SOME AMERICAN CRETACEOUS FISH SCALES, WITH NOTES ON THE CLASSIFICATION AND DISTRIBUTION OF CRETACEOUS FISHES.

By T. D. A. COCKERELL.

PREFACE.

By T. W. STANTON.

Fish remains are extremely abundant in several Cretaceous formations of the Rocky Mountains and Great Plains, but except in the Niobrara formation of Kansas, a fish skeleton well enough preserved for description or identification is the greatest rarity. The fishes are represented by separate scales, in some places associated with a few vertebrae and other fragmentary bones or by isolated teeth. In the original descriptions of both the Mowry and the Aspen shales of Wyoming the presence of fish scales is mentioned as a characteristic feature. Fossils of other classes are usually very rare in beds containing many fish scales. Many of the scales are beautifully preserved and show varied forms and more or less complex sculpture.

It had long been regretted that these fish scales had not been studied systematically, and when several papers on the scales of living and fossil fishes were published by Prof. Theodore D. A. Cockerell,[1] of the University of Colorado, Boulder, Colo., the hope was again quickened that these Cretaceous fish scales might prove to be of some value in stratigraphic identifications and correlation. Prof. Cockerell's offer to study fish scales collected by the United States Geological Survey was therefore welcomed, and early in 1916 the material from the Western States was placed in his hands. As a result of its study the accompanying paper has been prepared.

In connection with the Survey's stratigraphic and areal work on the coal and oil fields of the Rocky Mountain region many small lots of fish scales have been obtained from the Mowry shale, from the Aspen shale, and from other beds of about the same age in the areas where these shales are not characteristically developed, but no attempt has been made to do thorough collecting even in these formations, because no one in the Survey was qualified to identify the scales. The scales from other formations in the same region have been obtained incidentally in collecting invertebrate fossils and are so few in number that they probably do not fairly represent the fish faunas of the seas in which the formations were deposited. Similarly, the four species based on scales from the Chico group were all obtained in the Moreno formation at two neighboring localities on the west side of San Joaquin Valley, Cal., and can only be regarded as suggestive of the relationship, or lack of relationship, between the Cretaceous fish faunas of the Pacific coast and those of the Rocky Mountain region. The enormously thick section referred to the Chico group in this part of California has been divided by Anderson and Pack [2] into the Panoche formation below and the Moreno formation at the top. The Panoche formation is said to have a maximum thickness of 21,000 feet and the Moreno formation 2,500 or 3,000 feet. Fish scales are known to be present in the Cretaceous formations of the Coastal Plain, extending from New Jersey to Texas, but no attempt has yet been made to assemble them for study. The collections here treated are all of Upper Cretaceous age—that is, they are younger than the Comanche and Shasta series.

A brief statement will show the relative stratigraphic positions from which the fish scales described have been obtained and will explain why beds of approximately the same

[1] The scales of fresh-water fishes: Biol. Bull., vol. 20, pp. 367–386, 1911. Observations on fish scales: U. S. Bur. Fisheries Bull., vol. 32, pp. 119–174, 1912. Some fossil fish scales: Zool. Anzeiger, Band 45, pp. 189–192, 1914. Scales of Panama fishes: Washington Biol. Soc. Proc., vol. 28, pp. 151–159, 1915.

[2] U. S. Geol. Survey Bull. 603, pp. 34–57, 1915.

age are referred to different formations in different areas. The standard marine Upper Cretaceous section of the Upper Missouri region is as follows:

Montana group:
  Fox Hills sandstone.
  Pierre shale.
Colorado group:
  Niobrara limestone.
  Benton shale.
Dakota sandstone.

In Colorado east of the Rocky Mountains and over a considerable part of the Great Plains a limestone (Greenhorn limestone) is developed in the midst of the Benton shale, so that the Benton shale interval consists of three formations—the Carlile shale, Greenhorn limestone, and Graneros shale. In parts of the same area the Niobrara is also separable into two formations—the Apishapa shale above and the Timpas limestone below.

In the eastern half of Wyoming and around the Black Hills the Mowry shale is conspicuous in the lower part of the Colorado group as a hard, platy, ridge-forming shale, full of fish scales. In the Black Hills, where the Greenhorn limestone is recognized and the Benton is therefore divisible into three formations, the Mowry shale is treated as a member of the Graneros shale. In some areas where the Benton is not divided the Mowry is called a member of the Benton; in the Big Horn Basin it is recognized as an independent formation lying between the Frontier formation above and the Thermopolis shale below.

The Aspen shale, which certainly includes rocks of the same age as the Mowry shale, is restricted to western Wyoming, which is also the typical area of the Frontier formation. The section there is as follows:

Adaville formation.
Hilliard shale.
Frontier formation.
Aspen shale.
Bear River formation (restricted to western Wyoming).

In this section the time equivalent of the Colorado group extends from the top of the Bear River formation to about the middle of the Hilliard shale, and the upper part of the Montana group is probably absent. In western Colorado the whole of the Colorado group and the lower part of the Montana group are represented by an undivided mass of shale called the Mancos shale, and this is overlain by the coal-bearing Mesaverde formation, followed by the Lewis shale and in the southwest by the Pictured Cliffs sandstone. The Mesaverde formation is also recognized over a large part of Wyoming, and the only fish scales found in it were obtained in marine and brackish-water beds of the Rock Springs field.

Another set of names has been used in northern Montana on account of the development of different stratigraphic units. There the great shale mass corresponding to the Mancos extends only to the top of the Colorado group and is therefore called the Colorado shale. Above it in order come the Eagle sandstone, the Claggett shale, the Judith River formation, and the Bearpaw shale. Locally this succession is modified by the merging of the Claggett with the Eagle and Judith River and the development of the Horsethief sandstone above the Bearpaw shale.

The approximate relations of the above-mentioned local subdivisions of the Colorado and Montana groups are shown in the following table:

Relations of local subdivisions of Colorado and Montana groups.

	Standard section, upper Missouri region.	Eastern Colorado.	Black Hills and eastern Wyoming.	Southern Wyoming.	East side of Big Horn Basin.	Western Wyoming.	Western Colorado.	Northern Montana.
Montana group.	Fox Hills sandstone.	Fox Hills sandstone.	Fox Hills sandstone.					
	Pierre shale.	Pierre shale.	Pierre shale.	Lewis shale.	Meeteetse formation (fresh water).		Pictured Cliffs sandstone (southwestern Colorado).	Bearpaw shale.
							Lewis shale.	
				Mesaverde formation.	Mesaverde formation.	(?) Adaville formation.	Mesaverde formation.	Judith River formation.
								Claggett shale.
				Steele shale.	Cody shale.	Hilliard shale.	Mancos shale.	Eagle sandstone.
Colorado group.	Niobrara limestone.	Apishapa shale.	Niobrara formation.	Niobrara shale.				Colorado shale.
		Timpas limestone.						
	Benton shale.	Carlile shale.	Carlile shale.	Carlile shale.				
		Greenhorn limestone.	Greenhorn limestone.	Frontier formation.	Frontier formation.	Frontier formation.		
		Graneros shale.	Graneros shale. Mowry shale member.	Mowry shale.	Mowry shale.	Aspen shale.		
				Thermopolis shale.	Thermopolis shale.			

INTRODUCTION.

In offering a treatment of Cretaceous fishes, based principally on isolated or detached scales, one runs counter to the practice and prejudice of ichthyologists. The old scale classification of Agassiz has long been discarded and his terms are now used only in a descriptive sense. Even in that sense they are rather unsatisfactory, for there are many entirely different types of cycloid, ctenoid, and ganoid scales. Recent studies of the scales of living fishes show that they present excellent diagnostic characters and are highly distinctive of genera and families, though not always of species. Very closely allied species may have scales which can not be distinguished, the scale characters being more persistent than some of the other more adaptive features on which the species are separated. Some scales, as might be expected, exhibit convergent or parallel evolution, showing similar features in quite different groups of fishes. Facts of this sort are likely to be misleading, but they are in no sense peculiar to lepidology.

In former years a few authors have undertaken to diagnose or recognize Cretaceous fishes from the scales alone. Dr. A. S. Woodward, influenced no doubt by the evident confusion in the application of the names, has set aside these determinations as practically valueless. It was not possible to give a really intelligible account of the fossil teleost scales until those of living fishes had been rather fully investigated. To-day the situation is different, and we feel justified in proceeding on a new basis. The situation is not unlike that found in paleobotany. Students of living plants do not describe species from leaves alone except in the rarest instances. Yet, if paleobotanists had refused to take note of or describe all plant remains that did not include the reproductive parts, our knowledge of the past history of vegetation would to-day be fragmentary indeed. It is true that many of the generic references of fossil leaves are provisional and uncertain, and it is very easy to criticize any paleobotanic work on this basis; yet no careful student of the subject can deny that on the whole the study of fossil leaves has been of immense value for the advancement of botanic science as well as for stratigraphy. After spending much time in the study of fossil plants as well as fish scales, I can affirm that the scales are certainly not less characteristic than the leaves; in fact, the comparison is decidedly in favor of the scales. It can also be said that the scales are at least as distinctive as the fragments of jaws, teeth, and fins that form the basis of so many descriptions of Cretaceous fishes. It is not, however, a question of scales versus bones, where both are available. Throughout the greater part of the American Cretaceous strata distinctive skeletal remains of fishes are extremely scarce; only in the Niobrara can they be said to be at all abundant. On the other hand, scales are plentiful and widespread and may be found in innumerable places where no other fossils are obtainable. Consequently, to refrain from studying these scales is to set aside a valuable aid to stratigraphy as well as a chance of learning in considerable detail what the teleost fauna of the Cretaceous really was. The Cretaceous was a time of extraordinary importance for ichthyology, because it saw the rise and development of the higher fishes, with numerous types clearly pointing toward the modern fauna. For this reason it is especially desirable to note every fact which will throw light upon the Cretaceous history.

The study of fossil scales involves one difficulty. In studying modern fishes the investigator takes the scales from the middle of the side of the fish, where all their characters are fully developed. Scales from other situations may be quite uncharacteristic. Naturally no such selection has taken place in the preservation of the fossils, and consequently the specimens must be regarded with caution and set aside if there is any reason to think that they are not typical. Scales from the region of the caudal peduncle will be comparatively narrow, but their sculpture and markings will be normal. Latinucleate (regenerated) scales are as common among fossils as in recent fishes, and should not be used as types. They can be distinguished by the confused sculpture of the central region, without the fine circuli around the nucleus. In describing scales the free end is spoken of as the apex, the attached end as the base. The teleost scale is made up of fine fibrillae, which are in some genera longitudinal, as in *Amia* and *Albula*, but more usually concentric. In the true clupeids (herrings) they are transverse. These fibrillae are termed the circuli and are not growth lines. Growth lines

have often been observed cutting the circuli. In migratory fishes, such as the salmon, the growth lines differ in character and density, according to the environment, and consequently it may be possible to detect evidence of migratory habits in fossil fishes. Lines or grooves radiating from the center of the scale or from its direction are called radii. This term was long ago used by Cope in describing fossil fish scales; and it must be said of Cope that his descriptions of these structures were much better than those of most other authors, though lacking in many desirable details.

As in the case of fossil leaves, descriptions of scales without figures are unsatisfactory, especially if they are to be largely used by stratigraphers who have no intimate knowledge of lepidology. Consequently it has been considered necessary to illustrate this paper fully; and the enlarged figures, from photographs, bear testimony alike to the excellent preservation of much of the material and the skill of the photographer, Mr. W. O. Hazard, of the United States Geological Survey. Only those species have been described and figured which it seemed could be clearly recognized. Various others, evidently distinct but represented by poor or uncharacteristic material, have been set aside for the present. Additional collections, now that attention is called to the subject, will undoubtedly greatly increase the number of known species.

I am particularly indebted to Mr. T. W. Stanton, of the Survey, for assistance of every kind throughout this investigation. Without his kind help I should have found it very difficult to proceed. I am also greatly indebted to my colleague, Prof. J. Henderson, of the University of Colorado Museum, for advice and assistance. Dr. D. S. Jordan has given me much kind advice, though, of course, he is in no way responsible for my manner of treating the subject. He has furnished a manuscript list of all the families and higher groups of fishes, representing his most mature opinions. This I have mainly followed in the present paper. Dr. A. S. Woodward, of the British Museum, has sent me admirable photographs of fossil fish scales, two of which I have reproduced (Pl. XXXVII, figs. 1, 2), and when I was in London he kindly gave me access to the collections of the Museum. Unfortunately at that time I did not know that I should be specially interested in Cretaceous fishes and did not pay particular attention to their scales, except in the case of a few genera. The authorities of the United States National Museum and the American Museum of Natural History very kindly allowed me to examine their materials. I am indebted to the University of Kansas for the photographs of *Hypsodon* (*Portheus*), reproduced in Plate XXXIII, figures 1 and 2.

As students of fossil scales will need specimens of recent species, it may be worth while to explain a simple manner of preparing them. Remove a few scales from the middle of the side of the fish, avoiding regenerated scales, and place them, while wet, upon a slide. The skin covering the exposed part should be removed if it is thick. Cover the scales with a cover glass or, if they are large, with another slide. Hold down with one or more of the metal clamps used in microscopic work. Stick a gummed slide label on each side of the cover glass, overlapping, or, if two slides are used, round the ends of the slides. Remove the clamps when the material is dry, and the scales will remain in place.

STRATIGRAPHIC DISTRIBUTION.

GENERAL FEATURES.

In this discussion we are dealing almost entirely with a marine fauna. Scanty remains from the Judith River beds (see Acipenseridae) are of fresh-water origin, but they do not include any teleost scales. It is not until we come to the base of the Eocene, in the Rocky Mountain region, that we find scales of fresh-water bony fishes,[1] and the species obtained present all the characters of the highly organized modern group Centrarchidae (Micropteridae). The perchlike fishes are not found in American Cretaceous strata, and it is a question whether they may not have evolved in fresh water and later taken to the sea. At any rate, it must be said that so far as we know at present the Tertiary fishes mark a considerable advance on or at least change from their Cretaceous predecessors. It ought to be possible as a rule to distinguish a Cretaceous from a Tertiary deposit by means of a single well-preserved fish scale. The exceptions will be found in those groups

[1] A possible exception is U. S. Geological Survey locality 6603, in the Uinta Basin, Utah, which contains plant remains. Two poorly preserved scales are figured in Plate XXXVI, figures 16 and 17.

which range with little change from the Cretaceous to the present day—the berycoids, clupeids, or hemiramphids. In such groups only the recognition of the species and its identification with one from beds of known age could be of any service. Such a scale as that of *Pomolobus? chicoensis*, from the Chico, might belong anywhere from that time to the present day. So, also, with *Hemilampronites hesperius*, from the Fox Hills.

Just as the Tertiary fishes mark an advance on the Mesozoic, so also the later Cretaceous fishes present evidence of evolution and modernization. This statement applies not only to the Upper as contrasted with the Lower Cretaceous, but also, and rather markedly, to the Montana group as contrasted with the Colorado group. The scanty materials from the Fox Hills and Pierre now available already indicate the beginnings of modern groups which are absent from the older beds, and unquestionably later discoveries will emphasize the distinctions observed. Thus we seem to find evidence of a rather slow and gradual modernization of the fish fauna, the breaks in the series corresponding with the geologic breaks and not being attributable to any extraordinary migrations or sudden new developments.

