterior part of a cartilaginous plate‖, which extends forwards to the base of the valve of the pharyngeal aperture, where it terminates in a rounded edge, a line in breadth: this cartilage or rudimental thyroid is here obviously subservient to the maintenance of the patency of the œsophageal canal anterior to the glottis; and the remarkable fact of the presence of a sensitive epiglottis is perhaps explicable on the principle of its correlation with the above structure.

The œsophagus gradually expands into a pyriform but not wide stomach¶, which both in its form and diameter so nearly resembles the intestine that the limits between the two are outwardly not very easy to define. Both œsophagus and stomach are situated in the same continuous straight line as the rest of the alimentary canal. A slight constriction indicates the pyloric extremity of the stomach. The tunics of the stomach are pretty strong: its lining membrane has a smooth surface, and, in the specimen dissected, it was partly decomposed, apparently by the action of the gastric juice, which is a common occurrence in Fishes. The pylorus opens into the intestine by a circular valvular fold of the mucous membrane**, the margins of which are crenate.

Before describing the rest of the alimentary canal, a few words may be premised on the structure of the abdominal cavity††. This commences about half an inch behind the pectoral filamentary fins, and extends about half an inch beyond the anus. It is separated anteriorly from the pericardiac cavity, as in Fishes and Perennibranchiate Reptiles, by a distinct transverse septum.

* Tab. XXVI. fig. 1, *c*.
† Ib. fig. 1, *d*.
‡ Tab. XXV. fig. 2, *a*.
§ Tab. XXVI. fig. 1, *e*.
‖ Ib. *f*.
¶ Tab. XXV. fig. 2, *b*.
** Ib. *c*.
†† Ib. fig. 1.

Its muscular parietes are very thick, and are formed, not by what are called the 'abdominal muscles' in the higher vertebrates, but by the lateral series of oblique muscular fasciculi. The proper tunic of the abdomen is a strong glistening fibrous membrane*, which is lined by a delicate and transparent serous membrane†. This membrane is reflected over the ovaria‡, which occupy the sides of the abdominal cavity; and over the liver§, stomach, and intestine‖, which are situated between the two ovaria: from the anterior or under part of the intestine the two laminæ of the peritoneum are continued in a straight line, forming a kind of mediastinum¶ to the opposite parietes of the abdomen, which is thus divided into two lateral compartments in the two posterior thirds of its extent: these compartments gradually contract posteriorly into peritoneal canals, which intercommunicate by an oval aperture three lines in length, and have a common external outlet** in front of the anus††, but within the common cloacal sphincter. The common opening of the oviducts‡‡ is behind the anus.

The lungs§§ and kidneys are entirely posterior to the peritoneum.

The intestine is three inches and a half in length, and becomes gradually contracted to the vent; it is traversed throughout by a spiral valve‖‖, which performs six gyrations: the extent of intestine traversed by the first turn is the greatest, measuring above an inch: the second is suddenly shorter, being about four lines in length: the remaining folds gradually diminish to three lines in longitudinal extent. The valve terminates by forming a longitudinal ridge in the narrow rectum¶¶, which measures about an inch in length. The tunics of the intestine are thick and strong, especially the internal one, which presents a glandular structure similar to that in the Sturgeon: its surface is, however, proportionally less strongly honeycombed: it is increased at the beginning of the intestine principally by spiral linear elevations, in the interspaces of which there is a fine reticulation.

There was no pancreas, nor pancreatic cæca; neither could any trace of a spleen be detected.

The liver is a flattened subelongate unilobate gland, situated between the

* Tab. XXIV. fig. 2, *n.n.* † Ib. fig. 2, *m. m.* ‡ Tab. XXV. *g.* § Ib. *h.*
‖ Ib. *k.* ¶ Ib. *l.* ** Ib. *m.* †† Ib. *n.*
‡‡ Ib. *o.* §§ Ib. fig. 3. ‖‖ Ib. fig. 2, *d.* ¶¶ Ib. *e.*

stomach and right ovarium, chiefly in the anterior undivided part of the abdominal cavity, but extending about half an inch beyond the commencement of the peritoneal mediastinum: it is convex externally, and concave towards the alimentary canal, measuring two inches three lines in length, and eight lines in width. It is of a light brown colour, having its peritoneal coat speckled with dark brown spots. The gall-bladder* is lodged in a notch on the anterior surface of the left margin of the liver; it is sunk in the substance of the liver, with part of its surface exposed. The gall-bladder receives the bile by two cyst-hepatic ducts which enter its cervix, and the secretion is carried to the intestine by a single, short, but moderately wide cystic duct†, which terminates close to the pylorus, and by a similar but smaller valvular projection. Most of the veins of the abdominal viscera and of the abdominal parietes contribute to form the vena portæ: the hepatic veins are four or five in number, but there is a principal one‡, which emerges from the anterior part of the liver and forms the vena cava. This great vein, with three other vascular trunks, viz. the aorta, pulmonary artery, and pulmonary vein, penetrate the septum which forms the anterior wall of the abdominal cavity. This septum is formed by the fibrous membrane of the abdomen, which is then continued around the pericardium, to which it is united by a cellular medium: a portion of it is seen reflected in Tab. XXV. fig. 1, *d*. After dissecting away this fibrous tunic the true pericardium§ is brought into view: it is protected by the coracoid bones, which meet below it: one of these is seen turned back in fig. 3, *x*. Tab. XXV.; and the pericardium is removed on that side so as to expose the heart.

Circulating and Respiratory Systems.

The heart‖ consists of a single auricle, a ventricle, and a bulbus arteriosus. The auricle¶ is large, and is applied to the dorsal surface of the ventricle, but sends forward two apices or appendages into the interspace between the ventricle and the bulbus arteriosus; one on the right, the other on the left side. The vena cava** terminates in the right side of the auricle; it is joined by two superior cavæ and by the single large pulmonary vein: this vein††

* Tab. XXV. fig. 2, *g*. † Ib. fig. 2, *h*. ‡ Ib. *i*. § Tab. XXV. fig. 1 & 3, *e*.
‖ Tab. XXV. fig. 3, *a* & *b*. ¶ Tab. XXVI. fig. 2, *a*. ** Ib. fig. 2, *e*.
†† Ib. fig. 2, *f*.

does not, however, communicate with the sinus, but passes along entire and adherent to the inner surface of the vena cava as far as the auriculo-ventricular aperture, where it empties its contents into the ventricle by a distinct orifice, protected by a cartilaginous valvular tubercle. It needed only that the pulmonary vein should have been dilated before its termination in order to have established a biauricular structure of the heart, as in the Siren. The same functional advantage is, however, thus secured to the *Lepidosiren*, with a maintenance of the simple dicœlous type of the heart of the Fish: the continuation of the pulmonary vein preventing the admixture of the respired with the venous blood, until both have arrived in the ventricle.

The ventricle* is of an elongated form, truncate anteriorly where it is in contact with the bulbus arteriosus, and with an obtuse rounded apex at the opposite end: it is four lines in length, and two in breadth. The cavity of the ventricle is extremely small; its parietes are thick and reticularly muscular: a small round orifice leads into the bulbus arteriosus. This body† presents externally a simple transversely oval form; but its internal structure is more complicated than would be suspected from its external appearance. It is formed by a short spiral turn of the dilated aorta, which is concealed under a simple continuous outer fibrous coat: the area of this part of the vessel is almost entirely occupied by two continuous valvular projections, or their processes, which are attached by one edge to the internal surface of the aorta, and have the opposite margin projecting freely into the arterial cavity. If these internal valves were straight, they would resemble the single thicker valvular process which occupies the elongated bulbus arteriosus of the Siren: here, however, they follow the spiral turn of the aorta.

