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Considering that only about five per cent. of the flowers open, and consequently that that proportion of the pollen only is available for the fertilization of the plant, and that the anthers do not open by slits, as is most usual; but by two very minute pores, thus giving out the pollen grudgingly; that the pollen, even in the anther, is by no means abundant, but rather the reverse; taking, too, into consideration that each flower produces but one seed, one cannot help feeling surprise that the plant is so abundant. I think, however, this may be accounted for to a great extent, by the presence of the secretion of which I have spoken. The fact of its being more copious in the younger flowers while the styles are comparatively short, and the secreting glands are near the surface of the head of flowers, renders it almost impossible for an insect to crawl about the stage, formed by the compact head, without becoming so smeared with it, that on visiting an open flower much of whatever pollen might be exposed, would adhere to it, and be carried away by it; and for the same reason upon its visiting the mature stigmas of the closed flowers, a little only of the pollen, but quite sufficient, since there is only one ovule to be fertilised, would be left on each; the greater part remaining adhering to the insect, who would carry it from one flower to another. Thus it is not unlikely that by the pollen obtained by one visit to an open flower, very many of the closed ones would be fertilised.

Studies on the Elasmobranch Skeleton.

By William A. Haswell, M.A., B.Sc.

[Plates I. and II.]

In his well-known memoirs "Das Kopfskelet der Selachier" * and "Die Brust-Flossen der Fische,"† Gegenbaur has treated very exhaustively of the structure and homologies of these part s

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* Untersuchungen zur vergleichenden Anatomie der Wirbelthiere. Heft. 3.
† Op. cit. Heft. 2.

of the skeleton in the Selachoidei. There was an absence, however, in the material at his disposal, rich though it was, of certain southern forms of some little importance; and a study of some of those has enabled me to observe several points of some theoretical interest. The following is the list of the species examined :—

Heptanchus indicus.....	Complete skeleton.
Heterodontus (Cestracion) Phillipi ...	do.
Carcharodon Rondeletii	do.
Crossorhinus barbatus	do.
Cheiloscyllium furvum.....	do.
Squatina angelus	do.
Pristiophorus cirratus	do.
Trygonorhina fasciata	do.
Trygon pastinaca	do.
Urolophus testaceus..... ..	do.
Hypnos subniger	do.
Galeus canis	dried skull.
Scyllium stellarius	do.
Lamna cornubica	do.
Scymnus circaeensis	do.
Mustelus lævis.....	do.
Zygaena malleus	do.

The skeletons of the Australian species were all examined in the fresh state, and the drawings made from them (with the aid of the camera and sometimes of photographs), while in that state or after preservation in glycerine jelly after Prof. T. J. Parker's method, so that little or no distortion or alteration had taken place.

One of the principal objects which I have had in view has been to ascertain how far a comparison of all parts of the skeleton would bear out the deductions as to the affinities of the various groups, based by Hasse* on the structure of the vertebræ; and I have added at the close of the paper a synopsis of the anatomical characters of the skeleton in the principal sub-divisions, showing how far this has been carried out.

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* Morphologisches Jahrbuch, II., III., IV., and Supp. to IV.

The following is a short general summary of the leading points in the skeletal anatomy of the Plagiostomata.

The *vertebral column* of the Plagiostomata varies considerably in the degree to which the vertebræ become marked off from one another, and the embryonic tissue becomes ossified. In some *(Notidanus)*, no ossification takes place in the centra, and the segments are not very clearly separated from one another. In others *(Spinacidæ, Læmargidæ* and *Echinorhinidæ)*, each centrum presents a double osseous cone with the apices meeting in the middle and the cavities of the cones turned towards the anterior and posterior faces of the vertebra.* In the greater number of Sharks there is added to this double cone a series of osseous rays traversing the cartilaginous zone which forms the outer layer of the centrum. In one case only *(Squatina)* the rays are replaced by a series of concentric lamellæ surrounding the double osseous cone. In some sharks *(Notidanus* for example), each vertebra in the caudal region bears two neural arches. In the Rays ossification of the vertebral column is more perfect than in the Sharks, and the anterior portion of the spinal column becomes fused into a continuous bony and cartilaginous mass. In all the caudal vertebræ are distinguishable by the presence of inferior arches enclosing the caudal vessels. The first vertebra has its anterior surface modified for articulation with the occipital region of the cranium. In *Hexanchus*, in which the separation between adjacent vertebræ is very imperfect, the cartilage of the first vertebra is perfectly continuous with the cartilage of the cranium. In most other Selachii, however, the first vertebra developes lateral articular processes which articulate with the apposed surfaces of the occipital region of the skull. These lateral articulations are more markedly developed in the Rays, in which the median prolongation of the centrum of the first vertebræ fits into a deep excavation in the *basis cranii*, its apex being connected with the latter by a mesial ligament containing the rudimentary

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* This structure seems first to have been noticed by Home: *See* "On the nature of the intervertebral substances in Fish and Quadrupeds," Phil. Trans., 1809, pp. 177-184.

prolongation forwards of the notochord, while its sides articulate with the occipital condyles.

In the caudal region of Sharks the hæmal spines become specially produced to afford support to the ventral half of the broad caudal fin ; closely related to the dorsal surface of the vertebræ in this region, but not continuous with the neural arches and supporting the dorsal half of the fin are a series of cartilages which, though resembling produced neural spines, are not continuous with the neural arches, and do not agree in number with the latter ; and in the trunk the dorsal and anal fins possess cartilaginous supports which sometimes present the appearance of modified neural and hæmal spines. Frequently, however, the skeleton supporting these unpaired fins is entirely unconnected with the vertebral column, and, though in some cases the correspondence in position of its elements with the segments of the vertebral column seems to indicate some developmental relationship with the latter, in others, the skeleton of the fin becomes so modified by the formation of plate-like basal cartilages that this apparent correspondence is no longer traceable.

The *cranium* of the Plagiostomata is formed of an undivided mass of cartilage, strengthened in many cases by the deposition of superficial layers of bony matter. It consists, in essence, of a cartilaginous case into the sides of which are incorporated the cavities or capsules that serve to protect the three pairs of organs of special sense, the ear, the eye, and the nose ; in the walls of which are apertures for the egress of the cerebral nerves ; and from which project certain processes which serve for the attachment of muscles or for connection with the anterior visceral arches. In the middle line behind is the aperture of the foramen magnum, the plane of which is usually inclined from below and behind upwards and forwards ; its lower lip is deeply excavated in the Rays for the reception of the mesial process of the first vertebra ; and on either side of this is one of the condylar surfaces which are articulated with the lateral articular processes of the first vertebra. In some sharks *(Notidanidæ)*, the occipital region presents certain characteristics which assimilate it to the vertebral column ; in the middle above is a ridge seeming to prolong

rorwards the line of the dorsal spines; on each side is another ridge apparently continuous with the transverse processes, and a row of small foramina (through which pass divisions of the vagus nerve), which seem to continue forwards the row of spinal nerve-foramina. In a few other sharks (*Spinacidæ*) these peculiarities are traceable in a less decided form; but in the majority the mesial and lateral occipital ridges disappear. In front of the occipital is the auditory region of the skull, in which are contained the various divisions of the membranous labyrinth, and with which articulate laterally the hyo-mandibular cartilages. In the lower forms among the Plagiostomes the surface of the auditory region takes its form to some extent from that of the enclosed parts of the auditory apparatus, and elevations marking the position of the anterior and posterior semi-circular canals and of the vestibule are very prominent on the surface; in higher forms these elevations become less marked, and in some exceptional instances they may become so obscured as to be barely traceable. On the upper surface of this segment of the skull are the two small apertures of the *aqueductus vestibuli*; in the Sharks these two apertures are closely approximated to one another, and are situated at the bottom of a common pit or groove—the *parietal groove*. In the Rays, on the other hand, the two apertures are separated from one another by a distinct interval and do not lie in any common groove.

The articular surface for the hyo-mandibular in the lateral wall of the auditory region varies greatly in its form and position. In form it varies from a simple concavity to a complex articular surface, sometimes divided into two parts; it may be excavated on the lateral wall of the auditory region, or may be borne out from the general surface on prominent processes of the postero-lateral region of the cranium. In the Rays it is placed nearer the base of the cranium than in the Sharks, and is more elongated antero-posteriorly. Behind it in the Rays is sometimes a small articular surface for the first branchial arch.

In front of the auditory region is the orbital region, which presents on either side a deep concavity for the reception of the eye.

In most Sharks the orbital cavity is bounded below by a plate of cartilage—the *basilar plate;* but this is absent in all the Rays. It is frequently bounded in front and behind by præ- and post-orbital processes; and its wall is perforated by apertures for the egress of the facial, trigeminal, abducent and oculo-motor nerves. A shallow groove passing forwards from the aperture for the trigeminal marks the course of the ophthalmic branch of that nerve, and a series of foramina in the roof indicate the points at which the supra-orbital branches of the same nerve penetrate towards the roof of the skull. In front near the upper border of the orbit is a canal or notch by which the ophthalmic nerve reaches the upper surface of the skull; and in front of the orbit is a canal or notch (the *ethmoidal canal* or *notch*), by which it again passes downwards towards the lower lateral region of the olfactory capsule.

In front of the orbits are the olfactory capsules, which are more or less completely enclosed in cartilage, and are usually solidly connected with the rest of the cranium. Related to the olfactory aperture is a small cartilage, the *olfactory cartilage* usually of the form of an incomplete ring.

Between the nasal capsules the mesial portion of the skull is usually produced forwards into a longer or shorter rostrum, which may be single and contain a canal continuous with the cranial cavity, or may be composed of three solid bars of cartilage, a mesial and two lateral, which coalesce anteriorly. Directly or indirectly related to the skull are the palato-quadrate, Meckelian, hyoid and branchial arches.

At the sides of the gape are the labial cartilages, of which there are usually two pairs above and one below. In the Rays labial cartilages, as a rule, are absent.

The upper and lower jaws of the Elasmobranchii consist of the palato-quadrate and Meckelian cartilages respectively, the substance of the cartilage being usually deeply impregnated with osseous matter. The palato-quadrate is distinguishable in the Sharks into an anterior, palatine, and a posterior, quadrate, portion. It presents in *Notidanus* a process for articulation with the post-orbital process. In the *Notidanidæ* the palatine cartilages

of opposite sides are widely separated from one another by an interval occupied by ligamentous fibres, but bearing teeth. The two halves are more closely approximated in other Sharks; in some *(Cestracion, Scymnus)* they are very intimately connected. In the Rays the palatine and quadrate portions are usually not well marked off from one another, and the two halves are intimately united together in the middle line. In the Sharks a palatine process is developed for articulation with the *basis cranii*, but this is absent in the Rays. The articulation between the palato-quadrate and lower jaw may be single, but, more usually, is divisible into two parts.

In most Sharks the two halves of the lower jaw, or Meckel's cartilage, are freely movable on one another, *Cestracion* being the most important exception; in the Rays the movability is much less than in the Sharks, and the two rami may be united into a rigid bar.

In the simplest arrangement to be observed in the Elasmobranchii, the upper elements of the *hyoid arch* are similar in function and in relation to the arch to those of the succeeding branchial arches. They serve, that is to say, solely to suspend the ventral portion of the arch, and the union with the side of the cranium is slight and unimportant. In a further stage, such as is represented in *Cestracion*, these elements become a little more important and come into relation, slightly at first, with the palato-quadrate cartilage and lower jaw, which they help to suspend, still, however, being mainly related to the hyoid; in a yet more advanced stage (most Sharks) the cartilage becomes thicker and longer, its articulation with the skull becomes more complete, and by its distal extremity, which develops a special mandibular process, it is mainly related to the palato-quadrate and mandible, the relation to the hyoid having now become a subsidiary one; the *epi-hyal* has now become a *hyo-mandibular*. In a further stage (Rays) the hyoid undergoes a degeneration, loses its distinctness from the branchial arches, and is attached to the base of the hyo-mandibular, or is no longer directly related to it, but articulates separately with the side wall of the cranium. Finally (as regards

this degeneration), in *Hypnos* and *Trygonorhina* the hyoid, now become quite similar to the succeeding arches, is connected with the skull only through the epibranchial of the first branchial arch.

Related to the hyo-mandibular is the spiracular cartilage, a thin usually four-cornered plate supporting the wall of the spiracle.

The lower or distal portion of the hyoid arch consists of two lateral pieces on each side, and of a mesial cartilage or copula. The lateral pieces (as well as the hyomandibular) may bear rays similar to those of the branchial arches; the mesial piece may be a broad plate or a narrow band of cartilage, or, as, in many Batoidei, may become altogether aborted.

The *internal branchial arches*, which support the gill-pouches, are always five in number, except in *Hexanchus*, which has six, and *Heptanchus* which has seven. Each branchial arch, when typically developed, consists of a dorsal *basal* cartilage usually thin and leaf-like, and lying free close to the ventral aspect of the spinal column, sometimes styliform and articulating with the spinal column by a distinct joint (some Rays); of two *mesial* cartilages, a dorsal and a ventral, usually with deep grooves on their inner surface for the insertion of muscle; of a *copulare*, and of a mesial ventral *copula*. In most, however, the copulæ become greatly reduced and may form a single basibranchial plate as in the Rays; in *Myliobatis* and *Trygon* the copularia are likewise amalgamated with this basal-plate. The fifth arch has no copulare and no basal—its dorsal mesial articulating with the basal of the fourth: very often it is connected by articulation with the pectoral arch.

The *outer branchial arches*, which are a series of cartilages bounding the branchial apertures and situated at the extremity of the branchial rays, are more rudimentary in *Hexanchus* and *Heptanchus* than in other Sharks; they are best developed in *Cestracion*. They are absent in the Rays, though Gegenbaur found rudiments of them in *Rhynchobatus* and *Trygon*.

