

TRICERATOPS FLABELLATUS, Marsh. $\frac{1}{16}$ natural size.

FIGURE 1.—The skull; seen from the side.

FIGURE 2.—The same; seen from above.

a, nasal opening; b, orbit; c, supra-temporal fossa; e, epoccipital bone; h, frontal horn-core; h', nasal horn-core; p, pre-dentary bone; q, quadrate; r, rostral bone.

APPENDIX.

ART. LX.—*The Skull of the Gigantic Ceratopsidæ*;* by O. C. MARSH. (With Plate XII.)

THE huge horned Dinosaurs, from the Cretaceous, recently described by the writer,† have now been investigated with some care, and much additional light has been thrown upon their structure and affinities. A large amount of new material has been secured, including several skulls, nearly complete, as well as various portions of the skeleton.

The geological deposits, also, in which their remains are found have been carefully explored during the past season, and the known localities of importance examined by the writer, to ascertain what other fossils occur in them, and what were the special conditions which preserved so many relics of this unique fauna.

The geological horizon of these strange reptiles is a distinct one in the upper Cretaceous, and has now been traced nearly eight hundred miles along the eastern flank of the Rocky Mountains. It is marked almost everywhere by remains of these reptiles, and hence the strata containing them may be called the Ceratops beds. They are fresh-water or brackish deposits, which form a part of the so-called Laramie, but are below the uppermost beds referred to that group. In some places, at least, they rest upon marine beds which contain invertebrate fossils characteristic of the Fox Hills deposits.

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† This Journal, vol. xxxvi, p. 477, December, 1888; vol. xxxvii, p. 334, April, 1889; and vol. xxxviii, p. 173, August, 1889.

The fossils associated with the *Ceratopsidae* are mainly Dinosaurs, representing two or three orders, and several families. Plesiosaurs, crocodiles and turtles of Cretaceous types, and many smaller reptiles, have left their remains in the same deposits. Numerous small mammals, also of ancient types, a few birds, and many fishes, are likewise entombed in this formation. Invertebrate fossils and plants are not uncommon in the same horizon.

The *Ceratopsidae*, as the most important of this assemblage, will be first described fully by the writer, under the auspices of the United States Geological Survey. In the present paper, the skull of one of these gigantic reptiles is briefly described, and figured, as a typical example of the group.

THE SKULL.

The skull of *Triceratops*, the best known genus of the family, has many remarkable features. First of all, its size, in the largest individuals, exceeds that of any land-animal, living or extinct, hitherto discovered, and is only surpassed by that of some of the Cetaceans. The skull represented in Plate XII, the type of the species, is that of a comparatively young animal, but is about six feet in length. The type of *Triceratops horridus* was fully adult, and probably an old individual. The skull, when complete, must have been over eight feet in length. Two other skulls, both nearly perfect, now under examination by the writer, fully equal in bulk the two already described, and other similar specimens from the same horizon maintain equal average dimensions.

Another striking feature in the skull of this genus is its armature. This consisted of a sharp cutting beak in front, a strong horn on the nose, a pair of very large pointed horns on the top of the head, and a row of sharp projections around the margin of the posterior crest. All these had a horny covering of great strength and power. For offense or defense, they formed together an armor for the head as complete as any known. This armature dominated the skull, and in a great measure determined its form and structure.

The skull itself is wedge-shaped in form, especially when seen from above. The facial portion is very narrow, and much prolonged in front, as shown in Plate XII, figure 2. In the frontal region, the skull is massive, and greatly strengthened to support the large and lofty horn-cores, which formed the central feature of the armature. The huge, expanded parietal crest, which overshadowed the back of the skull and neck, was evidently of secondary growth, a practical necessity for the attachment of the powerful ligaments and muscles that supported the head.

The front part of the skull shows a very high degree of specialization, and the lower jaws have been modified in connection with it. In front of the premaxillaries, there is a large massive bone, not before seen in any vertebrate, which has been called by the writer, the rostral bone (*os rostrale*). It covers the anterior margins of the premaxillaries, and its sharp inferior edge is continuous with their lower border. This bone is much compressed, and its surface very rugose, showing that it was covered with a strong horny beak. It is a dermal ossification, and corresponds to the pre-dentary bone below. The latter, in this genus, is also sharp and rugose, and likewise was protected by a strong horny covering. The two together closely resemble the beak of some of the turtles, and as a whole must have formed a most powerful weapon of offense.

In the skull figured on Plate XII, the rostral bone was free, and was not secured. This was also true of the pre-dentary bone, and the nasal horn-core. Hence these parts are represented in outline, taken from another specimen, in which they are all present, and in good preservation.

The premaxillary bones are large, and much compressed transversely. Their inner surfaces are flat, and meet each other closely on the median line. In old specimens, they are firmly coössified with each other, and with the rostral bone. They send upward a strong process to support the massive nasals. Another process, long and slender, extends upward and backward, forming a suture with the maxillary behind, and uniting in front with a descending branch of the nasal. The premaxillaries are much excavated externally for the nasal aperture, and form its lower margin. They are entirely edentulous.

The maxillaries are thick, massive bones of moderate size, and subtriangular in outline when seen from the side. Their front margin is bounded mainly by the premaxillaries. They meet the pre-frontal and lachrymal above, and also the jugal. The alveolar border is narrow, and the teeth small, with only a single row in use at the same time. The teeth resemble, in general form, those of *Hadrosaurus*.

