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Article XIX.— DESCRIPTION OF A SKELETON OF *DIMETRODON INCISIVUS* COPE.

By E. C. Case.

Plates XV–XIX.

This specimen, No. 4636, Am. Mus. Nat. Hist., was found by the author in 1906, in the red clay on the south side of Godlin Creek in Archer Co., Texas. It consists of a skull and lower jaws, the vertebral column complete as far as the seventh caudal, the pelvis, femur, tibia and fibula of the right side and most of the ribs. The vertebral column was in position, while the pelvis, limb bones, ribs and skull were separated. The skull, as is common in the fossils of the genus, was broken in the median line and the right and left halves were somewhat separated. The condition of the bones and the careful work of the preparator, Mr. Hermann, has made it possible to restore the skull and vertebral column in proper position and practically free from distortion. This is one of the rare occasions where a fossil has been discovered in the Texas beds not distorted and with the bones in position. The happy chance which has preserved the skull so perfectly makes it especially valuable as it is possible to give the proportions and shape very exactly and to add several new points in the morphology.

As previously shown by the author,[1] the skull is very high in the facial region, with narrow, flat frontal and parietal regions and the posterior surface falling off very steeply but not vertically. In general the bones of the skull are as already described and figured.[2]

The bones of the brain case have been crushed somewhat to the left and the paroccipital slightly displaced; flat facets on the lower part of the squamosals (postparietals, suggested by Broom) indicate where they were normally attached.

A separate element homologous with that described by Cope and Case as a *stapes* in *Theropleura retroversa* is considered as the stapes of *Dimetrodon*. Dr. Broom, from analogy with elements of similar position in the

[1] Publication 55, Carnegie Institution, Washington, 1907.

[2] In working on this specimen I was so fortunate as to have the opportunity to go over the material with Dr. R. Broom, the able authority on the Permian reptiles of South Africa, and a perfect agreement was reached as to the position and relations of the bones; differences remained in one or two instances as to the proper names and homologies of certain elements, as noted in the text.

South African forms, would call this a tympanic, an element reaching from the exoccipital to the quadrate and leaving above it an opening in which he would expect to find the distal end of a stapes. He would regard the bones identified as stapes in *Labidosaurus* and *Naosaurus* (*Edaphosaurus*) as the tympanic also.

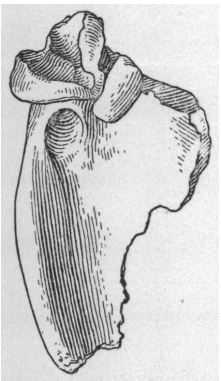


Fig. 1. Stapes of *Dimetrodon incisivus*. × ½ nat. size.

The *basisphenoid* has, on each side, descending from the outer edge of the lower surface, a flange-like process with an articular face on the outer surface. It is to this that the head of the stapes was applied, with the outer end fitting against the inner side of the quadrate. In form the stapes resembles the expanded wing of a bird. The proximal end, corresponding to the base of the wing, is divided by a deep groove into a circular face, which is applied to the face on the basisphenoid, and an elongate face on the portion of the still thickened edge which lies below and behind the circular face. Just below the circular face the bone is pierced obliquely by a large foramen. The main portion of the bone is expanded and proportionately thinner, the anterior edge is convex forward and rather heavy; the tip is broken off so that it is impossible to give the exact length, but it evidently reached nearly to the posterior edge of the quadrate. It seems to have been applied to the quadrate for a considerable portion of its length.

The *quadrate* extends far forward and is overlapped for a considerable distance by the pterygoid which lies on its inner side.

The position and relations of the *pterygoid* are shown to be different from previous interpretations in one or two important points. The strong external process, with its single row of teeth in sockets on the lower surface is placed obliquely to the jaw instead of horizontally; the flat outer faces are not on a plane with the side of the face but are inclined inwards, correspondingly the lower, tooth bearing edge, which is at a right angle to the outer face, is inclined upward and inward. The lower edges of the processes are thus inclined toward each other forming a space like an inverted V instead of being on a level.

