A NEW RESTORATION OF TRICERATOPS, WITH NOTES ON THE OSTEOLOGY OF THE GENUS.

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INTRODUCTION.

The life appearance of *Triceratops* has been depicted by numerous paintings and by at least three model restorations. During the years that have passed since most of these restorations were prepared, the discovery of many new specimens and especially of well-preserved skin impressions has added greatly to our knowledge of the probable life appearance of the horned dinosaurs. The accompanying photographic reproduction, made from a recently prepared model, aims to embody all of the evidence of recent discoveries and also to express my conception of this animal in the flesh. (See pl. 3.)

The model is based upon the mounted skeleton[1] in the United States National Museum made to one-fourteenth the linear dimensions of the original skeleton. It will be noticed that the head is quite different from the skull on the skeleton and in explanation it should be said that the skull and lower jaws on the mounted specimen pertain to a different individual than the axial and appendicular portions, but that with the latter was found a single large horn-core which was identified by the late Mr. J. B. Hatcher as resembling the horn-cores of *Triceratops clatus* Marsh, and on account of that resemblance, I have selected the skull of that species as the basis for the head in the present model.

The nonimbricating, scalelike texture of the skin as represented in the model is based, with modifications, upon the recently discovered Ceratopsian remains in the collections of the Canadian Geological Survey, at Ottawa, with which well-preserved skin impressions were found.[2] Although these skin impressions pertain to one of the more primitive Ceratopsians it is quite reasonable to expect that all of the horned dinosaurs had a scaled integument, though

[1] Gilmore, Charles W., Proc. U. S. Nat. Mus., vol. 29, 1905, pls. 1 and 2, pp. 433–435.
[2] Lambe, L. M., Ottawa Naturalist, vol. 27, 1914, p. 132, pl. 14.

the pattern of the scales may have varied considerably in the different genera, as they are known to do in the various Trachodont genera.

Since this model was prepared in 1915, a second Ceratopsian specimen (type of *Monoclonius cutleri* Brown) having impressions of the skin preserved has been discovered. According to Brown[1] the polygonal scales extended down over the belly, instead of the small rounded scales here represented as covering those parts in the model, but, of course, we can not be certain that the same arrangement of the scales prevailed in the genus *Triceratops*.

One other noticable departure from earlier restorations is in freeing the femoral part of the hind limb from the flank, thus adopting a reptilian form of limb, rather than the mammalian form previously used.

Future discoveries may show many features of the present restoration to be incorrect, but at the least it graphically portrays some of the discoveries made during the past 10 years, in our knowledge of the probable life appearance of these huge-headed reptiles now so long extinct.

NOTES ON THE OSTEOLOGY OF TRICERATOPS.

The entire collection of vertebrate fossils, in the United States National Museum, from the Lance formation of Wyoming has now been prepared for study and exhibition. This collection, made by the late J. B. Hatcher and his associates during the years 1889 to 1891, formed a part of what is known as the "Marsh collection" transferred to the Museum by the United States Geological Survey.

In the course of this work, specimens were found which contribute to a better understanding of the osteological structure of certain members of the Ceratopsia, and especially important was the uncovering of additional bones pertaining to the type-specimens on which *Triceratops obtusus* Marsh and *Triceratops calicornis* Marsh were founded.

Notes relating to the more important of these specimens are given in the following pages.

THE TYPE-SPECIMEN OF TRICERATOPS OBTUSUS MARSH.

The type of this species as enumerated by Hatcher[2] in 1907, consisted of "a pair of mandibular dentaries and the anterior portion of the nasals, a left maxillary, a squamosal parts of a pterygoid, and a vertebra." The finding of nearly the entire remaining parts of the skull (see pl. 4) is a welcome addition to the above material,

[1] Bull. Amer. Mus. Nat. Hist., vol. 37, art. X, 1917, p. 299, pl. 18.
[2] The Ceratopsia, Monograph 49, U. S. Geological Survey, 1907, p. 140.

and it now places the type on an adequate foundation for comparison with the other and better known species.

Although somewhat distorted latterly by pressure the skull is essentially complete, lacking only the rostral, premaxillary bones, and the median portion of the frill or demosupraoccipital.

That the skull belongs to the same individual as the type is shown by the similarity of the labels accompanying both, by the unusual bright yellowish color of the bones and also by the finding of fragments with the skull that fitted the dentaries, and fragments with the nasals and dentaries that were fitted to the skull.

The original description by Professor Marsh and the more recent description by Hatcher are given in their entirety below:

Professor Marsh described this species as follows:

A second new species, which may be called *Triceratops obtusus*, is represented by a large skull belonging to the same genus. The nasal horn core of this skull is very short and obtuse and so well preserved that it indicates the normal form and size. The entire length of this horn core is only 1 inch. Its summit is 3½ inches behind the premaxillary suture. The width of the nasals beneath the horn core is 5½ inches. The length of the squamosal from the quadrate groove to the posterior end is about 36 inches and its greatest width is 19 inches.

These two skulls [types of *T. calicornis* and *T. obtusus*] were both found by J. B. Hatcher in the Ceratops beds of Converse [Niobrara] County, Wyo.

Hatcher redescribes the specimens in the following:

The type (No. 4720, U. S. National Museum) of the present species consists of a pair of mandibular dentaries and the anterior portion of the nasals, a left maxillary, a squamosal, parts of pterygoid, and a vertebra. The specific name was suggested by the nasal horn core. The nasals, as shown in the accompanying figures, are extremely broad, and the nasal horn core is reduced to a broad, rounded, and rugose prominence, marked with a number of deep vascular grooves.

The dentary is exceptionally deep and the teeth are unusually large. Below the base of the coronoid process on either dentary the external surface of the bone presents a very sharp ridge that extends continuously throughout about one-third of its length. The posterior portion of the alveolar region of the left dentary bears evidence of having been affected by disease and presents extensive malformations. The mandibular fossa extends rather farther forward than is common in other species of the Ceratopsia. The dentary is exceptionally massive and the teeth are very large. There are a number of foramina on the external surface of the dentary, as shown in the accompanying figure.

Notwithstanding the scanty and fragmentary material upon which the present species is based, it would seem to be a valid one, as indicated alike by the characters of the dentary, the teeth, the nasal horn core, and that part of the nasals still preserved.

The type of the present species was found in Converse [Niobrara] County, Wyo., about 1 mile east of Lance Creek and 2 miles southeast of the U–L ranch. The horizon would be about the middle of Laramie [Lance], as those deposits are represented in this region. The locality is shown at +9, Pl. LI.

Principal Measurements of the Type-Specimen.

	mm.
Greatest length of dentary	670
Greatest depth of dentary	229
Length of dental series	535
Breadth of nasals at base of horn core	140
Distance from top of nasal horn core to inferior surface of nasals	75

I have been unable to find in the collections of the U. S. National Museum the squamosal mentioned by Marsh as pertaining to the type, and can say nothing concerning the form of this important element. The other portions of the skeleton preserved show no peculiarities worthy of note.

