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# Article XXXIII.—*ANCHICERATOPS*, A NEW GENUS OF HORNED DINOSAURS FROM THE EDMONTON CRETACEOUS OF ALBERTA. WITH DISCUSSION OF THE ORIGIN OF THE CERATOPSIAN CREST AND THE BRAIN CASTS OF *ANCHICERATOPS* AND *TRACHODON*.

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PLATES XXIX–XXXVII.

Remains of the Ceratopsia are comparatively rare in the Edmonton formation, only ten specimens having been seen during four season's work ot the American Museum parties. The rarity of this family in the Edmonton is in marked contrast to the Lance and Belly River formations where their remains are numerous. As the Edmonton is of brackish water origin and chiefly of water deposition the environment may not have been suitable to their presence in great numbers, certainly not to their preservation although remains of Trachodont dinosaurs are far more numerous than they are in the Lance.

The genera *Triceratops* and *Torosaurus,* so characteristic of the Lance formation, have not as yet been found in the Edmonton but two genera not heretofore known represent the family.

One genus, the subject of the present paper, is a large form represented in the collection of the American Museum by three fragmentary skulls and a separate supraorbital horn. Besides showing a unique type of crest this genus adds one more link in the morphological chain by which the ceratopsian crest has been developed.

## **Anchiceratops ornatus** gen. et sp. nov.

*Type of genus and species* No. 5251, an incomplete skull, anterior end and top of supraorbital horns missing.

*Horizon and locality.* Edmonton formation, 50 ft. above river, 7 miles below Tolman Ferry, Red Deer River, Alberta, Canada.

Paratype, No. 5259, brain-case and supraorbital horns nearly complete. Same horizon and locality as type.

*Generic and specific characters:* Skull large. Supraorbital horns rising close together, massive at base and divergent, curving outward, then forward. Crest large, thick and flat with small lateral fontanelles; border ornamented by large epoccipital bones; a pair of short knob-like processes on superior posterior end of crest. Squamosal intermediate in length between *Monoclonius* and *Triceratops*.

The type specimen is the skull of an old individual in which the elements have reached the maximum development and so united that the sutures are in some places difficult to determine. When found most of it had weathered out. The ends of the supraorbital horns and all that part of the skull anterior to the frontals had evidently been broken away previous to fossilization as the fractured parts were covered over by sandstone.

The paratype was found a few miles further down the river in a gypsiferous clay stratum in which *Ostrea* and *Leurospondylus* occur. Some of the nerve openings were slightly crushed on one side but thanks to the skillful work of Mr. Otto Falkenbach a unique cast of the brain cavity has been made showing the semicircular canals for the first time in the Dinosauria.

A third specimen is a poorly preserved skull of a young individual broken in such manner that it exactly duplicates the parts preserved in the type. It verifies the characters pointed out in the type.

The extraordinary development of the epoccipital bones, the close-set, knob-like processes on the posterior end of the crest and the fontanelles give an unusual appearance to the skull. In each specimen the bone that forms the brain-case as well as that of the crest is unusually thick, with such surfaces as were not deeply embedded in muscle, furrowed by wide vascular grooves.

The crest (Plates XXIX and XXX) is broad, flat and quadrilateral in outline and on the upper surface is composed of three elements, as in other genera of the family; paired lateral bones suturally distinct and a median element, which is interpreted as the fused postfrontals ('parietals').

*Styracosaurus albertensis* Lambe (Ottawa Naturalist, Vol. XXVII, No. 9, pp. 109–116, 1913), from the Belly River formation, resembles *Anchiceratops* in some respects and may have been its ancestor. In both the crest is comparatively flat with occipital bones unusually developed but in this later form the squamosals are progressively lengthened, the lateral fontanelles are reduced and the exoccipitals are shortened. The development of the supraorbital horns is also distinctive.

The lateral paired bones are the squamosals, their relation to other elements precluding any doubt as to identification. The squamosal is elongate and terminates just in front of the third epoccipital bone counting from the rear, opposite the posterior border of the fontanelle. It is intermediate in length between that of *Monoclonius* and *Triceratops*. In front its extent cannot be determined above the free border but posteriorly it is well defined. The extreme anterior border is concave and the angle formed by the two borders is produced into a sharp process followed by the epoccipital bones.

The epoccipital bones are one of the most striking features of the skull.

They are extensive, covering the margin of the crest completely, all firmly coössified to the underlying bone but with sutural union distinct. On the squamosal there are six, the anterior five about equal in size, the sixth very much larger. This last large one is missing from the left side. Following these on each side are three epoccipitals equally of enormous size. They are attached to the border of the postfrontals ('parietals') and directed backward and outward. The surface is slightly roughened and they taper from the thick elongate base to the rounded point and thin borders.

Immediately above the base of the last epoccipital is a pair of massive, short, curved processes suturally united to each other and in the type specimen not distinct from the postfrontals below. In the skull of the young specimen, No. 5273, however, one of these processes was taken off and found to be united by suture to the supporting bone. They are large and curve outward ending in short blunt points. They differ slightly in form and position from the hook-like processes of *Monoclonius* but, as in that genus, probably served as attachment for muscles and were not sheathed in horn.

It is not yet clear, in the classification of the Ceratopsia, how much importance should be attached to the development of the horns and the peripheral outgrowths of the skull. The horns may have been of some use as offensive and defensive weapons but there is so much variation in size in closely related species that I am inclined to regard them as a sexual character. The epoccipital bones probably served the same purpose as similar structures in the living *Phrynosoma*. These excessive outgrowths were gradually reduced as the animals became more specialized and are subject to considerable individual variation.

The fontanelles are about half as large as in *Monoclonius* and wholly within the boundary of the postfrontals. This reduction of the fontanelles has been brought about by backward growth of the thin lateral walls, clearly foreshadowed in the skull of *Monoclonius*.

Anteriorly the thick central part of the postfrontals diverge to surround a small median oblong fossa which in the paratype has been freed of matrix. It opens into a large central chamber on each side underneath the supraorbital horns. These passages are entirely enclosed and do not communicate with the supratemporal fenestræ, but in front they communicate with the orbital cavity by a round opening 35 mm. in diameter, situated on the upper anterior border of the orbit 65 mm. from the outside. These passages do not communicate with the brain and probably related to the circulatory system.

