

OBSERVATIONS ON THE GENUS OF FOSSIL
FISHES CALLED BY PROFESSOR COPE,
PORTHEUS, BY DR. LEIDY,
XIPHACTINUS.

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THE earliest reference which we have to any remains of the genus of fishes usually called *Portheus* is that found in Mantell's *Geology of Sussex*, p. 241, Pl. XLII, 1822. No systematic name is there assigned to this fish. Later, Louis Agassiz, in his *Poissons Fossiles*, vol. v, p. 99, referred to Mantell's description, and refigured the materials (*op. cit.*, Pl. XXV *b*, Figs. 1 *a*, 16), presenting at the same time additional figures of remains from the same locality (Pl. XXV *a*, Fig. 3 ; Pl. XXV *b*, Figs. 2, 3). All these he included, with other remains, under the name *Hypsodon lewesiensis*.

In 1871, in *Proc. Amer. Philos. Soc.*, vol. xii, p. 175, Professor Cope established the genus *Portheus*, founding it on materials collected in the cretaceous deposits of Western Kansas. The type of the genus was called *Portheus molossus*. Later, in the same volume, p. 330, Cope recognized the affinity of the remains figured by Agassiz, as above cited, to those of *Portheus*, as well as the fact that other remains had been included by Agassiz under the term *Hypsodon* which were not congeneric with *Portheus*. Professor Cope, therefore, restricted *Hypsodon* to those bones and teeth which differed generically from his own American materials, and included the remainder under *Portheus*. In this same paper, pp. 333, 335, Cope also referred to *Portheus* a species which he had described in 1870 (*Proc. Amer. Philos. Soc.*, vol. xi, p. 533) under the name of *Saurocephalus thaumas*. Both these species and others were fully described in his *Cretaceous Vertebrates*, published in 1875.

At this point it may be noted that in the year 1870 (*Proc. Acad. Nat. Sci. Phila.*, p. 12) Dr. Joseph Leidy described from the Cretaceous of Kansas the spine of a fish which he called

Xiphactinus audax, and which, without doubt, belongs to the Saurocephalidae. A more complete description and figures of this fossil spine were given by Dr. Leidy in his *Contributions to the Extinct Vertebrate Fauna of the Western Territories*, p. 290, Pl. XVII, Figs. 9, 10. This was published in 1873.

Professor Cope first recognized the affinities of this spine in a paper in Hayden's *Second Annual Report of the Geological and Geographical Survey of the Territories*, 1871, p. 418, where he assigned it to the genus *Saurocephalus*, in which genus he also arranged the species which he later called *Portheus thau-mas*. He compares the spine with one obtained from *S. prognathus*, a fish which he later relegated to the genus *Ichthyodectes*, itself a close relative of *Portheus*. From about this period up to 1874 Professor Cope held the opinion that certain fin remains belonged to *Portheus*, and probably to the pectoral fin, which it is now pretty certain belong to *Protosphyraena*. Other spine-like fin rays, whose resemblance to Leidy's *Xiphactinus* he admitted, he regarded as also belonging to *Portheus*, and probably to the ventral fins. He claimed, however, that *Xiphactinus* was distinct from both *Portheus* and *Ichthyodectes*; but he does not specify the points of difference. By the time of the publication of his *Cretaceous Vertebrates* in 1875, he had become convinced that the fin structures which are now assigned to *Protosphyraena* did not belong to *Portheus*; and to them he gave the name *Pelecopterus*. He had also learned that the ventral spine-like fin rays of his *Portheus* did not differ greatly from those of the pectoral fin (p. 204). Of *Xiphactinus* he says: "Dr. Leidy applied the name *Xiphactinus* to a genus indicated by a spine in some degree like those regarded above as ventrals of *Saurodontidae*. Whether it belongs to any of the genera above enumerated, or, if so, which of them, is a question which can only be settled by future investigation" (*op. cit.*, p. 190).

Accompanying a considerable collection of specimens of *Portheus* collected for me in Western Kansas, in the region of Butte Creek, are many large spines, some nearly complete, others in fragments. Some of these belong to the shoulder girdle which I have figured (Fig. 9), and this, I have no doubt, belongs to

Cope's genus *Portheus*. No more doubt exists in my mind regarding the generic identity of many of the other spines. Some of these, indeed, were found in a block of soft limestone, and were in close relation to jaws, vertebrae, etc., of *P. thau-mas*. These spines I have compared with Leidy's type of *Xiphactinus audax*, and I find no difference that can be regarded as generic. Both Cope, in his *Cretaceous Vertebrates*, and Crook, in *Palaeontographica*, vol. xxxix, p. 119, have described and figured spines of *Portheus* which differ in no essential respect from *Xiphactinus*. The genus *Ichthyodectes* possessed pectoral spines not greatly different in structure from those of *Portheus*; but none of them attain the size of those assigned to *Xiphactinus* and *Portheus*. Taking all the facts into consideration, it seems to me that there can be no reasonable doubt that *Xiphactinus* is the same as *Portheus*, and ought to supersede it as a name for this genus of fishes. It is quite probable that *X. audax* is the same as some one of Professor Cope's species of *Portheus*; but it will require a careful study of well-identified spines of all the species, and a comparison of them with Dr. Leidy's type specimen to decide the question. For the present, then, we must recognize six American species of *Xiphactinus*; viz., *X. audax* (Leidy), *X. molossus* (Cope), *X. thau-mas* (Cope), *X. lestrio* (Cope), *X. mudgei* (Cope), and *X. lowii* (Stewart).

In my study of the genus *Xiphactinus* I have been greatly aided by comparison of its various parts with those of the tarpon of our southern coast (*Tarpon atlanticus*). While the tarpon is in many respects quite unlike *Xiphactinus*, in others it strikingly resembles the latter. Although the two genera undoubtedly belong to different families, these families are closely related, and both belong to the order of *Isospondyli*. It was in this order that Professor Cope arranged *Portheus* and its related genera, but he believed that in them he found also characters which indicated relationship with the *Siluroids*. Such characters I am unable to perceive. *Xiphactinus* was an *Isospondylid*, generalized in some respects, but greatly specialized in others. This specialization shows itself especially in the teeth and paired fins.

The head of this genus has been described by Cope (*Cret. Vert.*, pp. 183, 191), by Newton (*Quar. Journ. Geol. Soc.*, vol. xxxiii, p. 505), and by Crook (*Palaeontographica*, vol. xxxix, p. 114). Each of these authors also presents figures of various parts. In the following pages I shall call attention to such features of structure as, in my judgment, are new to science, or which require additional treatment or correction.

