FOSSIL FISHES IN THE COLLECTION OF THE UNITED STATES NATIONAL MUSEUM.

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INTRODUCTION.

The collection of fossil fishes belonging to the United States National Museum, although not extensive, is a representative series, comprising characteristic species from all of the main geological time divisions from the Ordovician onward, and including about 170 type-specimens and other important material which has served in the description of species or determination of geological horizons. The greater part of the material was obtained under the auspices of the United States geological surveys and exploring expeditions, and a large quantity of fish remains was added to the collection through the acquisition of a number of important private collections, like those of Lesquereux, Lacoe, Sherwood, and others. Some foreign material, from various horizons, but chiefly Mesozoic and Tertiary, was acquired at different times by exchange or purchase.

Prior to the installation of the collection of fossil vertebrates in the new building of the United States National Museum the fishes had not been systematically studied, nor even fully accessible nor arranged, owing to lack of space accommodations; and until eight years ago no published list had been prepared of the important type-specimens it contains. In 1905, under the direction of Dr. George P. Merrill, a catalogue of the type specimens of fossil invertebrates, by Charles Schuchert and associates, was published by the museum, and two years later this was followed by a second part, including the type specimens of fossil vertebrates and fossil plants.[1] The second part of this Catalogue records a wealth of material upon which Leidy, Cope, and Marsh founded much of their early work in vertebrate paleontology.

[1] Catalogue of the type and figured specimens of Fossils, Minerals, Rocks and Ores, etc. Part 2. Fossil Vertebrates, Fossil Plants, etc. Bull. U. S. Nat. Mus., No. 53, pt. 2, 1907.

During the first half of the year 1914, in pursuance of arrangements made by Dr. Charles D. Walcott, the fossil fish remains in the United States National Museum were systematically arranged and put in order by the present writer, and a number of undescribed or scientifically interesting specimens were set aside for special study. The greater part of these were afterwards placed in the hands of Mr. R. Weber for the purpose of preparing suitable illustrations to accompany a report upon the collection, which is now printed in the following pages. To Dr. G. P. Merrill, head curator of geology, and to Mr. J.W. Gidley and Mr. C.W. Gilmore, of the Section of Vertebrate Paleontology, cordial thanks are returned for the enjoyment of many privileges and courtesies extended while the work of studying the collection was in progress.

A. ORDOVICIAN SYSTEM.

The earliest remains of vertebrate life anywhere found are those occurring at several Ordovician localities in Colorado, the Bighorn Mountains of Montana, and the Black Hills uplift of South Dakota. The longest and best known of these localities is Harding Quarry, a short distance west of Canon City, Colorado, where vast quantities of detached scales and other fragmentary hard parts of primitive fishes are contained in sandstone (now known as the Harding sandstone) usually correlated with the Lower Trenton of the eastern United States and Lower Bala of Wales. R. S. Bassler in his bibliographic index of American Ordovician and Silurian fossils places the Harding sandstone in the Black River groups because it underlies the Kinnswick limestone of uppermost Black River age.

Three species, supposed to represent true fishes, were established by Dr. C. D. Walcott,[1] after an examination of hundreds of fragments collected by himself and Dr. T. W. Stanton at Canon City in 1890 and 1891, and the ichthyic nature of the remains was confirmed by Dr. Otto Jaekel's study of microscopic sections of dermal plates belonging to two of the species.

Cope, however, in a review of Walcott's paper, expressed the opinion that it is "extremely unlikely that these forms are fishes, but they are more likely *Agnatha*." Under this latter term the author just quoted included the great extinct group of fishlike vertebrates to which he applied the name of Octracodermi, and to which he assigned a lower rank than that of Pisces proper.

[1] Walcott, C. D. Notes on the discovery of a vertebrate fauna in Silurian (Ordovician) strata. Bull. Geol. Soc. Amer., vol. 3, 1892, pp. 153–172. Doctor Jaekel's views as to the nature of the remains are appended to this article, and are again stated in a review published by him in Neues Jahrb. f. Mineral., 1895, p. 162. Cope's review is found in the American Naturalist for March 1893, pp. 268–269. See also the same journal for February, 1891, p. 137, for a notice of Doctor Walcott's first communication.

Influenced by the idea that some of the tuberculated dermal plates described by Doctor Walcott from the Canon City locality bore a strong resemblance to certain well-known Devonian fishes, such as *Coccosteus* and Asterolepids, the suggestion has been put forward by some writers that the fish beds at Canon City are probably not of Ordovician but of Devonian age. The suggestion appears untenable in view of the fact that the accompanying invertebrate fauna, represented by more than thirty species, exhibits clearly the facies of the Middle Ordovician limestone of New York and the Mississippi Valley. The same invertebrate fauna persists upward to a horizon 180 feet above the fish beds, and includes a number of highly characteristic forms, such as *Receptaculites oweni* and various molluscous and crustacean species. An excellent account of this and the corresponding section in Wyoming was published by N. H. Darton [1] in 1907, and two years later the same author [2] announced the discovery of fish remains in the Ordovician near Rapid City, South Dakota.

Still more recently, in 1913, the discovery was announced by T. D. A. Cockerell [3] of another locality in Colorado, near Ohio City, at which fish-remains occur similar to those found at Canon City, and accompanied by the same invertebrate fauna. Professor Cockerell is impressed by the extraordianry resemblance that the fish remains from the Ohio City locality bear to well-known types of Devonian fishes, and claims to have found representatives of three families, Diplacanthidae, Holoptychiidae, and Coccosteidae. These determinations are admitted, however, to be merely approximate, and can only be accepted in a provisional sense until the material has been carefully investigated. The Ordovician age of the containing beds seems to be conclusively established by the evidence of invertebrate remains.

OSTRACODERMI.

ASTRASPIDAE, new family.

An imperfectly definable family, known only by a single genus, *Astraspis*, which has the large median dorsal and ventral plates of the body armor constructed in the same fashion as in the Psammosteidae, out of fused polygonal tesserae, and the external ornament of these plates also similar in a general way to that observed in various genera of Heterostracous Ostracoderms.

[1] Ordovician of the Bighorn Mountains. Bull. Geol. Soc. Amer., vol. 17, 1907, pp. 541–566.

[2] Discovery of fish remains in the Ordovician of the Black Hills, South Dakota. Bull. Geol. Soc. Amer., vol. 19, 1909, pp. 567–568.

[3] Cockerell, T. D. A. Ordovician (?) fish remains in Colorado. Amer. Naturalist, vol. 47, 1913, pp. 246–247.

Genus ASTRASPIS Walcott.

ASTRASPIS DESIDERATA Walcott.

Plate 12, figs. 5, 6.

Astraspis desiderata WALCOTT, Bull. Geol. Soc. Amer., vol. 3, 1892, p. 166, pl. 3, figs. 6–14; pl. 4, figs. 1–4.

The original specimens upon which this species was founded are preserved in the United States National Museum collection, and are catalogued under the number 2351. They consist of fragmentary plates, ornamented with a coarse tuberculation, and not sufficiently complete to permit of even ordinal determination. A suggestion was made, however, by the original author that the form was allied to Devonian Antiarchs like *Asterolepis ornata.*

Some months after the presentation of Doctor Walcott's paper before the Geological Society in 1891, and before it had been printed in the bulletin, a unique and extremely important specimen of *Astrapis* was discovered at the type locality, and a brief description of it was given by Doctor Walcott in a footnote dated March, 1892, added to page 167 of his paper. This specimen is now preserved in the Museum collection (Cat. No. 8121) and is illustrated for the first time in the accompanying plate 12, figure 6. Preserved in the form of an impression of the outer surface, a plaster cast taken from the natural mold is shown in figure 5 of the same plate.

The later discovered specimen shows a structural characteristic which the earlier known fragments failed to disclose, namely, that the large element, or shield, is of compound nature, being made up of a large number of small polygonal tesserae in precisely the same manner as in Cephalaspids and Psammosteids. Moreover, the style of ornamentation is similar to that observed in the families just named, each of the small polygonal tesserae rising into a conspicuous central prominence which is surrounded by numerous minute stellate tubercles. The compound nature of the shield was recognized by Walcott, and the tuberculated ornament was compared by him with the somewhat similar features displayed in *Thyestes verrucosus* Eichwald, in which the larger tubercles are disposed in several longitudinal rows. Influenced by this consideration, and also by a resemblance in general outline, Walcott reached the conclusion that *Astraspis* was related on the one hand to "cephalaspidian fishes of the Silurian of Russia," and on the other to "Asterolepidae of the lower Devonian." [1]

The large compound plate of *Astraspis* was homologized by Walcott with the head-shield of Cephalaspids, although it fails to exhibit any trace of orbits and other prominences characteristic of that group or of other members of the Aspidocephalous order of Ostracoderms. Because these features are lacking in the impression of the plate be-

[1] Bull. Geol. Soc. Amer., vol. 3, 1892, p. 167.

fore us, we should prefer to compare it with the large dorsomedian shield of *Psammosteus* and *Drepanaspis*, more particularly with such forms as *Psammosteus taylori* Traquair, from the Scottish Old Red Sandstone, and the Russian *P. paradoxus*. For an account of the structure of the shield in the two last-named species we may refer to recent papers by Traquair, Woodward, and Preobrajensky in which the organization of Psammosteus is described.[1]

The large compound plate of *Astraspis* differs from the dorsomedian and ventromedian shields of known Psammosteidae not only in outline, so far as may be judged from the portion preserved, but also in the presence of a median and two lateral ridges, which extend over the anterior half of the plate in a longitudinal direction. The outermost of these folds is apparently very close to and parallel with the external margin of the plate. The ridges in question recall somewhat the rows of enlarged tubercles seen in the head-shield of *Thyestes* and *Trematapis*. Owing to their presence, and to the peculiar form of the shield, which resembles somewhat a dorsomedian plate of *Coccosteus*, it seems necessary to place the genus *Astraspis* in an independent family, closely allied to the Psammosteidae. Some further remarks on the genus *Psammosteus* will be found under the caption of Silurian fishes.

Formation and locality.—Hastings sandstone, Black River group; Canon City.

B. SILURIAN SYSTEM.

Family PTERASPIDAE Smith Woodward.

Genus PALAEASPIS Claypole.

PALAEASPIS AMERICANA Claypole.

Palaeaspis americana CLAYPOLE, Amer. Naturalist, vol. 18, 1884, p. 1224.
Palaeaspis bitruncata CLAYPOLE, Amer. Naturalist, vol. 18, 1884, p. 1224.
Palaeaspis elliptica CLAYPOLE, Proc. Amer. Assoc. Adv. Sci., 1885, p. 426.

This species is represented in the collection by a number of fragmentary remains, none of which adds to our knowledge of the structural organization. It deserves to be recalled, however, that the reported presence of paired appendages in this species has been disproved by Dr. Bashford Dean, his investigation of the type material having shown that the structures regarded as such by the original describer are in reality Elasmobranch spines resembling *Onchus*, which have become accidently associated with the dermal shields of *Palaeaspis*. The dorsal shield consists apparently of a single plate,

[1] Traquair, R. H. Additional notes on the fossil fishes of the Upper Old Red Sandstone of the Moray Firth Area. Proc. Roy. Phys. Soc. Edinb., vol. 13, 1897, p. 379. Woodward, A. S. On the Upper Devonian Ostracoderm, Psammosteus taylori. Ann. Mag. Nat. Hist., ser. 8, vol. 8, 1911, pp. 648–652. Preobrajensky, J. A. Ueber einige Vertreter der Familie Psammosteidae Ag. Sitzber. Naturforsch. Gesellsch. Univ. Dorpat, vol. 19, 1910, pp. 21–36. (Text in Russian.)

and differs from that of *Pteraspis* [1] in lacking a posterior median spine. So far as at present known, the genus is monotypic, and limited to the Salina beds (Cayugan or "Neontaric") of the New York State geological survey scheme of classification. Dr. O. P. Hay is in error in citing this genus as occuring in the Onondaga stage of the Devonian.

C. DEVONIAN SYSTEM.

Family ASTEROLEPIDAE Traquair.

Genus BOTHRIOLEPIS Eichwald.

BOTHRIOLEPIS COLORADENSIS Eastman.

Bothriolepis coloradensis EASTMAN, Amer. Journ. Sci., vol. 18, 1904, p. 254, text figs. 2, 4.

The type material upon which this, the largest known American species of the genus, was founded, is now preserved in the collection of the National Museum. It was collected, together with a quantity of other Devonian fish-remains, by Dr. Whitman Cross in 1903, from the Elbert formation of Rockwood and Devon Point in southwestern Colorado. The occurrence is interesting on account of demonstrating the widespread distribution of the genus in Upper Devonian time, and also because it is difficult to trace a route of migration which would connect this species with its nearest ally in the western hemisphere, *B. canadensis* Whiteaves, from Scaumenac Bay in the Province of Quebec, Canada.

BOTHRIOLEPIS NITIDA (Leidy).

Stenacanthus nitidus LEIDY, Proc. Acad. Nat. Sci., Phila., vol. 8, 1856, p. 11, and Journal, ser. 2, vol. 3, p. 164, pl. 16, figs. 7, 8.

Holonema rugosa COPE (*errore*), Proc. U. S. Nat. Mus., vol. 14, 1891, p. 456, pl. 30, fig. 7.

This species, known only by fragmentary portions of the dermal armor and appendages, occurs abundantly in the Catskill sandstone along the border line between New York and Pennsylvania. Numerous specimens belonging to this form are contained in the Sherwood and Lacoe collections, now the property of the United States National Museum. One specimen in the Lacoe collection calls for special notice, for the reason that it was figured and described by Cope as a pectoral limb of the genus *Holonema*. It is from the Catskill of Mansfield, Tioga County, Pennsylvania, and bears the catalogue number 1981. H. S. Williams, in 1893, first recognized it as an appendage of *Bothriolepis*, but erroneously referred it to *B. canadensis*.

[1] Important new light on the structure of this genus is contained in a paper by F. Drevermann, Ueber *Pteraspis dunensis*, published in Zeitschr. Deutsch. Geol. Gesell., vol. 56, 1904, pp. 275–289. It is noticed by Gaskell in his Origin of the Vertebrates, London, 1908. See also the following by Johann Kiaer: A new Downtonian fauna in the sandstone series of the Kristiania area. Vid.-Selsk. Skrifter, Kristiania, 1911, No. 7, pp. 5–22.

Family PSAMMOSTEIDAE Traquair.

Genus PSAMMOSTEUS Agassiz.

Syn. *Placosteus* and *Psammolepis* Agassiz; *Dyptychosteus* Preobrajensky.

This genus is represented in the United States National Museum collection by a few fragmentary remains from the Devonian of northwest Russia, received through the School of Mines at St. Petersburg. Until about a score of years ago little was known concerning the skeletal organization of the primitive chordates belonging to this and related genera, and competent authorities assigned *Psammosteus* to a position among the Elasmobranchs. In October, 1894, however, Dr. R. H. Traquair [1] published a description of a new species of *Psammosteus*, named by him *P. taylori*, from the Upper Old Red Sandstone of the Elgin district, Scotland, and in the light of his subsequent discovery of nearly complete specimens of *Drepanaspis* in the Lower Devonian of Germany, the Scottish author [2] suggested that *Psammosteus* should be placed in close association with *Drepanaspis* in the Heterostracous section of the Ostracodermi. Some further details concerning the body armor of *P. taylori* were made known by Dr. A. Smith Woodward [3] in 1911, the result of which was to confirm Doctor Traquair's reference of the genus to the Ostracoderms.

About the time when *Psammosteus* was first discovered in Scotland, in 1895, a brief notice of the various plates and spines of the same genus which are preserved in the Museum of the University of Dorpat was published by Dr. A. S. Woodward,[4] who had examined the remains three years previously, and in this article a figure was given of a dorsomedian shield of *P. paradoxus* Agassiz, from the Upper Devonian of Neuhausen, Livonia. A copy of Woodward's illustration of this plate is shown in the accompanying text-figure 1; and the reason for our noticing it thus particularly is because the identical specimen was again figured in 1910, by a Russian geologist who had evidently overlooked the earlier writings of Traquair and Smith Woodward, and proposed to establish a new genus and species upon the evidence of the plate in question.

In this paper by Doctor Preobrajensky,[5] the text of which is in Russian, the question of nomenclature is still further complicated by

[1] Ann. Scott. Nat. Hist., vol. 3, 1894, p. 225; also The Extinct Vertebrata of the Moray Firth Area, in Brown and Buckley's Vert. Fauna Moray Basin, 1896, pp. 260–263.

[2] Traquair, R. H. Report on fossil fishes . . . from the Silurian rocks of the South of Scotland. Trans. Roy. Soc. Edinb., vol. 39, 1899, p. 848.

[3] Woodward, A. S. On the Upper Devonian Ostracoderm, Psammosteus taylori. Ann. Mag. Nat. Hist., ser. 8, vol. 8, 1911, pp. 648–652.

[4] Woodward, A. S. The problem of the primaeval Sharks. Natural Sci., vol. 6, 1895, pp. 38–43, fig. 1.

[5] Preobrajensky, J. A. Ueber einige Vertreter der Familie der Psammosteidae Ag. Sitzber. Naturforsch. Gesell. Univ. Dorpat, vol. 19, 1910, pp. 21–36. pl. 2.

the fact that the type-species of the supposed new genus "*Dyptychosteus*" is named *tesselatus*, a title under which another species of *Psammosteus* had been previously described by Traquair.[1] If at some future time the Dorpat plate should be proved to be distinct from *Psammosteus paradoxus*, a new specific designation must be applied to it. For the present, however, we prefer to regard the term "*Dyptychosteus tesselatus*" as a synonym of *P. paradoxus*. Also, as far as one may judge from the published figure of the plate called by the Dorpat author *Psammosteus imperfectus*, this would appear to be one of the dorsomedian plates of *Ceraspis carinata* Schlüter.

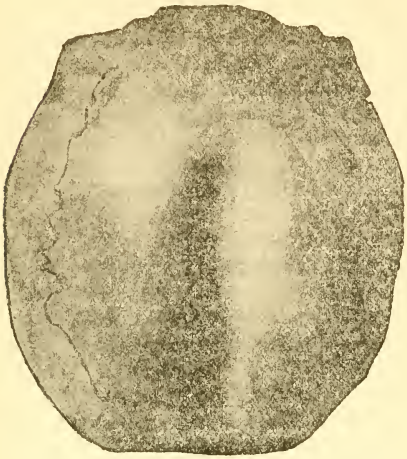


FIG. 1.—DORSOMEDIAN SHIELD OF PSAMMOSTEUS PARADOXUS AGASSIZ, WANTING SUPERFICIAL ORNAMENTATION. UPPER DEVONIAN, NEUHAUSEN, LIVONIA. (AFTER A. S. WOODWARD AND PREOBRAJENSKY.)

The type material upon which the last-named species was founded is now preserved in the Museum of Comparative Zoology at Cambridge, Mass. A side view of one of the dorsomedian plates of this form is shown in plate 11, figure 1.

HOLOCEPHALI.

Family PTYCTODONTIDAE Smith Woodward.

The typical genus of this family, *Ptyctodus*, which is at the same time the most abundant and widely distributed of any belonging in the same association, was established by Pander in 1858, upon the evidence of detached "teeth," or tritors as they are more properly called, found in the Middle Devonian of the Governments of St. Petersburg, Novgorod, and the Russian Baltic Sea provinces. In the National Museum collection are contained a number of interesting fish-remains from these localities in northwestern Russia, and also from the vicinity of Dorpat. These consist of *Ptyctodus* tritors (from Babino, Novgorod), *Dendrodus*, *Holoptychinus*, *Psammosteus*, and

[1] Proc. Roy. Phys. Soc. Edinb., vol. 13, 1897, p. 377, pl. 11, figs. 1, 2.

for the most part fragmentary and dissociated plates of Asterolepids. The records show that a small but characteristic assortment of Russian Devonian fishes was received in exchange from the School of Mines at St. Petersburg many years ago. Some well-preserved Ptyctodont dental plates from the Upper Devonian of Iowa (State quarry beds) are also contained in the collection.

The Ptyctodont type of dentition agrees so closely with that of modern Chimaeroids that the opinion has been generally held, until recently at least, the forms of Devonian fishes possessing these characteristic dental plates must have been similar in their organization to modern Holocephali, and should be provisionally included in the same subclass. The view as to the relationships of Ptyctodontidae which has commonly prevailed up until about the year 1906 is well stated by Dean in his monograph on Chimaeroids, published by the Carnegie Institution of Washington.[1]

The passage reads:

> The main virtue in the study of Ptyctodontids is to the writer this, that they present some evidence (1) that Chimaeroids are of Devonian stock; (2) that at this early period their dental plates were still but four in number, representing the dental structure of the jaw-halves of sharks; and (3) that the tritors existed as small points forming together a texture in the dental plates which is well known among early sharks.

In the same year (July, 1906) a totally different conception of Ptyctodont relationships was advanced by Dr. Otto Jaekel, of Greifswald, who declared his belief that Ptyctodonts belong to the Chondrostean division of ganoid fishes, and that sturgeons themselves are related to "Placoderms" (*i. e.*, Arthrodires *plus* Asterolepids). The reasons for advocating this novel view are not stated by the author, except that they resulted from his investigation of newly discovered Rhynchodont remains from the Upper Devonian of Wildungen, described by him under the preoccupied title of *Rhamphodus*.[2]

In the course of his investigation of the Wildungen fish-remains certain dermal plates having a characteristic form and tuberculated ornament were found, the like of which occur also in the Middle Devonian of Wisconsin, and recall the dermal ossifications of *Myriacanthus*. Jaekel, however, in his discussion of the Wildungen material published in July, 1906,[3] interprets these scale-like dermal structures as the elements of a primary, internally situated pectoral arch, and attempts a hypothetical reconstruction of the arch after the pattern

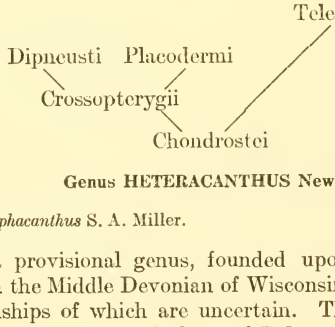
[1] Publication No. 32, 1906, p. 136.

[2] This generic name, with the type species of *Rhamphodus dispar*, was proposed by J. W. Davis in 1883 for certain Cochliodont teeth from the Lower Carboniferous limestone of Armagh. The dental plates upon which the so-called "*Rhamphodus tetrodon*" of Jaekel was founded are identical with the earlier described plates from the Eifel Devonian, known as *Rhynchodus major* Eastman. See Amer. Naturalist, vol. 32, 1898, p. 487; vol. 38, 1904, p. 296.

[3] Einige Beiträge zur Morphologie der ältesten Wirbeltiere. Sitzber. Ges. Naturforsch. Freunde Berlin, 1906, No. 7, pp. 180–189.

of the shoulder girdle in modern sturgeons. Impressed with the similarity which he observes between this conjectural arrangement and that presented by the body armoring of Arthrodires, he draws the inference that the latter group belong to the same stock as sturgeons. Apparently this view, together with the acceptance of Jaekel's reconstruction of a "shoulder-girdle" in Rhynchodus, influenced Dollo [1] to declare in favor of associating Ptyctodonts with Arthrodires.

It need only be said in this connection that the presence of an ossified pectoral arch in any genus of Ptcytodonts is an unconfirmed speculation very difficult to maintain in the lack of positive evidence; and the elements which have been interpreted as constituting it in a single genus are clearly of very different nature, being externally situated. And in case of any near affinity between Ptyctodonts and Arthrodires, we should expect the dental plates of the former to be accompanied by an ossified head-shield and other hard parts similar to those invariably associated with Arthrodires, which is precisely what we do not find in nature. The formerly prevalent view that Ptyctodonts are of Chimaeroid stock is in harmony with all the evidence thus far obtained. It may be of interest to introduce at this point a diagrammatic scheme taken from a paper by C. Tate Regan [2] for the purpose of showing graphically that author's ideas of the relationships of the sturgeons and "Placoderms" (*i. e.*, Arthrodires *plus* Antiarcha and Osteostraci, according to Regan's definition) to to the other orders of Teleostomes:



Genus HETERACANTHUS Newberry.

Syn. *Gamphacanthus* S. A. Miller.

This is a provisional genus, founded upon detached fin-spines occurring in the Middle Devonian of Wisconsin and adjoining states, the relationships of which are uncertain. Their association in the same beds with large dental plates of *Palaeomylus* and other Ptyctodonts affords reason for believing them to be of Chimaeroid nature, and for the present they may be tentatively referred to the family now under consideration.

[1] Dollo, L., Les Ptyctodontes sont des Arthrodères. Bull. Soc. Belge Géol., etc., vol. 27, 1907, pp. 1–12.
[2] The Phylogeny of the Teleostomi. Ann. Mag. Nat. Hist., ser. 7, vol. 13, 1904, pp. 329–349.

HETERACANTHUS UDDENI Lindahl.

Plate 1.

Heteracanthus uddeni LINDAHL, Journ. Cincinnati Soc. Nat. Hist., vol. 19, 1895 p. 95, pl. 6.

The spines of this species are less abundant than those of the coeval *H. politus*, which have a different general outline and a relatively coarse ornamentation. The type-specimen serving for the establishment of this species, now preserved in the Museum of the Cincinnati Society of Natural History, has the external surface partly denuded and is defective in preservation as regards the basal portion and anterior margin. Up to the present time, however, it has remained the most complete fin-spine of the species and genus thus far brought to light. During the past year a larger and still more perfect specimen has been found in the Cedar Valley limestone near Iowa City, Iowa, by Prof. Abram O. Thomas, of the State University, and placed in the writer's hands for study. It is shown of the natural size in plate 1.

The posterior or convex margin of the newly discovered spine is more strongly arched than in the type-specimen, and the distal portion is forwardly curved to a slight degree. On the other hand the anterior margin is not developed so strongly as to form a projecting shoulder toward the base, which is the case to a certain extent in the type-specimen, and in which respect an approach is indicated to the conditions observed in *Stethacanthus* and Lower Carboniferous species of *Oracanthus*. Nevertheless, the character of the ornamentation is practically identical with that of the original upon which the species is founded, and for that reason we are disinclined to regard the two spines as specifically distinct. In the specimen here figured, the entire outline of the inserted portion of the base is distinctly shown, and the resemblance of the inserted part to the base of Chimaeroid head-spines, and also those of Carboniferous forms like *Physonemus*, etc., is obvious. It is probable that the dermal defenses of this nature occupied a position immediately behind the head.

