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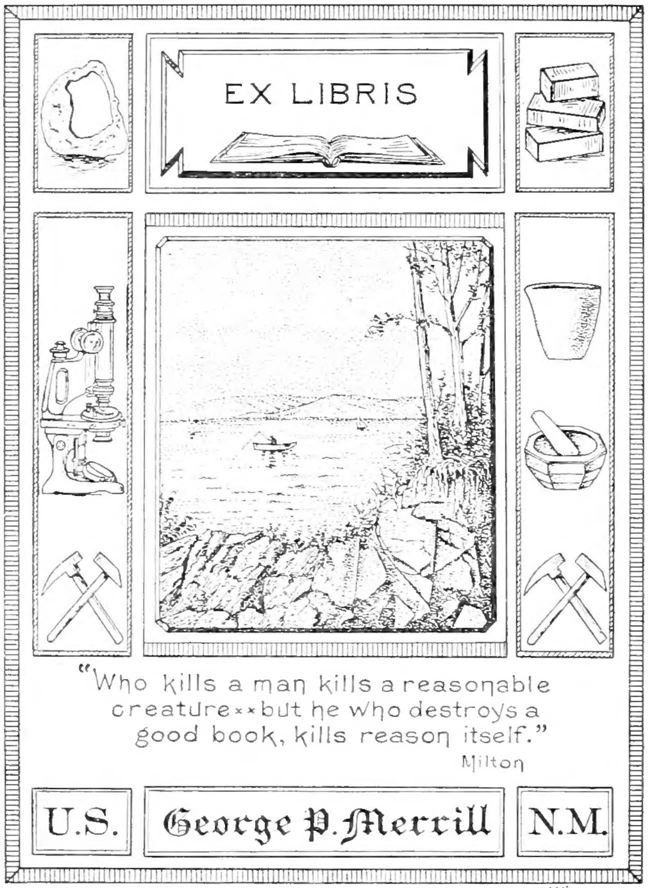
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"Who kills a man kills a reasonable creature ×× but he who destroys a good book, kills reason itself."
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SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 89

OSTEOLOGY OF THE ARMORED DINOSAURIA IN THE UNITED STATES NATIONAL MUSEUM, WITH SPECIAL REFERENCE TO THE GENUS STEGOSAURUS

BY

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ADVERTISEMENT.

The scientific publications of the United States National Museum consist of two series, the *Proceedings* and the *Bulletins*.

The *Proceedings*, the first volume of which was issued in 1878, are intended primarily as a medium for the publication of original, and usually brief, papers based on the collections of the National Museum, presenting newly acquired facts in zoology, geology, and anthropology, including descriptions of new forms of animals, and revisions of limited groups. One or two volumes are issued annually and distributed to libraries and scientific organizations. A limited number of copies of each paper, in pamphlet form, is distributed to specialists and others interested in the different subjects as soon as printed. The date of publication is printed on each paper, and these dates are also recorded in the tables of contents of the volume.

The *Bulletins*, the first of which was issued in 1875, consist of a series of separate publications comprising chiefly monographs of large zoological groups and other general systematic treaties (occasionally in several volumes), faunal works, reports of expeditions, and catalogues of type-specimens, special collections, etc. The majority of the volumes are octavos, but a quarto size has been adopted in a few instances in which large plates were regarded as indispensable.

Since 1902 a series of octavo volumes containing papers relating to the botanical collections of the Museum, and known as the *Contributions from the National Herbarium*, has been published as bulletins.

The present work forms No. 89 of the *Bulletin* series.

Richard Rathbun,
Assistant Secretary, Smithsonian Institution,
In charge of the United States National Museum

Washington, D. C., November, 18, 1914.

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OSTEOLOGY OF THE ARMORED DINOSAURIA IN THE UNITED STATES NATIONAL MUSEUM, WITH SPECIAL REFERENCE TO THE GENUS STEGOSAURUS.

By Charles Whitney Gilmore,
Assistant Curator of Fossil Reptiles, United States National Museum.

INTRODUCTION.

In 1877 Prof. O. C. Marsh described the first Stegosaurian fossils found on this continent. In a series of short papers appearing at irregular intervals up to the year 1897, he presented the more important facts relating to the osteological structure and the relationships of the genus *Stegosaurus*.

Of more recent years the principal contributions to our knowledge of this dinosaur have been through the work of Dr. F. A. Lucas, director of the American Museum of Natural History, but formerly of the United States National Museum, and Prof. R. S. Lull, of Yale University.

In the present paper it is proposed to give for the first time a detailed account of the osteological structure of *Stegosaurus*, to be followed by systematic descriptions of all the type-specimens of that genus and other armored dinosaur remains contained in the United States National Museum collections. With one exception the present work is based entirely upon National Museum material, the exception being a specimen generously loaned me several years ago by Mr. W. H. Reed, of the University of Wyoming, and here described as the type of a new species.

The collections in the United States National Museum were secured largely through the United States Geological Survey, which financed the explorations so energetically carried on by field parties under the direction of the late Prof. Othniel Charles Marsh.

The material at hand includes the remains of several individuals, each of which represents a considerable part of the skeleton; also a vast number of separate bones. Of the associated skeletons the type of *Stegosaurus stenops* Marsh is worthy of especial mention, since it represents the most perfect specimen of the genus yet discovered and the only one known that gives positive evidence as to the arrangement of the dermal armor. As contributing to our knowledge of the Stegosauria it ranks with the mummified carcass of *Trachodon* of more recent discovery and exploitation.[1]

When the Marsh collection was received at the National Museum in 1898 and 1899 a very small part of the Stegosaurian material was in condition for study. The preparation of this material was begun in 1906 and has continued, barring some interruptions, up to the close of the year 1913. All of the known *Stegosaurus*

[1] H. F. Osborn, Memoirs Amer. Mus. Nat. Hist., new ser., vol. 1, pt 2, 1912, pp. 33–54.

specimens in the collection have been prepared and are now available to the student and for exhibition purposes.

The greater part of the early work in the preparation of these fossils was done by Mr. N. H. Boss and myself, but that of later years has been carried on by Messrs. N. H. Boss, C. V. Bressler, and G. B. Giles, and I can not too highly commend the diligence, patience, and skill employed by them in extracting these fossils, often of a delicate nature, from a most refractory matrix.

Many of the wash drawings which are reproduced here through the courtesy of the United States Geological Survey were made by the late Mr. Frederick Berger and were prepared under the direction of the late Prof. O. C. Marsh. The later drawings are nearly all the work of Mr. Rudolph Weber. The photographs were made by Mr. T. W. Smillie, of the United States National Museum.

OCCURRENCE AND HISTORY.

The extensive collection of Stegosaurian remains in the National Museum has, with few exceptions, been obtained from two important, though widely separated, fossil deposits. These are Quarry 13, located in Albany County, Wyoming, and Quarry No. 1, in Fremont County, Colorado. The former, I may say without fear of contradiction, was the source of the greatest accumulation of Stegosaurian remains ever discovered, and from the latter has been obtained the wonderfully complete skeleton of *Stegosaurus stenops* (No. 4934, United States National Museum), in addition to many other valuable specimens.

Although the history of these quarries has been given in previous articles, it is thought advisable to append a brief review of their discovery, location, and the methods employed in working them, in order to complete the present record.

History of Quarry 13.

With the specimens upon which a portion of the present paper is based were many of the original field labels, on which the locality is given as "Quarry No. 13, 8 miles east of Como, Wyoming." Como was formerly a station on the Union Pacific Railroad, situated at the foot of the historic Como Bluff, but this section of the track was abandoned in 1898, and the station has long since ceased to exist.

In response to an inquiry made of Mr. W. H. Reed, of Laramie, Wyoming (the original discoverer), as to the history of the discovery of this deposit of fossils, he writes:

> In August, 1879, I could see the end of Quarry No. 10, where the type of *Brontosaurus excelsus* Marsh was found, so I took one of my men, Mr. E. G. Ashley, and we started out east from the main bluff (or Como-bluff). On the fourth day of our search, in the afternoon, being in the lowest of the Jura bone horizon, we found some hollow bones in the wash and soon after discovered the quarry. The first bones to be taken up was a nearly complete skeleton of *Allosaurus*. After this skeleton had been taken out, we found large quantities of *Stegosaurus* and *Camptosaurus* bones. This quarry was entirely different from any other Jurassic quarry I have ever seen, the matrix being a fine quality of sand. * * * There were also numerous small tubes with an outer crust of calcite. These were nearly uniform in size and about one-half inch in diameter. There were no large dinosaur bones found in this quarry, but it seemed to be a favorite resort for the smaller species. * * * The quarry was cut through by two gulches, and that portion on the west side of the west gulch was called 13 west, that part between the gulches was 13 east, and that on the east side of the east gulch was 13½. This is as I started the work, and I believe Brown continued this plan. * * * I find in my old notebooks the original locations that were filed in 1879 in order to hold it from trespassers.

An inclosure in the above letter shows the quarry to have been located in the northeast quarter of section 5, township 22 north, of range 76 west, Albany County, Wyoming.

Under the supervision of Mr. Reed, at that time employed by Prof. O. C. Marsh, Quarry No. 13 was worked for the remainder of the season of 1879 and during the summers of 1880, 1881, and 1882. In 1883 further excavations were made under the direction of Mr. J. L. Kenney, and in 1884, Mr. Fred Brown assumed charge of the explorations, which were continued uninterruptedly until the autumn of 1887, when the quarry was abandoned as exhausted.

The fossils in Quarry 13 were found in a stratum of sandy clay, as I have determined from the matrix still adhering to the bones, and as indicated in the section (fig. 1) made by Brown. This layer is intercalated between bands of marl or clay, green below and brownish above, all three lying between layers of sandstone. All are tilted at a considerable angle from the horizontal. The correlation of this layer with other fossil horizons in this region of Wyoming is discussed in a previous article on the Osteology of Camptosaurus, etc.[1]

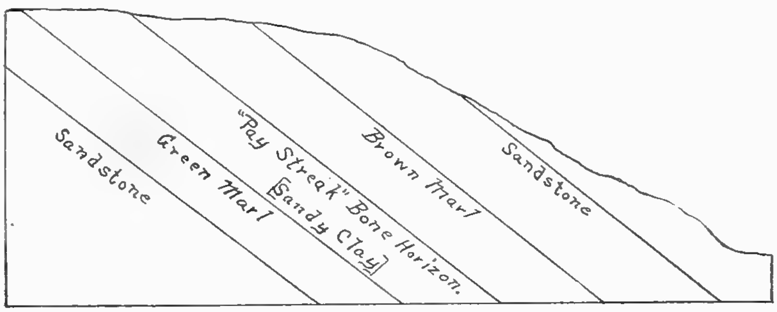

Fig. 1.—Section of Quarry 13. Made by Mr. Fred Brown in 1884.

Plan of work.—The fossils collected from Quarry No. 13 prior to 1882 are now preserved in the collection of the Yale University Museum, while the specimens resulting from the later excavations (the expense of collecting having been defrayed by the United States Geological Survey) are in the paleontological collections of the United States National Museum.

Rough sketch maps of the quarry were made by Reed, on which he indicated the relative positions of all of the important bones found. Unfortunately only a few of these are now available. Later Brown formulated a more detailed plan of recording the relative positions of the specimens uncovered. The quarry was divided (see fig. 2) into what he designated diagrams, beginning with No. 1 and ending with No. 13. In some cases it is found that one diagram represented a season's work, while in other instances several diagrams were worked out in one year, probably due to the varying number of fossils found in the different sections. The diagrams were subdivided into 2-foot squares and, the maps being platted on the scale of 2 feet to the inch, bones as found could be accurately located on them. Each bone or group of bones (when taken up in one block) was given a quarry number, the bones found in each diagram beginning with number 1 (except diagrams 2 and 3) and continuing serially for all of the specimens in that section. The number being placed on a label with the specimens as well as on the map, the precise position of a bone in relation to those found near it could be quickly and accurately determined when the specimens reached the laboratory. A compilation

[1] C. W. Gilmore, Proc. U. S. Nat. Mus., vol. 36, 1909, pp. 297-301.

of these diagrams was made in 1909 as shown in figure 2. A detailed map of "Quarry 13" with sketch drawings of the bones found in the different diagrams is shown in plate 37. There was no datum whereby diagrams 9 and 10 could be accurately located and the area worked by Reed can only be indicated in a general way.

