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Notes

ON THE GENUS MEGALICHTHYS, AGASSIZ: ITS HISTORY, SYSTEMATIC POSITION, AND STRUCTURE.

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INTRODUCTION.

At the meeting of the British Association, held at Edinburgh in 1834, Dr. Hibbert read a paper before the Geological Section on a series of fossil remains found in the Burdiehouse limestone, near Edinburgh. These contained a series of fish remains, among which, besides *Gyracanthus*, *Palæoniscus*, *Erynotus*, *Pygopterus*, were some bones, scales, and teeth, remarkable for their great size, and also some smaller rhombic enamelled scales.*

Prof. Agassiz being present the remains were submitted to him for his opinion. They proving new and strange to him, he, Drs. Hibbert and Buckland formed a committee to report on them. About this time Agassiz, whilst on a visit to Leeds, saw in the Museum there a fine and well-preserved head and part of the trunk of a fish, which he seems to have considered of the same species as the Burdiehouse remains. This new find having relieved his doubts concerning the Burdiehouse fish, he took the Leeds specimen as the type of his genus *Megalichthys*, and at that time included the large rounded scales and gigantic teeth, as well as the smaller rhombic enamelled scales, in this genus. Later, however, he separated the large rounded scales and the teeth, placing them in a new genus *Holoptychius*.†

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* See Poissons Fossils (Agassiz), Vol. 2, Pt. I., pp. 89 and 90.

† Poissons Foss., Vol. 2, Part I., p. 90.

It is very unfortunate that Agassiz made the Leeds fish his type, as undoubtedly the name Megalichthys was suggested to him by the great size of the Burdiehouse remains, for which in 1840* Prof. Owen instituted the genus *Rhizodus*.

SYSTEMATIC POSITION.—Agassiz classed *Megalichthys* in his heterogeneous group of "Sauroides."†

Sir P. Edgerton‡ next proposed its inclusion in the family *Sauroidei-dipterini* (*Sauroides-dipteriens* of Agassiz); its position in the *Saurio-dipterini* was also indicated by Pander§ and Huxley‖ on account of the close relationship of its head bones, &c., to those of *Osteolepis*, though they both seemed to hesitate for want of knowledge of the conformation and position of the fins.

In 1861 Prof. Young, in Dec. X. Geol. Survey, mentioned specimens in the Jermyn Street Museum, showing the form of fins, but unfortunately gave no description or figures.

In 1875 Mr. J. Ward, F.G.S. (Fossil Fish of North Staffordshire Coalfields), classed *Megalichthys* in this same family (*Saurio-dipterini*), and also stated that the pectoral fin is lobate.

Dr. R. H. Traquair, F.R.S., in a paper read before the Royal Physical Society, Edinburgh, on Feb. 20th, 1894, says that there can be no doubt that the true position of *Megalichthys* is in the family *Saurio-dipterini* as defined by Pander, Huxley, and others. In every matter of "Family" importance its structure closely conforms to that of *Osteolepis*.

In 1890 Mr. J. Ward, F.G.S., in his "Geology of the North Staffordshire Coalfields," classifies it in the same family; but in 1891 Mr. A. Smith Woodward, F.G.S., in vol. ii. of his Catalogue Fos. Fishes in the British Museum, places the genus *Megalichthys*

* Odontography, 1840, p. 75.

† Poissons Foss., Vol. II., Pt. II., p. 152.

‡ Morris's Catalogue Brit. Fossils.

§ Die Saurodipterinew, &c., devon Syst., p. 5.

‖ Dec. Geol. Survey X., 1861, p. 12.

along with *Osteolepis*, *Thursius*, *Dipterus*, and *Glyptopomus* in the family Osteolepidæ, and in this view Dr. Traquair seems to concur.*

STRUCTURE.—The body is much elongated, being about five times the length of the head, rounded and covered with rhomboidal scales which run in obliquely sigmoidal parallel lines from before backwards, the greatest obliquity being on the dorsal and ventral surfaces, the scales becoming smaller on the latter surface. Well marked ridge scales present (at least) in the posterior half of the fish, where they pass some little distance on to and strengthen the anterior basal portions of the unpaired fins; they also pass for some distance on to and strengthen the upper lobe of the caudal fin.

SCALES.—The superior surface is divisible into an anterior or covered, and a posterior or exposed, portion (Pl. VIII., Fig. G). The *anterior covered* area is smooth and covered with a thin layer of non-corpusculate bone or kosmin, and is crossed by a grove which runs more or less parallel with the anterior and superior edges of the posterior or exposed portion. The "overlap" of the scales is from above downwards and backwards. The posterior exposed area is rhomboidal in form and is covered with a glittering layer of ganoine which ceases on the sides with abrupt rounded margins which dip down to and slope to the surface of the scale. This part of the scale is deepest at the centre, and on section is seen to be composed of non-corpusculate bone, tufts, capillary tubes and the upper series of the haversian canals (Williamson). The *internal* surface is smooth with the exception of an elongated ridge or boss (not present in *M. lævis* Traquair) which runs more or less vertical to the axis of the body of the fish, and is situated between the anterior border and the centre of the scale.

The Haversian system is in direct communication with the scale surface giving rise to the wide pores.

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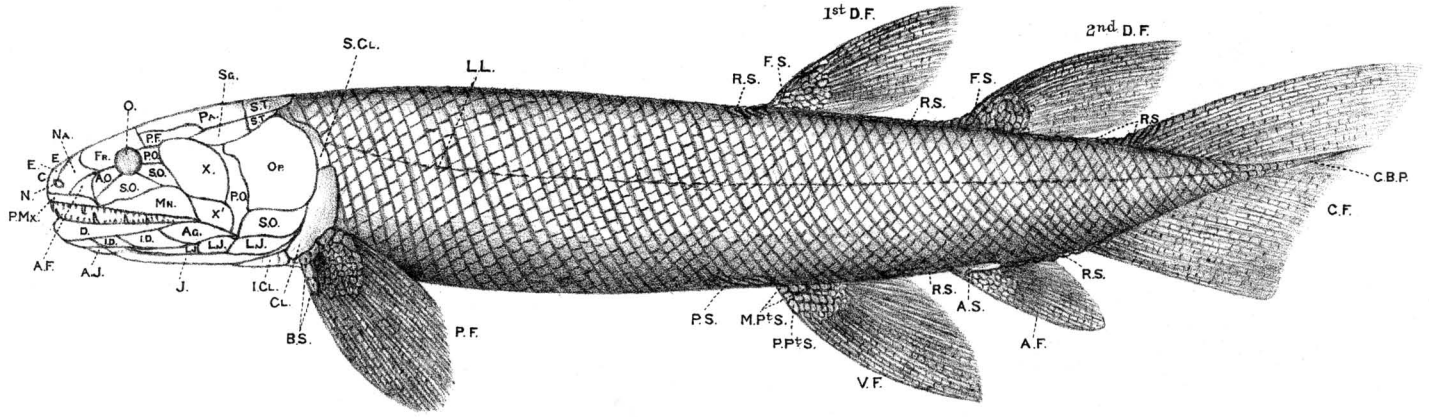
* Geo. Mag., Dec. III., Vol. VIII., No. 321, p. 123, Mar. 1891.