Where the postfrontals diverge to form the border of the postfrontal fossa they are smooth bars over which blood vessels passed into the fossa from the supratemporal fenestræ. They are slightly below the rugose surfaces in front and behind and in some specimens of *Triceratops* figured by Hatcher are entirely closed over by the upper surface of the postfrontals.

Lateral to the postfrontal fossa but distinct from it are the supratemporal fenestræ. These are at first elongate, narrow passages, the posterior border of which is formed by the squamosal and postfrontal. They open as in *Triceratops* posteriorly, this position having been brought about by the postfrontals overgrowing the parietals. Under the overhanging postfrontals they expand to large passages that communicate on the side of the face with the laterotemporal fenestra and open below in front of the quadrate. To the writer there seems little doubt of the identification of these passages.

The supraorbital horns (Plates XXXI and XXXII) are large as in *Triceratops* but differ in curvature. They approach each other in midline at the base nearer than in any described specimen of *Triceratops* except one figured by Hatcher (*loc. cit.*, pl. xxxvii) as *T. sulcatus*. They rise first upward and outward for a distance of half their length and then curve forward to the end and are divergent from origin to termination.

The orbit is large and circular, but the extent of the surrounding elements cannot be determined. The jugal forms the lower border of the orbit and continues down to overlap the quadrato-jugal. At the point of union a large pyramidal-shaped epijugal is attached equally to the jugal and quadrato-jugal. In *Triceratops* it is attached only to the jugal.

The laterotemporal fenestra is slightly larger than in *Triceratops* and as in that genus bordered by the jugal, the quadrato-jugal and the squamosal.

On the occipital of the type specimen the sutures separating the exoccipitals from the squamosals and the upper border of the parietals are well defined and the lower border of the parietal is indicated. In the paratype (Plate XXXIII) both upper and lower borders of the parietal are well defined. They have about the same extent as shown in the reproduction of *Triceratops horridus* (Monograph of the Ceratopsia, p. 121) where the elements are correctly identified.

The quadrate and quadrato-jugal are similar in form and extent to those of *Triceratops*.

*Measurements.*

| | mm. |
|---|---|
| Width of squamosals, widest part | 1300 |
| " between orbits, top of border | 340 |
| Greatest length of squamosal, antero-posteriorly, outer border | 320 |
| " " " three posterior epoccipital bones | 180 |
| Postfrontal fontanelle diameter, antero-posteriorly | 240 |
| " " " transversely | 175 |
| Width postfrontal narrowest part between fontanelles | 85 |
| Diameter of horns at base, anteroposteriorly, paratype | 150 |
| Height of horns above superior border of orbit | 570 |
| Width across ends of horns, restored | 950 |

## Origin of the Ceratopsian Crest.

If we compare a series of skulls (Text-fig. 1) of *Monoclonius*, *Anchiceratops* and *Triceratops*, representing respectively the succeeding geological formations, Judith River, Edmonton and Lance, the squamosals are seen to lengthen in each succeeding type and the lateral fontanelles, which were very large in *Monoclonius*, are much reduced in *Anchiceratops*, and have entirely disappeared in *Triceratops*. Thus we see a gradual backward extension of the squamosal correlated with a lateral expansion of the central part of the crest.

This central part of the crest has received a variety of interpretations. Marsh first identified it as the fused parietals, an interpretation that has been followed by most writers, including Hatcher and Lull in the Monograph of the Ceratopsia, (Monograph 49, U. S. Geol. Surv., 1907). Dr. O. P. Hay (Proc. U. S. Nat. Mus., Vol. XXXVI, pp. 95–108, 1909) showed that this interpretation could not be accepted and suggested (p. 97) that this part of the crest might be the fused supratemporals or possibly coalesced nuchal bones such as are found in the crocodiles. Later von Huene (Neues Jahrbuch für Min., Geo., Pal., 1911, Bd. II, pp. 146–162) identified the anterior end of the central part as parietal and the posterior end as a dermo-supraoccipital, an interpretation that from latest discoveries does not seem acceptable.

From the progressive lengthening of the squamosal in succeeding Ceratopsia it is evident that the central portion of the crest was developed first, probably as a posterior bar analogous to the crest of *Saurolophus*, a genus of the Trachodontidæ recently described by Brown (Bull. Am. Mus. Nat. Hist., Vol. XXXI, pp. 131–136, 1912).

In *Saurolophus* the parietal does not enter into the composition of the crest, the suture separating them being well defined. The crest is composed of the prefontals, frontals, and nasals. In the Ceratopsidæ the frontals are short, terminating in front of the orbit. But the postfrontals which support the supraorbital horns are apparently carried back as a solid continuous bar on each side uniting back of the postfrontal fossa to form the central portion of the crest.

Thus in the Ceratopsidæ the top part of the skull has continued to grow backward pushing the parietal downward so that no part of it appears on the upper surface. The extent of the parietals as well as of the supraoccipitals is clearly shown in the figure of *Triceratops horridus* (Monograph of the Ceratopsia, p. 121).

From the series of Ceratopsid skulls now in the American Museum it seems clear that the posterior crest is composed of the two lateral squamosals and the fused central postfrontals.

