

GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 4.

A Description of the Fossil Fish Remains

OF THE

Cretaceous, Eocene and Miocene Formations
of New Jersey

By HENRY W. FOWLER

of the Academy of Natural Sciences of Philadelphia

With a Chapter on the Geology by

HENRY B. KÜMMEL

TRENTON, N. J.

MacCrellish & Quigley, State Printers, Opposite Post Office.

1911.

Letter of Transmittal.

TRENTON, N. J., MARCH 17, 1911.

*The State Printing Board,
Trenton, N. J.*

GENTLEMEN—Chapter 46, Laws of 1910, provides that in addition to an annual administrative report, the State Geologist shall prepare or cause to be prepared such scientific reports as are pertinent to the work of his department, and that the State Printing Board shall have authority, on recommendation of the Board of Managers of the Survey, to order printed such scientific reports.

The Board of Managers of the Survey, on December 6, 1910, adopted the following motion: That the publication of reports on the Plant Remains of the Cretaceous Clay Beds, and on the Fossil Fishes of the Cretaceous and Miocene Formations of South Jersey, already prepared or in process of preparation under the direction of the State Geologist, be recommended for printing to the State Printing Board, as provided in Chapter 46, Laws of 1910.

In accordance with the above, I request that the State Printing Board order printed 1,500 copies each of the two reports above mentioned, 100 to be bound, the balance in stiff covers sewed, as provided in the specifications for printing the Geological Survey reports.

Respectfully submitted,

HENRY B. KÜMMEL,
State Geologist.

LETTER OF TRANSMITTAL.

STATE OF NEW JERSEY,
OFFICE OF COMPTROLLER OF THE TREASURY.

TRENTON, MARCH 20, 1911.

*Henry B. Kimmel, Esq.,
State Geologist,
Trenton, N. J.*

DEAR SIR—Your communication of the 17th inst., addressed to the State Printing Board, was laid before the Board at its meeting held on Friday, last, and, on motion, it was ordered that the publications referred to in your letter be printed and bound as requested. The work will be done by MacCrellish & Quigley, who were awarded the contract last fall.

Very respectfully,

E. J. EDWARDS,
Comptroller, as Secretary, State Printing Board.

INTRODUCTION.

The present work is intended simply as a descriptive summary of the fish remains known from the late Mesozoic and Cenozoic formations within the limits of the State of New Jersey. A full account of the stratigraphic paleontology of the Cretaceous is given by Dr. Stuart Weller, in his account of these formations, published in volume IV of the Paleontology series of the Geological Survey in 1907. Though no new collections have been made it is hoped that an exposition of the older ones, many of which have not been studied before, will be of value. The one great disadvantage is, as may have been expected, the lack of definite stratigraphic position for each species, the original data usually being incomplete or meager. This was due to the earlier collectors not attaching sufficient importance to preserving exact horizons and localities with their specimens. In many cases Dr. H. B. Kummel, through his familiarity with the local geology, has been able to indicate the horizon from which the specimens came, and all such references to the present classification in the text are on his authority. To avoid confusion such references are inclosed in brackets with the initial K. In some cases comparison with other material in the collection of the Academy has greatly facilitated determinations, especially in the case of types or authoritatively determined material. I have attempted to illustrate as well as describe each species, wherever possible, from specimens, though in some cases have been obliged to use the original accounts. This is especially true among the chimæroids, where I have also allowed reproductions from Dr. Louis Husakof's photographs. The general scheme of classification is that of Dr. David Starr Jordan, sometimes freely used or modified to suit present purposes.

Dr. O. P. Hay's Catalogue of Fossil Vertebrata of North America, and Dr. A. S. Woodward's Catalogue of Fossil Fishes in the British Museum, have been freely consulted with respect

to the diagnoses of the higher groups and generic synonymy. The writer is indebted to the Academy of Natural Sciences of Philadelphia, for the use of its library and collections, where most of this work was carried on. I am also under obligations to Dr. Henry B. Kümmel, the State Geologist, for the opportunity of consulting the collections of the State Geological Survey. All the figures are natural size, unless otherwise stated, in which case the reduction is shown by a line which indicates an inch. The material from the Geological Survey collections is indicated in the explanation by a *.

THE CRETACEOUS AND TERTIARY FORMATIONS OF NEW JERSEY.

H. B. KÜMMEL.

THE CRETACEOUS SYSTEM.

The Cretaceous strata of New Jersey outcrop southeast of a line from Trenton to New Brunswick, and as shown by well borings underlie all of South Jersey, although over most of the area they are deeply buried beneath later formations of Tertiary age and even along their belt of outcrop they are frequently covered with a mantle of sand and gravel of Quaternary age.

They comprise unconsolidated sands and clays, which dip 50 to 25 feet per mile to the southeast, and which have an aggregate thickness of from 500 to 1,000 feet, the greater thickness being found in the northern portion of the area. The lowermost beds are referred to the upper part of the Lower Cretaceous and are of non-marine origin. The middle and upper portions, however, belong to the Upper Cretaceous and contain an abundant marine fauna.

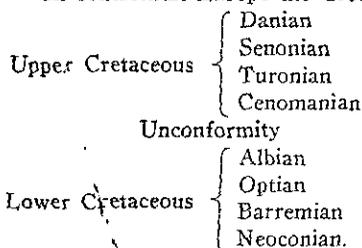
Raritan formation.—The Raritan formation is extremely variable, consisting chiefly of light-colored sands and clays, some of the latter being highly refractory. There is on the whole a preponderance of clays in the lower, and of sands in the upper, half of the series. Since it was laid down on an irregular surface its thickness is variable, ranging from 150 to 250 feet at the outcrop, but increasing to the southeastward, as shown by well-borings, to over 500 feet. Northeast of Trenton it rests unconformably upon the beveled Triassic shales, but farther southward upon the ancient crystallines of early Paleozoic or pre-Paleozoic age, and perhaps at undetermined points still farther south on earlier Cretaceous beds. It dips 40 to 50 feet per mile to the

southeast, the basal beds having the steeper inclination. The known fauna is very limited, consisting of a few pelecypods, some of which are blackish-water types, while two are typically marine, a plesiosaurian bone, and possibly an insect. Its flora embraces a wide range of genera and species, especially of dicotyledons, many of which are closely related to modern forms. It has been regarded by Ward as late Lower Cretaceous, and, therefore, approximately equivalent to the Gault of England and the Albian of continental Europe.¹ Berry, however, has recently presented the paleobotanical evidence for its Cenomanian age.²

Magothy formation.—The lignitic sands and clays referred to the Magothy formation, and regarded as the lowermost of the Upper Cretaceous formations, were until recently included in the Raritan. On the shores of Raritan Bay they attain a thickness of about 50 feet, but diminish to the southwest and along Delaware River are only 25 or 30 feet. They are slightly glauconitic near the top. The Magothy rests unconformably on the Raritan, but the discordance is not great and indicates only a slight epeirogenic movement. A marine fauna of 43 species, possessing close affinities to that of the Ripley beds of the south and to the Senonian of Europe, is found on the shores of Raritan Bay, but farther southwest the deposits are apparently estuarine. The flora is abundant and presents a much more recent aspect than that of the Raritan. It is regarded by paleobotanists as showing upper Cenomanian affinities.

Merchantville clay.—The Merchantville is a black, glauconitic, micaceous clay, usually greasy in appearance and mas-

¹ In continental Europe the Cretaceous system is divided as follows:



² Berry E. W., Bulletin No. 3, p. 20 *et seq.*, Geological Survey of New Jersey.

sive in structure, weathering to an indurated brown earth. Its thickness is about 60 feet. It is conformable to the Magothy formation below and the Woodbury clay above. Its invertebrate fauna is large and varied, and although it contains many forms common to the beds above and below, its most characteristic species are conspicuous for their absence or great rarity in the adjoining strata. The Merchantville clay represents the lower part of the Crosswicks clay of Clark, forms the base of the Clay-marl series of Cook, and is the lowest of the five formations in New Jersey which are correlated with the Matawan formation of Maryland.

Woodbury clay.—The Woodbury is a black, non-glaucous, jointed clay about 50 feet thick, which weathers to a light chocolate color, and when dry breaks into innumerable blocks, frequently with a conchoidal fracture. Its invertebrate fauna of 95 marine species is more closely allied to that of the Magothy than to the subjacent Merchantville. It is conformable both with the Merchantville below and the Englishtown sand above. It is the upper part of the Crosswick clay of Clark, and forms part of the Clay-marl series of Cook. It is also one of the formations correlated with the Matawan of Maryland.

Englishtown sand.—The Englishtown is a conspicuous bed of white or yellow quartz sand slightly micaceous and sparingly glauconitic. Locally it contains thin laminae of fine brittle clay. So far as known it contains no fossils. It decreases in thickness from 100 feet near Atlantic Highlands to less than 20 feet in the southern portion of the State. It represents the lower part of the Hazlett sand of Clark, and forms a part of Cook's Clay-marl series. It was formerly called the Columbus sand and is the equivalent of a part of the Matawan formation.

Marshalltown clay-marl.—The Marshalltown ranges from a black sandy clay to an argillaceous greensand marl. Locally it is abundantly fossiliferous, its characteristic invertebrate species being in part recurrent forms from the Merchantville, and in part a new element, which recurs again in a higher formation, although absent or inconspicuous in the immediately succeeding beds. Its thickness is 30 to 35 feet. It is a portion of the "laminated" sands which formed the upper part of the Clay marl

series of Cook, although in the southwestern portion of the State he referred these beds to the Navesink (Lower) marl. It was included in Clark's Hazlett sands, a sub-division of his Matawan.

The Wenonah and Mount Laurel sands.—Above the Marshalltown clay-marl there is a considerable thickness of sand regarding which there has been some difference of opinion. The terms Wenonah and Mount Laurel have both been applied to it in whole or in part. Lithologically these sand layers are not sharply differentiated from each other, although the lower part (Wenonah) is generally a fine micaceous sand and the upper part (Mount Laurel) is coarser and contains considerable greensand. Paleontologically, however, they are quite distinct. The Wenonah fauna is largely recurrent from the Woodbury, with comparatively few prominent species common either to the Marshalltown below or the Mount Laurel and Navesink above. The same elements are prominent again still higher in the Red Bank. The Mount Laurel invertebrate fauna is identical with that of the Navesink above, and is closely allied to the Marshalltown, but contains a foreign element, chief among which is the cephalopod *Belemnitella americana* and the brachiopod *Terebratella plicata*, so that the indistinct lithological line between the Wenonah sand and Mount Laurel sand is of considerable paleontological significance. The combined thickness of these formations is 40 to 80 feet, the Mount Laurel being limited to a very thin bed at Atlantic Highlands (Cook's sand-marl) but increasing much in thickness toward the southwest. The Wenonah sand is the highest bed correlated with the Matawan of Maryland, while the Mount Laurel is the base of the Monmouth.

Navesink marl.—The Navesink marl consists of greensand marl, mixed with varying amounts of quartz sand and fine earth, the latter of which contains much carbonate of lime in a powdery state. Where purest the marl has a dark-green or bluish-black color. The upper part of the bed contains progressively less greensand and is more clayey. The invertebrate fauna is large (121 species, Weller), and is allied with that of the Marshalltown and Merchantville beds, while the characteristic forms of

the Magothy, Woodbury and Wenonah are absent. The formation has a maximum thickness of about 40 feet, diminishing southward to 25 feet or less. It corresponds in general to Cook's Lower Marl, although locally beds referred by him to the Lower Marl have proved to be the Marshalltown. It rests conformably upon the beds below and grades upward into the Red Bank sand, or where that is absent into the Hornerstown marl.

Red Bank sand.—The Red Bank sand is for the most part a fairly coarse ferruginous yellow and reddish-brown quartz sand, locally indurated by the infiltration of iron. The lower beds are in many places somewhat clayey. The Red Bank invertebrate fauna has come chiefly from these clayey layers. In its essential features it is a recurrence of the *Lucina cretacea* fauna of the Magothy, Woodbury and Wenonah formations, and differs in important respects from the Navesink fauna immediately below. It occurs only in the northern part of the coastal plain, where its maximum thickness is 100 feet, but it thins out and disappears midway across the State. It is the Red Sand of Cook and earlier writers, but does not include certain sands in the southern portion which were correlated by him with the Red Sand of Monmouth county, but which in reality are referable to the Wenonah-Mt. Laurel horizon. With the overlying Tinton bed, it is the uppermost of the beds correlated with the Monmouth formation of Maryland.

Tinton bed.—A lense of green indurated clayey and sandy marl, having a thickness of from 10 to 20 feet, overlies the Red Bank sand in Monmouth County. Its invertebrate fauna is more closely allied to that of the Navesink than of the Red Bank and is characterized by large numbers of crustacean claws of the genus *Callianassa*. It is Cook's "indurated green earth," regarded by him and other writers as a part of the Red Sand, but in view of its faunal and lithologic differences it deserves some separate recognition.

Correlation of the Magothy-Tinton beds.—The assemblage of fossils making up the invertebrate faunas of the beds from the Magothy to the Tinton inclusive constitute a larger faunal unit, much more sharply separated from the faunas above and below

than are any of its constituent faunules from each other. Weller has shown that this larger faunal unit is made up of two or more distinct facies, one of which, the *Cucullaea* fauna, is characteristic of the more glauconitic beds; namely, the Merchantville, Marshalltown, Navesink and Tinton, while the other facies characterized by *Lucina cretacea* or its associates occurs in the clays or clayey sands of the Cliffwood, Woodbury, Wenonah and Red Bank formations. The two facies existed contemporaneously and migrated backward and forward across the present outcrop of these beds in New Jersey as deeper or shallower water conditions prevailed. The larger faunal unit is closely related to the Ripley fauna of Alabama, Mississippi and Texas. On faunal evidence all the formations from the Magothy to Tinton inclusive are referable to the Senonian of Europe, although on floral evidence the Magothy might be regarded as Cenomanian.

Hornerstown marl.—The Hornerstown marl is a bed of glauconite with clay and sand and not differing materially from the Navesink. Its fauna is meager, but is totally different in its essential characteristics from the faunas of all the underlying formations. *Terebratula harlani*, *Cucullaea vulgaris* and *Gryphaea dissimilaris* (Weller) are characteristic forms. A shell bed at the top of the formation is a conspicuous feature at many localities. The thickness is 30 feet or less. At the north it rests with apparent conformity on the Tinton; where that is absent it lies on the Red Bank, and farther south it is continuous with the Navesink, owing to the disappearance of the Red Bank. It is conformably overlain by the Vincentown except where overlapped by Miocene formations. It is the Middle Marl of Cook, the Sewell marl of Clark, and is a part of the Rancocas group.

Vincentown sand.—The Vincentown sand presents two phases, a calcareous or limesand, semi-indurated and largely a mass of broken bryozoan, echinoid, coral and other calcareous remains, and a glauconitic quartz-sand phase. The two phases occur in alternating layers, although the former is more common in the basal portion, particularly to the south, while the quartz-sand phase predominates in Monmouth County. The fauna of the limesand phase contains large numbers of bryozoa, echinoids and

foraminifera, while in the siliceous phase elements of the Hornerstown fauna occur in association with forms characteristic of the calcareous phase. Its thickness varies from 25 to 70 feet, but well-borings have shown that it thickens greatly down the dip. It rests conformably upon the Hornerstown marl and is overlain conformably by the Manasquan marl or overlapped by Miocene beds. It includes the "limesand" and "yellow sand" of Cook, the former of which was regarded by him as a part of the Middle Marl.

Manasquan marl.—The Manasquan marl in its lower portion (13-17) is composed chiefly of glauconite, but the upper part (8-12 feet) is made up of very fine sand mixed with greenish-white clay, piles of which look like heaps of ashes—hence the name "ash marl." The invertebrate fossils are not abundant and are poorly preserved, the commonest occurring also either in the Hornerstown or Vincentown. Its thickness is about 25 feet. It corresponds to the "green" and "ash" marls of Cook's Upper Marl bed and is the youngest of the Cretaceous formations exposed in New Jersey. It probably rests conformably upon the Vincentown and at most exposures is succeeded unconformably by Miocene or Pleistocene deposits, although locally it is overlain by a bluish marl of Eocene age without apparent unconformity.

Correlation of the Hornerstown, Vincentown and Manasquan.—The invertebrate faunas of these three formations are closely related and form a larger fauna sharply separated from the Ripleyian fauna of the underlying Magothy and Tinton beds. This fauna has not been recognized south of Maryland. It shows certain affinities with the lower or Maestrichtian division of the Danian series of Western Europe (Weller).

EOCENE SYSTEM.

Shark River marl.—Eocene deposits in New Jersey are limited in outcrop to small areas near Allenhurst (Deal), Shark River and Farmingdale, in Monmouth County, where a mixture of greensand and light-colored earth 11 feet in thickness and carrying Eocene fossils rests without apparent unconformity

upon the "ash" marl of the Manasquan. The conformity, however, is only apparent, well-borings indicating that the Shark River, as this formation has been called, probably overlaps the Cretaceous. Clark¹ considers that it is not possible to correlate the Shark River marl with any other known Eocene deposits and regards them as probably older than the Eocene of Maryland. By some other authors, however, they have been placed above the Maryland Eocene.

MIOCENE SYSTEM.

Beds of known Miocene age are widely distributed in the coastal-plain portion of New Jersey, where they overlap the Eocene and many of the Cretaceous formations. At the north they rest on beds ranging from the Eocene to the Hornerstown marl, while in the southern portion outliers are found upon the Mount Laurel sand.

Kirkwood formation.—Under the term Kirkwood have been included all beds of demonstrable Miocene age which outcrop in New Jersey. These beds vary lithologically in different regions, but they are predominantly fine micaceous quartz sands often delicately banded in shades of salmon-pink and yellow. Black, lignitic clays occur in many localities at or near the base. In the southern portion (Salem and the adjoining portion of Cumberland County) a thick (80-90 feet) bed of chocolate or drab-colored clay occurs, above which there are (or were formerly) exposures of a fine clayey sand containing great numbers of shells (the Shiloh marl of many reports), which, in the localities where it occurs, forms the upper bed of the Kirkwood. The thickness is about 100 feet or more along the outcrop. On the basis of the abundant invertebrate fauna in the beds at Shiloh, the Kirkwood is believed to correspond in a general way with the Calvert formation of Maryland, the lowest division of the Chesapeake group.

Well-borings at Atlantic City, Wildwood and other points along the coast have demonstrated the presence there of a great thickness of Miocene strata not apparently represented in outcrop.

¹ Report of the State Geologist of New Jersey for 1893, p. 346.

At Atlantic City clays, sands and marls from 390 to 1,225 feet below tide carry Miocene fossils, and at Wildwood those from 300 feet to 1,090 feet and perhaps to 1,244 are Miocene. From the fossils it is evident that strata referable to the St. Marys, Choptank and Calvert horizons of the Chesapeake group are present.

Cohansey sand.—Overlying the Kirkwood at its outcrop is a formation composed chiefly of quartz sand, locally with laminae and lenses of light-colored clay and occasional lenses of gravel. This formation outcrops over a wider area of the coastal plain than any of those heretofore discussed. Obscure casts of molluscan shells have been found in it, but these are of no value in determining its age. Plant remains from near Bridgeton indicate a flora comparable with that of certain European upper Miocene localities. It dips southeastward 9 or 10 feet per mile, and overlies the Kirkwood with seeming unconformity.

Inasmuch as sands and clays similar to the Cohansey are revealed in borings along the coast and there overlie clays carrying Miocene fossils characteristic of the St. Marys, the highest division of the Chesapeake group, the Cohansey apparently belongs to a still later stage of the Miocene or perhaps even to the Pliocene. It is possible, however, that as now defined it may represent in part at least the shoreward phases of the fossiliferous Miocene clays found in the borings along the coast, and that it should be correlated with the Choptank and St. Marys of Maryland. In the light of all data at present available, however, the former view seems most probably the true one.

PLIOCENE SYSTEM.

Beacon Hill formation.—Under the term Beacon Hill there were described certain beds of gravel and sand occurring as outliers on the higher hills of Monmouth County. Later the sand beds were correlated with the great body of sand now included in the Cohansey formation, leaving only the gravel in the Beacon Hill formation. It is chiefly quartz, but contains much chert and some hard sandstone and quartzite. The chert pebbles are uniformly much decayed and are frequently very

soft. The quartz and quartzites are often more or less corroded. The formation occurs as isolated remnants on some of the highest hills of the coastal plain. It is perhaps to be correlated with the Lafayette formation farther south.

CORRELATION OF LOCALITIES FURNISHING FISH REMAINS.

The fossils described in this report so far as any definite localities are given were obtained from comparatively few points. The same names recur again and again. Long Branch, Deal, Poplar, Shark River, Farmingdale, Hornerstown, Crosswicks, Pemberton, Birmingham, Vincentown, Blackwoodstown, Barnsboro, Mullica Hill, Allowaystown, Shiloh, and Stow Creek are frequently mentioned. At some of these localities the geological formation can be identified with certainty, while at others several formations outcrop in the pits from which the specimens probably were obtained so that there is some element of doubt. The following paragraphs indicate the possibilities at each locality.

Long Branch.—The Hornerstown marl outcrops north of Long Branch and at an early day was dug at several points. South of that place it is covered by the Vincentown sand (Cook's yellow sand), but was reached in pits at a few localities. Specimens labelled Long Branch are assumed to come from the Hornerstown marl.

Deal and Poplar.—The numerous marl pits along Poplar Brook near Poplar and Deal are in the Manasquan marl—the green marl and ash marl of Cook's Upper Marl. South of Deal, however, near the head of the north arm of Deal Lake the Shark River (Eocene) marl is found. It seems to be safe to conclude that specimens from Poplar are to be regarded as from the Manasquan marl, while those from Deal may be either from the Manasquan marl or the Shark River marl with chances perhaps favoring the former since the pits in the Manasquan were more numerous than those in the Shark River.

Shark River.—Eocene beds—the Shark River marl—are exposed in pits along Shark River above the village of that name. Some of these pits penetrated also the Manasquan marl, while

locally a dark astringent clay of Miocene age overlies the Shark River marl. Under these circumstances there is some uncertainty as to the formations from which the fossils came. Inasmuch, however, as the Shark River marl was better exposed here than elsewhere in the State most of the species are probably referable to this horizon, unless there is specific evidence to the contrary.

Farmingdale and Squankum.—Immediately north of Farmingdale in a large pit along the railroad there is an extensive exposure of the Manasquan marl overlain by a dark clay of Miocene age. Southwest of the village along Manasquan River is a line of openings mostly in the Manasquan marl, overlain by Miocene or Pleistocene deposits, but, as stated by Cook, two of them in the "blue and ash marls," *i. e.*, the Shark River and upper part of the Manasquan marl. Whitfield¹ cites numerous Eocene invertebrate forms "in the upper layers of the Upper Green marls at Shark River, Farmingdale and Squankum, New Jersey," so that it seems to be well established that Eocene fossils have been collected from Farmingdale and Squankum, although the Manasquan marl is the one most commonly exposed. In this report specimens labelled simply "from Farmingdale," "from Squankum" are tentatively referred to the Manasquan marl, although it is recognized that they may be from the Shark River formation. In the case of others there is no doubt since their labels expressly state "from the Eocene marl at Farmingdale," etc. The Miocene clay also may have yielded some forms.

Hornerstown.—Of the specimens herein described from Hornerstown it is probably safe to refer them all to the Hornerstown marl bed (Cook's Middle Marl), since that layer was extensively opened for marl at various points near Hornerstown during the years when these collections were made. However, the Red Bank sand occurs along the creek west of the village beneath which at a slightly lower level the Navesink marl is found. It is possible, therefore, that some material was ob-

¹ Gasteropoda and Cephalopoda of the Raritan Clays and Greensand Marls of New Jersey. Geol. Survey of N. J., Paleontology, Vol. II; also U. S. G. S. Monographs XVIII, 1891.

tained from one or the other of the lower formations and not from the Hornerstown marl.

Crosswicks.—Some material has been reported from "Crosswicks." If it was obtained near the village of that name it is referable to either the Woodbury clay or the Merchantville clay, both of which formations occur near that place, the former being the better exposed. Neither of these is a marl, although the Merchantville is generally a marly clay. If, on the other hand, the locality should be Crosswicks Creek, the specimens may have come from any one of half a dozen horizons, as all the formations from the Merchantville to Vincentown are well exposed along the creek between Crosswicks and New Egypt. Since, however, the Navesink marl (Cook's Lower Marl) was the only one actively exploited in those days, the chances are that they came from it, if the locality reference is to the creek. In the suggested correlations it has been assumed that the specimens came from the village and they are referred to the Woodbury or Merchantville clays, but with more or less doubt.

Birmingham.—At Birmingham there are extensive marl pits formerly worked by the Pemberton Marl Company. A few miles northeast of this point the Red Bank sand which separates the Navesink from the Hornerstown marl, disappears and the two marl beds are combined. It is the combined bed which was so extensively worked at Birmingham, and the specimens are referred to the Navesink-Hornerstown marl.

Pemberton.—The village of Pemberton lies a scant two miles east of Birmingham. Many of the fossils whose locality is cited as Pemberton, unquestionably came from the pits of the Pemberton Marl Company, as is shown by the donor, J. C. Gaskill, who was superintendent of the pits, and they are, therefore, referable to the Navesink-Hornerstown marl. At Pemberton, itself, the Manasquan marl is exposed in the creek banks and was formerly dug at numerous points above the village. Hence some of the material labelled Pemberton may be from the Manasquan formation. The outcrop of Vincentown sand lies between Birmingham and Pemberton, so that the possibility of some material coming from this horizon must not be overlooked.

Vincentown.—Below Vincentown the limesand (Vincentown sand) and Navesink-Hornerstown marl are exposed in a line of pits extending for two miles or more down stream to Eayrestown. At Vincentown and upstream for a mile or more the Manasquan marl was formerly dug. It seems best to refer to the Manasquan the specimens credited to Vincentown except where their occurrence in the limesand beds is expressly stated.

Blackwoodstown.—South of Blackwood are old pits in the Navesink-Hornerstown marl, which is here overlaid by the Vincentown limesand and that in turn by the Kirkwood (Miocene) sand. Specimens from “the greensand at Blackwoodstown” are clearly from the combined Navesink-Hornerstown bed. Other specimens may be from the Vincentown or the Miocene.

Barnsboro.—There are no marl beds at Barnsboro, but in the valleys of several branches of Mantua creek from one to three miles east, south and west of the village, there are numerous exposures of the Navesink-Hornerstown marl and several old pits, once extensively worked. The material from “Barnsborough” probably came from these pits. The Vincentown limesand is found at some points in the vicinity and above that the Kirkwood sand, either of which horizons may have furnished some specimens.

Mullica Hill.—A prominent bluff within the village and just south of the creek at Mullica Hill has always been a favorite collecting ground. The conspicuous feature of the section is a “5-foot indurated shell bed, filled with fossils. The matrix in which the fossils are imbedded is sandy, with pea-like quartz pebbles, the whole colored dark green by a considerable percentage of glauconite. Above the shell bed is a nearly pure greensand marl, while beneath it there are exposed 20 feet or more of yellow or red quartz sand containing poorly preserved casts of *Belemnitella americana*, *Gryphæa* and *Neitheca*.” This sand is the Mount Laurel sand, while the shell bed and overlying glauconite bed represent the Navesink marl and perhaps a portion of the Hornerstown marl, which, in this portion of the State, are not separated by any intervening horizon. Since the fossils collected at this exposure probably came chiefly from the shell

bed and lower portion of the marl they are unquestionably to be referred to the Navesink, or to the Navesink-Hornerstown marl.

In marl pits along the creek a mile or more above the village the upper portion of the Navesink-Hornerstown bed is exposed and above it the Vincentown limesand. These localities may have yielded some of the material credited to Mullica Hill. The Kirkwood sand is now exposed in a small bank in the southern limits of the village and overlies the Vincentown sand at the marl pits, and while the writer has never noted any fossils in it, the possibility of some Miocene forms being found in this locality must not be wholly overlooked.

Alloway and Riddleton.—A number of specimens are credited to "Allowaystown." No greensand marl beds are known nearer to Alloway than two and one-half miles northwest along the headwaters of Swede's Run. Here there are old pits in the Manasquan marl. Since these exposures are only a mile west of Riddleton, the material credited to that place may have come from them, but there is less certainty regarding that credited to Alloway. In the vicinity of the latter place there are numerous exposures of a dark, tough clay, sometimes called the Alloway clay,¹ known to be of Miocene age and now included in the Kirkwood formation. Possibly the material "from Allowaystown" may be Miocene and from this clay.

Shiloh, Jerico, Stow Creek.—Miocene fossils have been found in great abundance in the marl pits along the headwaters of Stow Creek near Shiloh and Jerico in Cumberland County. These beds have often been called the Shiloh marl and the specimens credited to Shiloh, Jerico and Stow Creek all came without question from these pits. These pits lie four and one-half to five miles southeast of Alloway and perhaps the material labeled Allowaystown is also from them. The Shiloh marl is regarded as a part of the Kirkwood formation.

Greensand No. 5, of New Jersey.—Many of the specimens are referred by Cope to "Greensand No. 5, of New Jersey," "Greensand No. 4, of N. J.," etc. From the localities cited it has been possible to identify "No. 5" as the Hornerstown marl, but I

¹ Report on Clay, Vol. VI., Final Report Series Geol. Surv. of New Jersey, 1904.

have not been able to find any certain explanation of these designations.

Whitfield¹ in discussing the paleontological horizons of the marl beds of New Jersey, speaks of "seven distinct horizons, six of which may be classed as Cretaceous and one as Eocene," which "conform very closely, if not exactly, to certain stratigraphical lines, which were long since established by the State Geologist * * *." These were 1) The Raritan clays; 2) The Camden clays at Fish House, containing 12 species of Unionidae; 3) The micaceous clays at Crosswicks Creek below the Lower Marl bed; 4) the Lower Marl bed; 5) the Middle Marl bed; 6) the Cretaceous portion of the Upper Marl bed (Manasquan marl), and 7) the Eocene portion of the Upper Marl (the Shark River). Possibly it is some such correlation as this that Cope had in mind. If so, his "Greensand No. 2" must be relegated to the Pleistocene as it is now known that the *Unionidae* clays at Fish House are not Cretaceous but Pleistocene; Greensand No. 3 may include the Merchantville, Woodbury, Marshalltown clays and certain clayey layers in the Englishtown and Wenonah sands. Greensand No. 4 would correspond to the Navesink marl, but might also include certain phases of the Red Bank sand.

¹ Whitfield, loc. cit. p. 19, 20.

DESCRIPTION OF SPECIES.¹

 Class PISCES.

THE FISHES.

Cold-blooded aquatic vertebrates breathing by means of gills not purse-shaped, but attached to cartilaginous or bony gill-arches. Skull with lower jaw. Limbs developed as fins, rarely wanting. Body usually covered with scales, bony plates or horny appendages, sometimes naked. Median line of body with one or more fins composed of cartilaginous rays joined by membrane

(The *Leptocardii* (Lancelets) and *Cyclostomes* (Lampreys), usually to be considered with all fish-like vertebrate faunas, are not known from any undoubted fossil remains, and comprise but a small number of existing forms. The opinions of many writers vary as to the value of the different sub-classes embraced in the present class, though most all agree as to the status of the lancelets and lampreys. I accept five, as the *Elasmobranchii*, *Holocephali*, *Dipnoi*, *Crossopterygia* and the *Actinopteri*. At the present time only the *Elasmobranchii* and *Actinopteri* are represented by existing types within the limits of New Jersey, though it is probable that some *Holocephali* may yet be found off our shores in deep water. The *Elasmobranchii* and *Holocephali* are, however, very abundant among the remains in our Cretaceous beds, and the former represent about half the entire number of fossil fishes known from that formation.

Sub-Class ELASMOBRANCHII.

SHARK-LIKE FISHES.

Teeth distinct. Jaws distinct from skull, joined to it by suspensory bones. Gill-openings five to seven slits on each side of pharynx. Membrane bones of head undeveloped, except some-

¹ By Henry W. Fowler.

times rudimentary opercle. Skeleton cartilaginous. Skull without sutures, mandibular suspensorium present. No air-vessel. Intestine with a spiral valve. Arterial bulb with three series of valves. Optic nerves united by a chiasma. Cerebral hemispheres united. Gills not free, attached to skin by outer margin. Ova few and large, impregnated and sometimes developed internally. Embryo with deciduous external gills. Tail heterocercal. Ventral fins abdominal. Males with large intromittent organs or claspers attached to ventral fins. Skin naked or covered with minute rough scales, sometimes with spines.

An almost perfect gradation exists from the true sharks to the skates, though the notidanid sharks are somewhat removed from the former. The orders are the *Ichthyotomi*, *Notidani*, *Asterospondyli*, *Cyclospndyli*, *Rhinæ* and *Batoidei*. The first of these is entirely extinct, though no fossils have been found in New Jersey referable to this group.¹ All the others are represented by living forms, and possibly at least one of the *Notidani* may occur off our shores in deep water.

Order NOTIDANI.

THE NOTIDANOID SHARKS.

Vertebral column imperfectly segmented, each segment equivalent to 2 vertebræ and bearing 2 neural arches. Gill-openings 6 or 7. Dorsal fin 1. Anal present.

This order contains the most primitive of existing sharks. Families 2, recent and extinct.

Family HEXANCHIDÆ.

THE GRISETS.

Eyes anterior or submedian. No nictitating membrane. Teeth above, 1 or 2 pairs, awl-like, next 6 broader, and each with several cusps, 1 enlarged. Teeth below, 6 large comb-like

¹I may note that a tooth of *Petalodus*, reported by Leidy, in Proc. Acad. Nat. Sci. Phila., 1876, p. 9. is doubtfully ascribed to the New Jersey Cretaceous and is therefore not likely admissible to that fauna.

laterally, besides small posterior. Gill slits 6 or 7. Spiracle small. Dorsal 1, no spine, opposite and like anal. No caudal pit. Viviparous.

Living species in warm seas, some reaching a very large size. Genera 2 or 3.

Genus HEPTRANCHIAS Rafinesque.

Heptanchias Rafinesque, Car. Nuov. An. Sicil., 1810, p. 13. Type *Squalus cinereus* Gmelin, monotypic.

Heptanchus, *Heptancus*, auct.

Aellopos Agassiz, Poiss. Foss., III, 1843, p. 376. Type *Aellopos wagneri* Agassiz, first species.

Notorynchus Ayres, Proc. Cal. Acad. Sci., I, 1856, p. 72. Type *Notorynchus maculatus* Ayres, monotypic.

Notorhynchus, auct.

Differs from *Hexanchus* in the presence of seven gill-openings. The fossils referred to this genus are only known from detached teeth. About 11 living, and about 33 extinct species have been described, mostly under the generic name *Notidanus*, which is properly a synonym of the earlier *Hexanchus*.

HEPTRANCHIAS PRIMIGENIUS (Agassiz).

Notidanus primigenius Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362 (Cumberland Co., Miocene).

Lateral teeth wide, thin, and greatly compressed. Coronal region wide, polycuspid, faces similarly convex, smooth and compressed. Cutting-edges entire. Anterior cusp enlarged, well inclined externally, and followed by 6 or 7 similar ones graduated to last, latter quite small. Preceding largest cusp 6 to 10 anterior small graduated cusps, graduated down, first scarcely larger than penultimate or last of external cusps. Graduation of these cusps also slight, as all small. Apices of all cusps compressed, not twisted. Root compressed, rather thin, outer face flattened and inner bulging a little convexly. Lower margin entire or slightly convex. In transverse section root somewhat cuneate. Height of largest example 20 mm.

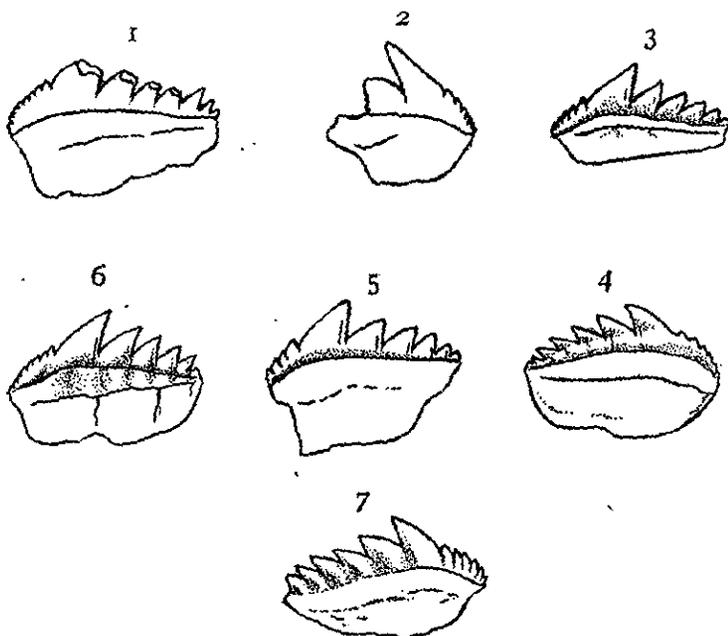


FIG. 1.—*Heptanclias primigenius* (Agassiz). 1-2, Allowaystown (Yarrow); 3-7, Charles Co., Md. (Thomas).

All of my examples agree largely with Agassiz's figures 16 and 17¹. Eastman considers *H. plectrodon* Cope identical².

Formation and locality. This species was originally found in the State in Cumberland County, in Miocene beds. Known only from detached teeth. My examples are 4 teeth from Monmouth County (W. Cleburne) without formation, though possibly Eocene; 2 teeth from the Miocene [Eocene? K], of Shark River in Monmouth County (T. A. Conrad); and 3 teeth from Allowaystown, Salem County (H. C. Yarrow), without formation.

Genus XIPHODOLAMIA Leidy.

Xiphodolamia Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 252.

Type *Xiphodolamia ensis* Leidy, monotypic.

Xiphodontolamia Leidy, l. c., nom. orig.

¹ Poiss. Foss., III, 1843, p. 218, Pl. 27, figs. 6-8, 13-17, (4-5 doubtful).

² Md. Geol. Surv. Miocene, 1904, p. 78.

Teeth awl-shaped, rather sigmoid, without any basal cusps, roots unequal or nearly equal and approximated.

Originally this genus was thought to be of uncertain relation. Woodward has suggested its relation with *Heptranchias*, pointing out that the teeth are apparently referable to the symphysis of the upper jaw of that genus¹. Provisionally, at least, I retain it as distinct.

XIPHODOLAMIA ENSIS Leidy.

Xiphodolamia ensis Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 252, Pl. 34, figs. 25-30. Vincentown, Monmouth County, Burlington County, Allowaystown, N. J.

Teeth slender, compressed laterally. Crown smooth, usually sigmoid, sabre-like in form, front edge sharp and hind border obtuse. Outer surface flat, inner convex. Cutting-edge entire. Apex erect, slender, sharp-pointed. No cusps. Root with both sides apparently approximated, so that ends are directed obliquely and parallel, and these sometimes nearly equal. Outer

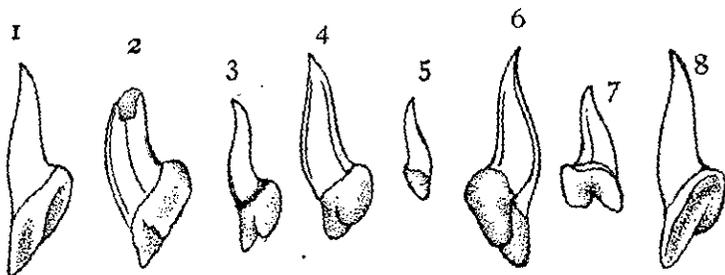


FIG. 2.—*Xiphodolamia ensis* Leidy. 1, Allowaystown (Yarrow); 2-5, Monmouth Co. (Knieskern); 6, Burlington Co. (Abbott); 7-8, Vincentown (Bryan).

surface depressed or concave, and inner bulging convexly, though inferiorly, inner surface also slopes down flattened. Length 28 mm.

This species is known only from the above described paratypes.

Formation and locality. I have examined Leidy's paratypes, doubtfully ascribed to the Cretaceous? of New Jersey. They

¹ Cat. Foss. F. Brit. Mus., I, 1899, p. 168.

are 4 teeth from Monmouth County (P. D. Knieskern); 4 from Vincentown [The Manasquan marl, K.] in Burlington County (T. M. Bryan); 1 from Burlington County (C. C. Abbott); 1 from Allowaystown, in Salem County (H. C. Yarrow). Originally there were 12 specimens in the Bryan collection, but I have only examined 4.

Order ASTEROSPONDYLI.

THE TYPICAL SHARKS.

Vertebral column well segmented, each segment forming a neural arch and one centrum. Vertebrae each with internal calcareous lamellæ radiating from central ring. Gill-openings 5. Dorsal fins 2. Anal fin present.

This order includes the greater number of living sharks.

Sub-Order PROARTHRI.

THE CESTRACIONT SHARKS.

Gill-openings 5, always lateral. Palato-quadrate apparatus articulated to preorbital part of skull. Dorsal fins 2, well developed, each with a large spine.

Usually three families are embraced in this group, all represented by fossil forms, and only one, the *Heterodontidae*, is found living, with a few species in the Indo-Pacific.

Family HETERODONTIDÆ.

THE BULL-HEAD SHARKS.

Body robust in front. Head high, thick. Mouth small, narrow, 7 upper lip lobes and fold on lower lip. Teeth alike in jaws, small and obtuse in front, large and molar behind. Nostrils confluent with mouth. Gills 5. Spiracles small. Two dorsals, strong spine on each. Caudal tip notched usually. Oviparous, egg-cases spiral.

Genera 15, all represented by extinct forms with *Heterodontus* still existing.

Genus ACRODUS Buckland.

Acrodus Buckland, Geol. Mineral, Ed. 2, II, 1837, p. 47. Type *Acrodus nobilis* Buckland, monotypic.

Thectodus Meyer and Plieninger, Beitr. Pal. Württemb., 1844, p. 116. Type *Thectodus crenatus* Meyer and Plieninger, first species.

Teeth conic, non-cuspidate, crown mostly striated, with one principal elevation, and one or more lateral prominences in either side diminishing outwards. Root much or moderately depressed. Symphyseal teeth few, relatively large. Notochord persistent. Two large hooked-shaped semi-barbed dermal spines immediately after each eye. Shagreen sparse, consisting of small, conical, radiately-grooved tubercles, sometimes fused into groups of three. Dorsal fin-spines longitudinally ridged and grooved, ridges not denticulated, and two posterior longitudinal series of denticles, not marginal, but placed together mesially. Anterior dorsal spine longer and more slender than posterior.

This genus is closely related to *Hybodus* Agassiz, and differs only in the rounded and non-cuspidate character of its teeth. The dorsal fin-spines are also scarcely to be distinguished from those assigned to the same, their determination being based on their association and stratigraphical order. Altogether, possibly 55 species may be referred to this genus.

ACRODUS HUMILIS Leidy.

Acrodus humilis Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 163. Limestone from New Jersey cretaceous.

Leidy, Rep. Geol. Surv. Terr. Hayden, 1873, pp. 300, 352, Pl. 37, fig. 5 (type).

Tooth depressed. Crown smooth, evenly convex over its entire upper surface, greatest width not quite one-third its length, ends rather angular, and long edges broadly projecting over narrow base, with under surfaces nearly level or but slightly inclined. Upper surface of crown, though with smooth aspect, shows reticulations, which, though rather coarse along median axis soon become smaller, and along edges are very minute. Base width about one-half that of crown, with ridge anteriorly and groove

posteriorly along longitudinal surfaces, former not very high and latter shallow. Lower surface of base flat. Length (width) 16 mm.

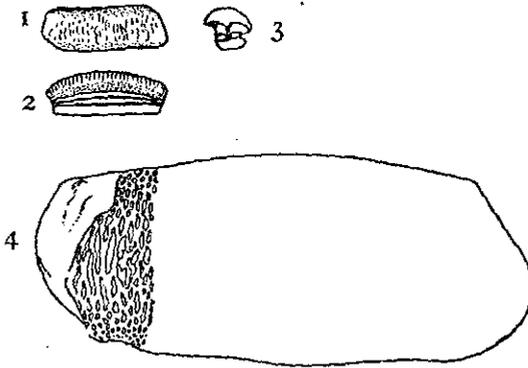


FIG. 3.—*Acrodus humilis* Leidy. (Type.) 1, upper view; 2, lateral view; 3, end view; 4, enlarged 4x.

Formation and locality. I have examined only the above example, the type ascribed to the "limestone from the New Jersey cretaceous," from Vincentown, in Burlington County [The Vincentown formation, K].

Sub-Order GALEI.

THE TRUE SHARKS.

Gill-openings 5, always lateral. Palato-quadrates apparatus not articulated with skull. Dorsal fins 2, well developed, each without spine.

This group contains the greater number of existing and fossil families of sharks.

Family GINGLYMOSTOMIDÆ.

THE NURSE SHARKS.

Eyes very small. Upper and lower lips developed, latter not extending across symphysis. Nasal and buccal cavities confluent. Nasal valves at both sides form one quadrangular flap before mouth, and each provided with a free cylindrical cirrus. Spiracle

minute behind eye. First dorsal above or after ventral, second opposite and somewhat before anal. Tail most abruptly bent up at base.

Large sharks of warm seas, referred to two genera.

Genus GINGLYMOSTOMA Müller and Henle.

Ginglymostoma Müller and Henle, Arch. Naturg., 1837, p. 396. (No species given.) Type *Squalus cirratus* Gmelin, virtually designated by Bonaparte, Nuov. An. Soc. Nat. Bologna, II, 1838, p. 212.

Plicodus Winkler, Arch. Mus. Teyler, III, 1874, p. 301. Type *Plicodus thielensis* Winkler, monotypic.

Acrodobatis Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 250. Type *Acrodobatis serra* Leidy, first species, designated by Hay, Bull. U. S. Geol. Surv., No. 179, 1902, p. 310.

Acrodontobatis Leidy, l. c., nom. orig.

Many series of teeth in jaws, each with a strong median cusp and one or two small basal cusps each side. Second dorsal nearly opposite anal. Tail about one-half rest of body.

About seven extinct and two existing species are known.

GINGLYMOSTOMA OBLIQUUM (Leidy).

Acrodobatis obliquum Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 250, Pl. 34, fig. 14. *Marl of Monmouth Co., N. J.*

Crown wider than high and base extended downward at middle in a rounded prominence, and backward posteriorly in a similar prominence. Summit arises in a tapering point, and lateral acute borders show seven denticles successively decreasing in size. Outer side presents two larger denticles succeeded by



FIG. 4.—*Ginglymostoma obliquum* (Leidy). (From Leidy.)

four minute ones. Inner acute border of crown long, convex in its course from base of main point. Length 7 mm. (From Leidy.)

About three existing and 39 fossil species have been referred to this genus.

ISURUS DESORII (Agassiz).

Oxyrhina minutus (nec Agassiz) Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Anterior teeth narrow, robust, much elevated and thick. Crown slightly curved inwards towards apex. Outer coronal surface more or less flattened, and inner well convex. Apex scarcely deflected. Cutting-edges entire. No basal cusps. Root thick, concave or flattened on outer surface, inner face with large, pronounced, bulging or convex surface, and each end a long divergent branch, often unequal and acute. Lateral teeth more compressed, root shorter and with more diverging ends, crown narrow, apex scarcely deflected, and usually entire cutting-edges gradually divergent to ends of base. Length varies to 54 mm.

According to Woodward this species differs from the existing *Isurus oxyrinchus* only in the less curvature of the lateral teeth. From worn and fragmentary examples of *Lamna elegans*, in which the inner coronal striæ seem to be obliterated, I cannot distinguish some material positively. Frequently the teeth of *Isurus* are more or less depressed basally on their inner surfaces. It is also almost impossible to distinguish the teeth of *Lamna cuspidata*, and no doubt a number of the teeth of the present species may be listed under that name. This form is known only from the detached teeth.

Formation and locality. A number of examples in the collections of the Academy from the Cretaceous marls, all without beds indicated, are: 1 tooth from "New Jersey" (E. D. Cope), 2 teeth from Deal [probably from Manasquan marl, K.] (Breed), 1 from Monmouth County (C. C. Abbott) and 8 more from the same region (W. Cleburne), 3 from Burlington County (T. A. Conrad), 5 from Vincentown [Manasquan marl or Vincentown limesand, K.] (T. M. Bryan), 2 from 5 miles from Mullica Hill (Abbott) and 1 from the latter locality [Navesink-Hornerstown marl, K.] (J. Da Costa) and 7 from Allowaystown in Salem County (H. C. Yarrow).

Though Leidy expressly states that the type of this species, a tooth only $\frac{1}{4}$ of an inch long, was presented to the Academy of Natural Sciences of Philadelphia by Dr. Knieskern, I have not located it among the collections. Leidy points out that it differs from *Ginglymostoma serra* in having the main point of the crown inclined to one side.

Formation and locality. Known only from the Eocene of New Jersey.

Family LAMNIDÆ.

THE MACKEREL SHARKS.

Body stout. Mouth wide. Teeth large, sharp. Gill-openings wide, all before pectorals, entirely lateral, not extending under throat. Spiracles minute or absent. First dorsal large. Second dorsal and anal very small. Tail slender. Caudal lunate, both lobes not very unequal and upper strongly bent upward. Caudal peduncle with strong lateral keel on each side. Pit at caudal root. Pectorals large. Ventrals moderate.

Large, fierce sharks in all seas, referred to eight or nine genera, of which three still persist to the present time. The muscular system and dentition reaches its greatest degree of specialization known among sharks in this family.

Genus ISURUS Rafinesque.

Isurus Rafinesque, Car. Nuov. Gen. Sicil., 1810, p. 11. Type *Isurus oxyrinchus* Rafinesque, monotypic.

Oxyrhina Agassiz, Poiss. Foss., III, 1836, pp. 87, 276. Type *Lamna oxyrhina* Valenciennes, monotypic.

Oxyrrhina, auct.

Isuroopsis Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, pp. 398, 408. Type *Oxyrhina glauca* Müller and Henle, designated.

Anotodus LeHon, Prél. Mém. Poiss. Tert. Belg., 1871, p. 8. Type *Anatodus agassizii* LeHon, monotypic.

Body mackerel or tunny-like, caudal peduncle slender. Snout rather long, pointed. Teeth long, lanceolate, cutting-edges sharp and entire, and no basal cusps. First dorsal large, entirely behind pectoral, or nearly midway between latter and ventral. Second dorsal and anal very small. Pectoral large.

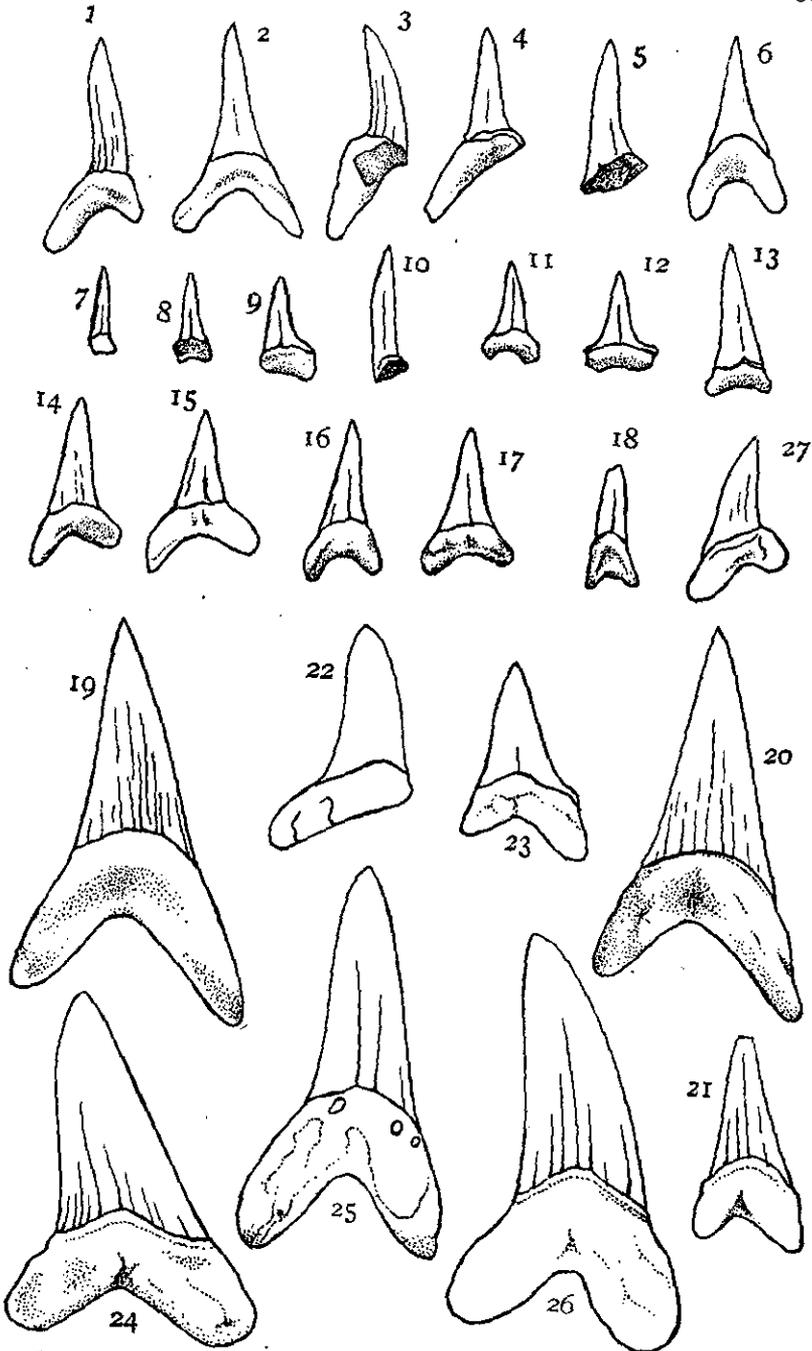


FIG. 5.—*Isurus desorii* (Agassiz). 1-22, Charles Co., Md. (Thomas); 22, Monmouth Co. (Cleburne); 23, Vincentown (Bryan); 24, Mullica Hill (Abbott); 25-26, Mullica Hill (Da Costa); 27, Charles Co., Md. (Thomas).