In most reptiles the basipterygoid processes of the basisphenoid are applied to the pterygoid near the middle point and opposite the inner end of the external process of the pterygoid when such a process is present. In *Dimetrodon* the basisphenoid is short and the middle point of the pterygoids far in advance, so there is a considerable interval between them. Well back

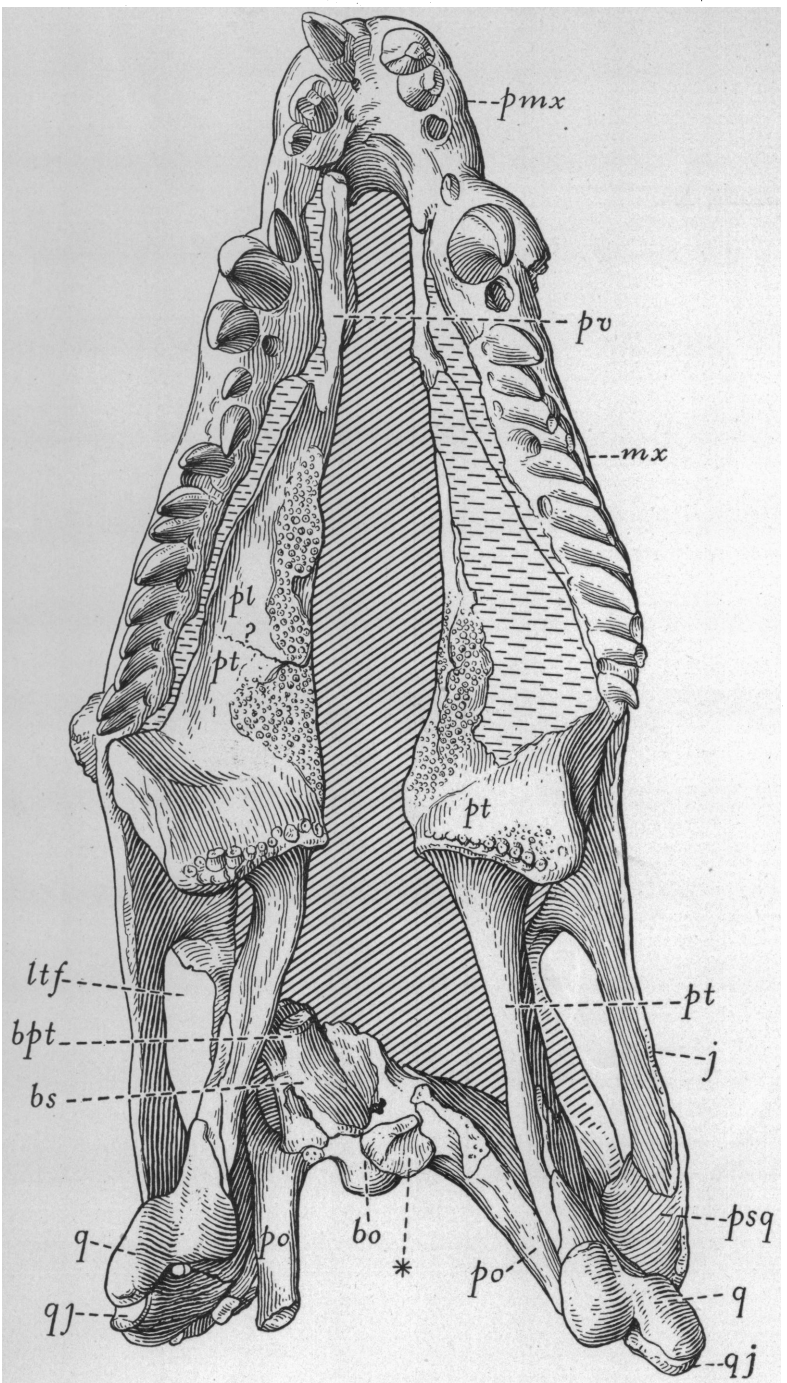


Fig. 2. *Dimetrodon incisivus*, inferior aspect of skull, slightly less than one half natural size. * facet on basisphenoid for head of stapes, *bpt*; basipterygoid process; *l.t. f.*, lateral temporal fenestra.