There were, however, certain environmental conditions which must have affected the rate of evolution and diversification. The inland seas of the American Paleozoic were drained by the Permian uplift, but during later Mesozoic time this country once more possessed a vast mediterranean sea, comparatively shallow and warm, which reached its maximum depth probably during the Niobrara epoch. A modern map of North America marked in some way to indicate the shallow-water areas, even down to 100 fathoms, will show how restricted is the distribution of the present littoral and shallow-water faunas. They exist, as it were, in broad rivers running mainly north and south. They are circumscribed by climate, by land, and by the open sea. In comparison the great Cretaceous inland sea must have afforded an amazing wealth of opportunity for multiplication and development, which may well have been the decisive factor in the evolution of many groups of marine organisms.

In this connection it is interesting to inquire whether there were radical differences between the supposedly contemporaneous faunas of Europe and America, and in America between the faunas of the Atlantic seaboard, the inland sea, and the Pacific coast. All these regions of course had types in common, and these appear to have been, at least principally, pelagic or open-sea organisms, such as *Uintacrinus* among the echinoderms and various sharks among the fishes. There were, however, many differences. Scales of fishes from the Chico, cut off from the inland sea by the western uplands, are all different from those in Rocky Mountain deposits. The Chico has a veritable clupeid, but so far no genuine clupeids have been found in the Benton, Niobrara, Pierre, or Fox Hills. The inland waters seem to have lacked berycoids, which are so characteristic of the European strata. Comparisons between the Old World and the New World faunas are hindered by the difference in age of some of the abundantly fossiliferous deposits. Not only do the highly differentiated faunas of Hakel and Sahel-Alma in Syria (Mount Lebanon) differ greatly from one another, but only about 10 per cent of their genera are common to the American Cretaceous. They must be referred to a later horizon than our Cretaceous fishes. The Cretaceous of Westphalia has more in common with the Syrian deposits than with the English chalk and should be intermediate in age between these two. Nearly half the genera of the English chalk are represented in the Kansas Niobrara, though perhaps the chalk is for the most part somewhat older. I have prepared more elaborate statistics, but owing to the uncertain standing of a good many of the species they are not as valuable as they look on paper. The tendency of future investigations will doubtless be to emphasize the differences in the faunas, especially as studies of scales are likely to reveal many of the smaller and more sedentary fishes.

Prof. J. Henderson, who has paid much attention to the Upper Cretaceous Mollusca, informs me that in his experience all the species of the Benton differ from those of the Niobrara, and all those of the Niobrara from those of the Pierre. The Pierre and Fox Hills, on the other hand, present faunas grading one into the other. As this did not wholly agree with some of the published records, I asked Mr. T. W. Stanton for his opinion. He replies that he is in perfect accord with Prof. Henderson. The

Colorado and Montana faunas had few if any identical species of Mollusca, though of course many genera occurred in both. Old records contrary to these opinions were based on errors. Thus *Inoceramus labiatus*, supposed to occur in the Niobrara of Kansas and Nebraska, was really from the Greenhorn limestone, well down in the Benton. We have, then, in the Upper Cretaceous two extremely marked faunal breaks. They must represent long periods, during which many things happened. Where no species of Mollusca persisted, surely no fishes could be expected to remain unaltered. Present information tends to confirm this opinion, and when a Benton fauna is found in beds ascribed to the Niobrara (see under *Holcolepis pulchellus*, p. 174) it is evident that there was an error in stratigraphy.

BENTON SHALE.

The previously recorded teleosts from the Benton are few, as follows:

Apsopelix. A genus not known from later rocks. Mr. Stanton informs me that Cope's locality (in Kansas) is certainly Benton.

Pelecorapis varius Cope. Mr. Stanton says almost certainly from the Benton; the *Inoceramus* referred to by Cope is presumably *I. labiatus*. Mr. Stanton adds, however, that if the Sibley referred to is the one now on the map there is some mistake, as this would place the locality in the Carboniferous.

Protosphyraena bentoniana Stewart.

Hypsodon lowii (Stewart). This and the last belong to genera common to the Niobrara and Pierre.

There is also a very dubious record of *Anogmius*. To these are added in the present paper the following species:

Holcolepis pulchellus [1] n. sp.
Holcolepis delicatus n. sp.
Holcolepis transversus n. sp.
Holcolepis obliquus n. sp.
Hypsodon? granulosus n. sp.
Ichthyodectes sp.
Leucichthyops vagans n. sp.
Erythrinolepis mowriensis n. sp.
Halecodon denticulatus n. sp.
Cimolichthys sp.

It is not at present certain that levels in the Benton can be distinguished by means of the fishes. Materials ascribed to the Aspen (for example, U. S. G. S. localities 4874, 3870) present a Mowry fauna, as they should, for the Aspen and Mowry are approximately equivalent.

[1] The rocks yielding this species were referred to the Niobrara by Beekly (U. S. Geol. Survey Bull. 596, pp. 40, 41, 1915), but the locality is in a faulted area and may well be on a Benton outcrop.

NIOBRARA FORMATION.

The recorded fish fauna of the Niobrara is very rich, comprising 23 genera, mostly found in Kansas. Several of these are discussed below, but I have no new species to add.

MONTANA GROUP.

The Montana group includes the Pierre shale and Fox Hills sandstone. The fishes are not sufficiently well known to throw any particular light on the divisions of the group. The following new forms, the last three of which are from the Fox Hills sandstone, are described in this paper:

Petalolepis? fibrillatus n. sp.
Cycloides? incertus n. sp.
Hypsodon? radiatulus n. sp.
Echidnocephalus? americanus n. sp.
Helmintholepis vermiculatus n. sp.
Cyclolepis stenodinus n. sp.
Hemilampronites hesperius n. sp.

According to previous records about half a dozen Niobrara genera (*Hyposodon, Syllaemus, Protosphyraena, Ichthyodectes, Empo* or *Cimolichthys*, and perhaps *Pachyrhizodus*) survived to the Pierre; but not one of these is recorded from the Fox Hills. This means little, perhaps, as hardly anything has been known of the Fox Hills fishes.

CHICO GROUP.

The following species from the Moreno formation of the Chico group of California are described below:

Chicolepis punctatus n. sp.
Pomolobus? chicoensis n. sp.
Erythrinolepis chicoensis n. sp.
Echidnocephalus? pacificus n. sp.

DESCRIPTION AND SYSTEMATIC DISCUSSION OF SPECIES.

PISCES.

Subclass CHONDROSTEI.

Family ACIPENSERIDAE.

Scutes of *Acipenser* (*A. toliapicus* Woodward) are known from the London clay (lower Eocene) of the Isle of Sheppey. The plates named *A. cretaceus* Daimeries, from the Senonian of Belgium, are said by Woodward to belong apparently to some fish related to *Dercetis* or *Eurypholis*, and therefore are not chondrostean at all. In the Belly River formation (Upper

Cretaceous) of Red Deer River, Alberta, Lambe found a scute which he called *Acipenser albertensis*. In the same deposit he found part of an elongated snout which bore a series of teeth, much like that of the more ancient *Saurorhynchus* (*Belonorhynchus*). This he named *Diphyodus longirostris*, but he did not attempt to indicate its affinities. It was afterward stated by Hatcher [1] that remains similar to both these fossils were common in the Judith River and Lance formations in certain localities in Montana and Wyoming. The associated fossils indicated fresh-water conditions, so the absence of such remains from the Upper Cretaceous marine beds is not surprising. The question naturally arises whether by any possibility the *Acipenser*, so called, was in fact a toothed sturgeon, *Diphyodus* representing the jaw of the same fish. The Saurorhynchidae seem not to have survived to the Cretaceous (*Stenoprotome* Hay, from Syria, being a very dubious representative), but it is possible that toothed sturgeons more or less intermediate between the Saurorhynchidae and Acipenseridae existed in that period.

Subclass TELEOSTEI.

Order HALECOMORPHI.

Family PROTOSPHYRAENIDAE.

Protosphyraena Leidy (*Erisichthe* Cope) is abundantly represented in the Niobrara of Kansas and has one species each in the Benton and Pierre. It is known mainly by the rostra and pectoral fins, and there is in the descriptions no mention of scales. *Hypsocormus*, considered to be related to it, has smooth scales, small and deeply imbricating.

Order ISOSPONDYLI.

Family ALBULIDAE.

I have supposed that the Albulidae (*Albula* and *Dixonina*) were the only fishes above the Halecomorphi that had longitudinal basal circuli or fibrillae.[2] I find, however, that this peculiarity is shared by *Alepocephalus agassizi* (Alepocephalidae). *Benthosphyraena macroptera*, also referred to the Alepocephalidae, has small round scales wholly unlike those of *Alepocephalus*. The *Alepocephalus* scales, although having longitudinal basal fibrillae, are in other respects entirely different from those of the Elopidae, being shaped much like the sole of the foot, the nucleus subapical, with coarse concentric circuli above it, the lower margin broader and thin, neither crenulated nor with radii. The albulid scale, on the other hand, is subquadrate, with broad crenate lower margin and a few distinct basal radii. The albulid fibrillae are tuberculate, as in the Dipneusti; this is not true of *Alepocephalus*.

In view of their primitive characters, the Albulidae must have existed in the Cretaceous. The recorded species which have been assigned to this family, however, do not appear to belong there. *Prochanos* is to be referred to Chanidae. *Istieus* goes in Pterothrissidae. *Ancylostylos* from Croatia may be referred to a distinct family, of which it is the typical genus. *Anogmius* Cope (*Syntegmodus* Loomis), from the Niobrara of Kansas, may go in Pterothrissidae, but not in Albulidae or Osteoglossidae, to which it has been referred. *Plethodus* forms a family, Plethodontidae, to which Hay also refers *Anogmius*. *Apsopelix*, to judge from Cope's description of the scales, seems to have some resemblance to the Albulidae, where it is provisionally placed by Hay. Cope states that the circuli are vertical, except in the region of the nucleus. The position of this genus must for the present remain undecided. Finally, *Petalolepis divaricatus* (Geinitz), based on a scale from the Turonian of Saxony, appears to be a genuine albulid. An American scale is provisionally referred to the same genus.

Genus PETALOLEPIS Steinla.

Petalolepis? fibrillatus Cockerell, n. sp.

Plate XXXI, figure 1.

Scale 8.5 millimeters in diameter, subquadrate, but with obtusely rounded angles, a very little longer than broad; lines of growth evident, concentric, but the very fine fibrillae strictly longitudinal from one end to the other, except that toward the basal margin they curve inward, becoming more or less transverse, following the wavy outline of the margin; the fibrillae are not tuberculate or beaded, as they are in *Albula;* as in *Petalolepis divaricatus*, on each side of the middle line in the basal region the fibrillae become curved and end by meeting each other at a very acute angle; there is a strong median plica on the basal half of the scale, but no ordinary radii, and this agrees with *P. divaricatus*.

[1] U. S. Geol. Survey Bull. 257, p. 69, 1905.
[2] U. S Bur. Fisheries Bull., vol. 32, p. 122, fig. 2, 1912.

U. S. G. S. locality 5094. Cretaceous, Mesa Verde formation, 14 miles north of Rock Springs, Wyo., a little east of center of sec. 26, T. 21 N., R. 104 W. (Collected by V. H. Barnett.)

A similar but much larger scale may represent a related species, but the surface as preserved presents a very fine irregular reticulation, with concentric lines of growth, and it can not be determined whether the fibrillae are longitudinal. So far as the visible characters go, this agrees with Winkler's problematic *Cycloides*, and it may provisionally stand as described below.

Cycloides? incertus Cockerell, n. sp.

Plate XXXI, figure 2.

Scale 16 millimeters in diameter (*C. incisus* Winkler is 17.5 millimeters in diameter), subquadrate; apical margin broadly rounded, apparently a little crimped; laterobasal angles obtuse but distinct; a very strong median plica on the basal three-fourths, the growth lines turned upward on approaching it, as in Winkler's figure.

U. S. G. S. locality 5177. Cretaceous, Mesaverde formation, about 5 miles southwest of Sycamore, Wyo., in the NE. ¼ sec. 12, T. 19 N., R. 103 W., in the Rock Springs region. (Collected by V. H. Barnett.)

In the general form and median plica this scale is suggestive of that of *Mugil curema*. The same sort of plica and basal margin may be seen in scales of the cyprinid *Cirrhina jullieni*. There is also a conspicuous median basal plica in *Chanos*, but it is broad and shallow, not forming a line.

Family LEPTOLEPIDAE.

A family found in the Cretaceous of Europe, surviving from the older Mesozoic. "Scales thin, cycloidal, and deeply imbricating, usually ganoid in their exposed portion; lateral line not observable." (A. S. Woodward.)

Family ELOPIDAE.

Genus HOLCOLEPIS Von der Marck.

This genus was called *Rhabdolepis* by Von der Marck in 1863, but Troschel had earlier (1857) used that name for a palaeoniscid fish. *Holcolepis* was proposed in 1868. Agassiz, who had proposed the name *Osmeroides* for an entirely different fish, unfortunately transferred it in 1844 to a species of *Holcolepis;* and in this he has been followed by several authors. The genus *Holcolepis* is certainly to be referred to the Elopidae, even after the removal of such genera as *Pachyrhizodus*, which A. S. Woodward places in that family. The teeth are minute, entirely different from those of *Pachyrhizodus*. The dorsal fin is less modified than in modern Elopidae. *Holcolepis* has not hitherto been reported from the North American Cretaceous, our nearest form being *Spaniodon simus* Cope, a form with smooth scales.

A. S. Woodward [1] described the scales of *Holcolepis* as "often ornamented in their exposed portion with delicate radiating lines of minute tubercles, marked in their covered portion with a few radiating grooves terminating in notches at the anterior truncated margin; hinder margin not serrated; course of lateral line indicated by a feeble ridge and a notch in the hinder border of most of the scales"—that is to say, the scales have basal radii; but in a later publication [2] Woodward shows a scale of *Osmeroides lewesiensis* (= *Holcolepis lewesiensis*) without any such radii.

Osmeroides divaricatus Geinitz, 1868, is based on the scales of an albulid fish, and takng up the name *Petalolepis* Steinla, published by Geinitz as a synonym, the species becomes *Petalolepis divaricatus*.

Osmeroides lewesiensis (Mantell) as determined by Geinitz from the Turonian of Saxony consists of a mixture of different things, none of them identical with the English fish. One, the most recognizable, is similar to the living genus *Pterothrissus* in the character of its scales. This form [3] unfortunately takes the cumbersome name *Kymatopetalolepis* of Steinla and may stand as *K. geinitzi* n. sp. It has four to six fanlike basal radii, the circuli between them broken into dots. The nucleus is subapical, and the apical region hyaline.

Osmeroides divaricatus Geinitz as figured by Fritsch [4] is wholly unlike the Geinitz species, having transverse basal circuli. There are three basal radii, and the basal margin is scalloped.

[1] Catalogue of fossil fishes in the British Museum, pt. 4, p. 11, 1901.

[2] The fossil fishes of the English chalk, pl. 23, fig. 8, 1907.

[3] Geinitz, H. B., Die Fossilen Fischschuppen aus dem Plänerkalke in Strehlen: Gesell. Natur- u. Heilkunde Dresden Denkschr., 1868, pl. 2, figs. 10–12.

[4] Fritsch, Anton, Die Reptilien und Fische der böhmischen Kreideformation, fig. 58, 1878.

