ICHTHYOTOMICAL CONTRIBUTIONS

II. THE STRUCTURE OF THE *AULOSTOMIDÆ*, *SYNGNATHIDÆ* AND *SOLENOSTOMIDÆ*

BY

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In the contribution published in 1908 (23 b) and in the present contribution I have endeavoured to give a fuller and more thorough account of the structure of the members of the old Cuvierian family "Bouches-en-flûte" and the old Cuvierian order "Lophobranchii" than it would be possible to gather from the previous literature; and in giving a broader base of facts than hitherto possessed, especially concerning their osteology, I hope to have settled the question, how far these forms are really related, and thus to have laid down a sound and reliable foundation for their future systematic arrangement. That previous knowledge of the structure of these fishes must be said to have been defective and that a thorough reexamination of their osteology was justified, is, I think, proved in the descriptive part of my papers and in the notes which I have added. The latter I have made so full and extensive, that any reader may be in the position to verify to what extent the descriptions given by me contain really new information, and to realize the confusion which on several points has been brought about, partly by defective observations, partly by ignoring facts already settled before.

The bulk of the present paper is merely descriptive; but in a concluding chapter I have set forth the systematic arrangement of the fishes under consideration which seems to me most in accord with the anatomical facts obtained.

Aulostomidæ.

Aulostoma.

The following account is based on specimens of *Aulostoma coloratum* M. and Tr. As far as I have seen the other species *A. chinense* (L.) does not show any differences of importance.

Exoskeleton.

Aulostoma is covered with scales; only on the head (including the posttemporal), and on the anterior part of the back are scales wanting; through the naked skin of the back is seen, more or less distinctly, the sculptured surface of three longitudinal, median, bony nuchal shields. The scales embrace basally the anterior margins of the second dorsal fin and anal fin and cover part of the caudal fin. Most of the scales are ovoid, with truncate hind margin, along which is a single row of large teeth; the latter are independent structures, separated from the

scale-plate, dropping off when macerated. The largest scales are found along the sides of the body, above and below the lateral line; their number of teeth, in specimens of about 50 ctm. length, is 33—37. In each row the middle teeth are largest, the size evenly decreasing towards the margins. The lateral, smaller teeth show basally a small extension, which appears to vanish on the larger and older ones towards the middle. On a scale of about 3 mm. length one of the longest teeth measures 0,352 mm., one of the shortest 0,112 mm. In another specimen of ca. 40 ctm. length, one of the lateral body-scales carries 28 teeth, a scale from near the middle line of the back 14 teeth, and one from the caudal fin 7. In a young specimen of 110 mm. length, scales from the sides of the body show 7 teeth; the scale-plate is 0,336 × 0,304 mm., the middle tooth 0,096 mm. in length; a scale from the middle of the belly in front of the anus carries only 3 teeth, one median and two lateral; the scale itself is 0,282 × 0,192 mm., the median tooth 0,096 mm. The median tooth apparently is the oldest, and new teeth are formed in pairs, one on each side of the first etc. in a similar way as G. WINTHER (58) has shown the scale-teeth to originate in *Gobius*. It would be of some interest to have for examination still younger specimens which might decide if the development begins with a simple scale-plate without any teeth, on which, later, a single, median tooth, appears, next the first pair of lateral ones and so on; or if perhaps one single tooth is the first to be formed, the appearance of a scale-plate the next step etc. In the latter case some light might be thrown on the origin of the dermal asperities found in two species of *Fistularia*; but it has to be remembered that in the latter genus the small hooklets or denticles form one piece with their basal enlargement (cfr. below).

The large scale-plates of *Aulostoma* are provided with a great number of concentric striæ, parallel to the margin; the number seems to be about double that of teeth present; in the small scales of young specimens only 2—3 striæ are found running along each margin [1].

The canal of the lateral line is not inclosed in the scales, but in a system of free, thin, bony tubes; these tubes are uncovered by scales from the postfrontal to about the level of the posterior margin of the ventral fins; from here and further backwards the tubes are sunk between the scales and more or less covered by these, but the tubes will never be found combined or coalesced with the scales.

Immediately below the skin, in the most superficial part of the muscles, is found a most richly developed system of long, narrow and flat ossifications, probably formed in the outermost layer of the intermuscular ligaments. Corresponding to the arrangement of the lateral muscles these ossifications appear in a double row on each side above the lateral line, from the head to the tail; below the lateral line the trunk shows two double series, the tail only one, as dorsally to the lateral line. In each double row the upper and lower members converge towards the tail, meeting at a very acute angle. In the dorsal row the upper anterior member is by far the largest, very much surpassing in size any of the others; it

is fastened by ligament to the epiotic of the skull and reaches backwards about as far as the anterior coalesced part of the vertebræ. Its upper surface is flat, and more or less observable through the skin, laterally to the median nuchal shields; the lower surface carries a thin vertical lamella, originating from its posterior half, to enlarge the face of muscular attachment. Much smaller, but still of considerable size, is the anterior member of the uppermost ventral row; it is in front connected by ligament with another separate ossification, which, passing over the branch given off from the posttemporal to the first vertebra, is fastened to the pterotic of the skull; thus it is from the outside covered by the posttemporal. The "inscription" itself lies below the plate representing the coalesced transverse processes of the anterior vertebræ and dissolves behind into a bundle of long fibres. Generally the anterior members of the whole system of "inscriptiones tendineæ" are the stoutest. Into the lowermost ventral double row project parts of the endoskeleton, viz. the posterior ends of the postclavicle and the coracoid; while the former bone ends as a needle, the latter forms a bundle of threads. In a similar way most of the ossified tendons, or "inscriptiones", are split up at both ends — more or less irregularly dichotomously[2].

Endoskeleton.

The vertebral column consists of 60 vertebræ, 24 (25) abdominal and 36 (35) caudal. The four anterior abdominal vertebræ (Pl. I, figs. 9, 10, Pl. II, fig. 10) are elongated and coalesced into one piece; but distinct sutures show the composition of originally separate elements. This part takes up about one-fifth of the whole length of the vertebral column. Seen from below (Pl. I, fig. 9) the corpora do not show much of the usual type; only the posterior one is more like a normal vertebral body, otherwise the combined neural arches and the coalesced transverse processes constitute the dominant part of the whole. The spinous processes form one vertical crest (Pl. I, fig. 10), the combined transverse processes a similar one on each side, sloping somewhat downwards and narrowing posteriorly. The single elements are immovably joined through sutures.

Closer examination of the lower surface will show that the bodies of the second and third vertebra are longer, the first and especially the fourth shorter; (in a specimen, where the whole coalesced part is 61 mm. in length, the first body is 14 mm., the second 17 mm., the third 18, and the fourth 12 mm.). The front end of the first corpus has partly preserved the usual type, but the posterior part, behind the openings for spinal nerves and blood vessels (n), is elongated and modified; the two following have both their ends elongated and modified to about the same extent, as will be evident on looking at the position of the nerve-openings; of the last vertebra only the anterior part is elongated and modified: here the nerve-openings n are found at the posterior end, and the posterior part of the transverse process appears separated as an independent process, as is the case with the following free abdominal vertebræ. The transverse processes on the second

and third vertebræ possess an elongated part, directed forwards (Pl. I, fig. 10); that of the second vertebra projects a little (Pl. I, fig. 9, 10*) and is connected by a strong ligament with the posterior end of the posttemporal.

On examining the lateral aspect of the coalesced vertebræ (Pl. I, fig. 10, Pl. II, fig. 10) we find the sutures partially repeating the features characteristic of the following free vertebræ: in the small bend (a) looking forwards we recognize the part lettered in the same way on the following free vertebræ (Pl. II, fig. 10) and on the front end of the first of the fused vertebræ; further, the process (b) of the latter, which is connected with the skull, will be found to correspond with the process (b) on the free vertebræ, that is to say, it must be regarded as an articular process, not as a transverse one, and the first vertebra has thus only developed the posterior part of the transverse process (t).

The nerve-openings observable in side view (n') are in a position about corresponding to that of the ventral ones (n, Pl. I, fig. 9).

All the following, free, abdominal vertebræ possess double transverse processes (Pl. II, fig. 10), i. e. there is an anterior and a posterior process on each side (or it may be put in this way: there is one transverse process of the same length as the whole vertebra but divided through a deep incision into an anterior and a posterior part). A posterior process on one vertebra joins with its hind margin the front margin of the anterior process on the following vertebra etc.; the two adjoining processes, belonging to two different vertebræ, are almost of the same length on the foremost vertebræ; but about from the 17th vertebra the posterior element (i. e. the anterior process of the 17th vertebra) grows a little longer than its fellow (the posterior process of No. 16), and on the 20th—24th vertebræ the difference is still more marked. On the foremost vertebræ these "double processes" are nearly horizontal and directed straight outwards but farther back they gradually pass into a position directed downwards and a little backwards, still, on the 24th vertebra (sometimes on the 25th) the long anterior transverse process does not unite with its fellow from the opposite side; but on the next the anterior processes join from opposite sides and form an inferior arch, terminating in a long, backwards directed, lower spine. This vertebra (No. 25 or 26) I therefore count as the first caudal vertebra. On the preceding, the last abdominal, vertebra the posterior transverse process is already much shortened, on the first caudal it is very small, and on the following it gradually vanishes.

The spinous processes originate from the posterior part of the neural arches. On most of the abdominal vertebræ they are only low, and laterally compressed; from about the 17th they rise somewhat and from the 20—21st they grow long and slender as in most bony fishes. The anterior part of the neural arch is shaped like a rather large, rounded process, which, together with its fellow from the opposite side, embraces the base of the preceding spinous process; this part is larger on the foremost vertebræ, and diminishes gradually backwards. Below this part is found the proper articulation, formed by a triangular pit into which fits a small process from the preceding neural arch.

Ribs are wanting.

Interspinous bones are developed not only in connection with the dorsal and anal fin rays, but in front of the dorsal fin a row of 9 or 10 rayless interneurals is found, beginning immediately behind the skull. The three foremost of the latter (Pl. II, fig. 10, 1—3) are more or less distinctly seen through the skin, which is here naked as already mentioned above, but the following 6 or 7 are hidden below the scales. They all consist of a horizontal part, lying below the skin in the shape of a longitudinal shield or plate, and a vertical part; they correspond in position to the anterior 9—10 vertebræ, their vertical part being really interposed in front of the spinous processes of the latter. This fact is less evident in the case of the four elongated and fused vertebræ, but very easily seen in the following free vertebræ. The modified interspinous bones form a continuous row, in which not only the horizontal shields are joined (through sutures) but also the vertical parts. The anterior three* are much larger than the rest, which decrease evenly in size backwards, especially with regard to their shield-parts. The upper face of the latter is sculptured with quite regular longitudinal striæ on the 3 anterior ones; feeble traces are seen on the fourth and still some faint and indistinct remnants may be observed on the following one or two. From the hind margin of the second passes out on each side a long, flat and slender splint of bone, looking like an ossified tendon fused to the shield; similar, but much shorter ones proceed from the posterior margin of the following shields, except the last, and are concealed below the plate of the next shield, while the long "cornua" from the second nuchal shield diverge among the muscles.

The vertical part (the main part or stem of the typical interspinous bone) is elongated longitudinally according as the upper edge is modified into a shield; it is most elongated and at the same time lowest in the 3 foremost interneurals (the "nuchal shields"), increasing in height backwards with decreasing length; its lower margin is cleft, thus embracing the crest formed by the fused arches and spinous processes. The foremost as well as the fourth to the tenth interneurals show most distinctly that the position is originally in front of the corresponding spinous processes as is usually the case in fishes. The foremost is connected with the supraoccipital by ligament. Immediately behind the row of rayless interneurals appear those supporting the (9—)10 isolated rays, which together constitute the first dorsal fin; each ray of the latter is a spine having a small separate fin-membrane. These interneurals are considerably smaller than the preceding and of a different shape (Pl. II, fig. 10, 10—16); they do not form a closed row nor do they reach to their corresponding vertebræ. The foremost corresponds to the 11th (or 10th) vertebra, between each of the following is an interspace with one or two spinous processes.

* Only these three "shields" have been mentioned previously. GÜNTHER (16a p. 537) says: "A long narrow bony shield, half as long as the snout, is joined to the occiput and extends along the neck." But l. c. p. 538 he says (*A. chinense*): "the three single plates of which the nuchal shield is composed are more distinct."

Like the preceding modified interneurals they all consist of only one single piece (are "unisegmented"); in position they are about horizontal. The interneurals supporting the second dorsal fin number 26 or 27; except the foremost and hindmost they are "bisegmented", a small ossicle (with a median cartilaginous centre) occupying the cleft base of each ray and connecting through cartilage with the main part or stem. The foremost interspinous bone is small and rayless, the next two support quite rudimentary rays. The two anterior are together interposed between two spinous processes (of the 34th and 35th or 35th and 36th vertebræ), but only the second almost reaches the spine; the following ones are interposed singly or in pairs (somewhat irregularly); from the sixth they reach almost to the base of the neural arch, from the twelfth almost to the corpus; the hindmost again are shorter.

The anal fin is supported by 26 interspinous bones, likewise bisegmented. The anterior bones slope forwards, the foremost is about horizontal in position; the fourth reaches the spinous process of the 35th (or 36th) vertebra, lying close behind the tip of its inferior spine[3].

The fin-rays of the unpaired fins. The isolated dorsal rays are spines (Pl. II, fig. 10, s), made up of one piece, without any joints; they are rather blunt, flat and somewhat weak, basally with a transversely rounded head, articulating with a transverse pit in the interneural[4].

The four anterior rays of the second dorsal are also pointed, unjointed like spines; the foremost two are rudimentary and both supported by the second interneural. The following rays are longitudinally cleft and jointed, but not branched distally.

Of the anal fin (29 rays) the 4 anterior similarly are short, spine-like, the rest like those of the second dorsal.

The caudal fin has 20 rays: 3 + 7 + 7 + 3; the three upper and lower rays short, pointed and without joints, the rest jointed; No. 5 to No. 15 are distally branched.

Closer examination of the skeleton of the end of the tail shows that two separate bones are interposed, like interneurals, above between the last vertebra and the last but one, and in a similar way also two bones below; but of the two lower the hindmost seems to be fused with the lower hypural bone of the last vertebra. The rays are arranged in the following way: the foremost short ray is interposed between the spinous processes of the third and second last vertebra; the two following short rays and the first upper jointed ray are supported by the "interposed" bones; the upper hypural bone carries 6 rays, the lower 5 or 6; of the rest of the lower rays, two jointed and two unjointed are supported by the lower "interposed" bones, the anterior short ray is correspondingly situated to the anterior upper one. As mentioned above only the rays 5—15, i. e. those supported by the hypural bones, are distally branched; of these the two middle ones — one from each hypural — are somewhat longer than the rest, causing the rhomboid outline of the caudal fin (probably homologous to the caudal filament in *Fistularia*).

Cranial skeleton. The head (Pl. I, fig. 4) is laterally compressed, its facial part, in front of the orbit, much elongated, tubiform, with terminal mouth.

The skull (Pl. I, figs. 1—4) is rounded above, somewhat flattened between the orbits; the preorbital part is about three times as long as the rest, forming a slender beak with sharp edges, concave below, except at the anterior end, where the vomer projects into a blunt keel.

Viewed from above (Pl. I, fig. 2) by far the greater part of the beak will be found made up by the mesethmoid (mes). At the front end of the latter the palatines (pa) are seen, suturally united to the skull and meeting each other in the middle line; behind these, part of the vomer (vo) is seen on each side of the mesethmoid. Behind the mesethmoid are the frontals (fr), and, wedged in between the posterior part of these, the supraoccipital (so); on each side of the latter the epiotics (ep). Besides are seen the pterotics (sq), postfrontals (pf), alisphenoids (al), prefrontals (prf), and — below the nasal openings — the preorbitals (ao). Furthermore, the exoccipitals (eo) and the basioccipital with the large condyle are seen from above. As previously stated parietals and opisthotics are wanting.

The supraoccipital takes no share in the occipital foramen, the exoccipitals meeting above the latter. Behind, the supraoccipital is cleft and deepened into a triangular pit, filled out with the strong ligament which connects the skull with the first nuchal plate. Each epiotic is provided with a knob (*), close to the suture with the supraoccipital, for the attachment of the above-mentioned ossified tendons.

On each side of the beak a narrow furrow runs from the front margin of the nasal opening to the end of the snout; imbedded in this furrow is the continuation of the supraorbital canal for the lateral line. Immediately in front of the nasal opening the furrow encloses a small osseous tube (Pl. I, figs. 1, 4) (na), evidently a rudiment of the nasal bone; otherwise the walls of the whole canal are membranous from where it leaves the frontal at the posterior border of the nasal opening. The greater part of the furrow is lodged in the mesethmoid, only the anterior third part in the vomer.

On the lateral aspect of the brain-case the upper sculptured face overhangs the lower, smooth face with sharp edges, under which the two articular facets for the hyomandibular are found, the anterior made up by the postfrontal and the prootic, the posterior by the pterotic. Between the anterior facet and the opening for the 7th nerve the prootic is provided with a spine, pointing backwards. As already stated the large pterotic (sq) is interposed between the prootic and the exoccipital, reaching downwards to the parasphenoid and basioccipital. In the orbits the prootics from both sides meet each other with processes bridging over the excavated upper face of the parasphenoid; thus a kind of myodome is present. The upper lateral part of the bridge is formed by the adjoining alisphenoid (al); the latter bone is in a peculiar way (as far as I know quite unique among

teleosts) produced in front of the postfrontal, forming the inferior part of the post-orbital process. I have not found any orbitosphenoid.

The basioccipital (ob) is laterally compressed, its occipital condyle broad, transversely ovoid, and convex. The parasphenoid (Pl. I, fig. 3) (pa) reaches far behind, where like the adjoining basioccipital it is compressed; between the prootics it broadens and in the orbits its upper margins send out a process in front of the opening for the 5th nerve in the prootics. The anterior part is situated between the prefrontals and its pointed front end stops on the mesethmoid without reaching the vomer, a peculiar feature also found in *Fistularia* and *Solenostomus*, but as far as I know in no other teleost. The greater part of the lower face of the beak belongs to the vomer (vo); the keelshaped front end of the latter carries a longitudinal strip of numerous small teeth.

Infraorbitals are wanting. The bone (ao) connecting the mesethmoid with the prefrontal I think represents the antorbital (preorbital), but it does not enclose any lateral line canal.

The opercular apparatus (Pl. I, fig. 4) shows the usual 3 elements; the interoperculum (io) is an elongated thin plate mostly covered by the preoperculum and reaching from the lower front end of the suboperculum to the mandibular articulation, connected with a short ligament to the angular.

The hyomandibular (hy) is obliquely directed forwards, its front face is concave, the inner margin of the concavity being somewhat produced, like a wing; the lower end is a thin cartilage connected with the proximal end of the symplectic (sy). The latter is extremely thin and so firmly joined with the preoperculum (pro), that it requires the utmost care to make out the boundaries; viewed from the inner face only the posterior end and the distal part are more easily seen, the preoperculum covering the rest so completely that only an exceedingly narrow brim may be detected along the upper margin of the preoperculum; viewed from the outside (Pl. I, fig. 4) only the extreme proximal end is hidden by the preoperculum. The quadrate (qu) is very large, sculptured on part of the outer face with fine striæ radiating from the neighbourhood of the articular head for the mandible. The palatine (pa) is small, its anterior part, which sends out a prominent and relatively well developed maxillary process, meets its fellow from the other side at the front end of the mesethmoid (Pl. I, fig. 2); behind, the palatine bifurcates (Pl. I, fig. 1); the upper branch is wedged in between the mesethmoid and the vomer, the lower branch covers the pointed and slender anterior end of the entopterygoid (Pl. I, fig. 4) (ept). A separate ectopterygoid is wanting. Where this bone ought to be, the entopterygoid broadens into a plate firmly joining the oblique anterior margin of the quadrate. The rest of the entopterygoid is a thin plate the upper margin of which embraces the lateral edges of the cranial beak, formed by the vomer and the mesethmoid. Behind the entopterygoid follows the metapterygoid (mt), the narrow anterior part of which in the same manner embraces the edge of the mesethmoid, while the posterior broader part

has its somewhat thickened upper margin firmly fastened below the edge of the broadest proximal part of the mesethmoid, reaching with a slender splint to the preorbital.

On the inner face of the suspensory apparatus two oblique ovoid patches of teeth are present, the anterior one on the entopterygoid *, the posterior on the metapterygoid.

The short ascending part of the preoperculum covers not only most of the lateral face of the hyomandibular, but also the front face below the hyomandibular foramen; the long horizontal part is on the outer face ornamented with fine striæ and reaches almost to the articular head of the quadrate.

The premaxilla (Pl. I, fig. 4 i), which bounds the mouth slit, is slender and edentulous, provided with the typical processes, as also is the case with the relatively large, posteriorly broadening maxilla (mx).

The articulation for the lower jaw is situated at a distance rather far behind the end of the snout; the mandible therefore is fairly long, and the mouth opening is extensible to a considerable degree. The mandible is high and laterally compressed, composed of the typical three parts; the angular (an) is very small and therefore easily overlooked. Two patches of teeth are found on the dental, an anterior small one on the upper edge close to the symphysis, and a large posterior one covering the upper part of the inner face.

Branchial apparatus. The whole gill-bearing part lies behind the articulation of the hyoid to the skull. The hyoid (Pl. II, fig. 7, 8) is composed of the typical elements, but the epihyal (eh) and the lower hypohyal (hy^{I}) are unusually large in proportion to the other constituents. The stylohyal (st) is laterally compressed and broadens towards the upper end, the inner face of which plays against the thin cartilage interposed between the hyomandibular and the symplectic.

The branchiostegals are four in number, belonging to the outer face of the epihyal, the uppermost is the stoutest and longest, at its end divided into filaments. The glossohyal is long and slender, surpassing in length the hyoid and the urohyal, which is laterally compressed and higher behind, where it is broken up into filaments. The first copula (Pl. II, fig. 3 co^{I}) or basibranchial is represented by a short cartilage, the second (co^{II}) is slender, styliform and osssified; no further copulæ are developed.

The gill-arches (Pl. II, fig. 3, 4) are provided with rows of thin bony plates, densely beset with teeth, in the place of gill-rakers. Along the whole anterior border of the first arch plates of this kind are found, from the upper to the lower end, the first gill-slit being very wide; otherwise the plates are mostly confined to the margins of the ceratobranchials only, those on the anterior border always being somewhat larger. The first arch consists of three parts, having no pharyngo-

* The anterior patch of teeth has been seen by GÜNTHER (16 a p. 536), but he ascribes it to the "palatine bones".

branchial; the second arch has all four parts developed, but the short and slender epibranchial (e^{II}) is widely separated from its ceratobranchial (c); it abuts against the hinder end of the flat pharyngobranchial (ph^{II}); the latter is on the pharyngial face beset with teeth, and reaches to the epibranchial of the first arch.

The third arch also has four parts; the hypobranchial (hy^{III}) has only a short cartilaginous part lying at the same level as that of the second arch, but a long, osseous process runs downwards, together with its fellow from the other side embracing the branchial artery; the epibranchial is still weaker than that of the preceding arch, almost rudimentary, and still farther away from the upper end of its ceratobranchial; its distal end articulates with both the third and fourth pharyngobranchial; the flat pharyngobranchial III is produced in front along that of the second arch; its under face carries an ovoid patch of teeth. The fourth arch consists only of two parts, the hypobranchial and epibranchial being absent; the pharyngobranchial IV is shorter than the preceding but like this provided with teeth. The fifth arch, as usually only one piece, carries the lower pharyngeal teeth, and on the anterior or outer border some tooth-plates along the hindmost gill-slit.

At the upper ends of all the ceratohyals the branchial lamellæ (Pl. II, fig. 4) are continued a short way upon the pharyngeal wall, supported by semicartilaginous strips of tissue, which appear as prolongations of the cartilage enclosed by the osseous sheaths of the ceratohyals.

Thus the branchial apparatus of *Aulostoma* foreshadows the condition found in the *Lophobranchii* as to the skeletal parts, in the fact, that the epibranchials II and III are reduced and separated from the rest of the arches, while the epibranchial IV is absent, and the basibranchials are reduced.

The shoulder-girdle (Pl. III, figs. 4, 5) has been so fully dealt with by STARKS (55 p. 629) that only some features have to be repeated here and a few new facts to be pointed out. The clavicular arch is composed of but two parts, the posttemporal and the clavicle, the supraclavicle being absent. The posttemporal is through ligament fastened to the somewhat serrated hind part of the pterotic (not also to the epiotic); its outer face lies in the skin and is sculptured; from the inner face, near the ventral margin, originates a flat branch, connected through ligament with the first vertebra; the posterior angle of the posttemporal further is bound by ligament to a blunt process on the transverse process of the second vertebra, and at the same time with the upper end of the clavicle. As is the case with all the members of the group treated here, the clavicle (cl) has a superficial sculptured plate, seen in the skin (Pl. III, fig. 4) and covering part of the fin-muscles. As in *Fistularia* the clavicle divides distally into two branches, the inner of which is united with the outer face of the scapular arch (Pl. III, fig. 4 i); but as the coracoid is produced forwards to unite also with the outer (or anterior) branch, the aperture between the branches, which is large in *Fistularia* (Pl. III, figs. 8, 9), in *Aulostoma* is reduced to a small foramen (Pl. III, fig. 5 f) (not visible from the outer aspect).

Inside the posterior upper angle of the clavicle is the postclavicle (pcl). In the scapular arch the scapular foramen is large; the coracoid (co), as shortly mentioned above, is broadly united to the clavicle, leaving only the small opening described; the lower edge, which is ventrally joined to its fellow from the opposite side, is thickened on the outer side and posteriorly produced into a flat bundle of osseous filaments, used for muscular attachments.

Of the four well developed pterygials (ba), the upper and smaller one is carried by the scapular.

The pectoral fin rays (15—16) are unbranched, but jointed except the uppermost (3—4).

The pelvic bones are not in contact; each is a triangular flat piece, with feebly pronounced muscular crest along its middle. The outer of the 6 ventral rays is unbranched, but jointed, the others branched and jointed. The position of the ventrals is about on the level with the 20th abdominal vertebra[5].

Visceral anatomy.

There are four complete gills and a large pseudobranch; a slit between the 4th gill-arch and the lower pharyngeal. The alimentary canal is without mesentery, short, and quite straight; the anal opening is situated immediately behind the ventral fins, just behind the end of the ventral rays when these are lying against the body. The oesophagus passes without boundary into the stomach; the latter is spindle-shaped, narrowing behind into a pyloric part, sharply marked off from the intestine. The oesophagus and stomach together are about of the same length as the rest of the alimentary canal. The small intestine sends out from its anterior end two well developed appendices pyloricæ, one on each side, the left being somewhat longer than the right; the intestine is wider anteriorly and tapers behind, where it is sharply bounded by a constriction from the short, wide rectum. In the stomach of one specimen from the West Indies (a medium-sized female) I found a wholly undigested herring 53 mm long and the vertebræ of another, otherwise completely macerated and digested small fish; in another (large, dried) specimen from the West Indies I also found the vertebræ of a small fish.

The liver encloses ventrally the oesophagus and part of the stomach, without reaching the pyloric part; to the right side it reaches higher up on the sides of the stomach than to the left; it is not properly lobed, but about in the middle of the right margin there is a deep incision leading to the gall-bladder; from the latter the long bile-duct passes backwards, lying close to the portal vein, and enters the front end of the small intestine between the two appendices pyloricæ.

The right cardinal vein is strongly developed, passing along the right kidney and leaving the latter at its anterior end to unite with the ductus Cuvieri, the left cardinal vein is small and its anterior part completely hidden in the left kidney.

The aorta passes to the left side of the corpora of the coalesced anterior vertebræ and continues in this asymmetrical position. A short way behind the last branchial vein, coming from the 3rd and 4th gill-arches, it sends out a pair of strong branches, each for one of the pectoral fins, and ventrally between the origin of these, it gives off the *arteria coeliaca*, which passes to the right side of the oesophagus between the stomach and the liver, following the portal vein and giving off branches to both oesophagus and stomach and one branch running forwards to the lower face of the air-bladder, entering the "red-corpuscle".

The air-bladder is very thin-walled and reaches from the oesophagus, about at the level of the front end of the liver, or the scapular foramen of the shoulder girdle, to behind the ventral fins. At the anterior end it is provided with a large, ovoid *rete mirabile* or "red gland"; besides the branch from the *arteria coeliaca*, just mentioned, it has a branch from the portal vein, closely following the artery.

The kidneys are above the rectum fused to a thick mass, below which is a urinary bladder; anteriorly the kidneys separate and filling out the impressions between the vertebral corpora take on the shape of narrow bands, which under the front end of the coalesced part of the vertebral column on each side form a small, slightly swollen "head-kidney". The latter are asymmetrical, the left being the larger. Through the "head-kidneys" pass out the above mentioned arteries for the pectoral fins. The head-kidneys seem not to contain any urinary tubules, but such are to be detected in the narrow strands of kidney-substance filling the grooves on each side of the body of the last (the 4th) coalesced vertebra.

On the outer side of each kidney run the large vagus-nerves, which leave the skull through the anterior exoccipital foramen, while a large nerve for the pectoral fin leaves through the posterior (that nearest to the condyle); a deeper-lying nerve for the pectorals passes out through the nerve-openings in the front end of the first of the coalesced vertebræ; through the openings in the following coalesced vertebræ, besides nerves, pass branches from the aorta.

Genital organs. The ovaries are large, paired sacs, posteriorly uniting into a very short common oviduct, opening as usual between the anal and urinary orifices.

Also the testes are paired, provided behind with a very short common duct[6].

Fistularia.

Exoskeleton.

In the 3 species examined: *F. tabacaria* L., *F. depressa* Gthr. and *F. petimba* (Lacép.) Jordan & Gilbert the equipment with dermal osseous structures is somewhat different.

I. In *F. petimba* the skin is rough to the touch (like sand-paper adhering to the fingers), the whole body being covered with minute hooklets. This I have found to be the case not only with quite small specimens from 130 mm. in

length* and larger ones from 170 to 385 mm., but in the largest specimens examined, surpassing 708 mm. in length. In *F. tabacaria* only the small and middle-sized specimens up to about 400 mm. in length show minute asperities of the same kind as in the former species. The smallest specimen at my disposal is figured on Pl. VII, fig. 1. It has a length of 43 mm.; the caudal filament exceeds the body, being about 52 mm. Most of the body is covered with proportionately large, hooked spinelets, only a longitudinal strip along the middle of each side, the head and the adjoining part of the body, being naked. The spinelets appearing on the crests of the head and on the nape are denticulations belonging to the deeper skeletal parts mentioned below. A much larger specimen (280 mm.) shows still a general coating with small asperities, most densely developed on the tail; but in two specimens of about 400 mm. the dorsal part of the body is to a great extent naked, whereas the lateral and ventral parts have their rugosity well developed. On the other side a third specimen, c. 350 mm., at first sight seems completely naked; but examined with a strong lens the tail ventrally to the lateral line shows very small asperities. In large specimens, exceeding 700 mm., I have not been able to detect any hooklets at all. Thus *F. tabacaria* in the fully adult state seems to be naked. The same is probably the case always with *F. depressa*, even in the youngest stages; but quite small specimens I have never seen. The six specimens examined by me, from 250 to 450 mm. in length, at all events show no trace whatever of asperities.

The spinelets in *F. tabacaria* and *F. petimba* are of the same type: a conical, sharply pointed hook, basally hollow and expanded into an extremely thin cup-shaped plate, generally with irregularly indented margins. In large specimens of *F. petimba* many of the asperities appear conical or blunt, having lost their hooked point, which has either been absorbed or worn away[7].

The dimensions of the asperities in some of the specimens examined are the following:

		Diam. of basal plate	Height of spine	Diam. of spine at base
Fistularia petimba				
A.	c. 720 mm.	0,160 × 0,176 — 0,240 × 0,288	0,064	0,043
B.	c. 710 —	0,160 × 0,176	0,064 — 0,080	0,032
C.	c. 340 —	0,160 × 0,176	0,064 — 0,096	0,032
Fistularia tabacaria				
A.	c. 400 —	0,080 × 0,088 — 0,128 × 0,136	0,112	0,016 — 0,024
B.	c. 350 —		0,080	0,016 — 0,019
C.	c. 280 —	0,096 × 0,112	0,080	0,024 — 0,032
D.	c. 43 —	0,080; — 0,208	0,080 — 0,096	0,008

II. In *Fistularia tabacaria* longitudinal rows of short spindle-shaped ossicles (of 4—8 mm. length in adult specimens), imbedded in the deeper layer of the cutis,

* The length in all cases mentioned is measured from the tip of the snout to the base of the caudal filament.

form a strip between the posterior end of the coracoidal plate and the ventrals, and behind these running backwards, below and parallel to the lateral line, to the end of the tail. In the youngest stage figured (Pl. VII, fig. 1) I have not been able to detect these structures, but in a specimen of about 280 mm. they are discernible, at all events anterior to the ventrals, and in larger ones they always seem to be present[8].

III. In *Fistularia petimba* a single median row of narrow longitudinally keeled scales, quite superficially imbedded, is found along the back, running from about the level of the ventrals to the base of the dorsal fin, and behind the latter to some distance from the end of the tail, where the hindmost scales grow shorter and finally take the shape of nodules; a similar row is found in the ventral median line, beginning in front of the ventrals at some distance behind the coracoids and, interrupted by the anus and anal fin, continuing on the tail, stopping at some distance from the caudal fin. In all large and medium-sized specimens I find these scales present, but in the smallest specimens (170 and 130 mm.) they seem not yet to be developed[9].

IV. Common to all 3 species are the dermal ossifications of the lateral line. On the short anterior part of the trunk, which is protected by the endoskeletal parts described below, these ossicles are tube-shaped, on the rest of the body they gradually take the form of narrow longitudinal shields each provided with a more or less prominent short keel or spine, most prominent on the tail where the shields form a kind of serrature. On the caudal filament, on which the lateral line is continued, the ossifications again take the shape of tubes. In the two species where dermal asperities are found, the latter may be present in the thin dermal layer covering the ossicles of the lateral line[10].

Endoskeleton.

The vertebral column does not show any important differences in the two species examined (*F. petimba* and *tabacaria*). In both species I have found the same number of vertebræ, 56 (4 + 52) abdominal and 31 caudal vertebræ[11].

The 4 anterior vertebræ (Pl. I, fig. 11, Pl. II, fig. 9) are modified in the same way as in *Aulostoma*, being extremely elongated and immovably united by sutures, forming one piece, which (in *petimba*) is between $^1/_5$ and $^1/_6$ of the whole length of the column. The spinous processes are united into one longitudinal crest, the transverse processes into a similar, but broader, almost horizontal plate, the members constituting which overlap each other towards the skull while those of the vertical plate are mostly joined with their margins.

As in *Aulostoma* the second and third vertebræ are by far the longest, their anterior and posterior portion being about equally elongated, whereas of the first vertebra only the posterior part, of the fourth only the anterior part is elongated and modified.

The first carries articular processes for connection with the skull, the fourth has on the posterior, unmodified part a small separate transverse process, corre-

sponding to the posterior one on the following vertebræ. From the anterior corner of the expanded transverse process of the second vertebra (at * in Pl. I, fig. 11) a strong ligament passes to the posttemporal. The following free abdominal vertebræ — like those of *Aulostoma* — are provided with two transverse processes on each side, but here the posterior process is always small compared with the anterior (Pl. II, fig. 9). The latter is especially large and distally flat and expanded on the 5—6 vertebræ immediately following the coalesced part. On the first caudal the posterior process suddenly disappears.

The inferior arch and spine form part of the anterior transverse process, being formed by a process on each side from the base of its lower face. The anterior 9—10 caudal vertebræ, which support the dorsal and anal fins, retain the transverse processes and are, except the first, provided besides with an upper set of similar, but shorter and more slender, pointed lateral processes, originating from the base of the neural arches. Behind these fins no lateral or transverse processes occur.

On all the free vertebræ articular processes are present, the anterior ones, as in *Aulostoma*, being large and high; on the caudals behind the fins similar inferior articular processes are developed. The vertebræ of the slender posterior part of the tail have their upper and lower spinous processes depressed, lying flat and overlapping caudally; at the end of the tail they rise again, and the last vertebra takes on the shape of a vertical plate, probably representing two hypural bones.

Ribs are wanting.

Connected with the vertebral column are some osseous structures, the anterior of which — the nuchal plates — are probably to be regarded as modified interneural bones, while the others seem to be ossified tendons or ligaments.

The three nuchal bones are longitudinal plates (firmly) joined together and over-lapping each other towards the tail; they are through connective tissue fastened along the vertical lamella representing the modified spinous processes of the first four elongated vertebræ.

Their upper face is sculptured and more or less visible through the skin; the lower face is concave and carries on the foremost part of the first plate a short median keel, fitting into a much broader triangular excavation of the neural spine of the first vertebra; on the hind part of the second plate a median furrow begins and gradually deepens on the third into a narrow groove between two low lamellæ, which are continued into long and thin prolongations, reaching backwards along the spinous processes of the 9 or 10 anterior free vertebræ.

The three nuchal plates are evidently homologous to the plates in the corresponding position in *Aulostoma*; and as in the latter genus they are doubtless to be regarded as modified interneurals, the same interpretation of the nuchal plates in *Fistularia* seems justified. Small specific differences are to be met with in the nuchal plates: in *Fist. petimba* they are broader than in *F. tabacaria*; in the latter the ventral median keel of the first plate (the rudiment of the "stem" of an ordinary

interneural) is much smaller, and the sculpture of the upper face shows a somewhat different pattern.

Behind the unpaired nuchal plates paired, symmetrically arranged structures appear in the shape of a double series of long, thin, laterally compressed bones on each side, running along the tips of the spinous processes to the end of the tail, only interrupted by the dorsal fin (Pl. II, fig. 9 td); a similar, ventral, double series occurs along the inferior spines of the tail, beginning just behind the anal fin. Each member of both series extends over a number of (4, 5 or more) vertebræ; the uppermost rows are situated just below the skin (in alcoholic specimens they may be more or less visible through the skin); in *Fistularia petimba* they so to speak embrace the row of median scales. The two above-mentioned prolongations from the 3rd nuchal evidently belong to the same system. That these bones are ossified tendons or ligaments is hardly to be doubted; they apparently are structures similar in kind to the subdermal ossifications which are so richly developed in *Aulostoma*.

Ossifications of a similar nature are further the two large, flat bones, which, fastened to the epiotics of the skull, are situated along the back, one on each side of the nuchal plates. The upper face is sculptured on the anterior half and to a great extent visible through the skin; from the lower face, near the inner margin, of the posterior half originates a thin vertical lamella, enlarging the surface for muscular attachment. Like the corresponding bones in *Aulostoma* these structures are simply ossifications of tendons of the anterior part of the dorsal lateral muscles.