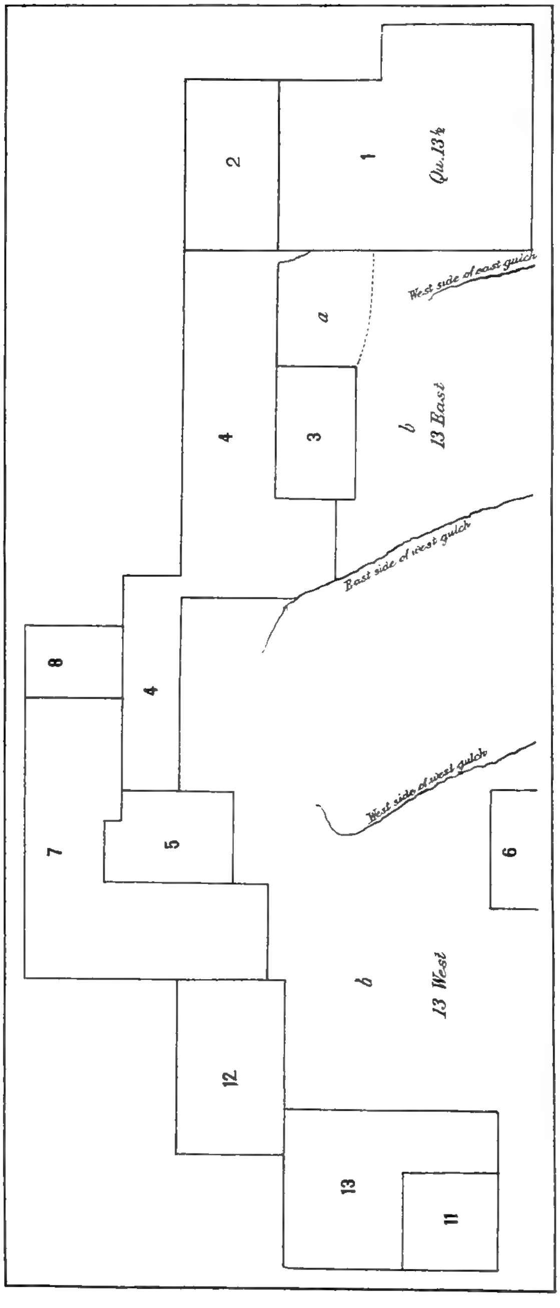

Fig. 2.—Map of Quarry 13, Showing the Relative Positions of the Diagrams as Worked by Messrs. Reed, Kenney, and Brown for Prof. O. C. Marsh, from 1879 to 1887, Inclusive. Scale About 30 Feet to the Inch. *1, 2, 3,* and *4*, Diagrams One to Four Worked by Brown in 1884; *5*, Diagram Five, Worked by Brown in 1885; *6*, Diagram Six, Worked by Brown in 1885; *7, 8, 11,* and *12*, Diagrams Seven, Eight, Eleven, and Twelve, Worked by Brown in 1886; *13*, Diagram Thirteen, Worked by Brown in 1887; *a*, Ground Worked by Kenney in 1883; *b*, Ground Worked by Reed in 1879, 1880, 1881, and 1882; *Qu. 13½* Is Only Relatively Located, Being on the East Side of East Gulch. Compiled from Diagrams Made by Mr. Fred Brown.

The list given below represents the fauna of this quarry.

Dinosauria.

**Stegosaurus ungulatus* Marsh.
**S. sulcatus* Marsh.
S. stenops Marsh.
**Diracodon laticeps* Marsh = *Stegosaurus stenops* Marsh.
**Camptosaurus dispar* Marsh.
**C. medius* Marsh.
**C. nanus* Marsh.
**C. browni* Gilmore.
C. depressus Gilmore.
**Dryosaurus altus* Marsh.
**Coelurus fragilis* Marsh.
**Morosaurus lentus* Marsh.
Morosaurus sp.
Allosaurus sp.

Chelonia.

Glyptops plicatulus (Cope).

Crocodilia.

Goniopholis sp.

Pisces.

Not determinable.

[Those marked with an asterisk (*) represent type-specimens.]

The list to follow is a complete record of all the bones found in diagrams 1, 2, 3, 4, 5, 7, 8, 11, 12, and 13 of Quarry 13 between the years 1883 and 1887, inclusive. By the aid of these lists with the map (pl. 37) the evidence for the association of the scattered parts of various individuals is graphically portrayed to the reader. Articulated and otherwise closely associated elements, where there is reason for believing they pertain to one individual, are given a single catalogue number. In some few instances quite widely separated bones have been thus catalogued on the evidence, as in the case of limb bones representing opposite sides and of the same dimensions, same degree of rugoseness of the points of muscular insertion, and of the articular ends, etc. This procedure has in some cases probably resulted in a wrong association of parts, but the verification of these determinations can now be readily made by any future student.

The following tables give the bones found in Quarry 13, and are arranged according to the diagrams shown in fig. 2.

Fossil bones found in diagram 1, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
1	Cervical vertebra	*Stegosaurus*	Cat. No. 7360.
2	do	do	Do.
3	Fragment of dorsal vertebra	do	Discarded.
4	Base of dermal plate	do	Cat. No. 7617.
5	Coracoid, right	*Stegosaurus*	Cat. No. 7345.
6	Ilium, right	*Camptosaurus dispar*	Cat. No. 7631.
7	Fragment		Discarded.
8	Dorsal centrum	Sauropod dinosaur	Not catalogued.
9	Fragment		Discarded.
10	Distal half of a rib		Not identified.
11	Fragments		Discarded.
12	Fragment		Do.
13	do		Do.
14	do		Do.
15	do		Do.
16	Fragment of rib		Do.
17	Scapula, left	*Camptosaurus dispar*	Cat. No. 5955.
18	Fragment		Discarded.
19	do		Do.
20	do		Do.
21	do		Do.
22	Proximal end of rib	*Stegosaurus*	Cat. No. 7357.
22½	Fragment		Discarded.
23	do		Do.
24	Portion of atlas	*Stegosaurus*	Cat. No. 7725.
25	Terminal phalanx	*Camptosaurus*	Cat. No. 5962.
26	Cervical rib	*Stegosaurus*	Cat. No. 7616.
27	Process of dorsal vertebra	do	Cat. No. 7707.
28	Fragment		Discarded.
29	Proximal half of rib	*Stegosaurus*	Cat. No. 7728.
30	Distal half of rib	do	Do.
31	Foot bone		Not identified.
32	Phalanx	*Camptosaurus*	Cat. No. 5962.
33	Dorsal rib	*Stegosaurus*	Cat. No. 7728.
34	Caudal centrum	Sauropod dinosaur	Not catalogued.
35	Cervical rib	*Stegosaurus*	Cat. No. 7616.
36	Fragment		Discarded.
37	do		Do.
38	do		Do.

Fossil bones found in diagram 1, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
39			Not found.
40			Do.
41			Do.
42	Ischium, right	*Stegosaurus*	Cat. No. 7356.
43	Dorsal vertebra	do	Cat. No. 7707.
44	Portion of humerus	Sauropod dinosaur	Discarded.

Fossil bones found in diagram 2, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
45	Caudal, anterior	*Stegosaurus*	Cat. No. 7814.
46	Phalanx	*Camptosaurus*	Cat. No. 7813.

Fossil bones found in diagram 3, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
47	Piece of rib	Sauropod dinosaur	Discarded.
48	do		Do.
49	Fragment		Do.
50	Tops of sacral spines	*Stegosaurus*	Not catalogued.
51	Fragment		Discarded.
52	do		Do.
53			Not found.
54	Fragments		Discarded.
55			Not found.
56			Do.
57	Fragments		Discarded.
58	do		Do.
59	Fragment		Do.
60	Caudal, transverse process	*Stegosaurus*	Not catalogued.
61	Fragment		Do.
62	Fragment of ilium	*Camptosaurus*	Do.
63	Sacral centrum	do	Cat. No. 7815.

Fossil bones found in diagram 4, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
1	Caudal centrum	*Stegosaurus*	Cat. No. 7735.
2	do	do	Do.
3	Top of caudal spine	do	Do.
4	Fragment		Discarded.
5	Top of sacral spines	*Stegosaurus*	Cat. No. 7734.

Fossil bones found in diagram 4, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
6	Terminal phalanx	*Camptosaurus*	Cat. No. 7732.
7	Dorsal centrum	*Stegosaurus*	Cat. No. 7791.
8	Parts of sacral spines	do	Cat. No. 7734.
9	Fragment		Discarded.
10	Metacarpal II	*Camptosaurus*	Cat. No. 5824.
11	Caudal spine	do	Cat. No. 7766.
12	Fragment		Discarded.
13	do		Do.
14	do		Do.
15	3 cervical centra	*Camptosaurus*	Cat. No. 5823.
16	Fragments		Discarded.
17	Scapula and coracoid, left	*Camptosaurus*	Cat. No. 5954.
18	Dorsal process	do	Cat. No. 7766.
19	Caudal process	do	Do.
20	Limb bone fragment		Discarded.
21	Fragment		Do.
22	do		Do.
23	Dorsal centrum	*Stegosaurus*	Cat. No. 7823.
24	Caudal vertebra	*Morosaurus*	Cat. No. 7817.
25	do	do	Do.
26	do	do	Do.
27	do	do	Do.
28	do	do	Do.
29	do	do	Do.
30	do	do	Do.
31	do	do	Do.
32	do	do	Do.
33	do	do	Do.
34	do	do	Do.
35	Femur, left	*Stegosaurus*	Cat. No. 7711.
36	Fragment		Discarded
37	Fragments		Do.
38	Fragments, vertebra		Do.
39	do		Do.
40	do		Do.
41	do		Do.
42	Ilium, left	*Morosaurus*	Cat. No. 7817.
43	Fragment		Discarded.
44	do		Do.
45	Fragment of ilium	*Morosaurus*	Cat. No. 7817.
46	Caudal vertebra	do	Do.
47	do	do	Do.
48	Caudal vertebra and chevron	do	Do.
49	do	do	Do.
50	do	do	Do.
51	do	do	Do.
52	do	do	Do.
53	do	do	Do.
54	do	do	Do.
55	do	do	Do.
56	do	do	Do.
57	do	do	Do.
58	do	do	Do.
59	do	do	Do.

Fossil bones found in diagram 4, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
60	Caudal vertebra and chevron	*Morosaurus*	Cat. No. 7817.
61	.....do	.....do	Do.
62	Tibia (proximal end)	*Stegosaurus*	Not catalogued.
63			Not found.
64	Dermal spine	*Stegosaurus ungulatus.*	Cat. No. 6099.
65	.....do	.....do	Do.
66	.....do	.....do	Do.
67	.....do	.....do	Do.
68	Caudal vertebra	.....do	Do.
69	.....do	.....do	Do.
70	.....do	.....do	Do.
71	.....do	.....do	Do.
72	.....do	.....do	Do.
73	.....do	.....do	Do.
74	.....do	.....do	Do.
75	.....do	.....do	Do.
76	.....do	.....do	Do.
77	.....do	.....do	Do.
78	.....do	.....do	Do.
79	.....do	.....do	Do.
80	.....do	.....do	Do.
81	.....do	.....do	Do.
82	.....do	.....do	Do.
83	.....do	.....do	Do.
84	.....do	.....do	Do.
85	.....do	.....do	Do.
86	.....do	.....do	Do.
87	.....do	.....do	Do.
88	Caudal vertebra, fragmentary	.....do	Do.
89	Fragment		Discarded.
90	Dermal plate	*Stegosaurus ungulatus.*	Cat. No. 6099.
91	.....do	.....do	Do.
92	Sacral rib	*Stegosaurus ?*	Cat. No. 7822.
93	Caudal vertebra	*Camptosaurus*	Cat. No. 7818.
94	Fragment		Discarded.
95	Caudal vertebra	*Stegosaurus*	Cat. No. 7735.
96	.....do	.....do	Do.
97	.....do	.....do	Do.
98	.....do	.....do	Do.
99	.....do	.....do	Do.
100	.....do	.....do	Do.
101	.....do	.....do	Do.
102	Sacral rib	.....do	Cat. No. 7822.
103	Fragment		Discarded.
104	.....do		Do.
105	Caudal centrum	Not identified	Cat. No. 7796.
106	.....do	.....do	Do.
107	.....do	.....do	Do.
108	End of rib		Discarded.
109	Dermal ossicles	*Stegosaurus*	Cat. No. 7947.
110	Caudal centrum	Not identified	Cat. No. 7796.