The *pectoral arch* is a stout cartilage, the lateral portions of which are curved backwards and inwards towards the vertebral column, with which they may articulate (Rays). The ventral

portion of the arch is divided in the middle line in Sharks, (except *Squatina* and *Heterodontus*), by a mesial more flexible region which permits of a good deal of motion of the two halves upon one another; but in the Rays the two halves are quite continuous with one another, the ventral portion of the arch forming (except in *Torpedo*), a rigid bar. Borne on the lateral portions of the arch towards its ventral aspect are the articular surfaces for the pectoral fins. Of these there are usually three, often placed in a horizontal line. Near the articular surfaces are the foramina for the transmission of the brachial nerves. The skeleton of the fin proper consists, when typically developed, of three basal cartilages—the *propterygium*, *mesopterygium* and *metapterygium*—and of a number of *rays*. In some Sharks *(Heterodontus)* the propterygium is absent, and in *Scymnus* the mesopterygium also; in Rays the mesopterygium is always small, and some of the radial cartilages may articulate with the shorter-girdle directly, while the propterygium and metapterygium are greatly elongated. In Sharks the pectoral fins are of moderate extent and do not articulate with the cranium; in Rays, on the other hand, they are greatly expanded, extend far forwards as well as backwards, frequently completely encircling the head, and the propterygium is, except in the *Torpedinidæ*, connected with the olfactory region of the skull, through the intermediation of an *ant-orbital* cartilage.

The *pelvic arch* is a straight or slightly curved bar of cartilage, with the outer extremities of which the pelvic fins are articulated. Usually it is perforated by two nerve-foramina on each side, and may develope longer or shorter processes or cornua in front of and behind the articular surface. Each pelvic fin contains usually only two basal cartilages, the hinder being much the more important, and having the greater number of the rays articulated to its outer border; connected with its distal extremity are the cartilages which form the skeleton of the clasper of the male.

The structure of the fins of the Elasmobranchii has been minutely studied in connection with the subject of the origin and nature of limbs. A detailed knowledge of the anatomy of these fishes seems

first to have been brought to bear on this question by Gegenbaur,* who came to the conclusion that the primitive limb-skeleton or Archipterygium resembled generally that of *Ceratodus.*† From this primitive form he traced the various modifications of the fin of fishes and the limbs of the higher vertebrates. The Elasmobranch fin, with which we are immediately concerned, he regards as having been developed from the Archipterygium by the suppression of the post-axial series of fin-rays—the metapterygium representing the axis of the archipterygium, and the mesopterygium and propterygium, together with the rays connected with them, having been derived from certain rays which he supposes to have been directly connected with the shoulder-girdle in the primitive fin. The archipterygium itself he regards as having been developed from a branchial arch and its connected rays. A similar view of the relations of the Elasmobranch fin to that of *Ceratodus* and the Crossopterygian Ganoids was embraced by Professor Huxley, and maintained by him as late as 1876,‡ but Huxley regarded the axis of the archipterygium as being represented by the mesopterygium, not the metapterygium, and does not give his adherence to the theory that the limbs are modified branchial arches.

Balfour § has shown more recently (1878) that the paired fins of *Scyllium* originate in two pairs of lateral ridges of epiblast, the embryonic limbs of each side being connected for a time by a low continuous ridge, which, however, soon disappears. In the messoblast subsequently growing into these folds of epiblast is developed a longitudinal bar of cartilage. The outer side of this is connected with a plate which extends into the fin and becomes segmented to form a series of parallel rays situated at right angles to the longitudinal bar. In front this longitudinal bar is continuous with the limb-arch. From these observations has been

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* Grundriss der Vergleichenden Anatomie.
† See Günther, Description of Ceratodus, Phil. Trans.. 1871.
‡ On *Ceratodus Forsteri*, with Observations on the Classification of Fishes, P.Z.S., 1876, pp. 24-59.
§ Monograph on the Development of Elasmobranch Fishes, pp. 101-104; Comparative Embryology, Vol. II., p. 49, (1881.)

deduced the theory that in their simplest form the paired fins of fishes are simply continuous lateral folds similar in their derivation to the unpaired fins, the continuous fold of each side becoming subsequently differentiated into the anterior and posterior fins.

From the formation of the pelvic plexus, some of the nerves going to which in Elasmobranchs are derived from vertebral segments situated considerably in front of the fin, Davidoff * deduced the conclusion that the limbs had moved backwards from an orginally anterior position, and regards the facts which he adduces as favouring Gegenbaur's hypothesis. If, he supposes, the paired fins were derived from continuous lateral folds, they would be developed in the place they were ultimately to occupy, and there would be no trace of any previous shifting backwards or forwards. Gegenbaur † also has endeavoured to show that the discovery of the lateral ridges supports rather than overthrows his theory,—the ridges being persistent embryonic structures marking the passage backwards of the pelvic fins.

Thacher (Proc. Connecticut Academy),‡ and, independently of him, Mivart (Trans. Zool. Soc. IX.) have sought to prove that a comparative study of the structure of the median and paired fins of adult Elasmobranchs and Ganoids leads to the same conclusion as the study of development, viz., that the paired and unpaired fins are strictly homologous structures, and are not developed by the modifiation of any pre-existing portion of the skeleton.

In a subsequent memoir § Balfour discusses the general bearings which he regards his embryological observations on *Scyllium* to possess upon the theory of the nature of limbs, pointing out that these observations are much more favourable to Thacher's and Mivart's views than to those of Gegenbaur and Davidoff.

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* Beiträge zur vergleichenden Anatomie der hinteren Gliedmasse der Fische, Morphol Jahrbuch, V., pp. 450-520 (1879.)

† Zur Gliedmassen-Frage, Morph. Jahrb. V., pp. 521-526 (1879.)

‡ I only know this memoir as quoted by Mivart, Balfour, and Davidoff.

§ On the Development of the Skeleton of the Paired Fins of Elasmobranchii considered in relation to its bearings on the Nature of the Limbs of the Vertebrata, P.Z.S., 1881, p.p. 656-670.

"If Gegenbaur's view were correct we should expect to find in the embryo, if anywhere, traces of the second set of lateral rays; but the fact is that, as may easily be seen by an inspection of figures 6 and 7, such a second set of lateral rays could not possibly have existed in a type of fin like that found in the embryo. With this view of Gegenbaur's it appears to me that the theory held by this anatomist to the effect that the limbs are modified gill-arches also falls, in that his method of deriving the limbs from gill-arches ceases to be admissible, while it is not easy to see how a limb formed on the type of the embryonic limb of Elasmobranchs could be derived from a gill-arch with its branchial rays."*

He also points out that Huxley's view that the proximal piece of the axial skeleton of the limb of *Ceratodus* is the mesopterygium, and that the fin of the Elasmobranchs is derivable from that of *Ceratodus* by the drawing in of the axis, is negatived by the proof afforded by the facts of embryology of the secondary character and late development of the mesopterygium. He shows also that the arrangement of the nerve-plexuses as described by Davidoff does not necessarily require the explanation given by that anatomist. The fact that some of the nerves which go to form the pelvic plexus are derived from vertebral segments in front of the position of the fins may be explained by a previously greater extent of the fin, just as well as by its movement backwards.†

Finally Owen (Proc. Zool. Soc, 1883) has recently given a short summary of his views on the subject of the homologies of the vertebrate limb, and has shewn how his theory of the origin of limbs from lateral appendages of hæmal arches gains support from Balfour's investigations on the development of the fins of the Elasmobranchii.

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* l. c. p. 669.

† I have ventured (On the Structure of the Paired Fins of *Ceratodus*. Proc. Linn. Soc., N.S.W., Vol. VII., p. 10.) to make the very obvious suggestion that the derivation of the pectoral and pelvic plexuses from a number of spinal nerves was a strong piece of evidence in favour of Balfour's theory and against that of Gegenbaur; but I am now inclined to think, in view of certain facts observed by Fürbringer (Morphologisches Jahrbusch, IX.) as to the origin of the nerves supplying the pelvic fin in some Teleostei with thoracic or jugular pelvis fins, that the position of the spinal nerves from which the plexuses are derived is too plastic a factor to support any wide generalisatioE at all.

CARCHARODON RONDELETII.

PLATE I., FIGS. 1-4.

SKULL AND VISCERAL ARCHES.

The upper surface of the occipital region of the skull (Plate I. fig. 1) is horizontally directed, and is continuous without interruption with the upper surface of the periotic and ethmoidal regions. The occipital crest is not well marked behind, but in front forms an elevated, though rounded, ridge, ending between the auditory foramina in a nearly vertical border. The parietal groove is shallow and open, and is excavated on the hinder part of a prominent parieto-frontal crest, which reaches as far forwards as the frontal foramen. A small median foramen lies in its front portion. On either side of the parietal groove, running forwards and slightly outwards, is a rounded elevation, which stops short a little way in front of the auditory foramen, and behind does not quite reach to the posterior margin of the skull. The anterior and posterior portions of this correspond to the elevations of the anterior and posterior semi-circular canals respectively. The vestibular promi nence is not well marked.

The articular surface for the hyo-mandibular (Plate I., fig. 2, Ar.), is borne outwards and backwards from the cranium on a very prominent process, which is produced into three prominent angles, one directed backwards, a second upwards, backwards, and a little outwards, and a third, the shortest, forwards and outwards. The posterior portion of the process projects far behind the plane of the foramen magnum, and bears a large aperture for the glosso-pharyngeal on its upper and posterior surface at some distance from the posterior angle, but behind the plane of the foramen magnum and of the orifice of the vagus; below it reaches to the plane of the base of the skull; and the anterior and upper portion reaches as high as the middle of the foramen magnum. The articular surface itself consists of two portions—a hinder, much larger, which is a shallow concavity and is bounded below by a slight raised ridge;

and an anterior, smaller, saddle-shaped, and placed in front of and above the other, from which it is not distinctly separated. This large and prominent articular surface distinguishes the present genus very markedly, though modifications in the same direction are to be observed in the case of *Galeus* and *Scymnus*.

There is no second foramen near that for the glossopharyngeal such as occurs in some genera. The orifice for the facial nerve is situated far forwards, separated by a considerable interval from the articular surface for the hyo-mandibular and near the trigeminal.

The orbit is covered above by a wide lamellar roof produced behind into a post-orbital process *(Po O)* which is likewise lamelliform, and is curved downwards and backwards; the latter does not come into direct relation with the palato-quadrate cartilage. In front, the roof bends down towards the base of the skull and bounds the orbit anteriorly, forming a distinct though not prominent præ-orbital process. Below, the orbit is bounded by a cartilaginous lamella which slopes downwards and outwards from the *basis cranii*. This lamelliform process or basal plate (*Ba*), is interrupted in front by a deep irregular incision, and behind there is a large oval foramen.

On comparing the skull of *Carcharodon* with a dried skull of *Lamna cornubica*, I can find little difference between the two. In both are the same postero-lateral processes for the articulation of the hyo-mandibular; in both the auditory foramina lie in a groove which runs along a broad central ridge; in both thin lamellæ of cartilage overarch the orbits; and both have the same form of three-barred rostrum. As, however, the structure of the skull in the family to which both these genera belong has never been described, I have entered with some minuteness into the above description.

The palato-quadrate is suspended, as in most Plagiostomes, by means of a hyo-mandibular, which is large and articulates with skull by a broad articular surface. Attached to the hyo-mandibular and hyoidean cartilages are about twenty irregular rays, with

a number of smaller intercalary cartilages towards their extremities; three of the rays on either side of the articulation between the hyo-mandibular and the hyoidean coalesce at their bases.

The copulare of the first branchial arch articulates with the hyoid copula; that of the second arch is united with its fellow by the intermediation of a small copula; it is connected externally with both the first and the second arches, as often occurs. The fifth arch has no copular. The basal plates of the first three arches are large and triangular; the third is bilobed at the apex; the mesial plates are deeply grooved internally near their proximal ends for the attachment of the strong adductors. The first arch has sixteen rays, the second thirteen; the third twelve. The fourth basal is confluent with the upper mesial of the fifth, their being no representative of the fifth basal.* The mesials of the fourth arch are deeply grooved for the adductors like those of the preceding three which they resemble in form; it has twelve rays. The fifth has no muscular grooves; it has no rays, but presents a strong continuous ridge on its outer surface in a position corresponding with that of the rays in the preceding arches.

The Shoulder-Girdle.

The mesial portion projects very strongly ventrad, forming a fold, and its front margin is greatly elevated towards the middle. The lateral halves are united by continuous cartilage; except at the dorsal extremities and the mesial uniting portion, they are strongly impregnated with osseous matter. The whole girdle is very broad, much broader than in *Carcharias*, slightly contracted near the line of junction, and narrowing slightly towards the dorsal extremity. There is no articular process or surface for the branchial skeleton. The articular surface for the pectoral fin is directed downwards and slightly backwards and outwards; it is of long, narrow form, constricted in the centre. The arrangement of the nerve apertures is in some respects peculiar, and very different from that to be observed in *Carcharias*.† The aperture of

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* A similar arrangement occurs in *Raja*, *Rlynchobatus*, *Scyllium*, and *Galeus*. Vide Gegenbaur, Untersuchungen, II., i., "Schultergurtel der Wirbelthiere."

entrance is situated nearly directly behind the articular surface about the middle of the arch; from this two canals lead, the one short and wide, passing outwards and a little forwards and downwards to open on the outer surface, the other narrow, and passing upwards, forwards, and slightly outwards to end above and behind the articular surface on the inner aspect of the cartilage close to the anterior border. The upper canal described by Gegenbaur in *Scyllium*, *Galeus* and *Pristiurus* is indicated on the right side only by a slight depression.

The Pectoral Fins. (Plate I., fig. 3.)