The missing squamosal mentioned by Hatcher was found in one of the recently opened boxes. The left squamosal, lacking the posterior end (see pl. 4), was attached to the skull. Although Hatcher collected this specimen, the presence of nearly the entire skull had obviously entirely escaped his memory, as no allusion is made to it in any of his writings. The characters pointed out by Hatcher for distinguishing this species are for the most part of a trivial nature and little dependence can be placed on them as representing constant specific differences. The peculiarities found in the dentaries may be attributed in a great degree to the severe crushing which these bones have undergone, in addition to the malformations in the left element to which Hatcher calls attention. A comparison of the dentaries with others in the collection of the United States National Museum fails to disclose any great degree of difference in the forward extension of the mandibular fossa, its apparent extension being due to the absence of the overlying splenial and to deformation of the bone by vertical pressure. The width of the nasals also appears to have been exaggerated by crushing. Of the specific characters pointed out by Hatcher, the reduced nasal horn core alone is probably valid, though it may be only a sex character. The supraorbital horns as compared with the types of *T. calicornis* Marsh and *T. elatus* Marsh are somewhat shorter and lack the great forward curvature. They are not quite as stocky as those of *T. brevicornus*, which they resemble most nearly in a lateral view.

After a careful comparison of this additional material of *T. obtusus* with the several types in the United States National Museum collections, and with the figures and descriptions of other species of the genus preserved elsewhere, I am unable to detect characters that would satisfactorily distinguish this species.

In the present accepted classification of the Ceratopsia, and especially of the species of the genus *Triceratops*, great importance is attached to the development of the nasal and supraorbital horn cores, and the peripheral outgrowths of the frill. It is not yet clear how much dependence can be placed on the differences found in these horns, or their almost complete absence as in *T. obtusus*. There is

great variation, as might well be expected in such highly specialized outgrowths, and the differences in sex, and stage of growth present other features that have also to be considered before a satisfactory conclusion can be reached as to what characters constitute valid specific differences. In fact, the whole group needs restudying. Such a revision assisted by the considerable number of new specimens discovered since the writing of the Ceratopsia monograph in 1907 may enable an investigator to straighten out this confusion. At the present time it appears quite certain that the number of described species is too great by a considerable number.

THE TYPE-SPECIMEN OF TRICERATOPS CALICORNIS MARSH.

At the time of writing the Monograph on the Ceratopsia, Hatcher[1] and Lull mentioned their inability to locate in the collections of the United States National Museum the lower jaws pertaining to the type-specimen of *Triceratops calicornis* Marsh, No. 4928, U. S. N. M. Upon opening a large box, listed as containing the skull of another individual in it was found the long misplaced dentaries. These are in an excellent state of preservation. In the same block of sandstone with the lower jaws was a posterior cervical vertebra and portions of several thoracic ribs.

The vertebra is from the posterior part of the neck and represents the seventh of the series counting backward from the skull, or it belongs behind the first of the series as illustrated in figure 2, plate 40, of the monograph cited above. Figure 2, Plate 5, shows this vertebra inserted in its proper position in the vertebral series. That this is the correct position of this element in the vertebral column is clearly shown by the shape and length of the transverse processes and also by the perfect articulation of the zygapophyses.

The dentaries except for their great size are similar to those of other described species, and the few minor differences observed do not add anything to the diagnosis of the species.

The principal measurements of the dentaries are:

	mm.
Greatest length	645
Greatest depth	170
Length of dental series	480

In the left ramus there are 38 rows of teeth in the dental magazine.

The type-specimen now completely assembled consists of the following parts:

Skull, lacking some parts of the frill, lower jaws, 2 cervical vertebrae (portions of atlas and other cervicals), 10 dorsal vertebrae (portions of other dorsals), 5 cervical ribs, 2 thoracic ribs (many parts

[1] Monograph 49, U. S. Geological Survey, 1907, p. 139.

of others), both pubes, both ilia (poorly preserved), sacrum (poorly preserved), and many ossified tendons.

CERATOPSIAN VERTEBRAE.

In plate 5, figure 1, is shown an articulated series of eight posterior dorsal vertebræ (No. 8091, U.S.N.M.), collected by Messrs. J. B. Hatcher and A. D. Sullins in 1891 on Schneider Creek, Niobrara County, Wyoming. These vertebræ are notable for their fine state of preservation and that they are from that part of the column of which but little is known at the present time. This series pertains to a member of the genus *Triceratops*, but the species has not yet been determined.

A DISEASED CERATOPSIAN SCAPULA.

In plate 6, figures 1 and 2, is shown two views of a Ceratopsian scapula, of the right side belonging to the genus *Triceratops*, which is of interest on account of the presence on the internal side, of an otherwise normal bone, of a large bony hornlike growth. Fossil bones are often found, and especially of the horned dinosaurs, showing fractures that have healed in life (see pl. 9) usually with a considerable enlargement at the point of fracture, but in the present specimen there is no evidence of the bone having been fractured, though this horn-like projection is doubtless an exostosial growth due to pathologic conditions. That it must have been very uncomfortable to the animal, and a serious handicap to the movement of the shoulder blade, is readily apparent.

The scapula (No. 8013, U.S.N.M.) was collected by the late J. B. Hatcher in 1891 from the Lance formation in Niobrara County, Wyoming.

RELATIONSHIPS OF CERTAIN CRANIAL ELEMENTS IN THE SKULL.

During the past few years several papers have been written in which the homologies of the bones of the Ceratopsian skull and brain case have been discussed in considerable detail. While each author has contributed to a better understanding of these elements and their relationships there is still a lack of unanimity of opinion regarding some of them. Certain modifications have led to such a rearrangement of the cranial elements that until correctly interpreted are as confusing as they are unusual. The coossification early in life of most of the bones, is another feature that still further adds to the difficulty of determining their true relationships. A restudy of specimens in the United States National Museum in conjunction with two *Triceratops* skulls recently prepared further elucidate the

homologies of these bones and also furnish corroborative evidence in support of the conclusions reached by me in an earlier study of a juvenile skull of *Brachyceratops*[1] *montanensis*.

In plate 8 is shown a fragmentary skull (Cat. No. 5740, U.S.N.M.) in longitudinal section. It is known by the field designation as Sk. 27,

