ON THE CHARACTERS OF SOME PALEOZOIC FISHES.

BY

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(With Plates XXVIII—XXVIII.)

I.—ON A NEW ELASMOBRANCH FROM THE PERMIAN.

Styptobasis knightiana Cope. Gen. et sp. nov. Fig. 1.

CHAR. GEN: The single tooth which represents this genus has an elongate compressed crown with two opposite simple cutting edges. Both faces are convex, the one much more so than the other. No lateral processes or denticles. The most remarkable peculiarity is in the root; it is very small, having no greater width than the crown, and contracting from the base of the crown to a truncate termination but a little distance removed from the former.

The crown of the tooth resembles that of an Oxyrhina, but the root is totally different. In this respect it resembles a Dendrodus.

CHAR. SPECIF.: Cutting edges of tooth continued to base of crown. Surface of crown everywhere smooth. Truncate extremity of root a crescent with obliquely truncate horns with coarsely rugose surface. Where the cutting edges are vertical their surface is below the more convex side of the crown. The root has a lateral edge at each side, which extends obliquely from below the cutting edge to the lateral angle of the truncate base, and is marked off from the base of the crown by a constriction. The base of the crown is openly emarginate by an angle of this constriction. On each side of this emargination the surface is transversely wrinkled. On the same side the root is similarly wrinkled; on the opposite side the wrinkling is less distinctly transverse.

Measurements.

	Millimeters.
Total elevation of tooth	.025
Elevation of crown	.020
Diameters of crown above base:	
Longitudinal	.011
Transverse	.005
Diameter of root:	
Longitudinal	.012
Transverse	.006

If this species be a Cladodont shark, which is quite possible, it agrees with Lambdodus St. J. and W. in its single simple crown, but that genus has a widely expanded horizontal root, thus differing generically from Styptobasis.

The *Styptobasis knightiana* was found by Mr. Wilbur C. Knight (to whom I dedicate the species with much pleasure), in what he determines as the Permian formation in eastern Nebraska. It was a large shark of carnivorous habits, and its presence indicates the existence of a marine fauna whose remains have not yet been discovered.

II.—On New Ichthyodorulites.

Hybodus regularis, sp. nov. Fig. 2.

Dorsal spine elongate, gently curved to the apex from the middle. Anterior border rounded, posterior rather broadly truncate, the latter fissured to two-fifths the length of the spine from the base, and two and two-thirds times as far from the base as the commencement of the anterior sculpture. The sculpture of the sides descends to opposite the middle of the posterior fissure. Thus the naked inserted portion of the spine is relatively short, and the sculptured portion is long. The latter is also nearly plane. The sculptures consist of longitudinal ribs, which are similar on the front and sides of the spine. Their interspaces or grooves are as wide as the ridges on the front and the anterior half of the spine, but they become narrower on the posterior half, while the ridges are scarcely narrower. The latter are everywhere regular, and do not inosculate, but run out successively toward the extremity on the posterior side. Eight ridges may be counted on the side at the middle of the length and thirteen near the base. Bottoms of the grooves smooth. There is a wide smooth band of surface on each side of the series of teeth, which is separated by an obtuse angle from the lateral face. The teeth are small, acute, and directed downward. They form two approximated rows, the teeth of one row alternating with those of the other.

Measurements.

	Millimeters.
Total length (10 millimeters added for apex)	290
Length of smooth base in front	48
Length of posterior fissure	129
Diameters at middle of fissure—	
Anteroposterior	23
Transverse	14
Diameter (anteroposterior) at middle of length	23
Between apices of teeth of one row	10

The fine specimen on which this species is based was obtained by Jacob Boll from a soft Mesozoic limestone in Baylor County, Texas, which is probably of Triassic age. The species approaches most nearly the *Hybodus major* of Agassiz, from the Muschelkalk. In that species the teeth are stated to be mere tubercles, which is not the case in this species.

Ctenacanthus amblyxiphias, sp. nov. Fig. 3.

Spine elongate, but little curved, moderately compressed; the posterior face with a flat median plane bounded by a shallow groove on each side. The ridges are wider than their interspaces, and they gradually become smaller posteriorly, so as to be half the diameter of the anterior ribs. The anterior border consists of a single rib of twice the diameter of the largest lateral ribs. Its front surface is smooth; the sides are marked with shallow grooves directed downward, and the border is serrate with subacute tubercles, which point backward. The tubercles of the ribs are closely placed and vary from round to transverse in shape, and have a finely grooved surface. The line of the posterior hooks is flush with the sides of the spine. They are small, decurved, and subacute.

The apex of the spine is wanting, so I can not give its length with certainty. It was probably about 10½ inches. Measurements: Length of fragment, 190 millimeters; length of base presented (at front), 42 millimeters; diameters at middle, anteroposterior, 28 millimeters; transverse, 17 millimeters; transverse diameter of spine 140 millimeters, from base of fore surface 11 millimeters.

The Permian formation of Texas; W. F. Cummins.

III.—On the Cranial Structure of Macropetalichthys.

The typical specimen of the *Macropetalichthys rapheidolabis* Owen remains one of the best for the elucidation of the type of fishes which it represents, although it is very imperfect. It has the advantage of having lost most of the surface of the cranial ossification, so that its true structure is the more easily determined. The cavities of the cranium are occupied by the Corniferous limestone, which formation is its proper horizon, and one of the orbits contains a characteristic brachiopodous mollusc. The extremity of the muzzle is broken away obliquely, and the (?) maxillary region of the right side is lost. The matrix has been split from the inferior surface so as to show much of the structure of the latter.

The orbits are much in advance of the line dividing the superior head-shield transversely into equal halves. There are no distinct indications of the existence of hyomandibular supports of a lower jaw. There are unsymmetrical transverse sections of hollow rods, which form areas immediately behind the position of the orbit on the inferior fractured surface of the specimen. The fractured surfaces are suboval, and have different directions of their long axes, owing probably to different directions of pressure. This they would be liable to from the extreme tenuity of their walls. It is probable that this genus had a lower jaw. As to the upper jaw, this was probably present also, but whether it belongs to the palatopterygoid arch or to the maxillary can not be stated. Its presence is indicated by the longitudinal transversely concave inferior surface of the element called jugal below. This articular surface might have supported some form of tooth, but as no such have been found associated with the rather abundant remains of Macropetalichthys, it is more probable that a distinct element was attached to this surface.

