

**Article XII.** — THE ANKYLOSAURIDÆ, A NEW FAMILY OF ARMORED DINOSAURS FROM THE UPPER CRETACEOUS.

BY BARNUM BROWN.

The collection of vertebrate fossils from "The Hell Creek Beds of Montana,"<sup>1</sup> made by the American Museum Expedition in 1906, includes a considerable part of the skeleton of a remarkably interesting dinosaur referable to the Stegosauria, although widely different from typical and better known members of that order. It represents a group of Stegosauria characteristic of the late Cretaceous of this country.

Separate teeth of this group from the Judith River Beds were described by Joseph Leidy in 1856, under the names *Palæoscincus* and *Troödon*. In 1902 Osborn and Lambe described parts of a skull and body plates from an equivalent formation in Canada, under the name *Stereocephalus*.<sup>2</sup> This name is preoccupied, having been previously used for a genus of insects.<sup>3</sup> The present remains represent one individual and were found by Mr. Peter Kaisen near Gilbert Creek, 120 miles north of Miles City, Montana. The writer wishes to thank Professor Henry F. Osborn for the opportunity of describing this material and Dr. W. D. Matthew for many valuable suggestions.

The striking features in this reptile are its sculptured, plated skull; large flat or low-ridged body plates, some of which are united as a shield; short-spined vertebræ with parapophyses never rising above the centra; posterior ribs coösfied to vertebræ.

The genus differs so much from the more typical Stegosaurians that it becomes necessary to form a new family for its reception.

ANKYLOSAURIDÆ fam. nov.

*Family characters.*—Skull massive, short, and broadly triangular with dermal plates solidly coösfied to cartilage bones. Teeth Stegosauroid with ovate-lanceolate flattened crowns and crenulate edges. Vertebræ amphiplatyan, solid throughout; neck short, backbone stiff. Body broad, covered with heavy armor plates arranged in rows.

<sup>1</sup> Brown, Bull. Am. Mus. Nat. Hist., Vol. XXIII, 1907, pp. 823-845.

<sup>2</sup> Contributions Canadian Palæontology, Vol. III, Part II, 1902, pp. 55-57.

<sup>3</sup> Arribálzaga, Bol. Ac. Arg., VII, 1884, p. 231.

**Ankylosaurus magniventris** gen. et sp. nov.

Type of species No. 5895, American Museum Collection.

*Generic Characters.*—Skull plates coössified in a continuous sculptured shield; elements of brain case not distinguishable; parietal crest very short, the bordering plates embossed; nostrils far forward. Vertebrae with spines not greatly elevated above centra; parapophyses not rising above neural canal. Anterior ribs with area for attachment of uncinatæ processes; posterior ribs firmly coössified with vertebrae. Scapula and coracoid coössified and curved.

*Stereocephalus* Osborn and Lambe,<sup>1</sup> representing this family in the Judith River Beds, will probably be found to be distinct when better known, but satisfactory distinctions are not at present available.

The type specimen of *A. magniventris* includes the skull with two teeth, scapula and coracoid, seven cervical, ten dorsal, and four caudal vertebrae, several ribs and more than thirty dermal plates.

SKULL.—The skull is about as broad as it is long and the outline from above forms an almost equilateral triangle (Figs. 1 and 2).

The anterior portion is strongly arched both transversely and antero-posteriorly. Behind the orbits and just above the brain the superior surface is depressed and terminates in a flat, short parietal crest. Plates coössified in a continuous surface cover the top and sides of the skull.

In the anterior region they are disposed with more or less bilateral symmetry. There is one very large central plate in front. Other plates have joined this one anteriorly but they are missing. Usually the plates are pentagonal but some are four and a few are six sided. On the anterior half of the skull each plate is defined by a deep circumscribing groove, but posterior to a line connecting the orbits the demarcations are less distinct. Although the original morphologically distinct plates are marked off by these surface grooves, they now form a continuous shield without sutures. For the most part the plates present a pitted surface, with numerous channels leading into foramina. The edges of the large plates are frequently raised while the center is depressed.

Five large lateral plates are preserved on each side. They form the lateral border and the four posterior ones extend over on the top surface. Each of these has an embossed center and the last one on each side projects in a spine-like process which marks the widest part of the skull. The posterior border is formed by the two large plates just mentioned and four smaller plates with embossed centers. The palatal part of the skull is badly disintegrated and the occipital region missing.