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LATERAL LINE.—I have not seen any evidence of this "sense organ," but it probably arises at a point on a level with the upper border of the operculum and traverses a longitudinal series of scales to an indetermined point on the caudal pedicle.

SHOULDER GIRDLE.—The pectoral arch exhibits well developed membrane bones, there being a large clavicle (Fig. C, Pl. XIX.) and a smaller infra clavicle (Fig. D, Pl. XIX.). A supra clavicular element was in all probability also present (as is the case in some other members of the order), but not having seen the bone I am unable to offer any opinion as to its characters.

FINS.—(*a*) *Paired fins.* These were represented by the "Pectoral" and "Ventral" fins, the latter being abdominal in position.

(1) *Pectoral fins.* These fins are obtusely lobate, and their superficial characters are beautifully shown in a specimen in the Science and Art Museum, Edinburgh (Pl. XVII., Fig. B), and also in the fine fish in the Leeds Museum (see Fig. C, Pl. XVII.).

CHARACTERS.—(*a*) Superficial. At the base of the fins are a series of large scales, which are continued along the post-axial and preaxial borders, the space between these being occupied by smaller scales arranged in many parallel rows. (*b*) The internal skeleton is, as pointed out by Prof. Miall,* indicated in *Magalichthys*, as in other fishes with lobate fins, by the external characters, the larger or fulcral scales covering the more rigid, and the smaller the more flexible parts of the internal structure (in the nearly allied family Rhizodontidæ this character is clearly indicated in a pectoral fin of *Strepsodus*, which is in the Science and Art Museum, Edinburgh). The lobe of the fins seems to be, as pointed out by Mr. A. Smith Woodward, supported by an endoskeletal cartilage (covered with a thin layer of dense bone, Cope), arranged on the plan termed archipterygial by Gegenbaur; the axis being shortened, whilst the parameres of the one side are atrophied, those of the other border enlarged. There is thus no di- or tri-basal arrangement of the cartilages as in

* Quart. Journ. Geo. Soc., Vol. XL., p. 347.

Polypterus, the skeleton being more like that found in *Ceratodus*, with the difference that the basal cartilage (*Metapterygium*) is somewhat shortened, the radials on its anterior border atrophied, those on the posterior border enlarged, and the cartilage seen along the post axial border of the fin being elongated to form a propterygium, this giving a structure similar to that shown in Fig. A, Pl. XVII.

Prof. Cope gives a section (Proc. W. S. Natl. Museum, Vol. XIV., p. 457) of the lobe of the pectoral fin of *M. nitidus* Cope, which shows a well-marked metapterygium, with radials springing from its tip and outer or posterior edge.

The dermal fin rays form a fringe around the lobe, they are closely articulated, the articulations being rather longer than broad, and covered with ganoine similar to that on the scales, distally they increase in number by dichotomisation and become much finer. The anterior rays are much more robust than those situated further back.

Ventral fins.—The fins are abdominal and their position and character are well shown in a fish in the Hugh Millar Collection in the Science and Art Museum, Edinburgh. Their basal characters are also well shown in the Leeds fish, the right one being the better preserved.

The fin is obtusely lobate, the base being invested with large scales which are continued along the internal or post-axial border; along the outer or preaxial border is a shorter series of large scales which meet the others (post-axial) at an acute angle. The space between these rows is occupied by a close series of smaller scales arranged in many parallel rows. Here, again, the external characters probably indicate the internal skeleton which is thus described by Prof. Miall: "The larger scales conceal a strong pro- and a metapterygium, whilst the smaller scales cover numerous radials which spring from the outer edge of the metapterygium."

The section of the basal portion of this fin given by Cope (op. cit.) goes to prove that a strong, well-marked axial rod or metapterygium was present, with well-marked radials springing

from its tip and posterior border, but none are shown on the anterior margin. I don't take this as proving that they were absent from the anterior border, as they might easily have been missed owing to the direction of the section, and it is highly probable, considering that the dermal rays not only spring from the tip and posterior border, but also from at least the distal portion of the anterior border of the fin lobe, that there were short radials on the anterior margin of the axial support distally; and considering the fact that the dermal rays, springing from this portion of the lobe, are much stronger and more robust than the others, it is very probable that their supporting ossicles were, although short, strong and robust, and from the above the conclusion seems to be that the skeleton of this fin was of a nature similar to that shown in Fig. E, Pl. XVII.

The dermal fin rays are similar to those of the pectoral fin in character and arrangement.

The pelvis is probably represented by an elongated cartilaginous element, covered with a layer of dense bone and having the distal end concavo-truncate (see Cope, op. cit., p. 458).

In the Leeds fish, between these fins are three large, elongated scales, one median and two lateral, which may be called "pelvic scales." On the left side of the median one the anus is well shown. The anus is not always in this position as is shown by other specimens. The difference is probably connected with the sex of the fish. (Pl. XIV., L P S and M P S, also Pl. XIII., P S.)

Unpaired fins.—There are two dorsal fins situated far back, the first being opposed to the ventral and the second to the anal fin, which arises close to the root of the tail. All the fins are lobate, the lobe being more acute than that of the paired fins.

Anal fin.—The superficial characters are well shown in several specimens, viz., in the Leeds fish, in the specimen in the Science and Art Museum, Edinburgh, described by Dr. Traquair (Proc. Roy. Phys. Soc. Edinb., Vol. VIII., p. 67), and in a specimen in the Lister Collection, Brighouse, &c. (Pl. XIV., A F, and Pl. XVI., A F).