The aorta‡ in the present most remarkable species fulfils at once the office of a systemic, a branchial, and a pulmonary artery: it distributes on each side six vessels corresponding to the six branchial cartilaginous arches. The mucous membrane is produced into a branchial fringe on the convex side of the 1st, 4th, 5th, and 6th branchial arches, and the corresponding arteries are minutely subdivided before they are continued to the dorsal side of the pharynx: these four pairs of vessels are therefore true or functional branchial arteries. The mucous membrane merely invests with a simple fold the second

* Tab. XXVI. fig. 2, *b*. † Ib. fig. 2, *c*. ‡ Ib. fig. 2, *g*.

and third branchial arches; and the corresponding arterial trunks* undergo no subdivision as they wind round them, but are continued entire, as in the Amphiuma and Menopoma, to their termination at the opposite side of the vascular circle. The branches which afterwards unite to form the single pulmonary artery on each side are given off from near the termination of the second and third pairs of the primitive aortic trunk; which thus combine the functions of both systemic and pulmonary arteries.

The branchiæ of the *Lepidosiren* resemble in form those of the Siren, consisting of separate elongated filaments, attached only by one extremity to the branchial arch; but these extremities are fixed directly to the branchial arch, and not to a common pedicle extended therefrom, as in the Siren. Viewed with a moderate lens the tripinnatifid structure is beautifully seen in each branchial filament. The first gill† consists of a single row of fourteen of these subcompressed filaments, each of which is about one line in length and a third of a line in breadth. The second gill‡, which is developed, as before stated, on the fourth branchial arch, is the largest, and consists of a double row of fifteen branchial filaments. The third gill§ has a similar structure. The fourth gill‖ consists, like the first, of a single row of fourteen tripinnatifid filaments, which are shorter and smaller than those of the first.

The cartilaginous branchial arches are developed on each side in the submucous tissue, and, as before stated, are not attached either to the hyoid apparatus below, or to the cranium above. The membrane covering the 3rd, 4th, and 5th arches is minutely papillose. The first branchial aperture or interspace¶ is a narrow slit three lines long, and is defended by a series of minute denticulations projecting from the branchial arch. Bristles are represented as passing through the five branchial interspaces in Tab. XXV. fig. 3. The second aperture** is the widest; it is five lines long, and its margins are smooth: the third aperture is also five lines long, but is narrower than the second: small cartilaginous teeth are developed from each of its margins, as in the first gill-aperture: the fourth and fifth apertures present the same structure but diminish in size.

Thus the branchial current, which flows through the interspaces of those

* Tab. XXVI. fig. 2, 2 & 3. † Ib. fig. 2, 1. ‡ Ib. fig. 2, 4. § Ib. fig. 2, 5.
‖ Ib. fig. 2, 6. ¶ Ib. fig. 1, 1. ** Ib. fig. 1, 2.

arches which support the gills, is subject to a previous filtration by the interlocking marginal denticles; while that which flows between those two branchial arches from which no gills are developed has a free and uninterrupted passage.

The gills do not form any external projection, as in the gill-bearing Perennibranchians, but are contained in a moderately capacious branchial chamber, the parietes of which are formed by a mucous and muscular stratum*; the external outlet is the vertical slit already described, situated immediately anterior to the filamentary pectoral member.

Thus although the organs for respiration through the medium of water correspond in all essential points with those of the true Fishes, yet the gills approximate in their filamentary form to those of the Perennibranchiate Reptiles. And, again, although the gills are four in number on each side, as in the Osseous Fishes, yet the number of branchial apertures and arches corresponds with that which characterizes the higher Cartilaginous Fishes. So that while we perceive, even in the organs for breathing water, a tendency towards the amphibious type, we find at the same time that the branchial as well as the osseous system manifests a most interesting and hitherto unexampled transitional structure between the Plagiostomous and Osseous Fishes.

We have next to consider that part of the Respiratory System which is organized for breathing immediately the atmospheric air, or the Lungs†: for I know not how otherwise to designate, according either to their physiological or morphological relations, those organs, which in the technical language of the ichthyologist would be termed the swim- or air-bladder.

The *trachea*‡, or, to use the same technical and partial nomenclature, the 'ductus pneumaticus,' is a short wide membranous tube, as in the Perennibranchiate Reptiles. The glottis§ opens near the posterior part of a long rudimental thyroid cartilage; a few lines posterior to the *isthmus faucium* the opposite end of the trachea dilates into a membranous sac which communicates by two large lateral apertures with the lungs. These are widest at their anterior extremities, and gradually decrease in diameter to the cloaca, behind which they terminate each in an obtuse point. They are lodged in the dorsal angle of the abdominal cavity behind the kidneys, and are attached

* Tab. XXVI. fig. 2, *h*. † Tab. XXV. fig. 3, *i*, *i*. ‡ Tab. XXVI. fig. 1, *k*.
§ Ib. fig. 1, *e*.

by cellular tissue to all the surrounding parts, and particularly to the ribs, of which they bear the impressions on their posterior surface. The anterior part of each lung is divided into four or five small lobes, of which the first is about half an inch long, of a triangular form, with the apex forming the most anterior part of the lung: the other lobes decrease in size, and at the distance of one inch and a half from the anterior end, the lung takes on the form of a simple compressed bag, and so continues to its posterior extremity. The parietes of the lung present a moderate thickness throughout, and the whole of the internal surface is cellular, the cells having the same proportional size and form as in the respiratory part of the lung of a serpent. The cells are largest and most subdivided at the anterior fourth part of the lung; the livid colour of which in the specimen dissected by me attested the great natural vascularity of the part.

The pulmonary artery*, formed by the union of the branches from the second and third branchial arteries, descends between the vena cava† in front and the left branch of the vena pulmonalis‡ behind, to the interspace of the lungs; here it distributes branches to the anterior lobes, and then divides: each division§ extends along the mesial side of its corresponding lung to the extremity. The blood distributed by the capillaries of this artery over the cells of the lung is collected into a vein‖ which returns along the lateral or outer margin of the lung as far as the commencement of the lobulated part; here it crosses obliquely the anterior surface of the lung, and unites with its fellow at the beginning of the interspace of the lungs: the common pulmonary vein runs parallel with and behind the vena cava for a few lines; then obliquely pierces the pericardium and enters the sinus formed by the expansion of the vena cava, and continues attached to the parietes of that sinus till it reaches the auriculo-ventricular aperture, where it terminates, close behind the singular cartilaginous knob before-mentioned.

Renal System.

The kidneys¶ are narrow bodies, three inches in length, and about two lines in diameter at their widest part, which is near the cloaca; from this extremity they gradually contract, as they pass forwards, to a fine point. They are

* Tab. XXVI. fig. 2, *l*. † Ib. *e*. ‡ Ib. *f*. § Ib. *m*. ‖ Ib. *n*, *n*.
¶ Tab. XXVII. fig. 7, *h*, *h*.

three-sided, with their broadest flattened surface turned forwards and covered by the peritoneum. The ureter* runs along their posterior and outer edge, and opens into the common termination of the oviducts. The kidneys are surrounded by a capsule of cellular membrane, beneath which there is a quantity of intense black pigment: the same pigment is developed from the membrane surrounding the oviducts above the kidneys. There is a small Allantoid bladder†.

Generative System.