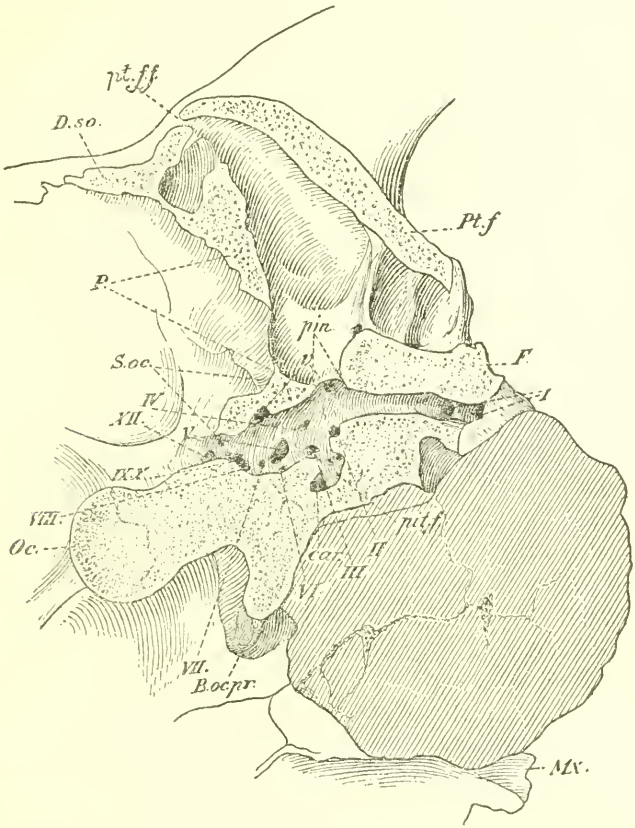


FIG. 1.—LONGITUDINAL SECTION OF SKULL SHOWING BRAIN CAVITY OF TRICERATOPS, FROM NO. 5740, U.S.N.M., ABOUT ONE-EIGHTH NATURAL SIZE. B. OC. PR., BASIOCCIPITAL PROCESS; CAR., FORAMEN FOR LEFT CAROTID ARTERY; D. SO., ANTERIOR END OF DERMOSUPRAOCCIPITAL; F., POSTERIOR PORTION OF FRONTAL; MX., MAXILLARY; OC., OCCIPITAL CONDYLE; P., PARIETAL, IT ALSO EXTENDS FORWARD AROUND THE PINEAL FORAMEN TO MEET THE THICKENED POSTERIOR END OF THE FRONTAL; PIN., PINEAL FORAMEN; PIT. F., PITUITARY FOSSA; PT. F., POSTFRONTAL; PT. FF., POSTFRONTAL FONTANELLE; S. OC., SUPRAOCCIPITAL; V., FORAMINA FOR EXIT OF SUPPOSED VEINS; I, II, III, IV, V, VI, VII, VIII, IX, X, XII, FORAMINA FOR EXIT OF CEPHALIC NERVES OF CORRESPONDING NUMBERS.

and was collected by Messrs. J. B. Hatcher and A. D. Sullins, in 1891 on Doegie Creek,[2] Niobrara County (formerly Converse County),

[1] Professional Paper 103, U. S. Geol. Survey, 1915.

[2] In plate 49 of Monograph 49, U. S. Geological Survey, 1907, Sk. 27, is indicated on the map as having been found on Bull Creek, but in figure 53 (p. 207) of the Dinosaurs of North America this same stream is designated Doegie Creek, which agrees with the original label found with the specimen. The former is probably an error made in transscribing the legends on the map.

Wyoming. On account of the absence of all the essential external portions such as the horn-cores, nasals, premaxillaries, and most of the squamosals, I am unable to determine the species to which this specimen belongs. It serves, however, to graphically illustrate the internal structure of the Ceratopsian skull, and especially the relatively small size and position of the brain cavity, and the large overlying sinuses.

A study of this sectional skull in conjunction with the posterior portion of the cranium of a second individual (Cat. No. 6679, U.S.N.M.; see Plate 7.) *Triceratops* species, and the disarticulated skull of *Brachyceratops montanensis* (Cat. No. 7951, see fig. 4) enables me to verify the work of other authors and in some instances to point out where they were in error. Commencing with the frill I think all authorities are agreed that the lateral bones are the squamosals. It is the median part of the frill that has been the subject of much discussion and a variety of interpretations. Marsh first identified it as the fused parietals, and he has been followed by most writers on the subject. Hay[1] showed that this identification could not be accepted and suggested that it might represent the fused supratemporals or possibly the coalesced nuchal bones. Huene[2] identified the anterior end of this central portion as parietal and the posterior end as a dermosupraoccipital, but it has been pointed out that this conclusion is not altogether acceptable. Gilmore[3] in describing the skull of *Brachyceratops* reached the conclusion that the parietal was entirely excluded from the dorsal surface of the skull in that genus—a conclusion verified by Brown[4] in a later study of other Ceratopsiam skulls. In the article cited above Brown also concludes that the median part of the frill represents the "fused postfrontals." The study of the disarticulated *Brachyceratops* skull which has the postfrontal bones entire (see fig. 4), shows conclusively that they do not extend backward to form any part of the crest. In fact a comparison of the top of the *Brachyceratops* skull with a *Monoclonius* skull, figured by Brown[5] shows a transverse line between the supratemporal fossae, separating their posterior ends from the frill portion as in *Brychyceratops* although it is not there recognized as a suture. That a suture does exist at this point is abundantly shown by several skulls and numerous separate frills. That the conclusion reached by both Gilmore and Brown that the parietal does not show on the dorsal surface of the skull is further substantiated by specimens Nos. 5740 and 6679, particularly the latter, which shows the parietal as extending upward and backward as a thin sheet of bone under-

[1] Proc. U. S. Nat. Mus., vol. 36, 1908, pp. 95–108.
[2] Neues Jahrbuch, vol. 11, 1911, pp. 146–162.
[3] Smiths. Misc. Coll., vol. 63, No. 3, 1914, p. 7.
[4] Bull. Amer. Mus. Nat. Hist., vol. 33, October, 1914, p. 543.
[5] Idem, vol. 34, October, 1914, pp. 549–558, fig. 1.

lapping the forward part of the dermosupraoccipital to which it is closely applied, by squamous suture, thinning out to a thin edge along the line indicated in *s.* plate 7. From a posterior view Huene depicts the lateral extent of the parietal quite clearly in figure 2 of the paper cited above, and Brown also shows its more limited develpment in the genus *Monoclonius.* (See fig. 2, Bull. Amer. Nat. Hist., vol. 33, 1914, p. 555.)

All writers are agreed as to the position of the postfrontals as being immediately in front of the dermosupraoccipital (called parietal, postfrontals, supratemporals, etc.) bone, but there is much dis-