CHARACTERS.—On each side of the lobe is a large "basal" scale, the function of which seems doubtful. The dermal rays are of similar character and arrangement to that of the pectoral fin.

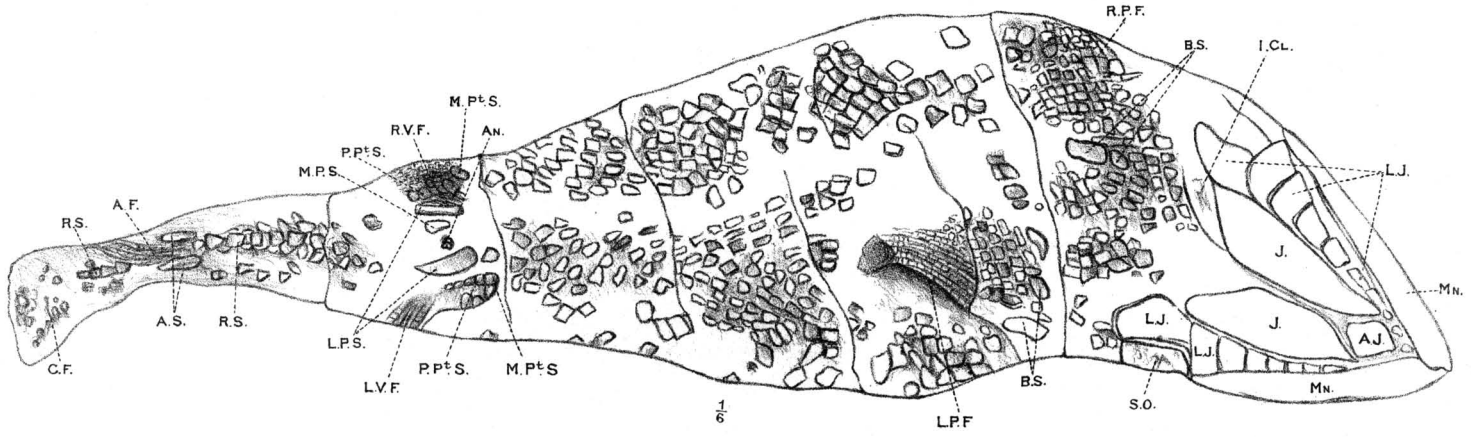
Internal Skeleton consisted of a single club-shaped axonost, its broad basal portion bearing several rod-like baseosts, which were jointed at intervals and bifurcating, the more anterior ones being the most robust. The dermal rays are much more numerous than the supporting ossicles, and were of a character similar to those of the pectoral fin.

Dorsal fins.—These fins were lobate, the lobe being more acute than that of the paired fins, the posterior fin is more strongly developed than the anterior, the dermal rays of both fins are similar in nature to those of the other fins, and the supporting skeleton is similar to that of the anal.

NOTE.—A specimen in the British Museum (No. 38,007) shows that the supporting (or internal) skeleton of the unpaired fins was of a similar nature to that described above.

Caudal fin.—(Pl. XVI. and Pl. XVII., Fig. H.) The structure (superficial) of this fin is well shown in several specimens in the Science and Art Museum, Edinburgh; Lister Collection, Brighouse; and Owens College, Manchester. The fin is intermediate in type between the diphycercal and heterocercal stages, and in general form reminds one of that of *Tristichapterus*, as pointed out by Dr. Traquair.

The rays arise from both the upper and lower margins of the body prolongation, those of the lower side commencing in advance of those of the upper (see Pl. XVI.). After the commencement of the rays the upper margin of the body slopes a little downwards, whilst the lower one first slopes somewhat rapidly upwards and backwards, then more gradually to meet the upper in a fine point, which is finally lost among the dermal rays, the scaly covering being continued to this point (Pl. XVI., and Pl. XVII., Fig. H).



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The greater number of the dermal rays arise from the lower aspect of the body prolongation, whilst the apex is formed by those arising from the dorsal side of the axis. (This is clearly shown in a specimen in Owens College Museum.) (Pl. XVII., Fig. H.) The posterior margin of the fin slopes obliquely upwards and backwards, and the dermal rays are articulated, covered with ganoine, increased by dichotomisation distally, the uppermost ones are the most robust and the proximal part of the upper border of the fin is strengthened by well-marked "ridge scales," which are continuous with those on the dorsal ridge of body.

Internal Skeleton. (Pl. XVII., Fig. F.) The specimen of *Megalichthys Hibberti* Ag., No. 38,007, already mentioned, shows that the internal structure was of a similar nature to that of *Tristichopterus alatus* Egerton,* viz., the more anterior dermal rays are supported on a series of "hour-glass" shaped interapophyscal osselets, each osselet having several rays opposed to their distal end, their proximal ends uniting with the distal extremities of elongated and thickened neural and hœmal spines of the vertebral column. More posteriorly the dermal rays seem to abut on the vertebral axis.

Vertebral Column.—In the Andersonian Museum, Glasgow, there is a slab which contains, besides the upper surface of the head, a good display of the vertebral column. About fifty vertebræ are shown, of which the anterior are the shortest and broadest, the caudal being the longer and narrower.

The notochord is partially persistent, the cartilages of the arches are superficially calcified, there are robust ring-shaped vertebræ, and several specimens (in the Science and Art Museum, Edinburgh; British Museum; in the Author's Collection, &c.) show well-marked neural spines, which have a cylindrical shaft, articular head, and are somewhat flattened distally. Hæmal spines are also shown in the caudal region in several specimens.

* See Mem. Geol. Survey (Figures and descriptions organic remains), Dec. X, Pl. 4 and 5, pp. 50-53.

HEAD.—*Internal anatomy* in *M.* (*ectosteorhachis*) *ciceronius* Cope,* the chondrocranium is in some degree ossified, and the parachordal cartilages are ossified to form two subtriangular bones which present one angle forwards, and having the internal side which bounds the chordal groove straight and longitudinally grooved. The antero-external side is oblique and nearly straight, and is overhung by the cranial roof. These ossifications embrace the chorda dorsalis posteriorily, and are continued a short distance posteriorily as a tube. Anteriorily the chordal grove is open, and we here get a good illustration of a permanent embryonic type (Cope, opus cit.).