The ovaria‡ are compressed bodies between four and five inches in length, situated, as above described, at the sides of the abdominal cavity; having a proper capsule beneath the serous investment, and with their posterior extremities continued a little way beyond the posterior line of reflection of the peritoneum. The ovisacs exhibited different stages of development: those on the posterior part of the ovarium were larger than those on the anterior. The larger ova are from one line to two lines in diameter; these were scattered throughout the whole length of ovary, and were separated by clusters of smaller ovisacs varying in size from one twentieth of an inch to invisible minuteness. The oviducts§ are long, tortuous, and commence each by a distinct aperture at their anterior part, which is in the form of a slit, about three lines in length ‖. The oviduct is closely attached throughout the greater part of its course to the outside of the capsula ovarii: its tunics gradually increase in thickness as it approaches the cloaca, but are nowhere complicated with a special glandular apparatus. The internal surface of the lower third of the oviduct presents small parallel oblique laminæ, like those in the uterus of the Shark. The two oviducts unite and form one strong muscular canal between the allantois and the ureters; and after receiving the contents of these parts, the common canal terminates in the posterior part of the cloaca.

Thus the female organs of generation in the *Lepidosiren*, both as regards the condition of the ovaria, caused by the partial or successive development of the ova, and the freedom of the oviduct, present a grade of development as high as that which characterizes the Plagiostomous Fishes; while the elongated

* Tab. XXVII. fig. 7, *i*. † Ib. *k*. ‡ Tab. XXV. fig. 1. *g*.; and Tab. XXVII. fig. 7, *l*, *l*.
§ Tab. XXVII. fig 7, *m*, *m*. ‖ Ib. *n*, *n*.

form of the ovaria and the convoluted disposition of the oviduct resemble more the same parts in the Axolotl, Amphiuma and Siren.

Concluding Observations.

Most naturalists have considered the Vertebrate animals to form four distinct classes, characterized by as many leading modifications of the respiratory organs; Mammals, *e. g.*, being distinguished by having lungs composed throughout of a dense spongy texture, and suspended freely in a thoracic cavity; Birds, by having spongy lungs firmly adherent to the posterior parietes of the thorax, and generally communicating with air-cells continued into the abdomen and other parts of the body; Reptiles, by membranous lungs extending into the abdominal cavity; and Fishes, by breathing with gills alone.

It is true, that the limits which separated the two classes of cold-blooded Vertebrates were overpassed by the Batrachian Reptiles, which possess gills during either a part or the whole of their existence; but as lungs of the Reptilian type coexisted with these gills in the mature animal, these have been always separated from Fishes, either as an order of Reptiles, or as a distinct class, under the name of *Amphibia*. Their air-breathing organs were, in fact, regarded as such essential indications of their superiority to Fishes, that when the heart of the Batrachia was believed to be dicœlous, and before it had been demonstrated that the most fish-like of the Amphibia, as the Siren, had a double auricle, they were equally regarded either as a class or sub-class of Reptiles.

In the *Lepidosiren*, however, we have a cold-blooded vertebrate animal, of which I may say in the very words of Cuvier when speaking of the Siren, "J'ai sous les yeux les poumons ou l'appareil vasculaire est aussi développé et aussi compliqué que dans aucune reptile." Nevertheless we cannot call it strictly and zoologically a Batrachian; not, however, because the heart has one instead of two auricles, for one, at least, of the Amphibia (the Proteus) possesses a single undivided auricle: and were even the 'septum auricularum' absent in the Salamander or Frog, these would not, therefore, be Fishes.

Neither can we call the *Lepidosiren* a Fish, simply on account of its having branchial arches and gills, inclosed in a branchial chamber, with a single

opercular outlet; because the larva of the tailless Batrachian presents at one period of its existence a similar structure; yet if that state were persistent instead of transitory, it would still be a Reptile and not a Fish. It cannot therefore be determined by the modifications of the respiratory organs whether the *Lepidosiren* be a Fish or a Reptile. Can it be proved to be a Fish by the modifications of its digestive system? A straight intestine with an internal spiral valve has hitherto been met with only in the class of Fishes; yet it occurs rather as an exceptional than a general structure in that class. Supposing that a spiral intestinal valve had been discovered in the *Amphiuma*, *Siren*, or *Proteus*, should we have been justified on that ground in removing such species to the class of Fishes? There is good evidence that the intestine of the *Ichthyosaurus* was provided with a spiral valve, yet it is not on that account regarded as a Fish. If I mistake not, indeed, the intestinal spiral valve of higher *Chondropterygii* is a structure dependent on a slight modification only of that peculiar disposition of the intestinal canal which characterizes the gill-breathing larvæ of the *Batrachia*: we have but to inclose the series of spiral coils of gut of the tadpole in a common investing membrane, so as to conceal the complication under a simple exterior, and little more is wanting to render the conversion of the one into the other structure complete.

In reviewing the peculiarities of the osseous system with reference to the affinities of the *Lepidosiren*, it may first be remarked, that no Amphibian has hitherto presented an unossified condition of the bodies of its vertebræ, or of the parts of the skull containing the organ of hearing. Would such osteological modifications, it may be asked, have sufficed to alter our opinion of the classific relations of the *Siren*? Such a condition of the skeleton, it may be answered, is by no means characteristic of the class of Fishes. If any general ichthyic character can be taken from the skeleton, it is the reciprocal union of the bodies of the vertebræ by opposite concave facets. Now the Perennibranchiate *Batrachia* do in fact present this very structure; yet they have not, any more than the *Ichthyosauri*, been transferred to the class of Fishes on that account: we may conclude, therefore, that their position in zoological classifications would not have been changed, even if their skeleton had resembled that of the *Lepidosiren*. It is only in a few fishes that the bones are green; neither in the scaly nor naked reptiles has the skeleton been found to

present this colour: yet it is almost superfluous to remark that so trivial a character would of itself have been totally inadequate to determine the classific characters of a doubtful species: it is only in conjunction with other modifications of structure that it assists in our present attempt to determine the true affinities of the *Lepidosiren*.

As regards the principal conditions of the organs of generation, the line of demarcation cannot be drawn between the *Amphibia* and the Plagiostomous *Chondropterygii*: and the structure of these organs in the *Lepidosiren*, while it shows its near affinity to the Reptiles, by no means proves that it is not a Fish.

The brain of the *Lepidosiren* like its generative system indicates its close relationship as a Fish with the *Amphibia*, but nothing more.

The optic nerves do not decussate, but come off from nearly the same point in front of the infundibulum: since, however, the same structure exists in the Sharks and Rays, this likewise fails to establish the amphibious character of the *Lepidosiren*.

On the other hand, the simple condition of the organ of hearing, consisting merely of the labyrinth without a cochlea, or a fenestra rotunda, might be taken as proof of the ichthyic nature of the *Lepidosiren*: the organ of hearing, however, presents, as is well known, a similar simple condition in the Perennibranchiate Reptiles.

In the organ of smell we have, at last, a character which is absolute in reference to the distinction of Fishes from Reptiles. In every Fish it is a shut sac communicating only with the external surface; in every Reptile it is a canal with both an external and an internal opening.

According to this test, the *Lepidosiren* is a Fish: by its nose it is known not to be a Reptile: in other words, it may be said that the *Lepidosiren* is proved to be a Fish, not by its gills, not by its air-bladders, not by its spiral intestine, not by its unossified skeleton, not by its generative apparatus, nor its extremities, nor its skin, nor its eyes, nor its ears, but simply by its nose; so that at the close of our analysis we arrive at this very unexpected result, that a Reptile is not characterized by its lungs nor a Fish by its gills, but that the only unexceptionable distinction is afforded by the organ of smell.