16 bisegmented interneurals support the dorsal fin. The foremost is short, about horizontal, and its lower end joins directly the dilated upper end of the spinous process of the first caudal vertebra; the following are interposed as usual, singly or in pairs or even three, between the spinous processes of the supporting vertebræ. With each lateral face of the first interneural an ossified tendon of the set in front of the fin is coalesced or firmly united; the like is the case with the hindmost interneural, a pair of tendons from the set behind the fin being joined with it.

The anal fin is supported by 15 interneurals, also bisegmented and with ossified tendons attached to the hindmost member. The first interneural is situated in front of the inferior spine of the first caudal, the following are interposed between the spines of 10 vertebræ.

The dorsal fin has 17—18 rays, the anterior 3, especially the foremost, extremely short; the anal fin has 16—17 rays, the anterior 2 very short[12].

The caudal fin has 10—11 + 2 + 10—11 rays, the 2 middle ones being extremely elongated, forming the peculiar filament. All the rays of the unpaired fins are laterally flattened, unjointed (but composed of two lateral halves), also the two composing the caudal filament. Only the caudal rays nearest to the caudal filament, 2 or 3 above and below this, are branched. The lateral line is continued along the filament almost to the tip, enclosed in a series of slender bony tubes; the presence of the latter may produce an appearance of joints[13].

The head (Pl. I, fig. 5) is flattened, the long tubiform snout depressed and almost hexangular in transverse section. The postorbital part of the skull is flat above, with deeply excavated postfrontal region (fig. 6), the interorbital part more or less concave; the proximal half of the preorbital part is roof-shaped, the distal half flat, the whole forming a broad and rather thin and flat beak, with sharp edges and concave underside (fig. 7). The preorbital part is about $2^1/_2$ times as long as the rest in *F. tabacaria,* fully 3 times in *F. petimba*; the greater part belongs to the mesethmoid (somewhat less than $^3/_4$ths); the whole terminal part (somewhat more than $^1/_4$) is made up by the vomer alone (while in *Aulostoma* the mesethmoid seen from above reaches along the middle line almost to the end of the snout).

On the upper aspect (fig. 6) the proximal part of the mesethmoid is seen forming the anterior borders of the nasal openings, while the other borders belong to the prefrontals (prf); above the nasal pits are found the frontals (fr), reaching far backwards, about to the posterior end of the skull, here embracing a great part of the narrow supraoccipital (so); the rest of the latter is enclosed between the epiotics (ep), which are coalesced behind the supraoccipital into one bone and form the median "occipital" crest. In the fossa on each side of the base of the latter is articulated the great ossified tendon (or muscular lateral plate); the somewhat swollen anterior, inner margins of the fossæ correspond to the knobs on the epiotics mentioned in *Aulostoma*. The end of the "occipital" crest is connected with the foremost nuchal shield. From above are further seen the postfrontals (pf), pterotics (sq) and the posttemporals (pt). The latter are in this genus firmly united with the skull, forming sutures with the pterotic, the frontal, epiotic and exoccipital. Besides are seen from above the exoccipitals (eo), broadly meeting from both sides over the foramen magnum and separated from the supraoccipital through the coalesced epiotics; finally, the knob-shaped, convex condyle is seen under the occipital foramen.

Parietals and opisthotics are absent.

From the triangular nasal groove a furrow, corresponding to that on the beak of *Aulostoma*, runs to the end of the snout, lodging the anterior part of the supraorbital lateral line; the median part of the mesethmoid and the vomer enclosed between the two furrows is elevated over the level of the lateral parts and sculptured, the pattern being somewhat different in the species examined; also the lateral parts of the mesethmoid are sculptured with fine radiating striæ. A row of slender, extremely thin tubes enclose the lateral line; no rudiment of a nasal bone, like that of *Aulostoma*, nor any antorbital bone is found here; the place taken up by the latter in *Aulostoma* is in this genus occupied by the front end of the prefrontal. The outer face of the prefrontal is deeply hollowed out (fig. 5, prf.); the upper border of the hollow is sharply serrated in *F. petimba* (and *depressa*), only crenulated in (adult) *F. tabacaria.*

On the lateral aspect of the brain-case as in *Aulostoma* a sharp crest (partly serrated in *F. petimba* and *depressa*) separates the upper from the lower surface, the two articular facets for the hyomandibular (fig. 7) are in the corresponding

position to those of *Aulostoma*, the prootic (pro) is provided with a sharply pointed ridge where the spine in *Aulostoma* is found, the pterotic (sq) is very large, combining below with the parasphenoid (pa) and the basioccipital (ob), the exoccipital carries a ventrally directed process just in front of the condyle for connection with the first vertebra — in short, if we take away the posttemporal, almost all the features and details resemble those of *Aulostoma*. Only at the orbit (Pl. I, fig. 8) we meet with some differences, especially in the extent of the alisphenoid (al), which here does not project laterally so far that it becomes visible as part of the postorbital process; on the other hand the alisphenoid is horizontally produced medially to meet its fellow from the opposite side, forming together with the prootic the bridge roofing over the "myodome". The anterior part of the "myodome" (the muscular fossa) is divided by a vertical lamella (l), rising from the excavated upper face of the parasphenoid; it appears like a process from the latter, but represents perhaps a basisphenoid (?). Below, (Pl. I, fig. 7) the basioccipital (ob) and the posterior part of the parasphenoid (pa) are flatly rounded, not keelshaped as in *Aulostoma,* and in front the parasphenoid reaches a good deal farther than in the latter, ending as a slender point, but as in *A.* without joining the vomer. The vomer (vo) has at the extreme anterior end a kind of knob from which starts ventrally a short median ridge or keel, carrying a few teeth, tapering behind; the hindmost part of the vomer is a slender point. The greater part of the under surface of the beak is here made up by the mesethmoid (mes).

Infraorbitals are wanting.

The 3 opercular bones (Pl. I, fig. 5) show in the main the same features as in *Aulostoma* the elongated posterior part of the suboperculum (s) is here divided into two long and slender branches, while in *A.* it is entire. The lamelliform interoperculum (io) surpasses in front the mandibular articulation.

The hyomandibular (hy) is still more sloping forwards than in *Aulostoma*; with the lower cartilaginous end it is connected with the horizontally placed styliform posterior end of the symplectic (sy). The greater part of the latter forms a vertical plate, the upper margin of which joins the skull, its posterior corner being firmly attached through ligament to the lower face of the prefrontal; in front the symplectic joins the metapterygoid (mt) in a long oblique suture, broadly overlapping the outer face of the metapterygoid; below, it unites with the preoperculum (pro) in a horizontal, straight suture, and, in front, in an oblique suture with the quadrate (qu).

The quadrate is very long, the outer face with an elevated, sculptured part, lying in continuation of the sculptured part of the preoperculum (pro), and in front carrying the articular head for the lower jaw; the upper, deeper situated part of the quadrate is smooth and joins the deep parts of the entopterygoid (ept) and metapterygoid (mt).

The palatine (pa) is small, with the relatively large maxillary process directed forwards; it does not meet its fellow from the opposite side; behind it is simply

pointed, not forked as in *Aulostoma,* and only immediately behind the maxillary process is found the connection with the vomer, below the somewhat broadened snout-end of the latter; its upper, inner margin is joined to the pointed front end of the entopterygoid. As in *Aulostoma* an ectopterygoid is wanting, being replaced by that part of the entopterygoid which unites with the oblique front margin of the quadrate. The upper margin of the entopterygoid is strongly thickened, its surface sculptured (fig. 5); it joins the lateral edge of the cranial beak, formed by the vomer and anterior part of the mesethmoid; along the remaining edge of the latter it is continued by the similarly thickened and projecting upper margin of the metapterygoid, which reaches to the prefrontal. In *F. petimba* (and *depressa*) this thickened part is strongly serrated, in *F. tabacaria* (adult) only crenulated.

On the inner face of the pterygoids no teeth are developed, but each palatine carries a row of teeth along its outer margin.

The obliquely ascending part of the preoperculum (fig. 5, pro) covers almost the whole lateral and the front face as well of the hyomandibular; the hyomandibular foramen is quite near to the articulation with the skull. The outer face of the preoperculum is beautifully ornamented with narrow ridges, crenulated or even more or less spiny.

The premaxilla (i) is small, pointed behind, and provided with a row of teeth; the maxilla (mx) is relatively large, broadening behind.

The articulation for the lower jaw is situated rather far behind the end of the snout, about at a level with the upper suture between the vomer and the mesethmoid. The mandible, therefore, which as in *Aulostoma* reaches farther forwards than the snout, is considerably elongated; it is composed like that of *Aulostoma*, with the small angular (an) in a similar place at the lower border, rather far from the posterior end. The upper margin of the dental, in front of its ascending part, its provided with teeth.

Branchial apparatus (Pl. II). As in *Aulostoma* the hyoid (fig. 5—6) is relatively short, and almost the whole gill-bearing part is situated behind the articulation of the hyoid to the skull. The hyoid appears at first sight to lack one of the typical elements, the stylohyal; but it cannot be doubted that this part really is present only in a reduced state and fused to the epihyal (eh). The latter is the largest piece, especially if seen from the outer side (fig. 5); the ceratohyal (ch) appears proportionately somewhat larger and the lower hypohyal (hy^I) somewhat smaller than is the case in *Aulostoma.* There are five branchiostegal rays, the lowermost very slender, fastened to the inner face of the ceratohyal, the others to the outer face, one to the same piece, the three to the epihyal; they increase in size upwards, the uppermost being especially stout and divided into two branches.

The glossohyal (fig. 1, gl) is extremely long, slender and laterally compressed; in length it surpasses the whole branchial apparatus; the urohyal also is long, angular and increasing in thickness behind, where it reaches the front ends of the coracoids, in *F. tabacaria* coossifying with the latter.

The first basibranchial, cartilaginous in *Aulostoma*, is here a bone, with broad and flat front end (Pl. II, fig. 1 co^{I}); it is the only basibranchial present.

The gill arches are completely smooth, without any trace of gill-rakers or teeth. The first arch is composed of 3 parts, a very short, clumsy hypobranchial, a long ceratobranchial and a slender epibranchial; the second arch consists of 4 parts, a pharyngobranchial (ph^{II}) provided with teeth being present in front of the slender epibranchial; the third arch has also 4 parts; its very slender epibranchial is separated from the ceratobranchial and articulates distally both with its own and the following pharyngobranchial; the first (ph^{III}) sends a process forwards along the whole length of the preceding pharyngobranchial; behind this process it is flat and beset with teeth. The fourth arch lacks the hypobranchial and the epibranchial, its tooth-bearing pharyngobranchial being supported by the preceding arch alone.

The fifth, the lower pharyngeal is richly provided with teeth.

As in *Aulostoma* the gills are continued on the pharynx wall, supported by cartilaginous prolongations from the ceratohyals (Pl. II, fig. 2).

The reduction of branchial skeletal parts in *Fistularia* seems about to be equal to that found in *Aulostoma*; only the epibranchials of the second and third arches appear less reduced, as the latter alone is separated from the ceratobranchial.

The following tabular view of the branchial apparatus in the two genera will immediately show the fundamental likeness [14].

Aulostoma.

Gill arch	Basibranch.	Hypobr.	Ceratobr.	Epibr.	Pharyngobr.
I	(+)	+	+	+	
II	+	+	+	+	+
III		+	+	+	+
IV			+		+
V			+		

Fistularia.

Gill arch	Basibranch.	Hypobr.	Ceratobr.	Epibr.	Pharyngobr.
I	+	+	+	+	
II		+	+	+	+
III		+	+	+	+
IV			+		+
V			+		

The shoulder girdle (Pl. III, fig. 8,9) has been fully described by STARKS (55 p. 630), and only a few remarks need be added.

The clavicular arch consists of 3 bones, a supraclavicle being present.

The posttemporal (Pl. I, fig. 5 pt) is suturally united to the skull (vide supra); its outer margin is sculptured, with granules (*F. tabacaria*) or spines (*F. petimba, depressa*); about midway between the occipital suture and the posterior end the inner face shows a knob (Pl. I, fig. 7 k) or rugosity for muscular attachment and for a strong ligament, going to the front part of the first vertebra, corresponding to the bony fork described in *Aulostoma*; the ligament passing from the hind end of the posttemporal to the anterior corner of the transverse process of the second vertebra is also found in *Fistularia*. The supraclavicle is short; it has a shallow concavity at the upper end for articulation with the posttemporal, and the lower end covers part of the outside of the clavicle.

The part of the clavicle (fig. 9, cl) corresponding to the sculptured plate in *Aulostoma* is small (just observable through the skin, but hidden below the opercular membrane); under its upper posterior corner the clavicle carries the long postclavicle (pcl), which broadens behind into a plate, partly sculptured on its outer face and more or less visible through the skin. Distally the clavicle bifurcates into an outer (anterior) (o) and an inner (posterior) (i) branch; along the inside of the clavicle and that of its inner branch is attached the scapular arch.

The latter consists as usually of the scapula (sc) and the coracoid (co). The first encloses the wide scapular foramen; but the part encircling the anterior border of the foramen is only very thin cartilage (easily lost in drying, probably, therefore, overlooked by STARKS). The inferior margin of the coracoid expands into a large plate, broadening behind the pectoral fin, the outer face being to a great extent sculptured and visible through the skin; anteriorly it combines with both branches of the clavicle, ending in front of the outer (anterior) branch of the latter as a flat, pointed process, to which the urohyal is fastened. The part between the clavicular branches unites with its fellow from the opposite side, a particularly firm connection being established at the level of the inner (posterior) branch (fig. 8).

The four pterygials (ba) are well developed, similar to those in *Aulostoma*; the uppermost, rather small one is fastened to the scapula, the remaining three are larger, laterally compressed and somewhat hour-glass-shaped in outline[15].

The pectoral fin has 15—16 soft unbranched rays, the uppermost rudimentary; the upper (4—5) rays are not jointed, as the rest are.

The pelvic bones, abdominal in position, are still farther apart from each other than in *Aulostoma*. Each is a flat bone with the exterior margin rounded in outline, the inferior straight. There are 6 ventral fin rays, the outer unbranched but jointed like the rest, which all are distally branched.

Visceral anatomy.

There are four complete gills and a large pseudobranchia, a slit between the fourth gill-arch and the lower pharyngeals.

The alimentary canal is for the greater part of its extent without mesentery; only about the last 4th part is provided with a mesentery; the whole alimentary canal is without curvatures, completely straight; compared with that of *Aulostoma* it is much longer, the anal opening lying much farther behind the ventrals, just in front of the anal fin as in most fishes. The oesophagus and stomach form together a long spindle-shaped part, by far the widest portion of the whole tract; the posterior pyloric part of the stomach is more muscular and narrow, sharply marked off from the intestine. Internally oesophagus and stomach are provided with longitudinal folds; the length of both together is two-thirds of that of the rest of the intestinal canal. The small intestine sends out from its front end one, conical, not very long *appendix pylorica*; the intestine commences about at a level behind the ventral fins, is widest anteriorly and tapers quite gradually backwards; the posterior fourth part is the rectum; the boundary between it and the small intestine is not very pronounced externally, no sudden change in width being found. As just mentioned the rectum and hindmost part of the adjacent intestine are suspended by a mesentery. In the pyloric part of the stomach of a large *F. petimba* from the Formosa Strait I found 8 small fishes, the longest ca. 50 mm., all belonging to the same species of the genus *Bregmaceros*, and more or less digested; of those most digested the otoliths were completely intact.*

The liver is small reaching only over half the length of the stomach, not lobed, pointed posteriorly, covering somewhat more of the ventral right side of the stomach than of the left. Quite near the posterior end the right margin has an incision for the gall-bladder, from which the biliary duct runs backwards following the intestinal artery and the portal vein, enclosed together with these in a peritoneal fold, like a kind of low mesentery along the stomach; it enters the intestine on its ventral side, immediately behind the base of the *appendix pylorica.*

The air-bladder is about twice the length of the liver, reaching from below the first of the coalesced vertebræ to the end of the last; here the main cavity of the bladder stops, but its posterior end sends out a pair of long, conical blind-sacs tapering to a point backwards and lying one on each outer side of the kidneys below the long and expanded transverse processes of the anterior free vertebræ; they are somewhat asymmetrical, the right reaching just behind the ventral fins, the left stopping just in front of them. About in the middle, a little behind it, the ventral wall of the main chamber contains a large, ovoid "red body"; at this spot the under-face of the air-bladder is tightly fastened to the stomach through a short "stalk", containing the principal vessels for the "*rete mirabile*", branches from the *arteria coeliaca* and the portal vein. The heart, the air-bladder, except its two prolongations, the whole liver and the greater part of the stomach, except its pyloric part, are enclosed in the "armoured" part of the trunk, protected on the sides and below by the large postclavicula and the coracoidal plates. The heart is situated between the distal branches of both clavicles and over the front ends of both coracoidal plates, the bulbus arteriosus lying over the hind end of the urohyal.

* Also KNER (28 b) p. 29 (260) has found a small fish in the stomach of a *Fistularia.*

The *aorta* crosses obliquely over the ventral face of the front end of the first vertebra, in the furrow seen on the first corpus (Pl. I, fig. 11**), to the left side where it is lying along the coalesced corpora, keeping up this asymmetrical position to the end of the body cavity, where it enters the subvertebral caudal canal.

The *arteria coeliaca* originates from the aorta a short way behind the entrance of the last branchial vein (or arteria revehens) ventrally where the arteries to the pectoral fins leave laterally; it passes to the right side of the oesophagus below the front end of the air-bladder and further along the right side of the stomach, giving off branches to the latter, the airbladder and the liver; at the gall-bladder it gives branches to the "red body" and follows the same course as the portal vein and biliary duct on to the front end of the pyloric appendage, where it still follows along the appendix with the biliary duct to the end of the latter and then separates from the portal vein, each of these vessels occupying in their further course backwards opposite faces of the intestine; in the mesentery of the hind part of the latter the *arteria coeliaca* leaves the intestinal wall and passing obliquely through the mesentery enters the dorsal body wall between the two gonads and anastomoses with the *aorta*.

The right cardinal vein is very large; imbedded in the right part of the kidney it enters from behind the coalesced part of the vertebral column, lying to the right side of the corpora, and receiving branchlets across the corpora from the opposite side, one for each vertebra. The left cardinal vein is wanting altogether. Along the left side of the coalesced vertebræ, imbedded with the aorta in a silvery sheath, a small vein runs forwards, anteriorly crossing over the right cardinal vein and going to the head. Small veinlets passing through the nerve-holes of the coalesced vertebræ join the right cardinal vein and the small "vertebral vein" on the left side. No branches from the aorta seem to enter the nerve-holes.

The kidneys are coalesced into one body reaching from the hind end of the body cavity to the last of the coalesced vertebræ. This body contains two symmetrically arranged urinary ducts, thus proving the originally paired condition of the kidneys. The ducts unite to a common, very short part opening as usual behind the (female) genital pore; there is no urinary bladder.

Dorsally over the front end of the air-bladder, just below the anterior end of the first vertebra, a small pyriform body is found on the left side, but nothing corresponding to it on the right side. I suppose it to be the remnant of the left pronephros, and a silvery thread, going backwards from it, I assume to be the rudiment of the pronephric duct (the condition of the old spirit material was such that a histological examination would scarcely give any reliable information).

Along the outer side of the aorta, dorsally to the air-bladder, runs the left vagus-nerve accompanied by the left sympathetic; the right vagus and the right sympathetic follow in a similar manner the right *vena cardinalis*; from the vagus and spinal nerves and probably also from the sympathetic branches are given off to the wall of the air-bladder.

Through the nerve-holes in the coalesced vertebræ only spinal nerves pass out.

A transverse commissure connects the two sympathetic trunks just in front of the rudimentary pronephros.

Genital organs. The ovaries appear to be unpaired, suspended by a mesoarium to the left side of the dorsal body wall. They are bandshaped and reach from the posterior end of the body cavity to a short distance behind the beginning of the intestine. Closer examination shows that two ovaries are present; posteriorly they unite into a short common oviduct with the usual opening behind the anus; above the rectum their double nature may be noticed, and as stated above the intestinal artery passes between them; but soon they externally appear quite coalesced; transverse sections reveal their double nature, the inner cavity being divided by a thin vertical partition. The numerous ovigerous lamellæ in each half leave part of the wall of the ovarial chambers free; in the middle of the fused ovarial band this free part is lateral, but behind and in front of the middle it may be more ventral. The testes externally resemble the ovaries, suspended by a mesorchium in the same position, band-shaped and of the like dimensions; transverse sections show that the band is made up of two closely joined gonads.

The peritoneum is silvery.

The axillary pore, behind the pectoral fin, mentioned by GÜNTHER appears to be the opening of the duct of a secreting gland. The latter is richly provided with blood vessels[16].

Syngnathidæ.

In the second Volume (Part 2) of his great work on Fossil Fishes, published between 1833 and 1843 (p. 275), L. AGASSIZ states that he has not been able to give any special information about the skeleton of this interesting group for want of preparations fit for examination; neither could he fill up this blank through the literature: "car je ne trouve nulle part une description détaillée du squelette et des écailles des Lophobranches".

Regarding the skeleton very nearly the same might be said to day: a complete description, accompanied by the necessary illustrations is up to the present date not to be found anywhere; although DUMÉRIL in 1870 gave a monograph or at all events a detailed account of this group based on the material of the Musée d'Histoire naturelle at Paris and of the whole literature then available*. The fullest and most correct information is that to be found in the Scandinavian literature. As early as 1850 KRÖYER in his "Fishes of Denmark" has given several good and

* SEGOND (52) p. 619 says 1873: "Auguste Duméril a rassemblé dans sa quatrième sous-classe tous les documents que nous possédons sur les lophobranches. J'espérais trouver dans ce travail consciencieux, des observations nouvelles sur les parties centrales des pégases et des syngnathes, mais ces nouveaux documents manquent encore à l'ichthyologie .... A. Duméril se contente de dire que le squelette des lophobranches ne diffère en rien d'essentiel de celui des poissons osseux."

correct descriptions; later LILLJEBORG (1891) and SMITT (1895) have supplied more or less complete accounts of the skeleton; regarding the composition of the skull, these authors especially SMITT have interpreted several features more correctly than any previous or later author; but they have not avoided some grave errors.

I may add that these Scandinavian authors also give much good information about the anatomy of the soft parts, and it ought to be mentioned that in 1833 RETZIUS already described the main anatomical features of the most common species of northern pipe-fishes so completely, that in several points the investigations published as late as 1902 by HUOT do not contain much that is really new. The few remarks about the osteology in HUOT's paper contain several errors; and the same may be said of the papers published by Mc. MURRICH, SCHÄFF, COPE, JORDAN & EVERMANN, SWINNERTON etc.

As to the systematic position of the Lophobranchs I shall here only mention that Cuvier in 1817 (Règne animal 1. Édit. II. p. 155) gave them rank as one of his 8 Orders or main divisions of the Class Pisces; he did so essentially on account of their gills. This elevated rank and isolated position has often been attacked; every one who has really examined their gills, has seen that these do not substantially differ from those of other Teleosteans; CUVIER himself has realized this fact, and so did RATHKE, RETZIUS, RYDER and several others. Nevertheless their isolated position is still maintained by many authors. Without entering further into any discussion of the systematic point I might only mention that in 1908 (23 b) I have expressed as my view, that the true Lophobranchii (or Syngnathidæ), the Solenostomidæ, the Fistularidæ, Aulostomidæ and the Centriscidæ form one natural group; and I have briefly pointed out some characters in the cranial structure which seem to me to raise this view above doubt.

The true Pipefishes, the *Syngnathidæ*, are a fairly homogenous family, naturally divided into two groups, one for which the well-known genera *Siphonostoma* and *Syngnathus*, the common pipefishes of European and N. American coasts, may serve as types, and one containing forms such as *Hippocampus*, the Sea-horse.

Proceeding to the osteology of this family, I think it most convenient to describe in some detail one type, and afterwards to point out some of the more essential features in which other forms deviate from this type. As type we may consider *Siphonostoma typhle*, a species which is to be found everywhere in the zostera-region of the Danish coasts, or at similar localities of the Baltic and the North Sea.

Siphonostoma typhle (L.).

Exoskeleton.

The dermal armour of *Siphonostoma* and other Syngnathids has often been described and its main features, I think, are so well known that a recapitulation here seems superfluous. Only regarding the nuchal plates and the composition of

the foremost "rings" of the trunk have I found it necessary to enter into details below in treating of the endoskeletal parts closely connected with them.

The arrangement of the dermal plates has been described by KRÖYER (29 p. 683), PETERS (41 p. 104), DUMÉRIL (12a p. 143, 12b p. 478), E. MOREAU (36 p. 28), SCHÄFF (50), LILLJEBORG (37 p. 437), SMITT (54 p. 675), HUOT (19 p. 202),* DUNCKER (13 p. 18, p. 62), a. o.; the shape and structure of the single plates, their relation to the layers of the skin etc. are especially mentioned by SCHÄFF, an account of their first development is given by KASANZEFF (24 p. 854).

The presence of "lateral-line organs" was first shown by DUNCKER (13 p. 22, Pl. 3); but as these organs — the existence of which I can confirm — are not enclosed in any canal, and some of them may appear on places, where the typical lateral line does not occur (e. g. on the operculum), it seems open to doubt if they really represent the true lateral line or some of the other dermal sensory organs found in teleosts.

Endoskeleton.

The vertebral column consists of 56 vertebræ; the anterior 19 I count as abdominal, as the front outline of the caudal armour, behind the anal opening, lies just beneath the middle of the 20th vertebra; this vertebra besides supports the anal fin and sometimes its transverse processes are joined to form the foremost inferior arch; but sometimes this is the case with the next vertebra. The three anterior abdominal vertebræ are immovably joined together (Pl. IV, fig. 4), their neural arches being firmly connected basally through sutures, with long dentations, while their corpora simply meet in the same way as those of all the remaining vertebræ. When macerated (even in hydrate of potassium) the three anterior vertebræ, therefore, always cohere, whereas the others drop off. The immobility is strengthened by the expanded clavicle, which is firmly united with the transverse processes of the two foremost vertebræ.

The first vertebra (Pl. IV, fig. 3, 4) is shorter than any of the following; in front it carries a pair of strong processes (a), articulated with the skull and behind continuing as wing-shaped transverse processes; the outer margin of the latter is embraced by folds of the anterior part of the clavicle. The spinous process is a low, elongated crest. The base of the neural arch has behind a deep triangular incision on each side, into which fits a long process from the next arch, corresponding to the process of the first vertebra; in this way the stiff connection mentioned above is brought about. The second vertebra carries on its middle a stout transverse process, somewhat bifid at the outer end, which is firmly bound by ligament to the clavicle. The neural arch and its spine are similar to those of the first vertebra.

The transverse process of the third vertebra is longer and more slender, the

* The small "intermedial" scutes which occur in most genera of Syngnathids, e. g. *Siphonostoma, Syngnathus, Nerophis*, have been overlooked as such by HUOT and mistaken for lateral-line organs.

neural arch only in front adapted for sutural connection with the preceding vertebra; the connection with the following being the same as that between the remaining abdominal vertebræ. These are in the main of one type, except the hindmost. They are long and slender, with long, flat and narrow, generally pointed transverse processes; the base of this process broadens gradually along the anterior half of the vertebra, more and more as we pass backwards, on the hindmost vertebræ almost reaching the front margin.

The spinous process is a low thin crest, in the middle over the level of the transverse process rising a little to form a vertical point. Articular processes are wanting, at most indicated as feeble undulations on the margins of the neural arches.

The hindmost abdominal vertebra (the 19th, Pl. IV, fig. 6, 7) supports the front part of the dorsal fin, but in different individuals a greater or lesser part; in structure, therefore, it corresponds to the 8 following caudal vertebræ, supporting the remaining greater part of the dorsal fin, but with the exception that it has no inferior arch. The triangular transverse process reaches basally along the whole anterior half of the vertebra, and backwards it extends along the lower margin of the corpus in the shape of a wing, rounded in outline (v). The spinous process as in the preceding vertebræ forms a thin longitudinal crest, but the upper margin of the latter carries some deep and narrow incisions (in the case figured two), strengthened along their margins with thickened ribs. Into each incision fits an interspinous bone. In some cases only the foremost interspinous bone is fastened to the posterior margin of the spinous process and for the rest to the following, the first caudal. The 8 (or 9) anterior caudals (Pl. IV, fig. 8, 9) show the same type as the last abdominal; only they are shorter, and the anterior extension of the transverse process is on the same level as the posterior wing; besides they possess inferior arches. The latter originates from the underside of the transverse process proper (fig. 9), near its hind margin; on the first caudal vertebra the distal ends of the arch may be separate and in position oblique towards the tail, while all the following form a short, vertical, inferior spine. Very often the first caudal vertebra has no inferior arch or only an indication of its basal part. The upper spinous processes each support 4 or 3 interspinous bones, the 8th, and sometimes also the second, 5. On the 8th caudal the posterior transverse wing is narrow and on the following it is wanting; evidently this structure is developed together with the muscles for the dorsal fin. As is well known the principal motor apparatus in the Syngnathids is the dorsal fin; to produce the powerful undulations of the latter the muscles to the fin rays are greatly developed, forming a voluminous layer inside the body muscles, separated from the latter by a pigmented membrane of connective tissue; the fin-muscles belonging to the outer part of this layer are basally attached to the transverse processes and their wing-like expansions. The remaining caudal vertebræ behind the dorsal fin are of one type, long and slender, with low dorsal crest, in the middle provided with a small vertical spine; the trans-

verse processes originate from the middle of the vertebra as short, flat triangles, pointing somewhat forwards; the posterior margin is thickened, the anterior quite thin. The inferior arch is situated under the middle, is short and so slender that the large vessels are to a great extent unprotected by skeleton. The vertebræ decrease in size evenly backwards; the last vertebra (Pl. IV, fig. 10) has no inferior arch, and immediately behind the transverse process it divides into two hypural bones, the upper of which is fused to the urostyle.

Of all the vertebræ, except the 3 anterior, the neural arches are basally pierced by more or fewer rounded openings.

Ribs are completely wanting. The distal ends of the transverse processes are by connective tissue fastened to the lateral plates of the dermal armour.

Interspinous bones. As modified interneurals may possibly be regarded the nuchal plates. The anterior smaller one covers the interspace between the occipital crest of the skull and the first spinous process; the posterior, larger and more elongated shield is situated over the spinous processes of the first and second vertebræ (Pl. IV, fig. 5). The anterior nuchal plate is provided with a median ventral keel, which — at all events in some individuals — may project rather far down in front of the spinous process of the first vertebra; the posterior also carries a median, but longitudinally cleft keel, embracing the lengthened spinous processes of the two anterior vertebræ. Thus these plates to a certain degree recall the structures found in *Aulostoma* where the interspinous origin of the nuchal plates is hardly to be doubted, a transition being found there through an uninterrupted series of structures gradually taking on the shape of ordinary interneurals. In *Fistularia* this transition is lost, but still some traces of their origin seem preserved, and besides the close relationship between the genera *Fistularia* and *Aulostoma* speak in favour of the interpretation accepted here. Now, in *Siphonostoma typhle* the presence of the ventral keel may indicate the last trace of the interspinous nature, but it may be of quite independent origin, and it is to be remembered that in some Syngnathids, e. g. *Hippocampus,* the anterior nuchal plate has no keel whatever, and that the relationship with the *Aulostomidae* is not very close. Furthermore the development of the embryo does not prove anything with regard to the nature of these shields. I have not been able to find them in a cartilaginous condition; they appear to originate as bone in connection with the spinous processes, from which they seem to be detached; but, on the other hand, they appear very early, before the median dermal plates are ossified.

The interspinous bones of the dorsal fin are bisegmented (Pl. IV, fig. 1, 8). The proximal (basal) segment is thin, the longitudinal muscular crest is wanting or slightly indicated, the cartilaginous axis richly developed. Close to the upper (cartilaginous) end it sends out a flat wing-like expansion to each side, or two, separated by an incision, sometimes almost closed to a foramen. Upon these expansions rest the medial margins of the upper lateral plates of the dermal armour, firmly attached by connective tissue (Pl. IV, fig. 12). Through the narrow apertures

left by the interspinous expansions and the dermal skeleton pass out the tendons of the fin-muscles to the rays. The distal segment is a small roundish cartilage, embraced by the cleft base of the fin-ray; it articulates with two neighbouring interneurals, and the whole series of these small cartilages is bound together by a ligament. The groups of interspinous bones attached to each vertebra are more or less fan-shaped; the median or the two median bones are generally straight, the anterior and posterior somewhat curved at their upper ends. The whole series produces a curious aspect, quite unique among teleosts.

It appears that in the larva the arrangement of these parts is more like that usually found in fishes, and is altered during growth. In larvæ from the brood-pouch the spinous processes of these vertebræ are only represented by the median rib just over the transverse process, and the cartilaginous interneurals are almost parallel between two simple spines.

The interneurals of the anal fin are proximally fused into one piece (Pl. IV, fig. 11); distally there are two branches each provided with similar expansions as the dorsal interneurals; the expansions are joined to the two anterior plates of the inferior lateral row; these plates lie in continuation of the middle-lateral plates of the trunk. As in the dorsal fin the tendons for the anal fin muscles pass through the narrow openings left by the internerneurals and dermal armour. The two confluent interneurals are connected through muscles with the lower face of the transverse processes from the foremost caudal vertebra; in specimens in which this vertebra has an inferior arch developed, the anal interneural is situated in front of the latter. The muscles constitute a narrow, fairly long and powerful bundle, which is easily separated into three, one for each fin-ray; to the inner side of this bundle are found the short and weak muscles originating from the interneurals. Outside the distal ends of the anal interneurals three small cartilages are found each embraced by its fin-ray; thus these interspinous bones are also bisegmented.

The fin-rays of the dorsal and anal fins are unjointed, and unbranched, like those of the pectoral fins; the rays of the caudal fin are all jointed, but unbranched; there are no short rays at the upper and lower margins of the caudal fin.

The number of rays is: D: 34—37; A: 3; C: 10.

Cranial skeleton. As in the other members of the group under examination the anterior part of the skull is highly elongated, Pl. V, figs. 1—4. The nuchal face as in *Aulostoma* and *Fistularia* slopes backwards so that the bones circumscribing the occipital foramen are visible from above. On the upper aspect (fig. 1) are seen: the supraoccipital (so), epiotics (ep), posttemporals (pt), pterotics (sq), frontals (fr), postfrontals (pf), prefrontals (prf), mesethmoid (mes) and vomer (vo). Along the middle of the last two bones a narrow, sharp crest is present. In front of the slightly expanded snout-end of the vomer is found a small cartilage, connected with the premaxilla and maxilla. The cartilage is a remnant of the contin-

uous ethmoidal cartilage found in the embryo and larva; during growth and ossification the cartilage is replaced by bones, only this small anterior median part and two basal lateral parts, each enclosed in the prefrontal (ectethmoid), being preserved.

The supraoccipital is in front wedged in between the frontals, behind it sends out a short, downwards directed nuchal process, connected through ligament with the anterior nuchal plate. The posterior margin of the epiotic projects like a crest, below which the strong tendon for part of the anterior lateral muscles is attached. Parietals and opisthotics are wanting.

The mesethmoid takes up more than half the length of the snout. The posttemporal (pt) is connected with the epiotic, pterotic and exoccipital; its pointed posterior end is bound to the front end of the clavicle by connective tissue.

On the lateral aspect the same bones are seen (Pl. V, fig. 4). On the posterior aspect (fig. 3) the exoccipitals meet each other above the foramen magnum as in *Aulostoma* and *Fistularia* and laterally each exoccipital projects into a process below the foramen, carrying an articular face for the process on the first vertebra. The condylar face is conically hollowed as usually; the margins of the hollow are stouter than the corresponding margins of the vertebræ.

On the lower aspect of the skull (Pl. V, fig. 2) the very large pterotics (sq) are particularly conspicuous, ventrally reaching the basioccipital (ob) and preventing the exoccipitals from meeting the prootics (pro). Between part of the latter and the basioccipital (ob) a cartilage is seen. The foramina for the nerves in the prootics are situated quite as in *Aulostoma* and *Fistularia,* those of the 5th nerve in the front face, towards the orbit, those of the seventh laterally (as typical in true Acanthopterygians); and the anterior articular surface for the hyomandibular also here belongs partly to the postfrontal, partly to the prootic, while the posterior belongs to the pterotic alone. A sharp ridge divides the part of the prootic visible from below from that looking towards the orbit; with this ridge a ligament from the hyomandibular is connected.

The parasphenoid (pa) is elongated, reaching farther in front than in *Aulostoma* and *Fistularia,* and connects in a long triangular suture with the vomer; it possesses a considerable orbital part, joining the frontal above and laterally bounding the fossa for the inferior musculi recti of the eye. A true "myodoma" is not developed, the prootics from both sides not meeting completely to form a bony roof over the origin of the eye-muscles.

The front end of the vomer is somewhat heart-shaped, edentulous; for a long way it is joined to the concave under face of the mesethmoid and its needle-shaped hind part reaches along the parasphenoid to the level of the prefrontals. The orbital wall of the brain-case is formed by the parasphenoid, prootic, postfrontal, alisphenoid (the latter, being small, is easily overlooked) and the frontal.

There is no canal for the lateral line in any of the cranial bones, nor in the preoperculum and preorbitals described below.

The mouth-parts are fairly large, except the intermaxilla (Pl. V, fig. 4, 5 i); the latter and particularly the maxilla (mx) is bound by strong ligaments to the snout-cartilage, the maxilla besides to the vomer and — as usual — to the maxillary process of the palatine. The mandible has three parts: the articular (ar) and dental (d) form together a large process for a branch of the tendon of the *M. adductor mandibulæ* (another is attached to the maxilla); the angular (an) is small and as usual connected by a strong ligament — here a long one — with the interoperculum.

Teeth are completely wanting on all the bones of the mouth and pharynx, also on the branchial arches. Of the suspensory parts the hyomandibular (hy) is stout, fairly short and, contrary to the case in *Aulostoma* and *Fistularia,* very little sloping forwards. On the upper inner margin it has a wing-like expansion, joined by ligament to the prootic as mentioned above; the lower end is cartilaginous and connected with the proximal part of the horizontal symplectic (sy); the latter is joined to a process on the inner side of the stylohyal by a long ligament (l). The symplectic bifurcates into two branches; the lower fork is horizontal, continuing the horizontal stem and enclosing a cartilaginous axis; in front it joins the quadrate (qu); the upper fork is an oblique plate connected with the two antorbitals (ao, ao′) (particularly with the posterior, the preorbital proper), replacing so to speak the metapterygoid, which is completely wanting. The upper branch of the symplectic is bound to the skull by connective tissue.

The quadrate (qu) is much elongated, its outer face convex, the inner concave, behind it is pointed, broadening anteriorly; the front margin, contrary to the case in *Aulostoma* and *Fistularia,* slopes from behind forwards. The outer face is sculptured and carries a longitudinal ridge from the posterior end to the articular head for the mandible. The upper margin is for a long way not in contact with the pterygoid, a feature not to be found in the genera hitherto described. Only two pterygoids are developed; the ectopterygoid (ect), bent, with the front part joining the palatine (pa), the hind part connecting with the entopterygoid (ept) and the anterior margin of the quadrate; the latter also joins the anterior broad part of the entopterygoid, which tapers backwards to a point without reaching to the symplectic. The outside of the entopterygoid is covered by the anterior preorbital bone (ao′), except in front, their upper margins being joined.