According to Dr. Young (see Quart. Journ. Geol. Soc., Vol. 22 (1866), p. 605) the basilar region is well ossified and includes a massive basioccipital which projects behind the vertical posterior wall of the cranium and sometimes has its length increased by coalescence with at least the first vertebral ring, whose neural process remains distinct. In a lateral view, the aliophenoides (?) and an incomplete interorbital septum (?) are well shown.

The hyomandibular is not shown in any of the specimens I have seen, but it is probably (as in *Rhizodopsis*)† covered by the preoperculum, and extends from the squamosal above downwards and slightly backwards to the articular extremity of the mandible below.

Cranial Anatomy (Pl. XV., Figs. A, B and C).—The whole of the cranium is covered with thick dermal plates, which exhibit a definite arrangement, and there is a considerable development of membrane bones on the roof of the mouth. The shield of the cranial roof is divided by a much-pronounced transverse suture into two parts. The posterior portion consists chiefly of a pair of long narrow bones (Pa.), the parietals, which are divided down the middle line by an irregular suture, the bones are twice as wide behind as in front, their external margins first run nearly straight

* Proc. Amer. Phil. Soc., Vol. 20, page 628. 1883.

† Trans. Roy. Soc. of Edinburgh, Vol. XXX., page 171 (Traquair).

forwards to a point a little behind their middle, then forwards and inwards for a short distance, and then nearly straight forwards to meet the posterior boundary of the bones of the anterior division. Along the outer edge of each parietal are two smaller bones (P.F. and Sq.), the anterior ones being narrow, elongated bones which in front meet the posterior extremity of the bones (Fr.) of the anterior division; from this point, where the bones are the broadest, the external margins run backwards to a point, a little in front of the centre of the parietal bones, where they join the posterior pair of bones (Sq.) by a suture which runs from without, inwards, and backwards. The posterior border of the bones (Sq.) is straight, and they are wider here than in front. Their outer border at first runs forwards and slightly outwards, then forwards, and then inwards and forwards to meet the external border of the anterior pair of bones (P.F.) at the junction of their posterior and middle thirds.

The anterior division of the cranial shield is divisible into a posterior (Fr.) and an anterior moiety (C.E.).

The posterior division is composed of two bones (Fr.), the Frontals, which are divided down the middle line by an irregular suture; their inner sides are longer than their outer, which are notched to form the upper boundary of the orbit. From the anterior edge of this notch, where the bones are the widest, they gradually narrow to form an obliquely truncated anterior extremity, which indents the posterior border of the bones (C.E.) in front, the union being by a semi-lunar suture, with the convexity forwards.

The anterior division (*Moignon inter maxillaire* Agassiz) is a cresentic shield which terminates the head anteriorly, and presents distinct indications of a division into a number of pieces, viz., Ethmoids (E.), Pre-frontals (P.F.), Nasals (N.), and pre-maxillary (PMx.) bones. The bones are usually firmly united, and form the "Compound Ethmoid." The pre-maxillary portions are separated by a median suture, and form the lower and anterior boundary of the shield. Above these in the centre is the

ethmoidal (E.), with the Nasals (N.) on each side, and more external still the bone probably represents the Pre- or Anterior frontals (A.F.). The nasals were perforated by and contained the olfactory organs, and the nares (Na.) were anteriorly placed on each side of the snout, as is the case in *Osteolepis* and in the recent fish *Polypterus* (see Pl. XV., Fig. B).

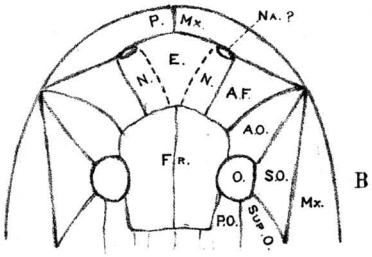
Behind the cranial shield, in the occipital region, are three bones, one median and two lateral. The central one is in the form of a narrow isosceles triangle, and the lateral ones form a pair on each side of it. These bones are regarded as the supra temporals by Dr. Traquair, Mr. Smith Woodward, and others.

Side of the Head. (Pl. XIII. and XV.)—This region is entirely covered with loose dermal plates.

The Orbit is anteriorly placed, being situated at the junction of the anterior and middle thirds of the head. Above it is bounded by the frontal bones, in front by a bone (A.O.) which probably represents the Anterior Orbital of *Polypterus*, below by an elongated triangular bone (S.O.), the Sub-Orbital, which rests on the anterior portion of the upper edge of the maxilla (Mx.) below, and extends from the pre-maxilla in front to a third bone ($S.O^1$)., which is triangular in shape, and forms the posterior inferior boundary of the orbit. This bone is the supra-orbital of Prof. Huxley. Behind the orbit is a square-shaped bone (P.O.), the post orbital.

Behind the orbital region is a large plate (X) which is somewhat oval and obliquely placed, it covers a large portion of the cheek, and is bounded in front by the post- and supra-orbitals, behind by an elongate bone (P.Op.), above by parts of the posterior frontals and synamosals, and below by another plate (X^1) which is somewhat rhomboidal in shape and fills the space between the larger cheek plate (X) above, the articular extremity of the mandible below, the hinder border of the maxilla in front, and the lower third of the anterior border of the bone (P.Op.) behind. This latter bone (P.Op.) may be considered as the preoperculum. It is a narrow, elongated, somewhat arched bone,

Proc. Yorks. Geol. and Polytec. Soc., Vol. XIV., Pl. XV.



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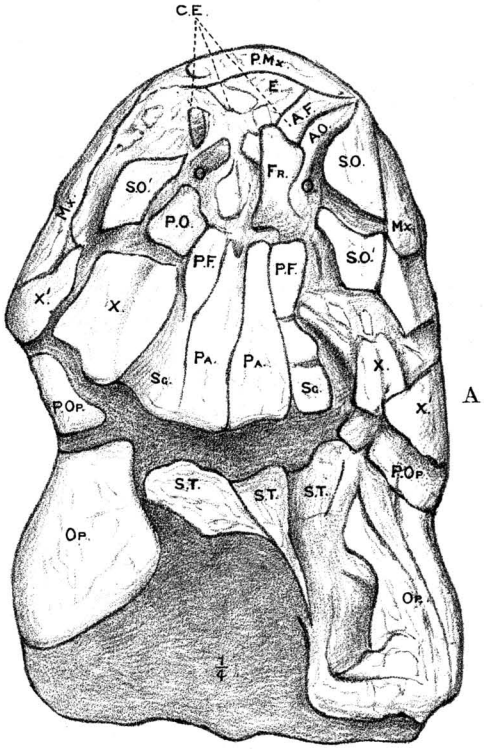