Formation and locality.—Cedar Valley limestone (Middle Devonian); Johnson county, Iowa.

DIPNOI.

Family CTENODONTIDAE Traquair.

Genus DIPTERUS Sedgwick and Murchison.

The earliest known occurrence of Dipterine remains in this country is that of a dental plate of *Dipterus* itself which has been described within the last few years from the Columbus limestone (Middle

Devonian) of Ohio.[1] Some half-dozen species, all of them founded on isolated teeth, are known from the Chemung-Catskill of New York and Pennsylvania, and great numbers are found in the Middle and Upper Devonian of Iowa. Although fish remains were reported from the Ouray limestone in the San Juan region of Colorado as long ago as 1874, and several species were brought to light by Dr. Whitman Cross in 1904, from the immediately underlying Elbert formation in the same region, no Dipterine remains were collected from the Colorado Devonian until the year 1909, when detached dental plates referable to three species already known from the Iowa Devonian were obtained by Doctor Cross. These specimens are now preserved in the Museum collection, and may be identified as belonging to *Dipterus mordax*, *D. pectinatus*, and *D. digitatus*. A single smooth crushing plate suggestive of the Synthetodus type of dentition is also contained in the collection made at the new locality, which is in the Elbert formation of Florida Valley, east side, in the Ignacio Quadrangle of southwestern Colorado.

A more particular account of these remains has recently been published (1915) in the Annals of the Carnegie Museum.[2] It may be here stated, without entering into details, that the evidence furfurnished by the three above-named species of *Dipterus*, and one undescribed *Synthetodus*-like plate, is sufficient for establishing a close correlation between the Elbert formation of Colorado and the Upper Devonian of the Cedar Valley region of Iowa. According to this correlation a somewhat later age must be assigned to the Ouray limestone than has hitherto been conceded.[3] The recent discovery of Dipterine remains in the San Juan country also simplifies the problem of distribution of this class of fishes in the Devonian. For we now find evidence that the line of communication between the Appalachian and Cordilleran regions during late Devonian times was actually by way of the Ohioan and Dakotan seas; and also that intermigration took place between the faunas of the Elbert formation and the so-called State Quarry beds of Iowa toward the close of the Devonian. This statement finds further confirmation in a discovery made by Dr. E. Kirk during the past year (1914) of a well-preserved *Dipterus* dental plate from the type section of the Jefferson limestone on Gallatin River, near Logan, Montana. The specimen has been recently added to the Museum collection. In plate 7, fig. 6, is shown a Coccostean ventro-lateral plate from the Elbert formation of the San Juan region, collected by Doctor Cross. Although clearly of arthrodiran

[1] Stauffer, C. S. The Middle Devonian of Ohio. Bull. Geol. Surv. Ohio, 1909, No. 10, p. 196.

[2] Eastman, C. R. Dipterus remains from the Upper Devonian of Colorado. Annals Carnegie Mus., vol. 9, 1915, No. 3, pp. 279–283.

[3] Hay, O. P. Description of a new species of Cladodus (*C. formosus*) form the Devonian of Colorado. Amer. Geologist, vol. 30, 1903, pp. 373–374. Girty, G. H. Devonian fossils from Colorado. The fauna of the Ouray limestone. 20th Ann. Rept. U. S. Geol. Surv., 1900, pt. 2, pp. 25–81. The Devonian fauna of the Ouray limestones. Bull. U. S. Geol. Surv., 1909, No. 391, 36 p., 10 pls.

nature, it is not capable of precise systematic determination. The text-figure 2, copied from a recent paper by Dr. W. K. Gregory, permits of a comparison of the cranial pattern of *Dipterus* and *Scaumenacia*. In still later studies by D. M. S. Watson and Henry Day (1916), slightly different homologies are recognized than those here indicated.

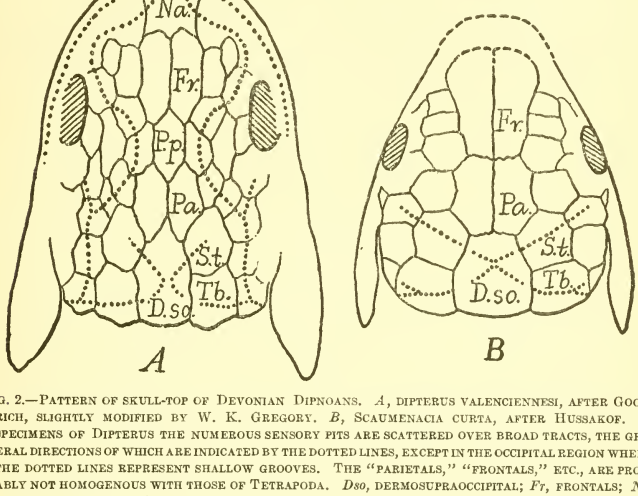


FIG. 2.—PATTERN OF SKULL-TOP OF DEVONIAN DIPNOANS. *A*, DIPTERUS VALENCIENNESI, AFTER GOODRICH, SLIGHTLY MODIFIED BY W. K. GREGORY. *B*, SCAUMENACIA CURTA, AFTER HUSSAKOF. IN SPECIMENS OF DIPTERUS THE NUMEROUS SENSORY PITS ARE SCATTERED OVER BROAD TRACTS, THE GENERAL DIRECTIONS OF WHICH ARE INDICATED BY THE DOTTED LINES, EXCEPT IN THE OCCIPITAL REGION WHERE THE DOTTED LINES REPRESENT SHALLOW GROOVES. THE "PARIETALS," "FRONTALS," ETC., ARE PROBABLY NOT HOMOGENOUS WITH THOSE OF TETRAPODA. *Dso*, DERMOSUPRAOCCIPITAL; *Fr*, FRONTALS; *Na*, NASOETHMOID REGION; *St*. SUPRATEMPORAL (PTEROTIC); *Tb*, TABULARE (EPIOTIC); *Parietal*, PREPARIETAL.

DIPTERUS ANGUSTUS (Newberry).

Plate 8, fig. 5.

Sagenodus angustus NEWBERRY, Trans. N. Y. Acad. Sci., vol. 16, 1897, p. 303, pl. 24, fig. 26.

The holotype, and until recently, the solitary known example of this species, is a worn and imperfectly preserved dental plate from the Catskill of Bradford County, Pennsylvania, now the property of the American Museum of Natural History. The illustration given of it in Newberry's posthumous paper is unsatisfactory, as it would seem to represent a complete tooth, disengaged from the matrix, and with nearly smooth superficial ridges. In point of fact the tooth is embedded in a block of hard sandstone, and the extermal margin is partially concealed by matrix, so that the entire outline of the tooth is not visible. Moreover, although the oral surface is considerably worn, it is plain that all of the ridges were tuberculated, this condition being very distinct in the two posterior ridges. As noted by Newberry, the anterior ridge is widely divergent from the others

A second specimen (pl. 8, fig. 5), preserved in the form of an impression, and apparently referable to this species, is contained in the United States National Museum collection. It is from the Chemung of Bradford County, Pennsylvania, and agrees closely in form and size with the type of *D. angustus* except that it displays one additional ridge near the posterior extremity, and all of the radiating ridges are distinctly tuberculated. The same separation is observed between the two anterior ridges as was noted by Newberry in his description of the type. The characters of this species resemble those of *Ctenodus serratus*, from the Coal Measures of Ohio, more nearly than other described species of Dipterus.

Family COCCOSTEIDAE Smith Woodward.

Genus DINICHTHYS Newberry.

Among the interesting remains of this genus contained in the United States National Museum collection may be mentioned the type mandible (Cat. No. 65) upon which the species *D. newberryi* Clarke was founded, from the Genesee shale of Bristol, New York. Another figured specimen is part of the head-shield of *D. pustulosus* Eastman (Cat. No. 19) from the Hamilton limestone of Milwaukee, Wisconsin. Indications of the same species in the Upper Devonian State Quarry beds of Johnson County, Iowa, have recently been discovered by Prof. Abram O. Thomas, of Iowa State University. Particularly noteworthy among the specimens obtained by him is a portion of the dorsomedian shield showing the posterior carinal process. It is shown in plate 8, fig. 8. The corresponding element of a closely related species from the Upper Devonian of Louisiana, Missouri, has recently been described under the name of *D. missouriensis* by E. B. Branson.[1] Some fragmentary Dinichthyid plates from the same locality are preserved in the Museum collection.

The older restorations of *Dinichthys* and allied European coccosteans are well known. Within recent years several writers have proposed certain modifications of the earlier arrangements of cranial and body plates in typical genera, not all of which can be said to be entirely successful. The latest attempted reconstruction of *Dinichthys terrelli* is that of E. B. Branson, published in the Ohio Naturalist for June, 1908,[2] which drew forth some critical comment by Bashford Dean in Science three years later (vol. 34, p. 801). The typical species of *Coccosteus*, and also that commonly referred to "*Brachydirus*" under von Koenen's term of *B. bidorsatus*, were made the subject of new reconstructions by G.

[1] Branson, E. B. The Devonian fishes of Missouri. Bull. Univ. Missouri, vol. 15, 1914, No. 31, p. 61, pl. 2, fig. 4.

[2] Vol. 8, pp. 363–369.

Gürich [1] in 1891, and some further changes in the restoration of Coccosteus were proposed in a series of articles by Otto Jaekel,[2] published during the first decade of the present century. Concerning one of the restorations put forward by the last-named author, that of the cranial shield of his so-called *Pachyosteus bulla*, it is to be noted that the pattern of plate arrangement is almost precisely the same as observed in primitive species of *Dinichthys*. This will be obvious from a comparison of the annexed text-figures 3 and 4, showing respectively the Wildungen species and *D. halmodeus* from the New York Devonian.

DINICHTHYS TUBERCULATUS Newberry.

Plate 2, fig. 1.

Dinichthys tuberculatus NEWBERRY, Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 98, pl. 32, fig. 3.

Of this species only isolated plates of the body armor are known, most of them imperfectly preserved. Only one, an antero-dorso-

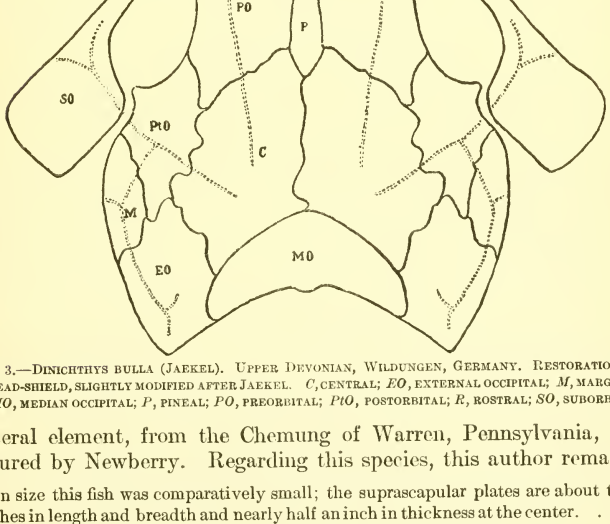


FIG. 3.—DINICHTHYS BULLA (JAEKEL). UPPER DEVONIAN, WILDUNGEN, GERMANY. RESTORATION OF HEAD-SHIELD, SLIGHTLY MODIFIED AFTER JAEKEL. *C*, CENTRAL; *EO*, EXTERNAL OCCIPITAL; *M*, MARGINAL; *MO*, MEDIAN OCCIPITAL; *P*, PINEAL; *PO*, PREORBITAL; *PtO*, POSTORBITAL; *R*, ROSTRAL; *SO*, SUBORBITAL.

lateral element, from the Chemung of Warren, Pennsylvania, was figured by Newberry. Regarding this species, this author remarks:

In size this fish was comparatively small; the suprascapular plates are about three inches in length and breadth and nearly half an inch in thickness at the center. . . . The dorsomedian is also very small: it was not more than three inches in breadth and length, judging from the portion preserved.

[1] Gürich, G. Ueber Placodermen und andere devonische Fischreste in Breslauer mineralogischen Museum. Zeitschr. Deutsch. Geol. Ges., vol. 43, 1891, pp. 902-913.

[2] Jaekel, O. Ueber Coccosteus und die Beurtheilung der Placodermen Sitzber. Ges. Naturf. Freunde Berlin, 1902, No. 5, pp. 103-115; Ueber die Organisation und systematische Stellung der Asterolepiden. Zeitschr. Deutsch. Geol. Ges., vol. 55, 1903, Mal-Protokoll, pp. 41-60; Einige Beiträge zur Morphologie der ältesten Wirbeltiere. Sitzber. Ges. Naturf. Freunde Berlin, 1906 No. 7, pp. 180-189; 1907, p. 172, text fig. 1.

Among the arthrodiran plates in the United States National Museum collection from the same horizon and locality are several that may be provisionally referred to this species, but owing to failure of preservation of the superficial ornament, a positive determination of the species is impossible. There is a tolerably complete antero-

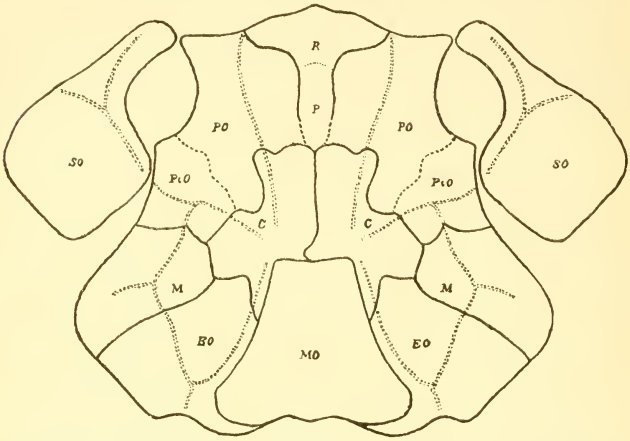


FIG. 4.—DINICHTHYS HALMODEUS (CLARKE). MARCELLUS SHALE (ERIAN), LIVONIA SALT SHAFT, NEW YORK. RESTORATION OF HEAD-SHIELD×⅔. LETTERING AS IN FIG. 3.

ventre-lateral plate in the collection, of relatively small size, and also a very good example of the dorsomedian, which has not been previously figured for this species. It is shown of slightly less than the natural size in plate 2, figure 1.

Formation and locality.—Chemung group (Upper Devonian); Warren County, Pennsylvania.

Genus MYLOSTOMA Newberry.

The arrangement of the grinding elements constituting the upper dentition of the best-known species of this genus, *M. variabile*, has been the subject of much discussion during recent years, chiefly by American writers. Up to the present time no evidence has been found of the occurrence of a pair of vomerine teeth in this genus corresponding to the so-called "premaxillary" teeth (in reality vomerine) of *Dinichthys;* but that a pair of such elements was developed is rendered at least a plausible supposition from analogy with *Dinomylostoma*, from the Portage shale of western New York.

Whereas in former years the problem of orientation of palatal grinding plates depended upon more or less theoretical considerations, we are now fortunately provided with evidence of the most positive

kind for the allocation of parts entering into the upper dental pavement. The evidence referred to is furnished by a single large compound plate, representing the fused members of the anterior pair of mylostomid dental plates, found in the isolated condition, and originally described by Louis Hussakof [1] in 1909 as the type of a distinct genus and species of Arthrodives. It has been suggested by the present writer [2] that the new genus proposed by Doctor Hussakof, and named by him *Dinognathus*, be maintained in a provisional sense,

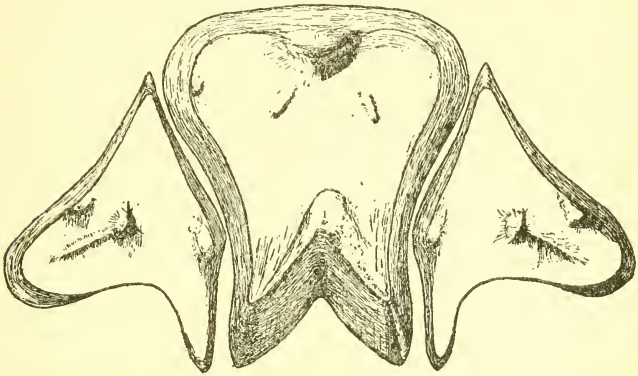


FIG. 5.—DINOGNATHUS FEROX (HUSSAKOF). CLEVELAND SHALE (UPPER DEVONIAN), LORAIN COUNTY, OHIO. RECONSTRUCTION OF THE UPPER DENTAL PAVEMENT.

and that there should be associated with it, on theoretical grounds, the unique mandible serving for the type of Newberry's species, *Mylostoma terrelli*.

A recent examination of the type material of both *Mylostoma* and *Dinognathus*, now preserved in the American Museum of Natural History, has satisfied the writer of the entire correctness of this view; and in text-figure 5 is illustrated our conception of the arrangement of the palatal dental elements of *Dinognathus*. It is to be noted that in this genus the anterior pair of palato-pterygoid dental plates is fused into a single crushing element. In *Dinichthys*, on the other hand, the so-called "shear-tooth" is to be interpreted as having arisen from the fusion of the anteriorly and posteriorly placed elements on either side of the upper jaw.

[1] Hussakof, L. The systematic relationships of certain American Arthrodires. Bull. Amer. Mus. Nat. Hist., vol. 26, 1909, p. 268, fig. 5.

[2] Science, vol. 29, 1909, p. 997; Bull. Mus. Comp. Zool., 1909, vol. 52, pp. 261–269.

TELEOSTOMI.

Family RHIZODONTIDAE Traquair.

Genus SAURIPTERUS Hall.

SAURIPTERUS TAYLORI Hall.

Plate 2, fig. 2; plate 7, fig. 5.

Sauripteris taylori HALL, Nat. Hist. N. Y., pt. 4, Geology, 1843, p. 282, text-fig. 130.—NEWBERRY, Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 112.—BROOM, Bull. Amer. Mus. Nat. Hist., vol. 32, 1913, pp. 459–463; Anat. Anz., vol. 45, 1913, pp. 73–78.—GREGORY, Ann. N. Y. Acad. Sci., vol. 26, 1915, pp. 358–362.

The extent of our information in regard to this genus has recently been summed up by Dr. Robert Broom, as follows:[1]

Sauripterus is known only by fragments of the head, a series of crushed vertebræ, a large number of scales and the beautifully preserved right pectoral fin with most of

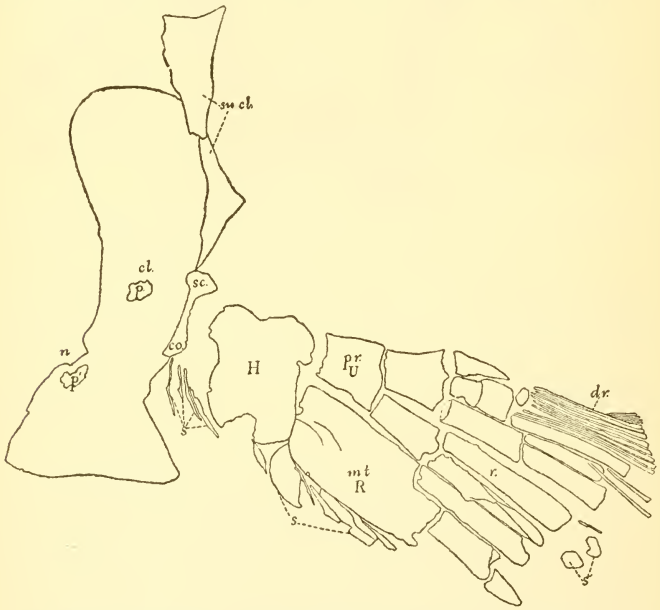


FIG. 6.—SAURIPTERUS TAYLORI HALL. CATSKILL, PENNSYLVANIA. RIGHT PECTORAL LIMB OF TYPE-SPECIMEN WITH PARTS IN THEIR NATURALLY ASSOCIATED POSITION. (AFTER W. K. GREGORY).

the cleithrum and part of the supraclavicle (text fig. 6). The large comparatively thin scales resemble those of *Rhizodopsis* and the cleithrum closely resembles that of *Rhizodus*. The vertebral centra are formed by rings of bone. Owing to the crushed condition of the vertebrae it is impossible to be quite sure whether the ring is entire or

[1] Bull. Amer. Mus. Nat. Hist., vol. 32, 1913, p. 461. See, also, on the Rhipidistia, the important article by D. M. S. Watson and Henry Day in Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 60, 1916, pt. 1, pp. 1-52.

made up of four parts. There is certainly a well-ossified neural arch and above this in some of the vertebrae at least a well-developed flattened neural spine. The teeth have the enamel deeply folded at the bases as seen in the figures given.

This passage is followed by a detailed description of the pectoral limb in the type-specimen, now preserved in the American Museum of Natural History; but there is no further discussion of the head parts. Still more recently the limb structure of the Rhipidistia, as exemplified by the same type-specimen of *Sauripterus* has been made the subject of searching investigation and comparison with other

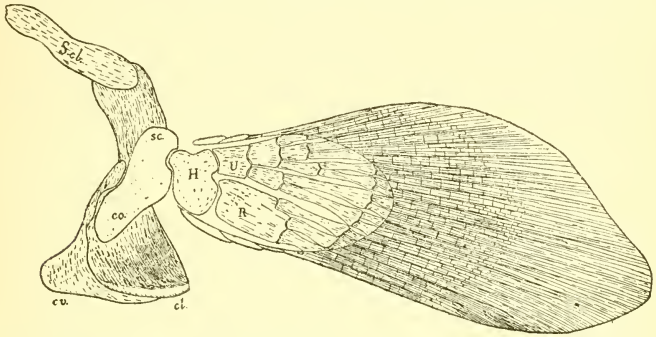


FIG. 7.—SAURIPTERUS TAYLORI HALL. CATSKILL, PENNSYLVANIA. RESTORATION OF THE RIGHT PECTORAL LIMB, SEEN FROM THE INNER SIDE. THE MESOPTERYGIAL SERIES IS REPRESENTED BY THE HUMERUS (H), ULNA (U) AND DISTALLY SUCCEEDING ELEMENTS; THE PREAXIAL RADIALS (R) ARE BARELY REPRESENTED. THE SCAPULACORACOID, CLAVICLE (*cv*), SUPRACLEITHRUM (*s. cl.*), AND FIN RAYS ARE CONJECTURALLY RESTORED FROM ANALOGY WITH RELATED GENERA. (AFTER W. K. GREGORY).

ichthyic and tetrapod appendages in a paper published during the present year by Dr. W. K. Gregory.[1]

As a result of his investigations Dr. Gregory adopts the view, already advocated by Doctor Broom, that the ascending blade in the shoulder-girdle of *Sauripterus* (text fig. 6) represents the cleithrum of primitive Stegocephali; and accordingly, he is able to recognize the the following homologies of parts:

RHIPIDISTIA.	PRIMITIVE TETRAPODA.
Interclavicular corium.	Interclavicle.
Clavicle ("infraclavicle").	Clavicle.
Supracleithrum ("supraclavicle").	?Fused with top of cleithrum.
Post-temporal.	Lost.
Coracoscapula.	Coracoscapula.
Fleshy lobe of fin.	Arm and hand.
Mesopterygium (single basal piece).	Humerus.
Mesopterygial axis.	Humerus, ulna, ulnare, digit V (?)
Preaxial parameres (radials) reduced or absent.	Lost.
Postaxial parameres.	Radius, carpus, digits I–IV (?)
Dermal rays.	Lost.

[1] Ann. N. Y. Acad. Sci., vol. 26, 1915, pp. 358–362.

The only specimen showing a portion of the cranial roof that has thus far come to light is that illustrated in plate 2, fig. 2, which shows the parietals, frontals and one each of the squamosals and postfrontals in natural juxtaposition. The parietals are of about the same relative length as in *Holoptychius*, and less elongate than in *Rhizodopsis* and *Onychodus;* but further than this it is not possible to make comparisons, owing to the inadequate preservation of parts. Nevertheless, being unique, the specimen is of importance for the bare hint it affords of the arrangement of cranial roofing plates in this genus. Another fragmentary head structure, to be interpreted probably as a portion of the basisphenoid of this or some closely related form, is shown in plate 7, fig. 5.

Formation and locality.—Catskill (Upper Devonian) near Blossburg, Pennsylvania.

D. CARBONIFEROUS SYSTEM.

ELASMOBRANCHII

Family CLADODONTIDAE.

Genus CLADODUS Agassiz.

Among the specimens of fossil fishes acquired by the United States National Museum from Dr. G. Hambach, of St. Louis, is a series of well preserved teeth of Cladodont, Petalodont, and Cochliodont sharks from different horizons of the Mississippian section, and also a number of interesting ichthyodorulites, some of which add to our knowledge of established species. These are noticed in the following paragraphs under their appropriate headings.

CLADODUS SPINOSUS Newberry and Worthen.

Plate 8, fig. 7.

Cladodus spinosus Newberry and Worthen, Pal. Illinois, vol. 2, 1866, p. 22, pl. 1, fig. 3.—E. B. Branson, 30th Ann. Rept, Dept. Geol. Nat. Resources Indiana, 1906, p. 1377, pl. 41, figs. 1, 2.

The large, highly ornate teeth belonging to this species are of rare occurrence in the St. Louis limestone, and few perfect specimens have been obtained. One which shows the characters of the base and lateral denticles very clearly is catalogued under the number 8104, from the Hambach collection. It is the largest of any that have come under the writer's observation, but unfortunately lacks the apical portion of the crown. From the amended definition of this species given by E. B. Branson I quote as follows:

Teeth of medium or large size, broader than high; base representing a little more than half of an imperfect hexagon, with the posterior side slightly longer than the others; thick, with a sharpish edge behind, before strong beveled, and under scooped out in a shallow sinus beneath the median cone; whole anterior border of base, above

the smooth beveled edge, set with many minute spines directed upward; these spines cover the antero-lateral edges of the base of the principal cone. Median cone conical, somewhat curved backward, rapidly tapering to an acute point; lower portion with a nearly circular section, finely and evenly striated longitudinally, near the point smooth, compressed, with cutting edges; lateral denticles 6-7 on either side, conical, striated and curved backward, exterior pair much larger than intermediate ones.

Formation and locality.—St. Louis limestone, Missouri.

CLADODUS ACULEATUS, new species.

Plate 10, fig. 4; plate 18, fig. 1.

Teeth small, the crown consisting of a long, slender, erect, and pointed median cone, with faint longitudinal striae, and a pair of similar lateral cones rising to about half the height of the principal cone, only slightly divergent, and all three with slight sigmoidal curvature. Root short, not very deep.