The anatomical facts already detailed fully justify this emphatic summary of the evidence deducible from the dissection of the *Lepidosiren*; yet it must

be confessed that the physiological consequences of the modifications of the nasal cavity above alluded to would have been far too insignificant to have established the ichthyic nature of the *Lepidosiren*, if, with coexisting gills and lungs, the modifications of the other organic systems had agreed with those of the Perennibranchians instead of with those of Fishes. For although it be true that the fish-like modification of any single system is insufficient of itself to determine the removal of the *Lepidosiren* from the *Amphibia*, in which it has hitherto been placed, to the class of Fishes, yet it is impossible to avoid arriving at that conclusion, when we consider the concurrence of ichthyic characters in so many parts of the organization of this most interesting species. The combination of cycloid scales, mucous ducts, quasi-fins supported each by a many-jointed ray, a gelatino-cartilaginous vertebral style united to the whole surface of the basi-occipital and not to two basilar condyles, the præopercular bone, the simple structure of the lower jaw, the double spines of the neur- and hæm-apophyses, the green colour of the ossified parts of the skeleton;—these external and osteological characters being associated with an intestinal spiral valve, with the absence of pancreas and spleen, the position of the anus anterior to the allantoid bladder, a dicœlous heart, six pairs of branchial arches with the gills concealed, the simple organ of hearing consisting only of the acoustic labyrinth excavated in cartilage and provided with large otolithes, and, lastly, the blind nasal sacs,—form a cumulative body of evidence in proof that the *Lepidosiren* is a Fish, which far outweighs the argument to the contrary, founded on the reptile-like development of its air-bladder, and its conversion into an organ of aërial respiration.

The weight of this argument is, in fact, very much diminished by the close approximation which certain of the abdominal Fishes, called 'Sauroid' by M. Agassiz, make to the *Lepidosiren* in the lung-like structure of the air-bladder. In the Freshwater *Amia* Cuvier states that its swim-bladder is as cellular as the lung of a Reptile*: and this genus also agrees with the *Lepidosiren* in the absence of pyloric cæcal appendages. In the genus *Lepidosteus*, again, Cuvier describes the air-bladder as being as cellular as in the *Amia*, and occupying the whole length of the abdomen†.

* "La vessie natatoire est celluleuse comme un poumon de Reptile." *Règne Anim.* ii. p. 327.

† Loc. cit. p. 329.

M. Agassiz has confirmed this statement, and further observes, that the ductus pneumaticus communicates with the pharynx by a large and regular slit, which he regards "as bearing even a closer resemblance to the entrance of the trachea of the Pulmoniferous *Vertebrata* in general, than the aperture by means of which the lungs communicate with the pharynx in the Perennibranchiate *Amphibia**." In the *Polypterus*, lastly, we find an approach to the *Lepidosiren* in the air-bladder being double, consisting of two long cylindrical lobes, but of unequal length, the left being the longest, and extending through the whole length of the abdomen: the communication of the trachea, or ductus pneumaticus, with the œsophagus, is also here described by Geoffroy St. Hilaire as consisting of a fissure provided with a constrictor muscle.

The *Polypterus*, moreover, presents a most interesting trait of affinity to the *Lepidosiren* in the shortness and straightness of its intestinal canal, which is provided with an internal spiral valve.

With these advances in the organization of the air-bladder in certain abdominal Fishes towards the reptilian structure of the lung, made by the *Amia* and *Lepidosteus* on the one part, in the cellular complication of a single cylindrical air-bladder; and by the *Polypterus*, on the other hand, in the division of the air-bladder into two lobes, with the slit-shaped glottis of the ductus pneumaticus described by Geoffroy and Agassiz; there wanted only the combination of the three characters, as it occurs in the *Lepidosiren*, of a double as well as cellular air-bladder, with a rudimental larynx, to dissipate the last doubts entertained by the stanchest realist as to the true homology, long ago pointed out by Harvey and Hunter, of the vesica natatoria and ductus pneumaticus of the ichthyologist.

Having indicated some of the affinities of the *Lepidosiren*, considered as a Fish, to certain species of the Sauroid family, I may further observe, that in the helmet-like plate into which a part of the frontal is developed, we perceive a resemblance to the genus *Heterobranchus* amongst the Siluroid family of abdominal soft-finned Fishes, most of the species of which also possess a bilobed air-bladder communicating with the œsophagus, and are deficient in pancreatic cæca.

When we consider also that the *Esocidæ* have all a large air-bladder, and

* Zoological Proceedings, 1834, p. 119.

want the pancreatic cæca, the analogy which *Lepidosiren* offers to one genus in that group, *Belone*, in the elongated slender form of the body and its green bones, is not without interest.

In the low condition to which the pectoral and ventral fins are reduced, the zoologist who deals merely with external characters would see in the *Lepidosiren* a transitional form between the abdominal and apodal groups of the *Malacopterygii*. But by far the most important affinities which a deeper research into the organization of the *Lepidosiren* brings to light, are those to the higher Cartilaginous Fishes which are indicated by the semiossified condition of its skeleton; by the removal of the acoustic labyrinth from the cavity into the parietes of the skull; by the number of branchial arches; by the simplicity of the maxillary apparatus; by the spiral intestinal valve; and, above all, by the condition of the oviducts as distinct tubes with two separate apertures.

From every group of Fishes, however, the *Lepidosiren* is sufficiently distinct to form the type not merely of a genus, but of a family; and, in the natural system, it forms a link connecting the higher Cartilaginous Fishes with the Sauroid genera *Polypterus* and *Lepidosteus*; and at the same time makes the nearest approach in the class of Fishes to the Perennibranchiate Reptiles.

EXPLANATION OF THE PLATES.

Tab. XXIII.

External Form and Skeleton of the *Lepidosiren annectens*, on the scale of 8 inches to a foot.

Fig. 1. Side view of *Lepidosiren annectens*.

2. Upper view of the same, in outline.
   - *a*. Filamentary anterior extremities, or pectoral fins.
   - *b*. ——— posterior extremities, or ventral fins.

3. Transverse section of the same, one inch in advance of the ventral filaments.

Fig. 4. Side view of the skeleton of *Lepidosiren annectens*.

a. Cartilaginous vertebral style, or 'chorda dorsalis," representing the bodies of the vertebræ.
b. Superior laminæ, or neurapophyses of the vertebræ.
c. Neurapophysial spines.
d. Dermal neurapophysial spines.
e. Inferior arches, or hæmapophyses of the caudal vertebræ.
f. Hæmapophysial spines.
g. Dermal hæmapophysial spines.
h. Basi-occipito-sphænoidal bone.
i. Ex-occipital bone.
k. Parietal bone.
l. Frontal bone.
m. Posterior frontal bone.
n. Intermaxillary bone.
o. Maxillo-pterygoïdian bone.
p. Tympanic hone.
q. Articular, and *r*. dentary, elements of the inferior maxillary bone.
s. Pre-opercular bone.
t. Stylo-hyoid bone.
u. Cerato-hyoid bone.
v. Scapulo-coracoid bone.
w. Jointed cartilaginous ray of pectoral fin.
x. Ribs.
y. Pelvic cartilage.
z. Jointed cartilaginous ray of ventral fin.
α. Intermaxillary teeth.
β. Dental plate of upper jaw.
γ. Dental plate of lower jaw.

5. Upper surface of the skull.
6. Superior or internal surface of the basi-occipito-sphenoidal bone; natural size.
7. Inferior surface of the lower jaw; two thirds natural size.