O. lewesiensis (Mantell) of Fritsch is also wrongly named. It is a scale with subapical nucleus and five strong basal radii, the basal margin very strongly scalloped. The scale has a strong resemblance to that of *Megalops cyprinoides*, and may therefore represent a fossil elopid of some unknown genus.

Osmeroides belgicus Winkler, 1874, is based on a scale apparently congeneric with the so-called *lewesiensis* of Fritsch but considerably broader and with more basal radii. It is a large scale, the transverse diameter being 15 millimeters.

The type of *Holcolepis*, *H. cretaceus* Von der Marck, is imperfectly known, and it is possible that the various species supposed to be congeneric could be divided into two genera with better materials. For the present I assume that the scale of *H. lewesiensis*, well figured by Woodward, is typical of the genus. Its most characteristic feature is the pseudoctenoid exposed area, ornamented with radiating lines of pustuliform markings, derived from the circuli. *H. latifrons* (Woodward), from the chalk of Kent, is similarly ornamented, but the lines are more broken up, producing, except near the margin, a pitted or malleate effect. The lateral line is very distinct. In *H. levis* (Woodward), from the chalk of Kent and Sussex, the scales possess "fine radiating ornament" and have distinct basal radii. They are therefore similar to those of the modern *Elops*, and the fish may not be congeneric with the others.

The modern Elopidae (*Elops*, *Tarpon*, *Megalops*) have very distinct basal radii, 3 in *Tarpon*, about 5 to 7 in *Megalops*, and 12 to 18 in *Elops*. The basal margin is very strongly crenate in *Megalops*, moderately in *Tarpon*, but feebly in *Elops*. In *Tarpon* the apical field has a radiating sculpture of minute tubercule-like elements, not clearly visible on casual inspection. This is the *Holcolepis* sculpture, but very much finer and less conspicuous. In *Megalops* the region above the nucleus shows granulations but not distinct radial lines; there is some approach to the condition of *Holcolepis latifrons*. *Elops*, above the nucleus, shows coarse transverse wrinkled lines, but the broad apical field is free from markings derived from the circuli and presents a number of parallel radii. Apparently, then, the early elopids (*Holcolepis*) had the exposed part of the scale prominently sculptured with lines or rows of tubercles derived from the circuli, while the covered part was either without evident sculpture, except the fine circuli, or had a few distinct radii. The development has been toward the loss of the apical sculpture and the strengthening and increase in number of the basal radii. It seems that these changes were in process or even perfected as early as the Cretaceous, but typical *Holcolepis*, as here understood, included the more primitive type. *Pachyrhizodus*, to judge from the figure of a scale of *P. subulidens* (Owen) published by Woodward (reproduced in Pl. XXXII, fig. 3), had scales of the *Holcolepis* type, with strong or coarse sculpture on the exposed portion, and the base rounded and without radii. The scale was parallel-sided, and longer than broad, the reverse being true of typical *Holcolepis*. Thus, though we may well place *Pachyrhizodus* in a distinct family, it may have had a common ancestor with the elopids, possessing the *Holcolepis*-like scale.

In the American Cretaceous fauna the species described below, based on scales, are referred to *Holcolepis*, as understood in a rather broad sense. Outside of the Elopidae the scales show a certain general resemblance to those of *Aulopus* (Aulopidae), but in that genus the margin is strongly dentate.

Holcolepis pulchellus Cockerell, n. sp.

Plate XXXI, figures 3, 4.

Scale 7 millimeters in diameter, approximately circular, the apical margin obtusely angulate in the middle; nucleus only a little above the middle; lower margin not at all crenate; six or seven basal radii very feebly indicated, not distinctly developed, not definitely cutting the circuli; apical field with very numerous parallel raised lines, but toward the nucleus with wavy lines as in *Elops*.

One mile south of the Boetcher ranch, in the NE. ¼ SW. ¼ sec. 32, T. 10 N., R. 81 W., North Park, Colo. (Collected by A. L. Beekly and Harvey Bassler.) This is Beekly's locality 37.[1] It is referred to the Niobrara, but the scales from this and several other localities referred by Beekly to the Niobrara resemble those from the Mowry and are therefore believed to have come from the Benton shale. All the localities

[1] Beekly, A. L., U. S. Geol. Survey Bull. 596, p. 42, 1915.

thus under suspicion failed to yield any characteristic Niobrara Mollusca, and the collection from Beekly's locality 59, which did include *Ostrea congesta* Conrad, offered no such scales, but only one of *Ichthyodectes*, the so-called "*Cladocyclus*."

H. pulchellus was also found on the northwest shore of Lake John, in the SE. ¼ SW. ¼ sec. 34, T. 10 N., R. 81 W., North Park, Colo., by Beekly and Bassler. This is Beekly's locality 35.

Holcolepis delicatus Cockerell, n. sp.

Plate XXXI, figure 5.

Scale 10 millimeters in diameter, subcircular, similar to *H. pulchellus*, but apical margin rounded, nucleus a little below the middle; lines of exposed area finer and denser, with more or less evident pits between; only vague indistinct suggestions of basal radii.

Big Horn Basin, in the SE. ¼ SE. ¼ sec. 15, T. 43 N., R. 94 W., Wyoming. Near base of Mowry shale. (Collected by C. T. Lupton.)

Holcolepis transversus Cockerell, n. sp.

Plate XXXI, figures 6–13.

Scales subquadrate, on sides nearly twice as broad as long, on other parts often narrow, varying to about as broad as long; laterobasal angles commonly rather prominent; apical margin broad, flattened or depressed in middle, not angular; no basal radii, but often a single median fold, rather indistinct; apical modified patch V-shaped, ornamented with a series of closely set interrupted ridges, without pits between; circuli fine, the lateral ones directed upward, meeting the margin at a very acute angle; nucleus approximately central.

Type a scale 9 millimeters in diameter, from U. S. G. S. locality 6682, Slate Creek, Mount Leidy quadrangle, Wyo. (Collected by Eliot Blackwelder.) Mollusks of this locality are said to be not characteristic and may belong either in the Montana group or the upper part of the Colorado group, but the fish scales indicate Colorado (Benton) age. Other scales in the same lot, referred to this species, are 11 millimeters and 14 millimeters in diameter.

I also refer to this species the following:

U. S. G. S. locality 6681. Cretaceous, probably Aspen, Slate Creek, Mount Leidy quadrangle, Wyo. (Collected by Eliot Blackwelder.) Scale 10.5 millimeters in diameter.

U. S. G. S. locality 6713. Cretaceous, Mowry shale, southeast of camp at old chimney, Sisters Hill, Buffalo, Wyo. (Collected by O. B. Hopkins.) Scale 9 millimeters long and 11 millimeters wide; another scale 7 millimeters wide.

The two following specimens are about as broad as long and probably came from the vicinity of the caudal peduncle.

U. S. G. S. locality 4421. Mowry shale, Casper region, sec. 29, T. 33 N., R. 74 W. sixth principal meridian, Wyoming. (Collected by E. W. Shaw.) Scale 12.5 millimeters in diameter.

U. S. G. S. locality 3417. Lower (Benton) part of Mancos shale, Steamboat Springs, Routt County, Colo., on ridge near mineral springs, just west of town and south of Yampa River. (Collected July 13, 1905, by T. W. Stanton and H. S. Gale.)

Holcolepis transversus is closely related to *H. steinlai* (Geinitz), published by Geinitz as *Acrogrammatolepis steinlai*, the figure upside down. The *H. steinlai* scale is 7 by 6 millimeters and has the nucleus apparently more basally placed than in *H. transversus*. It is from the Turonian of Saxony and may very likely be identical with the English *H. lewesiensis* (Mantell), from beds of about the same age.

Holcolepis obliquus Cockerell, n. sp.

Plate XXXII, figure 1.

Scales 10 millimeters in diameter, much broader than long, without any trace of basal radii. Similar in most respects to *H. transversus*, but remarkable for the brevity of the elements in the apical patch and for the lateral circuli being oblique, at the middle of the side reaching the margin at an angle of about 45°, and above this becoming almost transverse.

Type collected with *H. transversus*, in Mowry shale at U. S. G. S. locality 4421. Details are given above.

Holcolepis? mandible.

Plate XXXII, figure 2.

In confirmation of the existence of a typically elopid type of fishes in the North American Cretaceous, I give a figure of a mandibular ramus which seems to belong to *Holcolepis* or a closely related genus. It differs from that of *H. lewesiensis* in the straight (not concave) descending upper margin of the dentary, and in this respect more resembles the modern *Elops*.

It was collected by A. C. Veatch in the NW. ¼ SW. ¼ sec. 8, T. 19 N., R. 79 W., Carbon County, Wyo., and is ascribed to the Colorado group. From the associated scales, which include an imperfect specimen of *Holcolepis*, either *pulchellus* or a closely related species, I infer that the material is from the Benton. The mandible and the *Holcolepis* scale probably belong to the same species.

Genus RHACOLEPIS Agassiz.

Dr. D. S. Jordan has kindly sent me material of *Rhacolepis buccalis* Agassiz, from the Cretaceous of Ceara, Brazil. The scales are broad, with coarse, rather widely spaced circuli, transverse above and below the nucleus, and many of them broken or anastomosing above the nucleus. The apical margin is delicately plicate, with a series of parallel ridges, very much as in *Ctenothrissa*. This marking probably corresponds with the system of apical radii of *Elops* and has nothing to do with the pseudoctenoid sculpture, derived from the circuli, of *Holcolepis*. *Rhacolepis* is therefore entirely distinct from *Holcolepis*, and the scales can not be confused. It is just possible that the *Pachyrhizodus* scale, which seems from Woodward's figure (reproduced in Pl. XXXII, fig. 3) to be of the same general type as that of *Holcolepis*, is really constructed in the manner of *Rhacolepis*, but with the shape entirely different and the apical plicae much longer.

Genus NOTELOPS Woodward.

In the Brazilian Cretaceous *Notelops brama* (Agassiz), also received from Dr. Jordan, the circuli are finer and denser than in *Rhacolepis*. I can not make out any "delicate radiating ridges," mentioned by Woodward, but the material is not very good. Jordan and Branner[1] state that the scales are cycloid and entire. They are, in any event, wholly distinct from those of *Rhacolepis*.

Genus HELMINTHOLEPIS Cockerell, n. gen.

Scale cycloid, circular, or slightly longer than wide, about 17 millimeters across in the type; nucleus a little below the middle; circuli fine, concentric on basal half but longitudinal and very wavy, like minute worms, on apical half; the apical marginal area delicately longitudinally striate, with about five circuli between each pair of striæ or fine radii. This may not be elopid, but I do not know where better to refer it. The striate margin is like that of *Hypsodon*, but there are no tubercles, and the microscopic structure is very different. There are no radii in the basal field, and the lower margin is broadly rounded. Type *H. vermiculatus*.

[1] Smithsonian Misc. Coll., vol. 52, p. 9, 1908.

Helmintholepis vermiculatus Cockerell, n. sp.

Plate XXXII, figure 4.

Diameter about 17 millimeters.

U. S. G. S. locality 9184, Cretaceous, Fox Hills sandstone, north side of Thompson River, near top of ridge about 1¼ miles northeast of Milliken, sec. 1, T. 4 N., R. 67 W., Greeley quadrangle, Colo. (Collected by T. E. Williard.) The type scale partly overlaps a scale of *Hemilampronites hesperius*.

Family PTEROTHRISSIDAE.

The interesting family Pterothrissidae is represented to-day by *Pterothrissus* Hilgendorf (*Bathythrissa* Guenther) from deep water off Japan. It is related to the albulids, but the scales have the circuli of the median and basal regions (a large inverted V-shaped area) broken up into dots and fine rugae. In the Cretaceous rocks of Westphalia and Syria the family is represented by the genus *Istieus*, the scales of which are said to be elliptical, not pectinated (A. S. Woodward). *Anogmius*, from the Niobrara of Kansas, seems to be more or less related. *Kymatopetalolepis geinitzi* Cockerell, based on scales from the Turonian of Saxony, appears to be typically pterothrissid. *Chicolepis*, a new genus from the Chico, may also be referred to this family.

Genus CHICOLEPIS Cockerell, n. gen.

Scales broad, subquadrate, shaped as in *Pterothrissus*, with very broadly rounded apical margin; nucleus apical, very near the margin; sides with dense simple longitudinal circuli, passing vertically up to the apical margin; the whole area inclosed by lines drawn from the middle of the apex to the laterobasal corners is covered with minute punctiform dots, the circuli having combined to form an extremely dense honeycomb-like reticulation, the punctures round and often running more or less in transverse series. In the region of the

lateral circuli are here and there streaks of punctured surface. No ordinary radii, but a median line or plica from base to apex, most conspicuous on basal half. This superficially resembles *Petalolepis? fibrillatus*, but its structure is very different. Type, *C. punctatus*.

Chicolepis punctatus Cockerell, n. sp.

Plate XXXIV, figure 1.

Scale 16 millimeters in diameter; laterobasal corners rectangular.

U. S. G. S. locality 7030. Cretaceous, Chico group, south side of Ortigalito Creek, Cal., in Moreno formation. (Collected by Robert Anderson.) For further description of locality see *Pomolobus chicoensis*. The absence of the ordinary radii at once distinguishes this species from *Pterothrissus* and *Kymatopetalolepis*.

Family ICHTHYODECTIDAE.

The fishes assigned to the Ichthyodectidae can not be referred to Chirocentridae; the scales are radically and entirely different from those of the living *Chirocentrus*, and the teeth are implanted in deep sockets. Stewart also seems fully justified in separating the Saurodontidae, especially on account of the remarkable unpaired predentary.

Genus HYPSODON Agassiz.

The type of *Hypsodon* is *H. lewesiensis*, but unfortunately Agassiz included under this name fishes that were not even congeneric. Cope, commenting on this fact, remarked that *Hypsodon* included some fishes with teeth of equal length and others in which they were unequal. He proposed to restrict the name to the genus having equal teeth, and according to this decision *Hypsodon* would take the place of the genus later named *Pachyrhizodus* by Dixon. However, the specific name *lewesiensis* was adopted from Mantell, who had described the fish with unequal teeth as *Megalodon? lewesiensis*. It is this fish which Agassiz figured in "Recherches sur les poissons fossiles," volume 5, Plate XXVa, figure 3, and Plate XXVb, figures 1–3. This appears to fix the type in a contrary sense to Cope's decision, and *Hypsodon* takes the place of *Portheus* Cope. Stewart suppressed *Portheus* in favor of *Xiphactinus* Leidy, which was based on a pectoral fin spine of the same species as Cope's type of *Portheus*. *Hypsodon* is much older, and the giant fish of the Niobrara rocks will take the name *Hypsodon audax* (Leidy). *Portheus mantelli* Newton, from the English chalk, becomes *Hypsodon lewesiensis* (Mantell). In America the genus is well represented in the Niobrara and has one species, *Hypsodon lowii* (*Portheus lowii* Stewart), in the Benton.

The University of Kansas has remarkably well preserved material of *H. audax*, and through the kindness of Prof. S. J. Hunter I have received photographs of the scales, which are reproduced here.

Hypsodon audax (Leidy) Cockerell.

Plate XXXII, figure 8; Plate XXXIII, figures 1, 2.