There are many large continuous chambers in the upper part of the

<sup>1</sup> *Loc. cit.*

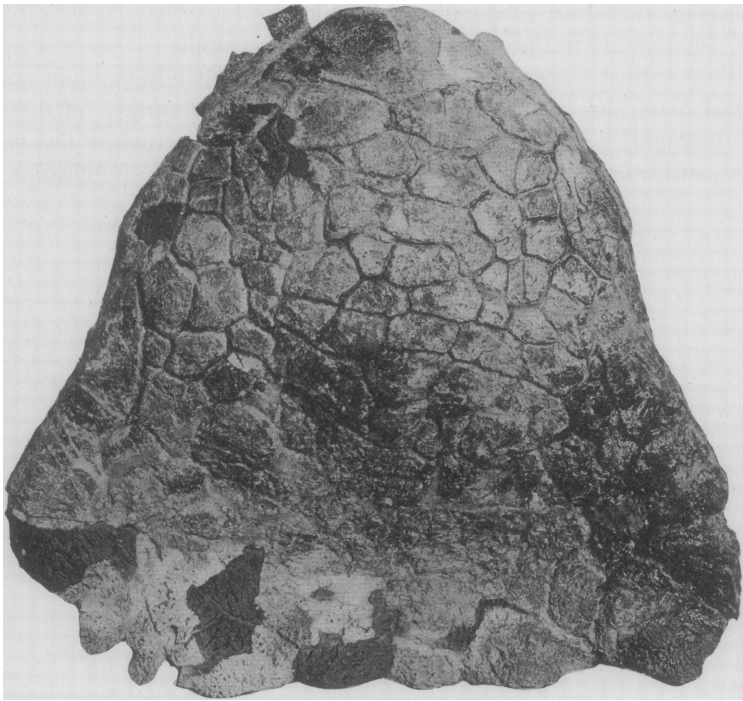


Fig. 1. *Ankylosaurus magniventris*. Top of skull. Several fragments were added after this photograph was taken.  $\frac{1}{2}$  nat. size.

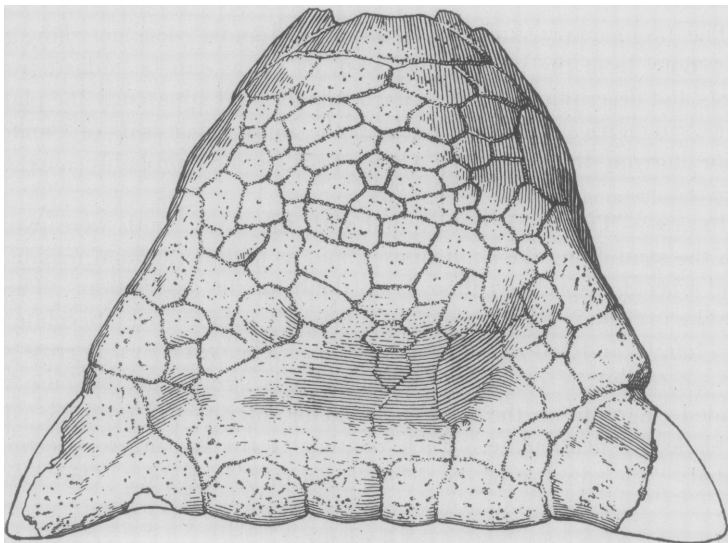


Fig. 2. *Ankylosaurus magniventris*. Top view of skull.  $\frac{1}{2}$  nat. size.

skull (Fig. 3) that are bilaterally symmetrical and may have been air chambers, comparable to the sinuses in Proboscidean skulls.

Two distinct osseous tissues, representing the chondrocranium and the dermal bones, are well defined on the broken inside surface of the skull, but the highly complex arrangement of this internal structure has not yet been satisfactorily interpreted. It is reserved for a future publication.

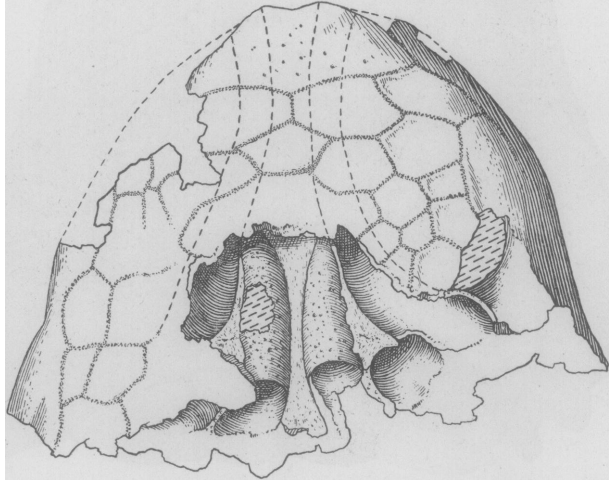


Fig. 3. *Ankylosaurus magniventris*. Top of skull during preparation, showing internal chambers.  $\frac{1}{2}$  nat. size.

The fragmentary skull of *Stereocephalus* Lambe<sup>1</sup> does not show generic distinctions from the present specimen, as far as can be judged from the figures and description, but it is much smaller, and apparently the plates are not as symmetrical. It was found in the Belly River beds of Canada, an earlier horizon than the Hell Creek beds, and is probably ancestral to *Ankylosaurus*.