The teeth in this species are of relatively small size and gracefully formed. They agree more nearly in general form with *C. gracilis* Newberry and Worthen, from the Coal Measures of Indiana, but are distinguished from this and from other known species by the greater height of the lateral denticles and their closer approximation to the principal median cone, which is extremely slender from base to apex. In the specimen selected as type (Cat. No. 8106, U.S.N.M.) of the new species, the total height is only about 11 mm., and a second specimen in the same collection is still smaller.

The two known specimens which have been obtained of this species are each contained in small black concretions found in the Caney shale of Antlers Quadrangle, Oklahoma, the exact locality being that referred to as No. 3987 in Doctor Girty's paper on the Fauna of the Caney Shale of Oklahoma.[1] An extensive collection of fossiliferous nodules from this and other localities in the same region was made by Doctor Girty, and is now preserved in the United States National Museum. Comparatively few of these concretions contain fish remains, but among them are several interesting forms, such as spines of *Stethacanthus*, arthrodiran body plates, and small Palaeoniscids showing the internal structure of the head. Two Coccosteus-like antero-ventro-lateral plates are shown in plate 10, figures 5 and 6. These remains are noticed hereinafter.

The only mention that has previously been made of the occurrence of fish remains in the Caney shale is to be found in Doctor Girty's discussion of the fauna in Bulletin 377 of the Geological Survey. The author there remarks (p. 13):

> Another neglected type is the fishes, represented not only by teeth but by what appear to be fragments of bone. In this connection may be mentioned agglomerations of organic fragments, possible of coprolitic origin, which occur as a rule in small concretions.

[1] Bull. U. S. Geol. Surv., No. 377, 1909, p. 75.

About 50 species of invertebrates are known from the Caney shale, and the beds are tentatively correlated in age with the uppermost Mississippian or base of the Pennsylvanian.

CLADODUS COMPRESSUS Branson.

For purposes of bibliographical record it may be stated here that the type-specimen upon which this species is founded was named *Cladodus striatus* in the original description.[1] It was pointed out by the present writer[2] that this name could not be used, Agassiz having already applied it to the type species of *Cladodus;* and in an article published in Science,[3] Doctor Branson proposed that it be replaced by the title of *C. compressus.*

Genus DICRENODUS Romanovsky.

Syn. *Carcharopsis* Agassiz; *Pristicladodus* M'Coy.

This genus is represented by a single species in the Mississippian rocks of this country, described by Newberry under the name of *Carcharopsis wortheni.*[4] A second North American species appears to be indicated by the specimen immediately to be described.

DICRENODUS TEXANUS, new species.

Plate 7, fig. 4.

Founded upon a unique tooth having a total height of 2.5 cm., and width at base of crown of 2 cm. In general form resembling the type of *D. wortheni* (Newberry), but anterior coronal face slightly concave, no lateral cusps at the base, and root with deep median sinus. Coronal margins strongly and evenly crenulated from the apex to the base, and summits of the lateral crenulations secondarily notched.

The type and solitary known specimen of the new cladodont just described is catalogued as No. 8097. It was collected by Prof. J. A. Udden, of the University of Texas, in 1914, from strata of Pennsylvanian age near San Saba, Texas, and by him presented to the Museum through the present writer. From the same horizon and locality Professor Udden also obtained the ichthyodroulite hereinafter referred to under the caption of *Physonemus gemmatus.*

Family PETALODONTIDAE Newberry and Worthen.

Of this extinct family only a single genus is known, *Janassa,* in which other skeletal parts have been found in natural association with the dentition. No fin-spines are known to occur in this genus, hence it is unlikely that such defenses were present in other members of the same family. Jaekel, however, in a valuable article on the

[1] 30th Ann. Rept. Dept. Geol. Nat. Resources Indiana, 1906, p. 1378.
[2] Memoir 10, N. Y. State Museum, 1907, p. 62.
[3] Vol. 27, 1908, p. 311.
[4] Pal. Illinois, vol. 2, 1866, p. 69, pl. 4, fig. 14.

structure of Petalodonts,[1] has suggested that the fin-spines known as *Stichacanthus* and *Physonémus* (including *Xystracanthus* and *Batacanthus*) should be associated on theoretical grounds with the teeth of *Polyrhizodus* and *Petalodus* respectively. He also conjectured that the teeth of *Petalodus* and *Ctenoptychius* were borne in the mouth of one and the same genus of Palaeozoic sharks.

Genus POLYRHIZODUS M'Coy.

Syn. *Dactylodus* Newberry and Worthen.

As remarked by Dr. A. S. Woodward in his Catalogue of Fossil Fishes in the British Museum (Part 1, p. 56), "no teeth of this genus having been found thus far in natural association, it is impossible to distinguish between specific characters and the variations exhibited by teeth in different parts of a single jaw." There is, however, some reason in support of Jaekel's surmise that the teeth of *Polyrhizodus* are associated in the same jaw with those having low and elongate crowns, commonly referred to *Chomatodus*.

POLYRHIZODUS CONCAVUS (St. John and Worthen).

Plate 8, fig. 4.

The teeth of this species resemble those of *P. princeps* (the type species of the so-called "*Dactylodus*"), but are smaller, and the base of the crown is more strongly arched downward in the middle. A single specimen in the Museum collection, catalogued as No. 8100, is peculiar in showing an apparently undivided root.

Formation and locality.—St. Louis limestone (Mississippian); near Alton, Illinois (from the Hambach collection).

POLYRHIZODUS GRANDIS, new species.

Plate 8, figs. 1, 2.

Teeth robust and of relatively large size, laterally elongated, with moderately high crown, the base line not much curved on the posterior face; the root subdivided into six or more tumid branches.

This species is founded upon two specimens in the United States National Museum collection, catalogued as Nos. 8104 and 8116, one of which has the crown very excellently preserved, but lacks a part of the root, and the other shows the latter structure in nearly perfect condition, but has the crown somewhat worn and fractured.

Probably to this species should be referred certain low and elongate *Chomatodus*-like teeth occurring in the same formation, by analogy with the association of two very similar types of teeth belonging to *P. concavus* Trautschold, from the Russian Coal Measures. This is in

[1] Jaekel, Otto, Ueber die Organisation der Petalodonten. Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, pp. 258–298.

accordance with Jaekel's proposed association of parts, already referred to.[1] One such tooth in the National Museum collection is catalogued as No. 8103, and represented of the natural size on plate 8, figure 6.

Formation and locality.—St. Louis limestone (Mississippian); near Alton, Illinois (from the Hambach collection).

Family PSAMMODONTIDAE De Koninck.

Genus PSAMMODUS Agassiz.

The teeth in this genus are quadrate, more or less elongated, rarely nearly square; root much thicker than the crown, and readily detached from the latter; coronal surface generally marked by transverse rugae, complete dentition consisting of from two to four longitudinal rows of pavement teeth in different species, as inferred from their form and marks of mutual contact.

PSAMMODUS PLENUS St. John and Worthen.

Plate 7, fig. 8.

Psammodus plenus St. John and Worthen, Pal. Illinois, vol. 7, 1883, p. 213, pl. 16, figs. 1–4; pl. 17, figs. 1–4.

Psammodus glyptus Newberry (*errore*), Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 210, pl. 19, figs. 7, 8.

The teeth of this species attain large size, and, according to the original authors, it is possible to distinguish between those belonging to upper and lower dental pavements. The form supposed by them to pertain to the upper jaw is described as "subrhomboidal, or of a laterally elongate-trapezoidal outline, gently arched antero-posteriorly." The supposed mandibular teeth "are distinguished by their subquadrangular outline and relatively narrower transverse diameter compared to the length."

According to the interpretation of the authors just quoted the teeth "were ranged in double rows upon the jaws," in the same manner as indicated by them in the case of *P. springeri*, and by Newberry in the case of his so-called *Archaeobatis gigas*, which latter can scarcely be maintained as a distinct genus. There exist, however, certain teeth of *P. plenus* which from their bilateral symmetry are assignable to a median position in the mouth, either above or below; and these were evidently bordered on either side by a row of lateral teeth. Two such teeth which we interpret as indicative of a median unpaired row have already been figured by Newberry under the erroneous designation of *P. glyptus*;[2] the original specimens are now preserved in the American Museum of Natural History, and have been compared by the writer with other teeth of the same species. The markings

[1] Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, p. 280.

[2] Monogr. U. S. Geol. Surv., vol. 16, 1889, pl. 19, figs. 7, 8.

in allusion to which the specific title was bestowed are the result partly of wear and partly of discoloration along concentric lines of growth, as shown by the arrangement of the pores in which the fine tubules terminate.

A number of well preserved examples of this species, all from the St. Louis limestone, are contained in the National Museum collection. An unusually large-sized grinding tooth, collected by G. Hambach, is shown of slightly less than the natural size in plate 7, fig. 8.

Formation and locality.—St. Louis limestone; near St. Louis, Missouri; also Illinois and Michigan.

Family COCHLIODONTIDAE Owen.

Genus PSEPHODUS Agassiz.

As in *Cochliodus*, so also in *Psephodus* and closely allied genera, it is probable that a series of helodoid teeth was associated in the same mouth as the large posteriorly placed grinding plates, which latter have resulted from the fusion of a double series on either side of the jaw above and below of narrow and elongate elements. A review of the literature describing the association of *Psephodus* and *Helodus*-like teeth has been given by E. B. Branson;[1] and the conclusion reached by this author is that probably in *Cochliodus* as well as in *Psephodus* no helodoid teeth were present in the complete dentition. Branson's view, which is directly contrary to the prevailing opinion of palaeichthyologists, is based upon his interpretation of the type of the following-named species.

PSEPHODUS LEGRANDENSIS Branson.

Plate 18, fig. 2.

Psephodus legrandensis BRANSON, Journ. Geol., vol. 13, 1905, p. 24, pl. 1, fig. 2.

The unique specimen serving as the type of this species shows the two series of crushing plates belonging to both halves of the same jaw, and it is supposed by the original author that these elements lie in their undisturbed natural position. It is further supposed by him that they were preceded in front by a pair of small-sized triangular teeth which were in contact with each other along the median line. According to this conjectural reconstruction, as stated by the author,[2] "no place remains on the jaw for the helodoid teeth which have been so generally considered as forming a component part of the dentition of this genus.

Through the kindness of Dr. Stuart Weller, of the University of Chicago, the present writer has had the privilege of examing the type

[1] Branson, E. B., Notes on some Carboniferous Cochliodonts, with descriptions of seven new species. Journ. Geol., vol. 13, 1905, pp. 20–34.

[2] Idem, p. 20.

specimen, which is now the property of the Walker Museum (Cat. No. 10038).

To the mind of the present writer the conclusion is irresistible that the anterior and posterior plates present in the right and left hand sides of the jaw have been crowded against one another so as to lie in juxtaposition along the median line as the result of post-mortem deformation. They did not naturally form a compact pavement during life, but the right and left halves were separated, leaving a V-shaped area between them, as in *Cochliodus*. This inferred separation throughout their length would permit of the presence of a series of *Helodus*-like teeth in contact with the front margin of the anterior pair of grinding plates, and it is not necessary to assume that their place was taken by a single pair of small triangular teeth. In a word, the evidence furnished by the type of this species does not appear to be irreconcilable with well established reconstructions of Psephodont and Cochliodont dentition.

Genus DELTODUS Agassiz.

A discussion of the relations between this genus and *Sandalodus* was published by E. B. Branson a decade ago, in an article entitled Notes on Carboniferous Cochliodonts.[1] We are not able to share this author's view that only a single dental plate is present on each side of the jaw above and below in *Sandalodus* instead of three, as in *Deltodus* and most Cochliodonts. Again, in his discussion of the teeth commonly known as *Deltodus occidentalis*, he undertakes to remove this species to *Sandalodus*, "because there is evidently only one tooth to each ramus of the jaw." This latter statement is merely an assumption resting upon negative evidence, and no proof has yet been adduced to show that the number of dental elements present in the mouth of *Sandalodus* was the same as in *Deltodus*.

DELTODUS OCCIDENTALIS (Leidy).

Plate 8, fig. 3.

Cochliodus occidentalis LEIDY, Trans. Amer. Philos. Soc., vol. 11, 1857, p. 88, pl. 5, figs. 3–16.

Deltodus occidentalis EASTMAN, Bull. Mus. Comp. Zool., vol. 39, 1902, p. 200, pl. 4, fig. 38; pl. 5, fig. 53.

Sandalodus occidentalis BRANSON, Journ. Geol., vol. 13, 1905, p. 27, pl. 1, figs. 8, 9.

Sandalodus occidentalis BRANSON, 30th Ann. Rept. Dept. Geol. Nat. Resources Indiana, 1906, p. 1384, pl. 41, fig. 33.

The complete synonymy of this species is given in the above-cited articles by E. B. Branson and the present writer. In our opinion, however, Doctor Branson is in error in transferring the species to the

[1] Journ. Geol., vol. 13, 1905, pp. 25–27.

genus *Sandalodus*, solely on account of our lack of knowledge of the anterior components of the complete dentition. The form of the large crushing teeth of this species is unmistakably that of *Deltodus*, as may be seen from an inspection of the example shown on plate 8, fig. 3, which is from the St. Louis limestone near St. Louis, Missouri. In geological range the species extends from the Burlington to the St. Louis limestone, inclusive.

ICHTHYODORULITES.

Under this head mention is made of certain interesting dermal defenses of Carboniferous sharks which are preserved in the collection and are worthy of special notice. The interpretation of some of these structures as belonging to primitive Chimaeroids is a novel feature. Generic names founded upon fin-spines and clasping organs are to be understood as used in a provisional sense only.

Genus CTENACANTHUS Agassiz.

In the year 1902 descriptions were published by the present writer[1] of several Kinderhook species of this genus, the types of which had been acquired by the United States National Museum. At the time of their description an exact record of the locality was unobtainable, but at a later date the information was received from Prof. Charles Schuchert that the types of *C. longinodosus*, *C. lucasi*, *C. decussatus*, and *C. solidus*, together with the figured specimens of *C. spectabilis* and *C. venustus*, were collected from the Kinderhook quarries at Le Grand, in Marshall County, Iowa. The formation as exposed in this vicinity is described in the Annual Report of the Iowa Geological Survey, vol. 7, 1896, pp. 221–226.

CTENACANTHUS GRACILLIMUS Newberry and Worthen.

Plate 5, fig. 4; plate 7, fig. 7.

Ctenacanthus gracillimus NEWBERRY and WORTHEN, Pal. Illinois, vol. 2, 1866, p. 126, pl. 13, fig. 3.—ST. JOHN and WORTHEN, Pal. Illinois, vol. 7, 1883, p. 238, pl. 24, fig. 1.

Acondylacanthus occidentalis NEWBERRY, Monogr. U. S. Geol. Surv., vol. 16, 1889, p. 206, pl. 25, fig. 6.

The reasons for uniting the "species" described by Newberry and Worthen as *Peltacanthus* (?) *occidentalis* with *C. gracillimus* of the same authors were pointed out by St. John and Worthen in 1883, and reaffirmed by the present writer in 1902.[2] Under the designation of *Acondylacanthus occidentalis* a distorted and worn spine from the St. Louis limestone was figured by J. S. Newberry in 1889, evidently through erroneous interpretation. The specimen should properly be referred to the species now under discussion, and a more per-

[1] Bull. Mus. Comp. Zool., vol. 39, No. 3.
[2] Idem., p. 86.

fect example, from the same horizon and locality, is shown in our plate 7, figure 7. In this, however, as in most examples of this species and of *Physonemus* from the St. Louis limestone, the fine details of tuberculate ornamentation have become obliterated. A smaller and more arcuate spine, or rather, the distal portion of one, presumably of the same species, is shown in plate 5, figure 4. Its curvature and smooth costae are suggestive of *Acondylacanthus attenuatus* Davis, from the Lower Carboniferous limestone of Ireland, but it has a narrower transverse section, and is best regarded as a rather strongly arched example of *C. gracillimus*. It is catalogued as No. 8101.

LIST OF SPECIES OF CTENACANTHUS OCCURRING IN THE MISSISSIPPIAN SERIES.

1. *C. coxianus* St. John and Worthen ..... Kinderhook; also Keokuk.
2. *C. decussatus* Eastman ..... Kinderhook; also Keokuk.
3. *C. depressus* Newberry ..... Kinderhook limestone.
4. *C. longinodsus* Eastman ..... Kinderhook limestone.
5. *C. lucasi* Eastman ..... Kinderhook limestone.
6. *C. sculptus* St. John and Worthen ..... Kinderhook limestone.
7. *C. semicostatus* St. John and Worthen ..... Kinderhook limestone.
8. *C. solidus* Eastman ..... Kinderhook limestone.
9. *C. spectabilis* St. John and Worthen ..... Kinderhook limestone.
10. *C. varians* St. John and Worthen ..... Kinderhook limestone.
11. *C. venustus* Eastman ..... Kinderhook limestone.
12. *C.*(?) *burlingtonensis* St. John and Worthen ..... Burlington limestone.
13. *C. gradocostatus* St. John and Worthen ..... Burlington limestone.
14. *C. acutus* Eastman ..... Keokuk limestone.
15. *C. cylindricus* Newberry ..... Keokuk limestone.
16. *C. excavatus* St. John and Worthen ..... Keokuk limestone.
17. *C. keokuk* St. John and Worthen ..... Keokuk limestone.
18. *C. xiphias* St. John and Worthen ..... Keokuk limestone.
19. *C. costatus* Newberry and Worthen ..... St. Louis limestone.
20. *C. deflexus* St. John and Worthen ..... St. Louis limestone.
21. *C. gemmatus* St. John and Worthen ..... St. Louis limestone.
22. *C. gurleyi* Newberry ..... St. Louis limestone.
23. *C. harrisoni* St. John and Worthen ..... St. Louis limestone.
24. *C. littoni* Newberry ..... St. Louis limestone.
25. *C. pellensis* St. John and Worthen ..... St. Louis limestone.
26. *C. angulatus* Newberry and Worthen ..... Chester limestone.
27. *C. canaliratus* St. John and Worthen ..... Chester limestone.
28. *C. similis* St. John and Worthen ..... Chester limestone.

Genus PHYSONEMUS M'Coy.

Syn. *Xystracanthus* Leidy; *Drepanacanthus* Newberry and Worthen.

The earliest and most primitive remains assignable to this "genus" are found in the Kinderhook limestone of the Mississippi Valley, where they are accompanied by small spines of *Stethacanthus*. The Burlington species of both genera are considerably larger than those from the Kinderhook, but they are feebly ornamented, and so too are the

Keokuk species. *Stethacanthus* seems to have attained its maximum size in the stage represented by the Keokuk limestone, as *Physonemus* did in the Burlington; and a marked diminution of size is observable in both genera toward the close of the Mississippian series.

A certain group of large *Physonemus*-like spines is peculiar in that the exserted portion is forwardly curved, instead of backwardly, as in most ichthyodorulites, and this feature appeared so anomalous to early authors, like Leidy, Newberry, and Worthen, as in their judgment to warrant a generic separation from *Physonemus*. Hence several species belonging to this category were described under the names of *Xystracanthus* and *Drepanacanthus*. The group of large, forwardly curved spines referred to includes such forms as the so-called *Drepanacanthus gemmatus* Newberry and Worthen, *D. anceps* Newberry and Worthen, *Xystracanthus acinaciformis* St. John and Worthen, *Physonemus gigas* Newberry and Worthen, and the defenses theoretically associated with the teeth of *Polyrhizodus rossicus* by A. Inostranzev [1] and O. Jaekel.[2] However, it seems preferable to retain all of the "species" represented by these spines within the limits of *Physonemus*, and their forward curvature favors the interpretation of these bodies as head spines and clasping organs such as are developed among recent and fossil Chimaeroids.

Following is a list of the known North American species of *Physonemus*, understood in its broader sense:

1. *P. hamus-piscatorius* Eastman.....Kinderhook.
2. *P. pandatus* Eastman.....Kinderhook.
3. *P. gigas* Newberry and Worthen.....Burlington.
4. *P. gemmatus* (Newberry and Worthen).....Keokuk.
5. *P. stellatus* (Newberry and Worthen).....Keokuk.
6. *P.* (?) *baculiformis* (St. John and Worthen).....Keokuk.
7. *P.* (?) *necis* (St. John and Worthen).....Keokuk.
8. *P. arcuatus* M'Coy.....St. Louis.
9. *P. acinaciformis* (St. John and Worthen).....Coal Measures.
10. *P. anceps* (Newberry and Worthen).....Coal Measures.
11. *P. asper* Eastman.....Coal Measures.
12. *P. mirabilis* (St. John and Worthen).....Coal Measures.

PHYSONEMUS GEMMATUS (Newberry and Worthen).

Plates 3 and 4; plate 5, fig. 3.

Drepanacanthus gemmatus NEWBERRY and WORTHEN, Pal. Illinois, vol. 2, 1866, p. 123, pl. 12, figs. 1, 2.

The only published figures of this species are imperfectly preserved spines in which the apical portion is lacking, and the inserted basal part is not completely shown. Two very large (25 cm. high) and well preserved spines belonging to the United States National Museum collection fortunately supplement each other as regards cer-

[1] Travaux Soc. Nat. St. Pétersb., vol. 19, 1888, pp. 1–18, figs. 7–10.
[2] Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, p. 281, fig. 5.

tain details; together they acquaint us with the entire outline, including the part inserted in the integument, and also show the characters of the superficial ornamentation more clearly than in the original illustrations of this species.

At first sight it may seem peculiar that the large, obliquely directed denticles seen along the concave margin near the distal extremity should occur on the anterior, instead of posterior, face of the spine. Similar conditions, however, have been noted by St. John and Worthen in the form described by them as *Xystracanthus* [=*Physonemus*] *mirabilis*, and the like is to be observed also in the still more arcuate and forwardly curved spines from the Russian Coal Measures which have been theoretically associated by Inostranzev[1] and Jackel[2] with the teeth of *Polyrhizodus rossicus*. We should not hesitate to refer these Russian spines to the genus *Physonemus*, and the interpretation that we should place upon them is to regard them as frontal clasping organs, of the same nature as those in *Squaloraja*, *Myriacanthus*, and recent Chimaeroids.

A single arcuate spine, much weathered and preserved partly in the form of an impression, but apparently referable to this species, was obtained by J. A. Udden in 1914 from Pennsylvanian strata near San Sabo, Texas, at the same locality that yielded the type of *Dicrenodus texanus*. It is contained in the Museum collection (Cat. No. 8108) and is shown in plate 5, figure 3.

PHYSONEMUS ARCUATUS M'Coy.

Plate 5, figs. 1, 2.

Physonemus arcuatus M'Coy, Ann. Mag. Nat. Hist., [2] vol. 2, 1848, p. 117, and Brit. Palacoz. Foss., 1855, p. 638, pl. 3 I, fig. 20.—Eastman, Bull. Mus. Comp. Zool., vol. 39, 1903, p. 208, text-fig. 12.

Spines of this species are of extremely rare occurrence in the Lower Carboniferous of the Mississippi Valley, and few perfect examples have been obtained from either this country or Great Britain. In general the known specimens are denuded of their superficial ornamentation, and the denticles along the concave margin are either worn or broken away. Two specimens which show the tuberculate ornamentation more perfectly than in any previously described example of this species are preserved in the Museum collection, and illustrated in plate 5, figures 1 and 2. They differ somewhat in general outline, one being slender and erect, and having the posterior denticles more strongly developed than in the other, which is more compact and arcuate. Nevertheless, we are not inclined to regard these differences as sufficient to warrant the establishment of a new

[1] Travaux Soc. Nat. St. Pétersb., vol. 19, 1888, pp. 1–18, with plate.

[2] Zeitschr. Deutsch. Geol. Ges., vol. 51, 1899, p. 281, text-fig. 5. The ornamentation of these spines is suggestive of certain species of *Oracanthus*.

species for the more slender variety, especially in view of the fact that the lower portion of the convex margin is not entire, and some of the posterior denticles have become lost.

Important to note is the fact that the original of plate 5, figure 2, displays very clearly the line of insertion at the base, and the direction of this line would seem to indicate that in this as in other species of *Physonemus*, the distal portion of the spine was forwardly curved. This disposes of the view formerly entertained that the *P. arcuatus* type of head-spine was homologous with the laterally compressed posterior branch of *Erismacanthus* (see pl. 7, figs. 2, 3). That this recurved portion of *Erismacanthus* spines was actually posterior in position follows as a necessary consequence of the interpretation of these organs as frontal claspers. It is probable that in *Physonemus*, as in *Heteracanthus*, the forwardly arched spines were situated immediately behind the head, at the junction with the neck.

Formation and locality.—St. Louis limestone; near St. Louis, Missouri (from the G. Hambach collection).

Genus ERISMACANTHUS M'Coy.

Of this genus two European and two American species have been described, all of the forms agreeing closely with the *Physonemus* type of frontal spine, but differing from it in that the spines are divaricated; that is, they consist of two branches extending in opposite directions in the same vertical plane. The imperfect ichthyodorulites known as *Gampsacanthus*, *Lecracanthus*, and *Dipriacanthus* appear to be of the same general nature, and may be provisionally regarded as the dissociated anterior branches belonging to *Erismacanthus*. The spines of this genus are somewhat asymmetrical, and were probably located on either side of the head region, whereas the bilaterally symmetrical *Physonemus* type of frontal spine occupied an occipital position.

ERISMACANTHUS FORMOSUS Eastman.

Erismacanthus formosus EASTMAN, Amer. Naturalist, vol. 36, 1902, p. 850, text-fig. 1; Bull. Mus. Comp. Zool., vol. 31, 1902, p. 212, text-fig. 13.

The type of this, the largest known species of the genus, was collected by Dr. G. Hambach in the St. Louis limestone of Missouri, and is now preserved in the collection of the United States National Museum.

ERISMACANTHUS MACCOYANUS St. John and Worthen.

Plate 7, figs. 2, 3.

Erismacanthus maccoyanus ST. JOHN and WORTHEN, Pal. Illinois, vol. 6, 1875, p. 461, pl. 22, figs. 1, 2, 4 (*not* fig. 3).—EASTMAN, Bull. Mus. Comp. Zool., vol. 31, 1902, p. 211.

The paired frontal claspers described under this name are all of small size, none so far as known exceeding 5 cm. in length. One of

the specimens described by the original authors[1] and doubtfully included by them in this species has since been interpreted by the present writer as belonging to an immature example of *E. formosus*. In the latter species the denticles along the concave margin of the posterior spine are closely approximated; in *E. maccoyanus* they are widely spaced. The United States National Museum collection contains well-preserved specimens of this form from the St. Louis limestone of Missouri (from the G. Hambach collection). One of the most perfect is catalogued as No. 8094, and shown in plate 7, figure 3.