of the external process, the slender *epipterygoids* are applied to the inner side of the pterygoid, not resting upon them as is usual; the lower end is heavier and broader and is fitted into a shallow groove on the pterygoid; in this thick lower end there is a flat facet which articulated with the basipterygoid process of the basisphenoid. This condition is very peculiar, for in the Cotylosauria,[1] Rhyncocephalia (*Sphenodon*), most Lacertilia and Dinosaurs, as *Allosaurus* and *Tyrannosaurus*, the basisphenoid articulates directly with the pterygoid at or near a point opposite the external process. Above the pterygoid the epipterygoid is very slender and its upper end is in contact with the lower surface of the postorbital.

Anterior to the external process the pterygoids are flat, horizontal

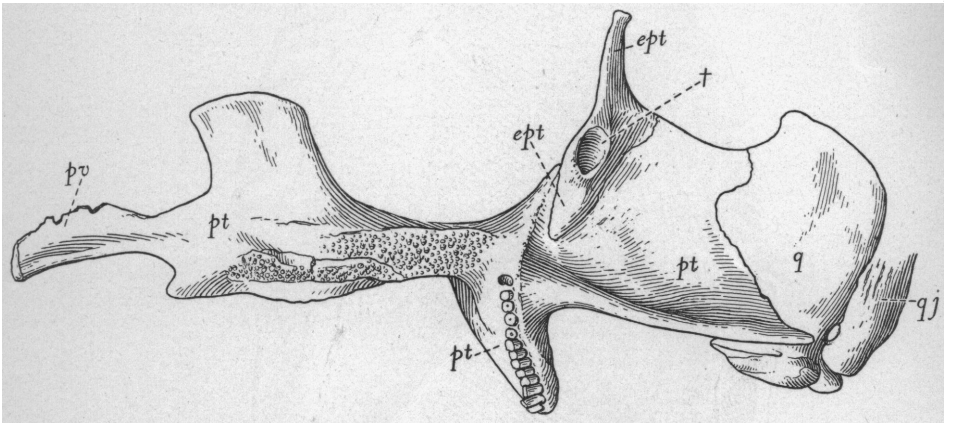


Fig. 3. *Dimetrodon incisivus.* Inner view of pterygoquadrate region with the bones nearly in the natural vertical position. × ⅓ nat. size. † facet for basipterygoid process. The portion of the pterygoid below the letters *pt* is horizontal; the part above rises vertically from the inner edge of the horizontal portion.

plates; these approach in the median line but are separated by a considerable interval. From the inner edges of the pterygoids rise vertical plates which are well shown on the left side. These rise very gradually from the posterior end but at about the middle of the anterior part of the pterygoid they rise very abruptly to the full height. The posterior edge of the vertical plate is concave forward and the whole plate is of little anteroposterior extent. Previous description [2] shows that these plates united anteriorly or were very closely pressed together and that they were in contact with the prevomers

[1] In *Diadectes* there is a bone seemingly overlying the pterygoid posteriorly, its limits are uncertain and it may be a part of the pterygoid but if it is an epipterygoid appearing on the under surface of the pterygoid it would have the same relations as in *Dimetrodon*, for the basisphenoid articulates with it.

[2] Carnegie Publication 55, p. 104.

below, anterior to the pterygoids. Two small fragments of bone which can not be placed in the skull are probably the anterior ends of these plates or of the prevomers and fitted close against the lower side of the premaxillaries. The vertical plates of the pterygoids and the ethmoid formed the median septum of the skull.