As in *Carcharias*,* the pro- meso- and meta-pterygia are all well developed and the latter is greatly elongated, having a large number of rays articulating with its pre-axiad border; but the mesopterygium is not quite distinct from the metapterygium, in fact is completely coalescent with it at the base, whereas in *Carcharias* the two cartilages remain quite separate. Articulating with the distal extremity of the propterygium is a lateral cartilage, formed, as in *Scyllium*, *Pristiurus* and *Carcharias* by the coalescence of the bases of three posterior propterygial rays, but not continuous with the latter—being separated from them by an articulation or interval of fibrous tissue; the front ray, which is very short, remains distinct and articulates separately with the propterygium. The propterygium and mesopterygium are relatively more important than in *Carcharias*, nine rays in all articulating with them; the bases of the last four mesopterygial rays are coalescent for a short distance. The elongated metapterygium articulates at its distal extremity with two accessory cartilages, the posterior of which is much the longer and bears nine rays, while the anterior bears three. The bases of four of the rays which articulate with the metapterygium are coalescent in pairs for a short distance at the base.

The arrangement of the basal cartilages described above seems to place the pectoral fin of *Carcharodon* in an intermediate position

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* Gegenbaur, "Untersuchunger zur vergleichenden Anatomie der Wirbelthiere." Heft, 2, 2te. Abschnitt, Brustflosse der Fische, p. 142, Tab. IX., fig. 5 (1865.)

between that of *Carcharias* and that of *Callorhynchus* *—the basal elements in the latter being reduced to two, of which the posterior may be regarded as the homologue of a coalescent meso- and metapterygium.

The whole of the long pointed fin of *Carcharodon* is supported by a framework of cartilaginous rays which extend nearly to its apex and are closely united into a continuous triangular plate. The middle rays, *i.e.*, those which reach nearly or quite to the apex of the skeleton of the fin, broaden out considerably distally, and sometimes divide. Between the distal portion of adjacent rays in the front half of the apical part of the fin are intercalated a series of accessory rays, an arrangement which I have not met with in any other form, though a rudiment of it is traceable in *Heterodontus Phillipi*.

The Pelvic Fins.

The pelvic cartilage presents a large oval aperture in its outer half near the anterior border; its outer extremity is produced into a process with which no fewer than six rays articulate. The basal cartilage is strong and curved, convex above, flat below; at its distal extremity are two small cartilages with which the long tapering flexible cartilage of the clasper articulates. The last ray, which is very short, is attached exclusively to the base of the cartilage of the clasper.

The Dorsal fins. (Plate I., fig. 4.)

The dorsal fin is supported by a cartilaginous skeleton which is separated by a fibrous interval from the spinal column. It consists of about twenty-eight rays, which slope for the most part backwards and upwards. The first ray is very short, but presents traces of division into three segments. The second, which is a little longer, divides into two branches; the third is simple, and consists of three segments, of which the basal is much the longest; the fourth is bifurcated, and each of the branches presents two articulations. The next six rays are either distinctly bifurcated near

* Vide Mivart, l. c.

the extremity or have intercalated rays between them; none of the rest of the rays are distinctly branched. The last five or six rays, which are very short, are supported on a series of irregular basal cartilages. The arrangement of the articulations is such that there are three more or less complete antero-posterior horizontal lines of them; that situated nearest the base is confined to the last eleven rays; the middle one stretches completely across the fin from side to side and the distal one, situated not very far from the middle, extends in an irregular line from the seventh ray to the eighteenth. The second dorsal and anal fins are very small, and consist of a few irregular rays without basal plates, and separated by a well-marked interval from the vertebral column.

The Caudal Fin.

The caudal fin is supported both by supra-vertebral and by sub-vertebral cartilaginous rays, of which the latter are more highly developed than the former. The latter begin a little in front of the upward bend of the spinal column. The first is a short triangular piece articulating movably with two of the hypurals. The following five, which become successively longer, likewise articulate with the hypurals, but the remainder, which gradually decrease in size from before backwards, coalesce with the latter at their bases without the intervention of any articulation. The supra-vertebral rays begin a little behind the commencement of the sub-vertebral; none of them coalesce with the neural arches. In front, where they are more irregular and more or less coalescent with one another, a few of them are separated from the neural arches by a slight interval occupied by fibrous tissue. In many cases a pair of rays may coalesce with one another; otherwise they correspond in number with the vertebræ.

HEPTANCHUS INDICUS.

Plate I., Fig. 5.

Skull and Visceral Arches.

The occipital region is characterised by the presence of three ridges—a central one continuous with the spinous processes

of the vertebræ, and two lateral ones continuous with the transverse processes. Its upper surface slopes obliquely upwards and forwards to the parietal groove, which is a deep pit continued forwards for a short distance by a rapidly shallowing concavity. The elevations for the anterior and posterior semi-circular canals are well marked and prominent. The articular surface for the hyo-mandibular is simple and not raised from the general surface. The orbit is bounded behind by a very prominent post-orbital process with which the palato-quadrate articulates. There is no basal plate; in front of and below the orbit and projecting downwards and outwards, is a prominent pointed process, the extremity of which is free; this, according to Gegenbaur, corresponds to the ant-orbital cartilage in Rays; it is not, however, related to the wall of the nasal capsule, but is placed behind the latter and arises from the contiguous portion of the base of the skull. The rostrum is represented by a pair of short processes of the ethmoidal region not extending beyond the level of the nasal cartilage. The walls of the nasal capsule are formed of cartilage only behind internally, and above, with a short external rim. The nasal cartilage is ring-shaped, with two short horns directed downwards. Below the orbit there is, as in *Hexanchus griseus* and *Heptanchus cinereus*, an extensive vertical articular surface for the palato-quadrate.

The hyo-mandibular is a long, narrow, curved and flattened cartilage bearing the hyoid at its distal extremity, and suspending also the palato-quadrate, though chiefly related to the hyoid. The hyoid cornua are very large: they bear a few delicate rays; distally they articulate with the hyoid copula. The first branchial arch has no *copulare*; its ventral mesial cartilage is connected with the postero-external angles of the hyoid copula The following five arches have all well-developed copularia; the second and third have distinct though small copulae; the fourth has no separate copula, the latter having become fused with the left copulare. The fifth and sixth copularia unite with the basibranchial plate. The seventh arch has no copulare as well as no basal, its ventral is broad and flattened, and unites with the basibranchial plate. The

basibranchial plate is broad and leaf-like in front, while behind it is produced into a rather slender process. This arrangement of the copulae differs from that observed in *Heptanchus cinereus* as described by Gegenbaur* in the absence of an independent copula for the fifth arch. In the first to the fifth branchial arches the basals of opposite sides touch one another in the middle dorsal line, the basals of the first being united with one another by cartilage. The basals of the sixth do not reach to the middle line. There are small but distinct muscular grooves on the dorsal and ventral mesial cartilages.

The external branchial arches are represented only by two pairs of cartilages in each; the one is connected with the external end of the basal; the other, which is much longer, with the ventral end of the ventral cartilage. The free ends of these two slender cartilages bend round the outer edge of the gill-partition towards one another, but do not meet. These obviously represent modified rays, and their presence would seem to indicate that the more highly developed external branchial arches of other Selachians are derived from greatly elongated rays which ultimately lose their connection with the internal arches.

The Pectoral Fins.

The pectoral fin is very similar to that of *Hexanchus griseus* as described and figured by Gegenbaur. The propterygium is small and bears no rays, articulating distally with the mesopterygium. The mesopterygium and the metapterygium bear a nearly equal number of rays, a few of them being bifurcate. The metapterygium bears a small articular cartilage at its extremity, and the latter sustains about four rays.

The shoulder-girdle is remarkable for the presence in the middle ventral line of a distinct four-sided lozenge-shaped cartilage let in to the arch, as it were, in front. This is a condition which I have not observed or seen described in any other form: it does not seem to occur either in *Heptanchus cinereus* or

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*l. c. p. 136, pl. XVIII., fig. 1.

*Hexanchus griseus.** The intercepted cartilage is temptingly like a presternal, but the absence of such an element in the skeleton of any group nearer than the Amphibia seems to preclude this explanation.

The Pelvic Fins. (Plate I., fig. 3.)

In the pelvic fin of *Heptanchus indicus* there are three distinct basal cartilages articulating with the pelvic girdle and bearing rays; these represent the præ- meso- and meta-pterygia of the pectoral fin. The first (*p. pt'.*) is the equivalent of the so-called pre-axial fin-ray. It is a small, pointed cartilage articulating with the anterior facet on the pelvic girdle, curving forwards and outwards and ending in a pointed extremity. By its outer posterior border it gives attachment to the four anterior fin-rays, of which the first two have their bases coalescent. The mesopterygium (*m. pt'.*) is a small quadrate cartilage articulating with the middle facet of the pelvic arch, and giving attachment to two fin rays † The remainder of the rays are attached along the outer border of the metapterygium (*mt. pt'.*) The latter is a long narrow cartilage, somewhat curved outwards. Distally it gives attachment to two cartilages; of these that situated more dorsad is a small nodule, articulating with which is a long narrow ray-like cartilage; the latter is applied closely to the dorsal surface of the cartilage of the clasper and strongly united with it by means of fibrous tissue; the more ventrally placed of the two cartilages articulating with the extremity of the metapterygium continues the axis of the fin, gives attachment at the base of its outer border to the last of the fin-rays, and distally is succeeded by a smaller cartilage with which the principal cartilage of the clasper articulates. The axial cartilage of the clasper is a slender, slightly curved cartilage, which presents no appearance of the longitudinal groove found in *Crossorhinus*. Distally it supports two small, blade-like freely movable ossified cartilages which are attached to its apex about the middle of their

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* Gegenbaur, Schultergurtel der Wirbelthiere, Op. cit. Heft. 2.

† If this middle basal cartilage is present in the European species it has escaped notice. (See Davidoff, Morph , Jahrb. V.; Mivart, l.c,p. 444, pl. LXXV., fig. 4.)

length. The latter support the end of the groove of the clasper, and by their rotation can open or close it.

The pelvic arch is narrow from side to side and very long antero-posteriorly—the greatest breadth being only about twice the length—convex ventrally, convave dorsally.

Unpaired Fins.

The dorsal fin is very simple, consisting of two broad and thin sheets of cartilage, an anterior and a posterior ; the former much the larger, having about 17 few-jointed rays united with their upper edge. Several of these rays are obscurely bifiurcate. This is very similar to the dorsal fin of *H. cinereus*,* except that the posterior basal cartilage in the latter is very small.

The anal fin is similar to the dorsal, but smaller and with fewer and shorter rays.

CROSSORHINUS BARBATUS.

Plate I., Figs. 6-8 and Plate II., Fig. 13.

Skull and Visceral Arches.

The cranium is very wide and depressed, as in *Scyllium catulus*, the interorbital breadth being relatively much greater than in *Chiloscyllium*. A noteworthy point in comparison with related genera is the much greater relative antero-posterior extent of the post-orbital region. The occipital surface slopes upwards and forwards, and meets the upper surface in a rounded ridge, in front of which the not very deep parietal groove is situated. The upper surface of the skull in front of this is marked by a shallow mesial longitudinal depression, the continuation forwards of the parietal groove ; it is bounded externally by a continuous raised border as far as the pre-orbital process.

The occipital region is not produced in the middle line behind. As in *Scyllium*, *Mustelus*, *Galeus*, and *Scymnus*, the lateral posterior

* Mivart, l. c., p. 443, pl. LXXV., fig. 2.

processes which articulate with the first vertebra are prominent, the first vertebra being wedged very closely into the median recess between them and very closely united to the skull, except in the middle line above, where a considerable interval occupied by fibrous tissue intervenes between the hinder part of the skull and the neural arch.* The apertures for the vagi, which are very large, are placed immediately above and in front of these lateral processes, and above and a little external to them are a pair of smaller apertures of unknown function. There is no trace of a median occipital crest. In the auditory region the elevations corresponding to the anterior and posterior semi-circular canals are prominent, though rounded, and less sharply marked off than in some nearly-related forms; between the anterior elevation and the lateral border of the skull is a rather deep hollow. The postero-lateral angles of the skull are somewhat curiously modified, the arrangement being more like that observed in *Carcharodon* than in *Scyllium*. The angles are drawn out into prominent processes, each of which exhibits three divisions, an antero-superior, an antero-inferior, and a posterior. The antero-superior is continued into the very prominent vertical ridge which separates off the upper surfaces of the cranium from the lateral. The antero-inferior forms the hinder portion of a ridge which bounds superiorly the articular surface for the hyo-mandibular. The posterior, which extends outwards and backwards, is grooved above for the glossopharyngeal, the aperture of exit of which is situated at its base; below it developes a ridge with which some of the ligaments for suspending the lower jaw appear to have been connected; this ridge occurs also in *Cheiloscyllium;* it runs forwards and inwards and ends some distance behind the basal angle. The articular surface for the hyo-mandibular differs from that of all forms with which I am acquainted † in being a very deep, almost conical hollow, which is situated below and a little in front of the antero-inferior process already mentioned. It is in the

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* A similar arrangement occurs in *Cheiloscyllium*.

† The corresponding articular surface in *Cheiloscyllium* is a wide and shallow concavity without any definite upper border, but with the lower border rather prominent, and formed by the ridge mentioned above as giving attachment to ligaments.

same transverse plane as the point of junction of the anterior and posterior semi-circular canals, and therefore excavated in the side of the cranium proper and not on the postero-lateral process. The opening of the facial is directly in front of this articular cavity, and is separated by a broad ridge from that of the trigeminal. The supra-orbital ridge is very prominent and forms to some extent a roof to the inner part of the orbit; it ends behind and in front in prominent post- and præ-orbital processes. There is a very broad and thin lamellar basal plate, nearly horizontal in position, but inclined slightly downwards externally; it presents a rather small oval opening in its hinder portion close to the lateral wall of the cranium.