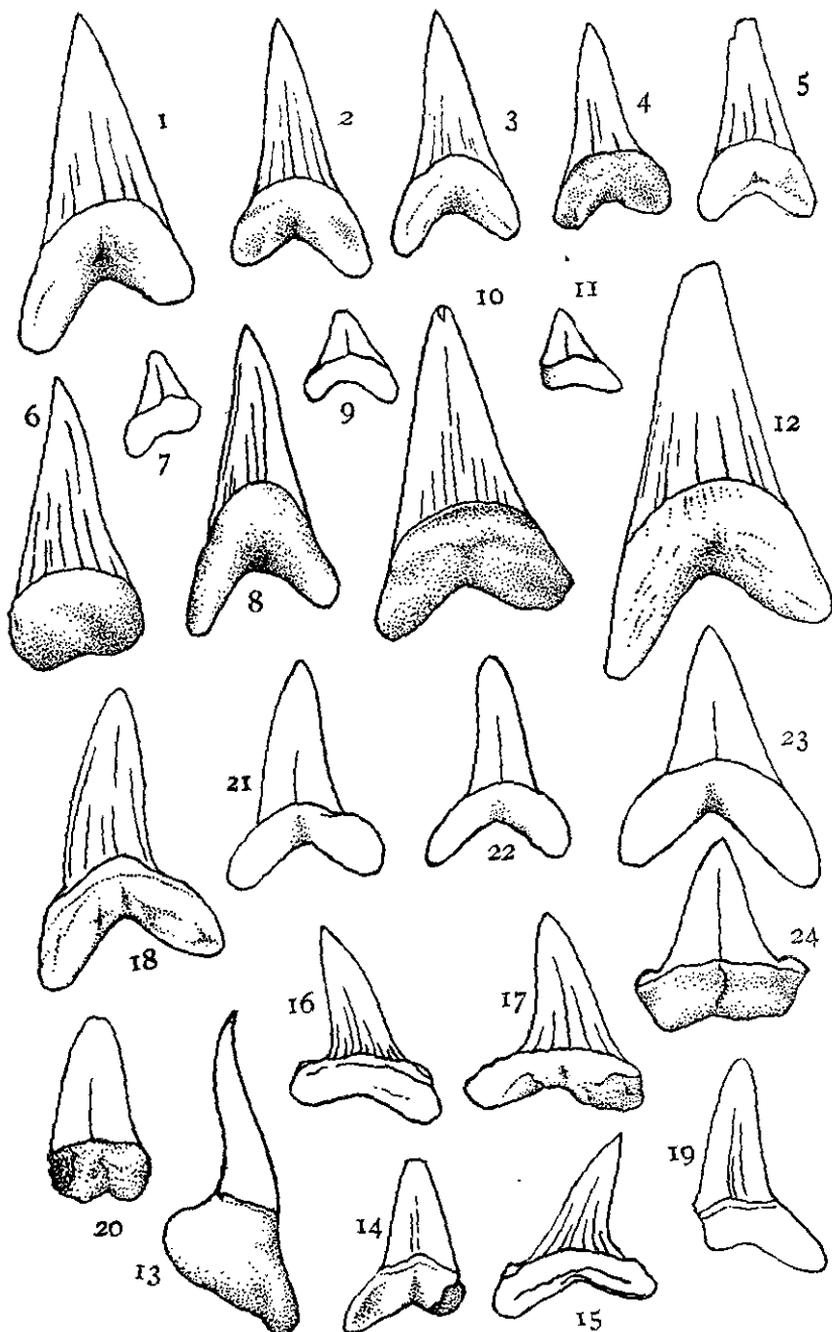


FIG. 6.—*Isurus desorii* (Agassiz). 1-13, Charles Co., Md. (Thomas); 14, Deal (Breed); 15-17, Monmouth Co. (Knieskern); 18-19, Monmouth Co. (Abbott); 20-24, Vincentown (Bryan).

Abbott's Monmouth County example is more compressed at the crown than the other examples. It also has flaring trenchant edges, and its inner face basally is swollen. His Mullica Hill examples agree largely with Da Costa's, which, in turn, differ from Maryland Miocene examples¹ in the slightly deflected crown, the latter more convex on its inner surface.

The present species does not seem to have been recorded previously from New Jersey, except if confused with *Isurus minutus*, as contended by Eastman.

In the Geological Survey collection I have examined 2 teeth without data, and 34 from Shiloh in Cumberland County (E. Davis) [from the so-called Shiloh marl of the Kirkwood (Miocene) formation, K.], probably belonging to this species.

ISURUS HASTALIS (Agassiz).

Oxyrhina xiphodon Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362 (Cumberland Co. Miocene).

Anterior teeth broad, thin, compressed, widely triangular. Crown slightly curved outward towards apex. Outer coronal surface flat or slightly concave, rarely with basal vertical wrinkles, and inner surface moderately and evenly convex. Apex usually deflected a little laterally. Cutting-edges entire. Sometimes an obsolete broad short convex basal cusp at one or each side of base. Root short, with usually blunt obtuse edges, outer surface flattened or slightly concave, inner surface moderately convex, and lower profile a little emarginated. Lateral teeth with coronal edges gradually curving to ends of base, and apex often slightly deflected externally. Length reaches 47 mm.

This species is known only from its detached teeth, usually to be identified by their broad and thin appearance. Woodward says it is almost impossible to distinguish many of the posterolateral teeth from those of *Isurus desorii* and the existing *Isurus oxyrinchus*. He suggests *Otodus apiculatus* Agassiz, with a rudimentary lateral denticle as a synonym. The present species does not seem to be very numerous among New Jersey fossils.

¹ *Oxyrhina desorii* Cope, Proc. Acad. Nat. Sci. Phila., 1867, p. 142.

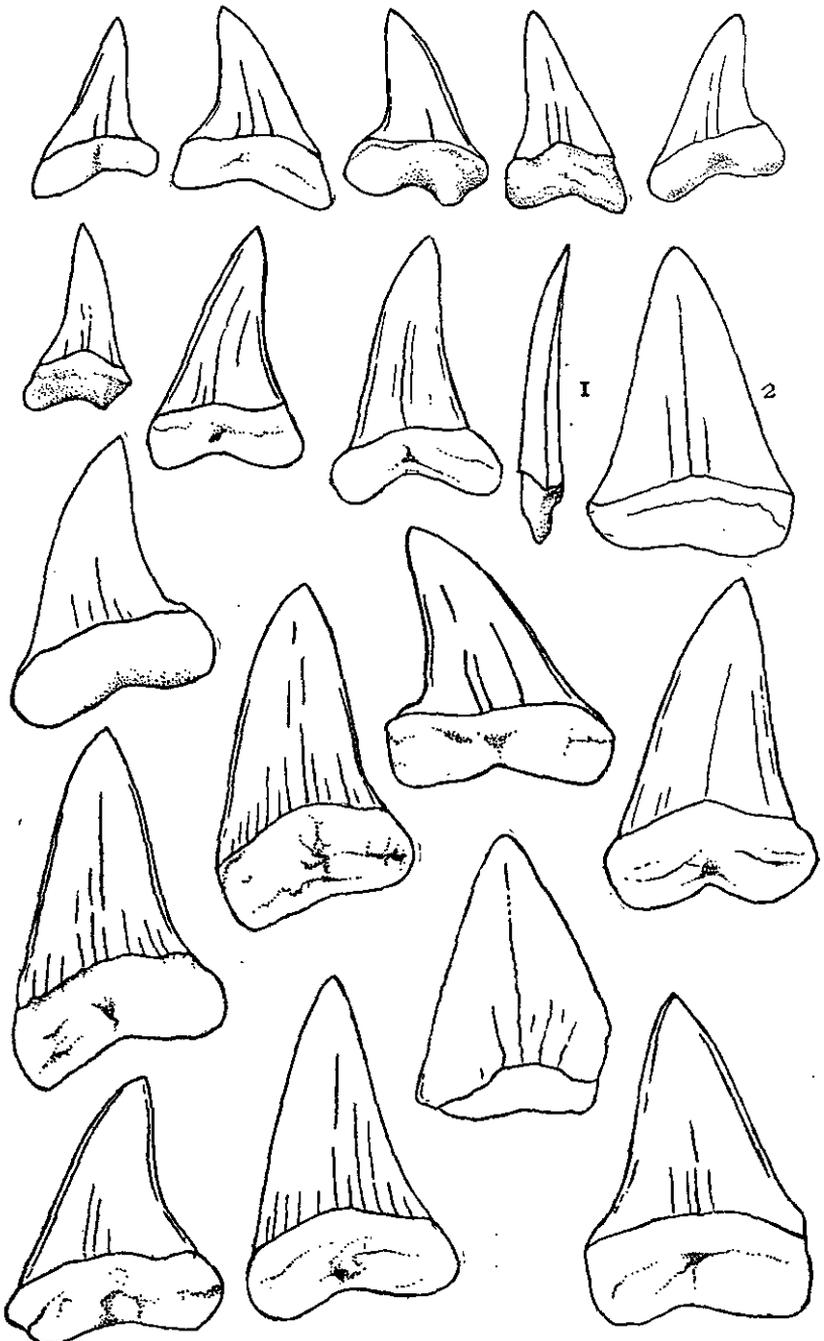


FIG. 7.—*Isurus hastalis* (Agassiz). 1-2, Vincentown (Bryan), and others from Charles Co., Md. (Thomas).

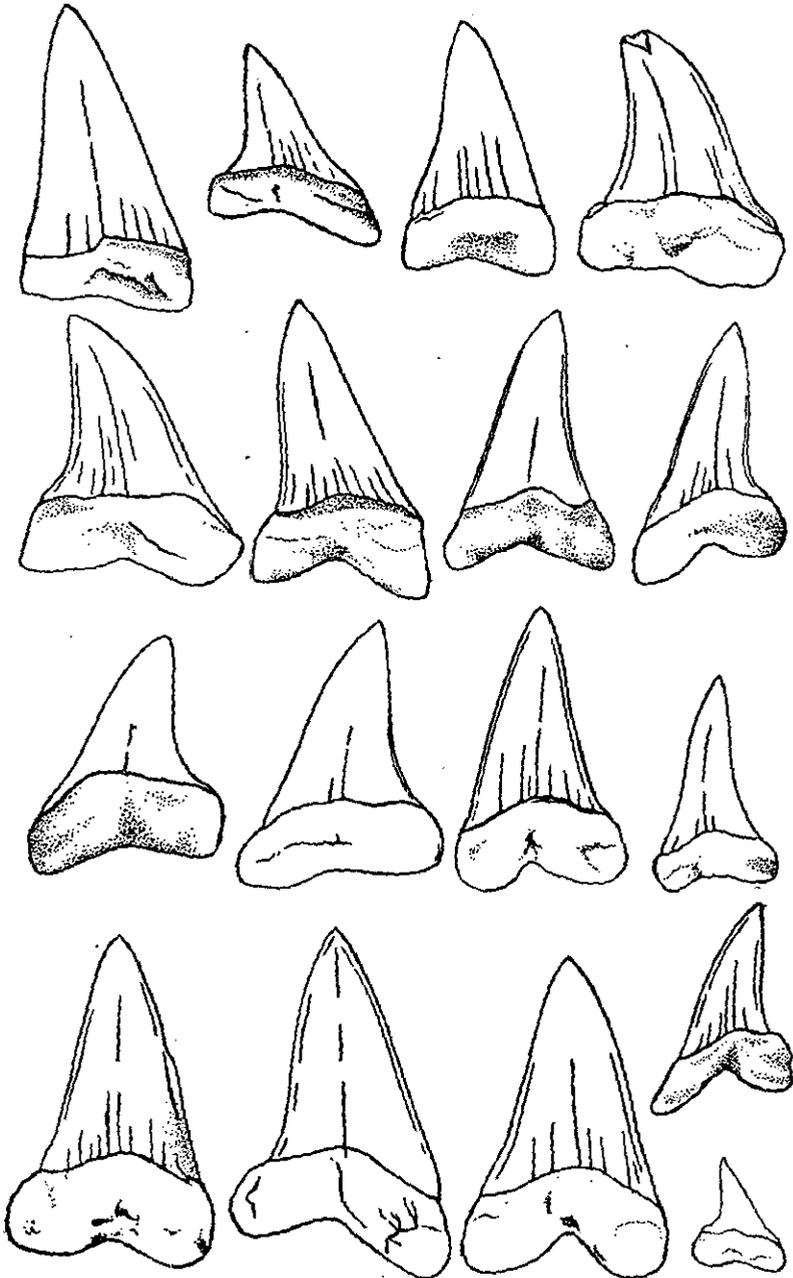


FIG. 8.—*Isurus hastalis* (Agassiz). Charles Co., Md. (Thomas).

Formation and locality. I have 7 teeth from the marls [Manasquan formation, K.] at Vincentown (T. M. Bryan), also 2 from Delaware (P. Uhler).

ISURUS ACUMINATUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 11. *New Jersey.*

Lamma acuminata (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on preceding).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 4. *No locality.*

Lamma mantelli (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on preceding).

Teeth moderately robust, compressed, and vary from widely angular to acuminate. Crown slightly curved out toward apex. Outer coronal surface mostly flattened, sometimes a few vertical basal wrinkles, and inner surface moderately and evenly convex. Apex usually deflected slightly to one side. Cutting-edges entire. Sometimes a low, obsolete, broad, basal cusp at one or each side of base, variable. Root short, with usually obtuse edges, outer surface flattened or concave, inner surface moderately convex, and lower profile a little emarginated. Anterior teeth comparatively wide, with only a gentle curved crown, and lateral teeth with root much broader than crown, thus forming a sudden basal expansion behind and often anteriorly. Length reaches 40 mm.

Known only from detached teeth. Although this species is usually known by the specific name *mantelli*, Agassiz's name *acuminata* occurs first on the same page in Morton's work. Morton's figure is rather incomplete, though it shows a basal cusp. His figure of *mantelli*, though also crude, represents a much larger tooth, and is probably the same as the one Agassiz publishes later.

Formation and locality. The following examples appear to belong to this species, most all evidently from the Cretaceous marls. They are: 5 imperfect teeth from "New Jersey" (C. C. Abbott), 2 from the same (Burt), 10 from Monmouth County (W. Cleburne), 1 from the same without donor, 1 from the same (P. D. Knieskern), 5 from the Miocene formation of

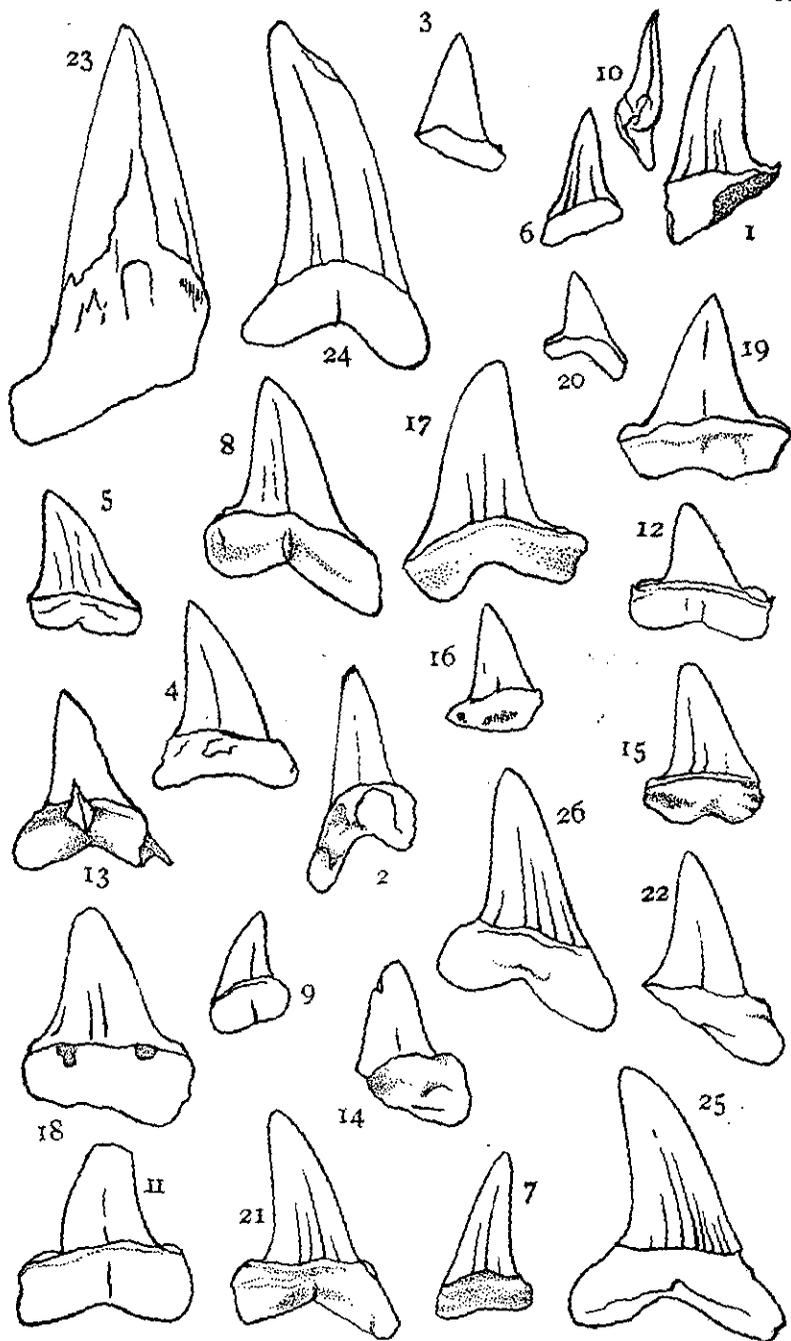


FIG. 9.—*Isurus acuminatus* (Morton). 1-2, New Jersey (Abbott); 3, Deal; 4-6, Shark River (Conrad); 7, Long Branch; 8-16, Monmouth Co. (Cleburne); 17, Monmouth Co. (Breed); 18-19, Vincentown (Bryan); 20, Burlington Co. (Conrad); 21-21, Mullica Hill (Abbott); 25-26, Allowaytown (Yarrow).

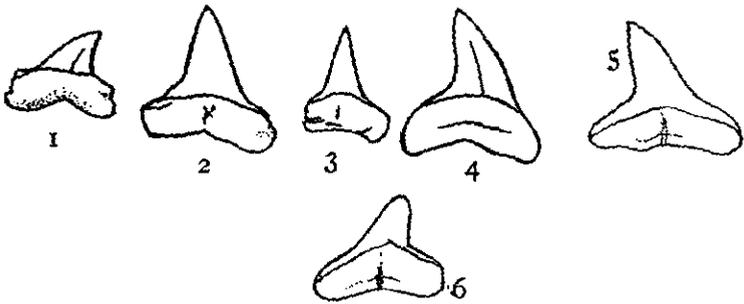


FIG. 10.—*Isurus acuminatus* (Morton). 1, Burlington Co. (Conrad); 2, Monmouth Co. (Knieskern); 3, Bridgeton (H. B. Abbott); 4, Burlington Co. (Conrad); *5-6, Vincentown (Dick).

Shark River (T. A. Conrad), 1 from Deal [Manasquan or Shark River formations, probably the former, K.] and 3 from Long Branch [Hornerstown ? K.], all without donor, 2 from Burlington County (T. A. Conrad), 2 from Vincentown [Manasquan formation, K.] (T. A. Bryan), 2 from Mullica Hill [Navesink marl ? K.] in Gloucester County (C. C. Abbott), 2 from Allowaystown in Salem County (H. C. Yarrow), and 1 from the Miocene of Cumberland County along the "Bridgeton Pike" (C. C. Abbott).

ISURUS SILLIMANII (Gibbes).

Oxyrhina minutus (nec Agassiz) Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Teeth moderately compressed, rather thin, and formed as a moderate isocetes triangle. Crown variably curved slightly outward, or inwards toward apex. Outer coronal surface flattened or slightly convex, inner surface flattened or slightly convex, and latter without basal vertical folds. Apex deflected, sometimes strongly so, to one side. Cutting-edges entire. Usually at base on either or each side one or two obsolete broad cusps, low, and their edges also entire. Roots short or moderate, outer surface flattened or slightly concave, inner surface bulging in prominent convexity, and lower profile forming a moderate emarginate blunt angle. Ends of roots deep, though not produced. Reaches a length of 34 mm. This description from 24 examples from the Calvert formation of Charles County, Md., in the Miocene.

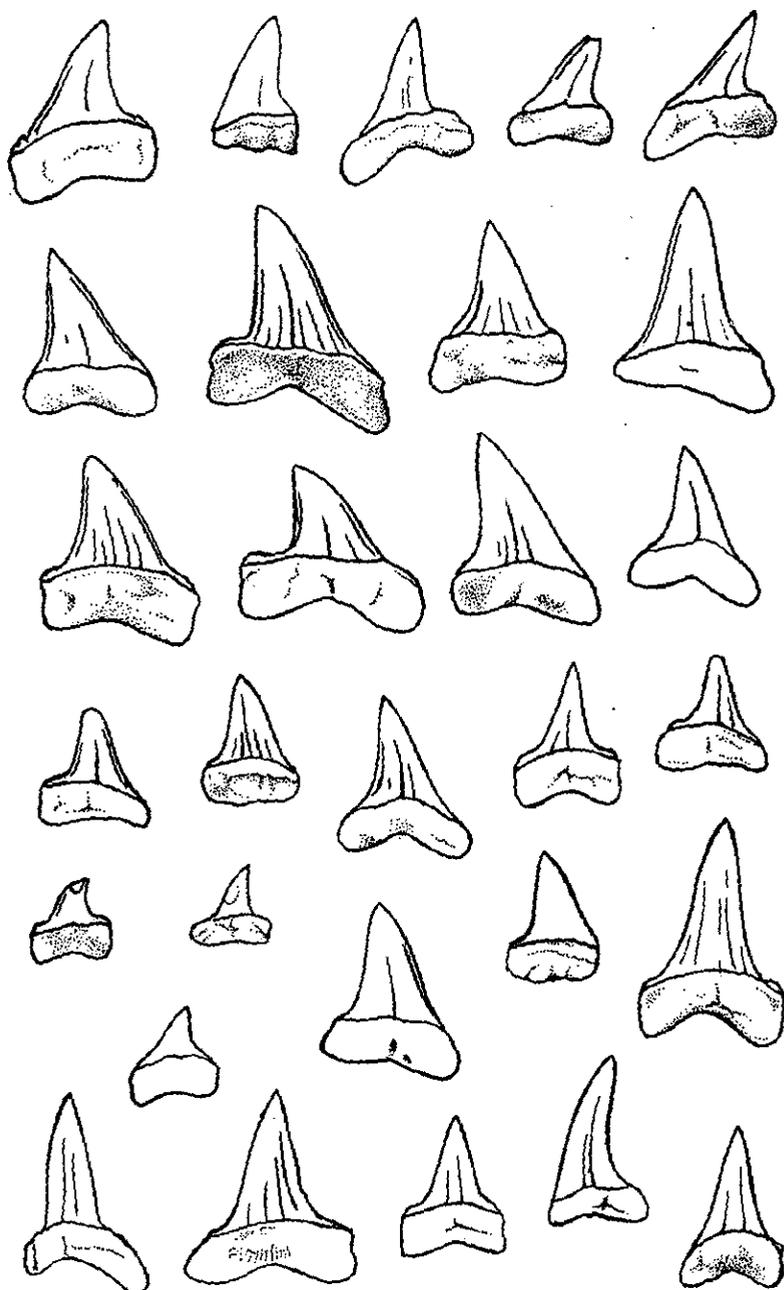


FIG. 11.—*Isurus sillimanii* (Gibbes). Charles Co., Md. (Thomas).

I have included this species entirely on the authority of Dr. Eastman,¹ who says that Cope partly, at least, determined apparently young examples of the present species as *Oxyrhina minutus*. The former also states that Cope's determination is further practically incorrect, and that some are *Isurus desorii* and others *Eulamia*.

Formation and locality. Cope's material was from the Miocene of Cumberland County.

ISURUS SP.

Oxyrhina sp. Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 296. (Greensand No. 4.)

A species with flat but narrower crown than the last [*Oxyrhina extenta* Leidy], and with perfectly smooth cementum, the base of the latter being serrulate in the convex side of the crown. No denticles. Crown with a lateral curvature. (From Cope.)

Formation and locality. Common in the "greensand, No. 4, New Jersey," according to Cope, though I have no examples.

ISURUS SP.

Oxyrhina sp. Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 296. (Greensand No. 4.)

With crown flatter and broader than the last; frequently oblique, but not curved, and not infrequently with lateral denticles. Cementum smooth, except a short distance from the base on the convex side striate-grooved. (From Cope.)

Formation and locality. Common in the "greensand, No. 4, New Jersey," according to Cope. It seems possible this may belong with *Lamna elegans*, representing its short posterior teeth.

Genus LAMNA Cuvier.

Lamna Cuvier, Regne Animal, II, 1817, p. 126. Type *Squalus cornubicus* Gmelin, restricted by Gill, Ann. Lyc. N. Hist. N. Y., VIII, 1861, p. 32.

Lamia Risso, H. N. Eur. Merid., III, 1826, p. 123. Type *Squalus cornubicus* Gmelin, monotype. (Preoccupied in insects.)

Selanonius Fleming, Brit. An., 1828, p. 169. Type *Squalus selanoneus* Walker, monotype.

¹ Md. Geol. Surv. Miocene, 1904, p. 81.

Body short, stout, back somewhat elevated. Snout prominent, pointed. Teeth triangular, pointed, entire, each with one small basal cusp on each side, though cusps sometimes obsolete on some teeth in young. Gill-openings wide. First dorsal and pectoral fins somewhat falcate, former close behind pectoral bases. Second dorsal and anal very small, nearly opposite one another.

Large fierce sharks in most cool seas, to which three existing species and about 34 extinct have been referred.

LAMNA CUSPIDATA Agassiz.

Lamna cuspidata Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 166. (Probably New Jersey Cretaceous.)

Cope, Proc. Am. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Lamna denticulata Cope l. c. (Cumberland Co. Miocene.)

Anterior teeth usually long, slender, compressed and moderately triangular, scarcely sigmoid in character. Crown usually slender, subulate, erect or sometimes diverging outwards. Outer coronal surface flattened or but slightly convex, smooth. Inner coronal face usually well convex, sometimes little flattened medianly, and entirely smooth. Apex erect or variously deflected. Cutting-edges prominent, entire. Usually one, sometimes two, small acute basal cusps on one or each side. Root large, outer face concavely depressed, and inner convexly bulging till very pronounced, the convexity usually with more or less complete sulcus. Branches of root usually long, moderately divergent, and angle between branches usually well marked. Lateral teeth broader, shorter, especially crowns, which are often well deflected, wider angle between branches of base and basal cusps varying quite broad. Length reaches 43 mm.

This is a very common fossil in the New Jersey marls and I have examined many teeth. This species is known only from detached teeth, scarcely distinguishable in many instances from those of *Isurus acuminatus*. The teeth may also be confused with those of other related sharks, though they do not appear to reach quite so large a size as the well-marked *Lamna elegans*. From *Isurus desorii* it may often be distinguished by the pres-

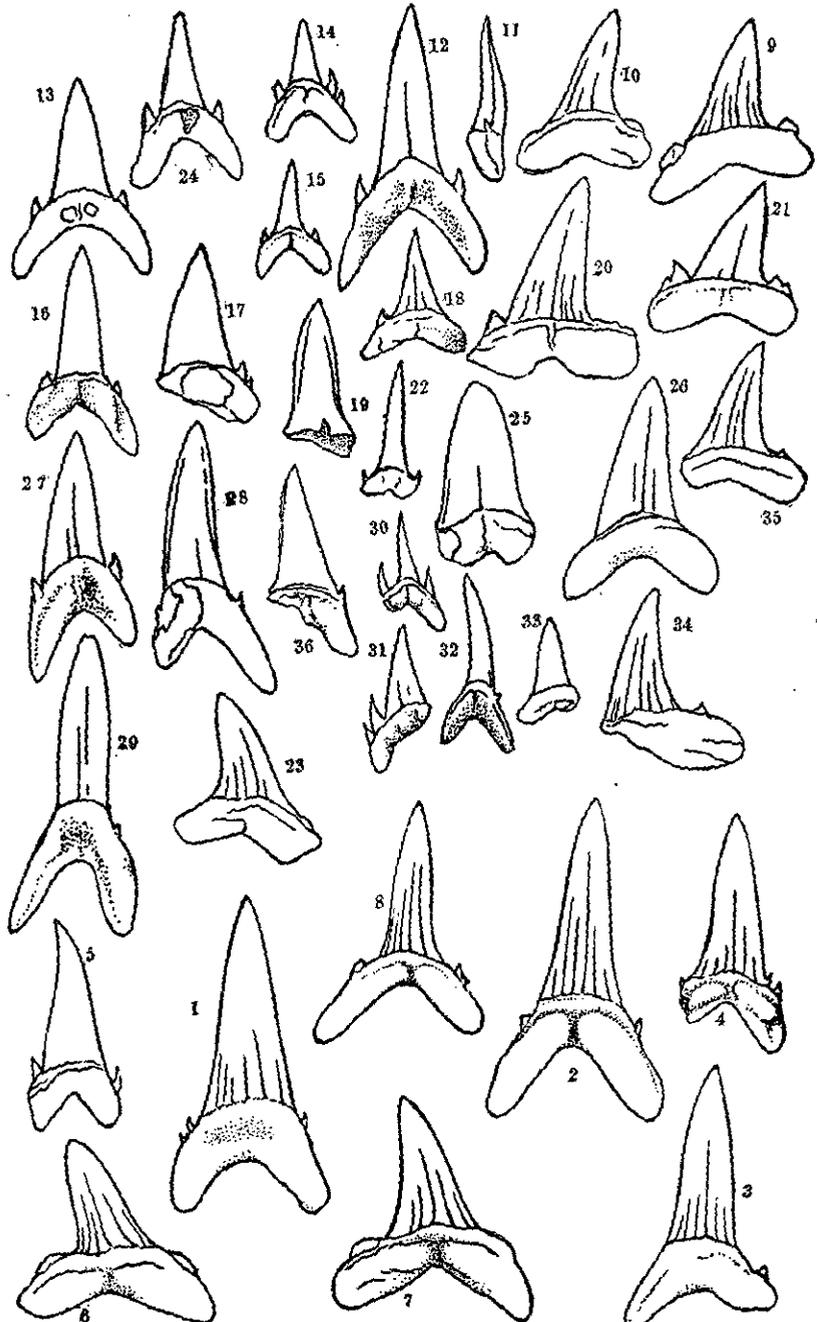


FIG. 12.—*Lamna cuspidata* Agassiz. 1, Farmingdale (Pilsbry); 2-3, Pemberton (Budd); 4, Monmouth Co. (Knieskern); 5, Vincentown (Bryan); 6-7, Burlington Co. (Conrad); 8, Monmouth Co. (Knieskern); 9-13, Burlington Co. (Budd); 14-15, Burlington Co. (Conrad); 16-21, Pemberton (Budd); 22-23, Allowaystown (Yarrow); 24-35, Vincentown (Bryan); *36, Shark R. (A. Shafter).

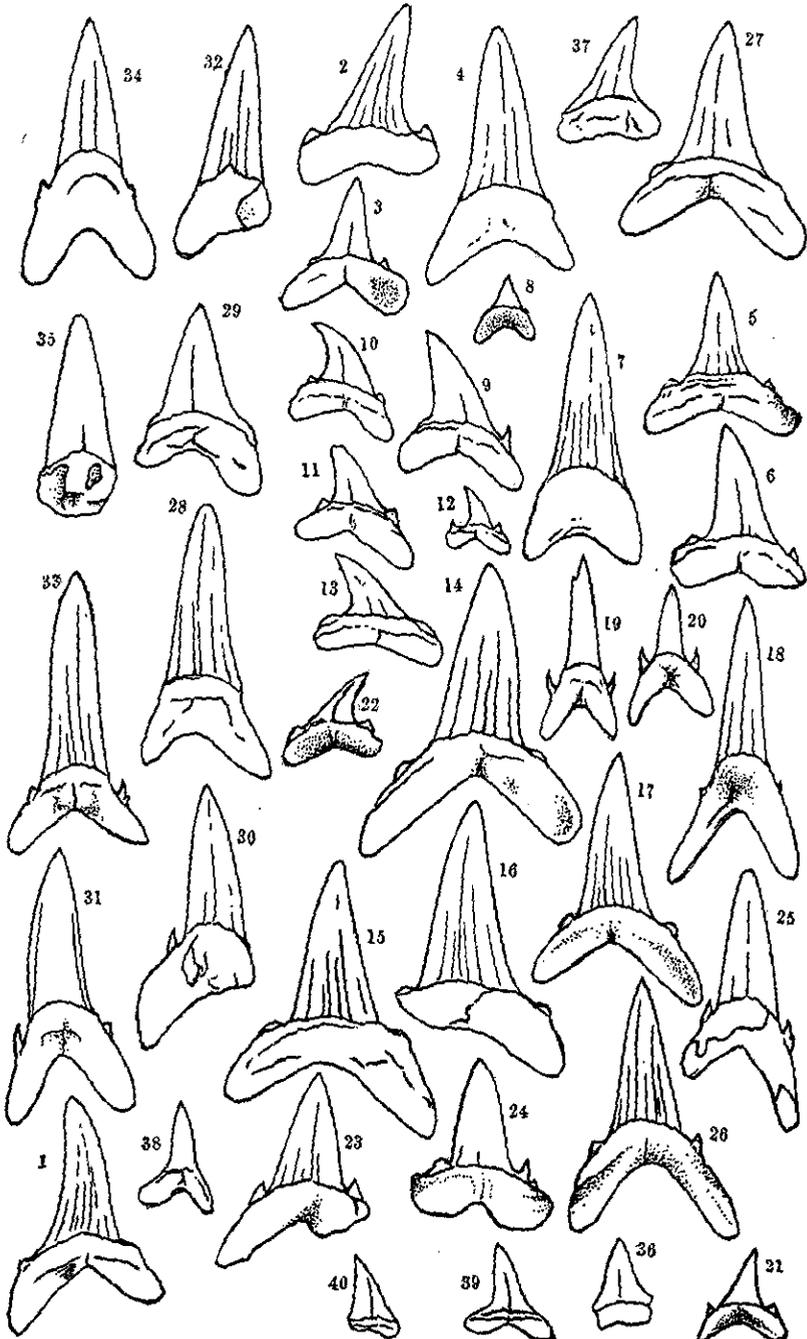


FIG. 13.—*Lamna cuspidata* Agassiz. 1-4, Monmouth Co. (Knieskera); 5-8, Monmouth Co. (Cleburne); 9, Monmouth Co. (Cleburne and Abbott); 10, Monmouth Co. (Cleburne); 11-12, Monmouth Co. (Cleburne and Abbott); 13-18, Burlington Co. (Conrad); 19-20, Burlington Co. (Budd); 21-22, Burlington Co. (Conrad); 23-26, Pemberton (Budd); 27, Allowaystown (Yarrow); 28-40, Vincentown (Bryan).

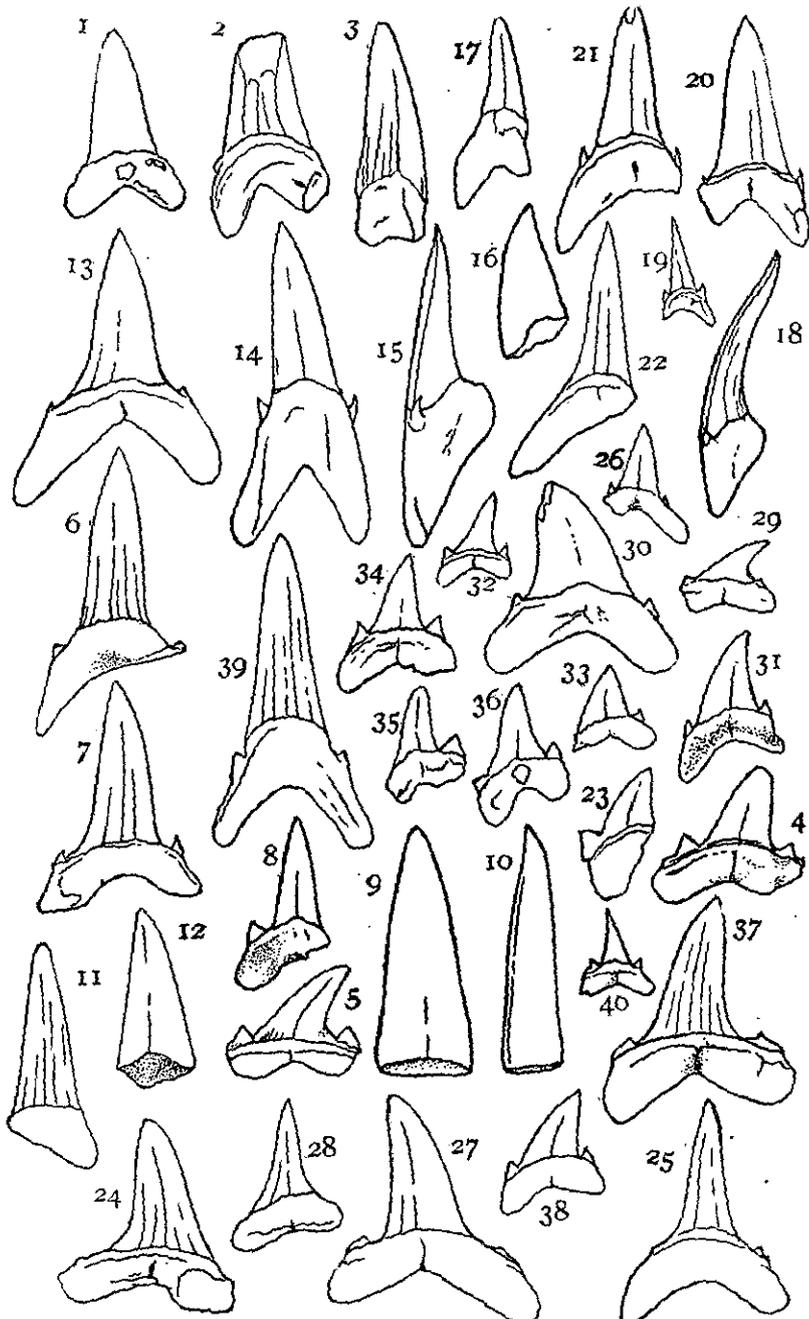


FIG. 14.—*Lamna cuspidata* Agassiz. 1, New Jersey (Cope); 2-3, New Jersey (Abbott); 4-5, New Jersey (Kilvington); 6-8, Shark R. (Conrad); 9-10, Long Branch (Chapman); 11-12, Long Branch; 13-17, Monmouth Co.; 18, Monmouth Co. (Knieskern and Abbott); 19-22, Monmouth Co. (Knieskern); 23, Monmouth Co. (Abbott); 24-26, Monmouth Co. (Knieskern and Abbott); 27-28, Monmouth Co. (Cleburne); 29-33, Monmouth Co. (Knieskern and Abbott); 34-36, Monmouth Co. (Cleburne); 37, Burlington Co. (Budd); 38, Burlington Co. (Conrad); 39, Farmingdale (Pilsbry); 40, Burlington Co. (Conrad).

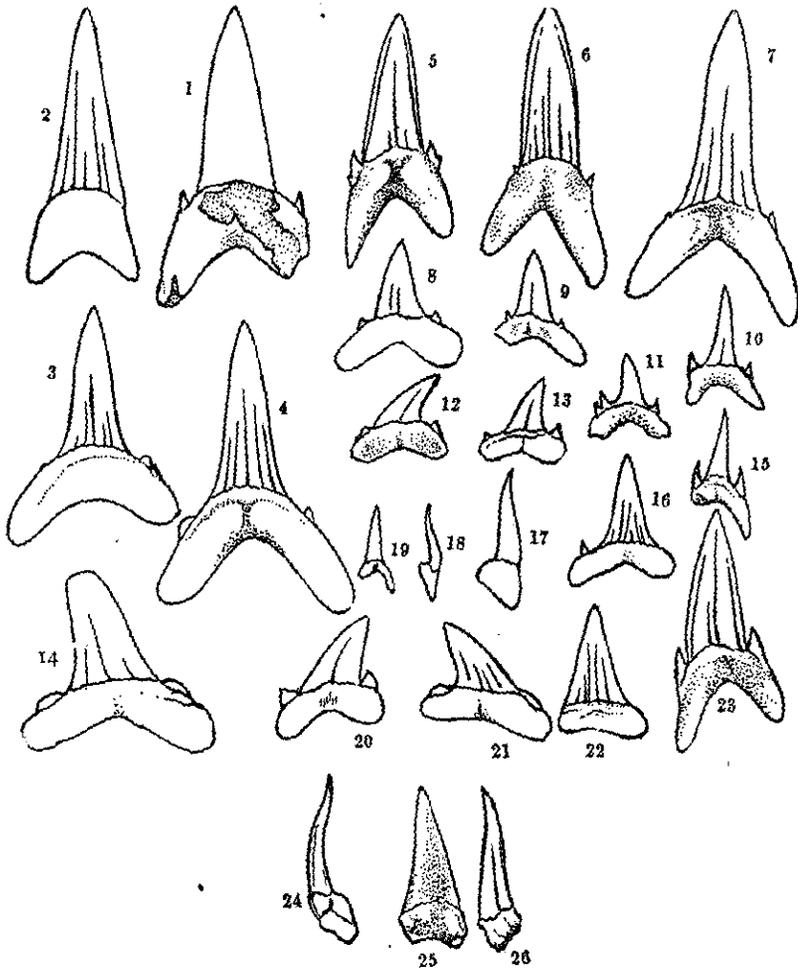


FIG. 15.—*Lamna cuspidata* Agassiz. 1, Vincentown (Bryan); 2-4, Monmouth Co. (Knieskern); 5-7, Vincentown (Bryan); 8-9, Monmouth Co. (Knieskern); 10-13, Burlington Co. (Conrad); 14, Burlington Co. (Conrad); 15, Vincentown (Bryan); 16, Pemberton (Budd); 17-19, Vincentown (Bryan); 20-21, Burlington Co. (Conrad); 22, Allowaystown (Yarrow); 23, Vincentown (Bryan); *24, Farmingdale (Johnson); *25-26, Farmingdale.

ence of small pointed basal cusps. Some of the specimens listed below may belong really to *Isurus desorii*, *I. acuminatus*, or others.

Formation and locality. The following teeth, none of which have the formation given, are in the collection of the Academy:

From "New Jersey" 3 (E. D. Cope), 8 (C. C. Abbott), 3 (P. D. Knieskern), 3 (Kilvington); Monmouth County 40 without donor, 18 (Knieskern), 178 (W. Cleburne), 1 (Abbott), 95 (Abbott and Knieskern); Farmingdale 2 (H. A. Pilsbry); Shark River 5 without donor and 26 (T. A. Conrad); Long Branch 20 without donor and 3 (H. C. Chapman); Burlington County 99 (Conrad) and 21 (C. Budd); Pemberton 31 (Budd); Vincentown 127 (T. A. Bryan); Allowaystown in Salem County 13 (H. C. Yarrow). [The geological horizons from which these came are probably as follows: Farmingdale, the Manasquan marl; Shark River, the Shark River marl (Eocene), perhaps the Manasquan marl; Long Branch, the Hornerstown or Manasquan; Pemberton, Manasquan; Vincentown, Manasquan marl, less probably the Vincentown limesand; Allowaystown, the Kirkwood (Miocene) K.]

In the collection of the Geological Survey I have found the following teeth: From the upper marl of Shark River [Eocene, K.] 8 (A. Shafter's pits), the upper marl [Manasquan, ? K.] of Farmingdale 1 (Johnson's pits). Manasquan marl, 1 mile south of Farmingdale, 9 fragmentary crowns without basal cusps, probably 7 teeth from Shiloh [Miocene, K.] (E. Davis), 1 from top of the Red Bank sand at Hornerstown, 104 from Monmouth County (Knieskern), and 5 without data.

LAMNA ELEGANS Agassiz.

Lamna elegans Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 166. (New Jersey Cretaceous.)

Cope, Proc. Am. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Anterior teeth long, slender, compressed and moderately triangular, scarcely sigmoidal in profile. Crown usually slender, subulate, erect or sometimes diverging outwards. Outer coronal surface flattened or but slightly convex, smooth. Inner coronal surface usually well convex, sometimes little flattened in middle, and marked with very many fine, delicate parallel vertical striæ. Apex erect or variously deflected. Cutting-edges prominent, entire. Usually one, sometimes two, small acute basal cusps in one

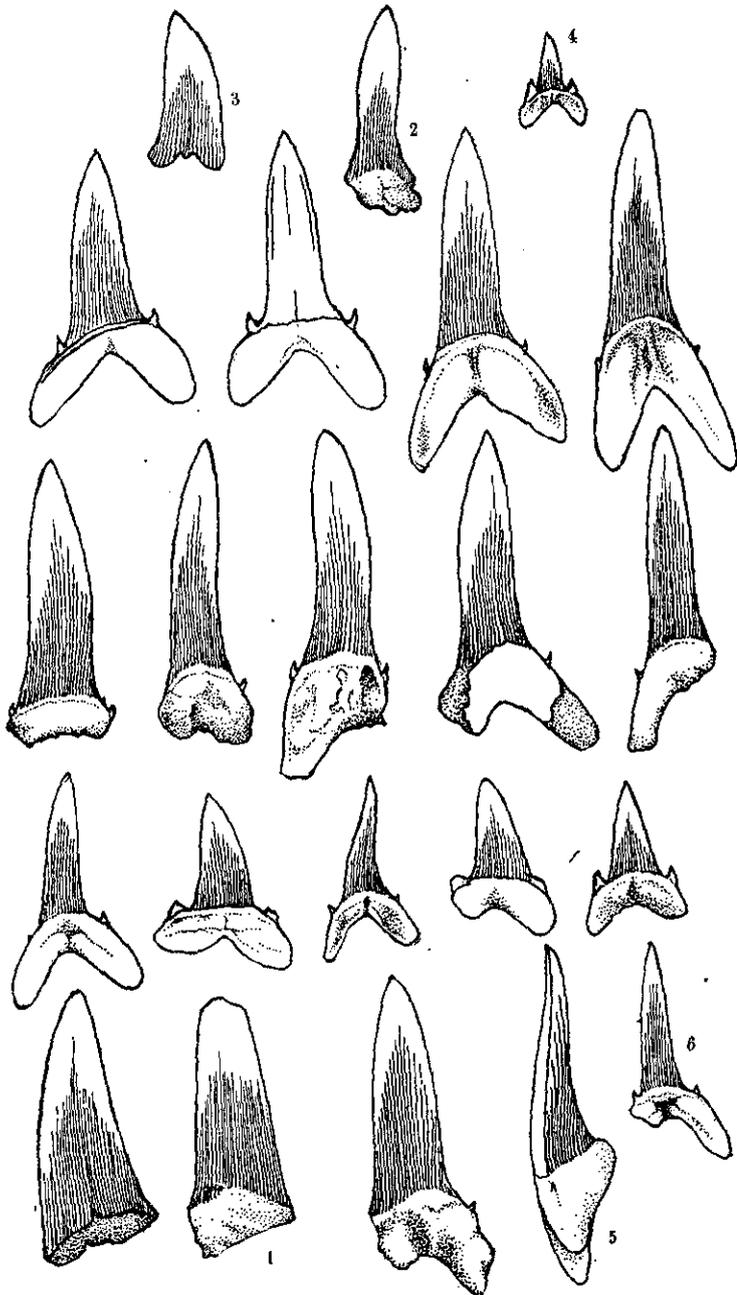


FIG. 16.—*Lamna elegans* Agassiz. 1-3, Deal; 4-6, Monmouth Co.; others from Vincentown (Bryan).

4 GEOL

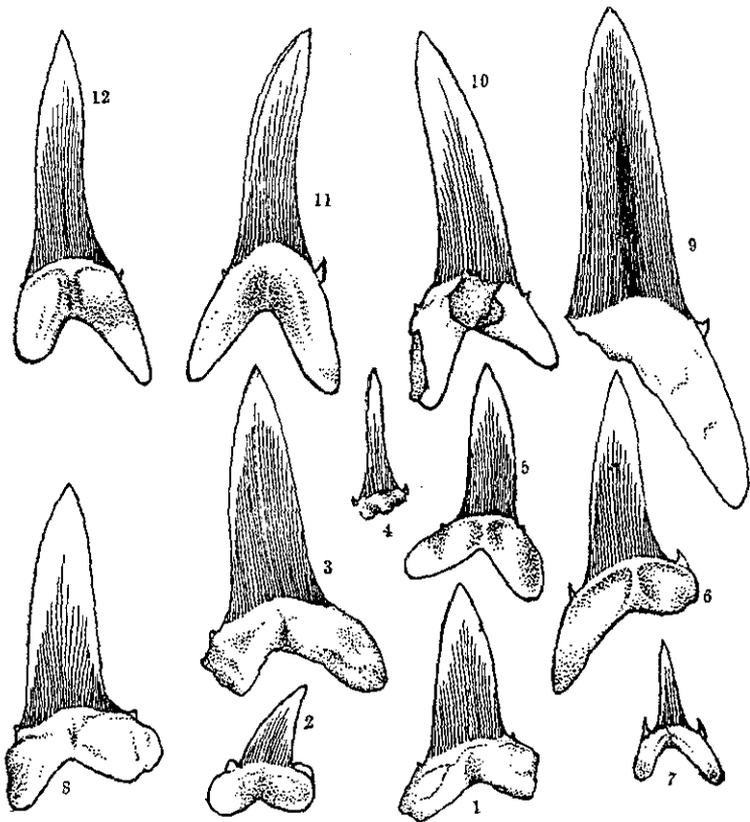


FIG. 17.—*Lamna elegans* Agassiz. 1, New Jersey (Cope); 2, Monmouth Co. (Knieskern); 3, Pemberton (Budd); 4-6, Vincentown (Slack); 7-12, Vincentown (Bryan).

or each side. Root large, outer face concavely depressed, and inner convexly bulging till very pronounced, the convexity usually with more or less complete sulcus. Branches of root usually long, moderately divergent, and angle between branches usually well marked. Lateral teeth with lower crowns, often well deflected, wider angle between branches of root and basal cusps varying till quite broad. Length to 65 mm.

This well-marked species is easily distinguished, when not worn, from the other species of the genus by the fine vertical striae in the inner coronal surface. It is quite variable, and in the variation of form closely resembles *Lamna cuspidata*.

Formation and locality. The following teeth are all from the Cretaceous and Eocene marls, without formation: New Jersey 5 (C. C. Abbott), 2 (E. D. Cope); Monmouth County 15 without donor, 68 (J. H. Slack, J. Parke, J. H. Powell, Jr., and Abbott), 17 (P. D. Knieskern), 3 (Knieskern and Abbott); Deal 84 no donor; Long Branch 11 no donor, 14 (H. C. Chapman); Shark River 1 (T. A. Conrad) and 3 (Knieskern); Farmingdale 6 (H. A. Pilsbry); Burlington County 10 (Conrad) and 8 (C. Budd); Pemberton 33 (Budd); Vincentown 188 (T. A. Bryan); Medford 1 (L. Woolman); Mullica Hill 1 (W. M. Gabb); Bridgeton 5 (Budd) and 1 (C. B. Barrett). The last are evidently Miocene.

In the Geological Survey collection I have examined the following teeth: From the Wenonah sand a little less than 1 mile southeast of Cranford's Corner 4 (J. Longstreet's pit), Manasquan marl 1 mile south of Farmingdale 11 mostly fragmentary, Shiloh [Miocene, K.] 4 (E. Davis), Woodbury clay east of Matawan 3 (D. Farry's brickyards), middle marl [Manasquan, ? K.] at Riddleton 2 (Hackett's pits), upper marl [Manasquan, K.] at Poplar 7, and 4 without data.

[The geological range of these specimens is from the Woodbury clay, Cretaceous, into the Miocene, K.]

LAMNA MUDGEI Cope.

Lamna mudgei Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II. 1875, p. 297, Pl. 42, figs. 11-12. *Niobara epoch of Kansas. Greensand No. 4, of New Jersey.*

Indicated by three teeth from the Niobara epoch of Kansas, and one from the greensand, "No. 4," of New Jersey. These teeth are rather stout, especially at the base, and the crown not

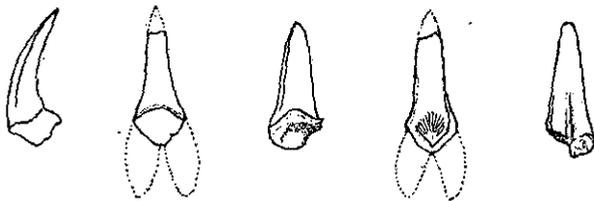


FIG. 18.—*Lamna mudgei* Cope. (From Cope.)

very elongate. The root is excessively protuberant, projecting horizontally beyond the convex side, and flat or truncate below the protuberance. The enamel is entirely smooth. Measurements of the New Jersey specimen: Length of crown, 14 mm.; diameter of base, longitudinal, 4 mm.; transverse, 7 mm.; long diameter of roots at basis of crown, 8 mm. (From Cope.)

The above description seems to be all that is known of this species in New Jersey.

Formation and locality. As given above, these fossils are Cretaceous.

LAMNA TEXANA Roemer.

Lamna sp. Leidy, Proc. Acad. Nat. Sci. Phila., 1872, p. 166. (New Jersey Cretaceous.)

Lamna texana Leidy, Rep. U. S. Geol. Surv. Terr. Hayden, 1873, p. 304, Pl. 18, figs. 46-47. (Clay near Haddonfield, in Camden Co., and Cretaceous greensand of Mullica Hill, in Gloucester Co.)

Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 296. (Greensand No. 4 of New Jersey.)

Anterior teeth long, slender, compressed, scarcely sigmoid in profile. Crown slender, moderately thickened, erect. Outer coronal surface flattened or but slightly convex, and smooth. Inner coronal surface convex, sometimes little depressed basally, and marked at least over greater extent basally with prominent vertical striæ. These striæ more sparse than in related species. Apex erect, scarcely deflected. Cutting-edges prominent, entire. No basal cusps. Root large, outer surface concavely depressed, and inner bulging in prominent convexity, usually with more or less complete sulcus. Branches of root usually long, moderately divergent, and angle between usually well marked. Length reaches 48 mm.

Leidy first notices the two teeth ascribed to this species from clay near Haddonfield, which he found with a skeleton of *Hadrosaurus foulkii* and shells of *Exogyra costata*, *Ammonites placenta*, etc. This species is only known from detached teeth, and may be distinguished from *Lamna elegans* by the coarser striæ on the outer coronal surface.

Formation and locality. Known from the Cretaceous. I have 26 teeth from Mullica Hill [Navesink-Hornerstown marl, K.]

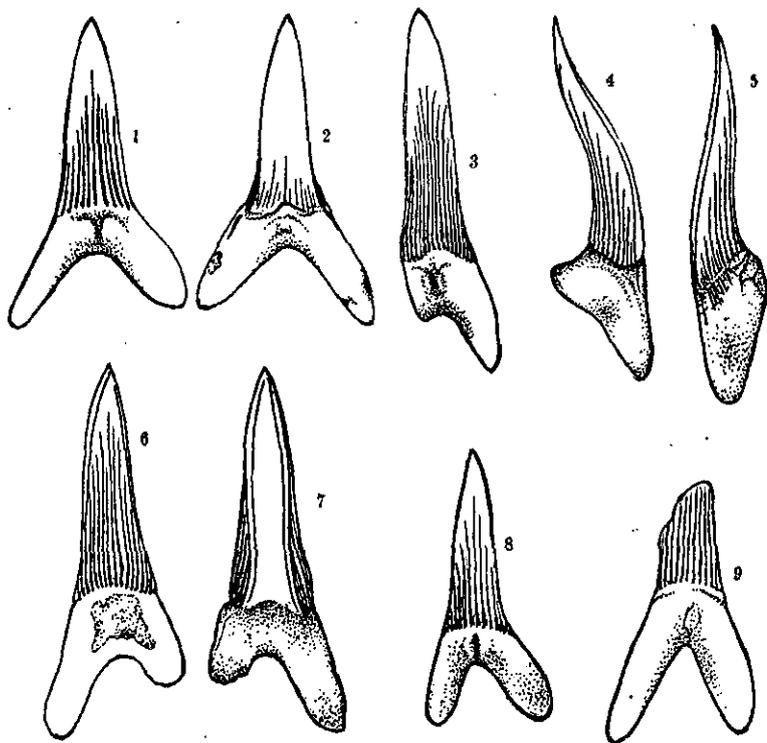


FIG. 19.—*Lamna texana* Roemer. 1-2, Pemberton (Budd); 3-4, Vincenttown (Bryan); 5-8, Haddonfield; 9, Mullica Hill (Gabb).

(W. M. Gabb), 2 from Haddonfield [Woodbury clay K.] (J. Leidy), 1 from Vincenttown [the Manasquan ? marl, K.] (T. M. Bryan) and 1 from Pemberton [Manasquan marl K.] (C. Budd).

Genus OTODUS Agassiz.

Otodus Agassiz, Poiss. Foss., III, 1843, pp. 266, 307. Type *Otodus obliquus* Agassiz, first species, restricted by Hay, Bull. U. S. Geol. Surv., No. 179, 1902, p. 304.