Fossil bones found in diagram 4, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
111	Caudal centrum	Not identified	Cat. No. 7796.
112	Fragment		Discarded.
113	....do		Do.
114	Cervical vertebra	*Stegosaurus*	Cat. No. 7353.
115	....do	....do	Do.
116	Fragment		Discarded.
117	Basal part of skull and other fragments.	*Camptosaurus*	Cat. No. 5997.
118	Fragment		Discarded.
119	Top of dorsal spine	*Stegosaurus*	Do.
120	Fragment		Do.
121	Caudal centrum (anterior)	*Stegosaurus*	Cat. No. 7765.
122	Fragment of dorsal rib	....do	Discarded.
123	Cervical vertebra	*Stegosaurus ungulatus.*	Cat. No. 7348.
124	Dorsal vertebra (anterior)	*Camptosaurus*	Cat. No. 7727.
125	Fragment		Discarded.
126	....do		Do.
127	Caudal centrum	*Stegosaurus*	Cat. No. 7358.
128	Top of caudal spine	....do	Not catalogued.
129	Fragment		Discarded.
130	Fragment of skull		Not catalogued.
131	Sacral rib	*Stegosaurus*	Cat. No. 7346.
132	3 sacral centra	....do	Do.
133	Caudal spine, anterior	....do	Not catalogued.
134	Process to dorsal	....do	Cat. No. 7716.
135	Rib portion	....do	Not catalogued.
136	Fragment of rib		Discarded.
137	Fragment		Do.
138	Metatarsals II, III	*Camptosaurus nanus.*	Cat. No. 5960; on mounted skeleton.
139	Fragment of dermal plate	*Stegosaurus*	Discarded.
140	Femur, right	....do	Cat. No. 7611.
141	Process to dorsal vertebra	....do	Cat. No. 7716.
142	Portion of cervical rib	....do	Not catalogued.
143	Cervical vertebra	*Camptosaurus*	Cat. No. 6001; on mounted skeleton of *C. browni.*
144	Cervical process	*Stegosaurus*	Cat. No. 7354.
145	Portion of dorsal rib	....do	Cat. No. 7731.
146	Fragment		Discarded.
147	Top dorsal spine	*Stegosaurus*	Not catalogued.
148	Sacral rib	....do	Cat. No. 7787.
149	Radius, left	*Stegosaurus stenops*	Cat. No. 4929.
150	Ulna, left	....do	Do.
151	Fragment		Discarded.
152	Cervical centrum	*Stegosaurus*	Cat. No. 7639.

Fossil bones found in diagram 4, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
153	Fragment of rib		Discarded.
154	Fragment		Do.
155	.....do		Do.
156	Proximal half of rib, left	*Stegosaurus*	Cat. No. 7731.
157	Fragment of rib	.....do	Do.
158	Portion of thoracic rib	.....do	Do.
159	Fragment of dermal plate	.....do	Discarded.
160	Portion of dorsal rib	.....do	Cat. No. 7731.
161	Cervical centrum	.....do	Cat. No. 7639.
162	Posterior cervical rib	.....do	Cat. No. 7780.
163	Fragment		Discarded.
164	Portion of cervical rib	*Stegosaurus*	Cat. No. 7788.
165	Fragment		Discarded.
166	.....do		Do.
167	Cervical vertebra	*Stegosaurus*	Cat. No. 7355.
168	Caudal centrum (anterior)	.....do	Cat. No. 7638.
169	Scapula, left	.....do	Cat. No. 7374.
170	Portion of dorsal process	.....do	Not catalogued.
171	Proximal half of rib, left	.....do	Cat. No. 7731.
172	Portion of dorsal rib	.....do	Do.
173	Fragment		Discarded.
174	Portion of dorsal rib	*Stegosaurus*	Cat. No. 7731.
175	.....do	.....do	Cat. No. 7731.
176	Fragment		Discarded.
177	.....do		Do.
178	Basioccipital portion of the skull	*Camptosaurus*	Cat. No. 5996.
179	Fragment of rib		Discarded.
180	Skull No. 4	*Stegosaurus*	Cat. No. 4935.
181	Fragment		Discarded.
182	.....do		Do.
183	Humerus, left	*Stegosaurus stenops*	Cat. No. 4929.
184	Scapula, left	.....do	Do.
185	Anterior dermal plate	*Stegosaurus*	Cat. No. 7615.
186	Fragment of plate	.....do	Do.
187	Metacarpal	.....do	Cat. No. 7418.
188	Intermedium	.....do	Cat. No. 7586.
189	Carpal bone	.....do	Do.
190	.....do	.....do	Do.
191	Dermal spine	.....do	Cat. No. 7359.
192	Caudal centrum	.....do	Cat. No. 7647.
193	Fragment		Discarded.
194	Dorsal centrum	*Stegosaurus*	Cat. No. 7648.
195	Cervical centrum	.....do	Cat. No. 7790.
196	Dermal plate	.....do	Cat. No. 7615.
197	Dermal plate, neck	.....do	Do.
198	Fragment	.....do	Discarded.
199	Ischium, left	.....do	Cat. No. 2111.
200	Metatarsal IV, right	.....do	Cat. No. 7365.
201	5 bones, left fore foot	*Stegosaurus stenops*	Cat. No. 4929.
202	Dermal scutes	*Stegosaurus*	Cat. No. 7615.
203	Process of cervical vertebra	.....do	Cat. No. 7640.
204	Portion of rib	.....do	Not catalogued.

Fossil bones found in diagram 4, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
205	Fragment of rib	*Stegosaurus*	Discarded.
206	do	do	Do.
207	Dermal plate	do	Cat. No. 7584.
208	do	do	Do.
209	do	do	Do.
210	do	do	Do.
211	do	do	Do.
212	do	do	Do.
213	Proximal end of rib	*Camptosaurus*	Not catalogued.
214	Metacarpal	*Stegosaurus*	Cat. No. 7418.
215	Fragment		Discarded.
216	Femur, left	*Stegosaurus*	Cat. No. 7380.

Fossil bones found in diagram 5, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
1	Dorsal centrum	*Stegosaurus*	Cat. No. 7807.
2	Metatarsal III, left	do	Cat. No. 7365.
3	2 phalanges	do	Cat. No. 7364.
4	Sacral rib (?)	do	Cat. No. 7816.
5	Piece of rib		Discarded.
6	Fragment		Do.
7	Caudal centrum	*Stegosaurus stenops*	Cat. No. 6135.
8	Fragment		Discarded.
9	Dermal plate	*Stegosaurus*	Cat. No. 7584.
10	do	*Stegosaurus stenops*	Cat. No. 4714.
11	do	do	Do.
12	Femur, right	do	Cat. No. 7380.
13	Caudal vertebra	do	Cat. No. 4714.
14	Ungual phalanx	*Stegosaurus*	Cat. No. 7369.
15	Caudal vertebra	*Stegosaurus stenops*	Cat. No. 6135.
16	do	do	Do.
17	Left scapula and caudal (Cat. No. 6135).	*Stegosaurus*	Cat. No. 7371, may be opposite to No. 7362.
18	Caudal vertebra	*Stegosaurus stenops*	Cat. No. 6135.
19	do	do	Do.
20	do	do	Do.
21	do	do	Do.
22	Chevron	do	Cat. No. 4714.
23	Sacral rib	*Stegosaurus*	Cat. No. 7799.
24	Chevron	do	Cat. No. 7363.
25	Dermal plate	do	Cat. No. 7584.
26	Cervical rib	*Camptosaurus browni*	Cat. No. 4282.
27	Fibula, right	*Stegosaurus*	Cat. No. 7380.
28	Dermal plate	do	Cat. No. 7584.
29	Pubis, left	do	Cat. No. 7771.

Fossil bones found in diagram 5, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
30	Femur, left	*Stegosaurus*	Cat. No. 7370.
31	Dermal spine	*Stegosaurus stenops*	Cat. No. 6135; pair.
31½	....do	....do	
32	Caudal vertebra	....do	Cat. No. 6135.
33	....do	....do	Do.
34	....do	....do	Do.
35	....do	....do	Do.
36	....do	....do	Do.
37	....do	....do	Do.
38	....do	....do	Do.
39	....do	....do	Do.
40	....do	....do	Do.
41	Caudal vertebra and chevron	....do	Do.
42	....do	....do	Do.
43	....do	....do	Do.
44	....do	....do	Do.
45	....do	....do	Do.
46	....do	....do	Do.
47	....do	....do	Do.
48	....do	....do	Do.
49	....do	....do	Do.
50	....do	....do	Do.
51	....do	....do	Cat. No 4714.
52	....do	....do	Do.
53	....do	....do	Do.
54	....do	....do	Do.
55	Caudal vertebra	....do	Do.
56	....do	....do	Do.
57	....do	....do	Do.
58	....do	....do	Do.
59	....do	....do	Do.
60	....do	....do	Do.
61	....do	....do	Do.
62	....do	....do	Do.
63	Caudal vertebra and chevron	....do	Do.
64	Caudal vertebra	....do	Do.
65	....do	....do	Do.
66	....do	....do	Do.
67	....do	....do	Do.
68	Caudal vertebra and chevron	....do	Do.
69	Caudal vertebra	....do	Do.
70	Caudal vertebra and chevron	....do	Do.
71	Calcaneum, left	*Stegosaurus*	Cat. No. 7367.
72	Caudal vertebra	....do	Not catalogued.
73	Dermal plate of tail	*Stegosaurus stenops*	Cat. No. 6135.
74	Foot bone	*Stegosaurus*	Cat. No. 7380.
75	Tibia and astragalus, right	....do	Do.
76	Dermal plate	*Stegosaurus stenops*	Cat. No. 4714.
77	3 digits of right hind foot, and skull.	*Stegosaurus*	Cat. Nos. 4280 and 2274.
78	Dermal plate	*Stegosaurus stenops*	Cat. No. 4714.
79	....do	....do	Do.
80	Tibia (young)	*Stegosaurus*	Cat. No. 7373.
81	Dorsal rib	*Camptosaurus browni*	Cat. No. 4282.

Fossil bones found in diagram 5, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
82	Chevron	*Stegosaurus*	Not catalogued.
83	Dorsal rib (5th of right side)	*Camptosaurus browni*	Cat. No. 4282.
84	Humerus, left	do	Do.
85	Radius, ulna, and manus, left	do	Do.
86	Caudal and chevron	*Stegosaurus stenops*	Cat. No. 6135.
87	Caudal vertebra	do	Do.
88	Caudal spines	do	Do.
89	Chevron	do	Do.
90	do	do	Do.
91	do	do	Do.
92	do	do	Do.
93	do	do	Do.
94	Caudal centrum	*Stegosaurus*	Cat. No. 7587.
95	Top of spine	*Camptosaurus*	Not catalogued.
96	capula and coracoid, right	*Stegosaurus*	Cat. No. 7361.
97	Process to caudal	do	Not catalogued.
98	Spinous process	*Camptosaurus browni*	Cat. No. 4282.
99	Sternal bone	*Stegosaurus*	Cat. No. 7618.
100	Fragment		Discarded.
101	Dorsal, seventh	*Camptosaurus browni*	Cat. No. 4282.
102	Dorsal, sixth	do	Do.
103	Dorsal, fifth	do	Do.
104	Dorsal, fourth	do	Do.
105	Dorsal, third	do	Do.
106	Dorsal, second	do	Do.
106	Thoracic rib (eighth of right side)	do	Do.
107	Head of dorsal rib	do	Do.
108	Caudal transverse	*Stegosaurus*	Not catalogued.
109	Piece of dorsal rib	*Camptosaurus browni*	Cat. No. 4282.
110	Top of spinous process	*Camptosaurus*	Discarded.
111	Fragment		Do.
112	Portion of dermal plate	*Stegosaurus*	Cat. No. 7584.
113	Portion of right ischium	*Camptosaurus browni*	Cat. No. 4282.
114	Fragment of spinous process	*Camptosaurus ?*	Discarded.
115	Ischium, left	*Camptosaurus browni*	Cat. No. 4282.
116	Dorsal rib (head)	do	Do.
117	Postfrontal	*Camptosaurus*	Cat. No. 7421.
118	Top of spine	do	Not catalogued.
119	Cervical rib	*Camptosaurus browni*	Cat. No. 4282.
120	Dorsal, eighth	do	Do.
121	Dorsal, ninth	do	Do.
122	Dorsal, tenth	do	Do.
123	Dorsal, eleventh	do	Do.
124	Dorsal, twelfth	do	Do.
125	Dorsal, thirteenth	do	Do.
126	Dorsal, fourteenth	do	Do.
127	Dorsal, fifteenth	do	Do.
128	Dorsal, sixteenth	do	Do.
129	Sacral vertebra, first	do	Do.