Xiphactinus audax Leidy, Acad. Nat. Sci. Philadelphia Proc., p. 12, 1870; U. S. Geol. Survey Terr. Rept., vol. 1, pp. 290, 348, pl. 17, figs. 9, 10, 1873.
Cope, U. S. Geol. Survey Terr. Rept., vol. 2, p. 276, 1875.
Hay, Zool. Bull., vol. 2, p. 27, 1898.
Stewart, Kansas Univ. Quart., vol. 7, p. 115, 1898; idem, vol. 8, p. 107, 1899; Kansas Univ. Geol. Survey, vol. 6, p. 267, pls. 33–47, 1900.
Saurocephalus audax (Leidy) Cope, Am. Philos. Soc. Proc., vol. 11, p. 553, 1870; U. S. Geol. Survey Terr. Ann. Rept. for 1870, p. 418, 1871.
Portheus? audax (Leidy) Hay, U. S. Geol. Survey Bull. 179, p. 384, 1902.

Scales extremely broad, the width about twice the length, though on the caudal peduncle they are undoubtedly much narrower. Exposed area densely covered with small tubercles, which in the apical region are arranged in longitudinal series, being in fact situated on longitudinal ridges. The basal region has fine concentric lines of growth, and numerous more or less broken radii, spread out in broad fan shape. The *Cladocyclus occidentalis* of Leidy, which has page priority over *Xiphactinus audax*, is based on just such scales, but whether of the species *H. audax* it is not at present possible to decide. Loomis thought the *C. occidentalis* scales belonged to *Ichthyodectes* (or *Gillicus*) *arcuatus* Cope, and wrote *Ichthyodectes occidentalis* (Leidy) for that species. This assignment certainly can not be maintained. It appears that the type locality of *C. occidentalis* is uncertain: On one page Leidy says that the material came from Nebraska; on another he says that it came from Sage Creek, Dakota. Leidy suggested that the scales before him probably belonged to several species.

The name *Cladocyclus* Agassiz was based on scales from Brazil (*C. gardneri* Agassiz), which do not appear to be identical with any of the North American or European genera, though there is close similarity in the branching lateral line canals. I have material of the Brazilian fish, kindly sent by Dr. D. S. Jordan. Woodward, in his "Fossil fishes of the English chalk," abandons the use of *Cladocyclus* for European fishes, remarking that Agassiz referred to this genus scales of the *Ichthyodectes* type, calling them all *Cladocyclus lewesiensis*. The scales which Geinitz called *Cladocyclus strehlensis* were in the main of this same type.

The question which now arises is whether scales of *Hypsodon* can be clearly distinguished from those of *Ichthyodectes*. Woodward figures *Ichthyodectes* scales, and they differ from those of *Hypsodon* only in the strictly entire basal radii. In *Ichthyodectes*, as I understand it, the basal part of the scale frequently splits along the radii, producing the appearance of a frayed edge of separated narrow bands. The lateral line canal is branched, more or less Y-like, or rarely in the complex manner of the Brazilian *Cladocyclus*. A photograph of "*Cladocyclus lewesiensis*," received from Dr. A. S. Woodward, shows the fraying-out effect very well and should represent *Ichthyodectes*. The species of *Hypsodon* and *Ichthyodectes* recorded from the Kansas Niobrara are numerous, and it will be difficult or impossible to connect them all up with their scales.

A very fine scale, 40 millimeters long and 35 millimeters broad, comes from the Niobrara of New Mexico (U. S. G. S. locality 8354, Meloche ranch, eastern edge of Raton quadrangle; collected by W. T. Lee). It is not at all of the same shape as the Kansas University *H. audax* scales, but it presumably comes from the caudal region, and is similar to one of the scales figured by Leidy as *Cladocyclus occidentalis*. The striae in the apical region are very delicate, and the tubercles are between the ridges instead of upon them; but this is probably a reverse impression. In view of the large size and general agreement in characters this scale is referred to *H. audax*.

A still larger *H. audax* scale comes from Wyoming (10 miles southeast of Glenrock, in the SW. ¼ NE. ¼ sec. 29, T. 33 N., R. 74 W.; collected by V. H. Barnett); it is 51 millimeters across.

Typical *H. audax* scales, about 50 millimeters across, have been found in the Mancos shale 1½ miles northeast of Columbine, Routt County, Colo. (Collected by Colorado Geological Survey.)

Hypsodon lowii (Stewart) Cockerell.

Plate XXXIV, figure 2.

Portheus lowii Stewart, Kansas Univ. Quart., vol. 7, p. 24, pl. 2, fig. 2, 1898.
Hay, U. S. Geol. Survey Bull. 179, p. 384, 1902.
Xiphactinus lowii (Stewart) Hay, Zool. Bull., vol. 2, p. 27, 1898.
Stewart, Kansas Univ. Geol. Survey, vol. 6, p. 293, pl. 48, fig. 2, 1900.

U. S. G. S. locality 7294. Cretaceous, Benton, sec. 20, T. 9 N., R. 77 W., half a mile northwest of Kerr's ranch, North Park, Colo. (Collected by A. L. Beekly and Harvey Bassler.) A large scale, 32 millimeters across, provisionally referred to *H. lowii*, as it is exactly the sort of scale that species might be expected to have.

Hypsodon? radiatulus Cockerell, n. sp.

Plate XXXII, figures 6, 7.

Scale 15 millimeters across, with apical ridges but apparently without the tubercles of *H. audax*. Another scale, 15.5 millimeters across, is of the same species but latinucleate (renovated). As this species comes from a later formation than the Niobrara, it is doubtless distinct from the Kansas fishes described.

U. S. G. S. locality 5177. Cretaceous, Mesa Verde, about 5 miles southwest of Sycamore, Wyo., in the NE. ¼ SE. ¼ sec. 12, T. 19 N., R. 103 W., in the Rock Springs region. (Collected by V. H. Barnett.) *Cycloides? incertus* is from the same locality and horizon.

U. S. G. S. locality 5174. Cretaceous, Mesa Verde, about 2½ miles north of Sycamore, Wyo., in the SE. ¼ sec. 17, T. 20 N., R. 102 W.

Hypsodon? granulosus Cockerell, n. sp.

Plate XXXII, figure 5.

Scale nearly circular, slightly broader than long, about 21 millimeters in diameter, basal and apical margins rounded; circuli fine, concentric, except in large exposed area extending to the region of the nucleus in the center of the scale, where the surface is finely rugose, without the definite tubercles of *H. audax;* apical margin longitudinally striate but not tuberculate;

base with about a dozen imperfect and broken radii.

U. S. G. S. locality 4874. Cretaceous, Mowry shale, 100 double paces south of the north quarter corner of sec. 19, T. 28 N., R. 91 W., near North Rawlins, Wyo. (Collected by O. P. Hopkins.)

It is possible that this species and *H.? radiatulus* belong to elopid fishes, and not to the Ichthyodectidae. With *H.? granulosus* occurred *Leucichthyops vagans* and *Holcolepis transversus*.

Genus ICHTHYODECTES Cope.

Plate XXXIV, figures 3, 4.

About eight species of *Ichthyodectes* are known from the Niobrara of Kansas. Three species occur in the chalk of England. The type species is *I. ctenodon* Cope from Kansas. At present we can do no more than recognize the genus fron the scales; it is doubtful whether the scales exhibit specific characters. The two following are characteristic:

U. S. G. S. locality 2402. Cretaceous, lower part of Colorado shale, creek north of Lower Sherburne Lake, Swift Current Valley, tributary to St. Marys River, Mont., latitude 48° 50–55′, longitude 113° 25′. (Collected by Bailey Willis and Stuart Weller.) Scale 6 millimeters in diameter.

U. S. G. S. locality 7277. Cretaceous, Niobrara, in the NE. ¼ SE. ¼ sec. 34, T. 7 N., R. 82 W., east of Clover Valley telephone line, about 3 or 4 miles south of Butler, North Park, Colo., yellow sandy material. (A. L. Beekly.) This is Beekly's locality 59.[1] *Ostrea congesta* occurred in the same material.

Ichthyodectes scales also occur in Benton rock north of Boulder, Colo., where they were collected by Prof. J. Henderson (Colorado Univ. Mus. 459). One of these scales, 15 millimeters in transverse diameter and about 11 millimeters long, is from the lateral line and is remarkable for the complex, treelike system of branching canals, quite as complex as in the Brazilian *Cladocyclus*. This species tends to weaken our conviction that *Ichthyodectes* and *Cladocyclus* are really different genera; but the scales of *Cladocyclus gardneri* differ in the basal region from those of *Ichthyodectes*, and in view of the difference of locality there is no great probability that the fishes are really congeneric. Moreover, as A. S. Woodward shows, *C. gardneri* differs also from *Ichthyodectes* in the more anterior position of the dorsal fin.

Ichthyodectes libanicus (Pictet and Humbert), from Syria, which I have examined in the American Museum of Natural History, has very broad scales, smooth and porcelain-like on their exposed parts. Woodward states that the species has the dentition of *Ichthyodectes*.

[1] U. S. Geol. Survey Bull. 596, p. 42, 1915.

Cretaceous fish scales from Turkestan.

Plate XXXIV, figures 6-12.

G. D. Romanowsky [1] has figured certain Cretaceous scales from Turkestan, and the figures are reproduced on Plate IV.

Figures 6, 7, 8, referred by Romanowsky to *Cladocyclus strehlensis* Geinitz, agree with *Hypsodon*.

Figure 9, referred to *Osmeroides lewesiensis* var., appears to be immature *Hypsodon*, the scale probably from the subcaudal region.

Figure 10, referred to *Cladocyclus strehlensis*, agrees with *Ichthyodectes*.

Figure 11, called *Osmeroides pectinolepis* Romanowsky, is imperfect and apparently latinucleate (regenerated); it may be *Ichthyodectes*.

Figure 12, called *Beryx* sp., can not be determined. It shows nothing to justify a reference to the genus *Beryx*.

Family PLETHODONTIDAE.

The scales of *Plethodus* are unknown; the species are distinguished by the form of the dental plates. *Anogmius* Cope, well represented in the Niobrara of Kansas, is placed in the Plethodontidae by Woodward and Hay. Its former reference to the Osteoglossidae was manifestly incorrect; no Cretaceous Osteoglossidae are known, nor are they likely to be found in marine strata. The scales of *Anogmius polymicrodus* Stewart, as described by A. S. Woodward, are "moderately thick, showing only lines of growth; they appear to have been deeply overlapping."

[1] Materialui dlya geologii Turkestanskago kraya, pts. 2, 3, 1884, 1890.

Family CLUPEIDAE.

Genus POMOLOBUS Rafinesque.

Pomolobus? chicoensis Cockerell, n. sp.

Plate XXXIV, figure 5.

Scales 4.2 millimeters broad, considerably broader than long, cycloid, with the hyaline apical margin at most slightly crimped; covered portion with very fine strictly transverse circuli; a more or less distinct median longitudinal groove or fold on basal half; three transverse radii, the second and third interrupted in middle, the interval a little greater than half the length of either lateral division.

U. S. G. S. locality 7030. Cretaceous, Chico group, south side of Ortigalito Creek, Cal., 1 mile above the mouth of its canyon and 1¼ miles northeast of Erreca's, in base of gully draining north along west line of the SW. ¼ sec. 28, T. 11 S., R. 10 E., and joining Ortigalito Creek near center of west line of section. In shale of Moreno formation, below the fossiliferous conglomerate. (Collected by Robert Anderson.)

This scale exactly agrees with the living genus *Pomolobus*, differing from *P. pseudoharengus* (Wilson), from Lake Ontario, only in the directly transverse, not distinctly oblique broken radii. It is very likely that other parts of the fish would reveal generic distinctions, but perhaps it is not impossible that *Pomolobus* dates from the Upper Cretaceous. It is a singular thing that such a type should be found in the California Chico but should wholly fail to appear (so far as my material shows) in the strata east of the Sierra Nevada, whereas to-day *Pomolobus* and its close relative *Alosa* are found only in the north Atlantic and (*Alosa*) Mediterranean. With reference to the antiquity of the clupeid type, it may be noted that A. S. Woodward [1] describes a fish from the Lower Cretaceous of Bahia, Brazil, as *Scombroclupea scutata*, and remarks that it does not differ much from *Clupea* itself. Typical *Scombroclupea* comes from the much later rocks of Mount Lebanon, in Syria, and it is very probable that the Brazilian fish, when better known, will prove generically distinct. In the North American Cretaceous we have recorded only one supposed clupeid type, *Syllaemus* Cope (*Leptichthys* Stewart). I have examined scales of *Syllaemus latifrons* Cope, the type of the genus, and the circuli are not transverse, as in Clupeidae.[2]

Family SALMONIDAE.

Genus LEUCICHTHYOPS Cockerell, n. gen.

Scales similar in type to those of the living *Leucichthys nigripinnis* (Gill); cycloid, the apical margin broadly rounded, the basal with a broad median lobe, the margin more or less concave between this and the rather prominent laterobasal angles; apical radii weak, about as in *Leucichthys;* no basal radii; circuli fine, concentric; growth lines very distinct, probably indicating that the fish was migratory. Scales from caudal region are narrower. Lateral line scales have a prominent canal, expanding basally. Type *L. vagans*.

Leucichthyops vagans Cockerell, n. sp.

Plate XXXIV, figure 13; Plate XXXV, figures 1–15.

The type scale is from U. S. G. S. locality 7095 and has a diameter of 9 millimeters. It is distinctly broader than long. The exact locality is the NW. ¼ SW. ¼ sec. 20, T. 11 N., R. 79 W., 1 mile southwest of Dean's ranch, North Park, Colo. This is Beekly's locality 19, supposed to be Niobrara but to judge from the fishes apparently Benton. The following are also referred to this species, although they may represent more than one species, not readily if at all separable on scale characters. The scales differ greatly in shape, but only as might be expected on different parts of the fish.

1. Scales of the same general form as the type.

Colorado group, in the NW. ¼ SW. ¼ sec. 8, T. 19 N., R. 79 W., Carbon County, Wyo. Scale 12.50 millimeters long and broad. Also second scale, incomplete.

U. S. G. S. locality 3880. Near base of Mancos shale, 4 miles east of Meeker. Colo. Scale 11 millimeters in diameter.

Graneros shale, Little Spring Creek, northeast corner of Sturgis quadrangle, Black Hills, in reddish rock. In addition to normal scales there is a large latinucleate (regenerated) one 13 millimeters in diameter.

U. S. G. S. locality 7275. Lower Benton, north bank of Norris Creek about 200 yards

[1] London Geol. Soc. Quart. Jour., vol. 64, p. 360, 1908.

[2] Zool. Anzeiger, Band 45, p. 190, 1914.

north of Norris house, 12 to 14 miles south of Walden, in the NE. ¼ SW. ¼ sec. 13, T. 8 N., R. 82 W., North Park, Colo. (Collected by A. L. Beekly.) This is Beekly's locality 57.[1] A large scale, diameter 14.5 millimeters.

2. Narrow scales, presumably from the caudal peduncle.

U. S. G. S. locality 6681. Probably Aspen, Slate Creek, Mount Leidy quadrangle, Wyo. (Collected by Eliot Blackwelder.) Scale about 9 millimeters across, distinctly convex. *Holcolepis transversus* occurs at the same locality and horizon.

U. S. G. S. locality 7110. Probably Benton, Beekly's locality 37.[2] Scale 8.2 millimeters across. *Holcolepis pulchellus* occurs at the same locality and horizon.