As is well known, the superior surface of the head-shield is divided into symmetrical tracts by well-marked lines. These areas have been regarded as the osseous cranial elements, and have been named by Newberry in correspondence with those of higher vertebrata.* The lines referred to, however, are not sutures, but tubes which belong to the lateral line system; and they traverse the centers of the true bony elements instead of bounding them. They join at the centers of some of the elements, and in such cases mark the points of origin of the osseous radii, whose direction they follow. The direction of these tubes is as follows in the present species, and approximately in all the other members of the genus: In the first place there is a frontal lyra, whose branches are parallel for a distance in front of the orbits (as far as the specimen is preserved), and which begin to converge at a point a little in front of the anterior border of the orbit. They join on the middle line about half an orbit's diameter behind the line connecting the posterior borders of the same. From this point they diverge at an angle a little greater than 90 degrees to a point immediately behind the superior border of the orbit, and nearly two orbits' diameter posterior to the latter. From this point two lines diverge, one toward the externo-posterior angle of the skull, the other downwards and forwards at an angle a little over 90 degrees from the other branch. The lines are all perfectly straight except those of the lyra, which are bent just in front of the anterior border of the orbits. That these lines represent tubes is readily seen where they are broken across. That of the lyra has a subtriangular section. Below it, in front of the orbit, is a smaller one of round section which the fracture of one side enables me to trace as far as opposite the anterior border of the orbit.

In their distribution these tubes do not nearly resemble those of Homosteus as represented by Traquair.† A closer resemblance can be traced to those of Coccosteus‡, of Dinichthys, and especially to those of Titanichthys.§ The lateral branches of the frontal lyra unite posteriorly at an angle in *Dinichthys terrellii*, are slightly separated by a transverse tube in *Titanichthys agassizii*, and are more widely separated in *Coccosteus decipiens*. In all three, divergent branches extend posteriorly, as in Macropetalichthys. In the three forms mentioned, these posterior branches send, anteriorly and exteriorly, a branch from a point close to the posterior border of the skull, on each side. This mar-

* The Paleozoic Fishes of North America, 1890, p. 43.

† Geological Magazine, 1889, p. 1, pl. I.

‡ Traquair, *loc. cit.*

§ Newberry, *l. c.*, pls. I and III.

ginal tube sends a branch laterally to the external angle of the skull in all the genera mentioned, except in Macropetalichthys, where this point can not be demonstrated in my specimen, owing to the loss of the border. Still more anteriorly on the postorbital bone it diverges again, sending a short branch inward and one forwards in Coccosteus and Titanichthys. In *Dinichthys terrellii* it does not divide, but continues, and joins the lateral tube of the lyra. In both Coccosteus and Macropetalichthys the transverse branch extends towards the middle line. In the former it unites with that of the opposite side, and forms at its middle portion, the posterior border of the lyra. In Macropetalichthys on the other hand, it joins the posterior tube at an angle well behind the extremity of the lyra as already described. Thus the last-named genus resembles Coccosteus in this one point more than it does any of the other Arthrodira. (Fig. 6.)

The cranial segments discernible are as follows. They may be readily traced on the specimen, since the sculptured surface and indeed the greater part of the bone-substances have disappeared, and the cast of the inferior surface is distinctly preserved. This surface, is however, wanting from most of the top of the muzzle, so that the relations of the ethmoid elements can not be made out. From the middle of the superior border of the orbits forwards extends an element which is prefrontal or frontal; but which one the injury to the top of the muzzle does not permit me to determine. It extends down on each side of the muzzle in front of the orbit. At the anterior border of the latter, it is pierced upwards and forwards by a deep notch-like groove which receives a corresponding wedgelike anterosuperior extremity of the element which I call provisionally the jugal or malar element. This bone extends below and behind the orbit, containing in the latter region a center of radiating ossification. The median or (?) frontoparietal element encroaches on the median element of the top of the muzzle as far forwards as opposite the middle of the orbits by a convex anterior border. Its ossification radiates from the junction of the lateral branches of the lyra, in all directions, and, while its anterior and lateral borders are easily discernible, its posterior ones are not so clear. It probably extends to a point half way between its anterior border and the posterior border of the head-shield. The posterior section of the prefrontal extends obliquely backwards and is succeeded by a wide longitudinally oval element, which from its position might be termed a postfrontal, although it includes within itself the region of the postorbital. Posterior to it is a subdiscoid element of similar size, and a little wider than long, which is in the position of the supratemporal element of the Stegocephalous skull. Its center is the point of divergence of three tubes already described, and its ossification radiates from the same point. Exterior to this element and the one in front of it, and joining the posterior face of the malar is a large area in the position of the Stegocephalous squamosal element. Ossification radiates from the posterior lateral angles of the head-shield, and there are two lines which penetrate the matrix more deeply than the rest. I can not make out that any canal radiates from this point except the one which reaches to the center of the supratemporal. This region corresponds to that of the intercalary of the fishes, but its boundaries I can not make out.

This arrangement of cranial elements may be compared with those of Coccosteus and Homosteus. It differs from the former in the presence of a malar bone bounding the orbit below, and in the presence of the "squamosal" behind it. In Homosteus, elements which occupy the position of the two mentioned are present (Traquair, *l. c.*), but they are called by Traquair postorbital and marginal, names which he applies to my possible postorbital and supratemporal. I think the elements described by Traquair are homologous with the malar and squamosal of Macropetalichthys, so that the "postorbital" (my postfrontal) and "marginal" (my supratemporal) must be sought for elsewhere in Homosteus. Traquair's "central" appears, from its position, to include my postfrontal, while the supratemporal may be embraced in the anterior part of Traquair's "external occipital." This question can, however, only be settled by the discovery of intermediate types. In any case, a general affinity to the Arthrodira is indicated by the segmental structure of the skull, as well as by the character of the tubes of the lateral line system.

The inferior surface of the skull presents the following characters. This is important, as I do not know of any description of this region in an Arthrodire, excepting in the cases of the Dinichthys and Titanichthys described by Newberry. (Fig. 6.)

In the first place the posterior part of the head-shield, the "median occipital" region of Traquair, is produced very far posteriorly, as in Homosteus. This region does not seem to have protected the brain, but rather the anterior part of the vertebral axis, and seems to have been a nuchal plate. In the specimen I am now describing, the posterior extremity of this element is broken away for a short distance on both sides of the middle line, revealing a cast of its interior. This is bilobate, by reason of a vertical constriction at the middle line. That this is not a cast of the cranial cavity is proven not only by its form, but by the fact that there is no cast representing a *medulla oblongata* or a *foramen magnum.* The chamber was absolutely closed posteriorly. The lateroposterior angle of this cavity is exposed by the loss of the external wall. It is obtusely angular. Turning now to the inferior aspect of the skull, we observed, at the middle line of the inferior-posterior border, a wide, upward excavation, looking backwards and downwards. It rapidly contracts into a groove with an angular superior middle line. Whether this groove is part of a tube can not be ascertained, owing to the loss of the bony tissue on each side and below, but it may be only the apical angle of a roof-shaped space, whose lateral slopes are produced on each side, sloping well downwards and outwards. These sloping faces of the matrix represent a pair of osseous plates, which descended on each side from the sheath of the myelon and chorda dorsalis, for the latter occupied this position in the groove already described. Such a structure would indicate the presence of a number of fixed vertebral elements, such as exists in the chimaeras, the rays, and the sturgeons. The two-thirds of the inferior face of the skull which lies in front of this groove is covered by a single thin plate, which may be the parasphenoid. Its posterior border reaches to the anterior extremity of the roof-shaped descending plates already described, and, joining them by a rounded angle, turns downwards and outwards, the descending portion sloping forwards into the horizontal portion. Where it joins the descending plates of the axis there are three grooves on each side, which are separated by two ribs. At the point of junction of the parasphenoid with the lateral alae of the axis, is situated what I suppose to be the foramen magnum. It is the direct continuation of the groove already described, and, being floored by the parasphenoid, has a triangular section. There is no trace here of a fossa for the chorda dorsalis, nor of an occipital condyle, nor is it probable that either existed at this point. The parasphenoid is thin, and there are no indications of teeth to be observed on it.