Genus STETHACANTHUS Newberry.

The spines referred to this genus present some resemblance to those of *Physonemus*, and also, in respect to their elongated inserted portion, to certain species of *Oracanthus*, such as *O. vetustus*, presently to be noticed. The maximum size in this genus appears to have been reached in the species known as *Stethacanthus productus*, from the Keokuk limestone of Iowa, the type and only known example of which is preserved in the collection of the United States National Museum. (Cat. No. 3841.)

Two small-sized spines referable to this genus have recently been described by L. Hussakof[2] from the Waverly of Kentucky under the new specific titles of *S. humilis* and *S. exilis*. They are preserved in phosphatic nodules from one or two localities near Junction City, in Boyle County. It is interesting to compare this occurrence of *Stethacanthus* spines with that of similarly formed spines under precisely the same conditions, within small, hard nodules, in the Caney shale of Oklahoma, at the dividing line between the Mississippian and Pennsylvanian. A portion of such a spine, which cannot be specifically identified with certainty, is among the specimens obtained by Doctor Girty from this horizon, and bears the Museum catalogue number 8110. It is from the locality numbered 6079 in Doctor Girty's Bulletin on the Caney Shale, published by the United States Geological Survey in 1909.

Genus HARPACANTHUS Traquair.

This genus, known hitherto by but a single species, *H. fimbriatus* (Stock), includes small, angularly bent spines, which are best interpreted as frontal claspers corresponding to those of recent male Chimaeroids.

HARPACANTHUS PROCUMBENS, new species.

Plate 7, fig. 1.

Spines resembling those of *H. fimbriatus* but distinguished from them by having a more closely spaced series of conical, recurved,

[1] Pal. Illinois, vol. 6, pl. 22, fig. 3.

[2] Hussakof, L. Descriptions of four new Palaeozoic Fishes from North America. Bull. Amer. Mus. Nat. Hist., vol. 32, 1913, pp. 245-250.

faintly striated denticles, eight in number, extending for a short distance backward from the distal extremity along what corresponds to the antero-inferior margin in the head-spines of modern Chimaeroids; the postero-superior margin opposite the series of recurved denticles gently reflected. A sudden curve in the direction of the spine takes place about midway its length, by which the distal portion of the shaft becomes deflected at right angles from the proximal portion. At the point where the abrupt curvature begins along the antero-inferior margin is seen a prominent semicircular knob-like expansion, which probably served for the attachment of muscles operating to depress the clasper. Surface of spine smooth throughout, but under the lens minute pittings are seen. Cross-section more or less oval, somewhat flattened.

The type and only known example of this species was collected by Dr. G. Hambach in the St. Louis limestone, near St. Louis, Missouri. It was acquired by the United States National Museum a few years ago, and is catalogued as No. 8095.

Genus ORACANTHUS Agassiz.

The spines belonging to this genus often attain a very large size, are much laterally compressed and triangular, rarely elongated and slightly arched; internal pulp-cavity very large, base of insertion usually not very deep, sometimes much extended in horizontal direction. Sides of exserted portion ornamented by large tubercles, with a tendency to become arranged in transverse series, sometimes fused.

ORACANTHUS VETUSTUS Leidy.

Plate 6, fig. 2.

Oracanthus vetustus LEIDY, Proc. Acad. Nat. Sci. Phila., vol. 7, 1856, p. 414, and Journ. Acad. Nat. Sci. Phila., [2] vol. 3, 1856, p. 161, pl. 16, figs. 1–3.—NEWBERRY, Trans. N. Y. Acad. Sci., vol. 16, 1897, p. 285, pl. 22, fig. 3.

The peculiar characters of the much extended base in the spines belonging to this species remained unsuspected until the publication of Newberry's posthumous paper in 1897, in which a single large and nearly complete spine was described and illustrated. In the same article is given a review of the principal literature of the genus, and more complete bibliographical references are brought together in J. W. Davis's monograph on Fossil Fishes of the Carboniferous Limestone (pp. 525–526).

The interesting specimen figured by Newberry was obtained from the Kinderhook limestone near Burlington, Iowa. In the Museum collection are two remarkably perfect specimens from the same horizon at Le Grand, Iowa, one of which is shown in plate 6, figure 2. Some differences are to be noted in the details of ornamentation of the spines that have been referred to this species, but they are not

considered as indicating more than individual variation. The differences will be appreciated from a comparison of the original of our plate 6, figure 2, with the complete specimen figured by Newberry. As regards the nature of the inserted portion, however, the two stand in substantial agreement, both being shallow and greatly elongated. Interesting to observe is the fact that the anterior extremity of the elongated base rises into a tumid "shoulder," recalling the very similar appearance presented by spines of Stethacanthus.

Formation and locality.—Kinderhook limestone (Mississippian); Le Grand, Iowa.

ORACANTHUS TRIANGULARIS, new species.

Plate 5, figs. 5, 6.

Spines attaining to a large size, of triangular cross-section in the distal portion, lateral face broad and triangular, resembling in conformation and size the spines of *Xystracanthys mirabilis* from the Coal Measures, except in being less arcuate, and in having more strongly developed conical denticles along the posterior margin. Superficial ornament consisting of large tubercles arranged in more or less regular transverse series, many of them fused together, forming discontinuous ridges.

A few spines presenting the above characteristics are contained in the Museum collection, and, although incomplete, are sufficiently well marked to warrant the establishment of a distinct species to receive them. No other spines are known from the American Lower Carboniferous which exhibit the same broad triangular outline and transversely ridged external surface, due to the coalescence of coarse tubercles in fairly regular series. At the same time the distal extremity is triangular and less laterally compressed in cross-section than is true of most species. The style of ornamentation somewhat resembles that of the type-species, *O. milleri*, and the long and tapering *Physonemus*-like spines which Inostranzev has described from the Russian Carboniferous in accompaniment with the teeth of *Polyrhizodus*. A small fragment from the Chester limestone of Illinois, described by St. John and Worthen as *Oracanthus rectus*, shows a tendency of the tubercles of the exserted portion to become fused into irregular transverse series. The same authors also figure the distal portion of a triangular spine, possibly belonging to the species under discussion, which they erroneously refer to *O. vetustus*.[1] In *O. milleri* the series of ornamented ridges extend obliquely over the sides of the exserted portion.

Formation and locality.—St. Louis limestone, near St. Louis, Missouri. (Cat. No. 8377, U.S.N.M.)

[1] Pal. Illinois, vol. 7, 1883, pl. 24, fig. 2.

Genus EDESTUS Leidy.

Through fortunate discoveries in this country and abroad, our knowledge of the peculiar structures known as the Edestidae has been largely augmented during recent years, and the number of described species increased to more than a score. A review of the existing literature was published by the present writer in 1903,[1] and, a decade later, a further review was contributed by A. Karpinsky,[2] former Director of the Russian Geological Survey. In the same year appeared an important article by O. P. Hay,[3] in which a specimen named by him *Edestus mirus* was declared to afford conclusive proof as to the dental nature of the much-debated segmented structures. This specimen is noteworthy also for having associated with it in the same block of matrix two *Orodus*-like teeth, thus suggesting that the segments of *Edestus* and related genera (*Toxoprion*, *Lissoprion*, *Helicoprion*) were in reality the fused symphysial teeth of Palaeozoic Cestracionf sharks. More recent contributions to our knowledge of this class of remains are two papers by Karpinsky,[4] one on the general nature of *Helicoprion*, the other describing a new species and a preliminary account of Edestus by Woodward.[5]

EDESTUS HEINRICHI Newberry and Worthen.

Plate 6, fig. 1.

Edestus heinrichi NEWBERRY and WORTHEN, Pal. Illinois, vol. 4, 1870, p. 350. pl. 1. fig. 1.

One of the largest and best preserved examples of this species has recently been added to the United States National Museum collection, and catalogued under the number 8032. It was collected a number of years ago by Mr. William Metcalf from the Coal Measures of Appanoose County, Iowa, and by him presented to the National Museum in 1914. Its total length is about 33 cm, and the number of segments indicated by separate teeth and sheaths is ten. Besides these, an eleventh and youngest formed segment, not yet consolidated with the fused mass at the time of the creature's death, when it became lost, is indicated by a smooth area on either face of the posterior half of the common base, where the newly formed

[1] Mark Anniversary Volume, pp. 279–289. New York, 1903.

[2] Karpinsky, A. On Helicoprion and other Edestidae: Verh. Kais. Min. Ges. St. Petersb., vol. 49, 1912, pp. 69–94.

[3] Hay, O. P. On an important specimen of *Edestus*, etc. Proc. U. S. Nat. Mus., vol. 42, 1912, pp. 31–38. pls. 1, 2. See also the following by the same author: On the nature of *Edestus* and related genera, with descriptions of one new genus and three new species. Proc. U. S. Nat. Mus., vol. 37, 1909, pp. 43–61, pls. 12–15. The specimens of *Edestus* described in these papers by Doctor Hay are now preserved in the collection of the United States National Museum. They include the types of *Edestus crenulatus*, *E. serratus*, *E. mirus*, and *Lissoprion ferrieri* Hay.

[4] Karpinsky, A. Notice sur la nature de l'organe hélicoïdal du Helicoprion. Bull. Soc. Ouralienne Sci. Nat. d' Ekatérinebourg, vol. 35, 1915, pp. 117–145. (Text in Russian and French)—A new species of Helicoprion (*H. clerei*). Bull. Acad. Imp. Sci. St. Pétersb., vol. 35, 1916, pp. 701–708. (Text in Russian.)

[5] Woodward, A. S. A new species of Edestus from Yorkshire. Nature, vol. 98, 1916, pp. 102–103.

sheath enveloped the immediately preceding segment. A specimen closely rivalling the one here figured in size and perfection of preservation, but showing a series of nine teeth instead of ten, has recently been acquired by the American Museum of Natural History.

TELEOSTOMI.

Order CROSSOPTERYGII.

The larger number of remains of "fringe-finned ganoids" belonging to the United States National Museum collection consists of Rhizodont scales (14 of them being types described by Cope and others), small Coelacanths, and more or less complete skeletons of Palaeoniscids, all preserved within concretions from the well-known Mazon Creek locality in Grundy County, Illinois. Most of these nodules were formerly contained in the Lacoe collection, acquired by the Museum about twenty years ago. The Lesquereux collection was especially rich in fossils from the Coal Measures of Linton, Ohio, and most of the fishes from this locality are Coelacanths. The so-called ichthyic genus and species, *Mycterops orcinatus* Cope[1] from the Coal Measures of Beaver County, Pennsylvania, is not of vertebrate nature, but founded upon arachnid fragments. The type is catalogued as No. 1977, and another specimen identified as a jugular plate of Coelacanthus by Jackel, is catalogued as No. 1975.

Family COELACANTHIDAE.

Genus COELACANTHUS Agassiz.

The earliest known representative of this genus is a small form occurring in the basal member of the Upper Devonian near Gerolstein, in Rhenish Prussia, first described by the late Prof. A. von Koenen[2] in 1895, and recognized as a true Coelacanth by Smith Woodward[3] in 1898. A single species, *C. welleri*, has been described by the present writer from the base of the Kinderhook limestone near Burlington, Iowa, and two species of this and a peculiar allied genus, *Palaeophichthys*, have been made known from remains preserved in nodules found at the famous Mazon Creek locality in Illinois.

In the Palaeontology of Ohio (vol. 1, 1873) twenty-seven species of fossil fishes are described from the Coal Measures of Linton, Ohio, and among the number are three belonging to the genus *Coelacanthus*. It is stated by Newberry[4] that the second most abundant species

[1] Amer. Naturalist, vol. 20, 1886, p. 1029.

[2] Koenen, A. von. Ueber einige Fischreste des norddeutschen und böhmischen Devons. Abhandl. Ges. Wiss. Göttingen, phys. Cl., vol. 40, 1895, p. 28.

[3] Woodward, A. S. Note on a Devonian Coelacanth fish. Geol. Mag., vol. 5, 1898, p. 529.

[4] Newberry, J. S. The Paleozoic Fishes of North America, Monogr. U. S. Geol. Survey, vol. 16, 1889, p. 213.

occurring at this locality is *Coelacanthus elegans;* and this author remarks:

> While perhaps a thousand specimens more or less perfect have been taken from one coal mine there, with the exception of a single one found at Morris (Illinois), no representative of this world-wide genus has been elsewhere seen in America

At the conclusion of the volume just cited Newberry records this additional observation in regard to *Coelacanthus ornatus:*

> This is a small species found at Linton, Ohio, where it is very rare. It is briefly described in the Palaeontology of Ohio, vol. 1, p. 340. Since the publication of that volume I have obtained several other specimens and find that it may be readily identified by its small size, relatively large cranial tubercles, and very thin, delicate scales on which the raised lines are parallel and do not converge as in *C. elegans* and *C. robustus.*

Again, at page 215 of the same work, the author remarks:

> Since the notice of the Mazon Creek fishes was published in the report of the Illinois Geological Survey I have received from there a single specimen each of *Eurylepis* and *Coelacanthus,* probably not distinct from those found at Linton.

It thus appears from the writings of Newberry that among the large number of Mazon Creek nodules examined by him, only a single specimen of Coelacanthus came under his observation, and that he identified as belonging to *C. elegans.* An allied small species was described by the present writer in 1903, and a supposed new form of large size has recently been discovered by Prof. E. H. Barbour in the Coal Measures of Nebraska.

COELACANTHUS ELEGANS Newberry.

Plate 9, figs. 5, 6; plate 11, figs. 3, 4.

Probably to this species should be referred a half dozen specimens in the United States National Museum collection, all much distorted and imperfect, but agreeing in scale characters and details of ornamentation of cranial plates with *C. elegans.* The fact that Newberry recognized the occurrence of this species at the Mazon Creek locality increases the probability that we have really to do with a form already known from Linton, Ohio, instead of with an undescribed representative of the genus. The specimens figured in the accompanying plates are catalogued under the following numbers, 4381, 4383, 4405, 4438.

Formation and locality.—Coal Measures, Mazon Creek, Illinois.

COELACANTHUS EXIGUUS Eastman.

Plate 10, fig. 1.

Coelacanthus exiguus EASTMAN, Journ. Geol., vol. 10, 1902, p. 538, text fig. 3; Bull. Mus. Comp. Zool., vol. 39, 1903, p. 189, pl. 5, fig. 48.

This is a small-sized species, none of the known examples exceeding 5 cm. in total length. The type and nine other specimens are

preserved in the Peabody Museum; a single specimen is found in the Museum of Comparative Zoology at Harvard College, and two others, both in counterpart and very well preserved, are the property of the United States National Museum. They were formerly in the Lacoe collection, and one of them bears an original label in Newberry's handwriting which reads: "*Palaeoniscus gracilis* New." It is catalogued as No. 4398, and is the original of our plate 10, figure 1. Whereas in the type-specimen only about nine caudal fin-rays are to be counted above and below, this specimen shows at least thirteen in the lower lobe.

Formation and locality.—Coal Measures; Mazon Creek, Illinois.

Genus PALAEOPHICHTHYS Eastman.

This peculiar crossopterygian genus has been provisionally referred to the Coelacanthidæ, but is distinguished from all other members of the family by its elongate, anguilliform body and continuous median fins. In the latter respect an agreement is to be noted with the specialized and problematical genus *Tarrasius*, from the Lower Carboniferous of Scotland, and also with *Conchopoma gadiforme* Kner, from the Lower Permian of Rhenish Prussia. Possibly both *Tarrasius* and *Conchopoma* should be regarded as aberrant Coelacanths.

PALAEOPHICHTHYS PARVULUS Eastman.

Plate 10, fig. 2.

Palaeophichthys parvulus EASTMAN, Ann. Rept. Iowa Geol. Surv., vol. 18, 1908, p. 253, fig. 37.

This is a very small species, attaining a total length of about 5 cm., with a remarkably short head and slender, elongated, anguilliform body. The median fins are continuous, the dorsal arising behind the occiput at a distance equal to about one-and-one-half times the length of the head itself, and the origin of the anal not far behind the middle of the body.

Besides the holotype of this interesting small species, but a single example has come under the writer's observation. It is a specimen formerly in the Lacoe collection, now the property of the United States National Museum, and catalogued as No. 4453. The nodule in which it is contained would seem to have been fractured by natural means and to have been exposed to atmospheric agencies for a considerable time, thus permitting oxidation to take place over the surface with consequent obliteration of a good many structural details. Thus, the precise point of origin of the median fins is indeterminable, the head bones are confused, and although the neural and haemal arches are clearly indicated in the anterior half of the trunk, they cease to be visible in the caudal region. Under the lens it is

possible to recognize faint traces of the squamation, the scales appearing to be very small and covered with delicate longitudinal striae. A portion of the lateral line scale-row is indicated by characteristic raised markings in the posterior part of the trunk, but the caudal extremity is not distinctly shown. Apparently the tail tapered gradually to a point, without being produced into a supplementary caudal fin. The sum total of morphological features presented by this peculiar genus and species is of extreme interest.

Formation and locality.—Coal Measures; Mazon Creek, Illinois.

Family PALAEONISCIDAE.

The earliest representative of this family, and of primitive sturgeons generally, is the genus *Cheirolepis,* remarkable for its small-sized squamation. A single species is known from the Devonian rocks of North America, described by Whiteaves as *Cheirolepis canadensis.* Three species of *Palaeoniscus* have also been founded upon isolated scales occurring in the Upper Devonian of New York State. These have been named *P. antiquus* and *P. reticulatus* Williams, and *P. devonicus* Clarke, but they are more properly assignable to *Rhadinichthys.*

Genus RHADINICHTHYS Traquair.

This genus, apparently indicated by isolated scale patches in the Upper Devonian rocks of this country, and represented by several species in the Lower Carboniferous of New Brunswick and the United States, persists as late as the Pennsylvanian in this country. One species, *R. deani,* occurring at the base of the Waverly, is remarkable for having yielded the first information we possess concerning the organization of the brain and internal ear of any fossil fish. Since the beautifully preserved brain structure of this species was first described,[1] similar remains have been found in the Coal Measures near Lawrence, Kansas,[2] and less well-preserved specimens are also contained in the collection of fossils from the Cancy shale of Oklahoma, already referred to.

One of the specimens from the latter locality showing the internal structure of the head of a small Palaeoniscid, presumably of *Rhadinichthys,* is catalogued as No. 8111, and another showing the greater part of a dentigerous mandible bears the number 8112.

[1] Ann. Rept. Iowa Geol. Surv., vol. 18, 1908, pp. 266–272.

[2] Twenhofel, W. H., and Dunbar, C. O. Nodules with fishes from the Coal Measures of Kansas. Amer. Journ. Sci., vol. 38, 1914, pp. 157–163. Moodie, R. L. A new fish brain from the Coal Measures of Kansas, with a review of other fossil brains. Journ. Comp. Neurology, vol. 25, 1915, pp. 135–181.

RHADINICHTHYS GRACILIS (Newberry and Worthen).

Plate 9, fig. 4.

Palaeoniscus gracilis NEWBERRY and WORTHEN, Pal. Illinois, vol. 4, 1870, p. 347, pl. 3, fig. 4.

The original illustration of this species, the only one hitherto published, is unsatisfactory in several respects, and the description given is very meager. The distinguishing characters are stated to consist in the smooth rhomboidal scales and remote position of the dorsal and anal fins, which are directly opposed to each other. The illustration which appears in the accompanying plate 9 is reproduced from a photograph of a well-preserved small specimen from the Mazon Creek locality (catalogued as No. 4401). The dorsal, of comparatively few rays, is very remote, and may have been displaced backward by deforming agencies during the fossilization process. The anal comprises 7, and the ventrals 6, well-separated rays. The head parts are not distinctly shown, and the squamation in the anterior part of the trunk has been disturbed. This would seem to be a very rare form in the American Carboniferous. The holotype is preserved in the Peabody Museum of Yale University.

Formation and locality.—Coal Measures; Mazon Creek, Grundy County, Illinois.

Genus ELONICHTHYS Giebel.

An amended diagnosis of this genus has been published by Traquair in his Monograph on the Ganoid Fishes of the British Carboniferous Formations (1877, p. 47). Four species have been described from the Pennsylvanian of the Mazon Creek locality, one of which, *E. peltigerus* Newberry, occurs also at Linton, Ohio. It is not known where the holotype of the latter species is preserved, but the counter-impression of the closely allied *E. hypsilepis* Hay is now the property of the United States National Museum (Cat. No. 4848).

ELONICHTHYS HYPSILEPIS Hay.

Plate 9, fig. 3; plate 10, fig. 3.

Elonichthys peltigerus hypsilepis HAY, Proc. Amer. Philos. Soc., vol. 39, 1900, p. 117, pl. 7.

The material at Doctor Hay's command at the time of establishing this species (regarded by him as doubtfully distinct from *E. peltigerus*) consisted of seven specimens, the most perfect one of which was figured by the author in an excellent photographic reproduction. As contrasted with *E. peltigerus*, Hay noted that in all of the specimens examined by him which were well enough preserved, "the scales in several perpendicular rows just behind the shoulder girdle

are twice as high as long. . . . These high scales gradually become reduced in height, so that those below the dorsal fin are about as high as long."

Doctor Hay remarks further that in his material "the caudal fin is fully one-third the total length of the fish, is deeply forked and has the prolongation of the body covered with pointed scales carried out apparently to its very tip. . . . Along the upper lobe of the tail are numerous striated fulcra. These diminish in height each way from the middle of the lobe." As regards contour of the back the same author observes:

> The body appears to have been somewhat elevated immediately under the dorsal fin, the latter being thus lifted somewhat. The sides of this elevation are covered with two rows, an upper and a lower, of narrow, rather long scales, which are directed parallel with the fin rays.

Probably to this species should be referred two specimens belonging to the United States National Museum collection, which are shown of slightly larger than the natural size in the accompanying plates (pl. 9, fig. 3; pl. 10, fig. 3). The form of body is, however, more slender than in the figured example of *E. hypsilepis* and *E. peltigerus*, and the dorsal and anal fins are relatively less elevated and more triangular. The anal fin-rays decrease more rapidly in depth behind, and there is a wider interval between the anal and caudal fins than is the case in those examples of *E. hypsilepis* or *E. peltigerus* which have come under the writer's observation. There is, however, substantial agreement in the number of rays of all the fins, and such differences as have been noted do not appear to warrant the recognition of a distinct species upon the evidence of these examples.

Formation and locality.—Coal Measures; Mazon Creek.

ELONICHTHYS PERPENNATUS Eastman.

Plate 9, fig. 1.

Elonichthys perpennatus EASTMAN, Journ. Geol., vol. 10, 1902, p. 539, text fig. 4; Bull. Mus. Comp. Zool., vol. 39, 1903, p. 190, pl. 5, fig. 49.

This is a very small species, having a total length of less than 4 cm., of which the head occupies a little less than one-fourth. The fins are extremely well developed, the pectoral unusually long, and anal with much extended base line. The fulcra are minute, scales relatively small, obliquely striated; dorsal ridge scales enlarged

Our knowledge of this gracefully formed and highly ornamented small species has hitherto been confined to the original holotype, now preserved in the Museum of Comparative Zoology at Harvard College. A second example, which seems referable to this species, is that shown in plate 9, figure 1. It is in counterpart, and bears the U.S.N.M. catalogue number 4326. The paired fins have become

lost, together with the greater portion of the caudal, and the recumbent rays of the dorsal have become closely appressed and are in part concealed by matrix. No other examples of this species besides the two that are here mentioned have come to light.

Formation and locality.—Coal Measures; Mazon Creek, Illinois.

Family PLATYSOMATIDAE.

Three species of the genus *Platysomus* have been established upon the evidence of a single specimen each from the Mazon Creek locality, all unsatisfactorily illustrated and described; and a fourth species (*P. palmaris* Cope) has been made known from the Permian of the southern part of Indian Territory. The species founded upon Mazon Creek types have been named as follows: *P. orbicularis*, *P. circularis*, and *P. lacovianus*. The first mentioned of these has been reinvestigated by the present writer and transferred to the genus *Cheirodus*. The holotype of *P. circularis* is preserved in the Museum of Illinois State University at Urbana, and the counter impression of the same specimen in the American Museum of Natural History, labeled in Newberry's handwriting.

Genus CHEIRODUS M'Coy.

In this genus the trunk is rhombic, pectoral fins insignificant, and pelvics absent; the scales are deep and slightly imbricated; margin of mouth toothless, pterygoid and splenial with two denticulated longitudinal ridges.

CHEIRODUS ORBICULARIS (Newberry and Worthen).

Plate 9, fig. 2.

Platysomus orbicularis NEWBERRY and WORTHEN, Palaeont. Illinois, vol. 4, 1870, pl. 3, fig. 1 (no description).

Cheirodus orbicularis EASTMAN, Bull. Mus. Comp. Zool., vol. 39, 1903, p.193, pl. 5, fig. 52.

It is not known where the holotype of this species is now preserved. A poor figure of this unique specimen was given by the original authors, unaccompanied by any textual description. Upon the evidence of a number of specimens belonging to the Peabody Museum of Yale University, one of which was labeled in Newberry's handwriting as pertaining to this species, an amended definition of it was drawn up by the present writer, which may be here restated:

A small species, attaining a maximum length of about 4.5 cm. Trunk deep, orbicular in outline, the dorsal margin elevated into a prominent peak at about its middle point, and the ventral margin angulated to a somewhat less extent at a point about midway between the branchial apparatus and the narrow caudal pedicle. Facial contour of head steep, cranial plates granulated and striated; the head with opercular apparatus contained about two and one-half times in the total length to the base of the caudal fin. Dorsal and anal fins arising at a considerable distance behind the mar-

ginal peaks, and extending close to the origin of the caudal fin; the latter nearly equilobate, its upper lobe with well-developed fulcra, and its width at distal extremity equalling about one-third the maximum depth of trunk. Dorsal fin with 50 or more rays, caudal and anal each with a somewhat lesser number. (Paired fins not observed.)

Scales ornamented externally with faint longitudinal striae and usually one longitudinal ridge situated near the anterior border of each scale; attached surface coarsely striated, the striae being nearly vertical on the deeper flank scales, but oblique on those situated dorsally and ventrally and in the caudal region. Scales of the anterior part of the trunk arranged in nearly vertical narrow bands, those toward the tail showing a slight downward and backward obliquity, and those at the base of anal fin reflexed forward toward the ventral margin.