A provisional genus, embracing species evidently of large size, and known only from the teeth, which are large, thickened, though somewhat compressed, elongately triangular, with sharpened and entire cutting-edges, and 1 or 2 rather large cusps each side basally. Roots also large and thickened.

All the species, of which about 38 have been described, are extinct.

Otodus appendiculatus Agassiz.

Otodus appendiculatus Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 199. (New Jersey Greensand.)

Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 295. (Greensand No. 5, N. J.)

Teeth robust, thickened and moderately compressed. Coronal surface slightly compressed, usually low or but moderately attenuated and sharply pointed. Outer face usually more or less flattened, or but slightly convex and smooth, sometimes a little concave basally, but without any vertical wrinkles. Inner coronal face usually well convex, rather prominently so basally, and smooth. Apex slightly deflected or erect. Cutting-edges trenchant, sharp, entire. Usually one large basal cusp on one or each side, sometimes two. These cusps vary from broad till quite slender, and are always sharply pointed and with entire cutting-edges. Root robust, thick, outer face usually flattened and inner face swelling in a large convexity. In profile lower margin varying rather widely crescentic, and ends sometimes flaring a little. Length to 36 mm.

This species seems to differ from *Otodus lanceolatus* chiefly in its smaller size. According to Woodward the anterior teeth are erect and slender, and the lateral teeth well inclined back, their front edges being more arcuate and longer than the hind ones. He further says that the thick root has the nutritive foramen not in a groove, and the outer coronal face has often a few indefinite vertical folds on its basal half.

Formation and locality. I have examined a number of detached teeth from the Cretaceous formations. They are: "New Jersey" 2 (T. A. Conrad), 1 (Burtt), 2 (W. M. Gabb), 1 without donor, 3 (C. C. Abbott); Monmouth County 1 (W. Cleburne), 3 (P. D. Knieskern and Cleburne), 3 (Abbott); Shark River 1 (Knieskern); Long Branch 4 (H. C. Chapman); Burlington County 4 (C. Budd); Crosswicks 1 (Conrad); Vin-

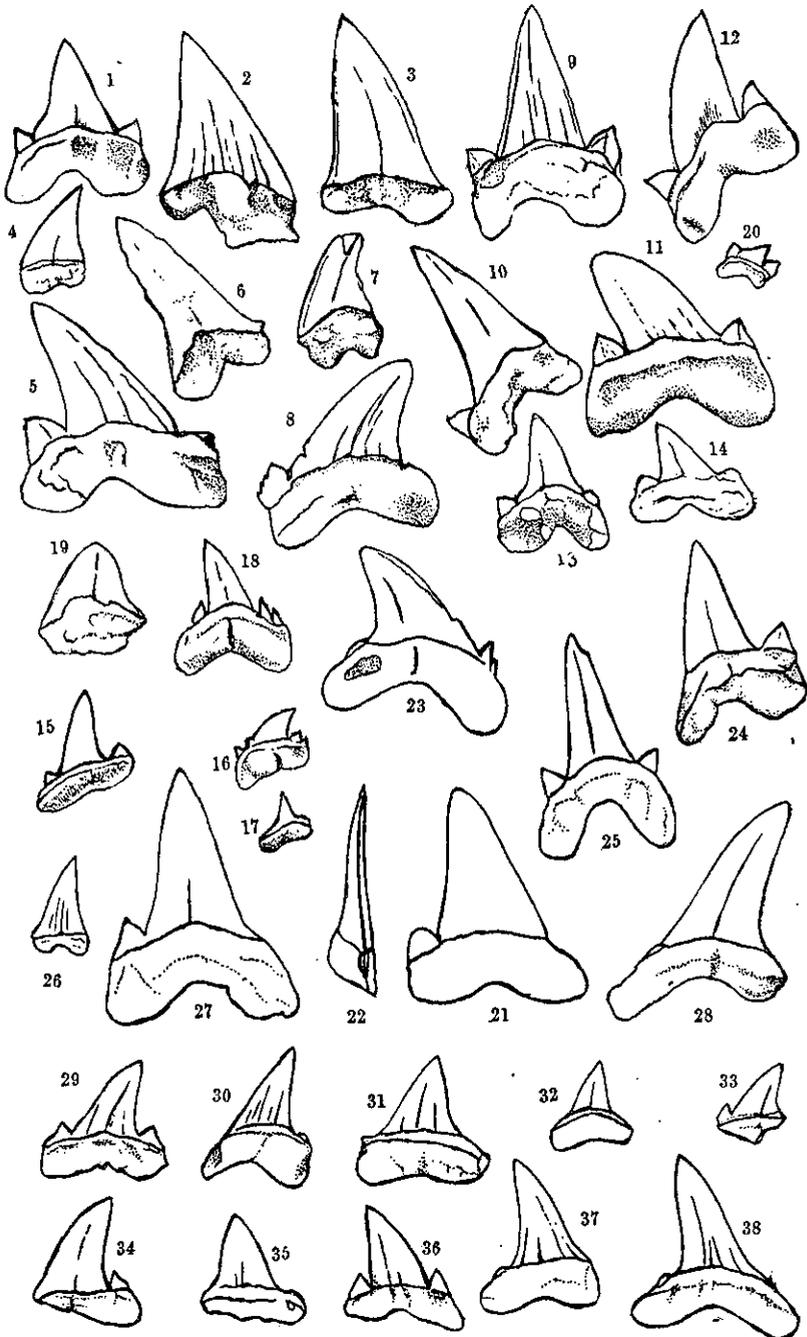


FIG. 20.—*Otodus appendiculatus* Agassiz. 1-4, Long Branch (Chapman); 5, New Jersey (Burt); 6-7, Blackwoodtown (Collins); 8, New Jersey (Conrad); 9-10, New Jersey (Gabb); 11, Mullica Hill (Abbott); 12, Monmouth Co. (Abbott); 13-14, Mullica Hill (Abbott); 15-18, near Long Branch (Chapman); 19, Monmouth Co. (Abbott); 20, Monmouth Co.; 21-22, New Jersey (Conrad); 23-38, Vincentown (Bryan).

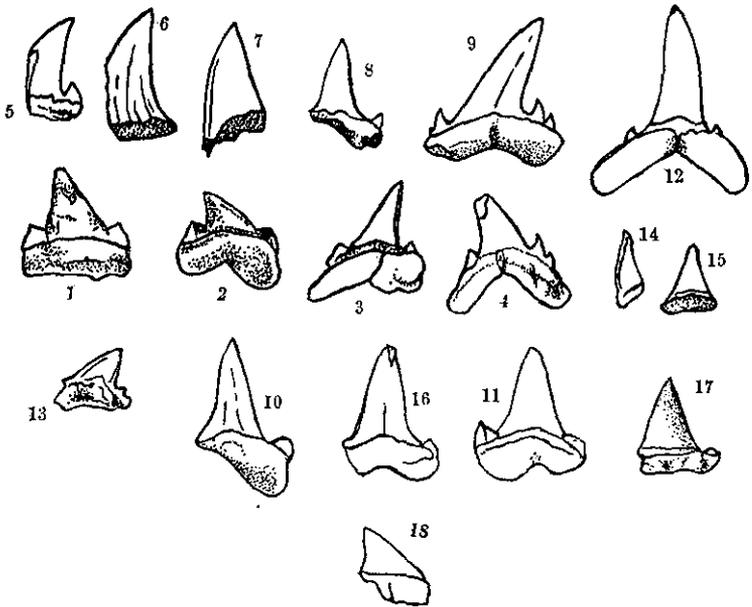


FIG. 21.—*Otodus appendiculatus* Agassiz. 1-2, Charles Co., Md. (Thomas); 3, Allowaystown (Yarrow); 4, Monmouth Co. (Cleburne); 5-7, Burlington Co. (Budd); 8, Shark R. (Knieskern); 9, Vincentown (Bryan); 10, Monmouth Co. (Knieskern and Cleburne); *11, no data; 12, Monmouth Co. (Knieskern and Cleburne); 13-15, Vincentown (Bryan); *16, near Crawford's Corner; *17, Shark R.; *18, one mile southwest of Farmingdale.

centown 25 (T. M. Bryan); Blackwoodstown in Camden County 2 (W. Collins); Mullica Hill in Gloucester County 3 (Abbott); Allowaystown in Salem County 1 (H. C. Yarrow).

In the collection of the Geological Survey are the following teeth: Marl at Shark River 1, Manasquan marl 1 mile south of Farmingdale 2, somewhat fragmentary; Monmouth County 12 (Knieskern), and middle marl (Manasquan) at Riddleton 2 fragments (Hackett's pits). [From the above enumeration of localities the fragments of specimens apparently have been derived from the Merchantville or Woodbury clay (Crosswicks), Navesink marl (Mullica Hill), Navesink-Hornerstown marl (Blackwood and Riddleton), Manasquan marl (Farmingdale) and the Miocene (Allowaystown) K.]

OTODUS LEVIS Gibbes.

Otodus levis Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 199, Pl. 26, fig. 141 (type). (New Jersey.)

Known only from the record of Gibbes from within the limits of the State. He says: "I have since seen one in the cabinet of the Academy from New Jersey." I cannot find that his figures

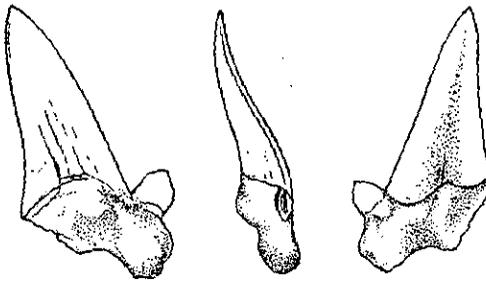


FIG. 22.—*Otodus levis*, Gibbes. (From Gibbes.)

differ from those I give as *Otodus appendiculatus*, except that he shows the crown deflected and more elongate.

Formation and locality. This species has been ascribed to the Eocene, but no special locality within the State has been given by Gibbes. It was originally obtained in the same formation of South Carolina.

OTODUS LANCEOLATUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 5. New Jersey.

Lamna lanceolata (Agassiz) Morton, Am. Journ. Sci. Art., 1835, p. 277 (name only, based on preceding).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 11, fig. 1. Arenaceous beds of New Jersey.

Lamna obliqua (Agassiz) Morton, Journ. Acad. Nat. Sci. Phila., VIII, 1842, p. 15 (name only, based on preceding).

Otodus obliquus Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 199, figs. 131-137. (New Jersey Eocene casts.)

Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 236. (Vincentown.)

Teeth robust, usually elongated as an isocles triangle, and rather thick. Coronal surface but slightly compressed, attenuated,

sharply pointed, and faces convex in varying degrees, but usually outer less so. Occasionally distinct vertical plications on outer coronal face. Apex usually erect, seldom deflected much. Cutting-edges mostly entire, or only occasionally in small examples with a few obsolete serrations near base. Usually one cusp basally on each side, often large, and edges entire. Rarely still a second smaller basal external cusp. Root robust, thick, outer face usually flattened, and inner face swelling in a large convexity. In profile lower margin of root emarginated to crescentic, and ends not much produced. Teeth reach 84 mm. in length.

This appears to be rather variable. Some writers think certain teeth ascribed to it may belong to *Carcharodon*, as in rare instances their edges show the faint serrations alluded to above. Though known only from detached teeth, this species would evidently have obtained some size, being very likely an all-sufficient predatory monster. The teeth are among the most abundant of all the sharks' teeth found in the fossil beds in the State. Unfortunately Morton's *Lamna lanceolata* is the oldest name available for this species, having virtually several years priority over the familiar *Otodus obliquus* Agassiz.

Formation and locality. I have examined many series of specimens in the collections of the Academy, most of which are without detailed data. New Jersey 5 (Burt), 1 (C. Budd), 1 (J. P. Wetherill), 1 (B. Coates), 14 (C. C. Abbott), 5 (E. D. Cope); Monmouth County 12 (J. H. Slack, J. Parke, J. H. Powell, Jr., Abbott), 1 (Powell), 1 (Abbott), 2 (Slack), 15 (W. Cleburne), 1 (Burt); Farmingdale 12 (H. A. Pilsbry in 1892); Shark River 1 (P. D. Knieskern); Long Branch 1, no donor, 1 (H. C. Chapman); Burlington County 3 (C. Budd), 39 (T. A. Conrad); Vincentown 84 (T. M. Bryan), 21 (Bryan on May 4th, 1875) from greensand, 1 (G. Bryan), 1 (C. B. Barrett); Pemberton 7 (C. Budd); Pointville 2 (W. F. Atlee in December, 1863); Fostertown 1 (H. N. Potts); Medford 6 (L. Woolman); Allowaystown in Salem County 1 (H. C. Yarrow).

In the collection of the Geological Survey are the following: Monmouth County 2 (P. D. Knieskern), upper marl of Far-

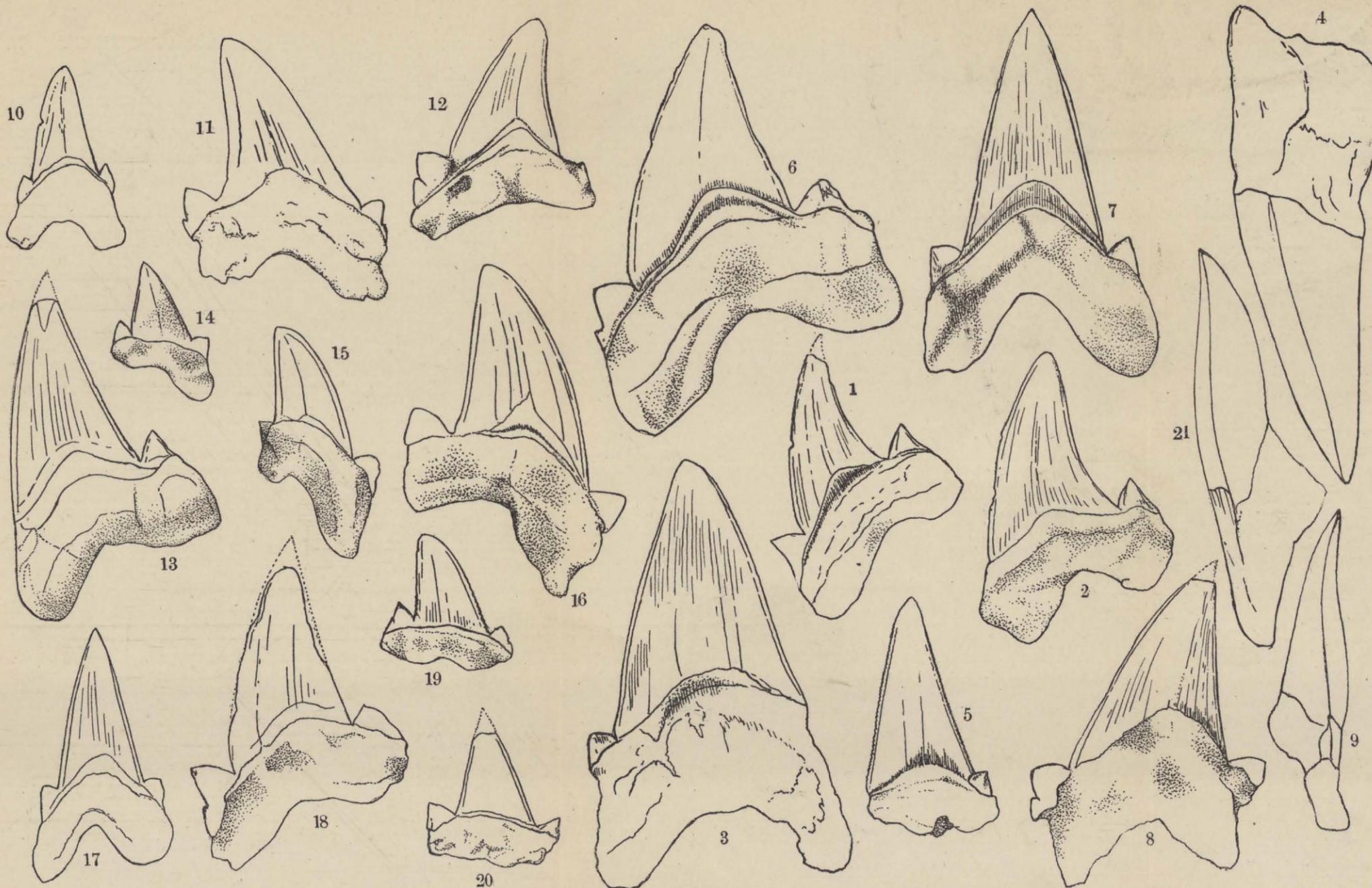


FIG. 23.—*Otodus lanceolatus* (Morton). 1, New Jersey (Wetherill); 2, New Jersey (Coates); 3-5, Monmouth Co. (Cleburne); 6-7, Burlington Co. (Wetherill); 8-9, Pemberton (Budd); 10-21, Vincentown (Bryan).

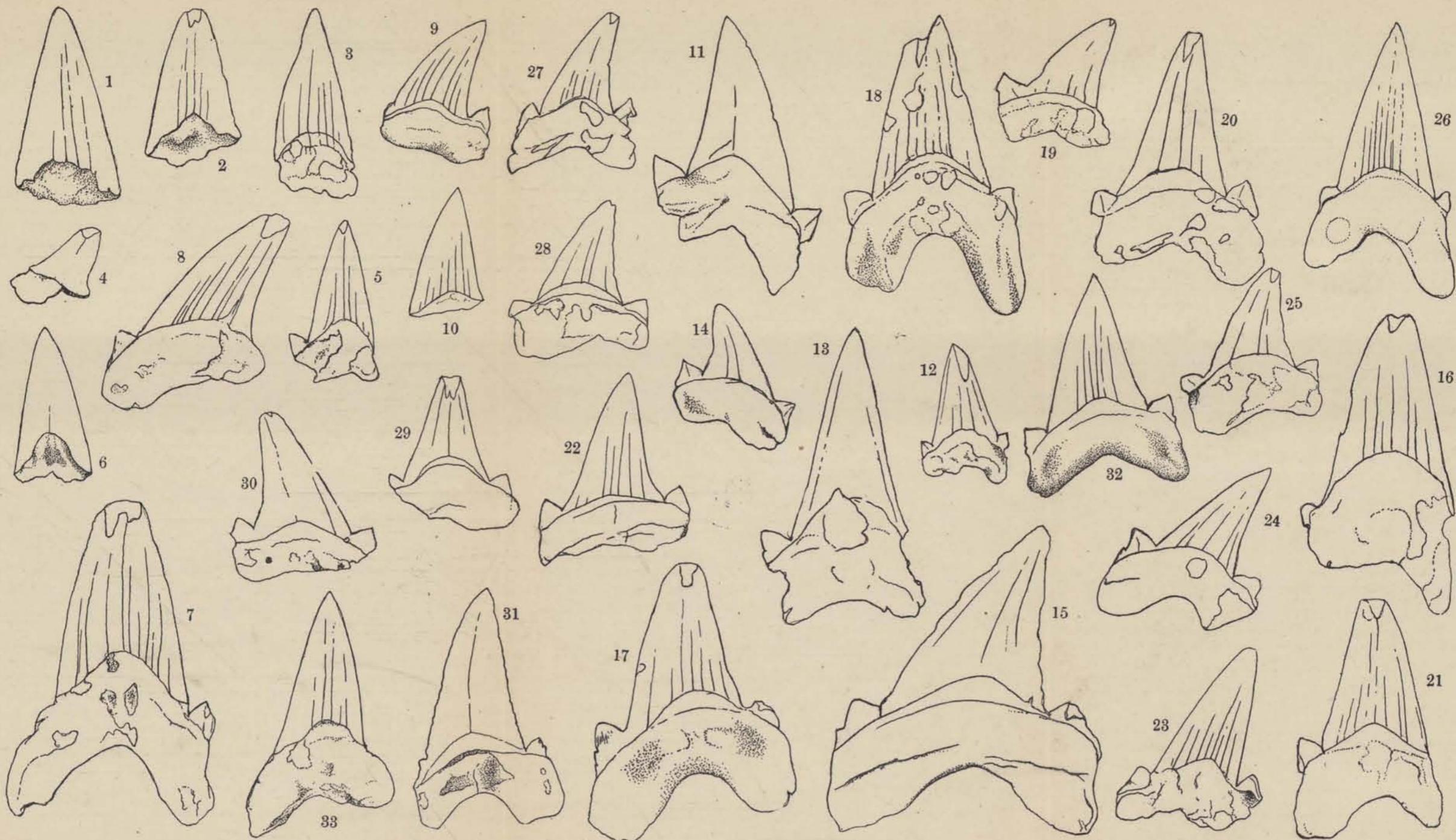


FIG. 24.—*Otodus lanceolatus* (Morton). 1, Monmouth Co. (Abbott); 2, Long Branch; 3, Long Branch (Chapman); 4, Shark R. (Knieskern); 5, Farmingdale (Pilsbry); 6, Burlington Co. (Budd); 7-10 Medford (Woolman); 11-32, Vincentown (Bryan); 33, Vincentown (Barrett).

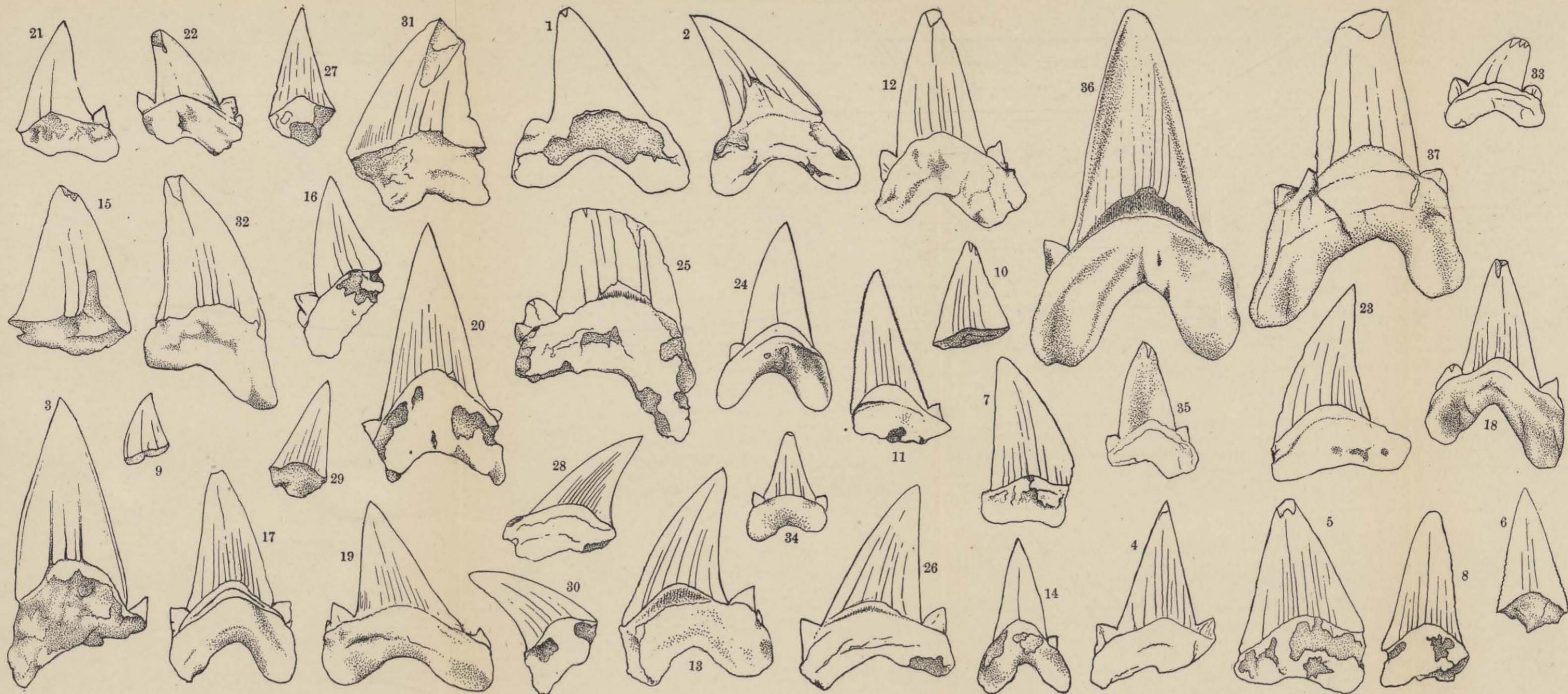


FIG. 25.—*Otodus lanceolatus* (Morton). 1-4, New Jersey (Cope); 5, New Jersey (Abbott); 6-7, Monmouth Co. (Slack, etc.); 8, Monmouth Co. (Slack); 9, Monmouth Co.; 10, Monmouth Co. (Burt); 11, Monmouth Co. (Cleburne); 12-13, Farmingdale (Pilsbry); 14, Burlington Co. (Budd); 15-18, Burlington Co. (Conrad); 19-20, Burlington Co. (Atlee); 21-26, Vincentown (Bryan); 27-30, Pemberton (Budd); 31-34 Charles Co., Md. (Thomas); *35 Shark R.; 36-37, Vincentown (Bryan).

mingdale 2 (Johnson's pits), upper marl of Shark River 1 (A Shafter's pits), Shiloh 16 (E. Davis), marl of Shark River 1 without donor, Manasquan marl 1 mile south of Farmingdale 6, somewhat fragmentary; upper marl at Poplar 1; Vincentown Cretaceous 1 (Dr. Brown); upper marl of Vincentown 1 (Dick's pit), and 14 without data.

[The material from the above localities, so far as any reference can be made, apparently came from the Manasquan marl, the Shark River marl and the Shiloh marl, *i. e.*, from the top of the Cretaceous, the Eocene and the Miocene, K.]

Genus CARCHARODON Müller and Henle.

Carcharodon (Smith) Müller and Henle, Arch. Naturg., 1838, p. 84. Type *Carcharodon verus* Agassiz, virtually monotypic.

Teeth large, flat, erect, regularly triangular, edges serrated. Spiracles minute or absent. First dorsal moderate, nearly midway between pectorals and ventrals. Second dorsal and anal very small. Caudal peduncle rather stout, lobes of lunate fin not very unequal. Pectorals large. Ventrals small.

Large pelagic fishes found in most all warm seas and reputed the strongest and most voracious of all fishes. The fossils embraced in this genus represent the remains of species many times larger, and thus far more formidable than those existing, or the so-called "man-eaters." It is possibly the sole survivor of about 19 described extinct species, all of which are only known from detached teeth.

CARCHARODON AURICULATUS (Blainville).

Squalus sp. Morton, Syn. Org. Rem. Cret. U. S., 1834, p. 16, Pl. 12, figs. 3 and 5. *New Jersey*.

Carcharias canceolatus (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on above and impr. err.).

Carcharias lanceolatus (Agassiz) Morton, Journ. Acad. Nat. Sci. Phila., VIII, 1842, p. 16 (name only, based on above).

Squalus sp. Morton, Syn. Org. Rem. Cret. U. S., 1834, p. 16, Pl. 12, fig. 4.
New Jersey.

Carcharias megalotis (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835,
p. 277 (name only, based on preceding).

• *Carcharodon acutidens* Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August,
1848, p. 146, figs. 39-44. (New Jersey.)

Carcharodon angustidens Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II,
1875, p. 295. (Greensand of No. 5, New Jersey.)

Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumber-
land Co. Miocene.)

Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 236. (Vin-
centown.)

Teeth comparatively narrow, robust, thickened and compressed. Coronal surface variably convex, though outer usually slightly more or less flattened. Apex often decidedly acuminate and deflected to one side. Cutting-edges usually coarsely serrated, the serræ often individually variable, and always graduated small towards tip of apex. Usually a broad basal cusp on each side, sometimes a second, and serrations in its cutting-edge usually enlarged. Tips of most all serratures rounded. Root variable, usually robust, outer face flattened concavely, and inner face often swelling in a large median bulge. In profile lower margin of root often evenly emarginate to crescentic, though ends not especially produced. Teeth reach 112 mm.

This is quite variable and shows many variations in the teeth. Some examples from the Maryland Miocene and others from Monmouth County, N. J., approach *Carcharodon polygurus*, but have the basal lateral cusps but slightly differentiated. Besides detached teeth this species is known from two nearly complete skeletons from near Antwerp in Belgium.

Formation and locality. I have examined a series of examples from the State now in the Academy, all detached teeth. Monmouth County 10 (P. D. Knieskern), 1 (Grier), 1 (C. C. Abbott); Deal 2 (C. Breed), 4 (W. G. Budd); Shark River 1 without donor, 3 (Knieskern), 2 from the Miocene (T. A. Conrad); Long Branch 2 (H. C. Chapman); Farmingdale (H. A. Pilsbry in 1892); Trenton Falls [Tinton Falls ? K.] (Abbott); Burlington County 1 (Abbott), 16 (Conrad), 7 (C. Budd), 2 (J. P. Wetherill), 4 (E. Hallowell); Pemberton 3 (C. Budd), 1 (T. M. Bryan); Vincentown 17 (C. B. Barrett), from the

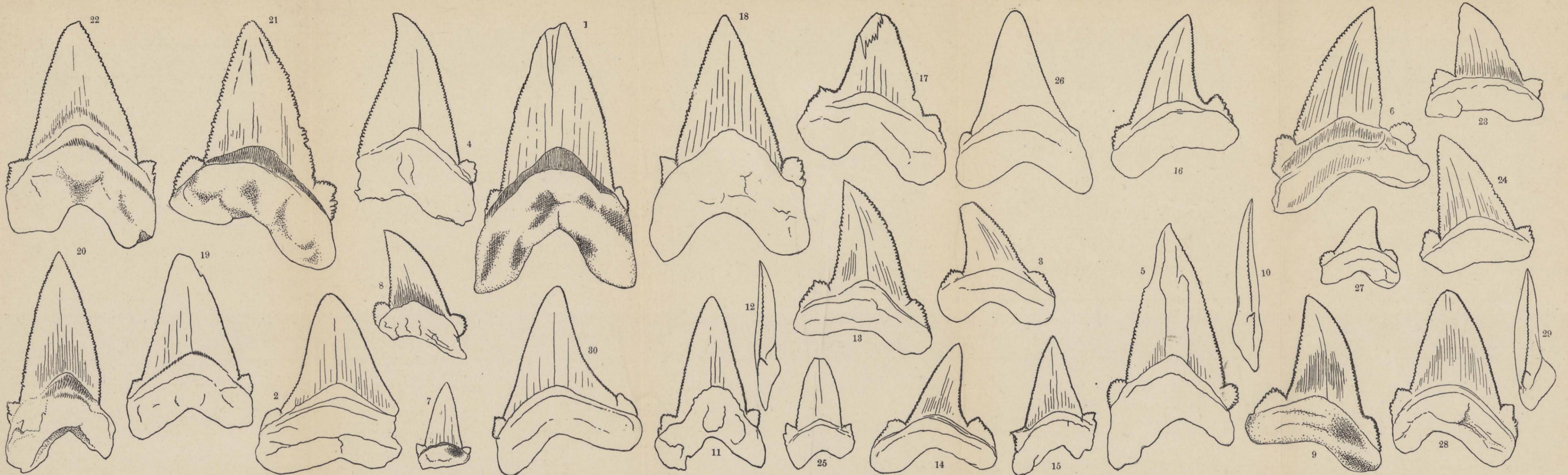


FIG. 26.—*Carcharodon auriculatus* (Blainville). 1, New Jersey (Wetherill); 2, Monmouth Co. (Knieskern); 3, Monmouth Co. (Grier); 4, Shark R.; 5, Burlington Co. (Hallowell); 6, Burlington Co. (Wetherill); 7, Burlington Co. (Abbott); 8, Burlington Co. (Conrad); 9-13, Pemberton (Budd); 14-29, Vincentown, Burlington Co. (Hallowell); 30, Cumberland Co.

greensand 115 (Bryan); Mullica Hill in Gloucester County 1 (Abbott); Cumberland County 1 (T. B. Gillette). The following labeled simply "New Jersey" are: 1 (Coates), 1 (Budd), 1 (Wetherill), 2 (Chaloner), 3 (Abbott), 1 (W. Cleburne), 4 without donor.

In the Geological Survey collection are the following teeth: Monmouth County 6 (Knieskern); Shiloh 9 (E. Davis); Vincentown Cretaceous 2 (Dr. Brown), and 3 without data. [The formations apparently represented are the Navesink-Horners-town bed, the Manasquan marl, Shark River marl and the Shiloh marl, *i. e.*, Cretaceous, Eocene, Miocene beds, K.]

CARCHARODON POLYGURUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31, Pl. 12, fig. 2.

"Found in both the arenaceous and calcareous strata" [the former evidently with reference to *New Jersey*].

Carcharias polygurus (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only, based on preceding).

Carcharodon megalodon Cope, Proc. Am. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Teeth comparatively broad, compressed and not especially thick. Coronal surface moderately convex, outer somewhat flattened. Apex slightly deflected to one side. Cutting-edges serrated, more distinct mostly in smaller examples, and then small. No basal cusps. Tips of serratures rounded. Root compressed, outer face flattened, and inner face rather evenly though usually moderately convex. In profile lower margin of root forms emargination often at an obtuse angle, or moderately crescentic. Ends of roots usually compressed and about as broad as rest of basal portion. Teeth range from 40 to 133 mm. in length.

This species seems to be known only from the large detached teeth. These are often with their edges so worn that the marginal serræ appear obsolete or in some cases to be absent. Probably the largest of all fishes, it having been estimated to have reached a length of over twice that of the largest known existing fish, *Cetorhinus maximus*, or nearly three times that of its nearest existing relative, *Carcharodon carcharias*. Bowerbank estimated the length of *Carcharodon megalodon* to be about 87

feet 7 inches. Its distribution through most all Tertiary seas must have rendered incessant the butchery of the majority of other aquatic animals. Smaller teeth of this species from the Maryland Miocene have their edges finely serrated, one showing traces of an imperfect or very obsolete basal cusp. Altogether, except some of Yarrow's examples, the entire series of New Jersey teeth examined differ little from Agassiz's figures, except in having the serrations along the cutting-edges worn.

Carcharias polygurus Morton seems to be the oldest available name for this species, and must, therefore, be adopted, *C. megalodon* Charlesworth, the name now widely adopted, not appearing until the following year.

Formation and locality. I have examined the following teeth from the Tertiary marls: Monmouth County 1 without donor, 1 (Grier); Shark River 2 (P. D. Knieskern); Burlington County 1 (T. A. Conrad); Vincentown 5 (T. M. Bryan); Atlantic City in Atlantic County 1 (E. Lippincott); Allowaystown in Salem County 3 fragments (H. C. Yarrow); "New Jersey" 1 (Spachman), 2 (J. P. Wetherill), 1 (G. Watson); "Delaware Bay" 1 (Corse), 1 (C. C. Abbott). I also have seen an example from Delaware (P. Uhler).

In the Geological Survey collection are 4 teeth without data. [The formations represented are apparently the Manasquan, Shark River and perhaps the Miocene, K.]

Genus CORAX Agassiz.

Corax Agassiz, Poiss. Foss., III, 1843, p. 224. Type *Galeus pristodontus* Agassiz, first species, restricted by Woodward, Cat. Foss. F. Brit. Mus., I, 1889, p. 423.

Teeth compressed, more or less triangular, usually with distinct marginal serrations. In external form very suggestive of teeth of *Sphyrna* or *Eulamia*, but differing in the absence of an internal cavity.

An imperfectly definable genus, comprising extinct species of small or moderate size, known only by the teeth. About 11 species have been described.

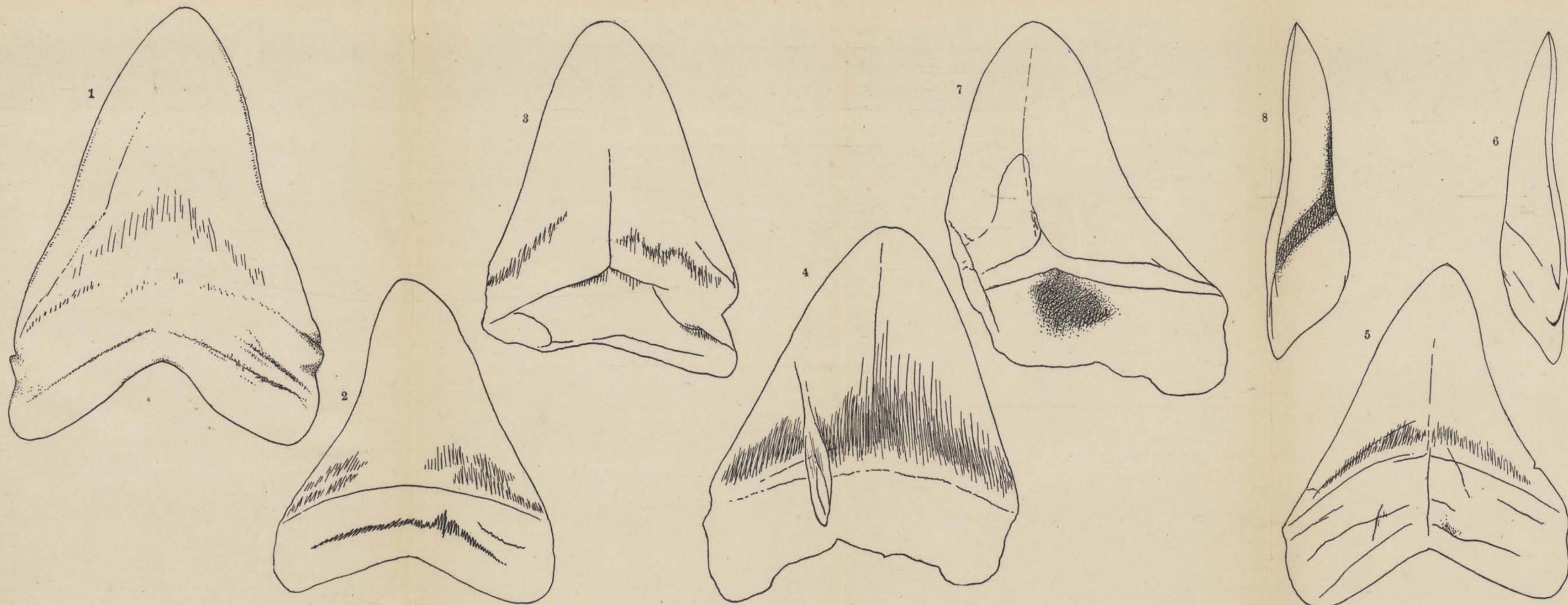


FIG. 27.—*Carcharodon polygurus* Morton. 1, New Jersey (Spachman); 2, New Jersey (Wetherill); 3, Delaware Bay (Corse); 4, Atlantic City (Lippincott); 5-6, New Jersey (Watson); 7-8, Monmouth Co. (Grier).

CORAX FALCATUS Agassiz.

Galeocerdo falcatus Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 295. (Greensand of New Jersey.)

Teeth moderately broad, greatly compressed, and moderately high. Crown moderately oblique to nearly erect, high, smooth, broad and greatly compressed. Outer coronal surface usually flattened or but slightly convex. Inner coronal surface convex. Apex slightly deflected, broad, compressed. Cutting-edges with feeble serrations, or almost smooth. No basal cusps. Root moderately broad, deep, compressed, inner surface depressed or slightly concave and outer surface moderately convex, not bulging much. Lower margin emarginate. Length 20 mm.

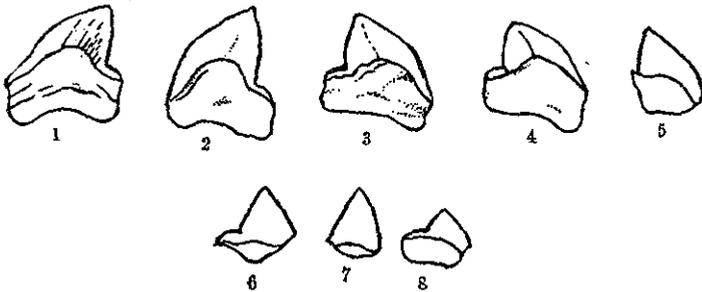


FIG. 28.—*Corax falcatus* Agassiz. 1-4, New Jersey (Kilvington); 5, Monmouth Co. (Knieskern); 6, Mullica Hill (Abbott); 7-8, Pemberton (Bryan).

This is a smaller species than the next, which it closely resembles.

Formation and locality. The following from the Cretaceous, without data as to the beds, seem to belong to this species: "New Jersey" 5 (Kilvington); Monmouth County 1 (P. D. Knieskern); Pemberton in Burlington County 2 (T. M. Bryan); Mullica Hill in Gloucester County 1 (C. C. Abbott). [The formations are probably the Navesink-Hornerstown marl and the Manasquan marl, K.]

CORAX PRISTODONTUS (Morton).

Squalus sp. Morton, Synop. Org. Rem. Cret. U. S., 1834, p. 31. Pl. 11, fig. 6.
No locality.

Galeus pristodontus (Agassiz) Morton, Am. Journ. Sci. Art., XXVIII, 1835,
p. 277 (name only, based on above).

Galeocerdo pristodontus Gibbes, Journ. Acad. Nat. Sci. Phila., (2) I, August,
1849, p. 162, fig. 70. (Burlington Cretaceous.)

Cope, Rep. U. S. Geol. Surv. Terr. Hayden, II, 1875, p. 295. (Green-
sand of No. 5, New Jersey.)

Teeth broad, greatly compressed, and nearly wide as high. Crown greatly oblique to sometimes erect, low, and greatly compressed. Outer coronal surface usually flattened, or usually considerably less convex than inner surface, and sometimes a few basal vertical wrinkles. Latter with surface evenly convex. Apex often deflected, especially in lateral teeth. Cutting-edges finely and entirely serrated. Basal cusp sometimes present, low, broad, lateral, variable. Root very broad, deep, usually deeper than crown, compressed, surfaces slightly convex or inner flattened and sloping down below trenchant, so that lower profile is slightly emarginate. Ends of roots blunt, not produced. The lateral teeth seem to differ only in having their apices deflected to one side. Length reaches 30 mm.

This species appears closely allied with *Corax falcatus*, if not scarcely distinguishable by its less inclined lateral teeth and larger size. The example recorded by Cope as *Galeocerdo appendiculatus* from the Maryland Miocene agrees largely with figures 16 and 17 of *Corax appendiculatus* Agassiz. The latter has been suggested by Woodward to be the hinder teeth of either *Corax pristodontus* or *Corax affinis*. Eastman says¹ "what species is meant by his citation² in the same place of the *nomen nudum* '*Galeocerdo appendiculatus* Ag.' cannot now be even conjectured, as there are no specimens in the collection bearing that designation." *Galeocerdo appendiculatus* Cope is not a *nomen nudum*, but the apparently wrong allocation of *Corax appendiculatus* in the genus *Galeocerdo*, as may be attested by an examination of the single specimen in the Thomas collection labeled in

¹ Md. Geol. Surv. Miocene, 1904, p. 90.

² Cope, Proc. Acad. Nat. Sci. Phila., 1867, p. 141.

Cope's own handwriting (see Fig. 29, No. 23). I might add that Morton's name is the earliest available for this species.

Formation and locality. I have examined the following teeth in the Academy's collection: "New Jersey" 1 from the greensand without data and 3 from the Cretaceous; Monmouth

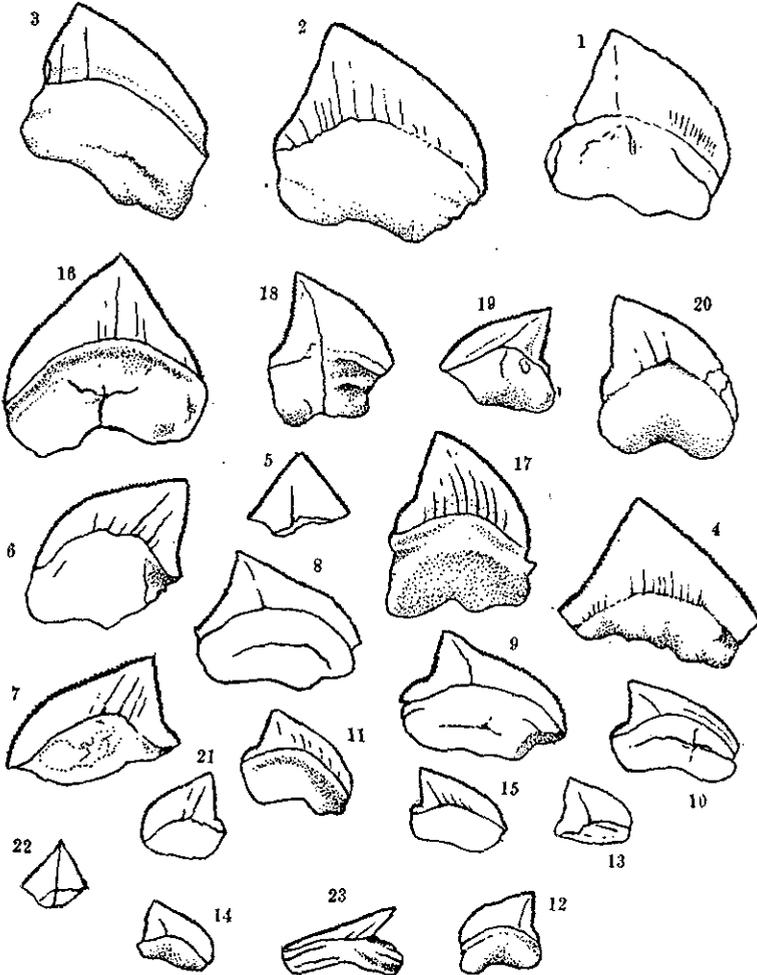


FIG. 29.—*Corax pristodontus* (Morton). *1, no data; 2-5, New Jersey; 6-14, Monmouth Co. (Slack); 15, Crosswicks (Gabb); 16-17, Vincentown (Bryan); 18-20, Pemberton (Budd); 21, Mullica Hill (Abbott); *22, one mile southeast of Crawford's Corner in Wenonah sand (J. Longstreet); 23, Charles Co., Md. (Thomas).

County 1 (C. C. Abbott), 8 (J. H. Slack); Crosswicks in Mercer County 1 (W. M. Gabb); Vincentown 2 (T. M. Bryan on May 4th, 1875), 2 (Bryan); Pemberton 3 (Bryan), 1 (C. Budd); Mullica Hill in Gloucester County 1 (Abbott).

In the Geological Survey collection I found the following: Monmouth County 1 (P. D. Knieskern) and a fragmentary crown from the Wenonah sand a little less than 1 mile southeast of Crawford's Corner (J. Longstreet's pit). [The formations represented are the Merchantville or Woodbury clay, the Wenonah sand, the Navesink-Hornerstown marl and the Manasquan marl, K.]

Family GALEORHINIDÆ.

THE REQUIEM SHARKS.

Body elongate. Head normal. Snout longitudinally and normally produced. Eyes with nictitating membranes. Gill-openings moderate, last above pectoral base. Spiracles small or obsolete. Oviparous. Dorsals 2, first high, short and entirely before ventrals. Second dorsal comparatively small, opposite anal. Tail mostly bent up from base of caudal fin, and sides without keel. Fins without spines.

This is the largest group of recent sharks, and with many closely related forms, difficult of determination, is found living in most all seas. The living forms comprise about 20 genera, and only to a few of them have fossils been referred. Also, two extinct genera have been described.

Genus GALEOCERDO Müller and Henle.

Galeocerdo Müller and Henle, Syst. Besch. Plag., 1838, p. 59. Type *Galeocerdo tigrinus* Müller and Henle, first species, restricted by Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, p. 402.

Galeodes Heckel, Sitz. Ak. Wiss. Wien, XI, 1853, p. 324. Type *Galeodes priscus* Heckel, monotypic.

Boreogaleus Gill, l. c.¹ Type *Squalus arcticus* Faber, specified, monotype.

Mouth crescent-shaped. Teeth similar in both jaws, large, oblique, coarsely serrated on both margins and with deep notch

¹ See diagnosis, p. 411.

on outer margin. Spiracles present. First dorsal opposite space between pectorals and ventrals. Caudal with double notch. Pit on tail above and below at caudal base.

Among existing species large sharks in most seas, referred to about four species. About 30 fossil species have been described.

Galeocerdo aduncus Agassiz.

Galeocerdo aduncus Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362.
(Cumberland Co. Miocene.)

Teeth compressed, broad, elevated, and rather thin. Coronal surfaces rather low, compressed, smooth, broad, pointed, and inner slightly more convex than outer, which is somewhat flattened in most cases. Apex usually deflected greatly to one side, and longer coronal margin mostly forming a very obtuse angle, sometimes nearly evenly convex. Cutting-edges finely serrated. Margin below notch with graduated serræ, those at notch largest, and generally at least four more conspicuous. No basal cusps. Root broad, compressed, deep internally and moderately convex, and externally rather concave and shallow. Lower margin usually moderately emarginate. Length 18 mm.

This species seems to be close to *Galeocerdo contortus*, and appears to differ chiefly in the coronal apex of the teeth, being flatly compressed and broad. According to Woodward, it closely resembles the living *Galeocerdo arcticus* in the dentition, but the teeth are smaller. I have identified the material here listed to some extent provisionally.

Formation and location. Known from upper Cretaceous and Miocene, where most likely the following were obtained: "New Jersey" 2 (Burit); Monmouth County 3 (P. D. Knieskern), 3 (W. Cleburne); Deal 1 (W. A. Powell); Shark River Miocene 3 (T. A. Conrad); Burlington County 4 (Conrad); Vincetown 2 (T. M. Bryan); Allowaystown in Salem County 1 without donor.

In the Geological Survey collection is a single tooth from the middle marl of Riddleton (Hackett's pits). [From the above

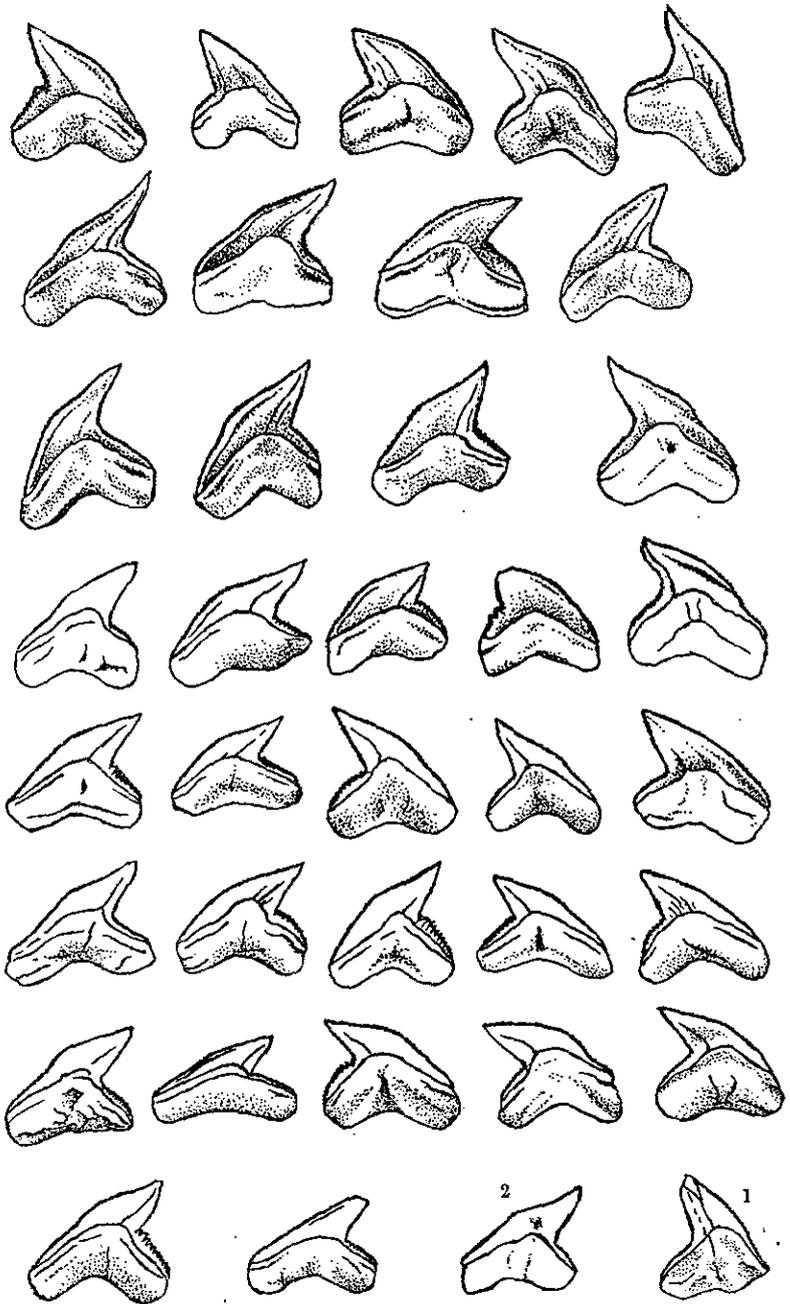


FIG. 30.—*Galeocerdo aduncus* Agassiz. 1, Monmouth Co. (Abbott); *2, Riddleton (Hackett), and others from Charles Co., Md. (Thomas).

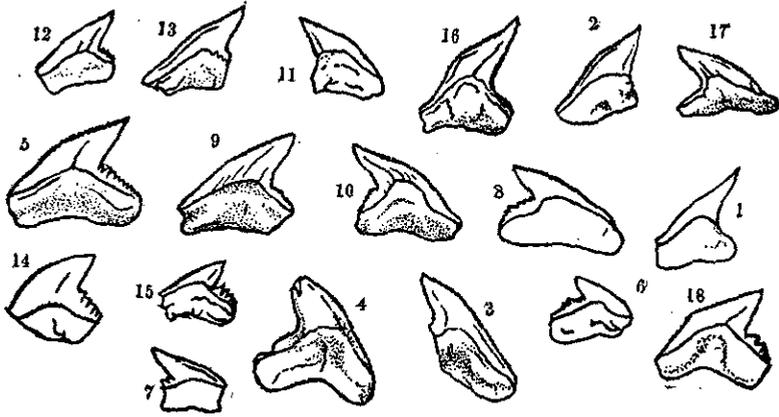


FIG. 31.—*Galeocerdo aduncus* Agassiz. 1-3, Monmouth Co. (Cleburne); 4-5, Monmouth Co. (Abbott); 6, Monmouth Co. (Knieskern); 7, Deal (Powell); 8-10, Burlington Co. (Conrad); 11-15, Vincentown (Bryan); 16-18, Allowaystown (Yarrow).

record the geologic formations are inferred to be the Navesink-Hornerstown marl, the Manasquan marl and the Kirkwood clay (Shark River Miocene) K.]

GALEOCERDO CONTORTUS Gibbs.

Teeth robust, well elevated, little compressed. Coronal surface well convex, high, and sharply pointed. Inner coronal surface, though evenly convex, scarcely more so than outer, which

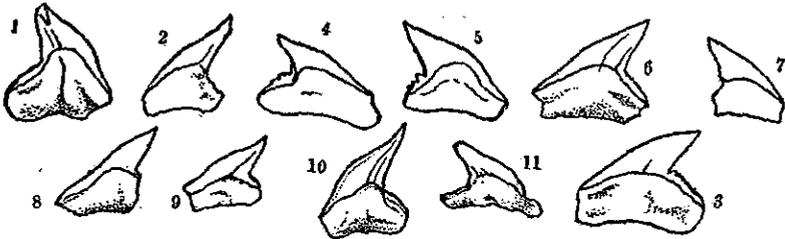


FIG. 32.—*Galeocerdo contortus* Gibbs. 1, Monmouth Co. (Abbott); 2, Monmouth Co. (Cleburne); 3, Monmouth Co. (Knieskern); 4-6, Burlington Co. (Conrad); 7-9, Vincentown (Bryan); 10-11, Allowaystown (Yarrow).

is more or less flattened basally. Apex elongated, slender or attenuated, usually well twisted, and deflected laterally. Longer

coronal margin usually a little undulated. Cutting-edges all finely serrated, margin below notch usually with slightly enlarged serræ, graduated externally. No basal cusps. Root robust, thick, outer surface depressed to slightly concave, and inner bulging convexly and extending high. Lower margin of root emarginate. Length 24 mm.