**TEETH.**—Two teeth were found with the skull; both were extricated from the sand filling the skull sinuses, and as no other animal remains were found with this specimen there is no doubt of the association. The teeth are alike in form. Each consists of a laterally compressed lanceolate crown and a long cylindrical root (Figs. 4 and 5). The root is oval in cross-section and constricted at the neck. The crown is swollen at the base with a rounded cingulum on the inner side. The anterior and posterior edges of the blade are denticulate. Each denticle is circular in cross-section and pointed. The number of denticles seems to be variable. One tooth has

<sup>1</sup> *Loc. cit.*

six on one side and seven on the other side; in the other tooth there are six denticles on each side of the central apical denticle.

The apical denticle is slightly posterior to the central vertical line, which gives the tooth a recurved appearance. The inner face is nearly flat with faint vertical ridges. The outer face is evenly rounded.

The teeth of Stegosauria are not differentiated in different parts of the jaw. The form and pattern is the same throughout each series, although the anterior or posterior teeth may be distorted by crowding.

In the American Museum Cope collection there are nearly three hundred



Fig. 4

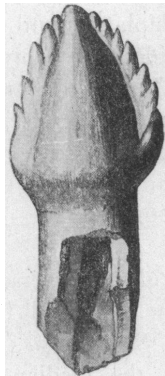


Fig. 5

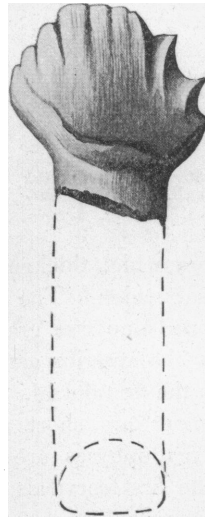


Fig. 6

- Fig. 4. *Ankylosaurus magniventris*. Type of genus and species. Inside view. 3 times nat. size.  
 Fig. 5. *Ankylosaurus magniventris*. Type of genus and species. Outside view. 3 times nat. size.  
 Fig. 6. *Palæoscincus costatus* Leidy. Type of genus and species. 3 times nat. size.

separate Stegosauroid teeth from the Judith River beds of Montana. They are, with less than a dozen exceptions, of exactly similar pattern — the crown of the tooth flattened into an antero-posterior blade and denticulate; the root rounded. Several resemble in form, but are larger than, the original type specimen of *Palæoscincus costatus* (Fig. 6) figured and described by Leidy.<sup>1</sup> Those in which the enamel is preserved show the denticles circular in cross-section and more distinct than in Leidy's type and resemble the tooth figured and referred to *Stereocephalus tutus* Lambe.<sup>2</sup> The two kinds of

<sup>1</sup> Proc. Acad. Nat. Sci. Phil., Vol. VIII, 1856, p. 72, and Trans. Am. Philo. Soc., Vol. XI, 1860, p. 146, plate ix, figs. 49-52.

<sup>2</sup> *Loc. cit.*

teeth in the Cope Collection are undoubtedly of the same species, and probably represent an undescribed species of the genus *Palæoscincus*. It seems probable that the tooth referred by Lambe to *Stereocephalus* (Fig. 7)

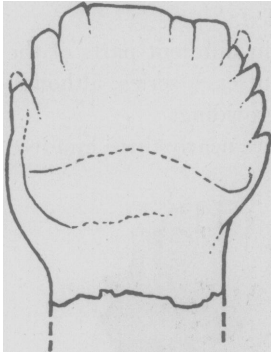


Fig. 7. *Stereocephalus tutus* Lambe. Tooth. 3 times nat. size.

also belongs to a species of *Palæoscincus*. None of these teeth resemble those of *Ankylosaurus magniventris*. The fragmentary tooth (Fig. 8), described as *Troödon formosus* Leidy<sup>1</sup> from the Judith River beds, does to a certain extent resemble the teeth of *Ankylosaurus* but at present its relation cannot be established with any degree of certainty. It is quite possible that the skull of *Stereocephalus* possessed teeth of this pattern.

VERTEBRÆ. *Cervicals*.—The centra of the cervical vertebræ (Figs. 9 and 10) are short, amphiplatyan and slightly cupped on the ends; the sides are deeply excavated.

There is a sharp hæmal ridge on the anterior vertebræ which thickens rapidly and is very broad near the beginning of the dorsal region. The parapophyses are small, except upon the atlas, deeply cupped and rise gradually from a position near the middle of the centrum in the anterior cervicals to near the top of the centrum in the first dorsal.

The spines are short and wide transversely. The anterior zygapophyses are widely separated from each other in the first cervicals, as in *Stegosaurus*, while the posterior zygapophyses approach the median line and unite in the first dorsals. The transverse processes are short and round with enlarged diapophyses. The neural canal is large.

Half of a centrum that is identified as the atlas shows an extensive surface for articulation with the occipital condyle, which must have been large. The single rib facet is much more extensive than in any of the succeeding cervicals and is low down on the side of the centrum.

*Dorsals*.—The centra of the dorsal vertebræ (Fig. 11) are long and cylindrical, amphiplatyan, and slightly cupped with articular faces expanded and sides broadly excavated. The vertical depth of the anterior end is



Fig. 8. *Troödon formosus* Leidy. Type of genus and species. 3 times nat. size.