The *temporal region* is as described previously, except that there is in this specimen no supratemporal opening. This seems to have been a variable character in *Dimetrodon*. Some skulls show a definite elongate opening of good size (1002 Univ. of Chicago), others show an indefinite opening and the bones with very thin edges (1001 Univ. of Chicago), in others the opening

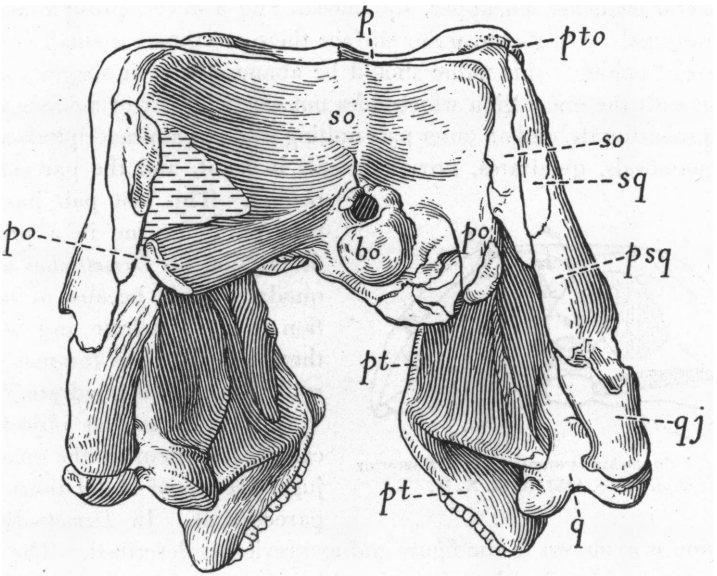


Fig. 4. *Dimetrodon incisivus*, posterior aspect of skull. Slightly less than one half natural size.

seems to be closed completely. In this specimen there is an opening at the proper place but it has every appearance of being due to the displacement of the bones due to crushing. The attachment of the bones was weak at best; an opening was either imminent or just disappearing.

The *axial skeleton* offers little new. The exact number of presacral vertebræ is shown to be twenty-seven. The spines of the third to the seventh vertebræ are cupped at the distal end showing cartilaginous attachment.

The anterior cervical *ribs* are double headed with large capitulum and tuberculum, the separation of these gradually decreases until on the four-

teenth, the separation between the two is no longer distinct and the whole head of the rib is in contact with the vertebræ. The last free rib is attached to the twenty-third or twenty-fourth vertebra, after this the ribs are fused with the transverse processes.

Discussion of the skull.

The condition of the temporal region in the skull suggests several important considerations.

In such forms as *Captorhinus* and *Labidosaurus* the roof of the skull is formed posteriorly by the parietals, frontals, postfrontals, postorbitals and two lateral elements, an upper, squamosal, and a lower, prosquamosal or quadratojugal. On the posterior surface there are three: a small pair, the tabulare ("epiotic," this name should be abandoned as it suggests a connection with the otic region which does not exist), a pair of median plates, the supraoccipitals, and an outer pair uniting with the supraoccipitals above, the squamosals, quadrates, prosquamosals in front, and the paroccipitals behind. This last pair has been referred to by me in a previous description of *Dimetrodon* as the quadratojugals, because of its relation to the quadrate and because there is a quadrate foramen separating it from the quadrate.

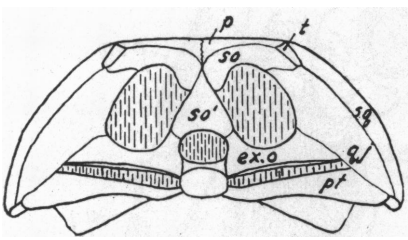


Fig. 5. *Captorhinus angusticeps.* Posterior aspect of skull of No. 4457, A. M. N. H.