Fossil bones found in diagram 5, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
130	Sacral vertebra, second	*Camptosaurus browni*	Cat. No. 4282.
131	Sacral vertebra, third	do	Do.
132	Sacral vertebra, fourth	do	Do.
133	Sacral vertebra, fifth	do	Do.
134	Caudal vertebra, first	do	Do.
135	Caudal vertebra, second	do	Do.
136	Caudal vertebra, third	do	Do.
137	Coracoid, right	*Stegosaurus*	Cat. No. 7362.
138	Supraorbital	*Camptosaurus*	Cat. No. 7632.
139	Dermal plate	*Stegosaurus*	Cat. No. 7584.
140	Ilium, left	*Camptosaurus browni*	Cat. No. 4282.
141	Fragment		Discarded.
142	Caudal centrum	*Stegosaurus stenops*	Cat. No. 4714.
143	Caudal and chevron	do	Cat. No. 6135.
144	do	do	Do.
145	Caudal vertebra	do	Do.
146	Caudal and chevron	do	Do.
147	do	do	Do.
148	do	do	Do.
149	do	do	Do.
150	do	do	Do.
151	do	do	Do.
152	do	do	Do.
153	do	do	Do.
154	Caudal vertebra	do	Cat. No. 6135.
155	do	do	Do.
156	do	do	Do.
157	Portion of dorsal rib	*Camptosaurus browni*	Cat. No. 4282.
158	Caudal, sixth	do	Do.
159	Caudal, fifth	do	Do.
160	Ilium, left	*Stegosaurus*	Cat. No. 7372; may be opp. 239 dgm .7.
161	Spine fragment		Discarded.
162	Rib fragment	*Stegosaurus*	Do.
163	Fragment		Do.
164	Fragment of plate	*Stegosaurus*	Do.
165	Pubis		Not found.
166	Scapula, right	*Stegosaurus*	Cat. No. 7362, coracoid 139 same indiv.
167	Ilium, right	*Camptosaurus browni*	Cat. No. 4282.
168	Caudal, third	do	Do.
169	Caudal, fourth	do	Do.
170	Caudal, seventh	do	Do.
171	Caudal, eighth	do	Do.
172	Caudal, ninth	do	Do.
173	Caudal, tenth	do	Do.
174	Caudal, eleventh	do	Do.
175	Caudal vertebra	do	Do.
176	do	do	Do.
177	Dermal plate	*Stegosaurus stenops*	Cat. No. 4714.
178	Chevron	*Camptosaurus browni*	Cat. No. 4282.

Fossil bones found in diagram 7, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
1	Calcaneum, left	*Stegosaurus*	Cat. No. 7398.
2	Phalanx	do	Cat. No. 7400.
3	Spinous process	do	Discarded.
4	Metacarpal	*Camptosaurus* (?)	Cat. No. 7785.
5	Fragment		Discarded.
6	Ungual phalanx	*Stegosaurus*	Cat. No. 7401.
7	Phalanx	do	Do.
8	Fragment		Discarded.
9	Metacarpal	*Stegosaurus*	Cat. No. 7401.
10	Fragment		Discarded.
11	do		Do.
12	do	*Stegosaurus*	Do.
13	do		Do.
14	Ilium, right	*Stegosaurus*	Cat. No. 7385.
15	Femur, right	do	Do.
16	Radius, right	do	Cat. No. 7401.
17	Scapula, left	do	Cat. No. 7371.
18	Fragment	do	Discarded.
19	Metacarpal V, right	do	Cat. No. 7401.
20	Foot bones, right fore foot	do	Do.
21	Ulna, right	do	Do.
22	Large dermal plate	do	Cat. No. 7585.
23	Caudal vertebra	*Diracodon laticeps*	Cat. No. 4288.
24	do	do	Do.
25	do	do	Do.
26	do	do	Do.
27	do	do	Do.
28	do	do	Do.
29	do	do	Do.
30	do	do	Do.
31	do	do	Do.
32	do	do	Do.
33	do	do	Do.
34	do	do	Do.
35	do	do	Do.
36	do	do	Do.
37	do	do	Do.
38	Dermal spine	do	Do.
39	do	do	Do.
40	do	do	Do.
41	Clavicle (?)	*Stegosaurus*	Cat. No. 7382.
42	Process to vertebra	do	Discarded.
43	Dermal plate	*Stegosaurus stenops*	Cat. No. 4714.
44	Rib	(?)	Not catalogued.
45	Scapula, left	*Camptosaurus browni*	Cat. No. 4282.
46	Coracoid, left	do	Do.
47	Small dermal plate	*Stegosaurus*	Cat. No. 7383.
48	Premaxillary, right	*Morosaurus* (?)	Cat. No. 7759.
49	Rib, fragment		Not catalogued.
50	Ungual phalanx	*Stegosaurus*	Cat. No. 7401.
51	Phalanx	do	Do.
52	do	do	Do.

Fossil bones found in diagram 7, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
53	Phalanx	*Stegosaurus*	Cat. No. 7401.
54			Not found.
55	Cervical vertebra	*Stegosaurus*	Cat. No. 7402.
56	Spinous process	*Diracodon laticeps*	Cat. No. 4288(?)
57	Dermal plate	*Stegosaurus*	Cat. No. 7585.
58	do	*Diracodon laticeps*	Cat. No. 4288.
59	Fragment of rib	*Stegosaurus*	Discarded.
60	Caudal vertebra	*Diracodon laticeps*	Cat. No. 4288.
61	do	do	Do.
62	do	do	Do.
63	do	do	Do.
64	do	do	Do.
65	do	do	Do.
66	Chevron	*Stegosaurus*	Not catalogued.
67	Metatarsal IV, left	*Camptosaurus nanus*	Cat. No. 7394.
68	Fragment of rib		Not catalogued.
69			Not found.
70	Ulna, right	*Stegosaurus*	Cat. No. 7754.
71	Pubis, portion of left	do	Cat. No. 7755.
72	Ungual phalanx	do	Cat. No. 7736.
73	Metacarpal V, left	do	Cat. No. 7783.
74	Piece of rib		Discarded.
75	Top of caudal spine	*Stegosaurus*	Not catalogued.
76	First dorsal	*Camptosaurus browni*	Cat. No. 4282.
77	Cervical, ninth with 1 rib	do	Do.
78	Cervical, eighth with both ribs	do	Do.
79	Fragment of dorsal spine	*Stegosaurus*	Discarded.
80	Right dentary	*Camptosaurus browni*	Cat. No. 4282.
81	Rib, fragment		Discarded.
82	do		Do.
83	Cervical, seventh	*Camptosaurus browni*	Cat. No. 4282.
84	Humerus, right	do	Do.
85	Rib, fragment		Not catalogued.
86	Cervical vertebra	*Stegosaurus*	Cat. No. 7812.
87	Cervical vertebra	do	Do.
88	Caudal vertebra	*Diracodon laticeps*	Cat. No. 4288.
89	do	do	Do.
90	Cervical rib	*Stegosaurus*	Cat. No. 7946.
91	Transverse process	do	Cat. No. 7808.
92	Fragment of rib	do	Discarded.
93	Fragment	(?)	Do.
94	Fragment of vertebra	(?)	Do.
95	Vertebra (young dorsal centrum)	*Stegosaurus*	Cat. No. 7393.
96	Dorsal centrum	do	Cat. No. 7810.
97	Fragment		Discarded.
98	Coracoid, right	*Camptosaurus browni*	Cat. No. 4282.
99	Caudal centrum	*Stegosaurus*	Cat. No. 7781.
100	Fragment of vertebra		Discarded.
101	Scapula, right	*Camptosaurus browni*	Cat. No. 4282.

Fossil bones found in diagram 7, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
102	Rib, proximal portion	*Stegosaurus*	Not catalogued.
103	Rib, fragment	do	Discarded.
104	Fragment of skull	*Camptosaurus*	Cat. No. 7421.
105	Ungual phalanx	*Stegosaurus*	Cat. No. 7782.
106	Process of caudal vertebra		Not catalogued,
107	Ungual phalanx	*Stegosaurus*	Cat. No. 7782.
108	Fragment of spine		Not catalogued.
109	Cervical, fourth	*Camptosaurus browni*	Cat. No. 4282.
110	Fragment of vertebra	*Stegosaurus*	Discarded.
111	do	do	Do.
112	do	do	Do.
113	Fragment		Do.
114	Metacarpal V, right	*Stegosaurus*	Cat. No. 7399.
115	Ungual phalanx	do	Cat. No. 7366.
116	Hyoid	do	Cat. No. 7377.
117	Fragment		Discarded.
118	do	*Stegosaurus*	Do.
119	Radius and ulna, right	*Camptosaurus browni*	Cat. No. 4282.
120	Manus, right	do	Do.
121	Fragment of vertebra	*Stegosaurus*	Discarded.
122	Caudal vertebra, anterior	do	Cat. No. 7388.
123	Fragment		Discarded.
124	Sternal bone	*Stegosaurus*	Cat. No. 7619.
125	Fragment		Discarded.
126			Not found.
127	Caudal centrum	*Stegosaurus*	Not catalogued.
128	Fragment		Discarded.
129	Caudal centrum, anterior	*Stegosaurus*	Cat. No. 7634.
130	Ungual phalanx	do	Cat. No. 7399.
131	Top of caudal spine	do	Not catalogued.
132	Transverse process of caudal	do	Do.
133	Sacral rib	do	Cat. No. 7786.
134	Caudal spine	do	Not catalogued.
135	Fragment		Discarded.
136	Fragment of vertebra	*Stegosaurus*	Do.
137	do	do	Do.
138	Supraorbital, right	*Camptosaurus*	Cat. No. 7632.
139	Fragment of vertebra	*Stegosaurus*	Discarded.
140	Tibia, right	do	Cat. No. 7387.
141	Astragalus	do	Do.
142	Caudal vertebra	*Stegosaurus stenops*	Cat. No. 6135.
143	Piece of rib	(?)	Not catalogued.
144	Piece of rib		Discarded.
145	Ungual phalanx	*Stegosaurus*	Cat. No. 7784.
146	Fragment		Discarded.
147	do		Do.

Fossil bones found in diagram 7, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
148	Metacarpal	*Stegosaurus*	Cat. No. 7417.
149	Fragment		Discarded.
150	Rib	*Stegosaurus*	Not catalogued.
151	Caudal vertebra	*Stegosaurus stenops*	Cat. No. 4714.
152	do	do	Do.
153	do	do	Do.
154	Dermal spines	do	Do.
155	do	do	Do.
156	Metacarpal	*Stegosaurus*	Cat. No. 7403.
157	Sternal bone	do	Cat. No. 7620.
158	Spinous process, caudal	*Stegosaurus stenops*	Cat. No. 4714.
159	Dermal spine	do	Do.
160	Fragment of rib		Not catalogued.
161	Fibula, left	*Stegosaurus*	Cat. No. 7389.
162	Fragment		Discarded.
163	Caudal vertebra	*Camptosaurus*	Cat. No. 7082.
164	First phalanx, digit I, manus	*Stegosaurus*	Cat. No. 7633.
165	Fragment		Discarded.
166	do		Do.
167	do		Do.
168	3 carpal bones, left foot	*Stegosaurus*	Cat. No. 7403.
169	Ungual, phalanx	do	Cat. No. 7419.
170	Caudal vertebra, process	do	Cat. No. 7798.
171	Astragalus	*Camptosaurus*	Cat. No. 7636.
172	Dorsal centrum	*Stegosaurus*	Cat. No. 7802.
173	Fragment		Discarded.
174	do		Do.
175	Fragment of rib		Do.
176	Pubis, left	*Stegosaurus*	Cat. No. 7420.
177	Ungual, digit IV, right hind foot	*Camptosaurus browni*	Cat. No. 4282.
178	Pubis, right	*Stegosaurus*	Cat. No. 7420.
179	Calcaneum, right	do	Cat. No. 7397.
180	Fragment		Discarded.
181	Phalanx	*Stegosaurus*	Cat. No. 7419.
182	Ischium, right	do	Cat. No. 7610.
183	Ischium, left	do	Do.
184	Metatarsal I, left foot	do	Cat. No. 7415.
185	Metatarsal III, left foot	do	Do.
186	Phalanx, digit III	do	Do.
187	Metatarsal II, left	do	Do.
188	Phalanx II	do	Do.
189	Ungual phalanx	do	Do.
190	Metatarsal IV	do	Do.
191	Phalanx	do	Do.
192	do	do	Do.
193	Coracoid	do	Cat. No. 7797.
194	Fibula, left	do	Cat. No. 7390; may be opposite of 200.
195	Caudal centrum	do	Cat. No. 7649.