<sup>1</sup> Proc. Acad. Nat. Sci. Phil., Vol. VIII, 1856, p. 72, and Trans. Am. Philo. Soc., Vol. XI, 1860, p. 147, pl. ix, figs. 53-55.

greater than that of the posterior end of the centrum in the first dorsals and vice versa in the last dorsals, indicating a highly arched body cavity. The spines are short thin plates, their anteroposterior diameter equaling the length of the centrum; they are posterior to the transverse middle line of the centrum. The neural arch is low and the parapophyses never rise entirely above the centrum.

*Ankylosaurus*, *Scelidosaurus*, *Polacanthus* and *Stegosaurus* form an interesting series in the increasing height of the neural arch and corresponding elevation of the parapophyses.

The anterior zygapophyses are united and trough-like. The posterior zygapophyses are convex below, forming with the anterior zygapophyses of the succeeding vertebra a close fitting tongue and groove union. Both

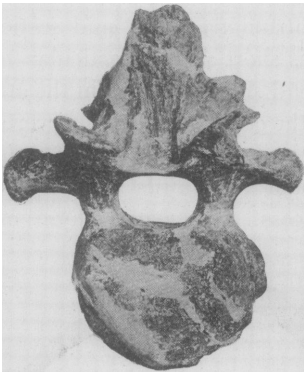


Fig. 9

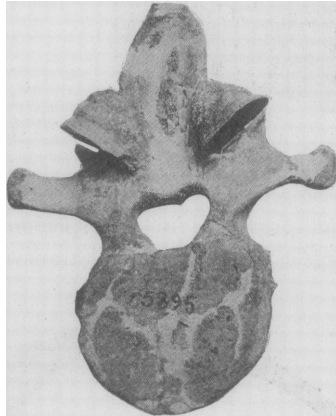


Fig. 10

Fig. 9. *Ankylosaurus magniventris*. Fifth (?) cervical vertebra, anterior end.  $\frac{1}{2}$  nat. size.  
 Fig. 10. *Ankylosaurus magniventris*. Seventh (?) cervical vertebra, posterior end.  $\frac{1}{2}$  nat. size.

extend considerably beyond the centra, thus reducing to a minimum the power of lateral movement.

The transverse processes are massive, short, and project obliquely upward but at a much smaller angle than in *Stegosaurus*.

They are excavated on the middle lower border for close union with the ribs. In the four posterior dorsals preserved the ribs are firmly coössified to the vertebræ (Fig. 12). The neural canal in the anterior dorsals is large and oval. In the posterior dorsals it is compressed laterally and small.

*Caudals*.—The caudal vertebræ are short, slightly cupped at the ends and wide transversely, indicating a short tail. In the anterior caudals the

transverse processes and chevrons are coössified with the centra. In the complete one preserved (Fig. 13), probably the ninth from the sacrum, the spine is quite straight and slender. In *Stegosaurus* all the anterior caudals have massive spines with heavy bifurcated tops. The transverse processes are straight, slender, and project at right angles to the centra. In *Stegosaurus* the transverse processes are expanded vertically, and their extremities curve downward.



Fig. 11. *Ankylosaurus magniventris*. Seventeenth (?) dorsal vertebra, side view.  $\frac{1}{4}$  nat. size.

The chevron is attached to the posterior end of the centrum but does not overlap the succeeding vertebra.

A centrum from the mid section of the tail is short and the articular facets at each end show a change in the attachment of the chevrons to an intervertebral position near this point. The smallest centrum preserved in this specimen is about two thirds the diameter of the largest and has a small transverse process. The zygapophyses of the

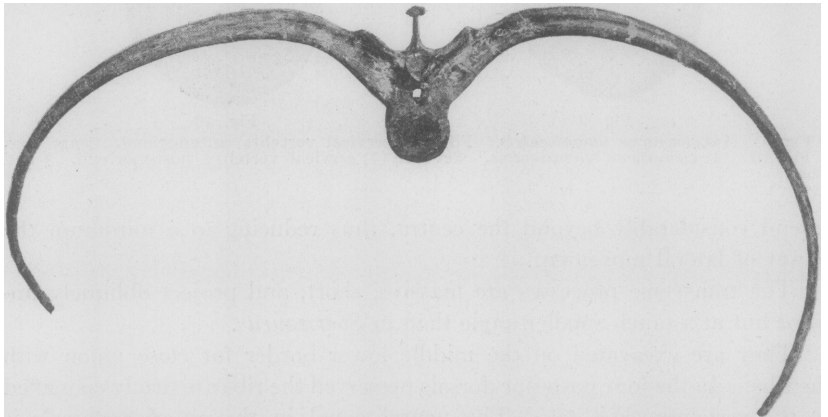


Fig. 12. *Ankylosaurus magniventris*. Nineteenth dorsal vertebra, with coössified ribs, anterior view.  $\frac{1}{12}$  nat. size.

anterior caudals are wide apart as in the cervicals. The neural and hæmal canals are large.