I regard the identification of the parietals as yet uncertain. Professor Cope was himself in doubt regarding them, and thought that perhaps what he called the supraoccipital might really be the coalesced parietals (*Cret. Vert.*, p. 183). Further

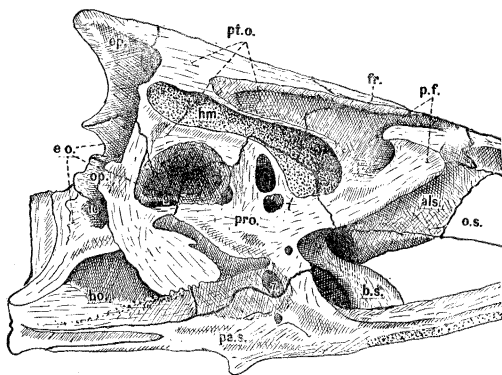


FIG. 1. — Skull of *Tarpon atlanticus*, seen from right side and partly from below. $\times \frac{1}{4}$.

on (p. 188) he concluded that the bones which he at first had identified as the epiotics were the parietals. Crook states that the parietals are completely separated by the large supraoccipital. He figures them (Pl. XVIII) as lying laterad of the epiotics, a situation which appears not probable. The small development of the supraoccipital in the tarpon permits the parietals to meet along their whole median borders, while each epiotic (Fig. 1, *ep.*), by its inner anterior angle, comes into contact with the outer posterior angle of the parietal. Should the supraoccipital now be enlarged we might expect the parietals to be reduced posteriorly and more or less separated. It seems to me that in the four rather complete skulls of *Xiphactinus* before me, two belonging to the United States National Museum, the others my own, I can recognize the

parietals as wedge-shaped narrow bones which lie between the anterior ends of the pterotics and posterior ends of the frontals on the outside, and the supraoccipital on the median side. I am inclined to believe that the parietals meet along the mid-line in front of the supraoccipital, and really include the elevated surface assigned by Crook to the latter bone, and said by him to be covered with coarse granulations. The posterior pointed end of each bone falls just mesiad of the epiotic. My determination of these bones may be erroneous, but I am wholly unable to find evidences of any suture defining the parietals as located by Dr. Crook.

The epiotics have been correctly mapped by Dr. Crook. Professor Cope was in doubt about the opisthotics. At first (*Cret. Vert.*, p. 183) he regarded them as forming the postero-lateral angles of the skull; but, on p. 188, he concludes that these angles are formed by the epiotics, and that the opisthotics are absent. Crook (*op. cit.*, p. 115) says that the opisthotics are the largest bones entering into the brain capsule. This I believe to be an error. I am of the opinion that the position and relations of the opisthotics of *Xiphactinus* are best explained by an examination of the tarpon (Fig. 1, *op.*). Here what may be regarded as the body of the opisthotic is rather small. Its upper end articulates with the pterotic (*pt.o.*), while the greater portion of the body lies against the exoccipital (*e.o.*). It bends forward, sending a small process to the proötic (*pro.*). From the lower border of the body of the bone there is sent downward and forward to the basioccipital a broad process which is as large as the remainder of the bone. In passing to the lower portion of the basioccipital, this process forms a bridge across a deep and broad fossa which is excavated in the basioccipital, but the roof of which is formed by the exoccipital. Now, the positions and forms of all the other bones in this region are in *Xiphactinus* almost identical with those of Tarpon. There are also the same deep cavities in the side walls of the skulls of the two genera. I believe, therefore, that we are justified in concluding that the opisthotic had somewhat similar form, position, and relationships. Moreover, I am convinced that this bone is present in three of the skulls at my

command ; although, on account of the distortion to which the skulls have been subjected, the determination is not as satisfactory as is desirable. Its lower process appears to have been much slenderer than in Tarpon. In Tarpon the lower process of the post-temporal is attached by a strong ligament to the posterior extremity of the opisthotic ; and, if I am correct in my determination of both these bones in Xiphactinus, they were brought into close connection.

The pterotics (squamosals of most authors) were proportionally more extensive bones in Xiphactinus than in Tarpon, and formed a more prominent process at the outer and hinder portion of the skull. Each included, I am satisfied, the area marked by Crook as belonging to the parietal. The pterotics furnished the larger part of the articular surface for the head of the hyomandibular. This surface was essentially as it is in Tarpon (Fig. 1, *hm.*).

As regards the proötics, Professor Cope's description (*Cret. Vert.*, p. 185) is not far out of the way, though brief. Dr. Crook is less fortunate when he states that the proötics are small. His error arose, if we may judge from his figure of *Ichthyodectes polymicrodus*, from his having carved the opisthotic out of the territory of the proötic. The proötics are really the largest of the otic bones. Professor Cope says that with the pterotic and opisthotic this bone bounded a large foramen. This so-called foramen is not really such, but a deep excavation, or fossa, in the side of the skull. In Tarpon this fossa is an inch deep, and about as much in diameter ; and it was quite as large in Xiphactinus. In the latter genus the anterior wall appears not to have been completely ossified, so that, in the skeleton, the fossa probably opened widely into the large cavity which lay above the brain, and which will be described further on. Since the cavity just referred to was in life probably filled with the primitive cartilage, the apparent opening from the fossa into it was merely an unossified part of the proötic.

In Tarpon the mouth of this fossa is somewhat triangular. Its floor is furnished by the exoccipital and the proötic, its posterior wall by the exoccipital and the pterotic, its roof by the pterotic, and the anterior wall by the pterotic and the

proötic. The sutures between the adjoining edges of each two of these bones meet in the apex of the fossa. The axis of the fossa is directed inward and upward. Without doubt, the fossa in the side wall of the skull of *Xiphactinus* was essentially the same as that in *Tarpon*.

In *Tarpon* there is, as has already been mentioned, an extensive fossa on each side of the skull, excavated principally in the basioccipital. This is so deep that only a thin wall of bone separates that on the right side from that on the left. Each fossa is continued forward on the outer surface of the proötic, becoming narrower and shallower. It is across this fossa that the broad process of the opisthotic is thrown as a bridge. A somewhat similar fossa existed in *Xiphactinus*, but on account of the compression suffered by the skulls its features cannot be definitely determined.

The proötic of *Xiphactinus*, like that of *Tarpon* (Fig. 1, *pro.*), provides a portion of the articular surface for the head of the hyomandibular. In *Tarpon* there are on the external surface of the proötic some four or five foramina. In *Xiphactinus* I have been able to detect only one of these, that for probably a branch of the facial nerve. It lies just below the anterior end of the articulation of the hyomandibular, and corresponds to that marked 7' in the figure of *Tarpon*. In *Tarpon* this foramen opens into a canal which runs backward in the proötic and emerges at the hinder border of the mouth of the fossa, above described as being walled in by the proötic, opisthotic, and exoccipital. This canal is then continued backward on the outer surface of the exoccipital beneath the opisthotic. It — or, at least, its hinder portion — serves to conduct the glosso-pharyngeal nerve. An opening has been found in *Xiphactinus* in the mouth of the fossa, and doubtless the canal was similarly prolonged both forward and backward.

Crook's statement that the parasphenoid is triangular in section, with the base of the triangle directed upward, is true only when the skull is held in an inverted position. The error is doubtless due to a slip of the pen. It is also erroneous to say that the finger-shaped processes outstanding from each side of the parasphenoid arise at the union of the parasphenoid and

basioccipital. They arise about opposite the union of the basisphenoid and the parasphenoid. These strong lateral processes are almost wholly absent in Tarpon. In both this genus (Fig. 1, *pa.s.*) and Xiphactinus there is, on each side, a strong process arising from the parasphenoid to meet the proötic. These processes form the side walls of the muscular canal. This canal was of greater extent perpendicularly in Xiphactinus than in Tarpon.

The basisphenoid is a Y-shaped bone, the upper end of which articulates with the proötics, while the lower end rests on the parasphenoid. It is almost twice as long as the corresponding bone in a tarpon of the same size (Fig. 1, *b.s.*).

So far as can be determined from the crushed skulls of Xiphactinus, the form and relationships of the alisphenoids and the orbitosphenoids were very much the same as in Tarpon. In this latter fish both of these pairs of bones are large (Fig. 1, *als.*, *o.s.*). The alisphenoids meet in the mid-line, below the brain, and thus continue forward the floor of the brain-case. In front of these are the large orbitosphenoids, ankylosed in the mid-line, as in the salmon. There is no distinct presphenoid.