Fossil bones found in diagram 7, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
196	Spine of caudal	*Stegosaurus*	Cat. No. 7649.
197	Coracoid, left	do	Cat. No. 2112.
198	Fragment of skull		Not catalogued.
199	Proximal end of rib	*Stegosaurus*	Do.
200	Fibula, right	do	Cat. No. 7384.
201	Fragment limb bone		Discarded.
202	Ulna	*Stegosaurus stenops*	Cat. No. 4929.
203	Head of rib	(?)	Cat. No. 7809.
204	Dorsal vertebra	*Stegosaurus*	Cat. No. 7789.
205	Fragment of spine		Discarded.
206	Metatarsal III, right	*Stegosaurus*	Cat. No. 7416.
207	Spine to vertebra	do	Not catalogued.
208	Caudals, thirteen to sixteen	*Camptosaurus browni*	Cat. No. 4282.
209	Part of vertebra	*Stegosaurus*	Cat. No. 7809.
210	Part of sacrum	do	Cat. No. 7386.
211	Caudal vertebra	*Camptosaurus*	Cat. No. 7082.
212	Humerus, right	*Stegosaurus stenops*	Cat. No. 4929.
213	Sacral rib	*Stegosaurus*	Cat. No. 7386.
214	Metacarpal	do	Cat. No. 7764.
215	Fragment		Discarded.
216			Not found.
217	Dorsal centrum	*Stegosaurus*	Cat. No. 7386.
218	Caudal, twenty-first	*Camptosaurus browni.*	Cat. No. 4282.
219	Caudal, twenty-second	do	Do.
220	Caudal, twenty-third	do	Do.
221	Caudal, twenty-fourth	do	Do.
222	Caudal, twenty-fifth	do	Do.
223	Caudal, twenty-sixth	do	Do.
224	Caudal, twenty-seventh	do	Do.
225	Caudal, twenty-eighth	do	Do.
226	Caudal, twenty-ninth	do	Do.
227	Caudal, thirtieth	do	Do.
228	Caudal, thirty-first	do	Do.
229	Caudal, thirty-second	do	Do.
230	Caudal, thirty-third	do	Do.
231	Caudal, thirty-fourth	do	Do.
232	Caudal, thirty-fifth	do	Do.
233	Caudal, thirty-sixth	do	Do.
234	Caudal, thirty-seventh	do	Do.
235	Caudal, thirty-eighth	do	Do.
236	Fragment of spine	*Stegosaurus*	Discarded.
237	Transverse process to caudal	do	Not catalogued.
238	do		Do.
239	Ilium, right	*Stegosaurus*	Cat. No. 7392.
240	Dorsal centrum	do	Cat. No. 7705.
241	Cervical centrum	do	Cat. No. 7708.

Fossil bones found in diagram 8, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal	Remarks.
1	Fragment of rib		Not catalogued.
2	Caudal centrum (anterior)	*Stegosaurus*	Cat. No. 7381.
3	Tibia, left	do	Cat. No. 7379.
4	Transverse process (caudal)	do	Cat. No. 7381.
5	Dermal spine	do	Cat. No. 7375.
6	Process (dorsal vertebra)	do	Cat. No. 7705.
7	Astragalus	do	Cat. No. 7378.
8	Portion of dermal plate	do	Not catalogued.
9	Fragment	do	Cat. No. 7381
10	Dorsal centrum	do	Cat. No. 7705.
11	Fragment		Discarded.
12	Sacral centrum	*Stegosaurus*	Cat. No. 7381.
13	do	do	Do.
14	Caudal process	do	Cat. No. 7703
15	Caudal centrum	do	Do.
16	Radius, right	*Stegosaurus stenops*	Cat. No. 4929.
17	Chevron	*Stegosaurus*	Cat. No. 7376.
18	Sacral rib	do	Cat No. 7381.

Fossil bones found in diagram 11, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
1	Cervical vertebra	*Stegosaurus*	Cat. No. 7405.
2	Dorsal vertebra	do	Cat. No. 7411.
3	Pieces of ribs	do	Discarded.
4	Portions of ilium	do	Do.
5	Part of rib	do	Cat. No. 6531.
6	Pubis, portion of right	do	Cat. No. 7609.
7	Cervical vertebra	do	Cat. No. 7404.
8	Caudal vertebra	do	Cat. No. 6629.
9	do	do	Do.
10	do	do	Do.
11	do	do	Do.
12	Spine to caudal vertebra	do	Do.
13	Dermal plate	do	Cat. No. 6531.
14	Plate fragment	do	Discarded.
15	Piece of rib	do	Do.
16	Rib, thoracic	do	Cat. No. 7411.
17	Caudal vertebra	do	Cat. No. 6531.
18	do	do	Cat. No. 6629.
19	do	do	Do.
20	do	do	Do.
21	do	do	Do.
22	do	do	Do.
23	do	do	Do.
24	do	do	Do.
25	do	do	Do.

Fossil bones found in diagram 11, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
26	Caudal vertebra	*Stegosaurus*	Cat. No. 6629.
27	do	do	Do.
28	do	do	Cat. No. 6531.
29	do	do	Do.
30	do	do	Do.
31	do	do	Do.
32	do	do	Do.
33	do	do	Do.
34	do	do	Do.
35	do	do	Do.
36	do	do	Do.
37	do	do	Do.
38	do	do	Do.
39	do	do	Do.
40	do	do	Do.
41	do	do	Do.
42	do	do	Do.
43	Dermal plate (tail)	do	Do.
44	Fragment	do	Discarded.
45	Caudal vertebra	do	Cat. No. 6531.
46	do	do	Do.
47	Dermal plate (tail)	do	Do.

Fossil bones found in diagram 12, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
1	Fragment, spinous process	*Stegosaurus*	Discarded.
2	Ungual phalanx	*Stegosaurus ungulatus.*	No. 6646.
3	Part of radius	do	Cat. No. 6646; Nos. 3 and 5 belong together.
4	Femur, right	do	Cat. No. 6646.
5	Part of radius	do	Do.
6	Portion of ilium	do	Do.
7	Dorsal centrum	do	Do.
8	Caudal centrum	*Stegosaurus*	Discarded.
9	Tibia, calcaneum, and astragalus, right.	*Stegosaurus ungulatus.*	Cat. No. 6646; coössified with astragalus.
10	Carpal bone (ulnar complex)	do	Cat. No. 6646.
11	Fragment of plate		Discarded.
12	Dorsal vertebra	*Stegosaurus ungulatus.*	Cat. No. 6646.
13	Ungual phalanx	do	Do.
14	Dorsal vertebra	do	Do.
15	do	do	Do.
16	Distal end of fibula, right	do	Do.
17	Humerus, right	do	Do.
18	Fragment		Discarded.
19	Caudal vertebra, anterior	*Stegosaurus ungulatus.*	Cat. No. 6646.
20	Fragment		Discarded.
21	Caudal vertebra, anterior	*Stegosaurus ungulatus.*	Cat. No. 6646.

Fossil bones found in diagram 12, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
22	Fragment		Discarded.
23	Fragments	*Stegosaurus*	Do.
24	Chevron (anterior)	*Stegosaurus ungulatus.*	Cat. No. 6646.
25	Top of caudal spine	do	Do.
26	Fragment of plate	*Stegosaurus*	Discarded.
27	Caudal vertebra (anterior)	*Stegosaurus ungulatus.*	Cat. No. 6646.
28	Piece of rib	do	Do.
29	Dermal spine (tail)	do	Do.
30	Fragment of dorsal process	do	Do.
31	Part of neural process, dorsal	do	Do.

Fossil bones found in diagram 13, Quarry 13.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
1	Head of rib	*Stegosaurus*	Cat. No. 6531.
2	Scapula, right	do	Cat. No. 7411.
3	Parts of skull and atlas, articulated	do	Cat. No. 6645.
4	Cervical vertebra	do	Cat. No. 7412.
5	Dermal spine	do	Cat. No. 7413.
6	Cervical centrum	do	Cat. No. 7412.
7	Parts of skull	*Stegosaurus stenops.*	Cat. No. 6645.
8	Spine of caudal vertebra	*Stegosaurus*	Not catalogued.
9	Dermal spine	do	Cat. No 7413.
10	Dermal plate	do	Not catalogued.
11	Dermal spine	*Stegosaurus stenops.*	Cat. No. 6629.
12	Chevron	*Stegosaurus*	Cat. No 6531.
13	Caudal vertebra	do	Do.
14	do	do	Do.
15	Dermal spine	do	Do.
16	do	do	Do.
17	Dermal spine (?)	do	Do.
18	do	do	Do.
19	do	do	Cat. No. 7413.
20	Dermal plate	do	Cat. No. 6531.
21	Chevron	do	Do.
22	Coracoid, right	do	Cat. No. 7411.
23	Rib	do	Do.
24	Spinous process, caudal	do	Not catalogued.
25	Rib, thoracic	do	Cat. No. 7411.
26	Dorsal vertebra	do	Do.
27			Not found.
28	Caudal vertebra	*Stegosaurus stenops.*	Cat. No. 6629.
29	do	do	Do.
30	do	do	Do.
31	do	do	Do.
32	do	do	Do.
33	do	do	Do.
34	do	do	Do.

Fossil bones found in diagram 13, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
35	Caudal vertebra	*Stegosaurus stenops.*	Cat. No. 6629.
36	do	do	Do.
37	do	do	Do.
38	do	do	Do.
39	do	do	Do.
40	do	do	Do.
41	Dorsal vertebra	*Stegosaurus*	Cat. No. 7411.
42	Fragment	do	Discarded.
43	Rib	do	Cat. No. 6531.
44	Fragment of plate	do	Discarded.
45	Dermal plate	do	Cat. No. 6531.
46	do	do	Do.
47	Caudal vertebra	do	Cat. No. 7410 (?).
48	Part of rib	do	Cat. No. 6531.
49	Pubis, left	do	Do.
50	Centrum of dorsal vertebra	do	Do.
51	Ischium	do	Do.
52	Part of rib	do	Do.
53	Dermal plate	do	Do.
54	Ischium	do	Cat. No. 6531 (?).
55	Fragment of plate	do	Discarded.
56	Fragment	(?)	Do.
57	Part of ischium	*Stegosaurus*	Cat. No. 6531.
58	Fragment of rib	do	Not catalogued.
59	Dorsal vertebra	do	Cat. No. 6531.
60	do	do	Do.
61	Dorsal vertebra and rib	do	Do.
62	Fragment of spine	*Stegosaurus*	Discarded.
63	Part of rib	do	Cat. No. 6531.
64			Not found.
65	Dorsal vertebra	*Stegosaurus*	Cat. No. 6531.
66	do	do	Do.
67	Rib portion	do	Do.
68			Not found.
69			Do.
70	Fragment		Discarded.
71	Dorsal vertebra	*Stegosaurus*	Cat. No. 6531.
72	do	do	Do.
73	do	do	Do.
74	Thoracic rib	do	Do.
75	do	do	Do.
76	Rib	do	Do.
77			Not found.
78	Fragment of rib		Discarded.
79	Sacrum and ilium	*Stegosaurus*	Cat. No. 6531.
80			Not found.
81	Fragments dorsal vertebra	*Stegosaurus*	Cat. No. 6531.
82	Dermal plate	do	Cat. No. 6531 (?).
83	Rib	*Camptosaurus*	Cat. No. 7406.
84	Chevron	*Stegosaurus*	Cat. No. 7410.
85	Caudal vertebra	do	Do.
86	Humerus, right	do	Cat. No. 7409.
87	Fragment sternal bone	do	Cat. No. 6531.