Tab. XXIV.

Muscular System of the *Lepidosiren annectens*.

Fig. 1. *a.* Dorso-lateral series of muscles.

b. Ventro-lateral series of muscles.

c. *Levatores pinnæ caudalis superiores.*

d. *Levatores pinnæ caudalis inferiores.*

e. *Levator scapulæ.*

f. *Retractor scapulæ.*

g. *Temporalis.*

h. *Biventer, seu apertor oris.*

i. *Mylohyoideus, seu constrictor branchiarum.*

The temporalis is an extremely powerful muscle, arising from the whole lateral part of the fronto-parietal bone, the median crest of which is developed for the purpose of increasing the surface of attachment, and consequently the bulk of the principal closer of the jaws. Small muscles pass from the ascending process of the upper maxillary to the under surface of the single intermaxillary bone, which they depress, and thereby serve to infix the sharp and slender intermaxillary teeth in the prey of the *Lepidosiren*. The analogue of the *biventer maxillæ* is a penniform muscle, and takes its origin from the upper and outer surface of the tympanic bone: it is inserted into the outer part of the lower jaw near the angle, and opens the mouth. Small choanoid muscles are attached to the base of the cartilage of each filamentary fin.

2. *a. a.* Fibro-gelatinous 'chorda dorsalis'. *b.* A portion of the central gelatinous part removed, leaving the fibrous capsule to which the ribs *r. r.* are attached.

c. Bone representing the anchylosed anterior and posterior basi-sphenoid and basi-occipital bones.

d. Pterygoid abutment, which is here a process of the superior maxillary arch.

e. Cartilaginous pedicle and joint of the lower jaw, strengthened externally by the tympanic bone.

f. Fibrous membrane filling the interspace of the pterygoids and forming the roof of the mouth.

g. Papillose mucous membrane of the palate.

h. Maxillary dental plate.

i. Intermaxillary teeth.

k. k. Cartilaginous representatives of the 'ossa petrosa,' containing the organ of hearing.

l. l. Internal stratum of muscular fibres (*intercostales*), commencing between the ribs, and continued over the upper or dorsal two thirds of the abdominal cavity. A portion (at the interspace of the letters) is dissected away to show the inner surface of the external muscular stratum.

m. m. Serous layer of the peritoneum: the letters on the right side show the line of reflection of this layer from

n. n. The glistening fibrous membrane of the abdominal cavity.

Fig. 3. The lower jaw, seen from behind, showing the trochlear cavities, *o. o.*, which are adapted to the convexities, *e. e.* fig. 2.

4. Under surface of the head of the *Lepidosiren*, showing the largely-developed *mylo-hyoideus, a.*, which is first exposed when the skin is dissected away: it arises not only from the rami of the jaw, but from the whole length of the preopercular bone, and is inserted with its fellow in a median raphé: it compresses the branchial cavity.

5. In this figure the preceding muscle is reflected to expose *b.* the retractor of the os hyoides, which is at the same time, through the attachment of the *genio-hyoideus, c*, a retractor and depressor of the lower jaw. This powerful muscle takes its origin from the median aponeurosis representing the sternum, and may be regarded as the homologue of the sterno-hyoideus: by retracting the os hyoides it dilates the branchial cavity, and is thus the principal muscle of aquatic inspiration.

6. Shows the muscles, *d. d.*, which are exposed by the reflection of the preceding ones: they are very thick, connect the hyoid with the coracoid arch, and both with the great ventro-lateral series of muscles.

Tab. XXV.

Fig. 1. Abdominal cavity and pericardium of *Lepidosiren annectens.*

a. Mylo-hyoideus. b. Sterno-hyoideus. c. Coraco-hyoideus. d. Fibrous membrane covering the pericardium *e. f.* Serous layer of the peritoneum reflected from the pericardiac septum. *g.* Right ovarium. *h.* Liver. *i.* Gall-bladder. *k.* Intestine. *l.* Mediastinal fold of the serous layer of the peritoneum. *m.* A bristle passed through the peritoneal outlet. *n.* The same through the anal orifice. *o.* The same through the uro-genital outlet. (The common cloacal passage is removed with the skin.)

2. Digestive organs of *Lepidosiren annectens.*

a. Œsophagus. *b.* Stomach, laid open. *c.* Pyloric valve. *d.* Spiral valve of intestine. *e.* Rectum. *f.* Liver. *g.* Gall-bladder. *h.* Valvular termination of *ductus choledochus. i. Vena cava hepatica.*

3. Heart, gills, and lungs *in situ,* of *Lepidosiren annectens.*

a. Auricle; the letter is placed on the right appendix. *b.* Ventricle. *c. Bulbus arteriosus. d.* The pericardium. *e.* The abdominal vena cava. *f.* The muscular stratum dissected off, to show *g.* the mucous membrane of the branchial chamber of the right side. Both are removed on the left side, to expose the gills and branchial arches: bristles are represented as passing from the mouth through the five interspaces of the branchial arches. *h.* The hyoid arch. *i. i.* The lungs: that on the right side is laid open to show its cellular structure. *x.* The left coracoid turned outwards, to show the heart: the right coracoid is *in situ,* with the pericardium attached to it.

4. Front view of the jaws and teeth of *Lepidosiren annectens.*

5. View of the upper or working surface of the dental plates of the lower jaw.

All the figures in this plate are of the natural size.

Tab. XXVI.

Circulating and Respiratory Organs of the *Lepidosiren annectens*, on the scale of one inch to half an inch.

Fig. 1. Branchial and pulmonary apparatus seen from the dorsal aspect. *a*. First lobe of the tongue. *b*. Second lobe of the tongue. *c. c*. Divaricated sides of the pharyngeal aperture, which has been slit open. *d*. Pharyngeal valve. *e*. Laryngeal aperture. *f*. Laryngeal or thyroid cartilage. The figures 1, 2, 3, 4 & 5, indicate the interspaces between the six branchial arches on each side, which conduct the water to the branchial chamber. *k*. The membranous trachea or ductus pneumaticus: its communication with the right lung is shown.

2. The same parts, with the heart, seen from the ventral aspect. *a*. The auricle; the letter is placed on the left appendix. *b*. The ventricle, laid open to show the termination of the vena pulmonalis, in which a black bristle is placed; the wide orifice of the auricle, and the aortic opening through which a white bristle is passed. *c*. The *bulbus arteriosus*, laid open to show the longitudinal valvular processes in its interior. *d*. Pericardium. *e*. *Vena cava abdominalis*. *f*. *Vena pulmonalis*. *g*. Arterial trunk common to the systemic, branchial and pulmonary circulations. The figures 1, 2, 3, 4, 5 & 6, indicate the branchial arteries on each side, of which the 2nd and 3rd chiefly go to form the pulmonary artery, *l*. *m. m*. The two divisions of the pulmonary artery, for the two lungs. *n. n*. The two corresponding veins, which return the aërated blood to *f*.

Tab. XXVII.

Fig. 1. A scale of the *Lepidosiren annectens*, magnified eight diameters. *a*. The inserted margin; *b*. the thick cuticle reflected from the posterior margin.

2. Mouth of the *Lepidosiren annectens*, twice natural size. *a*. The intermaxillary teeth. *b*. The three projecting angular pro-

cesses of the right maxillary dental plate. *c*. The corresponding processes of the left mandibular dental plate. *e*. A bristle inserted into the right olfactory sac, which opens upon the upper lip. *e'*. The left olfactory sac laid open, exposing the double series of olfactory laminæ.