Dr. Williston has objected to calling this element the quadratojugal because of its relations to the paroccipital. In *Dimetrodon* the condition is as shown in the figure and as previously described. The designation prosquamosal and quadratojugal being retained provisionally for the moment, it will be seen that the bones have essentially the same position as in *Captorhinus* and *Labidosaurus* with the exception of the lost tabulare. The supraoccipitals (not the dermal supraoccipital plates) have united with the exoccipitals and paroccipitals to form a posterior plate. The squamosals lie behind the lower process of the parietals and unite with a lower pair of elements exactly as in *Captorhinus*. Dr. Broom suggests that these are postparietals, homologizing them with the elements here called supraoccipital plates in *Captorhinus*, and would call the element here called prosquamosal, the squamosal. It seems to me much more probable that they are squamosals. The close relation of the primitive reptilia of the Texas Permian or Carboniferous to the higher amphibia warrants homologizing

the posterior plates with the supraoccipital plates of the Stegocephalia rather than with postparietals, elements which occur in the African forms of undoubtedly higher position and which have never been definitely determined in the American forms. With the development of the supraoccipital bone distinct from the supraoccipital dermal plates of the Stegocephalia and such forms as *Captorhinus*, the need for such plates would disappear and they would disappear with the need. This would leave the squamosals as the posterior lateral elements having the relations seen in *Dimetrodon* and I am disposed to retain the name.

With regard to the inferior pair of posterior elements there is perfect agreement among Drs. Broom, Williston and myself regarding their identity and relations. Now as to the proper name. It has been called quadratojugal by me because it lies outside of the quadrate, articulating with its posterior edge and is in part separated by a foramen, the quadrate foramen. It is true that this foramen carries no blood vessels or nerves but it is as persistent as the temporal fenestræ, which carry no vessels or nerves, and is entitled to as much weight in any natural classification. In the Dinosaurs, *Allosaurus* and *Creosaurus* there is a similar element which is only partly separated from the squamosal above, the suture runs part way between the bones and then disappears. In the Dinosaur *Tyrannosaurus* the suture and separation are complete. The relation of the element to the quadrate is exactly as in *Dimetrodon*. In all of these forms the paroccipital comes in contact with this element and in *Tyrannosaurus* with the parietal as well. So the condition in *Captorhinus* and *Labidosaurus* is not unique.

There is no inherent improbability that the element connecting the quadrate with the jugal is the prosquamosal (supratemporal), indeed if the arguments offered above have weight it must be so by exclusion. Other facts, however, may be cited in favor of this idea. The temporal region in the Stegocephalia is covered by the parietal, squamosal, prosquamosal, quadratojugal, and jugal. The prosquamosal is commonly the largest element of the temporal region; it articulates with the postorbital anteriorly, with the jugal below, and in many forms, as *Branchiosaurus*, etc., posteriorly, with the quadratojugal; it overlies the quadrate. The quadratojugal lies on the outer side of the quadrate and frequently extends up behind it; the portion which extends up behind the quadrate articulates with the posterior edge of the prosquamosal. This is exactly the relation of the outer pair of posterior elements in *Captorhinus* and the Pelycosauria.