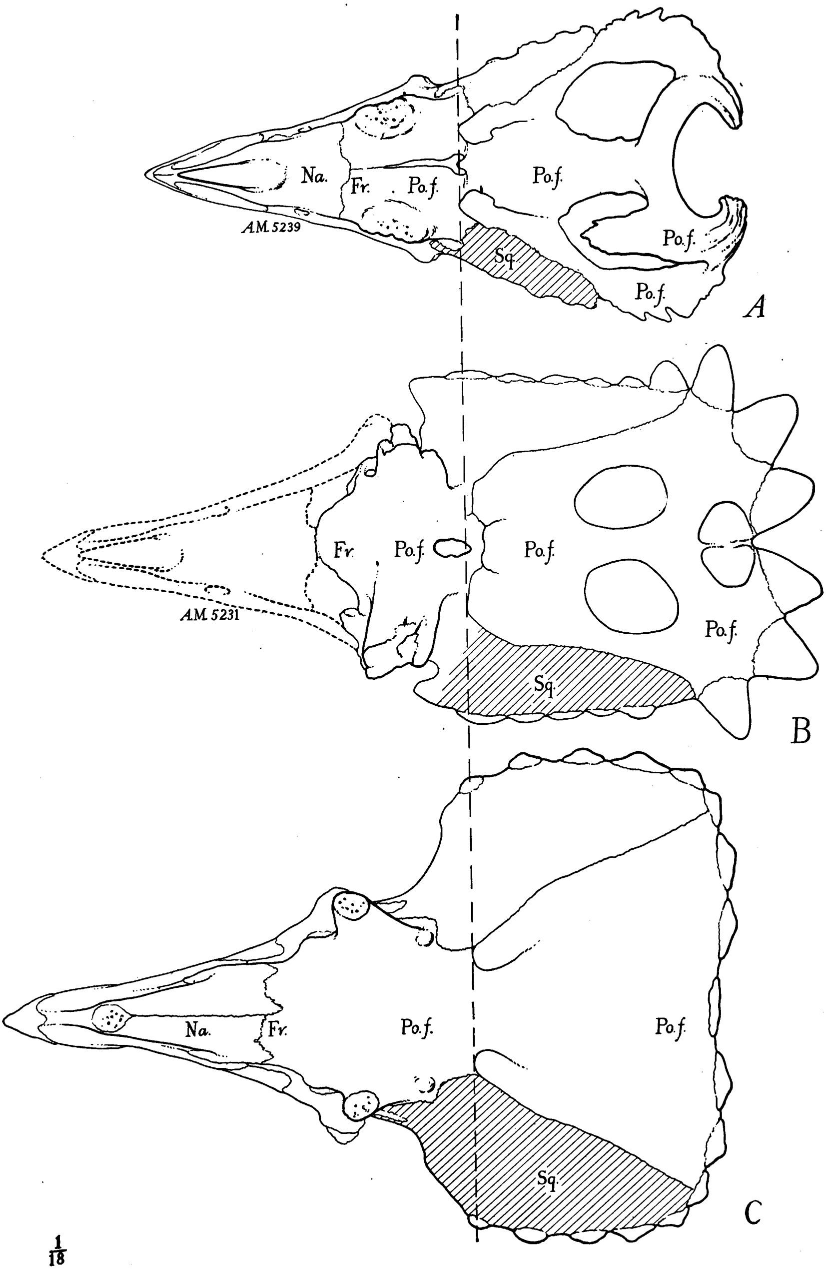



**Fig. 1. Outline of Ceratopsian skulls showing progressive lengthening of squamosals.** A, *Monoclonius;* B, *Anchiceratops;* C, *Triceratops.*

## Brain Casts of *Anchiceratops* and a Trachodont.

In the course of preparation of the paratype it was possible to make a cast of the brain (Plates XXXIV and XXXV) that in accuracy of detail has rarely been equalled in fossil crania. In this cast, as in all others prepared under my direction, the nerve courses have been continued through the brain-case to the point of exit at which the surrounding bone converges to form the opening. This method exaggerates the length of the nerves as well as their diameter at the terminal section but it is the only way to show the fenestræ, the course of the nerves and the thickness of the investing walls of the brain-case at such points. In this specimen the normal direction of part of the fifth and seventh nerves has been changed through crushing and the cerebral hemispheres are crushed almost flat.

As has been remarked by other writers, the form of the brain in reptiles can only be deduced approximately from the cast of a brain cavity because the brain is loosely invested in the dura mater and does not completely fill the cavity. I find, however, that in the Dinosauria the form of the brain and its divisions are most clearly defined in the carnivorous forms.

However diverse may be the modification of external bones of the skull those forming the inner walls of the brain-case have the same definite relation to each other throughout the Dinosauria. Each has a constant relation to a definite part of the brain, and there is slight variation in the nerve exits. If the nerves can be determined accurately the brain becomes the final arbiter of those elements that enclose it.

It may be remarked that all of the elements of the reptilian skull are recognizable in the Trachodontidæ, that the skull differs in minor respect from the Iguanodontidæ, and is of a much more generalized type than that of the Ceratopsidæ. A fragmentary uncrushed brain-case (Plate XXXVI) of a Trachodont dinosaur, No. 5236, collected in the Edmonton formation in 1911, offered exceptional opportunities for comparison with the brain of *Anchiceratops*, consequently it was sectioned and a cast made of the cavity (Plate XXXVII). In this specimen the supraoccipital and parietal are complete and the posterior half of the alisphenoid is present; that part of the brain-case that enclosed the cerebral hemispheres is missing.

The dinosaur brain can readily be divided into three general regions, cerebrum, cerebellum and medulla oblongata. Invariably the brain cast in a dorsal view shows a marked constriction on the sides between the medulla oblongata and the cerebellum. This constriction is formed by the enlarged otic mass marking the position of the semicircular canals. In the side view of the Trachodont brain-case (Plate XXXVII, B) there are six openings visible and almost in line. The anterior and largest of these is the foramen ovale for transmission of the three divisions of the fifth or trigeminal nerve. It is almost circular in outline, 17 mm. in diameter where it opens into the brain, and 27 mm. in diameter on the outside of the brain-case. Following this is a small opening which on the outside is divided by a narrow transverse bridge of bone, the upper division passing upward and backward, the lower division continuing downward on the side of the brain-case as an open channel. Both of these divisions are considered to be the passage of the seventh or facial nerve. Immediately back of the exit of the seventh nerve is seen a large somewhat square depression at the lower end of which a canal penetrates directly into the brain cavity. This circular canal, 4 mm. in diameter, is undoubtedly for the passage of the eighth or auditory nerve. Immediately in front of it at the base of the depression a funnel-shaped opening extends downward and backward within the mass of bone below the bridge of the seventh nerve, and immediately above it there is a larger opening which extends inward and upward into the otic mass but does not penetrate the inner wall of the brain-case. In this specimen and also in the brain-case of *Anchiceratops* these openings were sectioned independently and thoroughly explored. The former funnel-shaped opening is undoubtedly the fenestra rotunda enclosing the cochlea, the nature of which could not be determined. The upper, larger opening is the fenestra ovalis which continues into the semicircular canals. In this specimen the matrix was so hard that the semicircular canals were explored only on the left side and do not appear in the brain-cast on the right side. These canals have the normal reptilian position and open freely from one to the other with distinct ampullæ at the origin, but the horizontal is much shorter and smaller than either the anterior or posterior divisions. Immediately back of the eighth nerve is a depression in the bottom of which there is a large elliptical opening with the greatest diameter vertical. This foramen passes in just back of the otic mass and slightly above the internal opening of the eighth nerve. It is the foramen lacerum posterius, the common opening for the ninth, tenth and eleventh nerves. On the inner side of the brain-case just back of and below the foramen lacerum posterius there is a small foramen which runs upward and then opens into it, probably the passage of the jugular vein. Back of the common passage of the ninth, tenth and eleventh nerves there is a smaller foramen which opens into the depression of the foramen lacerum posterius, probably a passage for the transmission of the anterior condyloid artery. Back of the anterior condyloid foramen in line with the other openings is the large foramen for the transmission of the twelfth nerve. In the longitudinal section of this brain-case the union and extent of the elements forming the brain-case are clearly shown, and besides the foramina before mentioned there is just below the seventh and about 10 mm. behind the fifth, the opening for the sixth nerve which passes directly forward through the basisphenoid.