For the opportunity of studying this specimen I am greatly indebted to Prof. J. W. Spencer, of the University of Missouri, and to the late president of that institution, Prof. S. S. Laws, who lent it to me out of their museum.

I here describe the characters presented by another specimen of Macropetalichthys which belongs to the geological museum of the State of Ohio, and which was kindly lent me by the director of the survey, Prof. Edward Orton. This specimen is broken transversely across the median part of the area which includes the median occipital plate, showing that the posterior part of that area is a distinct element separated from it by suture. I call it therefore the median nuchal plate, and the two angular elements on each side of the posterior region, which are also shown to be distinct, I call the lateral nuchal elements. One of these is wanting in the specimen, showing that its junction with the median element is by a smooth squamosal suture. The anterior face of the nuchal mass has a vertical groove on the middle line which fits a corresponding keel of the cranium proper. The triangular foramen magnum issues at the inferior extremity of this keel; at the lateral extremity of this occipitonuchal suture under the free lateral margin of the skull is a fossa, one-half of which is in the cranium and one-half in the nuchal element. This looks like an articular glenoid cavity, possibly for the condyle of a mandible. It is bounded posteriorly by a transverse crest, posterior to which is the extensive longitudinal fossa beneath the free border of the nuchal plate. There is a small fossa on the middle line 26 millimeters in front of the occipitonuchal suture, in the parasphenoid bone. The anterior part of the skull is better preserved than in the skull of the *M. rapheidolabis* first described. The borders of the muzzle are bounded on each side by a shallow longitudinal fossa, which looks outward and downward. Each is bounded on the inner inferior side by a longitudinal crest which looks downwards and extends backwards and outwards. The palate between these ridges is concave from side to side. The median portion is filled with matrix so that the surface and its relations with the parasphenoid can not be seen. The lateral ridges are continued to below the orbit. In front of the supposed glenoid fossa is another longitudinally oval fossa below the edge of the skull. The chordal groove and the laminar plates descending on each side of it are as in the specimen first described.

The lateral nuchal element is separated from the median, so as to show that the latter has an approximately semicircular outline when seen from above. Viewed from behind, the nuchal element displays an obtuse median vertical keel with a shallow fossa on each side, bounded by an angle on each side at the superior margin, but fading out below. The vertical diameter is considerably greater relatively than in the *M. rapheidolabis*. I suspect that the specimen belongs to the *M. sullivantii* Newb.

Returning to the *M. rapheidolabis* I observe that the anterior borders of the descending axial alæ are about opposite to the lateral center of radiation of the lateral line tubes, or the center of the so-called supratemporal bone. Below the anterior border of the orbit, on each side of the middle line, about 7 centimetres apart, is a pair of medium-sized round foramina. Exterior to these, a little anteriorly, at double the space between the two median foramina, is another pair of foramina of oval section, which look outward, forward, and downward. The bony wall of the neural canal, already described, is quite thick.

There is no trace of pineal foramen such as is described by Newberry in Dinichthyidæ. The sclerotica was protected, but whether by a thin extension of the prefrontal and postfrontal bones or by a special ossification is not determinable. The impression only remains. A considerable fossa is inclosed between the descending axial plates and the lateral borders of the posterior part of the head-shield, which opens downward and outward. The sculpture of the surface of the skull is preserved in one or two places. It consists of round, flattened, rugose tubercles of a diameter of about 2 millimeters placed close together.

Affinities of Macropetalichthys and of the Arthrodira.—It has been shown by Agassiz that Coccosteus has a mandibular arch, and by Newberry that this region is present in the Dinichthyidæ. Traquair has also shown that in the former genus it is connected with the cranium by a suspensorium. Free elements beneath the anterior part of the head-shield have been demonstrated to exist in Homosteus by Traquair, which probably include a mandibular arch. The general resemblance of Macropetalichthys to the Arthrodira renders it almost certain that it possesses a lower jaw, and that it is a member of that order. I have included this order in the Crossopterygia with doubt * on the supposition that they possess a maxillary arch and suspensorium. The former is however not described so as to distinguish it from a palatopterygoid arch by authors, and no evidence of the existence of such an arch can be derived from American forms. Advance sheets of volume II of the Catalogue of Fossil Fishes in the British Museum, by A. Smith Woodward, show that this able authority places the Placodermata in the Dipnoi, thus indicating that they possess neither maxillary arch nor suspensorium.

There is much in the structure of the skull of Macropetalichthys to confirm this opinion. The nuchal portion of the structure with its lateral nuchal elements is represented by the cartilaginous mass which extends posterior to the median occipital bone in Ceratodus, in which this region has very much the form of the nuchal shield in Macropetalichthys, although it is relatively shorter. The chordal groove with its descending laminæ resembles much the produced occipital bone of Lepidosirem. The parasphenoid in both Lepidosirem and Ceratodus are produced posteriorly abnormally, and it is only necessary to imagine this part to be reduced to its normal length to have the conditions found in Macropetalichthys. The broad parasphenoid and vomer remind one of that of Ctenodus. As I have shown that Macropetalichthys is allied to Dinichthys, we can add in favor of the supposition of affinity to the Dipnoi the peculiar dentition of that genus. The ectetramerous † structure of the dorsal fin shown by Von Koenen and Traquair to exist in Coccosteus, and shown to be probably present in Dinichthys by Newberry, are in favor of the Dipnoan theory. Elements supposed to be the axial elements of pectoral fins are described by Dr. Newberry. These are simple and without lateral articulations, and are thus of the unibasal type which is general in Dipnoi as well as in some Crossopterygia and all Rhipidopterygia. They somewhat resemble those which I shall describe in this paper as characteristic of Megalichthys. It is on account of this part of the structure that the Arthrodira can not be arranged near to the sturgeons, where Macropetalichthys has been placed by Newberry and others, to say nothing of the cranial structure, which has no resemblance to that of those fishes.

I first referred Macropetalichthys to the Placodermata (Arthrodira) in a review of Professor Newberry's work on the Paleozoic Fishes of North America in the American Naturalist for September, 1890; and this view has been adopted by Mr. A. Smith Woodward as above mentioned.