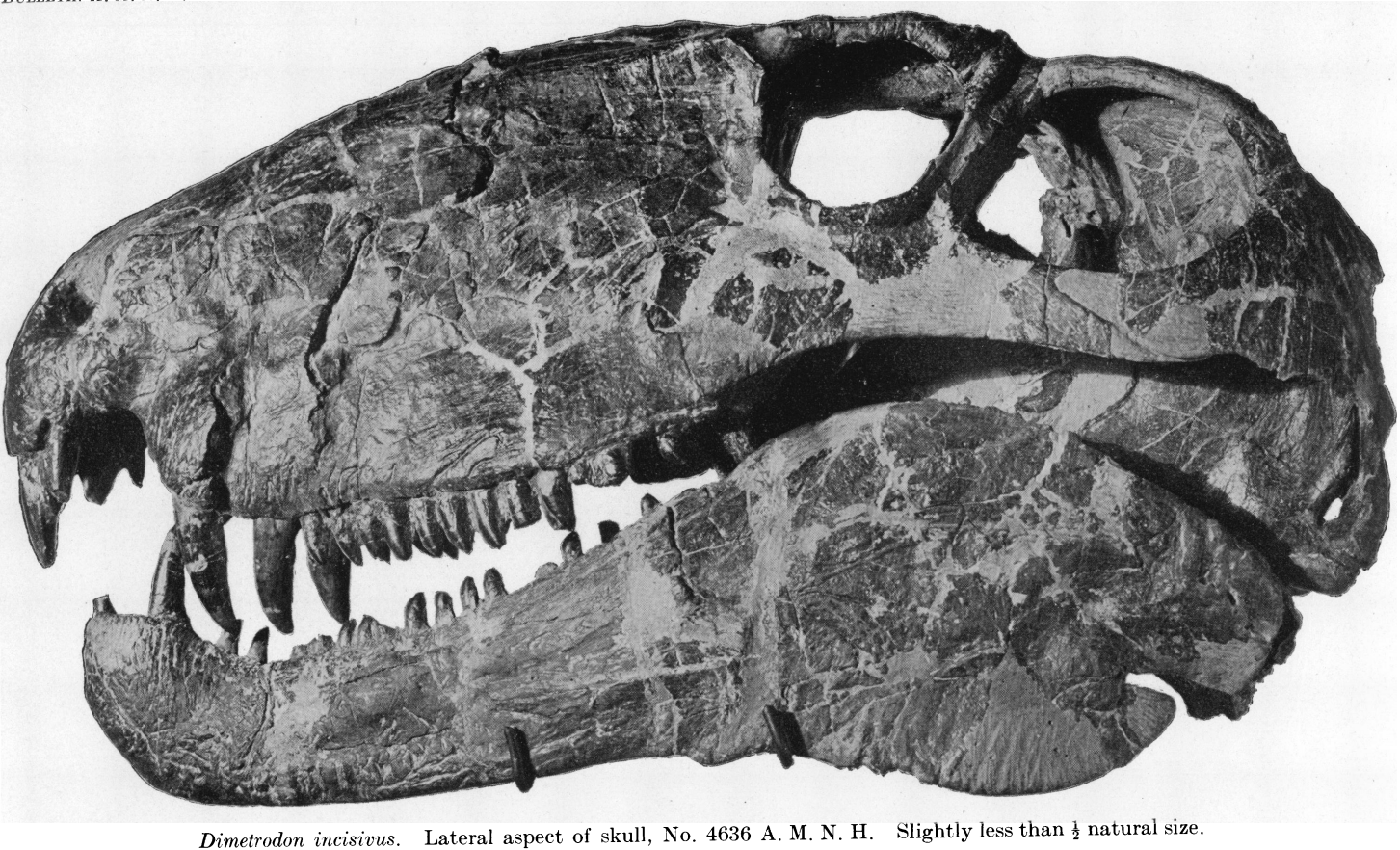
If we assume that this element covering the posterior and outer surface of the quadrate in *Captorhinus, Diadectes* and the Pelycosauria, and separated from the quadrate by a foramen in the last two, is the quadratojugal, then we have in the temporal region the full number of bones of the Stego-

cephalian skull, and this bone is, in many forms, where it articulates directly with the jugal (Rhyncocephalia, Theropodous Dinosaurs and Phytosaurs) unhesitatingly called the quadratojugal. If, on the other hand, we assume this bone to be a new element and the bone anterior to it in Pelycosaurs and Cotylosaurs to be the quadratojugal, the skulls are radically different from the Stegocephalian skulls, having one more element on the posterior surface of the skull, and one less in the temporal region.

The condition of the Pelycosaurian skull gives a hint as to the condition of the skull of *Sphenodon.* Baur claimed that in *Sphenodon* the squamosal and prosquamosal had united in a single element, but Swinnerton and Howse found no trace of any division of this element in even the youngest embryos. Is it not just as probable that the prosquamosal dropped down to the lower edge of the skull and formed the connecting link between the jugal and quadratojugal as that it rose and fused with the squamosal? In *Palæohatteria* the jugal joins the quadrate directly[1] but the squamosal (pr -squamosal?) projects down nearly between them. The quadratojugal, f present, was on the back of the skull. As the Cotylosauria can no longer ɔ considered as the primitive reptilian type, and, as the Rhyncocephalia (ı no longer be considered as derived from them by the simple development f temporal openings, the necessity of finding a prosquamosal bone in the skull of the Rhyncocephalia has passed.