The short palatine (pa) carries a prominent maxillary process. The preoperculum (pro) has a short ascending part covering part of the front face of the hyomandibular and extending to the cheek, embracing the origin of the cheek-muscle; the horizontal part is long, in front joining the posterior preorbital (ao) and — with a long oblique suture — the quadrate; the inner face caries a horizontal ridge connecting with the symplectic; (behind and) below the cartilaginous proximal end of the latter is the articular fossa for the stylohyal. The whole outer face is sculp-

tured, a longitudinal ridge, beginning from about the posterior angle, and continued by the above-described ridge on the quadrate, separates the cheek face proper from the inwards sloping under face.

The typical three opercular bones are present; but the suboperculum (s) is concealed by the operculum (o) (Pl. V, fig. 5), and the interoperculum (io) is generally only to be seen from below.

The operculum is large, vaulted, its upper anterior angle, outside the articulation with the hyomandibular, is drawn out into a muscle-process; the concave inner face shows a strong muscle-ridge, starting from the lower margin of the articular fossa. The suboperculum is extremely thin, sickle-shaped, hidden by the lower part of the operculum, only its hinder end is sometimes seen projecting outside the operculum into the opercular membrane; the latter besides encloses the two long and slender branchiostegal rays (r). Interoperculum (io) thin, fairly high, pointed at both ends, the front end joined by the ligament (li) to the angular, the hind end by the ligament (li') to the hyoid (to the process of the latter below which the branchiostegal rays are attached).

The infraorbitals are represented by the two large bones ao and ao' (Pl. V, figs. 4, 5), which however do not contain any lateral-line canal. The posterior (ao) is situated in the normal position for the antorbital (or preorbital); it is bound by strong connective tissue to the prefrontal, and in front of this spot it is emarginated for the nasal opening; inside the connection with the prefrontal the upper margin is firmly joined to the upper branch of the symplectic; the lower margin is suturally connected with the preoperculum, the front margin with the anterior preorbital (ao'). The latter is more elongated, its upper margin joined to the upper branch of the symplectic and to the entopterygoid, the lower margin to the outside of the quadrate; the front margin is free. The convex outer face of both antorbitals is sculptured; between their inner concave face and the outer face of the true suspensory bones is the *Musc. adductor mandibulæ,* the tendons of which appear below the margin of the foremost preorbital, branching to the mouth parts.

It is a curious fact that some of the previous authors did not recognise these bones as infraorbitals in spite of their position outside the muscles, covering these. That some authors have regarded the anterior infraorbital as the metapterygoid might be excused by the circumstance that its upper margin is suturally connected both to the entopterygoid and to the symplectic and thus to a certain degree plays the part of a metapterygoid; but in some other Syngnathids (e. g. *Nerophis*) it does not enter between the suspensorial bones, and besides its relation to the musculature ought to have prevented the mistake. That the posterior bone must be homologous to the preorbital, I think nobody will question; but in teleosts generally no bones are found in front of the preorbital; nevertheless they may occur in some fishes, as I have shown to be the case in *Amphisile*, where 1—4 small bones appear in this position. That no canal for the lateral line is present in the infra-

orbitals of *Siphonostoma,* and other Syngnathids is in accord with the fact that all the other bones of the skull as well as the dermal plates of the body are devoid of canals; and besides, if infraorbitals are found in other members of the group "*Solenichthyes*" (which is the case with *Amphisile, Centriscus, Aulostoma*) they also lack canals.

In *Siphonostoma,* and the Syngnathids generally, the connection between the cranial beak and the suspensory bones appears to be somewhat looser or weaker than in the preceding genera.

The hyoid (Pl. VI, figs. 1, 4, 5) is short, reaching only about to the front end of the first gill arch; it is composed of but 4 pieces, no division between an epihyal and a ceratohyal being visible. If we compare this form with *Aulostoma* and *Fistularia* it seems possible that the ceratohyal has vanished, or has been fused with the large lower hypohyal (hy^{I}); but I have not been able to find any trace of a suture, neither in the hypohyal nor in the epihyal, which might indicate two constituents. The lower hypohyal is very large as in the other members of the "*Solenichthyes*", and also here a considerable part of it covers the inside (fig. 4) of the epihyal (eh), whereas the latter overlaps on the outer side (fig. 5). The upper hypohyal (hy^{II}) is very small, roundish; the stylohyal (st) short and stout, with the articular head facing outwards, and carrying on the inner side, below the articular head, a strong process, which is connected by ligament with the symplectic. The epihyal on its outer side has a strong, triangular process, and below this are fixed the two long and slender branchiostegals (r), the upper of which is the stouter; both follow the opercular margins to the small gill-slit close to the nape (Pl. V, fig. 5 r).

The glossohyal (Pl. VI, figs. 1, 10 gl) is long and slender; the foremost longer part is cartilaginous; the proximal osseous part hardly projects over the anterior end of the hyoid; behind it is closed, without cartilage (sometimes a small separate nodule of cartilage is found between it and the first basibranchial). The urohyal is fairly long, reaching backwards past the level of the articulation of the hyoid; in front it is broad, head-shaped, the remaining part laterally compressed. Only two ossified basibranchials (copulæ) are present; the first (co_I) follows immediately behind the glossohyal; its anterior end is without cartilage, the cartilaginous posterior end joins the cartilaginous front end of the second basibranchial (co_{II}); the posterior end of the latter reaches the hypobranchials (hy) of the second gill-arch. Sometimes an indication of a third basibranchial is found midway between the second and third arches in the shape of a weak lenticular nodule of cartilage.

As in *Aulostoma* and *Fistularia* the parts of the branchial arches belonging to the roof of the pharynx are reduced. The first gill-arch has only two parts, the ceratobranchial (c_I) and the epibranchial (e_I); the latter is rudimentary and widely separated from the first. The lower end of the ceratobranchial is completely

ossified, while in all the following it is cartilaginous. The epibranchial is sometimes incompletely ossified. The second gill-arch is composed of the typical 4 elements, the hypobranchial (hy_{II}) joins its fellow at the posterior end of the second basibranchial; its cartilaginous hind end passes without any articulation directly into the cartilaginous part of the ceratohyal (c_{II}); the latter is widely separated from the epihyal (e_{II}) which joins the considerably longer pharyngobranchial (ph_{II}). The third gill-arch is devoid of hypobranchial, its epibranchial separated from the ceratohyal but articulated to the pharyngobranchial; the latter (ph_{III}) is joined to the upper and inner side of the preceding pharyngobranchial. The fourth and fiftth arches have only the ceratobranchial. Thus the branchial apparatus is still more reduced than in *Aulostoma* and *Fistularia,* not only the second and third epibranchials but also the first being separated from their ceratohyals; the fourth pharyngobranchial is lost, as well as the hypobranchials of the first and third arches; but two basibranchials are present; no trace of teeth. As the interspaces between the arches in the ventral median line are rather large, the whole gill-bearing apparatus appears elongated and reaches farther back than is usual in fishes; accordingly the operculum is also elongated. The five gill-clefts on each side are surrounded by gill-rakers, which are pointed and fairly long and contain an ossification (sometimes divided into two, the point being separately ossified); the gill-rakers are never directly joined to the skeleton, but enclosed in the skin, the posterior or inner row being farthest away from the skeleton; they do not go beyond the boundaries of the ceratobranchials.

The pectoral arch. This part seems to have been thoroughly examined by only two or three authors, Parker (in his great work on the Shoulder-girdle (40) 1868), Smitt (54), and lately Goodrich (15). None of these authors have made out the facts correctly; consequently their interpretation cannot be correct.

It is well known that the dermal armature in all *Syngnathidæ* is composed of large bony scutes, arranged regularly in series and forming rings round the body. In *Siphonostoma typhle* each ring of the trunk anterior to the dorsal fin and the anal opening is composed of 7 plates (Pl. III fig. 2), 3 pairs — namely the superior (sl), median (ml) and inferior (il) lateral plates —, and one unpaired, the ventral plate. The interspaces between the large plates are filled out by small and thin ones forming one median series along the back, two along each lateral aspect (i) and one along each side of the belly. This arrangement is found immediately behind the pectoral fin. Anterior to the pectoral the arrangement is somewhat different. Here the clavicle (cl) forms part of the exoskeleton; the superior lateral plate is wanting, likewise the ventral plate; but in the closely related *Syngnathus* the ventral is present. In the dorsal median line is found an unpaired, rather thick and solid longitudinal plate (n), and anterior to this, behind the skull, a similar one, but smaller (n'). These two "nuchal" plates I regard as belonging to the endoskeleton, being in my opinion interspinous bones. Finally a plate is found, which seems to correspond to the true or median lateral plate of the following

rings; as it covers part of the muscles of the pectoral fin I propose to call it the "cover-plate" (c). The inferior lateral plate has the greater part on the ventral side, where it forms a large junction with its fellow from the other side; it may be termed the "jugular plate" (j).

In a slit between the clavicle and the "cover-plate" in front, and the lateral and inferior lateral of the first ring behind, the basals or pterygials of the pectoral fin are immovably fixed [17].

Closer inspection shows that the clavicular arch only contains the posttemporal and the clavicle; the supraclavicle and the postclavicle are wanting. The posttemporal is already mentioned under the skull. The clavicle (Pl. III, figs. 1, 2, 6, 7 cl) has somewhat the form of a T; the anterior end of the horizontal branch is connected through ligament to the posttemporal; besides this branch is immovably fixed to the transverse processes of the 2 foremost vertebræ. The outer face of the anterior part of the horizontal branch is smooth and excavated, forming the interior wall of the tube leading to the gills; the hind part of the branch and the uncovered part of the stem are sculptured in the same way as the dermal plates. The lower end of the stem or vertical part is bifurcated, the outer branch (o) being connected with the lateral part of the jugular plate, the inner (i) with the horizontal part of the same. Through the passage thus produced a ventral portion of the lateral muscles goes to the urohyal.

The scapular skeleton is extremely weak; the cartilaginous part, preserved to a small extent in all bony fishes, here forms the greater part of the whole; in fact the ossifications appear so small in proportion to the cartilage, that the latter has been mistaken by the previous authors for the whole scapular skeleton.

The very small scapula (sc) has hitherto been quite overlooked; the coracoid (co) being much greater has not escaped attention but has been interpreted as an "interclavicle". PARKER wrongly supposed that it was composed of two pieces, and hence he described 2 "interclavicles"; SMITT observing better only corrected to one "interclavicle". GOODRICH figures only a "coraco-scapular cartilage"; the ossified coracoid is not represented in his figure, and the small scapular ossification is given as the first of his "5 radials" (i. e. pterygials).

The scapular foramen, present in other Teleosteans, here forms part of the large opening between the clavicle and the scapular arch; just in front of the scapular ossification pass the same nerves and blood-vessels which otherwise go through the foramen scapulare.

The 4 basals or pterygials (ba) are of peculiar shape. Their middle part is a narrow stalk, basally and distally they are laterally compressed and broad; so far their form might easily be derived from that found in *Fistularia* and *Aulostoma*. But in the Lophobranch the distal part is on both sides provided with 2 or 3 thin processes, which at their end are flattened out into more or less irregular plates. The latter lean against the dermal skeleton; those of the inner face are

immovably joined to the lateral and inferior lateral plate, those of the outer face to the dermal part of the clavicle and to the "cover-plate". In this way the structural arrangement before-mentioned is brought about; the whole part, on which the pectoral rays play, is solidly fastened between the lips of the slit in the armature. Through the narrow apertures left between the component skeletal parts the tendons pass from the pectoral muscles to the base of the fin-rays, thus arranged between and conducted by a system of "coulisses". In this way the whole scapular system is strengthened by the dermal armature, and the extremely thin and fragile, mostly cartilaginous, apparatus is rendered capable of forming the base for such powerful muscles as are really found here.

The peculiar structure of the pterygials and the mechanical part it plays, has hitherto escaped attention; only PARKER has observed the bony processes, which he compares with stag's-horns without understanding their functions.

The cleft base of the fin-rays embraces a small nodule of cartilage, which forms the joint with the cartilaginous mass resulting from the fusion of the distal ends of all the pterygials.

The (14) pectoral rays are as usual composed of two lateral halves, but unjointed and unbranched.

Osteology of other members of the Syngnathidæ.

In the other Syngnathids which I have examined the main features of the vertebral column are the same as in *Siphonostoma typhle;* i. a. the vertebræ supporting the dorsal fin are always provided with a secondary transverse process in the shape of a wing behind the primary one, whether they belong to the abdominal or the caudal portion. *Syngnathus acus* and *rostellatus* show hardly any pecularities worth mentioning.

In *Nerophis* the three anterior vertebræ are still immovably joined together, but the third is more loosely attached to the second than in the genera *Siphonostoma, Syngnathus* and *Hippocampus*. In *Nerophis æquoreus* the greater part of the dorsal fin is situated on the abdominal vertebræ. In two specimens (♀) 12 resp. 11 vertebræ are modified to this end, 8 belonging to the abdominal, 4 or 3 to the caudal series; the groups of interspinous bones are the following:

A: 6, 4, 4, 3, 4, 3, 3, 3	4, 3, 3, 6 *
B: 4, 4, 4, 3, 4, 3, 4, 3	4, 4, 3.

All the abdominal vertebræ are long, with stout transverse processes, distally expanded and more directed downwards than in *Siphonostoma,* probably corresponding to the more compressed shape of the body; besides, these processes are somewhat nearer to the front end than in *S.* The first caudal has a well-developed inferior (hæmal) arch; the last vertebra carries a single vertical plate, probably

* The three hindmost of the last group are densely crowded together.

representing two fused hypurals and the urostyle, and embraced by 7 fin-rays; the latter are all really ventral to the end of the chorda. The dorsal interspinous bones are relatively longer, the spinous processes lower than in *Siphonostoma;* they possess similar but more regular expansions (cfr. Pl. IV, fig. 12). Anal fin and anal interneurals are wanting.

Nerophis ophidion has similar vertebræ to the preceding species; only the last caudal vertebra is without any plate, the caudal fin being absent. The dorsal fin is for the greater part situated on the tail. A specimen (♀) with 34 dorsal rays has its dorsal fin supported by 11 vertebræ, 3 abdominal and 8 caudal; the grouping of the interneurals is the following:

3, 3, 4 | 3, 3, 3, 2, 3, 3, 4, 3.

The caudal vertebræ, except the last, are provided with hæmal arches; the last vertebra is rudimentary, without any processes save an indication of transverse processes. The number of caudal vertebræ in this specimen is 74!

In *Hippocampus* the vertebræ are shorter and stouter than in the preceding, elongated genera, but the general shape is the same. Also here the 3 anterior are immovable and first and second firmly joined to the clavicle. In the two species examined (*H. brevirostris* and *longirostris*) there are 11 abdominal vertebræ; the dorsal interspinous bones are connected with the two foremost caudal vertebræ (*H. brevirostris*, Pl. IV, fig. 2) or besides with the last abdominal (*longirostris*). The first caudal vertebra has a hæmal arch but open below, sometimes joined to the next, which also may be open below. The hæmal arches of the two anterior caudal vertebræ are directly in connection with the interspinous bones for the anal fin (Pl. IV, fig. 2). The secondary transverse process is very long, only separated by a narrow slit from the primary one on the vertebræ supporting the dorsal fin. The hæmal arches are considerably stouter than in the elongated genera, and, as the vertebræ are shorter, the protection of the large subcaudal blood-vessels is much the same as in other fishes. The spinous processes are somewhat more strongly marked than in the other genera. The last vertebra rudimentary.

In *H. brevirostris* (♂) the number of vertebræ is found to be: $37 = 11 + 26$.

The 15 (*H. brevirostris*) or 16 (*H. longirostris*) dorsal interspinous bones are bisegmented; the distal segment is a small cartilage; the proximal segment longer than in the preceding genera; the lateral expansions for connection with the 3 upper lateral plates of the armour are directed obliquely downwards. The row of interneurals is rather densely crowded, but two fanshaped groups may easily be distinguished, one for each supporting vertebra (8 and 7 members). In each group the lateral expansions are directed towards the middle, pointing backwards on the anterior members and forwards on the posterior.

The anal fin in *H. brevirostris* has 3 bisegmented interspinous bones (not fused together); the terminal segment is a small cartilage, the proximal is long, reaching

to the hæmal arches of the two foremost caudal vertebræ; the fin-muscles originate only from the first. The anterior interneural is somewhat stouter than the others and with well-developed expansions for connection with the foremost pair of lower lateral plates, which bound the anal space; on the following interneurals the expansions are only indicated.

H. longirostris seems only to possess two anal interneurals.

The number of fin rays in the dorsal fin is 17—18, in the anal 4; their structure is as in the preceding genera [18].

The other Syngnathids examined show essentially the same structure of the skull as *Siphonostoma*. *Syngnathus* (*acus* and *rostellatus*) only differs in minutiæ in the outline or form of some of the bones. In *Nerophis* (*æquoreus* and *ophidion*) (Pl. V, figs. 10, 9) the most conspicuous differences are the following. The entopterygoid is longer and joins the upper branch of the symplectic. The posterior antorbital (ao) is considerably more elongated, in *N. æquoreus* reaching past the suture between the mesethmoid and vomer, while the anterior is much smaller and not in contact with the cranial beak (very often it is almost rudimentary, not reaching behind to the posterior preorbital); along the latter, therefore, the entopterygoid (ept) is uncovered for a long way; the front margin of ao' almost reaches the suture between the quadrate and the ectopterygoid. The bones of the skull, the suspensorial parts are stouter, the maxilla broader and stouter etc. than in *Siphonostoma*. In *Nerophis ophidion* the snout is short and stout, the mesethmoid and vomer therefore particularly powerful. In both species these two bones are about of equal length. The nuchal tendons, fastened to the epiotics, are ossified in *Ner. ophidion* (fig. 9 t), as in *Aulostoma, Fistularia* and *Solenostomus*, but unossified in *N. æquoreus*.

In *Hippocampus* (Pl. V, fig. 6) the differences seem more obvious; they are partly due to the large spines on the frontals, the smaller ones on the mesethmoid and supraoccipital, but besides, the braincase proper is relatively larger in proportion to the snout, the latter being not only shorter but also broader than in the preceding genera. The nuchal face is oblique in the opposite direction, from below upwards and backwards; the supraoccipital and its crest is much larger, forcing the epiotics (ep) down on the sides of the skull and giving attachment to the tendons (at *), which in the other genera are fastened to the epiotics. The posttemporal (pt) sends out from its lower margin a process (p) to the lateral wing of the exoccipital. The hyomandibular (fig. 7 hy) is much longer, and somewhat more sloping forwards, the ascending part of the preoperculum (pro), therefore, longer. As in *Siphonostoma* the entopterygoid does not reach the symplectic. The operculum is higher than long, the subopercule extremely reduced, never visible from without (and very easily overlooked); the interopercule short but high. There are three antorbitals (ao, ao', ao''). The same is found in the other genera of the Hippocampine group, e. g. *Solenognathus (hardwickii)*, *Gasterotokeus* and *Phyllopteryx (foliatus)*. The posterior antorbital (ao) is small, especially in *Phyllopteryx* (Pl. V, fig. 8); in the latter the elongated middle antorbital (ao') is

provided with a hooked spine, pointing backwards. Also here the nuchal tendons appear to be fixed to the supraoccipital; the braincase is upon the whole similar to that of *Hippocampus*, but the snout is long and slender, and more than half its length is due to the mesethmoid.

In *Syngnathus* the branchial apparatus is like that of *Siphonostoma*, but in the other genera it differs considerably. In *Nerophis* (*æquoreus* and *ophidion*) the hyoid has only three pieces, the upper hypohyal, which in *Siphonostoma* is very small, being lost; there is only one branchiostegal, which bifurcates distally and is fixed to the inner side of the epihyal. The glossohyal is short but with long anterior cartilage, the urohyal long and stout. The gill-bearing part is still more elongated (Pl. VI, fig. 12); there are the same two basibranchials, but the first arch is provided with a hypobranchial, while all the following are devoid of hypobranchials; every trace of epibranchials is wanting, and the pharyngobranchials are reduced to one on each side, probably representing that of the second arch.* The gill-rakers are similar to those in *Siphonostoma.*

In *Hippocampus* (Pl. VI, fig. 11) (*brevirostris* and *longirostris*) the glossohyal (gl) is very short, the urohyal short and stout; the hyoid and the branchiostegals as in *Siphonostoma.* Basibranchials are totally absent. The first gill-arch possesses a hypobranchial and an epibranchial; the hypobranchial is longer than the ceratobranchial, and provided with flat lateral expansions; it is almost parallel to its fellow from the opposite side, or only feebly converging in front. The second arch is complete, having a pharyngobranchial, in the third only the hypobranchial is wanting. Thus, except the first arch, the gill-arches agree with those of *Siphonostoma.* The gill-rakers are somewhat longer than in the latter, but their ossified axis is confined to the basal part only.

The following tabular view of the genera examined will show the main features of the branchial apparatus:

Siphonostoma and *Syngnathus.*

Gill arch	(Copula) Basibr.	Hypobr.	Ceratob.	Epib.	Pharb.	Gill-rakers 1st row	Gill-rakers 2nd row
I	+		+	+		+	+
II	+	+	+	+	+	+	+
III	(+)		+	+	+	+	+
IV			+			+	+
V			+			+	

* Sometimes it may on the one side be divided in the middle by an articulation (representing 2d and 3d pharyngobranchial?); upon the whole it is often somewhat differently shaped on the two sides.

Nerophis.

Gill arch	(Copula) Basibr.	Hypobr.	Ceratob.	Epib.	Pharb.	Gill-rakers 1st row	Gill-rakers 2nd row
I	+	+	+			+	+
II	+		+		+	+	+
III			+		(+)	+	+
IV			+			+	+
V			+			+	

Hippocampus.

Gill arch	(Copula) Basibr.	Hypobr.	Ceratobr.	Epib.	Pharb.	Gill-rakers 1st row	Gill-rakers 2nd row
I		+	+	+		+	+
II		+	+	+	+	+	+
III			+	+	+	+	+
IV			+			+	+ [19]
V			+			+	

Pectoral skeleton. *Nerophis* has no pectoral fins in the adult state; only the larvæ possess well-developed pectorals, but without rays. In *Nerophis* the "pectoral ring" is composed mainly as in *Siphonostoma*, the only difference being that the second nuchal plate is joined to the clavicle, and the "cover-plate" is absent. As there is no slit in the armature for the missing pectoral fin the lateral plate of the following ring joins firmly on to the clavicle.

The clavicle is of the same type as in *Siphonostoma*, but every trace of the scapular arch has vanished together with the fin-muscles.

In *Hippocampus* (and its allies) the clavicular and scapular arches and the pterygials are in the main as in *Siphonostoma*[20]. The pectoral ring does not materially differ from that of *Siphonostoma*. Comparing the figure (Pl. III, fig. 3) with the other one (fig. 2), the same constituents will easily be found. In *Hippocampus* there are 3 nuchal plates, the posterior is generally not to be found in the Syngnathine group. The anterior fig. 3 n' is of very peculiar shape, joining the skull and apparently forming the top of the bent head, often described as the "corona". This part is wanting in some members of the Hippocampine group (*Gasterotokeus*, *Phyllopteryx*) but present in *Solenognathus*[21]. In *Phyllopteryx* the hindmost nuchal is provided with a long bony style, like the top of the supra-occipital, and several (paired) styles from the dermal armour supporting the curious dermals flaps characteristic of the genus.

Visceral anatomy.

All Syngnathidæ possess 4 complete gills and a well-developed pseudobranchia, consisting of 3—4 lamellæ (4 in *Siphonostoma*, 3 in *Nerophis* and *Hippocampus*) of the same structure as those of the branchial arches. The upper gill lamellæ of each row take their origin from the pharyngeal wall, as in *Fistularia* and *Aulostoma*. On each side are 5 gill-slits, which do not reach farther dorsally than the ceratobranchial part of the arch; the anterior slit, between the hyoid and the first gill-arch, is much smaller than the following 4. The gill-rakers have already been mentioned, as also the fact that the structure of the gill-lamellæ does not materially differ from that of other teleostean fishes. For further information about the latter point I may refer to DUMÉRIL (12 a, p. 148 and b, p. 480), where the older literature is cited, and to RYDER (48, p. 193) and HUOT (19, p. 220).

The anatomy of the internal organs has been worked out and more or less completely described by several authors, among whom, besides those quoted by DUMÉRIL, I might mention RETZIUS, KRÖYER, LILLJEBORG and HUOT. Here I need only point out, for comparison with the other genera under consideration, that the intestinal canal is simple,* (straight or nearly so in the elongated forms, coiled in *Hippocampus*), apparently without distinct stomach, the boundary between the stomach and intestine being only marked off by the entrance of the bile-duct, without pyloric appendages and without mesentery (or only with rudiments of the latter, as in *Hippocampus*, cfr. MOREAU (36, p. 30)). The liver is not lobed, provided with a gall-bladder lying in an incision of its right side. The aorta follows the left side of the vertebral column. The air-bladder is present and provided at its anterior end with a "red gland". A urinary bladder is developed. The kidneys show peculiarities hardly found in any other Teleosteans. Such are the complete absence of Malpighian corpuscles (a feature only occurring also in the related genus *Solenostomus*), the situation of the whole kidney-substance, carrying urinary tubules and both urinary ducts, on one side of the body cavity, the right, following the strongly developed right cardinal vein (the left appears to be absent). Further ought to be noted the fact, that the pronephros or at any rate the large pronephric corpuscle and glomus and the coiled-up anterior part of the pronephric duct, structures so evident in other teleostean larvæ, here appear to be completely absent in the newly hatched larvæ (from the marsupium) and never to be developed later. Also the simple structure of the genital gland in the male, the testis being tubiform with central canal (cfr. JUNGERSEN 23 a, p. 119, German translation p. 203), is a feature which among many others shows that the Syngnathids have deviated strongly from a normal type and have been highly specialized [22].

* A fact already known in 1673 to my countryman OLE BORCH (OLAUS BORRICHIUS) for *Syngnathus* (3 p. 159).

Solenostomidæ.

Solenostomus.

The genus *Solenostomus*, founded in 1803 by LACÉPÈDE (31, p. 102),* has been grouped with the *Syngnathidæ* since the days of CUVIER (9a, p. 157), in modern times always as representing a distinct family. The species of the genus seem always to have been rare in collections, a fact which explains that their anatomical structure has never been thoroughly worked out. The only anatomical accounts known to me are those given by PALLAS (39, p. 35) and by GÜNTHER (16b, p. 151); both are very incomplete and contain some errors. Most authors have confined themselves to renewed descriptions of the oldest known species, or besides to the establishing on quite external characters of a few (3) new ones. The material which I have had the opportunity to examine only contains two species: *Sol. cyanopterus* Blk. and *Sol. paradoxus* (Pall.), and I greatly doubt the existence of more than these two species. Of both I have had at my disposal male and female specimens, all from Japan. For this most valuable material I am greatly indebted to Dr. SHIGEHO TANAKA and Mr. ALAN OWSTON.

The geographical distribution is very wide, and the two species seem to occur at the same localities; in fact both *S. paradoxus* and *cyanopterus* have been taken together at Boshu, Japan (JORDAN 1901), and specimens of both species are present in my collection from Japan from localities which are not far from each other; according to DUMÉRIL both are found at Mauritius (Isle de France).** The geographical range embraces the Indian Ocean and the western part of the Pacific, from Zanzibar to New Guinea and to the eastern coasts of Japan. Inside this wide area the localities where specimens actually have been found are rather few and scattered; no captures at the coasts of the continents or the great islands have hitherto been mentioned (or at all events distinctly stated). All the localities known to me from the literature and from Museum-specimens, which I have had the opportunity to see, are the following: Zanzibar (*S. cyanopterus*); Mauritius (*S. cyanopterus* (= *bleekeri*), *S. paradoxus*); Maldives (*S. paradoxus*); Amboyna (*S. paradoxus* (and "*brachyurus*")); Ceram, Wahai *** (*S. cyanopterus*); New Guinea (*S. cyanopterus*); "China" (*S. cyanopterus*);

* The name *Solenostomus* (1815 altered by RAFINESQUE to *Solenostoma*) was originally used by KLEIN 1744 for some true *Syngnathidæ*, later, 1761, by SEBA for a species of the present genus, described in Thesaurus, Vol. 3, p. 106 and figured ibid. Pl. 34, fig. 4. This species is generally interpreted as identical with *Sol. paradoxus* (*Fistularia paradoxa*) of PALLAS, which also in my opinion is correct (cfr. for example the shape of the caudal peduncle).

** if *S. bleekeri* is = *cyanopterus*.

*** This locality, given by BLEEKER (2 p. 308) in the following words: "Habit. WAHAI, Ceram septentrionalis, in mari", has led to the erroneous conclusion that *Solen. cyanopterus* also occurred at HAWAII, in the Pacific! We meet the misunderstanding for the first time in KAUP (25 p. 2), who says: "Dr. Bleeker obtained his specimens in the sea of Hawaii and Ceram"; later we find it in JORDAN and SNYDER (22, p. 4) and in JORDAN and EVERMANN (21 b, p. 118); the latter say: "The only Hawaiian reference is that given by Bleeker. It is doubtful if the species really occurs in these islands"; and in the Synonymy they quote "Bleeker 1854, Natuurk. Tijdschr. Nederl. Indie, VI, p. 507, HAWAII and CERAM".

Boshu (Awa), Japan (*S. cyanopterus*, *S. paradoxus*); Jogashima, Japan (*S. cyanopterus*); Yenoura, Japan (*S. paradoxus*); Yodomi, Japan (*S. paradoxus* ("*leptosoma*")). All the Japanese localities are from the eastern coast of Hondo near the entrance to the Bay of Tokyo. Regarding their habits nothing definite is known; they most likely occur among sea-weeds, probably in shallow water; in fact two specimens of *S. cyanopterus* Jogashima kindly sent by Dr. TANAKA were taken "among sargassum". The time of breeding is unknown; I may only mention that a female *S. paradoxus* in my possession taken at Yenoura, Suruga Gulf, $^{7}/_{12}$ 1903, carried eggs with embryos and hatched embryos in the pouch.

As all current descriptions contain some more or less grave errors I have found it advisable to conclude my account of the anatomical structure with a revised definition of the genus and of the two species examined.

The following anatomical description has mainly been based on specimens of *Sol. cyanopterus*; the few points in which *Sol. paradoxus* differs are so small and insignificant that they can most conveniently be included in the definition of this species as given below.

Before describing the structures found by dissection I wish to point out a few features visible from without which seem not to have been observed hitherto or at least not to have been noted in the descriptions or figures known to me.

Such are the peculiar small cutaneous prolongations or "villi" scattered over a great part or most of the skin, also on that of the fins. In some specimens they are all quite small and difficult to see, in others some of them are at certain places rather prominent and easily seen, showing a tendency to symmetrical arrangement. The smallest ones are simple, low elevations, or like bluntly conical warts; the more developed are not only larger but may be more or less branched. In male specimens of *S. cyanopterus* they are specially large and frequently branched behind the anus, at the posterior margins and on the ventral sides of the "hump" carrying the anal and second dorsal fins; in some specimens in the British Museum very visible papillæ form a ring round (on) the eyeball, and these papillæ seem always to be present, but often difficult to see. They occur in both sexes and in both species examined,* but seem to be very variable as to their number and development (seasonal? perhaps more strongly developed at breeding time?)[23]. At the mandibular symphysis *S. cyanopterus* has a well developed barbel; in spite of its size it has hitherto been overlooked, most likely because it is concealed between the mandibular rami. In *S. paradoxus* it seems less developed.

In addition to the well-known sexual difference shown by the ventral fins,

DUMÉRIL gives the name correctly (12 b, p. 498): "Les 3 indiv. décrits par M. Bleeker . . . ont été pris dans la mer, à l'île Wahai et au nord de l'île Ceram". Wahai is (according to Andree's and Stieler's maps) a town on the north coast of Ceram.

* In 2 specimens of *S. paradoxus* in the Brit. Museum (a from Amboyna, Dr. Bleeker's collection, b from the Maldives, coll. S. Gardiner) I found them strongly developed; less visible on most of the specimens of *S. cyanopterus*, but always distinguishable, mostly so on spec. g (from China, coll. by Sir E. Belcher).

another is to be found in the nasal organ. The triangular fossa just anterior to the eye, where the nasal openings ought to be, shows in the male its hind part beset with thin cutaneous lamellæ radiating from beneath a flap hanging down from the upper margin of the fossa (Pl. VII, fig. 6). The lamellæ are thin, low at their upper end, enlarged below into projecting flaps; they are richly provided with blood-vessels; in each a small vessel follows the margin and breaks up into a network in the interior. In the female the skin of the fossa is smooth and even. Any real nasal openings I have not been able to detect.

In the male of *Sol. cyanopterus* the height of the snout at the middle of its length is greater than in the female, and the whole profile of the anterior part of the head is different (cfr. fig. 6, Pl. VII). The proportions of the height of the snout to its length (from the front margin of the eye to the end) are in the male about as 1 to 3, in the female ca. 1 to 4. In *Sol. paradoxus* there seems not to be any marked sexual difference in the form of the snout; but the material of this species at my disposal is too scanty and besides not well enough preserved for settling this point with certainty.

No lateral line canals are to be found, neither on the head nor on the body.

The following measurements have been made on 5 specimens of *S. cyanopterus* and 2 of *S. paradoxus*. Of *S. cyanopterus* specimens A and C are from Zanzibar, kindly lent me from the R. Museum at Berlin, the others, *S. paradoxus* included, are from Japan (*S. cyanopterus* B and D from Jogashima, E from Boshu, Sagami Sea; *S. paradoxus* B from Yenoura, Suruga Gulf).

Mm.	*Solenostomus cyanopterus*					*S. paradoxus*	
	♂ A	♂ B	♀ C	♀ D	♀ E	♂ A	♀ B
From snout to end of caudal fin	96	105	109	92	125	61	94
„ „ „ end of tail	65	71	81	65	95	46	68
„ „ „ nape	29	30	33	27	38	19	26
„ „ „ front margin of eye	22	21	26	20	29	15	19
Height of snout at its middle	8	8	7	5,5	7—8	2	3(2,8)
From foremost caudal fin-ray to end of caudal fin	36	41	32	30	32	17	28
Length of ventral fin	20	20	22	18	31	10	17
Height of first dorsal fin	17	17	17	15	20	11—12	15
Greatest height of thorax, between D_1 and V	13,5	13	16,5	14	22	9	10
Height of narrowest part of body	6	6	6	6 (5,8)	7	3	4
„ between D_2 and A	10	12	13	10	16	6—7	7
Length of tail, from anus	8	14	15	14	17	10	15
„ of vertebral column	40	42	45	40	55	27	40—41
From gill-slit to anal opening	21	27	30	24	38	16—17	26

Exoskeleton.

The dermal skeleton (Pl. VII, fig. 6) is composed of large ossifications arranged in transverse and longitudinal series, leaving large interspaces of naked skin. The shape and arrangement as well as the number of these ossifications are almost the

same in both species. Only on the high part of the body, anterior to the first dorsal and the ventrals, do unpaired ossifications occur, a row of 5 scutes forming an uninterrupted keel along the median dorsal line, while another, but interrupted, series, composed of 4 (exceptionally 5 or 3) median scutes, is found along the ventral margin. The members of the dorsal row are more or less cruciform, their longitudinal stems suturally united together, their transverse branches — except that of the first — united to the uppermost members of each of the paired transverse series. The scutes composing the latter are star-like, their branches mostly joined together, thus forming a kind of meshwork; the ventral members meet their fellows from the other side or are firmly united to the median unpaired ventral scutes. In this way the whole forepart, anterior to the fins, is apparently made immovable, forming a kind of "thorax". Of the transverse rows on each side of the "thorax", 3 behind the pectoral are most regular; in front of the pectoral the clavicle (cl) enters between the dermal ossicles, and the arrangement appears less regular. The hindmost of the 3 regular series consists of 6 members, the ventral of which is joined to the posterior median scute (No. IV); the upper 4 are not connected with the next row in front. This row contains 4 scutes, the ventral of which is joined to the median scutes II and III. All 4 members are connected with the 4 forming the next transverse row; the ventral scute of this row meets its fellow from the opposite side and moreover joins the unpaired scute No. II; the second upper one is connected with a branch of the clavicle. The next transverse row just in front of the pectoral also contains 4 dermal scutes; the ventral joins its fellow from the opposite side; between the uppermost and the second upper enters the clavicle, combining through a separate process with each. No more complete transverse series are to be found, the shoulder girdle forming the greater part of the skeleton at the anterior border of the body; only ventral dermal scutes are present corresponding to the ventral members of the transverse rows. The foremost pair always meet in the ventral median line, while behind them is interposed, between the next pair, the foremost unpaired scute I. Comparing several individuals some minor irregularities may be found in this region, while the more complete transverse series always seem to be identical as to arrangement and number.

Behind the thorax, on the slender part of the body and on the tail, an arrangement of the dermal scutes in vertical transverse rows is more or less pronounced, but in accordance with the greater mobility of this part the connections between the component members are partly dissolved, and no unpaired median scutes are found nor any junction between the scutes of the opposite sides at the margins of the body. Apart from the higher, hump-like, part carrying the second dorsal and the anal each transverse row is composed of 2 or 3 members, rows of 3 alternating — but not quit eregularly — with rows of 2. In some of the 3-membered rows the members may be more firmly connected, in others only loosely or not at all, and the rows do not always correspond on both sides; that is to say, the same row which on the right side consists of 3 members may on the left only possess

two, and vice versa. At the end of the tail the rows are often incomplete, lacking upper or lower members. On the "hump" 3 large, anchor-shaped, marginal scutes are developed, reaching from the base of the second dorsal and the anal to the nearest members of the ordinary rows, being joined to these or interposed between them; thus, on this part of the tail, transverse rows of 5 or 4 members are found, and probably a certain amount of stiffness is acquired in this way. Sometimes only the dorsal set is firmly connected with the neighbouring upper scute, while the ventral set is interposed between the corresponding lower ones, sometimes the reverse is the case, and in some specimens both sets are firmly connected. In one (female) specimen of *S. paradoxus* 4 anal marginal scutes occur instead of 3.

Setting aside the marginal scutes of the "hump" the other scutes might as well be described as longitudinally arranged in 3 lateral rows*, an upper, a median, composed of fewer but larger members, and a lower. The number of scutes in the upper and lower longitudinal rows generally differ slightly, the one having one or two more than the other, and generally the number is not quite the same on both sides; the latter is also the case with the median row (comp. the table below, where the numbers are given). The shape of the scutes is more or less that of a star, with 4 or 3 branches. All the dermal scutes are provided with keels, most prominent in *S. paradoxus,* here producing a spiny aspect especially on the slender part of the body and on the tail.

The total number of transverse rows behind the pectorals, which naturally is the same as that of plates in the upper and lower longitudinal rows of body and tail, is for *S. cyanopterus* 28—30, for *S. paradoxus* 29—33 (for details comp. the table below).