Species of Macropetalichthys.—It is evident that the two crania which I have described in the preceding pages belong to two different species. The larger is the *M. rapheidolabis* of Owen, and the smaller the *M. sullivantii* Newberry. In the latter the nuchal element and its included

* Synopsis of the Families of the Vertebrata. American Naturalist, October, 1889.
† Cope, American Naturalist, 1890, p. 116.

chamber have a greater depth in proportion to the width and length of the skull than in the former. They may be characterized as follows:

Posterior nuchal depth $\frac{1}{5}$th width and $\frac{1}{6}$th length of skull above; *M. rapheidolabis;* fig. 4.

Posterior nuchal depth entering width behind $2\frac{1}{2}$ times and length $4\frac{3}{4}$ times; *M. sullivantii;* fig. 5.

The skull of the *M. sullivantii* is rather narrower than that of the *M. rapheidolabis.*

The half width at the foromam magnum enters the length to the anterior border of the lateral marginal fossa $3\frac{1}{2}$ times, while it enters but 3 times in the *M. rapheidolabis.*

IV—On the pectoral limb of the genus Holonema Newberry.

Described from fragmentary or single plates by Claypole and Newberry, the *Holonema rugosa* Claypole remained a vertebrate of uncertain affinities. At the meeting of the American Association for the Advancement of Science held at Indianapolis, August, 1890, Prof. H. S. Williams exhibited photographs of the posterior part of the carapace of a newly discovered specimen, which includes the greater part of the two median dorsal plates and the posterior laterals. The rounded posterior outline of the carapace is similar to that seen in Bothriolepis, and neither this nor any of the specimens described up to that time demonstrate the distinctness of this form from that genus.

In the collection of Mr. R. D. Lacoe, of Pittston, Pennsylvania, which that gentleman kindly placed at my disposal, there are specimens of this genus from Mansfield, Tioga County, Pennsylvania. The largest of these is a lateral plate of the plastron, partly represented by a very distinct mold of the matrix. It measures 190 millimetres in length and 105 millimetres in width. Besides this, there is a nearly complete pectoral spine, which is of much interest, as this part of the skeleton has not been previously known. (Fig. 7.)

This spine belongs to a smaller individual than any of those of the *Holonema rugosa* yet described, but until the range of dimensions of that species is known it will not be safe to regard it as representing another species. The range of size of the *Bothriolepis canadensis* is very considerable. The spine differs from that of both Bothriolepis and Pterichthys in being without complete segmentation. It is continuous throughout to the apex. This, then, will constitute the generic distinction so far known between Holonema and Bothoiolepis. The tissue of the spine is disposed in tesseræ, as in the other genera allied. A single series of three elongate narrow hexagons extends down the center of the external face, and the lower space is divided by sutures, which extend from the lateral angles of the hexagons to the border of the spine. The apex of the spine from the last hexagon, and for a length nearly equal to it, is not tessellated.

The spine is nearly straight and tapers symmetrically to an acute apex. The head is rounded and looks slightly inwards, and its surface is slightly produced inwards and backwards in a low free angle. The inner edge of the spine is armed with a row of tooth-like processes about twenty-two in number, which are directed backwards. There are no teeth on the external edge of the spine. The surface is thrown into rather coarse obtuse somewhat irregular longitudinal ridges, which inosculate more or less, and resemble in general that of the plate of the shell of the *Holonema rugosa*. Eight or nine ridges may be counted at the middle of the length of the spine. Length of spine 54 millimetres, width at base 11 millimetres, at middle 7 millimetres.

From Mansfield, Pennsylvania, collected by A. C. Sherwood for R. D. Lacoe.

V.—On the paired fins of Megalichthys nitidus Cope.*

This species was referred by me to a genus distinct from Megalichthys on account of the annular ossification of the vertebræ, those of the latter genus having been described by an English authority as amphicœlous. Dr. Traquair has, however, shown that the vertebræ of the *Megalichthys hibbertii* are annular, and specimens kindly sent me by Mr. John Ward, of Longton, Staffordshire, and identified as belonging to that genus, quite resemble those of the *M. nitidus*. I therefore provisionally, at least, withdraw the generic name which I conferred on the latter. It is not uncommon in the Permian bed of Texas. (Fig. 8.)

I have described the basis of the posterior part of the skull in this species and in the smaller *M. cicceronius* Cope,† and I can now give an account of the characters of the limbs. I am enabled to do this by making longitudinal sections of both anterior and posterior limbs of both sides of the fine specimen of the *M. nitidus*, which served as the type of my original description. (Fig. 9.)

The paired fins or limbs are of the "obtusely lobate" type according to Woodward, but approach those of the Arthrodira very distinctly. The general form is short for a fin of the unibasal type, as it is fusiform, terminating in a rather rapid acumination. The superior, exterior, and inferior faces are covered with small scales covered with ganoine, and the rays are confined to the internal edge. The axis of the pectoral fin consists of a single robust element, probably cartilaginous, but invested with a thin layer of dense bone. The interior structure is cellular, the cells of irregular amœbiform outlines, and surrounded by a distinct layer colored like the matrix, and not like the osseous tissue. This element extends to the extremity of one of the fins which has unfortunately lost its apex. On the other it disappears at three-fifths the distance from the base, owing probably to the obliquity of the section. On the in-

* *Ectosteorhachis nitidus* Cope. Proceed. Amer. Philos. Soc., 1880, p. 56.

† Loc. cit., 1883, p. 628.

ternal border of the fin on both sides short and undivided parallel rays diverge towards the body.

It is evident that this fin does not resemble that of Ceratodus, nor that of any of the unibasal fins of the distichous type. The axial element is not segmented, unless it be near to the extremity, nor is it branched. It supports simple rays alone, and these at the internal edge only.

The section of the ventral fin shows, like the pectoral fin, rays on the internal border, and also at the extremity. There are none on the external border, where the axial bones are close to the integument. The base of the pubis is exposed. The extremity is concavo-truncate, is coarsely cellular within, and is bounded by a thin external bony layer. Like the pectoral fin, the greater part of the ventral axis is occupied by a single element, which is rod-like, slightly constricted medially, and truncate at the extremities. The proximal extremity equals less than half of that of the pubis, but it constitutes the axis of the limb, as may be readily seen by reference to the external form of one of them. This fin is bent at this articulation, and is bent again at the extremity of the axial rod, beyond which the apex tapers rather rapidly. The section shows no second axial segment in the distal part of the main axis, but two pairs of nodules and distad of these two transverse rows of segments of three radii, more distal segments being lost. Those of the proximal row are longer than those of the distal one, and the external are the most robust. The structure resembles that of a Batrachian tarsus or carpus rather curiously; but this may be due to the position of fractures of the radii distad to the axial rod. Another cartilaginous, bony-sheathed segment appears in this fin, which is half the dimensions of the principal one and projects a little beyond it on its inner side, lying parallel to and close to it. It is followed, after an interspace, by seven radii which lie closely parallel, and soon terminate, probably owing to injury. Each is divided into two or three segments, but whether normally or abnormally can not be stated. There is no segment connecting this one with the pubis, but there is a rounded extremity of possibly a short stout segment opposite the extremity of the latter, within the proximal extremity of the principal axial segment. Whether this fin is unibasal or pluribasal remains therefore uncertain; but if there be more than one elemental axis, there are not more than two.