The palato-basal articulation takes place through the intermediation of a very thick and short ligament inserted immediately in front of the orbit, where there is a small but well-marked articular surface looking outwards and forwards.

The ethmoidal canal is not even represented by a notch.* The præfrontal opening is large and its lateral borders diverge anteriorly unlike those of *Scyllium*. In front of it the *basis cranii* rises up and is extended into three thin lamellar processes, of which the middle one or rostrum is nearly straight and ends in a free extremity between the nasal capsules, while the lateral become rather expanded, and, their anterior ends curving downwards, form a part of the roof of the corresponding nasal capsule. Immediately behind the frontal foramen is a slender process which passing outwards and forwards, becomes greatly expanded at its extremity to form the outer and inferior wall of the nasal capsule.

The labial cartilages form a chain of three strong bones on either side, forming a nearly complete ring round the mouth only interrupted by a space in the middle above and below.

The proximal extremity of the hyomandibular presents anteriorly a stout peg-like process corresponding to the deep articular cavity of the side of the skull. Distally it presents a broad surface for the

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* This is a marked point of distinction between the present form and *Scyllium* and *Cheiloscyllium*.

palatoquadrate. The hyoid is a stout, gently curved, cartilage more than half as long again as the hyo-mandibular. The rays are connected with the hyo-mandibular only near the skull, and with the hyoid for a short space some distance from the proximal end; the two sets curve round and meet, leaving a wide opening opposite the articulation between the two cartilages; they coalesce and subdivide in a highly complex manner. The spiracular cartilage is a delicate lamella of oblong shape with the two inner angles and the antero-external produced into short processes.

The body of the hyoid is rather narrower than the branchial copula and strongly arched forwards. Externally it presents two cornua an anterior short and stout for articulation with the hyoid and a posterior, rather longer for the copulare of the first branchial arch.

The ventral mesials of the first four branchial arches are longer but narrower than the dorsals; they both have deep excavations for the adductor muscles, those of the dorsal cartilages being the larger, and being perforated. The first arch bears ten rays, the second likewise ten, the third eight, the fourth six; a number of the rays have hooked extremities. On the posterior border of each ventral mesial cartilage, in continuation of the row of rays, is a lamelliform process, very prominent in the first arch, becoming very low in the fourth. A slender cartilage represents the dorsal end of an external branchial arch, and in the second, third, and fourth arches, but not in the first, an irregular flattened cartilage represents the ventral portion; the first of these ventral cartilages of the external branchial arches is not connected with the internal arch; the others articulate with the ventral mesials. The dorsal portion of the fifth arch coalesces as usual with that of the fourth. The dorsal mesial of the fifth is deeply excavated for the muscle; the ventral slightly. The latter is much thicker than these of the preceding arches; it presents two conical processes; the one on its inner, the other on its outer surface, the latter nearly corresponding in position to the rays of the preceding arches.

The first branchial arch has a short and thick copular which articulates with the hinder angles of the body of the hyoid. The copularia of the second arch are very long, and with those of the third articulate with the anterior border of a broad common copula. The latter, which is twice as broad as long, has a strongly convex anterior border, and a waved concave posterior border; its outer border is directed slightly back as well as out, and with it the fifth arch articulates. It presents a trace on one side of a longitudinal division into three parts, the outer of which may represent the copular of the fifth. With the posterior border of the copula is articulated a short arrow-head-shaped urobranchial cartilage.

Pectoral Fins. (Plate II., fig. 13.)

The shoulder-girdle is characterised, in accordance with the general form of the animal, by its very great breadth—its transverse being much greater than its dorso-ventral extent—and also by the solidity of its texture—there being no mesial connecting portion of more flexible cartilage uniting the lateral halves as in other Sharks. The mesial or transverse portion of the arch is but slightly angulated ventrad in the middle. The articular surfaces are placed on prominent processes, the long axis of which is antero-posterior, or nearly so. In front of each of them, as in *Cestracion*, is a very prominent crest, and between the articular surface and the crest is a very large foramen; the second foramen is situated on the other side of the articular process, between it and the inner edge of the cartilage, at the ventral extremity of a wide shallow groove on the under surface of the lateral portion of the girdle; a little on the ventral side of this opening is a conical tubercle. The lateral portions of the arch are strongly incurved, but their dorsal extremities are still widely separated from one another; they end in a blunt point.

In the skeleton of the fin itself the propterygium is well-developed, and consists of two nearly equal cartilages, the more distal of which has a narrow accessory cartilage running along its outer border. But the propterygium has no direct relation to any

of the fin-rays. The mesopterygium consists of one elongated, slightly curved cartilage which bears on the distal half of its outer border a series of eight fin-rays. The metapterygium is long and narrow, and bears eleven rays, a twelfth being borne by the small accessory cartilage at the apex. The meso- and metapterygia are separated from one another throughout a considerable part of their length by a well-marked space. The rays are likewise separated at their bases by well-marked intervals; distally, however, they expand and become closely apposed, except in the case of about six of the inner rays, each of which becomes shortly bifurcated. The skeleton of the pectoral fin in the nearly related *Ginglymostoma* differs from that of *Crossorhinus* in the basal cartilages being relatively simaller. In the existence of the interval between the *mesopterygium* and the *metapterygium*, the latter bears some resemblance to *Cheiloscyllium ocellatum*, as described and figured by Mivart (l. c., p. 448, pl. LXXVI., fig. 4), but the space is very much larger in the latter.

Pelvis and Pelvic Fin. (Plate I., fig. 8.)

The pelvic cartilage is nearly straight, flattened from above downwards, and a little expanded at either end. The anterior basal cartilage is small and unimportant; there is no mesopterygium, several rays articulating directly with the pelvis.

The skeleton of the clasper consists of a long ossified cartilage marked on its dorsal aspect by a deep groove, the lips of which are closely approximated; this axial cartilage ends distally in a strong pointed spine, articulated around the base of which and ensheathing it are four more or less scale-like pointed bones capable of being divaricated from the axis of the appendage so as to spread out in a radiating manner from the base of the spine.

Unpaired Fins.

The dorsal fins are of nearly equal size; the anterior contains fourteen, the posterior fifteen rays, each, except the first two or three, with an expanded upper or distal piece, and each, with the

exception of the last two or three, with a short basal element. In general structure these fins bears a close resemblance to the corresponding parts in *Ginglymostoma* (Mivart, l.c., p. 446, pl. LXXVI., fig. 1), except that the rudimentary basal plate is not represented. The anal fin is smaller than the second dorsal, with fifteen rays of similar shape to those of the dorsals.

There are fifty-five pairs of well-developed ribs. Of these a good many are divided into two segments.

The caudal portion of the vertebral column is but slightly curved. Its neural rays, about forty-five in number, are nearly twice the length of the hæmal rays.

Of the peculiarities in the structure of the skeleton of *Crossorhinus*, the most noteworthy are the form of the articular cavity for the hyo-mandibular, the abnormal shape of the rostrum, the absence of the external branchial arches, and the rigid nature of the ventral portion of the pectoral arch. These, besides other less important characteristics, definitely mark off the genus from the *Scyllidæ* with which it was previously placed. A characteristic feature of the skeleton of *Crossorhinus* is the presence throughout all the cartilages of innumerable small bony centres, giving the skeleton a remarkably hard and rigid texture.

PRISTIOPHORUS CIRRATUS.

Plate I., Figs. 9-12.

Skull and Visceral Arches. (Plate I., fig. 9.)

In general form the skull, were the rostrum removed, would not be unlike that of *Heterodontus*. The plane of the occipital foramen is vertical. The surfaces of articulation for the hyo-mandibular are antero-posteriorly elongated and placed low down near the base, as in Rays. The auditory apertures are placed close together near the middle line, and are placed at the bottom of a deep excavation which is continued in front into a short shallow

open groove. The post-orbital processes are not conspicuous. The palato-basal articulation is placed far back on a level with the hinder boundary of the orbit. The rostrum is formed of a mesial and two lateral parts; the former being a prolongation of the roof and floor of the cranium, and containing a canal continuous with the cranial cavity and running forwards to the end of the snout. The lateral parts are continuous behind with the cartilage of the olfactory capsules; they form thin plates bordering the mesial part and perforated by numerous apertures. The hyoid arch, as in Sharks generally, articulates above with the distal extremity of the hyo-mandibular; ventrally it unites with a copula which has the form of a very narrow curved bar. Both the hyo-mandibular and the hyoid cartilages are provided with rays.

The hyoid copula is represented by a transverse band. There is a common branchial copula without any trace of transverse division. The first branchial arch is connected not with this, but with the hyoid copula The second, third, and fourth arches have well-developed copularia, which decrease in size from before backwards. The muscular excavations on the first four arches are perforated by foramina. The external branchial arches are represented by slender cartilages.

Pectoral and Pelvic Fins. (Plate I., figs. 11 and 12.)

In the pectoral arch the hinge-like central portion found in other Sharks is not well marked, the two halves being capable of very little motion upon one another. As in the Sharks generally the dorsal ends of the arch are wide apart from one another and have no articulation with the spinal column. The propterygium is only represented by a slender, ray-like cartilage; the mesopterygium and metapterygium on the other hand are well-developed, and contribute nearly equal shares to the support of the rays; the metapterygium bears at its extremity a polygonal accessory cartilage with which a few short irregular rays articulate.* There is nothing in the

* In the general arrangement of the cartilages there is a close resemblance to *P. japonicus*, as described and figured by Mivart (l. c., p. 453., pl. LXVIII., fig. 1.)

structure of the pectoral fin presenting in any way an approximation to the Rays.

The pelvic arch is a nearly straight bar, slightly arched forwards in the middle, with short, broad, anteriorly directed processes at either end. There is a short pre-axial ray or propterygium, with which three short rays are connected; there is no representative of a mesopterygium, but none of the rays articulate directly with the pelvic arch, the long narrow metapterygium supporting all the rest.

Unpaired Fins.

The unpaired fins present broad plate-like basal cartilages closely united with the vertebræ.

The vertebæ of *Pristiophorus* present solid, deeply biconcave centra, which on a mesial transverse vertical section exhibit, as in the case of *Selache*, two pairs of cartilaginous tracts passing from near the centre to the supero-lateral and infero-lateral parts of the vetebræ.

TRYGON PASTINACA.

Plate II., Figs. 10-12.

Vertebral Column. (Plate II., figs. 10 and 11.)

The anterior vertebral plate presents a very prominent, continuous, spinous ridge. In the hinder half of the plate the transverse processes are likewise developed on each side into a wide thin lamina perforated at its base by 9 or 10 irregular apertures. In front this lamina is developed into a free flap. Behind it is continuous with a plate of cartilage which stretches horizontally across the middle line, becoming synchondrosed with the spinous ridge. The horizontal plate corresponds to the horizontal bar found in a corresponding position in *Hypnos*, but, differs from the latter in being closely united with the spinous ridge. It is connected externally, as in *Hypnos* also, with the pectoral arch, the connection being effected by means

of a somewhat complicated articulation. Each lateral lamella, formed apparently as above noted by the transverse processes, developes just below the part where the mesial bar arises from it, a thick, laterally projecting process with a truncate terminal face; above and a little behind this is a wide aperture in the root of the horizontal lamella into which the dorsal end of the pectoral arch fits, while the truncate lateral process articulates with a concave oval surface on the inner border of the arch at some little distance below. There is a considerable resemblance between this arrangement and that already described as occuring in *Trygonorhina*, except that in the latter there is no connection between the horizontal bar and the lateral laminæ, and the articulation with the pectoral arch is effected entirely through the former, which is a development from the spinous ridge.

Another peculiarity which the anterior vertebral plate of *Trygon* presents is the presence of a series of articular facets for the branchial arches. The chief of these articular surfaces is that for the fifth branchial arch; this is situated on a little angular projection on the lateral border of the vertebral plate, close to the front portion of the lateral lamina. In front of and a little internal to this on the ventral surface of the plate is a pair of short triangular ridges; these articulate or are synchondrosed with the basal plates of the fourth branchial arch. In front of and a little external to those, near the lateral borders of the plate, is a pair of small elevations which articulate with the third branchial arch. There are no ribs attached to any part of the spinal column.

Skull and Visceral Arches. (Plate II., fig. 12.)

In the skull the plane of the foramen magnum is very nearly vertical. The occipital condyles lie a little behind, on projecting processes. The orifice for the vagus is close to the foramen magnum. The elevations for the anterior and posterior semi circular canals are tolerably well marked. The orifices of the auditory organs are situated far apart, and are not connected by

any common groove or depression. The articular surface for the hyoid is an antero-posteriorly elongated surface placed close to the base of the skull. In front of it is a wide bridge of cartilage for the protection of the facial. Behind it are the two small articular facets with which the hyoid and first branchial arches articulate. These are borne on a rather conspicuous ridge, which in front forms the posterior and upper boundary of the articular surface for the hyo-mandibular, and behind is continuous with the processes bearing the occipital condyles. The post-orbital process takes the form of a long and broad, thin lamina of cartilage stretching outwards and forwards from the post-orbital region of the roof of the skull. The cavity of the cranium dilates considerably in front towards the region of the olfactory capsules, which are greatly elongated transversely and connected together in the middle line. The præ-frontal foramen is very wide, and is continuous behind with the supra-cranial fontanelle. The præorbital process has the form of a short pointed projection. The ant-orbital cartilages are vertically compressed, blade-like laminæ articulating with the lateral angles of the olfactory capsules and directed backwards and outwards.

The hyo-mandibular is made up, as in most Rays, of two distinct segments, of which the distal is much the smaller.

In *Trygon*, as in many of the Batoidei, the ventral elements of the hyoidean arch are not connected with the hyomandibular. In *Trygon pastinaca* they articulate directly with the periotic region of the skull just behind the surface of articulation for the hyo-mandibular. The hyoid is intimately connected with the first branchial arch, and the latter in turn also articulates with the auditory region of the skull behind the articulation for the former.