In the tarpon the brain-case is roofed over behind by the supraoccipital. In front of this the proötic sends upward and inward a plate of bone which meets a similar plate from the opposite proötic. This roof is continued forward by plates of bone which grow mesiad from both the alisphenoids and the orbitosphenoids. These two pairs of bones also send out great lateral plates, which abut against the postfrontal and the lower surface of the frontal. In the mid-line above the brain, the united orbitosphenoids send upward a more or less interrupted crest of bone. Between the brain-case, as thus roofed over, and the parietals, pterotic, and frontals, there is a great space an inch high and extending from one side of the skull to the other, and in life this is probably filled with the primitive cartilage. The arrangement of this portion of the head may be understood by an examination of Parker's figures of the salmon (*Trans. Phil. Soc. London*, vol. clxiii, pp. 95-145, Pls. I-VIII). In Tarpon there are two foramina in the proötic which open from the outside into the cavity here described. One of these is

found in the lower anterior angle of the great lateral fossa; the other is seen just above the foramen 7'. These foramina are probably closed with membrane in life. They are not found in *Xiphactinus*.

In *Xiphactinus* the alisphenoids and the orbitosphenoids appear to have had the same extent and relations, at least as seen from below, and I have no doubt that there was in the skull the same large amount of primitive cartilage that we find in Tarpon to-day.

The frontals of *Xiphactinus* were much broader than they are in Tarpon. In a tarpon whose skull had to one of *Xiphactinus* the ratio in length of 9.5 to 10.5, the width of the frontals bore the ratio of 1 to 2. Since the breadth of the nasal region of *Xiphactinus* was little less, we may appreciate Professor Cope's characterization of their expression as being bulldog-like.

To a broad flat surface of the very stout prefrontal of *Xiphactinus* was applied the superior articulating surface of the malleolar body of the palatine. In Tarpon the palatine is similarly connected with the prefrontal, except that the ethmoid bone sends outward a process which takes part in the articulation. Professor Cope states that in the alewife the articulation of the palatine is wholly with the ethmoid.

The lower surface of the ethmoid furnishes an articular surface for the anterior condyle of the maxillary. Since this condyle in *X. thaumas* is much larger than that of *X. molossus*, we ought to find a corresponding difference in the ethmoids of the two species.

There can be no doubt that the orbit of *Xiphactinus* was surrounded by a ring of orbital bones, just as it is in Tarpon. In a skull of *X. molossus* before me (No. 1646, U. S. N. M.), the superorbitals are wanting, but the border of the frontals shows distinctly that a row of thick bones has been articulated with it. In Tarpon there are three of these superorbitals. Crook has figured a preorbital in *Xiphactinus*.

In Tarpon the posterior suborbitals are very large, extending backward over the cheek as far as the preopercle. In nearly their whole extent they are membranous. It is certain that

they were quite as extensive in *Xiphactinus*, and composed of very thin bone. Crook has figured them as extending well back from the orbit, and I find them pressed down on the metapterygoid and hyomandibular of *X. thaumas*.

Dr. Crook states that the ossified sclerotic of *Xiphactinus* forms a complete ring, meaning, I take it, that it does not consist of more than one piece of bone. Having a portion of the sclerotic in my possession which closely resembles those figured by Professor Cope (*Cret. Vert.*, Pl. XL, Fig. 3; Pl. XLIII, Fig. 4), I am inclined to believe that the sclerotic consisted of two separate pieces of bone, and this is the usual condition of the sclerotic of fishes.

No one has yet, so far as I know, described the nasals, and I have not succeeded in identifying them. In *Tarpon* each of these bones is a rugose scale which lies partly on the outer border of the ethmoid. It might easily become detached during maceration, and this accident may have happened to this bone in the skulls of *Xiphactinus* that I have examined.

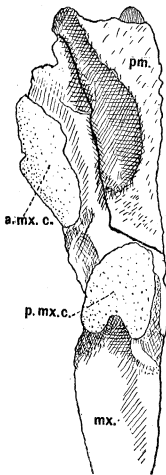


FIG. 2. — *Xiphactinus thaumas*, maxillary and premaxillary, seen from above. $\times \frac{1}{2}$.

The maxillaries and the premaxillaries are the most characteristic bones of this genus, and especially on the number and the character of the teeth borne by them have been founded most of the different species. Frequently, however, the premaxillary has been separated from the maxillary. I believe that the species may be identified from the condyles of the maxillary. At least, these condyles are quite different in the two species which I have been able to examine, *X. thaumas* and *X. molossus*. Fig. 2 represents the maxillary of the former species, Fig. 3 that of *X. molossus*. From these figures it will be seen that in *X. thaumas* the posterior condyle (*p.mx.c.*) is notched behind, while that of *P. molossus* is excavated in front.

It appears, too, that the condyle is more extended longitudinally in *X. thaumas*, more transversely in *X. molossus*. Examining the anterior condyle, the one which

articulates with the ethmoid, we find that in *X. thaumas* it is large and elongated, and approaches the posterior condyle within a distance equal to half its own length. In *X. molossus* the condyle is much smaller, regularly oval, and far removed from the posterior condyle. It is to be expected that the other species of the genus will exhibit likewise their distinctive characters. I am inclined to believe that these condyles underwent some individual variation, and they have in many cases suffered distortion during fossilization, and this must be taken into account. The left maxilla belonging to the same individual of *X. molossus* from which Fig. 3 was drawn possessed an additional condylar surface, nearly round and small, just in front of the posterior condyle. It is to be inferred that the ethmoids of the various species, and especially the surface of the palatine with which the posterior maxillary condyle articulates, will exhibit characters corresponding to those shown by the latter.

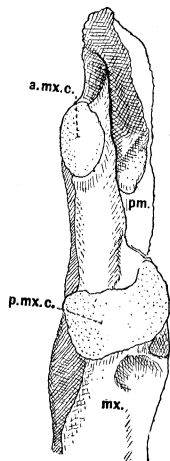


FIG. 3. — *X. molossus*, maxillary and premaxillary, seen from above. $\times \frac{1}{2}$.

I call attention to the fact that it is as yet difficult to distinguish the various species by means of characters furnished by the lower jaws. In the case of *X. molossus* there are discrepancies between Professor Cope's description of the number and character of the teeth and one of his figures. The lower jaw of the type specimen is figured on Pl. XXXIX of the *Cretaceous Vertebrates* and again on Pl. XL, Fig. 1. The statement is made in the text (p. 195) that there are in all 20 teeth; but in the figure last referred to there are 27 teeth represented, and these do not all agree in size either with the statements of the text or with the other figure. The explanation of this discrepancy, evidently, is that the figure on Pl. XL has, so far as many of the teeth are concerned, been erroneously restored. *X. thaumas* is said (*op. cit.*, p. 197) to have rather more numerous teeth than *X. molossus*, and in the specimen described there are said to be 23. I possess two dentaries which I regard as belonging to *X. thaumas*. In these there are 24

teeth, and their sizes and arrangement agree well with Cope's figure of the dentary of this species presented by him (*Cret. Vert.*, Pl. XLIII, Fig. 3). Probably it will be well not to rely too much on the number of the teeth as a specific character.