It remains therefore demonstrated that the fin structure in Megalichthys is very simple, and does not in the least resemble that of Polypterus on the one hand nor that of Ceratodus on the other. It seems to be intermediate in character between that of the latter genus and that of Pterichthys, or perhaps that of the imperfectly known Arthrodira.

VI.—ON THE NON-ACTINOPTERYGIAN TELEOSTOMI.

Material is not at present accessible in the United States from which to learn the structure of the median fins in the Holoptychiidæ and Osteolepididæ. In drawing up my synopsis of the Families of the Vertebrata, in 1889*, I assumed that these fins had the primitive structure, such as is found in the oldest members of the Teleostomi (Tarassiidæ), Dipnoi, and other subclasses, viz, that the axonosts are equal in number to, and continuous with, the neural spines of the Vertebrata. This definition threw the families in question into the Crossopterygia as distinguished from the Rhipidopterygia. In the latter the axonosts are much reduced in number, so that one or two fused into a single piece supports each dorsal and anal fin.

Professor Traquair has, however, stated that the dorsal fins of the Osteolepidæ are of the Rhipidopterygian type, and Mr. A. Smith Woodward, in vol. II of the Catalogue of Fossil Fishes in the British Museum,† confirms this statement, and shows that the Holoptychiidæ agree with them in this respect. He does not adopt the superorder Rhipidopterygia, but combines it with the Crossopterygia, and he places the families mentioned, together with the Rhizodontidæ, which is my Tristichopteridæ, in the order to which I referred the latter, the Rhipidistia. As regards this original reference, it is clearly necessary on the evidence brought forward by Traquair and by Woodward. I do not see, however, that the Rhipidopterygia can be properly combined with the Crossopterygia, since the structure of the median fins is radically different, and one which offers as good ground for superordinal distinction as do the paired fins offer ground for the separation of the Actinopterygia. The Tarassiidæ and the Polypteridæ possess the characters of the median fins which I viewed as characteristic of the Crossopterygia, while the paired fins, so far as can be discovered from the descriptions of the former,‡ indicate two distinct orders within it.

With this new information in our possession, it appears to me that the relations of these fishes are best expressed in the following way:

There are four superorders of the Teleostomi, or true fishes, which differ in the structure of the fins:

I. Median fins each with a single bone representing axonosts.
  Paired fins unibasal .... *Rhipidopterygia*
II. Median fins with numerous axonosts.
  Paired fins with baseosts; pectorals with axonosts, which are distinct from baseosts .... *Crossopterygia*
  Paired fins with baseosts; pectoral fins with axonosts and baseosts confounded; pluribasal .... *Podopterygia*
  Pectoral fins only with baseosts, these confounded with axonosts and pluribasal .... *Actinopterygia*

* American Naturalist, p. 856.
† L. c., 1891, p. 321.
‡ Smith Woodward, *l. c.* II., p. 317.

RHIPIDOPTERYGIA.

The orders of Rhipidopterygia are the following. They all have actinotrichia in place of fin-rays:

I. Paired fins with the basilars arranged on each side of the median axis, or archipterygial.
   Median fins with basilars .... *Taxistia*
II. Paired fins with the basilars arranged fan-shaped at the end of the short axis.
   Median fins with basilars .... *Rhipidistia*
   Median fins without, caudal fin with, basilars .... *Actinistia*

The Taxistia includes but one family, the Holoptychiidæ, which is of Devonic and Carbonic age. The Rhipidistia includes the Tristichopteridæ from the Devonic and Carbonic; the Osteolepidæ from the same, and possibly the Onychodontidæ, which are Devonic.

The Actinistia includes the single family of the Cœlacanthidæ, which appears in the Lower Carbonic and ranges to the Upper Cretacic in both Europe and America.

In all of the Rhipidopterygia the tail is either heterocercal or diphycercal and the chordadorsalis persists. The scales have a layer of ganoine, which extends also on the head. The latter has a well-defined persistent transverse suture separating the parietal from the frontal elements.

The *Crossopterygia* includes two orders, as follows:

Baseosts and axonosts well developed; actinotrichia; no fin rays; pectorals unibasal .... *Haplistia*
Baseosts rudimental; fin rays; pectorals tribasal .... *Cladistia*

But one family is included in the Haplistia, the Tarasiidæ, from the Lower Carbonic of Scotland. The Cladistia are represented by a family which is not known in the fossil state, the Polypteridæ of the rivers of Africa. The vertebræ in this genus are ossified and biconcave.

The *Podopterygia* has also two orders. They are thus defined:

Branchiostegal rays present .... *Lysopteri*
No branchiostegal rays .... *Chondrostei*

In these orders the notochord is persistent, and there are either actinotrichia or fin-rays which are more numerous than the baseosts. Tail heterocercal or diphycercal.

VII.—On new Species of Platysomidæ.

Platysomus palmaris sp. nov.

This species is represented by about a hundred fragments of bodies of various sizes, some of which include the scapular arch, but none the fins. All the fragments are covered with scales, and in a number of them the median line of the belly is preserved. In the scapular arch the character of the allied forms is observed in the presence of a closely fitting interclavicular bone which bounds the recurved inferior extremity of the clavicle on each side. The anterior face of the clavicle is expanded inwards below, so as to be wider than the external face, and its inner edge is in contact with the corresponding edge of the opposite clavicle, so as to inclose a short tube with the interclavicles. The scales of the inferior row differ from the others in having only half the diameters of the others, so that two scales are articulated to the inferior edge of each scale of the next to the bottom row. Each of these narrow vertical scales of the inferior row sends up an acute process which fits a corresponding pit in the scale of the row above it. This character resembles what is seen in the genus Benedenia Traquair in a general way. There are two such rows of scales in the type of that genus, *B. deneënsis* Traqu., and I can not make out from Traquair's figure and description whether they are longitudinally fissured or not. The figure represents vertical grooves, which may be sutures. The decision of this point must depend on further examination. I place this species provisionally in the genus Platysomus, but I do not find this character to be described in other species of the genus, according to the descriptions of authors.