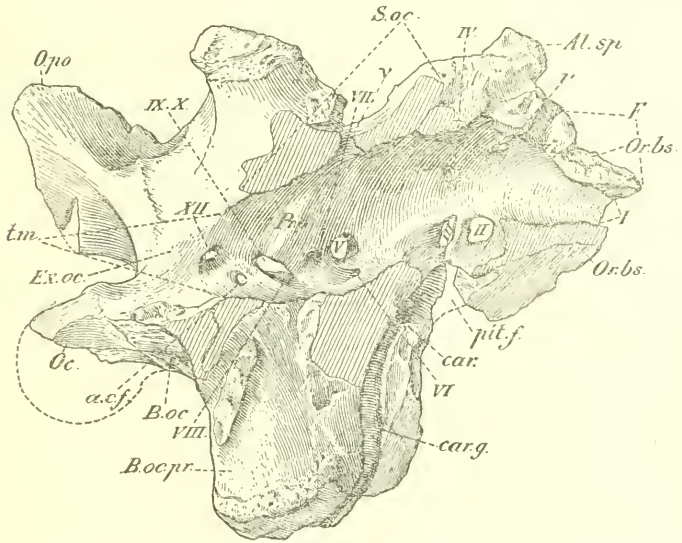


FIG. 2.—LONGITUDINAL SECTION OF BRAIN CASE OF TRICERATOPS SERRATUS MARSH NO. 2416, U.S.N.M. ABOUT ONE-THIRD NATURAL SIZE. A. C. F., ANTERIOR CONDYLOID FORAMEN; AL. SP., ALISPHENOID; B. OC., BASIOCCIPITAL; B. OC. PR., BASIOCCIPITAL PROCESS; CAR., FORAMEN FOR LEFT CAROTID ARTERY ENTERING PITUITARY FOSSA; CAR. G., GROOVE FOR RIGHT CAROTID ARTERY; EX OC., EXOCCIPITAL; F., EXTENT OF THE ARTICULATION OF THE FRONTAL WITH THE UNDERLYING ORBITOSPHENOIDS; OC., OCCIPITAL CONDYLE; OR. BS., ORBITOSPHENOID; O. PO., PARAOCCIPITAL PROCESS; PIT. F., PITUITARY FOSSA; PRO., PROOTIC; S. OC., SUPRAOCCIPITAL; T. M., FORAMEN MAGNUM; V., FORAMINA FOR EXIT OF SUPPOSED VEINS; I, II, III, IV, V, VI, VII, VIII, IX, X, XII, FORAMINA FOR EXIT OF CORRESPONDING CEPHALIC NERVES.

agreement as to the extent of these elements. Marsh, Hatcher, Lull, Brown, and Lambe considered the postfrontal as including nearly all of that portion of the skull between, and including the horn cores and an area on the lateral surface extending down and back of the orbit to its inferior level. Huene correctly recognized a portion of the lateral area posterior to the orbit as being the postorbital and so it stood until the discovery of the *Brachyceratops* skull which demonstrates conclusively that the postorbital in that genus includes the horn above the eye and that the lateral extension of the post frontals is not external but internal to the supraorbital horn cores, as shown

in figure 4. I can hardly believe, in the light of the *Brachyceratops* skull, that the postorbital bone has been so reduced in size in *Triceratops* as indicated by Huene. In a recent paper by Lambe[1] the small bones interposed between the prefrontals and identified as the frontals represents without question the forward ends of the postfrontals.

The frontals, as pointed out by Huene,[2] do not appear on the dorsal surface, but are excluded from that view by the overlying prefrontals (the lachrymals of Huene). Figure 6 shows a longitudinal section of the skull of *Triceratops flabellatus* Marsh after Lull where

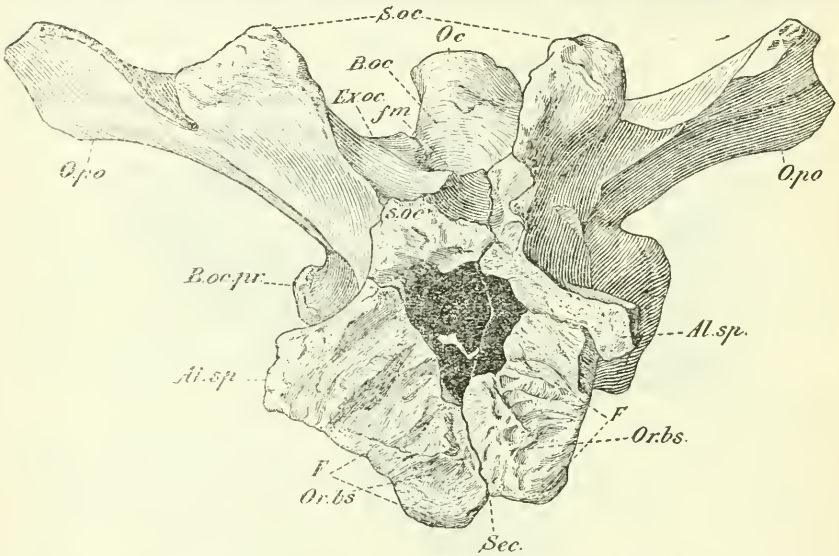


FIG. 3.—SUPERIOR VIEW OF BRAIN CASE OF TRICERATOPS SERRATUS MARSH, No. 2416, U.S.N.M. ABOUT ONE-THIRD NATURAL SIZE. AL. SP., ALISPHENOID; B. OC., BASIOCCIPITAL; B. OC. PR., BASIOCCIPITAL PROCESS; EX OC., EXOCCIPITAL; F., SHOWING EXTENT OF THE ARTICULATION OF THE FRONTAL WITH THE UNDERLYING ORBITOSPHENOIDS; FM., FORAMEN MAGNUM; OC., OCCIPITAL CONDYLE; O. PO., PARAOCCIPITAL PROCESSES; OR. BS., ORBITOSPHENOIDS; SEC., LINE INDICATING POINT OF SEPARATION OF TWO HALVES OF BRAIN CASE, OF WHICH A SECTION IS SHOWN IN FIG. 2; S. OC., SUPRAOCCIPITAL.

the frontal = prefrontal + postfrontal) is indicated as having an inferior branch directed downward and backward from the nasals to the anterior part of the brain case. This lower branch represents the true frontal as is clearly shown by the juvenile *Brachyceratops*[3] skull in which the overlying pre- and postfrontals exist as distinct elements. A study of the sectioned skull (No. 5740, U.S.N.M.) plate 8 and text figure 1 now enables me to definitely determine for the first time the posterior extent of the frontals, as being the thickened bone immediately overlying the olfactory lobe of the brain,

[1] Museum Bull. No. 12 Canada Department of Mines, pl. 9, figs. 1, 2, 1915.
[2] Neues Jahrbuch, vol. 11, 1912, fig. 1.
[3] See Prof. Paper 103, U. S. Geol. Surv., 1917, p. 10, fig. 6.

see *F*, figure 1, and extending back to the pineal foramen, see *pin*, figure 1. In the great thickening of the bone and its relationship to the brain and underlying structure, it closely resembles the frontal of *Diplodocus longus* Marsh as shown in figure 5, *Fr.* In specimen No. 5740, U.S.N.M., the sutures are almost entirely obliterated, but