In *Nodosaurus* Marsh,<sup>1</sup> a contemporary Stegosaur from the Lance Creek

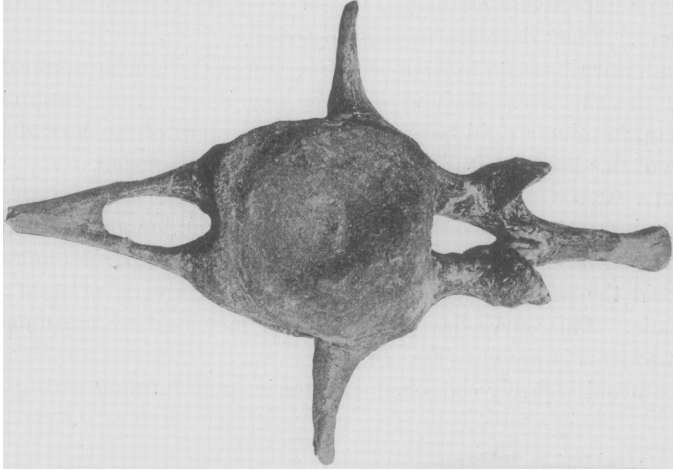


Fig. 13. *Ankylosaurus magniventris*. Ninth (?) caudal vertebra, anterior end.  $\frac{1}{4}$  nat. size.

beds of Wyoming, the caudal vertebræ are said to be longer than in *Stegosaurus*.

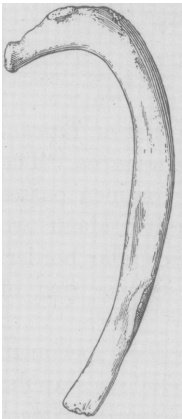


Fig. 14. *Ankylosaurus magniventris*. Anterior dorsal rib, center view showing unciniate process.  $\frac{1}{8}$  nat. size.

**TENDON BONES.**—Ossified tendons are present at least in the dorsal region; in a series of four articulated dorsals they are preserved in position. The bones are rod-like in mid section and expanded at the ends. Apparently there were two tendon bones to each vertebra. They were attached, one on each side, along the top and side of each dorsal spine, and overlapped the two succeeding vertebræ. These bones are shorter and more expanded at the ends than in the Trachodontidæ or the Ceratopsidæ.

**RIBS.**—The ribs are massive and widespreading. In the arch they rise as high as the tops of the spines (Fig. 12). On the three anterior ribs preserved there is an enlarged rugose area at this highest point of the arch which may have served for attachment of the heavy shoulder muscles.

At a point midway between the middle and the distal end on the posterior outer border of each rib there is an enlarged roughened area (Fig. 14) which appears to correspond morphologically to the unciniate processes of the

<sup>1</sup> Am. Jour. Sci. (3), Vol. XXXVIII, 1889, p. 175.

Sphenodon and the crocodile. The relative position is the same. If distinct processes existed in *Ankylosaurus* they were possibly in a rudimentary state or imperfectly ossified as in the crocodile and are not preserved in the fossil. They decrease in size posteriorly.

The anterior ribs seem to have been free, but in the four posterior dorsals preserved the ribs are coössified with the neural arch from capitulum to tuberculum, forming a rigid framework for the support of the dermal armor. The girth of this huge creature exceeded that of the *Mastodon*.

SCAPULA AND CORACOID.—The scapula is thick and massive. Its blade is strongly curved downward proximo-distally and moderately concave on the inner surface. It tapers to a thin rounded tip. Near the union with the coracoid the superior border is curved outward nearly at right angles to the blade. This curve has probably been increased by crushing. No acromian process is present (Fig. 15).

The coracoid is firmly coössified with the scapula forming with it a very



Fig. 15. *Ankylosaurus magniventris*. Scapula and coracoid, outer view.  $\frac{1}{2}$  nat. size.

extensive glenoid cavity, similar to but more extensive than that of *Trachodon*. Evidently the head of the humerus was large, as in *Stegosaurus*. The borders of the coracoid are missing. The large coracoid foramen passes diagonally inward and backward. On the external surface it is about two inches and on the internal surface one half inch from the scapular border. The strongly curved, coössified coraco-scapula closely resembles that of *Scelidosaurus*.

In the American Museum Collection there is an undescribed specimen, from the Jurassic of Montana, referred to *Stegosaurus*. It includes a scapula, humerus, vertebræ and dermal plates. The humerus is typically Stegosauroid. The scapula has a short curved blade. The similarity of these curved scapulæ throws grave doubt on the elements figured by Marsh in his restoration of *Stegosaurus*. The scapula figured in that restoration has a straight blade and resembles that of *Apatosaurus*.

DERMAL ARMATURE.—The dermal plates are uniformly low, ranging

in size from one inch square to fourteen inches in length and ten inches in width. They are unsymmetrical in form but all resemble an inverted V in cross-section. The larger plates (Fig. 16) are almost flat with a low dorsal ridge near one border. In others the ridge extends the full length of the plate near the middle, and the sides meet in an acute angle.