U. S. G. S. locality 8916. Mowry shale, Big Horn Basin, Wyo. (Collected by C. T. Lupton.) For exact data see description of *Holcolepis delicatus* (p. 175), which occurred with it. The narrow *Leucichthyops* scale is accompanied by others of the normal type.

3. Broad, lateral line scales.

U. S. G. S. locality 6682. Cretaceous, probably Colorado group, Slate Creek, Wyo. (Collected by Eliot Blackwelder.) Accompanied by a typical scale of the same species and by scales of *Holcolepis transversus*.

U. S. G. S. locality 7095. Probably Benton, in the NW. ¼ SW. ¼ sec. 20, T. 11 N., R. 79 W., 1 mile southwest of Dean's ranch, North Park, Colo. This is Beekly's locality 19, the type locality of *L. vagans*. Narrow scales also occur. There is also a scale of *Holcolepis obliquus*.

U. S. G. S. locality 7100. In the NW. ¼ SE. ¼ sec. 8, T. 11 N., R. 81 W., northeast of the Hill ranch, North Park, Colo. Beekly's locality 26,[2] said to be Niobrara but probably Benton. (Collected by A. L. Beekly and G. J. Finlay.) The scale is 8 millimeters in diameter and is accompanied by a typical scale and one of *Holcolepis*.

U. S. G. S. locality 7110. Beekly's locality 37 (see above).

The scales of *Leucichthyops* certainly appear to indicate a primitive salmonid fish; the bones were probably delicate and rarely preserved. The scales show a certain resemblance, however, to those of *Thymallus*, though in that genus the lateral line scales are much narrower and the median basal lobe is very large. It is, of course, possible that in the Cretaceous the Salmonidae and Thymallidae were not differentiated. None of the European scales figured by Geinitz or Fritsch are of the *Leucichthyops* type. The scales of *Aulolepis typus* Agassiz, as figured by Woodward,[3] are curiously similar to those of *Leucichthyops* but wholly lack the radii in the apical field.

[1] U. S. Geol. Survey Bull. 596, p. 38, 1915.
[2] Idem, p. 42.

Genus CYCLOLEPIS Geinitz.

The name *Cyclolepis* has been applied to subcircular or oval scales, with concentric circuli, nucleus central or subcentral, and all radii and ctenoid elements wholly absent. This is, of course, the salmonid type of scale, excellently typified by the living *Stenodus mackenziei*, from Alaska. *Caranx* scales are very similar but have the circuli more or less distinctly angular at the sides. The scale which Fritsch erroneously calls *Aspidolepis steinlai* Geinitz, from the Cretaceous of Bohemia, has the shape and moderately eccentric nucleus exactly as in *Stenodus*. A difficulty in dealing with scales of this simple type is that uncharacteristic scales of quite different fishes may closely simulate them, as shown by H. F. Taylor [4] in figures of essentially cycloid scales from the head of *Cynoscion*. Of course, the more characteristic scales of the same fishes would be almost sure to appear also in the deposits.

Cyclolepis stenodinus Cockerell, n. sp.

Plate XXXV, figure 16.

Scale oval, its greater diameter 12 millimeters; nucleus central (not eccentric as in *Stenodus*); circuli simple and concentric; rather strong growth lines, indicating possible migratory habits. Another scale, doubtless of the same species, is practically circular.

U. S. G. S. locality 9190. Fox Hills sandstone, Greeley quadrangle, Colo. (Collected by T. E. Williard.) For details of the locality, see description of *Hemilampronites hesperius* (p. 185), which was found with it. The mollusk *Callista nebrascensis* Meek and Hayden was in the same material.

[3] Woodward, A. S., The fossil fishes of the English chalk, pl. 19, figs. 3b, 4, 1903.
[4] U. S. Bur. Fisheries Bull., vol. 34, pl. 52, 1914.

Family ERYTHRINOLEPIDAE Cockerell, n. fam.

Genus ERYTHRINOLEPIS Cockerell, n. gen.

Scales rather small, subtriangular or subcircular, cycloid; basal margin slightly or not crenate; circuli normal and concentric on basal half but excessively fine on apical half; radii apical, basal and lateral, but very irregular and often broken. The scales closely resemble those of the South American fresh-water Erythrininae but lack the coarse vertical circuli of the apical area. They may also be compared with the Old World Cyprinidae, and more remotely with the African fresh-water genus *Phractolaemus*. They also show some resemblance to *Pantodon*.[1]

While I was puzzling over the scales, I received a paper by Eastman [2] in which it is set forth that the Cretaceous teeth of the genus *Onchosaurus* Gervais (*Ischyrhiza* Leidy; *Gigantichthys* Dames) agree very closely with those of the living fresh-water *Hydrocyon* and *Hoplias*, characoid genera.[3] It appeared to be a confirmation of Eastman's results that fish scales so similar to those of the Erythrininae (*Hoplias*, *Hoplerythrinus*, and *Erythrinus*) should occur in the Mowry shale. I wondered whether the Mowry could be a fresh-water deposit; and this suspicion seemed to receive some confirmation in the collection from U. S. G. S. locality 6603, in the Uinta Basin, Utah, assigned to the Mowry and including poorly preserved remains of land plants. This lot, however, included no *Erythrinolepis* scales. Mr. Stanton informed me that although Mollusca were rarely found in the Mowry, two localities on the southeastern border of the Big Horn Mountains had yielded ammonoids probably belonging to the genus *Metoicoceras*, and one of them yielded *Inoceramus*. These are clearly marine. One of these localities (4941) yielded also scales of *Erythrinolepis*, as well as those of *Holcolepis*. It must be said that the Mowry shale contains scales belonging to genera also present in undoubtedly marine Benton, and *Erythrinolepis* or a very closely related form occurs in the Chico. It can not be held, consequently, that *Erythrinolepis* is a fresh-water genus. It is also out of the question to consider *Erythrinolepis* to be the scales of *Onchosaurus*, for the latter belongs to a very much later period.

The apical field of the *Erythrinolepis* scale appears in most specimens to be without any circuli, but in one good example (locality 4941, Big Horn Mountains) radiating excessively fine apical circuli can be seen, about four or five to one of the basal field. Laterally these circuli are nearly at right angles to the lateral ones, which are nearly vertical at this point. In the Erythrininae it is the apical series of circuli which is much coarser than the basal, and the lateral apical ones are continuous with the basal. We must suppose that *Erythrinolepis* represents a distinct family, Erythrinolepidae, though it can not be adequately defined.

Erythrinolepis mowriensis Cockerell, n. sp.

Plate XXXVI, figures 3–6.

Scales obtusely subtriangular, the base gently convex; radii basal, apical and lateral, very irregular, and often incomplete. The type is about 5 millimeters in diameter.

Type from U. S. G. S. locality 6713, southeast of camp at old chimney, Sisters Hill, Buffalo, Wyo., in Mowry shale. (Collected by O. B. Hopkins.) *Holcolepis transversus* is from the same locality.

Some other collections contain this species, as follows:

U. S. G. S. locality 4896. North of Wolf Creek canyon, Big Horn Mountains, Wyo. (Collected by T. E. Williard.) Accompanied by *Holcolepis* and *Leucichthyops*.

U. S. G. S. locality 4941. About $2\frac{3}{4}$ miles west of Klondike, Wyo. (Collected by T. E. Williard.) With *Holcolepis*. The *Erythrinolepis* scale figured is 7 millimeters in diameter.

These localities are all in the Mowry shale.

Erythrinolepis chicoensis Cockerell, n. sp.

Plate XXXVI, figures 1, 2.

Very similar to *E. mowriensis* but nearly circular, a little broader than long, not subtriangular. The type is 11 millimeters in diameter; another is 10 millimeters. This is a larger species than *E. mowriensis*.

[1] Biol. Bull., vol. 20, pl. 3, fig. 18, 1911.

[2] Eastman, C. R., Dentition of *Hydrocyon* and its supposed fossil allies: Am. Mus. Nat. Hist. Bull., vol. 37, pp. 757–760, 1917.

[3] Dr. G. A. Boulenger, of the British Museum, writes me that he has read Dr. Eastman's paper and thinks his identification of *Onchosaurus* with the Characinidae highly probable. He adds: "I shall be pleased if he is right, as I predicted the discovery of Upper Cretaceous characinids in 1905 (Rept. Brit. Assoc.)." I thought it possible that *Phractolaemus* might be found to have similar teeth, but Dr. Boulenger informs me that the teeth of this genus do not show the characteristic base of *Onchosaurus* and *Hydrocyon*.

U. S. G. S. locality 7030. Cretaceous, Chico group, south side of Ortigalito Creek, Cal., in Moreno formation. (Collected by Robert Anderson.) For additional particulars see description of *Pomolobus chicoensis* (p. 180).

Family CTENOTHRISSIDAE.

The remarkable genus *Ctenothrissa*, from the Cretaceous of England and Syria, has the pelvic fins enlarged and far forward, and the type species was originally described by Pictet as a *Beryx*. Woodward pointed out the numerous differences from the berycoids and placed the fishes in a distinct family among the Isospondyli. It must be stated, however, that the scales of *C. radians* (Agassiz), which I am able to figure (Pl. XXXVII, fig. 1) through the kindness of Dr. Woodward, are extraordinarily like those of the berycoid *Hoplopteryx* (Pl. XXXVII, fig. 2), though the latter have coarser circuli. The scales also resemble those of *Myripristis* (Holocentridae), a living berycoid. The lateral circuli are vertical, not transverse, as in the clupeoids. It seems probable, therefore, that *Ctenothrissa* represents a real advance in the direction of the Percomorphi and should stand as the type of a superfamily Ctenothrissoidea, of equal rank with the Clupeoidea (Clupeoidei) and Salmonoidea (Salmonoidei). I examined the scales of *C. radians* (Agassiz) and *C. microcephala* (Agassiz) in the British Museum a number of years ago. The latter are remarkable for their width and are excellently figured by Woodward in his work on the fishes of the English chalk, Plate XVIII, figure 9. Figure 8 of the same plate, based on a scale from Reigate, Surrey, is evidently quite distinct. It is extremely broad, with about 12 basal radii arranged fanwise, and the apical margin bears long spinelike teeth. Except for the shape, this resembles the scales of the Gonorhynchidae.[1] It may be designated *Gonorhynchops* (n. gen.) *woodwardi* n. sp., and may be separated from the gonorhynchid *Charitosomus* by the shape of the scales. The latter genus, with elongate scales, is known from the Cretaceous of Westphalia and Syria. *Aulolepis* Agassiz, the other genus ascribed to the Ctenothrissidae, has totally different cycloid scales. It occurs in the Turonian of Sussex, Kent, and Surrey. The scales resemble in a general way those of the living berycoid *Plectromus lugubris* (Gilbert), from Bering Sea, but the latter lack the strong concentric lines on the exposed portion. The large lateral line canal or ridge is also suggestive of the berycoids.

[1] Compare Am. Mus. Nat. Hist. Bull., vol. 3, pl. 4, fig. 4, 1890.

Order INIOMI.

Family ENCHODONTIDAE.

Stewart recognizes a separate family, Stratodontidae, for *Stratodus* and *Cimolichthys*.

Genus HALECODON Cockerell, n. gen.

A genus of Enchodontidae related to *Halec* Agassiz is represented by the palatine and ectopterygoid, the suture being between the tenth and eleventh tooth from end in type. The palatine resembles that of *Halec* but is more slender, with the teeth, except the two apical ones, smaller. There are no long teeth like those of *Enchodus*. The ectopterygoid, compared with that of *Halec*, is much more elongated basally and bears on its apical half a great number of small teeth. The superior angle is above the basal end of the tooth row. Type *H. denticulatus*.

Halecodon denticulatus Cockerell, n. sp.

Plate XXXVI, figure 7.

Length of the combined bones about 54 millimeters, the palatine slender and pointed at end. Teeth at end of palatine about 1.7 millimeters long, sharply pointed; teeth on ectopterygoid about 1 millimeter long.

U. S. G. S. locality 3870. Cretaceous, Aspen shale, near Spring Valley, Wyo., in the SW. $\frac{1}{4}$ SW. $\frac{1}{4}$ sec. 24, T. 15 N., R. 118 W. (Collected by A. R. Schultz.) With it are various scales, including poorly preserved *Holcolepis*, probably *transversus*.

Halecodon is doubtless without scales but probably with some dermal scutes. A. S. Woodward[2] says of *Halec:* "A regular squamation of very small scales, the exposed area of each quadrangular in shape; no enlarged scutes." In a later work, however,[3] he states that no traces of scales have been observed in the species described, but enlarged dermal scutes occur on the tail. All reference to scales is omitted from the generic diagnosis, and thus *Halec* in this respect agrees with the

[2] Catalogue of fossil fishes in the British Museum, pt. 4, p. 212, 1901.
[3] The fossil fishes of the English chalk, p. 55, 1902.

other Enchodontidae. No doubt *Halecodon* has similar features.

Genus CIMOLICHTHYS Leidy.

The American forms from the Niobrara of Kansas, described under five names by Cope, are now considered to represent a single species, *C. nepaholica* (Cope). A specimen (Colorado Univ. Mus. 5388) collected by Prof. Mead in the Benton (Cretaceous) west of Laramie, Wyo., represents the top of the head and agrees excellently with this genus. The skull was a trifle smaller and somewhat narrower than that of *C. lewesiensis* Leidy, and also narrower than the American *C. nepaholica*. No doubt a distinct species is indicated, but more material is desirable. It is not certain that *Stratodus* can be distinguished from *Cimolichthys* by the parts here preserved.

Genus ENCHODUS Agassiz.

Enchodus sp.

Plate XXXVI, figure 9.

The operculum of a species of *Enchodus* was discovered in the Colorado shale of the Milk River coal field, Mont. U. S. G. S. locality 6187, in sec. 3, T. 29 N., R. 19 E., in black shale south of Miller's No. 1 ranch. (Collected by L. J. Pepperberg.) Numerous species are known from the Niobrara of Kansas.

Family TOMOGNATHIDAE.

The only known representative of the Tomognathidae, *Tomognathus mordax* Dixon, is founded on fragments from the chalk of Kent, Sussex, and Surrey. It is said to suggest affinity with the deep-sea Stomiatidae. No scales are mentioned in the description, and there presumably were none, as in the living forms supposed to be related.

Family MYCTOPHIDAE.

The family Myctophidae has been made a depositary for miscellaneous more or less obscure genera. *Ichthyotringa* Cope, from the Niobrara of South Dakota, has been referred to *Rhinellus* Agassiz, a genus of the Westphalian and Syrian Cretaceous. Hay considers the genus to belong to the Dercetidae (Heteromi), but it has been regarded as the type of a distinct family, Rhinellidae, though Dr. D. S. Jordan (in letter) doubts the validity of this course. Four species of *Sardinius* or *Leptosomus*, small fishes with (at least in two of them) cycloid scales, are described from the Niobrara of South Dakota. I can add nothing to Hay's account. *Osmeroides illustrans* (Woodward), described under *Sardinioides*, from the chalk of Kent, shows affinity with the Aulopidae.

Family NOTACANTHIDAE.

Pronotacanthus Woodward is from the Cretaceous of Mount Lebanon, Syria. No scales can be distinguished. The modern representatives of the family are described as having very small cycloid scales.

Order APODES.

Family ANGUILLAVIDAE.

Anguillavus Hay, from the Cretaceous of Mount Lebanon, retains the pelvic fins. The scales are said to be rudimentary or absent.