A single small specimen, catalogued as No. 4404, fairly well preserved and in counterpart, is contained in the United States National Museum collection (from the R. D. Lacoe coll.). One of the halves of this specimen is shown of the natural size in the accompanying plates, and some of the details, such as scale ornament, lateral line, and minute conical teeth are more clearly seen with the aid of a lens in examining the opposite half, which is not figured. For so small a specimen, the dorsal peak at the middle of the back is very prominently elevated, and the appearances do not indicate that this is merely an immature example of some larger form. An understanding of the conformation of the head parts in this and related forms [1] may be gained from consulting the memoir by Dr. R. H. Traquair "On the structure and affinities of the Platysomidae," published in volume 29, 1879, of the Transactions of the Royal Society of Edinburgh.

Formation and locality.—Coal Measures; Mazon Creek, Grundy County, Illinois.

E. FISHES OF THE TRIASSIC SYSTEM.

For the purpose of the present contribution it is not considered practicable to enter into a lengthy or detailed account of the large store of fossil fishes from Mesozoic and Cenozoic horizons belonging to the collections of the United States National Museum, in view of the fact that the majority of these belong to well-known genera, the anatomical structure of which approaches rather closely to that of modern forms, and the systematic position of which is pretty certainly ascertained. A few general remarks on the collection of post-Palaeozoic fishes as a whole, followed by particular notice of certain new or especially interesting species, will be sufficient for this section of the report.

Triassic fishes are extremely well represented in the Museum collection. From the Triassic rocks of eastern North America very extensive collections were made in the Connecticut Valley region dur-

[1] A restoration of the skeleton of *Cheirodus granulosus* (Young) is given in plate 5, figure 1, of this memoir and one of *Platysomus striatus* Agassiz in plate 6, figure 1.

ing the early nineties by Mr. S. Ward Loper, of Middletown, Connecticut, under the direction of Prof. W. M. Davis; and in particular, the specimens obtained by him from one or two localities near Guilford, Connecticut, deserve notice for the excellence of their preservation, and the clearness with which certain doubtful points in the anatomical structure are revealed. Several typical examples from this locality have been selected for illustration in plates 12 and 13.

A number of fine examples of Semionotid fishes from the Newark system of New Jersey (pl. 12, fig. 3), and a few from the Richmond coal field of Virginia, both of Upper Triassic age, are contained in the collection. An exceptionally perfect specimen of *Semionotus elegans* Newberry (Cat. No. 8109) from Boonton, New Jersey, is shown in plate 15, figure 3. The genus *Dictyopyge*, founded upon a nearly complete fish from the Richmond basin, is invested with some historical interest on account of its having been studied by Charles Lyell, Philip Grey Egerton, and Louis Agassiz during the fourth decade of the last century.[1]

From the Cordilleran region of this country a large quantity of fish-remains, now in the National Museum collection, was obtained by Dr. C. D. Walcott in the years 1879-80, when exploring the Kanab Canon of Utah and Arizona as his first work in connection with the United States Geological Survey. During the past decade some further remains from the Shinarump group of southwestern Colorado have been obtained by Dr. Whitman Cross, who has shown that there are strong reasons for correlating the Triassic portion of this group, as defined by Powell, with the lower part of the Dolores formation of Colorado. In the course of his discussion of the homotaxial relations of this group, Doctor Cross introduces a section in Kanab Valley, Utah, made by Doctor Walcott in 1879, showing the precise position of the beds (Nos. 11 and 13) whence the fish remains were derived. A reptilian fauna occurs in the Shinarump conglomerate, and the fish beds of the Kanab section occur some hundreds of feet above this member.[2]

Although the fish-remains from this section are extremely fragmentary, it is possible to recognize with certainty the presence of the genera *Lepidotus* and *Pholidophorus;* and on first examining this material the writer concluded from their general aspect that they indicated a foreshadowing of Liassic conditions.[3] During the past year, however, more complete specimens of the genus *Lepidotus* have been studied, the largest and best preserved of which are illus-

[1] Lyell's paper on the coal field of the James River, near Richmond, Va., is found in Quart. Journ. Geol. Soc., vol. 3, 1847. Some interesting correspondence between Lyell and Egerton has recently come to light, and is published in the Annals of the Carnegie Museum (vol. 9, 1914, pp. 139-148).

[2] Cross, W. The Triassic portion of the Shinarump Group. Journ. Geol., vol. 16, 1908, pp. 97-123. A Devonian fish fauna from this region is also mentioned by Dr. Walcott.

[3] Triassic Fishes of Connecticut. Conn. State Geol. Nat. Hist. Surv. Bull. 18, 1911, p. 35.

trated in the figures at the bottom of plates 12 and 13. Although a precise specific determination is impossible, nevertheless a near comparison may be made with the Semionotid form described by Michael as *Prolepidotus gallineki*, from the Upper Keuper of Silesia.[1] (A series of naturally associated Lepidotid scales is shown in plate 10, figure 7.) The character of the Kanab Valley fish-fauna certainly differs markedly from that of the eastern United States, the differences being probably attributable to the different nature of the sedimentation in the two regions.

A very important suite of material from the Trias of South Africa comprising well-preserved specimens of *Semionotus capensis* Woodward is contained in the collection. The anatomical structure of this species has been carefully investigated by the late Dr. E. Schellwien.[2] Finally, mention should be made of a small but interesting collection of fossil fishes from the Hawkesbury Series at Gosford, New South Wales, one specimen among the number being a peculiar form of *Belonorhynchus*, presently to be described. The ichthyic fauna of this formation has been investigated principally by Dr. A. S. Woodward.[3]

Family CATOPTERIDAE Woodward.

This family comprises Triassic fusiform fishes resembling Palaeoniscids in general structure, but having an abbreviate heterocercal tail, and lepidotrichia which only slightly exceed the radials in number. The latter also appear to be formed chiefly of one proximal segment. The ganoid scales are rhombic; the teeth slender and conical.

The family is accompanied in the Trias by other chondrosteans which became eel-shaped (*Belonorhynchidae*) and died out during that period. Still others, which gradually lost their scaly covering and head bones (*Chondrosteus*) continued to survive, and are represented by the sturgeons of the existing fauna. The relations of this family are, therefore, with modern sturgeons rather than with the two surviving genera of Protospondyli, *Amia* and *Lepidosteus*.

Genus CATOPTERUS Redfield.

The type-species of this genus, *C. gracilis*, was described by J. H. Redfield in 1837. A decade later the second known species of *Catopterus* was described by Sir Philip Grey Egerton, when the new genus *Dictyopyge* was established by him upon the evidence of fairly well preserved specimens from the Richmond coal field of Virginia.

[1] Michael, R. Ueber eine neue Lepidosteiden-Gattung aus dem oberen Keuper Oberschlesiens. Zeitschr. Deutsch. Geol. Ges., vol. 45, 1893, pp. 710-729.

[2] Schellwien, E. Ueber Semionotus Ag. Phys-ökon. Ges., Königsberg, 1901.

[3] Woodward, A. S. The fossil fishes of the Hawkesbury Series at Gosford. Mem. Geol. Surv. New South Wales, Palaeont., No. 4, 1890.

CATOPTERUS GRACILIS Redfield.

Plate 12, figs. 1, 2; plate 13, figs. 1, 2.

Catopterus gracilis J. H. REDFIELD, Ann. Lyceum Nat. Hist., N. Y., vol. 4, 1837, p. 37, pl. 1.—NEWBERRY, Monograph. U. S. Geol. Surv., vol. 14, 1888, p. 55, pl. 16, figs. 1–3.—EASTMAN, Conn. State Geol. Nat. Hist. Surv. Bull. 18, 1911.

Among the most instructive specimens that have come under the writer's observation for elucidating the much vexed subject of the cranial osteology of this species and genus, first mention should be made of one of the original cotypes of *C. gracilis*, now preserved in the Peabody Museum at Yale University; and scarcely inferior in importance are several small specimens from the Connecticut Valley region belonging to the United States National Museum. Two of these latter, from Durham, Connecticut, are shown in the accompanying plate 12, and a larger one from Guilford, in plate 13, figure 1. The original of plate 13, figure 2, from the Trias of Durham, Connecticut, is of value for illustrating how the depth of body is apparently increased by accidental crushing prior to fossilization. In this specimen it is easy to distinguish the row of dorsal ridge-scales which has been pushed over to one side and occupies a position at some distance below the upper contour line of the fossil. Examples of mechanical deformation of this kind point to the extreme degree of caution that is necessary in attempting to trace the dorsal and ventral contours of crushed specimens of this and the accompanying genus *Semionotus* in the Triassic rocks of North America.

To speak more particularly of the cranial osteology, it must be admitted that scarcely anything can be added to the facts already known. The bones forming the cranial roof are as a rule firmly coalesced and their sutures concealed by the tubercular ornamentation. Apparently the superior border of the orbits is formed by the large-sized frontals, which are bounded behind by the parietals (the latter separated in the median line by a small-sized supra-occipital) and squamosal. The inferior border of the orbit is formed by the expanded posterior portion of the maxilla, which is of relatively large size and decidedly Palaeoniscid-like in form. This plate bears numerous fine, acutely conical teeth, and there is also present a small dentigerous premaxilla, which is often found detached from the other mouth-parts.

Just how the facial plates are arranged in the space lying between the orbit and shoulder-region (clavicle) is difficult to determine. Newberry's interpretation of the elements covering this area in a single specimen studied by him is open to serious question. At least one postorbital is present in its normal position behind the eye, and there may possibly be another, or suborbital, below it. Behind these plates is the area commonly occupied by the operculum and suboper-

culum, but the preoperculum was probably much reduced and nearly concealed by adjacent elements.

Formation and locality.—Upper Trias; Connecticut Valley and New Jersey.

Family BELONORHYNCHIDAE Woodward.

Of this family of Triassic chondrosteans, only a single genus which is capable of satisfactory definition has hitherto been discovered. This is *Belonorhynchus*, represented by about a dozen species. Under the term of *Saurichthys* Agassiz are provisionally included several species which may be generically identical with *Belonorhynchus*, as suggested by Otto Reis,[1] but for the present, following Woodward's example, it seems preferable to retain the established systematic arrangement.

Two representatives of *Belonorhynchus* have been described by A. S. Woodward from the Upper Trias of Gosford, New South Wales. These have been named *B. gigas* and *B. gracilis*, and differ from other known species in the form of dermal scutes and minor details of the fins and scales. From the same horizon and locality a single very peculiar specimen has been obtained which recalls in some respects, such as body contour and character of the remote dorsal fin, the smaller of these species (*B. gracilis*). But the conformation of the head and obtuse, rounded snout does not agree at all with the features which we are accustomed to associate with members of this genus for the corresponding region; and the specimen in question is clearly anomalous in this regard.

The specimen just referred to belongs to the Museum collection, and is shown in plate 14, figure 3. It is embedded in the same slab of sandstone in which are contained several specimens of *Cleithrolepis*, *Semionotus*, and *Dictyopyge*, the whole block being entered under the catalogue number 1842. Unfortunately the condition of the specimen does not permit of a closer identification than to suggest being included as an aberrant representative of the Belonorhynchidae, with much abbreviated snout. Sutures in the cranial shield are not distinguishable, and it would appear as if the actual bone substance had been fractured and exposed to weathering. Under such circumstances we are not warranted in establishing a new genus or species upon the evidence of the solitary specimen before us, but a figure of it is given in the hope that further enlightenment may be at some later time forthcoming.

[1] Geogn. Jahresb., 1891, p. 149.

Family SEMIONOTIDAE Woodward.

A study of the characters of this family shows that the genera included under it are fully developed Protospondyli, that is to say, they belong clearly to that large group of "ganoid" fishes which flourished chiefly during the Triassic and Jurassic periods, but declined rapidly, and is represented at the present day by only two fresh-water genera, *Lepidosteus* and *Amia*. From what ancient stock the Semionotidae and other Protospondli are descended we do not precisely know, but it may reasonably be inferred that the late Palaeozoic forerunners (*Acentrophorus*, etc.) of the higher suborder were derived from a modified type of chondrostean. Beyond this, when we inquire as to the origin of the Chondrostei themselves, we find but few facts for our enlightenment. Their origin is at least as ancient as that of the "fringe-finned ganoids," but there is as yet no evidence of a genetic connection between the Chondrostei and crossopterygians. Enough, however, has been ascertained to show that already in the Trias and probably even earlier the divergence between chondrosteans and Protospondyli was strongly marked.

SEMIONOTUS ELEGANS (Newberry).

Plate 15, fig. 3.

Ischypterus elegans NEWBERRY, Monogr. U. S. Geol. Surv., vol. 14, 1888, p. 37, pl. 7, fig. 2; pl. 10, fig. 1; pl. 14, figs. 1, 2.
Ischypterus modestus NEWBERRY, Monogr. U. S. Geol. Surv., vol. 14, 1888, p. 38, pl. 9, figs. 1, 3.

The original specimens serving for the establishment of this species are now preserved in the American Museum of Natural History in New York. They are nearly complete fishes, but much crushed, and in becoming flattened their characteristic features have become obscured. A large-sized specimen, 17 cm. in total length, and more perfectly preserved than any other example of this species seen by the writer, is contained in the United States National Museum collection (Cat. No. 8109). It is from the Trias of Boonton, New Jersey, and represented in my plate 15, figure 3.

Genus LEPIDOTUS Agassiz.

Syn. *Prolepidotus* Michael.

Numerous species of this genus have been described, but many are imperfectly known. No indications of the genus have yet been reported from this country, with the exception of certain isolated scales from the Kiowa shales (Cretaceous) of Kansas. The following new species is regarded as standing in close relations with *L. gallineki* (Michael), from the Rhaetic of Upper Silesia.

LEPIDOTUS WALCOTTI, new species.

Plate 12, fig. 4; plate 13, fig. 3.

An imperfectly definable robust species of moderate size, attaining a total length of about 30 cm., and exhibiting similar proportions as in *L. minor* and *L. notopterus;* apparently closely related to the Upper Triassic *L. gallineki.* Scales smooth, thick, deeply overlapping, not serrated; clavicle extremely massive; head parts and paired fins not observed; dorsal with about 15 stout rays. (Cat. No. 8119, U.S.N.M.)

It is to be regretted that no complete individuals of this early representative of the genus have yet been discovered. The examples figured in the accompanying plates are the most perfect which are contained in the collection made by Doctor Walcott during his first work in connection with the United States Geological Survey. Although the collections were made more than 35 years ago by Doctor Walcott, in whose honor I have pleasure in dedicating the species, it does not appear that any other person has obtained fish remains from the Utah Trias, nor has any other species of *Lepidotus* been described from this country.

Although fish remains were found by Doctor Walcott in considerable abundance in the Kanab section, no other fossil vertebrates were noticed by him. Besides *Lepidotus,* the only other genus that can be certainly identified among the remains is *Pholidophorus,* evidently of primitive character. A single saurian tooth, perhaps crocodilian, has also been recognized. This latter is significant in view of the fact that a Triassic saurian fauna has been found on the Little Colorado in Arizona, in the San Juan Valley, Utah, not far from the Colorado River, at various points in southwestern Colorado where Doctor Cross has been engaged in survey work for many years, and in the vicinity of Lander, Wyoming, where Dr. S. W. Williston has made collections. In the opinion of Doctor Cross, as stated to the writer in a personal communication, "the horizon exploited by Williston [1] in Wyoming is the same as that which furnished the vertebrates described by Lucas [2] in Arizona.

The section made by Doctor Walcott in the Kanab Valley, Utah, was first published by Doctor Cross, as already remarked, in 1908. That part of it lying above the Permian is here introduced in order to show the relations of the beds which carry a vertebrate fauna.

SECTION IN KANAB VALLEY, UTAH, MADE BY C. D. WALCOTT, 1879.

Jurassic.

	Feet.
1. White Cliff sandstone, massive, cross-bedded, light gray, broken into five principal belts by horizontal lines of bedding	585

[1] Williston, S. W. Notice of some new reptiles from the Upper Trias of Wyoming. Journ. Geol., vol. 12, 1904, pp. 688–697.

[2] Lucas, F. A. Vertebrates from the Trias of Arizona. Science, vol. 14, 1901, p. 376. A new batrachian and a new reptile from the Trias of Arizona. Proc. U. S. Nat. Mus., vol. 27, 1904, pp. 193–195.

SECTION IN KANAB VALLEY, UTAH, MADE BY C. D. WALCOTT, 1879—continued.

Triassic.

	Feet.
2. Vermilion sandstone; cross-bedded, friable, readily disintegrating, forming the foothills and slope to the more compact sandstones at the northern end of Vermilion Cliff Canyon	650
3. Gray and reddish-brown cross-bedded sandstone. Horizontal beds of varying thickness divide the mass into bands of from 25 to 100 feet in thickness	300
4. Evenly bedded red sandstones; upper portion an indurated, dark reddish-brown stratum; indurated layers alternate with more friable layers and shales beneath	120
5. Massive gray sandstone, cross-bedded; upper portion is a light-gray massive friable bed. The entire mass is subdivided into six principal beds by subhorizontal lines of bedding of a dark, more indurated sandstone. The beds are from 20 to 80 feet in thickness, and may be seen on many steep escarpments along the canon	310
6. Solid, partially cross-bedded sandstone, changing from gray to various shades of red	20
7. Evenly bedded, light-red sandstone with a thin layer of intercalated gray sandstone	20
8. Dark-red sandstone; massive layers alternating with shale, which disintegrates and forms a sloping talus to the gray sandstone beneath	180
9. Light-gray sandstone	5
10. Bedded sandstone of various shades of red and gray. The layers of sandstone and their shaly partings are irregular in thickness. Scolithus borings occur in great numbers in a friable yellow sandstone. Fragments of vegetable matter and carbonized wood also were seen	230
11. Thin layers of sandstone, alternating with bands of fine argillaceous shale holding fish teeth and shells	25
12. Massive light-brown sandstone, broken up into thick layers	50
13. Alternating layers of sandstone and fine argillaceous shales with fish teeth, etc.	25
A detailed section of 13 is as follows:	
a. Light sandy layers with shaly partings	7
b. Fine, smooth, arenaceous and argillaceous shales, drab brown to red with fillets of green. A few fish scales were found	6
c. Fine-grained, light-colored sandstone, 2 to 4 feet in thickness	4
d. Same as (*b*), only more fossiliferous	8
14. Reddish-brown friable sandstone, broken into layers 1 to 6 feet thick, with shaly partings	120
15. Alternating bands of marls and shales, with layers of friable light and reddish-brown sandstone	70
16. Reddish-brown sandstone broken up into layers 2 to 7 feet in thickness with a stratum of gray sandstone at the base	20
17. Arenaceous and earthy gypsiferous shales; marlites, purple, brown, bluish-green, and green, forming low, rounded foothills and slopes from the Vermilion cliffs to the Shinarump conglomerate	650
18. Gray conglomerate and sandstone. Conglomerate formed of small, agatized pebbles and holding silicified wood	50
Total of Triassic	2,845

F. FISHES OF THE JURASSIC SYSTEM.

There are a number of well-preserved specimens of ganoid fishes in the collection from the Lias of Lyme Regis, Dorsetshire, the Lias of Holzmaden, Württemberg, the Upper Jurassic Lithographic limestone of Solenhofen, and a few types, chiefly of *Pholidophorus*, described by the present writer from the Jurassic of the Black Hills, South Dakota. Some of the larger and more interesting specimens from Solenhofen (*Squatina*, *Gyrodus*, *Aspidorhynchus*, etc.) are to be seen on exhibition in the hall of fossil vertebrates.

In contrast to the large and attractive specimens of the usual type with which we are familiar from the Solenhofen locality, two small forms, evidently juvenile, call for special notice, being in each case the only known example of the young of the species represented. These are described in the following paragraphs.

Family ASPIDORHYNCHIDAE.

The most recent discussion of the structural organization of typical members of this family is that of Paul Assmann, in the first volume

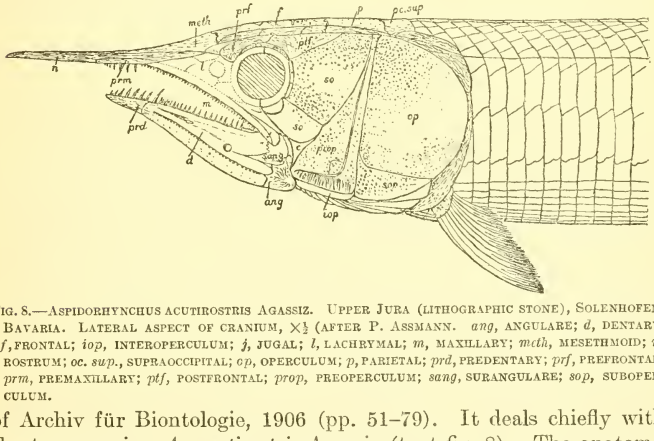


FIG. 8.—ASPIDORHYNCHUS ACUTIROSTRIS AGASSIZ. UPPER JURA (LITHOGRAPHIC STONE), SOLENHOFEN, BAVARIA. LATERAL ASPECT OF CRANIUM, ×½ (AFTER P. ASSMANN. *ang*, ANGULARE; *d*, DENTARY; *f*, FRONTAL; *iop*, INTEROPERCULUM; *j*, JUGAL; *l*, LACHRYMAL; *m*, MAXILLARY; *meth*, MESETHMOID; *n*, ROSTRUM; *oc. sup.*, SUPRAOCCIPITAL; *op*, OPERCULUM; *p*, PARIETAL; *prd*, PREDENTARY; *prf*, PREFRONTAL; *prm*, PREMAXILLARY; *ptf*, POSTFRONTAL; *prop*, PREOPERCULUM; *sang*, SURANGULARE; *sop*, SUBOPERCULUM.

of Archiv für Biontologie, 1906 (pp. 51–79). It deals chiefly with the type species, *A. acutirostris* Agassiz (text fig. 8). The anatomy of the allied genus *Belonostomus* has been carefully investigated by Dr. Benjamin Vetter [1] and some well preserved examples belonging to the Carnegie Museum have recently been figured by the present writer.[2]

[1] Vetter, B. Die Fische aus dem lithographischen Schiefer im Dresdener Museum. Mitthell. Kön. Mineral.-Geol. Prähist. Museum Dresden, pt. 4, 1881.

[2] Memoirs Carnegie Museum, vol. 6, Nos. 6 and 7, 1914–15. The plates for these two publications, and also those for Memoir No. 5 of the same volume, were printed without proofs having been submitted to the author; and in the case of one of the illustrations, that of *Squatina minor*, the original drawing, which is misleading, was not prepared under his direction.

Genus BELONOSTOMUS Agassiz.

BELONOSTOMUS TENUIROSTRIS (Agassiz).

Plate 14, fig. 2.

Aspidorhynchus tenuirostris Agassiz, Poiss. Foss., vol. 2, pt. 2, 1833, pp. 14, 143, 297.

Belonostomus tenuirostris Wagner, Abh. Bayer. Akad. Wiss., Math.-Phys. Cl., vol. 9, 1863, p. 691.—Vetter, Mittheil. K. Min.-Geol. Mus. Dresden, pt. 4, 1881, p. 85.—Eastman, Mem. Carnegie, Mus., vol. 6, 1914, Nos. 6, 7.

The beautifully preserved example shown in plate 14, figure 2, is of interest for displaying an early growth stage in the young of this species. Its total length being a trifle under 14 cm., it is much the smallest individual yet recorded. The rostrum appears relatively longer than in the adult, and extends for a relatively greater distance in advance of the presymphysial bone; thus proving that in this species, as is also true for *Aspidorhynchus*, the snout and mandible attain their full development at an early stage, subsequently increasing only in thickness. This condition was first noted by Vetter in the type species of *Aspidorhynchus*, and his observations on the jaws of that form are of sufficient interest to be quoted in this connection:

Der Oberkiefer (mit Rostrum) ist hier wie dort aus denselben Elementen zusammengesetzt und im ganzen auch ähnlich gebildet, namentlich ist der Ausschnitt (échancrure), in welchen der Unterkiefer hineinpasst und welchen Agassiz ausdrücklich als ausschliessendes Merkmal von Asp. hinstellt, auch bei Bel. vorhanden, wenn auch noch etwas mehr abgeflacht (was namentlich bei *B. münsteri* der Fall zu sein scheint); jedenfalls entsteht er hier wie dort durch das Zusammentreffen von Maxillare und Intermaxillare unter sehr stumpfem Winkel und Ueberlagerung des Vorderendes des ersteren durch letzteres. Dagegen ist das Rostrum bei Asp. stets erheblich über die Spitze des Unterkiefers hinaus verlängert (beiden jungen Individuen verhält auch die Länge des vorragenden Theils zur ganzen Länge, vom vorderen Orbitalrande angerechnet, wie 2 zu 3, bei den alten wie 1:2,3 bis mindestens 1:2) und dicht vor derselben um ein Viertel seiner ganzen Länge über jene vorragt. Bei Asp. gliedert auch die relativ kurze Spitze des Unterkiefers als Praemandibel ab, bei Bel. läuft sie continuirlich und sehr schlank aus und der obere Unterkieferrand bildet nur eine schwache Vorragung gegenüber dem "Ausschnitt" des Oberkiefers.

In the same connection the author describes the arrangement of scales on the flanks of *Aspidorhynchus*, and compares it with the conditions observed in *Belonostomus*, a character often difficult to trace in actual specimens. We quote also the following paragraphs:

Es erscheint mir somit wohl zulässig, für alle Arten von Belonostomus eine ziemlich gleichartige Form und Anordnung der Schuppen anzunehmen, welche sich wesentlich durch Folgendes auszeichnet: 1) Die Schuppe der Seitenlinie ist durchaus am höchsten. 2) Darüber folgt eine mittelhohe Schuppe von im Groben halbkreisförmigem Umriss. 3) Ueber dieser sitzen nur noch eine oder höchstens zwei kleine dorsale Schuppen. 4) Unter der Seitenlinienschuppe schliesst such eine mittelhohe Schuppe mit beinah horizontalem Unterrand an. 5) Die erster der ausserordentlich niedrigen Ventralschuppen ist besonders hinten etwa doppelt so hoch als die folgenden.