On the upper surface of the brain-case there are five foramina which appear on the cast as processes of the cerebellum. They are invariably situated in suture lines and all probably transmitted veins. The central one on top and the next below it on each side are situated in the suture between the parietal and the supraoccipital and in life undoubtedly passed through the brain-case. The largest of these diverticulæ on each side is directly above the foramen ovale and 25 mm. from it, between the parietal and the proötic. In other brain casts of *Trachodon* and *Tyrannosaurus* there are additional diverticulæ given off from the cerebral hemispheres which mark the suture line between parietal and frontal.

These diverticulæ are most important in determining the position and extent of the parietal. They vary in number but are present in all casts that I have examined of *Trachodon, Triceratops, Anchiceratops* and *Tyrannosaurus* wherever the brain-case has been carefully sectioned and probed. In *Triceratops* and *Anchiceratops* there are two large processes on the cerebellum and two on the cerebrum and in *Anchiceratops* they pass into but do not penetrate the suture lines shown in Plate XXXIII defining the extent of the parietal.

In the brain-case of *Anchiceratops* the nerve openings follow the same plan as those of *Trachodon* with the following exceptions. In the crowding back of the skull elements the alisphenoid has entirely enclosed the ophthalmic branch of the fifth nerve, $V^1$ which passes entirely through it whereas in *Trachodon* $V^1$ is indicated simply as an uncovered channel. In this specimen the semicircular canals were opened and the cast made from them, but the cochlea was not preserved, if indeed it is present as a distinct division in this form. This specimen shows clearly that Dr. Hay (*loc. cit.*) was in error and that Hatcher was correct in describing the opening of the ninth, tenth and eleventh nerves. This opening does appear as Hatcher has described it just in front of the twelfth nerve, back of that part of the exoccipital which extends down to the basioccipital process. It extends forward, however, and opens into the brain-case with the eighth nerve in the present case. The passage appears to be broken on both sides in this specimen. On the inside of the brain-case shown in the cast (Plates XXXIV and XXXV), between the common opening of the ninth, tenth, eleventh, and that of the twelfth nerves there is a small opening determined, as in *Trachodon* as the anterior condyloid foramen for transmission of a vein. Opening directly from the foramen ovalo on the left side are two small canals that pass into the brain at the base of the seventh. These were probably for transmission of veins. The pituitary body is quite large and shows at its posterior end a long central process and on either side the entrance of the carotid arteries. Anteriorly there are two similar processes, the ophthalmic branches of the internal carotid artery.

## EXPLANATION OF PLATES.

Plate XIX. Skull of *Anchiceratops ornatus*, type, one twelfth natural size. A, side view; B, dorsal view of crest.

Plate XXX. Skull of *Anchiceratops ornatus*, type, one twelfth natural size. A, ventral view of crest; B, anterior view, postfrontal fontanelles showing through supratemporal fenestræ.

Plate XXXI. *Anchiceratops ornatus*, paratype, front view, one seventh natural size.

Plate XXXII. *Anchiceratops ornatus*, paratype, side view, one seventh natural size.

Plate XXXIII. *Anchiceratops ornatus*, paratype, occipital view, one third natural size.

Plate XXXIV. *Anchiceratops ornatus*, brain cast of paratype, nearly three fourths natural size. A, dorsal view; B, right side.

Plate XXXV. *Anchiceratops ornatus*, brain cast of paratype, nearly three fourths natural size. A, oblique side view; B, ventral view.

Plate XXXVI. Trachodont brain-case, No. 5236, incomplete, two thirds natural size. Right half, outside and inside views.

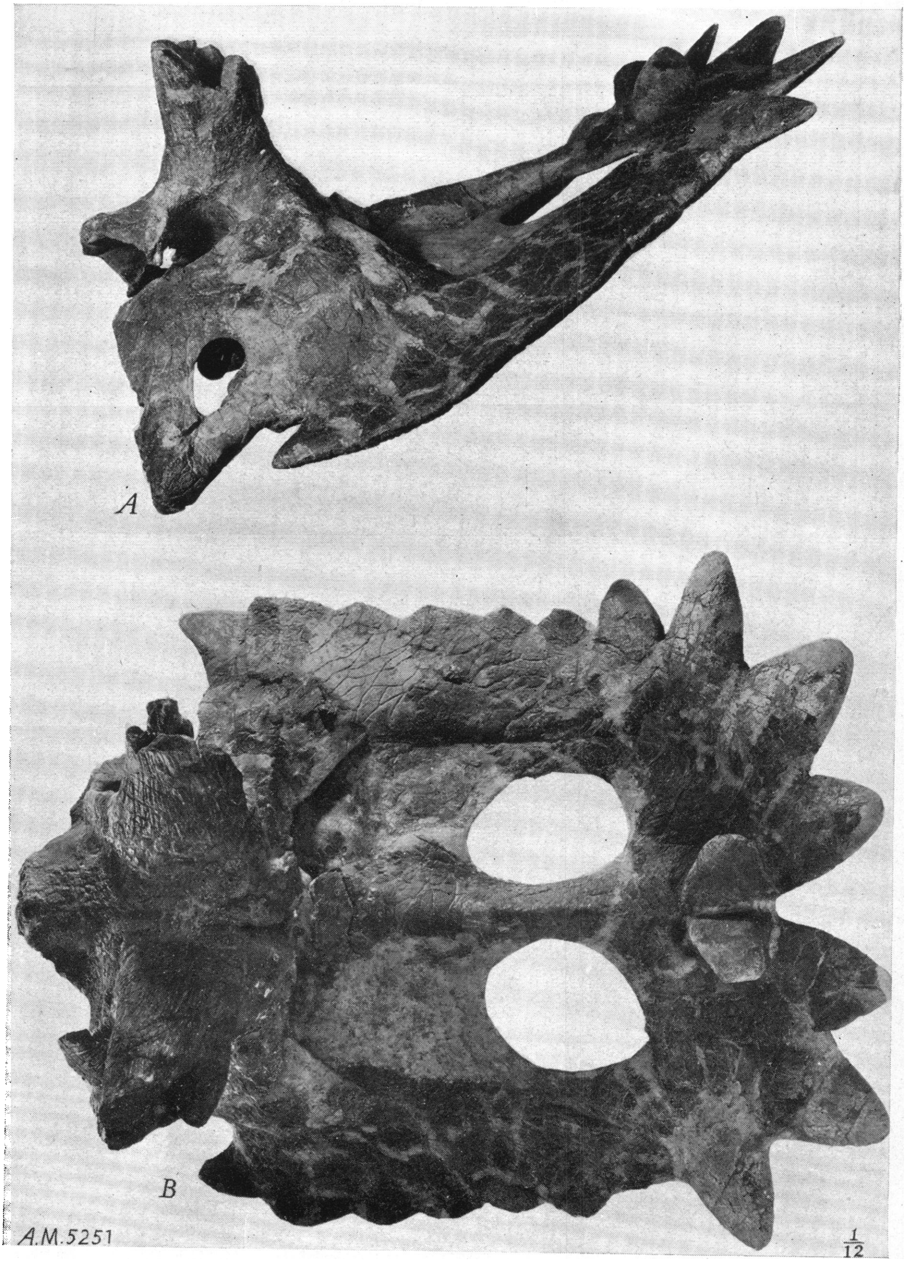
Plate XXXVII. Trachodont brain cast, No. 5236, incomplete, three fourths natural size. A, dorsal view; B, side view; C, ventral view.