The hyoid arch, as in Rays generally, has but a slender copula, and articulating with the ventral extremity of each ventral mesial is a flattened bar of cartilage, which passes almost straight forwards to end in a free extremity; this seems to represent the copulare.

Pectoral Fins.

The pectoral arch is characterised by the solidity of its structure and the massiveness of its lateral portions. The upper and lower nerve-foramina are very large ; there are no accessory foramina as in *Trygonorhina*. The articular surfaces for the fin are placed on a horizontal ridge, at the extreme anterior and posterior ends of which are placed the surfaces for the propterygium and the metapterygium respectively ; the former is a long oval with the long axis vertical and the surface directed outwards ; in the intermediate ridge is a concavity for the mesopterygium. Close to the inner lateral border of the arch is the articular surface for the fifth branchial arch, which is double and somewhat raised above the general surface. The propterygium has articulating with its distal extremity a stout ray with which are connected a number of fin rays. The mesopterygium is very small but occupies all the interval between the propterygium and the metapterygium; none of the rays articulate directly with the shoulder girdle. The metapterygium is divided into four segments.

The pelvic arch is a strongly curved cartilage which is produced behind over the acetabular facet into a strong spine ; a little in front of this it develops a prominent angular ridge on its outer surface. The metapterygium bears distally two very short cartilages which continue the axis of the fin and give origin to a few short rays ; the mesopterygium is not represented.

UROLOPHUS, sp. ?

Plate II., Fig. 14.

The main difference between the skeleton of this species and that of *Trygon pastinaca* consists in the presence between the nasal cartilages of a pair of very slender, crescentic, cartilaginous cornua, attached to, but not continuous with, the cartilage of the front of

the skull. These are inclined downwards and backwards and may represent upper labial cartilages, or may perhaps be regarded as representing a rudimentary rostrum.

The anterior vertebral plate presents laterally very broad and long wings representing the coalescent and produced transverse processes. In the middle it presents a prominent vertical lamina formed of the coalescent spinous processes. This ends some distance in front of the position of the shoulder girdle, with which it has no connection. There are thirty pairs of ribs, of which the majority are of considerable length.

HYPNOS SUBNIGER.

Plate II., Figs. 6-9.

Skull and Visceral Arches. (Plate II., figs. 6 and 7.)

In general shape the skull recalls to some extent that of *Heterodontus*. It is long, rather narrow and high, broadest behind in the occipital and auditory regions, narrower between the orbits and becoming broader again in front in the olfactory region. The foramen magnum is very large; its plane is very oblique, and a large space occupied only by membrane intervenes between the upper border of the foramen and the commencement of the neural arches of the vertebræ. The condyles, as in *Torpedo*, are placed close to the foramen magnum. As in *Torpedo*, also, the aperture for the vagus is very large. Immediately above and a little in front of it is a short but well-marked process directed outwards; this is rudimentary in *Torpedo*. Below and behind the foramen the postero-external angle of the skull is drawn out into a dorso-ventrally compressed process with the extremity of which the basal cartilage of the first branchial arch articulates. This is an arrangement which seems, so far as I have observed, to be peculiar to this genus. As in *Torpedo*, the articular surface for the hyo-mandibular is long, narrow, and nearly horizontal, situated low down nearly on a level with the base of the skull. The elevation

marking the position of the posterior semi-circular canal, which is absent in *Torpedo*, is well-developed in the Australian genus.

Neither the præ-orbital nor the post-orbital processes are developed, and the orbit is devoid of basal plate. There is neither ethmoidal notch nor foramen.

The olfactory region resembles that of *Torpedo* but there are no distinct præorbital processes, and the fins articulate with the anterior extremities of the nasal capsules.

The hyo-mandibular is a long cartilage, longer than the greatest width of the skull, dorso-ventrally compressed and broad proximally, but narrowing distally; it is divided into two by a distinct transverse suture (as in many Rays) the outer piece being much shorter than the inner. Both upper and lower jaws are extremely slender. The hyoid arch is small, and quite similar to, though smaller than the branchial arches; above it is incomplete, and not in any way connected either with the skull or with the hyo-mandibular, its dorsal end articulating with the *basal of the first branchial arch*, which articulates with the postero-external process of the skull in the manner already noticed. Though this arrangement of the anterior visceral arches is not, as will subsequently be seen, peculiar to the present form, it is a modification which has hitherto escaped notice. In the Sharks the hyoid arch proper (which is much more important and much more sharply marked off from the branchial arches than in the Rays) is suspended from the skull by means of the hyo-mandibular, with which it articulates towards its distal extremity. The hyo-mandibular cartilage is thus in the Selachoidei a true hyo-mandibular suspensorium. But in the majority of the Rays, as pointed out by Gegenbaur, it has no such dual function, the hyoid arch being but slightly, if at all, connected with it, and its sole function being that of a mandibular suspensorium. In *Torpedo* the basal of the hyoid arch unites with the postero-lateral angle of the skull; it is free below except where a short cross-piece unites it with the ventral end of the first branchial arch. The first branchial arch is attached to the ventral end of the second, and the second and third have each distinct copular pieces uniting with the basilar plate.

The arrangement of the rest of the branchial apparatus in *Hypnos* is likewise peculiar. The copular elements of the hyoid and of the first, second, and third branchial arches are united below on either side to a thick longitudinal bar of cartilage which unites behind to the basi-branchial plate, close to its fellow, but diverges in front so as to leave a considerable triangular space, and ends in a free thickened extremity some little distance in front of the hyoid arch. Though these bars present no trace of longitudinal division they seem to correspond to the copularia of the hyoidean and three anterior branchial arches. The fourth and fifth branchial arches unite dorsally, as very commonly occurs, the basal of the fifth arch not being represented; from their point of union a long process passes inwards and backwards. The fifth arch has an articulation with the shoulder girdle.

Pectoral Fins. (Plate II., fig. 8.)

The shoulder-girdle is distinguished by the slenderness of its mesial ventral portion, which, as in Rays generally, is formed of one continuous bar, not interrupted by any fibrous interval such as occurs in *Torpedo*. It bears externally the lateral masses of cartilage with which the pectoral fins articulate, and an upwardly directed process of each lateral mass is movably articulated with a dorsal bar of cartilage which runs inwards towards the middle line of the dorsal surface. The dorsal ends of these two bars are united by a flattened mesial cross-piece, which is placed well above the vertebral column, not being connected with it save by fibrous tissue. Such an entire absence of cartilaginous connection between the pectoral arch and the spinal column is found in no other Ray with the exception of *Torpedo*. (Vide Gegen. Unters. II., 1, p. 81.) The three facets for the pectoral fin are borne on three short processes. The propterygium is made up of no less than nine joints which decrease in size distally, the whole having much the appearance of a magnified fin-ray. The mesopterygium is a small cartilage shorter than the propterygium, and is divided into seven segments. Each of the rays of the fin is bifurcate at the tip.

The cephalic fin consists of two curved cartilaginous styles connected with the skull as above noticed, having a series of short irregular rays attached along their anterior border, and of a series of irregular rays between them. The latter are not directly connected with the skull, and do not form a rostral prolongation of it as in *Torpedo*.

Pelvic Fins. (Plate II., fig. 9.)

The pelvic arch is a straight, rather narrow bar, continued externally into a pair of long, pointed, lateral processes directed forwards and outwards. The axial cartilage of the fin is narrow and pointed. Nearly all the fin-rays are bifurcate. The anterior rays articulate directly with the pelvic girdle, the first being shorter than the rest and representing the pre-axial fin-ray; there is no basal cartilage representing the mesopterygium.

There are two distinct dorsal fins of about ten to twelve rays each, placed close to one another on the short tail. The caudal fin itself is very small.

TRYGONORHINA FASCIATA.

Plate II., Figs. 1-5.

Vertebral Column.

The anterior vertebral plate presents a very strong odontoid process with a crescent-shaped articular surface at its extremity, and at the base of the odontoid process two concave articular surfaces for the occipital condyles. The spinous processes of the anterior vertebral plate are combined into a very prominent mesial ridge, and the transverse processes are likewise amalgamated, as in Rays generally, and develope about the middle of the length of the plate on either side a strong vertical process which reaches nearly as high as the spinous ridge. The spinous ridge ends some distance in front of the hinder extremity of the vertebral plate, and behind it

is a much smaller lamella which develops lateral projections embracing the dorsal extremities of the pectoral arch, so as to form sockets for the reception of the latter.

There are about twenty-five pairs of rather long slender ribs.

Skull and Visceral Arches. (Plate II., figs. 1 and 2.)

In general form the skull is somewhat expanded laterally and depressed dorso-ventrally, distinguished by its elongate rostrum and large olfactory capsules.

The plane of the foramen magnum slopes slightly forwards. Below it is the deep mesial excavation for the reception of the odontoid process, the concave articular surface for which is nearly as wide as the foramen. The condyles are borne on short lateral processes. The vagus foramen is separated by a considerable interval from the foramen magnum. Immediately in front of and external to it is a slender bridge of cartilage.

The articular surface for the hyo-mandibular is long and narrow, placed, as in *Hypnos*, close to the base of the skull and extending on to the postero-lateral process. The auditory foramina are very large, and are placed well apart from one another, only a very slight depression connecting them.* The elevations marking the position of the anterior and posterior semi-circular canals are very well-marked. Behind the orbit is a distinct post-orbital process, and in front of it are the very large and laterally projecting olfactory capsules. As in the Batoidei generally there is no basal plate. The foramen for the trigeminal is separated from that for the facial by a slight interval; behind the latter as in *Rhynchobatus* is an obliquely-placed bridge of cartilage. With the outer and posterior angle of the olfactory capsules is connected a compressed, curved, pointed cartilage, which represents the lateral process of the ethmoidal region of *Rhynchobatus*.

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* The absence of a deep parietal groove seems to be characteristic of the *Batoidei*.

The rostrum is a long spout-like structure, the concavity in which is continuous behind with the cerebral cavity. In front it gradually narrows, the excavation becoming shallower, and expands at the extremity into a thin sheet with a truncated terminal border; near each angle of the flattened terminal portion of the rostrum is a small rounded aperture.

The hyo-mandibular begins above in a broad extremity which articulates with the surface already noticed on the auditory region of the skull. Dorsally it presents a prominent ridge. The hyoidean arch is incomplete dorsally and becomes articulated to the dorsal mesial of the first branchial arch. The latter developes a short process which, as in *Hypnos*, articulates with the occipital region of the skull behind the surface of articulation for the hyo-mandibular. The copulare of the hyoid is produced anteriorly into a prominent flattened process. The hyoid copula is represented by a very long, slender, rib-like cartilage, which is not expanded into any broad mesial plate. The basal of the first branchial arch is in very close relationship to the ventral surface of the spinal column. The mesials of this and the three following arches present very deep and wide muscular fossæ which pass into one another across the articulation. The ventral mesial cartilage of the first branchial arch developes a flattened anterior process which articulates with the hyoid capula; behind it articulates with the second branchial arch at the point of junction of the ventral mesial and the copulare. The second arch has a strongly curved ribbon-like copulare; those of the third and fourth are united; the fifth arch has no copulare. The copularia of the second, third, and fourth arches, and the ventral mesial of the fifth articulate with a very wide basi-branchial plate. The ventral mesial of the fifth articulates with the shoulder girdle.

Pectoral Arch and Pectoral Fins. (Plate II., figs. 3 and 4.)

The pectoral arch is remarkable on account of the size and form of its lateral masses. The whole girdle has the form of an oval hoop, with the long axis transverse, the ventral side straight and the lateral portions greatly expanded. There is a narrow dorsal

interspace, the pointed dorsal extremity of each half of the arch being received into a socket formed for it by a produced portion of the spinous ridge of the anterior vertebral plate in such a way that motion is only possible round a transverse axis passing through the two joints. The outer border of the transversely expanded lateral portion of the girdle gives origin behind nearly at right angles to an extremely prominent lamella, concave inwards and convex outwards and directed outwards as well as backwards. This lamella presents externally four horizontal ridges, the most prominent being the third reckoning from above downwards. This ridge connects the articular surfaces for the pro- meso- and metapterygia, and between the two last itself gives attachment directly to a number of fin-rays. The articular surface for the propterygium is placed on the produced border by which the expanded part of the hoop and the lateral lamellæ unite. A little behind it is the less prominent articular surface for the mesopterygium. Between the two are two large nerve foramina, the one above and the other below ; these pass directly from within outwards. The articular surface for the metapterygium is placed on the posterior border of the lateral plate at the extremity of the prominent ridge ; it is a little less conspicuous than that for the propterygium. About midway between the ridge which bears the articular surfaces and the one above it is a horizontal row of fine small pores. The articular surface for the branchial arch is an ovate elevation situate close to the inner border of the lateral portion of the arch. The ventral bar is deeply grooved below. Among described forms the shoulder-girdle of *Trygonorhina* approximates most nearly to that of *Rhinobatus* (Gegenbaur, l. c. II., p. 82, pl. V., fig. I.A.)

The propterygium consists of a stout proximal portion with four short distal joints, with the extremity of the last of which three irregular rays articulate. The mesopterygium is small ; between it and the metapterygium is a wide interval where the fin rays articulate directly with the shoulder-girdle itself. The metapterygium is smaller than the propterygium ; two short cartilages are added to its extremity. The majority of the fin-rays of the pectoral fin bifurcate at their extremity.

Pelvic Fins. (Plate II., fig. 5.)