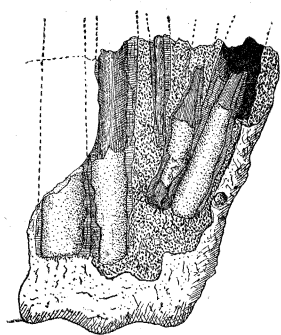


FIG. 4. — *Xiphactinus*. The mandible near symphysis, with bone broken away to show the roots of the teeth. $\times \frac{1}{2}$.

Professor Cope states (*Proc. Amer. Philos. Soc.*, vol. xii, p. 175) that the teeth of these fishes descend in their alveoli to the depth of an inch. The large teeth really have much longer roots than thus indicated. In the lower jaw the bases of the large teeth near the symphysis descend nearly to the lower border of the jaw. Fig. 4 presents a view one-half the natural size of the symphyseal end of the mandible of a species of *Xiphactinus*, seen from the outside. The bone has been broken away so as to expose the roots of the teeth, and portions, too, of these are missing. The teeth in life had a very large pulp, and the cavity containing this pulp had, since burial, been filled up with crystallized calcite. This, in the drawing, is stippled. Where the calcite has fallen out and exposed the inner surface of the dentine the shading has been made by perpendicular lines. The broken edges of the dentine itself are shaded by horizontal lines.

Cope and Crook have both figured the articulation of the lower jaw with the quadrate. It appears to me that the figures of

both are more or less erroneous, or, at least, misleading. Professor Cope (*Cret. Vert.*, p. 194) states that the articular is distinct, wedge-shaped, short, and supports half the cotylus. He describes the angular as having a prominent angle, like half an ellipse, and extending in a long sword-shaped process

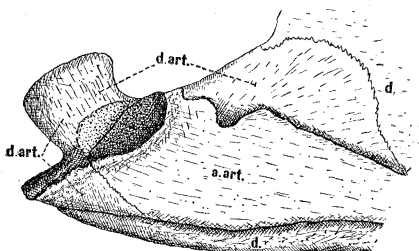


FIG. 5. — *Xiphactinus*. Proximal end of lower jaw. $\times \frac{1}{2}$.

on the inside of the ramus to beyond its middle. A lower jaw of *Xiphactinus* (No. 3782, U. S. N. M.), in almost perfect condition (Fig. 5), enables me to correct some of these statements. Cope's articular is not short, but its continuation forward forms the long sword-shaped process that he regards as belonging to the "angular." In short, this articular corresponds to the autarticulare of Van Wijhe (*Niederländ. Archiv. f. Zool.*, vol. v, pp. 207-320) and originates from the ossification of Meckel's cartilage. Cope's angulare is not the true angulare, but is Van Wijhe's dermarticulaire, a membrane bone. In *Lepisosteus*, *Amia*, and *Polypterus* these bones remain distinct. Van Wijhe (*op. cit.*, pp. 306, 307) makes the following statement in speaking of the elements of the lower jaw of the genera mentioned above: "Eine Vergleichung mit den Teleostiern zeigt, dass was bei diesen als Articulare angegeben wird durch eine Verschmelzung des Autarticulare mit dem Dermarticulaire entstanden ist." Here, however, in this Cretaceous genus of Teleosts, we find these elements still distinct from each other. In the genera of so-called Ganiods referred to above the autarticulare is very short; but, relying on two good specimens of *Xiphactinus* and one of *Ichthyodectes*, I am confident that the proximal end of the autarticulare is continuous with the long sword-shaped process described by Cope, and that this process is entirely distinct from the dermarticulaire.

If the true angulare ever was present in *Xiphactinus*, it has become consolidated with the dermarticulaire. In a specimen of *Ichthyodectes* there is present a surface to which an angulare seems to have been sutured. Crook represents it as present.

Professor Cope's figure of the lower jaw of *Xiphactinus* (*Cret. Vert.*, Pl. XXXIX) at first sight gives one the impression that the rounded head of the quadrate articulated with a similar rounded head belonging to the lower jaw. The latter, however, is the "prominent angle, like half of an ellipse," and the quadrate was supposed to enter its cotylus mesiad of this angle and well forward. My Fig. 5 shows the jaw seen from within. The cotylus is furnished partly by the autarticulare and partly by the dermarticulaire. The head of the quadrate sits in its cotylus on the mesial side of the broad process of

the dermarticulare. I know of no recent fish which possesses such an arrangement. The tarpon has a very different articulation in this region, since it resembles closely the articulation between two vertebrae of a bird. The advantages of such an articulation as that of *Xiphactinus* are obvious, since this species doubtless preyed on large fishes, and possibly on some of the large aquatic reptiles of its era. Fig. 6 represents another specimen of the jaw of *Xiphactinus* (No. 1646, U. S. N. M.). At *q.c.* is seen the condyle of the quadrate; *ep.h.* is the lower end of the epihyal, and *c.h.* the upper end of the

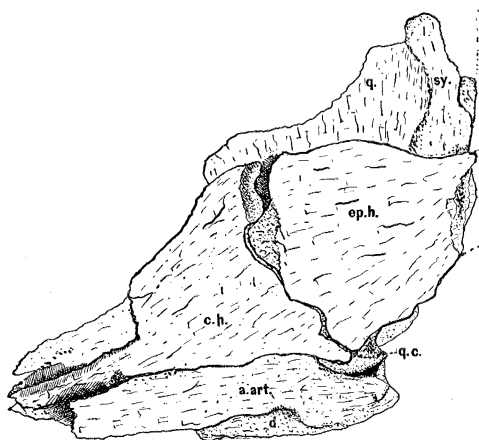


FIG. 6. — *X. molossus*, showing quadrate, autarticular, and hyoid bones. $\times \frac{1}{2}$.

ceratohyal. These bones are closely appressed to the inner surface of the quadrate and of the lower jaw.

The entopterygoid, or mesopterygoid (Fig. 7, *m.pg.*), has a smooth, slightly convex surface sloping inward and upward to form a partial floor for the orbit. Unless its width has been excessively altered by pressure, it was much narrower than the corresponding surface of Tarpon. In the latter the entopterygoid meets the upper anterior angle of the quadrate, these two bones thus excluding the ectopterygoid from contact with the metapterygoid. In *Xiphactinus*, on the contrary, these two last-mentioned bones have a considerable union (Fig. 7).

The bones of the palato-quadrate arch have been described as being devoid of teeth. I have, however, found a consider-

able patch of small teeth on the entopterygoid (Fig. 7, *t.*), and another smaller patch on the ectopterygoid (Fig. 7, *t.*¹). In the Tarpon teeth occur on the vomer, parasphenoid, pterygoids, and even on the quadrate.