### *Abbreviations, Plates XXXIII–XXXVII.*

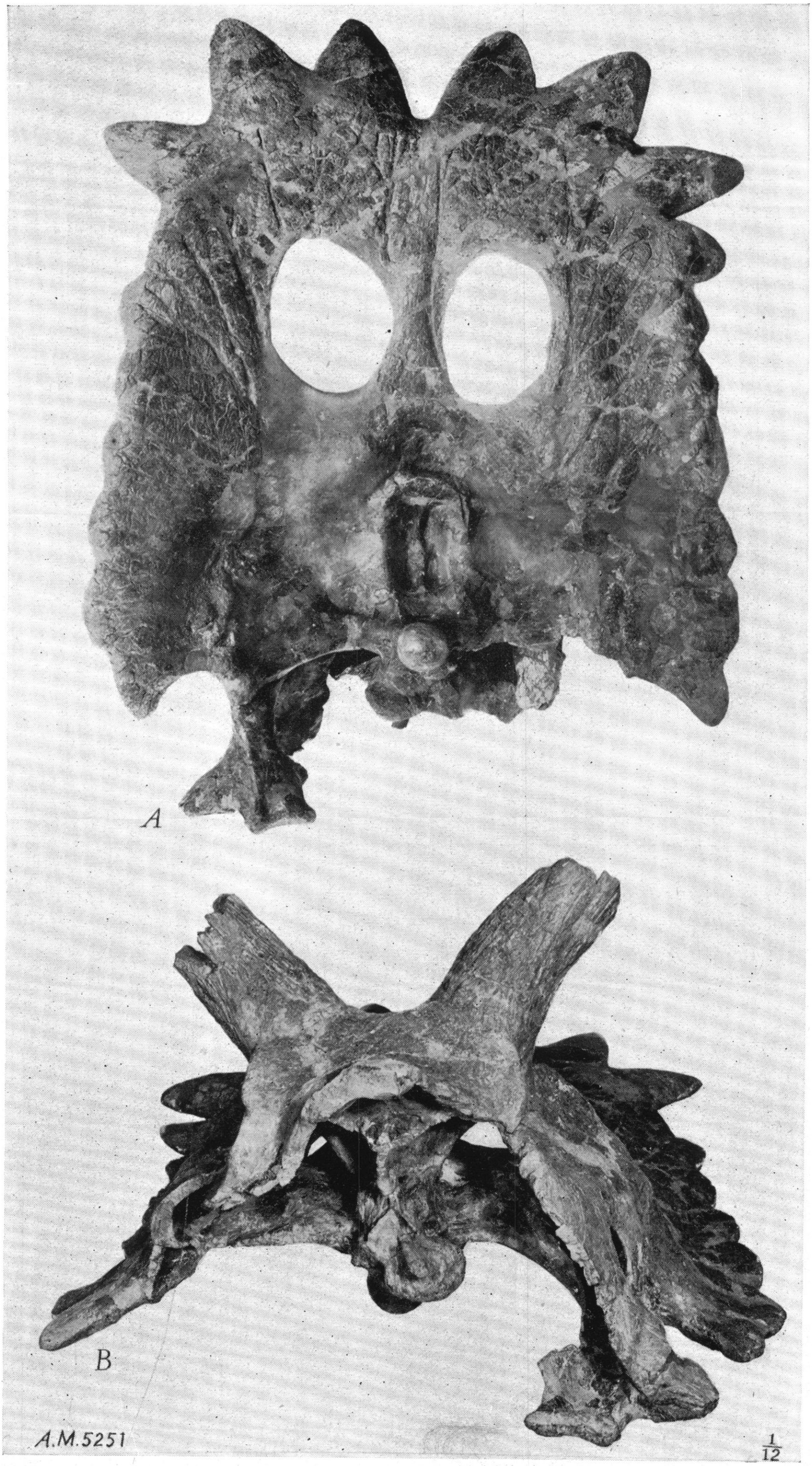
*a.c.f.*, anterior condyloid foramen.
*Al.sp.*, alisphenoid.
*a.s.c.*, ascending semicircular canal.
*B.oc.*, basioccipital.
*B.sp.*, basisphenoid.
*car.*, entrance of carotid artery into pituitary fossa.
*Cbl.*, cerebellum.
*cbl.p.*, process of cerebellum.
*cer.*, cerebrum.
*Cer.p.*, process of cerebrum.
*Ex.oc.*, exoccipital.
*f.o.*, fenestra ovalis.
*f.r.*, fenestra rotunda.
*h.s.c.*, horizontal semicircular canal.
*j.v.*, passage of jugular vein.
*med.*, medulla oblongata.
*op.a.*, ophthalmic branch of internal carotid artery.
*Pa.*, parietal.
*pit.*, pituitary body.
*p.s.c.*, posterior semicircular canal.
*Pr.ot.*, proötic.
*S.oc.*, supraoccipital.
*, veins and diverticulæ.