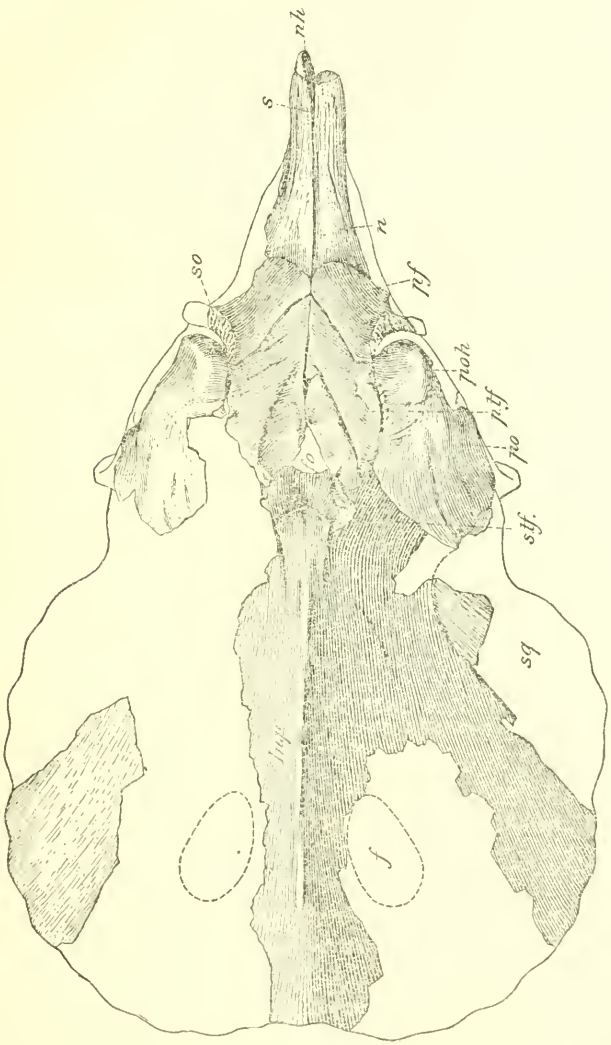


FIG. 4.—SKULL OF BRACHYCERATOPS MONTANENSIS GILMORE. TYPE NO. 7951, U.S.N.M. ONE-THIRD NATURAL SIZE. SUPERIOR VIEW; F., FENESTRA IN FRILL; FO., POSTFRONTAL FONTANELLE; IN. P., DERMOSUPRAOCCIPITAL; N., NASAL; NH., NASAL HORN CORE; PF., PREFRONTAL; PO., POSTORBITAL; POH., POSTORBITAL HORN CORE; PTF., POSTFRONTAL; S., SUTURE SEPARATING TWO HALVES OF NASAL HORN CORE; SO., SUTURAL BORDER FOR MISSING SUPRAORBITAL BONE; SQ., SQUAMOSAL; ST. F., SUPRATEMPORAL FOSSA. (AFTER GILMORE.)

in a second brain case of *Triceratops serratus* Marsh (No. 2416, U.S.N.M., see figs. 2 and 3) the olfactory lobe is entirely inclosed by what Hay regarded, and I believe correctly, to be the united orbitosphenoids. Such a condition is unusual, for in no other reptile living or extinct have I observed these bones thus inclosing this part of the brain. Usually the frontal forms the median upper boundary and I presume such a condition will be found to prevail

in most Ceratopsian skulls. In fact, in specimen No. 5740 U.S.N.M., a longitudinal ridge, that may represent a coalesced suture, runs along the inside of the wall of the brain case for the olfactory lobe and if correctly interpreted shows that the frontal did contribute to the upper boundary of this part of the brain. By comparing specimens Nos. 5740 and 2416 it was possible to determine the exact extent of the articulation between the frontals and the underlying sutural surfaces of the orbitosphenoids in No. 2416, as indicated in figure 3, *F*. It will also be noted that these sutural surfaces continue backward over the superior surfaces of the alisphenoid and supraoccipital bones, thus entirely surrounding the large median opening above the cerebrum lobe of the brain. This aperture as shown in figure 3 is larger than it would be normally as all of the borders present broken edges. The question now arises, what bone articulated with these sutural surfaces? After a study of many reptilian skulls both recent and extinct it is found that the parietal is the only bone that fills all requirements. As in other reptilian skulls it here articulates anteriorly with the frontals; ventrally with the supraoccipital, alisphenoids, and in all probability also with the prootic. Furthermore, specimen No. 5740, U.S.N.M., shows that immediately behind the thickened rounded posterior end of the frontal is a well-defined median foramen leading from the brain case into the large air chamber above (see *pin.* fig. 1), and represents without question the interparietal or pineal foramen. The position of this foramen on the median line and near the sutural union of the parietal and frontal, and largely if not entirely within the former bone, is in entire agreement with the location of this foramen, in *Diplodocus* see *f. pin.*, figure 5, the living *Hatteria*, and in the Ichthyosauria and Plesiosauria. The large air chamber or sinus into which the pineal foramen opens, extends upward into the base of the large horn cores with an external outlet through an opening at the junction of the postfrontals with the dermosupraoccipital see *pt. f. f.* figure 1. This opening has been designated pineal foramen by Marsh; "the postfrontal foramen," by Hatcher; the "postfrontal fontanelle," by Lull and Lambe; the "supratemporal fossae," by Hay; and the "pseudopineal foramen," by Huene. The term "postfrontal fontanelle" is perhaps the more appropriate designation for this opening rather than "postfrontal foramen" the use of which was advocated in my study of the *Brachyceratops*[1] skull for the reason that it represents an opening not yet roofed over by bone, or, in other words, the coalescence of the postfrontals with one another and with the dermosupraoccipitals which had begun in the earliest known Ceratopsians had not been perfected, except in old individuals belonging to the last we know of the race.

[1] Prof. Paper 103, U. S. Geol. Survey, 1914, p. 18

Specimen No. 5740 shows that portion of the parietal around the pineal foramen and extending upward above the supraoccipital to have been very thin on the median line. Whether it becomes heavier laterally can not be determined, but higher up it widens perceptibly provided all of the bone is parietal, but it again thins out into a wide sheet of bone that underlaps the dermosupraoccipital as shown in plate 7, *P.* as has been previously described.