Vergleicht man nun damit die für Aspidorhynchus typischen Verhältnisse, welche aus zahlreichen Darstellungen hinlänglich bekannt sind, so stösst man auf folgende durchgreifende Unterschiede: 1) Die Seitenlinienschuppe erreicht höchstens dieselbe, meistens eine erheblich geringere Höhe als die darunter folgende. 2) Diese schneidet unten wie die erstere mit schiefem Rande ab. 3) Darunter folgt eine mittelhohe Schuppe, deren hinterer Rand in der Regel länger ist als ihr Längsdurchmesser, und nun erst kommen die niedrigen Ventralreihen. 4) Die über der Seitenlinienschuppe stehende Schuppe ist noch ansehnlich hoch und von regelmässigem Umriss. 5) Darüber kommen mindestens 3 Reihen rhombischer, durchweg stark sculptirter Schuppen.

The scale arrangement in the specimen in hand is not clearly displayed. On the other hand the head bones, teeth of the maxillary and mandible, vertebral rings with their fused arches, and all of the fins, are distinctly visible. The dorsal fin comprises at least 10 rays, and the anal a larger number, apparently about twice as many.

Formation and locality.—Lower Kimmeridgian (Lithographic Stone); Solenhofen Bavaria. The figured specimen is catalogued as No. 23.

Genus NOTAGOGUS Agassiz.

This genus closely resembles *Propterus*, but differs in the non-elongation of the anterior rays of the dorsal fin, which are very widely spaced, and in the less deeply forked character of the caudal fin.

NOTAGOGUS MINUTUS, new species.

Plate 14, fig. 4.

Founded upon a very small (5 cm. long), nearly complete fish, in which the proportions of head and trunk are very similar to those (Cat. No. 8379, U.S.N.M.) of *N. inimontis* Thiollière, but with more slender form of body, the two portions of the dorsal less widely separated, each consisting of about nine rays, and posterior border of scales smooth.

This is one of the smallest known species of *Notagogus*, and it is probable that the unique specimen upon which it is founded is an immature individual. At the same time its characters appear tolerably distinct, and as it cannot be identified as the young of any known form we are warranted in describing it as representing a separate species. Another small form accompanying the holotype in the same horizon is the recently described *N. decoratus*, in which the anterior portion of the dorsal comprises about 10 rays, all widely spaced with the exception of the first three. *N. inimontis* is known only from the Cerin locality in the ancient province of Bugey, France.

Formation and locality.—Lower Kimmeridgian (Lithographic Stone); Solenhofen, Bavaria.

G. FISHES OF THE TERTIARY SYSTEM.

A rich assortment of fossil fishes from the Green River Eocene of Wyoming and other western localities is contained in the collection, and among the number are included several important type speci-

mens. From the Miocene of Florissant, Colorado, quantities of *Amyzon* remains, and from corresponding strata in Esmeralda County, Nevada, large numbers of Leuciscus skeletons have been added to the collection. There is also an abundant representation of Eocene and Miocene ichthyic remains from the Atlantic coast region, and from foreign Tertiary horizons mention should be made of a number of fine slabs from the Upper Eocene of Monte Bolca, in northern Italy. In the following pages some of Cope's types which have not previously been figured receive attention, and two or three new species of Tertiary fishes are described.

Family OSTEOGLOSSIDAE.

This family, first appearing in the Eocene, is represented by several modern genera, two of which, *Osteoglossum* [1] and *Arapaima*, are found in South American rivers. *Heterotis* is a tropical African genus. The skull in this group has a distinctly primitive appearance, the superficial bones being thinly covered by skin and having a sculptured surface. The wide nasals, frontals, and parietals meet in the middle line, and the supraoccipital scarcely reaches the surface. Both the premaxilla and maxilla are toothed, and share in forming the margin of the mouth; there is no supramaxilla. The suboperculum is small, often hidden behind the preoperculum, and likewise the interoperculum (Goodrich).

Genus DAPEDOGLOSSUS Cope.

Syn. *Phareodus* Leidy (undefined).

The largest and best known species of this genus is *D. testis* Cope, from the Green River Eocene of Wyoming, of which beautifully preserved specimens exist in the United States National Museum, and in the American Museum of Natural History, New York. One nearly complete skeleton in the latter institution is instructive for having the bones of the skull partly dissociated and displayed to excellent advantage for study. It is catalogued as No. 4587. Through comparison with this specimen it has been possible to identify positively the isolated skull shown in plate 16, figure 1, as belonging to this species. This well-preserved cranium is the property of the United States National Museum (Cat. No. 4916), and has been carefully prepared so as to reveal the underside, freed from the matrix. Its primitive characters are evident, and among surviving genera the resemblance is closest to *Heterotis* of tropical Africa.

[1] For an investigation of the cranial osteology of this genus, see the following: Bridge, T. W. On certain features of the skull in *Osteoglossum formosum*. Proc. Zool. Soc. London, 1895, pp. 302-310.—Ridewood, W. G. On the cranial osteology of the fishes of the families Osteoglossidae, Pantodontidae, and Phractolaemidae. Journ. Linn. Soc. Zool., vol. 19, 1905, pp. 252-282.

Family GONORHYNCHIDAE.

This family, represented in the Upper Cretaceous by *Charitosomus*, and in the middle Eocene by *Notogoneus*, is known to have but one surviving species in the modern fauna. This is *Gonorhynchus greyi*, a specialized form which inhabits the seas off Japan, South Africa, Australia, and New Zealand. It has the head and body covered with small ctenoid scales, and carries a ventral barbel on the prolonged snout. The supraoccipital separates the parietals, the premaxilla

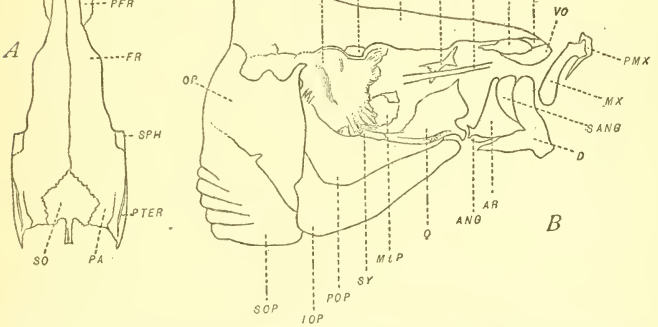


FIG. 9.—NOTOGONEUS OSCULUS COPE. GREEN RIVER EOCENE; TWIN CREEK, WYOMING. DORSAL (*A*) AND LATERAL (*B*) ASPECTS OF CRANIUM, ⅔. (AFTER L. HUSSAKOF). *ANG*, ANGULAR; *AR*, ARTICULAR; *D*, DENTARY; *E*, ETHMOID; *FR*, FRONTAL; *HM*, HYOMANDIBULAR; *IOP*, INTEROPERCULUM; *MLP*, METAPTERYGOID; *MX*, MAXILLA; *OP*, OPERCULUM; *PA*, PARIETAL; *PFR*, PREFRONTAL; *PMX*, PREMAXILLA; *POP*, PREOPERCULUM; *PSP*, PARASPHENOID; *PTER*, PTEROTIC; *Q*, QUADRATE; *SANG*, SURANGULAR; *SO*, SUPRAOCCIPITAL; *SOP*, SUBOPERCULUM; *SPH*, SPHENOTIC; *SY*, SYMPLECTIC; *VO*, VOMER; *X*, CHEEK-PLATE.

articulates with the maxilla and excludes it from the margin of the small mouth. According to Smith Woodward the members of this family are related to the Scopelidae.

Genus NOTOGONEUS Cope.

Syn. *Protocatostomus* Whitfield.

The type species of this genus is *N. osculus* Cope, from the Green River limestone of Wyoming, in size attaining a length of about 60 cm. The general structure of the head in this species is indicated in the accompanying text-figure 9, taken from L. Hussakof,[1] who combined in the diagram details shown by three specimens preserved in the American Museum of Natural History.

In plate 15, figure 2, is shown a young individual, which is the smallest known belonging to this species. It adds nothing to our

[1] Bull. Amer. Mus. Nat. Hist., vol. 25, 1908, p. 83.

knowledge of the species in displaying characters already observed, but it is interesting for the same reason that the young of other species are interesting to which we have called attention in the present article and figured in plate 14—namely, immature examples of *Belonostomus, Notagogus,* and *Acanthurus* (pl. 14, fig. 1) (the last from the upper Eocene of Monte Bolca, Italy). These young individuals acquaint us with early growth stages of the several species in question, and enable us to compare the relative proportions of different parts at different periods in the life history for the species in question. The original of our plate 15, figure 2, is catalogued as No. 6037.

Formation and locality.—Green River Eocene, Wyoming.

Family CYPRINODONTIDAE.

In this family, which includes forms of extremely small size, the mouth is protractile, teeth are present on the jaws and pharyngeals, but rarely on the palate; the palatoquadrate arch is more or less reduced; and the supraoccipital extends forward to the frontals, separating the parietals in the median line. Only two or three extinct genera are known with certainty. Modern forms are mostly confined to fresh waters, but a few are found in brackish water and on the seacoast.

Genus GEPHYRURA Cope.

In July, 1891, E. D. Cope published descriptions of five new species of fossil fishes from a supposed Lower Tertiary horizon in Ree Hills, South Dakota. Three of the forms were regarded as typical of new genera, which were named by the author *Gephyrura, Proballostomus,* and *Oligoplarchus;* the taxonomic relations of the first two being with the cyprinodonts, and of the last named with the percoids. The holotypes of these new genera and species are now preserved in the American Museum of Natural History and have recently been studied by the present writer. Although the type of *Gephyrura* was referred by Cope with some hesitation to the cyprinodonts, there does not appear to be the slightest doubt as to the correctness of this association; and the unique specimen available for study evidently stands in close relations with the new cyprinodont genus immediately to be described from the Lahontan beds near Hazen, Nevada. For convenience of reference, however, we may first restate the specific characters of *G. concentrica,* as defined by Cope.

GEPYRURA CONCENTRICA Cope.

Gephyrura concentrica Cope, Amer. Naturalist, vol. 25, 1891, p. 654.

Char. specif.—The only specimen is broken vertically across the middle, and the posterior half shifted so as to lie immediately below its proper position. It appears that little or no part of the fish has been lost. Radii, P. 9; D. 9; C. 6-16-8; A. II 11.

V. 1–6; vertebrae, 10–18. Scales in twelve longitudinal rows between dorsal and ventral fins, and equal in number to the vertebrae on the longitudinal line, or 28. Head covered with scales; five in a vertical line on the operculum. The dorsal, pectoral, and ventral fins are rather small. The caudal fin is probably not much forked, if at all. The orbit is large, but its outlines are not well preserved. The head enters the total length four and a quarters times to the base of the caudal fin-rays, and slightly exceeds the depth at the ventral fins. Total length, 61 mm.; length of head, 15 mm.; length to base of ventral fin, 24.5 mm.; length to base of anal fin, 30 mm.; depth at ventrals, 14 mm.; depth at caudal peduncle, 6 mm.

Formation and locality.—Oligocene (?) Ree Hills, South Dakota.

PARAFUNDULUS, new genus.

A genus closely related to existing killifishes, and also to the extinct *Gephyrura*, but distinguished from the latter chiefly by its smaller and less conspicuously marked scales, larger number of dorsal fin rays, and presence of a hypural bone. Caudal fin gethyrocercal.

Type of the genus.—*Parafundulus nevadensis*, new species.

PARAFUNDULUS NEVADENSIS, new species.

Plate 16, fig. 2; plate 17; plate 18, fig. 3.

A small form attaining a total length of about 5.5 cm., in which the length of the head and opercular apparatus is contained three and one-half times. Dorsal comprising 11 rays, supported by an equal number of interspinous bones, and inserted opposite a point midway between the pelvics and anal. Scales small and thin, with fine concentric markings, crossed by a few inconspicuous radiating proximal striae.

Fin formula: D. 11; C. 23; R. 10; V. 9; P. 11–12.

The specimen (Cat. No. 8120) selected as type of this species is photographed of the natural size in plate 16, figure 2, and a drawing of it is reproduced in plate 18, figure 3. It is the most perfect of several that were obtained in 1905 by Mr. N. H. Darton, in strata of very white clay near Hazen, Nevada, which have received the name of Lahonton beds. From the same locality a single species of stickleback, known as *Gasterosteus doryssus* Jordan, was described almost simultaneously in 1907 by Drs. D. S. Jordan [1] and O. P. Hay.[2] Besides the type several other examples of this species, shown in plate 17, were collected by Mr. Darton at the same locality, and are now preserved in the collection of the United States National Museum. The writer is indebted to his colleague, Mr. John Treadwell Nichols, of the American Museum of Natural History, for helpful suggestions in regard to comparing this form and its scale characters with the existing *Fundulus*.

Formation and locality.—Lahontan beds; near Hazen, Nevada.

[1] Pub. Univ. Cal., vol. 5, 1907, No. 5, p. 131, figs. 25, 26; Smiths. Misc. Coll., vol. 52, 1910, p. 117.
[2] Proc. U. S. Nat. Mus., vol. 32, 1907, pp. 271–273, figs. 1–3.

Family CYPRINIDAE.

Genus AMYZON Cope.

This is an extinct genus related to modern suckers, but with a more extended dorsal fin. It is stated by Woodward to be "scarcely distinguishable from *Sclerognathus*, but with pharyngeal bones expanded behind." Mr. J. T. Nichols has pointed out to the writer that the Canadian species *A. brevipinne* approaches very closely to existing buffalo fishes of the genus *Ictiobus;* and Cope, in his description of *Amyzon*, has remarked upon its near relations with *Bubalichthys*.

AMYZON BREVIPINNE Cope.

Plate 19, figs. 1, 2.

Amyzon brevipinne Cope, Proc. Acad. Nat. Sci. Phila., 1893, p. 402.—Lambe, Trans. Roy. Soc. Canada, vol. 12, 1906, pp. 151–155, pl. 1.

The type of this species was obtained from beds in British Columbia supposed to be of late Eocene or early Miocene age. It has never been figured, but one small specimen from Horsefly River, British Columbia, and another belonging to a different species (not of *A. commune*, however), have been described and illustrated by Dr. L. M. Lambe within recent years.

To this species should probably be referred two specimens figured in plate 19, which were collected in 1910 by Mr. J. B. Umpleby from beds of supposed Lower Miocene age, near Republic, Washington. These are now the property of the National Museum, and are catalogued as Nos. 81 and 8117. They are the largest and best preserved examples of this species yet brought to light.

Genus LEUCISCUS Cuvier.

LEUCISCUS TURNERI Lucas.

Leuciscus turneri Lucas, 21st Ann. Rept. U. S. Geol. Surv., 1901, pt. 2, pp. 223–224, pl. 31.

The holotype of this species (Cat. 4302*a*), and a large number of well-preserved specimens from the Esmeralda formation in western Nevada, are contained in the United States National Museum collection. The age of these beds is discussed by H. W. Turner in the Twenty-first Annual Report of the United States Geological Survey, 1899–1900 (part 2, pp. 203–205), and in the same volume (pp. 209–220) the fossil plants occurring in this formation are described by F. H. Knowlton.

Nothing can be added to our knowledge of the species beyond the information already contributed by Dr. F. A. Lucas.[1] There may be compared with it, however, a specimen that apparently belongs to

[1] 21st Ann. Rept. U. S. Geol. Surv., 1901, pp. 223–224, and Proc. U. S. Nat. Mus., vol. 23, 1900, pp. 333–334, pl. 7.

this or a closely related species, from the Madison Valley, Montana, which is shown of slightly larger than the natural size on plate 18, figure 4. Mr. Earl Douglass, who collected a small number of fish remains from this locality, is of the opinion that the strata containing them is of Oligocene or Lower Miocene age. An undetermined species of *Osmerus* is apparently indicated by the original of plate 18, figure 5, from the same locality as the last. Both are preserved in the Carnegie Museum in Pittsburgh. In plate 19, figure 3, is shown an example of an undetermined cyprinodont species from the Tertiary of Mexico.

Family SILURIDAE.

Fossil representatives of this family are uncommon, and for the most part imperfectly preserved. Fragmentary remains from the Lower Eocene have been assigned to *Arius*, and others from the Lower Miocene to *Ameiurus*. The undermentioned specimen is the only nearly complete example of the latter genus that has been discovered in the fossil state.

Genus AMEIURUS Rafinesque.

AMEIURUS PRIMAEVUS, new species.

Founded upon a unique specimen without locality label, but as far as may be judged from the appearance of the matrix it would seem to have been derived from the Green River Eocene of Wyoming. Clearly related to the more generalized and representative genus of modern North American catfishes *Ameiurus*, it differs from all living species in its shorter anal, consisting of only 12 rays, and in this respect resembles the more specialized genus *Leptops*, known by a single species. It is shown in plate 20.

The holotype of this species is a nearly complete skeleton having a total length to the base of the caudal fin of 21.5 cm., in which the length of the head including the supraoccipital process is contained three times. Head broad behind, not much contracted forwards; surface sculpture consisting of anastomosing rugae and pittings as in the recent *A. catus;* orbits small; fontanelle situated just before the origin of the supraoccipital process. Maximum breadth of head in its flattened condition equal to its length. Vertebrae 29 in number, with strong neural spines. Dorsal fin between the pectorals and ventrals, with about six branched rays of moderate length (its spine broken away). Pectoral spines strong, smooth, less than half as long as the head. Ventrals with eight, anal with apparently not more than twelve rays. Rays of caudal fin mostly broken away, but the curved line formed by their articulation with hypural fin-supports indicating that the fin was rounded. (Cat. No. 8122, U.S.N.M.)

This is an extremely interesting and well-preserved specimen, save that the caudal fin is for the most part lacking, and the dorsal has been folded under the neural spines and partly concealed by them.

The supraoccipital process has been shifted slightly to one side of the anterior vertebrae, and was apparently not in direct connection with them. The relations are evidently very close with the existing *A. catus*, excepting as regards the smaller number of anal fin rays and nonserrate character of the pungent pectoral spines. With respect to the short-based anal fin, it may be said that although only a dozen rays are now visible in the specimen, a few more may have been present in advance of those now to be seen, but became lost or were cut away by careless trimming of the specimen along the ventral margin. In fact, one can almost certainly distinguish, although faintly, traces of a few interspinous bones in advance of the foremost anal fin ray now appearing in the specimen. At the most, however, we must admit that this fin was shorter than in existing species of *Ameiurus*, but otherwise the differences are of but minor character.

The latter observation appears the more remarkable if we accept the view as correct that the fossil before us is of Middle Eocene age. How closely *Rhineastes*, from the Green River Eocene, agrees structurally with modern species of Silurids, cannot be determined, as it is known only by fragmentary remains. But in the nearly complete skeleton which we are now considering we find evidence that the typical expression of the genus *Ameiurus*, as we know it to-day, was already attained in the early Tertiary, and has persisted unchanged ever since.

Formation and locality.—Supposedly from the Green River Eocene of Wyoming.

Family PERCIDAE.

This family and the small one known as Aphredoderidae, now nearly extinct, are included in Doctor Gill's superfamily Percoidea. The types of most of Cope's species of *Amphiplaga*, *Asinepos*, *Erismatopterus*, and *Trichophanes*, belonging to the Aphredoderidae, are preserved in the collection of the United States National Museum. The nearly complete example of *Trichophanes foliarum* Cope, which has recently been figured by T. D. A. Cockerell,[1] is the property of the American Museum of Natural History, and the types of Cope's species of *Mioplosus* are divided between this institution and the National Museum.[2]

Fossil perches in the restricted sense of the term are represented in the Tertiary rocks of this country by the genera *Mioplosus*, *Plioplarchus*, and *Oligoplarchus*. The first of these differs from *Perca* in having fewer vertebrae and a spineless operculum. It is known by several species in the Green River Eocene, of which the genotype, *M. labracoides* Cope, is the most common. Probably the so-called *M.*

[1] Amer. Naturalist, vol. 42, 1908, p. 571.

[2] For lists of specimens see the published catalogues of type and figured specimens belonging to these museums, already referred to. The parts dealing with fishes were published in 1907 and 1908, respectively.

longus is only a young example of this form, the individuals of which show a considerable amount of variation. In plate 21 is shown a large (44 cm. long) and well-preserved specimen which may be referred to *M. labracoides*, notwithstanding the fact that it displays one abdominal and one caudal vertebra in excess of the normal number occurring in the type-species. The type of *M. multidentatus* Cope has not been figured. It is preserved in the American Museum of Natural History.

Formation and locality.—Green River Eocene; Wyoming.

Genus PLIOPLARCHUS Cope.

This extinct genus, closely related to *Mioplosus*, is represented by three Lower Tertiary species, of which only one, *P. whitei* Cope, has been illustrated. The differences between this species, which is the type, and *P. sexspinosus*, are stated to consist in the more numerous spinous, and less numerous soft rays, of the dorsal and anal fins. In *P. whitei* the radial formula is:

D. IX–12; C.–17–; A. V–14; V. ?; P. 13.

And in *P. sexpinosus* it is:

D. X–13; C. –17–; A. VI–9.

In *P. septemspinosus* the formula is given as:

D. XI–?; A. VII (?)–12.

PLIOPLARCHUS SEXSPINOSUS Cope.

Plate 15, fig. 1.

Plioplarchus sexspinosus COPE, Amer. Journ. Sci., vol. 25, 1883, p. 416; Rept. U. S. Geol. Surv. Terr., vol. 3, 1884, p. 729.

In the original description it is stated that "this species is represented by two specimens, both of which lack the head and body anterior to the dorsal fin." These specimens are now in the United States National Museum collection, and one of them, marked "type," is catalogued as No. 4236. It is from the Lower Tertiary, perhaps Miocene, near Sentinel Butte, in Billings County, North Dakota. A much more complete example, also from the type locality, is shown in our plate 15, figure 1. In it the anal fin is seen to have six spinous and twelve soft rays. The specimen bears the catalogue number 8118.

Formation and locality.—Miocene (?); top of Sentinel Butte, North Dakota.

PLIOPLARCHUS SEPTEMSPINOSUS Cope.

Plate 22.

Plioplarchus septemspinosus COPE, Amer. Naturalist, vol. 23, 1889, p. 625.

This species was established by Cope upon the evidence of four distorted and mutilated specimens from shales near Van Horn's ranch, on the John Day River, Oregon, the strata whence they were

obtained being supposed by Cope to be approximately equivalent to the Amyzon beds. The specific characters are thus diagnosed by the author:

The mouth is small, and opens obliquely upward. Premaxillary and dentary teeth in several rows. Size larger than that of the *P. whitei* Cope, and the scales are less numerous and of larger size. The spinous rays are less numerous than in that species and the *P. sexspinosus*. Formula: D. XI.—?; A. VII—? 12; the soft anal rays at least 12, possibly more. Scales in five or six rows above the vertebral column and in 10 or 12 below it. Radiating ridges of proximal portion strong; disk and distal portion scarcely roughened. Caudal vertebrae, 15.

The specimens are all too much injured to permit of complete measurements. The largest measures from the end of the muzzle to the base of the caudal fin 260 mm., and 90 mm. in depth at the vertical fins. The last dorsal spine measures 36 mm. A lateral dorsal scale is 6 mm. in length.

Family CICHLIDAE (Chromidae).

Known in the fossil state by a single Eocene genus, the numerous modern forms are tropical and subtropical fresh-water fishes. There is no ingrowth from the suborbitals forming a suborbital shelf, no supramaxilla, and a suture divides the lower pharyngeals.

Genus PRISCACARA Cope.

This, the only known fossil genus, differs from all existing members of the family in the possession of vomerine teeth. Small, conical teeth are present along the margin in both jaws, and the preoperculum is serrated. According to Haseman,[1] there are six branchiostegal rays.

Of the seven species which have been described by Cope from fresh-water Tertiary formations in this country, the types of six are preserved in the United States National Museum. These species, according to Cope, fall into two sections. "In the first," he writes, "the ventral spine is very strong, and there are but 10 or 11 soft dorsal radii: here belong *P. serrata, P. cypha, P. oxyprion,* and *P. testudinaria.* In the second, the first ventral spine is weak and slender, and there are 13 or 14 radii of the second dorsal fin; in this division belong *P. liops, P. pealei,* and *P. clivosa.*

PRISCACARA DARTONAE, new species.

Plate 23.

A species of large size, attaining a total length of 28 cm. to base of caudal fin, in which the length of the head and opercular apparatus is contained two and three-fourths times. Maximum depth entering into total length 2.7 times. Dorsal contour strongly arched and frontal profile rising steeply to a point just in front of the origin of the dorsal fin; the vertebral column arched anteriorly so as to be directed

[1] Haseman, J. D. The relationship of the genus Priscacara. Bull. Amer. Mus. Nat. Hist., vol. 31, 1912, pp. 97–101.

nearly parallel to the dorsal contour. Spinous rays of all the fins relatively weaker than in other known species, those of the dorsal fin not quite equalling the soft rays in length; pectoral fin rays when appressed against the ventral margin reaching to the anal; the latter having the second and third spines about equally developed. Vertebrae: 10 abdominal, and 15 caudal. Radial formula:

D. XI.–11; A. III.–8; V. I–5.

The holotype upon which this species is founded is a large (35 cm. long) and handsome specimen, excellently preserved, and remarkable for its steep facial profile and correspondingly increased depth of body as compared with other species. The vertebral column is also prominently flexed anteriorly, and the number of vertebrae is greater than in related species. The number of spinous rays in the dorsal fin is also greater by one than in either *P. serrata* or *P. oxyprion*, and the the number of rays in the anal fin the same as in these species. The spinous rays of all the fins are less robust than in any described species, and those of the dorsal fin are relatively shorter. In form of body this species stands in rather close agreement with *P. clivosa* Cope, which is smaller, and differs in fin characters and number of vertebrae. In other respects the new species shows considerable resemblance to *P. oxyprion*, in particular the number of anal and pelvic fin-rays being the same. One may say that it is intermediate in respect to the majority of its characters between these two species, *P. oxyprion* and *P. clivosa;* and although attaining as large a size as the type-species, *P. serrata*, it is much less formidably armed. Correlating with a weaker defense, it was probably of less active habits.

The writer takes pleasure in naming this species in honor of his friend, Mrs. N. H. Darton, of Washington, who with her husband has collected fish remains from western Tertiary horizons. (Cat. No. 2381, U.S.N.M.) To Mr. Darton the writer is indebted for the opportunity of studying the remains collected from near Hazen, Nevada (see p. 291, under *Parafundulus*) and from the Black Hills uplift of South Dakota.

Formation and locality.—Green River Eocene, near Fossil, Wyoming.

UNCERTAIN PLACE.

Genus ISCHYRHIZA Leidy.