The hyomandibular (Fig. 7, *hm.*) is in many respects like that of Tarpon, but, like the other bones of the extinct genus, is of more massive construction. The anterior border of the

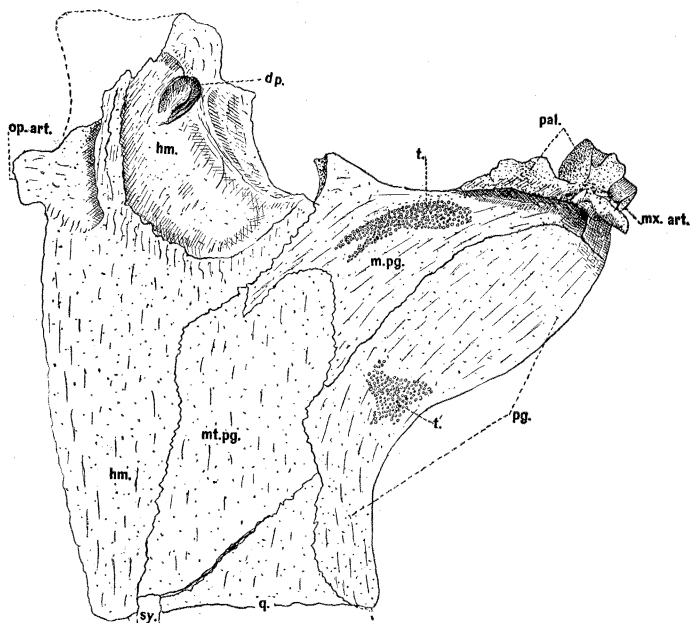


FIG. 7. — *X. thaumas*. Hyomandibular and palato-ptyergoid bones. $\times \frac{1}{4}$.

bone extends further forward than it does in Tarpon. In the latter the anterior border falls, with a sigmoid curve, in a general downward direction, crossing the posterior angle of the metapterygoid. In *Xiphactinus* the anterior border of the hyomandibular runs rapidly forward, so as to come into contact with and pass mesiad of the posterior border of the entopterygoid. The greatest width of the hyomandibular from the articulation of the operculum to the anterior border is nearly equal to the distance from the anterior border to the anterior end of the palatine. In Tarpon the latter distance is about 2.5 times the greatest width of the hyomandibular. However,

on account of the relatively greater depth of the head in *Xiphactinus*, the width of its hyomandibular has about the same ratio to its length that we find in Tarpon.

In Tarpon the process for articulation of the operculum projects from the hinder border of the bone more than in *Xiphactinus*. In the latter genus the surface for the operculum of *X. molossus* scarcely passes beyond the border of the bone ; but in *X. thauwas* the surface is at the extremity of a considerable process.

As a result, perhaps, of its large size, the hyomandibular of *Xiphactinus*, as well as that of Tarpon, is provided with prominent ridges and depressions, and with foramina leading into its interior. Many of these are repeated in the two genera with much faithfulness. In both genera there is found running down near the middle of the outer surface of the bone a high crest, like the spine of the human scapula. This crest has its origin, we may say, in two low rounded ridges, one beginning at the anterior end of the hyomandibular head, the other at its posterior end, the two ridges converging and meeting opposite the articular surface for the opercular. Here the resultant crest becomes much more elevated, thin, and sharp, and continues to the lower end of the bone. The plane of the crest is directly outward and slightly backward. Both in front and behind the crest is a deep fossa, the posterior one the best defined. The anterior border of the preopercular occupies a part of the posterior fossa. This fossa, in Tarpon, ends above in a deep depression immediately in front of this process for articulation of the opercular ; but from the upper border of this depression one or more large canals enter the bone, and, passing upward, emerge by several mouths in another depression on the inside of the bone just below the head of the hyomandibular. It is quite probable that one or more branches of the facial nerve pass downward through these canals.

In *Xiphactinus* the posterior fossa ends above, just as described, and broad channels are seen passing upward from it in the bone ; while on the outside, just below the anterior end of this hyomandibular articulating surface, there is a depression

like that found in Tarpon. There can be no doubt, therefore, that the upper end of this hyomandibular is hollowed out similarly in the two genera. In a specimen of *X. molossus* before me, two bridges of bone are thrown across the upper end of the posterior fossa on the mesial surface of the hyomandibular. On the same surface of the hyomandibular there is a well-marked median crest, in front of which is a broad shallow fossa. It is in the upper end of this fossa that the depression is found that has just been described, and which in *Xiphactinus* is represented in Fig. 7, *dp*. This depression, it is to be noted, faces the deep fossa which has already been described as occurring in the side wall of the skull. Its significance can only be determined by an examination of a fresh Tarpon. Both depressions probably furnish insertions for muscles.

The opercular of this genus is not well known. Cope states that it is thin and broad. Crook figures a portion of the bone, but this reaches downward only about to the middle of the preoperculum. I have a fragment of a bone 50 mm. by 100 mm. which appears to be the opercular of *X. thaumas*, and this, too, has every appearance of ending about halfway down the preoperculum. This piece of bone has an articular surface resembling that of Tarpon for connection with the preopercular, and, like Tarpon, there are just below this surface, and on the inner side of this bone, one or two large openings into the interior of the bone. This mention of the opercular may attract attention to it. It appears rather improbable that it is really so short as above described.

In each of the three specimens of *Xiphactinus* before me there is present, attached to the posterior outer angle of the skull, a bone which seems to occupy the position of the post-temporal. If such it is, it was very different from that of Tarpon. It is not much over an inch in length, and less than two inches broad, but very thick. In a specimen of Tarpon the bone is rather thin and much longer. In *Xiphactinus*, on account of the crushed condition of the skulls, the relations of the bone are hard to make out, but it seems to be connected with the opisthotic and the epiotic. In many fishes the post-temporal bone is very short and stout.

If I have correctly determined the bone figured here (Fig. 8), the supraclavicular, by its great length, compensated for the shortness of the post-temporal. Its length is about equal to that of the parasphenoid.

The shoulder girdle has received very unfortunate treatment. It appears to have been misunderstood by both Professor Cope

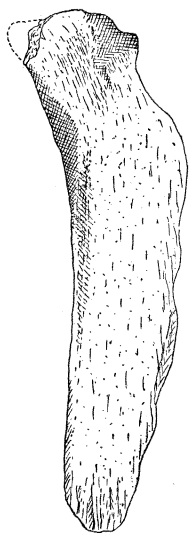


FIG. 8. — *X. molossus*.
Suprascapula? $\times \frac{1}{2}$.

and Dr. Crook, being by both writers described in an inverted position. Cope gives figures in his *Cretaceous Vertebrates* as follows: Pl. XL, Fig. 9 (cleithrum?); Pl. XLII, Figs. 2-5; Pl. XLIV, Figs. 10, 11. Most of these depict the scapula and the parts immediately adjacent. Cope describes the "coracoid" as a stout flat rod, narrower than the cleithrum (clavicle), and appressed to the inner face of the latter nearly to its distal end (*Cret. Vert.*, p. 186). He was unable to state whether or not there was present a precoracoid, but said that the "coracoid" occupied the position of the precoracoid in some fishes. According to his conception, the scapula was placed high up on the body, although his restoration of the fish on Pl. LV does not so indicate. Dr. Crook has presented figures of the girdle of *Xiphactinus* (*op. cit.*, Pl. XVII), of his *Ichthyodectes polymicrodus* (Pl. XVI) and of *I. anaides* (Pl. XV).

There can be no doubt that all these figures represent bones which belong to the side of the body opposite to that to which they are assigned, and that what is regarded as the ventral end is the dorsal. To demonstrate this it is only necessary to compare the figures with the prepared shoulder girdle of a shad. Dr. Crook recognized that Professor Cope's coracoid was really the precoracoid; nevertheless, he has represented it as running ventrally from the coracoid, instead of toward the dorsal end of the cleithrum.