The pelvic arch is very slender and very wide from side to side, as in Rays generally. Its lateral extremity presents two articular surfaces, one for the propterygium (pre-axial fin-ray) the other for the metapterygium. The mesopterygium is not represented. In front of the articulation a strong compressed process extends forwards and outwards, and behind on the dorsal surface just over the two articulations is a very prominent, slender, curved process which extends backwards and upwards. The propterygium consists of a long and three short joints, the last bearing several rudimentary fin rays. The metapterygium consists of a long basal joint and three shorter distal segments; it bears twenty-four rays none of which are bifurcated.

Unpaired Fins.

The dorsal fin is small, with about fourteen rudimentary rays supported on two elongated, laterally compressed cartilages, the continuity of which with the spinous processes is manifest. The anal is very similar to the dorsal. The caudal is rudimentary.

The dorsal fin is described and figured by Mivart, l. c., p. 454, pl. LXXVIII., fig. 6.

SUMMARY.

In the following summary are enumerated the principal characteristics of the skeleton in such families of the *Plagiostomi* as I have had the opportunity of examining. The division of the Selachoidei into two principal sub-orders—the *Palæoselachii* and the *Neoselachii*—seems to me to follow as a necessary conclusion from the researches of Gegenbaur on the anatomy of the skull. The prefixes have reference, I need hardly add, not to the relative geological age of the two groups, but to their relative degree of specialisation; the structure of *Notidanus* is certainly much more archaic than that of any other Shark.

SELACHOIDEI.

In the skull the post-orbital processes are usually well developed, the orbit is usually provided with a cartilaginous floor formed of the basal plate; there is always a palato-basal articulation; the rostrum usually consists of three bars with large foramina at the base. There are a series of external branchial arches; the first branchial arch never articulates with the skull; the hyoid arch is supported by the hyo-mandibular; the copula of the hyoid has the form of a broad plate connected with its distal extremity. The pectoral fin is not connected with the skull by means of an ant-orbital cartilage; the ventral portion of the pectoral arch is divided in the middle by a more flexible portion into two lateral halves usually slightly movable on each other, and the dorsal extremities do not articulate with the spinal column. The pro- and meta-pterygia of the pectoral fin are never greatly elongated, and usually have the form of relatively broad plates.

PALÆOSELACHII.

(NOTIDANIDÆ.)

The vertebral column is scarcely ossified. There are two neural arches for each centrum, at least in the caudal region.

The occipital region of the skull is not so sharply marked off from the spinal column as in other *Elasmobranchii;* it presents above a mesial ridge continuous with the spinous processes, and at the sides ridges continuous with the line of the transverse processes. The plane of the occipital region is vertical or inclined from below upwards and backwards. There is no lateral occipito-vertebral articulation. The principal vagus foramen is placed far from the foramen magnum; the lower roots of the nerve pass out by from three to five distinct canals which are in line with the foramina for the spinal nerves. The vestibulum forms a distinct eminence on the surface of the infero-lateral portion of the auditory region. The articular surface for the hyo-mandibular is simple and not sharply marked off from surrounding parts. The post-orbital process presents an articular surface for the palato-quadrate. The orbit has no cartilaginous floor. There is an

ethmoidal canal. There is no tri-radiate rostrum. Representing the ant-orbital cartilage of Rays is an ant-orbital process. There are either six or seven branchial arches; the external arches are incomplete. There is only one dorsal fin; its rays are supported by a broad basal cartilage.

NEOSELACHII.

The centra of the vertebræ are well ossified.

The occipital region is well marked off from the vertebral column. The plane of the foramen magnum is vertical or slopes forwards. The principal vagus foramen is usually approximated to the foramen magnum, and there is never a row of accessory foramina in line with the foramina for the spinal nerves. There is no distinct elevation on the surface of the skull marking the position of the vestibule. The articular surface for the hyo-mandibular is complex. The post-orbital process never presents an articular surface for the palato-quadrate. The orbit has a cartilaginous floor. There is no process representing the ant-orbital cartilage of the Rays. There are never more than five branchial arches. There are two dorsal fins which may or may not present broad basal cartilages.

Cestraciontidæ.

The centra of the vertebræ present radiating bony lamellæ.

There is only a small tubercle representing the occipital crest, and the occipital region is sharply marked off from the vertebral column. The principal vagus opening is placed close to the lateral occipital process, and there is no row of accessory foramina. The elevation marking the position of the posterior semi-circular canal is placed on the posterior aspect of the cranium; there is no distinct elevation for the vestibule. There is an ethmoidal canal. The auditory foramina open at the bottom of a fossa which is continued forwards into a groove excavated on a longitudinal mesial ridge. The orbit has a cartilaginous roof. There is no prominent rostrum; the ethmoidal region is longer than in other

Selachoidei, and the olfactory capsules are remote from the orbits. The hyo-mandibular takes a comparatively unimportant part in the suspension of the lower jaw and palato-quadrate.

There are two dorsal fins, and these possess broad plate-like cartilages, and are closely related to the spinal column.

Lamnidæ.

The centra of the vertebræ present radiating lamellæ.

The articular surface for the hyo-mandibular is simple, but borne on a projecting portion of the postero-lateral region of the skull. The post-orbital process does not articulate with the palato-quadrate. The orbit has a cartilaginous floor. There is no ant-orbital process representing the ant-orbital cartilage of the Rays. The external branchial arches are well-developed. There is a well developed three-rayed rostrum. The hyo-mandibular bears a series of cartilaginous rays. The hyoid copula is a broad plate. The meso- and metapterygia are partly coalescent; the primary rays of the pectoral fins have intercalated among them a series of accessory rays which do not reach the basal cartilages. The dorsal and anal fins possess no broad basal cartilages and do not articulate with the spinal column.

Scylliolamnidæ.

The centra of the vertebræ present radiating lamellæ.

The articular surface for the hyo-mandibular is a deep conical hollow into which fits a peg-like process of the latter cartilage. The rostrum is single, and does not advance much beyond the level of the olfactory capsules. There is a basal plate forming a floor for the orbit. There is neither ethmoidal canal nor notch. There are rays on the hyo-mandibular as well as on the hyoid arch. The hyoid copula is a broad plate. The external branchial arches are rudimentary. The pectoral arch presents no ventral mesial flexible interval as in other Sharks. All the three basal cartilages of the pectoral fin are well-developed. The unpaired fins do not present expanded basal plates.

SCYLLIDÆ.

The centra of the vertebræ present radiating lamellæ.

The articular surface for the hyo-mandibular is situated in great part on a postero-lateral process of the skull ; it is saddle-shaped, and not very deep. There is no ethmoidal canal. The rostrum is three-barred. The dorsal fin has no broad basal cartilages.

RHINIDÆ.

The centra of the vertebræ are devoid of radiating lamellæ.

The post-orbital process is produced forwards and unites with the præorbital process. The shoulder-girdle resembles that of the Rays in presenting a rigid ventral portion ; and the skeleton of the pectoral fin has the pro and meta-pterygia elongated in an antero-posterior direction as in the Rays. The skeleton of the dorsal fin presents wide basal cartilages apparently continuous with the neural spines, and has no distinct rays.

PRISTIOPHORIDÆ.

The centra of the vertebræ are devoid of radiating lamellæ of bone.

The ethmoidal region of the skull is produced forwards into a long, dorso-ventrally compressed rostrum, perforated by a longitudinal canal, which is continuous behind with the cranial cavity. The copula of the hyoid is reduced to the form of a narrow strip of cartilage. There are rays on the hyo-mandibular as well as on the hyoid arch. The propterygum is very small. The dorsal fins are supported by broad thin plates continuous with the neural arches of the vertebræ.

BATOIDEI.

The post-orbital processes are small or absent; the orbit is devoid of cartilaginous floor. There is no palato-basal articulation. The rostrum, when present, is usually imperforate at the base. There are no external branchial arches ; the first branchial arch is sometimes directly connected with the skull. When the hyoid arch is supported by the hyo-mandibular the articulation takes

place near the proximal extremity of the latter. The ventral portion of the pectoral arch forms a continuous and rigid bar; the dorsal extremities of the arch are connected either with the spinal column or with one another. The pro- and metapterygia of the pectoral fins have the form of elongated narrow bars, and the mesopterygium is insignificant. The anterior portion of the pectoral fin is connected by a cartilage—the antorbital cartilage—with the ethmoidal region of the skull.

Pristidæ.

The ethmoidal region of the skull is prolonged forwards into a very long, straight, dorso-ventrally compressed rostrum, traversed by a median and two pairs of lateral longitudinal canals. The first dorsal fin has broad basal cartilages apparently continuous with the neural spines, and a series of short rays.

Rhinobatidæ.

The ethmoidal region of the skull is produced into a rather long rostrum. The first branchial arch articulates with the skull. The hyoid arch is not connected with the hyo-mandibular. The copulari of the branchial arches are distinct from the copulæ. The dorsal fin has broad basal cartilages, apparently continuous with the neural spines, and a series of short rays. The pectoral arch articulates directly with the spinal column. The pro- and metapterygia are segmented; between the mesopterygium and the metapterygium a number of the rays articulate directly with the shoulder-girdle. There are well-developed ribs.

Torpedinidæ.

The ethmoidal region is not produced into a rostrum. The articular surface for the hyo-mandibular is not wide. The copularia of the branchial arches are distinct from the copulæ. The hyoid arch is not connected with the hyo-mandibular. The pectoral arch is not directly connected with the spine; it is not so rigid in the middle ventral line as that of other *Batoidei*. The anterior portions of the pectoral fins are detached, and articulate with the front of the ethmoidal region of the skull. None of the rays articulate directly with the shoulder-girdle. There are well-developed ribs.

Rajidæ.

The articular surface for the hyo-mandibular is borne on a prominent process of the postero-lateral region of the skull. The ethmoidal region is produced into an undivided rostrum. The hyoid arch is connected with the base of the hyo-mandibular. There is only one branchial copula; the copularia are not amalgamated with it it. The pectoral arch articulates directly with the spinal column. The *propterygium* articulates with the skull by means of an ant-orbital cartilage; the pectoral fin is interrupted in front, with no detached cephalic fin. Short ribs are present. Some of the rays of the pectoral fin articulate with the shoulder-girdle.

Trygonidæ.

There is no distinct rostral prolongation of the skull. The articular surface for the hyo-mandibular is elongated antero-posteriorly; it is situated near the base of the skull, and not borne on a prominent process. The branchial copula is coalescent with the copularia. The hyoid arch sometimes articulates with the proximal extremity of the hyo-mandibular, sometimes with the cranium directly. The pectoral fins are continuous in front; the pectoral arch articulates with the spinal column. None of the rays of the pectoral fin articulate directly with the pectoral girdle. There are no ribs.

Myliobatidæ.

The cranium is elevated in front. There is no distinct rostrum. The articular surface for the hyo-mandibular is a tolerably deep hollow, situated close to the base of the skull, but not so much elongated as in most other Rays. The branchial copularia coalesce with the copulæ. The hyoid arch is not related to the hyo-mandibular nor to the skull, but articulates with the base of the first branchial arch, which articulates with the skull behind the hyo-mandibular. The pectoral fins unite in front of the skull; the pectoral arch articulates with the spinal column. There are no ribs.

Explanation of the Plates.

Au—Auditory apertures in parietal groove. *Ar*—Articular surface for hyo-mandibular. *PSC*—posterior semi-circular canal. *ASC*—anterior semi-circular canal. *Po O*—post-orbital process. *Pr O*—præ-orbital process. *fo*—fontanelle. *or*—foramen of exit of ophthalmic nerve from the orbit—op^1 foramen by which the ophthalmic nerve passes downwards and outwards towards the nasal capsule (posterior opening of the ethmoidal canal.) *R*—rostrum. *Ol*—Olfactory capsule. *Vg*—foramen of exit of the vagus nerve. *II*—foramen for the optic nerve. *B p*—Basal plate. *Pl*—palato-quadrate. *Mck*—Meckel's cartilage. *HM*—hyo-mandibular. *Hy*—hyoid arch. Br^1, Br^2, etc.—Branchial arches. *p pt*—propterygium. *m pt*—mesopterygium. *mt pt*—metapterygium. *p*—pectoral arch. *pl*—pelvic arch. *ppt'*—anterior basal cartilage of pelvic fin. *m pt'*—middle basal cartilage of pelvic fin. *mt pt'* posterior basal cartilage of pelvic fin. *cl.*—axial cartilage of clasper.

Plate I.

Fig. 1. Skull of *Carcharodon Rondeletii* from above.
„ 2. The same from the side.
„ 3. Pectoral fin of the same.
„ 4. Dorsal fin of the same.
„ 5. Pelvic fin of *Heptanchus indicus*. *M pt'*—mesial basal cartilage.
„ 6. Skull of *Crossorhinus barbatus* from above.
„ 7. Pectoral fin of the same.
„ 8. Pelvic fin of the same.
„ 9. Skull of *Pristiophorus cirratus* from above.
„ 10. Branchial skeleton of the same.
„ 11. Pectoral arch and pectoral fins of the same.
„ 12. Pelvic arch and pelvic fins of the same.

Plate II.

Fig. 1. Skull of *Trygonorhina fasciata* from above.
„ 2. Branchial skeleton of the same.
„ 3. Lateral view of pectoral arch of the same. *Sf*—superior nerve-foramina. *i f*, inferior nerve foramina, *p*, facet for propterygium. *m*, facet for mesopterygium. *mt*, facet for metapterygium.
„ 4. Pectoral fin of the same—*r*—rays articulating directly with the pectoral arch.
„ 5. Pelvic arch and pelvic fins of the same.
„ 6. Skull of *Hypnos subniger*.
„ 7. Diagram showing the connections of the hyo-mandibular, the hyoid, and the first branchial arch with the skull in *Hypnos subnig r*.