Family URENCHELYIDAE.

Urenchelys Woodward, from the Cretaceous of Mount Lebanon, differs from Tertiary and living eels by having a distinct caudal fin. The scales are described as "rudimentary." A species provisionally referred to the same genus occurs in the Turonian of Sussex and Kent.

Family ENCHELIIDAE.

Enchelion Hay, from Mount Lebanon, has no scales.

Order HETEROMI.

Family HALOSAURIDAE.

Genus ECHIDNOCEPHALUS Von der Marck.

Echidnocephalus? americanus Cockerell, n. sp.

Plate XXXVI, figure 10.

Scale subquadrate, longer than broad, 3 millimeters wide; nucleus subapical; apical margin not ctenoid but ragged and free from circuli (exactly as in living *Halosaurus*); circuli very distinct, the lateral ones parallel with margin; nine basal radii, very distinct, arranged fanwise; lower margin deeply crenate.

U. S. G. S. locality 5138. Brackish-water beds of Mesaverde formation, about 26 miles northeast of Rock Springs, Wyo., in sec. 15, T. 21 N., R. 103 W. (Collected by V. H. Barnett.) The character of the fish suggests marine conditions. The scale agrees excellently with the modern Halosauridae, such as *Halosaurus* and *Aldrovandia*, differing only in

the more ordinary rounded nuclear area, which is elongated in the living fishes.

Echidnocephalus, from the Upper Cretaceous of Westphalia, is said to be essentially identical with *Halosaurus*, so I refer the scale provisionally to that genus.

Echidnocephalus? pacificus Cockerell, n. sp.

Plate XXXVI, figure 11.

Scale 6 millimeters wide, cycloid, subquadrate, rounded apically; sides rather convex; laterobasal corners very obtuse, not salient; nucleus just below the apex; six basal radii, rather widely spaced, arranged fanwise; basal margin shallowly crenate. This is more like *Halosaurus*, whereas *E.? americanus* is like *Aldrovandia*, the very apical nucleus and absence of deep basal crenation being *Halosaurus* characters.

The extremely apical nucleus also occurs in *Bathysaurus agassizi*, which, however, has subcircular scales without a trace of radii.

U. S. G. S. locality 7027. Cretaceous, Chico group, foothills between Little Panoche and Ortigalito creeks, Cal., in first canyon south of Laguna Seca Creek, in limy layer between lower gray sandstone and fossiliferous grit bed in upper part of Moreno formation. (Collected by Robert Anderson.)

Family DERCETIDAE.

A. S. Woodward says of the Dercetidae: "Ordinary scales small or wanting, but two or more continuous paired series of enlarged scutes along flanks; no median dorsal or ventral scutes." The scales are more or less triangular, the outline resembling that of shark teeth (*Isurus*). The type of *Dercetis* is *D. scutalus* Agassiz, from the Cretaceous of Westphalia. According to Woodward these fishes are apparently allied to the Halosauridae and Notacanthidae. If so, they should be placed in the order Heteromi. *Leptotrachelus longipinnis* Cope, referred to the Dercetidae, occurs in the Niobrara of South Dakota. *Triaenaspis virgulatus* Cope, also from the Niobrara of South Dakota, is referred by Woodward to *Leptotrachelus*, but Hay states that the genus *Triaenaspis* is valid. *Leptotrachelus* also occurs in the Upper Cretaceous of England, Westphalia, and Syria. Boulenger refers the Dercetidae to the Heteromi.

Order HAPLOMI.

Family CROSSOGNATHIDAE.

Crossognathus Pictet, from the Neocomian of Switzerland and Hanover, is said to have the scales large, very deeply overlapping, smooth, and not serrated or crenulated on posterior margin; a simple tube pierces the lateral line scales. *Syllaemus* Cope was formerly referred to this family, but Woodward now considers it a primitive clupeoid. It has not the transverse circuli of the scales of Clupeidae.

Apsopelix and *Pelecorapis* of Cope have been listed under Crossognathidae; Hay placed the first doubtfully in Albulidae, the second in Mugillidae.

Apsopelix sauriformis Cope came from Bunker Hill station on the Union Pacific Railroad of Kansas. Mr. T. W. Stanton tells me that this is certainly in the Benton. Cope says that the scales are "large and cycloid. They do not present a trace of radii but are marked with fine and close concentric grooves [circuli]; these assume a vertical direction on the exposed surface, and are there more irregular, the more marginal ones terminating above and below. But few (i. e., the central) grooves are truly circular."

Order SYNENTOGNATHI.

Family HEMIRAMPHIDAE.

Genus HEMILAMPRONITES Steinla.

The generic name *Hemilampronites* was published by Geinitz from Steinla's manuscript for certain scales found in the Turonian of Saxony. The species was called *H. steinlai* Geinitz. As a matter of fact the scales agree well enough with *Hyporhamphus* and would be referred to that genus without question were they not from the Cretaceous.

Hemilampronites hesperius Cockerell, n. sp.

Plate XXXVI, figure 13.

Scale 12 millimeters in diameter, broader than long, cycloid, without radii (*Hyporhamphus* has a few); circuli of apical field extremely fine and regular, extending across scale; the other circuli much coarser and widely spaced at sides, where they pass transversely and more or less obliquely (especially above) to the margin, the upper nearly at right angles with the fine circuli of the apical field.

Differs from *H. steinlai* by the absence of basal radii and the oblique upper lateral circuli.

U.S.G.S. locality 9190. Cretaceous, Fox Hills sandstone, Greeley quadrangle, Colo., in second large ravine 2¼ miles south of Milliken and half a mile west of railroad track near Wildcat Mound, in sec. 23, T. 4 N., R. 67 W. (Collected by T. E. Williard.)

A related fish (*Hemiramphus edwardsi* Bassani) has been found in the upper Eocene near Verona. Regan suggests that *Cobitopsis* from the lower Oligocene of France, referred by Woodward to the Ammodytidae, may belong to the same group as the fishes now discussed, in the immediate vicinity of *Chriodorus*, if indeed distinct from that genus. No scales were found on the fossil *Cobitopsis*. Ammodytid scales[1] are very unlike those of the Hemiramphidae.

Order PERCOMORPHI.

Suborder BERYCOIDEI.

Family PLATYCORMIDAE Jordan (in letter).

Platycormus Von der Marck, from the Cretaceous of Westphalia, is described by Woodward as having the scales ctenoid, of moderate size, more or less ornamented with granulations, and extending over the opercular apparatus, head, and base of median fins. There are no enlarged or thickened scales. This genus, along with *Omosoma* Costa, from Mount Lebanon, and *Berycopsis* Dixon, has been provisionally regarded as belonging to the Stromateidae. It is also to be noted that the Cretaceous scales figured by Geinitz in the work already cited (especially his fig. 3; fig. 4 may be latinucleate) as *Aspidolepis steinlai* agree with those of the Stromateidae (*Poronotus*).

Family BERYCOPSIDAE Jordan (in letter).

Berycopsis Dixon is represented by three species in the English chalk. At the British Museum I examined the large broad scales of *B. major* Woodward, from the Middle Chalk of Cuxton, Kent. They are about 25 millimeters broad, with fine grooving toward the apex; they are not strictly ctenoid. These scales are extremely like those of *Hoplopteryx lewesiensis*. *Berycopsis elegans* Dixon, the type of the genus, has much smaller scales, and it seemed to me hardly possible that it could be congeneric with *B. major*. Woodward states, however, that the structural characters of the two are about the same. *B. pulchellus* (Dixon) is allied to *B. major*.

Family HOPLOPTERYGIDAE Cockerell, n. fam.

Based on *Hoplopteryx* Agassiz. Resembling the Trachichthyidae, but anal spines four, as in Berycidae; scales as in Holocentridae. Dorsal fin without the notch or division of the Holocentridae, and its spines much fewer (six). Anal fin very much shorter than in *Beryx*, but dorsal longer. Although the scales of *Hoplopteryx* resemble those of *Berycopsis*, the fish is very different in a number of characters and can not be very closely related. Both anal and dorsal fins of *Berycopsis* are extremely long. *Beryx insculptus* Cope, from the Cretaceous of New Jersey, is very imperfectly known, but the scales agree with *Hoplopteryx* and not with *Beryx*. It may be provisionally called *Hoplopteryx? insculptus*.

The berycoid fishes were certainly well developed in Cretaceous time, and to-day we seem to have only remnants of a once more numerous group. The modern families, for scales of which I am indebted to Dr. D. S. Jordan, the United States National Museum, the United States Bureau of Fisheries, and the Museum of Comparative Zoology, have the following scale characters:

Polymixiidae: *Polymixia japonica* Steindachner has very broad scales, with strongly crenulated lower margin, and the apical margin strongly, irregularly dentate. It differs from the Holocentridae at once in the broad fanlike basal undulations rather than distinct radii, though it is approached in this by *Ostichthys*. It differs from *Ostichthys* by the much smaller, irregular teeth, and radically in the widely spaced circuli, the lateral ones oblique and entering the margin. In *Ostichthys* the circuli are excessively fine (though the scale is much larger), and the lateral ones are vertical. I know of no Cretaceous scale like that of *Polymixia*.

Holocentridae: The holocentrid scale seems to be the ancient one of the group, to judge from the fossils, though the fins of the modern family are much modified. The very strong, widely spaced apical keels terminating in teeth, so well shown in the scale figured by Geinitz and quite wrongly atrtibuted to *Macropoma mantelli*, appear (even more widely

[1] See Gill, Theodore, U. S. Nat. Mus. Proc., vol. 28, p. 162, 1904.

spaced) in the living *Ostichthys pillwaxi*, from the Hawaiian Islands (Pl. XXXVI, fig. 8). *Myripristis* scales differ from those of *Ostichthys* by the much closer teeth, about three to one. *Flammeo* scales are not nearly as broad as those of the genera just mentioned, and the basal margin has a distinct median prominence, sometimes broken up into several little ones in *F. scythrops*. *Holocentrus* scales are broad, usually with several radii close together in the middle of the base.[1] The apical teeth are like those of a coarse comb, not keeled as in *Ostichthys* and the Geinitz scale.

Berycidae: Scales of *Beryx splendens* Lowe are cycloid, with the broad hyaline marginal area beset with small tubercles or spines. In other species, as *B. lineatus*, the marginal area is beset with long spines, the most apical projecting beyond the margin. Basal radii are feeble or absent. The structure of the apical field is thus different in the Berycidae from that of the Holocentridae. In the former there are spines scattered over a surface, in the latter strong ridges or apical teeth. The true berycid type apparently does not appear among the Cretaceous fossils.

Trachichthyidae: *Trachichthys australis* has the broad and very dense scales constructed after the type of the Berycidae, the apical field being densely spinose. Dr. Jordan kindly sends me scales of two other genera, which he formerly placed with the Berycidae but has more recently referred to the Trachichthyidae. They are utterly diverse from each other and from the other berycoids here discussed. *Plectromus lugubris* (Gilbert), from the vicinity of Bogoslof Island, Bering Sea, has subquadrate cycloid scales, with widely spaced circuli, and three or four basal radii arranged fanwise. *Caulolepis longidens*, from deep water off Hawaii, has very small roundish scales, with four or five very widely spaced spinelike marginal projections.

Monocentridae: *Monocentris japonicus* has the scales with a high central keel or crest, but otherwise it is of the *Trachichthys* type, with spinose apical field.

We must evidently consider that the modern berycoids are variously specialized descendants of the Cretaceous forms, none of them retaining the same combinations of characters. The precise arrangement of the Cretaceous genera for the present remains uncertain. Woodward figures the scales of the English Cretaceous *Homonotus* Dixon and *Trachichthyoides* Woodward. Both have scales of the holocentrid type, not of the berycid-trachichthyid type. The opercular apparatus of *Trachichthyoides* readily separates it from *Hoplopteryx*. Some of the genera, as *Dinopteryx* Woodward, from Mount Lebanon, have cycloid scales.

The total absence of berycoids from the interior region of the United States has seemed remarkable. The Cretaceous scales from the Rocky Mountain region that I have examined do not include any undoubted berycoids, though a few poorly preserved specimens, which I have not ventured to describe, might conceivably be aberrant berycoids. Cope's genus *Pelecorapis* is of uncertain affinities. The scales of *P. berycinus* Cope, as figured by him, closely resemble those of *Hoplopteryx? insculptus* (Cope). The type of the genus is, however, *P. varius* Cope, found in Kansas, almost certainly in the Benton. It is said to have abdominal ventral fins, and to be related in a general way to the Scombresocidae, Atherinidae, etc. It can not well belong to the berycoids, nor does Cope's account of the scales suggest such a reference. The second species, *P. berycinus*, is of very doubtful generic position. It is equally uncertain as to locality and age, and may very well not be from Montana, as Mr. Stanton informs me. We are thus still left without berycoids in the Cretaceous mediterranean sea of America.

Order ACANTHOPTERI.

It is possible that the Stromateidae existed in Cretaceous time. The scale of *Aspidolepis steinlai* Geinitz, from the Turonian of Saxony, certainly resembles that of the living *Poronotus*. It is cycloid, with the lateral circuli more or less angled. *Omosoma* Costa, from Mount Lebanon, has been provisionally referred here. Woodward describes the scales as small, smooth, and cycloid, apparently longer than deep, extending over the opercular apparatus, head, and base of anal and dorsal fins. Woodward[2] remarks that the Cretaceous fishes which he provisionally assigned to the Stromateidae are primitive scombroids of uncertain

[1] See U. S. Bur. Fisheries Bull. for 1912, pl. 36, fig. 26.

[2] The fossil fishes of the English chalk, p. 5, 1902.

affinities. It must be said that the stromateid scale of to-day is very similar to that of the scombroids, and it is thus easy to suppose that the Cretaceous fishes were rather of the latter than the former group.

Carangidae are recorded from the Cretaceous of Europe and Syria, the principal genus being *Aipichthys* Steindachner, with small, thin, cycloid scales and a series of ventral ridge scales on the short abdominal region before the dorsal fin. *Bathysoma lutkeni* Davis, from the Danian of Scandinavia, said by Woodward [1] to be "very curiously specialized."

Prolates Priem, with "scales small and very finely serrated," is from the Upper Cretaceous of France and has been referred to the Percidae. So far as I know, the typical percoid scale does not appear in the Cretaceous, but is first found near the base of the Tertiary, in a fresh-water deposit, as described below.

Family CENTRARCHIDAE.

Genus CENTRARCHITES Cockerell, n. gen.

Fresh-water fishes with scales agreeing with Centrarchidae or Micropteridae but not definitely assignable to a known genus. Type *C. coloradensis*.

Centrarchites coloradensis Cockerell, n. sp.

Plate XXXVI, figure 12.

Scale subquadrate, transverse diameter 9 millimeters; apical margin not distinctly dentate, but apical field with a broadly triangular *ctenoid* patch, as in the young of *Ambloplites;* nucleus far apical of middle, just below lower end of ctenoid patch, the surrounding circuli transversely oval (more so than in modern genus); basal radii occupying about middle third (transversely) of scale, about nine, close together, with very fine transverse circuli between; lateral circuli parallel with margin.

U. S. G. S. locality 7087. Eocene, Coalmont formation, about 1 mile southwest of Walden, Colo. (Collected by A. L. Beekly.) This is Beekly's locality 1.[2] With it is a fragment of a *Viviparus* and a fragment of a *Laurus*-like leaf. There is also another species of fish scale, nearly circular, with very fine circuli, possibly salmonoid.