Number of dermal scutes.

	Narrow part of trunk + tail				Total number of transverse rows, including the 4 on "thorax"	
	Median lateral row		upper / lower lateral rows			
	left side	right side	left side	right side	left side	right side
S. cyanopterus						
A ♂	13	13	26 / 26	26 / 26	30	30
B ♂	13	14	26 / 24	26 / 25	30 (28)	30 (29)
C ♀	12	13	25 / 24	25 / 24	29 (28)	29 (28)
D ♀	13	11	25 / 25	25 / 25	29	29
E ♀	15	15	24 / 24	25 / 24	28	29 (28)
S. paradoxus						
A ♂	13	13	28 / 25	26 / 28	32 (29)	30 (32)
B ♀	20	21	28 / 28	29 / 28	32	33 (32)

* Günther (16 b, p. 151) only counts 2 rows; probably a misprint or a lapsus calami, since previously (42, p. 137) he gave the number correctly as 3.

Endoskeleton.

The vertebral column (Pl. VII, fig. 3) is composed of 33 vertebræ, 19 abdominal and 14 caudal. Ribs are wanting. The 3 anterior vertebræ are suturally united, the remaining only connected by means of the corpora, no articular processes being developed.

The 5 anterior vertebræ are larger and stouter than the rest, especially the 2nd and 3rd are large; from the 6th the vertebræ decrease in size backwards, only the last being again somewhat enlarged and together with the last but one expanded into a large vertical plate supporting the rays of the caudal fin.

Strong anterior articular processes on the 1st vertebra overlap corresponding processes on the exoccipitals, allowing the skull to be moved vertically. The tendons for the muscles which raise the head are ossified (as in *Fistularia, Aulostoma, Nerophis ophidion*), forming on each side a large flat bone, in front fastened to the epiotic, behind dissolving into numerous fine threads (Pl. III, fig. 10 td). Posteriorly the 1st vertebra is immovably joined to the 2nd by means of strong denticulations, and in the same way the second joins the third. Spinous processes are developed on all the vertebræ. Transverse processes are wanting on the anterior 4 and only indicated on the 5th; from the 6th on all the remaining abdominal vertebræ show a well-developed transverse process, increasing in size backwards and becoming more and more directed downwards; on the first caudal it joins its fellow from the opposite side forming a strong laterally compressed inferior spine. No "secondary" transverse processes occur on any of the vertebræ.

The superior and inferior spinous processes on the 9th or in another specimen the 10th caudal (the 28th or 29th vertebræ) are almost vertical, those on the following inclined or bent forwards; this position is apparently due to the extreme development of the parts supporting the caudal fin. On most of the vertebræ a process occurs from the base of the neural arch behind the spinous process and a similar one ventrally in the corresponding position (i. e.: on the abdominal vertebræ behind the transverse process, on the caudal behind the inferior arch). On the penultimate caudal vertebra these processes are fused with their fellows from the opposite side, distally expanding into a large, laterally compressed plate. Probably the still larger plate surrounding the last vertebra is made up of corresponding elements fused with the true upper and lower spines and the hypurals. To elucidate the exact composition of this ray-supporting apparatus an examination of sufficiently young specimens would be necessary. That the extraordinarily large size of the caudal plate is caused by the great development of the fin is very evident and needs no further explanation.

If we compare the vertebral column with that of the Syngnathidæ the chief points of resemblance seem to be the intimate connection of the 3 anterior vertebræ and the absence of articulations between the neural arches of all the other vertebræ; in general shape there are no obvious resemblances, neither with the Syngnathidæ nor with *Fistularia, Aulostoma* or *Centriscidæ*.

As the muscles for the second dorsal (and the anal) do not show any particular development and as correspondingly no muscular processes on the vertebræ supporting these fins are present either, we are justified in supposing that these fins are not used for locomotion in the way characteristic for the Syngnathidæ[21].

The interspinous bones of the first dorsal fin are unisegmented, 5 in number. The first is broad and stout, its lower end bifurcated, in one specimen skirting over the tip of the spinous process on the 6th vertebra; the anterior branch forms a broad plate, the front margin of which seems firmly connected at its lower extremity with the underside of the 5th median dermal scute; the posterior branch is narrow but fairly strong; together with it the following 3 interspinous bones are enclosed in the space between the spinous processes of the 6th and 7th vertebræ, closely packed together; the fifth interneural is a short broad plate, firmly embraced by the bifurcated tip of the 8th vertebral spine. Thus the supporting apparatus for the large rays of the first dorsal is in this way considerably strengthened.

The interspinous bones of the second dorsal and the anal are bisegmented, the distal segment being only represented by a cartilaginous nodule, very much like that of the Syngnathidæ.

The second dorsal fin is supported by 17 interspinous bones. Distally the 1st is laterally compressed, flattened out into a plate supporting the anterior corner of the dorsal "hump"; in a similar way the posterior corner of the hump is strengthened by an expansion formed by the fusion of the distal parts of the 2 or 3 hindmost interneurals. The 3 anterior are enclosed in the space between the spinous processes of the 1st and 2nd caudal vertebræ, the following 3 or 4 between the 2nd and 3rd, next 3 or 4 between the 3rd and 4th, then 4 or 5 between the 4th and 5th, and finally 2 or 3 behind the latter. There are no connections with the marginal scutes of the dermal skeleton, consequently the bony expansions at the distal end of these interneurals characteristic for the Syngnathidæ are not developed here.

Those of the anal fin are likewise 17 or 16, the anterior 2 distally fused together, and the same is the case with the posterior 3 or 2. The first is situated in front of the inferior spine of the first caudal; the following interspace encloses 3, the next 3 each have 4, and the last very short one lies behind the inferior spine of the 5th caudal.

The 5 fin-rays of the first dorsal are strong and long, pointed, without any longitudinal or transverse division; they are to be regarded as spinous rays.

The number of rays in the 2nd dorsal and the anal (in the specimens examined by me) is 18—20 in *Sol. cyanopterus,* 21—22 in *S. paradoxus* (comp. the tab. p. 322 [56]); that of the caudal fin always 16. The fin-rays of the 2nd dorsal and of the anal are feeble, unbranched but ending in a bundle of extremely fine threads; the distal part of most of them is transversely jointed, only some of the anterior are without joints. The caudal rays are comparatively strong, the median

and longest less strong; all are simple, unbranched, evenly tapering and pointed; viewed under a microscope their distal part appears longitudinally divided, but the two halves are tightly adpressed; no joints (or only a few and indistinct traces) are to be seen[25].

The cranial skeleton. In general appearance the head resembles that of a Syngnathid. In proportion to the brain-case the snout part is extremely prolonged and strongly compressed laterally. As in Syngnathids the quadrato-mandibular articulation is situated almost below the front end of the vomer, thus the position of the mandible when the mouth is closed is almost vertical (opposite to the case in *Fistularia, Aulostoma* and *Centriscus,* but agreeing with *Amphisile, Siphonostoma* etc.). On the upper side of the skull 3 crests are observed, one median, shorter, on the supraoccipital, and 2 lateral, longer, beginning at the hind margin of the epiotics, running forwards on the frontals, rising in height over the orbits and from here converging towards the mesethmoid, where they merge into one sharp edge just above the anterior ends of the nasal fossæ. The crests are (or may be) finely denticulated (especially in *S. paradoxus*).

The supraoccipital joins the frontals; parietals (and opisthotics) are absent.

The epiotic is large; just below the posterior end of the crest mentioned above an ossified tendon for the strong nuchal muscles is fastened (cfr. p. 315 [49]), and below this bone the epiotic is connected with the upper fork of the posttemporal (pt). The exoccipital carries a lateral process for connection with the articular process of the first vertebra; both exoccipitals meet above the occipital foramen. The articular face of the basioccipital is concave, oblique in position, sloping from behind forwards and downwards. On the lower face of the skull the basioccipital is laterally expanded (above the parasphenoid) and in front separated from the prootic by a narrow cartilage (as in *Syngnathus*). The pterotic (sq) is large, reaching the basioccipital below and thus intervening between the exoccipital and the prootic. Posteriorly the pterotic carries a crest, connected with the lower fork of the posttemporal; in front it forms together with the prootic the posterior articular face for the hyomandibular, while the anterior articular face belongs to the prootic and postfrontal.

The greater part of the cranial "beak" belongs to the mesethmoid. This bone embraces most of the nasal fossa, forming the greater part of its roof and floor and its whole median wall, while the rest of the fossa is bounded by the frontal and prefrontal. Just in front of the nasal fossa the mesethmoid carries a strong lateral spine, which may be more or less branched, and seems most strongly developed in *S. paradoxus.*

The vomer (vo) is short in proportion to the mesethmoid, laterally compressed towards its front end. As in *Syngnathus* a small rounded rostral cartilage is present. The posterior end of the vomer underlies only the foremost part of the mesethmoid, reaching behind about to the level of the oblique suture between the

quadrate and the symplectic, ending far in front of the parasphenoid. The anterior end of the parasphenoid is found at a level with the middle of the nasal fossa. Thus a large part of the lower face of the mesethmoid intervenes between the vomer and parasphenoid forming alone the roof of the mouth-tube as in *Fistularia* and *Aulostoma;* this part of the mesethmoid is excavated below, with projecting margins, to which the suspensory bones (entopterygoid and mainly the symplectic (sy)) are fastened. The parasphenoid forms an obtuse angle below the posterior margin of the orbit and reaches along the prootics and basioccipital almost to the articular condyle of the latter. At the posterior orbital wall the parasphenoid sends out an ascending process to meet the front part of the prootic and the alisphenoid. Between this process and its fellow from the opposite side the upper face is somewhat hollowed for the attachment of the inferior musculi recti of the eye. As far as I could make out no bridging over of this muscular fossa by the prootics or alisphenoids is found, and consequently no "myodoma" is developed. The alisphenoid is fairly large, forming part of the orbital wall between the frontal, postfrontal, prootic and ascending process of the parasphenoid.

The intermaxilla (i) has a distinct but small ascending part connected with the rostral cartilage; the maxilla (mx) is relatively large, as usual connected with the vomer and rostral cartilage and with the maxillary process of the palatine. The lower jaw (Pl. VI, fig. 6) seems only to be composed of the articular (ar) and the (edentulous) dental (d); a separate angular I have not been able to make out.

The hyomandibular (Pl. VII, fig. 3 hy) is short, comparatively slender; its outer face joining the preoperculum is sculptured, its inner face anteriorly drawn out into a slight ala; its lower end is cartilaginous and joins the hind end of the horizontal symplectic (sy). The latter forms a long and high plate, the upper margin of which joins the mesethmoid, the lower margin is thickened and contains a cartilaginous axis; the bifurcation characteristic for the Syngnathids is absent here. Anteriorly it joins the quadrate in a long oblique suture, and its upper anterior point overlaps suturally the posterior end of the entopterygoid (ept). As in Syngnathids the metapterygoid is wanting. The entopterygoid is a narrow lamella, joining the ectopterygoid (ect) anteriorly in a short suture. The latter is sabre-shaped, joining the anterior thickened margin of the quadrate in a long suture, and in a short suture connecting with the palatine (pa); this bone is short and stout, giving off as usual a short, diverging maxillary process. The quadrate (qu) is long and high, its anterior margin almost vertical (thus in position intermediate between that in *Fistularia* and *Aulostoma* on the one side and Syngnathids on the other); the upper margin in front touches the entopterygoid, but apart from this a narrow membranous strip intervenes between these bones as a feeble indication of the large interspace found in *Syngnathus*; the outer face is very slightly convex with a longitudinal (denticulated) crest running towards the articular head for the mandible and continuing a similar crest along the preoperculum.

The ascending part of the preoperculum (pro) is short, slightly oblique, its

anterior margin embracing the origin of the cheek-muscle; the long horizontal part joins the quadrate in an oblique suture, a little past the middle of the snout; with the lower part of the symplectic it connects through a rounded crest running on the inner face along the upper margin. A reticulated sculpture adorns the outer face of the preoperculum as well as that of the quadrate, entopterygoid and symplectic; the more prominent crests are finely denticulated[26].

Three opercular bones are present as usual[27]. The operculum (Pl. VII, fig. 6 o) is large, somewhat fan-shaped, the surface reticulated and carrying 3 crests radiating from the upper muscular process, the uppermost one following the upper margin. The suboperculum (s) is a long and extremely narrow bone, almost bristle-like, posteriorly tapering; keeping at some distance from the operculum it curves round the anterior, lower and posterior margins of the latter. It has hitherto apparently been mistaken for one of the branchiostegals. The interoperculum is disconnected from the suboperculum and situated on the inner face of the preoperculum, forming a very thin lamella, as usual connected by ligament with the mandible.

Nasals and infraorbitals are completely wanting, and no lateral-line canals are to be found in the preoperculum or in any other bones of the skull.

The hyoid (Pl. VI, fig. 2, 3) is very unlike that of the true Lophobranchiates, being here complete, composed of all the typical parts: 2 hypohyals (hy^{I}, hy^{II}), small on the outer aspect (fig. 2), a long ceratohyal (ch), a short epihyal (eh), and a very short stylohyal (st); the latter carries on its outer face a long horizontal process pointing forwards and lodged into a fossa on the inner side of the preoperculum. On the inner face of the hyoid (fig. 3) both hypohyals — especially the lower — are produced into long processes covering the anterior part of the ceratohyal.

The urohyal (Pl. VII, fig. 3 u) is long and slender, posteriorly cleft into 2 long branches, the left again bifurcating. Only one branchiostegal (r) is present, fixed along the outer face of the epihyal and ceratohyal. The single stem is soon bent at an open angle and then divides into two slender branches, the lower of which is much longer than the upper and following the equally slender suboperculum curves round the operculum about to the upper end of the gill-slit[28].

The branchial skeleton (Pl. VI, fig. 9) is reduced and rudimentary, even more than is the case in the *Syngnathidæ*. All unpaired elements — glossohyal and basibranchials (copulæ) are wanting, and there are no traces of gill-rakers. On the other hand, teeth are present on the lower and upper pharyngeals. The first gill-arch consists of two slender bones about of equal length, connected through an undivided cartilage; they represent the hypobranchial and ceratobranchial. The second arch consists of three or four parts: a rather long hypobranchial, connected by undivided cartilage with the ceratobranchial, and a very small, rudimentary epibranchial, carrying a single tooth; this part may be absent; in the specimen figured it is developed only on the right side; the fourth part, the pharyngobranchial, is widely separated from the rest, united to the pharyngeal belonging to the third arch. Of the third arch the hypobranchial is wanting, as in the *Syngna-*

thidæ; the remaining three (or two) parts being the ceratobranchial, a rudimentary epibranchial (the latter sometimes absent) with two teeth, and, widely separated from the rest, the pharyngobranchial. The fourth and fifth arches only consist of the ceratobranchial, that of the fifth — the "lower pharyngeal" — expands into a narrow plate carrying a number of pointed teeth.

The two „upper pharyngeals" (Pl. VI, fig. 7, 8) are joined end to end, and on the ventral face each expands into a tooth-bearing lamella with its margin dorsally enrolled; they are — as already stated — widely separated from the other parts of the branchial skeleton, but the rows of gills are continued almost to their posterior end, on the pharyngeal membrane. A comparison with the *Syngnathidæ* and with *Fistularia* and *Aulostoma* tends to show that these two pharyngobranchials really belong to the second and third arches, as stated above.

In tabular form the main features of the branchial skeleton would be:

Gill-arch	Basibranch-ials	Hypobr.	Ceratobr.	Epibr.	Pharyngo-br.	Gill rakers
I		+	+			
II		+	+	[+]	+	
III			+	[+]	+	
IV			+			
V			+			

Compared with the other genera, *Hippocampus* (Pl. VI, fig. 11) would be the one, which in construction of the gill-apparatus is the nearest to *Solenostomus*.

The shoulder-girdle (Pl. VII, figs. 3, 4, 5). The clavicular arch is composed of 3 parts: the posttemporal (pt; supraclavicular I), the supraclavicular (II) (scl) and the clavicular (cl); as in Syngnathids the postclavicular is wanting. The posttemporal does not form part of the skull, as is the case in Syngnathids; seen from the outer side (Pl. VII, figs. 3, 5) it appears bifurcated, the upper branch suturally united to the epiotic (ep), the lower one to the pterotic (sq); from the inner face a process combines with the exoccipital. With its hind end articulates the upper end of the slender and fairly long supraclavicle (scl), which in turn is articulated on the outer face of the upper end of the clavicle. The clavicle (cl) resembles to a certain degree that of the Syngnathids; the two processes p and p′ combining with the dermal plates, the first behind, the latter in front of the pectoral fin, are easily recognisable as homologous to the parts in *Siphonostoma* or *Hippocampus* lettered in the same way in figs. 2, 3 and 7, Pl. III; but a great difference is apparent in the fact, that in *Solenostomus* no connection between the clavicle and the anterior vertebræ has been established; the great anterior expansion of the clavicula used for this connection in Syngnathids is therefore absent here, the corresponding part only being used for connection with the supraclavicle. In this point some resemblance to *Fistularia* is apparent; and the lower part of the clavicle

resembles that of *Fistularia* still more, as it divides into an outer (anterior) larger (o), and an inner (posterior) narrower branch (i). To the latter is joined the greater part of the scapular arch, only the lower anterior end of the coracoid being connected with the outer branch; thus a large opening is surrounded by the clavicle and the coracoid. In *Aulostoma* the corresponding opening is reduced to a mere hole through the enlargement of the anterior part of the coracoid; in the Syngnathids, on the other hand, the same space is open ventrally (only closed with the dermal skeleton) because the coracoid here has not developed any anterior process.

The scapular arch (Pl. VII, figs. 4, 5), while in general shape recalling that of Syngnathids, is in some respects intermediate between this and that of Aulostomids, especially of *Fistularia*. The unossified, cartilaginous part of the arch is proportionally much smaller than in Syngnathids, not very much greater than in *Fistularia*. As in the Syngnathids the scapula (sc) is very small, at first sight appearing like a pterygial, but the scapular foramen is restricted to the scapular region; this foramen is narrow, vertically elliptic, bounded by the scapula and part of the clavicle. The latter condition might be derived from that found in *Fistularia*, if we suppose the thin cartilaginous anterior part of the scapula in the latter to have been suppressed in *Solenostomus*.

The coracoid (co) is the largest bone of the arch; its slender anterior branch is tipped with cartilage, firmly connected with the outer branch of the clavicle; its lower posterior angle is drawn out into a process (co′) apparently corresponding to that lettered in the same way in the other genera. The 4 pterygials (basals) (ba) are rather large, resembling those in Syngnathids, being laterally compressed, in their middle constricted into a narrow stalk; distally their cartilaginous ends are confluent, forming one continuous semicircle, the upper part of which belongs to the scapula. The outer face of this semicircular cartilage is even, but the inner (medial) face (fig. 4) is provided with a number of elevations or columns between which the tendons from the medial muscles to the fin rays are guided. Ligaments passing from one to another of these columns, and the skin connecting with their distal ends, convert the fossæ between them into regular holes for the tendons. Thus, only the inner faces of the pterygials show structures (cartilaginous) comparable to the peculiar osseous excrescences occurring on both faces of the pterygials in Syngnathids. Of the 4 pterygials the lowermost is by far the largest, as also is the case in all the other genera[29].

The base of each of the feebly ossified fin-rays embraces a separate small nodular cartilage, which by means of a saddle-shaped face plays on the convex margin of the combined pterygial (and scapular) cartilage; quite as in Syngnathids. Most of the fin-rays — some of the superior and inferior only being excepted — are jointed; all are unbranched, the distal ends forming a bundle of extremely fine threads.

The ventrals are almost vertical in position, with that face outwards which

in most fishes is turned towards the belly. Accordingly, the pubic bones (Pl. VII, fig. 3 p) are not lying flat but stand upright. Those margins, which are usually as inner margins in contact, are here not only free of each other but diverge, pointing upwards and outwards; whereas those margins, which are usually the outer margins and diverge, here converge and (nearly) meet ventrally. Each pubic bone forms a large erect plate somewhat inclined from the mid-ventral line towards the lateral body wall; it is thick behind where the ventral rays are attached, extremely thin at the upper and anterior margins. The interior is to a great extent cartilage, and the lower anterior part is almost unossified. The outer surface carries a strong crest (cr) dividing between the muscles to the lowermost, spinous, ray and those to the other rays; above and parallel to this crest a smaller and less prominent one is found in addition. The upper margin of each pubic is firmly joined to the lateral body-wall (especially through dense connective tissue to the inside of the second dermal scute from below in the posterior transverse thoracic row); the lower margin of the anterior part joins the median ventral scute, here meeting its fellow from the opposite side. The posterior ventral corner (*) of the thick hind part is tightly fastened to the inside of the lowermost scute of the last row of the thorax. In this way the skeletal support of the ventral fin-muscles is strengthened[30].

Of the 7 rays in the ventral fin the outer (lower) is an undivided spine; the remaining 6 are biramous, the two main branches parting nearest to the base in the innermost (uppermost) rays. Each of the two main branches is again longitudinally split, but the two halves are tightly pressed together. Indistinct traces of a transverse articulation are visible. In the female some of the peculiar thread-like appendices for retention and nutrition (?) of the eggs and young are ossified; these ossifications appear as rather long, slender branches from the divided rays, except the uppermost one; they are generally twisted in a corkscrew-like manner and end in a small rounded knob; (counting from below the 2nd ray carries 2, the 3rd 3, the 4th 5, the 5th 4, the 6th only 1 of these osseous branchlets in an old and large specimen of *S. cyanopterus* in my possession)

Number of fin-rays in the specimens examined.

	P	V	D_1	D_2	A	C
Sol. cyanopterus.						
A ♂	26	7	5	18	18	16
B ♂	27	7	5	20	20	16
C ♀	27	7	5	18	20	16
D ♀	26	7	5	19	19	16
E ♀	24	7	5	19	19	16
Sol. paradoxus.						
A ♂	26	7	5	22 ?	23?	16
B ♀	24	7	5	22	23	16

In the literature we find the following:

	P	V	D_1	D_2	A	C
Solen. cyanopterus.						
Bleeker 1851	22	11	5	19	19	12
Günther 1866	26*					
	18	7	5	18	16—17	14
Duméril 1870	26**			18**	18**	20**
	25	7	5	16	16	20
Günther 1870	26	7	5	18	16—18	
Jordan and Snyder 1901	27	7	5	20	19	15
Solen. paradoxus.						
Seba 1758		7	4	3		13
Pallas 1770	c. 25	7	5	c. 18	c. 12	14
Bleeker 1854	25	7	5	20	20	15
Duméril 1870 ♂	27	8				
Duméril 1870 ♀	25	7	5	18	18	16
Günther 1870	25	7	5	20		
Jordan and Snyder 1901	24	7	5	21	22	16***
Tanaka 1908	c. 23	7	5	19	16	15****

Remaining anatomical features and visceral anatomy.

In the female the inferior (outer) margins of the two ventrals are united at the base for quite a short distance but otherwise free of each other; the upper (inner) margins are fused with the abdominal skin, the fusion reaching to the front border of the anus; in this way is formed the often-mentioned brood-sac. The lining of this sac carries a great number of filaments arranged in longitudinal rows; most of the filaments take their origin from all the fin-rays except the lowermost (outer) spinous ray, but quite a number form one row along the middle line of the abdomen; the longest and most developed are those of the anterior half of the sac, but along the fin-rays they are found almost to the hind margin of the sac, gradually decreasing in length, the hindmost being very small.

Part, if not all, of the filaments on the rays contain a slender, undulated or twisted bony axis, an outgrowth from the bone of the ray, as mentioned above under the osteology of the ventrals. This axis only occupies the basal part of the

* The number 26 is given in the description, 18 in the formula.

** These numbers are given for „*Sol. bleekeri* A. Dum." which I consider as identical with *cyanopterus* Blk.

*** The number of caudal rays taken from the figure.

**** TANAKA's species "*Sol. leptosoma*" I regard as a male *S. paradoxus*. The number of caudal rays is that given in T.'s figure. Also BLEEKER's *Sol. brachyurus* is in my opinion = *paradoxus*; no number of fin-rays is stated. KAUP 1856 has the following numbers for "*Solen. paradoxus*" P: 27, V: 7, D_1: 5, D_2: 18—19, A: 18—19, C: 15, but his "paradoxus" comprises both *cyanopterus* and *paradoxus*. His material of 5 specimens is still in the Museum of Paris and contains 2 *paradoxus* (1 from Isle de France, 1 from the Indian Ocean) and 3 *cyanopterus* (2 from New Guinea, 1 from Isle de France; the latter = "*S. bleekeri*" Dum.).

filament, scarcely reaching to the middle of its length (Pl. III, fig. 11 ax). When the filament is laid under the microscope the bony axis appears transparent and refringent, but its bony nature is easily shown through staining, e. g. with alizarine or hæmatoxyline; I suppose it is the structure about which GÜNTHER says (16 b, p. 151): "A slightly undulated canal runs along the interior of the filament". In the filaments from the middle line of the abdominal skin I have found no bony axis. All the filaments are richly beset with shorter or longer branchlets or twigs. Each branchlet is expanded at its end into a regular concave disc, looking like a sucker; this I take to be the special organ of retention for the eggs and young. I am not able to elucidate the special manner in which the retention is brought about, whether each egg is always held by one sucker, and the young also, or if in the latter case two or more discs are at work. My only specimen with a few eggs and newly hatched young still contained in the sac (a *S. paradoxus*) is not well enough preserved to show things definitely; it seems to have been somewhat dried and shrivelled before being preserved in alcohol, but the presence of traces of discs fastened to the eggs, one on each, and also to the embryos, I have ascertained with certainty. Whether the filaments are also organs of nutrition I am not in a position to decide; they are provided with blood-vessels, from the stem entering every branchlet; thus the nutritive function seems to me to be at least possible, a secretion to the interior of the sac being probable. Certainly many questions of great interest regarding the biology and development of these curious fishes are to be solved, and it is to be hoped that some day one of the zoologists having the opportunity of observing the living animals in their natural surroundings will take up the task.

Possibly the whole interior lining of the brood-sac belongs to the ventrals; the real condition might perhaps be, that both ventrals as in the Gobies are coalesced along their upper or inner margins and the coalesced part again fused with the abdominal skin; if this interpretation should prove to be the correct one, the power of sending out filaments would be possessed only by the fin; this question — perhaps of no great importance — could most probably be solved by an examination of the histology of appropriate material or of developmental stages.

On the "thorax" only the dorsal part of the muscles is fully developed, most of the lateral body-wall below the vertebral column being devoid of muscles; the same is the case on the posterior, slender portion of the body with part of the ventral body-wall. The myomeres are here well developed along the whole part provided with dermal ossifications and further along a narrow strip close to the ventral middle line of the belly, from the ventrals to about the anus; the intervening lateral space of the body-wall, covering the side of the intestine, is — like the "linea alba" — devoid of muscles. No division into myomeres is seen in the strong dorsal muscles reaching from the skull to the level of the 3rd transverse row of scutes; and this part of the musculature is provided with a flat strong ossification (Pl. III, fig. 10 td), corresponding to that found in *Fistularia*, *Aulostoma*,

and *Nerophis ophidion*; narrow in front, where it firmly joins the epiotic, it widens gradually backwards, finally dissolving into a number of threads. Between the skull and the first transverse row of scutes it may be seen through the skin, the remaining part being more or less concealed by the overlying upper members of the 3 anterior transverse rows of scutes.

The branchial cavities of the left and right sides communicate through a large, oval opening (Pl. VII, fig. 3 o) under the branchial skeleton, a condition only found in a few other fishes (e. g. *Zeugopterus* and some other flounders). There are 4 complete gills (i. e. composed each of 2 rows of branchial lamellæ) (Pl. III, fig. 11 I—IV) and a well-developed pseudobranch (fig. 11 ps); the 5 gill slits on each side are small, oblique, somewhat like button-holes in shape (as in Syngnathids), and as stated above not provided with gill-rakers. The branchial laminæ are rather short and clumsy, intermediate in shape between the type found in Syngnathids and that of fishes generally; their number in each row from 6 to 12, the anterior row of the first gill having 9, the posterior of the last gill only 6. The pseudobranch consists of a single row of 8 leaves arranged along the inner, posterior border of the hyomandibular and preoperculum, in front of the first slit. As in Syngnathids the gills are not restricted to the gill-arches but for a great part take their origin above and below these from the soft walls of the pharynx; the rows are almost vertical in spite of the oblique position of the gill-arches.[31]

As in Syngnathids the alimentary canal (Pl. III, fig. 11) is simple, straight, without any externally visible demarcation between stomach and intestine, and without mesentery. The muscular oesophagus (oe) widens evenly into a thin-walled, somewhat spindle-shaped dilatation, distended with food; it suddenly narrows where the intestine passes from the "thorax" into the slender part of the body, just above the root of the ventrals and below the most expanded part of the air-bladder. Immediately in front of this narrowing the dilatation ventrally fills out the space between the two halves of the pelvis and the posterior end of the liver, forming here a kind of cuneiform sacculation, no doubt only an accidental adaptation to the given space, due to the state of stuffing with food in the specimen dissected. On the ventral side of the anterior half of the spindle-shaped dilatation, in the median line, the bile-duct enters (at bd in the figure), as in Syngnathids the only indication of the beginning of the intestine (duodenum); thus the greater part of what at first sight seems to be a "stomachal" dilatation is really formed by the small intestine. The remaining part of the latter fills most of the body cavity in the slender, posterior part of the body; at the spot * in the figure a circular constriction marks off the beginning of the rectum (r)*. The fold and the small sacculation apparent at ** in the figure is — as far as I can see — only an accidental formation due to an accumulation of the contents.

* The rectum and adjacent parts unfortunately were somewhat damaged during my dissection of the only specimen which I could sacrifice; hence I am not quite sure about a few features, e. g. the possible existence of an urinary bladder.

The liver (l) is laterally compressed with sharp ventral edge. The left part is seen below the alimentary canal, while the right side of the latter is covered by the right part. From an incision in the posterior edge of the right part proceeds the bile-duct, turning upwards and forwards to the intestine. The gall-bladder is situated as in Syngnathids between the right side of the alimentary canal and the right part of the liver; the bile-ducts from the liver, the portal vein and hepatic artery as well as the hepatic vein seem to be arranged quite as in the Syngnathids.

The alimentary canal in the dissected specimen contained rather large crustaceans (Palæmonids; one fairly well preserved specimen was about 12 mm. in length).[32]

The existence of an air-bladder has hitherto been denied (cf. GÜNTHER 16 b p. 151; BOULENGER 4 c p. 633). Nevertheless, if sufficiently transparent specimens are held against the light an oval, clear body is always to be seen over the intestine just below the first dorsal, and always in the same way filling a downward bend of the intestine, thus suggesting the presence of an air-bladder. Through dissection the suspicion is confirmed and the fact easily settled. The air-bladder (bl) is irregularly pyriform, anteriorly narrowing into a point reaching about to the hind end of the oesophagus, posteriorly also tapering but more abruptly, and ending behind the level of the ventrals.

The kidneys (Pl. III, fig. 11 k) reach from below the second vertebra to the end of the body cavity. From the level of the 12th vertebra they are united into one body containing in its middle, between the two ducts, the right cardinal vein, which seems the only one developed and is anteriorly embedded in the right kidney. The anterior part of each kidney represents the "head kidney", as it contains a large "pronephric glomerulus" (or "glomus"), from which the wide, straight duct passes backwards through the whole organ; at some distance behind the "glomus" urinary tubules appear and are present in the whole remaining part of the kidney. As usual in teleosts the "head-kidney" has no tubules, consisting only of lymphatic tissue surrounding the "glomus" and the beginning of the duct; the latter part is not convoluted, as otherwise in bony fishes, but straight like its continuation through the secreting nephros. The secreting tubules of the latter are short, combining to wide collecting tubules regularly grouped around the duct into which they debouch. No malpighian corpuscles (or glomeruli) are to be seen. Thus the kidney of *Solenostomus* only in the latter respect resembles that of Syngnathids; in almost every other respect it is not only different but very peculiar; especially so in preserving the whole pronephric duct and the pronephric glomerulus, a feature very rarely met with in bony fishes (from my own experience I only know of *Zoarces viviparus* possessing that structure in the adult state). In Syngnathids a "head-kidney" is not only absent in the adult, but a "pronephros" ("glomus") seems not at all to be formed in the embryo according to HUOT, whose

statements I am able to confirm for embryos in that stage of development at which they leave the marsupium.

The anterior part of the testis (te), situated under the posterior part of the air-bladder, is somewhat irregularly coiled, the remaing part being straight and gradually tapering into a narrow thread lying close to its fellow from the other side below the kidney; above the rectum the testis (or vas deferens, no boundary between the two being observable) widens a little again. If the two male ducts are united at all it can only be at the junction with the urethra, like the case in Syngnathids. (As stated p. 325 [59] this part unfortunately has been somewhat damaged.) The male organ is of the same peculiar type as that of Syngnathids, i. e. it forms a simple hollow sac or tube.

I regret that the scarcity of my material did not allow me also to dissect a female specimen. I have only had the opportunity to look at a partly dissected specimen in the British Museum (probably the one which had been used by GÜNTHER for his anatomical statements) and to write down the following note: "The ovaries are situated in the anterior part of the body cavity, each with a long narrow oviduct; the two oviducts seem to unite into an enlarged portion above the rectum"[33].

Family *Solenostomidæ*.

Two dorsal fins, the anterior spinous. Ventrals present, very large. Tail short, caudal fin very large. Skin with star-like dermal ossifications in transverse and longitudinal rows. No visible lateral line. Gill-openings wide, opercular membranes free of isthmus. Nasals, infraorbitals and metapterygoid wanting. Hyoid complete; branchial skeleton reduced. Supraclavicle present, postclavicle absent; scapular foramen closed. Vertebræ without articular processes, upper and lower spines long and well developed. The 3 anterior vertebræ immovable, suturally united. Ribs absent. Pseudobranchia present, well developed. Gills 4, gill-rakers absent, branchial slits 5. Air-bladder present, without duct. Intestinal canal simple, straight, without stomachal sac or pyloric appendages.

Genus *Solenostomus* Lacép.

General form laterally compressed. Snout tubular, very long and strongly compressed. Mouth an oblique slit, bounded above by the premaxilla, toothless. Chin with a barbel, more or less concealed. Olfactory organ an open pit, smooth in the female, provided with radiating lamellæ in the male. 3 opercular bones present, subopercular extremely thin, bristle-like; interopercular lamellar, concealed. One bifid branchiostegal. Septum between the branchial cavities perforated by a large opening. Anterior part of body high, forming a thorax, posterior part slender; tail very short, its anterior part high, dorsally and ventrally forming a kind of

hump, carrying the second dorsal and the anal; the posterior part carrying the caudal fin lower. The soft skin, covering the dermal ossifications, with scattered small (more or less developed, in some places branched) cutaneous papillæ.

Anterior dorsal with 5 spines, short but high, at posterior border of thorax, opposite to ventrals; the latter very large, with one spine and 6 bifurcated soft rays; free in male, united to abdomen in the female, forming a brood-sac. Second dorsal and anal opposite, long and rather low, composed of numerous soft, unbranched rays, like those of the pectorals. Caudal fin extremely large, with strong, unbranched rays, the middle ones longer and somewhat more slender than the rest.

Glossohyal and basibranchials absent, epibranchials absent or quite rudimentary; pharyngobranchials apparently one — but composed of two — on each side, provided with teeth like the lower pharyngeals.

D1. 5, V. 7, C. 16.

Solenostomus cyanopterus Bleeker 1859.

Syn: S. paradoxum Blk. 1852, 1853.
S. paradoxus Kaup 1856, pro parte.
S. cyanopterus Duméril 1870.
S. Bleekeri „ „

Snout rather stout, its height in the middle of its length being in the male about 1/3 of its length (from anterior margin of the eye to the end of the snout), in the female about 1/4. Caudal peduncle stout, the membrane of the caudal fin beginning very near or almost close to the second dorsal and anal (closest in the male). Profile of second dorsal and anal evenly arched. Colour brown, minutely dotted with black and whitish, or pink with small purplish-brown spots. Eye red. First dorsal fin with two large, ovate, black ocelli between the first 3 rays.

P. 24—27, D. 5/18—20, A. 16—20, C. 16, V. 7.

Solenostomus paradoxus (Pallas).

Syn: Solenostomus varius rostro serrato etc. Seba 1758.
Fistularia paradoxa Pallas 1770.
Solenostomus paradoxus Lacép. 1803.
Solenostomus „ pro parte Kaup 1856.
Solenostomus paradoxus Duméril 1870.
Solenostoma brachyurum Bleeker 1855.
Solenostoma leptosoma Tanaka 1908.

Snout elongated, its height (apparently in both sexes) in the middle being about 1/7 of its length (from anterior margin of eye). Caudal peduncle slender, the membrane of the caudal fin beginning at a distance from the second dorsal and anal of more than half the length of these fins (about 2/3 in the female, 5/6 in the

male). The rays in the middle and behind the middle of the anal and second dorsal somewhat elongated, thus giving the profile of these fins a higher and more acutely arched shape than in the preceding species.

Colour light brownish, irregularly mottled with orange spots; membrane of first dorsal with two dark ocelli between the first 3 rays.

P. 24—26, D. 5/18—22, A. 18—23, C. 16, V. 7.

Conclusion.

With the preceding part of the present contribution I have finished my account of the principal structural features, especially the osteology, of the fishes which in my first contribution I considered to be a group of related forms and (23 b p. 42 [4]) provisionally had designated as "Hemibranchii (÷ Gastrosteidæ and Aulorhynchidæ) + "Lophobranchii" (Solenostomidæ and Syngnathidæ)", at the same time pointing out a number of characteristics in the composition of the cranial skeleton, which seemed to me an expression of natural affinity. Since the publication of my first paper I have had the great satisfaction of learning that the author of the latest attempts at a systematic arrangement of the Class Pisces, C. T. REGAN, has adopted my view (45 b and c). Furthermore he has given the group as circumscribed by me a systematic name, namely *Solenichthyes*, to replace the, of course, quite provisional designation quoted above. Originally, however, REGAN only included *Amphisile* and *Centriscus* under the name *Solenichthyes* (cfr. 23 b Note 1, p. 42); but later (45) he has extended its domain to embrace all the forms pointed out by me as related. Although I do not like the name on purely etymological grounds*, I adopt it and am going to use it in the following systematic arrangement, in which I shall try to condense the principal characteristics set forth and treated at length in the descriptive parts of my work.

Suborder *Solenichthyes.*

Snout tubiform, mouth terminal, the ethmovomerine part of skull and mandibular suspensory parts anterior to hyomandibular being greatly elongated; palatine short and connected with front end of vomer; metapterygoid, if present, removed from contact with the hyomandibular. Parietals and opisthotics absent; pterotics joining cranial base below, preventing exoccipitals from meeting prootics. Opercular apparatus consisting of the 3 usual bones. Lateral line bones of head reduced in number or absent; infraorbitals, if present, only represented by preorbitals, never containing any lateral line canal. Anterior 3—6 vertebræ immovable. Ribs absent. Gills 4, pseudobranchia present; branchial slits 5.