The more definitely the anatomy of the primitive reptiles is known the more apparent it becomes that the theory which places the Rhyncocephalia as a central type directly derived from the Cotylosauria and giving rise to two main branches of Reptilia is inadequate and must undergo a serious reëxamination.

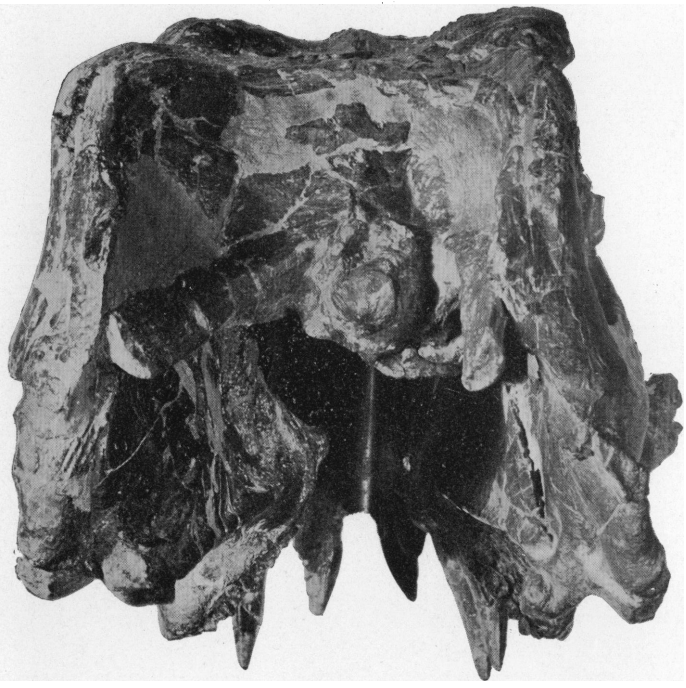
[1] Credner Zeitsch. d. Deutsch. Geol. Gesell., Jahrg. 1888, s. 546.

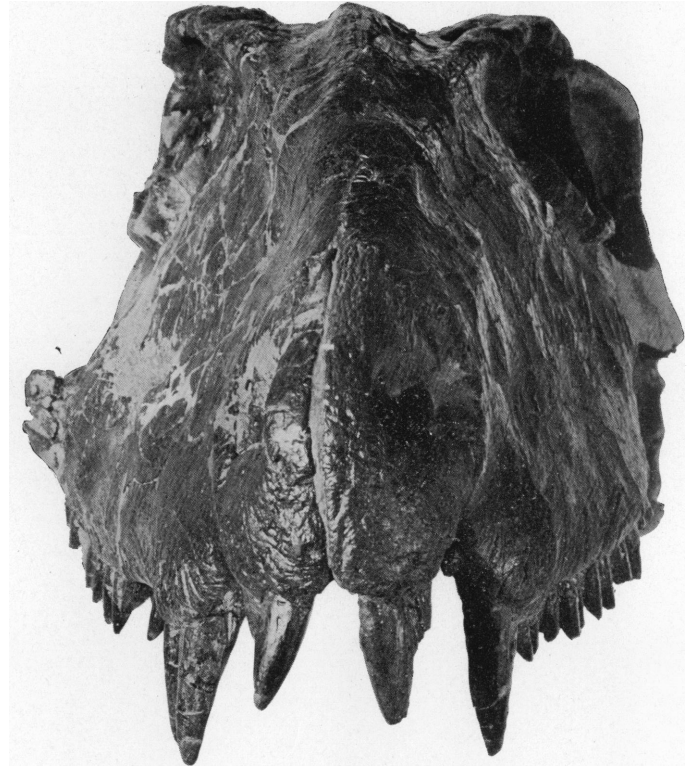


Dimetrodon incisivus. Lateral aspect of skull, No. 4636 A. M. N. H. Slightly less than $\frac{1}{2}$ natural size.