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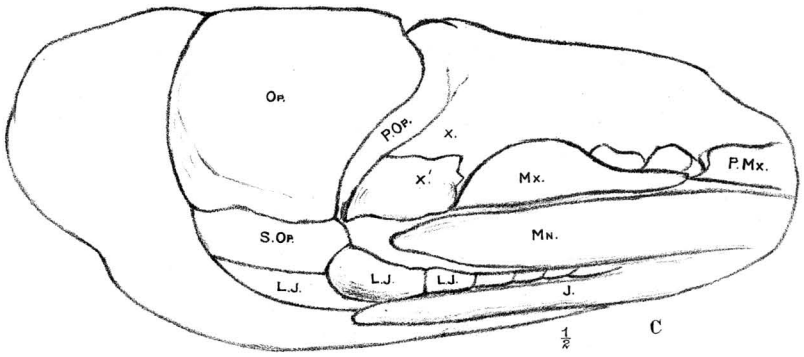

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the convexity being backwards; its direction is from above downwards and slightly backwards. Above it articulates with the squamosals (Sq.), and from this point it passes down behind the posterior border of the bones X and X^1 to meet the articular extremity of the mandible below, and behind are two bones (Op. and S.Op.). The former of these bones (Op.) represents the Operculum and the latter (S.Op.) the Suboperculum.

The two cheek plates X and X^1 are probably equivalent to the cheek cuirass of *Lepidosteus* (or as Dr. Traquair remarks of the same bones in *Rhizodopsis*),* to the posterior set of suborbitals in *Lepidotus* and in the Palæoniscidæ. By Agassiz † the bones X and P.Op. were considered to be the equivalent of the so-called pro-opercalum of *Polypterus*, while the lower one X^1 he compared to the little bone fixed above the posterior edge of the maxilla in Salmonidæ, &c., and which Mr. Parker considers to be the homologue of the malar bone of other vertebrata.

The opercular bones (Op. and S.Op.) were largely developed. The operculum is a large square-shaped bone with its posterior superior angle much rounded, it is broader above than below and behind than in front. It is bounded above by the posterior half of the squamosals in front, and behind these by the lateral pair of suprateuporals; in front is the preoperculum; behind the bones of the shoulder girdle and below by a plate (S.O.), which it overlaps, the suboperculum. This latter bone is much narrower and has the anterior superior and posterior inferior angles much rounded. The bone is bounded above by the operculum, in front by the lower part of the preoperculum, behind by the clavicle, and below by a bone (L.J.) which is to be regarded as the most posterior of the lateral jugulars. (Plates XIII., XIV., and XV., Fig. C.)

Jaws.—The maxillæ are of an elongated triangular shape, the alveolar border being the longest and the posterior one the shortest. The greatest depth of the posterior expansion varies in

* Trans. Roy. Soc. Edinburgh, Vol. XXX., p. 177.

† "Poisson's Fossiles," Vol. II., part 2, p. 92.

the different species, being in *M. Hibberti* Agassiz about a third the greatest length. The anterior angle is pointed, the others somewhat blunt. A specimen in the Author's Collection shows on the upper edge of the bone, and a short distance from the anterior extremity, a short, blunt projection, similar to the one mentioned by Dr. Traquair on the maxilla of *Rhizodopsis* (op. cit., p. 172). (Pl. XIX., Fig. A.)

The pre-maxillæ are separated by a median suture, and form the lower and anterior boundary of the cranial shield. When seen from the palatal surface the bone is spatulate, with a rounded fore edge.

The mandible is of a very complex structure, but the component parts are, in the older fishes, firmly united together. Behind there is a distinctly ossified articular element. The upper and outer border, in front of the angular bone (Ag), is formed by an elongated element (D), the dentary bone, which is deep and thick at the symphysis, but from this point it gradually tapers backwards to a fine point. Its lower border is bounded by a series of three plate-like, lenticular bones, which form a series in front of the angular element (Ag), and are termed infra dentaries. The inner wall of the ramus is formed by a thin sphenial lamina, and between this and the dentary is a series of three or four stout lenticular bones, the laniaries. (~~Pl. XVIII. and~~ Pl. XIX., Fig. B.)

DENTITION.—*Upper.* The pre-maxillæ and vomerine bones bear within and close to either outer extremity a large tooth, and on each side of the middle line in front is a similarly socketed large tooth. The small marginal teeth are continuous with two curved rows of equally small teeth which pass in front of the outer tusks, and curving inwards, meet in the middle line anterior to the basilar bar, whose surface is closely set with fine denticles.* Behind, on either side, are two palatine bones, which seem to be wedged in between the maxillæ and pterygoid bones. Each plate bears a marginal row of short, stout, conical teeth,

* Young, op. cit., p. 605.

the rest of the surface being set with similar but smaller teeth, which are more distant over the anterior portion of the bone, but posteriorly pass into a dense rasp of minute denticles. Outside these the edges of the maxillæ are set with small, conical teeth, continuous in front with those on the edge of the premaxillæ.

Lower dentition.—The outer edge of the dentary bone of the mandible bears a row of small, conical teeth. Within these are four large, strong, conical teeth, which are distantly placed. The anterior one is the largest, and is firmly socketed in the thickened symphisial extremity of the dentary bone, the others lie *within* the edge of the dentary bone, and are attached to the series of laniary bones (Pl. XVIII.). The edge of the sphenial bone also bears numerous rasp-like teeth.

From the above it will be seen that the dentition is that of a predatory fish.

TEETH.—*External characters.* They are round in transverse section, conical, more or less curved, bases plicated, and many are covered with very fine striæ, which merely involves the outer portion of the enamel (Young, Davis). These lines are sometimes parallel or anastomose to form a fine reticulation.

Internal characters.—The walls of the teeth are infolded, the folding being simple at the commencement of the external fluting, but as we pass towards the root the folds become wonderfully beautiful and complex, but the vertical tubes formed by the infolding never form such an interlacing network as in the Dendrodont type (Dr. Traquair).*

The gill flap, anteriorly and inferiorly, is completed by a series of bony plates, the jugulars, which lie between the mandibular rami, and which, together with the infraclavicular bones which lie along their posterior border, cover in and protect the underlying branchial arches.