* Because the fishes themselves are not tubiform, only their snouts being so.

Intestinal canal simple, without stomachal sac. Air-bladder present, ductless. Ventrals (if present) abdominal in position, 5—7 rays. Fin-rays of pectoral, (second) dorsal and anal fins distally unbranched.

A. Post-clavicle and metapterygoid present; anterior 4—6 vertebræ elongated, more or les modified; vertebræ with articular processes. (4—5 branchiostegal rays.) Lateral line canals present (at least on head: *Centriscus*): Aulostomata ("Bouches-en-flûte").

1st Family: *Centriscidæ.*

Mouth toothless. Body laterally compressed, stiff; tail short, movable. All the components of mandibular suspensorium present; palatine, ento- and metapterygoid connected with the elongated ethmo-vomerine part of skull. Nasal and preorbital well developed, the first containing a lateral line canal. Hyoid of normal composition; 4 branchiostegal rays; branchial skeleton complete, upper and lower pharyngeals carrying teeth. Posttemporal suturally united to skull; supraclavicle present; scapular foramen enclosed in scapula; pectoral pterygials stout, leaving no interspaces. Anterior 5—6 vertebræ elongated, their transverse processes, except those of the first and last, firmly connected with large dermal plates. Two dorsal fins, anterior spinous, the spines, except 1—3 of the foremost, fused with their interneurals; posterior dorsal opposite to anal. Outer ray of ventral spinous. Two nasal openings. Appendices pyloricæ absent.

Genera: *Centriscus, Amphisile.*

2nd Family: *Aulostomidæ.*

Mouth toothed; body elongated, tail short. Occipital condyle convex. Ectopterygoid wanting, other suspensory bones present; palatine, ento- and metapterygoid (in *Fistularia* also symplectic) connected with ethmo-vomerine part of skull. Nasal quite rudimentary or absent; preorbital rudimentary or absent. Hyoid composed as usual of 5 pieces; 4 or 5 branchiostegals; branchial skeleton reduced, only one basibranchial being ossified, 4th epibranchial absent, the remaining 3 more or less separated from their cerato-branchials; 1st pharyngobranchial absent, 2nd—4th and lower pharyngeals provided with teeth. Posttemporal present, supraclavicle present or absent; scapular foramen enclosed in scapula; pterygials elongated, leaving interspaces between. Anterior 4 vertebræ much elongated and suturally united, their transverse and spinous processes forming continuous lamellæ. Transverse processes of free abdominal vertebræ divided into an anterior and a posterior part. First dorsal fin, if present, spinous, second dorsal opposite to anal. Ventral fin with 6 rays, the outer unbranched, but jointed. Lateral line canals developed. Two nasal openings. One or two appendices pyloricæ.

Genera: *Aulostoma, Fistularia.*

B. Postclavicle and metapterygoid absent; anterior 3 vertebræ suturally united, not specially elongated; vertebræ without articular processes. (1—3 branchiostegal rays.) Lateral line canals absent. Lophobranchii.

3rd Family: *Solenostomidæ.*

Mouth toothless; body laterally compressed, tail short. Nasal and infraorbitals (preorbitals) absent. Palatine, ecto- and entopterygoid and symplectic connected with ethmo-vomerine part of skull. Hyoid of normal composition; 1 branchiostegal ray; branchial skeleton reduced, glossohyal and basibranchials wanting, epibranchials absent or quite rudimentary, only 2nd and 3rd pharyngobranchials present, remote from ceratobranchials, provided with teeth like the lower pharyngeals. Posttemporal attached to skull, supraclavicle present; scapular foramen closed below, being surrounded by scapula and clavicle; pterygials elongated with open spaces between, not fixed between dermal plates. Upper and lower spinous processes long and slender. Skin with large stellate ossifications, leaving large spaces unprotected. Gill-opening wide, opercular membrane free of isthmus. Two dorsal fins, anterior spinous; posterior opposite to anal; tail-fin very large. Ventrals very large, with 7 rays, the outer spinous. Nasal organ an open pit. Appendices pyloricæ none.

Genus: *Solenostomus.*

4th Family: *Syngnathidæ.*

Mouth toothless; body elongated, angular or laterally compressed, tail long. Nasal absent; 2 or 3 infraorbitals (preorbitals) present. Palatine, entopterygoid (sometimes also ectopterygoid) and symplectic connected with snout part of skull. Hyoid only composed of 3—4 pieces; 1—3 branchiostegal rays; branchial skeleton reduced, basibranchials being absent or reduced to 2, hypobranchials 1—2, epibranchials 3, remote from ceratobranchials or completely absent, 2nd and 3rd or only 2nd pharyngobranchial present, toothless as also lower pharyngeals. Posttemporal suturally united to skull; supraclavicle absent; upper part of clavicle expanded and connected firmly with transverse processes of the two foremost vertebræ. Scapular foramen continued below into interspace between clavicle and coracoid; pterygials with open interspaces, their distal parts fixed between dermal scutes. In some members coraco-scapular and pterygial skeleton absent as also pectoral fins. Transverse processes on vertebræ well developed, connected with dermal plates; spinous processes low crests, except on the vertebræ carrying the dorsal fin, the spinous processes of which are elevated and divided, each supporting a group of interneurals; a secondary transverse process on the same vertebræ, behind the primary one, for attachment of muscles moving the dorsal fin. Skin with complete armour of dermal plates. Gill-lamellæ few on each branchial arch, short and clumsy, with large transverse leaflets. Gill-opening dorsal, very small, the margins of opercular membrane being largely fused to isthmus and body. One dorsal fin, anal small, below dorsal, or absent; caudal fin small, in some members

rudimentary or quite absent; in latter case tail more or less prehensile. Ventrals absent. Two nasal openings. No pyloric appendices.

a. Subfamily: *Syngnathini.* Preorbital bones 2; nuchal plates generally 2 (one prenuchal and one nuchal); rarely 3 nuchals (one prenuchal and 2 nuchals).

Genera: *Siphonostoma, Syngnathus, Ichthyocampus, Nannocampus*†, *Urocampus, Doryichthys, Leptoichthys*†, *Coelonotus*†, *Stigmatophora**, *Nerophis, Protocampus*†**.

b. Subfamily: *Hippocampini.* Preorbital bones 3; nuchals 3 or 2; in latter case prenuchal wanting.

Genera: *Hippocampus, Solenognathus, Phyllopteryx, Gastrotokeus, Acentronura*†.

+. 3 nuchals, a prenuchal or "corona" being present.
Hippocampus, Solenognathus.

++. 2 nuchals, a prenuchal absent.
Gastrotokeus, Phyllopteryx.

The genera marked with † I have not seen.

That all the members of the group *Solenichthyes* are aberrant and much specialised is evident, and that they must all be derived from one common stock of less specialised forms is hardly to be doubted. But where their parentage is to be sought, or to which of the other groups of existing Teleosts they are most nearly related, is to me still an open question. As fossils, carrying quite the same stamp as in modern time, they date far back in the tertiary formations; the existing genera *Amphisile, Aulostoma* and *Solenostomus* as well as true Syngnathids ("*Syngnathus bolcensis*" Zign.) are found in Eocene (Mt. Bolca and Mt. Postale), *Fistularia**** at least in Oligocene formations (Glarus schists); unfortunately the extinct Eocene genera *Urosphen, Solenorhynchus* and *Calamostoma* (Mt. Bolca and Mt. Postale), which are undoubtedly *Solenichthyes*, the first belonging to the *Aulostomidæ*, the

* 3 nuchals are present, a small prenuchal, a large first nuchal and a smaller second nuchal. Of the two preorbitals the posterior (true preorbital) is very short, the anterior extremely long.

** I have omitted the genus *Osphyolax* (with a single species: *pellucidus*) described by Cope (Proc. Ac. Sc. Philadelphia, 1875, p. 450, Pl. 25; the description repeated in Jordan and Evermann 21 a p. 775). I am quite sure that it is due to a mistake. Judging from the figures and description it must simply be a *Nerophis æquoreus*, the dorsal fin of which has been damaged and deprived of its larger anterior part. This would explain not only the shortness of the dorsal fin, containing 16 rays in stead of 40—44, but also the peculiar dorsal tube in front of the fin, which is said to be "closed above by a series of small radiate ossicles in the median line, between which the cavity may be entered by small bodies." These small ossicles evidently are the upper ends of interspinous bones with their peculiar osseous expansions, which have been laid bare by the abrasion of the front part of the dorsal fin. The "free superior edges (of lateral scutes), which form a series of longitudinal lateral grooves" in the "lumbar region" I imagine are also due to accident (and drying?).

*** "*Fistularia tenuirostris*" Ag. from Mt. Bolca cannot in my opinion be a true *Fistularia*; but it belongs at all events to the *Solenichthyes*, as also the genus *Pseudosyngnathus* (*Syngnathus opisthopterus* Ag.), which is no Syngnathid.

two latter to the *Solenostomidæ* *, do not throw any light upon the question of derivation from other forms, but they may prove to be of use in filling up some of the gaps between the now existing genera. Leaving aside the latter point for the present and only considering the existing forms reviewed above I think it will be agreed, that the Syngnathids are the most aberrant and most strongly specialised Solenichthyes. Compared with the other forms the Syngnathids have acquired a more complete dermal armour and an elongated tail; at the same time they have lost the first dorsal and the ventrals, and reduced or lost the anal; the second dorsal, taking up the function of locomotion, has generally been lengthened and often encroaches upon a greater or lesser part of the trunk; the metapterygoid is lost, the shoulder girdle has lost the postclavicle (and supraclavicle), the clavicle, expanding above, has been connected firmly to the anterior vertebræ, while the pectoral skeleton is weakened like the branchial skeleton. Less transformed are the *Solenostomidæ* which have kept the first (spinous) dorsal fin and the ventrals (with a spine); the metapterygoid is lost, the shoulder girdle has lost its postclavicle but is otherwise complete, while the pectoral skeleton is weakened, tending greatly towards the structure found in Syngnathids, as also does the branchial skeleton and the vertebræ in losing the articular processes. Upon the whole the majority of characteristics combine the Solenostomids with the Syngnathids, with which they have been placed since CUVIER established his *Lophobranchii*; the correctness of his view in this respect may now I think be regarded as settled. But on the other hand the *Solenostomidæ* show likenesses with different members of the group *Aulostomata*; some of these likenesses may perhaps seem to be of less importance — a matter, however, by no means easy to judge with any degree of certainty. Thus, the extreme shortness of the tail in proportion to the trunk and head, the lateral compression of body and head, the mandibular barbel remind one of *Aulostoma* (while the position of the mouth slit is more like that of Syngnathids and Centriscids). Further, there are some external likenesses with *Centriscus* in the (dorsal) fins — as already alluded to by REGAN (45 a and c) —**, in the stiffness of the trunk, and, I might add, in the dermal ossifications: from a four-sided shape with cruciform crests, which the large lateral plates show in the adult *Centriscus* and all the scales in the young ones, the stellate dermal scutes in *Solenostomus* — and besides also the plate-forms found in *Syngnathidæ* (cfr. *Hippocampus* and those of young *Syngnathus*) — could easily be derived.

In the group *Aulostomata* the family *Aulostomidæ* approaches the group *Lophobranchii* (*Solenostomidæ* and *Syngnathidæ*) in the commencing reduction of the branchial skeleton and in the fact that the upper parts of the rows of branchial

* In a forthcoming paper I hope to show that *Calamostoma* (*breviculum* Ag.) must belong to the *Solenostomidæ*. That the genus *Solenostomus* itself is represented in the Mt. Bolca formation, as also *Amphisile*, I know from photographs, kindly sent to me from the Museo Civico in Verona.

** BOULENGER (4 c, p. 633) has also expressed the opinion that "the unique genus *Solen.* may be regarded as in many respects intermediate between the Centriscidæ and the Syngnathidæ."

lamellæ leave the gill-arches and take their origin from the pharyngeal wall; further in the shape of the pectoral pterygials, and in the weakening of the anterior border of the scapular foramen; if the weak or cartilaginous anterior part of the scapula atrophied, we should have the condition found in *Solenostomus*, from which a step farther leads to that of *Syngnathidæ*. The large ossified nuchal tendons, so characteristic of the *Aulostomidæ*, also occur in *Solenostomidæ* and at least in one of the *Syngnathidæ*, namely *Nerophis ophidion*. The genus *Fistularia*, besides, has the symplectic connected with the ethmoid region of the skull as in the *Lophobranchii*, and with the *Syngnathidæ* it shares the loss of the first dorsal fin, which in *Aulostoma* is so to speak going to disappear. In both *Aulostoma* and *Fistularia* the outer ray of the ventral fin has given up its spinous character, perhaps a step towards degradation of the fin; the separation of the pelvic bones in the median line and the weak structure of these bones might possibly point in the same direction.

In spite of the many features of far going specialisation the family *Centriscidæ* must be considered to contain upon the whole the least aberrant members of the suborder *Solenichthyes*; to this conclusion point the facts, that all the components of the mandibular suspensory parts are present, that nasals are well developed, that the branchial skeleton is complete, the shape of the pectoral pterygials, the structure of the ventral fins etc.

Notes.

Aulostoma.

[1] p. 270 [4]. The scales are regarded by most authors as simply ctenoid. A figure is found in KNER (28 b, p. 259 [28]); the scale represented shows seven teeth, united basally into one part, which appears separated by a distinct boundary line from the main scale-plate; that this representation is incorrect can easily be verified.

[2] p. 271 [5]. The very conspicuous system of "inscriptiones tendineæ" is — as far as I know — only mentioned in recent times, by A. S. WOODWARD (59, p. 375), in his definition of the genus *Aulostoma*: "Intermuscular bones very numerous and long". But already AGASSIZ who, curiously enough, does not appear to have known their existence in the living forms, states for the fossil *A. bolcense* (1, T. 4, p. 282): "De nombreuses arêtes musculaires effilées paraissent avoir soutenu les muscles tout le long de la colonne vertébrale", and fig. 3 of his Pl. 35 shows these structures very distinctly.

[3] p. 274 [8]. BRIDGE (5, p. 576) has correctly described the interspinous bones for the unpaired fins in *Aulostoma chinense*; but he does not mention the anterior ray-less elements of the anterior part of the trunk, in front of the spinous section of the dorsal fin.

[4] 274 [8]. KNER (28 b, p. 257 [26]) declares that the dorsal spines in *Aulostoma (chinense)* are not true spines, without, however, demonstrating why: "Sie tragen ebenso wenig die Merkmale eines Stachels an sich, wie jene der *Notacanthinen*, von denen später die Rede sein wird*. Die Strahlen der übrigen Flossen sind gegliedert und am Ende so breit und compress, wie bei den Lophobranchiern. Die Gliederung ist ziemlich spärlich, äusserst zart und sogar oft leicht zu übersehen, der Übergang vom un- zum gegliederten Strahle erfolgt hier fast unmerklich. Nur die Strahlen der Bauchflossen und die letzten der zweiten Dorsale und der Anale sind zugleich gabelig getheilt".

[5] p. 279 [13]. Very little is to be found in the literature about the osteology of *Aulostoma*; generally the few remarks apply to the family (or "superfamily") including both *Aulostoma* and *Fistularia*, and as the latter apparently has been examined oftener, the remarks seem mostly or wholly based on *Fistularia*, nothing particularly concerning *Aulostoma* being stated. This is the case e. g. with the statement found in several authors about the four anterior vertebræ being elongated (COPE, GILL (1884), JORDAN & EVERMANN, REGAN etc.) or elongated and fused together (GÜNTHER, SM. WOODWARD, BOULENGER), and the absence of ribs. A few remarks concerning the cranial skeleton are given by CUVIER (9 b, T. 2, p. 625). After having pointed out some cranial features characteristic for his family "*Bouches en flûte*" (i. e.: *Fistularia, Aulostoma, Centriscus* and *Amphisile*), especially regarding the composition of the elongated snout ("Les frontaux en forment la base; l'ethmoïde, excessivement alongé, en fait la plus grande partie; et le vomer, placé au bout du précédent, forme la pointe."), he continues: "Dans la *fistularia tabacaria*, le museau est en demi-cône grêle et un peu creux à sa face inférieure. Les apophyses anté et post-orbitaire continuent la courbe régulière et à peu près circulaire du bord orbital du frontal, de sorte que plus des deux tiers des orbites sont entourés par les frontaux." It is quite evident from this description, that *Aulostoma* is meant instead of *Fistularia*, and every doubt is removed, when we read the description of "l'*aulostome chinois*", quoted below p. 339 [73] note 14. Through some mistake the names have simply been exchanged.

The most important contributions are given by STARKS (55); after having pointed out the characteristics for the "superfamily" e. g. that "parietals are absent, pterotic interposed between and entirely separating prootic from exoccipital; condyle of basioccipital a round knob" etc. (p. 624), he states for *Aulostoma*: "post-temporal not united to cranium; palatines united to each other and to cranium; each transverse process behind fourth vertebra is formed equally by a process from each adjoining vertebra (or each end of each vertebra carries a half of each transverse process)"; and p. 629 he gives the following description of the skull: "The epiotics are large, low, conical bones on each side of the supraoccipital. Each articulates to the frontal anteriorly, to the exoccipital posteriorly, and to the pterotic at its outer edge. The pterotic forms the posterior lateral angle of the cranium. It is anterior to the exoccipitals, which form, with the basioccipital, a posterior projection. The exoccipitals project downwards on each side far below the condyle of the basioccipital. They meet broadly above the foramen magnum." A full and in all essentials very correct description is given of the shoulder girdle, illustrated with a figure. The only point in this description I wish to correct is the statement on p. 630: "The hypocoracoid (my coracoid) is attached along its entire anterior edge to the clavicle without leaving the usual opening between." The opening is really found, but very small indeed; cf. my fig. 5, Pl. III.

The branchial arches are figured by RATHKE (44, Tab. I, Fig. 4, *Aulostoma (Fistularia) chinense*). The figure is correct in every essential; his description, given below, as well as the explanation of the figure and the tabular summary on p. 19 show, that R.'s interpretation of the component parts is also the right one. He writes on p. 17: "Anmerkung. Eine sehr merkwürdige Abweichung von der Regel, nach welcher bei den Gräthenfischen die Kiemen-

* I have not been able to find anything about the *Notacanthini* in the continuation of KNER's work in the 43th and 44th vols. of the Wiener Sitzungsberichte.

bogen gebildet sind, bietet die *Fistularia (Aulostoma) chinensis* dar. Bei ihr hangen nur die zu dem vordersten Bogen gehörigen Segmente, deren es 3 giebt, unter einander innig zusammen: von den 4 Segmenten aber, die einem jeden der 2 folgenden Bogen angehören, ist bei Exemplaren dieses Fisches, die eine Länge von fast 1½ Fuss haben, das dritte und äusserst kleine von dem zweiten und beträchtlich grossen ungefähr um 3 bis 4 Linien nach oben hin entfernt; und um eben so weit stehen auch die beiden Segmente von einander ab, die dem vierten oder hintersten Kiemenbogen zugehören, und wovon das oberste dem vierten Segmente der beiden davor liegenden Kiemenbogen entspricht. Die Lücke zwischen den angegebenen Gliedern wird allein durch die Haut des Schlundes ausgefüllt." The elongated glossohyal is noticed on p. 4. On the other side the statement about the opercular apparatus being only composed of 2 pieces (l. c. p. 76) is wrong. RATHKE's figure is copied by BRÜHL (6 a, Tab. IV, fig. 11) and his statements referred to l. c. p. 119; and also repeated by DUVERNOY in Cuvier's Leçons, T. VII, p. 257, p. 268. This information seems to have been quite overlooked later. The next author who mentions the branchial skeleton is COPE (8, p. 457) who (incorrectly) states: "Superior branchihyals (= epibranchials) cartilage, three superior pharyngeals (= pharyngobranchials)."

[6] p. 280 [14]. But little information regarding the visceral anatomy of the *Aulostomidæ* or *Fistularidæ* is found in the literature.

Already DUVERNOY (in CUVIER's Leçons etc. 2. Edit., 4th vol., 2, p. 143) pointed out that in CUVIER's family "*Les bouches-en-flûte*" the intestinal canal did not possess any stomachal blind-sac; he adds: "Le canal alimentaire semble tout d'une venue; à peine peut-on y reconnaître une première partie distincte qui serait l'estomac." But DUVERNOY seems only to have examined *Centriscus scolopax**, not *Fistularia* nor *Aulostoma* (nor *Amphisile*).

Of internal structures in *Aulostoma* GÜNTHER (16 a, p. 537) gives the following account: "The stomach is spacious, elongate, with thin membranes, which become thicker towards the pylorus; it passes without curvature or dilatation into the intestine, which is extremely short, quite straight, without curve or circumvolution, and rather wider at its commencement than posteriorly; two pyloric appendages of moderate size on each side of the pyloric portion of the stomach. Air bladder large."

In the stomach G. found remains of small fish. (LACÉPEDE 31, T. 10, p. 101 mentions fish-eggs and worms.) Curiously enough neither GÜNTHER nor later authors mention the position of the anal opening close behind the ventrals and far from the anal fin.

The number of gills, the presence of a pseudobranchia and the slit behind the 4th gill-arch are rightly mentioned by previous authors (LACÉPÈDE, GÜNTHER, JORDAN etc.).

Fistularia.

[7] p. 281 [15]. Minute dermal asperities in Fistularians are mentioned for the first time by KLUNZINGER (27, p. 515). In a very young specimen, 13 Ctm. long, from the Red Sea, which he considered as representing a new species (*Fistularia villosa* Klzgr.) he found the "Rumpf dicht mit kurzen weichen Dörnchen oder Härchen überzogen." Later HILGENDORF (17, p. 231) observed the same asperities in two small specimens, one (108 mm.) from Japan, another from New Britain, and concluded that they as well as KLUNZINGER's *F. villosa* simply were young stages of *F. serrata* Cuv., "die im erwachsenen Zustande nackt ist." Apparently without knowing Hilgendorfs observations LÜTKEN (33, p. 584 [176]) also declared that *F. villosa* Klzg. must be the young *F. serrata*, to which he referred a specimen of 130 mm. length in the Museum

* I very much regret in my first contribution (1908) to have completely overlooked that CUVIER's Leçons, l. c. p. 143, and especially p. 365, contain a complete description of the alimentary canal of *Centriscus scolopax*; *inter alia* it points out the entrance of the bile-duct, and concludes: "Ici, comme dans les cyprins, l'œsophage et l'estomac réunis, sont rudimentaires." On p. 492 the liver is described, p. 564 the gall-bladder mentioned, and p. 612, absence of the pancreas.

of Copenhagen, coated wtth spinelets; and further, LÜTKEN stated that he found a similar coating well developed on the tail and posterior part of the body of a *F. tabacaria* of 280 mm. length and not completely disappeared from the tail of another, still larger specimen of 415 mm. length; hence he concluded that the species *F. serrata* and *tabacaria* both went through a "*villosa*-stage", which in the latter apparently was of greater duration. That LÜTKEN (like Hilgendorf) considered „*F. serrata*" as always naked in the adult state is easily explained through the fact, that his material of Fistularians from the Indo-Pacific really contained only the *F. depressa* Gthr. Quite naturally therefore he referred his young „villose" specimen of 130 mm. length to a naked „*F. serrata*"; now I refer the same specimen to the species *F. petimba* not only on account of its rough skin but also because the head shows the characteristics of this species. The splitting up of the old *F. serrata* into two species, the one naked, the other rough, is due to GÜNTHER (16 c, p. 68); only the first he designated with a new species-name, *depressa*, while he left the old name *serrata* for the latter, the rough one, for which JORDAN (& GILBERT) later perhaps more correctly introduced as new name *petimba*, originally used by LACÉPÈDE for specimens captured by COMMERSON in the Indo-Pacific.

8 p. 282 [16]. These structures were observed by GÜNTHER (16 a, p. 531), and earlier by AGASSIZ (1, T. 4, p. 278; comp. p. 338 [72]).

9 p. 282 [16]. The median scales in *F. petimba* were also observed by GÜNTHER („*F. serrata*" 16 a, p. 535), and compared by him to the dorsal spines of *Aulostoma*: "They are evidently rudiments of the spinous portion at least of the dorsal fin, which, in *Aulostoma*, is more developed, the spines being free." It seems difficult to understand how the author would be able to reconcile this hypothesis with the fact that *F. petimba* has scales or "spines" of quite the same structure along the belly and on the upper and lower side of the tail. Their presence on "the abdomen" G. himself has mentioned.

10 p. 282 [16]. The ossicles of the lateral line have been noticed by several previous authors (GÜNTHER a. o.).

11 p. 282 [16]. The number of vertebræ is differently given by different authors; thus e. g. CUVIER (9 b, T. 1, p. 231) has 56 abdominal, 33 caudal vertebræ, GÜNTHER (16 a, p. 529) 4 + 49/33 in *F. tabacaria*; (p. 533) 47/34 (Rüpp.), 47/29 (Rosenthal)* in *F. serrata*; JORDAN and EVERMANN (21 a, p. 756): 4 + 44 to 49 + 28 to 33. Probably the number varies individually within narrow limits, with no value for the distinction of the species.

12 p. 284 [18]. Remarks about the vertebral column, or more or less incomplete descriptions, are found in various authors. The modification of the anterior part has early been observed, but as far as I am aware CUVIER was the first to settle its composition of four vertebræ in the almost complete and correct description of the column, given in the second edition of his Leçons etc. (1835, 9 b, T. 1, p. 227). LACÉPÈDE (31, T. 10, p. 95) and ROSENTHAL (47, p. 31) regard the anchylosed part as one single vertebra, while MECKEL (35, p. 232) has at all events indicated a compound structure in the following words: "Bei *Fistularia* besteht gleichfalls der erste, sehr längliche Wirbel aus mehrern, durch Fugen verbundenen Stücken", and CUVIER & VALENCIENNES (10, p. 359) speak of coalescence of vertebræ in this way: "Plusieurs [poissons] ont aussi les corps d'une partie de leur vertèbres soudés ensemble; on en voit des exemples dans les cyprins, les silures et les fistulaires, et de plus marqués encore dans un grand nombre de chondroptérygiens." AGASSIZ (1, T. 4, p. 276) uses rather indistinct terms: "La colonne vertébrale offre cela de très-particulier, que toute sa partie antérieure ne présente

* GÜNTHER has not observed that ROSENTHAL counts the 4 anterior vertebræ as one; the number thus ought to be quoted as 50/29.

qu'une masse continue sans articulation. Les vertèbres ne commencent à être distinctes que près des ventrales."

Figures of the whole skeleton are given by ROSENTHAL (47, Tab. 9, Fig. 8) ("*Fist. serrata*", if *F. petimba* or *depressa* I am not able to decide) and AGASSIZ (1, Atlas, Vol. 4, Tab. 35, Fig. 1) (*F. tabacaria*, wrongly on the plate designated as *Aulostoma chinense*); in both figures the system of ossified tendons along the vertebræ is omitted. Separate figures of the anchylosed anterior part are given by BRÜHL (6 a, Tab. 9, Fig. 38, 40; 6 b, Tab. 10, Fig. 10, 11; in both works *F. tabacaria**) and OWEN (38, p. 41, Fig. 35, *F. tabacaria*; copied by GOODRICH 15, p. 412). A very detailed and elaborated description of the anterior coalesced vertebræ is found in KLEIN (26 a, p. 327—28); nevertheless K. declares that he was not able to find "real sutures" between the component vertebræ, and therefore he feels not quite sure about their number, but supposes it to be four. BRÜHL furthermore has figured other parts of the vertebral column (esp. in 6 b, Tab. 10, Figs. 9—15, 17—23), but some of his figures are not quite correct (e. g. 13. 19 and others). He seems to be the only author, who figures anything of the ossified tendons, of which one only is represented in 6 b, Tab. 10, Fig. 23; the text says: "r—r': an die spina angelegter, sehr langer, knöchener Flossenstrahl." I suppose that GÜNTHER is speaking of these structures when he states (16 a, p. 533): "... the interneurals long, horizontally situated, so that they form together one continuous bony strip." Evidently G. has not observed the paired symmetrical arrangement of the structures in question. Also AGASSIZ possibly has these bones in view (and not only the nuchal plates?) when he writes (1, T. 4, p. 278): "Enfin, il y a de semblables pièces allongées, sur la ligne médiane du dos, qui semblent rappeler la tendance qui règne généralement chez les Aulostomes, à avoir une dorsale épineuse."** The "pièces semblables" are evidently the spindle-shaped bones imbedded in the skin of *Fist. tabacaria*, forming the strip along each ventral side peculiar just for this species and mentioned on p. 281 [15] of this work; this will be seen from the words immediately preceding the above quotation: "En avant des ventrales, et depuis leur insertion jusqu'au bout de la queue, on remarque en outre une série de lames cornées, acérées, et qui paraissent avoir quelque analogie avec les écussons abdominaux des Belones."

The 3 nuchal plates seem first to have been specially noticed by GÜNTHER (16 a, p. 532), who describes: "A narrow strip [of shields] along the median line of the back behind the skull; they are, in fact, confluent neural spines, belonging to the anterior portion of the vertebral column)." This interpretation I think must now be given up. Later they are described by KLEIN (26 a, p. 326) as one narrow plate, behind drawn out into a long point "welches gespalten sich auf die Dornfortsätze der 3 vorderen abgesonderten Wirbel legt."

The large lateral bones, which are fastened to the epiotics, are well described by AGASSIZ (1, p. 278) and still better by GÜNTHER (16 a, p. 532). In comparing them with the similar structures in *Mugil* which GÜNTHER (cfr. l. c. p. 412) regards as "processes of the paroccipital", he apparently does not consider them simply as ossified tendons. The same comparison with *Mugil* is found in DARESTE (11, p. 1089): "Les occipitaux externes présentent de très-grand prolongements osseux, qui s'extendent dans la région dorsale et sont l'exagération d'une disposition qui se rencontre chez les Mugiloides."

[13] p. 284 [98]. While already LACÉPÈDE supposed the caudal filament to be a ray (31, T. 10, p. 93: "Cet appendice .... ressemble entièrement par sa contexture aux rayons articulés des

* In the work 6 b BRÜHL believes he is dealing with *Aulostoma chinense*; the mistake I think is due to the wrong labelling of a skeleton in the Paris Museum, probably the same which served AGASSIZ for his figure, mentioned above, and wrongly designated as *Aulostoma chinense* on his plate; but while AGASSIZ in his text has corrected the mistake BRÜHL has not been aware of it.

** They are at all events figured on the fossil *F. Koenigii* (1, T.4, Pl. 35, Fig. 5), and AG. remarks in the description of this species: "Au dessus de la colonne vertébrale on remarque quelques osselets qui paraissent correspondre au pièces impaires du milieu du dos, que j'ai mentionnées en décrivant la charpente solide du *F. tabacaria*."

nageoires, et présente des articulations entièrement analogues à celles de ces derniers") MECKEL curiously enough (35, p. 200) believed it to be a continuation of the vertebræ ("Bei *Fistularia* findet sich die merkwürdige Anordnung, dass sich die immer kleiner werdenden Wirbel über die Schwanzflosse hinaus in einen langen, sehr dünnen Faden verwandeln, welcher nur in seinem Anfange in unvollkommene Wirbel abgetheilt erscheint"). KNER (28 b, p. 259 [28]) has partly seen the continuation of the lateral line on the caudal filament: "Letzterer (der Seitencanal) setzt sich durch die Mitte der Caudale zwischen zwei fadig verlängerten Strahlen weit hinaus fort."

The structure of the fin-rays generally is already mentioned by AGASSIZ (1, p. 278) in so far as he says that they are "peu divisés et à peine articulés." KNER (28 b, p. 257 [26]) on the other side says that in all the fins the rays are simple, unjointed and unbranched, and of a similar compressed shape as those in the Lophobranchiata." He has evidently not examined the ventrals carefully enough.

[14] p. 288 [22]. The cranial skeleton of *Fistularia* has early and often been examined, but a thorough, sufficiently illustrated, description has hitherto never been published, and very many of the statements made by previous authors are incorrect. The figures of ROSENTHAL (47, pl. 9, figs. 8—12) are rather small and imperfect, and the explanation (l. c. p. 30) is too incomplete and defective to be of any use now.

In the last (6th) volume of his "System der vergl. Anatomie" (1833) MECKEL has given some scattered notes regarding the visceral (suspensory and branchial) skeleton. P. 107—108 he describes and recognizes the 3 opercular bones and points out the presence of the preoperculum (cfr. also p. 113, 114); p. 122 he remarks that the hyoid ("vordere Zungenbeinäste") is small, flat and low (p. 123), only composed of two pieces, the first (i. e. the stylohyal) and second (i. e. epihyal) being absent, and the fourth (i. e. the two hypohyals combined) single and very small, and that the whole is almost entirely made up of the third (i. e. the ceratohyal), which is elongated and curved (p. 126); it carries 5 branchiostegal rays or rather "4, because the upper is split into two branches, which form the first and second ray." P. 135 it is stated that the basibranchials (die "tiefe unpaare mittlere Schicht des Zungenbeins") are wanting, while a urohyal ("das oberflächliche mittlere Zungenbein") is present (repeated on p. 142); p. 148 is noticed that the glossohyal ("der vor der Vereinigung der vorderen Seitenäste liegende Knochen oder Knorpel") is very long; p. 152 that the branchial arches are small and slender, and p. 154 that they are of a very simple structure: "Von einer Theilung des langen, geraden Kiemenstückes in zwei Hälften findet sich keine Spur. Nur in den vorderen Bögen findet sich ferner ein oberes, sehr kleines, nach vorn gewandtes, gleichfalls gerades Stück, das keine Kiemen trägt und daher eben so gut oberer Schlundkopfknochen seyn kann." Finally p. 161 and p. 162 is correctly stated that gill-rakers are completely absent.

AGASSIZ (1, p. 277) describes quite correctly those features, which may be seen without separating a mounted skeleton, and which might be of use in comparing with fossils. Worth mentioning is that he describes the 3 opercular bones rightly. He has seen the long glossohyal and counts 5 branchiostegals, but besides he adds two more at the symphysis of the hyoid; this mistake is due to the preparation, in which a strip of dried up skin is preserved; the latter also accounts for the following mistake: "La membrane qui forme le tube buccal, entre l'appareil hyoïde, les mâchoires et les pièces operculaires, est soutenue par de nombreuses fibres osseuses très-grèles." In CUVIER's Leçons etc. (9 b, T. 2, p. 626) is found the following: "Dans l'*aulostome chinois**, le museau est large, mince et plat comme une épée à deux tranchants. Le mastoïdien (i. e. the posttemporal) donne en arrière une apophyse qui dépasse beaucoup le condyle. Dans ces deux poissons [*Fist.* and *Aul.*], le basilaire, au lieu d'une facette articulaire creuse, conique, comme nous en avons vu jusqu'à présent, donne

* i. e. *Fist. tabacaria*, cfr. above p. 335 [69] note 5. Perhaps the same wrong labelling, which caused the designation of *F. tabacaria* as *Aulostoma chinense* on pl. 35 in AGASSIZ's work as well as BRÜHL's mistake, is also the cause of the exchanging of the same names in CUVIER's Leçons.

au contraire une facette convexe, et qui forme un véritable condyle semblable à celui des reptiles."

In KÖSTLIN's, from a modern view, somewhat curious work (30) observations about cranial structures in the most different fishes are scattered in a rather bewildering way; among these also some remarks on *Fistularia*. On p. 317 he says: "Auch bei Fistularia und Syngnathus scheinen sich die beiderseitigen Scheitelbeine hinter der schmalen Hinterhauptschuppe ein wenig zu berühren." What are here named parietals are evidently the epiotics; thus for *Fistularia* the observation is correct, but not for *Syngnathus*. The structure of the ethmoidal region in *F.* seems quite obscure to K., as he p. 343 ascribes nasals to *Fistularia*, but coalesced with the ethmoid "as in *Trigla* and *Heterobranchus*", and further on p. 361 about the antorbital bone: "Eine besondere Grösse erreicht die Platte bei einigen Fischen, deren Nasenbeine oder deren Siebbeine ungewöhnlich entwickelt sind. So streckt sie sich bei Fistularia an jedem Rande des Siebbeins sehr lang nach vorn aus; bei Syngnathus und Lepidoleprus zieht sie sich, wie die angrenzenden Nasenbeine, sehr lang nach vorn aus." Does K. mean the lateral parts of the mesethmoid? On p. 362 an arch of infraorbitals is ascribed to *Fistularia*. On p. 378 the suspensory apparatus for the mandible is mentioned in terms rather difficult to understand, but to which the key is found on p. 375, where K. compares his terminology with that of CUVIER: "Endlich ist von den Acanthopterygiern noch Fistularia zu nennen, wo die einzeln Stücke der Quadratbeingruppe sich so gegen einander verschieben, dass das untere Stück (i. e. the quadratum) viel mehr nach vorn liegt, als das obere (i. e. the hyomandibular); der gewöhnliche Zusammenhang der Stücke wird aber darum nicht aufgehoben. Sowohl das untere (ɔ: quadratum) als das vordere Stück (i. e. the metapterygoid) sind hier in die Länge gezogen; dieses bildet den unteren Rand der Augenhöhle und articulirt mit dem vordern Stirnbein; das untere Stück (ɔ: quadratum) gränzt theils an das Flügelbein (i. e. entopterygoid) theils an das Siebbein (which latter statement is wrong!), und die Gelenkfläche ist mit ihm ganz nach vorn gerückt; das obere Stück (ɔ: the hyomandibular) ist sehr klein und verkümmert." As will be seen on closer examination, K. regards the symplectic and the metapterygoid as one piece, not to mention the smaller defects. He adds: "Unter den übrigen Fischen kommt fast dieselbe Anordnung bei Syngnathus vor", which to a certain degree may be true!

BRÜHL (6 a, Tab. 9, Fig. 38) has figured the skull, but his figure does not give details of any importance. The lettering shows only some of the most conspicuous parts, such as AGASSIZ had already mentioned. Of the suspensorial parts and adnexa, for example, he evidently has only recognized the preoperculum (Pop) and quadrate (u. Gb., i. e. "unteres Gelenkbein"), while the whole palato-pterygial part is marked: o. St and Gb? (i. e. "oberes Stück" and „Gelenkbein"?; that is to say B. was not able to make out its composition). BRÜHL's text contains but very few observations, dispersed in a similar way to those of KÖSTLIN. P. 88, speaking of the different ways in which "Schnabelbildungen" may arise in fishes, he states that one way (the fourth) may be "Durch einen sehr gestreckten Riechbeinkörper mit Hülfe ähnlicher Haupt- und vorderer Stirnbeine(?) bei Fistularia, Aulostoma. Dass Zwischen- und Oberkiefer hier keinen Antheil an der verlängerten Kopfbildung haben, zeigt die eben cit. Figur (Tab. 9, Fig. 38), wo die genannten Knochen (ibid.: Z. K. und O. K.) kleine absteigende Knochenstiele darstellen." On p. 96 he mentions Polypterus, Synbranchus, Tetraodon and Fistularia as examples of fishes, where the pterygo-palatine arch has given up its articulation with the skull and acquired a connection by means of suture. P. 111 he observes that "Der Zungenknochen (i. e. the glossohyal) ist sehr lang bei Aulostoma chinense (after RATHKE), Fistul. tabacaria and Syngnathus." On p. 123, Note 4, he states against RATHKE (who (44, p. 77) ascribes only one opercular bone to *Fistularia* and several other genera) that his figures show for *Fistul.* as for several other genera that the opercular apparatus is "mehr weniger normal gebaut d. i. aus 4, 3 und wenigstens 2 Stücken bestehend." The lettering of his Fig. 38 on Pl. 9 shows that he only recognized 2 in Fistularia, and that he regarded the interoperculum as the suboperculum, while the real suboperculum is omitted.