Fig. 8. Pectoral fin of the same.
,, 9. Pelvic arch and pelvic fin of the same.
,, 10. Coalescent anterior vertebræ of *Trygon pastinaca* seen from below,
,, 11. The same from above. *a*—process for articulation with the pectoral arch. *b*—tubercles with which the branchial arches articulate. *c*—nerve foramina.
,, 12. Skull of the same species.
,, 13. Pectoral arch of *Crossorhinus barbatus*.
,, 14. Nasal and labial (?) cartilages of *Urolophus*, seen *in situ* from the front.

NOTES AND EXHIBITS.

Mr. Macleay exhibited for Mr. James Macdonald, who was unable to be present, a specimen of a very curious little fish, which his nephew, Master John D. Wilson, had captured at the North Shore in an empty shell. Mr. Macleay said that it was a species of *Salarias*, and as far as he had been able to examine it, thought it was new.

Mr. Pedley exhibited three specimens of *Centriscus gracilis*, an extremely rare fish in Port Jackson.

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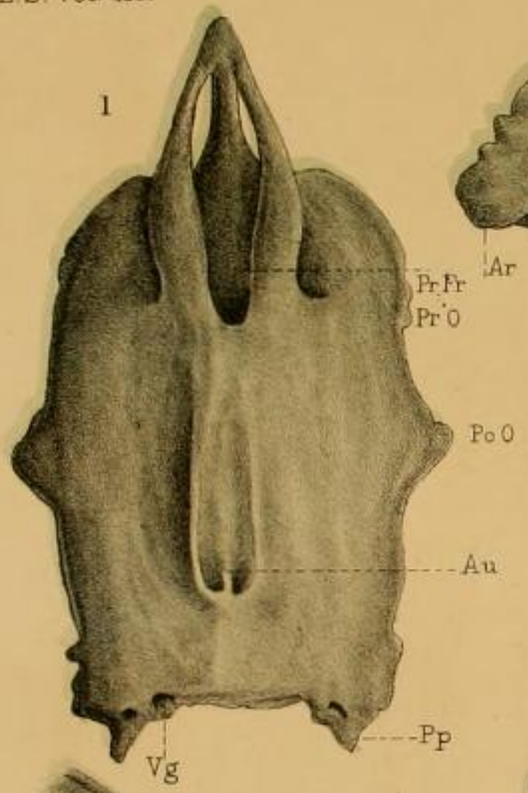

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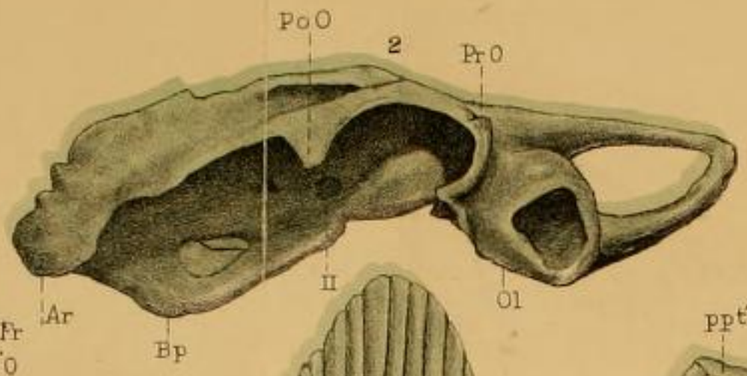

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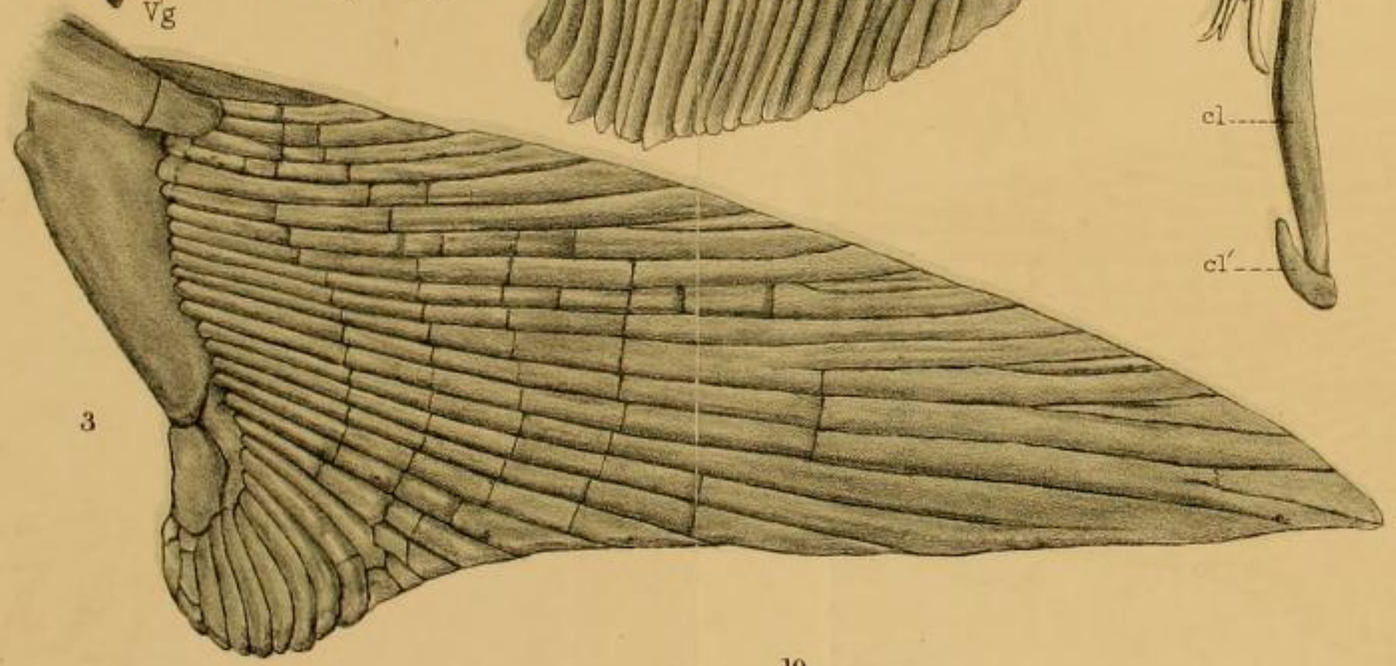

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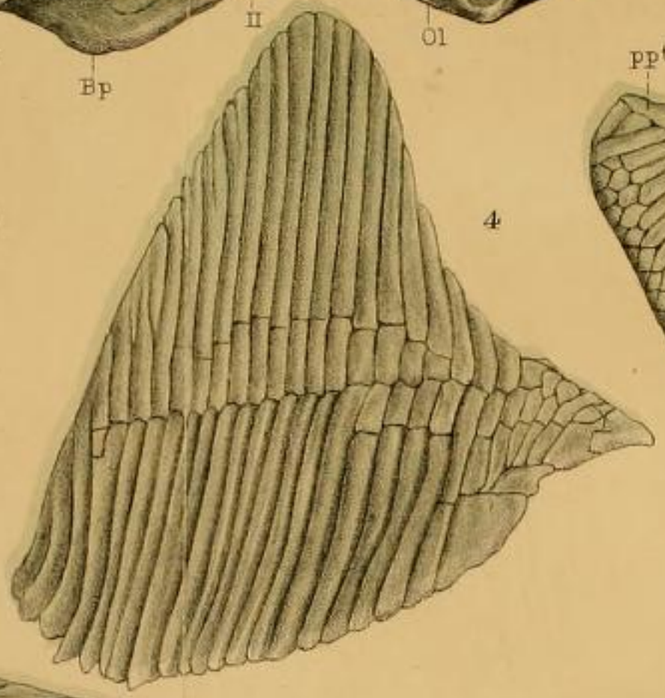

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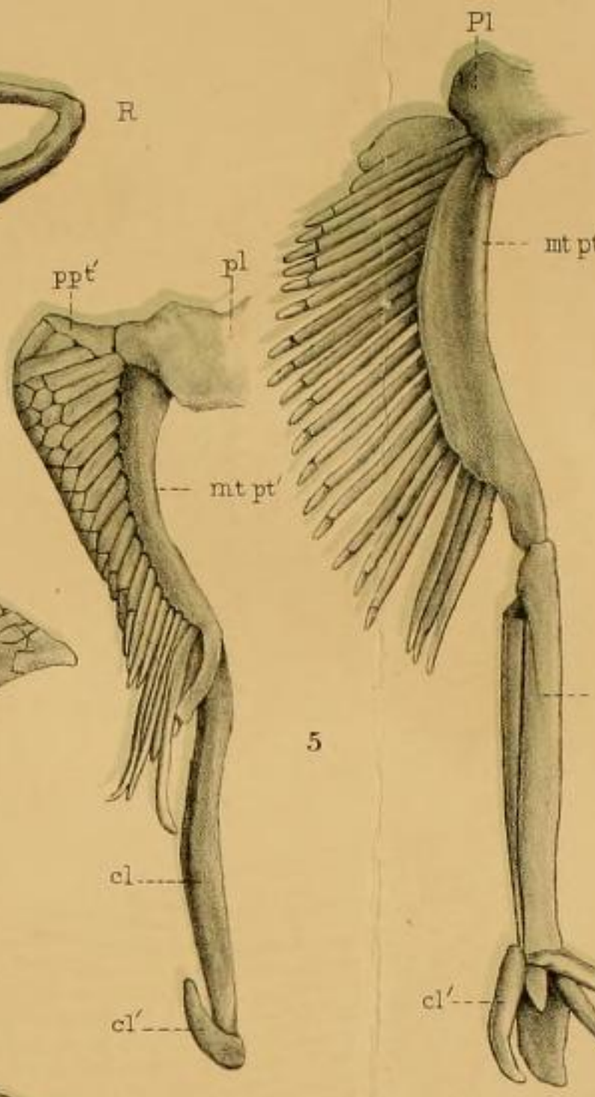

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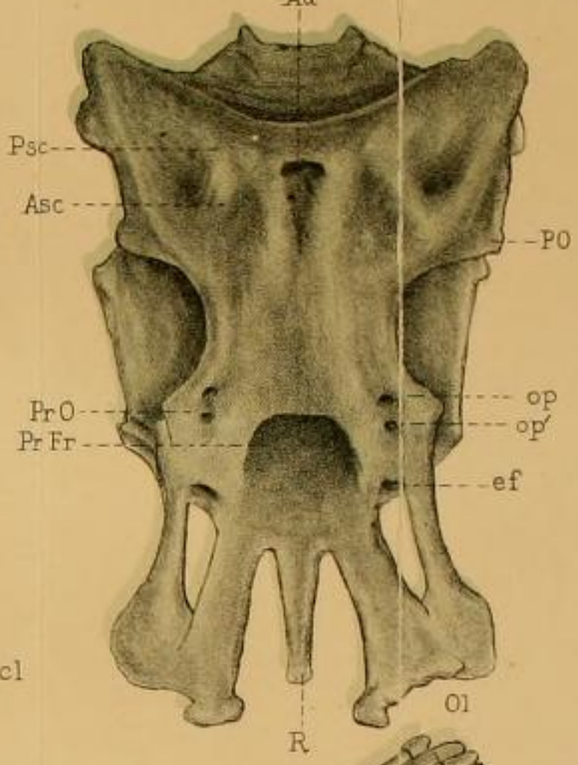

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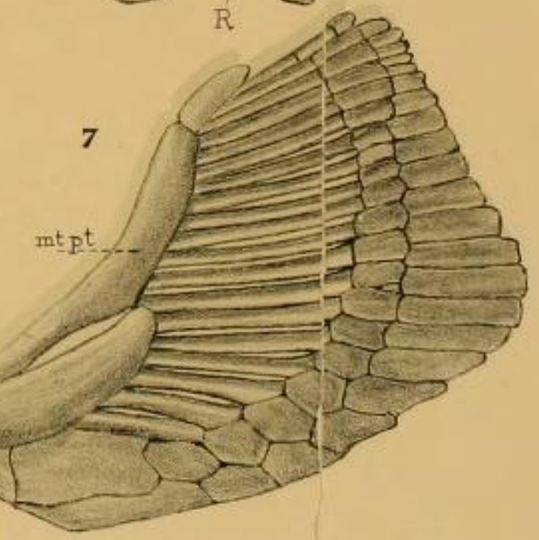

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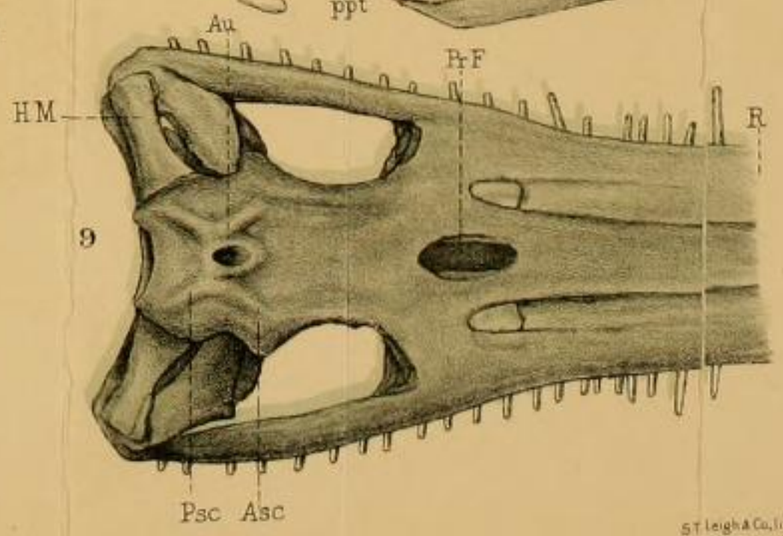

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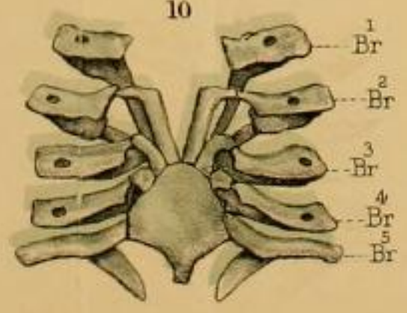

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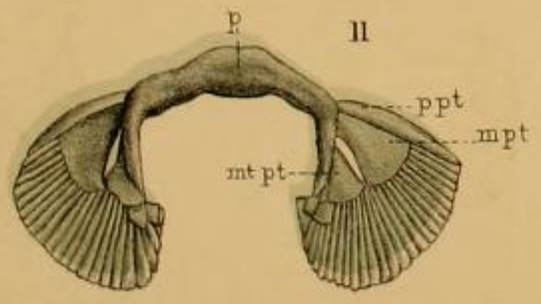

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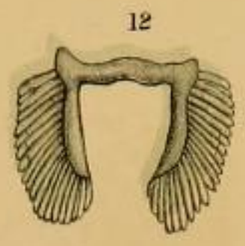

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S.T. Leigh & Co., lith., Sydney.