[1] The fossil fishes of the English chalk, p. 253, 1912.

[2] U. S. Geol. Survey Bull. 596, p. 63, 1915.

PLATE XXXI.

PLATE XXXI.

FIGURE 1. *Petalolepis? fibrillatus* Cockerell (p. 172). Type, × 6. U. S. G. S. locality 5094. U. S. N. M. catalogue No. 8662.

2. *Cycloides? incertus* Cockerell (p. 173). Type, × 3. U. S. G. S. locality 5177. U. S. N. M. catalogue No. 8663.

3, 4. *Holcolepis pulchellus* Cockerell (p. 174):

3. Type, × 8. U. S. G. S. locality 7110. U. S. N. M. catalogue No. 8664.

4. Another specimen, × 6. U. S. G. S. locality 7108. U. S. N. M. catalogue No. 8665.

5. *Holcolepis delicatus* Cockerell (p. 175). Type, × 4. U. S. G. S. locality 8916. U. S. N. M. catalogue No. 8666.

6–13. *Holcolepis transversus* Cockerell (p. 175):

6. Type, × 4. U. S. G. S. locality 6682. U. S. N. M. catalogue No. 8667.

7. × 3. U. S. G. S. locality 6681. U. S. N. M. catalogue No. 8668.

8. × 3. U. S. G. S. locality 6713. U. S. N. M. catalogue No. 8669.

9. × 4. U. S. G. S. locality 6682. U. S. N. M. catalogue No. 8670.

10. × 4. U. S. G. S. locality 6713. U. S. N. M. catalogue No. 8671.

11. × 4. U. S. G. S. locality 3417. U. S. N. M. catalogue No. 8672.

12. × 4. U. S. G. S. locality 6682. U. S. N. M. catalogue No. 8673.

13. × 3. U. S. G. S. locality 4421. U. S. N. M. catalogue No. 8674.

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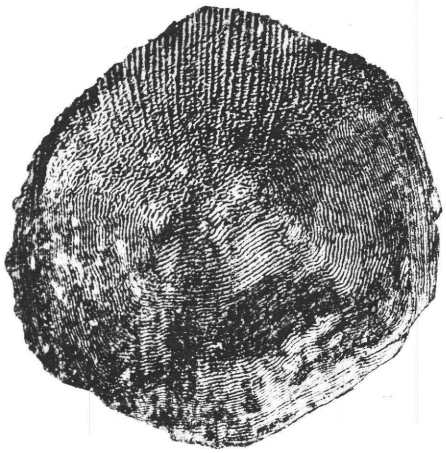

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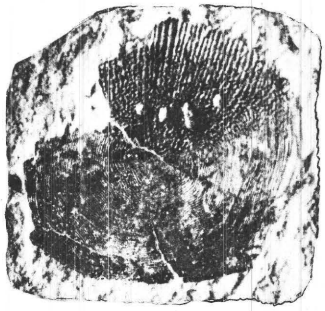

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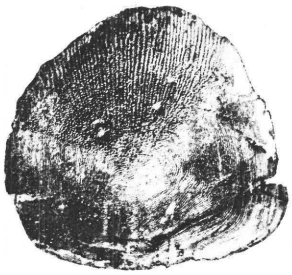

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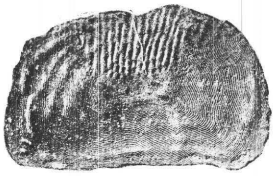

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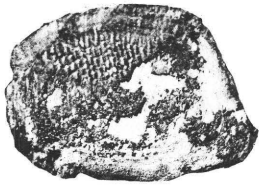

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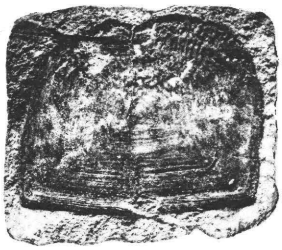

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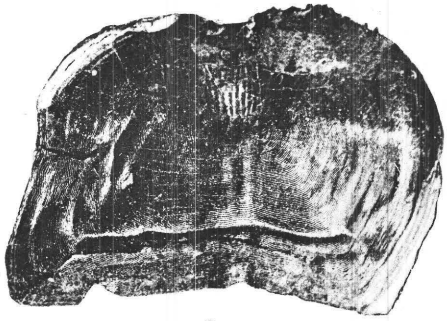

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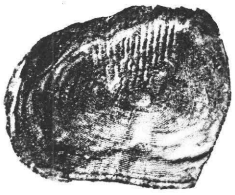

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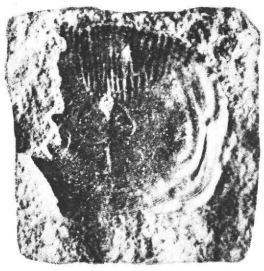

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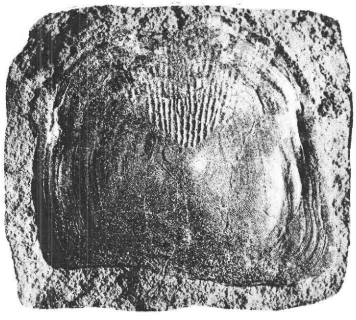

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CRETACEOUS FISH SCALES

PLATE XXXII.

PLATE XXXII.

FIGURE 1. *Holcolepis obliquus* Cockerell (p. 175). Type, × 3. U. S. G. S. locality 4421. U. S. N. M. catalogue No. 8675.

2. *Holcolepis?* mandible, × 2 (p. 175). Carbon County, Wyo. U. S. N. M. catalogue No. 8676.

3. *Pachyrhizodus* scale from Cretaceous of England. After Woodward, Geol. Assoc. Proc., vol. 10, pl. 1, fig. 8, 1888 (p. 174).

4. *Helmintholepis vermiculatus* Cockerell (p. 176). Type, × 3. U. S. G. S. locality 9184. U. S. N. M. catalogue No. 8677.

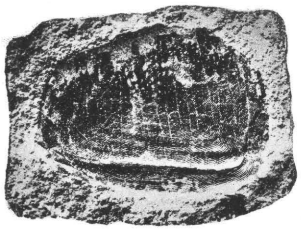
5. *Hypsodon? granulosus* Cockerell (p. 178). Type, × 4. U. S. G. S. locality 4874. U. S. N .M .catalogue No. 8678.

6, 7. *Hyposodon? radiatulus* Cockerell (p. 178):

6. Type, × 3. U. S. G. S. locality 5177, U. S. N. M. catalogue No. 8679.

7. Latinucleate scale, × 3. U. S. G. S. locality 5174. U. S. N. M. catalogue No. 8680.

8. *Hypsodon audax* (Leidy). Scale, × 2 (p. 177). U. S. G. S. locality 8354. U. S. N. M. catalogue No. 8681.



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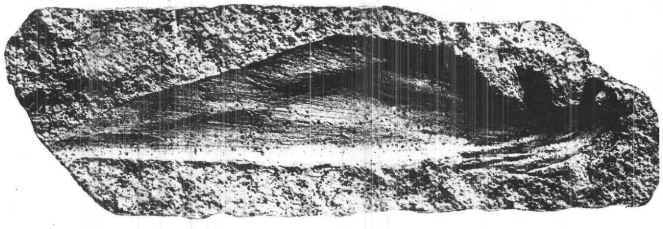

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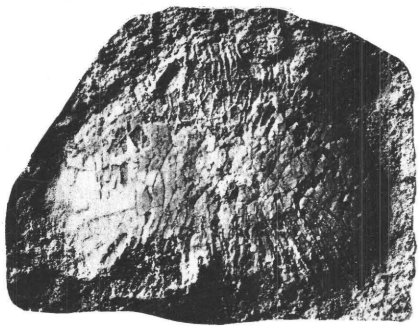

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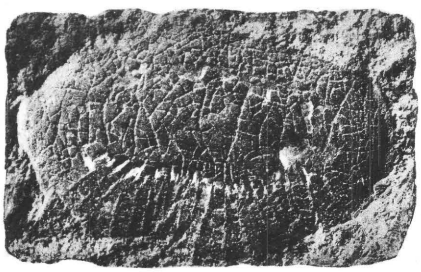

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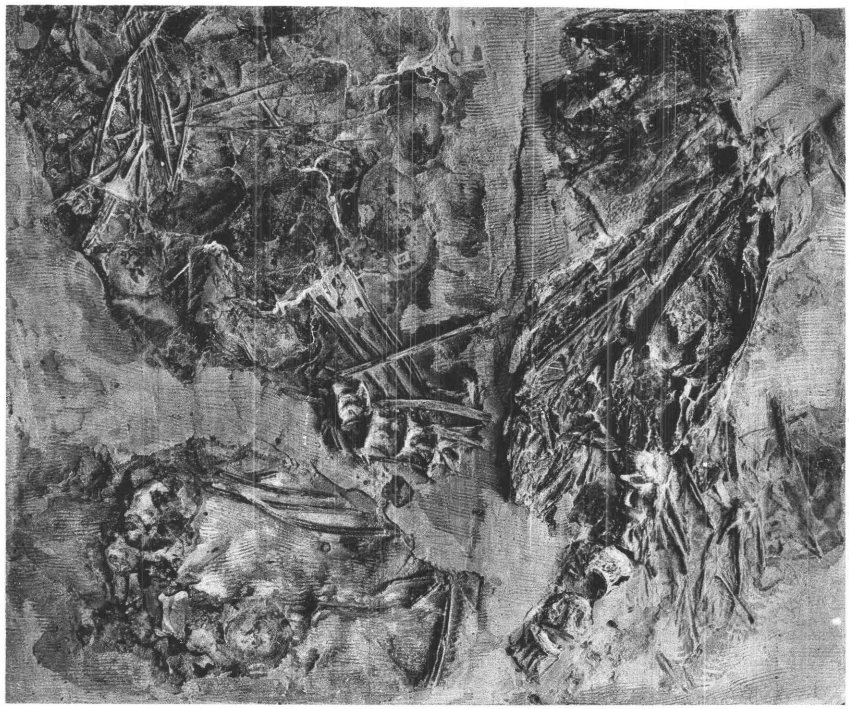
CRETACEOUS FISH SCALES

PLATE XXXIII.

PLATE XXXIII.

FIGURES 1, 2. *Hypsodon audax* (Leidy) (p. 177):

1. Specimen showing several scales and parts of skeleton. University of Kansas collection.
2. Part of same specimen, more enlarged.



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CRETACEOUS FISH SCALES

PLATE XXXIV.

PLATE XXXIV.

FIGURE 1. *Chicolepis punctatus* Cockerell (p. 177). Type, × 3. U. S. G. S. locality 7030. U. S. N. M. catalogue No. 8682.

2. *Hypsodon lowii* (Stewart) Cockerell (p. 178). Scale, × 2. U. S. G. S. locality 7294. U. S. N. M. catalogue No. 8683.

3. *Ichthyodectes* sp. (p. 179). Lateral line scale, × 4. U. S. G. S. locality 2402. U. S. N. M. catalogue No. 8684.

4. *Ichthyodectes* sp. (p. 179). Lateral line scale, × 4. U. S. G. S. locality 7277. U. S. N. M. catalogue No. 8685.

5. *Pomolobus? chicoensis* Cockerell (p. 180). Type, × 10. U. S. G. S. locality 7030. U. S. N. M. catalogue No. 8686.

6–12. Cretaceous fish scales from Turkestan (p. 179). Copied from G. D. Romanowsky, Materialui dlya geologii Turkestanskago kraya, pts. 2, 3, 1884, 1890.

6–8. *Hypsodon* sp. Figured as *Cladocyclus strehlensis* Geinitz. Op. cit., pt. 3, pl. 17, figs. 6a–c.

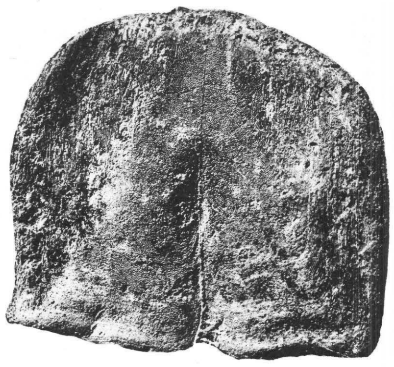
9. *Hypsodon?* sp. Figured as *Osmeroides lewesiensis* (variety). Idem, pt. 2, pl. 23, fig. 4a.

10. *Ichthyodectes* sp. Figured as *Cladocyclus strehlensis*. Idem, pt. 2, pl. 23, fig. 4b.

11. *Ichthyodectes? pectinolepis*. Figured as *Osmeroides pectinolepis* Romanowsky. Idem, pt. 3, pl. 17, fig. 5.

12. Undetermined scale. Figured as *Beryx* sp. Idem, pt. 3, pl. 17, fig. 4.

13. Fragment of Mowry shale, × 2, showing scales of *Erythrinolepis mowriensis*, *Leucichthyops vagans*, and *Holcolepis transversus* (pp. 182, 180, 175). U. S. G. S. locality 4896, north of Wolf Creek canyon, Big Horn Mountains, Wyo. U. S. N. M. catalogue No. 8687.



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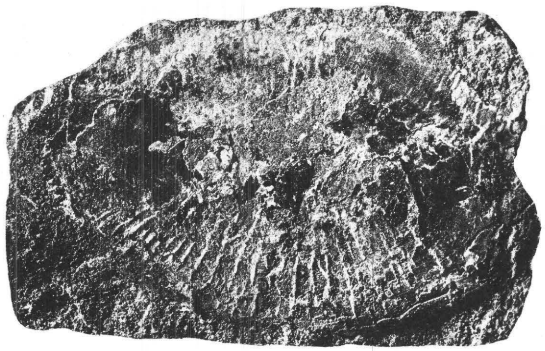

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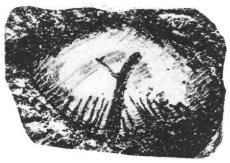

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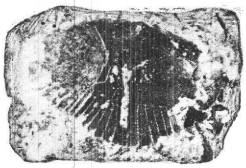

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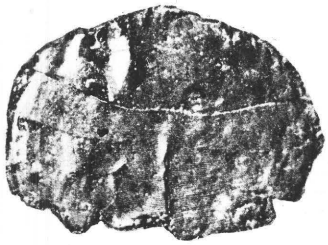

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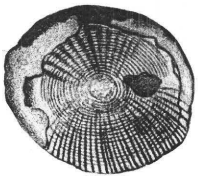

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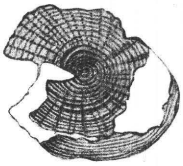

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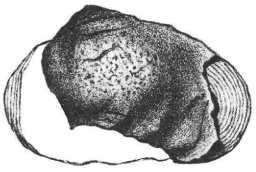

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CRETACEOUS FISH SCALES

PLATE XXXV.

PLATE XXXV.