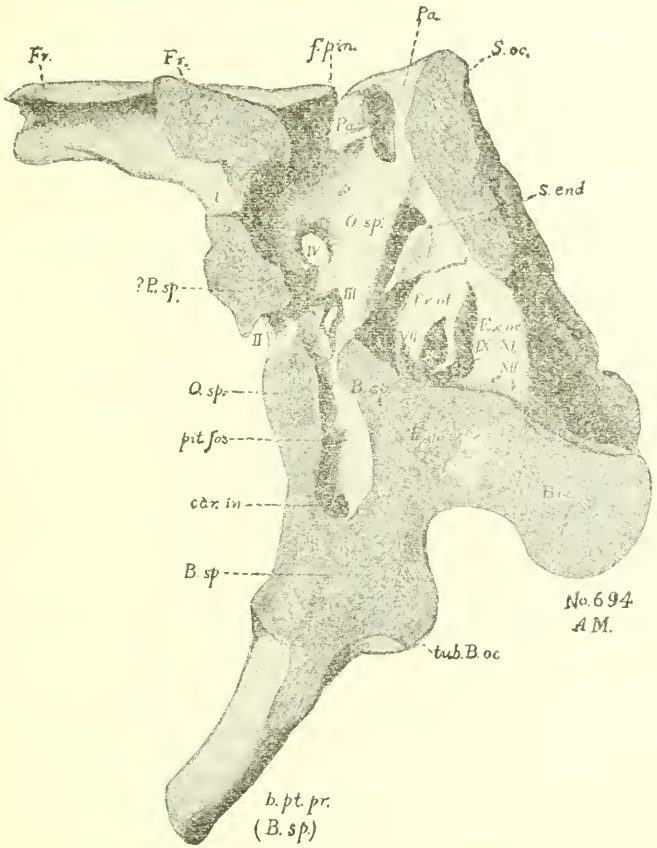


FIG. 5.—LONGITUDINAL SECTION OF SKULL OF DIPLODOCUS LONGUS MARSH, NO. 694, AMER. MUS. NAT. HISTORY. ONE-HALF NATURAL SIZE. B. OC., BASIOCCIPITAL; B. PT. PR., BASIPTERYGOID PROCESSES; B. SP., BASISPHENOID; CAR. IN., FORAMEN FOR RIGHT CAROTID ARTERY; EX. OC. EXOCCIPITAL; F. PIN., PINAL FORAMEN; FR., FRONTAL; O. SP., ORBITOSPHENOID; PA., PARIETAL; PIT. FOS., PITUITARY FOSSA; PR. OT., PROOTIC; ?P. SP., PRESPHENOID; S. END., SACCUS ENDOLYMPHATICUS; S. FC., SUPRA-OCCIPITAL; TUB. B. OC., BASIOCCIPITAL TUBEROSITY; I, II, III, IV, V, VI, VII, IX, XI, XII, FORAMINA FOR EXIT OF CORRESPONDING CEPHALIC NERVES. (AFTER OSBORN.)

In figure 2 *S. oc.*, the supraoccipital is indicated as extending from the top of the foramen magnum to the sutural surface above the foramen for the exit of the IV nerve. Hay in figuring this same specimen[1] regarded only the lower or posterior half as supraoccipital,

[1] See Proc. U. S. National Museum, vol. 36, 1909, pl. 2, fig. 1.

the upper or anterior half the parietal. Their junction being indicated by the foramen at the extremity of the left cerebellar process.[1] Brown in discussing the brain case of *Anchiceratops* and of a Trachodont dinosaur[2] regards this same point as being the position of the suture between these two bones. In none of the specimens discussed above can a suture be detected at this point, and the presence of a sutural surface on the upper end of the bone here called supraoccipital (see *s. oc.*, fig. 3), seems to me to clearly indicate the forward extent of this bone to be as shown in figure 2, *S. oc.*

FIG. 6.—LONGITUDINAL SECTION OF SKULL OF TRICERATOPS FLABELLATUS MARSH, FROM NO. 1821, YALE UNIVERSITY MUSEUM. ONE-SIXTEENTH NATURAL SIZE. BO., BASIOCCIPITAL; D., DENTARY; EXO., EXOCCIPITAL; FR., PRE- AND POSTFRONTAL (FRONTAL OF LULL); H., POSTORBITAL HORN CORE; MX., MAXILLARY; NAS., NASALS; NH., NASAL HORN CORE; NO., NASAL OPENING; PA., DERMOSUPRAOCCIPITAL (PARIETAL OF LULL); PD., PREDENTARY; PF., POSTFRONTAL; PL., PALATINE; PMX., PREMAXILLARY; Q., QUADRATE; R., ROSTRAL; SO., SUPRAOCCIPITAL; SQ., SQUAMOSAL; N., SINUSES BENEATH POSTFRONTAL BONES; XO., POSTFRONTAL FONTANELLE. (AFTER LULL.)

SUMMARY.

The principal facts now established from the latest study of the Ceratopsian skull and brain case are:

1. The presence in *Triceratops* of a well-defined pineal foramen.

2. That neither the frontals nor parietals are visible from a dorsal view of the skull.

[1] This foramen appears to go entirely through the bone in specimen No. 2416, shown in figure 2, but in No. 5740, although there is a deep pit, see *v*, figure 1, it appears not to reach the outer surface.

[2] See Bull. Amer. Mus. Nat. Hist., vol. 33, 1914, p. 547.

3. That the prefrontals and postfrontals which in the normal reptilian skulls are lateral elements have in the Ceratopsian cranium shifted their position from a lateral to a dorsal position supported beneath by strong vertical buttresses. That such a change has taken place is further indicated by the fact that in the older and more primitive Ceratopsians the complete coalescence of the post- and prefrontals of opposite sides on the median line has not always been perfected, though I know of no Lance specimens where this complete coalescence has not been completed.

After a study of the brain case in *Camptosaurus*, *Stegosaurus*, *Trachodon*, *Allosaurus*, and *Triceratops* it appears that no matter how diverse the modifications of the external bones of the skull may be, those forming the brain case have the same definite relations to each other and to the brain itself. Lambe considered the postfrontal as including nearly all of that portion of the skull between the horn cores and an area on the lateral surface extending down and back of the orbit to its inferior level. Huene correctly recognized a portion of the lateral area posterior to the orbit as being the postorbital and so it stood until the discovery of the *Brachyceratops* skull which demonstrates conclusively that the postorbital in that genus includes the horn above the eye and that the lateral extension of the postfrontals is not external but internal to the supraorbital horn cores, as shown in figure 4. I can hardly believe, in the light of the *Brachyceratops* skull that the postorbital bone has been so reduced in size in *Triceratops* as indicated by Huene. In a recent paper by Lambe[1] the small bones interposed between the prefrontals and identified as the frontals represented without question the forward ends of the postfrontals.

EXPLANATION OF PLATES.

PLATE 3.

Life restoration of *Triceratops elatus* Marsh. Modelled by Charles W. Gilmore 1915. Based on the mounted skeleton in the United States National Museum. About one-twenty-eighth natural size.

PLATE 4.

Skull and jaws of *Triceratops obtusus* Marsh. Type. No. 4720, U.S.N.M. Viewed from the left side. About one-twelfth natural size.

PLATE 5.

FIG. 1.—Series of eight articulated posterior dorsal vertebrae of *Triceratops*, sp. No. 8091, U.S.N.M. About one-eighth natural size. Viewed from the right side. The transverse processes of the left side are perfectly preserved.

[1] Museum Bulletin No. 12, Canada Department of Mines, pl. 9, figs. 1 and 2, 1915.

FIG. 2.—Cervical and dorsal vertebrae of *Triceratops calicornis* Marsh. Type. No. 4928, U.S.N.M. About one-eighth natural size. The second vertebrae from the left is the posterior cervical found in the block of sandstone with the dentaries and is here shown in its proper position in the vertebral series.

PLATE 6.

FIG. 1.—Right scapula of *Triceratops*, sp. No. 8013, U.S.N.M. Oblique internal view. Shows the horn-like growth protruding from the inner side of the shaft.

FIG. 2.—Same as above. Direct internal view. Both figures about one-eighth natural size.

PLATE 7.

Posterior view of skull of *Triceratops*, sp. No. 6679, U.S.N.M. About one-eighth natural size.

D. So., dermosupraoccipital; *Ex. oc.*, exoccipital; *Q.*, quadrate; *P.*, parietal; *S.*, indicates the upper extent of the parietal where it underlaps the dermosupraoccipital, at this point the two bones are slightly separated, the intervening space being filled by matrix.