The nasal bones are large and massive, and greatly thickened anteriorly to support the nasal horn-core. In the skull figured on Plate XII, these bones are separate, but in older individuals, they are firmly coössified with each other, and with the frontals. The nasal horn-core ossifies from a separate centre, but in adult animals, it unites closely with the nasals, all traces of the connection being lost. It varies much in form in different species.

The frontals form the central region of the skull, and have been greatly strengthened to support the enormous horn-cores which tower above them. These elevations rest mainly on the frontal bones, but the supra-orbitals, the post-orbitals, and the post-frontals, have, apparently, all been absorbed by the frontals, to form the solid foundation for the horn-cores.

These horn-cores are hollow at the base, and in form, position, and external texture, agree closely with the corresponding parts of the *Bovidae*. They vary much in shape and size, in different species. They were evidently covered with massive, pointed horns, forming most powerful and effective weapons.

The orbit is at the base of the horn-core, and is surrounded, especially above, by a very thick margin. It is oval in outline, and of moderate size. Its position and form are shown in Plate XII, figure 1, *b*.

The enormous posterior crest is formed mainly by the parietals, which meet the frontals immediately behind the horn-cores. The margin is protected by a series of special ossifications, which, in life, had a thick horny covering. These peculiar ossicles, which extend around the whole of the crest, may be called the epoccipital bones (Plate XII, figures 1 and 2, *e*). In old animals, they are firmly coössified with the bones on which they rest.

The lateral portions of the crest are formed by the squamosals, which meet the parietals in an open suture. Anteriorly, they join the frontal elements which form the base of the horn-core, and laterally, they unite with the jugal. The supra-temporal fossæ lie between the squamosals and the parietals, as shown on Plate XII, figure 2, *c*.

The base of the skull has been modified in conformity with its upper surface. The basi-occipital is especially massive, and strong at every point. The occipital condyle is very large, and its articular face, nearly spherical, indicating great freedom of motion. The basi-occipital processes are short and stout. The basi-ptyergoid processes are longer, and less robust. The foramen magnum is very small, about one-half the diameter of the occipital condyle. The brain-cavity is especially diminutive, smaller in proportion to the skull, than in any other known reptile.

The exoccipitals are also robust, and firmly coössified with the basi-occipital. The supra-occipital is inclined forward, and its external surface is excavated into deep cavities. It is firmly coössified with the parietals above, and with the exoccipitals on the sides. The post-temporal fossæ are quite small.

The quadrate is robust, and its head much compressed. The latter is held firmly in a deep groove of the squamosal. The anterior wing of the quadrate is large and thin, and closely united with the broad blade of the pterygoid.

The quadrato-jugal is a solid, compressed bone, uniting the quadrate with the large descending process of the jugal. In the genus *Triceratops*, the quadrato-jugal does not unite with the squamosal. In *Ceratops*, which includes some of the smaller, less specialized, forms of the family, the squamosal is firmly united to the quadrato-jugal by suture. Above this point, it shows a number of elevations, which are wanting in *Triceratops*.

The quadrato-jugal arch in this group is strong, and curves upward, the jugal uniting with the maxillary, not at its posterior extremity, but at its upper surface, as shown in Plate XII, figure 1. This greatly strengthens the center of the skull which supports the horn-cores, and also tends to modify materially the elements of the palate below. The pterygoids, in addition to their strong union with the quadrate, send outward a branch, which curves around the end of the maxillary. This virtually takes the place of the transverse bone. The latter is thus aborted, and is represented only by a small, free ossicle resting upon the posterior extremity of the maxillary.

The lower jaw shows no specialization of great importance, with the exception of the pre-dentary bone already described. There is, however, a very massive coronoid process rising from the posterior part of the dentary, which is well shown in Plate XII, figure 1. The articular, angular, and surangular bones, are all short and strong, and the splenial is comparatively slender. The angle of the lower jaw projects but little behind the quadrate.

The unique characters of the skull of the *Ceratopsidae* are especially the following:

- (1) The presence of a rostral bone, and the modification of the pre-dentary to form a sharp, cutting beak.
- (2) The frontal horn-cores, which form the central feature of the armature.
- (3) The huge, expanded parietal crest.
- (4) The epoccipital bones.
- (5) The aborted transverse bone.

These are all features not before seen in the *Dinosauria*, and show that the family is a very distinct one.

Ordinates—Percentage of transmission.

The peculiar armature of the skull has a parallel in the genus *Phrynosoma*, among the lizards, and *Meiolania*, among the turtles, and it is of special interest to find it also represented in the Dinosaurs, just before their extinction.

Such a high specialization of the skull, resulting in its enormous development, profoundly affected the rest of the skeleton. Precisely as the heavy armature dominated the skull, so the huge head gradually overbalanced the body, and must have led to its destruction. As the head increased in size to bear its armor, the neck first of all, then the fore limbs, and later the whole skeleton, was specially modified to support it.

These features will be discussed in a later communication, but to the present description of the skull should be added the fact that the anterior cervical vertebrae were firmly coossified with each other, an important character not before observed in Dinosaurs.

The skull represented on the accompanying plate is the type specimen of *Triceratops flabellatus*, Marsh. It was found in the Ceratops beds of Wyoming by Mr. J. B. Hatcher, who also discovered the type of the genus *Ceratops*, in the same horizon in Montana.

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* This Index contains the general heads BOTANY, CHEMISTRY, GEOLOGY, MINERALS, OBITUARY, ROCKS, ZOOLOGY, and under each the titles of Articles referring thereto are mentioned.