Fossil bones found in diagram 13, Quarry 13—Continued.

Original quarry Nos.	Name of bone.	Name of animal.	Remarks.
88	Fragment	*Stegosaurus*	Discarded.
89	Dermal plate	do	Cat. No. 6531.
90	Dermal plate	do	Do.
91	Cervical vertebra		Not catalogued.
92	Fragments		Discarded.
93	Chevron	*Stegosaurus*	Cat. No. 7410.
94	do	do	Do.
95	do	do	Do.
96	Pubis, right	do	Cat. No. 6646.
97	Fragment		Discarded.
98	do		Do.
99	Dorsal centra	*Stegosaurus*	Cat. No. 6531.
100			Not found.
101	Pubis, part	*Stegosaurus*	Cat. No. 6646.
102	Pubis, left	do	Do.
103	Pubis, part	do	Cat. No. 7608.
104	Fragment	do	Discarded.
105	Chevron	do	Cat. No. 7407.
106	Ungual phalanx	*Camptosaurus*	Cat. No. 7408.
107	Pubis, part	*Stegosaurus*	Cat. No. 6646.
108	Right fibula, proximal half	do	Do.
109	Fragment of rib		Discarded.
110	Median caudal vertebra	*Stegosaurus*	Cat. No. 7410.
111	Pubis, right	do	Cat. No. 6531.

History of Quarry No. 1.[1]

This quarry was situated on the west side of Oil Creek (Four Mile Creek) at the entrance to Garden Park, Fremont County, some 9 or 10 miles east by north of Canon City, Colorado (pl. 1). A map of this region, drawn by Mr. M. P. Felch, shows it to have been located in the northeast quarter of the southeast quarter of section 28, township 17 north, range 70 west.

Fossil bones were first discovered in this locality in 1876 by the family of Mr. M. P. Felch. Through the Canon City and Denver newspapers the matter was brought to the attention of Professor Marsh, and in the spring of 1877 Dr. S. W. Williston was sent to Canon City to investigate the alleged discoveries. The quarry, opened by Doctor Williston, was worked for several years for Professor Marsh under the very careful and skillful supervision of Mr. Felch. In the autumn of 1886[2] this quarry was abandoned and nothing further was done here in the way of collecting until 1900, when, under the direction of the late Mr. J. B. Hatcher, Mr. W. H. Utterback reopened the quarry (see upper figure, pl. 1) for the Carnegie Museum, of Pittsburgh, Pennsylvania, and worked it for a year with fair results.

All of the fossils collected prior to 1882 are now in the Yale Museum, while those found in subsequent years are in the United States National Museum and Carnegie Museum collections.

[1] Extracted chiefly from Hatcher's account published in Annals of the Carnegie Museum, vol. 1, 1901, pp. 333–337, figs. 1 and 2.

[2] In the Annals of the Carnegie Museum Hatcher writes: "In 1884 all work at this locality was abandoned," but a map made by Felch and collections in the National Museum show work done there in 1886.

In this quarry the bones are for the most part found in a very hard layer of sandstone,[1] though they occasionally extend down for a short distance into the underlying clays. The bone-bearing horizon is not more than 3 feet thick vertically and has been worked over only a few hundred square feet, yet a wealth of material has been found, as evidenced by the faunal list given below, which does not begin to represent the number of individuals recovered.

According to Hatcher [2] "The bone-bearing stratum is about 150 feet above the red Triassic sandstones." He also says: "That the lowermost dinosaur beds of Garden Park are of an earlier age than those of Como Bluff."

Plan of work.—The fossil bones lay buried in a thick stratum of heavily bedded sandstone. Not only was the stone extremely hard, but it was also considerably fractured, both vertically and horizontally, in such manner as to greatly increase the difficulties encountered in properly taking up the bones. Mr. Felch, however, overcame these difficulties in a most commendable manner. The specimens were quarried out in large blocks of stone, the contained fossils thus being retained in their original relative positions. Each articulated or partially articulated skeleton was given a number (for example, the type of *Stegosaurus stenops* was designated by the field number "Sk. 11"). The skeleton was divided into irregular-sized groups, each group being indicated by a number, as Gr. 1, Gr. 2, etc. The pieces of stone comprising the different groups were lettered, each group beginning with A and continuing alphabetically. The skeleton, group, and block designations were painted on the stone, so that, aided by the rough sketch diagrams made and properly marked at the same time, the work of assembling the blocks in the laboratory was reduced to a minimum. Considering the early date of this work, which was before the development of modern field methods, the painstaking care and ingenuity displayed by Mr. Felch in collecting this difficult material with such success is most remarkable.

The list that follows shows the fauna of Quarry No. 1.

DINOSAURIA:
- * *Ceratosaurus nasicornis* Marsh.
- **Labrosaurus ferox* Marsh.
- **Stegosaurus stenops* Marsh.
- *Stegosaurus armatus* Marsh.
- * *Morosaurus agilis* Marsh.
- **Haplocanthosaurus priscus* Hatcher.
- **Haplocanthosaurus utterbacki* Hatcher.
- **Diplodocus longus* Marsh.
- *Brontosaurus* sp.
- *Allosaurus fragilis* Marsh.
- *Cœlurus agilis* Marsh.

DINOSAURIA—Continued.
- *Laosaurus gracilis* Marsh.
- *Camptosaurus medius* Marsh.

CROCODILIA:
- *Goniopholis* sp.

CHELONIA:
- **Probaena sculpta* Hay.
- *Glyptops plicatulus* (Cope).

PISCES:
- * *Ceratodus güntheri* Marsh
- *Ceratodus* sp.

MAMMALIA:
- *Dryolestes gracilis* Marsh.

[Those marked with an asterisk (*) represent type-specimens.]

[1] Dr. George P. Merrill has kindly made a microscopic examination of the sandstone in which the bones were found, and his conclusions are as follows:

"The sandstone consists mainly of quartz granules with a little feldspar and flecks of brown mica, with a relatively large amount of interstitial calcite which serves as a cement. The grains of sand are not greatly rounded, in some cases are angular, indicating that they have not been subjected to much wear. I am inclined to regard them as of river, lake, or estuary origin rather than consolidated beach sands which would, under ordinary conditions, show greater signs of wear."

[2] Annals of the Carnegie Museum, vol. 1, 1901, p. 336.

OSTEOLOGY OF STEGOSAURUS.

In the pages that follow is given, for the first time, a detailed account of the complete skeletal anatomy of *Stegosaurus*. These descriptions are based entirely upon specimens belonging to the vertebrate paleontological collections of the United States National Museum, and primarily upon the very complete skeleton, briefly described [1] by Marsh as the type of the species *S. stenops*. (Cat. No. 4934.) I have selected this specimen on account of its comprising a considerable part of one individual, and from the fact that most of the bones were found articulated, or at least so little disturbed, that there can be no question raised as to their proper association. Where important structural differences exist, reference is made to other individuals, and bones not represented in this specimen or not sufficiently preserved to show their more important characteristics are described from other specimens.

Skull.

Plates 5, 6, 7, 8, 9, and 10.

The cranium belonging to the type of *Stegosaurus stenops* is unique as being the most perfect skull of the genus yet discovered, and although slightly distorted from pressure, it is otherwise most perfectly preserved, as is well shown in plate 19, fig. 1, reproduced from a photograph of the specimen.

In the National Museum collections are five other cranii, in varying degrees of preservation. Two of these are to a great extent disarticulated. These, however, are of especial value in the proper interpretation of the elements in the articulated skulls, and they also make possible a more detailed description of the separate bones of the skull than could otherwise be given.

Summary of cranial materials.—The cranii in the United States National Museum are as follows:

1. *Stegosaurus stenops.* Complete skull and jaws from Quarry No. 1, Canon City, Colorado. Collected by M. P. Felch, 1886. Mounted with skeleton No. 4934. Sectioned.
2. *Stegosaurus* sp. Disarticulated skull and portions of lower jaw. No. 4935, from Quarry 13, diagram 4, Como, Albany County, Wyoming. Collected by Fred Brown, 1884.
3. *Stegosaurus stenops.* Occiput and brain case, with a few other elements. No. 6645, from Quarry 13, diagram 13, Como, Albany County, Wyoming. Collected by Fred Brown, 1887.
4. *Stegosaurus* sp. Fragmentary skull and portions of lower jaw. No. 7637, from Quarries 13 East and 13 Middle, Como, Albany County, Wyoming. Collected by W. H. Reed, 1882.
5. *Stegosaurus armatus* Marsh. Posterior half of skull. No. 4936, Quarry No. 1, Canon City, Colorado. Collected by M. P. Felch, 1884. Sectioned.
6. *Stegosaurus stenops*? Posterior portion of skull. No. 2274, Quarry 13, diagram 5, Como, Albany County, Wyoming. Collected by Fred Brown, 1885.

[1] Amer. Jour. Sci., ser. 3, vol. 34, 1887, p. 414.

Known elements of the Stegosaurian skull.—

Alisphenoid	*al. sp*	Postorbital	*po*
Angular	*an*	Postfrontal	*po. f*
Articular	*ar*	Postsupraorbital	*po. so*
Basisphenoid	*bs*	Prefrontal	*pf*
Basioccipital	*bo*	Premaxillary	*pm*
Dentary	*d*	Prearticular	*p. ar*
Exoccipital	*ex. o*	Predentary	*pd*
Frontal	*f*	Presupraorbital	*p. so*
Jugal	*j*	Proötic	*pro*
Lachrymal	*l*	Pterygoid	*pt*
Maxillary	*m*	Quadrate	*q*
Nasal	*n*	Quadratojugal	*qj*
Orbitosphenoid	*or. sp*	Splenial	*s*
Palatine	*pl*	Squamosal	*sq*
Presphenoid	*p. sp*	Surangular	*sa*
Paraoccipital (opisthotic)	*p. oc*	Supraoccipital	*so*
Parietal	*p*	Vomer	*v*

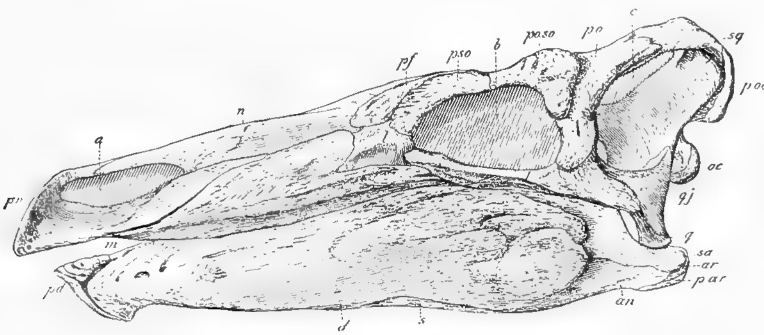

FIG. 3.—SKULL OF STEGOSAURUS STENOPS MARSH. LATERAL VIEW. TYPE. CAT. NO. 4934, U.S.N.M. LESS THAN $\frac{1}{4}$ NAT. SIZE. *a*. ANTERIOR NARES; *an*, ANGULAR; *ar*, ARTICULAR; *b*, ORBIT; *c*, INFRA TEMPORAL FOSSA; *d*, DENTARY; *j*, JUGAL; *l*, LACHRYMAL; *m*, MAXILLARY; *n*, NASAL; *oc*, OCCIPITAL CONDYLE; *p.ar*, PREARTICULAR; *pd*, PREDENTARY; *pf*, PREFRONTAL; *pm*, PREMAXILLARY; *po*, POSTORBITAL; *p. oc*, PARAOCCIPITAL; *po.so*, POSTSUPRAORBITAL; *p.so*, PRESUPRAORBITAL; *q*, QUADRATE; *qj*, QUADRATOJUGAL; *s*, SPLENIAL; *sa*, SURANGULAR; *sq*, SQUAMOSAL.

Description.—A study of this material shows that Marsh's figures of the skull of *Stegosaurus stenops*, which have appeared in numerous American and European publications, are incorrect in many of their details. The inaccuracies are in great part due either to the complete coalescence or to the obscure condition of many of the sutures, and also in some instances to a wrong interpretation of cracks in the skull (No. 4934) as representing sutural articulations. These errors have been corrected in the drawings, and a more detailed mention of them will follow in the discussion of the separate skull elements.