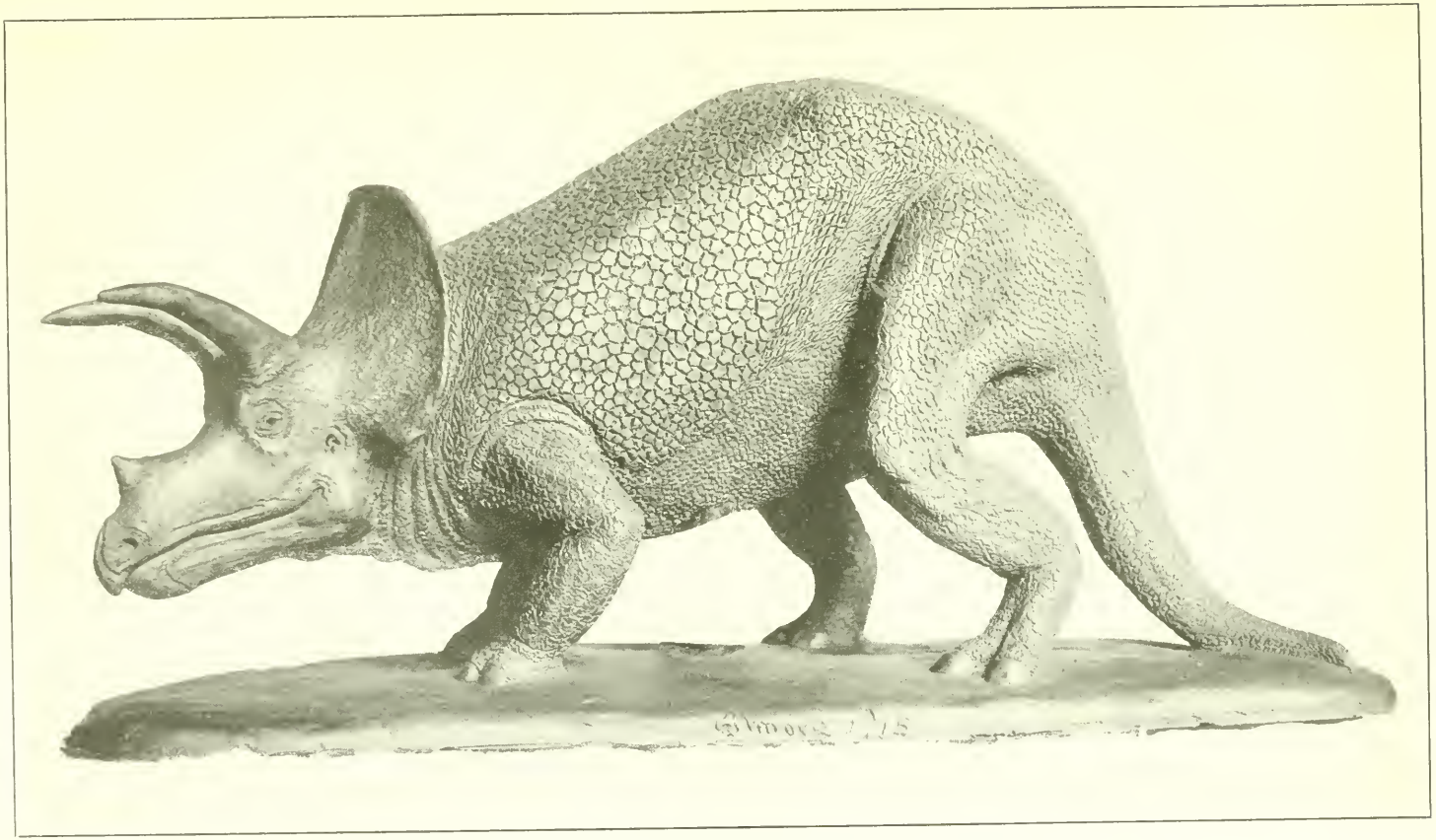
PLATE 8.

Longitudinal section of *Triceratops* skull through the center of brain case No. 5740, U.S.N.M. About one-eighth natural size. Explanatory drawing of this speciment shown in text figure 1.

PLATE 9.

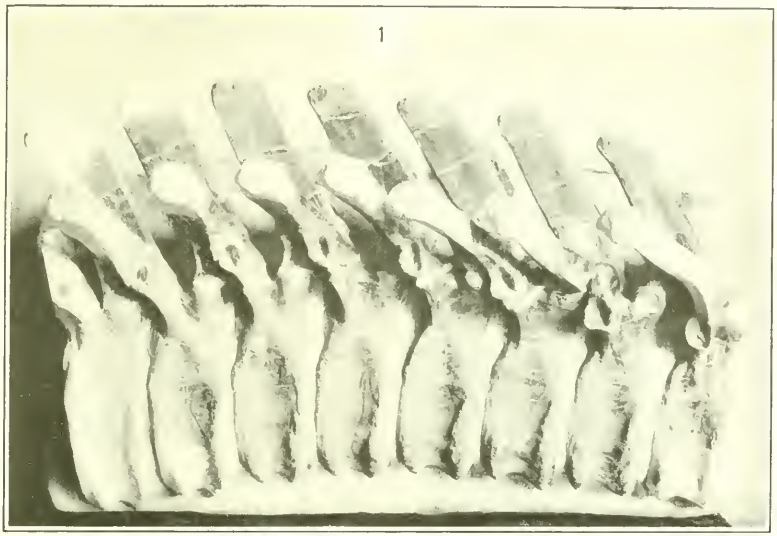
Postorbital horn cores of *Triceratops elatus* Marsh. No. 4708, U.S.N.M. Viewed from the back about one-eighth natural size. This specimen is of interest as showing that the right-horn core was broken off during life, evident from the fact that the stump had healed and rounded over. The size of the horns and other parts belonging to this specimen indicate they belonged to an old individual.

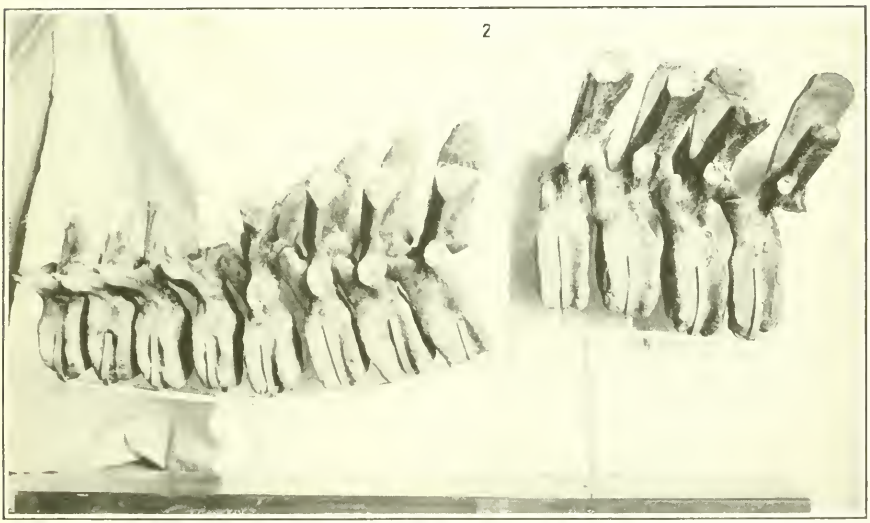
The specimen known by the field designation as "Sk. 11" was collected by the late J. B. Hatcher in 1890 from the Lance formation near Buck Creek, Niobrara County, Wyoming.