The peculiar teeth first described by Leidy from the Cretaceous of New Jersey under this name, and since found in the Eocene of the Atlantic Coast region and in the Fox Hills Cretaceous of New Mexico, were conjectured by Cope to have belonged to teleost fishes, allied to the Esocidae. He also proposed that certain coalesced caudal vertebrae ("hypural fans") accompanying the Cretaceous teeth and occurring also in the Eocene of Maryland and South Carolina, should

be theoretically associated with the same genus. A somewhat different view has been expressed by the present writer,[1] who suggests that the Cretaceous fans may have belonged to *Protosphyraena* or some similar form, and that the Tertiary fans, which differ from the Cretaceous in having the terminal centrum attached, properly belong to swordfishes.

In accordance with this latter interpretation, the large fan which is shown in plate 16, figure 3, from the Phosphate Beds of South Carolina, may be provisionally assigned to *Xiphias*, and the detached tooth of *I. mira* Leidy shown in plate 11, figure 2, from the Ripley Group (Cretaceous) near Dumas, in Tippah County, Mississippi, should be assigned to a different taxonomic position. Cope's conjecture that the teeth of *Ischyriza* indicate affinity with the Esocidae is accepted by O. P. Hay and others, and seems plausible. The type of *I. mira*, together with other specimens from New Mexico, are preserved in the American Museum of Natural History

EXPLANATION OF PLATES.

PLATE 1.

Heteracanthus uddeni Lindahl, p. 245.

Head-spine, natural size. Devonian (Cedar Valley limestone); Johnston County, Iowa.

PLATE 2.

FIG. 1. *Dinichthys tuberculatus* (?) Newberry, p. 249.

Dorsomedian plate, natural size. Devonian (Chemung); Warren County, Pennsylvania.

FIG. 2. *Sauripterus taylori* Hall, p. 252.

Naturally associated cranial roofing plates, natural size. Devonian (Catskill); near Blossburg, Pennsylvania.

PLATE 3.

Physonemus gemmatus (Newberry and Worthen), p. 263.

Spine, × ⅔. Mississippian (Keokuk limestone); near Keokuk, Iowa.

PLATE 4.

Physonemus gemmatus (Newberry and Worthen), p. 263.

Spine, × ⅔. Mississippian (Keokuk limestone); near Keokuk, Iowa.

PLATE 5.

FIGS. 1 and 2. *Physonemus arcuatus* M'Coy, p. 264.

Two spines natural size. Mississippian (Keokuk limestone); Keokuk, Iowa.

FIG. 3. *Physonemus gemmatus* (Newberry and Worthen), p. 264.

A much weathered, arcuate spine, natural size. Pennsylvanian; near San Saba, Texas.

[1] Maryland Geol. Survey, Eocene, 1901, p. 111. Miocene volume, 1904, p. 93.

FIG. 4. *Ctenacanthus gracillimus* Newberry and Worthen, p. 261.

Spine, natural size. Mississippian (St. Louis limestone); near St. Louis, Mo.

FIGS. 5 and 6. *Oracanthus triangularis*, new species, p. 268.

Spine, natural size. Part of spine? × ⅔. Mississippian (St. Louis limestone); near Alton, Ill.

PLATE 6.

FIG. 1. *Edestus heinrichi* Newberry and Worthen, p. 269.

A large, well-preserved series of fused dental segments × ½.
Pennsylvanian; Appanoose County, Iowa.

FIG. 2. *Oracanthus vetustus* Leidy, p. 267.

Dorsal spine, × ½. Mississippian (Kinderhook); Le Grande, Iowa.

PLATE 7.

Harpacanthus procumbens, new species, p. 266.

FIG. 1. Fin-spine, natural size.
Mississippian (St. Louis limestone); St. Louis, Missouri.

Erismacanthus maccoyanus St. John and Worthen, p. 265.

FIGS. 2, 3. Fin spines, natural size.
Mississippian (St. Louis limestone); St. Louis, Missouri.

Dicrenodus texanus, new species, p. 256.

FIG. 4. Tooth, natural size.
Pennsylvanian; near San Saba, Texas.

Sauripterus taylori (?) Hall, p. 252.

5. (?) Basisphenoid, natural size.
Devonian (Catskill); near Blossburg, Pennsylvania.

Coccosteus, species, p. 246.

6. Antero-ventro-lateral plate, natural size.
Devonian (Elbert formation); near San Juan, New Mexico.

Ctenacanthus gracillimus Newberry and Worthen, p. 261.

7. Fin-spines, natural size.
Mississippian (St. Louis limestone); St. Louis, Missouri.

Psammodus plenis St. John and Worthen, p. 258.

8. A large-sized dental plate, natural size.
Mississippian (St. Louis limestone); near St. Louis, Missouri.

PLATE 8.

Polyrhizodus grandis, new species, p. 257.

FIGS. 1, 2. Dental plates, natural size.
Mississippian (St. Louis limestone); near Alton, Illinois.

Deltodus occidentalis (Leidy), p. 260.

FIG. 3. Dental plate, natural size.
Mississippian (St. Louis limestone); near St. Louis, Missouri.

Polyrhizodus concavus (St. John and Worthen), p. 257.

4. Dental plate, natural size.
Mississippain (St. Louis limestone); near St. Louis, Missouri.

Dipterus angustus (Newberry), p. 247.

5. Impression of dental plate, natural size.
Devonian (Chemung); Bradford County, Pennsylvania.

Chomatodus-type of tooth, p. 257.

6. Associated with *Polyrhizodus grandis*. Natural size.
Mississippian (St. Louis limestone); (?) near St. Louis, Missouri.

Cladodus spinosus Newberry and Worthen, p. 254.

7. Tooth, natural size.

Dinichthys pustulosus Eastman, p. 248.

8. Posterior process of dorsomedian plate, natural size.
Upper Devonian; Johnson County, Iowa.

PLATE 9.

Elonichthys perpennatus Eastman, p. 275.

FIG. 1. An incomplete example, natural size.
Pennsylvanian; Mazon Creek, Illinois.

Cheirodus orbicularis (Newberry and Worthen), p. 276.

2. A fairly well-preserved specimen, natural size.
Pennsylvanian; Mazon Creek, Illinois.

Elonichthys hypsilepis Hay, p. 274.

3. A nearly complete specimen, $\times\frac{1}{3}$.
Pennsylvanian; Mazon Creek, Illinois.

Rhadinichthys gracilis (Newberry and Worthen), p. 274.

4. A well preserved small specimen, $\times\frac{1}{3}$.
Pennsylvanian; Mazon Creek, Illinois.

Coelacanthus elegans (?) Newberry, p. 271.

FIGS. 5, 6. Two distorted incomplete skeletons, $\times\frac{1}{2}$.
Pennsylvanian; Mazon Creek, Illinois.

PLATE 10.

Coelacanthus exiguus Eastman, p. 271.

FIG. 1. A well-preserved example, $\times\frac{1}{3}$.
Pennsylvanian; Mazon Creek, Illinois.

Palaeophichthys parvulus Eastman, p. 272.

2. A specimen with the structural details impaired by oxidation, $\times\frac{3}{8}$.
Pennsylvanian; Mazon Creek, Illinois.

Elonichthys hypsilepis Hay, p. 274.

3. Skeleton in nodule showing fin structure, natural size.
Pennsylvanian; Mazon Creek, Illinois.

Cladodus aculeatus, new species, p. 255.

4. A tooth, $\times\frac{4}{3}$.
Mississippian (Caney shale); Antlers Quadrangle, Oklahoma.

Arthrodiran antero-ventro-lateral plate, p. 255.

FIGS. 5, 6. Two plates preserved in concretions, $\times\frac{4}{3}$.
Mississippian (Caney shale); Oklahoma.

Series of naturally associated Lepidotid scales, p. 279.

FIG. 7. Specimen, $\times\frac{2}{3}$.
Triassic, Kanab Canyon, Arizona.

PLATE 11.

Ceraspis carinata Schlüter, p. 242.

FIG. 1. Dorsomedian plate, side-view, natural size.

Middle Devonian; Eifel, Germany. Original in Museum of Comparative Zoology, Cambridge, Mass.

Ischyrhiza mira Leidy, p. 298.

2. Tooth, natural size. Cretaceous; near Dumas, Mississippe.

Coelacanthus elegans Newberry, p. 271.

FIGS. 3, 4. Two distorted examples, $\times\frac{4}{3}$.
Pennsylvanian; Mazon Creek, Illinois.

PLATE 12.

Catopterus gracilis Redfield, p. 280.

FIG. 1. Part of skeleton, including head with scales in place, $\times\frac{2}{3}$.

2. A crushed example, $\times\frac{2}{3}$.
Triassic; Durham, Connecticut.

Semionotus micropterus Newberry, p. 278.

3. Nearly complete specimen, $\times\frac{2}{3}$.
Triassic; Guilford, Connecticut.

Lepidotus walcotti, new species, p. 283.

4. Patch of scale impressions, $\times\frac{2}{3}$.
Triassic portion of Shinarump group; Kanab Valley section, Utah.

Astraspis desiderata Walcott, p. 238.

FIGS. 5, 6. Natural impression of body shield and plaster cast from same, $\times\frac{2}{3}$.
Ordovician (Harding sandstone of Black River); Canon City, Colorado.

PLATE 13.

Catopterus gracilis Redfield, p. 280.

FIG. 1. Fish on slab of shale, $\times\frac{2}{3}$.
Triassic; Guilford, Connecticut.

2. An incomplete specimen, $\times\frac{2}{3}$.
Triassic; Durham, Connecticut.

Lepidotus walcotti, new species, p. 283.

3. An incomplete individual, $\times\frac{2}{3}$.
Triassic portion of Shinarump group; Kanab Valley section, Utah.

PLATE 14.

Acanthurus, species indeterminate p. 290.

FIG. 1. Skeleton of young example, $\times\frac{2}{3}$.
Upper Eocene; Monte Bolca, Italy. Original in Museum of Comparative Zoology, Cambridge, Mass.

Belonostomus tenuirostris (Agassiz), p. 286.

2. Young individual, $\times\frac{4}{3}$.
Lithographic limestone, Solenhofen, Bavaria.

Belonorhynchus (?) species, p. 281.

3. Specimen, $\times\frac{2}{3}$.
Upper Triassic; New South Wales.

Notagogus minutus, new species, p. 287.

4. A complete skeleton on slab, $\times\frac{4}{3}$.
Lithographic limestone; Solenhofen, Bavaria.

PLATE 15.

Plioplarchus sexspinosus Cope, p. 295.

FIG. 1. Complete skeleton on slab, $\times\frac{2}{3}$.
Tertiary (Miocene);
Top of Sentinel Butte, North Dakota.

Notogoneus osculus Cope, p. 289.

2. Skeleton of young individual, $\times\frac{2}{3}$.
Eocene (Green River); Wyoming.

Semionotus elegans Newberry, p. 278.

3. A complete skeleton on slab of sandstone, $\times\frac{2}{3}$.
Triassic; Boonton, New Jersey.

PLATE 16.

Dapedoglossus testis Cope, p. 288.

FIG. 1. Well-preserved cranium, $\times\frac{2}{3}$.
Eocene (Green River); Wyoming.

Parafundulus nevadensis, new species, p. 291.

2. Nearly complete individual, in white clay matrix, $\times\frac{4}{3}$.
Tertiary (Lahonton beds); near Hazen, Nevada.

Xiphias? species, p. 298.

3. Hypural fan, natural size.
Tertiary (Eocene beds); Coosa River, South Carolina.

PLATE 17.

Parafundulus nevadensis, new species, p. 291.

A group of specimens, natural size.
Tertiary (Lahonton beds); near Hazen, Nevada.

PLATE 18.

Cladodus aculeatus, new species, p. 255.

FIG. 1. Teeth.
Mississippian (Caney); Antlers Quadrangle, Oklahoma.

Psephodus legrandensis Branson, p. 259.

2. Naturally associated dental plates of holotype.
Mississippian Kinderhook; Le Grand, Iowa.

Parafundulus nevadensis, new species, p. 291.

3. Drawing of skeleton figured in plate 16, figure 2.
Tertiary (Lahonton beds); near Hazen, Nevada.

Leuciscus (cf. *L. turneri*), p. 292.

4. Skeleton, natural size.
Oligocene or Lower Miocene; Madison Valley, Montana.

Osmerus (?) species, p. 293.

5. Skeleton.
Oligocene or Lower Miocene; Madison Valley, Montana.

PLATE 19.

Amyzon brevipinne Cope, p. 292.

FIG. 1. Nearly complete skeleton, $\times\frac{1}{2}$.
2. Skeleton lacking head portion, $\times\frac{2}{3}$.
Tertiary (Lower Miocene); near Republic, Washington.

Cyprinodont, p. 293.

3. Example of an undetermined species, $\times\frac{3}{4}$.
Tertiary; Mexico.

PLATE 20.

Ameiurus primaevus, new species, p. 293.

Nearly complete skeleton of holotype, $\times\frac{1}{2}$.
Eocene (Green River); Wyoming.

PLATE 21.

Mioplosus labracoides Cope, p. 295.

A large well-preserved specimen, $\times\frac{1}{3}$.
Eocene (Green River); Wyoming.

PLATE 22.

Plioplarchus septemspinsous Cope, p. 295.

One of the type-specimens, $\times\frac{1}{2}$.
Miocene (?); Van Horn's Ranch, on the John Day River, Oregon.

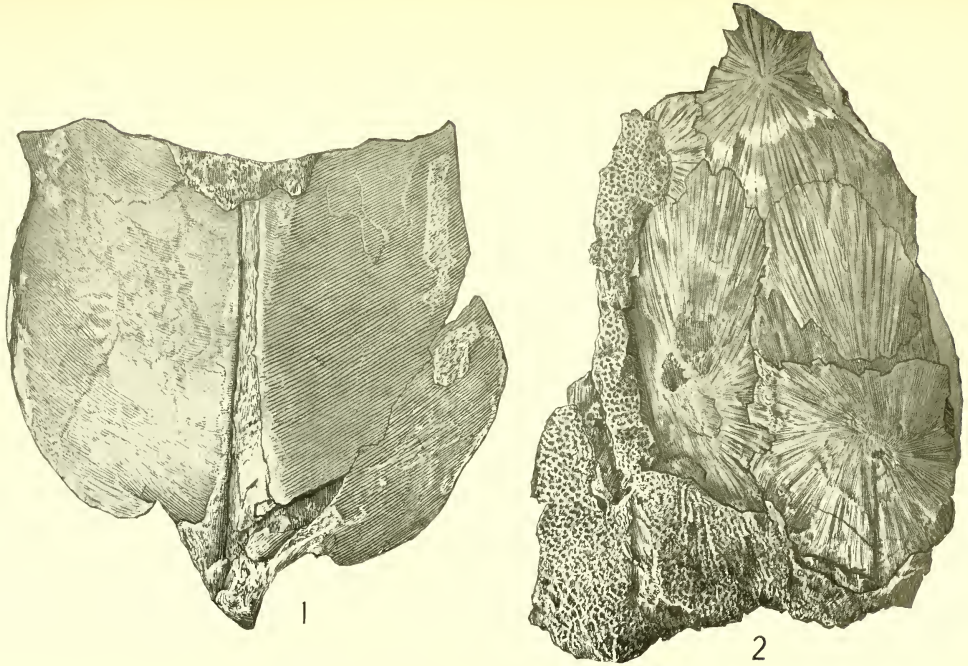
PLATE 23.

Priscacara dartonae, new species, p. 296.

Complete skeleton of the holotype, $\times\frac{1}{2}$.
Eocene (Green River); near Fossil, Wyoming.

HETERACANTHUS UDDENI.

FOR EXPLANATION OF PLATE SEE PAGE 298.

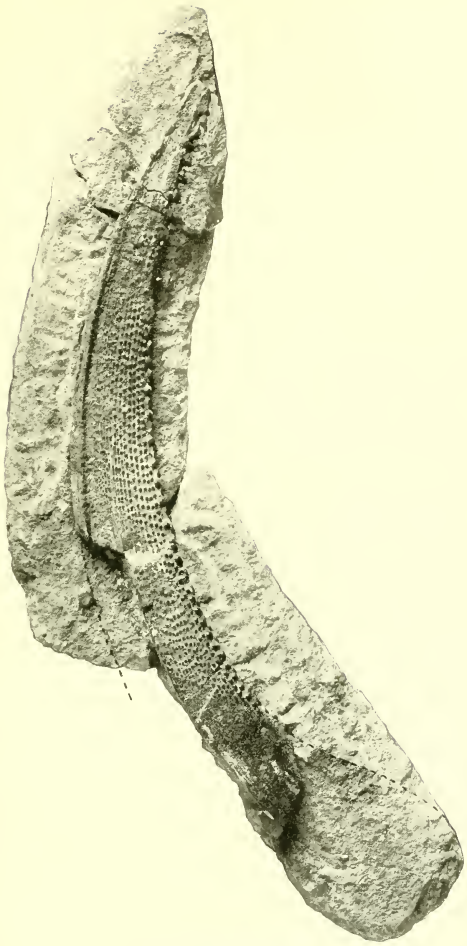


DINICHTHYS TUBERCULATUS AND SAURIPTERUS TAYLORI.

FOR EXPLANATION OF PLATE SEE PAGE 298.

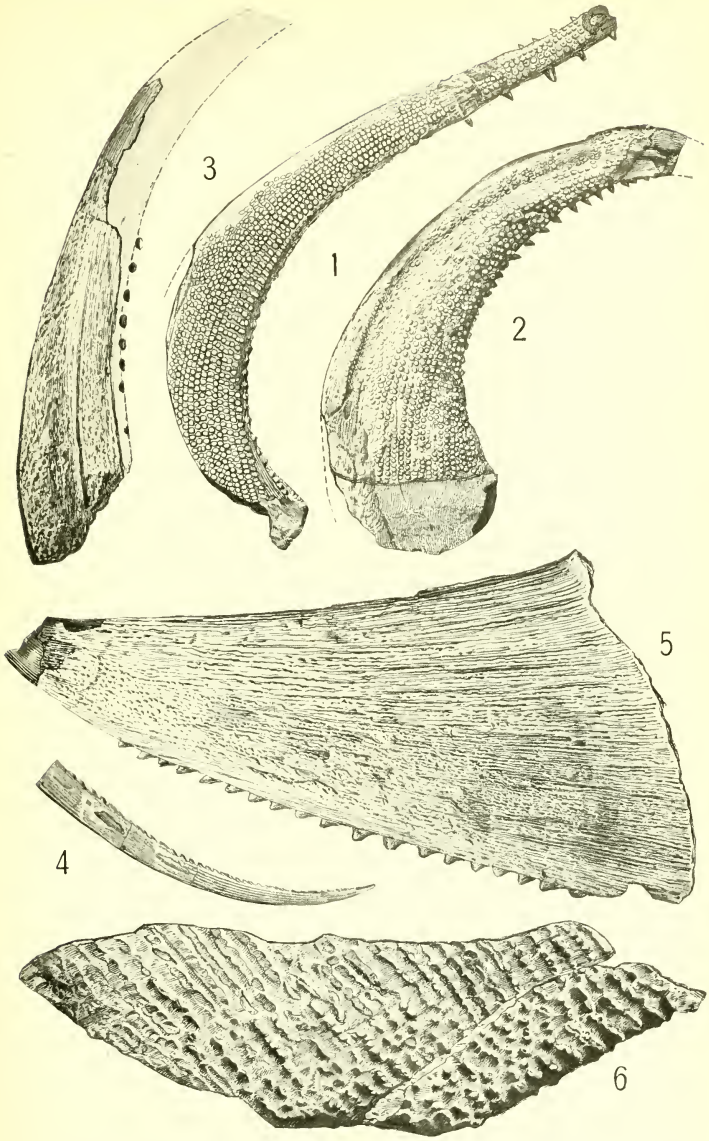
PHYSONEMUS GEMMATUS.

FOR EXPLANATION OF PLATE SEE PAGE 298.



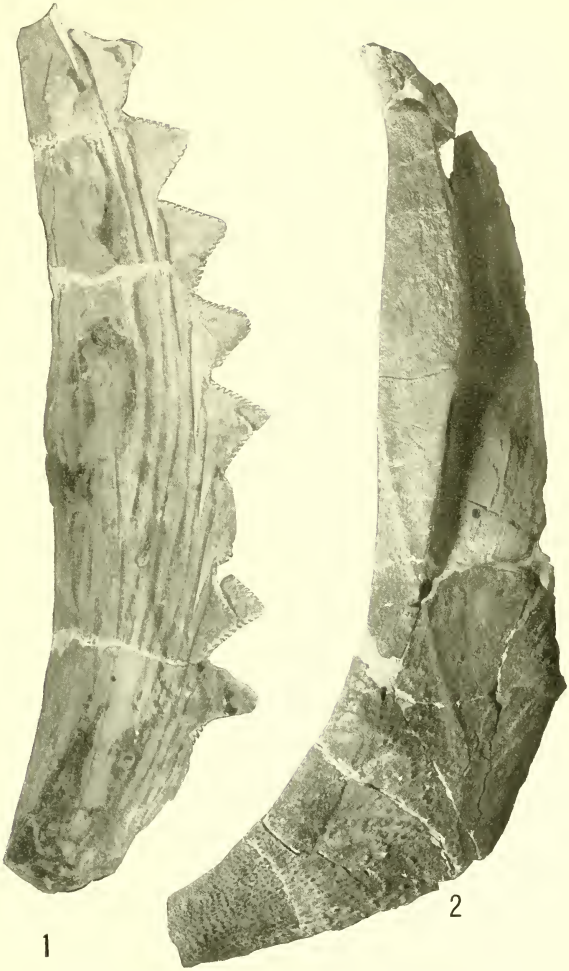
PHYSONEMUS GEMMATUS.

FOR EXPLANATION OF PLATE SEE PAGE 298.



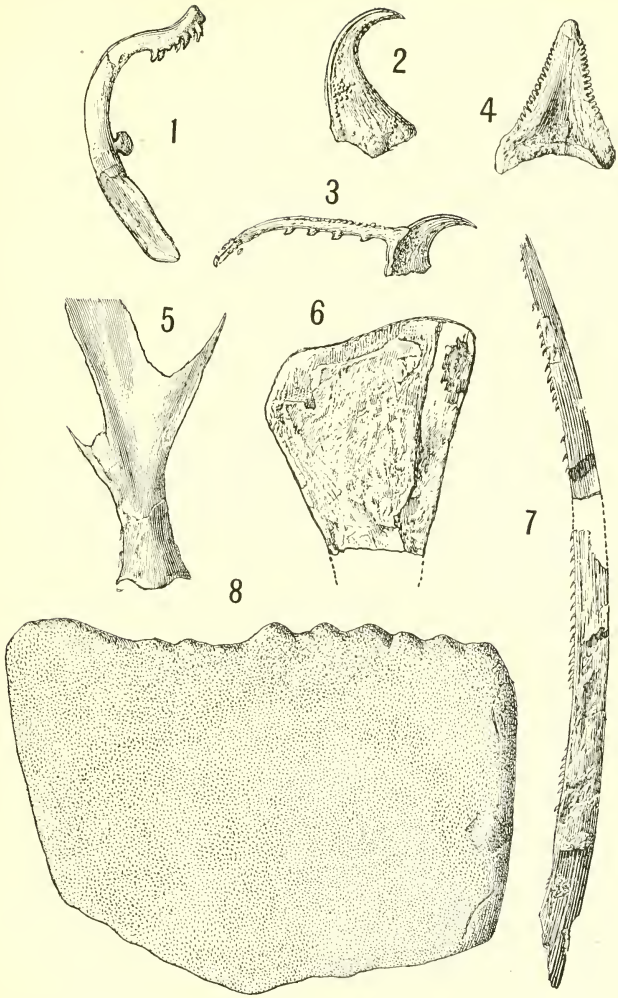
PHYSONEMUS ARCUATUS, P. GEMMATUS, CTENACANTHUS GRACILLIMUS, AND ORACANTHUS TRIANGULARIS.

FOR EXPLANATION OF PLATE SEE PAGES 298 AND 299.



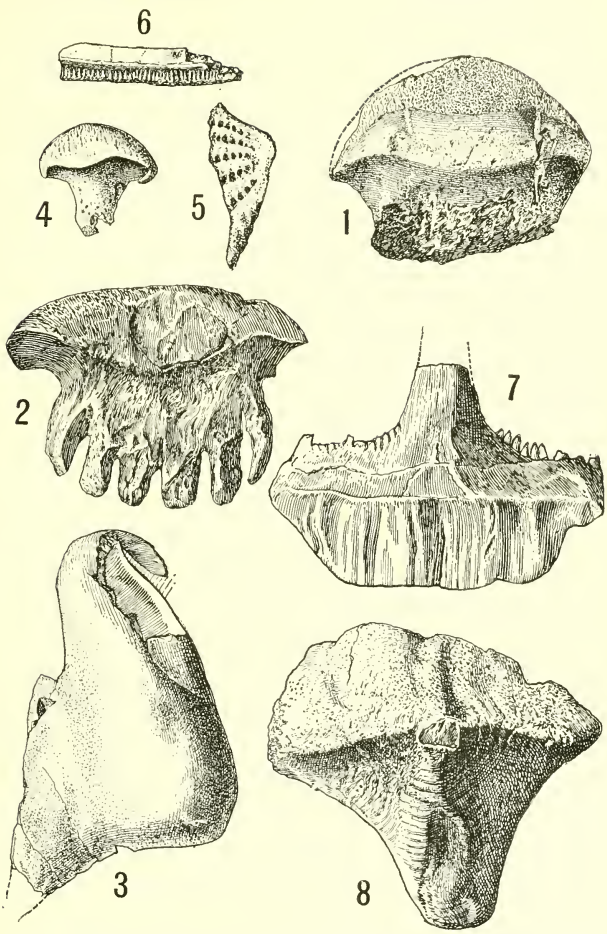
EDESTUS HEINRICHI AND ORACANTHUS VETUSTUS.

FOR EXPLANATION OF PLATE SEE PAGE 299.



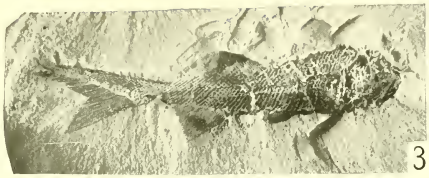
HARPACANTHUS PROCUMBENS, ERISMACANTHUS MACCOYANUS, DICRENODUS TEXANUS, SAURIPTERUS TAYLORI, COCCOSTEUS, SPECIES, CTENACANTHUS GRACILLIMUS, AND PSAMMODUS PLENIS.