Viewed from the side (pl. 5 and fig. 3) the skull of *Stegosaurus* is long and slender, the facial portion being especially produced. With the jaw in position the outline of the skull is wedge shaped, the apex being directed forward. The nares are long, and, as in *Camptosaurus*, are situated well in front. The orbit is large, measuring about one-fifth of the total length of the skull, and placed well back. The infratemporal fossae are somewhat smaller. Marsh has pointed out that "all of these openings are oval in outline and are in a line nearly parallel with the top of the skull."

The great vertical depth of the median part of the lower jaw is especially noteworthy. A measurement taken below the orbit shows it to be over one-half the whole depth of the head, an unusual proportion in dinosaurian anatomy.

From a superior view the wedge-shaped form of the skull is still apparent. The only visible openings are the small subcircular supratemporal fossae. There are no supraorbital vacuities as found in *Camptosaurus* and *Iguanodon*, this region being entirely roofed over by the supraorbital and postfrontal bones. This view is well shown in plate 6.

Viewed from the back, as shown in plate 9, figure 2, the skull and mandible present a nearly quadrate outline.

In its general proportions and outlines the skull of *Stegosaurus* is found to resemble that of *Camptosaurus* more nearly than that of any other American dinosaur, though it should be borne in mind that the shape and arrangement of their constituent elements differ considerably.

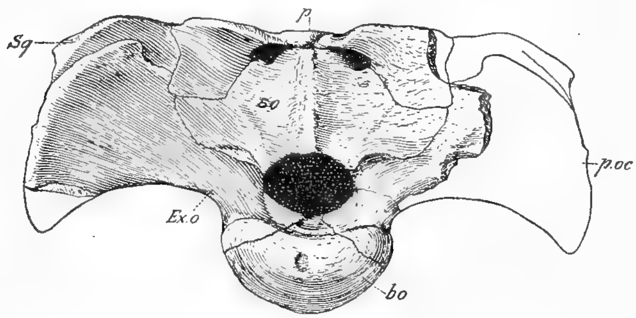

FIG. 4.—POSTERIOR VIEW OF THE SKULL OF STEGOSAURUS STENOPS? MARSH. CAT. NO. 2274, U.S.N.M. ½ NAT. SIZE. *bo*, BASIOCCIPITAL; *Ex.o*, EXOCCIPITAL; *p*, PARIETAL; *p.oc*, PARAOCCIPITAL; *so*, SUPRAOCCIPITAL; *Sq*, SQUAMOSAL.

Basioccipital (*bo.*).—The basioccipital is terminated posteriorly by a moderately broad, rounded occipital condyle. The smooth articular surface is continued forward on the underside (pls. 5 and 7, *oc.*). The condyle in No. 4934 is considerably narrower transversely than in skulls Nos. 2274 and 6645, as may be seen by comparing text figures 4 and 5 with figure 2, plate 9. The occipital condyle is inclined ventrally to the longer axis of the skull, so that when articulated with the neck the longer axis of the skull would form an obtuse angle with the axis of the anterior cervical vertebrae, as it does in *Camptosaurus*, *Trachodon*, *Triceratops*, and *Diplodocus*.

The basioccipital articulates, as shown by the detached element in specimen No. 4935, with the basisphenoid by a deep vertical suture, without a median tongue-like extension, as found in *Camptosaurus*. In front of the condyle the inferior surface is deeply concave longitudinally, and convexly rounded transversely, and without median pit, as found in some predentate dinosaurs. On the anterior median part of this surface is a notch between the blunt basioccipital processes. These abut against similar processes on the posterior end of the basisphenoid (pl. 7). The median line of the superior surface is shallowly concave transversely and forms the floor of the foramen magnum. On either side are the beveled, sutural surfaces for articulation with the exoccipitals.

The exoccipitals, as in *Camptosaurus*, participate in the formation of the occipital condyle. (See fig. 4.)

Exoccipital (*ex. o.*) and *Paraoccipital* (*p. oc.*).—The exoccipitals are the largest bones of the occipital segment. They form the lateral boundaries of the foramen magnum, and, as mentioned above, contribute to the formation of the occipital condyle. Viewed posteriorly they rise from heavy expanded pedestals that rest laterally on the oblique lateral surfaces of the basioccipital, as shown in figure 4.

The upper portion develops a vertically expanded wing-like paraoccipital process, which extends outward and backward at an angle of 45° to the main axis of the skull, ending at a point posterior to the occipital condyle (pl. 6). Dorsally the exoccipitals are united by the widely expanded supraoccipital, and the union of these bones is greatly strengthened by the processes developed on the postero-external angles of the supraoccipital, which lap along the upper posterior surfaces of the exoccipitals, forming a longitudinal swelling of the bones at this point (pl. 9, fig. 2, also text figs. 4 and 5). The dorsal border of the paraoccipital process supports the parietosquamosal processes. In specimen No. 2274 the squamosal passes from the dorsal to the anterior surface near the outer end, as shown in figure 4, but in No. 4934 the squamosal appears to cover the entire dorsal border (see fig. 2, pl. 9). The other sutures of the occipital region in this specimen are coalesced and the union of the elements can not be clearly determined. In specimen No. 4935 the right exoccipital is wholly detached and shows beautifully the chief characteristics of this bone.

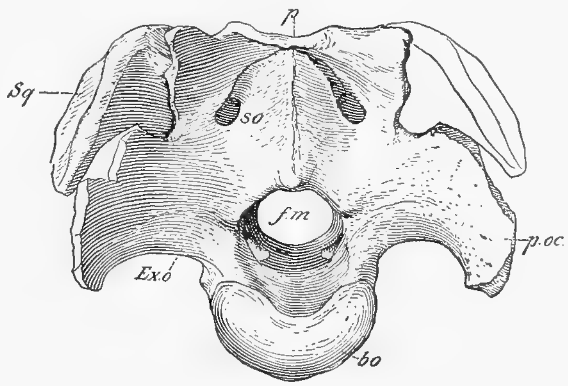

FIG. 5.—POSTERIOR VIEW OF THE SKULL OF STEGOSAURUS STENOPS? MARSH. CAT. NO. 6645, U.S.N.M. ½ NAT. SIZE. *bo*, BASIOCCIPITAL; *Ex.o*, EXOCCIPITAL; *fm*, FORAMEN MAGNUM; *p*, PARIETAL; *p.oc*, PARA-OCCIPITAL; *so*, SUPRAOCCIPITAL; *Sq*, SQUAMOSAL.

The opisthotic and exoccipital in *Stegosaurus* evidently unite early in life, for in none of the skulls is there any indication whatsoever of their sutural union.

These coalesced bones unite with the proötics by a long lapping suture on the anterior surface. The end of the paraoccipital process is broadly rounded from above downward, and in the articulated skull the lower half projects free, and hides the upper end of the quadrate from a posterior view.

The exoccipital is pierced by two small foramina. The more posterior one enters the brain case just within the entrance of the foramen magnum and serves as exit for the twelfth or hypoglossal nerve (XII, fig. 10). Anterior to and separated by a thin wall of bone from the exit for the twelfth nerve is the anterior condyloid foramen.

Supraoccipital (*so.*).—The supraoccipital in *Stegosaurus*, as in all other predentate dinosaurs,[1] where the elements of the skull are known, forms the upper boundary of the foramen magnum.

Viewed from behind the supraoccipital is a comparatively wide bone, wedged in between the exoccipitals and parietals (fig. 4). The median dorsal border does not unite by suture with the overlying parietals, but, as in *Camptosaurus* has a

[1] F. von Huene has recently shown that the supraoccipital in *Triceratops* extends to the foramen magnum. See Neues Jahrbuch, vol. 2, 1912, pp. 147, 148, figs. 1 and 2.

finished surface, which was probably covered by cartilage. In very old individuals these bones sometimes coalesce, as is shown by specimen No. 6645 (fig. 5). On the posterior surface is a blunt vertical median ridge extending from the upper border of the foramen magnum to the top of the bone. On the latero-ventral angles thin processes are developed, which extend outward and backward and lap along the exoccipitals. The posterior surface is inclined forward from the vertical at an angle of 35°. Ventrally it articulates by wide, oblique, heavy sutural surfaces with the exoccipitals (fig. 4). The anterior surface is deeply excavated and forms a considerable part of the posterior boundary of the brain case. On the anterior lateral borders, well shown in specimen No. 6645, are notches which reach the exterior by an opening between the supraoccipital and parietal. These would appear to correspond with those noted by Hay [1] in the brain case of *Triceratops*. They probably transmitted blood vessels, for no nerves are known to leave this part of the brain. Similarly placed foramina are present in the supraoccipital (Cat. No. 5692, U.S.N.M.), described and figured by Lull [2] as belonging to *Pleurocoelus nanus* Marsh. In this connection it might be well to call attention to the close resemblance of this bone to the supraoccipitals of *Stegosaurus* and *Camptosaurus*, more particularly to the latter. That it pertains to a member of the Ornithopoda I am fully convinced and, in all probability, should be referred to the genus *Dryosaurus*, as being the only representative of the Camptosauridae known to occur in the Arundel formation.

Basisphenoid (*bs.*) and *Presphenoid* (*p. sp.*).—The basisphenoid is a short bone which unites posteriorly with the basioccipital and dorso-laterally with the proötics, alisphenoids, and slightly, if at all, with the exoccipitals. The median ventral surface is deeply concave transversely, and on the latero-anterior end a pair of diverging processes are given off, which extend backward and downward, with surfaces in front near their extremities for union with the pterygoids (pl. 7). The dorsal surface is continuous with the basioccipital and completes the floor of the brain case. The pituitary fossa is deep and extends backward somewhat beneath the floor of the median vesicle (*pi.* fig. 3, pl. 10). At its bottom and on either side are short foramina, which lead outward and backward, opening externally into vertically elongated slits on the sides of the basisphenoid (*c.* fig. 10). These serve to transmit the carotid arteries.

Anterior to this fossa the bone contracts rapidly to a narrow-pointed process, which probably represents the persphenoid, although its complete anterior extent can not be determined from available material. (See *p.sp.* fig. 10.)

Alisphenoid [3] (*al. sp.*).—The alisphenoid is a small subtriangular bone (fig. 10) resembling very closely the corresponding element in *Camptosaurus*.[4] Specimen No. 4935, upon which the description to follow is based, shows the alisphenoids detached, but in all other skulls they are so closely coössified as to be almost indistinguishable. Dorsally it unites with the parietal, frontal, and to a slight degree with the postorbital. The outwardly turned anterior end is received in a transverse notch on the lower and outer side of the frontal. The lower posterior border

[1] Proc. U. S. Nat. Mus., vol. 36, 1909, pp. 103.
[2] Maryland Geol. Survey, Lower Cretaceous, 1911, p. 192, pl. 15, figs. 3*a*–*c*.
[3] In part the orbitosphenoid of H. F. Osborn, Mem. Amer. Mus. Nat. Hist., new ser., vol. 1, pt. 1, p. 5.
[4] C. W. Gilmore, Proc. U. S. Nat. Mus., vol. 36, 1909, pp. 208–209, fig. 5.

forms the anterior boundary of the foramen ovale in much the same manner as in *Camptosaurus*.[1] The external surface contributes to the inner wall of the supratemporal fossa, while the internal forms a portion of the brain case containing the cerebral hemispheres.

Orbitosphenoid (*or. sp.*).—The presence in the skull of *Stegosaurus* of ossified orbitosphenoids is clearly shown by two specimens, Nos. 2274 and 4936 (fig. 10, also fig. 2, pl. 10). As shown by specimen No. 4936, upon which the following description is based, there are two curved plate-like bones, united ventrally on the median line to form that part of the brain case containing the olfactory lobes. Dorsally they unite exclusively with the frontals, and posteriorly with the alisphenoids. Above the point where the orbitosphenoids unite in front is an opening which undoubtedly gave exit to the olfactory nerves. They appear to have left the brain through this single orifice (*ol.*, fig. 2, pl. 10), at least no bony partition separating them has been observed. On the posterior borders of these bones are foramina for the exit of the second, third, and fourth nerves.

Parietal (*p.*)—The dorsal portion of the parietal segment of the skull is formed by the parietal, an unpaired element in *Stegosaurus*, as in all known dinosaurian skulls.