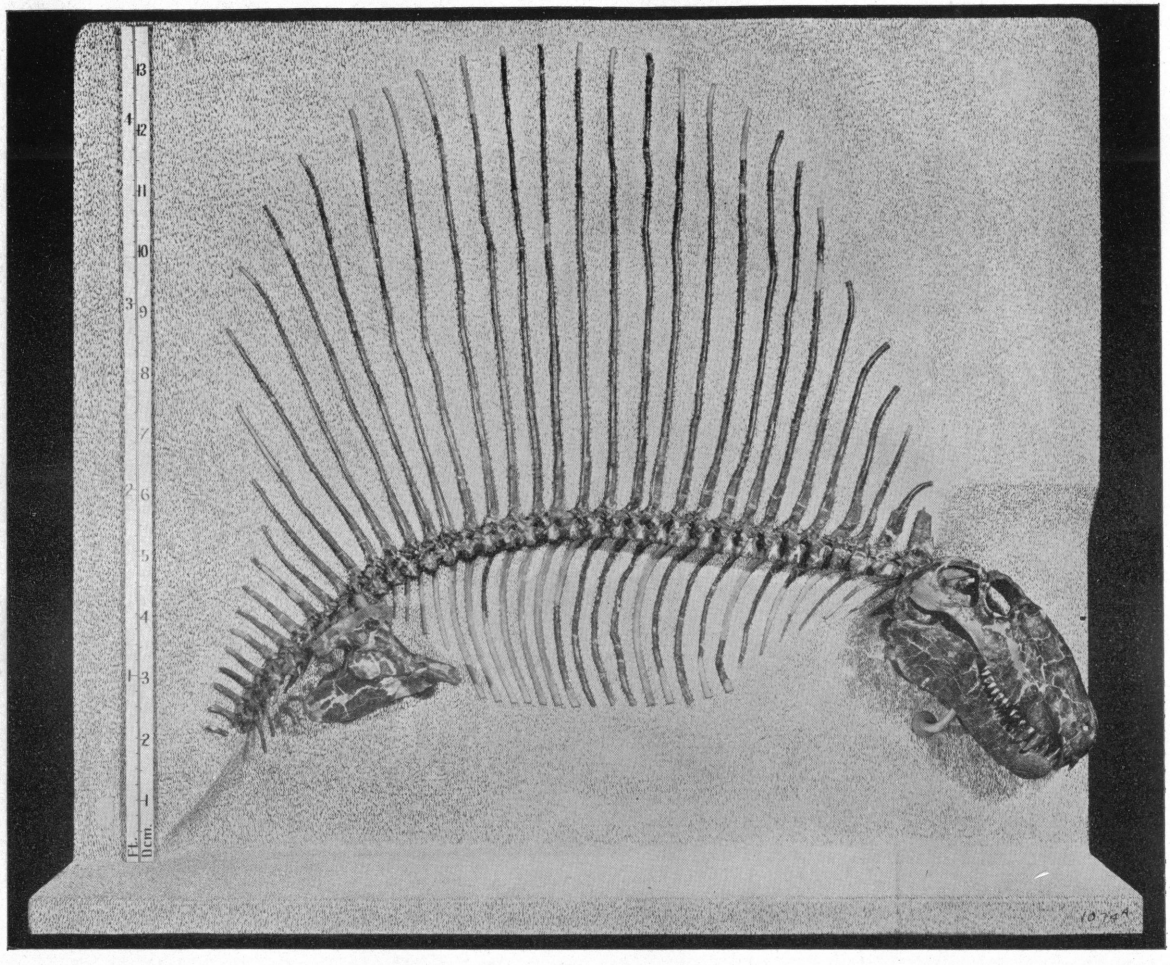
Dimetrodon incisivus. Superior aspect. Less than ½ nat. size.

Dimetrodon incisivus. Inferior aspect of skull. Less than ½ nat. size.





Dimetrodon incisivus. Posterior and anterior aspects of skull. Less than ½ nat. size.



Dimetrodon incisivus, mounted skeleton, No. 4636 A. M. N. H. Mounted by A. Hermann. Greatly reduced. Scale in feet and decimetres.