In still another type, which if correctly interpreted covered the neck and fore part of the body, the dorsal ridge rises from the posterior end and terminates near the center at its highest point. From this highest point a lateral ridge descends to the border on either side, thus forming three surfaces. The shortest side of these plates is in front and concave, which allows considerable vertical movement with preceding and succeeding plates. In some plates the dorsal ridge is a curved line which decreases in height anteriorly and, with the lateral borders, forms a beak-like termination.

The outer surfaces of all plates are channelled by deep vascular grooves

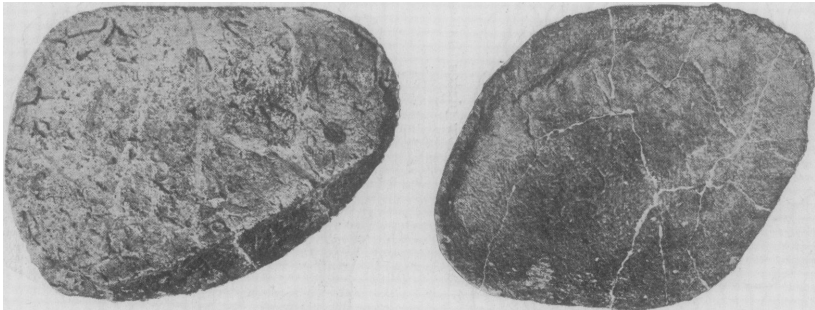


Fig. 16. *Ankylosaurus magniventris*. A, Outer view of large dermal plates from posterior dorsal region. B, ventral surface of same plate.  $\frac{1}{4}$  nat. size.

that lead into foramina and resemble the surface markings of a Ceratopsian skull. On the inner or visceral surface there are small spicules of bone and foramina. The free borders of the plates are irregular. Nearly all show a rugose area at each end for union with preceding and succeeding plates.

Two of the largest plates are united along one edge and on the visceral surface are coössified with a thick curved plate of bone similar to that described as a nuchal buckler in *Stereocephalus tutus*.<sup>1</sup> Two other large plates, broken on the edges, are solidly coössified to heavy bone, like those just described, and with them represent part of a continuous shield. On account of its wide arch this shield could only have covered some part of the posterior dorsal or pelvic region. In these plates the dorsal ridge is near one border whereas in *S. tutus* it is near the middle of the plate. It is

<sup>1</sup> *Loc. cit.*, p. 56.

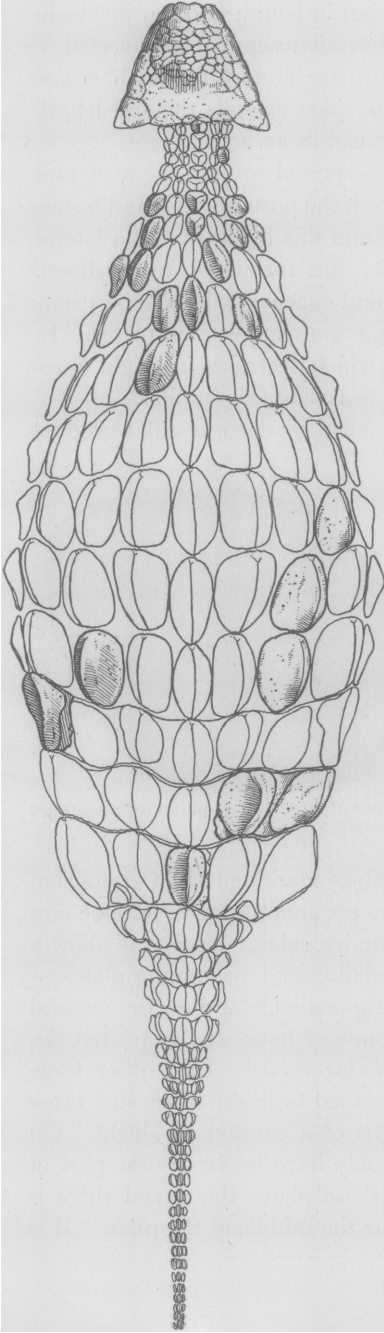


FIG. 17. *Ankylosaurus magniventris*. Outline restoration. Shaded portion show plates that are present, with probable location. About  $\frac{1}{4}$  nat. size.