Figg. 3 & 4. Brain and organ of hearing of the *Lepidosiren*, twice natural size.

a. a. Cerebral hemispheres. *b*. Optic lobe. *c*. Medulla oblongata. *d*. Cerebellum and fourth ventricle. *e*. Pineal gland. *f*. Bilobed pituitary body, forming the floor of the third ventricle. *g*. Mammillary body. *h*. Olfactory nerves. *i*. Optic nerves. *k*. Cartilaginous wall of acoustic chamber or labyrinth. *l*. Sac and nerve of smaller otolithe. *m*. Sac and nerve of greater otolithe. *n*. Semicircular canals. *o*. Fifth pair of nerves. *p*. Eighth pair of nerves.

5. Brain of the *Menopoma*. (From Meyer, Analekten fur Vergleichende Anatomie, tab. vii. fig. 5.)

6. Brain of the *Menobranchus*. (Ibid. tab. vii. fig. 6.)

Both these figures are of the natural size.

The same letters indicate the same parts as in Figg. 3 & 4.

7. *a*. Œsophagus. *b*. Stomach. *c*. Intestine. *f*. Liver. *g*. Gall-bladder. *h. h*. Kidneys. *i. i*. Ureters; both are reflected downwards and outwards to show, *k*. Allantoid bladder. *l. l*. Ovaria. *m. m*. Oviducts. *n. n*. Anterior apertures of the same.

These parts are figured as seen from behind.

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a

b

3

5

α β

m m o

s s

k

t

1

6

7

r

q

4

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d c

k l m n

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C.O. & H. Scharf del.

G. Jarman sc.

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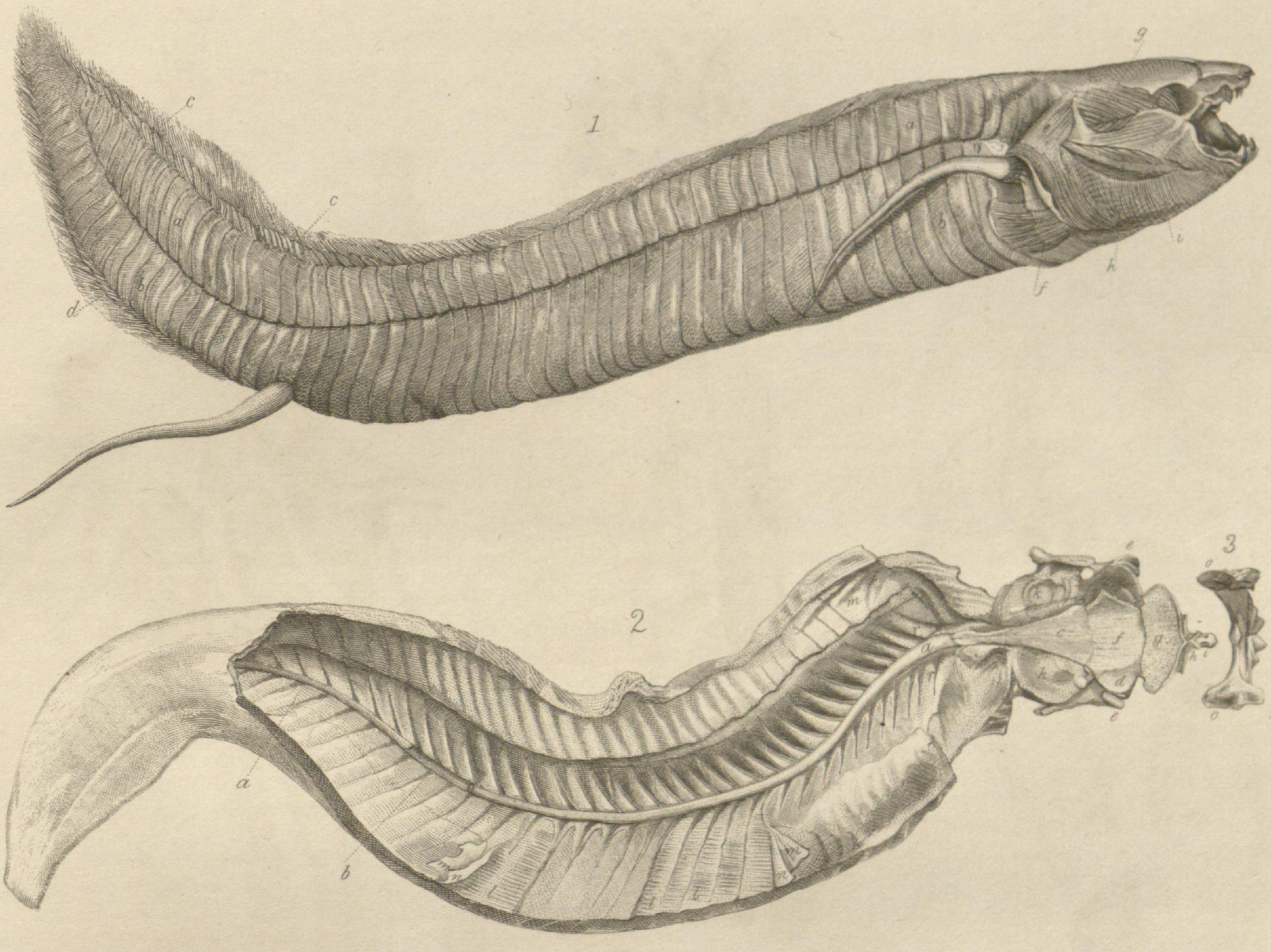

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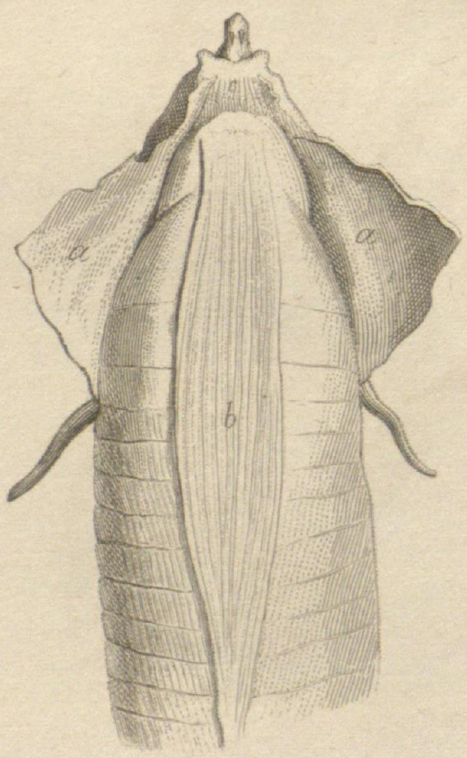

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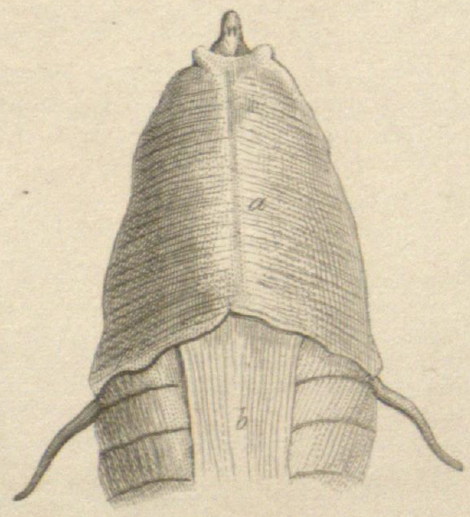