This species does not appear to have ever been recorded from New Jersey before.

Formation and locality. A plentiful species in the Maryland Miocene, and the following, except the last, are probably from the upper Cretaceous: Monmouth County 2 (C. C. Abbott), 3 (W. Cleburne), 2 (P. D. Knieskern) and 1 without donor; Burlington County 3 (T. A. Conrad); Vincentown [Manasquan marl, K.] 3 (T. M. Bryan); Allowaystown in Salem County 2 (H. C. Yarrow).

GALEOCERDO LATIDENS Agassiz.

Teeth very broad, well compressed, low, and rather thin. Coronal surfaces low, well compressed, smooth, moderately broad, pointed, outer somewhat depressed or flattened and not



FIG. 33.—*Galeocerdo latidens* Agassiz. Allowaystown (Yarrow).

quite so convex as inner. Apex usually well deflected to one side, and longer coronal margin usually rather evenly convex. Cutting-edges finely serrated. Margin below notch with graduated serræ, those at notch largest, generally several rather conspicuous. No basal cusps. Root very broad in proportion, well compressed, not very deep, outer surface a little concave and inner a little convex. Length 18 mm.

This species closely resembles *Galeocerdo aduncus* and may be distinguished with difficulty. The only conspicuous character

appears to be the broader base with the lower crown. It has not before been reported from New Jersey.

Formation and locality. I have eight teeth from near Allowaystown in Salem County, probably from the Miocene beds (H. C. Yarrow).

Genus HEMIPRISTIS Agassiz.

Hemipristis Agassiz, Poiss. Foss., III, 1843, pp. 237, 302. Type *Hemipristis serra* Agassiz, first species, restricted by Woodward, Cat. Foss. Fish. Brit. Mus., I, 1889, p. 450.

Dirrhizodon Klunzinger, Verh. Z. B. Ges. Wien., XXI, 1871, p. 664. Type *Dirrhizodon elongatus* Klunzinger, monotypic.

Body elongated. Teeth elevated, triangular, mostly curved or inclined backward towards apex, both coronal edges becoming coarsely serrated. Root divided with two divergent branches. Upper teeth relatively large, broad, flat. Front lower teeth slender, subulate, curved inward, without denticles or only one or two minute basal points. Gill-openings wide. First dorsal close behind pectoral base. Second dorsal over anal. Caudal with upper lobe much longer, notched near end.

A single living species in the Red Sea, and seven extinct species have been described.

HEMIPRISTIS SERRA Agassiz.

Hemipristis serra Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Lateral teeth broadly triangular, well compressed, and with moderate thickness. Crown elevated, well compressed, falcate, surfaces convex, but outer slightly flattened, and smooth. Sometimes a few short basal wrinkles vertically on outer surface. Cutting-edges strongly serrated, serræ becoming slightly enlarged, or remaining subequal in size well on apex, though not extending to its tip. Apex usually strongly deflected laterally, usually inner serræ more numerous and much smaller than those on external edge. Often surfaces of crown are slightly twisted or undulated in places, giving quite irregular profiles. No basal cusps. Root well compressed, inner surface often flattened or

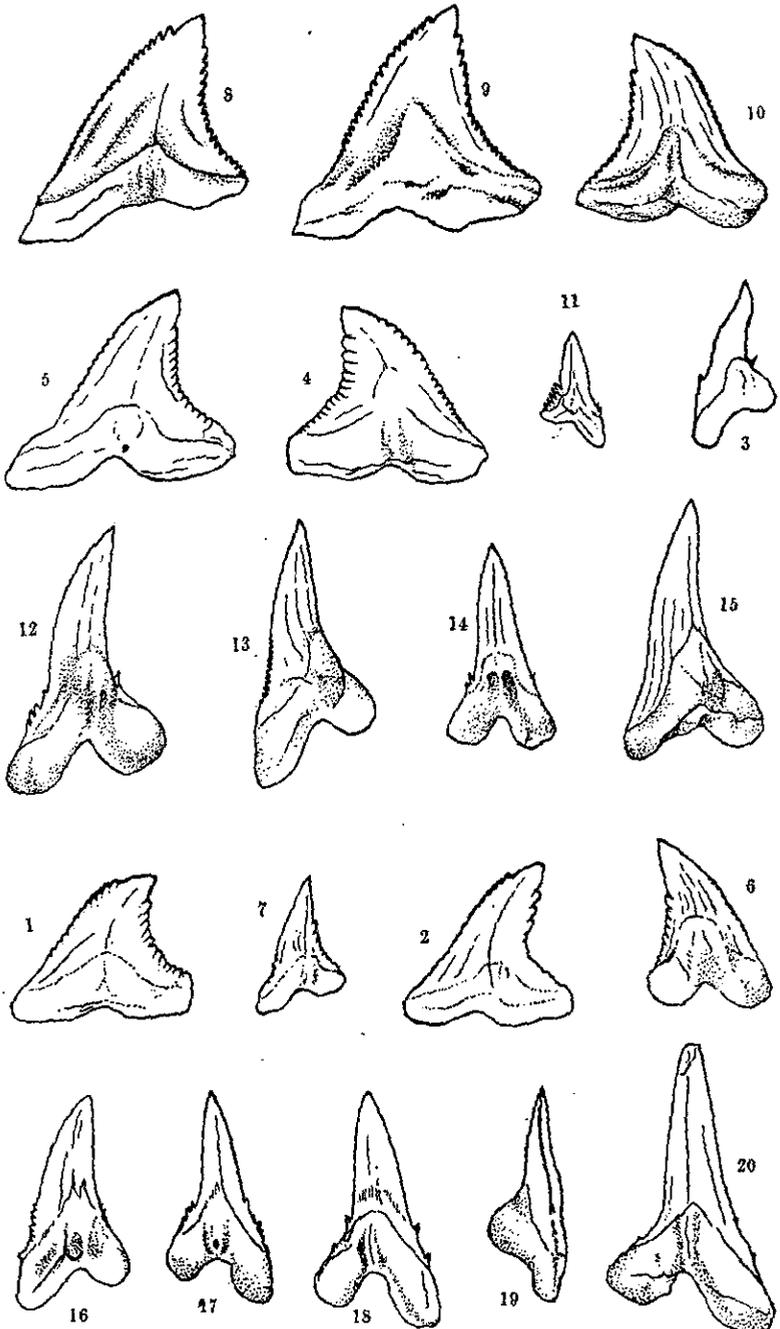


FIG. 34.—*Hemipristis serra* Agassiz. 1-2, Pemberton (Bryan); *3, Vincentown (Dick); 4-5, Salem Co. (Uhler); 6-7, Allowaystown (Yarrow); 8-20, Charles Co., Md. (Thomas).

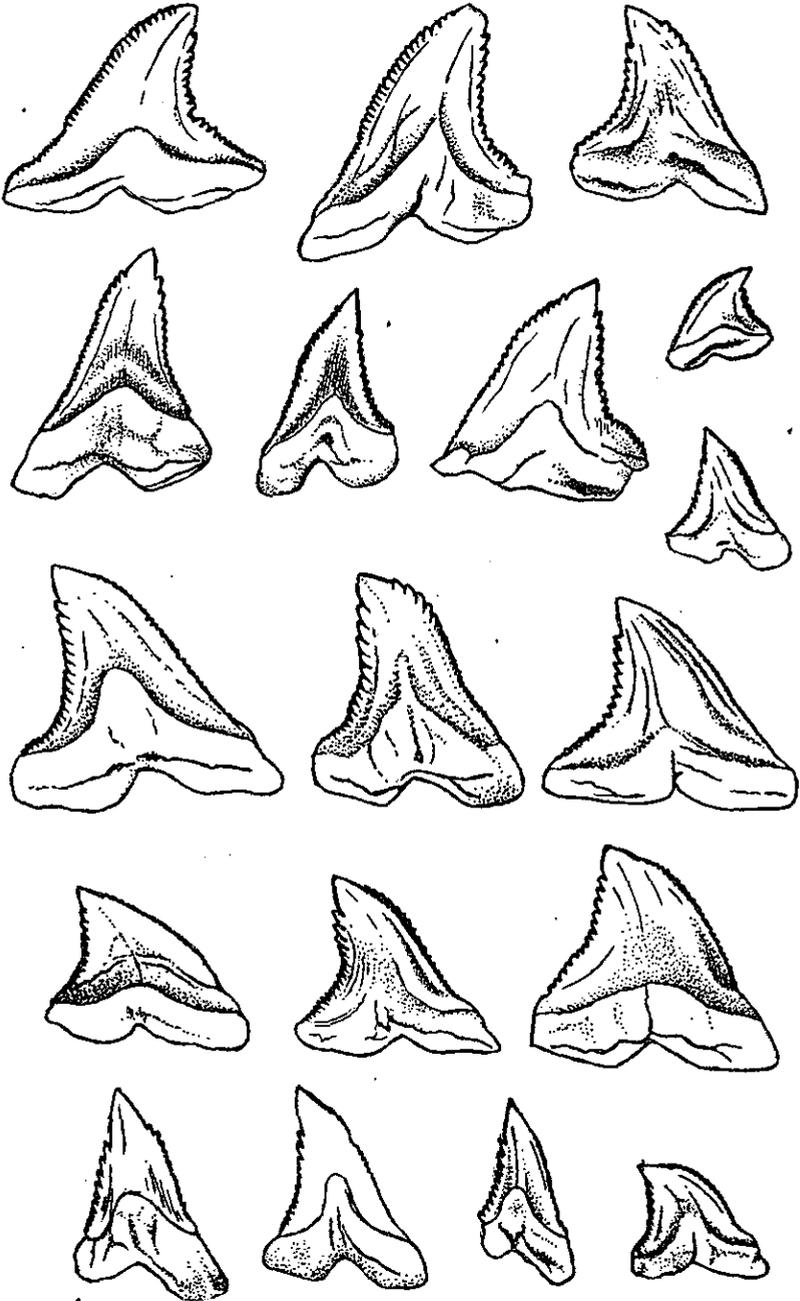


FIG. 35.—*Hemipristis serra* Agassiz. Charles Co., Md. (Thomas).

concave, and outer moderately convex. Ends of root widely diverging, and lower edge usually a little emarginated medianly. Cutting-edges of lower front teeth very sharp or blade-like along each edge of crown for apical half. These teeth also differ in often having no serratures, and others show one to twelve basally. They also have a very swollen or protruding inner base, frequently with a median sulcus, and the ends of the root are often markedly unequal. Length reaches 4 cm.

This is a strongly marked form, and only the median slender lower teeth somewhat suggest *Isurus* or *Lamna*, but are much thicker. Most all of Agassiz's figures agree with my material.

Formation and locality. I have examined the following from New Jersey: Monmouth County 11 (P. D. Knieskern); Long Branch 1 without donor; Pemberton 2 (T. M. Bryan) and Vincentown 1 (Bryan) in Burlington County; Mullica Hill in Gloucester County 1 (W. M. Gabb); Allowaystown 9 (H. C. Yarow); in Salem County 5 (P. Uhler).

I have also examined a tooth in the Geological Survey collection from Shiloh in Cumberland County (E. Davis). [From the above citation of localities the specimens are probably from the Navesink-Hornerstown marl, the Manasquan marl of Cretaceous and from the Kirkwood formation of the Miocene, K.]

Genus GLYPHIS Agassiz.

Glyphis Agassiz, Poiss. Foss., III, 1843, p. 243. Type *Glyphis hastalis* Agassiz, monotypic.

Cynocephalus (Klein) Walbaum, Pet. Arted. Gen. Pisc., III, 1792, p. 579.

Type *Squalus glaucus* Linnæus, second species, virtually restricted by Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, p. 401. (Name considered inadmissible as simply a reprint, also preoccupied.)

Prionodon Müller and Henle, Syst. Besch. Plag., 1838, p. 35. Type *Squalus glaucus* Linnæus, first species. (Name preoccupied.)

Prionace Cantor, Journ. Asiat. Soc. Bengal, XVIII, 1849, p. 399. Type *Squalus glaucus* Linnæus, virtually as this name is proposed to replace *Prionodon*.

Body slender. Head rather long, slender. Teeth in both jaws strongly serrated in adult, those in upper broad and lower narrower, straight and claviform. No spiracles. Embryo not attached to uterus by a placenta. First dorsal large, inserted

midway between pectoral axils and ventrals. Second dorsal much smaller than first, usually not larger than anal.

Large, slender, swift, voracious sharks in warm seas, comprising about two existing and 27 extinct species.

GLYPHIS EGERTONI (Agassiz).

Galeocerdo egertonii Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Glyphis subulata Gibbs, Journ. Acad. Nat. Sci. Phila., (2) I, August, 1849, p. 194, Pl. 25, figs. 86-87. (New Jersey Greensand, from Wetherill.)

Teeth broadly triangular, well compressed. Crown compressed, erect or moderately inclined, and notched on each margin, though posterior or external most conspicuous. Surfaces smooth, convex on inner and outer flattened, latter sometimes with a few vertical basal folds or wrinkles. Cutting-edges finely and conspicuously serrated, the serratures usually extending to the apex. Apex pointed, sometimes deflected. No basal cusps. Root compressed, outer surface depressed or concave and inner moderately convex. Ends of root widely divergent, and lower margin usually emarginate. Length about 17 mm. in larger.

The lower teeth are said to be probably narrower than the upper. The specimens I have listed all appear to belong to this species, though the differences between *Aprionodon gibbesii*, *Sphyrna prisca* and *Glyphis egertoni* are scarcely evident in some cases. The latter may, to some extent, be characterized by its broad upper teeth.

Formation and locality. The following teeth are probably from the upper Cretaceous or Miocene beds [the Navesink-Hornerstown bed marl, the Manasquan marl, the Kirkwood formations, K.], though no such information is given on any of the labels. Monmouth County 2 without donor, 2 (P. D. Knieskern), 26 (Knieskern, W. Cleburne, C. C. Abbott); Burlington County 13 (T. A. Conrad); Vincentown 15 (T. M. Bryan); Mullica Hill in Gloucester County 3 (Abbott); Allowaystown in Salem County 48 (H. C. Yarrow).

The following teeth in the collection of the Geological Survey are probably this species: Monmouth County 1 (Knieskern), 2

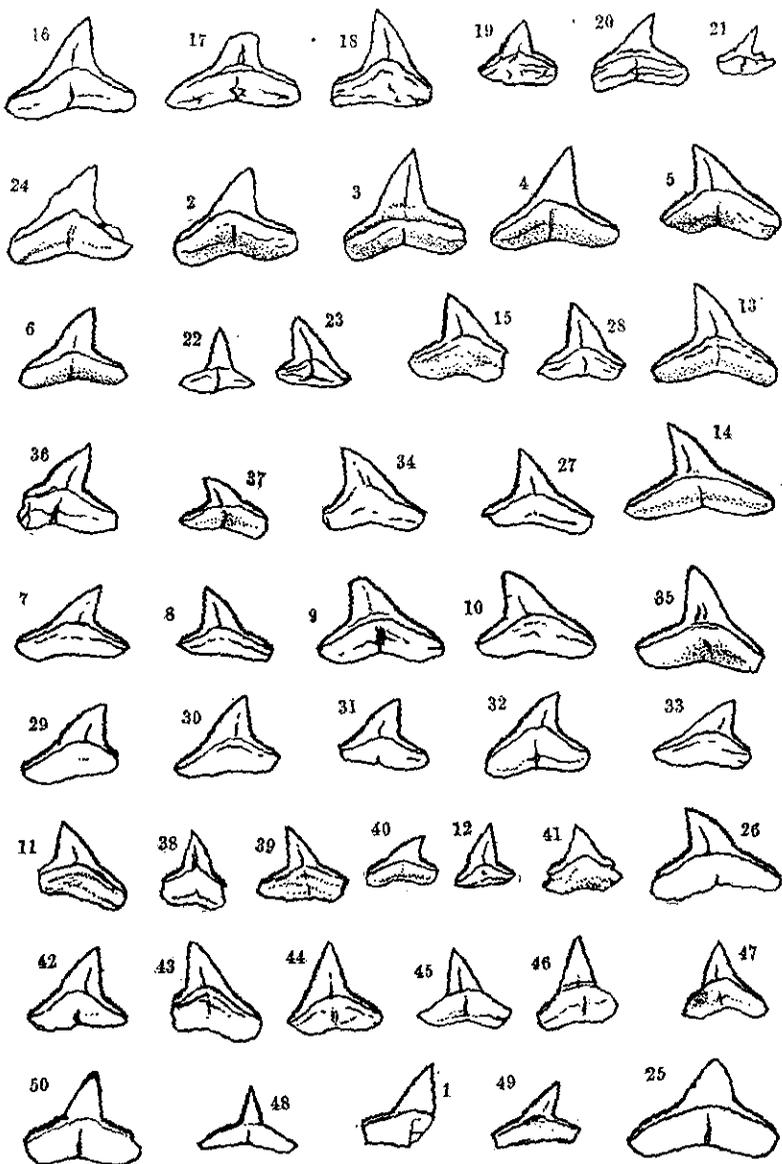


FIG. 36.—*Glyphis egertoni* (Agassiz). *1, no data; 2-11, Monmouth Co. (Knieskern, etc.); 12, Monmouth Co. (Knieskern); 13-15, Burlington Co. (Conrad); 16-24, Vincentown (Bryan); *25, Vincentown (Dick); 26, Mullica Hill (Abbott); 27-47, Allowaystown (Yarrow); *48-49, Riddleton (Hackett); *50, no data.

from the middle mari at Riddleton (Hackett's pits) and 1 without data.

Family SPHYRNIDÆ.

THE HAMMER-HEAD SHARKS.

Mouth crescent-shaped, under "hammer." Teeth in jaws similar, oblique, each with notch on outside near base. Nostrils anterior and eyes on side of "hammer." Last gill-opening over pectoral. No spiracles. First dorsal and pectorals large, and dorsals nearer pectorals than ventrals. Second dorsal and anal small. Pit at caudal root, single notch towards fin tip.

Large sharks, among living forms easily distinguished by the peculiar form of the head, which is slightly different in each species. Though a number of generic names have been proposed, they are now generally referred to the single genus *Sphyrna*.

Genus SPHYRNA Rafinesque.

Sphyrna Rafinesque, Ind. It. Sicil., 1810, pp. 46, 60. Type *Squalus zygena* Linnæus, virtually first species, restricted by Jordan and Gilbert, Bull. U. S. Nat. Mus., 1882, p. 26.

Sphyrna, auct.

Cestracion (Klein) Walbaum, Pet. Arted. Gen. Pisc., III, 1792, p. 580. Type *Squalus zygena* Linnæus, virtually first species, restricted by Gill, Ann. Lyc. N. Hist. N. Y., VIII, 1861, p. 37.

Sphyrnias Rafinesque, Analyse de la nature, 1815, p. —? Type *Squalus zygena* Linnæus, virtually, as this name is offered to replace *Sphyrna* considered too short.

Cestrorhinus Blainville, Bull. Soc. Philomath. Paris, 1816, p. 121. Type *Squalus zygena* Linnæus, first species.

Zygena Cuvier, Règne Animal, II, 1867, p. 27. Type *Squalus zygena* Linnæus, first species, by tautonomy, but preoccupied in insects.

Zygena, auct.

Platysqualus Swainson, Lard. Cab. Cyclop. N. H., II, 1839, p. 318. Type *Squalus tiburo* Linnæus, monotypic.

Eusphyrna Gill, Ann. Lyc. N. Hist. N. Y., VII, 1862, pp. 403, 412. Type *Zygena blochii* Cuvier, designated, monotypic.

Reniceps Gill, l. c. Type *Squalus tiburo* Linnæus, designated, monotypic.

Characters of the genus expressed in those of the family.

About six existing species have been described, grading almost perfectly from the narrow hammer of *Sphyrna blochii* to that of

the kidney-shaped head of *Sphyrna tiburo*. The fossils are only known from detached teeth, which seem to be largely doubtfully located in this genus, owing to their close resemblance to those of *Eulamia*, and are referred to six species.

SPHYRNA GIBBESII Hay.

Teeth compressed, triangular and moderately thick. Crown moderately large, compressed, sharp-pointed, its base width about one-half its height, outer face flattened and inner evenly convex, surfaces smooth. Apex slightly deflected. Cutting-edges entire. At base of crown 3 or 4 broad-pointed cusps, graduated down externally till outer are quite small. Edges of cusps entire, though trenchant. Root rather wide, moderately thick, inner surface flattened or slightly concave, and outer surface moderately swollen convexly. Lower edge of root a little emarginate. Length 8 mm.



FIG. 37.—*Sphyrna gibbesii* Hay. Monmouth Co. (Knieskern).

My examples seem to be this species, which appears to be characterized by its small size, entire cutting-edge and enlarged basal cusps. They agree largely with Gibbes' figure of *Sphyrna denticulata*. The species has not before been recorded from New Jersey.

Formation and locality. I have six teeth from Monmouth County (P. D. Knieskern). These are without definite indication as to which of the Cretaceous beds they were found in, but presumably the upper would be correct.

SPHYRNA PRISCA Agassiz.

Zygæna prisca Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Cumberland Co. Miocene.)

Lateral teeth well compressed, with broad base, triangular. Crown small, narrowly triangular, compressed somewhat smooth, outer surface flattened and inner surface evenly convex.

Outer basal surface rarely with several short wrinkles. Apex deflected more or less laterally, slender-pointed. Cutting-edges finely serrated and serræ of about more or less even size. Lateral coronal margins long, but little less than rest of crown itself when measured to notches, and low. Serræ always more or less conspicuous on these lateral crown margins, even when obsolete or absent on coronal margin above notches. No basal cusps. Root compressed, usually wide, conspicuous, depressed or concave externally, and inside swelling slightly convex. Ends of

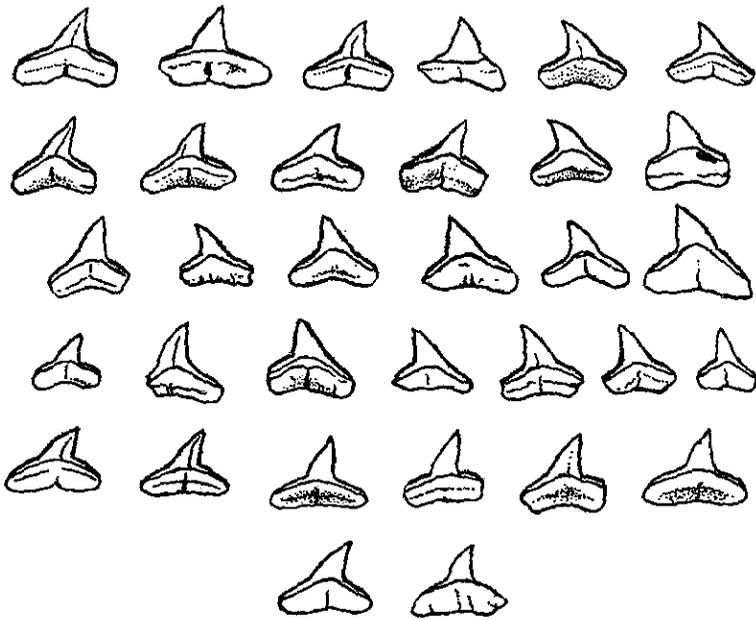


FIG. 38.—*Sphyrna prisca* Agassiz. Charles Co., Md. (Thomas).

roots widely diverging, so that lower edge is concave or at least slightly notched medianly. Length reaches 15 mm. This description from a series of examples from the Maryland Miocene.

This species is close to *Glyphis egertoni*, and possibly material identified with it may belong to that species, but, following Cope, I have allowed it all to fall with the present provisionally. The crown in most of the examples is conspicuously narrow or small, and the root is mostly very wide. Several examples with extremely wide roots suggested a new species to Cope, but they

are scarcely different in other respects. They have been called *Carcharias collata* by Eastman. I have not examined any New Jersey material.

Formation and locality. Known only by Cope's record from the Miocene of Cumberland County.

Order BATOIDEI.

THE RAYS.

Body typically disk-like, broad, flat, margin of disk usually formed by expanded pectorals. Tail comparatively slender. Gill-openings inferior, slit-like, 5 in number. Spiracles present. Vertebrae cyclospondylous, or each one with internal calcareous lamellæ not radiating, arranged in one or more concentric circles or series around central ring. Dorsal fins inserted on tail when present. No anal fin. Caudal fin small or wanting.

The extremes of specialization in this group widely depart from the typical sharks, though many intergradations render them nearly complete. As many fossils have been found, they probably evolved quite early. Except the Rajidæ, most all the members of this group are ovoviviparous.

Sub-Order SARCURA.

Tail comparatively thick, with two dorsals and a caudal fin, but no serrated caudal spine.

About four families are usually admitted, and all represented by at least a few fossils.

Family PRISTIDÆ.

THE SAW FISHES.

Body elongate, depressed. Snout saw-like, much produced, flat, armed with strong teeth on each side set at right angles to its axis. No tentacles. No nictitating membrane. Teeth in

jaws minute, obtuse. Nostrils inferior. Gill-openings moderate, inferior. Spiracles wide, behind eye. Dorsal fins large, without spines, first nearly opposite ventrals. Caudal well developed, bent upward. A fold along each side of tail. Pectorals moderate, front margin quite free and not reaching to head.

Large shark-like rays, with the disk gradually passing into the tail, found in most warm seas about sandy shores. A single existing genus, the exact batoid prototype of the Pristiophoridae. The fossil species of this family are all provisional, being known chiefly by rostral teeth, fragments of the rostrum, detached vertebrae, etc., thus rendering the descriptions too imperfect for final determination. They have been referred to three genera, besides to the existing *Pristis*.

Genus PRISTIS Linck.

Pristis Linck, Mag. P. Naturg. Gotha, VI, 1790, p. 31. Type *Squalus pristis* Linnæus, monotypic.

Pristobatus Blainville, Bull. Soc. Philomath. Paris, 1816, p. 121. Type *Pristis antiquorum* Latham, first species.

Pristibatis, *Pristobatis*, auct.

Myriosteon Gray, Proc. Zool. Soc. Lond., 1864, p. 163. Type *Myriosteon higginsii* Gray, monotypic. (Proposed as "probably indicating a new group of Echinodermata," though really based on one of the hollow cartilaginous rostral rods of *Pristis*.)

Pristiopsis Fowler, Proc. Acad. Nat. Sci. Phila., 1905, p. 459. Type *Pristis perrotteti* Müller and Henle, designated.

Eopristis Stromer, Beitr. Pal. Oester. Ung., XVIII, 1905, p. 52 (16). Type *Pristis (Eopristis) reinachi* Stromer, monotype.

Characters of the genus expressed in those of the family.

About eight existing species are known, and about 19 extinct species have been described.

PRISTIS AMBLONDON Cope.

Pristis amblodon Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 312. *New Jersey Eocene Greensand*.

Hussakof, Bull. Amer. Mus. Nat. Hist. N. Y., XXV, 1908, p. 34, fig. 11 (types).

Rostral teeth well compressed. Front margin convex, and surface smooth. Hind margin convex and smooth. Length of smaller example (imperfect) 26 mm.

The two fragmentary examples I have, evidently of this species, both show their front and hind edges convex. Cope pointed out this character originally, adding that both edges were also curved to the tip, though one curvature greater than the other. Further,

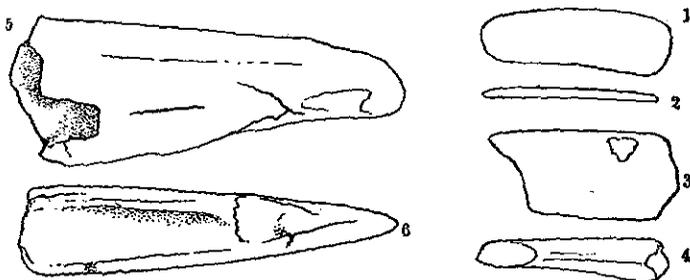


FIG. 39.—*Pristis amblodon* Cope. 1-4, Monmouth Co. (Cope); 5-6, Pemberton (Bryan).

he says the teeth are not curved out of the horizontal plane, and his example measured 32 mm.

Formation and locality. Two examples described above, rostral teeth from Monmouth County (E. D. Cope), are credited by Cope to the New Jersey Eocene.

PRISTIS CURVIDENS Leidy.

Pristis curvidens Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 414. Near Pemberton, N. J., Greensand.

Teeth of rostrum well compressed. Front margin evenly convex and surface smooth. Hind margin slightly concave, sometimes a little oblique on sinistral surface, and each edge distinct or a trifle trenchant or keeled. Distal edge of front margin more suddenly convex than hind margin, and convexity of former begins more distally. Teeth nearly or quite level in horizontal plane to well decurved. Length reaches 96 mm.

This species seems to be characterized chiefly by having its rostral teeth considerably curved downward. The type was about 22 cm. long.

Formation and locality. The following examples in the collection of the Academy, all rostral teeth, have been examined: Monmouth County 1 (P. D. Knieskern); Burlington County 1

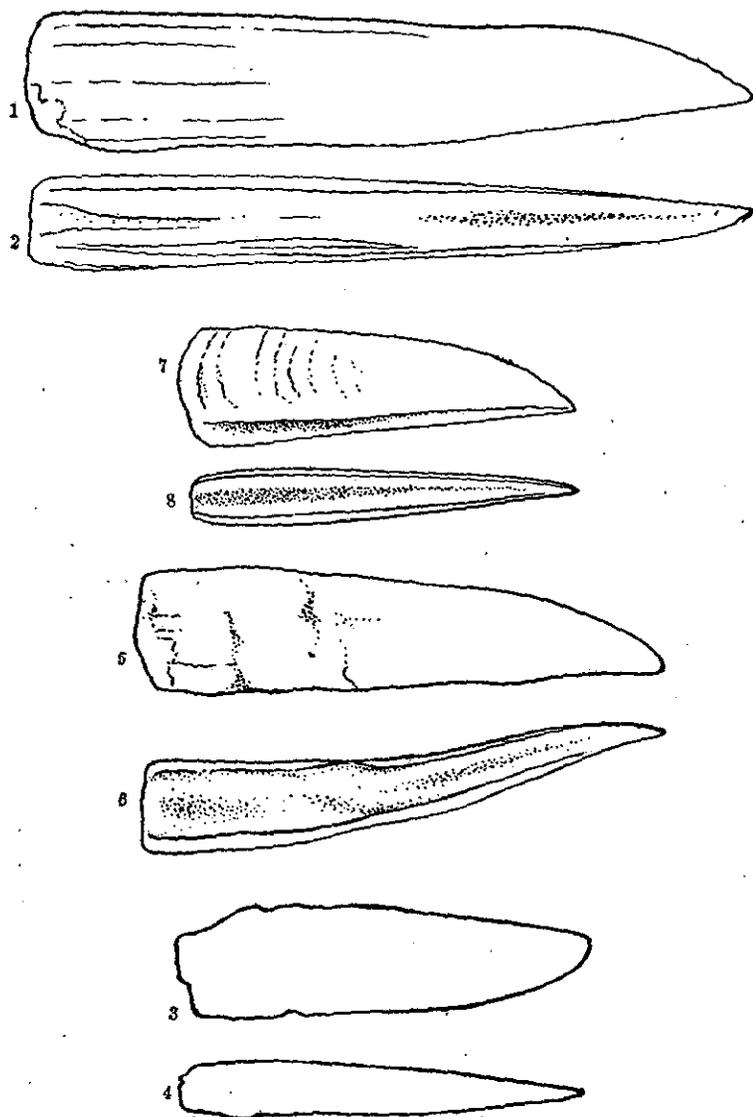


FIG. 40.—*Pristis curvidens* Leidy. 1-2, Monmouth Co. (Knieskern); *3-4, Monmouth Co. (Knieskern); 5-6, Burlington Co. (Conrad); 7-8, Vincentown (Bryan).

(T. A. Conrad); Vincentown 1 without donor and Pemberton 1 (T. M. Bryan).

I have also seen a rostral tooth in the collection of the Geological Survey without data. So far as determinable, the geologic horizon is probably the Manasquan marl.

Sub-Order MASTICURA.

Tail comparatively slender, dorsal fin single or wanting, and tail above usually armed with one or more serrated spines.

This group comprises four families, of which the *Ptychodontidæ* are entirely extinct. Of the latter *Ptychodus mammillaris* Agassiz has been ascribed to the Cretaceous of Delaware, though no representatives have been found in New Jersey.

Family MYLIOBATIDÆ.

THE EAGLE RAYS.

Disk broad. Nasal valves forming rectangular flap with posterior margin free and attached by frenum to upper jaw. Oviparous. Skull less depressed than usual among rays, its surface raised so that eyes and spiracles are lateral in position. Skin smooth. Tail very long, slender, whip-like, with single dorsal near its root, behind which is usually a strong retrorsely serrated spine. Pectorals ceasing at sides of head and reappearing in front of snout as one or two cephalic fins supported by fin rays. No differentiated spines in pectorals in males, sexes similar. Ventrals not emarginate.

The existing forms large sting rays in warm seas, feeding chiefly on mollusks, which they crush with their large grinding teeth. All the known six genera are represented by extinct species, though only three of the former have persisted till the present time.

Genus MYLIOBATUS G. St. Hilaire.

Myliobatis G. St. Hilaire, Descr. Egypt, 1809, Pl. 26, fig. 1. Type *Myliobatis bovina* G. St. Hilaire, second species.

Myliobates, auct.

Ictætus Rafinesque, Analyse de la nature, 1815, p. 93 (nom nud.).

Ptychopleurus Agassiz, Poiss. Foss., III, 1838, Pl. 45, figs. 1-3. Type *Ptychacanthus faujasii* Agassiz, virtually monotypic.

Holorhinus Gill, Proc. Acad. Nat. Sci. Phila., 1862, p. 331. Type *Rhinoptera vespertilio* Girard, virtually monotype.

Bates Probst, Jahresh. Ver. Vaterl. Naturk. Württ., XXXIII, 1877, p. 88. Type *Bates spectabilis* Probst, monotypic.

Disk broad, pectoral fins not continued to snout end, ending on head sides, and reappearing on snout front as one or two cephalic fins supported by fin-rays. Tail very long, slender, whip-like, with single dorsal fin near root, behind latter usually strong retrorsely serrated spine. Nasal valves form rectangular flap, hind edge free, attached by frenum to upper jaw. Teeth hexangular, large, flat, tessellated, median usually broader than others. Skull less depressed than usual among rays, surface raised so eyes and spiracles are lateral in position. Ovoviviparous. Skin smooth, without pectoral spines, and sexes alike. Ventrals not emarginate.

The existing species, about 15, are large sting-rays feeding largely on mollusks which they crush with their large grinding teeth. They are found in most all warm seas. About 80 extinct species have been described.

MYLIOBATIS BISULCUS (Marsh).

- Myliobates bisulcus* Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 229.
Eocene greensand of Monmouth Co., N. J.
 Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 239 (remarks).

Dental plate with central row of teeth marked along median line by a deep groove, otherwise remarkably smooth and flat. (Marsh.)

The account by Marsh is insufficient, and the species may be considered purely nominal until further elucidated. Leidy thinks *M. fastigiatus* may be the lower dental plate, in which case Marsh's name would have priority.

Formation and locality. The type was originally in the Museum of Yale College, and was from the Eocene [Shark River K.] greensand of Monmouth County.

MYLIOBATIS FASTIGIATUS (Leidy).

- Myliobates fastigiatus* Leidy, Proc. Acad. Nat. Sci. Phila., 1876, p. 86. *Monmouth Co., N. J. Eocene.* (No description).
 Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 238, Pl. 31, fig. 11, Pl. 33, fig. 6 (types).
Myliobatis fastigiatus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 32 (type).

Dental plate arched in form, composed of nine median teeth and a row of about four lateral teeth on each side. Enamel surface convex, with strong median and lesser convex transverse lateral convexity, so that surface is undulated. Basal surface presents concave surface sloping each side from median range, though latter with convex surface and not sharply defined. Transverse

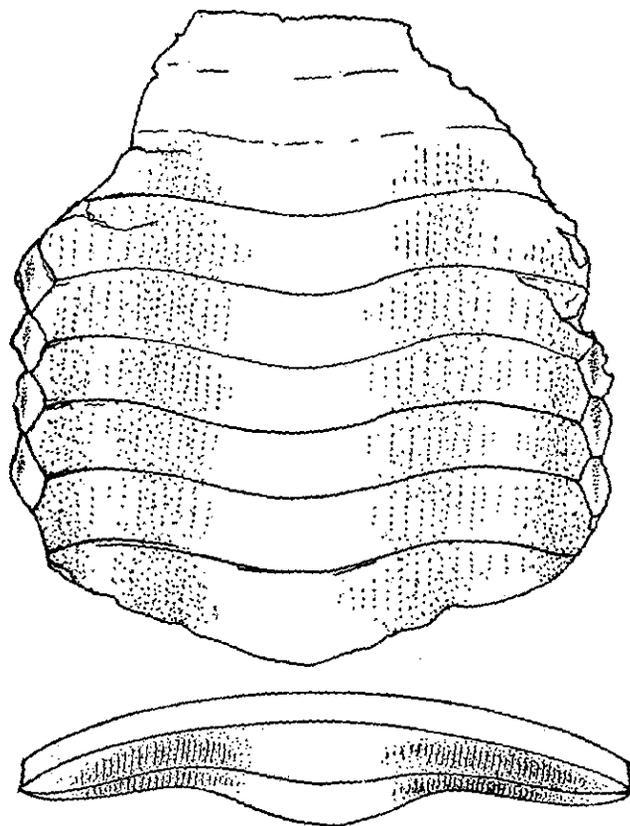


FIG. 41.—*Myliobatis fastigiatus* (Leidy). (Type.) Monmouth Co. (Cleburne).

median sutures backward in median convexity and forward on concave depressions. Vertical diameter of median teeth about one-seventh horizontal diameter, their surfaces with feeble vertical wrinkles in concave depressions and on lateral depressions, otherwise nearly smooth. Lateral small teeth rather hexagonal, horizontal diameter about three-fifths to two-thirds vertical diam-

eter, and surface of each with a depression. Length (width) 82 mm.

Known from the type described above and a paratype. Both are thought to be the upper dental plates, anteriorly abraded by the attrition of food. Leidy suggested *M. bisulcus* may possibly prove to be the lower jaw of this species, as it has a median deep groove. The other example he describes has seven large median transverse teeth in its dental plate. Although Hussakof has

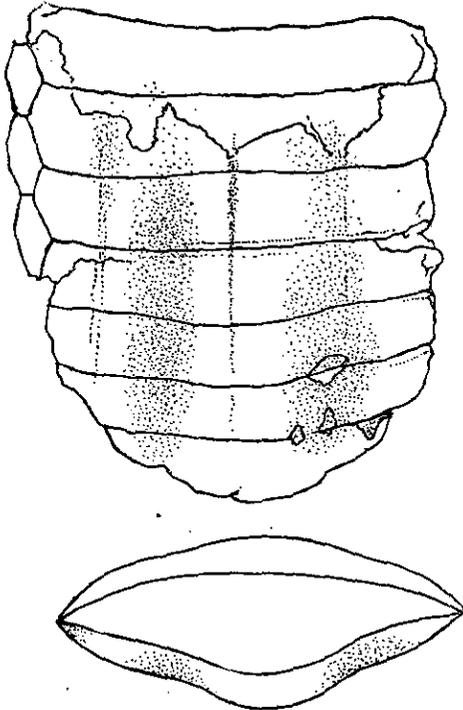


FIG. 42.—*Myliobatis fastigiatus* (Leidy). (Paratype.) Monmouth Co. (Slack).

listed an example of this species as typical and being in the American Museum in New York, the original of Leidy's figure 11 is in the Academy. Further, his example is said to be an upper dental pavement with 11 median and several small lateral teeth. Leidy states that this example has seven median teeth, together with three small teeth of the first row of one side.

Formation and locality. Known from the Eocene of Monmouth County by the type (W. Cleburne) and one paratype (J. H. Slack).

MYLIOBATIS GLOTTOIDES Cope.

Myliobatis glottoides Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 293.
Eocene bed at Farmingdale, Monmouth Co., N. J.

Hussakof, Bull. Amer. Mus. Nat. Hist. N. Y., XXV, 1908, p. 32, fig. 8
(type).

Dental plate convex in longitudinal as well as transverse direction, composed of eight teeth, and lateral portions on either side each slightly convex, and thin off to single series of lateral teeth. On median line teeth suddenly swollen, forming together broad,

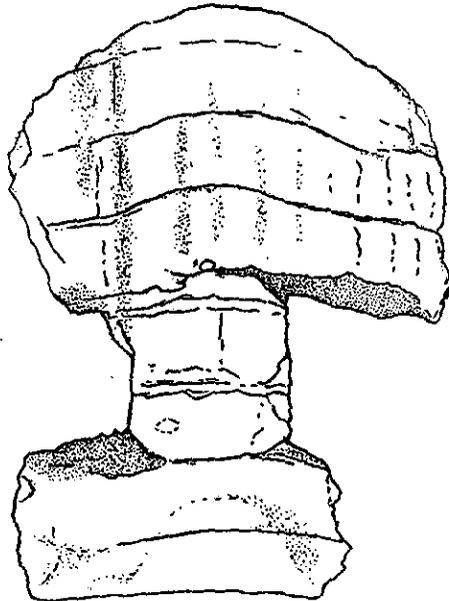


FIG. 43.—*Myliobatis glottoides* Cope. (From Hussakof.)

obtuse median ridge. Transversely each tooth is nearly straight, extremity slightly and abruptly curved backwards. Worn surface forms sub-triangular concavity. Basal surface obtusely angulate in median line below. Vertical diameter of median teeth about one-fourth horizontal diameter. Length (width) about 60 mm. (damaged). (Largely from Cope.)

Cope says this species is thick-toothed like *Myliobatis pachyodon* Cope and *Myliobatis holmesii* Agassiz, but they are not so

clearly three-ribbed in section as this one. *Myliobatis obesus* is somewhat similar, but much wider, with more curvature of teeth and biserial laterals. Each tooth is both wider (longer) and deeper than in most of the described species.

Formation and locality. Known from the Eocene [Shark River marl K.] of Farmingdale in Monmouth County. I have not examined any specimens.

MYLIOBATIS MAGISTER (Leidy).

Dental plate depressed in form, thick, composed of six median teeth, and apparently no traces of lateral teeth. Enamel surface convex, with slight median concave longitudinal depression, so

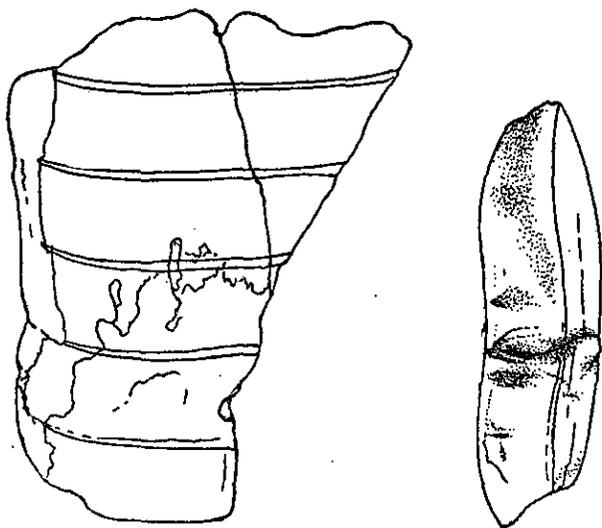


FIG. 44.—*Myliobatis magister* (Leidy). Vincentown (Bryan).

that surface is double convex with each side sloping down strongly convex. Basal surface presents convex surface sloping each side from median longitudinal convexity. Transverse median sutures nearly horizontally straight, or curving slightly posteriorly each side. Vertical diameter of median teeth about $4\frac{7}{8}$ of horizontal diameter (imperfect) and their surfaces almost entirely smooth. Length (width) about 60 mm. (damaged).

The above-described fragment is the only example I have seen from our limits, and seems to agree with *Myliobatis magister*, which species has not been recorded before from New Jersey. It is evidently a lower dental plate. Eastman has pertinent remarks concerning this species.¹

Formation and locality. One example from Vincentown (T. M. Bryan) from the marl [Manasquan, K.].

MYLIOBATIS JUGOSUS (Leidy).

Myliobates jugosus Leidy, Proc. Acad. Nat. Sci. Phila., 1876, p. 86. (Eocene marl beds of Burlington Co., N. J.) (No description).
Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 240, Pl. 31, figs. 4-5. *Vincentown, Burlington Co., N. J.*

Transverse tooth nearly straight, ends angular and possibly articulated with small lateral hexagonal teeth. Crown forms thick median, transversely convex prominence, with sides extended, outwardly thin. Triturating surface transversely convex on median prominence and becoming nearly flat on its reflected sides. An-

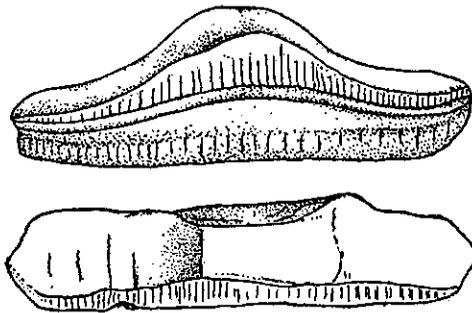


FIG. 45.—*Myliobatis jugosus* (Leidy). (From Leidy.)

terior inclining surface of crown and projecting posterior surface indicate somewhat imbricated arrangement of median teeth. Base of crown opposite median eminence concave, and this curvature at sides slightly deflected. Root straight on its attaching surface. Vertical diameter about five in horizontal diameter. Length (width) about 63 mm. (From Leidy.)

¹ Md. Geol. Surv. Eocene, 1901, p. 100, Pl. 12, fig. 3, Pl. 13, figs. 1a, 1b.

Leidy notes that the above tooth at the median prominence is no thicker than in the smaller of the dental plates described as *Myliobatis fastigiatus*, while it is considerably broader. The prominence appears as an exaggeration of the median ridge of the dental plate of *M. fastigiatus*, due to the more abrupt depression of the sides of the crown. In this specimen the coronal eminence is unsymmetrical.

Formation and locality. Only the above-described tooth, said to be from the Eocene [Manasquan ? K.] marl beds at Vincetown, in Burlington County (T. M. Bryan), and presented to the Academy of Natural Sciences of Philadelphia. I have not located this specimen.

MYLIOBATIS LEIDYI Hay.

Myliobatis leidy Hay, Amer. Nat. XXXIII, 1899, p. 785 (name based on Leidy).

Myliobates serratus (nec Meyer 1848) Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 239. *Greensand of Burlington Co., N. J.*

Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 239, Pl. 32, fig. 5. (Pemberton Eocene, same example.)

Dental plate depressed in form, composed of six median teeth and a single series of lateral teeth on each side. Triturating sur-

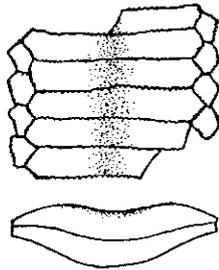


FIG. 46.—*Myliobatis leidy* Hay. (From Leidy.)

face of plate dull, but slightly impressed along median line, inclines forward and downward on first tooth, apparently as result of wearing. Transverse sutures of median teeth gently curved with convexity backward. Lateral teeth hexagonal, nearly broad as fore and aft wide. Sutures generally, especially outer parts

of median transverse sutures and those uniting median and lateral teeth, as well as these together, remarkable for their unusually serrulate condition. Root surface slopes strongly in each side from median line. Vertical diameter of median tooth about one-sixth of horizontal. Length (width) about 27 mm. (From Leidy.)

Leidy originally identified this species with *Myliobatis serratus* Meyer, though according to Hay, as the latter was from the lower Miocene, he names Leidy's specimen *M. leidyi*. Leidy also pointed out its resemblance to the dental armature of *Myliobatis toliapicus* Agassiz and *M. suturalis* Agassiz.

Formation and locality. Known only from the above-described dental plate ascribed to the [Manasquan, K.] marl of Pember-ton in Burlington County (C. H. Budd). I have not located it in the collection of the Academy, where it was originally deposited.

MYLIOBATIS RECTIDENS Cope.

Myliobatis rectidens Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 294.

Harrisonville, Gloucester Co., N. J. Miocene?

Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 32, fig. 9 (type).

Dental plate apparently depressed in form, composed of seven median teeth and at least two series of lateral teeth each side. Median teeth entirely plane and with perfectly transverse sutures, the series very slightly convex in both directions. Vertical diameter of median teeth about five in horizontal diameter. Several of lateral teeth in inner series at least wider than long. Length (width) about 70 mm. (damaged). (Largely from Cope.)

Cope says this species resembles *Myliobatis gigas* Cope, though in the latter there are twice as many, or 12, teeth in a series of the same length and width as the present. In this species the median series are straight and in *Myliobatis gigas*¹ are recurved at the extremities.

Formation and locality. The type specimen now in the American Museum of New York seems to be the only one known. Cope

¹ Eastman identifies *Myliobatis vicomicanus* Cope with this species in Md. Geol. Surv. Miocene, 1904, p. 73, Pl. 28, figs. 3a, 3b, Pl. 29, figs. 1a, 1b.

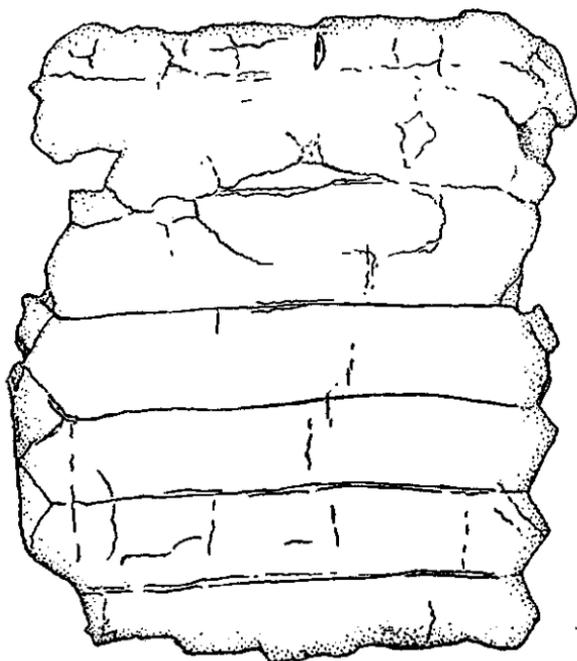


FIG. 47.—*Myliobatis rectidens* Cope. (From Hussakof.)

states it is from marl excavations at Harrisonville, Gloucester County. [These marls are now referred to the Navesink-Hornerstown bed. The Vincentown limesand also occurs here and the Miocene clay appears on the higher slopes in the neighborhood, K.] I have not seen this example.

MYLIOBATUS OBESUS (Leidy).

Myliobates obesus Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 396. *Green-sand of Burlington Co., N. J.*

Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 236, Pl. 31, fig. 6-10, Pl. 34, fig. 44 (types of *M. rugosus* and *M. obesus*). (Pemberton and Mullica Hill.)

Myliobates rugosus (nec Meyer 1844) Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 395. *Marl of New Egypt, Ocean Co., N. J.*

Dental plate arched in form, composed of four median teeth and at least a row of lateral teeth each side. Enamel surface in general evenly convex. Basal surface convex, swelling to median longitudinal axis moderately. Transverse median sutures curve

at first slightly convex back till posterior are quite convex. Vertical diameter of median teeth about five in horizontal diameter, their surfaces with usually distinct transverse or vertical wrinkles or nearly smooth. Length (width) 59 mm.

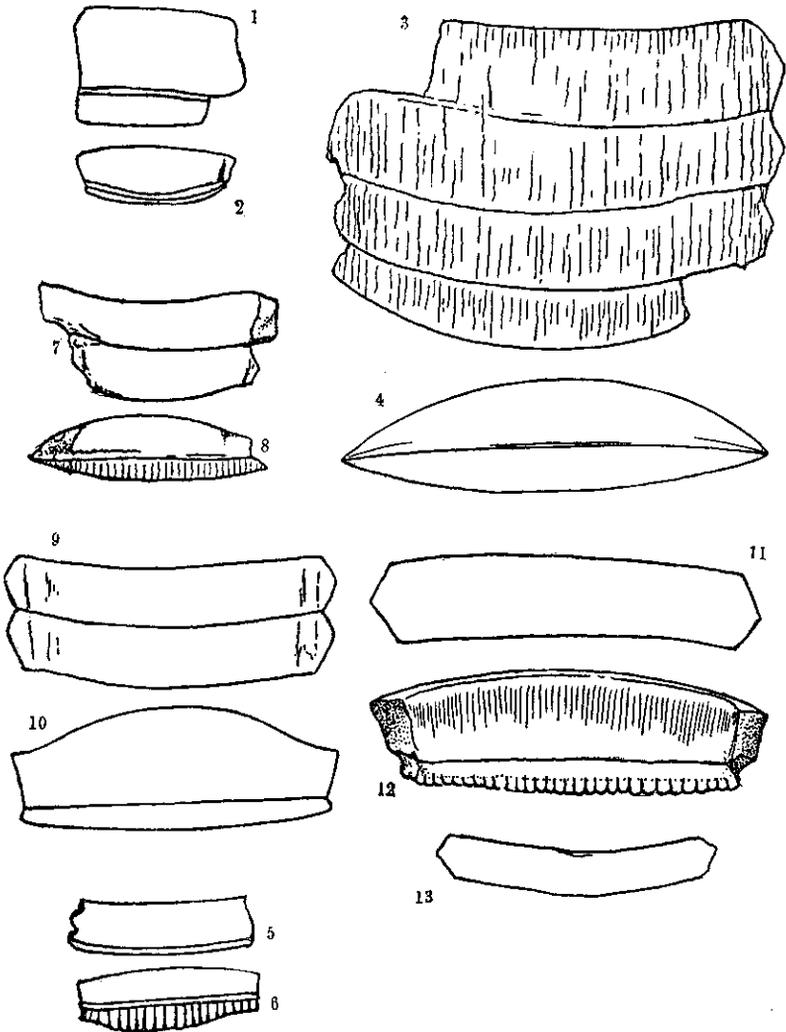


FIG. 48.—*Myliobatis obesus* (Leidy). 1-2, Monmouth Co. (Abbott); 3-4, New Egypt (Conrad) (type of *Myliobates rugosus* Leidy); *5-6, Farmingdale; 7-8, Pemberton (Budd); 9-10, Vincentown (Bryan) (type of *Myliobates obesus* Leidy); 11-13, Mullica Hill (Atkinson).

This seems to be the most abundant species found in New Jersey, and is characterized largely by its convex surface, with slightly convex striae posteriorly.

Myliobates rugosus Leidy is preoccupied by *Myliobatis* (*Zygobatis*) *rugosus* Meyer, Neu. Jahrb., 1844, p. 335, from the lower Miocene of Weinheim, and for this reason *obesus* is retained.

Formation and locality. Known chiefly from the Cretaceous marls. I have examined the following examples: The type from New Egypt in Ocean County (T. A. Conrad); the type of *Myliobates obesus* Leidy from Vincentown (C. H. Budd), both Burlington County; 2 from Mullica Hill in Gloucester County (W. B. Atkinson). [The Hornerstown marl, the Vincentown limesand and the Manasquan marls, all Cretaceous, are the formations apparently involved, although the Miocene is known near Mullica Hill, K.]

MYLIOBATHIS KUMMELI sp. nov.