FIGURES 1–15. *Leucichthyops vagans* Cockerell (p. 180):

1. Type, × 4. U. S. G. S. locality 7095. U. S. N. M. catalogue No. 8688.
2, 3. Two scales, × 3. Carbon County, Wyo. U. S. N. M. catalogue Nos. 8689, 8690.
4. Scale, × 4. Black Hills, S. Dak. U. S. N. M. catalogue No. 8691.
5. Scale, × 3. U. S. G. S. locality 3880. U. S. N. M. catalogue No. 8692.
6. Scale, × 3. U. S. G. S. locality 7275. U. S. N. M. catalogue No. 8693.
7. Narrow scale, × 3. U. S. G. S. locality 6681. U. S. N. M. catalogue No. 8694.
8. Scale, × 4. U. S. G. S. locality 8916. U. S. N. M. catalogue No. 8695.
9. Narrow scale, × 4. U. S. G. S. locality 7110. U. S. N. M. catalogue No. 8696.
10. Lateral line scale, × 4. U. S. G. S. locality 6682. U. S. N. M. catalogue No. 8697.
11. Lateral line scale, × 4. U. S. G. S. locality 7095. U. S. N. M. catalogue No. 8698.
12. Lateral line scale, × 4. U. S. G. S. locality 7110. U. S. N. M. catalogue No. 8699.
13. Lateral line scale, × 4. U. S. G. S. locality 7100. U. S. N. M. catalogue No. 8700.
14. Lateral line scale, × 4. U. S. G. S. locality 7110. U. S. N. M. catalogue No. 8701.
15. Latinucleate scale, × 4. Black Hills, S. Dak. U. S. N. M. catalogue No. 8702.
16. *Cyclolepis stenodinus* Cockerell (p. 181). Type, × 4. U. S. G. S. locality 9190. U. S. N. M. catalogue No. 8703.


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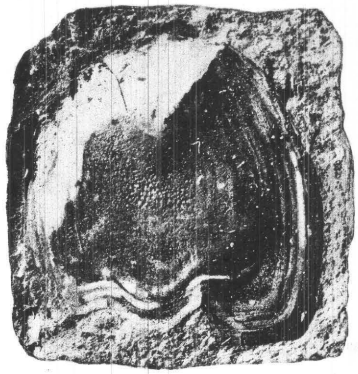
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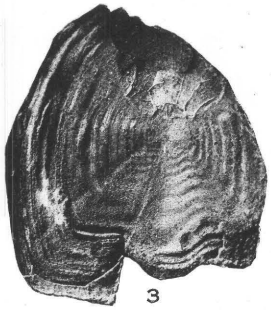
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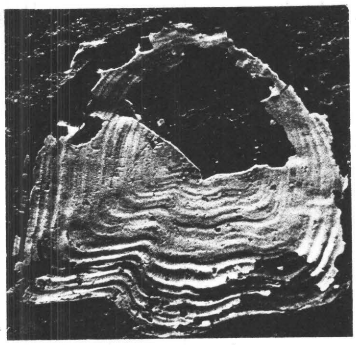
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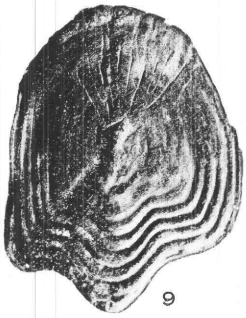
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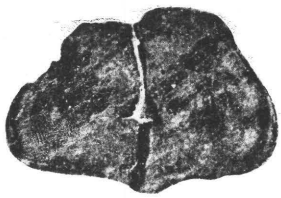
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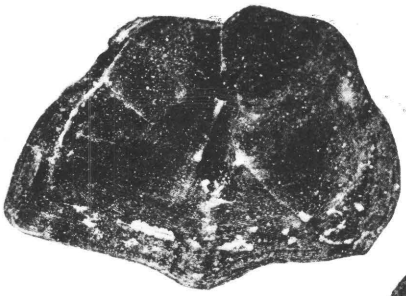
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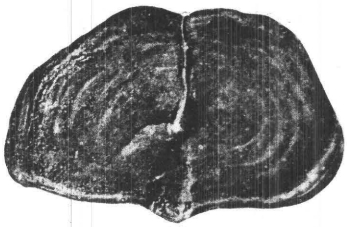
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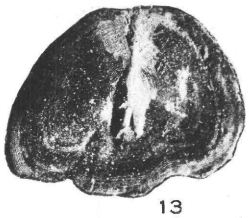
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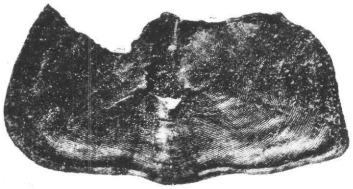
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16

CRETACEOUS FISH SCALES

PLATE XXXVI.

PLATE XXXVI.

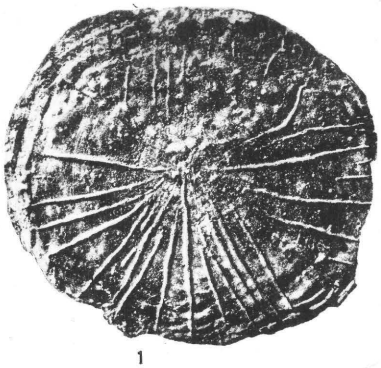
FIGURES 1, 2. *Erythrinolepis chicoensis* Cockerell (p. 182):

1. Type, × 4. U. S. G. S. locality 7030. U. S. N. M. catalogue No. 8704.
2. Smaller scale, × 4. U. S. G. S. locality 7030. U. S. N. M. catalogue No. 8705.

3–6. *Erythrinolepis mowriensis* Cockerell (p. 182):

3. Type, × 4. U. S. G. S. locality 6713.
4. Scale, × 4. U. S. G. S. locality 6713.
5. Scale, × 4. U. S. G. S. locality 6713. 3–5, U. S. N. M. catalogue No. 8706.
6. Scale, × 4. U. S. G. S. locality 4941. U. S. N. M. catalogue No. 8707.

7. *Halecodon denticulatus* Cockerell (p. 183). Type. Palatine and ectopterygoid, × 1.5. U. S. G. S. locality 3870. U. S. N. M. catalogue No. 8708.
8. *Ostichthys pillwaxi* (p. 187). Apical region of scale, × 1.85. Honolulu market.
9. *Enchodus* sp. (p. 184). Operculum, × 2. U. S. G. S. locality 6187. U. S. N. M. catalogue No. 8709.
10. *Echidnocephalus? americanus* Cockerell (p. 184). Type, × 8. U. S. G. S. locality 5138. U. S. N. M. catalogue No. 8710.
11. *Echidnocephalus? pacificus* Cockerell (p. 185). Type, × 4. U. S. G. S. locality 7027. U. S. N. M. catalogue No. 8711.
12. *Centrarchites coloradensis* Cockerell (p. 188). Type, × 4. Eocene. U. S. G. S. locality 7087. U. S. N. M. catalogue No. 8712.
13. *Hemilampronites hesperius* Cockerell (p. 185). Type, × 6. U. S. G. S. locality 9190. U. S. N. M. catalogue No. 8713.
14. Latinucleate (regenerated) scale of undescribed species, with marginal teeth resembling those of the berycoids, × 3. U. S. G. S. locality 4867. Cretaceous, Mowry shale, sec. 1, T. 26 N., R. 88 W., near North Rawlins, Wyo. U. S. N. M. catalogue No. 8714.
15. Scale of undescribed species with marginal teeth suggesting the berycoids, × 10. U. S. G. S. locality 4426. Cretaceous, Mowry shale, SE. ¼ sec. 27, T. 33 N., R. 74 W., about 5 miles southwest of Careyhurst, Wyo. U. S. N. M. catalogue No. 8715.
16. Scale of undescribed species, × 10. U. S. G. S. locality 6603, SE. ¼ sec. 18, T. 1 S., R. 10 W., Uinta special base line, Utah. Said to be Mowry shale. The collection contains plant remains and may be from a fresh-water deposit. U. S. N. M. catalogue No. 8716.
17. Scale of undescribed species, perhaps clupeid, with fine transverse circuli, × 4. Transverse diameter 12.5 millimeters. From the same station as figure 16. Presumably fresh water. U. S. N. M. catalogue No. 8717.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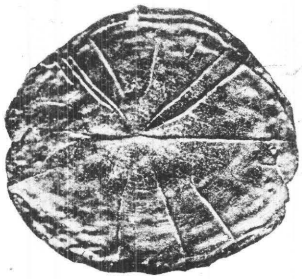
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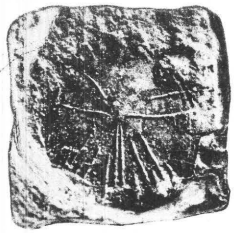
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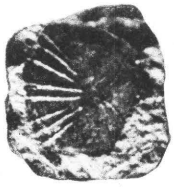
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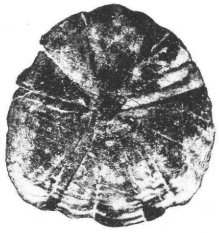
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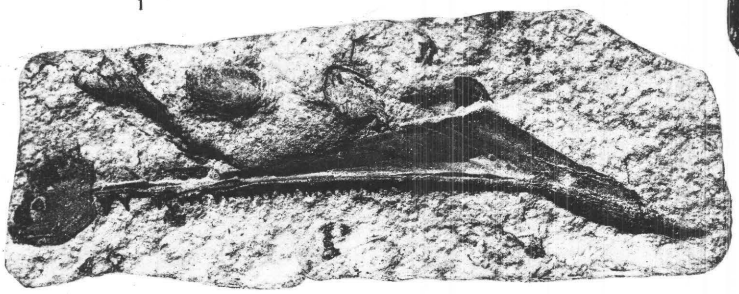
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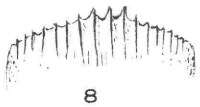
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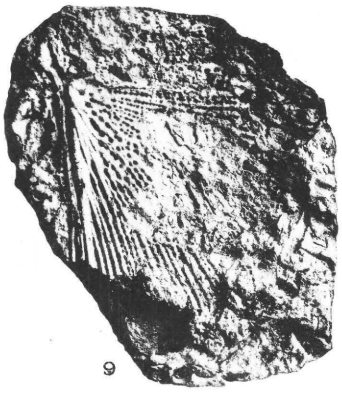
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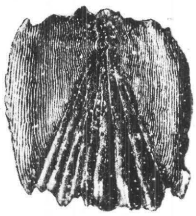
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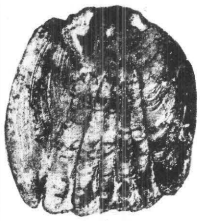
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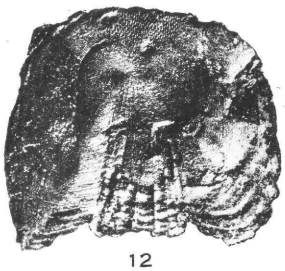
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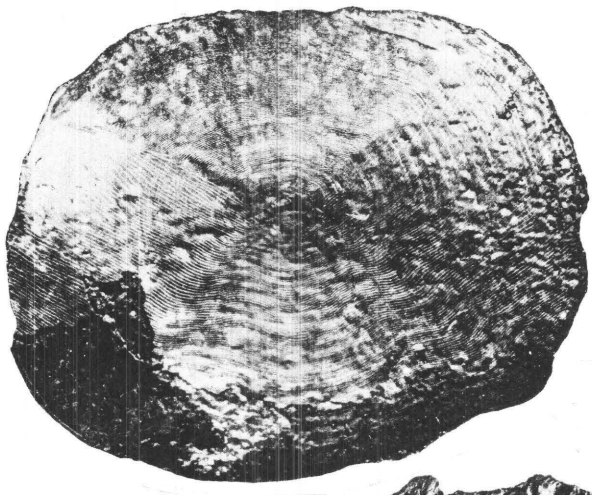
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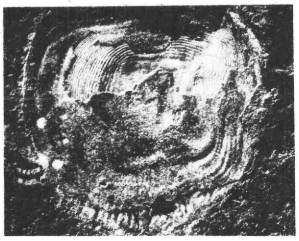
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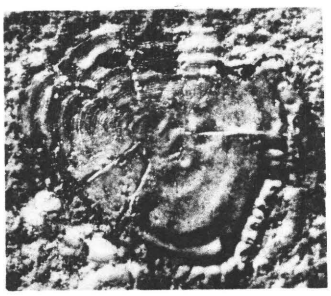
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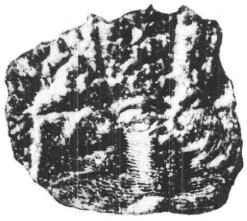
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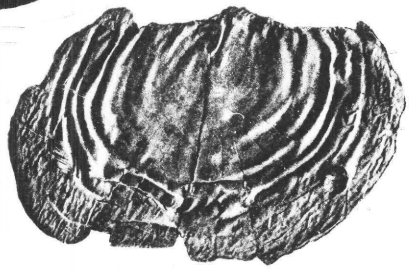
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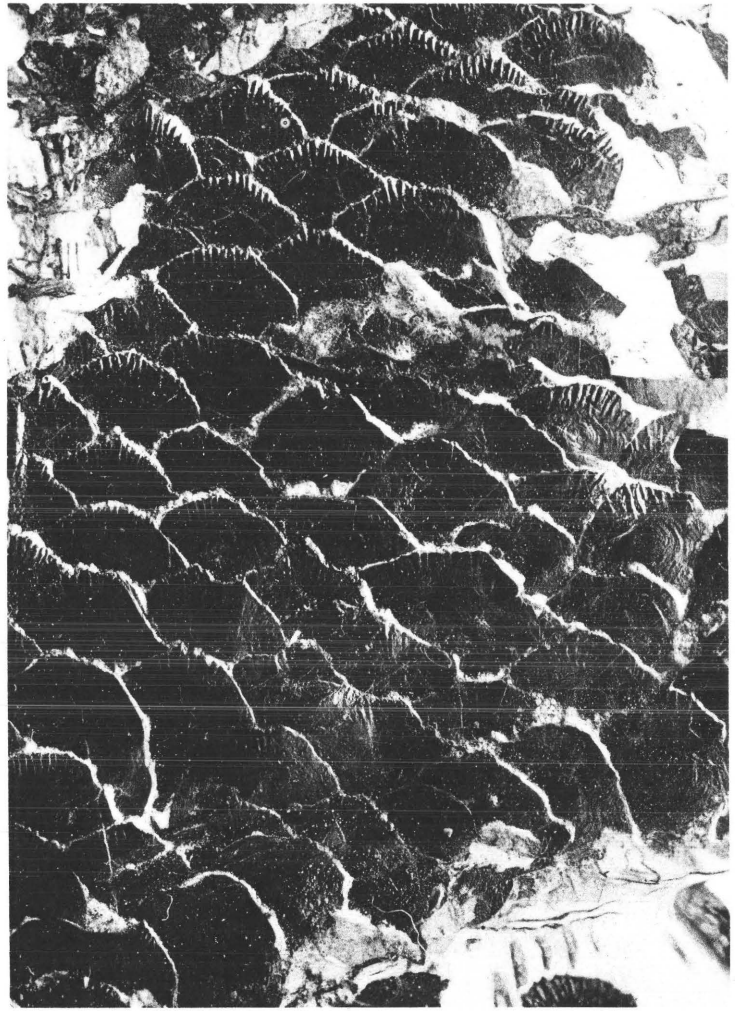
CRETACEOUS FISH SCALES

PLATE XXXVII.

PLATE XXXVII.

FIGURE 1. *Ctenothrissa radians* (Agassiz) (p. 183). Cretaceous of England. From a specimen in the British Museum.
2. *Hoplopteryx lewesiensis* (Mantell) (p. 183). Cretaceous of England. From a specimen in the British Museum.



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CRETACEOUS FISH SCALES