By far the most complete and correct account of the skull is that of GÜNTHER (16 a, p. 532). After having described the general form and the frontals he says: "The greater part of the upper surface of the snout is formed by the ethmoid, whilst the vomer occupies the anterior fourth or fifth. The præfrontal is situated in front of the orbit, elongate and triangular. There is a deep and long groove on the side of the snout for the muscles of the jaws; its bottom is entirely ossified, and formed by the tympanic (the quadrate), preoperculum, entopterygoid, pre- and mesotympanic (= metapterygoid and symplectic), these bones being exceedingly long. The entopterygoid (= entopterygoid) and pretympanic (= metapterygoid) are situated immediately below the ethmoid, and provided with a crenulated ridge which is externally visible. The bones which in other fishes constitute the bottom of the tympanic cavity below the orbit, are carried forwards before the orbit in *Fistularia*; the epitympanic (= hyomandibular) appears to be absent." And later is added: "Turbinal bone (= nasal) very small; infraorbitals none."

On page 530–31 the 3 opercular bones are correctly described, as well as the branchiostegals, but in "*F. serrata*" G. (p. 534) incorrectly gives the numbers as 6. The absence of gill-rakers is noted as well as the "series of three elongate patches of (villiform) teeth on each side of the roof of the pharynx" and the long series of teeth on the lower pharyngeals; features which already LACÉPÈDE (31, p. 92) had pointed out (but L. regarded the operculum as composed of only one piece). "The glossohyal", GÜNTHER finally adds, "is exceedingly long, half as long as the tube."

Thus, with the exception of the statements, that the hyomandibular ("epitympanic") is absent and a nasal ("turbinal") present, GÜNTHER's above-quoted description proves to be quite correct; but except few remarks on the frontals he does not give any information whatever about the bones composing the brain-case. Ten years later DARESTE (11, p. 1089) gave the following account, which seems inferior to that of Günther, and contains some errors emphasized by me below: "Le type des Fistulaires est caractérisé tout d'abord par l'allongement de la région de la tête qui précède la cavité crânienne: les frontaux principaux, très-allongés et soudés entre eux, sont précédés par un ethmoïde excessivement long, lequel est lui-même précédé par un vomer également assez long. Cet allongement des os antérieurs du crâne s'accompagne d'un allongement considérable de l'aile temporale; donc les trois os principaux, temporal (= hyomandibular), tympanique (= metapterygoid) et jugal (= quadrate), sont soudés au sphénoïde dans toute leur étendue. Au contraire, les mâchoires et l'aile palatine sont fort petites. L'aile palatine s'unit au vomer non-seulement par le palatin, mais aussi par le ptérygoïdien interne. Les frontaux antérieurs sont très-écartés des palatins. La boîte crânienne, très petite, ne porte pas de véritable crête. Les frontaux principaux s'unissent aux mastoïdiens (= pterotics) et aux frontaux postérieurs. Les occipitaux externes (= epiotics) présentent de très-grands prolongements osseux, qui s'étendent dans la région dorsale et sont l'exagération d'une disposition qui se rencontre chez les Mugiloïdes."

Thus DARESTE has not observed anything about the most remarkable points in the composition of the brain-case either: the relation of the pterotics, and of the epiotics to their neighbours and the absence of parietals etc.

The first author to analyse in details the skull of *Fistularia* is KLEIN.

KLEIN (26 b and c) has given most elaborate and painstaking descriptions of the single bones composing the skull (not of the suspensorial nor the branchial skeletal parts), descriptions which hardly anybody will be able to understand without having the necessary preparations in his hands; and even so it is hard work to follow the author. I can therefore well understand that SWINNERTON (56 a, p. 575) has given up the "attempt to explain the why and the wherefore of Klein's tangle in describing the auditory region." Nevertheless, the descriptions are generally very correct, but the interpretations are often more or less deficient. Through careful study of KL.'s work it will be evident, that — overlooking the dividing suture — he regards the prootic and the postfrontal as one piece, which together with the pterotic he designates "ala temporalis"; as "ala orbitalis" he considers the alisphenoid, which he quite correctly describes with all minutiæ. The posttemporal is regarded as "squama

temporalis", or pterotic, in spite of the fact, that he has rightly observed that the "hinder part" of his "ala temporalis" contains the exterior semicircular auditory canal, as the pterotic does in other fishes, and that his "squama temporalis" here does not take any share in the formation of the wall of the brain cavity, as the pterotic normally does. The coalesced epiotics together with the supraoccipital are described as "occipitale superius"; but he has, however, observed (b, p. 144) that: "Die in den Gehörkapseln sich entwickelnden occipital. extern., epiotica, sind mit der untern Fläche des occipital. superius verwachsen", which fact he later repeats (c, p. 186 and especially p. 207). In a parenthesis on p. 142 he states: "parietal. lassen sich nicht als abgesonderte Platten darstellen", and later, on p. 246 he declares, that he has not been able to find parietals in several fishes, among others *Gasterosteus* (where parietals are present!) and *Fistularia*; "sie sind entweder als völlig mit den frontalia verwachsen, oder überhaupt fehlend zu betrachten." He rightly describes the parasphenoidal fossa for the eye-muscles and points out that there is no proper eye-muscle canal; further the prefrontals (b, p. 188) (only his remark about the attachment of the "Infraorbitalbogen" is wrong, in as much infraorbitals are totally wanting!). In the snout region (b, p. 221—22) he commits a mistake in regarding the whole dorsally visible part as one bone, the mesethmoid, his "septum narium"; his "vomer" is only the ventrally projecting, keelshaped part of the real vomer (the part carrying teeth). Finally (b, p. 251) he mentions *Fistularia* among other fishes which lack nasalia. It is worth pointing out that KLEIN is the only earlier author — as far as I have seen — who has examined the inner aspect of the brain-case; the descriptions of the inner structures, which — it may be said by the way — are by no means easy to make out, are dispersed throughout his work; a good deal is to be found in (c) on page 206—07. Upon the whole KL.'s account is very scattered; the principal descriptions of the posterior part of the skull will be found in (a, p. 325) b, pp. 141—144; of the anterior part 188—89; p. 221—222; several details are found in c, p. 140, 186, 206 etc.

JORDAN and EVERMANN state (21 a, p. 755) that the long tubiform snout in *Fistularia* is "formed by the symplectic, proethmoid (=? prefrontal), metapterygoid, mesopterygoid (= entopterygoid), quadrate, palatines, vomer, and mesethmoid." "Post-temporal coossified with the cranium. Branchiostegals 5 to 7." "Gill-rakers obsolete. Basibranchial elements wanting." And on p. 756 they add a tabular formula of the branchial skeleton after Mr. RUTTER, which is correct, save on two points: 1) a first basibranchial is present, and 2) the 3 pharyngobranchials are to be referred to the second, third and fourth arch, not to the first, second and third. Already in 1871 COPE (8, p. 457), calling attention to the structure of the branchial skeleton in the fishes, for which he founded his group *Hemibranchii*, ascribed to *Fistularia* "three osseous anterior superior branchihyals (= epibranchials) and three superior pharyngeals, directed forwards."

SIEBENROCK (53, Pl. 5, Fig. 17) figures the brain-case of "*F. serrata*", seen from above; the figure is good in most respects but defective on one essential point: the sutures between the supraoccipital and the epiotics are omitted, because S. regards the supraoccipital + the two epiotics as one bone, which he calls "Supraoccipitale" (so). Describing on p. 131 the connections of the posttemporal („Suprascapulare", s. sc.) he says: "Die sonst übliche Verbindungsweise mit dem Paroccipitale (= epiotic) kann hier nicht stattfinden, weil dieser Knochen gänzlich fehlt. Eine weitere Merkwürdigkeit bilden die Parietalia, die zu einer unpaaren Platte vereinigt sind und vom Supraoccipitale bei *F. tabacaria* Linné nahezu, bei *F. serrata* Bloch aber gänzlich bedeckt werden. Daher reichen die Frontalia (fr.) so weit nach rückwärts, dass sie nach Wegnahme der Suprascapularia (= posttemporals) theilweise den Hinterrand des Schädels begrenzen helfen." What S. here regards as the coalesced parietals is simply the supraoccipital (shown in my figure 6 on Pl. I as so), and there is no difference between the species; in my specimens of "*F. serrata*" (i. e. *petimba*), the narrow supraoccipital is quite as visible as in *F. tabacaria*.

SWINNERTON (56 a, p. 575 f. f.) compares the skulls of *Gasterosteus*, *Syngnathus* and *Fistularia*, which he believes all to be more or less related to each other and therefore has put together in one group, his *Thoracostei*. In quoting S. below, I emphasize the mistakes

regarding *Fistularia*. On p. 575 S W. writes: "... all are alike in the absence of an opisthotic* and basisphenoid, the even upper surface, the sculpturing of the roofing bones, the simplicity of the post-temporal, the essential shape of the ethmoid and the great size of the supra-occipital, which separates the parietals widely, and appears to separate the hinder portion of the frontals. In Gasterosteus the exoccipital extends forwards between the pterotics and basioccipital to the pro-otic. In the others the pterotic extends ventrally to the basioccipital, and also part of the way into the large membranous space between this and the pro-otic, thus separating the exoccipital widely and the basioccipital partially, from the pro-otic .... In the sphenoidal region of Fistularia the pro-otic completely encloses the foramen for the exit of part of the fifth nerve, and forms the hinder boundary of the other exit. The large alisphenoid forms the front boundary of the rest. No eye-muscle canal is present, consequently the parasphenoid lies flat against the floor of the cranium. Laterally it sends out processes up to the sphenotic (= postfrontal; in *Fist.* the process is united to the prootic and does not at all reach the postfrontal)." P. 576: "In the anterior portion of the cranium, Fistularia and Syngnathus present the same features as those given above for Gasterosteus, but it is greatly elongated, and almost completely ossified. In the first this region is proportionally much wider, because the narrow pre-ethmoid is supplemented laterally by the nasals." "In the visceral skeleton all are alike in the tendency towards weakening of the branchial apparatus**, in the great forward slant of the hyomandibular***, in the great elongation of the symplectic, in the great reduction or complete suppression of the metapterygoid cartilage****, in the absence of an ectopterygoid*****, and in the possession of the acrartete condition."† "In Fistularia the reduction of the branchial skeleton has advanced much further than in Syngnathus, for all the basibranchials and the fourth epibranchial are absent. The pharyngobranchials of the second to fourth arches are present, but, unlike those of Gasterosteus, the first two are fused; the third is free, and all are rod-like, and lie one behind the other." P. 577: "In the hyoid arch the basihyal (= glossohyal) though present during development, is absent in the adult Syngnathus††, but attains a great length in Fistularia." "Of the bones immediately concerned in the gill-cover and branchiostegal membrane, the operculum alone survives in Syngnathus†††, but are all present, together with five branchiostegal rays, in the Fistularia." P. 578: "In Fistularia the inner lamina of the suborbital bone alone remains, the quadrate is much larger posteriorly, and the pterygoid bone bears a close resemblance to that of Gasterosteus. Between the hinder process of the last named bone and the suborbital is the undoubted metapterygoid, which thus occupies a similar position to, but is much smaller than, a in Syngnathus."†††† What SWINNERTON here calls the suborbital must be the symplectic in *Fistularia*; of sub-

* In *Gasterosteus* an opisthotic is present!

** In *Gasterosteus* I cannot admit any "weakening" of this apparatus.

*** In *Gasterosteus*, *Spinachia*, etc. the hyomandibular is not more sloping forwards than in very many other fishes (nor in *Syngnathus*).

**** In *Gasterosteus*, *Spinachia*, *Eucalia*, *Apeltes* etc. an ossified metapterygoid is present (overlooked by SWINNERTON in his monograph!); in *Syngnathus* only (as in the other Lophobranchiates) it is absent.

***** The ectopterygoid is present in *Syngnathus* (and Lophobranchiates generally).

† The acrartete condition is defined by SWINNERTON as the condition, in which the attachment of the palatine cartilage or its derivatives is confined solely to the preethmoid cornua. Now, in *Fist.* the palatine is attached to the vomer alone.

†† It is present in all adult Syngnathids.

††† In *Syngnathus* and all the Lophobranchiates all 3 opercular bones are present, and 1 or 2 branchiostegals.

†††† a in Syngnathus is the anterior infraorbital bone; comp. the reproduction of SWINNERTON's figure 50, p. 356 [90] with my fig. 4 on Pl. V, and what is said on p. 356 [90] of this paper.

orbitals this genus has no trace whatever. From the above quotations it will appear that GÜNTHER, publishing in 1861, had by far a more correct apprehension than SWINNERTON in 1902, of the cranial structures in *Fistularia*.

In his admirable paper on the shoulder-girdle in the Hemibranchiates STARKS (55, p. 624) correctly points out the absence of opisthotics and parietals and the position of the pterotic, the form of the occipital condyle, the presence of the long ossified lateral nuchal tendons as cranial features common to both *Fistularia* and *Aulostoma*. But in adding: "basisphenoid bridging anterior edges of prootics above rectus muscles of eye making basis cranii appear double, but no myodome in continuation", he makes a mistake: there is no basiphenoid in the described position, the bridge is formed by the prootic itself, in *Fistularia* together with the alisphenoid — as already known to KLEIN. As osteological characters distinguishing *F.* from *Aulostoma* S. mentions, that the palatines are free from the cranium, the posttemporal united suturally to the latter, and that the transverse processes are normal. The latter point is less correct, in so far that the double transverse processes are also found in *Fistularia*, the posterior one is only very small compared with the corresponding process in *Aulostoma*.

[15] p. 289 [23]. While LACÉPÈDE (31, p. 92) only observed, that the anterior part of the body in *Fistularia* was enclosed in a kind of armour, consisting of 6 long bony plates, hidden below the skin, AGASSIZ (1, p. 278) had a more complete notion of these elements and referred the large ventral plates to the coracoid ("humérus"), the lateral to the postclavicle ("l'os styloïde"); besides he remarks that the pterygials ("os carpiens") are well developed.

ROSENTHAL (47, pl. 9, Text p. 31) designates the shoulder-girdle as "Gürtel" (without entering into its composition), the postclavicle as "Seitenschuppen", the coracoidal plates as "Vordere Bauchschuppen, die vom Winkel des Gürtels entstehn", the ossified nuchal tendons as "Lange Rückenschuppen, die vom Hinterhaupt abgehn."

BRÜHL (6 a, Pl. 12, Fig. 36) gives a rather poor and incorrect figure on which sc (i. e. "scapula") is the posttemporal; the suprascapular is omitted; the lateral (dermal) part of the clavicle is lettered V. A. 1 (i. e. "Vorderarm, erstes Stück" = scapula in the present paper); the real scapula and three pterygials are lettered H. W. (i. e. "Handwurzel"), and the coracoid V. A. 2 (i. e. "Vorderarm, zweites Stück"); the postclavicle and the coracoidal plates are marked "? 1′" and "? 2′", probably indicating that they may be regarded as separate parts belonging to the two "Vorderarm-Stücke". In the text nothing is found about these questions; upon the whole are only found two statements, the one wrong (p. 174), viz. that *Fist.* has only one "Schulterblatttheil" (the posttemporal), the other (p. 176) that it has two "Ober- und Vorderarmknochen."

GÜNTHER (16 a, p. 532) apparently regards the posttemporal as part of the skull: "The process on which the humeral arch is suspended is very long, reaching as far backwards as the operculum; suprascapula and scapula (= supraclavicle) short, simple; the humerus (i. e. the clavicle) emits a process backwards for the coracoid (i. e. the postclavicle), another downwards for the radius and ulna (i. e. scapula and coracoid), and finally a third for its symphysis. There are three bones participating in the symphyseal junction of the humeral arch: the urohyal, which is very elongate, the humeral and the pubic bones. Radius and ulna reduced to a single subcircular bone; there are four narrow, longish carpal bones (i. e. pterygials)." (I suppose that part of the scapula is looked upon as one of these "carpal bones", the small uppermost pterygial having been overlooked; otherwise the statement, that there is only one subcircular bone representing the scapula and coracoid, is unintelligible). Farther down he describes the postclavicle ("coracoid") as composed of two bones; and the ventral shields or "pubic bones". Curiously enough G. has not seen that the ventrals are provided with typical "pubic bones"; and in the diagnosis of the family *Fistularidæ* (p. 529) he expressly states, that the ventrals "are separate from the pubic bones, which remain attached to the humeral arch."

A very lengthy and circumstantial description of the shoulder-girdle (and the urohyal) is

given by KLEIN (26 a, p. 326—27); but, curiously enough, he does not give any morphological interpretation of the constituents described in so many words; only the ventral coracoidal plates he designates, like GÜNTHER, as "Beckenknochen."

COPE (8, p. 457) regarded the coracoidal plates as interclavicles, and this interpretation later has been generally accepted, until STARKS (p. 625) declared that these bones were not separated from the coracoids. Thus we find these elements called interclavicles in the description of JORDAN and EVERMANN (21 a, p. 756, 757), which otherwise in the main follows GÜNTHER but uses other names; they only speak of 3 pectoral ossicles (i. e. pterygials).

In SIEBENROCK's paper (53, p. 131) only the posttemporal and its connection with the cranial bones are described; S. correctly places *Fist.* among the fishes, which possess all three elements in the clavicular arch: posttemporal, supraclavicle and clavicle.

STARKS (55, p. 625, 630) describes in detail the ventral coracoidal plate and the shoulder-girdle, giving a very good figure. The few points, in which I have anything to add, will be found on pag. 289 [23] of my paper; they are in the main the structure of the scapula and the connection between the coracoid plates from the opposite sides in the ventral median line, which latter point seems not to have been observed by STARKS.

Recently SWINNERTON (56 b, p. 379) has raised the question about a probable separate existence of the ventral coracoidal plates as interclavicles in the group of fishes, comprising *Fistularia*. As his own contribution to the question only regards *Gasterosteus*, which in my opinion does not at all belong to this group, I shall later come back to it in treating of this genus. Only I may just state here, that the considerations set forth by STARKS have in my opinion lost nothing in validity through SWINNERTON's observation.

[16] p. 292 [26]. That there are four gills, a well developed pseudobranchia and a slit behind the fourth gill-arch has been seen by previous authors, but some, MECKEL f. i. (p. 18) deny the presence of a pseudo-branch; already LACÉPÈDE mentions the presence of the pseudobranchia here as well in *Aulostoma* ("le rudiment d'une cinquième branchie"); L. also says that COMMERSON has found the stomach, in the specimens dissected by him, very long, and filled with small fishes.

KNER (28 b, p. 29 [260]), after having made the following statements: "die Rechenzähne sind äusserst kurz und spitz (they are really wanting); Schlundzähne konnte ich nicht wahrnehmen", adds: "Der Darm macht keine Windungen (im lang gestreckten Magen fand sich ein Fischchen vor), die dünnwandige Schwimmblase reicht nur bis zu den grossen queren Fortsätzen der Bauchwirbel." (*Fistularia immaculata* = *F. serrata* autt.).

GÜNTHER (16 a, p. 535) gives the following information about the visceral anatomy of *Fistularia* ("*serrata*"): "The greater portion of the case formed by the bony shields behind the head is filled by the air-bladder, the membrane of which is thin, coating the interior surface of the upper and lateral shields, and firmly attached posteriorly to the muscular mass which commences behind those shields. A portion of the stomach and liver also are enclosed in that anterior portion of the abdominal cavity. The stomach is elongate, subcylindrical, and passes gradually into the intestine, which is short and straight to the vent. I observe only one short pyloric appendage, enveloped by a portion of the pancreas, which is situated along the whole posterior side of the stomach and encircles its pyloric portion. The spleen is elongate, ovate. The abdominal cavity is extremely narrow from the point where the muscular mass of the vertebral column commences. The kidneys are thick and very long, extending along the whole abdominal cavity upwards to the air-bladder."

The kidneys have been described by HYRTL (20 b, p. 70) in "*Fist. serrata.*" He also states that a urinary bladder is absent. But some pages before in the same work, p. 38, he says: "Eine sehr unansehnliche Andeutung einer Harnblase als spindelförmige Erweiterung des einfach gewordenen Harnleiters habe ich an ... *Fistularia serrata* ... wahrgenommen." I have not been able to see the least trace of a bladder.

The genital organs have been correctly described by HYRTL (20 a, p. 406) in *F. serrata.*

The olfactory organ of *Fistularia* has been described by BURNE (7, p. 633). In the accompanying figure LAC ("lacrymal scute") is the prefrontal, N (supposed to be the nasal) part of the ethmoid.

Syngnathidæ.

17 p. 303 [37]. DUNCKER's description (13, p. 21—22) of the two anterior body rings is different from that given by me. As upper parts of D.'s foremost ring, his "Schulterring", are regarded the superior lateral scutes (sl in my fig. 2 on Pl. III) which I refer to the second ring, that behind the pectoral, to which they undoubtedly belong. As lateral parts of the "shoulder-ring" D. further counts two "plates" on each side, one in front of the pectoral fin, the "Skapularschild", one behind, the "Axillarschild"; the first is the dermal part of the clavicle + the "coverplate" (Pl. III, fig. 2 c), the "Axillarschild" is my median lateral plate (Pl. III, fig. 2 ml) of the second ring (the first ring of typical composition). Finally, as inferior parts of the "Schulterring" are regarded two plates on each side, my "jugular plate" (Pl. III, fig. 2 j), which he termes "Infrascapulare", and my inferior lateral plate of the second ring (fig. 2 il). Thus the difference really consists in the facts: 1) that D. regards my first and second rings as only one, the "Schulterring"; 2) that he has apparently not observed that the clavicular dermal part and the "cover-plate" are two separate structures.

18 p. 306 [40]. Regarding the structure of the vertebral column, which is examined without great difficulty, several features have earlier been noticed, and more or less correct information will be found scattered through the literature. While the peculiar arrangement of the interspinous bones for the dorsal fin has been very early noticed and later has been mentioned by several authors, as also the immovable connection between the shoulder-girdle and the two anterior vertebræ, the fact that the three anterior vertebræ besides are immobile, because their neural arches are suturally united, seems never to have been observed before.

SCHNEIDER in Petri Artedi Synonymia Piscium etc. 1789 (49) p. 338—39 and Tab. II, figs. 20—21 has given some primitive and rough, not quite correct, representations of transverse sections of *Syngnathus typhle* (or *acus*) and (fig. 22) a small part of the skeleton at the region of the dorsal fin, seen from the side. The latter figure is extremely incorrect but — as far as I know — hitherto the only existing, representing the peculiar groups of the parts supporting the fin-rays; they are here called: "Processus spinosi in radios 4—6 diffusi". Thus the fact that interspinous bones are combined with the spinous processes has escaped attention.

MECKEL (35) p. 202 remarks that the vertebræ in *Syngnathus* are elongated, p. 203 that articular processes are wanting or at least "höchst unmerklich"; p. 204 that the spinous processes are split: "Ihre Schenkel bestehen aus fünf bis sechs zarten, dünnen Stäbchen, die fast senkrecht in die Höhe steigen und sich an den meisten zu einem einfachen, mittlern, langen, aber niedrigen Blatte vereinigen, das aber unter der Rückenflosse theils bedeutend höher wird, theils sich von vorn nach hinten in drei, vier bis fünf in dieser Richtung aus einander weichende Strahlen spaltet, welche die Flossenstrahlen tragen." Thus, M. has overlooked the presence of interspinous bones ("Nebendornen" Meckel). On p. 244 he adds that ribs are wanting, a fact also mentioned by CUVIER and VALENCIENNES (10, p. 296).

KRÖYER (29, p. 685) describes the vertebral column in *Siphonostoma typhle* in the following way: "The vertebral column consists of 55 vertebræ, proportionately large and strongly built, especially the foremost, lying over the abdominal cavity; these are moreover for the greater part provided with strongly developed transverse processes. On the other hand the abdominal vertebræ almost completely want spinous processes; the latter, however, are found on the nine or ten anterior caudal vertebræ, to which the dorsal fin is attached, and are very conspicuous and of peculiar shape, each of them being split into three or four, with the points free, projecting, rays; thus this part of the column being formed like a finely

serrated saw. Ribs could not be observed." Regarding *Syngnathus acus* KR. says (p. 701): "The vertebral column consists of 66 vertebræ*, the 22 of which are situated over the abdominal cavity, the remaining 44 may be regarded as caudals. Thus the vertebræ in number agree with the (transverse) rows of scutes; they are proportionately large and strong. In all the abdominal vertebræ the transverse processes are strongly developed in length, while the spinous processes may be said almost to be absent, the neural canal generally appearing in the shape of a simple roof with sharp crest. On the two last abdominal vertebræ, however, and on the eight anterior caudals, i. e. on the vertebræ carrying the dorsal fin, are found, quite as in the preceding species (*S. typhle*), strongly developed spinous processes of peculiar shape, each formed by four divergent rays (only exceptionally five or three). The interspinous bones, attached to these rays, are of an extreme slenderness. The transverse processes of the vertebræ decrease in length with the beginning of the dorsal fin, and disappear, almost completely vanishing, at its end. The transverse processes of the first vertebræ in the pipe-fishes are of peculiar form: large, flat, blade- or wing-shaped, behind strongly elongated (quite to the transverse processes of the next vertebra), and pointed like a dagger. The inferior spinous processes begin to appear on the first caudal, but they are always very small, and the canal, which they form for the blood-vessels, is very incomplete, because they only take up a small part of the length of the vertebræ, thus large interspaces being left between them. On the other hand the lower surface of the caudals is hollowed out into a rather deep furrow." In a similar way KR. describes the column at length in *Nerophis æquoreus*. Here he finds 82 vertebræ, about 30 belonging to the abdominals; he points out the difference from the preceding in the shape of the transverse processes. Regarding the vertebræ, supporting the dorsal fin, he says; "In the vertebræ, lying under the dorsal fin (24th to 35th, both included, or the eight last abdominal and a pair of the anterior caudal vertebræ) the spinous processes divide each into three to four large spines, supporting the same number of strong interspinous bones." About the last caudal vertebræ, carrying the rudimentary caudal fin, is said that it appears to have no plate-shaped enlargement at its end.

KNER (28 a, p. 57—58) in his description of the muscles of the dorsal fin and the action of the latter as a locomotory apparatus, mentions that in *Syngnathus* "die langen Flossenträger am Skelete in fächerartig auslaufende Bündel gestellt sind, und zwar sitzen bei *Syngn. rubescens* acht solche Bündel, deren jedes aus 3—5 Flossenträgern besteht, auf eben so vielen Wirbeln auf .... Bei *Hippocampus* sind dagegen die langen Flossenträger fast parallel, nur die vorderen und hinteren etwas divergirend und die Flosse sitzt (wenigstens bei *Hipp. guttulatus*) bloss auf drei Wirbeln auf, deren obere Schenkelbögen statt einfache Dornfortsätze zu bilden, sich sogleich in drei kurze strahlig auslaufende Knochenfasern zertheilen, auf welche die Flossenträger sodann aufsitzen." KNER's statements are repeated by DUMÉRIL (12 a, p. 140, b, p. 475) without any further additions of his own; only p. 142, p. 476 he mentions as a character of these fishes, the absence of ribs. COPE (8 p. 457) remarks: "Anterior vertebræ modified, the diapophyses much expanded." MOREAU (36, p. 29): "Les vertèbres correspondent aux anneaux du corps et sont par conséquent en nombre égal; elles sont relativement développées, grosses et longues avec très-grandes apophyses. Les apophyses épineuses sont généralement larges, elles presentent au niveau de la dorsale une disposition singulière, elles se divisent en tiges plus ou moins nombreuses qui sont en rapport avec autant d'interépineux." p. 30 the latter point is repeated with the addition, that "ces tiges sont tantôt presque droites, parallèles (Hippocampes), tantôt divergentes comme les branches d'un éventail (Syngnathes). Les interépineux ont leur extrémité supérieure très-développée."

RYDER (48, p. 197 and Pl. XVII) observed in the "larvæ" of *Hippocampus* the distal segment of the interspinous bones as a separate cartilage, articulated to the still cartilaginous proximal part. "In adult specimens, the interspinous basalia which are at this young stage

* In CUVIERS's Leçons etc. I, p. 232 the same number is given for *Syngn. acus*; for *Hippocampus* $15 + 46 = 61$.

nearly in contact with the notochord by their proximal ends, are pushed farther out and become apposed upon and interposed between the spinous dorsal radii springing directly from three vertebræ."

Mc. Murrich describes and figures (34, p. 648—49, and Pl. XLII, fig. 2) the developing interspinous bones in the larval *Syngnathus peckianus* as cartilaginous rays, resting directly on the membrane surrounding the spinal cord *; in later stages (l. c. fig. 6) they are said to be united distally by a longitudinal bar, resting on which are cartilaginous nodules (i. e. the distal interspinous segment of the adult), each supporting a fin-ray. The urostylic cartilages for the, at first heterocercal, tail-fin are large and may be compared to the interspinous rays of the dorsal fin. The anal fin (the interspinous rays of which are not mentioned or figured) is, wrongly, stated to atrophy in the adult.

Lilljeborg (32, p. 449) gives the number of vertebræ in *Siphonostoma typhle* as 52—55, of which the anterior 17—18 are abdominal. "The two first are modified and longer than the remaining, strongly coalesced, the border between their neural arches having disappeared, and serving as attachment for the shoulder-girdle. To this end the transverse processes of the first vertebra are very much expanded, giving strong and immovable attachment to the upper ends of the clavicles. Also the transverse processes of the second are somewhat expanded, and their ends are attached to the clavicles, where the latter are bent. Otherwise the vertebræ in general have transverse processes, to the end of which the plate-rings are fastened. These processes are longest on the abdominal vertebræ and generally truncated. The spinous processes are low, laterally compressed and plate-shaped, only little or not at all separated, and show a series of several rods [connected by thin lamellæ. The anterior caudal vertebræ, which support the dorsal fin, have the spinous processes somewhat more elevated, and with 3—4 free points, to which the interspinous bones of this fin are attached. Ribs are wanting."

Smitt (54), who has so admirably interpreted the suspensory parts of the head-skeleton which are by no means so easy to make out as the vertebræ, only says regarding the latter (p. 666), that they are but slightly ossified, elongated, "the processes straight and of uniform breadth or slightly broader at the top; but in the vertebræ above which the dorsal fin is attached, the upper spinous processes are divided sagitally (in the longitudinal direction of the body) into three or four divergent branches. Distinct hæmal arches appear only at the beginning of the caudal region, where a few may be found." Thus it does not seem clear, if Smitt has observed the interspinous bones or not.

Bridge (5, p. 578) describes at length the (34) interspinous bones in *Siphonostoma typhle* and mentions briefly those of *Hippocampus guttulatus*. He points out their bisegmental structure, the distal segment being represented by a cartilaginous nodule, and says that in *Siphonostoma* they exhibit "a slight tendency to become arranged in groups of four each. In each group the segments converge slightly towards their proximal ends, where they are firmly attached to the summit of the neural arch of a subjacent vertebra. Distally the segments diverge slightly and their dorsal extremities expanding somewhat come into apposition, and form with one another a continuous peripheral margin." Into the bony structures, which build up the latter, he does not enter, nor has he any remarks regarding the structure of the supporting vertebræ.

Jordan and Evermann (21 a, p. 759) in their diagnosis of the order Lophobranchii adopt the remarks of Cope, quoted above; the same are repeated in later works, by Jordan and Snyder (22, p. 3) and Jordan and Evermann (21 b, p. 117).

Huot (19, p. 252) remarks: "Dans la région du corps où se trouve la nageoire dorsale, les apophyses épineuses se prolongent par des cartilages interépineux qui, eux-mêmes, se prolongent par les rayons cartilagineux(!) des nageoires", which mode of stating the facts is

* These cartilaginous rods are according to Mc. M.'s figure 2, as well as my own observations in *Siphonostoma typhle* and *Syngn. rostellatus*, parallel to each other, as are the interspinous bones in most adult bony fishes.

somewhat misleading; further he mentions that the vertebral column in Lophobranchs, where the tail-fin is absent, is pointed behind, while in forms with a caudal fin the last vertebra is provided with "deux lames cartilagineuses situées dans le plan médian de symmétrie, l'une dorsalement, et l'autre ventralement" (both are really ventral in position).

REGAN (45 c, p. 5) remarks that, in contrast to the Centriscidæ and Amphisilidæ (his Solenichthyes), the "anterior vertebræ are not elongate."

[19] p. 308 [42]. The skeleton of the head has been examined by several authors. Curiously enough some facts have been correctly stated by older observers which later authors have failed to interpret properly, apparently because they did not know the previous literature or at all events did not consult it carefully enough, every support from illustrations being missing.

Already LACÉPEDE (31, T. III, p. 44, p. 60) correctly gave the number of branchiostegal rays as two in *Siphonostoma typhle* (and the *Syngnathi*) and in *Hippocampus*.

MECKEL (35, p. 343), speaking of the suspensorial apparatus in Teleosts, which (with exception of the pterygo-palatine part) he calls "Gelenktheil des Schlafbeins" and regards as representing the quadrate of Reptiles and Birds in spite of his own statement, that it consists "at least of two bones", says: "In Hinsicht auf die Grösse ist sie bei den *Syngnathen* vielleicht am ansehnlichsten. Hier wird der bei weitem gröste Theil des Unterkiefers nicht durch das eigentliche Unterkieferbein, sondern durch sie gebildet. Das oberste Stück (i. e. the hyomandibular) ist klein und bildet kaum den dreissigsten Theil der ganzen Knochensammlung, die aus mehreren länglichen, einander ganz oder zum Theil von innen nach aussen bedeckenden besteht." With these words M. only shows that he did not partake in the old mistake, involved in the name "*Syngnathus*", viz. that the upper and lower jaws were partly coalesced; but M. does not attempt to analyse these parts which even to the latest authors have been most difficult to make out and have almost never been correctly interpreted.

The brain-case proper is not at all mentioned by M. But in the last volume of his work, completed much later than the first (1833), several more or less correct statements concerning the opercular and branchial apparatus are given. Thus he correctly describes the three opercular bones (p. 110); further he gives the number of branchiostegal rays as 2—3 in *Syngnathus* and *Hippocampus* (p. 118; later, p. 129, he says 3—4); he says (p. 126) that the hyoid only consists of one piece, that a urohyal ("das mittlere oberflächliche Zungenbein") is present (p. 135), in *Hippocampus* very short and slender, and that it does not reach the clavicles (p. 142, 144); on the other side he does not find any glossohyal ("der vor der Vereinigung der vorderen Seitenäste liegende Knochen oder Knorpel"); it is absent together with all the other unpaired parts lying behind the hyoid (the basibranchials, which he names "die tiefe mittlere Zungenbeinschicht") or at most developed in the shape of a slender and long cartilage (p. 145, 148). The branchial arches, which TIEDEMANN (Deutsches Archiv T. 2, p. 111) had declared to be cartilaginous, he correctly regards as ossified (p. 135, 155). The presence of gill-rakers he denies on p. 162, but later, p. 168, he states their presence.

Before the publication of the last volume of MECKEL's work CUVIER and VALENCIENNES (10, T. 1, p. 296) had declared the branchiostegal rays to be absent, and in the excellent work on the branchial apparatus in the Vertebrates, published about at the same time (1832) as the 6th volume of MECKEL's work, RATHKE too was of this opinion (44, p. 6); and he — like MECKEL — thought that the hyoid consisted of only one piece (p. 3). Among fishes lacking the copula for the hyoid (i. e. my first basibranchial) R. mentions *Syngnathus*, while the glossohyal is present as a slender rod as well as the urohyal ("Zungenbeinkiel") (p. 4); he found no basibranchials (p. 12), and no teeth on the lower pharyngeals, which are "schmale und schlanke Bogen." On p. 76 he regards the opercular apparatus as only consisting of one piece. In the tabular view on p. 20 he resumes his observations of the branchial skeleton in *Syngn. rondeletii* in the following way:

Erster Kiemenbogen					Zweiter Kiemenbogen					Dritter Kiemenbogen					Vierter Kiemenbogen					Schlundkiefer	
Verbindungsglied	1stes Glied	2tes Glied	3tes Glied	4tes Glied	Verbindungsglied	1stes Glied	2tes Glied	3tes Glied	4tes Glied	Verbindungsglied	1stes Glied	2tes Glied	3tes Glied	4tes Glied	Verbindungsglied	1stes Glied	2tes Glied	3tes Glied	4tes Glied	Mittelstück	Seitenstück
1	1	1	1	1	—	1	1	1	—	—	1	1	1	—	—	—	1	—	—	—	1

Transcribed into the formula used by me in the present paper the above formula would be:

Gill arch	Basibranchial	Hypobr.	Ceratobr.	Epibr.	Pharyngobr.
I	+	+	+	+	+
II		+	+	+	
III		+	+	+	
IV			+		
V			+		

If we compare my formula on p. 307 [41] of the present paper the difference will be easily perceived at once.

CUVIER (LAURILLARD) (9 b, p. 646) gives the following account of the Lophobranches: "Ces poissons ont ... le squelette plutôt fibreux qu'osseux; cependant la composition du crâne ne s'écarte point de celle des poissons osseux. Dans le *syngnathe*, l'orbite est complètement fermé, en avant, en haut et en arrière, par les frontaux, et en bas par le temporal (= hyomandibular) et le préopercule, qui font l'office de sous-orbitaires; le museau est très alongé.

L'*hyppocampe* a le museau moins long, les frontaux étroits, et portant au dessus de l'orbite chacun une apophyse presque verticale qui forme une sorte de corne. La partie postérieure du crâne est pyramidale et creusée de chaque côté à la face occipitale d'une fosse profonde formée par le mastoïdien (= pterotic) et l'occipital externe (= epiotic)." Nothing is found about the other cranial structures, neither in the volume quoted nor in the following volumes.

The work of KÖSTLIN (30) contains some scattered remarks (pp. 309, 317, 337, 338, 342, 356, 361, 370, 378, 394, 400) concerning the skull, but they are so defective and incomplete, that it seems hardly possible to decide, if he had a tolerably correct understanding of its structure or not. The suspensorial and branchial parts are not mentioned.

HOLLARD (18, p. 565), who is of the opinion that the "Lophobranches" are to be combined with the "Ganoïdes proprement dits", only mentions the opercular apparatus in the Syngnathids. He describes the large operculum as well as the small suboperculum; the interoperculum apparently is overlooked. Regarding the preoperculum is said: "Confondu en avant avec la série sous-maxillaire, il n'est reconnaissable qu'à ses rapports avec l'hyoïde. Ce dernier lui-même ne porte plus ici que deux ou trois rayons branchiostéges filiformes."