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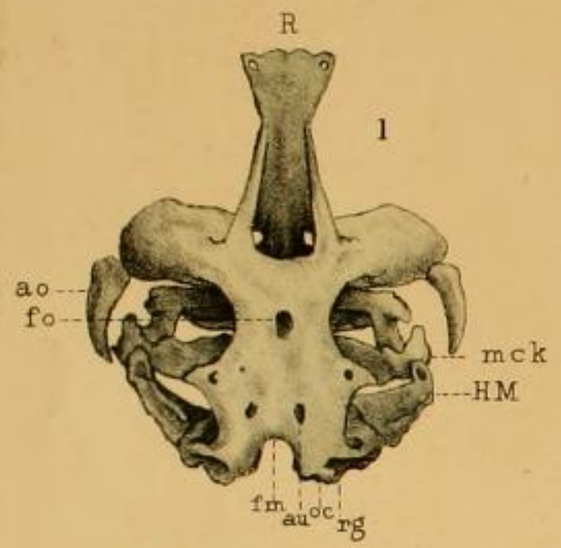

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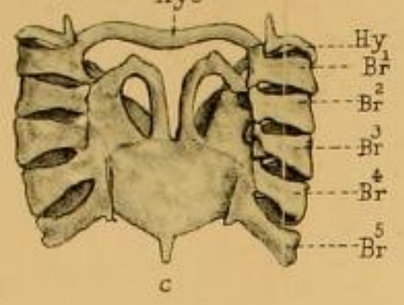

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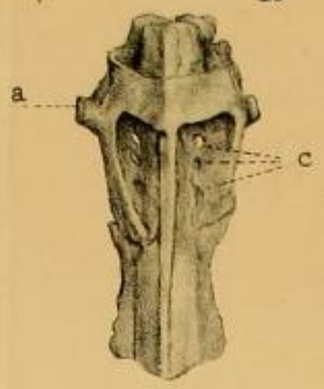

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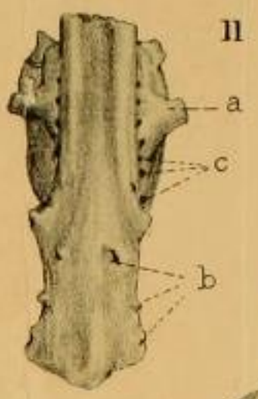

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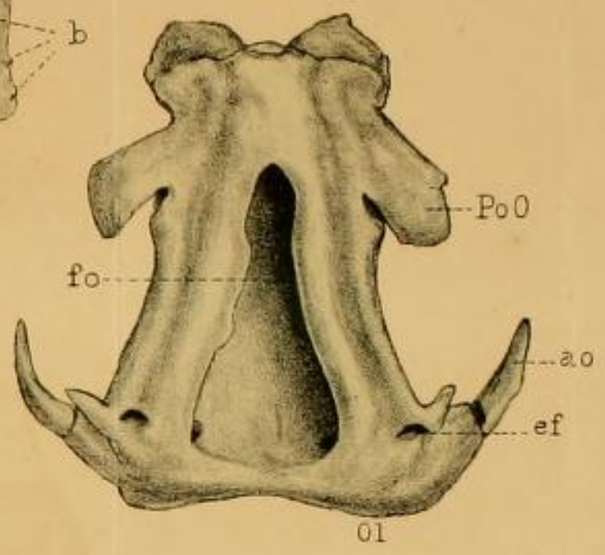

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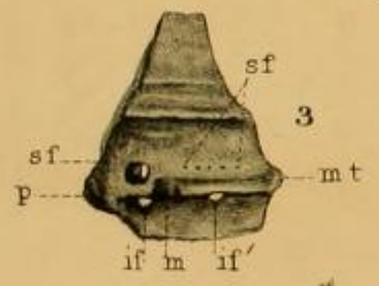

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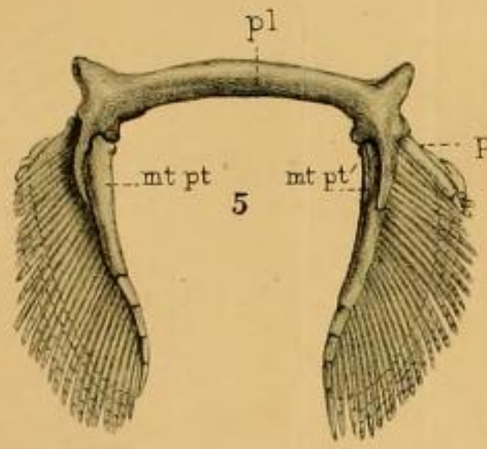

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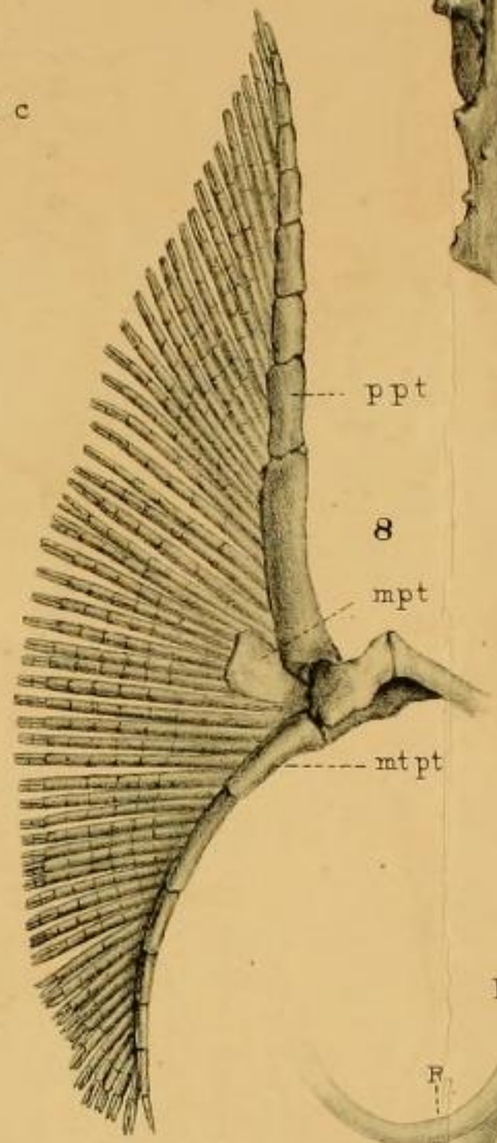

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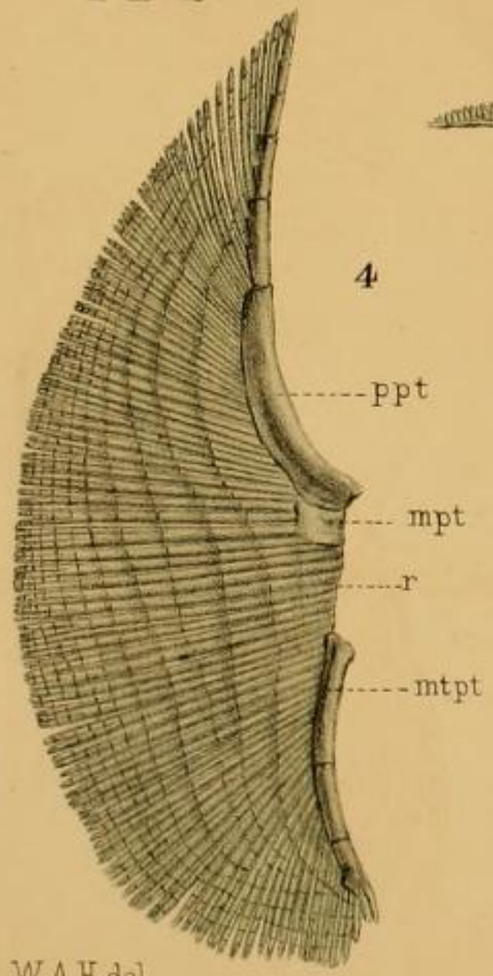

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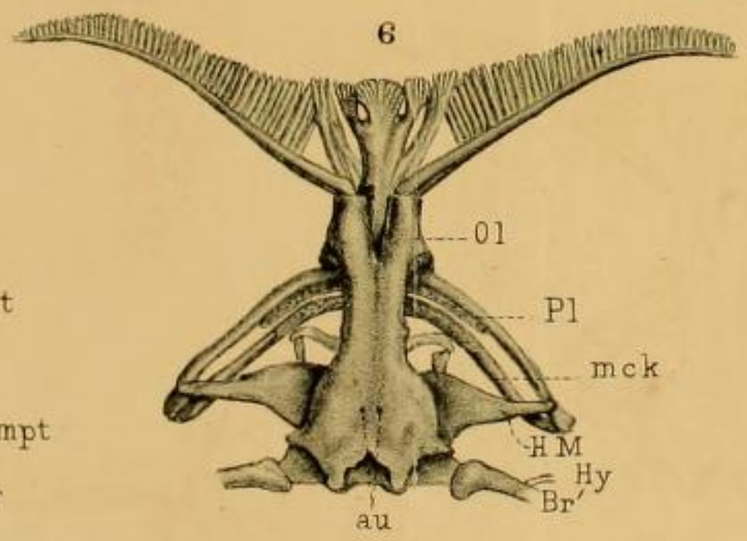

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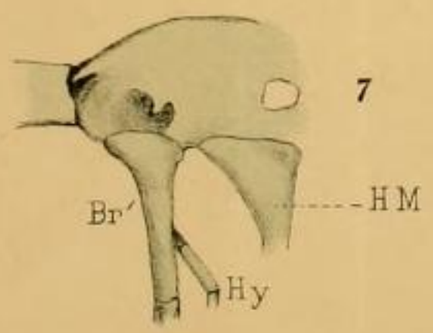

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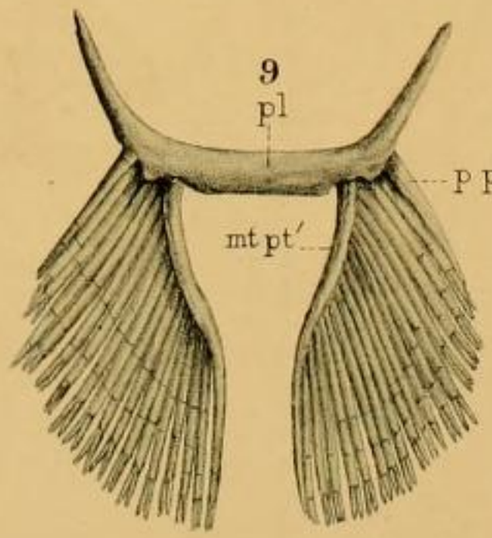

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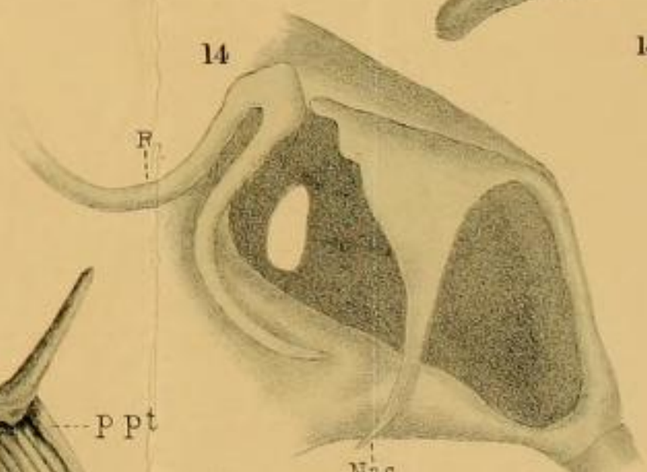

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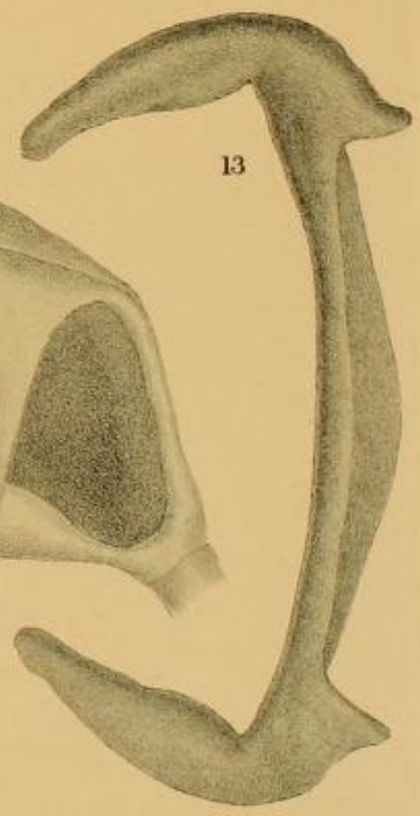

W.A.H. del.

S.T. Leigh & Co, lith, Sydney