Dental plate depressed in form, moderately thick, composed of 17 median teeth, and at least two series of lateral teeth. Enamel surface generally slightly convex, with slight median concave longitudinal depression, so that surface is very slightly double convex, with each side sloping down somewhat strongly convex. Median depression concavely so shallow as to scarcely appear concave. Basal surface largely well and evenly convex from median axis, inclining well towards each side. Transverse median sutures posteriorly, rather evenly, though slightly convex, but anteriorly becoming somewhat slightly double convex. Vertical diameter of anterior median teeth about one-ninth of horizontal diameter, and of posterior teeth much greater. Lateral teeth hexagonal, 13 in one series on right side and two series of 10 in the inner and seven in the outer on left side. Though all enameled surfaces smooth median teeth show a number of vertical wrinkles extending more or less transversely over dental area, with pronounced ridge submedianly extending over at least first 12 median teeth. This ridge assymmetrical or a little nearer right than left side. At lateral portion of each median tooth are one or

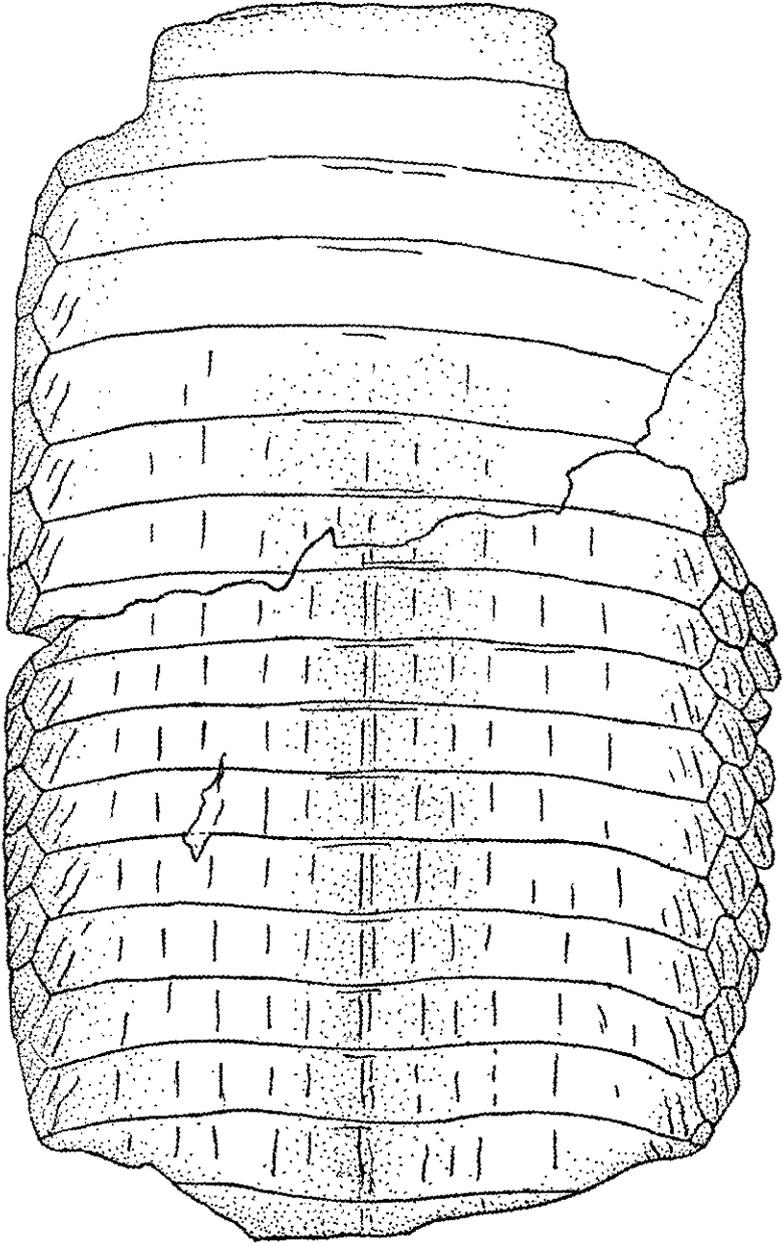


FIG. 49.—*Myliobatis kummeli* Fowler. (Type.)



FIG. 50.—*Myliobatis kummeli* Fowler. (Type, in transverse sectional view).

two wrinkles of enameled surface, directed obliquely towards central keel. Similar wrinkles occur on each lateral tooth. Length (width) about 100 mm.

This species is only known to me from the above-described dental plate, which is nearly entire. It seems to differ from any other American species, and certainly from any I have examined in the lateral wrinkles on the enamel, which are not only distinct on the lateral teeth, but also on the lateral moieties of the median as well.

Formation and locality. Specimen No. 7395, type, collection of the New Jersey State Geological Survey. From the marl of Stow Creek Township in Cumberland County [the so-called Shiloh marl, which is referable to the Kirkwood formations of the Miocene, K.] (Isaac Smalley in March of 1880).

(I take pleasure in dedicating this species to Dr. Henry B. Kümmel, the State Geologist of New Jersey.)

MYLIOBATUS PACHYRHIZODUS sp. nov.

Dental plate depressed in form, thick, especially medianly, composed of seven median teeth, and at least two series of lateral teeth. Enamel surface slightly convex, with slight median depression, scarcely concave, also each side sloping very slightly to edges. Basal surface greatly convex, formed as median elevated axis from which each side slopes abruptly down. Transverse median sutures rather evenly and distinctly convex. Vertical diameter of median teeth about one-fifth of horizontal diameter. Lateral teeth rather large, only on right side, four in inner and apparently same number in outer series. Enamel surfaces smooth, without any very distinct wrinkles. Length (width) about 53 mm.

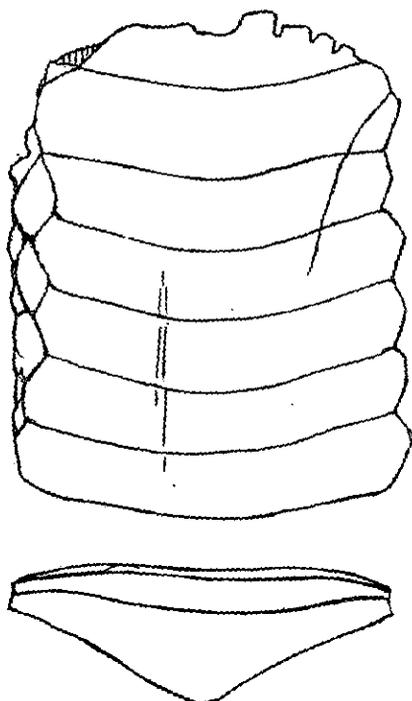


FIG. 51.—*Myliobatis pachyrhizodus* Fowler. (Type.)

Known from the above-described dental plate, unfortunately imperfect. This species is distinguished by its very thick root.

Formation and locality.—Specimen No. 6660, type, in the collection of the Geological Survey of New Jersey, and is from the upper marl [Manasquan, K.] at Poplar.

(*Pachyrhizodus*, i. e., thick-rooted tooth.)

Genus AETOBATUS Blainville.

Aetobatus Blainville, Bull. Soc. Philomath. Paris, 1816, p. 112. Type *Raja narinari* Euphrasen, tenth species, virtually restricted by Gill, Proc. U. S. Nat. Mus., 1894, p. 112.

Ætobatis, *Ætobatus*, *Aetobatis*, *Aetobates*, auct.

Goniobatis Agassiz, Proc. Boston Soc. N. H., VI, 1839, p. 385. Type *Raja flagellum* Schneider, monotypic.

Stoasodon Cantor, Journ. Asiat. Soc. Bengal (Cat. Malay. Fish.), 1849, p. 434. Type *Raja narinari* Euphrasen, monotypic, and name based on *Ætobatis* Müller and Henle=Blainville.

Differs from *Myliobatis* in having the teeth uniserial, very broad, and no small lateral ones. Upper dental lamina straight and lower lamina projecting beyond upper, curved. Free hind edge of nasal valve deeply emarginated.

A single existing species in tropical seas, and 13 extinct species have been described, the latter only known from dental plates.

AETOBATUS PERSPICUUS (Leidy).

Aetobatis perspicuus Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 396. *Monmouth Co., N. J. Eocene?*

Aetobatis perspicuus Leidy, Journ. Acad. Nat. Sci. Phila., (2) VIII, 1877, p. 244, Pl. 31, fig. 13 (type).

Median tooth of dental plate well arched or angular, turning abruptly upward at end of tooth. Enamel surface rather broad, flat, and end only slightly rounded. Greatest width or vertical diameter of enameled surface usually uniform, and about one-seventh in entire horizontal diameter. Anterior edge of tooth angularly convex greater part of its extent, feebly deflected for-

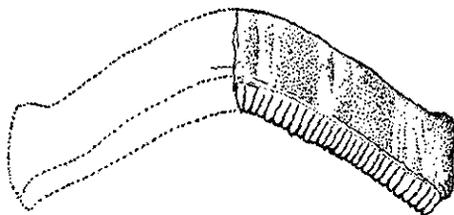


FIG. 52.—*Aetobatus perspicuus* (Leidy). (From Leidy.)

ward laterally, and at end presents projection adapted to crescentoid depression or socket of contiguous tooth. Posterior edge presents a narrow flange along greater portion of its length, and crescentoid socket at end of tooth adapted to receive projecting border of contiguous tooth. Root with laminae projecting posteriorly about space equal to one-half vertical diameter of enameled surface, and all directed obliquely towards median axis of tooth. Length (width) about 60 mm. (From Leidy.)

Formation and locality. Only the type known described above, from the Eocene of Monmouth County (J. L. Burtt), originally presented to the Academy, but which I have not seen.

Genus *PLINTHICUS* Cope.

Plinthicus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 316. Type *Plinthicus stenodon* Cope, monotypic.

Known from thin and rather depressed teeth. Related to *Aëtobatus*, but differing in having the roots of the teeth projecting but slightly posterior to enameled surface.

One species described, extinct.

PLINTHICUS STENODON Cope.

Plinthicus stenodon Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 316. *Shiloh, Cumberland Co., N. J. Miocene.*

Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 33, fig. 10 (type).

Dental plate greatly depressed, mostly with transverse or horizontal teeth nearly straight or but slightly and rather evenly con-

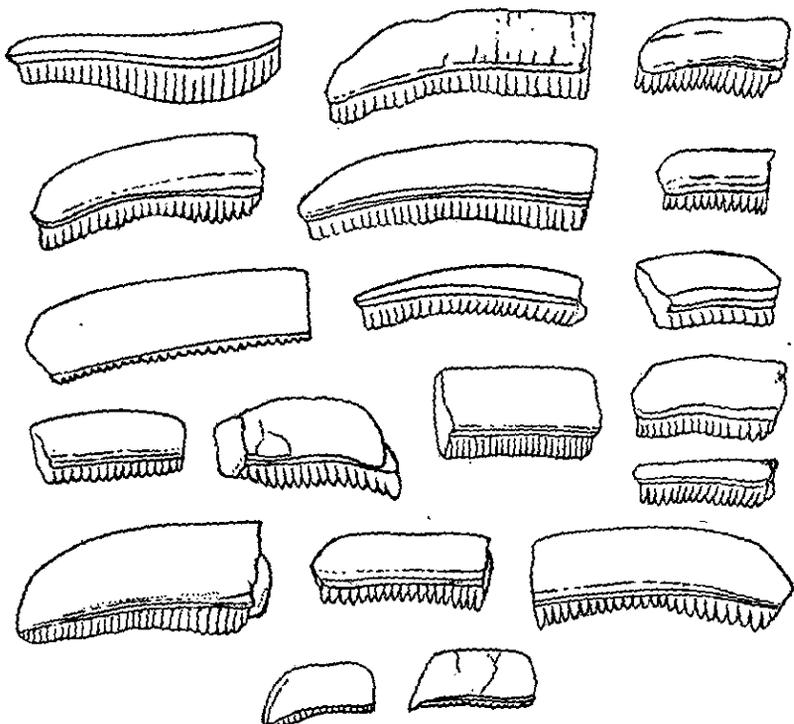


FIG. 53.—*Plinthicus stenodon* Cope. Charles Co., Md. (Thomas).

vex. Enamel surface broad, depressed or usually more or less flattened, and edges of front teeth at least varying more or less convex. Greatest width or vertical diameter of enameled surface usually uniform, and about one-fourth in entire horizontal diameter. Root low, greatly depressed, greatly inclined backward, so that beginning of lower level surface is about opposite medial lesser diameter of enameled surface. Posterior part of root always seen projecting a little more or less for slight distance behind enameled surface as latter is viewed from above: Entire surface of root marked with moderately numerous sutures, all parallel, and most distinct behind. Front edge of enamel surface curves slightly convexly over root, leaving a slight longitudinal groove below. Posterior edge just below enamel with a slight longitudinal ridge. Length (greatest breadth) 40 mm. Here described from examples from the Maryland Miocene.

Known only from the dental plates.

Formation and locality. I have not examined any examples from New Jersey where it has been ascribed to the Miocene. Cope originally had a single example and I do not think any others have been recorded from the State since [Shiloh marl, Kirkwood formation, Miocene, K.].

Genus RHINOPTERA Cuvier.

- Rhinoptera* (Kuhl) Cuvier, Règne Animal, Ed. 2, II, 1828, p. 401. Type *Myliobatis marginata* G. St. Hilaire, first species, restricted by Bonaparte, Nuov. Ann. Sci. Nat. Bologna, II, 1838, p. 201.
- Zygobatis* Agassiz, Poiss. Foss., III, 1843, p. 79. Type *Myliobatis jussieui* Cuvier, virtually monotypic.
- Zygobates*, auct.
- Trikeras* Harless, Abh. N. Phys. Class., V, 1850, p. 841. No species given.
- Mylorhina* Gill, Ann. Lyc. Nat. Hist. N. Y., 1865, p. 136. Type *Rhinoptera lalandii* Müller and Henle, designated, monotypic.
- Micromesus* Gill, l. c. Type *Rhinoptera adspersa* Müller and Henle, designated, monotypic.
- Trycera* (Koch) Doderlein, Man. I. Med., III, 1885, p. 242. Type *Trycera typica* Koch (= *Myliobatis marginata* G. St. Hilaire), nom. in syn.

This genus resembles *Myliobatis* in its dentition, having the teeth in several series, the median being very broad. It differs, however, in the emarginated muzzle and having the cephalic fins below the level of the disk.

The existing species, about 10, distributed in tropical seas. About five extinct species have been described.

RHINOPTERA DUBIA Leidy.

Dental plate depressed, evidently upper or enameled surface well convex and lower or basal surface equally concave, though both surfaces evenly so. Enamel surface smooth, of usually even thickness, and edges usually abrupt. Extremities of tooth form rather obtuse angle, and apex would form medianly in vertical diameter. Vertical diameter of enamel surface nearly one-seventh of horizontal. Root not visible as enameled surface is viewed from above, low, greatly depressed, sometimes moderately deep, and uniformly concave. Vertical grooves rather variable, numerous or moderate. Greatest breadth 46 mm.

This species does not ever appear to have been noted from New Jersey before. Many of my examples agree entirely with Leidy's, but other specimens must be admitted somewhat provisionally, as they are possibly teeth belonging to *Myliobatis*. Known only from detached teeth or dental plates.

Formation and locality. The following examples in the collection of the Academy have been examined: Monmouth County 10 (W. Cleburne) and 2 (P. D. Knieskern); Vincentown, in the marl of Burlington County 1 (C. B. Barrett), and 1 said to be from the Miocene labeled "Bridgeton Pike" (C. C. Abbott).

I have also examined some fragmentary dental remains in the collection of the Geological Survey taken from well-borings at 214 feet on July 23d, 1909, on the beach front at Bradford Cottage, Fortesque, in Cumberland County. From 200 to 214 feet the shell-beds were in a tough, leathery mud, and in this horizon were found the fragments of the present species. For information and these specimens the Survey is indebted to Mr. S. P. Foster, of Elmer, and Mr. C. Holaday, of Hornersville. A comparison with a large series of examples from the Maryland Miocene, with which they agree in most respects, would point to their being from the same formation.

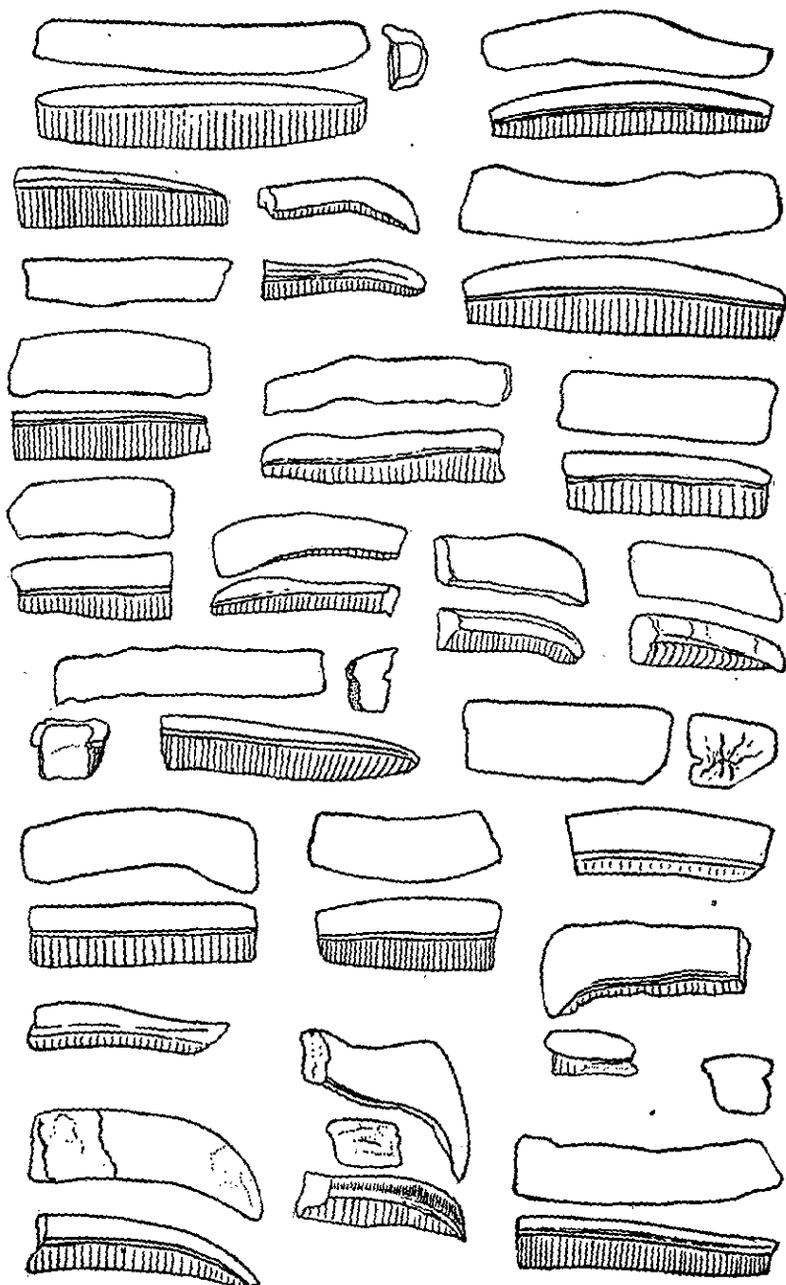


FIG. 54.—*Rhinoptera dubia* Leidy. Charles Co., Md. (Thomas).

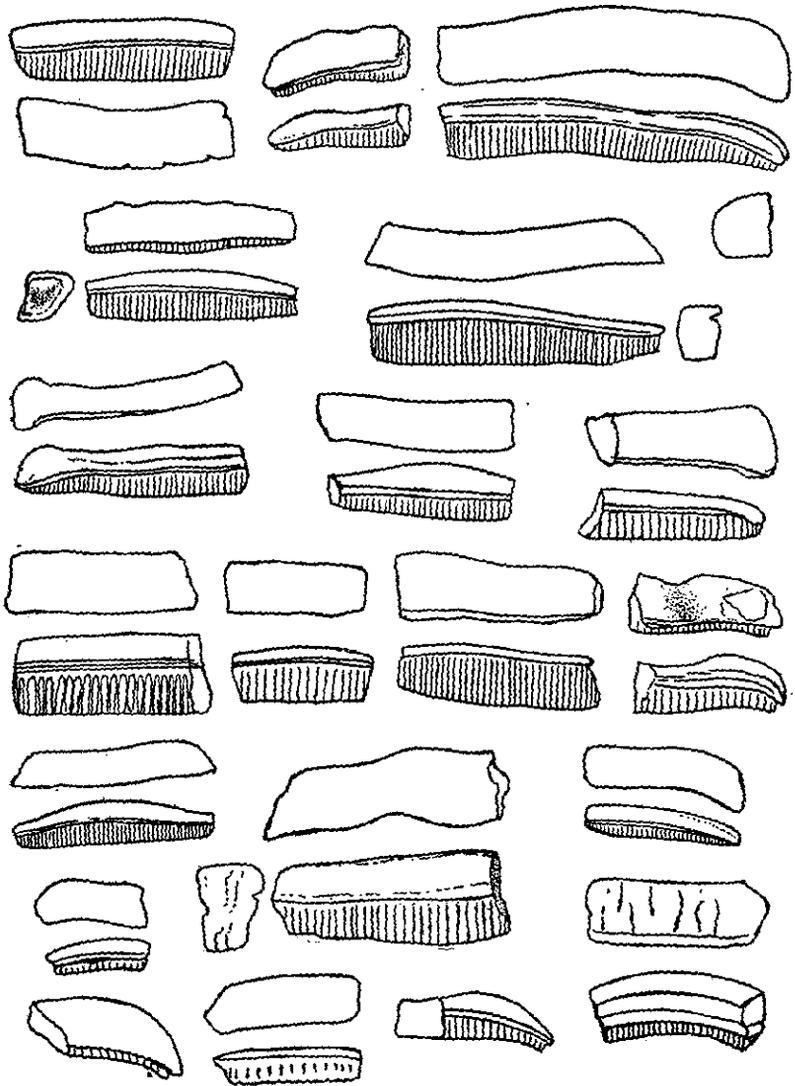


FIG. 55.—*Rhinoptera dubia* Leidy. Charles Co., Md. (Thomas).



FIG. 56.—*Rhinoptera dubia* Leidy. *Fortesque.

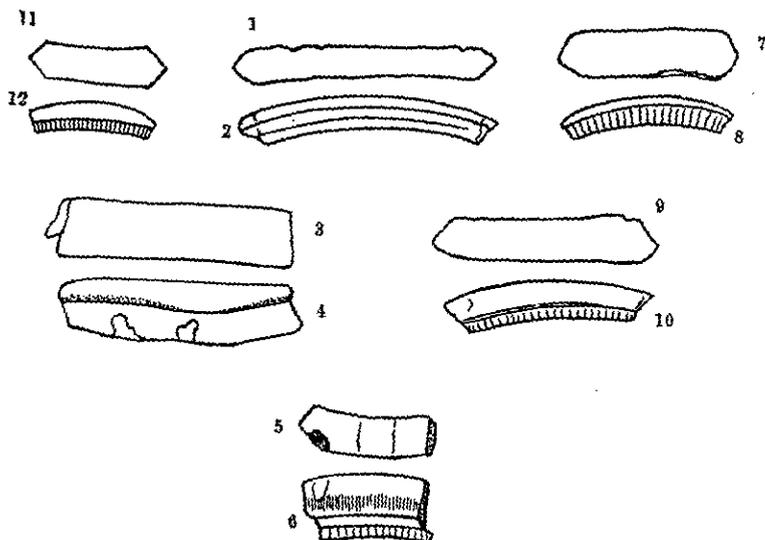


FIG. 57.—*Rhinoptera dubia* Leidy. 1-2, Monmouth Co. (Knieskern); 3-8, Monmouth Co. (Cleburne); 9-10, Vincentown (Barrett); 11-12, Bridgeton Pike (Abbott).

FRAGMENTARY SELACHIANS.

A large number of detached vertebræ (Figs. 58, 59) are in the collection of the Academy, representatives of which I have fig-

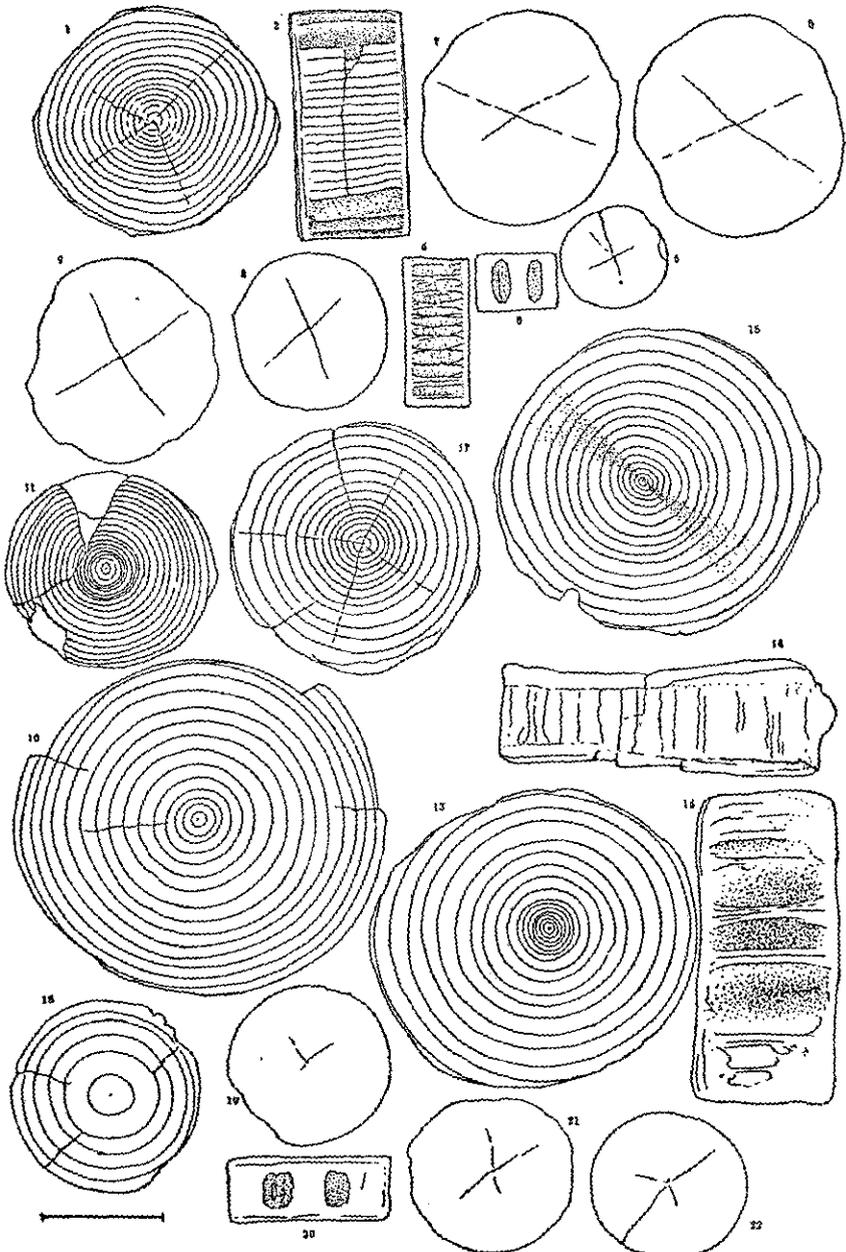


FIG. 58.—Detached vertebrae. 1-12, Vincentown; 13-14, Pemberton (Ashurst); 15-17, Mullica Hill; 18-22, Shiloh (Conrad).

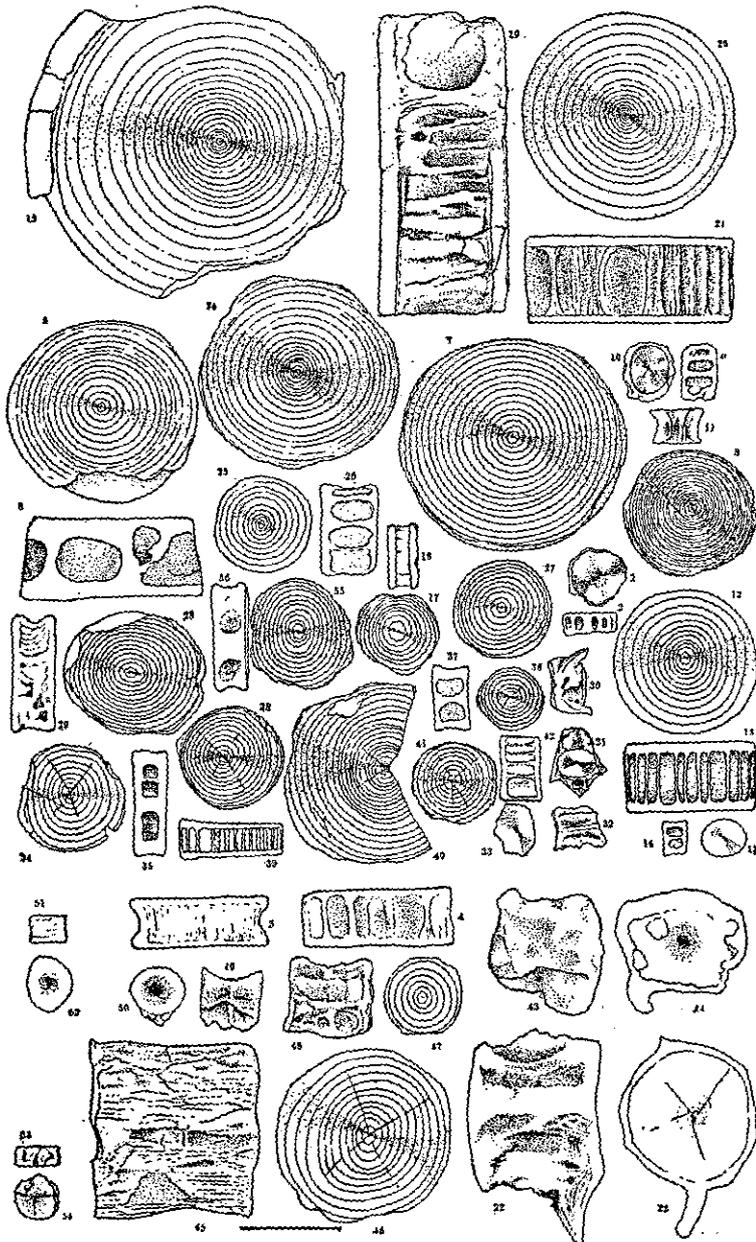


FIG. 59.—Detached vertebræ. 1-2, New Jersey (Abbott); 3-4, Long Branch (Chapman); 5-6, Monmouth Co. (Slack); 7, Monmouth Co (Vandyke); 8, Monmouth Co. (Abbott); 9-11, Monmouth Co. (Cope); 12-15, Monmouth Co. (Cleburne); 16-17, Farmingdale (Pilsbry); 18-21, New Egypt (Chaloner); 22-23, Pemberton (Budd); 24-26, Pemberton (Ashurst); 27-34, Vincentown (Bryan); 35-46, Blackwoodtown (Lamb); 47-48, Allowaystown (Yarrow); 49-50, Lenoia (Conard); *51-52, Wenonah Sand; *53-54, Hurffville (Hurff); 55-56, Charles Co., Md. (Thomas).

ured in this connection, though I have been unable to locate their true identity. Many are, no doubt, selachians, though many may also belong to teleosts. They are all from Cretaceous beds, but are without stratigraphical position, like most all of the older col-



FIG. 60.—*Myliobatis* spine? Vincentown (Bryan).

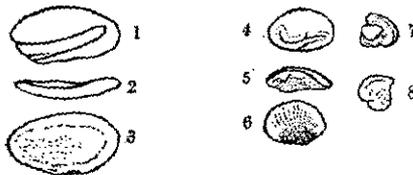


FIG. 61.—Teleost otoliths. 1-3, Haddonfield; 4-8, Mt. Laurel (Woolman).

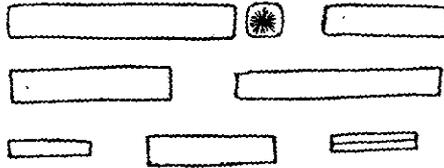


FIG. 62.—Rays from a batoid fish? Vincentown (Bryan).

lections. There is also a spine, possibly of *Myliobatis* (Fig. 60), and several teleost otoliths (Fig. 61). Several small, thin, rod-like fossils may also belong to rays (Fig. 62).

Sub-Class HOLOCEPHALI.

THE CHIMÆRAS.

Teeth united to form bony plates. Jaws coalescent with skull. Gill-openings single in each side of pharynx, leading to four gill-slits. Skull without system of membrane bones, as opercles, suborbitals, etc. Skeleton cartilaginous. Mandibular suspensorium wanting. Intestine with a spiral valve. Derivative radii sessile in sides of basal bones of limbs. Pectoral fins normally

developed, placed low. Ventral fins abdominal. Males with claspers attached to ventrals. Skin scaleless, its muciferous system well developed.

This group generally includes six families.

Order CHIMAEROIDEI.

Characters included in those of the sub-class.

Family CHIMÆRIDÆ.

THE CHIMÆRAS.

Body elongate, rather robust anteriorly, tapering posteriorly. Head compressed. Mouth inferior, small. Upper lip deeply notched. Jaws with teeth confluent into four bony plates above and two below. Nostrils confluent with mouth, separated by narrow isthmus. Free gills 3, half gills 2, one on each side. Rakers small. Isthmus moderate. Males usually with cartilaginous hook on snout above, prickly at tip, turned forward. No spiracles. Skin naked, rarely somewhat prickly. Lateral line present, usually branched anteriorly. Dorsal usually divided, anteriorly with strong posteriorly grooved spine. Caudal low, fold-like. Pectorals free, low. Ventral abdominal, many rayed. Males with claspers.

The existing forms are remarkable for their striking appearance. They are all natives of deep water and cold seas. Reproduction is oviparous, the egg-cases long, elliptical and with silky filaments. About 17 genera have been described, all extinct, and only *Chimæra* persisting to the present time. Possibly *Chimæra affinis* (Capello) may occur in deep water off our coast, though it has not ever been so recorded.

Passalodon was founded on vomerine teeth and *Psittaoodon* on mandibular teeth of two European fossils. Woodward says¹ "the species mentioned below have also been determined upon

¹Cat. Foss. F. Brit. Mus., II, 1891, p. 84.

the evidence of detached teeth, and, by a misunderstanding of the generic characters, the majority of the American forms have hitherto been ascribed to *Ischyodus*. Most of the type specimens of the latter are in the collection of Prof. E. D. Cope, Philadelphia, where the present writer has had the privilege of examining them, and many of the specific distinctions cited in the diagnoses would be regarded as varietal in Britain." However, the present writer seems justified in following the views of Husakof, who has studied these specimens now in the American Museum of Natural History in New York City.

Genus EDAPHODON Buckland.

Edaphodon Agassiz¹, Poiss. Foss., III, 1843, p. 351. Type *Edaphodon bucklandi* Agassiz, restricted by Woodward, Cat. Foss. Fishes, II, 1891, p. 80. *Edaphodus*, auct.

Passalodon Buckland, Proc. Geol. Soc. London, II, 1838, p. 687. No description or species.

Psittacodon Agassiz, Poiss. Foss., III, 1843, pp. 340, 348. Type *Chimæra mantelli* Agassiz, virtually designated, first species.

Dipristis Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 230. Type *Dipristis miersii* Marsh, monotypic. (Not of Gervais.)

Eumylodus Leidy, Rep. U. S. Geol. Surv. Terr., I, 1873, p. 309. Type *Eumylodus laqueatus* Leidy, monotypic.

Diphrissa Cope, Proc. Acad. Nat. Sci. Phila., 1875 (Feb. 9th)², (2) p. 19. Type *Ischyodus solidulus* Cope, designated, monotypic.

Mandibular tooth massive, with no definite thickening on outer aspect, symphyseal facette very broad. Anterior tritor 1, sometimes smaller one below. Median tritor 1, occasionally divided longitudinally. External tritors 2. Palantine teeth robust, no well-defined thickening on outer aspect, and three tritors as two inner and one outer. Vomerine teeth mostly triangular in side view, tritors on oral edge. Postoral region laterally expanded, without any thickening.

The species, about 26, are all extinct.

¹ Buckland, Proc. Geol. Soc. Lond., II, 1838, p. 687. Descr. imperfect, no species given.

² Issued April 20th, 1875.

EDAPHODON STENOBRYUS (Cope).

Ischyodus stenobryus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 285. *Hornerstown, N. J., Greensand No. 5.*

Edaphodon stenobryus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 39, Pl. 2, figs. 6-7 (types).

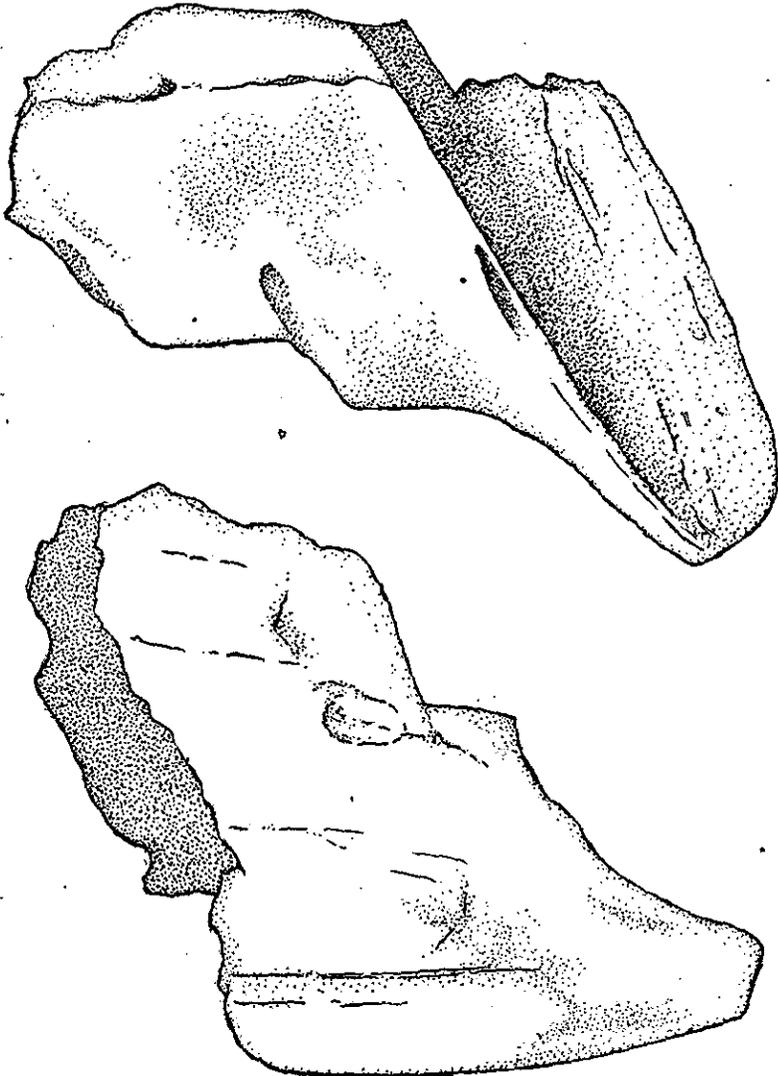


FIG 63.—*Edaphodon stenobryus* (Cope). (From Hussakof.)

Mandibulars compressed, outer edge rising rapidly from little behind apex, first to a shoulder which supports first exterior dentinal area, and then steeply to an oblique border which bears hind dentinal area. Dentinal areas very small, inner represented by two columns widely separated from each other. Inner masticatory margin remains parallel with lower edge of jaw, marking one-third total depth. Grinding face vertical behind. External areas very narrow, and behind anterior smaller one appears in position of inner one of *E. tripartitus*, thus representing outer part of large removed from former, narrow, and extends little anterior to anterior border of anterior outer. Apex of jaw obtuse, and terminal area on its superior aspect oval, and continues as edge of a lamina along outer margin of beak. No symphyseal plane, whole jaw much compressed and narrowed. Length 70 mm. (From Cope.)

Said to have much the form of *Leptomylus forfex*, and approaching *E. laterigerus*.

Formation and locality. Only known from the type, a pair of mandibulars now in the collection of the American Museum, N. Y. They are from "Greensand No. 5" [the Hornerstown marl, K.] at Hornerstown in Monmouth County. I have not seen this species.

EDAPHODON TRIPARTITUS (Cope).

Ischyodus tripartitus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 286. Hurffville, N. J. Upper bed of Greensand.

Edaphodon tripartitus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 40, fig. 16, Pl. 3, figs. 5-6 (types).

Ischyodus mirificus (nec Leidy) Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 314 (note).

Ischyodus longirostris Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 287. Birmingham, N. J. Greensand No. 5.

Mandibulars little more than twice as long as deep, rami converging in slight curve and ending in narrow produced symphyseal beak. Outer face of mandible with two longitudinal convexities, inner nearly vertical, and with short symphyseal plane. Dentinal areas moderate, anterior border not much produced, inner represented by three adjacent areas or three columns united at their adjacent borders, and outer more than twice as large as either of two interior ones. Latter separated from inner angle of

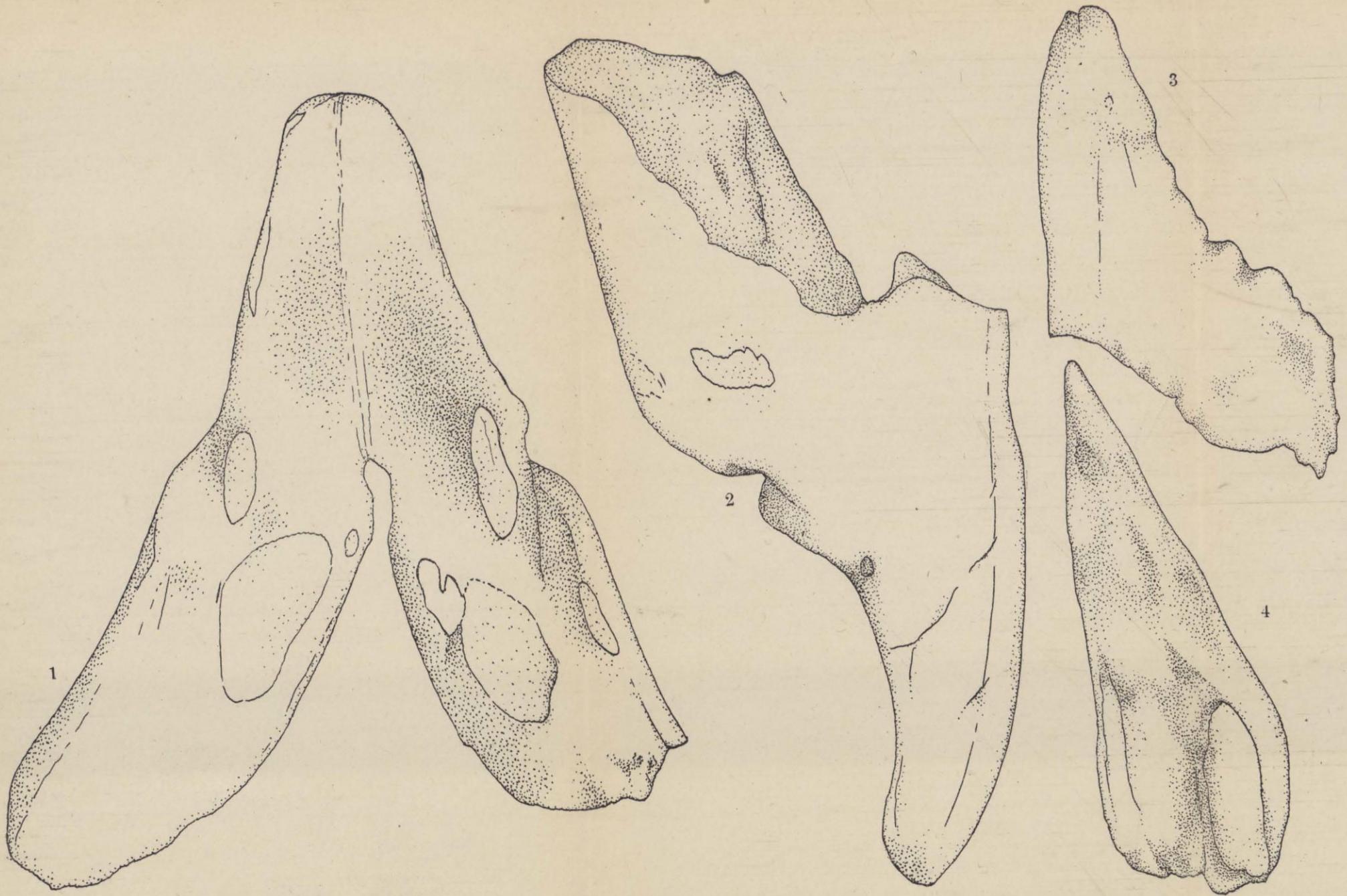


FIG. 64.—*Edaphodon tripartitus* (Cope). 1-3, Types of *Ischyodus tripartitus* Cope; 4, Type of *Ischyodus longirostris* Cope; (all from Hussakof).

jaw by an oblique plane of same width. External areas narrow, posterior quite small, anterior elongate and extends far in advance of inner areas along summit of horizontal ridge, latter produced as strong step on outer margin. Outer narrow border rises abruptly opposite middle of anterior area, causing masticatory face to be very oblique at that point. Superior groove wide, outer face not produced. Length 175 mm. (From Cope.)

This is the largest American species of the genus and said to be not uncommon. Hussakof has united *Ischyodus longirostris* Cope with this species after an examination of the types. According to Cope the former differed in having the inner dental area of the mandibular undivided, contracted and separated by a plane from inner margin. Outer posterior area lost in his specimen, but outer anterior opens in front of interior on horizontal step which forms strong angle of outer border. This border, therefore, abruptly excavated from that point forward, while inner border descends gradually from inner angle. Terminal area quite large and oblique. Symphyseal face large, inferior border of jaw obtuse and jaw end narrowly compressed. Palatal characterized by its small size and posterior position of anterior dental area, so that bone appears more produced. Posterior areas large.

Formation and locality. The type, consisting of both mandibulars and left palatal, are from Hurffville in Gloucester County. The type of *I. longirostris* consists of one mandibular and one palatal, both from Birmingham in Burlington County (J. C. Gaskill). All are recorded as from the greensand No. 5. [According to the present classification all would be referred to the Hornerstown marl, although at both these localities the Hornerstown and Navesink marl beds are united in a single layer, so that they may be from the Navesink or lower member, K.]. They are now in the American Museum of New York. I have not examined these specimens.

EDAPHODON LATERIGERUS (Cope).

Ischyodus laterigerus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 243.

Hornerstown, New Jersey. Cretaceous Greensand No. 5.

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 288 (type).

Edaphodon laterigerus Hussakof, Bull. Amer. Mus. N. H., XXV., 1908, p. 38, Pl. 1, figs. 7-8 (type).

8 GEOL.

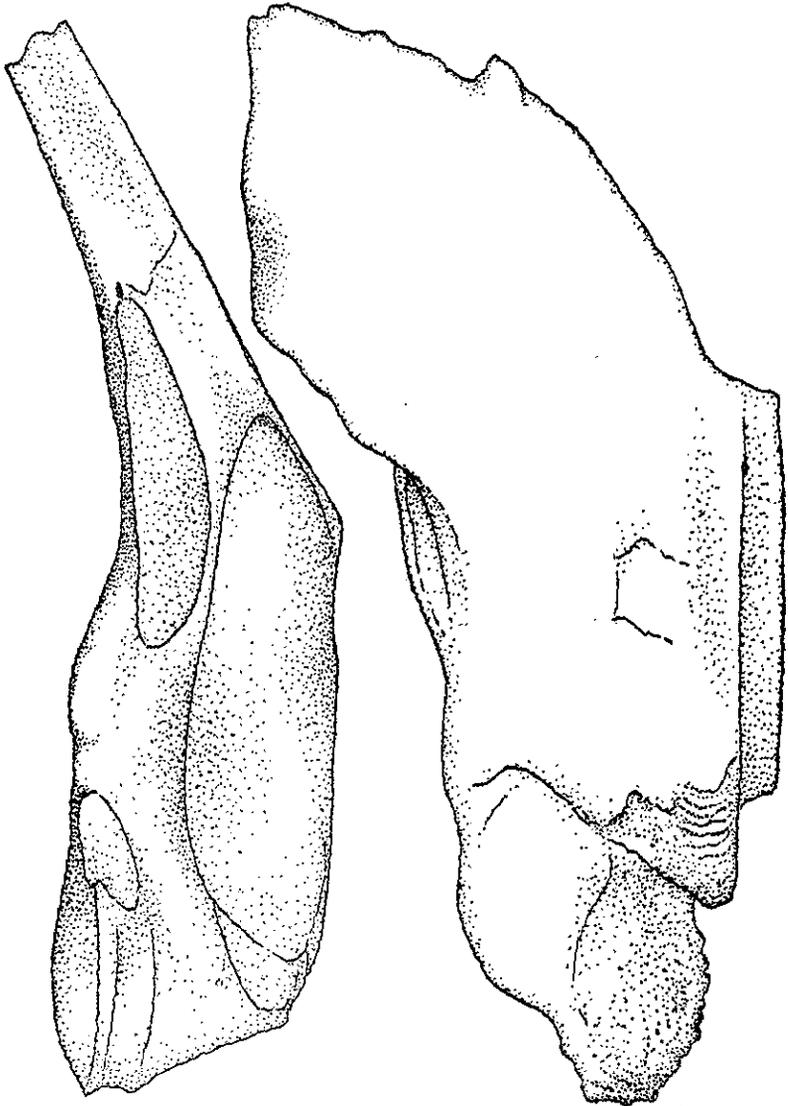


FIG. 65.—*Edaphodon laterigerus* (Cope). (Type, from Hussakof.)

Mandibular little more than twice as long as deep, end prolonged and more flattened than any other species from our region, and thoroughly and regularly curved outwards and backwards. Inner dentinal area undivided, extending to inner margin of superior face of mandible, large in all dimensions. Below

a slender intero-lateral column. Anterior area produced anterior to inner area. External areas on laminar crests of border, posterior area very small or less than one-third anterior, and anterior crest produced, or long and narrow, its middle marking anterior end of great inner area. When two mandibular rami are in place it follows from the above that median line of beak forms deep concavity walled in by high anterior outer crest. Posterior outer crest well developed, also prolonged acutely beyond posterior dental area. External terminal column largely developed vertically. Length about 165 mm. (From Cope.)

Known only from the above example, the type, said by Cope to approach *E. smockii*, but of double its size, more compressed and curved, with a much smaller posterior outer dental area and a very long anterior outer crest.

Formation and locality. The type is a large left mandibular, almost perfect, from the marl [Hornertown K.] at Hornertown in Monmouth County (J. C. Meirs), now in the American Museum at New York. I have not examined this specimen.

EDAPHODON SMOCKII (Cope).

Ischyodus smockii Cope, Proc. Boston Soc. N. H., XII, 1869, p. 316. *New Jersey. Cretaceous Greensand.*

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 284, 288. Hornertown. Greensand No. 5.

Edaphodon smocki Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 39, Pl. 2, figs. 4-5 (type).

Mandibular moderately long and stout. Outer face uniformly concave transversely, inner also with longitudinal concavity much stronger. Surface striæ longitudinal, sometimes broken. Dental areas large, surfaces rather plane, elevated supero-anteriorly, and plane of posterior face descends abruptly from supero-anterior margin of each. Outer margin, therefore, an incline of two steps, inner of one. Outer areas narrowed in front, and inner areas more obtuse and large, separated by very narrow strip from outer posterior, undivided and extending to inner margin of superior face of mandible. Length about 58 mm. (From Cope.)

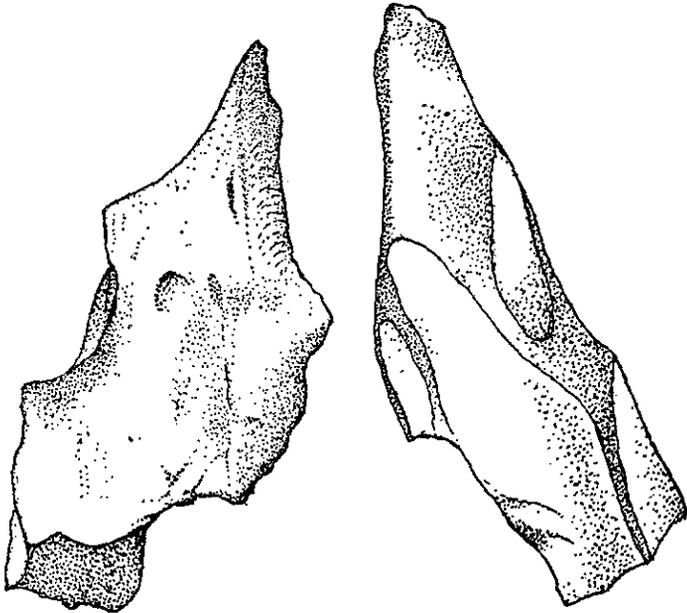


FIG. 66.—*Edaphodon smockii* (Cope). (Type, from Hussakof.)

This seems to be a well-marked species, about half the size of the smaller *E. divaricatus*. It is much less stout than in the latter and also less elongate than *E. tripartitus*.

Formation and locality. Known from the types in the American Museum at New York, consisting of three mandibular teeth and two fragments, and one of these represented only by an anterior extremity is thought by Hussakof to be probably different. They are all ascribed to the Greensand No. 5 [Hornerstown marl, K.] from Hornerstown in Monmouth County (J. C. Miers). I have not examined any specimens.

EDAPHODON EOCÆNUS (Cope).

Ischyodus eocænus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 288.

Eocene greensand of Farmingdale, Monmouth Co., N. J.

Edaphodon eocænus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 37, fig. 14 (type).

Mandibular with outer border of beak rising abruptly to considerable elevation, supporting anterior outer dentinal area. Lat-

ter oval, well within border, cut off at its posterior portion, but in advance of position of inner area. Dentinal areas moderate, inner undivided, extending to inner margin on upper face of mandible, and outer area produced anterior to inner area. Inner and posterior outer dentinal areas lost. Length, to anterior outer area, 50 mm. Terminal column laminar, extending well back on outer edge of beak. Outer face of jaw uniformly convex to anterior outer area, apex transverse, not compressed. Symphyseal face not well marked. (From Cope.)

This species is stated by Cope to be quite near *E. mirificus*, differing in uniform convexity of outer face, which in the latter is

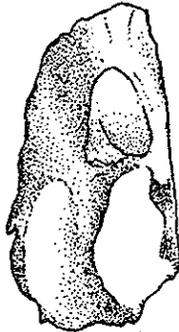


FIG. 67.—*Edaphodon eocenus* (Cope). (Type, from Hussakof.)

partially concave. Cope says the palatal areas are large, elongate, but not on elevated bases as in *E. smockii*. Outer face of palatal smooth, lower border very oblique to interior, which is longitudinally grooved. The specimen he had included five dentinal columns, inner borders more or less exposed, and median or interior column longest. This piece was similar in generic characters to that of *E. mirificus*.

Formation and locality. The type consists of a mandibular in the American Museum at New York. Two paratypes are a palatal and a fragment, all from the Eocene greensand of Farmingdale in Monmouth County. I have not examined any examples.

EDAPHODON INCRASSATUS (Cope).

Ischyodus incrassatus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 289. Hornerstown, New Jersey. Greensand of Cretaceous No. 5.
Edaphodon incrassatus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 38, Pl. 1, figs. 5-6 (type).