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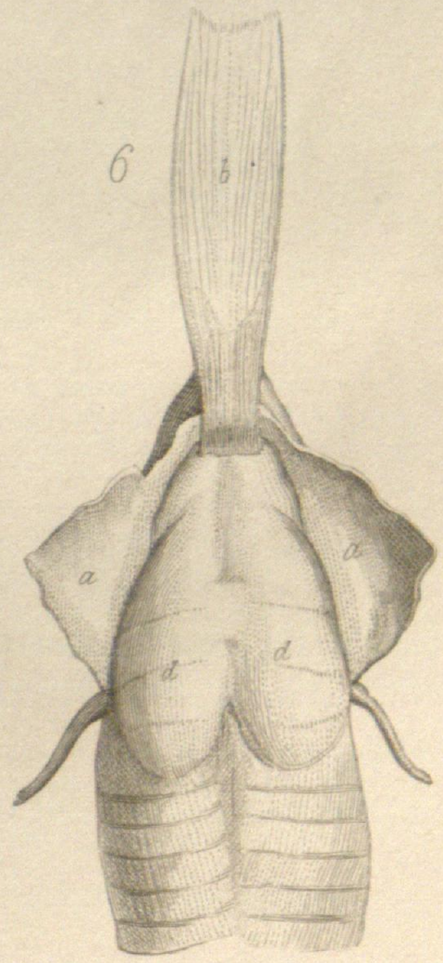

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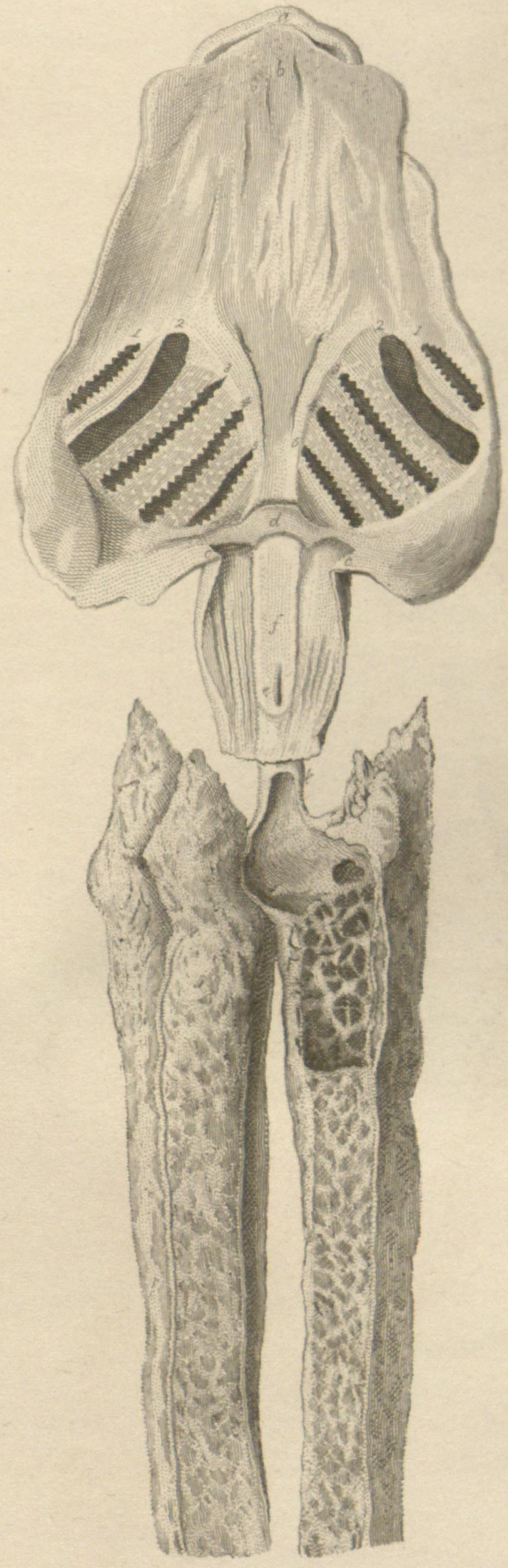

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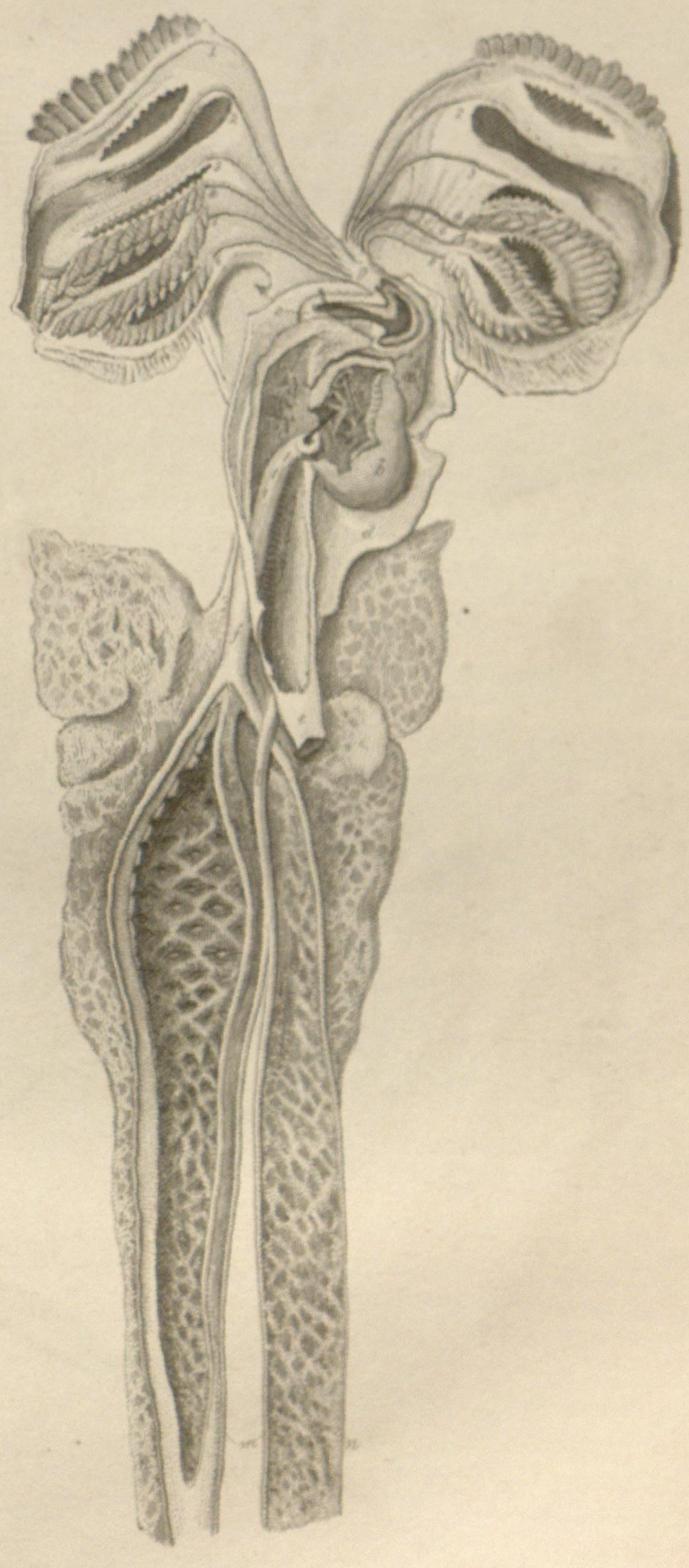