The scale-series tend slightly backward from the vertical below, without distinct curvature. The scales on the sides in front are about five times as deep as long, and they graduate in size to the lowest undivided row, where they are about twice as deep as long. The small scales of the inferior row are twice as deep as long, and their depth is about half that of the scales of next series above them. The sculpture of the scales consists of narrow vertical ridges, which are curved slightly backwards below. About ten may be counted crossing a transverse line on each scale. Each of the narrow scales of the inferior row possesses a median angular keel which extends from the anterior edge downwards and backwards, but which does not reach the posterior edge of the scale. The external face of the clavicle is vertically striate like the scales, and horizontally striate on the recurved portion. The interclavicle has more distant longitudinal ridges, and one ridge on each side of the low median keel is broken up into enamel tubercles.

The body is acute below. This is always the case, whether the fragments are compressed or not.

Measurements.

	Mm.
Diameters of anterior median scale:	
Anteroposterior	2
Vertical	10
Diameters of lowest normal scale:	
Anteroposterior	3
Vertical	4
Depth of scale of inferior border (specimen No. 2)	2.5
Length of interclavicle (specimen No. 3)	10
Width of interclavicle in front (No. 3)	8
Diameter of interclavicular tube, transverse (No. 3)	7

From the Permian bed of the southern Indian Territory. Collected by W. T. Cummins.

I have been principally guided in the determination of this form by the monograph of the Platysomidæ published by Dr. Traquair, in the Transactions of the Royal Society of Edinburgh, vol. 29, p. 343. Dr. Traquair there demonstrates clearly that the Platysomidæ belong to the Lysopteri near to the Palæoniscidæ, and that they are not allied to the Dapediidæ.

Platysomus lacovianus sp. nov.

Radial formula: D. 28, C. 30, A. 25. Body deep, superior and inferior outlines very convex, superior convexity posterior to the inferior. Scales in nearly vertical series of few in a series, each scale with about nine closely placed parallel ridges. These are parallel to the sides of the scales in the lower and middle parts of the body, but on the superior regions they are directed forwards as well as downwards, being oblique to the long axis of the scale. The ventral border is furnished with a single series of scales with a free acute extremity, forming a serrate line. No such series is noticed on the dorsal outline. The head is badly preserved; the pterotic and post-frontal regions have a striate sculpture like that of the scales.

Measurements.

	Mm.
Length of specimen	37
Greatest depth of specimen	22
Length of base of dorsal fin	7

This species is probably allied to the *Platysomus circularis* M. & W.* In it the radial formula is given at D. 40, C. 30, A. 30. The scales are also said to be smooth. This may be an appearance only, due to the loss of the ganoine layer; but if correctly stated the scales are very different from those of the *P. lacovianus*.

The typical and only specimen of the *P. lacovianus* is preserved in the cabinet of Mr. R. D. Lacoe, of Pittston, Pennsylvania, to whom I am indebted for the opportunity of examining it. It is in a concretion from the Coal Measures of Mazon Creek, Illinois.

* Report of the Geological Survey of Illinois, p. 347, Pl. IV, Fig. 2.

EXPLANATION OF PLATES.

PLATE XXVIII.

Fig. 1. *Styptobasis knightiana* Cope, tooth natural size; fig. 4 base view.

Fig. 2. *Hybodus regularis* Cope, $\frac{1}{6}$, nat. size, left side; *a* section of middle of posterior groove; *b* is at middle of closed portion.

Fig. 3. *Ctenacanthus amblyxiphias* Cope, about $\frac{1}{2}$ nat. size; right side, both extremities lost; *a* front view; *b* section at open groove; *c* section at broken apex, $\frac{1}{3}$ nat. size.

PLATE XXIX.

Fig. 4. *Macropetalichthys rapheidolabis* N. O. & E. type; skull one-third nat. size; 1 from above; 2 from below; 3 posterior view. Lettering; *Pro* preorbital; *Pto* postorbital; *c* central; *sq* squamosal; *Sp* supratemporal; *Eo* exoccipital; *Mo* median occipital; *Mx* ? maxillary or malar; *Pas* parasphenoid; *nc* chordal canal.

PLATE XXX.

Fig. 5. *Macropetalichthys sullivantii* Newb., cranium, $\frac{1}{4}$ nat. size; 1 from below; 2 from behind; front of cranium proper from behind at suture with nuchal shield.

Fig. 7. *Holonema* sp. pectoral spine, nat. size.

PLATE XXXI.

Fig. 6. Diagrams of superior sides of head shields of Dinichthyidae. 1 *Dinichthys terellii* Newb., $\frac{1}{12}$ natural size, 2 *Titanichthys agassizii* Newb., $\frac{1}{14}$ nat. size; both from Newberry.

Fig. 11. *Platysomus lacovianus* Cope, $\frac{2}{3}$ nat. size; a vertical band of scales showing sculpture.

PLATE XXXII.

Fig. 8. *Megalichthys nitidus* Cope, type; about $\frac{1}{7}$ nat. size. Fig. 1 head and part of body from below; 2 head from above; 3 head from side; 4 head from front.

Fig. 9. *Megalichthys nitidus* Cope, sections of fins; 1 of left fore fin; 2 of right hind fin, both from below; nat. size.

PLATE XXXIII.

Fig. 10. *Platysomus palmaris* Cope, parts of 3 individuals, nat. size; *2a–b* inferior parts of plate band, from 2, enlarged; *3a–b* front and inferior views of scapular arch from 3, *cl* clavicle; *Icl* Inter-clavicle.

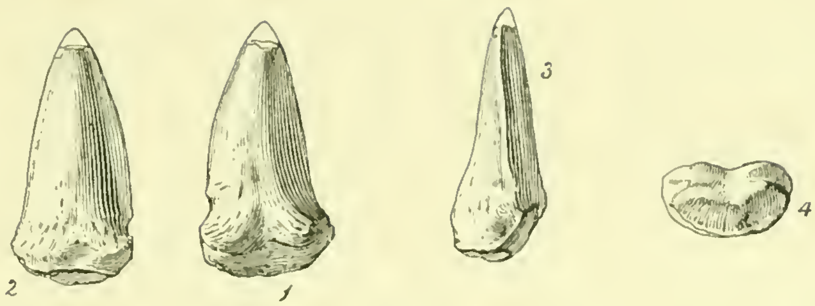


Fig. 1.

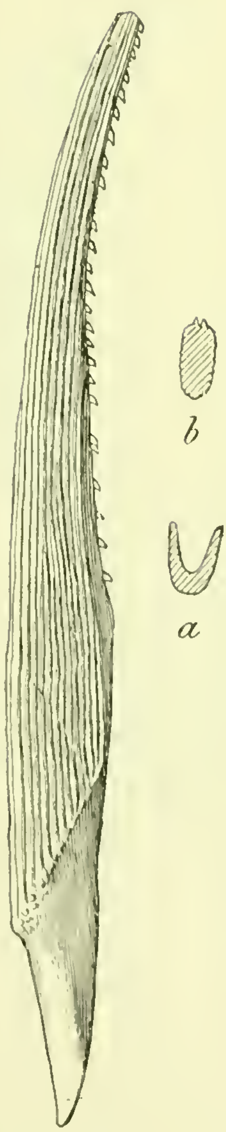


Fig. 2.