KRÖYER (29) in describing the single species of Pipefishes found at the Danish coasts, has given some osteological information which must be said to be of value and, taken together, to render a more complete and correct account of the structure of the skull than it would be possible to gather from any of his predecessors.

On p. 679 (*Siphonostoma typhle*) he states that he could only observe two long, very

slender, bristle-like branchiostegal rays on each side; and four pair of branchial arches, provided with gill-rakers in the shape of short spines (p. 680). The mandibular and suspensory parts are mentioned in the following words (translated by me) (p. 685): "The intermaxillaries, situated over and a little in front of the maxillaries, form the whole upper border of the mouth; they are very slender, almost like bristles, except at the middle of the upper border of the mouth, where they meet. Here they expand like a club, but an ascending part is completely lacking. The maxillaries are hardly longer than the intermaxillæ, but much stouter, flat, expanded behind or oarshaped. The lower jaw very broad in proportion to its length (its greatest width behind larger than half of the length), plate-shaped, with a longitudinal crest on the outer face, the anterior margin semilunar and convex, the posterior semilunar and concave. The temporal bone (i. e. the hyomandibular) has a very short, broad and flat shape. *Os tympanicum Cuv.** extremely elongated and slender, linear, in front deeply forked, the lower branch longer and horizontal, the upper one somewhat curved upwards. Symplecticum large, elongated, plate shaped, somewhat obliquely-foursided, in front drawn out into a long point." It will be seen that KRÖYER here regards the real symplectic as a metapterygoid; but what is meant with "Symplecticum" I am not able to decide (the infraorbitals?).

Describing *Syngnathus acus* KR. says (p. 700): "The intermaxillaries are about as in the preceding species (*S. typhle*), only smaller in proportion to the size of the body. Also the maxillæ are shorter than in *S. Typhle* but very much broader, curved somewhat like an S, the end expanded like a shovel or spade. The very small mandible is so short and broad that its shape almost forms a quadrant. The palatine consists of two branches, almost equal in length, the one (the articular part) somewhat stouter, the other slender and pointed; they meet at a somewhat obtuse angle. The temporal short, very broad (its width plainly greater than half its length), stout, flat, irregular. Tympanicum and Symplecticum about as in the preceding species. The vomer slender almost like a bristle. The ethmoid about equal in length with the vomer, but much broader and stouter than the latter, although of elongated and narrow, sword-like shape; behind it appears cleft like a fork. The preoperculum about of the same length as the snout, very strongly pointed in front, feebly curved shaped like a very elongated triangle or rather like a dagger. The opercular bone much vaulted, thin or scale-like, rounded behind, truncate in front, with a longitudinal crest or ridge a little over the middle of its height. The suboperculum hidden below the operculum, very elongated, narrow, sabre-shaped. The interoperculum, which contributes considerably to the formation of the snout and has the whole length of the latter, is strongly pointed, dagger-like behind, in front, however, broad, thin, plate-shaped, truncate. Eye-bones (*ossa infraorbitalia*) seem to be completely missing." Thus, with exception of the mistakes regarding the symplectic and "tympanic" and the infraorbitals, KRÖYERS's description — as far as it goes — is quite correct.

Under *Nerophis æquoreus* KR. (p. 709) mentions that he only found one branchiostegal ray; on p. 713 he correctly points out some small differences from the preceding species in the shape of the same cranial elements which were described in these.

Among distinctive characters common to all Syngnathids PETERS (41, p. 103) mentions: "der einfache Kiemendeckel ohne Suboperculum, die Verwachsung des Interoperculums mit dem Präoperculum", statements which it had been better to omit.

PARKER (39, p. 32, note [1]) who had the notion that the Lophobranchii were in some way related to the "generalised Ganoids", supports this idea of the presence especially of "jugulars", "so rare in the Teleostei, namely in *Elops* and *Megalops*. These are well developed in *Syngnathus* and *Hippocampus*; although I am not aware that any other Ichthyotomist has observed this fact." The supposed "jugulars" of course are the interopercular bones.

* CUVIER uses the name "Tympanale", not "Tympanicum", for the Metapterygoid; KRÖYER elsewhere uses the name "Symplecticum" for the same bone, for which CUVIER and later authors have used the name.

DUMÉRIL describes briefly (12 a, p. 145, b, p. 478) the intermaxillaries, maxillaries and mandible; the latter articulated to the quadrate ("jugal" or "quadrato-jugal"), which is much elongated and forms part of the tubiform snout, together with the ethmoid, vomer and nasal and the coalesced sub- and interoperculum; a, p. 149, b, p. 481 he remarks that 2 or 3 branchiostegal rays are found and adds that the preoperculum is absent and repeats the wrong statement that the suboperculum and interoperculum are coalesced to form part of the tube. Some of these incorrect statements will be found still surviving in the later literature.

COPE (8, p. 457) states for his *Lophobranchii* (comprising *Solenostomidæ*, *Syngnathidæ*, *Hippocampidæ*): "Mouth bounded by the premaxillary above; posttemporal simple, coossified with the cranium. Basis cranii simple .... Inferior and superior pharyngeals and superior branchihyals (i. e. epibranchials) wanting or unossified." To COPE's diagnostic skeletal characters RYDER (48. p. 193) makes the following, not very fortunate, addition: "Opercle a simple plate." On p. 196 he says regarding *Hippocampus*: "There appear to be no mesial hyal elements at all, which also seems to be the case with the adult, the medial skeletal elements of the tongue being suppressed." Further he (correctly) adds that the lower mesial elements of the branchial skeleton also appear to be absent.

POUCHET (42) in describing the development of the head skeleton in *Syngnathus* found 3 branchiostegal rays very early present. Regarding the adult structures so very little is mentioned that it is impossible to make out, how far P. had a tolerably complete or correct acquaintance with their peculiarities. p. 83 he says: "Chez l'adulte, quand on cherche à séparer par les procédés ordinaires, macération, cuisson, etc., le symplectique du jugal (i. e. the quadrate) la branche cartilagineuse se brise et son extrémité reste adhérente au jugal, dans lequel elle est fortement engagée. De façon que le cartilage qui constituait le temporal primordial (i. e. the cartilaginous rod representing the hyomandibular + the symplectic), se retrouve ici dans trois os chez l'adulte: 1° le temporal (i. e. hyomandibular); 2° le symplectique; 3° le jugal." However correct this statement in itself will be found to be, it may still be open to doubt, if P. has really been acquainted with the peculiar shape and connections of the symplectic in the adult.

E. MOREAU (36, p. 29) describing the head of the *Syngnathidæ* says: "La bouche est à l'extrémité d'un tube dont les parois sont constituées en bas par une aponévrose et les interopercules, latéralement par l'appareil tympanique, en dessus par les ptérygoïdiens, les palatins et le vomer .... La mâchoire supérieure est formée par les intermaxillaires très-grèles, très-courts, débordés en dehors par les maxillaires qui se terminent en une sorte de palette élargie. La mâchoire inférieure est constituée, d'une façon normale, par trois os, le dentaire, l'articulaire et l'angulaire; elle est articulée avec l'appareil tympanique composé par ses quatre osselets."

Here we meet for the first time with the correct statement that the mandible is composed of three pieces as nsual; but unfortunately M. does not enter into an analysis of the suspensory parts. In saying, however, that the latter is composed of "its four bones", he shows that he cannot be quite right. Where 4 bones are present, these always are the hyomandibular, symplectic, quadrate and metapterygoid. But the latter is absent here; probably the infraorbitals, which M. nowhere mentions, have been taken among the suspensory bones. Under the "Appareil branchial" M. further (p. 30) mentions the operculum, suboperculum and interoperculum, but he states wrongly: "il n'y a pas de préopercule." He describes the hyoid (without mentioning its composition of pieces), carrying "two or three" branchiostegal rays, and an elongated urohyal ("sous-hyoïdien").

MC. MURRICH (34) has given a careful and in several points correct description of the head-skeleton in *Syngnathus peckianus*; it is partly supported on transverse sections, and due attention is paid to the cartilaginous parts of the developing young and of those preserved in the adult; furthermore this account is illustrated with figures. On p. 626 he describes the adult cranium. He has correctly seen that the orbitosphenoids, basisphenoid and nasals are wanting. The epiotics he takes to represent the parietals, but he seems to be inclined to

regard these bones as "dermo-epiotics", "for they directly overlie the epiotics, appearing like a parostosis formed upon these bones." Alisphenoids seem to him to be absent, and about the posttemporal he is indecided but inclined "to consider it homologous, to a certain extent at any rate, with the supra-temporal of Amia."

In the ethmoid he (p. 629) mentions a canal, which he (wrongly) takes "to be the continuation of the main slime canals, which also traverses the frontals." His account of the development of the visceral and suspensory parts in the young is good and correct; only, as far as I can see, the cartilage which according to MAC MURRICH represents the metapterygoid, must belong to the entopterygoid; and it seems hardly credible that only 4 cartilaginous branchial arches should be present, in as much as the adult possesses five. In the adult, however, M.'s interpretations apparently contain some graver errors. He recognizes the stylohyal ("interhyal") and finds the hyoid consisting of "a cerato- and hypohyal", "the epihyal being apparently absent"; but in saying (p. 638) that "the genio-hyoid element (i. e. the glossohyal) does not appear to ossify and in fact has disappeared", he certainly is wrong; and regarding the suspensory parts, he considers the posterior infraorbital (my true antorbital) as the metapterygoid, in spite of his observation of its being "separated from the symplectic by a quantity of muscular tissue." The anterior infraorbital he correctly regards as such. Further he did not understand the interoperculum, which he, however, has seen, but mentions as "a scale-like bone, which has no special representative in other Teleosts." He only describes one pterygoid, apparently my ectopterygoid, and denies the existence of intermaxillaries, and interoperculum, and about the preoperculum he says that it "appears to be absent, or at any rate very rudimentary."

Among the extremely detailed descriptions of the single bones, composing the skull of Teleosts, which are contained in the work of V. KLEIN (26 b and c), are some concerning the Syngnathids (*Syngnathus*, *Hippocampus*, *Gasterotokeus*, *Leptoichthys*, *Phyllopteryx*). (b) p. 135 he correctly states that no eye-muscle-canal is found; p. 136, that the parasphenoid — as in *Fistularia* — does not reach the vomer anteriorly, which at all events does not hold good for *Syngnathus* and *Hippocampus*; p. 150 he mentions, that "alæ orbitales" (i. e. alisphenoids) may be separated from the "alæ temporales" (i. e. the prootic) in some Syngnathids; p. 234—36 the anterior, ethmovomerine, part is described at great length, but apparently correctly in most respects (that nasals are lacking is not mentioned). (c) p. 128 the basioccipital condyle is said to be about convex in *Syngnathus*, decidedly convex in *Gasterotokeus* and *Phyllopteryx*; the first is certainly, the latter probably wrong. p. 157 under the lengthy description of the exoccipitals, parietals are mentioned in *Phyllopteryx*; but a thorough examination of the detailed description of the "occipitalia externa" (i. e. the epiotics), found on p. 197—98, reveals that the parietals in question must be the epiotics, while V. KLEIN's "occipitalia externa" (or epiotics) are really the posttemporals; and quite the same will be found to be the case with the parietals ascribed to *Hippocampus* on p. 197; they also are the epiotics, and the posttemporal is taken to be "occipitale externum." On the other hand v. K. declares on p. 217, where the supraoccipital is dealt with, that in *Syngnathus* the parietals are not separated from the frontals. Finally on p. 251, under the "squama temporalis" or pterotic, the following statement is found: "Bei den mir bekannten Syngnathidæ reichen die Kiefersuspensorien, welche die Seiten der röhrenförmigen Schnauze bilden, nicht an die squamæ", which is wrong.

SCHÄFF (50, p. 12) describes the cranial skeleton of *Siphonostoma typhle* and figures the skull from above (Fig. 4, the vomer omitted), and the whole head seen from the side (Fig. 18). He regards the epiotic as parietal and (with MC. MURRICH) the posttemporal as a "supratemporal." He rightly denies the existence of a nasal. In the suspensory part he, too, does not recognize the preoperculum, which he takes to be the symplectic; he has correctly interpreted the infraorbitals and the palatine, but about the remaining pterygo-palatine series he only says: "Innerhalb dieser Infraorbitalia liegen die Pterygoidea, die hier jedoch nicht berücksichtigt werden." The intermaxilla and maxilla are correctly observed, but regarding the lower jaw is said: "Das Mandibulare ist stark entwickelt, Articulare, Angulare und Dentale

jedoch nicht zu unterscheiden" (p. 14). Of *Hippocampus* the skull is figured from above (Fig. 11); the figure and the corresponding text (p. 21) show the posttemporal interpreted as a pterotic, the epiotic as a parietal.

LILLJEBORG (32, p. 437), in giving a diagnosis of the genus *Syngnathus* (including as subgenus *Siphonostoma*) says that all 3 opercular bones and 2–3 bristle-like branchiostegal rays are present (about the opercular apparatus L., however, is mistaken, cfr. below).

Describing *Siphonostoma typhle* L. (p. 443) states that the preoperculum is wanting, and 2 branchiostegal rays are present; p. 446 the skull is described in detail, upon the whole correctly; inter alia is said that the opisthotic, basisphenoid and orbitosphenoid are absent and the alisphenoid present. Incorrect is the following: "The ethmoid, lying on the fore part of the vomer in the shape of a keel, does not reach back to the anterior ends of the frontal. The visible parts of the parietals are small." In the interpretation of the suspensory bones (p. 447) some greater errors occur in as much as L. considers the preoperculum to be the interoperculum, while the preoperculum is said to be absent, and takes the real interoperculum to be the metapterygoid. The infraorbitals are correctly interpreted, but his statement, that the borders between them and partly the border against the "interoperculum" (i. e. the preoperculum) are obliterated, is wrong. He further seems inclined to see some more infraorbitals behind the posterior one (ao in my figure). The pterygo-palatine bones and the mouth-parts are correctly observed and described (L.'s "mesopterygoid" is = my entopterygoid). About the branchial skeleton is only said that "os linguale" (the glossohyal) is very short, but the "basibranchiostegal bone" (presumably the urohyal) is long, slender and rod-shaped, and that according to MC. MURRICH the epihyal is wanting in the small and short hyoid.

SMITT (54) is, as far as I have seen, literally the only author, who almost without any mistakes has described the suspensory skeleton of a Syngnathid; I therefore think it just to quote his description in extenso:

"In the Deepnosed Pipefish (*Syngnathus typhle*) the elongation of the snout is produced in the following manner. The ethmovomerine part is elongated like a staff, and coated below by the long and narrow parasphenoid bone, while the frontal bones extend forward above in the form of long and narrow covering-bones over about half of the said elongation. The hyomandibular bone is an oblong, quadrangular but irregular, vertically set disk, which is united at a right angle below with the abnormally developed os symplecticum, which is directed forward, extends below the eyes, and sends out a branch obliquely upward towards the lateral ethmoid (prefrontal) bone, while a second, still longer, horizontal branch meets a process in a backward direction from the quadrate bone. This horizontal branch of the symplecticum is partly naked (without covering bones) externally, but is covered behind and below, throughout the greater portion of its extent, by the preoperculum. The vertical (posterior) branch of the preoperculum lies outside the hyomandibular bone and is united above to the inferior margin of the suborbital bones. The obliquely ascending branch of the symplecticum, on the other hand, is separated by a space, occupied by the masticatory muscles, from the two posterior suborbital bones, which bound the orbit below, but is united to the hind superior corner of the anterior suborbital (the preorbital) bone, where the latter meets the lateral ethmoid bone. The foremost suborbital bone forms the greater part of the side of the snout, being united in front as a covering bone to the ento-(meso-)pterygoideum and the quadrate bone, but leaving behind the latter an opening in the middle for about a third of the depth of the snout; the middle suborbital bone is united below to the symplecticum; the hindmost suborbital bone both to the symplecticum and, behind, to the preoperculum. We refer to the opercular apparatus a narrow, lancet-shaped, thin bone which lies along the inside of the horizontal, forward branches of the preoperculum and the symplecticum and the horizontal, backward branch of the quadrate bone. This lancet-shaped bone is united by ligaments behind to the upper part of the ceratohyoid bone and in front to the angular part of the lower jaw. The latter union clearly shows that the bone must be an interoperculum, corresponding most nearly in form and position to the inter-

operculum in Tetrodon for example, though here it has passed within the symplecticum and become united behind to the upper part of the outside of the ceratohyoideum, instead of retaining its union to the suboperculum, which is here reduced to an extremely thin disk within the lower margin of the operculum.

The lower jaw is remarkable for its extraordinary depth behind and its sharply curved and toothless dental part. The maxillary bones are comparatively well-developed and their hind (lower) extremity is expanded; but the toothless intermaxillaries are small, styliform, and without nasal processes. The palatine bones are shorter than the maxillaries and of fairly uniform breadth. At the anterior angle of the union of each palatine bone to the top of the ascending branch of the quadrate bone we find the narrow pterygoid bone, which is bent at an obtuse angle, and behind the said union, close to the ridge of the snout, the entopterygoid bone, which is united in the same manner to the quadrate bone." On p. 664 S. adds: "The tongue is wanting, and the glossohyoid bone can hardly be discerned; but the urohyoid bone is comparatively long."

The only point, in which S. seems to be mistaken, is that he has found 3 suborbital bones; in fact his anterior sub- or infraorbital is only the anterior outer, plateshaped part of the entopterygoid.

SMITT's work, although it is translated into English, seems not to have been noticed by later authors, at any rate not so far as the Lophobranchiates are concerned; and all the later authors are far inferior to him in their interpretations.

GILL (14 b, p. 156) says: "Some erroneous conceptions have been entertained and misstatements made respecting features of the pipefish's structure. Only a few need be here noticed, however. Such are the statements that the preoperculum and interoperculum are wanting, that the intermaxillaries are also absent, and that the symplectic is a very important element. The preoperculum and interoperculum, as well as intermaxillaries, are developed, but I am unable to identify the symplectic. In no respect do the Lophobranchs deviate so materially from ordinary fishes as has been supposed. But, as long ago shown by Parker, they manifest, in addition to the peculiarities generally noticed, deviations in the scapular arch. There is no posterotemporal, the posttemporal and proscapula being immediately connected, and the "coraco-scapular plate" is entire and not broken up into hypercoracoid and hypocoracoid bones." What GILL regards as preoperculum and interoperculum is not clear, but he undoubtedly did not recognize the large symplectic. In a later paper (14 c, p. 805) G. has adopted SCHÄFF's figures and interpretations, and accordingly he says: "the preoperculum is absent"; about the interoperculum and symplectic nothing is stated.

JORDAN and EVERMANN (21 a, p. 759) include among the distinctive characters for their order Lophobranchii the following cranial features: "Superior branchihyals (i. e. epibranchials) and pharyngeals, and basal branchihyals (i. e. hypobranchials) wanting or not ossified. Posttemporal simple, coossified with the cranium; basis of cranium simple ... Gillcovers reduced to a large simple plate." Most of these statements are probably taken from COPE, but they are not correct; they are repeated later by JORDAN and SNYDER (22, p. 3).

A. S. WOODWARD (59, p. 370) in the Synopsis of Families included under his Suborder Hemibranchii states for the *Lophobranchii* (*Solenostomatidæ* and *Syngnathidæ*) "opercular apparatus much reduced", and p. 380 for the Family Syngnathidæ: "opercular apparatus reduced to operculum."

SWINNERTON (56 a, p. 554) referring to his fig. 50, copied below, says about *Syngnathus* (*Siphonostoma*): "The palatine bone (pa.) has the same characters as in the stickleback and like that is partially enclosed posteriorly by the single pterygoid (c.). The ethmoid region ... is seen to owe its great length to elongation, not of the hinder half, containing the mesethmoid cartilage, but to that of the front half, consisting purely of ethmoid plate. Nevertheless the mesethmoid bone (fig. 50 e. m.) has apparently extended quite to the anterior end, including the preethmoid cornu. The palatine bone (pa.) which is attached to the pre-ethmoid cornu (pa′.) between the mesethmoid bone and vomer is carried too far forward for it to bear any relationship to the parethmoid bone (e. p. b.)." To the above I would remark 1) that the pterygoid

in *Syngnathus* is not single, an ento- and an ectopterygoid being present*; 2) that the part of S.'s supposed ethmoid reaching about from e. m. in his figure to pa.′ is really the vomer. Thus the palatines (in the adult) have no connection with the ethmoid at all. The "acrartete" condition, upon which S. lays great stress, I think (with DARESTE, who many years ago observed the same) is of no great systematic value. p. 575 SW. compares the head skeleton of *Gasterosteus*, *Fistularia* and *Syngnathus*. As I have previously under *Fistularia* quoted his words at some length and also noted some of the mistakes regarding *Syngnathus*, I may refer the reader to p. 353 [77] of this paper. Here I need only point out that SW. has correctly observed the position of the pterotic, peculiar to all Lophobranchs as well as the whole group here under consideration, and furthermore some features in the branchial skeleton of *Siphonostoma*, regarding which he says (p. 577): "In Syngnathus the first and second basibranchials and the second hypobranchial alone are present; the fourth epibranchial has gone, but the edentulous pharyngobranchials, though rod-like, occupy the same position relatively to one another as in *Gasterosteus*."

Otherwise his interpretation of the visceral (incl. suspensory) skeleton is far from being fortunate. Thus, not only the statements concerning the absence of the basihyal (i. e. glossohyal) and the suboperculum are wrong, but also a good deal of the description quoted below, which refers to his figure 50; the latter I have copied here, and it should be compared with my figures 4, 5, 9, 10, on Pl. V. "The true infraorbital, or rather the first bone of the suborbital series (fig. 50, s. o.′), articulates with the parethmoid (e. p. b.) above, and forms the lower border of the narial opening. Ventrally it appears to divide into two laminæ, lying on the outer and inner sides respectively of the cheek muscles, and is attached by its lower border to the combined symplectic and pre-operculum (sym. + o. pr.). In front of the latter lies the greatly extended quadrate (qu.), of which only the small part indicated by the dotted line originated by ossification of cartilage. Along its upper and anterior borders lie three bones, a, b, c, whose homologies are uncertain; b. and c. together have all the relationships of the pterygoid in the stickleback, but as b. is developed in relation to the vestigial metapterygoid process, it must be the metapterygoid bone. a. is probably the nasal. The palatine is insignificant and edentulous." What SW. here calls the inner lamina of s. o.′ must be the symplectic (comp. my fig. 5 on Pl. V); the combined symplectic and preoperculum is simply the preoperculum alone; b. is the entopterygoid, c. the ectopterygoid. That his fig. 50 is wrong with regard to the vomer and mesethmoid, is already stated above.

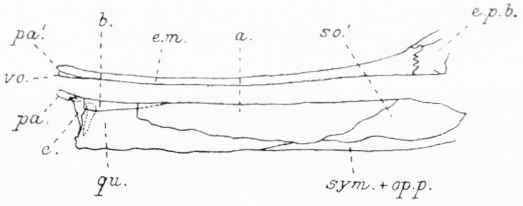

Fig. 1. Reproduction of SWINNERTON's fig. 50.

HUOT (19) describes (p. 211) and figures the cartilaginous skeleton of the newly hatched young of *Syngn. dumerilii*, *S. acus* and *Hippocampus guttulatus*. Regarding the skeleton of the adult he more *en passant* makes only the following remarks, which he ought to have omitted, p. 221: "Il n'y a pas de squelette operculaire ni de rayons branchiostiges", and p. 252: "Le squelette céphalique est en partie membraneux, en partie cartilagineux." (Perhaps the latter statement does not concern the adult, which seems not quite clear; but on p. 280 sub No. 11 of his "Conclusions", which certainly regard the adult, is said: "Le squelette est presque entièrement fibreux. On ne rencontre de cartilages nets que dans la région cranienne et dans les rayons des nageoires").

BOULENGER (4 a, p. 152 and b, p. 174) in the diagnosis of the Group III, *Lophobranchii*, of his Suborder *Catosteomi* includes the following osteological characters: "Præoperculum

* Neither is the pterygoid single in the *Gasterostei*, but here anteriorly only the ectopterygoid is present, while posteriorly, joining the hyomandibular, is found a metapterygoid, which is overlooked by SWINNERTON.

absent; symplectic much elongate; branchial apparatus more or less reduced ...; posttemporal simple, immovably attached to the skull."

REGAN (45 c, p. 8) wrongly states that "the head is capable of considerable movement in the vertical plane, the occipital condyle being convex."

Developmental stages of the head skeleton have been examined more or less thoroughly by POUCHET (43) (*Syngnathus*), RYDER (48) (*Hippocampus*), MC. MURRICH (34) (*Syngnathus*), SWINNERTON (56 a) (*Siphonostoma*) and HUOT (19) (*Syngnathus, Hippocampus*). With exception of MC. MURRICH and SWINNERTON (cfr. above) these authors seem not to have paid sufficient attention at the same time to the adult structures, and therefore some of their interpretations of the cartilages or incipient bones are not always quite correct, but it would lead too far here to enter into details regarding this matter.

[20] p. 308 [42]. The earliest remarks regarding the shoulder-girdle and scapular arch, known to me, are those of KRÖYER (29); under *Syngn. acus* he mentions on p. 699 that the nuchal plates, in the Pipefishes generally, are soldered together with the spinous processes of the underlying vertebræ and the shoulder-apparatus, the first nuchal also with the occipital bone; upon the whole the plates of the first ring are coalesced with the shoulder to such an extent, that they can only with difficulty be separated from the latter. p. 702 is said that the shoulder only consists of one bone (i. e. the clavicle), which is correctly described in details; of the scapular arch K. has only observed one bone, after his description evidently the coracoid; but it is regarded as the "upper arm"; "the remaining bones of the arm and hand are quite rudimentary." The same two parts KR. finds in *Nerophis æquoreus* (p. 714) "where the forearm and hand have completely vanished."

PARKER (40, p. 30) figures the shoulder-girdle, seen from the inner side, of *Syngn. acus*. He correctly observed the posttemporal and the clavicle; but, as already mentioned p. 303 [37] of the present paper, he did not understand the scapular arch: the coracoid he regards as two separate "interclavicular" bones; the scapula is completely overlooked, and the cartilaginous part of the scapular arch is considered to be the whole "true shoulder-girdle", "of extreme interest, as it is persistently soft, and has undergone no segmentation."

COPE (8. p. 457) has adopted the posttemporal and also the "well developed interclavicles."

MOREAU (36, p. 30) only says: "Ceinture scapulaire non attachée au crâne, mais à la colonne vertebrale et aux boucliers antérieurs." That v. KLEIN (26 c) takes the posttemporal to be the epiotic ("occipitale externum" v. Kl.) is mentioned above p. 353 [87]. On p. 251 he says: "Die Schultergürtel legen sich an den ersten Wirbel an"; a statement only partly correct.

SCHÄFF (50) does not examine the shoulder-girdle; but on p. 22 he describes in *Hippocampus* "die Platte, welche die Brustflossen trägt." From this description it is evident, that S. regards the dermal part of the clavicle, the "cover plate" and the "jugular" plate as one piece, and that he has no understanding of the attachment of the pectoral fin.

LILLJEBORG (32, p. 449) after a correct description of the posttemporal and clavicular bones says that "on the inner margin of the clavicle .... is found a thin, almost membrane-like, cartilaginous plate, which may represent the coracoid and scapular bones, and at the posterior margin of this plate is the attachment of the pectoral fin, which thus appears to be but weak." The ossified parts (coracoid, scapula and basals) are thus completely overlooked.

SMITT (54, p. 666) gives a figure, which is only a combined and somewhat altered copy of those of PARKER; the coraco-scapular part is introduced into PARKER's figure of the clavicular skeleton; the latter is corrected in so far that it has only one "interclavicle", but SMITT has not seen that this bone is really the coracoid. The four basals or pterygials are wrongly represented, only their basal parts, which are enclosed in the coraco-scapular cartilage, being present in the figure; evidently their distal parts, which PARKER compared with

"stag's-horns", have been broken off. Thus neither SMITT nor PARKER had any idea of the part these distal branched ends play as means of fixation of the pectoral fin.

The few remarks by GILL (14 b) and JORDAN and EVERMANN (21 a), apparently following PARKER, are quoted above. SIEBENROCK (53, p. 118) describes the posttemporal in *Hippocampus* and mentions the attachment of the clavicle to the two anterior vertebræ.

GOODRICH (15) ascribes (p. 414) to the Lophobranchii "very small pectoral radials", p. 415 adding for the subtribe B (including Syngnathidæ and Hippocampidæ): "with a row of distal cartilages." That his (original) figure 413 D is incorrect was stated on p. 303 [37] of the present paper.

REGAN (45 b, p. 79) characterizing the *Syngnathoidei* says: "post-temporal simple, suturally united to the cranium; no supracleithrum; cleithrum firmly attached to the transverse processes of the two anterior vertebræ." Later (45 c, 1910) p. 8 he states that "the clavicle is attached to the expanded transverse process of the first vertebra."

[21] p. 308 [42]. Regarding the nuchal plates, the size and shape of which are often described by systematists, I may point out that most members of the Hippocampine group are possessed of three, a fact which does not seem to have been observed before. Thus MOREAU (36, p. 35) says for *Hippocampus*: "Il y a deux pièces nuchales"; the anterior is described in detail and its shape compared with a crown. "La seconde pièce nuchale est allongée, elle est étroite, elle fait une espèce de toit au-dessus de l'espace vide, qui reste entre les deux pièces latérales supérieures du premier anneau du tronc ou de l'anneau scapulaire (i. e. the upper parts of the clavicle)." From this description follows that the hindmost nuchal plate has escaped attention. SCHÄFF (50, p. 21) does not mention any number of nuchals in *Hippocampus*, but he seems not at all to understand the structures of the nuchal region: "Die Exoccipitalia und das Supraoccipitale bilden mehrere zu einem kronenartigen Gebilde verschmolzene Stacheln, an welche sich auf Nackenschildern noch einige Hervorragungen anschliessen." This seems to mean that S. regards the anterior nuchal, the "corona", as part of the skull. No better is the following: "Das erste Schild, welches auf den Kopf folgt, besteht aus zwei auf der Medianlinie des Rückens verschmolzenen, oberen Seitenschildern, deren Stacheln wie die der gewöhnlichen Schilder beschaffen sind. Auch die zugespitzte, nach unten gerichtete Fläche, die sich an den Körper legt, ist vorhanden. Dann aber tritt noch jederseits vorn ein schräg nach unten verlaufender Teil hinzu, der sich mit dem die Brustflosse tragenden Stück (i. e. the clavicle) verbindet. Nach vorn spitzt sich die Rückenfläche dieses ganzen Schildes zu und läuft in drei kleine Fortsätze aus, vor welchen die Nackenschilder mit ihren Erhebungen liegen."

DUNCKER (13, p. 21) correctly says that "Das stark bewehrte Pränuchale von *Hippocampus* wird als Corona bezeichnet"; but he only mentions a Pränuchale and a Nuchale in Lophobranchs generally.

[22] p. 309 [43]. The presence of the pseudobranchia in the *Syngnathidæ* has often been denied or overlooked. Thus MECKEL (35, 6. vol., p. 181) and KRÖYER (29, p. 679) deny its existence, while RETZIUS, KAUP, GÜNTHER, DUMÉRIL, RYDER, MOREAU, LILLJEBORG, JORDAN and EVERMANN, HUOT, perhaps still more authors, do not mention it at all. But already 1841 JOH. MÜLLER (37, p. 78) stated regarding the *Lophobranchii*: "Haben einige Federchen einer Nebenkieme vor dem ersten Kiemenbogen. Untersucht wurden die Gattungen *Syngnathus* Linn., *Hippocampus* C."

Solenostomus.

[23] p. 311 [45]. Only some of the cutaneous papillæ on the snout have been observed by previous authors, and only by the older, while later authors do not mention them. The mandibular barbel at the chin seems not at all to have been noticed.

SEBA (51, p. 106) in his definition of Solenostomus (paradoxus) says: "Solenostomus varius, *rostro cirrato*; pinnis dorsali et ventralibus prælongis" (or in Dutch: "Bonte Sole-

nostomus, met een gebaarden snuit, en zeer lange rug- en buikvinnen"); and the description l. c. p. 107 runs: "Ima rostri sede, per totam ejus longitudinem, sex paria nigricantium cirrorum aut barbularum propendent. Pari postremo oculi superimminent" (in Dutch: "Aan het ondereinde van den snuit langs deszelvs lengte hangen 6 paar swartagtige baardtjes af. Booven het agterste paar staan de oogen").

PALLAS (39, p. 33) ".... *rostrum* .... subtus longitudinaliter bicostatum & *ramentorum* nigrorum tribus paribus æquidistantibus barbatum." His fig. 6 on Tab. IV is bad enough but better than that of SEBA; it shows 3 pairs of filaments below the snout but the hinder pair at some distance in front of the level of the eye. The slender shape of the snout and of the caudal peduncle ("Pone hos processus [i. e. the "hump" for D_2 and A] cauda adtenuatior" etc.) proves sufficiently that his species really must be our *Solen. paradoxus.*

BLEEKER (2 a, p. 308) describing "Solenostoma paradoxum" = our *S. cyanopterus* does not mention any cutaneous filaments; but later (2 b, p. 52) he states for "Solenostoma paradoxum Lacép. Rafin." = our *S. paradoxus*: "... *rostro* acuto ... sextuplo longiore quam parte gracillima alto, inferne multicirrato."

KAUP (25, p. 2) says about his "Solenostomus paradoxus"; "Some of the specimens have little skinny tags round the mouth and rostral tube, as represented in Pallas's figure." Of the 5 specimens known to Kaup, and by him called *S. paradoxus* (which all belong to the Museum of Paris), 3 are *Sol. cyanopterus* and 2 *Sol. paradoxus.*

[24] p. 316 [50]. Information about the vertebral column is only given by GÜNTHER, BOULENGER and REGAN.

GÜNTHER (16 b, p. 151): "The vertebral column is composed of eighteen abdominal and fifteen caudal vertebræ, the vertebræ gradually decreasing in length backwards, so that the shortness of the tail is caused not only by the smaller number of vertebræ, but also by their much lesser length. Neural and hæmal spines are developed." REGAN (45 c, p. 8): "The præcaudal vertebræ have short transverse processes and the caudal vertebræ are much abbreviated; ribs are absent." BOULENGER (4 c, p. 633): "Anterior vertebræ elongate, without transverse processes; no ribs."

[25] p. 317 [51]. DUMÉRIL (12 b, p. 496) incorrectly states: "les rayons de toutes les nageoires non articulés."

About the number of fin-rays in the ventrals and first dorsal most authors agree; only BLEEKER gives for *S. cyanopterus* V = 11, presumably having counted some of the bifurcated rays as two rays, and DUMÉRIL gives 8 rays in the ventrals of the male *S. paradoxus.* That SEBA gives 4 rays in the first dorsal, together with other apparent mistakes, I think is due to the bad state of his single, dried, specimen, which his figure clearly proves. The number 16, which without exception I have found in my specimens, I think will prove to be the normal number. I hardly believe that a variation between 12 and 20, as the table on p. 323 [57] shows, would be possible, where a caudal fin is developed and enlarged to such a degree, as is the case in the present genus. In the other fins, where the number of fin-rays are greater and their structure weaker, the numbers apparently vary slightly.

[26] p. 319 [53]. BOULENGER (4 c, p. 633) states: "no præoperculum; symplectic elongate", the only remarks about cranial structures found in the literature.

[27] p. 319 [53]. GÜNTHER (16 b, p. 150) states for the whole Order V. Lophobranchii, comprising Solenostomidæ: "Gill-cover reduced to a large simple plate." A. S. WOODWARD (59, p. 379) for *Solen.*: "Opercular apparatus reduced to operculum and very few branchiostegal rays." Also JORDAN and SNYDER (22, p. 3) repeat for the Lophobranchs: "Gill covers reduced to a large simple plate."

[28] p. 319 [53]. GÜNTHER (16 b, p. 151): "Branchiostegals four, very thin." The same is repeated by JORDAN and SNYDER (22, p. 3).

[29] p. 321 [55]. C. TATE REGAN (45 b, p. 79) says: "pectoral arch normally attached to skull; post-temporal and supracleithrum similar to stellate ossifications on body"; and later (45 c, p. 8): "The membrane bones of the pectoral arch are a trifurcate post-temporal, loosely attached to the cranium, a supra-clavicle, and a clavicle. The pterygials are four in number, rather large, but very thin and similar to those of Syngnathus as figured by Parker."

[30] p. 322 [56]. GÜNTHER (16 b, p. 151): "The pelvis consists of two pairs of cartilaginous laminæ, the convex margin of the anterior fitting into an angle of a dermal bone which separates the pelvis from the well-ossified humeral arch."

[31] p. 325 [59]. About the gill-apparatus the only previous statements are the following: GÜNTHER (16 b, p. 151): "pseudobranchiæ absent"; BOULENGER (4 c, p. 633): "gill-lamellæ small rounded lobes"; REGAN (45 b, p. 79): "gills lobate", and (45 c, p. 8): "The gill-fringes are reduced in number and thickened."

[32] p. 326 [60]. About the alimentary tract PALLAS says (39, p. 35): "*Ventriculus* vesicularis. *Canalis alimentarius* amplus, æquabilis, fere recta a ventriculo ad anum deductus. *Hepar* dexterius, sub initio canalis alimentarii." GÜNTHER (16 b, p.151): "Intestinal tract very simple, with a stomachic dilatation, without pyloric appendages."

[33] p. 327 [61]. PALLAS (39, p. 35): "*Ovarium* posterius duplex, ad dorsum longitudinalia, linearia, in anum terminata; referta ovulis flavescentibus, *grano papavereo* sicco fere æqualibus." GÜNTHER (16 b, p. 151) only remarks: "Ova very small." The ova preserved in the ventral pouch of my specimen of *S. paradoxus* measure 0,64—0,69 mm., and they have been partly dried.

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List of reference letters.

Skull.

al: alisphenoid
ao'', ao', ao: preorbitals
eo: exoccipital
ep: epiotic
f: frontal
mes: mesethmoid
na: nasal
ob: basioccipital
pa: parasphenoid
pf: postfrontal
prf: prefrontal
pro: prootic
pt: posttemporal
so: supraoccipital
sq: pterotic (squamosal)
vo: vomer

Mouth parts.

an: angular
ar: articular
d: dentary
i: intermaxilla
mx: maxilla

Suspensory apparatus.

ect: ectopterygoid
ept: entopterygoid
hy: hyomandibular
mt: metapterygoid
pa: palatine
pro: preoperculum
qu: quadrate
sy: symplectic

Opercular apparatus.

io: interoperculum
o: operculum
s: suboperculum

Hyoid.

ch: ceratohyal
eh: epihyal
gl: glossohyal
hy^{I}: lower hypohyal
hy^{II}: upper hypohyal
r: branchiostegal ray
st: stylohyal
u: urohyal

Branchial skeleton.