LIFE RESTORATION OF TRICERATOPS ELATUS MARSH.

FOR EXPLANATION OF PLATE SEE PAGE 111.





VERTEBRAE OF TRICERATOPS.

FOR EXPLANATION OF PLATE SEE PAGES 111–112.

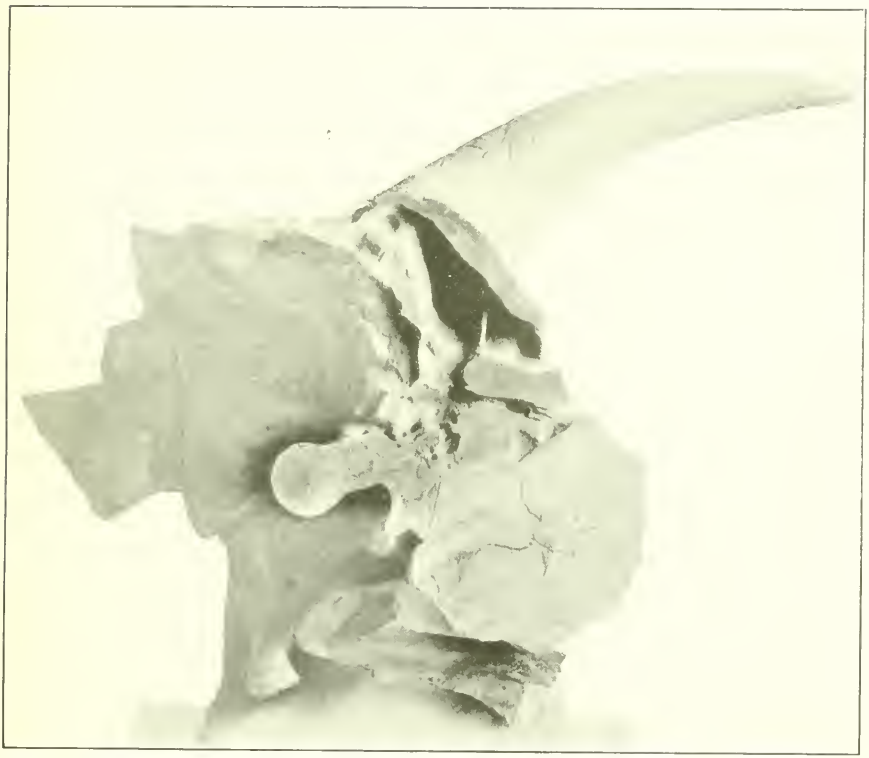
1 2

SCAPULA OF TRICERATOPS.

FOR EXPLANATION OF PLATE SEE PAGE 112.

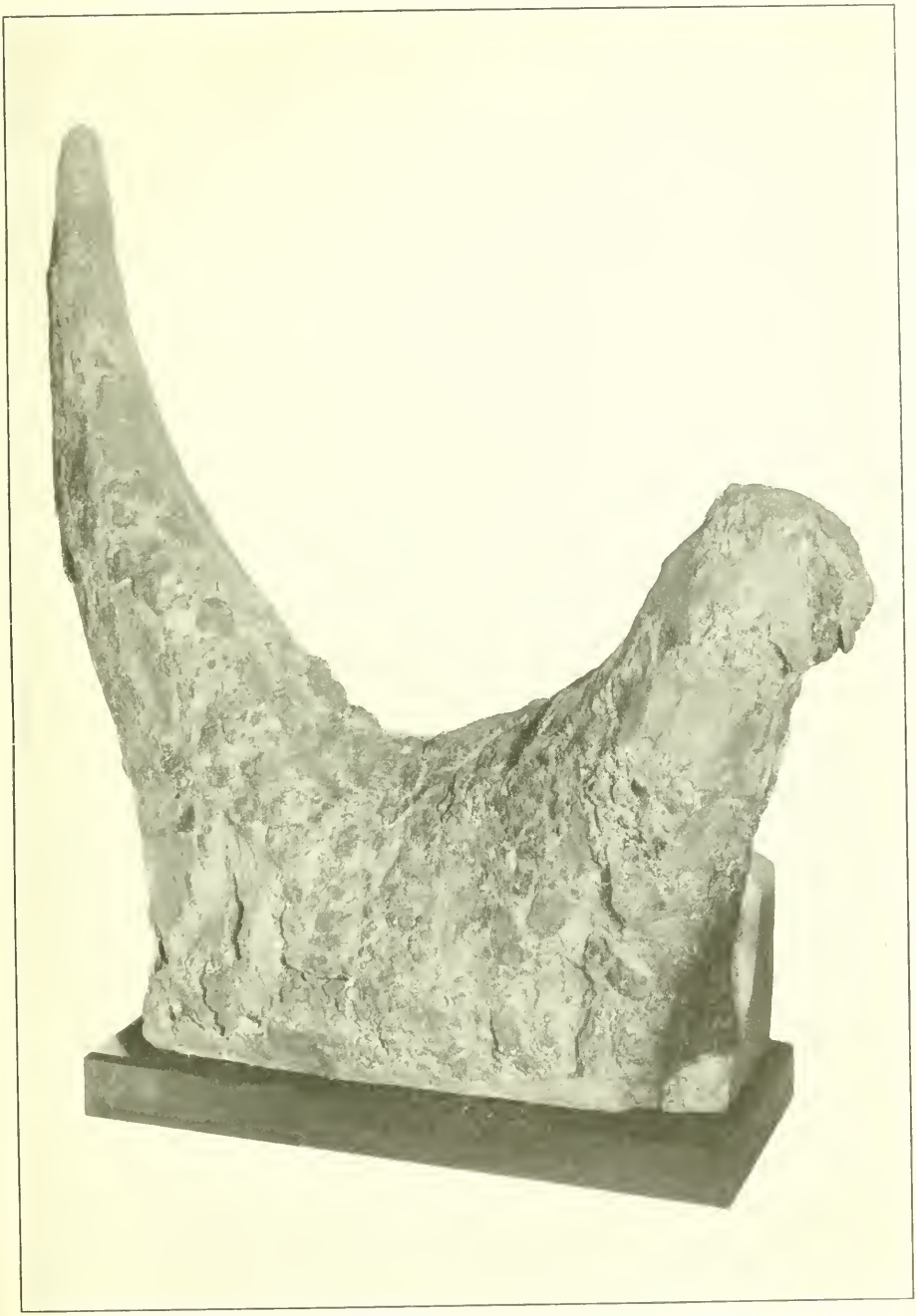
SKULL OF TRICERATOPS.

FOR EXPLANATION OF PLATE SEE PAGE 112.



SECTIONAL SKULL OF TRICERATOPS.

FOR EXPLANATION OF PLATE SEE PAGE 112.



HORN CORES OF TRICERATOPS ELATUS MARSH.

FOR EXPLANATION OF PLATE SEE PAGE 112.