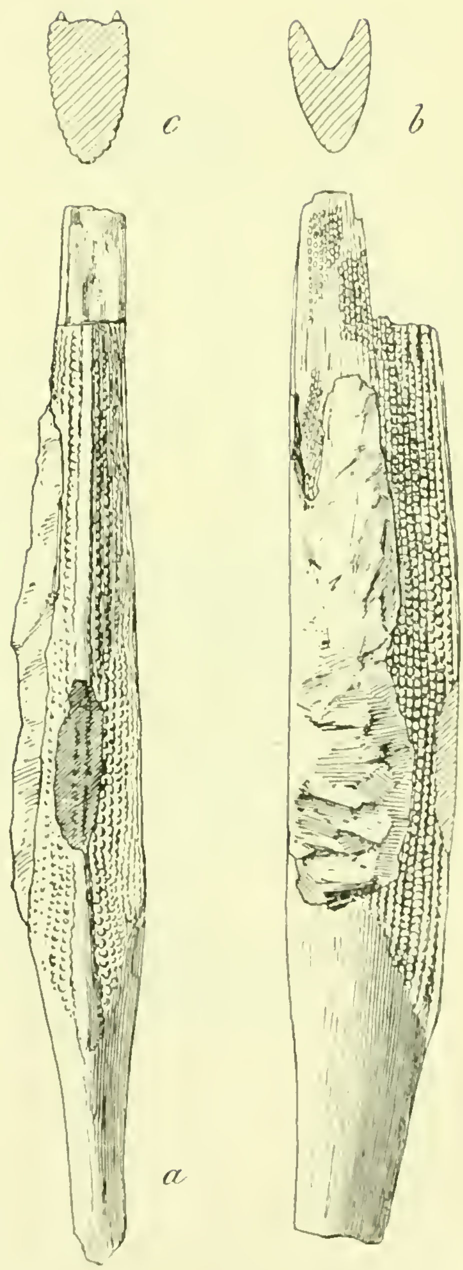
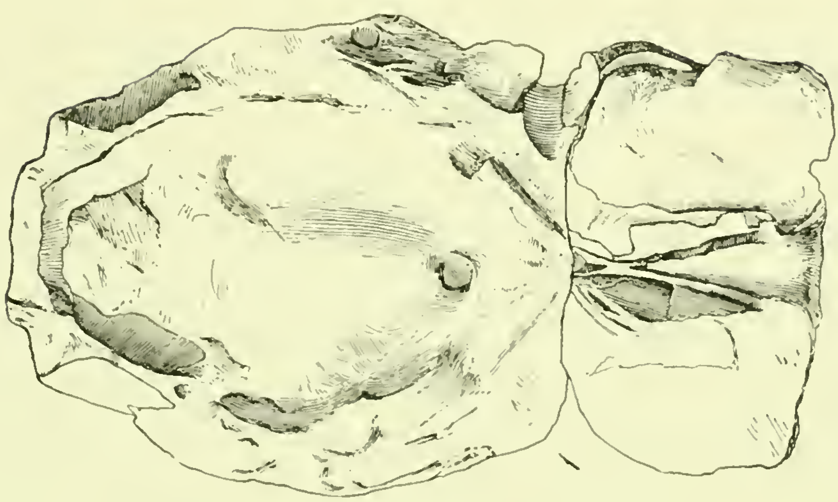


Fig. 3.

FIG. 1. *Styptobasis knightiana* Cope.
FIG. 2. *Hybodus regularis* Cope.
FIG. 3. *Ctenacanthus amblyxiphias* Cope.

FIG. 4. *Macropetalichthys rapheidolabis* N. O. & E.

Fig. 7.



3

Fig, 5.

2

Fig. 5. *Macropetalichthys sullivanti* Newb.
Fig. 7. *Holonema* sp.

Fig. 11.

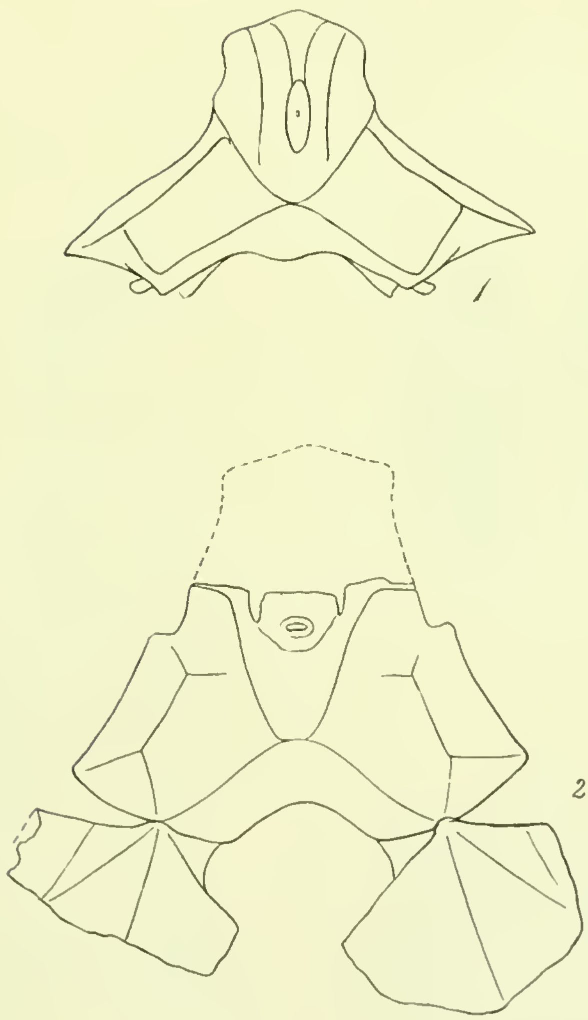


Fig. 6.

Fig. 6. (1) *Dinichthys*; (2) *Titanichthys*.
Fig. 11. *Platysomus lacovianus* Cope.

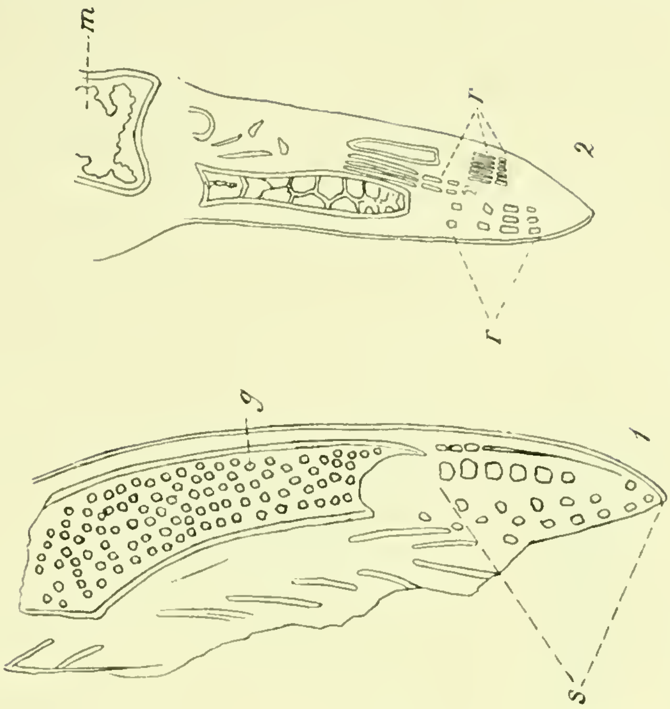


Fig. 9.