Mandibular with beak little curved outward, long, thick, symphyseal face a narrow border along inner edge. Convexity of lower half of outer face of jaw very strong, so that lower border thicker than in any other of our species. Inner dentinal area un-

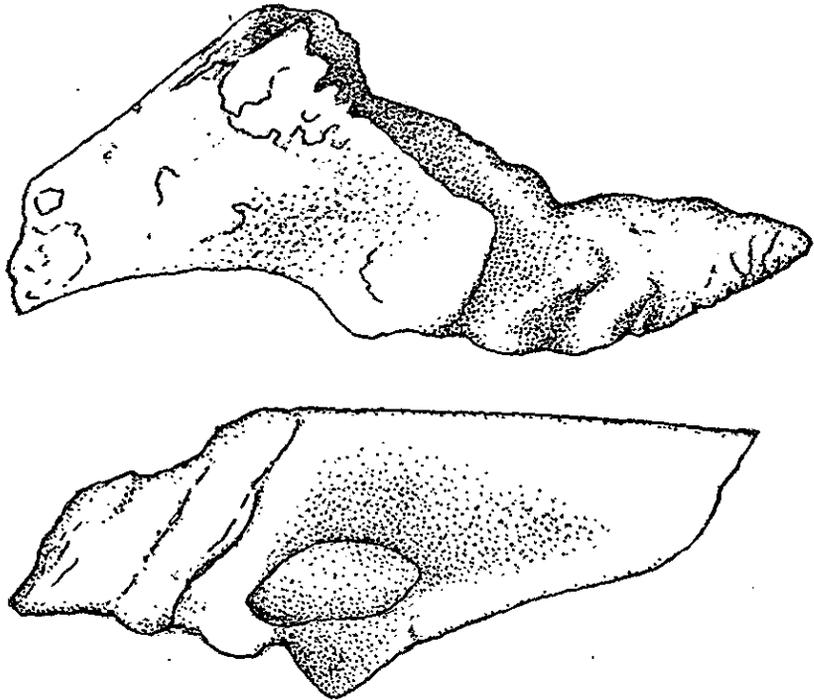


FIG. 68.—*Edaphodon incrassatus* (Cope). (Type, from Hussakof.)

divided, of median extent, extending to inner margin of superior face of mandible, apex marking only middle of anterior oval outer area instead of anterior extremity, latter horizontal on a considerable tuberosity removed well within outer border of jaw so that latter not angulated there as in some similar species. Length 125 mm. (From Cope.)

Formation and locality. Only known from the type, an imperfect right manibular in the American Museum at New York, from the "Greensand of the Cretaceous No. 5" [Hornerstown marl, K.] at Hornerstown in Monmouth County (J. G. Miers). I have not examined this example.

EDAPHODON FECUNDUS (Cope).

Ischyodus fecundus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 290. Medford, N. J. Greensand of Cretaceous, No. 5, from Birmingham and Hornerstown.

Edaphodon fecundus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 38 (type).

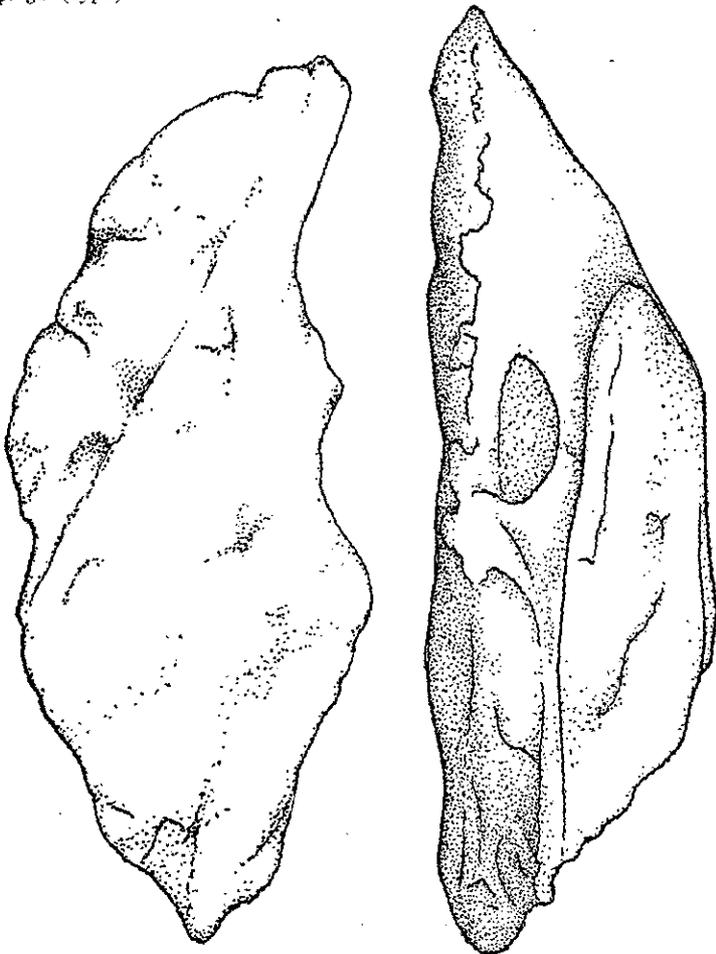


FIG. 69.—*Edaphodon fecundus* (Cope). (Type, from Hussakof.)

Mandibular moderately long, long axis strongly curved, and outer side concave in vertical as well as transverse section. Inner face also concave, with narrow symphyseal plane along inner border. Inner border of beak with same abrupt descent as outer. Dentinal areas moderate, inner undivided, both narrowed anteriorly and terminating on same transverse line. Anterior outer

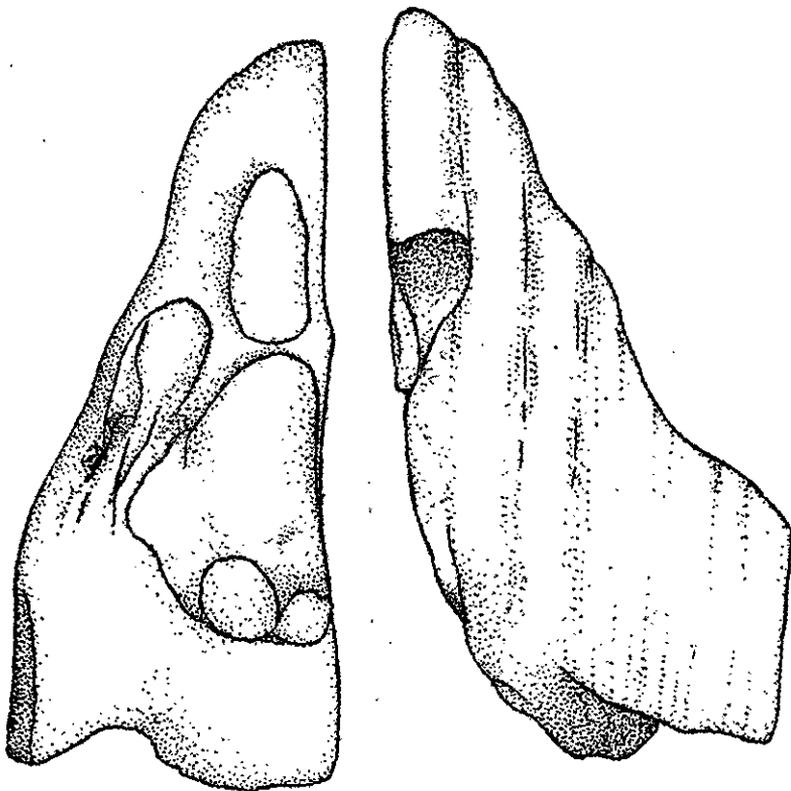


FIG. 70.—*Edaphodon fecundus* (Cope). (Type, from Hussakof.)

rather small and wide, horizontal, so that apex rises abruptly above outer border of beak. Posterior outer area rather small, while inner large and extending to inner edge of upper face of mandible. Apical column an oblique lamina. Length 135 mm. (From Cope.)

According to Cope this species is second in size in the genus to *E. tripartitus* or about twice the size of *E. smockii*. Palatals nar-

rowed and truncate in front, and dentinal areas large, especially posterior. Superior groove deep, and outer face extensive and longitudinally ridged.

Formation and locality. Known from eight lower jaws, some with palatals, of which seven mandibulars and one palatal are in the American Museum of New York. They are from the marl [Hornerstown marl, K.] at Birmingham and Hornerstown. Cope also had an example from Medford. I have not seen any material.

EDAPHODON MIRIFICUS Leidy.

Edaphodon mirificus Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. *Burlington Co., N. J. Cretaceous Greensand.*

Leidy, Rep. U. S. Geol. Surv. Terr., I, 1873, pp. 306, 350, Pl. 37, figs. 6-12 (types).

Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 38, Pl. 2, fig. 3 (Cope's material).

Ischyodus mirificus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 291. (Barnesborough and Hornerstown, N. J. Greensand No. 5.)

Ischyodus monolophus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 314. *Barnesboro* (Barnesborough), *Gloucester Co., N. J. Greensand.*

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 289 (type, Greensand No. 5).

Ischyodus gashillii Cope, l. c., pp. 285, 290. *Birmingham, Greensand of New Jersey, No. 5.*

Mandibulars a little more than twice as long as deep, rami converging in a curve and ending in a long, symphyseal, bird-like beak. Outer surface of each mandibular concave medianly and convex above and below. Outer profile concave anteriorly, then sloping up convexly, and below and behind convex. Inner symphyseal edge beveled, flat and rather narrow, and below this and posteriorly slightly convex with several longitudinal striæ. Oral surface of beak concave and posteriorly forms plane sloping inwards, this largest dental area. Anteriorly and externally another small rounded dental area, situated on a slight convexity, and followed back by a concavity at first rather spacious and then narrow where it separates a third dental area. Latter situated just inside external crest of mandible and about opposite middle in length of largest dental area, and elongate, though same width as anterior dental area about twice as long. A fourth short, nar-

row dental area on external oral extremity of beak, and another still shorter along inner edge. A fifth area, small, varying in elliptical pattern, at posterior symphyseal bevel opposite front of largest oral dental area, and followed by a prominent ridge which is convex with about two rather prominent longitudinal ridges, and curving back forms edge of mandible ramus posteriorly inside.

Upper maxillaries a little more than twice as long as wide, and their depth a little less. Form generally depressed. Upper surface of each with a deep wide gutter extending forward about two-thirds its length and ending in a deep pit, anterior to which area is

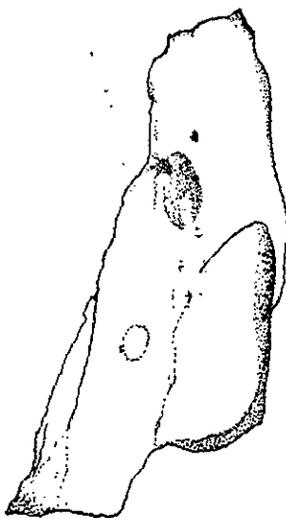


FIG. 71.—*Edaphodon mirificus* Leidy. (Type of *Ischyodus gaskillii* Cope, from Hussakof.)

flat and horizontal. Sides of upper maxillaries flat and sloping obliquely out. Lower surface with prominence in front sloping forward, its crest giving rise to an elongated round dental area sloping slightly down behind, where a crest forms, which gives rise in turn to largest dental area. Latter extends well back and close to inner edge, rounded, and also sloping down concavely behind, while laterally it also extends well towards outer edge. Just external to largest dental area another elongated dental area arising on a slight convexity opposite hind region of anterior dental areas, and extending back opposite deep posterior con-

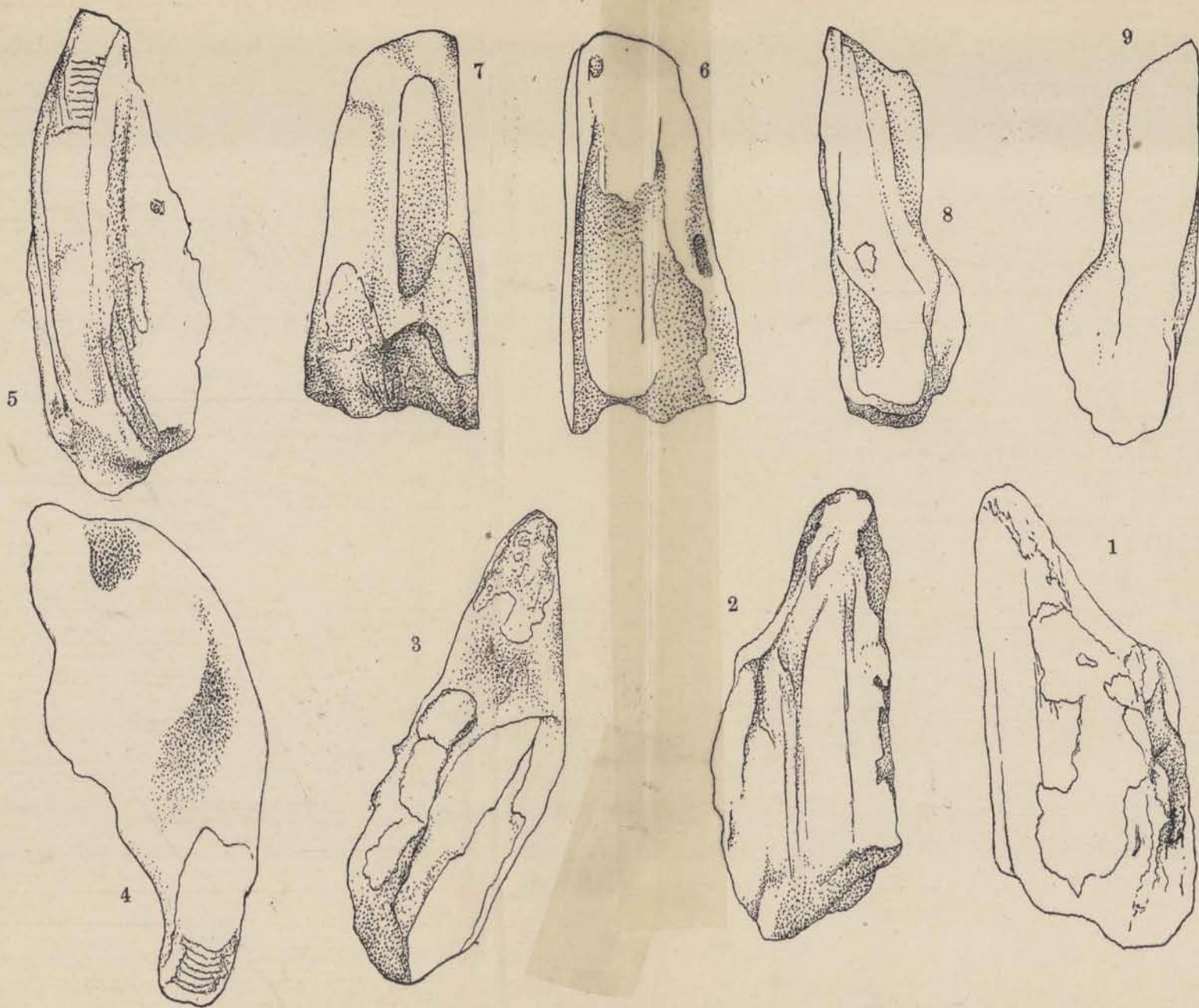


FIG. 72.—*Edaphodon mirificus* Leidy. *1-5 New Jersey; 6-9, New Jersey "greensand."

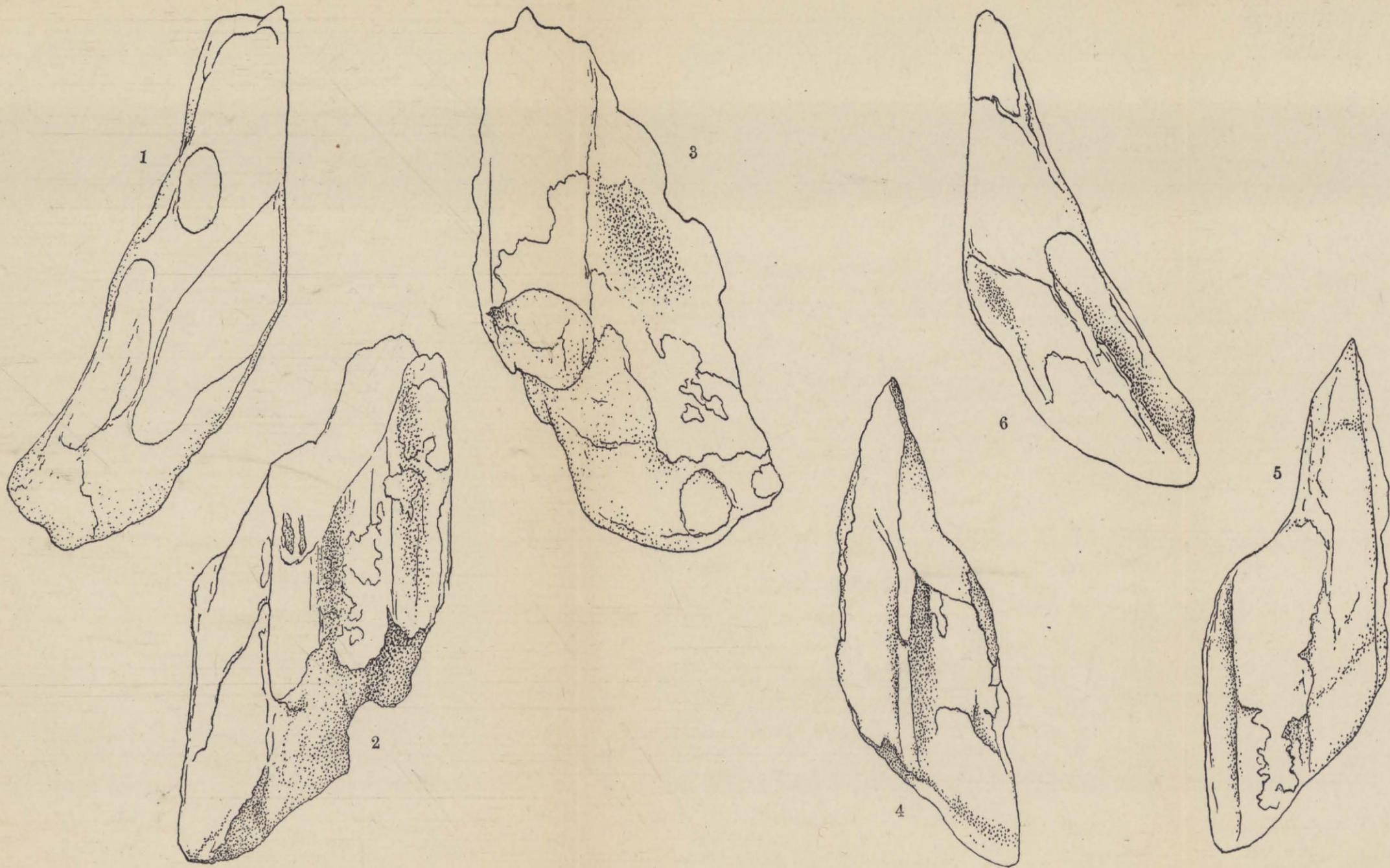


FIG. 73.—*Edaphodon mirificus* Leidy. *1-6, New Jersey (6616).

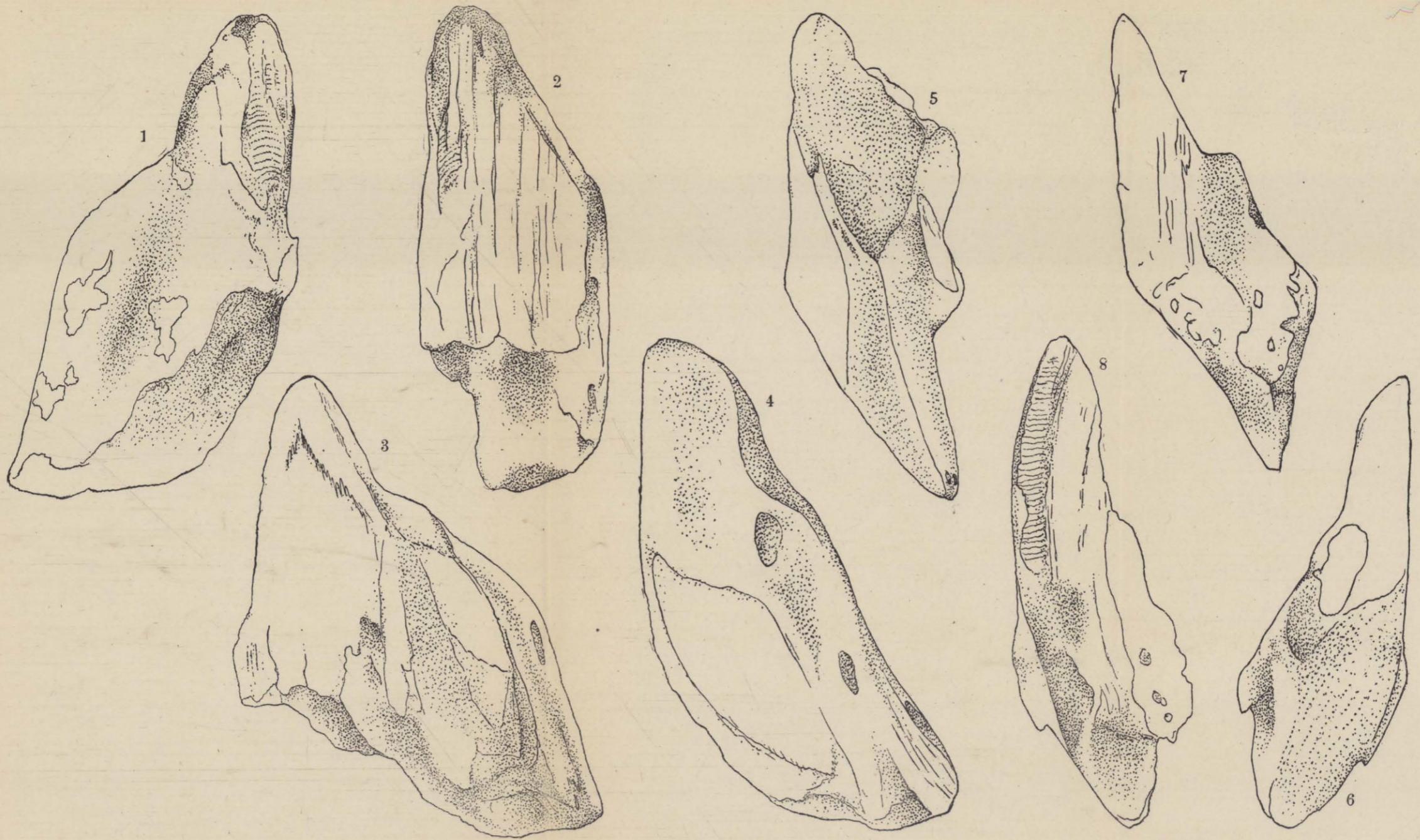


FIG. 74.—*Edaphodon mirificus* Leidy. *1-8, New Jersey (6658).

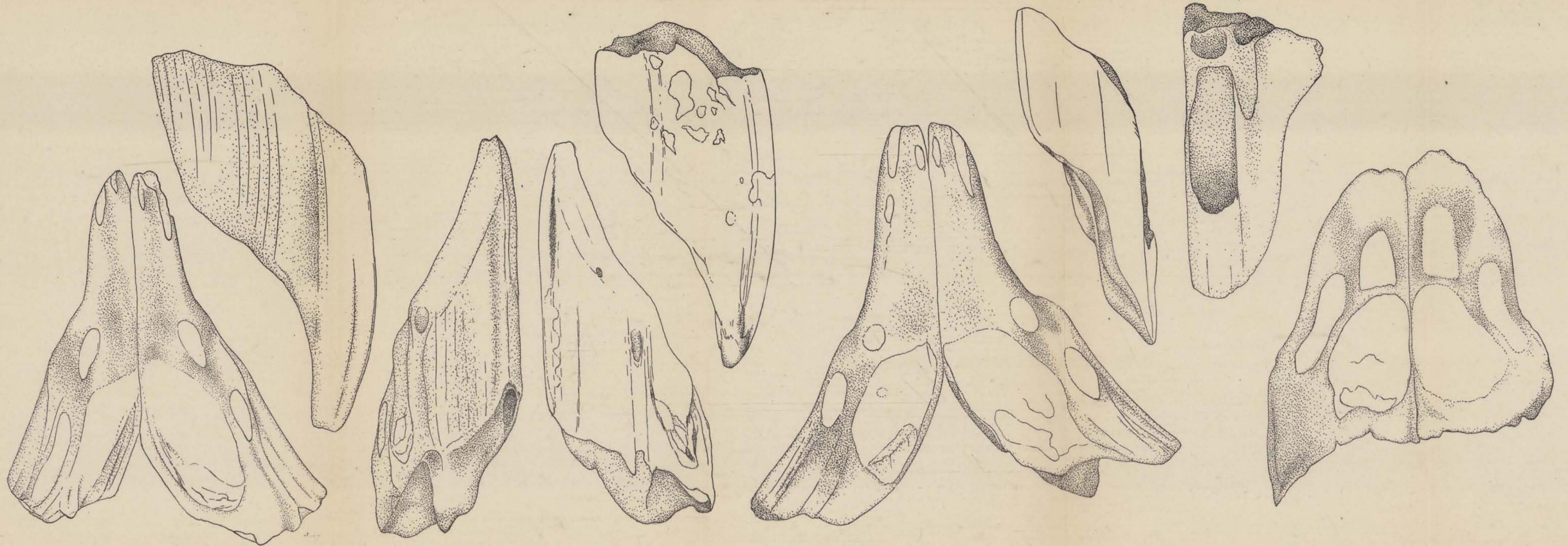


FIG. 75.—*Edaphodon mirificus* Leidy. (Types.)

cavity of largest dental area. Between anterior and lateral dental areas on oral surface a concave depression extending back to largest dental area. Posteriorly on oral surface externally edge arises in an elevated ridge, apex forming about opposite concavity in largest dental area, surface inside evenly concave. Inner surface of upper maxillary entirely flat.

As Leidy pointed out, the dental areas appear as white chalky friable spaces, which have more or less decomposed, leaving the little more durable tubules of the vaso-dentine projecting from their surfaces. He supposes originally tubecular structures were found over the dental areas covering the dental columns, but have now disappeared, leaving only their depressed and crumbling surfaces as now seen. These dental columns, corresponding with the dental areas, may all be located at the posterior ends of all the maxillaries. Length of longest lower maxillary 14 cm.

I have described several of Leidy's types above, now in the Academy, and note that the others agree in most respects, as he has already remarked. At present they are a pair of maxillaries and two pairs of mandibulars. Another small example, a right mandibular, agrees. It is from the New Jersey greensand, and shows a few transverse crescentic striae on its damaged inferior surface.

Formation and locality. Known from the Cretaceous greensand at Barnsboro and Hornerstown [the Hornerstown marl probably, K.]. According to Hussakof *Ischyodus gaskillii* Cope and *I. monolophus* Cope, the types of which he has examined, and which are now in the American Museum at New York, are a small left mandibular, apparently of a young individual, and two mandibular teeth, respectively, of the present species.

I have also seen several examples in the collection of the Geological Survey. They are a right and left mandibular from the Cretaceous of "New Jersey," and one right and two left mandibulars without data.

EDAPHODON MIERSII (Marsh).

Dipristis miersii Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 230. *Horners-*
town, N. J. Upper Cretaceous Marl.

Ischyodus miersii Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 292.
(Hornerstown, Monmouth Co., N. J.)

Mandibular with long and straight beak, and outer face concave to base of anterior outer dentinal area. Long axis of jaw straight, also inferior border. Inner dentinal area undivided, transversely thickened, narrow and extending to inner edge of superior face of mandible. Anterior outer dental area not produced anterior to border of inner area, not on a projection, and not extending as far as inner. Apical area end of a curved laminar column. Length 100 mm. (From Cope.)

This species was originally described by Marsh from an ichthyodurite he assigned to a chimæroid fish. It was a nearly perfect dorsal spine about 356 mm. long, somewhat curved, remarkably slender, tapering regularly to its apex, compressed transversely, outline generally suboval, posterior surface slightly concave in lower portion, upper half of this surface armed with two rows of very sharp decurved teeth while corresponding part of anterior face had sharp cutting-edge finely serrated toward distal end, and sides of spine smooth or faintly striated. He also noted that fragments of this species of much larger size were not uncommon in the same geological horizon in other parts of the State.

Formation and locality. Cope had a broken mandible and a dorsal spine, which latter he thought identical with the one noticed by Marsh. All the material examined by these two writers was from the upper Cretaceous marl bed near Hornerstown [the Hornerstown marl] in Monmouth County (J. G. Meirs). The identity of the mandible, described above from Cope, must be considered provisional, resting entirely on the fact that it was topotypic and has not been demonstrated positively to belong to the same fish to which the ichthyodurite belonged.

EDAPHODON DIVARICATUS (Cope).

Ischyodus divaricatus Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 315.
Cretaceous marl of Burlington Co., N. J.
 Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, pp. 285, 292. (New Jersey greensand, No. 5, from near Hornerstown.)

Right mandibular a trifle more than twice as long as deep, and rami would apparently converge in a slight curve, nearly an

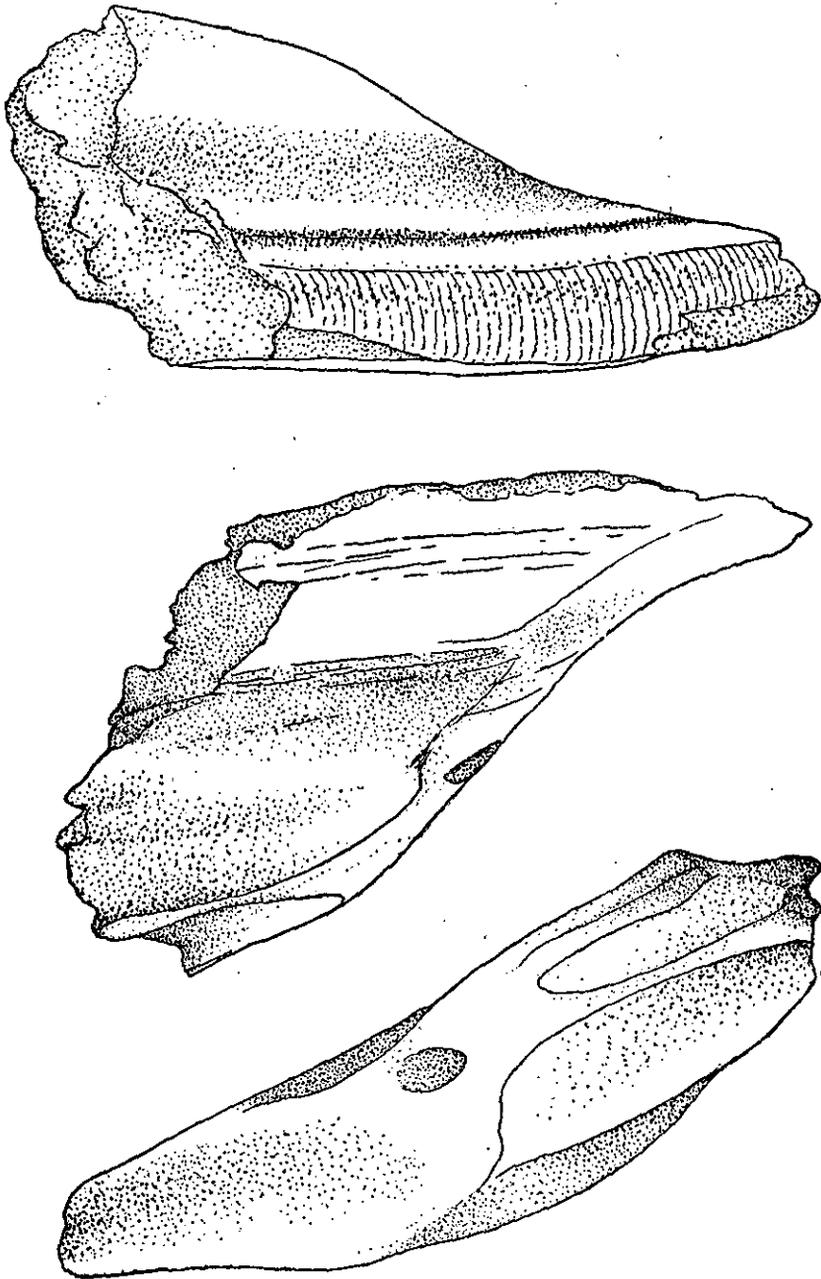


Fig. 76.—*Edaphodon divaricatus* (Cope). (Type.)

isocles triangle, ending in a moderate symphyseal beak. Outer surface of mandibular concave medianly and convex above (below damaged). Outer profile concave anteriorly, then sloping up somewhat undulated and ending above convexly, below and behind (damaged) apparently more or less convex. Inner symphyseal edge beveled rather short and deep and flattened, except behind, where a slight convex ridge projects and continued back as a groove along posterior inner edge. Inner surface of mandibular below and behind symphysis very slightly concave above and equally convex below, with several indistinct longitudinal striæ. Oral surface of beak well concave and posteriorly forms plane sloping slightly inwards, equally slightly convex, edges not elevated externally. Inner dental area largest, comprising whole inner posterior surface, extending forward slightly before anterior dental surface as sharp angle along inner edge, and forming deep undulation or loop just below anterior outer dental area. Latter smallest of dental areas, rounded, and placed on comparatively level surface. Posterior outer dental area much longer than anterior, close to edge, elongated and still closer to inner dental area, only separated by a narrow level area. Lower surface of mandibular exposing rather broad longitudinal area marked with numerous even broadly lunate striæ. Length 115 mm.

Only the type described above have I been able to examine. Cope had three other examples besides the type from Greensand No. 5, near Hornerstown, in Monmouth County. He notes that they showed the general peculiarities, as interrupted masticatory surface, small external areas, anterior subround and opposite or behind apex of very large inner. Narrowed beak forms an angle with posterior part of jaw and penetrated by a laminar column of little width.

Formation and locality. This species is recorded as from the Cretaceous marls of Burlington County and near Hornerstown in Greensand No. 5. It is tentatively referred to the Hornerstown marl.

EDAPHODON SOLIDULUS (Cope).

- Ischyodus solidulus* Cope, Proc. Am. Philos. Soc. Phila., XI, 1867, p. 244.
 Hornerstown, Monmouth Co., N. J. Greensand No. 5.
Diphriassa solidula Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 283.
 (Hornerstown, N. J. Greensand No. 5.)
Edaphodon solidulus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 39.
 Pl. 2, figs. 1-2 (type).

Mandibular compressed, rather deep, or depth about half its length. No distinct external crests. Terminal area of beak forms round extremity of a narrow column. Inner and outer margins, anterior to large area, of equal elevation, regularly curved outwards without angulation. No anterior outer den-

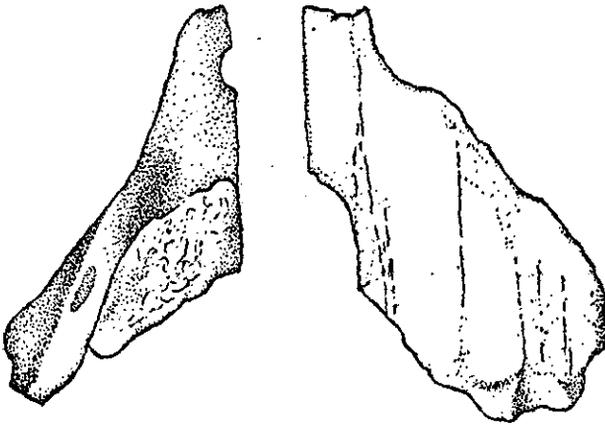


FIG. 77.—*Edaphodon solidulus* (Cope). (Type, from Hussakof.)

tinal area. Posterior outer dentinal area very small and faces inwards from gradual elevation of outer superior margin. Inner area very large, undivided, accompanied on inner margin by a slender column which issues in posterior corner of symphyseal plane. Length (restored) about 64 mm. (From Cope.)

This species was made the basis of a separate genus by Cope. The large inner area of dentinal tubules, with a terminal one issuing near the apex, and only a single small external dentinal area were the chief characters he advanced. However, I accept Hay's action in merging *Diphriassa* with *Edaphodon*.

Formation and locality. Known only from the type, a left mandibular, from "Greensand No. 5" [the Hornerstown marl, K.] at Hornerstown in Monmouth County (J. G. Miers) now in the American Museum at New York.

EDAPHODON LATIDENS (Cope).

Diphriassa latidens Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 283.

Greensand of New Jersey, No. 5.

Edaphodon latidens Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 38, fig. 15 (type).

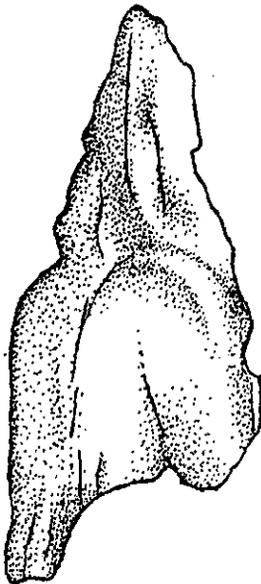


FIG. 78.—*Edaphodon latidens* (Cope). (Type, from Hussakof.)

Mandibular with anterior portion of beak narrowed, apical area flat or crescent-like. Inner area very wide, leaving but narrow border on outer side. This band but little oblique, edge slightly elevated and without any dentinal area. Single outer column issues near border, hind edge in transverse line with anterior edge of inner area, its front end extending short distance beyond. Anterior border of inner area broad and obtuse. Length 94 mm. (From Cope.)

Formation and locality. Only known from an imperfect mandibular ascribed to the "Greensand of New Jersey No. 5" [the Hornerstown marl, K.] and now in the American Museum at New York.

EDAPHODON sp.

Right palatal depressed, a trifle more than twice as long as wide, and depth about one-third length. Upper surface with a deep wide gutter ending in a deep pit, anterior to which area is flattened and horizontal. Side flattened and sloping obliquely out. Lower surface with conspicuous prominence in front or crest,

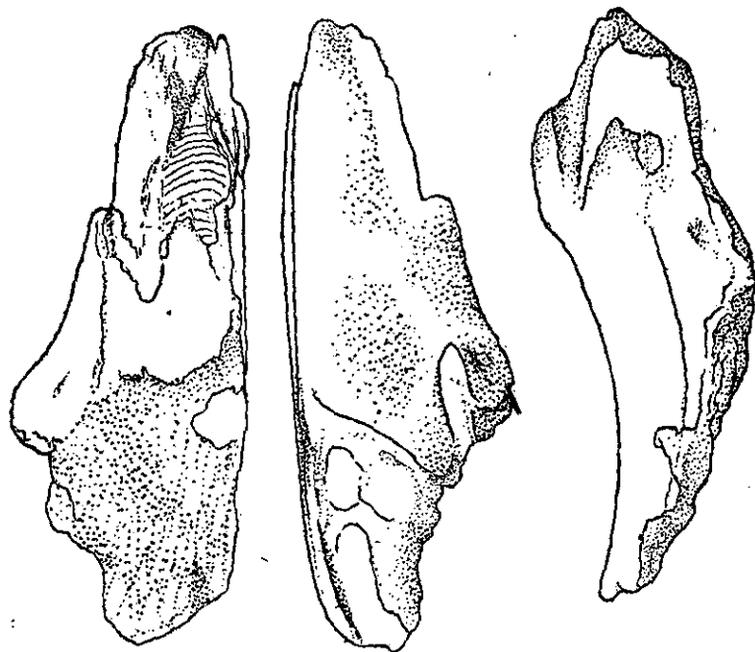


FIG. 79.—*Edaphodon* sp. New Jersey "greensand."

sloping steeply forward. Apex of crest gives rise to anterior dental area, latter elongated, scarcely wider posteriorly, though at that point deeply concave, and extending slightly behind front of inner posterior dental area. External posterior dental area arises very slightly behind front end of posterior inner dental area. Inner surface of upper maxillary entirely flat. Length 70 mm.

I have but the single example, fragmentary, described above. It somewhat resembles the palatal of *E. mirificus*, except that the anterior dental areas are much longer and arise on a much higher crest.

Formation and locality. Recorded only as "from the Greensand of New Jersey."

EDAPHODON sp.

Mandibular bone, right ramus, a trifle more than twice as long as deep, and width a little more than a third its length, so that rami would converge nearly in a triangle, ending in a short, deep symphyseal beak. Outer surface of mandibular generally de-

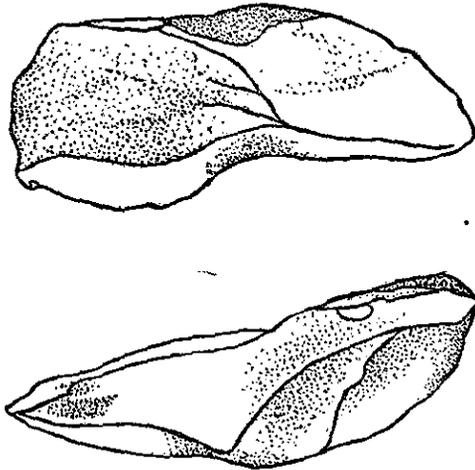


FIG. 80.—*Edaphodon* sp. New Jersey "greensand" (Gabb).

pressed, slightly concave medianly and equally slightly convex above and below. Outer profile undulated slightly anteriorly, arising somewhat convexly behind above. Lower anterior profile convex, then sloping up posteriorly and hind profile vertically convex. No beveled symphyseal edge, though anteriorly well depressed or flattened, then surface rather convex, and flaring slightly, more so inward, behind. Oral surface well marked by lateral edges, though these scarcely prominent ridges, except slightly at anterior symphyseal region and posterior ex-

ternal. Front region of oral surface, near symphysis, and about midway in its length or opposite front of inner dental area, distinct concavities. Inner dental area extends forward slightly before middle in length along inner edge and externally well towards outer edge. Below anterior symphyseal region traces of parallel striæ transversely. Lower surface of mandibular largely convex. Length 63 mm.

Besides the above fragment another with same data seems to resemble the posterior or outer flange of the palatal of *E. mirificus*.

Formation and locality. I have two fragments "from the Greensand of New Jersey" (W. M. Gabb).

EDAPHODON sp.

Mandibular bone, right ramus (hind end largely broken away) about half long as deep, and rami probably well diverging behind. Symphyseal plain, moderate, distinct. Outer mandibular surface generally depressed, somewhat concavely. Inner dentinal area large, and apparently begins a little behind outer, though latter but imperfectly preserved. Length about 68 mm.

The above fragment is in the collection of the Geological Survey and is without data, though, like the next, was most likely from the Cretaceous of New Jersey. Similarly it suggests *E. incrassatus*, but is too imperfect for satisfactory comparison.

Formation and locality. Not given.

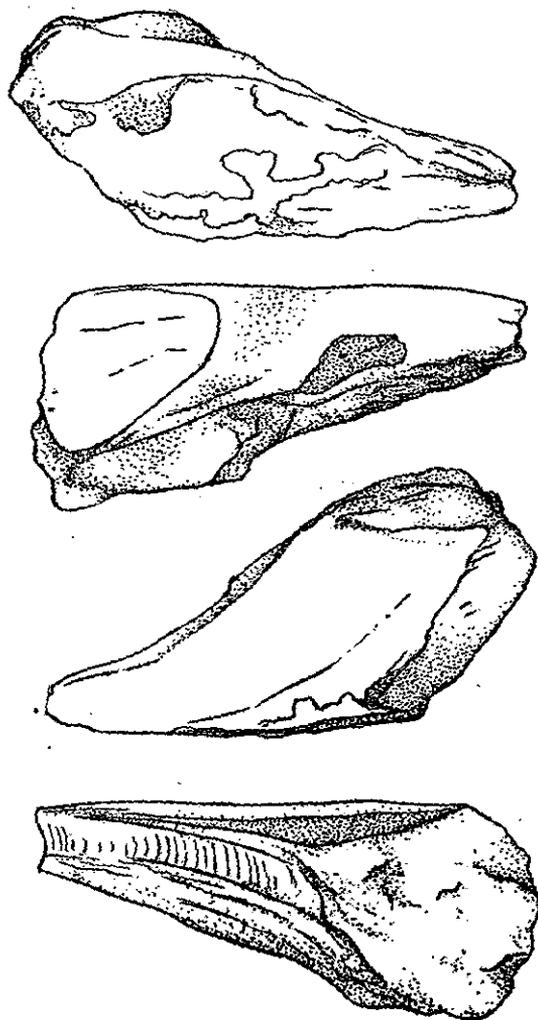


FIG. 81.—*Edaphodon* sp. *New Jersey.

EDAPHODON sp.

Mandibular bone, right ramus (probably half broken away) a trifle more than half deep as long, and width similar, and rami probably slightly diverging. Symphyseal plane moderate, distinct. Outer mandibular surface generally depressed. Inner dental area (only anterior portion remains) extends to inner

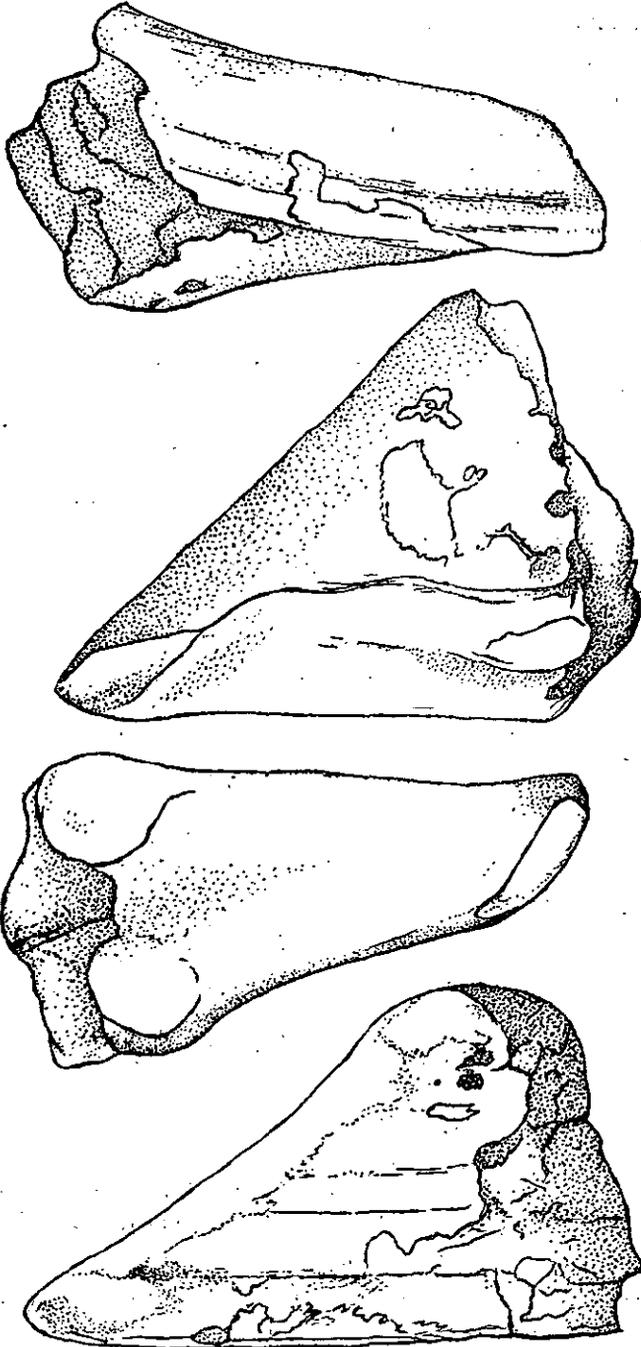


FIG. 82.—*Edaphodon* sp. *New Jersey.

mandibular edge, and in front begins slightly behind outer dental area. Latter similar, and apparently large. Length about 80 mm.

This fragment is in the collection of the Geological Survey and is without data. It suggests *E. incrassatus* and may be identical or referable to some similar species as yet undescribed.

Formation and locality. Not given.

Genus BRYACTINUS Cope.

Bryactinus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 282. Type *Bryactinus amorphus* Cope, monotypic.

This genus differs from *Edaphodon* in having several dental areas exposed along outer edges, the apical tube exposed at both extremities and the excavation of posterior half of inner face.

A single extinct species known.

BRYACTINUS AMORPHUS Cope.

Bryactinus amorphus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 282, Pl. 45, fig. 12. *Hornerstown, N. J. Greensand of No. 5.*
Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 37, fig. b (type).

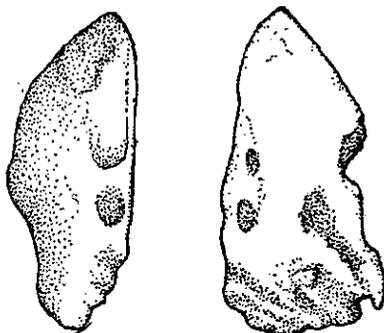


FIG. 83.—*Bryactinus amorphus* Cope. (Type, from Hussakof.)

Dental plate triangular, base representing grinding face, not level, but like others slightly convex. Opposite angular ridge only extends half jaw length, then sinks and exposes hind end of apical column of dentine. On grinding surface along outer border three other columns issue, not parallel in their courses, but

divergent from nearer origins. Inner face behind posterior exit of apical column excavated, possibly for application of another bone. Grinding face convex at middle, divided into two planes behind, outer narrow and elevated, and inner oblique and separated by an obtuse angle from excavation of inner side. Length 42 mm. (From Cope.)

Formation and locality. Known only from the type described above, from the "Greensand No. 5" [Hornerstown marl, K.] of Hornerstown, N. J., and now in the American Museum at New York. I have not seen this example.

Genus ISOTÆNIA Cope.

Isotania Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 293. Type *Isotania neocasariensis* Cope, monotypic.

Differs from *Edaphodon* in lacking superior groove. Representing two anterior dentinal columns of the latter are two similar exposures, both on same plane and masticatory face together, only separated by a narrow partition.

A single species, extinct.

ISOTÆNIA NEOCASARIENSIS Cope.

Isotania neocasariensis Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 293. *Hornerstown, N. J. Greensand No. 5.*

Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 41, Pl. 3, figs. 3-4 (type).

Palatal with three solid planes, widest opposite to dentinal columns and parallel, and nearly wide as latter. Lateral planes not parallel with one another, wider forms acute angle with last described and narrower very obtuse angle so as nearly continuous with same, running out into it posteriorly. More vertical side retains same depth throughout. One end of bone rounded and truncate, other end excavated directly at right angles to dentinal areas and then continued as an edentulous plate. Length 93 mm. (From Cope.)

Formation and locality. Known only from the above-described type from "Greensand No. 5" [the Hornerstown marl, K.] at

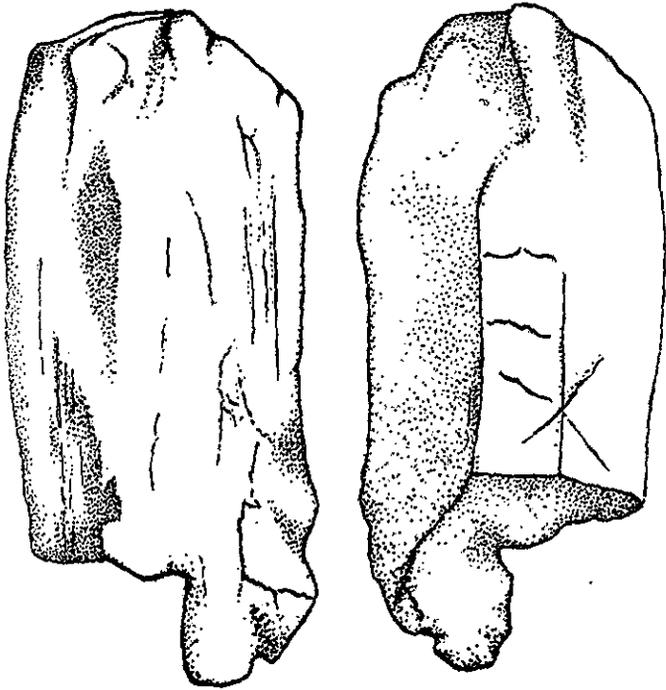


FIG. 84.—*Isotania neocasariensis* Cope. (Type, from Hussakof.)

Hornerstown in Monmouth County (J. G. Miers), and now in the American Museum at New York. I have not seen this specimen.

Genus LEPTOMYLUS Cope.

Leptomylus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 313. Type *Leptomylus densus* Cope, monotypic.

This genus is related to *Psaliodus* Egerton,¹ differing in having a single small, narrow dentinal area near the inner margin of the mandibular, which is also without any symphyseal bevel. Median interior longitudinal ridge obtuse and little marked, coated with dense glossy layer.

Species 3, all extinct.

¹ This genus shows no dentinal areas in the mandibulars.

LEPTOMYLUS COOKII Cope.

Leptomylus cookii Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 384.
Near Mount Holly, Burlington Co., N. J. Greensand No. 5.

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 282. (Near Mount Holly,
Burlington Co., N. J. Greensand No. 5.)

Leptomylus cookii Hussakof. Bull. Amer. Mus. N. H., XXV, 1908, p. 41,
Pl. 2, figs. 8-9 (type).

Mandibular with posterior portion curved out from symphyseal, latter much compressed and moderately prolonged with inner face quite concave, posteriorly outer face also slightly concave. A single obtuse external crest descends gradually to plane

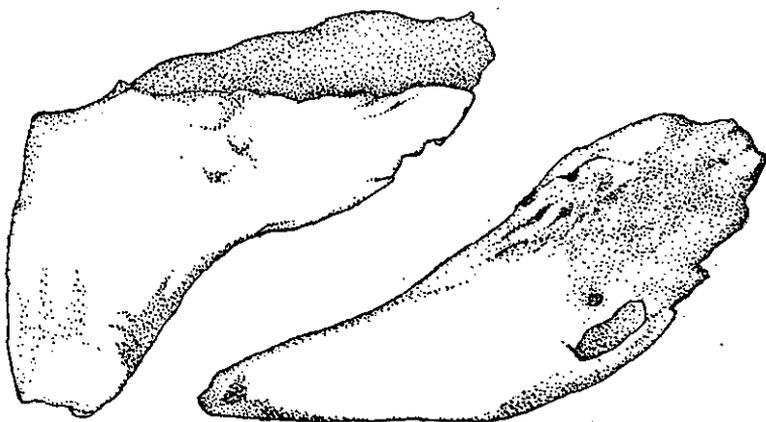


FIG. 85.—*Leptomylus cookii* Cope. (Type, from Hussakof.)

of beak, presenting no dentinal area. A single small oval area represents internal, lies along inner margin and latter much thickened, rolled over inwards and symphyseal face very narrow. End of beak (broken away) in section shows no inferior plate-like column, but a round column, which issues on upper surface of beak behind apex. Length nearly 70 mm. (From Cope.)

Cope says the apical dentinal column distinguished it from *L. densus*, in which no such column exists. He also says at hind fractured section of jaw apical column is seen, while internal dentinal area not, latter occupying only a pocket, not a column. The species is like *Edaphodon solidulus* in the apical column,

which has same form in both, though two dentinal faces latter possesses are those of true *Edaphodon*.

Formation and locality. Known only from the type, described above, a right mandibular, from the marl near Mount Holly in Burlington County, referred to by Cope as "Greensand No. 5" [but now recognized as the combined Navesink-Hornerstown marl bed, K.] now in the American Museum at New York.

LEPTOMYLUS DENSUS Cope.

Leptomylus densus Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 313.
Birmingham, N. J. Cretaceous marl pits.

Cope, Rep. U. S. Geol. Surv. Terr. II, 1875, p. 281. (Birmingham, N. J. Greensand No. 5.)

Mandibular with front end prolonged, slightly narrowed, hind face plane, and transversely concave longitudinally. When external edge rises internal falls off, and narrow dentinal area directed obliquely upwards and inwards. Inner face, above an anterior thickened margin as deep as prolonged beak, concave, but again convex near superior margin. Marked with obscure curved, coarse lines parallel to hind outer edge. Lower or front edge a contracted ridge, inner plane vertical and upper part of inner face expanding upwards. Dentinal column supporting tubercle large as a goose quill. No other columns. Length from first point about 140 mm. (From Cope.)