### *Cerebral nerves.*

I, olfactorii.
II, optici.
III, motores oculorum.
IV, pathetici.
V, trigemini.
VI, abducentes.
VII, faciales.
VIII, auditorii.
IX, glossopharyngei.
X, pneumogastrici.
XI, accessorii.
XII, hypoglossi.




ANCHICERATOPS ORNATUS. Type.

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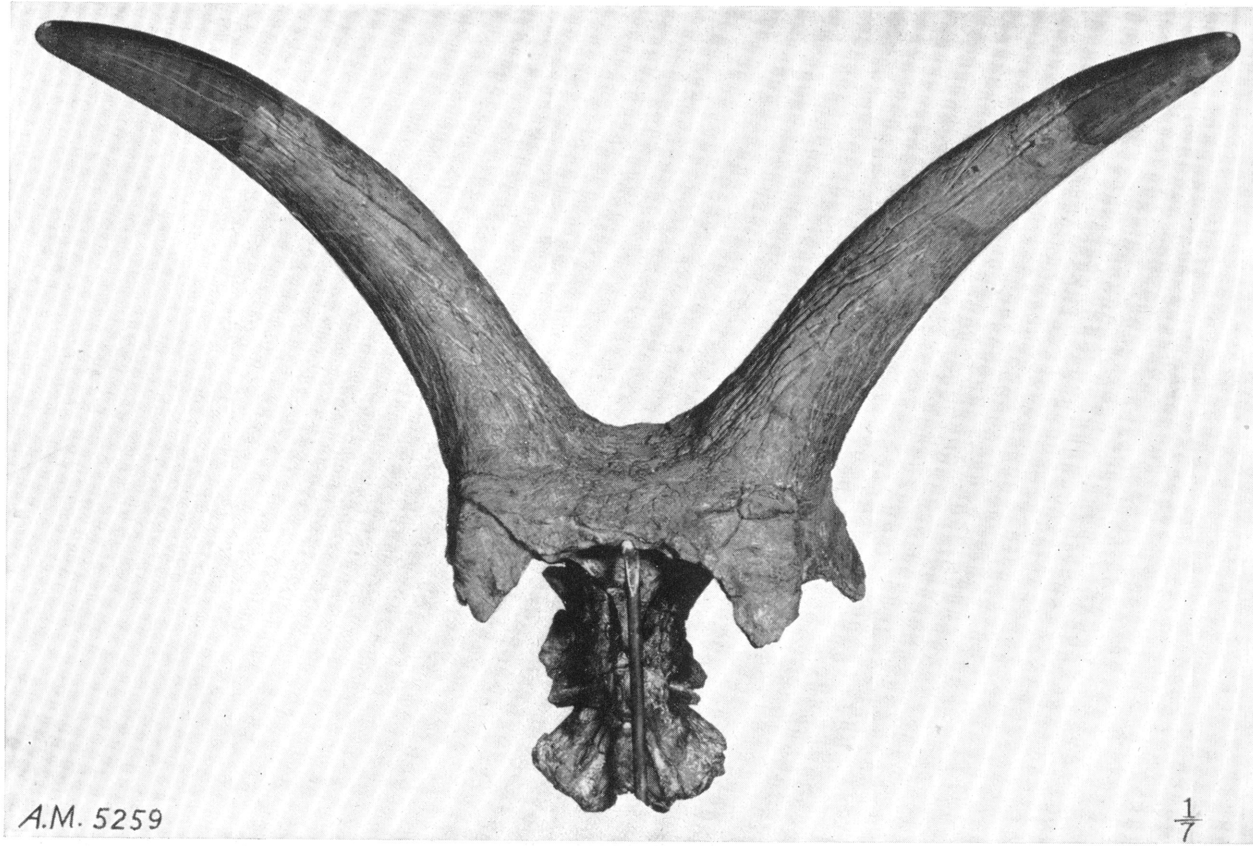
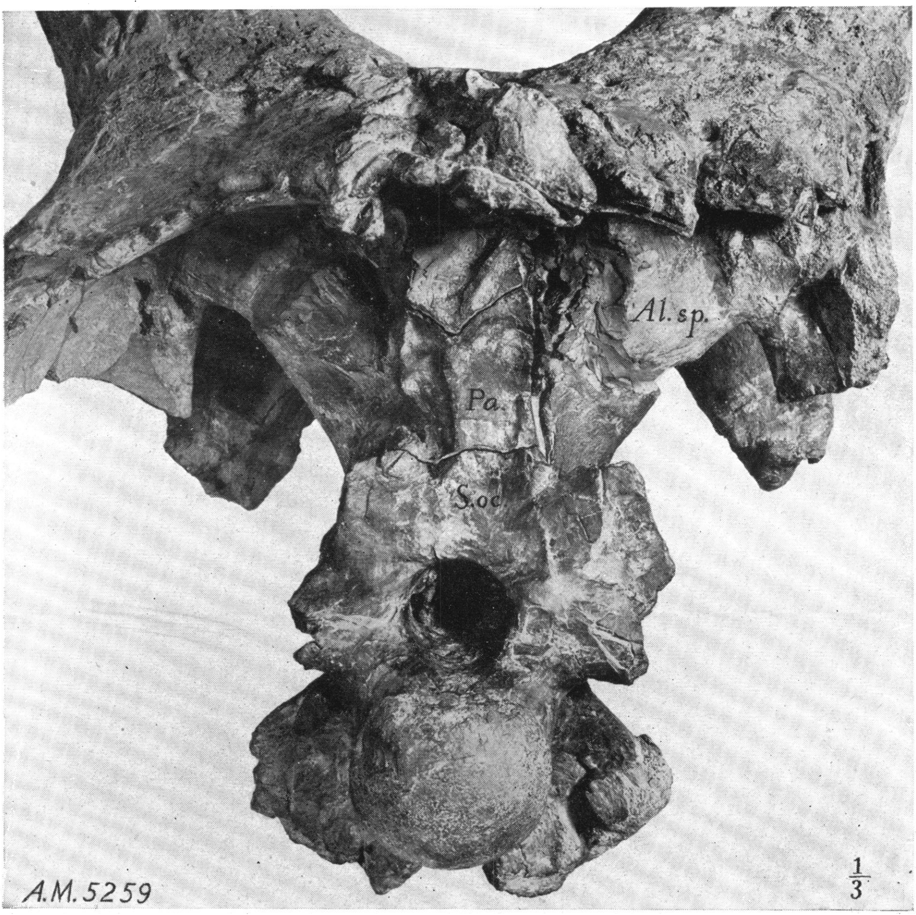
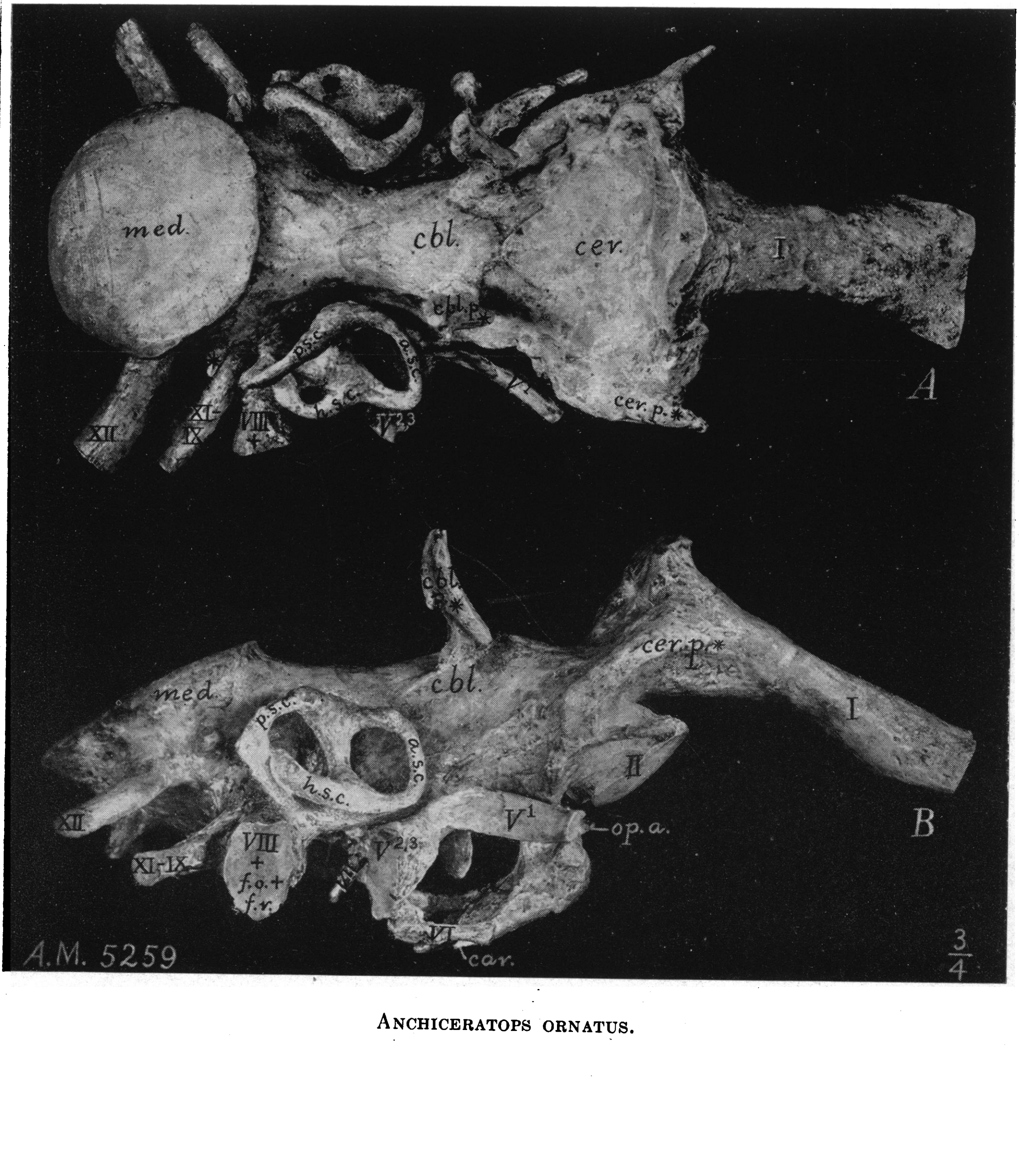