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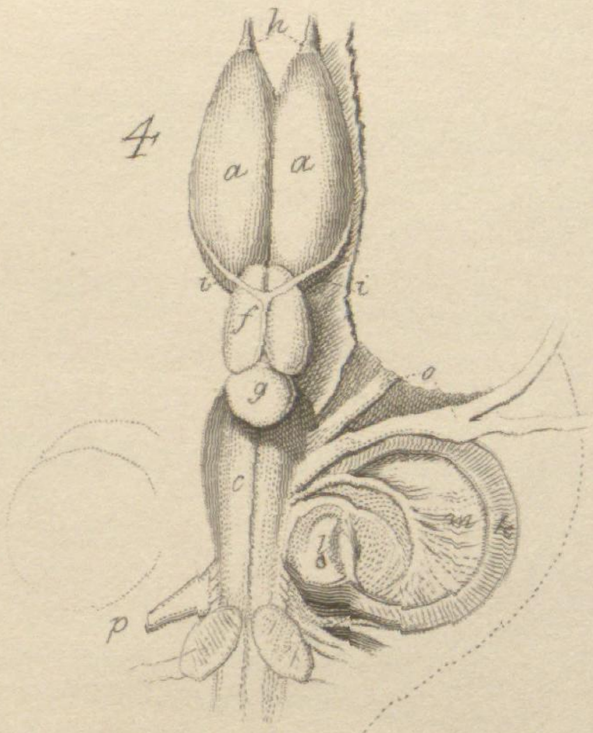

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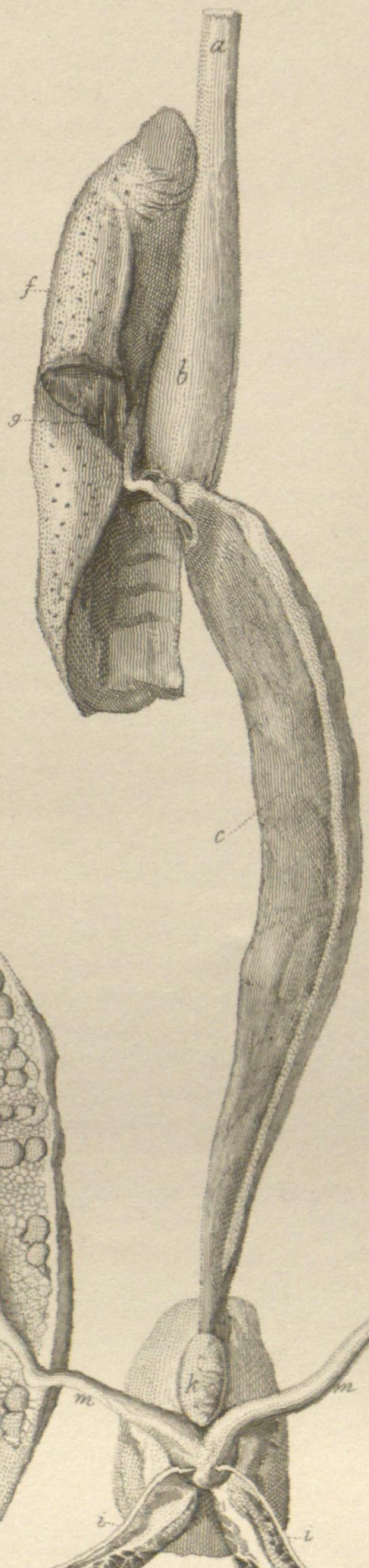

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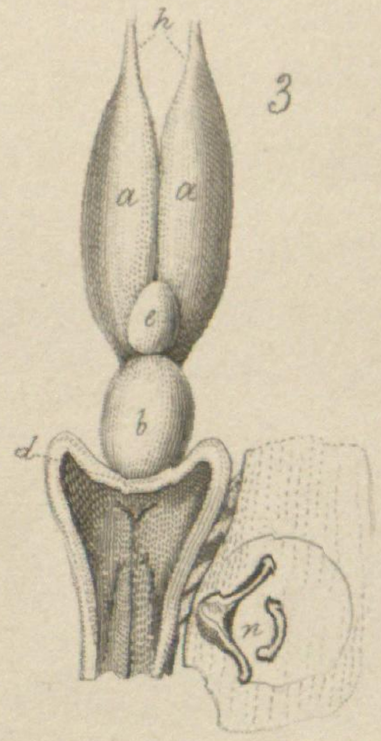

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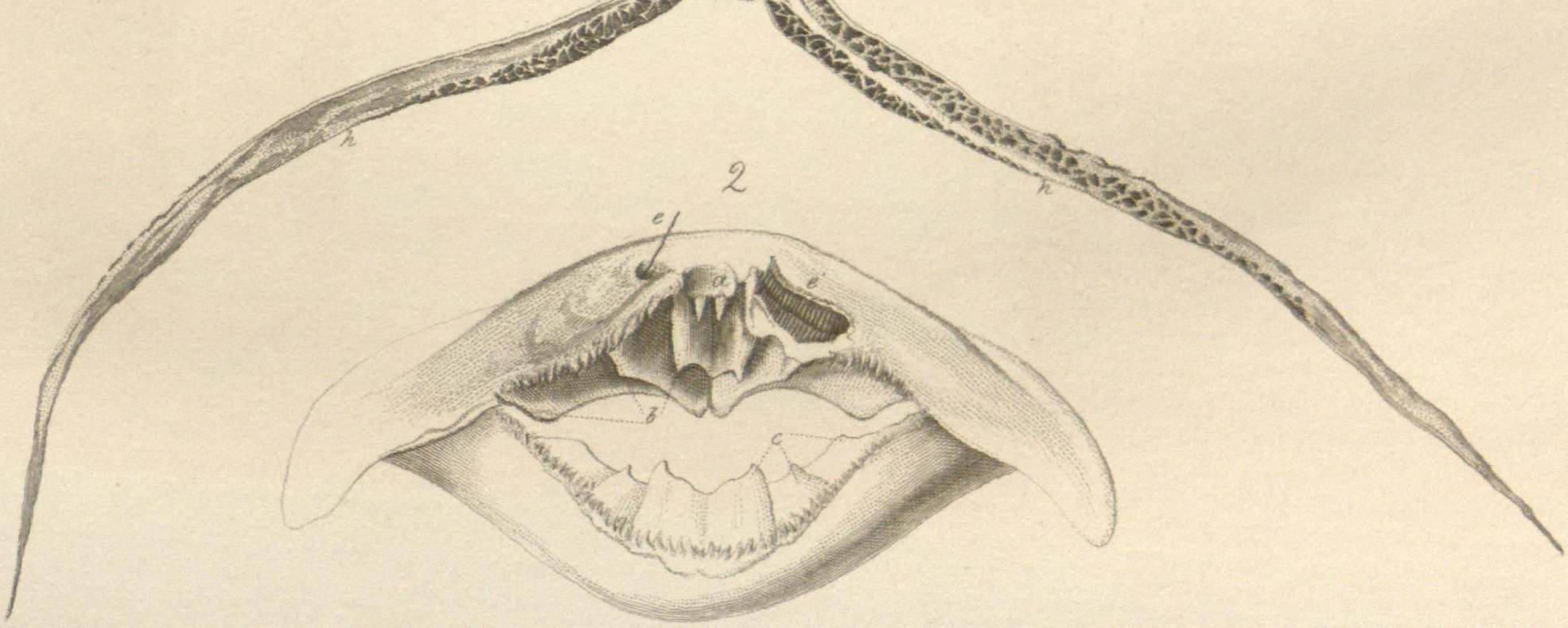

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