Cope also describes a palatal he thinks may belong to this species. It differs from *Edaphodon* in the presence of two very narrow dentinal bands, which are opposite and parallel, one on the outer margin and the other within the inner margin of the bone. Form much depressed and spade-like, superior face scarcely descending regularly to edge. Outer margin expands an inch behind end and beveled off from continued width of upper face, latter showing slight longitudinal striæ. Proximally usual large groove.

Formation and locality. Known only from Cope's account, reproduced above, based on a mandibular from the "Greensand No. 5" [the Navesink-Hornerstown marl bed, K.] of Birmingham in Burlington County (J. Gaskill). Also a supposed palatal, with same data.

LEPTOMYLUS FORFEX Cope.

- Leptomylus forfex* Cope, Proc. Acad. Nat. Sci. Phila., 1875 (Feb. 9th), p. 19 (nomen nudum). New Jersey Cretaceous.
Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 281. *Hornerstown and Barnesborough, N. J. Greensand No. 5.*
Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 41, Pl. 3, figs. 1-2 (type).

Mandibular much elevated, elevation being confined to outer side which rises as a lamina, causing masticatory face nearly vertical much its length, and but short extent level to apex. Slight marginal swelling where anterior outer dental should be, and an abrupt rise in margin to position occupied in *Edaphodon* by posterior outer area. Inner border of masticating surface parallel to inferior border of jaw except where two converge to apex, here entire face included between them occupied by large symphyseal facet. Inner dentinal area represented by narrow acuminate patch on inner angle of masticatory face opposite tuberosity representing anterior outer. Apical area very narrow, extends same distance along exterior angle of superior face. Length 135 mm. (From Cope.)

Cope also notes that the palatal found in connection with the mandibles of *Edaphodon mirificus* does not pertain to them, and is only inferentially referred to this species. The resemblance to the species is very great. Its oblique superior and outer face greatly extended, while inner narrow and vertical. Usual superior groove present, close to edge of latter. Inferior border quite thin. Only two dentinal areas, these exceedingly small and representing outer and anterior inner of species of *Edaphodon*. Length 140 mm.

Formation and locality. Known from the type, described above, from "Greensand No. 5" [the Hornerstown marl, K.] at Hornerstown in Monmouth County (J. C. Miers), now in the American Museum at New York. Cope also had a mandibular and palatal from near Barnsboro in Gloucester County (J. C. Vorhees [probably from the combined Navasink-Hornerstown marl beds, K.]).

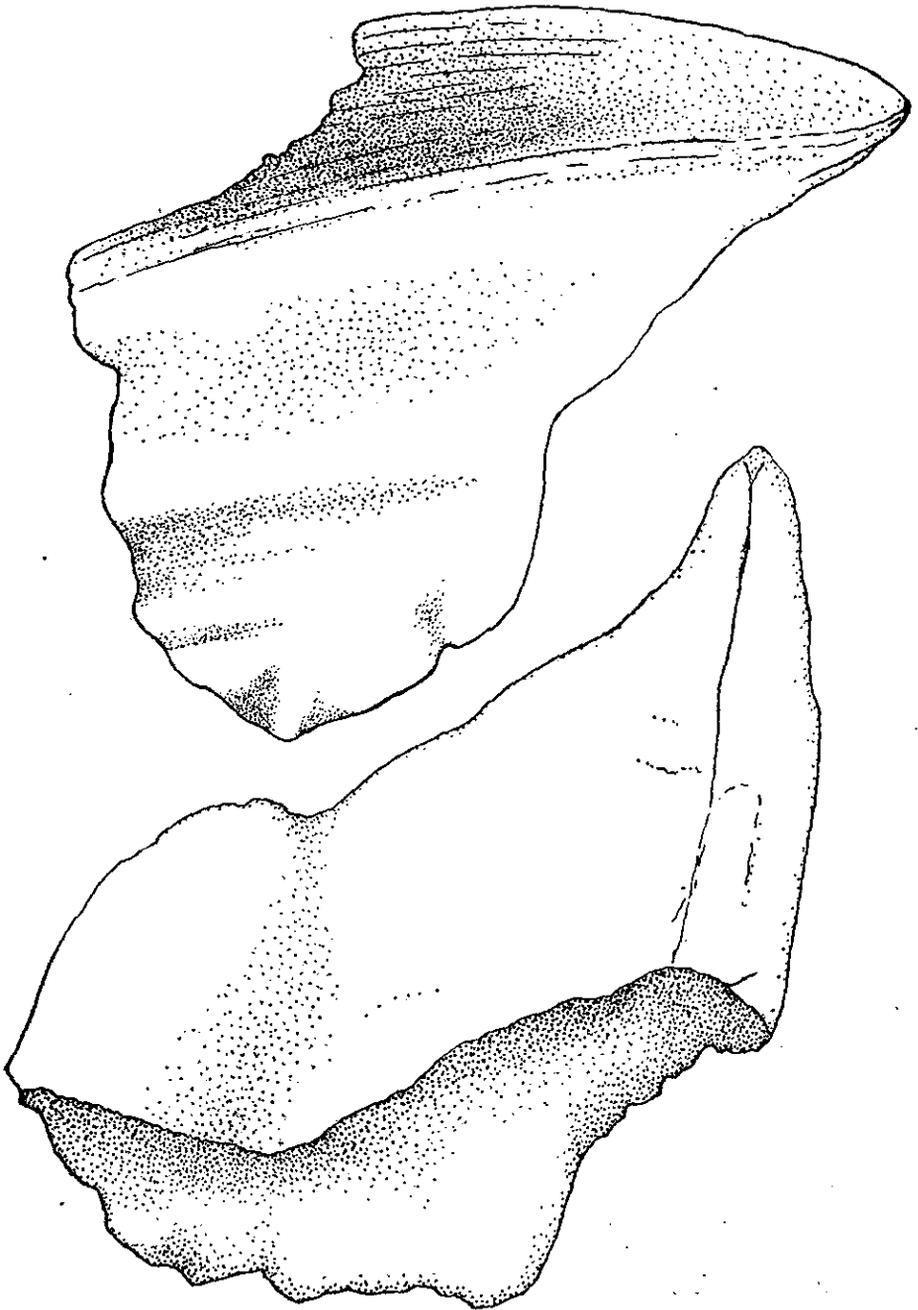


FIG. 86.—*Leptomylus forfex* Cope. (Type, from Hussakof.)

ICHTHYODORULITES.

This group is purely artificial, and is used merely as a repository for various spines, dermal armature, tubercles, etc., of such cartilaginous fishes as sharks and chimæras, which are only known from fragmentary remains. It often follows that such incomplete indications of these animals are very similar in the various genera, and that their determination as to higher rank is very difficult, if not impossible, for which reason it would be convenient to at least indicate them in this provisional arrangement. About 82 genera have been described.

Genus CYLINDRACANTHUS Leidy.

Cylindracanthus Leidy, Proc. Acad. Nat. Sci. Phila., VIII, 1856, p. 12. Type

Cylindracanthus ornatus Leidy, monotypic.

Cælorhynchus (nec Giorna) Agassiz, Poiss. Foss., V, 1843, pp. 892. Type

Cælorhynchus rectus Agassiz, first species, and name only, restricted by Hay, Bull. U. S. Geol. Surv., No. 179, 1902, p. 331.

Glyptorhynchus Leriche, Poiss. Eoc. Basin Belge, 1906, p. —(not consulted).

Spine very long, slender, gradually tapering, rounded in section, without denticles, external face longitudinally ridged and grooved, each ridge corresponding to wedge-shaped plate which forms small sector of spine. Central cavity relatively small, sometimes in part simple, but usually divided by median partition. Division plane passing through middle of partition, thus allowing spine to be readily split into two symmetrical halves.

This genus was originally thought to be possibly allied with the sword fishes, and others have thought it located near the chimæroids. Its true position must still be considered doubtful.

CYLINDRACANTHUS ORNATUS Leidy.

Cylindracanthus ornatus Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 12.

Cretaceous near Pemberton, Burlington Co., N. J. (W. Taylor), and Alabama.

Cælorhynchus ornatus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 294. (Eocene Marl of Farmingdale, Monmouth Co., N. J.)

Spine cylindrical, slightly tapering (both ends damaged). Surface with longitudinal striæ of more or less even length,

variation in striæ only due to greater width or depth of grooves separating them, and entire surface evenly smooth to touch. As spine narrows occasionally, two will unite and then continue singly. Striæ vary 35 to 45 in number. Length (damaged) 87 mm. Diameter 14 mm.

All the smaller examples exhibit about 35 or 36 striæ, while in the largest there are 45. Allowing for the flutings, which are not over 10, the variation is considerable.

Formation and locality. The types, three fragmentary spines from the "Cretaceous near Pemberton" [may mean the Navesink-Hornerstown marl just west of Pemberton at Birmingham, the Vincentown limesand nearer town, or the Manasquan marl, exposed in the banks of the creek at Pemberton, K.], in Burlington County (W. Taylor), and four small fragmentary spines from the Eocene marl of Farmingdale in Monmouth County (A. J. Smith).

CYLINDRACANTHUS ACUS (Cope).

Calorhynchus acus Cope, Proc. Amer. Philos. Soc. Phila., XII, 1870, p. 294.

Eocene Marl of Farmingdale, Monmouth Co., N. J.

Cylindracanthus acus Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 44, fig. 1 (type).

Fragment of small spine with single median cavity, and externally 19 ridges separated by narrow grooves. Length about 29 mm. (From Cope.)

Cope originally states this to be a portion of the muzzle of a fish similar to *C. rectus*, but smaller, also much smaller than *C. ornatus*, and differing from the latter in much fewer ridges.

Formation and locality. The type, described above, from the Eocene marl of Farmingdale in Monmouth County (A. J. Smith), and now in the American Museum at New York.

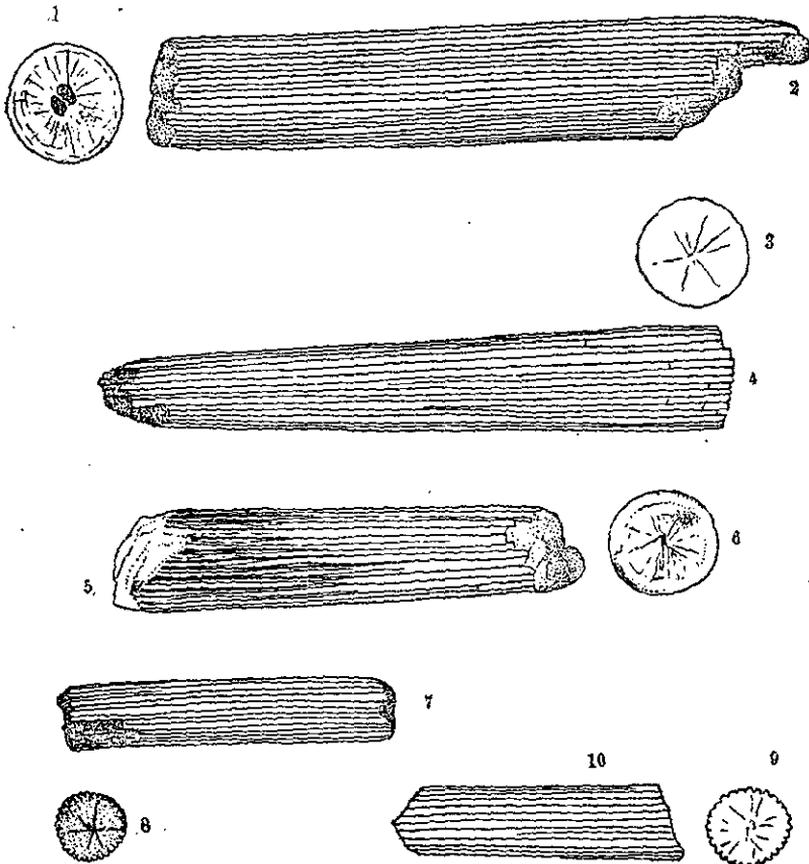


FIG. 87.—*Cylindracanthus ornatus* Leidy. 1-6, New Jersey; 7-10, Monmouth Co.



FIG. 88.—*Cylindracanthus acus* Cope. (Type, from Hussakof.)

Genus SPHAGEPŒA Cope.

Sphagepœa Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 241. Type *Sphagepœa aciculata* Cope, virtually designated, monotypic.

Spine slender, acute, nearly straight, with thin projecting anterior edge deeply notched from tip to short distance above base, producing an acute dentition. No teeth behind, but two prominent ridges separated by a deep groove. Sides of spine longitudinally grooved. The single extinct species known.

SPHAGEPŒA ACICULATA Cope.

Sphagepœa aciculata Cope, Proc. Amer. Philos. Phila., XI, 1869, p. 241.

Cretaceous Greensand of the upper bed, Birmingham, N. J.

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 293. (Birmingham, N. J. Greensand No. 5.)

Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 50, fig. 22 (type).

Spine much compressed in general form, but section of edentulous portion broad as deep. Sides with two elevated ridges, anterior only continued to near tip, gradually broken into series of tubercles near base. Length about 140 mm. (From Cope.)

Cope says this spine may be referred to either a pycnodont, chimæroid or possibly even a plectognath fish. He also adds it resembles the spine of *Microdon muchalis* figured by Dixon.

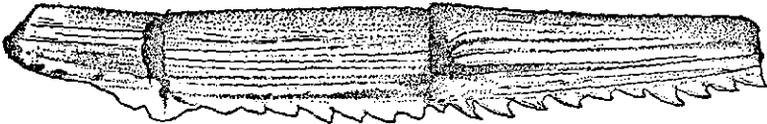


FIG. 89.—*Sphagepœa aciculata* Cope. (Type, $\frac{2}{3}$ size, from Hussakof.)

Formation and locality. Known only from the type which Cope says was discovered in the Cretaceous greensand of the upper bed at the pits of the Pemberton Marl Company, Birmingham, in Burlington county (T. Kite). Hussakof, however, gives the locality as Hornerstown. [In either event it seems referable to the Hornerstown marl, K.].

Sub-Class ACTINOPTERI.

THE TRUE FISHES.

Membrane head bones, as opercle, preopercle, etc., developed. Skeleton sometimes cartilaginous, usually bony. Skull with sutures. Lungs imperfectly developed, or degraded to form swim-vessel, or entirely absent. Heart developed, divided into an auricle, ventricle and arterial bulb. Gills with their outer

edges free, their bases attached to bony arches, normally four pairs of these, and fifth pair being typically modified into tooth-bearing lower pharyngeals. Ova small. Median and paired fins developed, latter with distinct rays. No claspers.

Series GANOIDEI.

THE GANOID FISHES.

A scarcely definable assemblage of largely provisional nature first used by Agassiz for those fishes armed with bony plates instead of the usual type of cycloid or ctenoid scales. The orders are: *Lysopteri*, *Chondrostei*, *Selachostomi*, *Pycnodonti*, *Lepidostei* and *Halecomorphi*.

Order PYCNODONTI.

THE PYCNODONTS.

Notochord persistent, without ossifications in its sheath. Opercle small. Preopercle large. Branchiostegal apparatus reduced. No subopercle or interopercle. No infraclavicles.

This order contains a single family.

Family PYCNODONTIDÆ.

THE PYCNODONTS.

Trunk deeply fusiform or cycloidal. Mouth gape small. Prehensile teeth on premaxillary and dentary, wanting on maxillary (if this bone present) and pterygo-palatine arcade, tritorial on single vomer and splenials, and all teeth without vertical successors. Cranial bones robust, median occipital plate separating parietals. Facial bones delicate or wanting. Opercle reduced till small, preopercle large. Branchiostegals not more than two. Mandibular suspensorium much inclined forward. Notochord persistent, without ossifications in sheath. Scales rhombic when present, frequently wanting on whole or part of caudal region, and almost invariably strengthened by inner rib on anterior edge

and united by peg-and-socket articulation in connection therewith. Fin-rays robust, majority well-spaced and articulated, fulcra absent, except perhaps quite at base of caudal fin. Dorsal and anal more or less extended.

This family, of which all its members are extinct, is apparently most closely related to the sturgeons, near which it has been placed. About 15 genera have been described.

Genus *PYCNODUS* Agassiz.

Pycnodus Agassiz, Poiss. Foss., II, 1835, p. 183. Type *Zeus platessus* Blainville, first species, restricted by Woodward, Cat. Foss. Fishes, III, 1895, p. 276.

Periodus Agassiz, l. c., p. 201. Type *Periodus hoemigii* Agassiz, monotypic.

Trunk deeply fusiform, gradually passing into slender caudal peduncle. Teeth smooth or with slight apical pit and feeble rugosity. Oral vomerine surface slightly convex from side to side, with five longitudinal series of teeth. Splenial dentition comprising three series of teeth, innermost largest. Head and opercular bones externally rugose and punctate. Neural and hæmal arches of axial skeleton of trunk expanding to encircle notochord. Scales covering front part of body before median fins. Fin rays delicate, spaced, articulated, somewhat divided distally. Pelvic fins present. Dorsal and anal low, fringe-like, former occupies greater part of back and latter much shorter, arising posteriorly. Caudal with slightly excavated hinder border.

About 32 species have been described.

PYCNODUS PHASEOLUS Hay.

Pycnodus phaseolus Hay, Amer. Nat., XXXIII, 1899, p. 788 (name only, based on Leidy).

Pycnodus faba (nec Meyer) Leidy, Rep. U. S. Geol. Surv., I, 1873, pp. 292, 349, Pl. 19, fig. 15-16. *Greensand Marl of Crosswicks, Burlington Co., N. J.*

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 280. (*Greensand No. ? of N. J.*)

Jaw fragment with three broad teeth arranged obliquely parallel with one another from within backward and outward. Outline

elongated, bean-shaped, slightly concave in front and convex behind, and slightly wider externally than internally. Length of tooth about 20 mm. (From Leidy.)

The above paratype, figured by Leidy, differs from his type in not having small lateral teeth in at least one series each side of the median, and on one side traces of a second series.

Formation and locality. Originally from the Cretaceous of Mississippi, but also known from Leidy's record of the above-described example from the greensand marl of Crosswicks in

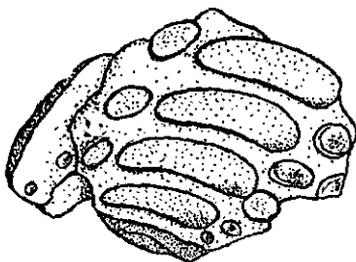


FIG. 90.—*Pycnodus phaseolus* Hay. (Type, from Leidy.)

Burlington County (J. H. Slack). This example was said to have been in the collection of the Academy, but I have not located it. [A marly clay, the Merchantville formation, outcrops at Crosswicks village, but no true marl beds occur within several miles of that place. The Navesink marl was formerly dug along Crosswicks Creek, south of Walnford, and 6 or 7 miles above Crosswicks village. It is impossible to determine whether the specimen is referable to the Merchantville clay or to the Navesink marl, probably the latter, K.]

PYCNODUS ROBUSTUS Leidy.

Pycnodus robustus Leidy, Proc. Acad. Nat. Sci. Phila., 1857, p. 168. *Greensand of New Jersey*.

Leidy, Rep. U. S. Geol. Surv. Terr., I, 1873, pp. 293, 350, Pl. 37, figs. 18-19 (type).

Tooth elongate, rather depressed, slightly convex anteriorly as viewed above, with either end very slightly tapering and rounded. Edges all rounded and like surface smooth. Viewed below

tooth deeply excavated, leaving trenchant edges all around and longer ones slightly more approximated than edges of upper surface. Length about 29 mm.

This was probably inclined from left downward to right end, and beginning at former greater portion beveled as triturating

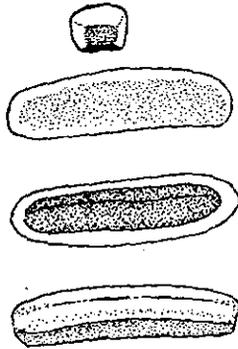


FIG. 91.—*Pycnodus robustus* Leidy. (Type).

surface, leaving lower right portion more convex. Coloration brownish and all about edges rather pale slaty.

Formation and locality. Only the type, described above, without definite locality or geological horizon (G. H. Cook) is known. It is now in the collection of the Academy.

Order LEPIDOSTEI.

THE BONY GANOIDS.

Skeleton bony. Subopercle and preopercle present, also coronoid and mesacoracoid. Branchiostegals present. Ventral fins abdominal, with basilar segments rudimentary, as in ordinary fishes. Primary radii of hind limb generally reduced to one rudiment. Optic nerves form chiasma. Intestine with spiral valve. Arterial bulb with several pairs of valves. Air vessel lung-like, cellular, connected, with œsophagus by duct. Skin covered with ganoid or cycloid scales. Tail heterocercal.

Family LEPISOSTEIDÆ.

THE GAR PIKES.

Body elongate, subcylindrical. Jaws mostly elongate, spatulate or beak-like, upper projecting beyond lower. Eyes small. Premaxillary forms most of upper jaw edge. Maxillary transversely divided in several pieces. Lower jaw composed of as many pieces as in reptiles, coronoid present. Both jaws with outer series of small teeth followed by one or two series of large teeth, besides series of small close-set rasp-like teeth on jaws, vomer and palatines. Large jaw teeth of conic form, pointed, striate, placed at right angles to jaw. These teeth resting in rather deep furrow protected on outside by raised border of jaw, on inside by similar ridge, pierced in center by foramen communicating with maxillary canal through which nerves and blood-vessels enter pulp cavity of tooth. Forms of folded dentine layers within teeth peculiar. Pharyngeal teeth rasp-like. Tongue toothless, short, broad, emarginate, set free at tip. Nostrils close to upper jaw tip. Gill-membranes somewhat connected, free from isthmus. Gills 4, slit after fourth. Gill-rakers very short. Pseudobranchiæ present. Branchiostegals 3. Accessory gill on inner side of opercle. Air-vessel cellular, lung-like, somewhat functional. Stomach not cœcal. Pyloric appendages numerous. Intestinal spiral valve rudimentary. Body covered with hard rhombic ganoid scales or plates, imbricated in oblique series extending downward and backward. External skull bones very hard, rugose. Fins with fulcra. Dorsal fin short, rather high, posterior, nearly opposite similar anal. Tail heterocercal, in young produced as filament beyond caudal. Caudal convex. Pectorals and ventrals moderate, few rayed, latter nearly midway between former and anal.

The existing forms are large fishes, chiefly of the fresh waters of North America, referred to one or two genera. Several generic names have been applied to the fragmentary fossil forms, which are here included under *Lepisosteus*. It seems likely that the existing forms are divisible into two genera, of which *Cylindrosteus* may also be maintained.

Genus LEPISOSTEUS Lacépède.

Lepisosteus Lacépède, Hist. Nat. Poiss., V, 1803, p. 330. Type *Lepisosteus gaviat* Lacépède, first species, restricted by Jordan and Gilbert, Proc. Acad. Nat. Sci. Phila., 1877, p. 84.

Lepidosteus, auct.

Psallisostonus Walbaum, Pet. Arted. Gen. Pisc., III, 1792, p. Type (no species given, except "Esocis species L.") *Esex osseus* Linnæus, affixed by Fowler, Proc. Acad. Nat. Sci. Phila., 1906, p. 81. (Name inadmissible as only a reprint.)

Cylindrostesus Rafinesque, Ich. Ohien., 1820, p. 72. Type *Lepisosteus platostomus* Rafinesque, first species, restricted by Jordan and Gilbert, l. c., p. 87.

Atractostesus Rafinesque, l. c. Type *Lepisosteus ferox* Rafinesque, first species, restricted by Jordan and Gilbert, l. c.

Sarchirus Rafinesque, Journ. Acad. Nat. Sci. Phila., I, pt. 2, 1818, p. 418. Type *Sarchirus vittatus* Rafinesque, monotype.

Pneumatostesus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 242. Type *Pneumatostesus nahunticus* Cope, monotype.

Clastes Cope, Rep. U. S. Geol. Surv. Terr., 1872 (1873), p. 633. Type *Clastes cycliferus* Cope, second species, restricted by Woodward, Cat. Foss. Fishes, III, 1895, p. 445.

Trichiurides Winkler, Arch. Mus. Teyler, IV, 1876, p. 31. Type *Trichiurides sagittidens* Winkler, monotypic.

Characters included in those of the family.

LEPISOSTEUS KNIESKERNI sp. nov.

Detached scale of lateral line unevenly rhomboid in contour of enameled surface, both upper and lower anterior edges slightly concave and upper posterior side longest. Enameled surface with number of minute pores, and median transverse short excavation (evidently a pore of lateral line) about first three-sevenths



FIG. 92.—*Lepisosteus knieskerni* Fowler. (Type.)

in length of scale. This pore opens on under side of scale in a pore placed about last third in its length, and continued back horizontally as rather deep groove. Inner or lower surface of scale rough, not enameled, with short hook-like process at upper angle. Length about 17 mm.

This species is only known to me from the above-described type, No. 2264, Acad. Nat. Sci. Phila., from Monmouth County, N. J. (Dr. P. D. Knieskern). Unfortunately it is without other data and is accompanied by two small fragmentary bones, one minutely denticulated, possibly belonging to the same animal? This fossil is quite interesting as indicating the first instance of the antiquity of *Lepisosteus* within our limits.

Formation and locality. No formation or definite locality has been given for this species, which would, however, seem to be Cretaceous? (Named for Dr. P. D. Knieskern, who collected the type.)

Order ISOSPONDYLI.

THE ISOSPONDYLOUS FISHES.

Anterior vertebræ simple, unmodified, without auditory ossicles. Symplectic present. Opercles distinct. Pharyngeal bones simple above and below, lower not falciform. Jaw bones developed. Maxillary broad, distinct from premaxillary, forms part of upper jaw edge. No barbels. Shoulder-girdle well developed, connected with cranium by bony post-temporal. No interclavicles. Mesocoracoid arch always well developed, as in ganoids, forming bridge from hypercoracoid to hypocoracoid. Gills 4, slit after fourth. Air-vessel, if present, with pneumatic duct. Scales usually cycloid, sometimes ctenoid, occasionally absent. No developed photophores. Dorsal and anal fins without true spines. Adipose fin present or absent. Ventral fins abdominal, sometimes wanting.

A large group, containing about 54 families, some of which show characters analogous in some of the ganoid *Halecomorphi*, seemingly pointing to a possible line of descent. The present order is a very large group, containing a vast number of marine, soft-rayed fishes among living forms, though the fossils are much less numerous.

Family RAPHIOSAURIDÆ.

Dentition with short stout fangs occupying alveoli, of which inner side and part of anterior posterior walls incomplete Teeth

more or less pleurodont, but extremity of root received into conic fundus of alveolus. Premaxillary bones well developed, maxillaries more so, and enter largely into composition of mouth border. Well developed angle of mandible.

This family differs from the *Chirocentridæ* in its dentition. All its species are extinct. Genera about 21. I may note that *Pachyrhizodus* Dixon¹ is antedated by *Raphiosaurus* Owen,² and therefore the present family appellation should stand as above rather than as *Pachyrhizodontidæ*.

Genus CONOSAURUS Gibbes.

Conosaurus Gibbes, Smiths. Contrib. Knowl., II, 1851, p. 9.² Type *Conosaurus bowmani* Gibbes.

Conosurus, auct.

Conosaurops Leidy, Proc. Acad. Nat. Sci. Phila., 1868, p. 202. Type *Conosaurus bowmani* Gibbes, virtually, as this name proposed to replace *Conosaurus* believed preoccupied.

Detached teeth conic, in transverse section circular, solid, sharp-pointed, slightly curved backward, fluted near base on inner face with smooth and fine enamel, and with an expanded osseus support.

Only a single species.

CONOSAURUS BOWMANI Gibbes.

Conosaurus bowmani Leidy, Proc. Acad. Nat. Sci. Phila., 1868, p. 200. (Greensand of Burlington Co.)

Conosaurus bowmanii Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 276. (Greensand of Burlington Co.)

Fragment of jaw slightly compressed, outer surface above less inclined than inner above, also former nearly plane or scarcely convex and latter slightly concave with inclination extending well down. As viewed above fragment slightly convex in general contour. At present three teeth alternate with four deep alveoli, latter appear as slightly ellipsoid pits of rather large size when

¹Geol. Sussex, 1850, p. 374.

²Rep. Brit. Assoc. Adv. Sci., 1841 (1842), pp. 145, 190.

viewed from above. Anterior tooth perfect, inclined slightly back, entirely conical, and tip directed slightly inside. Last two teeth damaged apically, solid, similar to first, and last smallest. Teeth all placed close together. Length 70 mm.

The above example is described by Leidy and referred to this species. Another smaller fragment, similar, only with two teeth, an alveolus between and traces of one externally to each tooth,

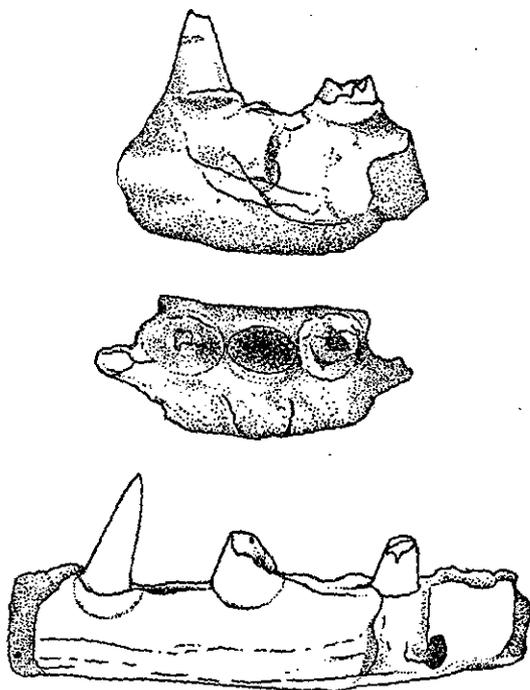


FIG. 93.—*Conosaurus bowmani* Gibbes. Burlington Co. (Taylor).

agrees in having solid conic teeth. In this fragment the external face, apparently, of the jaw, is well inclined. Length about 41 mm.

Formation and locality. The two fragments above described are from the greensand of Burlington County [which are Cretaceous, K.] (W. J. Taylor). The species was originally ascribed to the Eocene of South Carolina.

Family ICHTHYODECTIDÆ.

Body elongate. Snout not produced. Teeth acuminate, almost or exclusively confined to premaxilla, maxilla and dentary bones. Supraoccipital prominent, partly or completely separating parietals in median line. Squamosals reduced, otic region very prominent. Parasphenoid enclosing basicranial canal. Cheek-plates well developed. Mandibular suspensorium inclined forwards, but mouth gape wide. Premaxilla and maxilla robust and firmly fixed, both entering upper mouth border. Opercular apparatus complete, with branchiostegal rays, but no gular plate. Vertebral centra well ossified, none with transverse processes. Ribs nearly or completely encircling abdominal cavity. Hæmal arches more or less fused at base of tail. Intermuscular bones present. Post-temporal bones in contact with posterolateral angles of cranium. Scales thin, cycloid. Fin-fulcra absent. Fin rays divided and closely articulated distally. Dorsal and anal fins remote, latter elevated into an acuminate lobe anteriorly.

Represented by about eight genera, all extinct. Possibly the most salient character, as distinctive from the *Chirocentridæ* is the anal fin having an elevated anterior lobe.

Genus SAUROCEPHALUS Harlan.

- Saurocephalus* Harlan, Journ. Acad. Nat. Sci. Phila., III, 1824, p. 337. Type *Saurocephalus lanciformis* Harlan, monotypic.
Saurodon Hays, Trans. Amer. Philos. Soc. Phila., (2) III, 1830, p. 475. Type *Saurodon lea* Hays, monotypic.
Daptimus Cope, Proc. Acad. Nat. Sci. Phila., 1873, p. 339. Type *Saurocephalus phlebotomus* Cope, specified, monotypic.

Teeth hollow, in sockets, compressed to sharp edge in front and behind. Maxillary and dentary teeth almost uniform, only slightly increasing in size backwards, and those on premaxillary not much enlarged. Successional teeth formed on inner side of functional teeth, and a series of nutritive foramina on inner face of jaw below alveolar border or inner margin of each dental alveolus deeply notched. Small toothless presymphyseal bone

in mandible. Vertebræ about 60 ($= 25 + 35$). Centra exhibiting two deep longitudinally extended pits on each side.

About 20 species.

SAUROCEPHALUS LEANUS (Hays).

Saurodon lea Hays, Tr. Amer. Philos. Soc. Phila., (2) III, 1830, p. 476.
Upper Cretaceous of Pensauken Creek.

Saurodon leanus Hays, l. c., p. 477, Pl. 16, figs. 1-10 (type).

Cope, Proc. Amer. Philos. Soc. Phila., XI, 1870, p. 536 (compiled).

Cope, U. S. Geol. Surv. Wyom., 1871, p. 421 (reference).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 255. (Greensand No. 5, N. J.)

Saurocephalus leanus Harlan, Tr. Geol. Soc. Pa., I, pt. 1, 1834, p. 83 (not consulted).

Harlan, Med. Phys. Res., 1835, p. 286 (remarks).

Morton, Amer. Journ. Sci. Art., XXVIII, 1835, p. 277 (name only).

Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 302 (compiled).

Leidy, Tr. Amer. Philos. Soc. Phila., XI, 1857, pp. 91, 94, Pl. 6, figs. 12-15 (largely compiled).

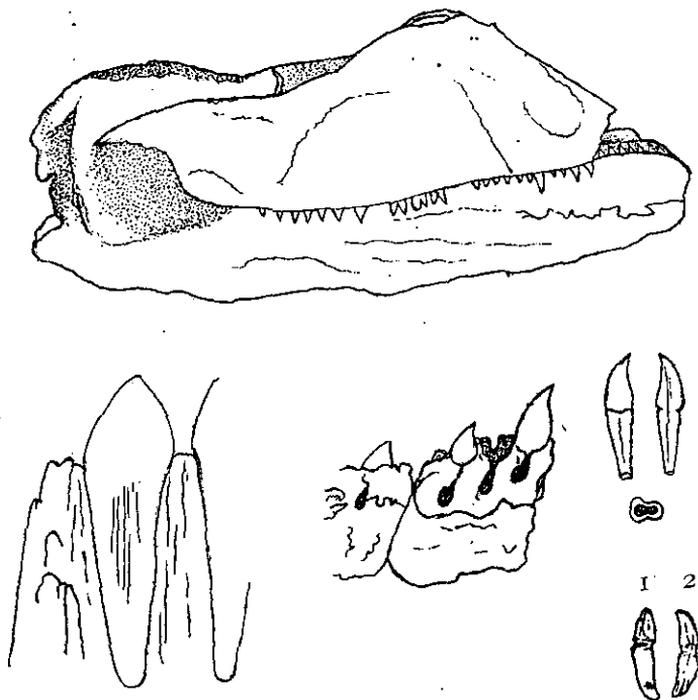


FIG. 94.—*Saurocephalus leanus* (Hays). 1-2, Allowaystown (Yarrow), and others type (from Hays).

Portion of mandible with rami nearly parallel, below through whole extent of fragment in contact apparently united by suture. Posteriorly on each a smooth shallow cavity. Near hind end appearance of suture, most distinct on left side. Dental bone with single row of alveoli continued in front for teeth. Just below alveolar border a series of foramina, one foramen to each alveolus. Teeth of mandible (crushed?) close within upper. Just within dental bone on left side rectangular portion of undetermined bone. Premaxillaries very distinct, united behind by squamous suture to upper maxillary, and apparently lachrymal, anteriorly premaxillaries rounded, and hind portions each side with four or five teeth. A lachrymal between premaxillary and maxillary on each side, deep groove on its front portion passing forward and down becomes smaller as it descends. Each lachrymal with small smooth superficial groove on upper portions, inside small smooth, slightly convex, apparently articulating surface. Maxillary above and in front, near junction with lachrymal, with smooth convex articulating surface inclining little inwards and alveoli for teeth distinct. Near alveolar edge, on inner surface regular series of foramina. Outer surfaces of maxillary and premaxillary with shagreen appearance. Teeth in both jaws close together, uniserial, in distinct alveoli, similar or mandibular rather more compressed, and anterior of latter also smaller than posterior. Crowns of teeth enameled, smooth, lanciform, slightly inclined inwards, and those at hind part of mandible slightly curved forward. Roots hollow, slightly grooved externally, and very slight groove internally. Apparently 9 or 10 intermaxillary teeth and about 30 in each maxillary. Length about 87 mm. (From Hays.)

Formation and locality. The type was found in the upper Cretaceous marl of Pensauken creek 5 miles southeast of Moores-town (J. Brick). [The headwaters of Pensauken Creek originate in the belt of Navesink-Hornerstown marl south of Mount Laurel, so that the specimen may be referred to that horizon, K.] I have not examined any examples unless a detached tooth from the marl at Allowaystown [Miocene, K.] (H. C. Yarrow) is identical.

Family ENCHODONTIDÆ.

Snout not produced. Teeth fused with supporting bone, not in complete sockets, those on pterygo-palatine arcade and dentary largest. Supraoccipital not prominent, but extending forwards to frontals and separating small parietals in median line. Squamosal reduced, only partly covering otic region, which projects laterally. No basicranial canal. Check-plates well developed. Mandibular suspensorium vertical or inclined backwards, and mouth gape wide. Premaxilla delicate, considerably extended, and excluding great part of slender maxilla from upper mouth border. Opercular apparatus complete, with few slender branchiostegal rays and no gular plate. Vertebral centra well ossified, none with transverse processes. Ribs not completely encircling adominal cavity. Compound hypural bone at tail base. Intermuscular bones present. Scales delicate or absent, but occasional longitudinal series of scutes and dorsal series, when present, unpaired. Fin fulcra absent. Rayed dorsal never extended much, usually near middle of back, and sometimes an adipose fin behind.

Related to the existing *Evermanellidæ* and *Alepisauridæ*, both fishes of the deep sea. All the members of this family are extinct and comprise about 10 genera.

Genus ENCHODUS Agassiz.

- Enchodus* Agassiz, Poiss. Foss., V, 1843, p. 64. Type *Enchodus halcyon* Agassiz, first species, restricted by Woodward, Cat. Foss. Fishes, IV, 1901, p. 191.
- Isodus* Heckel, Russegger. Reis., III, 1846-49, p. 342. Type *Isodus sulcatus* Heckel, monotypic.
- Ischyrocephalus* Marck, Zeitsch. Deutsch. Geol. Ges., X, 1858, p. 248. Type *Ischyrocephalus gracilis* Marck, monotypic.
- Solenodon* Kramberger, Jahrb. Geol. Reichsanst., XXXI, 1881, p. 373. Type *Solenodon neocomiensis* Kramberger, first species, restricted by Woodward, l. c., p. 204. (Preoccupied by Brandt 1833.)
- Holcodon* Kramberger, Rad. Jugoslav. Akad., LXXII, 1885, p. 19. Type *Saurocephalus? lycodon* Kner, virtually monotypic.
- Euryganthus* Davis, Tr. Roy. Dublin Soc., (2) III, 1887, p. 601. Type *Euryganthus ferox* Davis, monotypic.

Trunk elongate-fusiform, and, like head, laterally compressed. Mandible little prominent, with inner widely-spaced series of large slender teeth, front largest, also marginal series of minute teeth all nearly or completely solid. Premaxillary in form of vertical lamina, deepest in front, tapering behind, with uniserial small teeth. Maxillary long, slender, either finely toothed or edentulous at oral edge. Palatine thickened, tumid, with only one large tooth fixed at front end. Ectopterygoid robust, with single spaced series of large slender teeth, gradually diminished in size backwards. No teeth barbed. Operculum strengthened on inner side by ridge extending horizontally back from point of suspension. Cranial roof with deep median longitudinal depression, lateral and occipital margins ornamented like other external bones, with ridges and tubercles of ganoine. Branchiostegal rays about 12-16. Vertebræ 40-50, about half caudal. Centra at least long as deep, constricted mesially, and marked with small irregular longitudinal ridges. Rudimentary dermal scutes not overlapping, in single median series between occiput and dorsal and along course of lateral line. Pair of enlarged hook-shaped dermal scutes at base of tail, one on either side of caudal peduncle. All except foremost rays of each fin finely divided distally, but none excessively elongated. No post-clavicular plate. Dorsal and anal large, neither much longer than deep, and former arising much before middle point of trunk, latter also far forwards. Posterior adipose dorsal. Caudal forked, with curved fulcral rays and stout articulated undivided rays at base both above and below. Pectoral large. Ventral much smaller than pectoral, and far forward.

About 30 species have been described.

ENCHODUS FEROX Leidy.

Enchodus ferox Leidy, Proc. Acad. Nat. Sci. Phila., 1855, p. 397. Greensand near Mount Holly, N. J.

Emmons, Man. Geol. Ed. 2, 1860, p. 214, fig. 182 (no loc.).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 277. (Below Greensand No. 5, New Jersey.)

Hay, Bull. Am. Mus. N. H., XIX, 1903, p. 68, fig. 50 (Cope's material).

Hussakof, Bull. Am. Mus. N. H., XXV, 1908, p. 72 (Cope's material).

Sphyræna Morton, Synop. Organ. Rem. Cret., 1834, p. 32, Pl. 12, fig. 1. (Blue Marl of Monmouth Co.)

Enchodus pressidens Cope, Proc. Am. Philos. Soc. Phila., XI, 1869, p. 241. *Cretaceous Greensand of New Jersey*.

Cope, Rep. U. S. Geo. Surv. Terr., II, 1875, p. 277. (Greensand No. ? of N. J.)

Fragment of left premaxillary with base of anterior tooth (damaged). Length 38 mm.

Tooth (damaged) compressed laterally, forming rather broad longitudinal concave groove each side, and constricted convex surface with numerous fine parallel vertical basal striæ. Broad expanded convex surface smooth. Entire cutting-edges sharp. Crown of this tooth tapering rapidly to broad compressed and finally sharp point. Base of crown slightly flaring a little behind. Length 36 mm.

Another tooth comparatively broader, without striæ, form more compressed so convex side faces assymmetrical laterally. This tooth also shows very minute serræ along its cutting-edge. Length 38 mm.

The above examples are described in detail as they are Morton's originals. This species is the most abundant of the genus within our limits. It seems to be characterized by the cutting-edges of the large teeth extending both sides basally.

Formation and locality. Besides the above-described examples, ascribed to the "Blue marl of Monmouth County" [either Navesink or the Shark River, probably the former, K.] (3); a large fang and portion of attachment from "the Greensand at Freehold in Monmouth County" [Navesink marl] (J. H. Slack 1); also portion of jaw with three large conic teeth without other locality than New Jersey (C. C. Abbott 1); portion of jaw and its attachment labeled New Jersey, and fragment of jaw with two large solid teeth and a series of externals of small size from Burlington County. The following detached teeth seem to belong to this species: 1 of moderate size found with *Hadrosaurus foulkii* at Haddonfield [in the Woodbury clay, K.]; 1 from "New Jersey" (C. C. Abbott); 1 from "New Jersey" (E. D. Cope); 1 from the Cretaceous of "New Jersey" (J. Leidy); 1 imperfect from Monmouth County (C. C. Abbott); 1 from Vincetown in Bur-

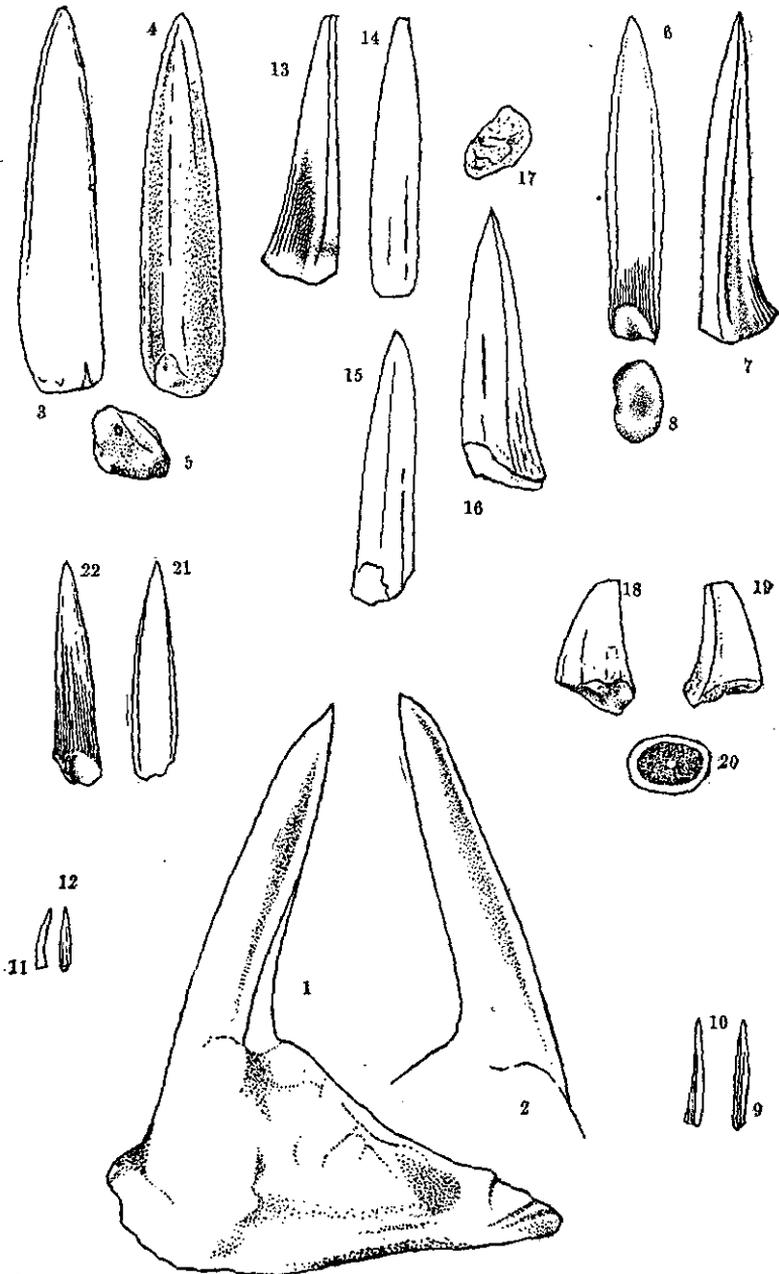


FIG. 95.—*Enchodus ferox* Leidy. 1-2, New Jersey "greensand (Slack); 3-5, New Jersey (Abbott); 6-8, New Jersey (Cope); 9-12, New Jersey (Leidy); 13-17, Monmouth Co. (Morton); 18-20, Monmouth Co. (Abbott); 21-22, Haddonfield.

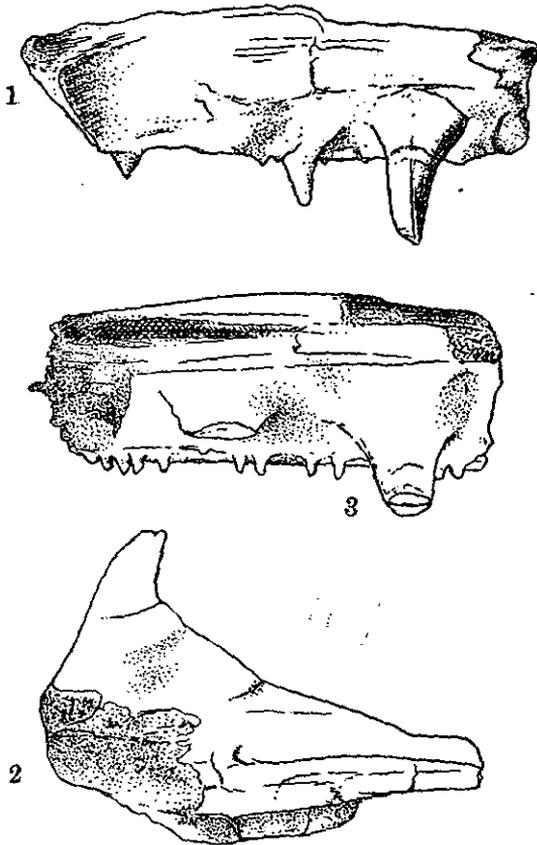


FIG. 96.—*Enchodus ferox* Leidy. 1, New Jersey (Abbott); 2, New Jersey; 3, Burlington Co.

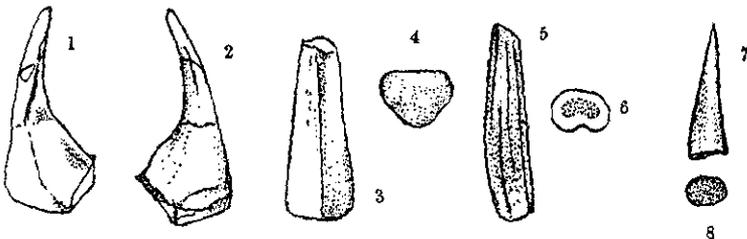


FIG. 97.—*Enchodus ferox* Leidy. *1-6, one mile southwest of Farmingdale in Manasquan Marl; *7-8, near Crawford's Corner in Wenonah sand.

lington County [Manasquan marl or the Vincentown limesand, K.] (T. M. Bryan). I have allowed *Enchodus pressidens* Cope to fall with this species, as suggested by Hay.

ENCHODUS SEMISTRIATUS Marsh.

Enchodus semistriatus Marsh, Proc. Amer. Assoc. Adv. Sci., 1869 (1870), p. 230. *Lower Cretaceous Marl Bed of New Jersey.*

Phasganodus semistriatus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 277. (Greensand of No. 4, New Jersey.)

Tooth slightly sigmoid in shape, compressed, with front sharp cutting-edge minutely denticulated. Rounded posterior surface marked by delicate striæ, except near apex, which latter is furnished with a barb. Length about 23 mm. (From Marsh.)

Marsh also identified some smaller teeth more nearly straight, but apparently without the apical barb.

Formation and locality. Known from detached teeth from the "lower Cretaceous marl bed of New Jersey" [probably meaning the Navesink marl bed, K.].

ENCHODUS SERRULATUS sp. nov.

Tooth somewhat sigmoid in form, well compressed, and front cutting-edge sharp, very finely serrated. Convex posterior sur-

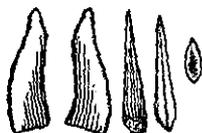


FIG. 98.—*Enchodus serrulatus* Fowler. (Type.)

face with many fine longitudinal basal striæ, not reaching apex or cutting-edge. No distinct barb, but apex with entire cutting-edges, posterior extending below short distance as minutely serrated edge. Striæ quite deep and distinct on basal part of crown. Length 16 mm.

Formation and locality. A single tooth, without formation, from Vincentown in Burlington County [the Manasquan marl, K.] (T. M. Bryan). This example approaches *E. semistriatus*, but differs in its posterior serrated apical keel, the apex itself being entire. Type No. 5,866, Academy of Natural Sciences of Philadelphia.

(*Serrulatus*, with little serræ.)

ENCHODUS GENTRYI (Cope).

Phasganodus gentryi Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. *Miocene of Cumberland Co., N. J.*

Enchodus gentryi Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 72 (type).

Long tooth of jaw anteriorly slender, curved back, front view shows cutting-edge from apex to base and no cutting-edge or angle on posterior face (unless at damaged apex). On one side cementum smooth, on other and posteriorly crown keeled-striate from base to near apex. Length 10 mm. (From Cope.)

This species seems to be distinguished by having a single cutting-edge on the large front teeth in the jaw.

Formation and locality. Known only from the type now in the American Museum at New York. It was from the Miocene [the Kirkwood formation, K.] at Shiloh in Cumberland County. I have not seen any material.

ENCHODUS TETRÆCUS Cope.

Enchodus tetræcus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 278. *Cretaceous No. 4, Delaware and New Jersey.*

Hay, Bull. Amer. Mus. Nat. Hist., XIX, 103, p. 74, figs. 54-55 (types).
Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 73 (note on types).

Elongate anterior teeth narrow and slender, greatest basal diameter at right angles to upper part of crown. Posterior side, as usual, much more convex than anterior, two faces separated by



FIG. 99.—*Enchodus tetræcus* Cope. (Type, from Hay.)

cutting-edges, both of which extend to base of crown. Shallow groove runs just behind each cutting-edge to base, giving latter an unsymmetrical figure 8 form of section. Anterior face but little convex, perfectly smooth and posterior very convex, marked with sharply defined grooves about half way to apex from base between lateral shallow grooves. Fifteen may be counted from side to side. Length of crown 30 mm. (From Cope.)

Formation and locality. Known from various teeth, the type a palatine tooth, in the collection of the American Museum at New York. It is from the "Cretaceous No. 4" at St. Georges, Delaware, though Cope also had other material from the same horizon in New Jersey. Not seen by me.

ENCHODUS OXYTOMUS Cope.

Enchodus oxytomus Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 278.
Clays below Cretaceous, No. 4, N. J.

Long tooth from front extremity of premaxillary or dentary. Differs from other species of the genus in extent to which hind cutting-edge prolongs downward toward base of tooth, nearly equaling in this respect anterior edge. As in all other species of the genus cutting-edges not opposite, and a section of base unsymmetrical. Cementum mostly smooth. Crown rather broad for its length, which is below average of Cretaceous species. (From Cope.)

Only known from the above incompletely described example, originally in the Cope collection.

Formation and locality. Known only from "clays below Cretaceous No. 4." Not seen by me.

ENCHODUS SP.

Tooth solid, curved, compressed, rounded convexly behind and constricted to sharp cutting-edge in front, and (though imperfect) apparently entire. Crown as viewed from cutting-edge

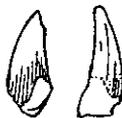


FIG. 100.—*Enchodus sp.* Monmouth Co. (Slack).

deflected convexly to one side, and basally slightly expanded. Each side of base with fine parallel striæ of rather uneven depth, and not extending up more than basal two-fifths. Length 14 mm.

Formation and locality. A single imperfect tooth, with front cutting-edge extending whole length, from Monmouth County (J. H. Slack), without formation.

ENCHODUS SP.

Tooth solid, slightly sigmoid, conic, swelling basally so that transverse section would be deeply elliptical, and apex compressed transversely with lateral keel extending downward each



FIG. 101.—*Enchodus* sp. Monmouth Co. (Knieskern).

side for about two-sevenths length. Edge of each keel under a lens slightly roughened. Surface of tooth entire or smooth, though basally with minute parallel striæ of various perfection. Length 11 mm.

Formation and locality. A small tooth, without formation, from Monmouth County (P. D. Knieskern).

ENCHODUS SP.

Teeth similar to the last except entirely conic, without any keel whatever. Possibly striæ were one time present, but only one example shows basal longitudinal striæ now. All are rather

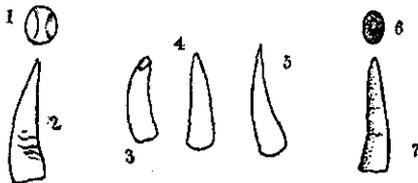


FIG. 102.—*Enchodus* sp. 1-2, New Jersey (Burt); 3-5, Monmouth Co. (Knieskern); 6-7, Vincentown (Bryan).

compressed basally so as to appear elliptical in transverse section. Length of largest 18 mm.

Formation and locality. Like the last from Monmouth County (P. D. Knieskern) 7. Besides these, also another tooth showing several transverse rings below its middle, from "New Jersey" (Burtt), and one from Vincentown [the Vincentown limesand or the Manasquan marl, K.] in Burlington County (T. M. Bryan).

Order HAPLOMI.

THE PIKE-LIKE FISHES.

Mouth with teeth. Post-temporal normally attached to cranium. Parietals separated by supraoccipital. Symplectic present. Opercular bones well developed. Mescoracoid wanting. Coracoids normal. Hypocoracoid and hypercoracoid separate, with developed actinosts. Pharyngeals distinct, superior directed forward, 3 or 4 in number, lower not falciform. No interclavicles. Scapular arch joined to cranium by post-temporal. Front vertebræ unmodified. Air-vessel with distinct duct. Head usually covered with cycloid scales, like on body. Fins with soft rays. Dorsal low, mostly posterior, first ray occasionally stiff or spine-like. No adipose fin. Pectoral placed low. Ventral abdominal, rarely wanting.