In the centre are two elongated plates, the principal jugulars (P.J.). They are broader behind than in front; their posterior

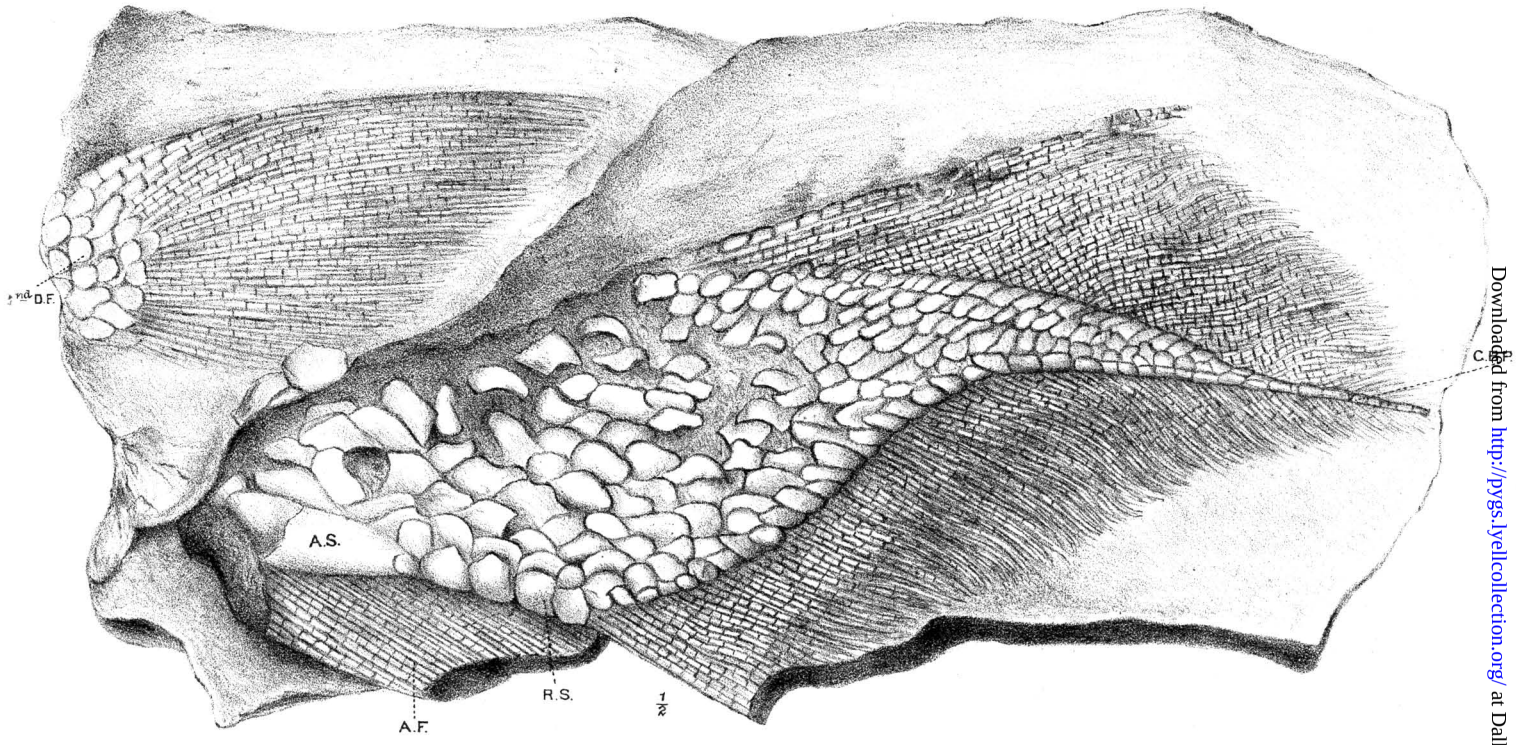
* Geo. Mag., Dec. III., Vol. VIII., No. 321, p. 123. 1891.

end is rounded, the anterior truncated. Behind the symphysis of the mandible, and between, and partly overlapped by, the anterior ends of the principal jugulars, is a well-marked azygos plate, the medial jugular (M.J.). On each side are a series of well-marked lateral jugulars (L.J.), which increase in size from before backwards; they run along the inner sides of the mandibular rami, and extend some little distance behind the posterior border of the principal jugulars. There are probably nine of these plates on each side. (Pl. XIV.)

Conclusion.—(Pl. XIII.) The body of *Megalichthys* was much elongated, somewhat rounded, and covered with rhomboidal ganoine-covered scales, arranged in sigmoidal rows, running from above downwards and slightly backwards.

The head is long (about one-fifth length of body), broad, and depressed, all the external bones being covered with a dense layer of ganoine. Cranial roof is covered with well-developed bony plates, which form a compact shield divisible into an anterior and a posterior moiety. The nares are placed on each side of the rounded, depressed snout. The orbit is anteriorly placed, being at the junction of the anterior and posterior third of the head, and is bounded in front, below, and behind by well-developed bones. Behind, the cheek is covered by a series of loose dermal bones. The opercular bones are well marked. The jaws are powerful and well developed, the gape extending far back. There are teeth of two sizes on the jaws, the large ones being internal. Small, numerous, rasp-like denticular teeth were also present on the well-developed membrane bones of the mouth and on the edge of the sphenial. Between the mandibular rami the branchial apparatus is defended by a series of jugular plates, there being two principal, one median, and nine lateral plates on each side. The vertebral column is well developed, there being well-ossified ring-shaped centra, neural and hæmal arches. Neural spines were present, and in the posterior part of the fish hæmal also.

The shoulder girdle well developed; paired fins obtusely obate and fulcrate, the ventral being abdominal in position.



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There are two dorsal fins, the second being the larger and more powerful; the first rises at a point about equal to five-eighths the total length of the fish, measuring from the snout, the second being about three-sixteenths further back; the first is opposed to the ventral and the second to the anal fin, which is smaller than the others and more lanceolate in shape, and is situated close to the origin of the caudal fin. All these fins are lobate, the lobe being more acute than that of the paired fins, and well-marked fulcral scales are also present. The caudal fin is powerful, and intermediate in type between the diphycercal and heterocercal stages; its posterior margin slopes obliquely upwards and backwards, and the majority of the dermal rays spring from the under side of the body prolongation. The fish was evidently very powerful, and of predaceous habits.