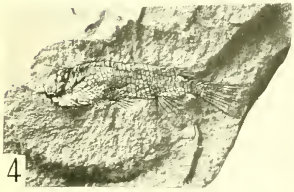
FOR EXPLANATION OF PLATE SEE PAGE 299.

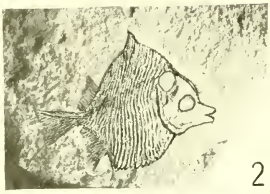


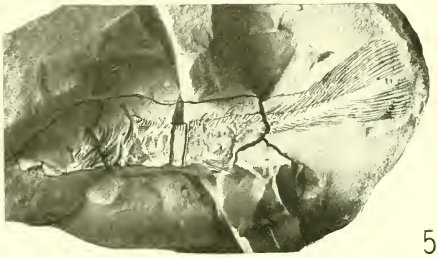
POLYRHIZODUS GRANDIS, DELTODUS OCCIDENTALIS, POLYRHIZODUS CONCAVUS, DIPTERUS ANGUSTUS, POLYRHIZODUS GRANDIS, CHOMATODUS, SPECIES, CLADODUS SPINOSUS, AND DINICHTHYS PUSTULOSUS.

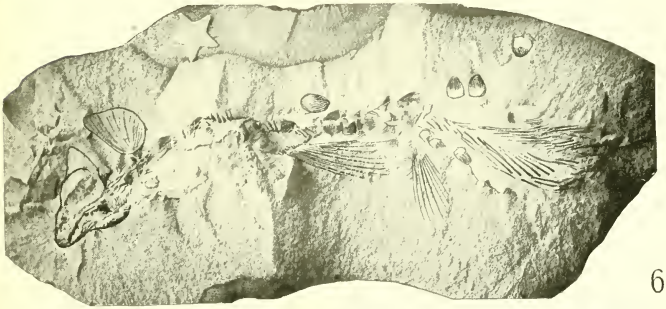
FOR EXPLANATION OF PLATE SEE PAGES 299 AND 300.





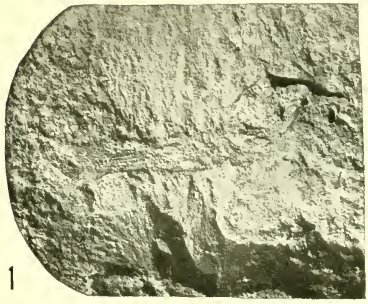


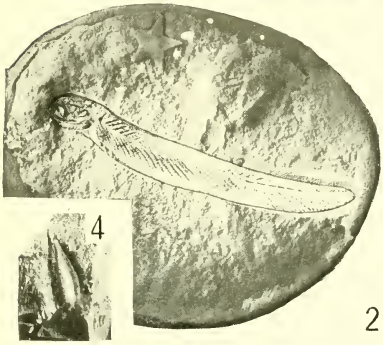


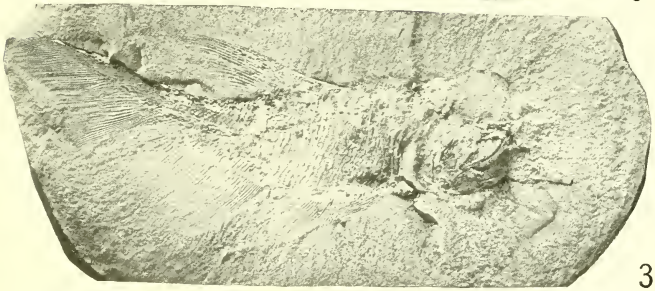


ELONICHTHYS PERPENNATUS, CHEIRODUS ORBICULARIS, ELONICHTHYS HYPSIPLEPIS, RHADINICHTHYS GRACILIS, AND COELACANTHUS ELEGANS.

FOR EXPLANATION OF PLATE SEE PAGE 300.





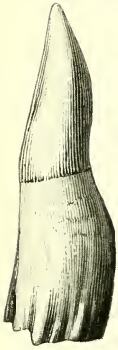


COELACANTHUS EXIGUUS, PALAEOPHICHTHYS PARVULUS, ELONICHTHYS HYPSILEPIS, CLADODUS ACULEATUS, ARTHRODIRAN PLATES, AND LEPIDOTID SCALES.

FOR EXPLANATION OF PLATE SEE PAGES 300 AND 301.

1

4

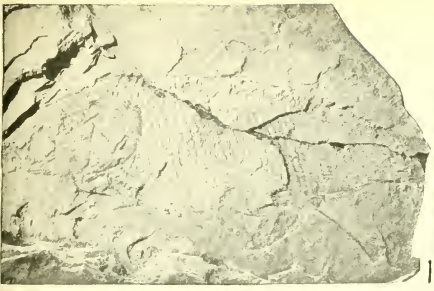


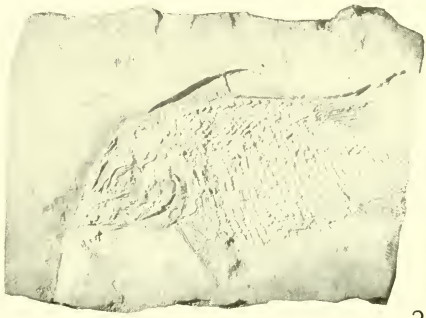
2

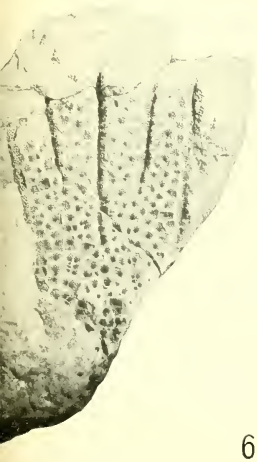
3

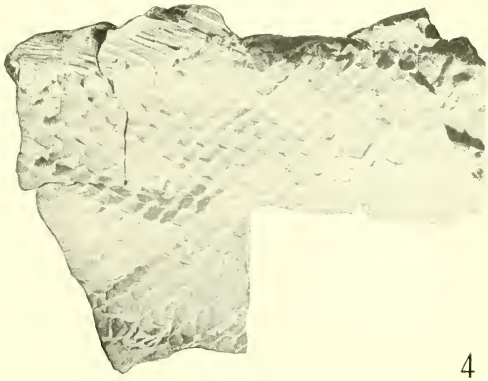
CERASPIS CARINATA, ISCHYRIZA MIRA, AND COELACANTHUS ELEGANS.

FOR EXPLANATION OF PLATE SEE PAGE 301.



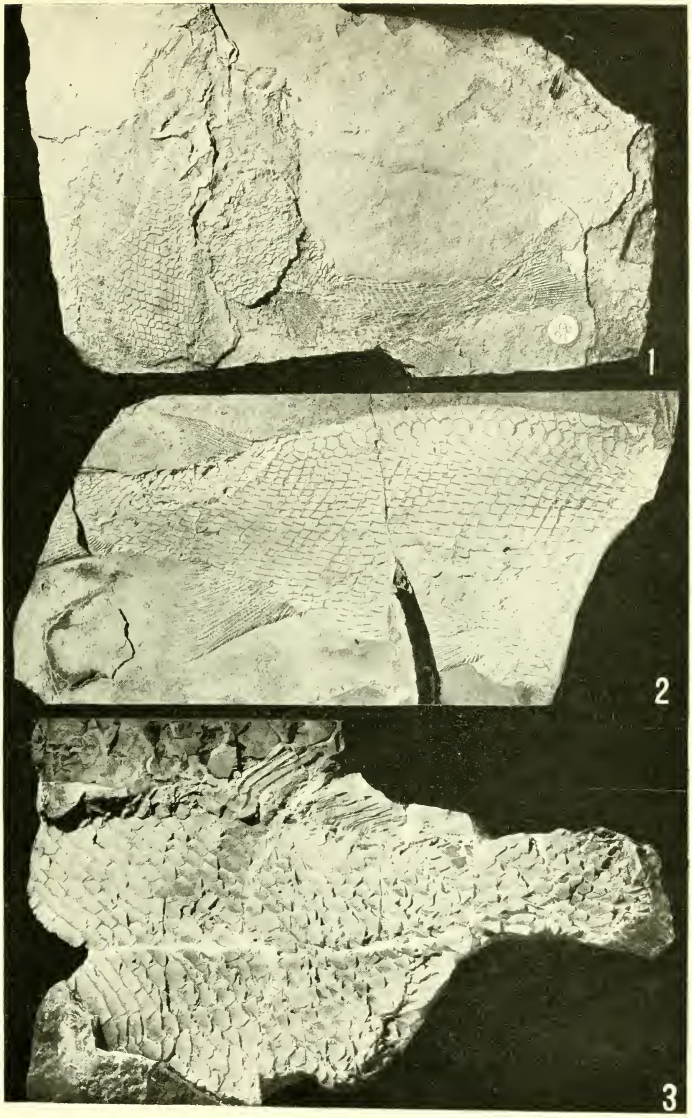






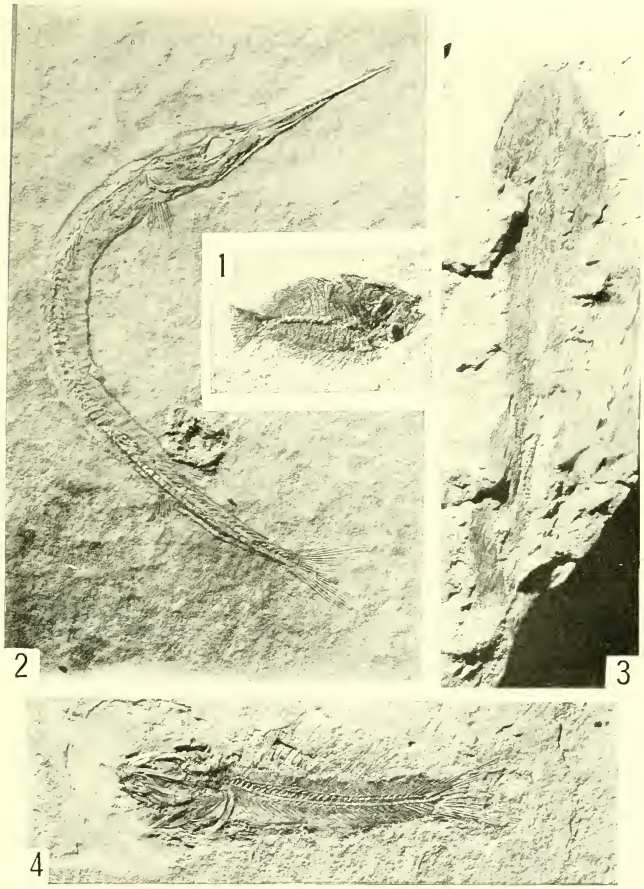
CATOPTERUS GRACILIS, SEMIONOTUS MICROPTERUS, LEPIDOTUS WALCOTTI, AND ASTRASPIS DESIDERATA.

FOR EXPLANATION OF PLATE SEE PAGE 301.



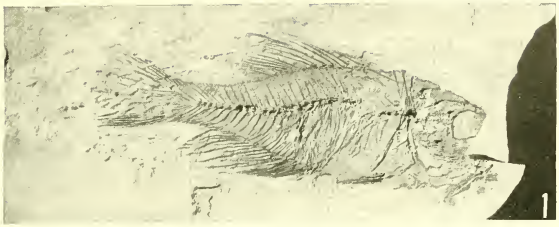
CATOPTERUS GRACILIS, AND LEPIDOTUS WALCOTTI.

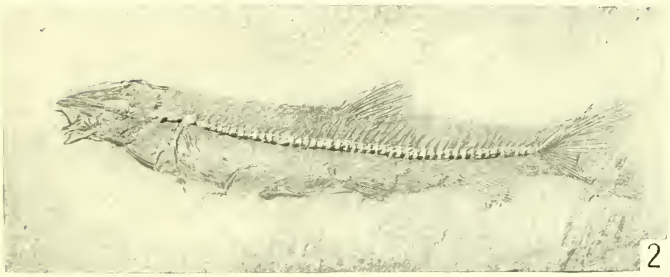
FOR EXPLANATION OF PLATE SEE PAGE 302.



ACANTHURUS, SPECIES, BELONOSTOMUS TENUIROSTRIS, BELONORHYNCHUS (?) SPECIES, AND NOTAGOGUS MINUTUS.

FOR EXPLANATION OF PLATE SEE PAGE 302.



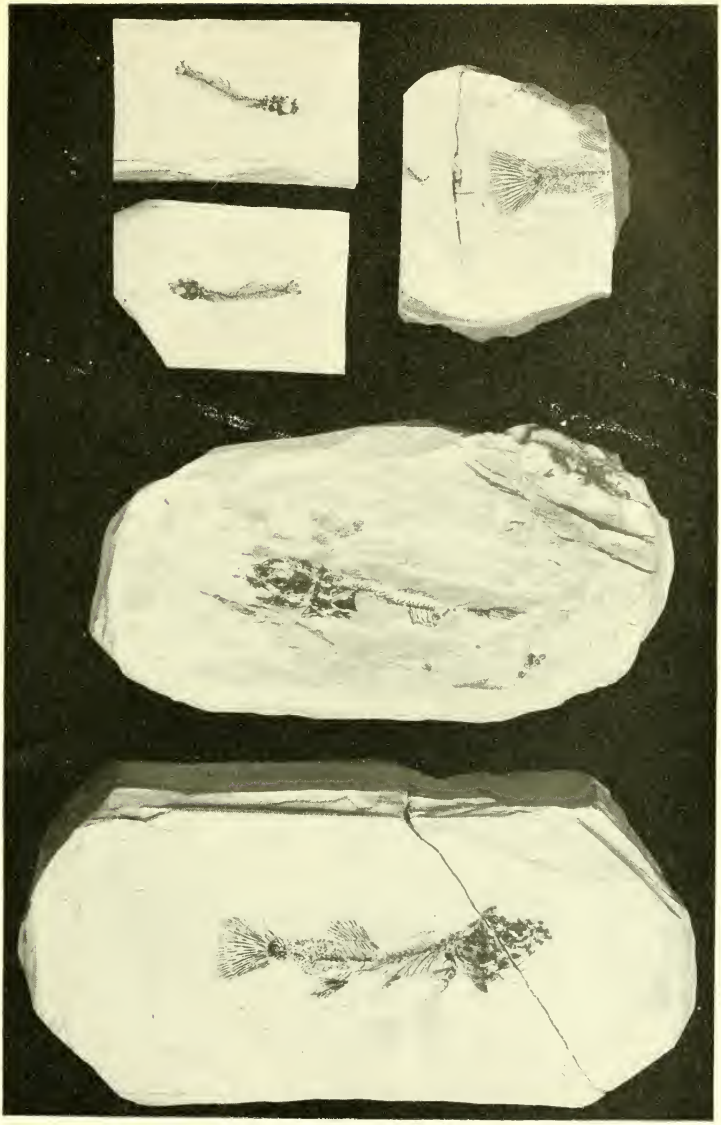


PLIOPLARCHUS SEXSPINOSUS, NOTOGONEUS OSCULUS, AND SEMIONOTUS ELEGANS.

FOR EXPLANATION OF PLATE SEE PAGE 302.

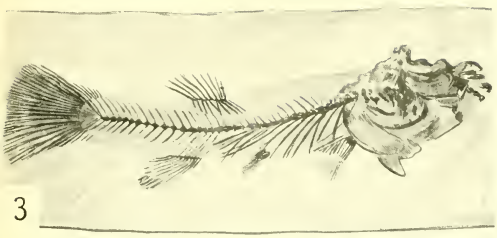
DAPEDOGLOSSUS TESTIS, PARAFUNDULUS NEVADENSIS, AND XIPHIAS?, SPECIES.

FOR EXPLANATION OF PLATE SEE PAGES 302 AND 303.



PARAFUNDULUS NEVADENSIS.

FOR EXPLANATION OF PLATE SEE PAGE 303.



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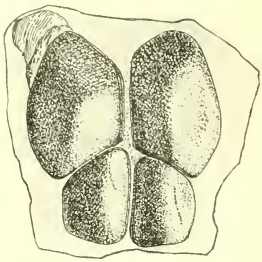

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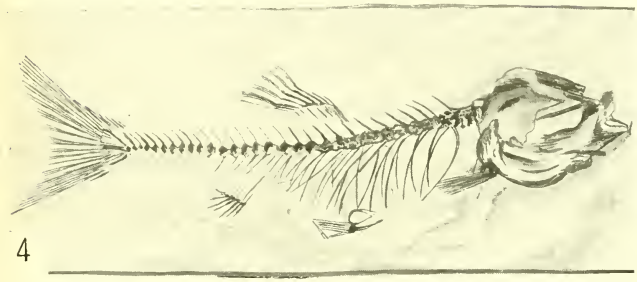

4

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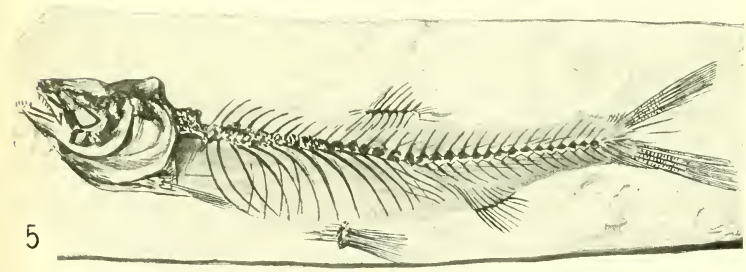
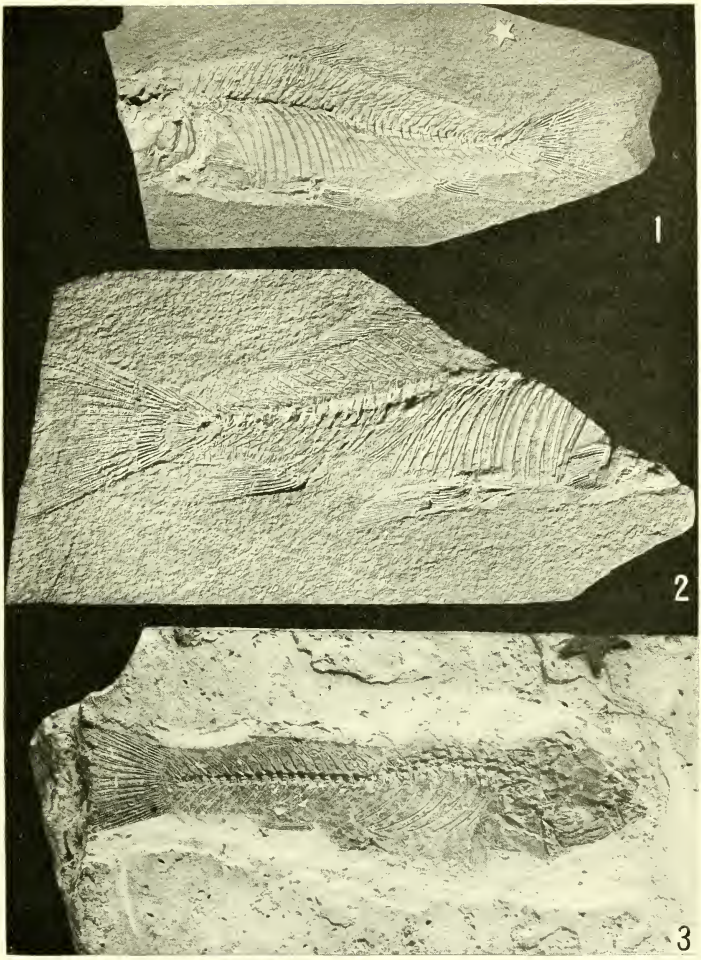


5

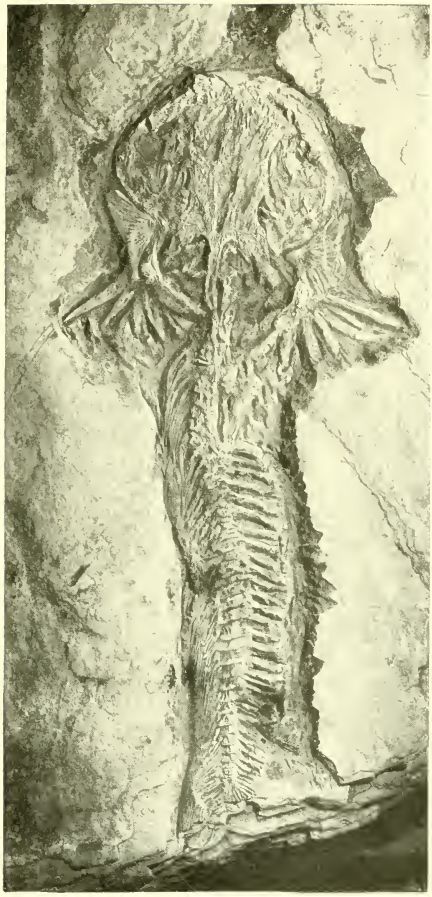
CLADODUS ACULEATUS, PSEPHODUS LEGRANDENSIS, PARAFUNDULUS NEVADENSIS, LEUCISCUS, AND OSMERUS (?) SPECIES.

FOR EXPLANATION OF PLATE SEE PAGE 303.



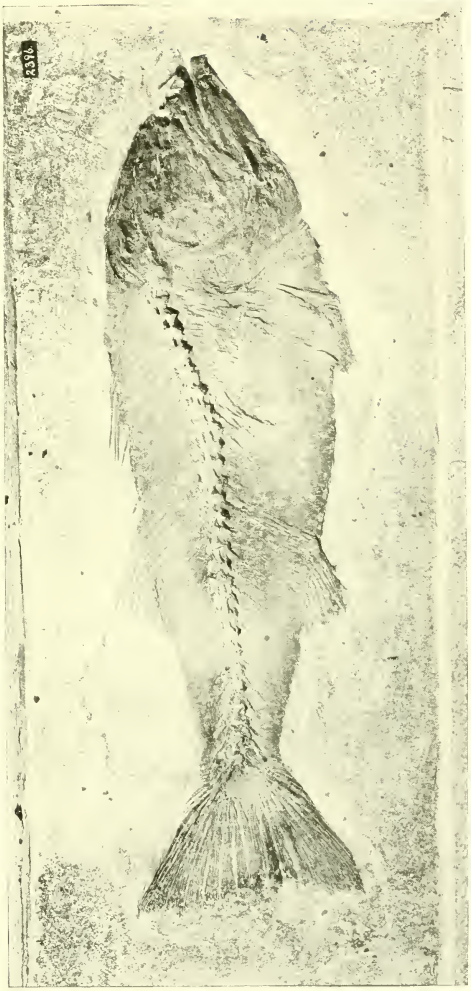
AMYZON BREVIPINNE, AND CYPRINODONT.

FOR EXPLANATION OF PLATE SEE PAGE 303.



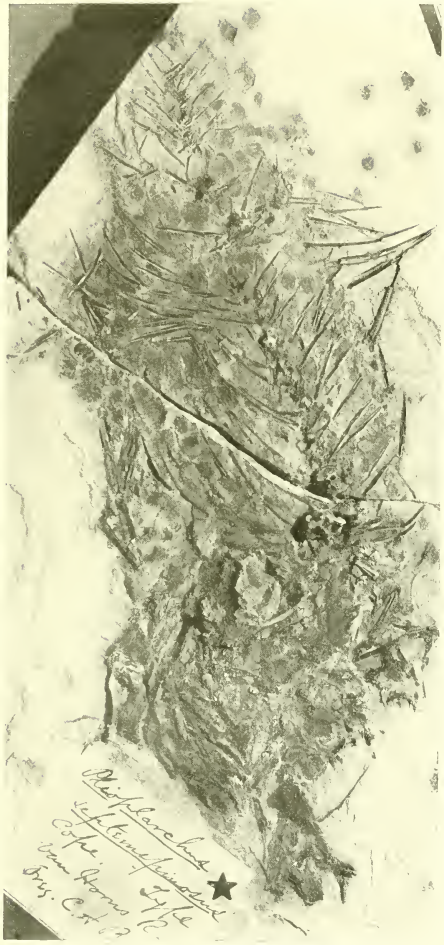
AMEIURUS PRIMAEVUS.

FOR EXPLANATION OF PLATE SEE PAGE 303.



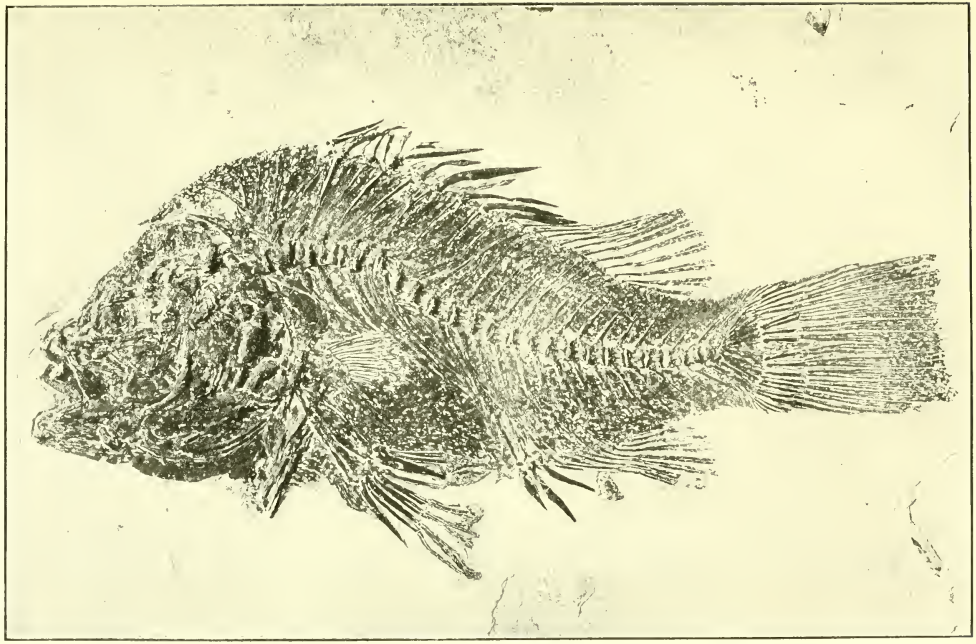
MIOPLOSUS LABRACOIDES.

FOR EXPLANATION OF PLATE SEE PAGE 303.



PLIOPLARCHUS SEPTEMSPINOSUS.

FOR EXPLANATION OF PLATE SEE PAGE 304.



PRISCACARA DARTONAE.

FOR EXPLANATION OF PLATE SEE PAGE 304.