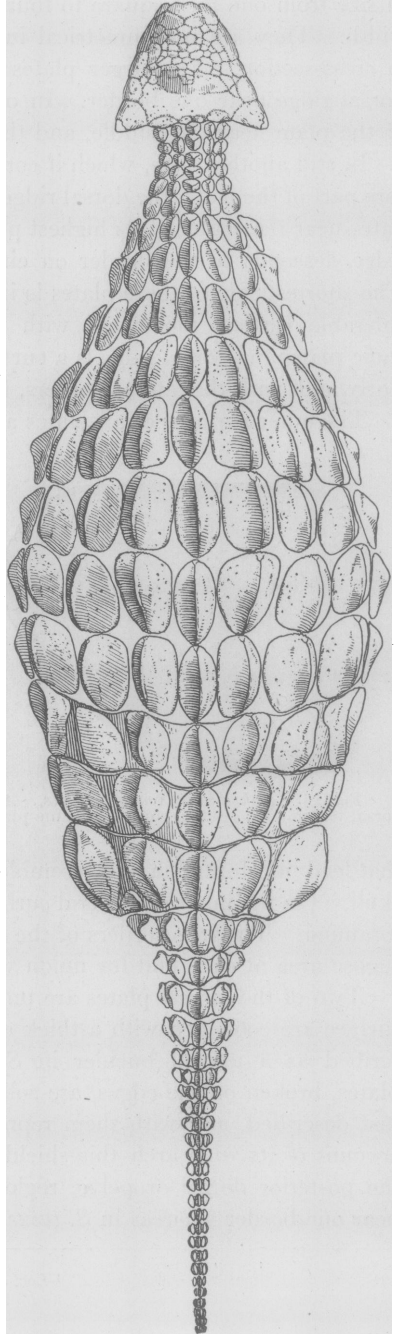


FIG. 18. *Ankylosaurus magniventris*. Restoration of dermal armature. Tail rings copied from Lambe's figure of *Stereoscephalus tutus*. About  $\frac{1}{4}$  nat. size.

highly probable that the circle of plates described in *S. tutus* as a nuchal buckler really formed one of a series of rings that encased the tail as in Glyptodons.

In *Ankylosaurus magniventris* the armor increases in weight, size and solidity toward the pelvic region. So far as known this armature is quite flat and lacks the peculiar large plates and caudal spines so characteristic of *Stegosaurus* (Figs. 17 and 18).

Nor are there any elevated spinous plates as in *Polacanthus* and *Acanthopholis*. The plates of *Nodosaurus*, a contemporaneous armored Stegosaur from the Lance Creek beds, are described as small, quadrangular in form and arranged in rows.

The plates associated with the carnivorous dinosaur *Tyrannosaurus* Osborn<sup>1</sup> are quite distinct in character. They are smooth on the surface with fewer grooves and foramina, much thicker and less regular in outline. They were probably more deeply embedded in the flesh. A comparison with the Ceratopsia cannot be made for very little is known of the dermal armature of that group. None of the plates figured by Marsh as belonging to *Triceratops* are known to have been definitely associated with bones of that genus.<sup>1</sup> In several years of field experience, during which the writer has found many fragmentary skulls and parts of skeletons of *Triceratops*, no dermal plates were found associated.

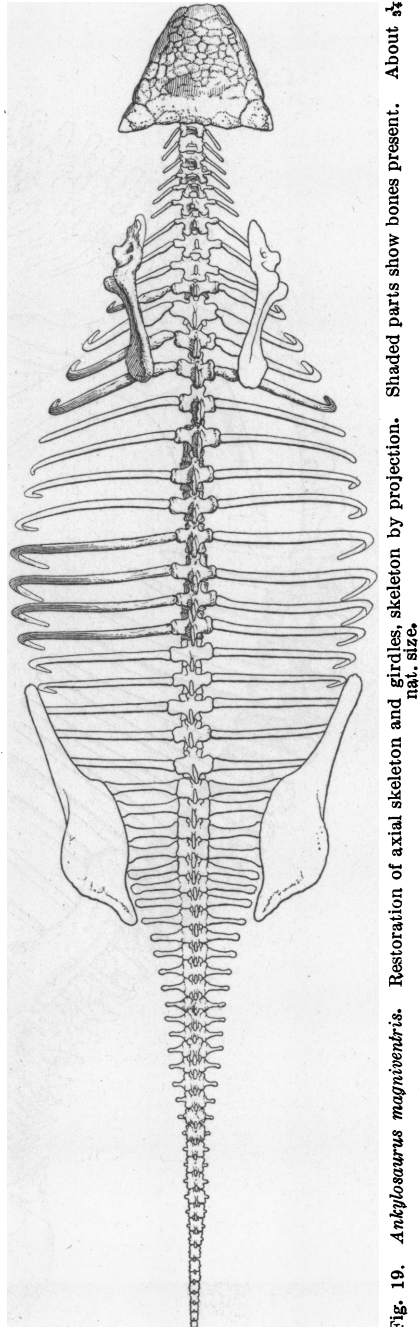


Fig. 19. *Ankylosaurus magniventris*. Restoration of axial skeleton and girdles, skeleton by projection. Shaded parts show bones present. About  $\frac{1}{2}$  nat. size.

<sup>1</sup> Bull. Am. Mus. Nat. Hist., Vol. XXI, p. 263, and Vol. XXII, pp. 295-296.

<sup>2</sup> The Ceratopsia Mon., U. S. Geo. Surv., Vol. XLIX, 1906, p. 65.