NOTE.—The proportions of certain of the bones of the head vary, as shown in the following table:—

	Parietal Division of Cranial Roof.	Maxilla.	Mandible.
M. Hibberti Ag.	Longer than the Fronto-Ethmoidal division.	Three times as long as greatest depth.	Five times as long as deep.
,, *intermedius* A.S.W.	Do.	Posterior expansion deep.	Do.
,, *pygmæus* Tr. ...	?	?	Three and a half times as long as deep.
,, *laticeps* Tr. ...	Shorter than the Fronto-Ethmoidal division.	More than four times as long as deep.	Do.

Before concluding this paper I must acknowledge, with warmest thanks, the great obligation I am under to the following gentlemen for the privilege of examining the specimens under their care, viz., Dr. R. H. Traquair, F.R.S., Mr. A. Smith Woodward, F.G.S., Dr. C. B. Crampton (Owens College), Mr. Crowther (Leeds Museum), and Mr. Rowe (Brighouse).

Explanation of Plates.

Throughout the plates the same letters apply to the same bones or parts of the fish.

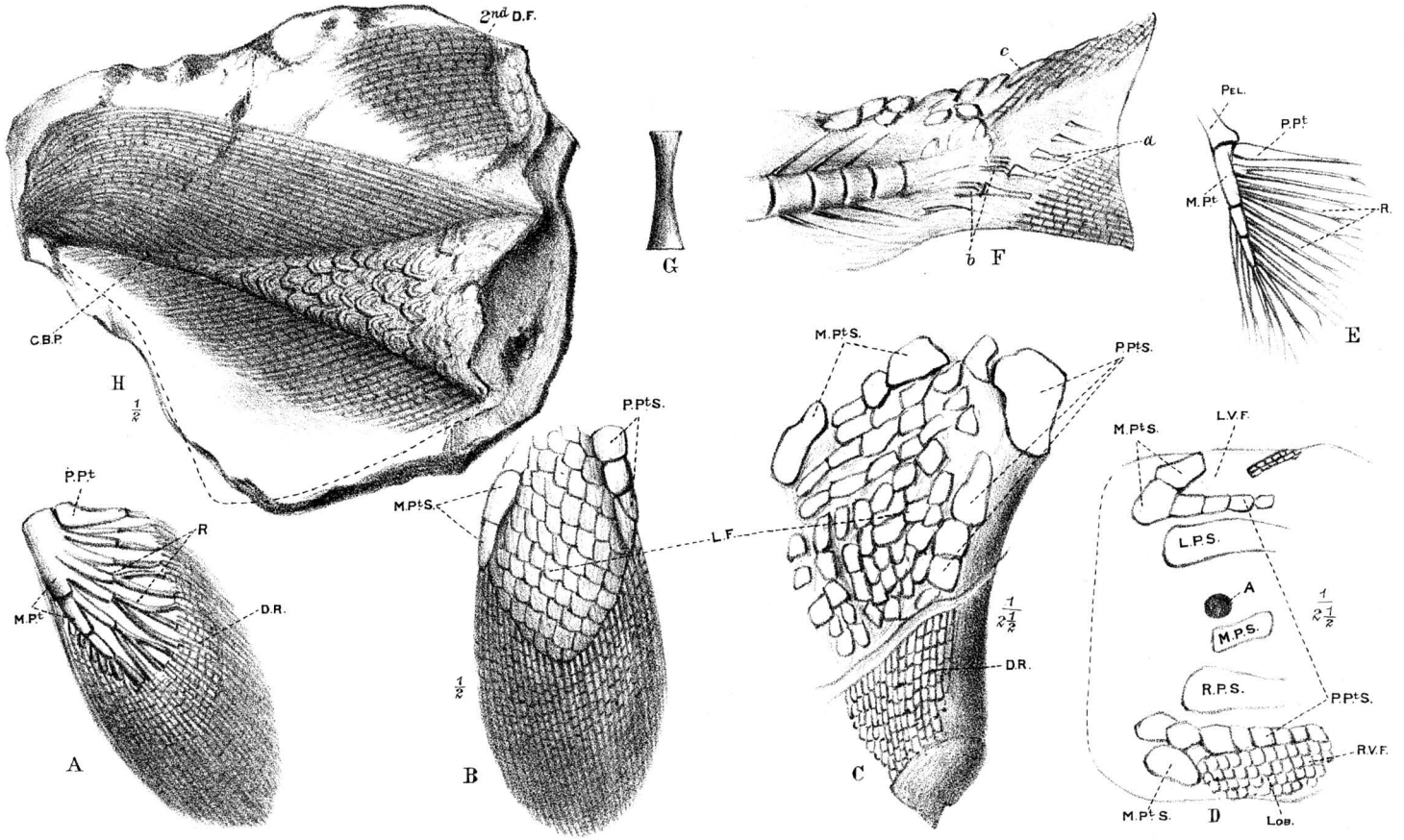
Head Bones, &c.

ST.	Supratemporals.	P.Op.	Pre-operculum.
Pa.	Parietals.	Op.	Operculum.
Fr.	Frontals.	S.Op.	Sub-operculum.
Sq.	Squamosal.	PMx.	Premaxilla.
P.F.	Posterior Frontal.	Mx.	Maxilla.
E.	Ethmoidal.	D.	Dentary.
N.	Nasal.	ID.	Infradentaries.
Na.	Nares.	Ag.	Angular.
A.F.	Anterior or Prefrontal.	L.J.	Lateral Jugulars.
A.O.	Anterior orbital.	J.	Jugulars (principal).
S.O.	Sub-orbital.	S.Cl.	Supra-clavicular,
S.O^1.	Supra orbital.	Cl.	Clavicle.
P.O.	Post orbital.	I.Cl.	Infra-clavicular.
O.	Orbit.	Az.J.	Azygos Jugular.
X & X^1.	Cheek plates.		

Parts of Body, &c.

L.L.	Lateral line.	
P.F.	Pectoral fin.	
V.F.	Ventral fin.	
A.F.	Anal fin.	
1st D.F.	1st Dorsal fin.	
2nd D.F.	2nd Dorsal fin.	
C.F.	Caudal fin.	
B.S.	Basal scales.	
R.S.	Ridge scales.	
F.S.	Fulcral scales.	
P.S.	Pelvic scales.	L.P.S. Lateral pelvic scales. M.P.S. Medial pelvic scales.
A.S.	Anal scales.	