One result of Crook's error is that the coracoid is brought into a position dorsad of the scapula. The materials employed by both Cope and Crook were defective, that portion of the

cleithrum and coracoid belonging ventrad of the fin articulation being mostly wanting. Fortunately I have on one block both the right and left halves of the shoulder girdle in nearly perfect condition. To one half are also attached some of the remarkable fin rays of this genus. A figure is presented of the right half of the girdle seen from without (Fig. 9). In this figure the cleithrum conceals a part of the coracoid,¹ but the latter is so broad that a considerable portion of it is seen. In *Tarpon* there is along the upper border of the coracoid a long fontanelle between this bone and the cleithrum. If such a fontanelle was present in *Xiphactinus* it is concealed beneath the cleithrum. In *Tarpon* there are two or three foramina in the coracoid just below the scapula. They are in life closed by membrane. They are wanting in *Xiphactinus*. The outer surface of the dorsal limb of the cleithrum of *Xiphactinus* is broad and convex to the very hinder border. It thus resembles *Tarpon*, and differs from *Alosa sapidissima*, in which the hinder portion of this surface is rough and excavated for muscles. In the extinct genus there is an extensive fossa on the inner surface of the upper limb of the cleithrum. The upper half of this fossa lies between an outer and an inner plate of the cleithrum. Further down, the fossa is limited mesially by the precoracoid. There seems to be no such fossa in *Tarpon*, and that of *Alosa* is very shallow. In both *Tarpon* and *Alosa* the precoracoid is a much less important bone than it is in *Xiphactinus*.

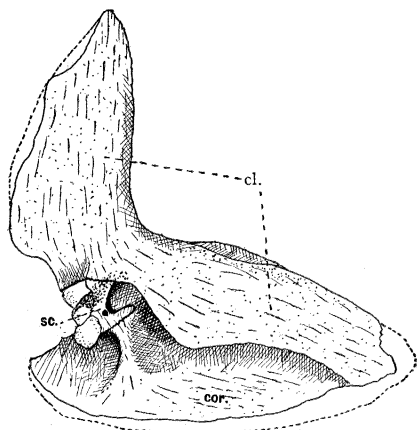


FIG. 9. — *Xiphactinus*. Shoulder girdle. $\times \frac{1}{4}$.

¹ I employ for the elements of the shoulder girdle the terms in common use, except that I use Gegenbaur's name cleithrum instead of clavicle. For the latter element Dr. Gill has proposed the term proscapula; for coracoid, hypocoracoid; for scapula, hypercoracoid; and for precoracoid, mesocoracoid.

The pectoral fins have been described by Professor Cope and Dr. Crook (Cope, *Cret. Vert.*, pp. 186, 193, 204; Crook, *Palaeontographica*, vol. xxxix, p. 119). Neither of these authors compares the fin structure with that of other fishes, although a community of structure is perhaps implied. The large saber-shaped spines, each consisting of an upper and a lower half, are remarkable enough; but when comparison is made with the fins of a shad or of a tarpon the arrangement of all the parts is easily comprehended. The first pectoral ray of *Xiphactinus* resembles quite closely that of Tarpon. It differed in being, relatively to the size of its owner, somewhat, but not enormously, larger. It differed further in having lost, apparently to the very tip of the ray, the cross-segmentation. In Tarpon this persists in the distal half of the ray. Doubtless, the spine-like rays of *Xiphactinus* were not so flat as they are now presented to us. It is quite probable that the rays succeeding the first one were,

toward their distal extremities, not only cross-segmented, but also longitudinally split, as in other fishes.

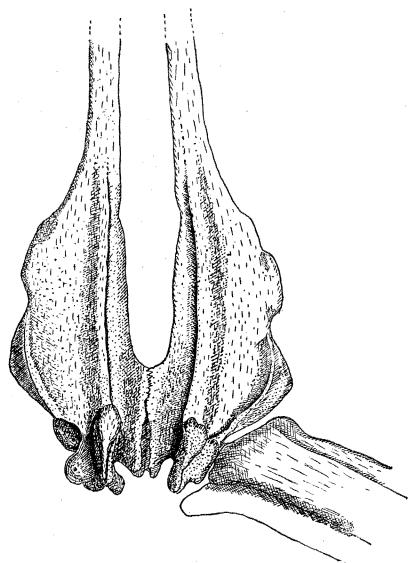
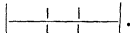


FIG. 10. — *X. thaumas*. Pelvic bones and base of fin. $\times \frac{1}{4}$.

Professor Cope (*Cret. Vert.*, p. 186) has described the ventral fins and their supporting bones. The latter, pelvic actinosts, usually termed the pelvic bones, are called by Professor Cope the femora. He also figures them (p. 192, Fig. 9, and Pl. XLV, Figs. 7, 7a). I possess a well-preserved specimen of the pelvis and the ventral fins of *X. thaumas*, and from these it becomes evident

that the pelvis figured by Professor Cope was very defective. This may be seen by comparing the figures above referred to with my Fig. 10, which represents the pelvic actinosts seen

from below. These pelvic bones are, as stated by Professor Cope, massive, and expanded vertically on the outer side to support the facets for the ventral fin.

The right and left bones are strongly sutured together. In front of the facets and of the suture the bones become much thinner, but wider. At the same time there is, descending from the outer border of each bone, a crest of moderate height, while from the same portion of the outer border there arises a much higher crest, so that a cross-section of the pelvis in front of the fin articulation would somewhat resemble this figure . Just laterad of the inner border of each bone there is found on the upper side a prominent ridge, running from the fin articulation toward the anterior end of the bone. On the lower side, and nearly opposite the upper ridge, is a similar ridge. Elsewhere the bone is very thin. If now the thin portions of bone were broken and had crumbled away, there would be left a thick process standing out on each side and two rods, the ridges just described. Such was doubtless the condition of the bones which Professor Cope figured. Just how far forward the pelvic actinosts extended is not known, since those figured by both Professor Cope and myself have been broken. In Tarpon these bones are very long and slender. In Elops, a close ally of Tarpon, they are relatively shorter and also broader behind.

Professor Cope has quite correctly described the facets for articulation of the ventral fin. My Fig. 11 represents the positions and forms of these facets. The bone is that of the right side, and is looked at laterally. The upper facet is for the reception of an articular surface on the base of the upper half of the first ventral ray; the large lower facet for an articular surface on the lower half of the same ray. The other two facets are for succeeding rays, or possibly for baseosts. There was undoubtedly a disc-like baseost between the upper half of the first ray and the articular surface of the pelvic bone; and there may have been other rudimentary baseosts.

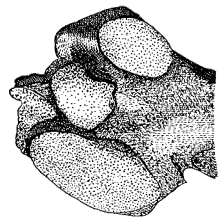


FIG. 11. — *X. thaumas*. Side view of articulation for pelvic fin. $\times \frac{1}{2}$.

The planes of the two surfaces which support the first ray approximately coincide and are directed outward, somewhat backward, and slightly downward, a position different from that given by Cope.

The first and spine-like ventral ray is constructed like the first pectoral, and may also be compared with that of other *Iso-spondyli* such as the lake-trout (*Cristivomer*) and tarpon. Like the first pectoral ray, it seems to have wholly lost its transverse segmentation. These spines, however, show no special physoclistous characters, as Professor Cope supposed they did. The first ray of my specimen of the ventral fin of *X. thauomas* is 38 mm. wide at the base, and was perhaps originally 60 cm. long; but this was a very large fish, since its upper jaw had a length of 38 cm. Professor Cope states that the first three rays were spines, and that there were probably no additional rays. However, it seems probable that the rays succeeding the first one were much feebler, were segmented, and longitudinally split. There were certainly more than three rays, for, in my specimen, I make out six or eight, and there were probably nine. The second ray has only about one-third the diameter of the first, and those following become gradually, probably rapidly, reduced. The inner rays must have been very short, since I find finely split and segmented rays at a distance of only 90 mm. from the base of the rays. In Fig. 10 I have represented the bases of the first and second rays. On the anterior border of the first ray the broader upper half of the ray is seen to project some distance beyond the lower half. It will be noticed, also, that on account of the expansion of the pelvic bone in front of the fin articulation, the fin could not be brought in front of a perpendicular to the body at that point.