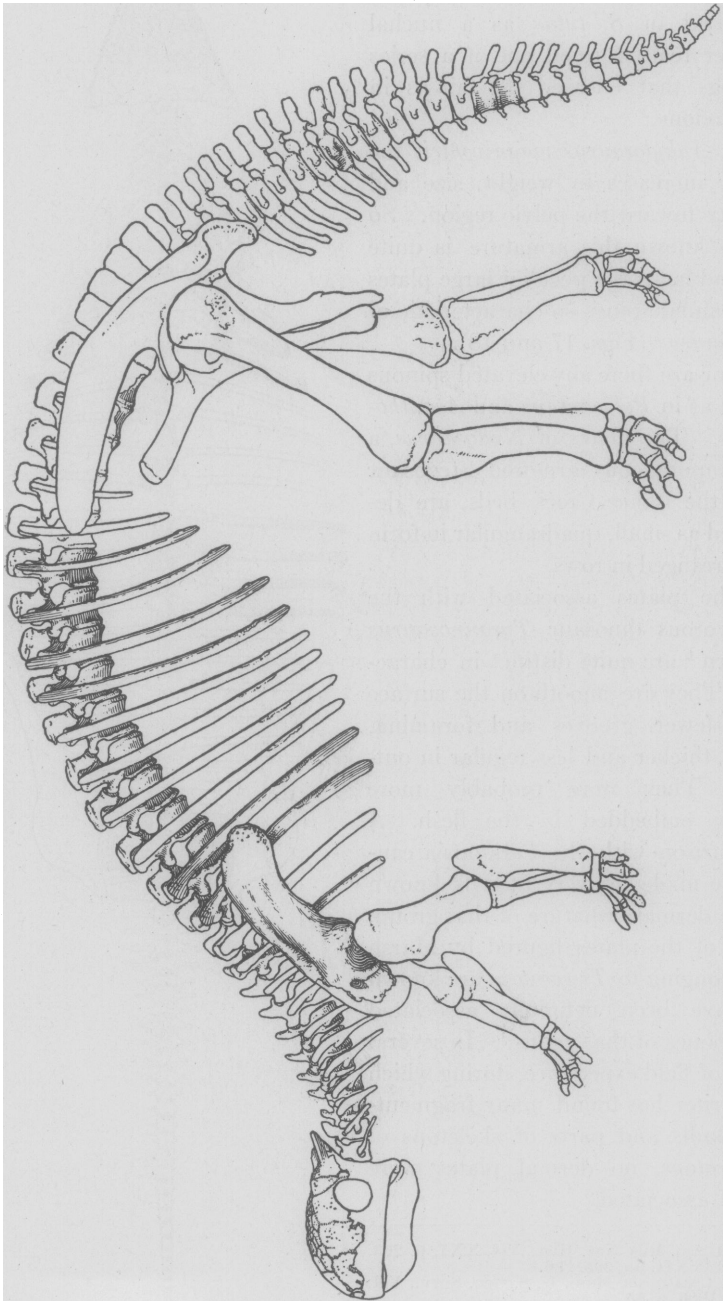


Fig. 20. *Ankylosaurus magniventris*. Restoration of skeleton with the dermal armature omitted. Shaded parts show bones present. Outline parts taken from *Stegosaurus* and modified to conform.  $\frac{1}{4}$  nat. size.

RESTORATION.—From the lines indicated by the bones present, this dinosaur presents a striking parallel to the large Glyptodonts. The rapid change in character from the cervical to the dorsal vertebræ shows a short powerful neck. The back is strongly arched with a minimum of flexibility in the segments. The ribs, coössified to the posterior dorsals, form a rigid body frame peculiarly fitted to support the complete armor that covered the body. The heavy scapula and coracoid and large glenoid cavity indicate massive fore limbs as in other Stegosauria.

In the restorations (Figs. 19 and 20) the shaded portions show bones that are preserved in the specimen. The missing parts are restored in outline after *Stegosaurus* with such modification as the parts present necessitate, as in the skull, the short vertebral spines, the long dorsal and short caudal vertebræ, the wide spreading ribs with uncinatè processes, curved scapula and coracoid, and shorter limbs and tail.

#### *Measurements.*

	mm.
Skull, length . . . . .	550
“ width, posterior end, about . . . . .	700
“ “ anterior border of orbits . . . . .	460
“ center of brain cavity to posterior end of crest . . . . .	110
Vertebra 7th ? cervical, length of centrum anteroposteriorly . . . . .	70
“ 17th ? dorsal, “ “ “ “ . . . . .	130
“ 9th ? caudal, “ “ “ “ . . . . .	60
“ 7th ? cervical, width of centrum, posterior end . . . . .	120
“ 17th ? dorsal, “ “ “ “ “ . . . . .	125
“ 9th ? caudal, “ “ “ “ “ . . . . .	120
“ 7th ? cervical, height of centrum and spine . . . . .	250
“ 17th ? dorsal, “ “ “ “ “ . . . . .	295
“ 9th ? caudal, “ “ “ “ “ . . . . .	280
Scapula, extreme length of blade . . . . .	600
“ and coracoid, length of glenoid cavity . . . . .	175
“ “ “ width “ “ “ . . . . .	140
Extreme width of body cavity . . . . .	1650