ANCHICERATOPS ORNATUS. Paratype.


ANCHICERATOPS ORNATUS. Paratype.

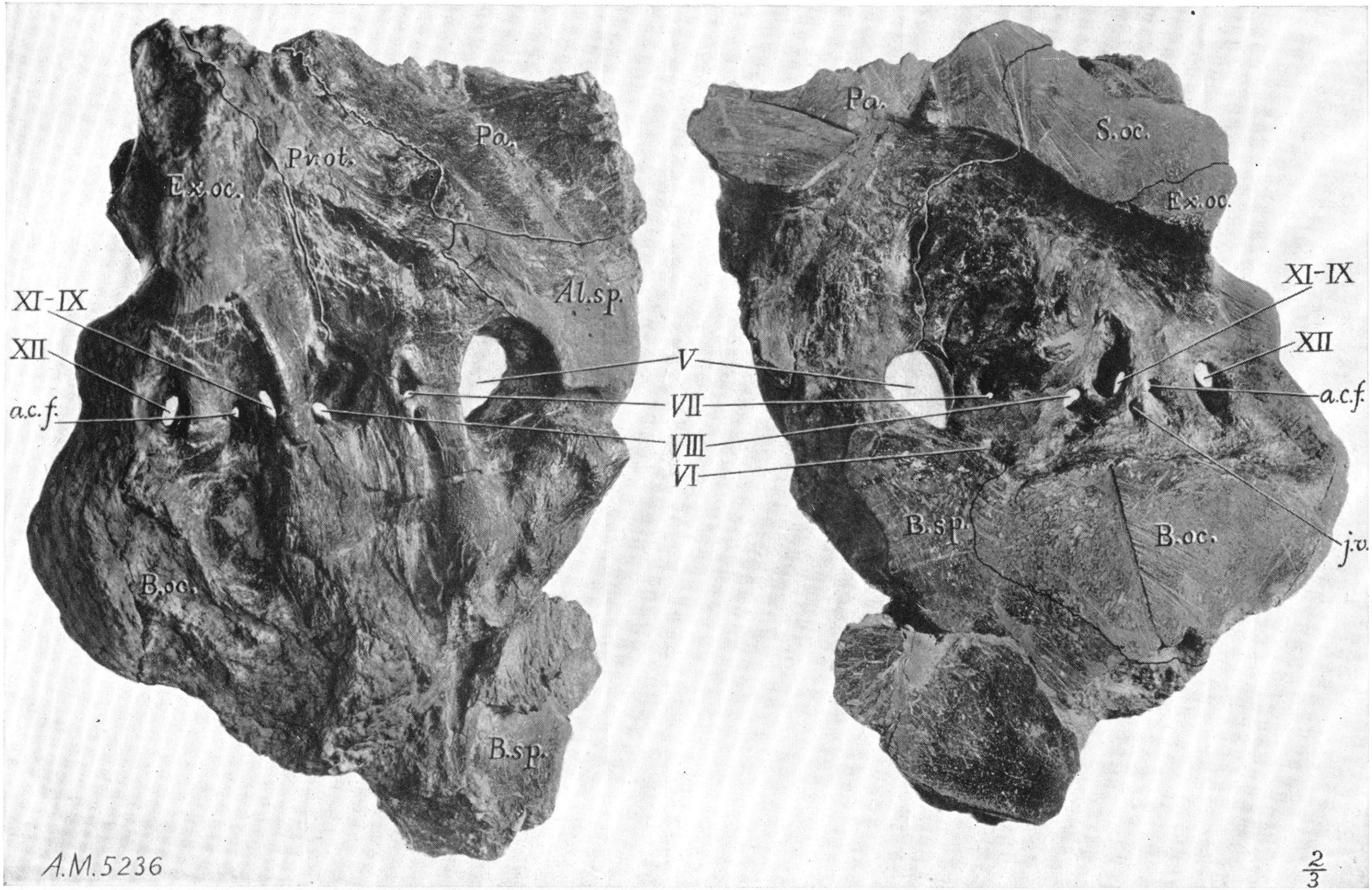



ANCHICERATOPS ORNATUS. Paratype.




Anchiceratops ornatus.


ANCHICERATOPS ORNATUS.


Pa.
Pr.ot.
Ex.oc.
Al.sp.
XI-IX
XII
a.c.f.
V
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A.M.5236
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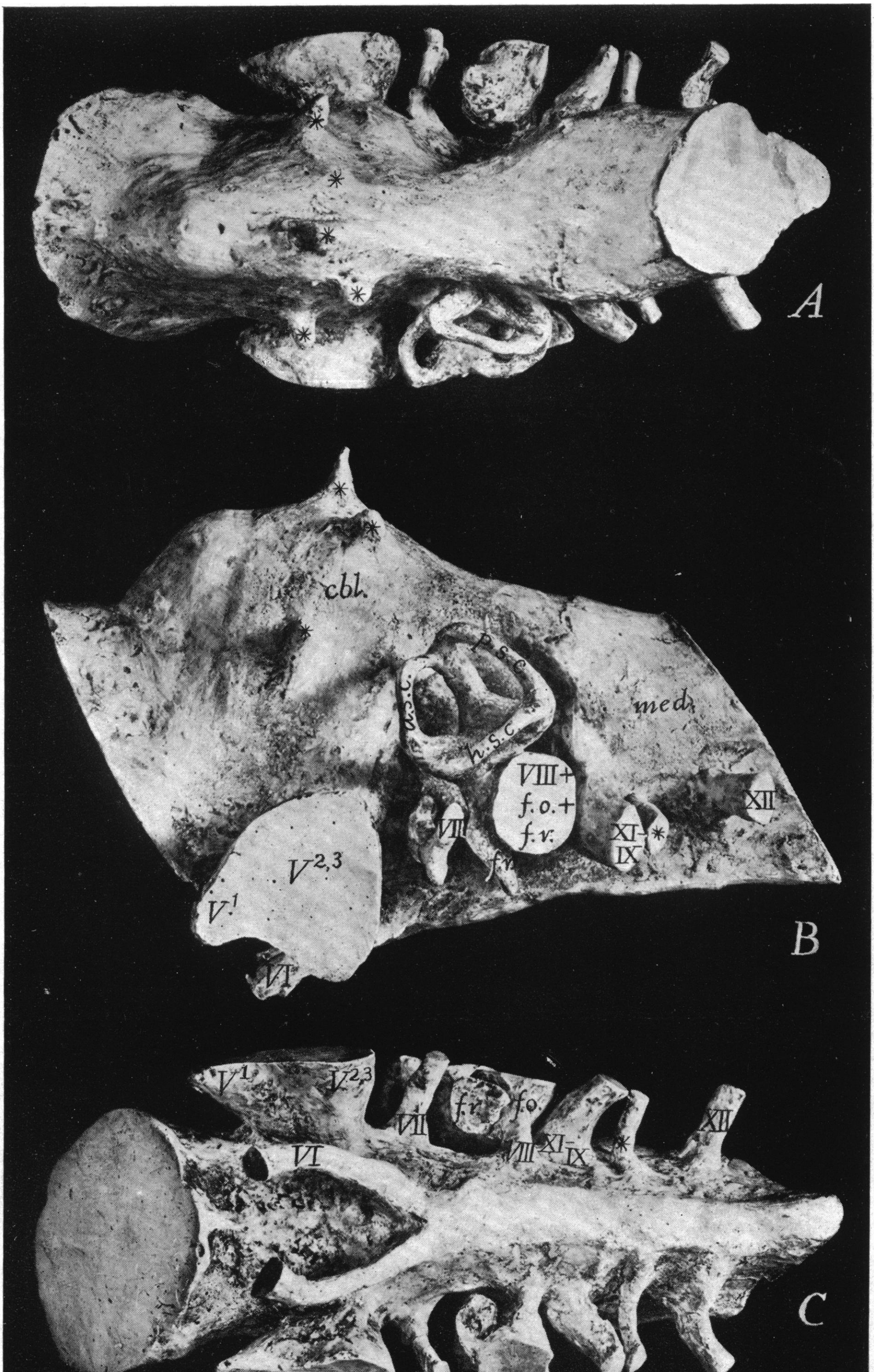
Trachodont.


A
cbl.
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VIII+
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TRACHODONT.