Proc. Yorks. Geol. and Polytec. Soc., Vol.XIV., Pl.XVII.



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A.	Anus.
MPt. S.	Metapterygial or preaxial scales.
MPt.	Metapterygium.
P.Pt. S.	Propterygial or post-axial scales.
PPt.	Propterygium.
C.B.P.	Caudal body prolongation.
L.F.	Lobe of fin.
R.	Radials.
D.R.	Dermal rays.
Pel.	Pelvis.

Plate XIII.

Restored figure of *Megalichthys* Ag. From specimens in the Leeds, Science and Art, Edinburgh, Owens College, and Brighouse Museums, the author's, and other collections.

Plate XIV.

Specimen of *Megalichthys Hibberti* Agassiz. Ventral surface shown, one-sixth natural size. Leeds Museum (after Prof. Miall, F.R.S., slightly altered).

Plate XV.

A. *Megalichthys Hibberti* Agassiz (type). Skull seen from the upper surface. Leeds Museum.

B. *M. Hibberti* Ag. Diagrammatic representation of the bones of the fronto-ethmoidal and orbital regions, and also premaxillæ and maxillæ.

C. *M.* (*maxillaris*) *Hibberti* Ag. Skull, lateral view. Leeds Museum.

Plate XVI.

M. Hibberti Agassiz. Caudal region, the body prolongation into the caudal fins being beautifully shown. Second dorsal and basal portion of anal fins also seen. Brighouse Museum.

Plate XVII.

A. Diagrammatic representation of the internal skeleton of the pectoral fin of *Megalichthys*.

B. *M. Hibberti* Ag. Pectoral fin. Science and Art Museum, Edinburgh.

C. *M. Hibberti* Ag. Left pectoral fin of the specimen figured on Plate II. Leeds Museum.

D. *M. Hibberti* Ag. Anal region, showing anus, pelvic scales, basal portions of ventral fins.

E. *Megalichthys*. Diagrammatic representation of the skeleton of the lobe of the ventral fin. The distal end of the pelvis also shown (Pel.).

F. *Megalichthys Hibberti* Agassiz (No. 38,007, type, British Museum). Caudal fin showing portions of the internal skeleton. S.O.—Supporting ossicles (axonosts).

G. Supporting ossicle of caudal fin of *Megalichthys Hibberti* Ag.

H. *M.* (*Rhomboptichius*) *intermedius* A. S. Woodward. Caudal fin, Owens College Museum, Manchester.

Plate XVIII.

M. intermedius? A. S. Woodward. Mandible seen from the inner side, the splenial bone being absent. S.Mp.—Symphysis of mandible (dentary bone of). S.L.—Symphysical laniary tooth. L.T. 2 and L.T. 3.—Second and third laniary teeth. S.T.—Small tooth from edge of dentary bone. L.B. 1 and L.B. 2.—First and second laniary bones. ID.—Infradentary. Specimen in the Brighouse Museum.

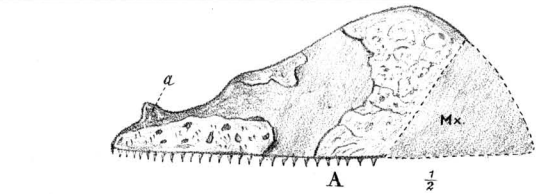
Plate XIX.

A. *M. Hibberti* Ag. Maxilla (Author's Collection), showing the anterior articular projection (*a*).

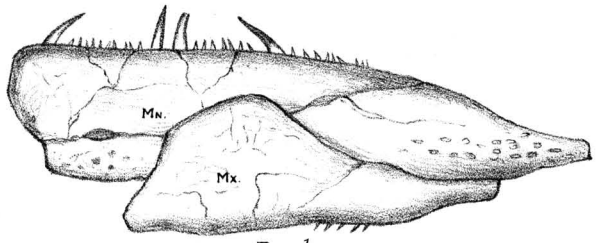
B. ,, ,, Mandible and maxilla. Author's collection.

C. ,, ,, Clavicle. British Museum.

D. ,, ,, Infra-clavicular. Author's collection.



A $\frac{1}{2}$



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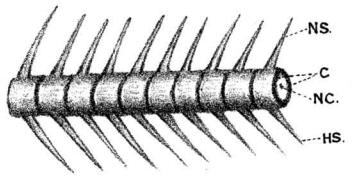

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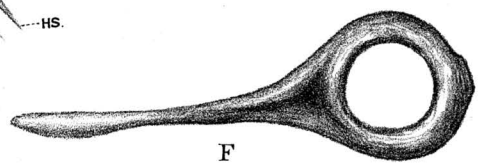

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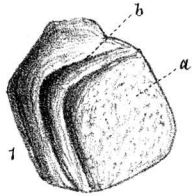

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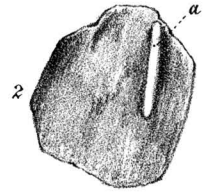
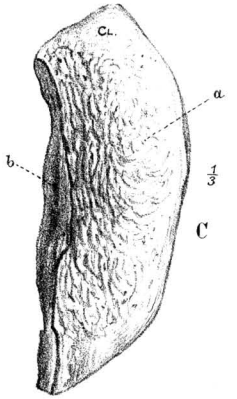
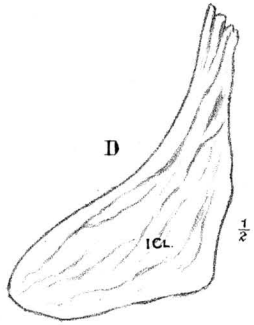




$\frac{1}{3}$ C



$\frac{1}{2}$

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E. *M. Hibberti* Ag. Portion of vertebral column. N.C.—Notochordal interspace. C. — Centra. N.S. — Neural, and H.S., hæmal spines. Science and Art Museum, Edinburgh.

F. *M.* (*Rhomboptychius*) *intermedius* A. S. W. Vertebra with spinous proces. Author's collection.

G. *M. Hibberti* Ag. Scales. 1. Superior surface. (*a*) Ganoine-covered exposed portion. (*b*) Covered area showing groove. 2. Inferior surface. (*a*) Bos. Author's collection.

NOTE.—When not mentioned otherwise, the specimens are figured natural size.