The fishes of this group are interesting as showing osteological characters more in agreement with the *Isospondyli*, thus more or less annectant with that order and the *Acanthopteri*. About six families are known, comprising a number of mostly fresh-water forms among existing fishes. The extinct forms have been referred entirely to the *Esocidæ* and *Pæcilidæ*.

Family ESOCIDÆ.

THE PIKES.

Body elongate, not elevated, more or less compressed posteriorly, broad anteriorly. Head long, snout prolonged and depressed. Mouth large, its cleft forming about half length of head. Upper jaw not protractile, most of its margin formed by maxillaries, which are quite long and provided with a supple-

mental bone. Lower jaw the longer. Premaxillaries, vomer and palatines with broad bands of strong cardiform teeth which are more or less movable. Lower jaw of strong teeth of different sizes. Tongue with a broad band of small teeth. No barbels. Gill-openings very wide. Gill-membranes separate, free from isthmus. Gill-rakers tubercle-like. Pseudobranchiæ glandular, hidden. Branchiostegals 12 to 20. Stomach not cæcal, without pyloric appendages. Air-vessel simple. Basis cranii simple. Head naked above. Cheeks and opercles more or less scaly. Scales small. Lateral line weak, obsolete in young and developed in adult. Dorsal posterior, opposite and similar to anal. No adipose fin. Caudal fin emarginate. Pectoral fins small, inserted low. Ventrals rather posterior.

A single genus, *Esox*, represented by 5 or 6 living species and 4 extinct. I have, however, included *Ischyrrhiza* as only provisionally, following Hay's suggestion.

Genus ISCHYRHIZA Leidy.

Ischyrrhiza Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. Type *Ischyrrhiza mira* Leidy, monotype.

Tooth with crown apparently laterally compressed, conical, covered with smooth shining enamel. Fang more robust than crown, curved pyramidal, quadrate in section, with base rugged and divided antero-posteriorly. Pulp cavity expanded within fang, closed below and narrowing towards crown.

An imperfectly defined genus, known only from detached teeth, though subsequently vertebræ have also been identified as identical. The three species described are extinct.

ISCHYRHIZA MIRA Ledy.

Ischyrrhiza mira Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. *Cretaceous Greensand of Burlington Co., N. J.* (L. T. Germain.)

Leidy, Holmes's Post-pliocene Foss. S. C., 1860, p. 120, Pl. 25, figs. 3-9. (Greensand of New Jersey.)

Cope, Proc. Amer. Philos. Soc. Phila., XII, 1872, p. 355 (name only).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 280. (Greensand, No. 5, New Jersey, near Harrisonville.)

Tooth with crown compressed, elongate, acuminate, with entire keel extending along each edge to base, and transverse section elliptical. Enamel of crown smooth. Root about equal in length to crown, conic continuation of crown apparently, and below hollow. Length 28 mm.

Formation and locality. Originally from the Cretaceous

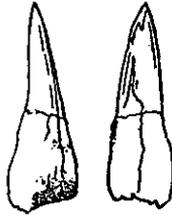


FIG. 103.—*Ischyrrhiza mira* Leidy. Haddonfield (Ford).

greensand and No. 5. I have examined a single tooth, described above, in the matrix or Hadrosaurus clay from Haddonfield (J. Ford). [The specimen from Haddonfield is referable to the Woodbury clay; from Harrisonville (Cope) to the Hornerstown marl or Vincentown limesand, K.]

Order ACANTHOPTERI.

THE SPINY RAYED FISHES.

Mouth edge formed by premaxillary. Maxillary normally distinct, always present, sometimes ossified with premaxillary. Shoulder-girdle connected by post-temporal with skull. Post-temporal normally furcate, usually not ossified with skull. Hypercoracoid and hypocoracoid distinct, ossified, former usually perforate. No mesocoracoid or interclavicles so far as known. Pharyngeals well developed, lower rarely united, third upper largest, fourth often absent. Opercular apparatus complete. Front vertebræ unmodified, without ossicula auditus. Gill-opening before pectorals. Gills laminated. Air-vessel typically without duct in adult. Scales variable, typically ctenoid. Lateral line usually extends high. Front dorsal and anal rays typically

simple or spinous, and all fin rays often articulate. Pectorals placed above plane of abdomen, actinosts always present. Ventrals mostly anterior, normally attached by pelvis to shoulder-girdle, usually with a spine and five rays, sometimes absent, sometimes without spine or with many rays, or otherwise modified.

The great majority of living fishes belong to this group, represented by usually very incomplete fossils. As it is impossible to limit or define the present assemblage of fishes by any special one or group of characters, not only as comparatively few of these have been examined, and therefore the necessary data is not available, most likely their genetic relations may never be demonstrated, and this is due in large measure to the meager palæontological record. The transition of forms is quite variable from those with characters approaching the *Haplomi* to those more typical of the spiny-rayed series. About 27 sub-orders have been defined.

Sub-Order PERCESOCES

Branchial arches well developed, bones all present except fourth superior branchi-hyal. Third superior pharyngeal much enlarged. Lower pharyngeals distinct. Scales cycloid. Spinous dorsal usually present. Pectorals elevated, about level with upper hind opercle angle. Ventrals I, 5, abdominal.

About six families, two of which are entirely extinct, have been included in this group. The existing forms mostly fresh-water or shore fishes of small size, though many quite large and voracious.

Family SPHYRÆNIDÆ.

THE BARRACUDAS.

Body elongate, subterete. Head long, pointed, pike-like. Jaws elongate, lower considerably projecting. Upper jaw nonprotractile, its border formed by premaxillaries, behind which are broad maxillaries. Large sharp teeth of unequal size on both jaws and palatines. No teeth on vomer, usually a very strong sharp canine near tip of lower jaw. Opercular bones without

spines or serratures. Gill-openings wide, gill-membranes not united, free from isthmus. Gills 4, a slit behind fourth. Gill-rakers very short or obsolete. Pseudobranchiæ well developed. Branchiostegals 7. First superior pharyngeal not present, second, third and fourth separate, with teeth. Lower pharyngeals separate. Air-vessel large, bifurcate anteriorly. Many pyloric cœca. Vertebrae 24. Body covered with small cycloid scales. Head scaly above on sides. Lateral line well developed, straight. First dorsal over ventrals, of 5 rather stout spines. Second dorsal remote from first dorsal, similar to anal and opposite to it. Caudal forked. Pectorals short, placed in or below line of axis of body. Ventrals I, 5, abdominal, in advance of middle of body.

Usually a single genus, *Sphyræna*, is allowed, but, according to Hay, *Dictyodus* is admitted.

Genus DICTYODUS Owen.

- Dictyodus* Owen, Rep. Brit. Assoc. Adv. Sci., 1838, p. 142. No species given.
 Type *Dictyodus destructor* Owen, Cat. Foss. Rept. Pisc. Mus. Roy. Coll. Surg., 1854, p. 161.
Sphyrænodus Agassiz, Poiss. Foss., V, pt. 1, 1844, p. 98. Type *Sphyrænodus priscus* Agassiz, first species, restricted by Woodward, Cat. Foss. Fishes, V, 1901, p. 473.

Teeth moderate, compressed, and each side with sharp keel, often finely serrated. Apex sometimes notched.

Scarcely distinguished from *Sphyræna*, and known only from fragmentary jaw and teeth. Only two species, described below. Woodward refers this genus to the *Scombridæ*.

DICTYODUS SILOVIANUS (Cope).

- Sphyrænodus silovianus* Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. *Miocene of Cumberland Co., N. J.*
Dictyodus silovianus Hussakof, Bull. Amer. Mus. N. H., XXV, 1908, p. 71, fig. 37 (type).

Fragment of jaw with five teeth and alveoli for four others. Jaw compressed and slightly curved, with smooth surface. Teeth subequal, compressed, rather short and acute, without roots, and

at their bases alveolar borders notched. Length of fragment 20 mm. (From Cope.)

Formation and locality. Known only from the above, obtained

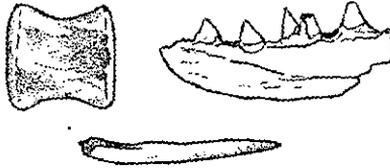


FIG. 104.—*Dictyodus silovianus* (Cope). (Type, $\times 1\frac{1}{2}$, from Hussakof.)

in the Miocene of Cumberland County and now in the American Museum at New York. Not seen by me.

Dictyodus speciosus (Leidy).

Sphyrana speciosus Leidy, Proc. Acad. Nat. Sci. Phila., 1856, p. 221. *Miocene Marl of Cumberland Co., N. J.* (E. Davis.)

Sphyranodus speciosus Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Miocene of Cumberland Co., N. J.)

Detached teeth compressed, without roots, inner side much less convex than outer, so that transverse section would be unevenly elliptical, and cutting-edge on each side extending completely from base to apex, and also minutely serrated. Enameled

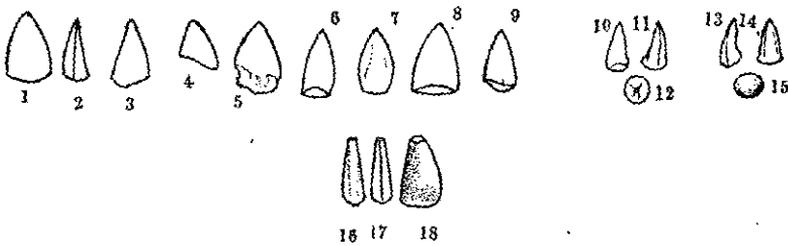


FIG. 105.—*Dictyodus speciosus* (Leidy). 1-9, Monmouth Co. (Knieskern); 10-15, Vincentown (Bryan); 16-18, Charles Co., Md. (Thomas).

surface smooth, without striæ. Anterior tooth shows only single cutting-edge, and though well compressed opposite edge well convex and forming slight apical barb. Basally and around convex edge many minute vertical striæ. Length of largest example 10 mm.

These examples all agree with Leidy's account and strongly suggest the teeth of our existing barracudas.

Formation and locality. Originally from the Miocene marl of Cumberland County, it is very likely my nine examples are from the same formation in Monmouth County (P. D. Knieskern). Cope also had a single anterior tooth from the same formation in the Thomas collection from Charles County, Md.¹ It seems to agree, as much as its fragmentary nature will permit, with the New Jersey material. Also two small teeth from Vincentown [probably the Vincentown limesand or the Manasquan marl, K.] (T. M. Bryan), may also belong to this species, though they are somewhat more curved.

Sub-Order BERYCOIDEI.

THE BERYCOID FISHES.

No suborbital stay. Shoulder-girdle and pharyngeals normal. Vertebrae 24 to 30. Head with conspicuous mucous cavities. Body naked or variously scaled, sometimes scales greatly specialized. Air-vessel with persistent duct in some forms throughout life. Dorsal fin with few or many spines. Ventrals thoracic or subabdominal, each with spine, usually seven branched rays, latter varying five to ten, and in one group spine greatly enlarged, with rays reduced in number.

Usually six families admitted, mostly living fishes in tropical seas, and three are also represented by extinct forms.

Family BERYCIDÆ.

Body oblong or ovate, compressed. Eye lateral, usually large. Mouth wide, oblique. Premaxillaries protractile. Maxillary rather large, usually with supplemental bone. Bands of villiform teeth on jaws and usually on vomer and palatines. Canines sometimes present. Suborbitals narrow, not ensheathing cheeks. Opercular bones usually spinous. No barbels. Gill-rakers mod-

¹ Proc. Acad. Nat. Sci. Phila., 1867, p. 142.

erate. Gills 4, slit after fourth. Pseudobranchiæ present. Gill-membranes separate, free from isthmus. Branchiostegals 7 or 8. Pyloric cœca numerous. Body covered with ctenoid or cycloid scales, foliate or granular. Cheeks and opercles scaly. Head with large muciferous cavities, covered by thin skin. Dorsal fin continuous, spines weak, 2 to 8. Anal spines 2 to 4. Caudal usually forked. Ventrals thoracic, mostly I, 7, number of rays usually greater than I, 5.

Genera about eight, of which three are extinct. Most of the existing forms are bathytic.

Genus BERYX Cuvier.

Beryx Cuvier, Règne Animal, Ed. 2, II, 1829, p. 151. Type *Beryx decadactylus* Cuvier, first species.

Body deep, compressed, abdomen trenchant without enlarged scutes. Head large. Snout short. Eye large. Mouth oblique, mandible end prominent. Both jaws, vomer and palatines with villiform teeth. Opercles serrated. Opercle usually with spine. Preopercle unarmed. Air-vessel simple. Pyloric cœca numerous. Body covered with rather large ctenoid scales regularly arranged. Head with thin bones and high ridges with deep muciferous cavities. Dorsal continuous, with four to six spines. Anal spines 4, rays 26 to 30. Ventrals with about ten articulated rays.

About six fossil species have been described. The existing species are brilliantly colored red and occur in deep water.

BERYX INSCULPTUS Cope.

Beryx insculptus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 240.
Lower Greensand bed of Monmouth Co., N. J. Dark clay marl just below Upper Greensand bed at Hornerstown.

Cope, l. c., XII, 1872, p. 357 (name only).

Cope, Rep. U. S. Geol. Surv. Terr., II, 1875, p. 272, Pl. 52, fig. 4
(Greensand No. 5, N. J.)

Hussakof, Bull. Amer. Mus. Nat. Hist., XXV, 1908, p. 63, fig. 31 (type).

Body stout. Scapular arch and cranium strongly marked with narrow elevated ridges which form a reticulate relief. Scales

large, thick, also large and narrowly exposed below lateral line, where in seven longitudinal series and not less than two above. In lateral line 23 scales, possibly a few more, as point of departure from suprascapula lost and greater part of cranium broken away. Sculpture of scales consists of a series of radiating ridges, whose interspaces are equal to them, and whose extremities project as

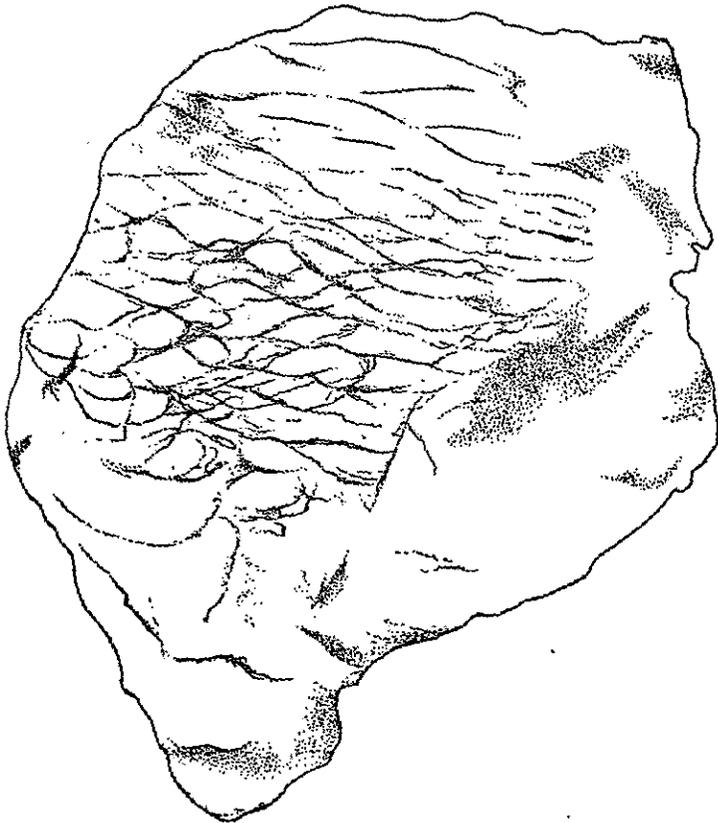


FIG. 106.—*Beryx insculptus* Cope. (Type, from Hussakof.)

short acute points. These ridges interrupted at short distance from middle of exposed surface, forming irregular obtuse elevations, while middle of area divided by shallow grooves into irregular areas. Whole sometimes crossed by one or two shallow interrupted concentric grooves. Tubes of lateral line not extending behind middle of exposed area, acute, with an areolate rugose

surface. Series of small smooth scales continues lateral line to middle of tail. Fins not well preserved, but pectoral radii remain and are of stout proportions. Dorsal and caudal rays very stout. Length about 143 mm. to probably hind margin of pectoral arch. (From Cope.)

Cope has pointed out its distinguishing characters as compared with several European fossil forms.

Formation and locality. Known from part of the trunk, the type now in the American Museum at New York, having been found in the lower greensand [Navesink marl, K.] of Monmouth County (S. Lockwood). Another example was also taken just below the upper greensand in the dark clay marl [Red Bank formation, K.] at Hornerstown, in the same county (J. Meirs), and was in the Marsh collection. I have not seen this species.

Sub-Order PERCOMORPHI.

THE PERCH-LIKE FISHES.

Body variously formed, usually oblong. Head usually compressed laterally. Mouth and dentition various, usually terminal with lateral cleft. Teeth typically pointed in bands on jaws, vomer and palatines. Premaxillary forming mouth edge, usually protractile. Mandibular bones distinct. Opercular bones well developed, normal. Preopercle typically serrate. No cranial spines. No bony stay connects suborbitals with opercle. Gill-rakers various, usually sharp, stout, dentiferous. Gills 4, slit behind last. Pseudobranchiæ typically well developed. Gill-membranes usually separate, sometimes joined, rarely attached to isthmus. Branchiostegals few, usually 6 or 7. Lower pharyngeals mostly separate, usually with cardiform teeth, third upper moderately enlarged, elongate, and not articulated to cranium, and fourth usually present. Air-vessel usually present, without air-duct in adult, simple, generally adheres to abdominal walls. Stomach caecal, with pyloric appendages. Intestines short in carnivorous forms, long in herbivorous. Shoulder-girdle attached to cranium by distinctly forked post-temporal, not adnate

to cranium or ossified with it. Coracoids normal, hypercoracoid with median foramen. Pectoral actinosts normal, 3 or 4, hour-glass shaped, longer than broad. Vertebrae from 24 to 100, usually numerous in pelagic, extra-tropical and fresh-water forms. Scales variously cycloid, ctenoid, sometimes rough or wanting, also small or large. Lateral line various, generally regularly arched, sometimes wanting. Dorsal fin various, spinous portion usually present, sometimes absent. Anal usually like rayed dorsal, spines present or absent. Caudal usually lunate, various, sometimes absent. Pectorals usually well developed. Ventrals sometimes rudimentary or absent, generally present, thoracic, subjugular or subabdominal, usually with one spine and five or more rays.

This group is apparently somewhat provisional, and does not seem to have been exactly defined, though two series of families have generally been admitted, as the *Scombroidea* and the *Percoidea*, comprising a vast army of living fishes typified by the mackerels and perch, respectively. A few remains have been found in the New Jersey Cretaceous, representatives of each.

Family ISTIOPHORIDÆ.

THE SAIL FISHES.

Body elongate, much compressed. Caudal peduncle with two fleshy crests or keels. Bones of upper jaw consolidated into a sword, which is roundish on edges and spear-like, shorter than in the sword fishes. Teeth in jaws small, persistent and granular. Gills reticulated as in sword fishes. Vertebrae 24, elongate and hour-glass shaped. Neural and hæmal spines flag-like. Ribs well developed. Air-vessel very large, sacculate, of many separate divisions. Intestine short, straight. Body covered with elongate scutes. Dorsal single or divided into 2 contiguous parts, first much longer than second, fin-rays distinct, first rays distinctly spinous. Anal divided. Last dorsal and anal rays suctional. Ventrals attached to pelvic arch, each with one or two rays.

The recent forms comprise about two genera, and are oceanic or pelagic, resemble the sword fishes, though of smaller size. The fossils, known only from fragmentary rostra, have been referred to the existing *Istiophorus* and two other genera.

Genus ISTIOPHORUS Lacépède.

Istiophorus Lacépède, Hist. Nat. Poiss. III, 1802, pp. 374, 375. Type

Istiophorus gladifer Lacépède, monotypic.

Histiophorus, auct.

Makaira Lacépède, l. c., IV, 1803, pp. 688, 689. Type *Makaira nigricans* Lacépède, monotypic.

Machara, *Macaria*, auct.

Nothistium Hermann, Observ. Zool., 1894, p. 304. Type *Histiophorus americanus* Valenciennes, virtually, as based on *Guebucu* Marcgrave, though no binomial given.

Zanclurus Swainson, Nat. Hist. An., II, 1839, p. 239. Type *Zanclurus indicus* Swainson, monotypic.

Body slender, much compressed. Rostrum usually shorter and less flattened than in sword fishes, edge more rounded, and mandible more developed. Many small teeth on jaws and palatines. Air-vessel sacculate. Intestine short, nearly straight. Body covered with elongate scales, rougher than sword fishes. Dorsal fin very high, continuous, as in young spear fishes and sword fishes, rays numerous, none aborted, first rays much higher than body depth. Anal divided. Ventral present, rays 2 or 3.

The recent forms large fishes of warm seas, the number of species uncertain, likely several, and one recently found on our coast. About six extinct forms.

ISTIOPHORUS ANTIQVUS (Leidy).

Xiphias antiquus Leidy, Proc. Acad. Nat. Sci. Phila., VII., 1855, p. 397.

Greensand of Burlington Co., N. J. (C. H. Budd.)

Histiophorus antiquus Cope, Proc. Boston Soc. N. H., XII, 1869, p. 310 (reference).

Rostrum well depressed, transversely oval in section, its short diameter about one-half its long diameter, and anteriorly becoming more cylindrical. Length about 265 mm. (From Leidy.)

This was a large species, known only from its rostrum, and especially characterized by its depressed form with the dentary surfaces on one plane.

Formation and locality. Only the type known, described above, from the greensand of Burlington County (C. H. Budd). Not seen by me.

ISTIOPHORUS HOMALORHAMPHUS (Cope).

Histiophorus homalorhamphus Cope, Proc. Boston Soc. Nat. Hist., XII, 1869, p. 310. *Eocene or Miocene Greensand near Squankum, N. J.*

Rostrum in general form nearly cylindrical, tapering slightly, depressed above and below, though former surface more so, thus forming wide ovoid in transverse section with lesser diameter one-seventh greater or horizontal at its base. Near end of rostrum vertical diameter but little less than that of horizontal. Upper surface evenly convex, and each side slopes down rather evenly below somewhat in a plane, these surfaces approximating toward end of rostrum and intermediate space at first moderately convex, but gradually becoming very constricted. At base two small approximated foramina a little below middle in vertical diameter. Surface of rostrum entirely minutely porous. Length 170 mm.

The examples described above seem to be identical with Cope's. This species differs from *I. antiquus* in its more cylindrical form and having the dentary surfaces on two planes. The following characters are gathered from Cope's account.

Rostrum nearly cylindrical, with a slight depression, transverse diameter exceeding vertical by less than one-eighth of former. Dentigerous inferior bands not separated by a groove, width of each two-thirds lesser diameter, each forms with other a strong obtuse angle and basally flattened, then curved upwards at external margin. Alveolæ numerous, small, 5 in one-tenth of an inch. Base broken, but longer diameter $4\frac{2}{3}$ of length. Surface of base not dentigerous, with numerous anastomosing striæ. Length about 110 mm.

Formation and locality. Eocene or Miocene greensand near Squankum in Monmouth County (W. S. Vaux). Only known from the above-described type, an osseous muzzle, and three

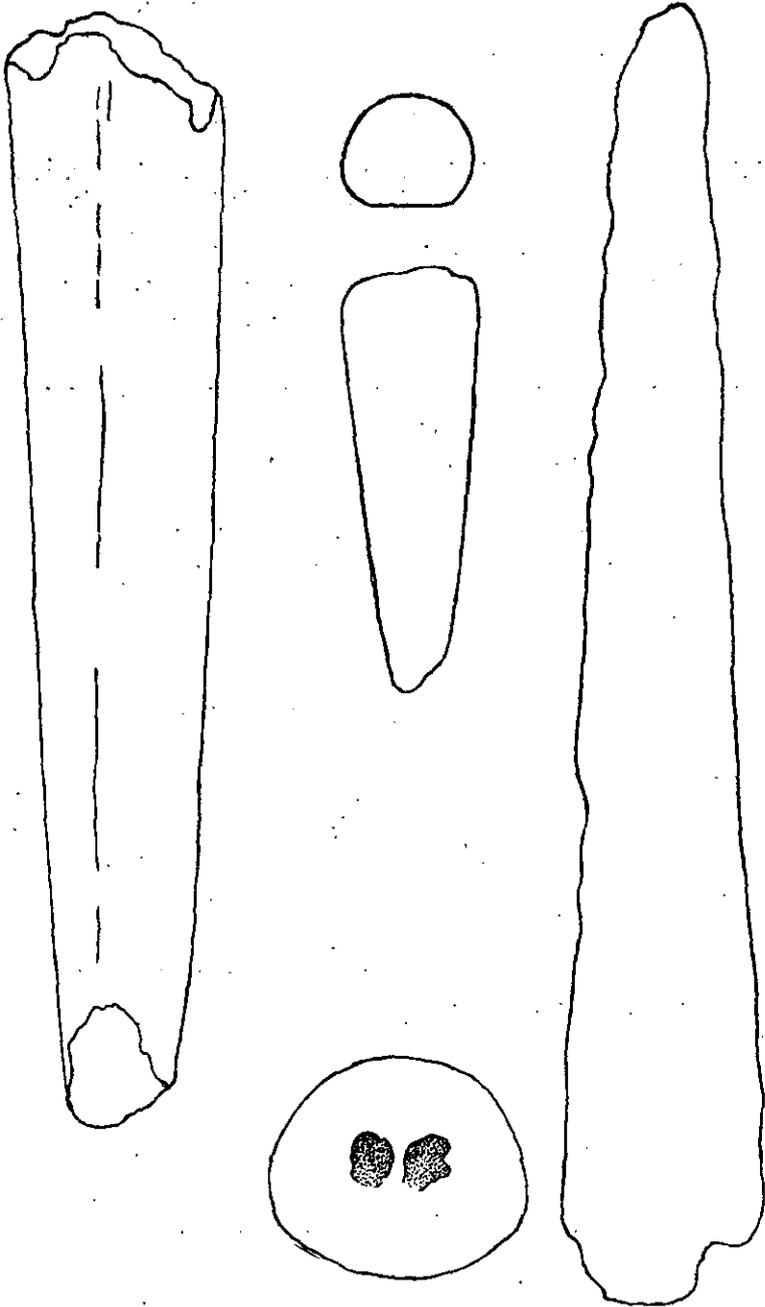


FIG. 107.—*Istiophorus homalorhamphus* (Cope). Vincentown (Bryan).

others from Vincentown [Manasquan marl, K.] in Burlington County (T. M. Bryan).

ISTIOPHORUS PARVULUS (Marsh).

Histiophorus parvulus Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 227
Eocene Greensand, Squankum Marl Company, in Monmouth Co.

Rostrum slender, very pointed, compressed transversely, and lower surface nearly flat. Brush-like teeth on this portion reduced to two narrow bands. Remaining surface irregularly striated. Length about 76 mm. (From Marsh.)

Formation and locality. This small species was originally based on the above-described type from the Eocene greensand from the pits of the Squankum Marl Company in Monmouth County (O. B. Kinne), and presented to the Yale Museum. [According to Cook only the Cretaceous marl (the Manasquan) was dug at this company's pits, K.] Not seen by me.

Genus EMBALORHYNCHUS Marsh.

Embalorhynchus Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 228. Type
Embalorhynchus kinnei Marsh, monotype.

According to Marsh this was a small species of sword fish allied with *Cylindracanthus* of the Eocene. The beak resembles in general form that of *Cylindracanthus*, but is much smaller, tapers more rapidly and has its lower surface flattened and marked by two shallow grooves. Like the rostrum of *Cylindracanthus* it has a double cavity at the base and single median one.

One fossil species described.

EMBALORHYNCHUS KINNEI Marsh.

Embalorhynchus kinnei Marsh, Proc. Amer. Ass. Adv. Sci., 1869, p. 228.
Eocene Greensand, Squankum Marl Company, Monmouth Co.

Rostrum small, short, tapering rapidly, inferior surface flattened and marked by two shallow grooves. Base of rostrum with double cavity and single one through median portion of shaft.

Upper surface very delicately fluted. Length about 65 mm. (From Marsh.)

Marsh thought the fish probably did not exceed 15 inches in total length.

Formation and locality. Only the type known, described above, from the "Eocene greensand at the pits of the Squankum Marl Company" in Monmouth Co. (O. B. Kinne). [See comment on preceding specimens, K.] Not seen by me.

Family SPARIDÆ.

THE PORGIES.

Body oblong or more or less elevated. Head large, crests of skull usually largely developed. Mouth small, terminal, low, horizontal. Premaxillaries little protractile. Maxillary short, peculiar in form and in articulation, without supplemental bone and slipping for most part of its length under preorbital edge, which forms more or less distinct sheath. Preorbital usually broad. Teeth strong, those in front of jaws conical, incisor-like or molar. No vomerine or palatine teeth. Hind nostril larger, usually more or less oblong or slit-like. Preopercle entire or serrate. Opercle without spines. Gill-membranes separate, free from isthmus. Gills 4, large slit behind fourth. Gill-rakers moderate. Pseudobranchiæ large. Lower pharyngeals separate. Air-vessel present, usually simple. Pyloric cœca few. Vertebræ usually 24. Intestinal canal short. No suborbital stay. Body covered with rather large adherent scales, never truly ctenoid. Head sides usually scaly. Lateral line well developed, concurrent with back, not extending on caudal. Dorsal fin single, continuous or deeply notched, spines usually strong and depressible in a groove. Dorsal spines heteracanthous, 10 to 13. Anal rather short, similar to rayed dorsal, spines 3. Caudal usually concave. Ventrals I, 5, thoracic, usually with distinct scale-like basal appendage.

The recent genera, about 12, carnivorous shore fishes of tropical seas, most valued as food. Fossils have also been referred to some of these as well as about eight others.

CROMMYODUS Cope.

Crommyodus Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p. 243. Type
Phacodus irregularis Cope, virtual designation and monotypic. (*Phaco-*
odus preoccupied.)

Teeth fusiform, irregularly and closely crowded on surface of an elongate semidiscoid bone of possibly hyoid apparatus. Masticatory surface moderately convex. Crown abruptly contracted below into short root, which presents very small orifice for admission of nutrient vessels, etc. Teeth thus somewhat shape of an onion inverted. Pulp cavity large. Superficial layer of crown very thin, its structure not known, but its punctate appearance resembles that of a worn surface of vaso-dentine.

Cope also states the successional teeth as very abundant, and closely placed. They appear to rise through the spongy tissue of the bone without reference to any definite line of succession or superposition. Those of the inferior series, visible on under surface of bone, have an average larger size than those on upper surface which are in use. A single extinct species.

CROMMYODUS IRREGULARIS (Cope).

- Phacodus irregularis* Cope, Proc. Boston Soc. Nat. Hist., XIV, 1869, p. 33.
Miocene near Shiloh, Cumberland Co., N. J.
Crommyodus irregularis Cope, Proc. Amer. Philos. Soc. Phila., XI, 1869, p.
243 (reference).
Cope, l. c., XIV, 1875, p. 362 (reference).

Teeth, though irregularly arranged for short distances in longitudinal lines, transversely ovate, closely packed or with slight intervals. Those at outer and inner margins of bone considerably smaller than median and more rounded. Crown of successional teeth flattened, as well as those in use. Median teeth number 5 in one-half inch, and lateral 7 in same length. Surface of root finely striate, striæ coarser at point of convergence at orifice of pulp cavity. Crown in many teeth broken away, leaving short conic pulp cavity and its thin walls exposed. Bone convex in transverse direction, descending more gradually on convex margin. Length of bone about 40 mm. (From Cope.)

Formation and locality. Known from the Miocene marl [Kirkwood, K.] near Shiloh in Cumberland County. Not seen by me.

Sub-Order PHARYNGOGNATHI.

THE LABROID FISHES.

Nostrils double. Gills $3\frac{1}{2}$, without slit after last. Lower pharyngeals fully united. Scales weakly ctenoid or cycloid. Dorsal and anal fin spines not very strong. Ventrals thoracic, each with one spine and three rays. Otherwise not differing much from the *Percoidea*.

The existing forms are mostly large tropical fishes, with bright colors and strong dentition. About four families are admitted.

Family LABRIDÆ.

THE WRASSE FISHES.

Body oblong or elongate. Mouth moderate, terminal. Pre-maxillaries protractile. Maxillaries without supplemental bone, slipping under membranaceous preorbital edge. Front teeth usually very strong, canine-like. Jaw teeth separate or soldered together at base, not forming continuous plate. No vomerine or palatine teeth. Lips thick, longitudinally plicate. Nostrils round, with two openings on each side. Gill-membranes somewhat connected, sometimes joined to narrow isthmus. Gills $3\frac{1}{2}$, slit after last arch, small or obsolete. Pseudobranchiæ well developed. Branchiostegals 5 or 6. Lower pharyngeals completely united into one bone, without median suture, this bone T-shaped or Y-shaped, its teeth conical or tubercular. Air-vessel present. No pyloric cœca. Body covered with cycloid scales. Lateral line well developed, continuous or interrupted, often angularly bent. Dorsal fin continuous, spinous portion usually long, spines rather slender, 3 to 20. Anal like rayed dorsal, spines 2 to 6. Ventrals thoracic, I, 5, inserted below pectorals, latter sometimes thoracic.

The existing forms comprise about 60 genera, largely in tropical seas. Their dentition is admirably adapted for crushing the shells of mollusks, upon which most of them feed. About 11 extinct genera have been described, and some few species referred to several of the existing genera.

Genus PHYLLODUS Agassiz.

Phyllodus Agassiz, Poiss. Foss., II, pt. 2, 1844, p. 238. Type *Phyllodus toliapicus* Agassiz, first species, restricted by Woodward, Cat. Foss. Fishes, IV, 1901, p. 546.

Paraphyllodus Sauvage. Bull. Soc. Geol. France (3) III, 1875, p. 615. Atypic.

Pharyngeal dentition compact, tritoral, leaf-shaped, showing pile of successional teeth beneath each functional tooth, and middle teeth much larger than marginal teeth. Upper pharyngeal bones apparently fused together with lower pharyngeals.

This extinct genus is only known from the pharyngeal dentition. About 20 or more species have been described.

PHYLLODUS CURVIDENS Marsh.

Phyllodus curvidens Marsh, Proc. Amer. Assoc. Adv. Sci., 1869, p. 229. *Miocene Marl, near Shiloh, Cumberland Co.*

Cope, Proc. Amer. Philos. Soc. Phila., XIV, 1875, p. 362. (Miocene of Cumberland Co.)

Central portion of pharyngeal dental plate with very thick teeth, longest of which considerably curved, so that crushing surface of plate transversely concave. (From Marsh.)

Marsh says this species is readily distinguished by the unusual thickness of the teeth and the longest being considerably curved.

Formation and locality. Known from the Miocene marl near Shiloh [Kirkwood, K.] in Cumberland County. Not seen by me.

PHYLLODUS ELEGANS Marsh.

Phyllodus elegans Marsh, Proc. Amer. Ass. Adv. Sci., 1869, p. 228. *Eocene Greensand at Farmingdale, in Monmouth Co.*

Pharyngeal dental plate obtusely triangular, small, and triturating surface a little convex. Central teeth enlarged, circular,

well depressed or disk-like with central portion well pressed down, giving each tooth appearance of shallow cup. Only rims of each tooth covered with smooth enamel. Though most all teeth circular they vary into irregularities of circular design. Marginal teeth all smaller, similar, only with triturating surfaces less concave, and enameled marginal ring less defined, so enamel extends equally over concave median portions. Successional teeth equally enlarged median as seen from lower sur-



FIG. 108.—*Phyllodus elegans* Marsh. Monmouth Co.

face, as they are above, and marginal teeth also correspondingly reduced. Longest diameter 18 mm.

The above-described example agrees with Marsh's account, which states the lateral or smaller teeth to be rather few.

Formation and locality. Known only from the type ascribed to the Eocene greensand at Farmingdale (A. J. Smith), and presented to the Yale Museum, and another example in the Academy from Monmouth County (P. D. Knieskern), most likely from the same horizon, though this is not given. [See comment on page 180, K.]

INDEX.

Names in italics represent synonyms.

A.	PAGE.	C.	PAGE.
Acanth opteri,	168	<i>Carcharias cancellatus</i> ,	59
<i>Acrodobatis</i> ,	30	<i>collata</i> ,	80
<i>serpa</i> ,	30	<i>lanceolatus</i> ,	59
<i>Acrodontobatis</i> ,	30	<i>megalodon</i> ,	62
Acrodus,	28	<i>megalotis</i> ,	60
<i>humilis</i> ,	28	<i>polygurus</i> ,	61, 62
<i>nobilis</i> ,	28	Carcharodon,	58, 59
Actin opteri,	22, 144	<i>acutidens</i> ,	60
<i>Æliopos wagneri</i> ,	24	<i>angustidens</i> ,	60
<i>Ætobates</i> ,	98	<i>auriculatus</i> ,	59
<i>Ætobatis</i> ,	98	<i>carcharias</i> ,	61
<i>Ætobatus</i> ,	98	<i>megalodon</i> ,	61
<i>perspicuus</i> ,	99	<i>polygurus</i> ,	60, 61
<i>Ætobates perspicuus</i> ,	99	<i>verus</i> ,	59
<i>Ætobatis</i> ,	98	Cenomanian,	8
<i>Ætobatus</i> ,	98	Cestracion,	77
Albian formation,	8	Cestraciont sharks,	27
Alepisauridæ,	157	<i>Cestrorhinus</i> ,	77
<i>Allopos</i> ,	24	Cetorhinus maximus,	61
<i>wagneri</i> ,	24	Chimæra,	109
Alloway, formations near,	20	<i>affinis</i> ,	109
Ammonites placenta,	52	<i>mantellii</i> ,	110
<i>Anotodus</i> ,	31	Chimæras,	108, 109
<i>agassizii</i> ,	31	Chimæridæ,	109
Aprionodon gibbesii,	75	Chimæroidei,	109
Aster ospondyli,	23, 27	Chirocentridæ,	152, 154
<i>Atractosteus</i> ,	150	Chondrostei,	145
B.		<i>Clastes</i> ,	150
Barnsboro, formations near,	19	<i>cycliferus</i> ,	150
Barracudas,	169	Cohansey sand,	15
Barrennian formation,	8	<i>Calorhynchus</i> ,	141
Batoidei,	23, 80	<i>acus</i> ,	142
<i>Bates</i> ,	84	<i>ornatus</i> ,	141
<i>spectabilis</i> ,	84	<i>rectus</i> ,	141
Beacon Hill formation,	15	<i>Conosaurops</i> ,	152
Berycidæ,	172	Conosaurus,	152
Berycoidei,	172	<i>bowmani</i> ,	152
Berycid fishes,	172	<i>bowmanii</i> ,	152
Beryx,	172	<i>Conosurus</i> ,	152
<i>decadactylus</i> ,	173	Corax,	62
<i>insculptus</i> ,	173	<i>affinis</i> ,	64
Birmingham, formations at,	18	<i>appendiculatus</i> ,	64
Blackwudetown, formations at,	19	<i>falcatus</i> ,	63, 64
Bony ganoids,	148	<i>pristodontus</i> ,	64
<i>Boreogaleus</i> ,	66	Cretaceous, European,	8
Bryactinus,	134	Cretaceous formations described, ..	7
<i>amorphus</i> ,	134	Crosswicks, formations near,	18
Bullhead sharks,	27	Crommyodus,	182
		<i>irregularis</i> ,	182

	PAGE.		PAGE.
Crossopterygia,	22	Englishtown sand,	9
<i>Cyclospondyli</i> ,	23	<i>Eopristis</i> ,	81
Cyclostomes,	22	Esocidæ,	166
<i>Cylindracanthus</i> ,	141, 180	<i>Esox</i> ,	167
<i>acus</i> ,	142	<i>osseus</i> ,	150
<i>ornatus</i> ,	141, 142	<i>Eulamia</i> ,	42
<i>rectus</i> ,	142	<i>Eulamia</i> ,	62, 78
<i>Cylindrosteus</i> ,	149, 150	<i>Eumylodus</i> ,	110
<i>Cynocephalus</i> ,	74	<i>laqueatus</i> ,	110
		<i>Eurygnathus</i> ,	157
		<i>ferox</i> ,	157
D.		<i>Eusphyra</i> ,	77
<i>Daptimus</i> ,	154	<i>Lyvermanellidæ</i> ,	157
<i>phlebotomus</i> ,	154	Exogyracostata,	52
Danian,	8		
Deal, formations near,	16	F.	
Dictyodus,	170	Farmingdale, formations near,	17
<i>silovianus</i> ,	170	Fishes,	22
<i>speciosus</i> ,	171	Fragmentary selachians,	105
<i>Diphriassa</i> ,	110, 127		
<i>latidens</i> ,	128	G.	
<i>solidula</i> ,	127	Galei,	29
Dipnoi,	22	Galeocerdo,	64, 66
<i>Dipristis</i> ,	110	<i>aduncus</i> ,	67, 70
<i>miersii</i> ,	110, 123	<i>appendiculatus</i> ,	64
<i>Dirrhizodon</i> ,	71	<i>arcticus</i> ,	67
<i>elongatus</i> ,	71	<i>contortus</i> ,	67, 69
		<i>egertonii</i> ,	75
E.		<i>falcatus</i> ,	63
Eagle rays,	84	<i>latidens</i> ,	70
Eocene system,	13	<i>pristodontus</i> ,	64
<i>Edaphodon</i> , 110, 127, 129, 130, 131,		<i>tigrinus</i> ,	66
132, 135, 138, 139		<i>Galeodes</i> ,	66
<i>bucklandi</i> ,	110	<i>priscus</i> ,	66
<i>divaricatus</i> ,	116, 124	Galeorhinidæ,	66
<i>eoœenus</i> ,	116	<i>Galeus pristodontus</i> ,	62, 64
<i>fecundus</i> ,	119	Ganoidci,	145
<i>incrassatus</i> ,	118, 131, 134	Gar pikes,	149
<i>laterigerus</i> ,	112, 113	Gault,	8
<i>latidens</i> ,	128	Ginglymostoma,	30
<i>miersii</i> ,	122	<i>obliquum</i> ,	30
<i>mirificus</i> ,		<i>serra</i> ,	31
117, 121, 130, 131, 139		Ginglymostomidæ,	29
<i>smocki</i> ,	115	Glyphis,	74
<i>smockii</i> ,	115, 117, 120	<i>egertoni</i> ,	75, 79
<i>solidulus</i> ,	127, 137	<i>hastalis</i> ,	74
<i>stenobryus</i> ,	111	<i>subulata</i> ,	75
<i>tripartitus</i> ,	112, 116, 120	<i>Glyptorhynchus</i> ,	141
<i>Edaphodus</i> ,	110	<i>Goniobatis</i> ,	98
Elasmobranchii,	22	Greensand No. 5 of New Jersey, ..	20
Embalorhynchus,	180	Grisets,	23
<i>kinnei</i> ,	180	<i>Guebucu</i> ,	177
Enchodontidæ,	157		
<i>Enchodus</i> ,	157, 158, 164, 165	H.	
<i>ferox</i> ,	158	Hadrosaurus foulkii,	52, 159
<i>gentryi</i> ,	163	Halecomorphi,	145, 151
<i>halcyon</i> ,	157	Haplom,	166, 169
<i>oxytomus</i> ,	164	Hemipristis,	71
<i>pressidens</i> ,	159, 161	<i>serra</i> ,	71
<i>semistriatus</i> ,	162	<i>Heptanchus</i> ,	24
<i>serrulatus</i> ,	162	<i>Heptanchus</i> ,	24
<i>tetræcus</i> ,	163		

	PAGE.		PAGE.
<i>Heptranchias</i> ,	24, 26	<i>desorii</i> ,	42
<i>plectrodon</i> ,	25	<i>hastalis</i> ,	35
<i>primigenius</i> ,	24, 25	<i>oxyrinchus</i> ,	35
Heterodontidæ,	27	<i>oxyrinchus</i> ,	32, 35
Heterodontus,	27	<i>sillimanii</i> ,	40
Hexanchidæ,	23		
Hexanchus,	24	J.	
<i>Histiophorus</i> ,	177	Jerico, formations near,	20
<i>americanus</i> ,	177		
<i>antiquus</i> ,	177	K.	
<i>homalorhamphus</i> ,	178	Kirkwood formation,	14
<i>parvulus</i> ,	180	Kümmel, H. B., report by,	7
<i>Holeodon</i> ,	157		
Holocephali,	22, 108	L.	
<i>Holorhinus</i> ,	84	Labridæ,	183
Hornerstown, formations near,	17	Labroid fishes,	183
Hornerstown marl,	12	<i>Lamia</i> ,	42
<i>Hybodus</i> ,	28	<i>Lamna</i> ,	42, 74
		<i>Lamna</i> ,	52
I.		<i>acuminata</i> ,	38
Ichthyodectidæ,	154	<i>cuspidata</i> ,	32, 43, 50
Ichthyodorulites,	141	<i>denticulata</i> ,	43
Ichthyotomi,	23	<i>elegans</i> ,	32, 43, 48, 52
<i>Ictatus</i> ,	84	<i>lanceolata</i> ,	57, 58
Introduction,	5	<i>mantelli</i> ,	38
<i>Ischyodus</i> ,	110	<i>mudgei</i> ,	51
<i>divaricatus</i> ,	124	<i>obliqua</i> ,	57
<i>eocænus</i> ,	116	<i>oxyrhina</i> ,	31
<i>fecundus</i> ,	119	<i>texana</i> ,	52
<i>gaskillii</i> ,	121, 123	Lamnidæ,	31
<i>incrassatus</i> ,	118	Lampreys,	22
<i>laterigerus</i> ,	113	Lancelets,	22
<i>longirostris</i> ,	112, 113	Lepidosteï,	145, 148
<i>miersii</i> ,	123	<i>Lepidosteus</i> ,	150
<i>mirificus</i> ,	112, 121	Lepisosteidæ,	149
<i>monolophus</i> ,	121, 123	Lepisosteus,	149, 150, 151
<i>smockii</i> ,	115	<i>ferox</i> ,	150
<i>solidulus</i> ,	110, 127	<i>gavial</i> ,	150
<i>stenobryus</i> ,	111	<i>knieskerni</i> ,	150
<i>tripartitus</i> ,	112	<i>platostomus</i> ,	150
• <i>Ischyrrhiza</i> ,	167	Leptocardii,	22
<i>mira</i> ,	167	Leptomylus,	136
<i>Ischyrocephalus</i> ,	157	<i>cooki</i> ,	137
<i>gracilis</i> ,	157	<i>cookii</i> ,	137
<i>Isodus</i> ,	157	<i>densus</i> ,	137, 138
<i>sulcatus</i> ,	157	<i>forfex</i> ,	112, 139
Isospondyli,	151	Long Branch, formations near, ...	
Isospondylous fishes,	151	Lysopteri,	145
Isotænia,	135		
<i>neocæsariensis</i> ,	135	M.	
Istiophoridæ,	180	<i>Macaria</i> ,	177
Istiophorus,	177	<i>Mackera</i> ,	177
<i>antiquus</i> ,	177, 178	Mackerel sharks,	31
<i>gladifer</i> ,	177	Magothy formation,	8
<i>homalorhamphus</i> ,	178	<i>Makaira</i> ,	177
<i>parvulus</i> ,	180	Manasquan marl,	13
<i>Isuropsis</i> ,	31	Marshalltown formation,	9
Isurus,	31, 32, 42, 74	Masticura,	84
<i>acuminatus</i> ,	38, 43, 47	Merchantville formation,	8
<i>desorii</i> ,	32, 35, 43, 47		

	PAGE.		PAGE.
Microdon nuchalis,	144	Oxyrhina,	31, 42
Micromesus,	102	<i>desorii</i> ,	35
Miocene system,	14	<i>glauca</i> ,	31
Mount Laurel sand,	10	<i>minutus</i> ,	32, 35, 40, 42
Mullica Hill, formations near,	19	<i>xiphodon</i> ,	35
Myliobates,	84	Oxyrrhina,	31
<i>bisulcus</i> ,	85		
<i>fastigiatus</i> ,	85	P.	
<i>obesus</i> ,	93, 95	<i>Pachyrhizodontida</i> ,	152
<i>rugosus</i> ,	93, 95	<i>Pachyrhizodus</i> ,	152
<i>serratus</i> ,	91	Paraphyllopus,	184
Myliobatidæ,	84	Passalodon,	109, 111
Myliobatis,	84, 99, 101, 102, 108	Pemberton, formations near,	18
<i>bisulcus</i> ,	85	Percesoces,	169
<i>bovina</i> ,	84	Perch-like fishes,	175
<i>fastigiatus</i> ,	85, 87, 91	Percoidea,	176, 183
<i>gigas</i> ,	92	Percomorphi,	175
<i>glottoides</i> ,	88	<i>Periodus</i> ,	146
<i>holmesii</i> ,	88	<i>hoemigii</i> ,	146
<i>jugosus</i> ,	90	Petalodus,	23
<i>jussieuii</i> ,	101	<i>Phacodus irregularis</i> ,	182
<i>kummeli</i> ,	95	Pharyngognathi,	183
<i>leidyi</i> ,	91	<i>Pharganodus genryi</i> ,	163
<i>magister</i> ,	89, 90	<i>semistriatus</i> ,	162
<i>marginata</i> ,	101	Phyllopus,	184
<i>obesus</i> ,	93	<i>curvidens</i> ,	184
<i>pachyodon</i> ,	88	<i>elegans</i> ,	184
<i>pachyrhizodus</i> ,	97	<i>toliapicus</i> ,	184
<i>rectidens</i> ,	92	Pike-like fishes,	166
<i>rugosus</i> ,	89	Pikes,	166
(<i>Zygobatis</i>) <i>rugosus</i> ,	95	Pisces,	22
<i>serratus</i> ,	92	<i>Platysqualus</i> ,	77
<i>suturalis</i> ,	92	<i>Plicodus</i> ,	30
<i>toliapicus</i> ,	92	<i>thielensis</i> ,	30
<i>vicomicanus</i> ,	92	Plinthicus,	100
<i>Mylorhina</i> ,	101	<i>stenodon</i> ,	100
<i>Myriosteon</i> ,	81	Pliocene system,	15
<i>higginsii</i> ,	81	<i>Pncumatosteus</i> ,	150
N.		<i>nahunticus</i> ,	150
Navesink marl,	10	Poplar, formations at,	16
Neocomian,	8	Porgies,	181
<i>Nothistium</i> ,	177	<i>Prionace</i> ,	74
Notidani,	23	<i>Prionodon</i> ,	74
Notidanoid sharks,	23	<i>Pristibatis</i> ,	81
<i>Notidanus</i> ,	24	Pristidae,	80
<i>primigenius</i> ,	24	<i>Pristiopsis</i> ,	81
<i>Notorhynchus</i> ,	24	Pristis,	81
<i>Notorynchus</i> ,	24	<i>ambledon</i> ,	81
<i>maculatus</i> ,	24	<i>antiquorum</i> ,	81
Nurse sharks,	29	<i>curvidens</i> ,	82
O.		<i>perrotteti</i> ,	81
Optian,	8	(<i>Eopristis</i> ,) <i>reinachi</i> ,	81
Otodus,	53	<i>Pristobatis</i> ,	81
<i>apiculatus</i> ,	35	<i>Pristobatus</i> ,	81
<i>appendiculatus</i> ,	53, 57	Proarthri,	27
<i>lanceolatus</i> ,	54, 57	Psaliodus,	136
<i>levis</i> ,	57	<i>Psalliosotomus</i> ,	150
<i>obliquus</i> ,	53, 57, 58	<i>Psittacodon</i> ,	109, 111
		<i>Ptychacanthus faujasi</i> ,	84
		Ptychodontidæ,	84

INDEX.

191

	PAGE.		PAGE.
Ptychodus mammillaris,	84	Sphyræna,	170
<i>Ptychopleurus</i> ,	84	<i>Sphyræna</i> ,	159
Pycnodonti,	145	<i>speciosus</i> ,	171
Pycnodontidæ,	145	Sphyrænidæ,	169
Pycnodonts,	145	<i>Sphyrænodus</i> ,	170
Pycnodus,	146	<i>silovianus</i> ,	170
<i>faba</i> ,	146	<i>speciosus</i> ,	171
phaseolus,	146	Sphyrna,	62, 77
robustus,	147	bioclii,	77
R.		<i>denticulata</i> ,	78
<i>Raja flagellum</i> ,	98	gibbesii,	78
<i>narinari</i> ,	98	prisca,	75, 78
Rajidæ,	80	tiburo,	78
Raphiosauridæ,	151	<i>Sphyrniæ</i> ,	77
Raphiosaurus,	152	Sphyrnidæ,	77
Raritan formation,	7	Spiny rayed fishes,	168
Rays,	80	<i>Squalus</i> ,	38, 57, 59, 60, 61
Red Bank sand,	11	<i>arcticus</i> ,	66
Requiem sharks,	66	<i>cinereus</i> ,	24
<i>Rentceps</i> ,	77	<i>cornibicus</i> ,	42
Rhinæ,	23	<i>glaucus</i> ,	74
Rhinoptera,	102	<i>pristis</i> ,	81
<i>adspersa</i> ,	102	<i>selanoneus</i> ,	42
dubia,	103	tiburo,	77
<i>lalandii</i> ,	102	<i>zygana</i> ,	77
<i>vespertilio</i> ,	84	Squankum, formations near,	17
Riddleton, formations near,	20	<i>Stoasodon</i> ,	98
		Stow Creek, formations near,	20
S.		T.	
Sail fishes,	176	Teleost otoliths,	108
<i>Sarchirus</i> ,	150	Tertiary formations,	7
<i>vittatus</i> ,	150	<i>Thectodus</i> ,	28
Sarcura,	80	<i>crenatus</i> ,	28
Saurocephalus,	154	Tinton beds,	11
leanus,	155	<i>Trichiuridæ</i> ,	150
<i>lanciformis</i> ,	155	<i>sagittidens</i> ,	150
<i>lycodon</i> ,	157	<i>Trikeras</i> ,	102
<i>Saurodon</i> ,	154	True fishes,	144
<i>lea</i> ,	154, 155	sharks,	29
<i>leanus</i> ,	155	<i>Trycera</i> ,	102
Saw fishes,	80	<i>typica</i> ,	102
Scombridæ,	170	Turonian,	8
<i>Scombroidea</i> ,	176	Typical sharks,	27
Selachostomi,	145	V.	
<i>Selanontus</i> ,	42	Vincetown, formations near,	19
Senonian formation,	8	Vincetown sand,	12
Shark-like fishes,	22	W.	
Shark River, formations near,	16	Wenonah sand,	10
Shark River marl,	13	Whitfield, R., divisions of Cretaceous by,	21
Shiloh, formations near,	20	Woodbury clay,	9
<i>Solenodon</i> ,	157	Wrasse fishes,	183
<i>neocomiensis</i> ,	157	X.	
Sparidæ,	181	<i>Xiphodolamia</i> ,	25
Sphagepœa,	143	<i>ensis</i> ,	25, 26
<i>aciculata</i> ,	143	<i>Xiphodontolamia</i>	25
aciculata,	144		
<i>Sphyra</i> ,	77		

Z.		PAGE.	PAGE.
<i>Zanclus</i> ,	177	<i>Zygana</i> ,	77
<i>indicus</i> ,	177	<i>blochii</i> ,	77
<i>Zens platessus</i> ,	146	<i>Zygobates</i> ,	102
		<i>Zygobatis</i> ,	102