In *Cristivomer* and *Tarpon* I find a rudimentary ray in front of, and lying on the base of the first ray. It is short, but has a very long muscular process directed forward and upward. It is more reduced in *Tarpon* than in *Cristivomer*. I find no evidence of its presence in *Xiphactinus*.

The vertebral column has been described by Professor Cope (*Cret. Vert.*, pp. 188, 193, 195, 199), and briefly by Dr. Crook (*op. cit.*, p. 117). I have noted some hitherto undescribed

peculiarities which are of interest. I have a considerable number of the vertebrae of *X. thaumas*, including unconnected vertebrae belonging to the anterior portion of the column, and a section about two feet in length from the tail region. I have also numerous vertebrae belonging to some indeterminable species, probably *X. molossus*. Access is permitted me to vertebrae of probably *X. molossus*, belonging to the United States National Museum. These belong mostly to the tail.

I will first describe the peculiar structure of the neural arches in the latter region. The drawing presented will assist in the understanding of my description (Fig. 12). The neural arches here, as elsewhere in this fish, are connected with the centra

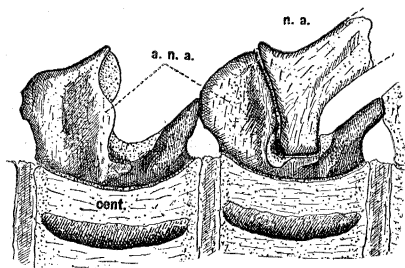


FIG. 12. — *X. thaumas*. Two tail vertebrae. $\times \frac{1}{4}$.

by suture, and have usually fallen out before burial, leaving long grooves where their bases were inserted. This was the case with the third vertebra behind the right-hand one shown in Fig. 12. When we come to examine the arches more closely we discover that each lateral half is not a single piece, but consists of two pieces, a basal piece (*a. n. a.*) and the arch proper (*n. a.*). That the proper arch is a distinct piece is shown, not only by the existence of a suture, but likewise by the fact that in the vertebra on the left hand of the figure the arch has fallen out of its place before fossilization. The basal or accessory piece is inserted by a shallow gomphosis into the centrum for nearly the whole length of the latter. It rises high in front and projects so far forward as to come into contact with the basal piece of the next vertebra in front. Behind, the basal piece is directed upward and backward in a rather slender process, which abuts against the anterior edge of the basal piece of the next vertebra behind. It is thus seen that these basal pieces provide the anterior and posterior zygapophyses. They remind us of the articulating processes of certain other fishes, Mugil, etc. Between the anterior and posterior

processes the basal pieces are excavated to receive the bases of the neural arch, as shown in the figure. The two basal pieces of each vertebra are distinct. Together they seem to form a saddle in which rides the neural arch.

I find this same structure of the neural arches in some of the vertebrae belonging to the specimens in the United States National Museum; but in one section of connected vertebrae an arch like those above described is succeeded in the next vertebra behind by an arch in which every trace of a suture between the arch and the apparent basal piece is lost. This vertebra is shown in Fig. 13. The form of the base of the arch is not greatly different from that of the arch with accessory piece in Fig. 11, and we may even convince ourselves that we can trace a part of the

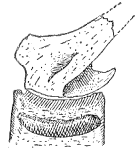


FIG. 13. — *Xiphactinus*. Transitional neural arch. $\times \frac{1}{4}$.

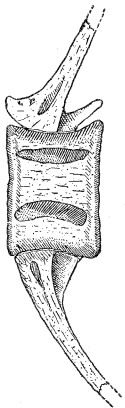


FIG. 14. — *Xiphactinus*. Neural arch without accessory piece. $\times \frac{1}{4}$.

boundary line between the two portions. There is evidently at this point of the vertebral column a sudden change from neural arches furnished with basal accessory pieces to arches without these, or consolidated with them. Further backward the form of the arches becomes modified somewhat, so that they resemble the one shown in Fig. 14. A section 14 inches long and containing 7 vertebrae having arches of this kind is before me. This condition shows us that the neural arches which are provided with basal pieces are confined to the anterior or middle portion of the tail region, while the hinder portion contains no such vertebral structures. We are reminded that in *Amia* the middle portion of the caudal vertebral column is composed of two rings for each muscular segment, while the anterior and posterior portions have vertebral centra of the ordinary kind. It seems as if the tail portion of the vertebral column of the Amioid fishes and of the Isospondyli retained primitive conditions longer than the abdominal portion.

It is difficult to determine what explanation is to be given of the presence of these basal pieces. The so-called zygapophyses of fishes are regarded as being outgrowths from the neural arches, exogenous and not autoge-

nous processes. It might be said, possibly, that the basal pieces are the proper arches, while the pieces which are borne on them are the spinous processes. I hold that there are two objections to this view. The first is, that what are sometimes called free spinous processes are always unpaired pieces. The second is, that when the lateral halves of the arches remain distinct from each other and are prolonged into spines, as they are in various fishes, *Amia* and *Salmo*, for instance, the spinous portion is never, so far as we know, developed in the embryo as pieces separate from the base of the arcuale. This is true in the case of *Amia*, which I have investigated. We must, therefore, seek some other explanation. The key to the understanding of the problem is, it seems to me, to be found in the vertebral column of that primitive fish, *Amia*. We may call this fish to our assistance since the *Isospondyli* are believed to have had ancestors not far removed from *Amia*.

In the middle region of the tail of *Amia* there are for each muscular segment two vertebral rings, the one bearing the arches, upper and lower, the other archless. If a transverse section be taken through the middle of the arch-bearing ring, there will be found an X of cartilage, the upper arms of which are continuous with the cartilage of the neural arch. In like manner the lower arms will be seen to be continuous with the cartilage of the haemal arch. If a section is made similarly through the archless disc, a similar X of cartilage is found ; but the arms project beyond the outer surface of the disc but a short distance. These archless discs are developed in *Amia* from ossifications arising in the intercalated cartilages, upper and lower, and the arms of the X are the unossified portions of these cartilages. There appears to be no reason why these intercalated cartilages should not sometimes take on a hypertrophied growth. In the sharks they often become considerably larger than the true neural arches themselves.

In case these intercalated cartilages should become thus enlarged and arch-like, each might develop a bony investment that would simulate the bony neural half-arch, and thus would rest on the top of its proper epicentrum.¹

¹ For figures illustrating the architecture of the vertebral column of *Amia*, see the May number of the *American Naturalist* of the present year.

Coming now to the anterior region of the vertebral column of *Amia*, we find that each vertebra is formed through the suppression of certain of the elements which, in the tail region, constitute the vertebral rings or discs, and the union of the remaining elements of each muscular segment into a single mass. The lower intercalated cartilages are suppressed. The upper intercalated cartilages hypertrophy, and their ossifications unite with the bones developed in the bases of the lower arch, thus giving origin to the centrum. The ossification that we might expect to find developing in the base of the cartilaginous neural arch, the epicentrum, is aborted, while the ossification of the enlarged intercalated cartilage, the pleurocentrum, pushes itself into the place of the epicentrum, and thereafter supports the neural arch.