I—V: gill-arches
c: ceratobranchial
co: copula (basibranchial)
e: epibranchial
hy: hypobranchial
ph: pharyngobranchial

Shoulder-girdle and pectoral arch.

ba: basals (pterygials)
cl: clavicle
co: coracoid
pcl: postclavicle
pt: posttemporal
sc: scapula
scl: supraclavicular

Plate I.

(For letters see List p. 364 [98].)

Figs. 1—4: *Aulostoma coloratum.*

Fig. 1: Skull from left side. *: knob for attachment of ossified tendon.
— 2: Skull from above.
— 3: Skull from below.
— 4: Skeleton of head from left side.

Figs. 5—6: *Fistularia tabacaria.*

Fig. 5: Skeleton of head from left side.
— 6: Skull from above. k: rugosity for attachment of ligament to first vertebra (cfr. p. 289 [23]).

Figs. 7—8: *Fistularia petimba.*

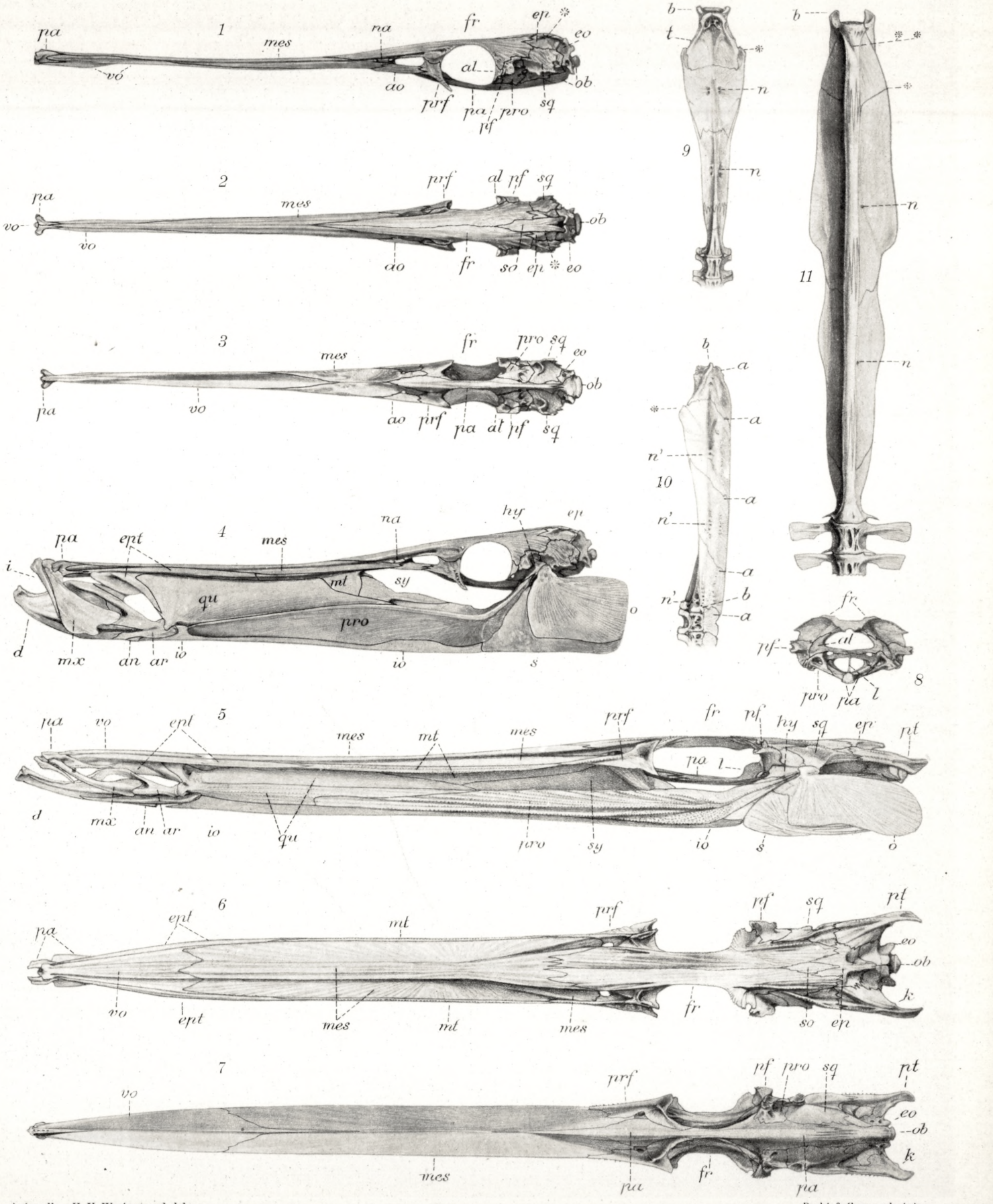
Fig. 7: Skull from below. l: lamelliform process from parasphenoid.
— 8: Front view of posterior wall of orbit. Frontals and parasphenoid cut through transversely.

Figs. 9—10: *Aulostoma coloratum.*

Fig. 9. Anterior four coalesced vertebræ and foremost free vertebræ, from below. b: articular process; t: transverse process; * attachment for ligament to posttemporal; n: openings for passage of nerves and blood-vessels.
— 10: the same, from left side. n': openings for nerves and vessels; a: anterior part of neural arch (cfr. p. 272 [6]).

Fig. 11: *Fistularia petimba.*

Fig. 11: Anterior four coalesced vertebræ and foremost free vertebræ from below. **: furrow for aorta crossing over to left side. *: attachment for ligament connected with posttemporal.



Autor dir. H. V. Westergaard del.

Pacht & Crone phototyp.

Plate II.

(For letters see List p. 364 [98].)

Figs. 1—2: *Fistularia petimba.*

Fig. 1: Pharynx partly dissected to show branchial skeleton; upper pharyngeal wall cut through along its middle line and turned outward.

— 2: Upper part of branchial skeleton and gills, from right side.

Figs. 3—4: *Aulostoma coloratum.*

Fig. 3: Pharynx prepared in similar way as in Fig. 1, showing gill-clefts, tooth-plates representing gill-rakers etc.

— 4: Upper parts of branchial skeleton and gills, right side. v: branchial vessels.

Figs. 5—6: *Fistularia petimba.*

Fig. 5: Right hyoid, outer face. (st): stylohyal coalesced with epihyal eh.

— 6: The same, inner face.

Figs. 7—8: *Aulostoma coloratum.*

Fig. 7: Right hyoid, inner face.

— 8: The same, outer face.

Fig. 9: *Fistularia petimba.*

Fig. 9: Anterior part of vertebral column; left side. 1—3: nuchal plates; td: ossified tendons (posterior ends cut away).

Fig. 10: *Aulostoma coloratum.*

Fig. 10: Abdominal and anterior caudal vertebræ; left side. a, b, t and * as in Figs. 9—10 on Pl. I; 1—3: nuchal plates; 4—16: interspinous bones; s: spinous rays of dorsal fin.

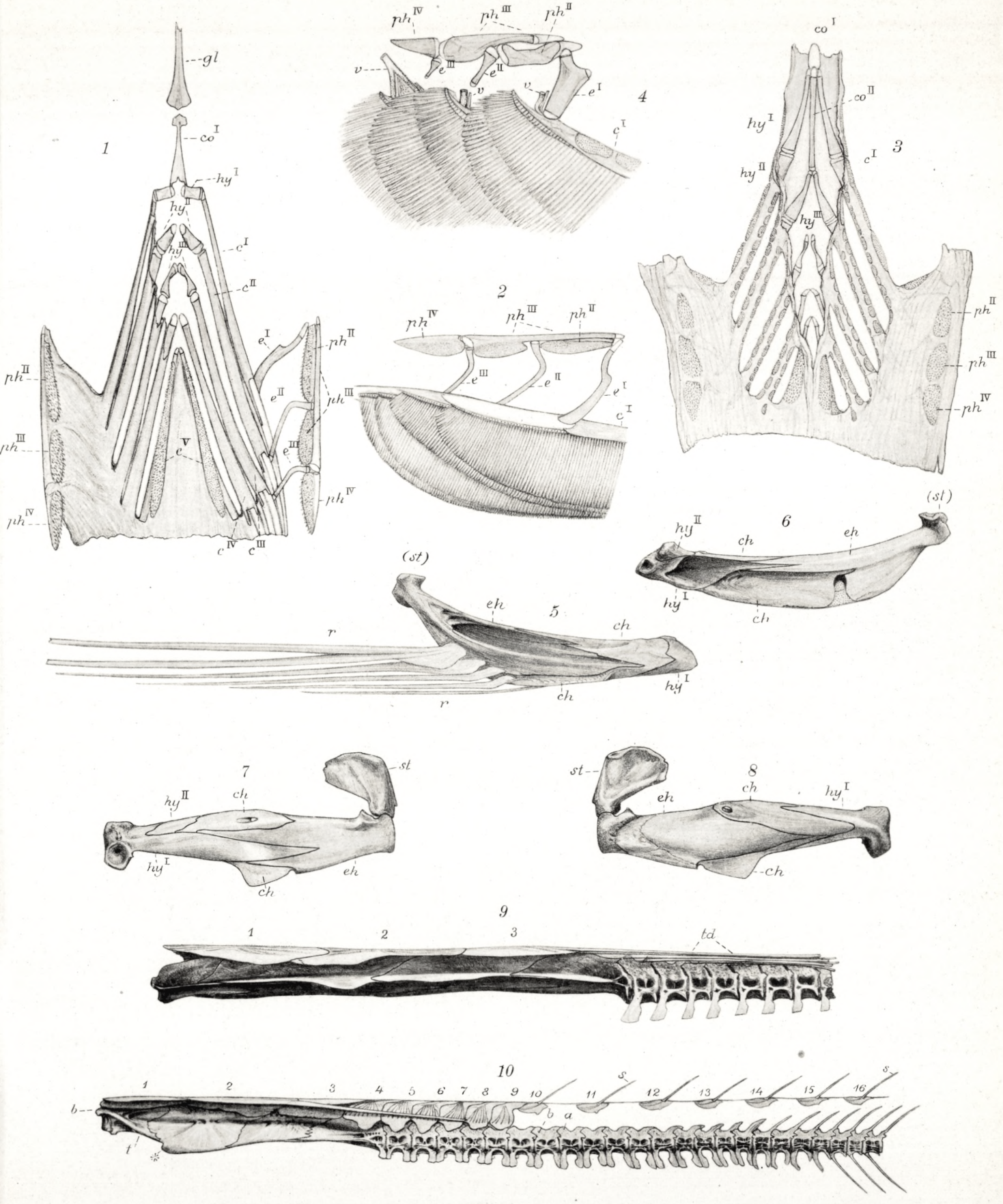

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Plate III.

(For letters see List p. 364 [98].)

Figs. 1—2: *Siphonostoma typhle.*

Fig. 1: Left shoulder-girdle and pectoral arch, anterior vertebræ and part of dermal skeleton; inner side. I—III: anterior vertebræ; t: transverse processes; ml, il: median and inferior lateral plates; j: jugular plate; o: outer, i: inner fork of clavicle; co': posterior part of coracoid.

— 2: Same parts, outer aspect. n': prenuchale; n: nuchale; sl, ml, il: superior, median and inferior lateral plates; c: cover plate; j: jugular plate; i: intermedial scutes; p, p': processes of clavicle cl.

Fig. 3: *Hippocampus sp.*

Fig. 3: Left shoulder-girdle and anterior part of dermal armour; outer aspect n': "corona" (prenuchale); n'': posterior nuchale; I: body of foremost vertebra; v: ventral dermal plates.

Figs. 4—5: *Aulostoma coloratum.*

Fig. 4: Left shoulder girdle, without posttemporal; outer aspect.

— 5: The same, inner aspect. f: opening between inner (i) and outer (o) fork of clavicle and coracoid (co).

Figs. 6—7: *Siphonostoma typhle* (juv.).

Fig. 6: Left shoulder girdle and pectoral fin; inner aspect.

— 7: The same; outer aspect.

Figs. 8—9: *Fistularia petimba.*

Fig. 8: Left shoulder girdle, from inner side; without supraclavicular and posttemporal; i, o, f etc. as in Fig. 5.

— 9: The same, outer aspect.

Figs. 10—11: *Solenostomus cyanopterus.*

Fig. 10: Part of musculature, visceraetc. of ♂. ps: Pseudobranchia; I—IV: first to fourth row of gills; o: opening between gill-chambers; c: heart; oe: oesophagus; i: intestine; r: rectum; bd: entrance of bile-duct; *, **: comp. p. 325 [59]; l: liver; td: ossified tendon; k: kidney; bl: air-bladder; te: testis.

— 11: Filament (magnified) from brood-sac of ♀, showing suckers on ends of branchlets; ax: bony axis.

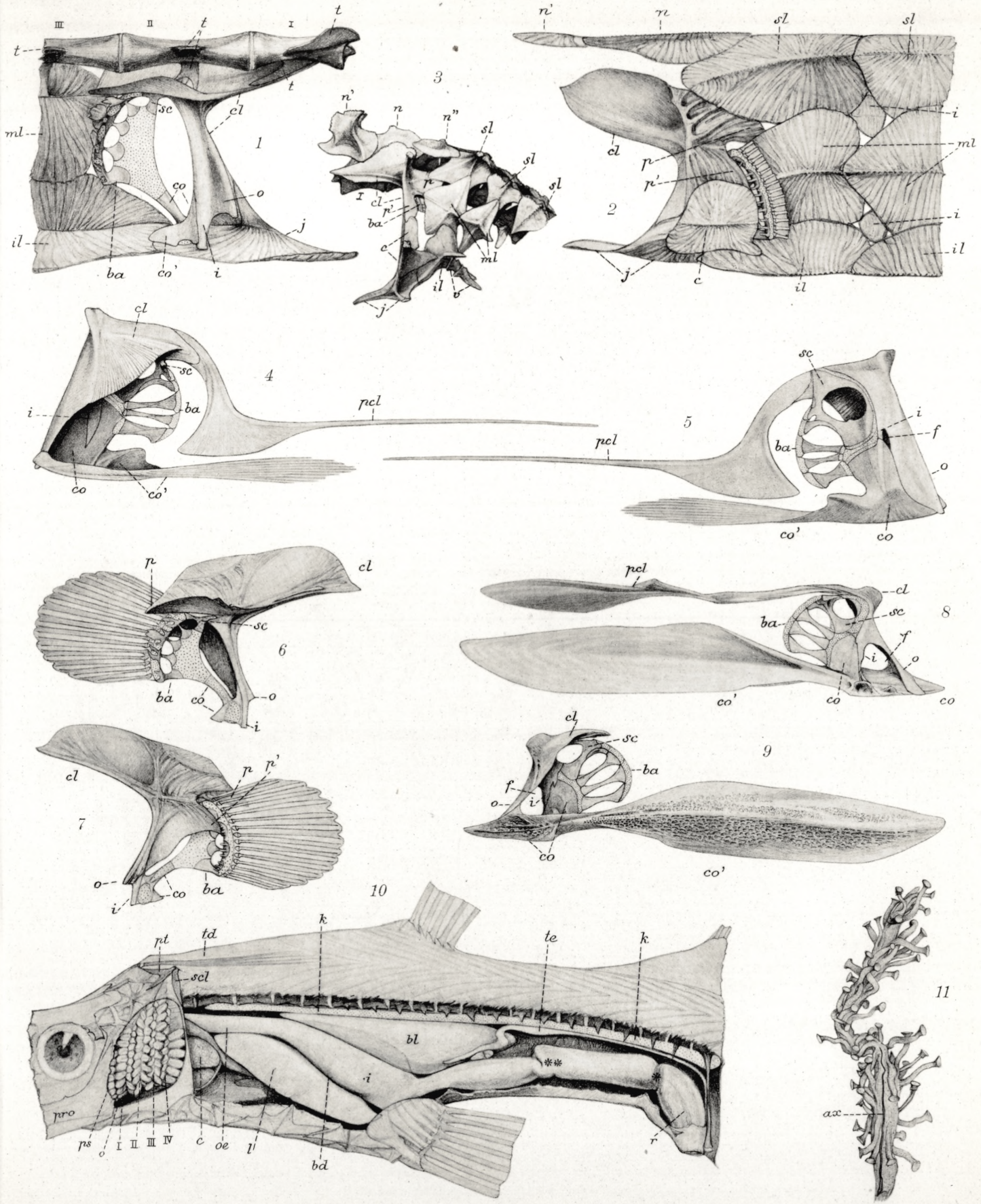

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Plate IV.

(For letters see List p. 364 [98].)

Fig. 1: *Siphonostoma typhle.*

Fig. 1: Last two abdominal and anterior caudal vertebræ with dorsal and anal fins, from left side; showing interspinous bones arranged in fanshaped groups. t: transverse process; v: wing-shaped secondary process for attachment of fin-muscles; sp: inferior spine; a: anus; between the latter and the abdominal vertebræ part of viscera is seen.

Fig. 2: *Hippocampus brevirostris.*

Fig. 2: Corresponding part to that of Fig. 1, from left side.

Figs. 3—4: *Siphonostoma typhle.*

Fig. 3: Anterior three vertebræ, from below (much enlarged); a: articular process, connecting with skull; t: transverse process.

— 4: The same, from left side.

Fig. 5: *Syngnathus acus.*

Fig. 5: Anterior three vertebræ, from left side. n: nuchale in situ (part of the laterally expanded plate cut away).

Figs. 6—11: *Siphonostoma typhle.*

Fig. 6: Last abdominal vertebra, from right side. i, i: incisions in spinous process, for insertion of interspinous bones. Other letters as in Fig. 1.

— 7: The same from above.

— 8: First caudal vertebra, from left side. i: interspinous bone; u: its terminal upper end; e: bony expansion just below the latter.

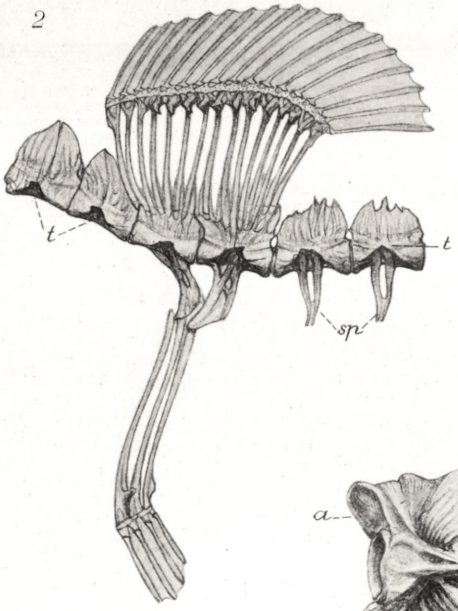
— 9: The same, seen from behind. ia: inferior (open) arch. Other letters as in Fig. 8.

— 10: Last caudal vertebra, left side. h_1 h_2: upper and lower hypural bones.

— 11: Coalesced interspinous bones for anal fin with cartilages removed (much enlarged). e: bony expansions for connection with dermal scutes, originating just over terminal end u.

Fig. 12: *Nerophis æquoreus.*

Fig. 12: Three groups of interspinous bones for dorsal fin, from above; showing lateral bony expansions (e) on the left side, and on the right side the same overlapped by the superior lateral (sl) and upper intermedial scutes (i). The posterior 3 interspinous bones belong to one vertebra; the 2 other groups each of 4 interspinous bones are supported each by one vertebra, the smaller interneurals connected with the intermedial scutes i being the hindmost of each group. u: terminal end of interspinous bones.



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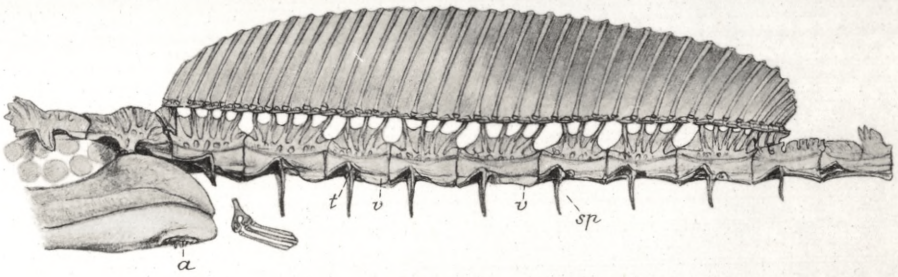

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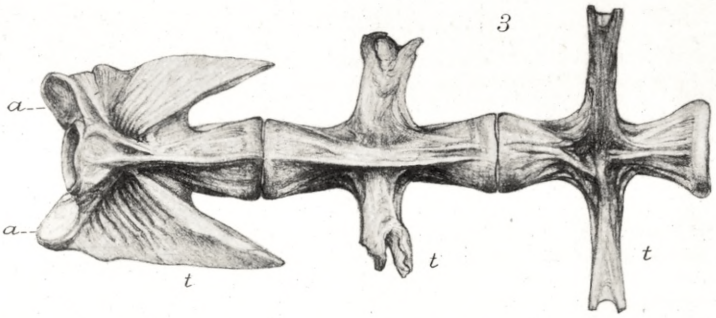

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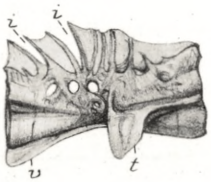

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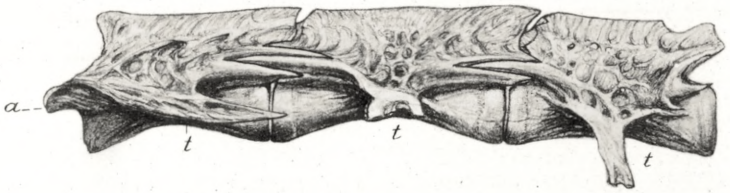

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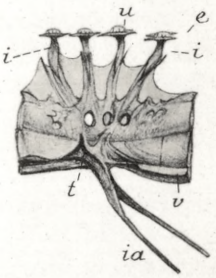

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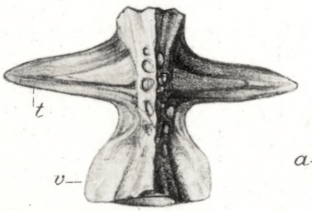

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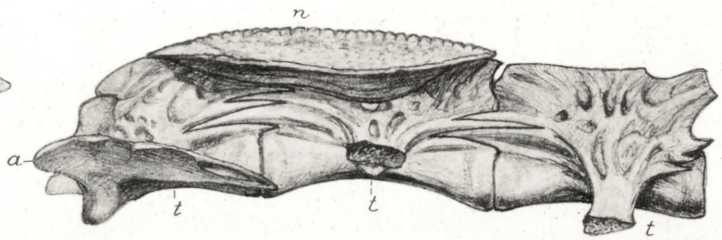

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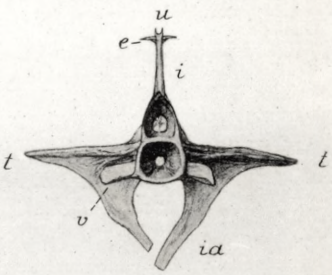

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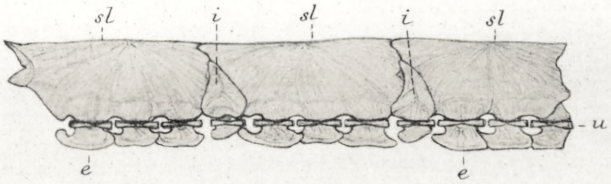

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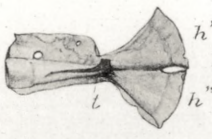

Plate V.

(For letters see List p. 364 [98].)

Figs. 1—5: *Siphonostoma typhle.*

Fig. 1: Skull from above (magnified). c: snout-cartilage.
— 2: The same from below.
— 3: Skull from behind.
— 4: Head skeleton from left side. Entopterygoid (ept) and preorbitals (ao' ao) are removed a little from contact with the cranial beak.
— 5: Mouth-parts, suspensory and opercular parts and hyoid from right side, inner aspect. l: ligament between symplectic (sy) and stylohyal; li: ligament between angular (an) and interoperculum (io); li': ligament between interoperculum and hyoid (h). Through the transparent interoperculum (io) the skeletal parts covered by the latter are visible.

Figs. 6—7: *Hippocampus brevirostris.*

Fig. 6: Skull from left side. *: groove for attachment of nuchal tendon; p: branch of posttemporal (pt) connecting with exoccipital (eo).
— 7: Suspensory parts and preorbitals from left side, outer aspect.

Fig. 8: *Phyllopteryx foliatus.*

Fig. 8: Head-skeleton from left side. g: gill-opening; h: hyoid; u: urohyal.

Fig. 9: *Nerophis ophidion.*

Fig. 9: Head-skeleton from right side. n': prenuchale; t: ossified tendon of nuchal muscles; x: dermal plates.

Fig. 10: *Nerophis æquoreus.*

Fig. 10: Head-skeleton from right side. x: as in the preceding figure; h: hyoid; u: urohyal.

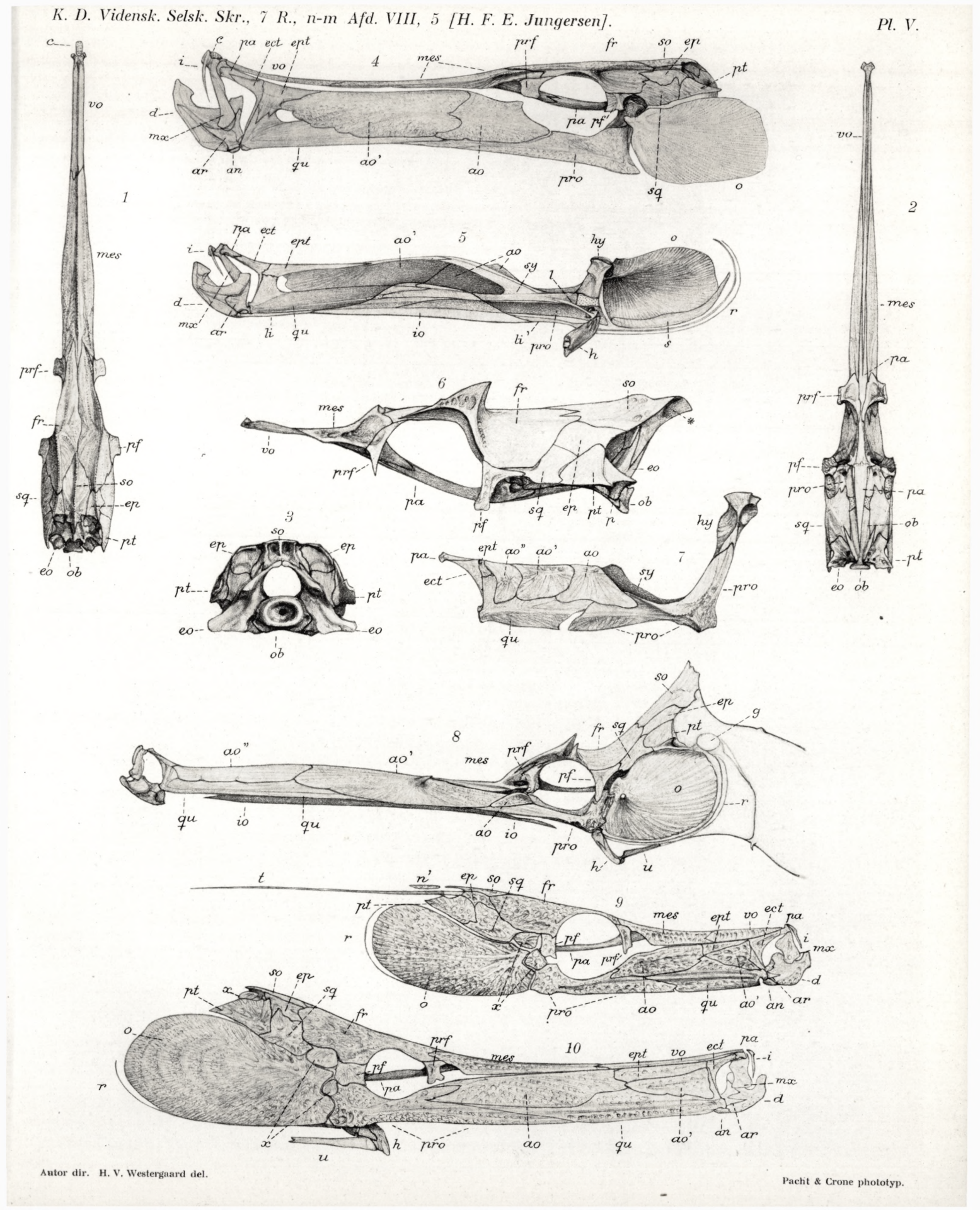

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Plate VI.

(For letters see List p. 364 [98].)

Fig. 1: *Siphonostoma typhle.*

Fig. 1: Hyoid and pharynx showing gill-clefts and branchial skeleton, from right side. Ends of branchiostegal rays (r) cut away.

Figs. 2—3: *Solenostomus cyanopterus.*

Fig. 2: Hyoid and branchial skeleton from left side, outer aspect.
— 3: Left hyoid, inner aspect.

Figs. 4—5: *Siphonostoma typhle.*

Fig. 4: Right hyoid, inner aspect. Greater part of branchiostegal rays cut away.
— 5: The same, outer aspect.

Figs. 6—9: *Solenostomus cyanopterus.*

Fig. 6: Left maxilla inferior, outer aspect.
— 7: Upper pharyngeals from right side, lower aspect.
— 8: The same, from above.
— 9: Branchial skeleton. Upper pharyngeals showing lower face (comp. Figs. 1 and 3 on Pl. II).

Fig. 10: *Siphonostoma typhle.*

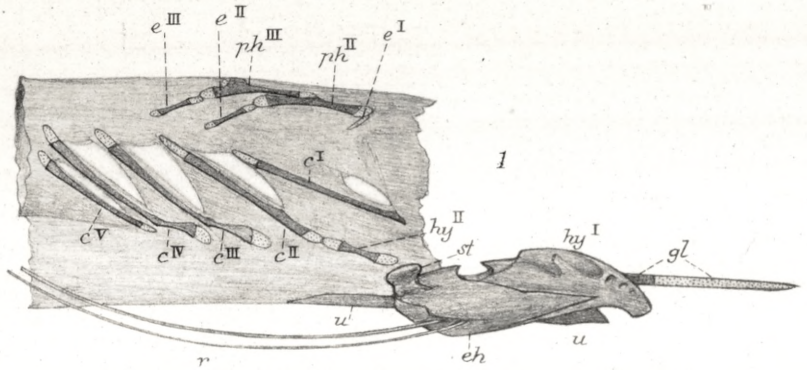
Fig. 10: Pharynx and branchial skeleton, prepared in a similar way as Figs. 1 and 3, Pl. II.

Fig. 11: *Hippocampus longirostris.*

Fig. 11: Branchial skeleton, prepared as the preceding.

Fig. 12: *Nerophis æquoreus.*

Fig. 12: Hyoid and branchial skeleton, prepared as in Figs. 10 and 11.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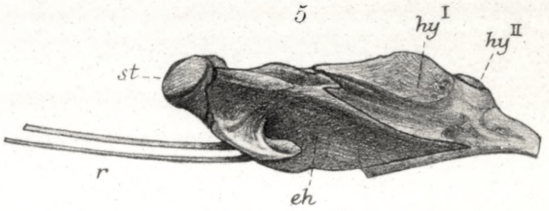
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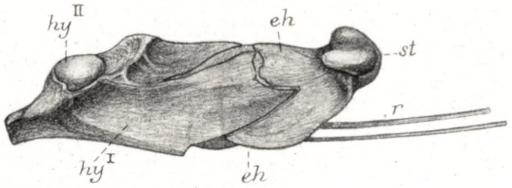
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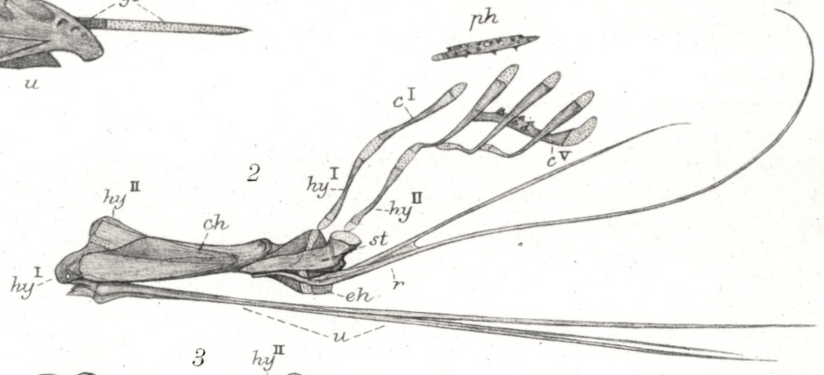
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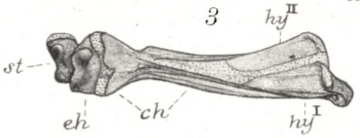
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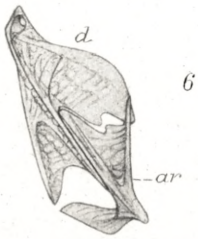
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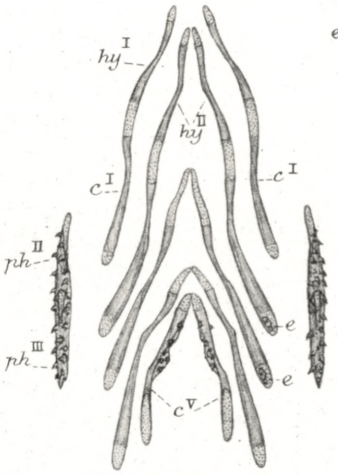
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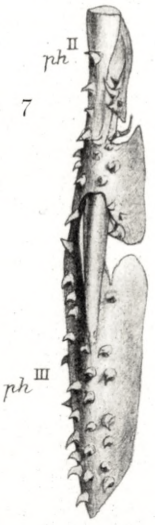
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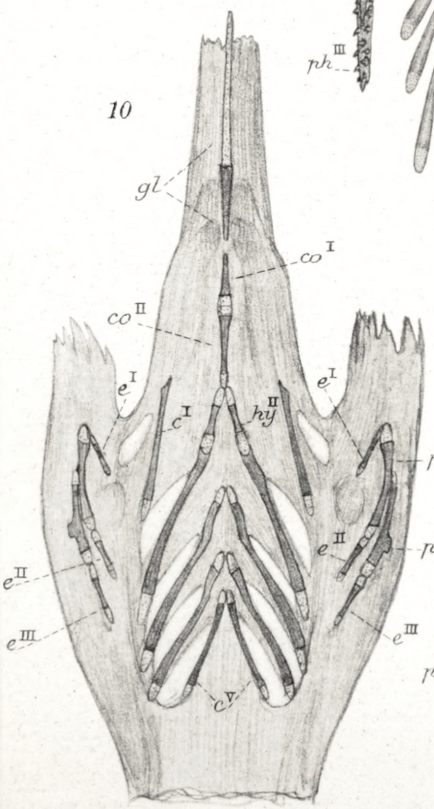
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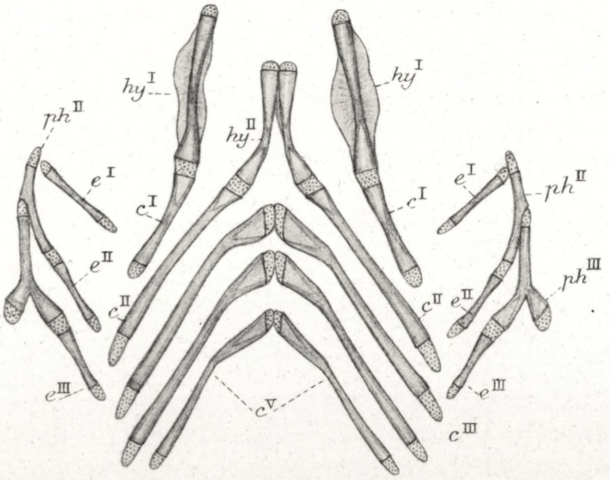
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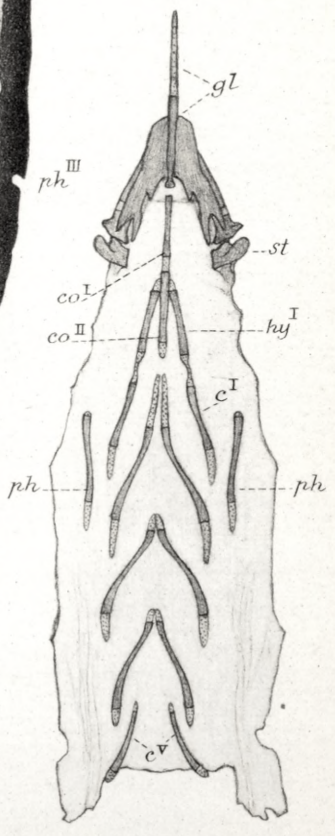
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Plate VII.

(For letters see List p. 364 [98].)

Figs. 1—2: *Fistularia tabacaria.*

Fig. 1: Young *Fistularia* of 43 mm. length (without the caudal filament). v: rudiment of ventral fin.
— 2: Part of skin of the same, more strongly magnified, showing dermal hooklets. v: ventral fin.

Figs. 3—6: *Solenostomus cyanopterus* ♂.

Fig. 3: Skeleton, from left side. Operculum and shoulder-girdle (except posttemporal) removed; I—III: anterior three immovable vertebræ; o: indication of opening between branchial cavities; p: pubic bone; cr: muscular crest on the same; * lower posterior part of pelvis.
— 4: Left shoulder-girdle and pectoral arch, inner aspect; without posttemporal and supraclavicular. p and p': processes on clavicle (comp. Figs. 1, 2, 3, 6 and 7 on Pl. III).
— 5: Left shoulder-girdle and pectoral fin, outer aspect.
— 6: ♂, showing dermal skeleton, nasal organ, operculum (o) and suboperculum (s), branchiostegal ray (r) etc. I—V: superior row of unpaired median scutes; I—IV: lower row of unpaired scutes; 1—6: members of the thoracic transverse rows of scutes.


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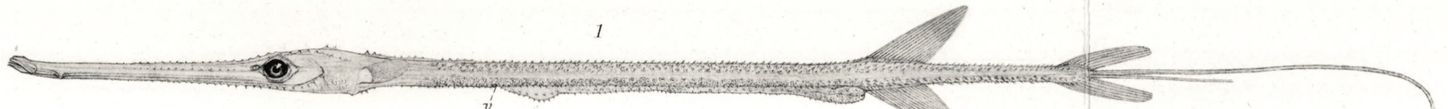
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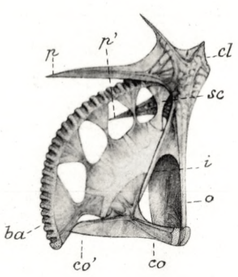
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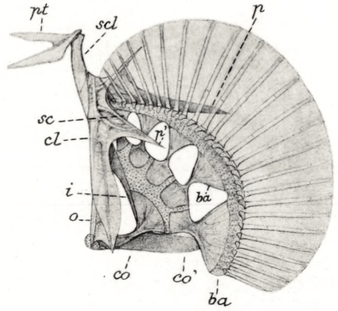
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