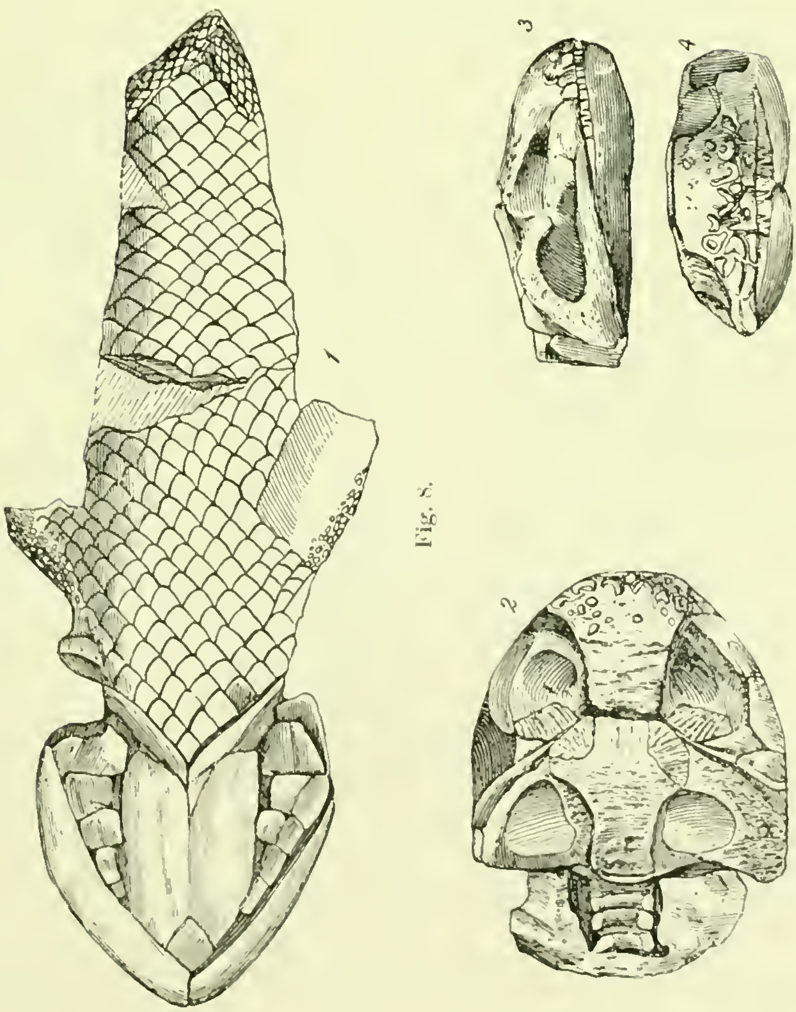


Fig. 8.

FIGS. 8, 9. *Megalichthys nitidus* Cope.

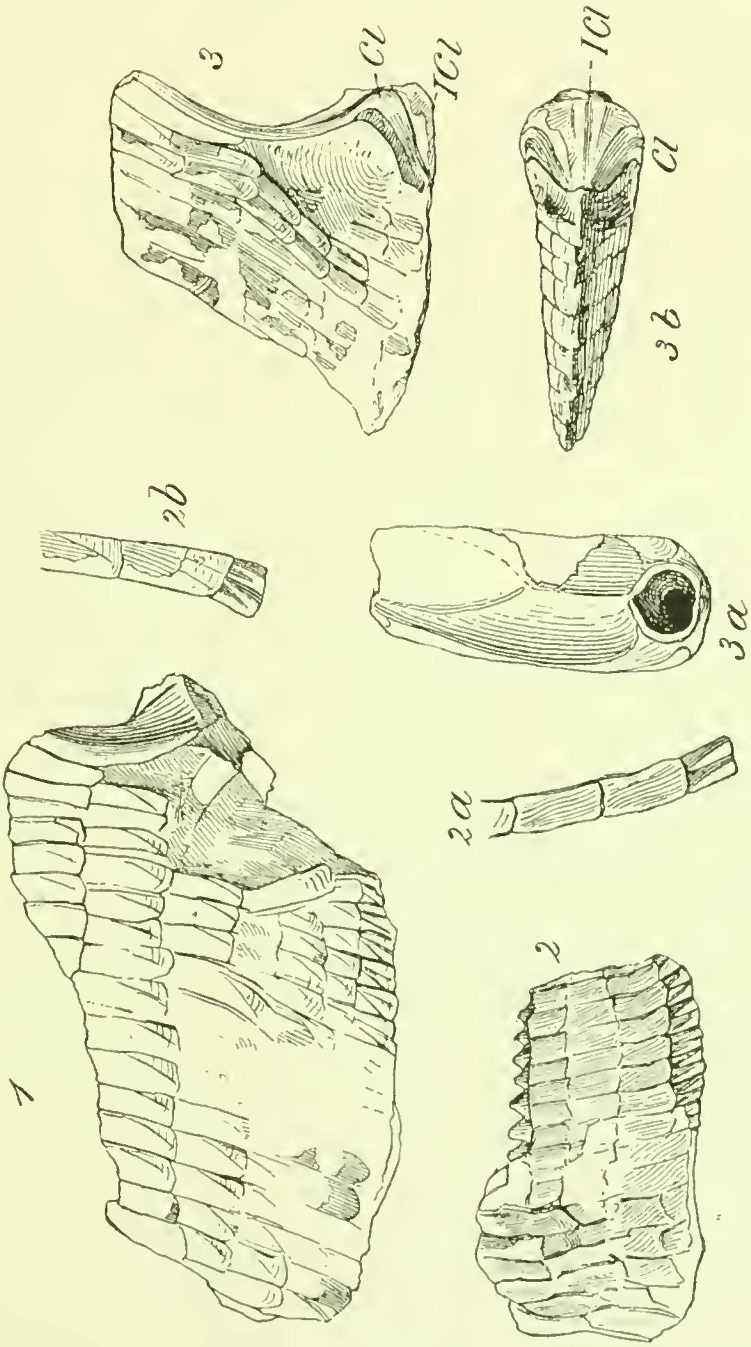


FIG. 10. *Platysomus palmaris* Cope.