Now we have the choice of two suppositions, neither of which, however, may be the true one. We may hold that a distinct bone was developed in the somewhat elongated and projecting intercalated cartilage, and this, of course, rested on the top of the pleurocentrum; when the latter was pushed forward beneath the neural arch to take the place of the aborted epicentrum, this newly developed bone was carried along and was thus brought between the pleurocentrum and the base of the neural arch.

Or we may hold that the bone which I have found in *Xiphactinus* supporting the true neural arch is simply the epicentrum itself, aborted, indeed, in *Amia*, nevertheless persisting in *Xiphactinus*, but crowded upward out of its original seat on the notochord.

Either of the above suppositions presupposes that the upper half of the vertebral centrum takes its origin from the pleurocentrum. Professor Cope held that the vertebrae of fishes are "intercentra," that is, have originated in the suppression of all the other elements through the excessive development of the hypocentra. But the very existence, in many genera, of a cartilaginous X in a transverse section of the centrum is proof that its upper portion has been derived from either the bases of the upper arches or the pleurocentra. The deep gashes in the vertebral centra of *Xiphactinus*, where the arches have

fallen out, furnish evidences that this cartilaginous X was present.

The anterior neural arches of *Xiphactinus*, probably all of those belonging to the abdominal region, are very different from those of the tail. One of these abdominal neural half-arches, as seen from without, is presented in Fig. 15; another, seen from the mesial side, is given in Fig. 16. These neural arches are coössified neither with the vertebral centra nor with their fellow bones. The base is hemispherical and planted in a broad excavation in the upper surface of the centrum. The two excavations of each centrum are close together, and it seems probable that the juxtaposed borders of the right and

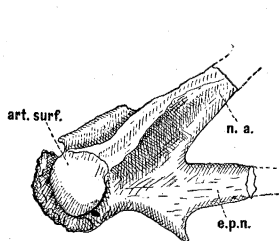


FIG. 15.

FIG. 15. — *X. thaumas*. Neural arch near head, seen from without. $\times \frac{1}{2}$.

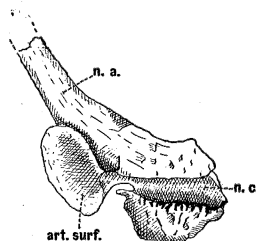


FIG. 16.

FIG. 16. — *X. thaumas*. Neural arch near head, seen from within. $\times \frac{1}{2}$.

left elements of each arch are in contact both below and above the neural canal. Behind the base of the neural half-arch is a broad smooth surface (Fig. 16, *art. surf.*) looking mesially, and in life coming into contact with a similar surface on the anterior end of the next vertebra behind and looking outward (Fig. 15, *art. surf.*). These surfaces remind us strongly of the zygapophyses of the higher animals.

At the base of each of these half-arches we find a strong rod-like process directed outward and backward. These processes are the epineurals (Fig. 15, *e.p.n.*). They were confluent with the bases of the arches just as they are in *Alosa* and *Tarpon*. It is entirely probable that *Xiphactinus* and its allies were as bony fishes as our just-mentioned modern genera.

The excavations for the insertion of the neural arches are broadest toward the region of the head. Farther backward

they become longer and narrower. Professor Cope describes all the centra as having on each side two lateral grooves, except the two or three centra near the head, called by him the "cervicals." However, so far as I can determine, the vertebral centra of the abdominal region have only one lateral groove on each side. Close to the head this groove becomes quite insignificant and is placed close to the pit for the neural arch.

The attachment of the ribs deserves notice. They are not joined directly to the centra but through the medium of distinct pieces of bone, the parapophyses. These are very short, and are sunken in circular pits so deeply that they scarcely rise above the surface of the centrum. Each has a concavity for the reception of the head of a rib. Some specimens in my possession have the parapophysial pits empty. In others the parapophyses are present, but without rib heads. In a few the head of the rib yet remains.

Distinct parapophyses are found in a number of fishes, as *Cristivomer*, *Alosa*.

It may be here remarked that the vertebral centra of Tarpon are very different from those of *Xiphactinus*, being very solid, smooth, and wholly devoid of the deep lateral grooves. Most of the neural arches have become coössified with the centra, and appearances indicate that in the young fish there were separate parapophyses, which later coalesced with the centra. The vertebral column has attained a much higher grade of development than that of *Xiphactinus*.

The specimen that I have above referred to *X. thaumas*, I believe to be such ; but lest it prove to be something else I shall here attempt a description and a comparison with other species. It certainly is not *X. molossus*, since that species has the distal extremity of the maxillary upturned like a saber. Moreover, as I have already illustrated (Fig. 2), the condyles are very different from those of undoubted specimens of *X. molossus*. It cannot be *X. mudgei*, since this species possesses four subequal teeth in the premaxillary, while in my specimen there are present only two teeth. Moreover, the vertical extent of the maxillary behind the posterior condyle is too great. The specimen possibly belongs to *X. lestrio*. Cope

speaks of the two maxillary condyles of that species as being large and separated by a space. This description, though vague, would fit my specimen. But *X. lestrio* is stated to have three, and sometimes four, premaxillary teeth. As I have said, I find no evidence of a third tooth. The total length of the upper jaw of my specimen, including the premaxillary, is 380 mm. The height of the maxillary from lower border to top of posterior condyle is 125 mm., almost exactly one-third the length. Applying this proportion to Cope's figure of *X. lestrio* (*Cret. Vert.*, Pl. XLII, Fig. 1), we find that his drawing of the maxillary would have to end at the right hand within about 8 mm. beyond its present limit, in order to represent the complete bone. It is very evident that a much more considerable piece of that maxillary was wanting. Had this missing portion of that bone had the form and proportions possessed by my specimen, the drawing would have to extend 25 mm. further to the right. This would make the jaw much longer in proportion to its height than my specimen.

As a matter of fact, I find no serious discrepancy between Cope's description of his *Portheus thaumas* and my specimen. I give description of the upper jaw.

Upper jaw heavy and massive ; its height being apparently greater in proportion to its length than in other species, one to three. Premaxillary broadly oval ; its major axis 130 mm., its transverse 110 mm., its greatest thickness 40 mm. Teeth two, the most anterior projecting 55 mm. beyond the bone ; its diameter at base 20 mm. Second tooth 22 mm. long, probably not full grown. Maxillary extending forward against inner surface of premaxillary nearly to the anterior border of latter. Condyles as shown in Fig. 2. Tooth border sinuous, slightly concave just behind premaxillary suture, then convex to beyond large teeth, then again more strongly concave ; finally convex, and rounding into the distal border. Upper border descending rapidly from posterior condyle and concave to point three-fifths of distance to distal extremity, there forming an angle, and again concave until it begins to round into the distal border. In general, the distal third of the maxillary bends downward instead of upward. On dental border there are in front, first,

traces of four or five small and medium teeth, then five large teeth, two of which are yet present and projecting 40 mm., then some 40 teeth from 11 mm. in length to mere points. Extreme height of maxillary 125 mm.; its height 72 mm., at a point on upper border 125 mm. behind the anterior border of posterior condyle. This enters into the total length of the upper jaw 5.3 times, and into height at condyle 1.75 times.

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