Viewed from above, the parietal is a short, heavy bone with laterally expanded ends. The superior surface is flattened and without median longitudinal crest or ridge. The median lateral surfaces drop abruptly, at right angles to the upper surface, and form the inner boundary of the supratemporal fossae. The least transverse width of the parietal between the fossae in No. 4934 measures 34 mm. Anteriorly it unites with the broad frontals by an evenly (in No. 4934) rounded imbricating suture (pl. 6). In other specimens this suture is more angular, as shown in figure 1, plate 10. The antero-lateral angles meet the postorbital and postfrontal and in *S. stenops* excludes the frontal from the supratemporal fossa. In *S. armatus* (fig. 1, pl. 10), the frontal participates in the boundary of this fossa. Latero-posteriorly are vertically expanded processes, which extend backward and outward along the top of the supraoccipital, meeting a branch of the squamosal by a lapping suture about the center of the posterior boundary of the supratemporal fossa. The median posterior border of the parietal thins out to a rounded edge, which in most skulls slightly overhangs the underlying supraoccipital. The median ventral surface is hollowed out transversely and forms the principal part of the roof of the brain case.

Frontal (*f.*).—The frontals are paired bones, although in old individuals the suture coalesces. Above the orbits they are thick and heavy, with a sutural edge 15 mm. long between the anterior process of the postorbital and the posterior process of the prefrontal which unites with the postfrontal. They overlie the parietals posteriorly as is shown by specimen No. 6645. Viewed from above the frontal region is flat. From this view each bone sends out a sharp narrow anterior process which unites on the median line between the posteriorly directed fingerlike processes of the nasals. The nasal processes overlie the frontals, being received in the longitudinal grooves shown at *ns.*, figure 1, plate 10. External to these grooves

[1] Compare fig. 5, Proc. U. S. Nat. Mus., vol. 36, 1909, with fig. 10, i. e., by the development of a slender process which meets the basisphenoid, well shown in a skull of *S. armatus* (Cat. No. 4936, pl. 10.)

the antero-external part of the dorsal surface is concavely beveled for the anticuation with the overlying portion of the prefrontals (*ps.*, fig. 1, pl. 10). The postero-external angles of the frontals are much thickened and are roughly beveled for sutural union with the anterior internal process of the postorbital. As mentioned previously, in *S. stenops*, the frontal is excluded from the supratemporal fossa, but reaches it in a skull of *S. armatus*, No. 4936. (See fig. 1, pl. 10.) The posterior ventral surface is concave transversely and forms the roof covering the olfactory lobes of the brain. The orbital margin is horizontally concave.

Prefrontal (*pf.*).—The prefrontal, as shown in specimen No. 4934, is an elongated subelliptical bone which overlies the superior surface of the frontal and nasal bones at their junction (*pf.*, pl. 6). The outer border articulates with the postfrontal and presupraorbital bones and more anteriorly it meets the lachrymal. The posterior end is separated from the anterior process of the postorbital by an intervening part of the frontal measuring 15 mm. on the superior surface.

Postfrontal (*po.f.*).—The postfrontal, viewed from above, is an irregularly shaped element which completely fills the space between the external supraorbital bones and the postorbital and prefrontal, and frontal (see *po.f.*, pl.6). The dorsal surface of this element is rugosely roughened, and it unites with the frontal by a comparatively short sutural edge. I was at first inclined to regard this element of the skull as a supraorbital bone, but I am indebted to Dr. R. Broom for first pointing out to me that it should be identified as the postfrontal, and that the so-called postfrontal, postorbital complex represents only the postorbital. That this is the proper relation of these elements appears to be indicated by a very similar arrangement found in the disarticulated skull of a small Ceratopsian, *Brachyceratops montanensis* [1] Gilmore, recently acquired by the National Museum.

Postorbital (*po.*).—The postorbital is a triradiate bone with one short, stout process, extending inward and uniting with the frontal and parietal; a second posteriorly directed branch unites by squamous suture with the outer surface of the squamosal and forms the upper temporal bar; the third, the longer one of the three, is a descending process which overlaps externally an upgrowth from the jugal and thus forms a postorbital bar separating the orbit from the infratemporal fossa. The latter process, as in *Camptosaurus*, is trihedrial in cross-section. It descends to the lower border of the orbit (see *po*, pl. 5), not part way as in *Camptosaurus*, *Trachodon*, and *Iguanodon*. On the external surface at the junction of the three branches is a roughened protuberant area over which the hollowed out opposing surface of the postsupraorbital is attached. The postorbital as here identified, is in part the postfrontal of Marsh.

Proötic (*pro.*).—The proötic is not clearly differentiated in any of the skulls before me, although its approximate position and relationships can be determined. As in *Crocodylus* and *Camptosaurus*, this bone fills the area between the basisphenoid below, the alisphenoid in front, and the parietal and supraoccipital above, and in all probability the opisthotic behind, although the proötic and opisthotic are so fused as to be unrecognizable as separate elements. The foramen ovale in the alligator and in *Camptosaurus* is between the proötic and alisphenoid, the larger part of it being in the proötic. This foramen occupies a similar position in *Ste-*

[1] Smiths. Misc. Coll., vol. 63, 1914, p. 5, pl. 2.

gosaurus, as plainly shown by specimen No. 6645. On the lower lateral surface this bone is pierced by a small foramen (VII, fig. 10) for the exit of the seventh or facial nerve. More posteriorly the proötic forms the anterior border of the internal auditory meatus (VIII, fig. 10).

Lachrymal [1] (*l.*).—The lachrymal as seen in specimen No. 4934 (see *l*, pl. 5) is a small, irregularly shaped bone lying wedged in between the maxilla, nasal, jugal, and prefrontal. It is overlapped on the upper posterior border by the presupraorbital.

Supraorbitals (*p.so* and *po.so*).—The supraorbital in *Stegosaurus* is composed of two separate pieces, which as a matter of convenience, in referring to them, I shall designate as the pre- and post-supraorbital bones (see *p. so* and *po. so*, pl. 6). In *Scelidosaurus* as described by Owen in his Fossil Reptilia of the Liassic (p. 10), the supraorbital is present but consists of a single bone.

Marsh,[2] as shown by his figures of the skull, based upon specimen No. 4934, has considered the supraorbital as consisting of one element.[3] In this, however, he is in error, as clearly shown by two partly disarticulated skulls, Nos. 6645 and 4935. In fact, now that it is known that there are two bones in this region, the sutures appear quite distinct in No. 4934, and the outlines of the elements can be clearly traced, as indicated in plate 6. These elements make a complete roof over the orbit, there being no supraorbital fossa as found in *Camptosaurus* and *Iguanodon bernissartensis*. The articulated supraorbital bones are well shown in the skull of *S. stenops* No. 4934. From a lateral view, see fig. 3, the postsupraorbital is a small triangular bone which overlaps the antero-lateral surface of the postorbital. It forms the rounded postero-dorsal boundary of the orbit, and extends forward above the orbit nearly to its center where it unites by a straight transverse suture with the presupraorbital. The presupraorbital is a comparatively long, narrow, curved bone which completes the upper boundary of the orbit, and unites in front with the prefrontal and lachrymal. As shown in plate 6, these two elements form the external boundary of the upper half of the orbit.

Nasals (*n.*).—The nasals are long bones and form the greater portion of the upper surface of the snout. Posteriorly they articulate with the frontals by overlapping finger-like processes, while in turn they are overlapped on this end by the prefrontals. (See pl. 6.)

Laterally, the nasals turn abruptly down to unite with the maxillae and premaxillae, and are only slightly in contact with the lachrymals on the infero-posterior angles. The pointed anterior ends are overlapped by the backwardly directed processes of the premaxillae. The upper surfaces of these bones are flattened throughout the greater part of their length, although transversely rounded above the narial orifice. The nasal in specimen No. 4934 measures 248 mm. in length.

Premaxillae (*pm.*).—In *Stegosaurus*, as in all known predentate dinosaurs excepting *Hypsilophodon foxii*, the premaxillary bones are edentulous. In skull

[1] Adlachrymal of Gaupp. Beiträge zur Kenntnis des Unterkiefers der Wirbelthiere. Anat. Anz., vol. 39, 1911.

[2] Amer. Journ. Sci., ser. 3, vol. 34, 1887, pl. 6, figs. 1, 2, 3.

[3] Catalogue of Fossil Reptilia and Amphibia, pt. 1, 1888, p. 176. Lydekker in a footnote comments on the skull of *Stegosaurus* as follows: "This bone forming the upper border of the orbit and connecting the pre- and post-frontals appears to be an element usually not represented as a distinct bone."

No. 4934, that part of the bone visible on the outer surface is an oblong, oblique plate, the upper border of which is notched by the nostril. Posteriorly it sends backward a gradually narrowing process which is intercalated between the nasal and maxillary, terminating at a point about midway between the narial and orbital openings. The regularly curved, anterior end of the premaxillary is continued upward into a posteriorly directed process which overlaps the anterior end of the nasal, thus completing the boundary of the narial orifice. On the anterior ends of the cojoined premaxillae the median surface is transversely concave, leaving two diverging ridges extending down toward the latero-external angles of the nose. The surface of these bones is comparatively smooth, not rugose as in *Camptosaurus*. The palatal surface is hollowed out transversely. The right premaxillary of No. 4934 has an alveolar border 61 mm. in length. The greatest width of the articulated premaxillae is 59 mm. The more important features of the premaxillary are well shown in plates 5 and 6, and plate 9, figure 1. In No. 4935 the postero-internal borders are shown to be in contact with the vomers.

Maxillae (*m.*).—The maxillary is a large bone of rudely subtriangular outline, whose outer surface forms the greater part of the cheek portion of the skull (pl. 5, *m*). Its superior border meets the premaxillary, nasal, and lachrymal bones. Posteriorly it articulates externally with the jugal and internally with the palatines. In advance of the dentigerous portion of the maxilla, a triangular flattened extension is applied to the lower median surface of the premaxillary, terminating somewhat forward of the center of the narial opening. In specimen No. 4935 this end appears to be in contact with the vomer. The right maxillary of No. 4934 has a height of 54 mm. above the dentigerous border at its center. The dental or alveolar border is swollen transversely, the teeth being placed on the internal margin. In this maxillary I am able to count an unbroken series of 22 teeth and there may have been two or three more on the anterior end. The 22 teeth occupy a longitudinal space of 129 mm. A fragmentary maxilla belonging to specimen No. 6645 shows the usual row of foramina which pierce the bone above the level of the tooth roots. The greatest length of the right maxillary of No. 4934 is 214 mm.

Jugal (*j.*).—The jugals are preserved *in situ* in No. 4934, as shown in plate 5, *j*. They are long slender bones with expanded ends, which form the lower boundaries of the orbits. On the upper posterior end an ascending process underlaps a descending process from the postorbital, and with the quadratojugal completes the postorbital bar. Posteriorly it meets the quadratojugal by squamous suture. Anteriorly, it appears to overlap the maxillary and lachrymal by a flattened end. In his published drawings of this skull, Marsh indicates the anterior termination as being posterior to the anterior boundary of the orbit, but a close examination of the specimens shows that they extended some distance in advance of this point, as indicated in the corrected drawing (pl. 5). The greatest length of the right jugal of No. 4934 is 109 mm.

Quadratojugal (*qj.*).—The quadratojugal, as shown by specimen No. 6645 (see *qj.*, fig. 6), is a small irregularly shaped bone, having a much expanded posterior end which articulates suturally with the lower postero-external side of the quadrate. A comparatively thin, finger-like extension is directed forward and laps along the inner side of the posterior extension of the jugal. In this specimen it has a greatest length of 50 mm.

On account of the complete coalesence of the quadrate with the quadratojugal in the skull of *S. stenops*, No. 4934, Professor Marsh was not able to detect its presence as a separate element, and in the original drawings of the skull it was indicated as a forwardly directed process of the quadrate.

Quadrate (*q.*).—The quadrate, a large, stout bone, is transversely compressed throughout its upper half into a quadrangular plate. Toward the distal end, however, it thickens in all dimensions. In the skull of *S. stenops* (No. 4934) both quadrates have been retained in their natural relations and are but little distorted. (See fig. 2, pl. 9.)

The right quadrate of this specimen has a length of 129 mm.; the left element, which has been more subjected to vertical pressure, is somewhat shorter. The antero-posterior diameter of the quadrate (right), just below the squamosal end, is 39 mm.; and just above the mandibular end is 24 mm. The transverse width of the latter end is 33 mm.

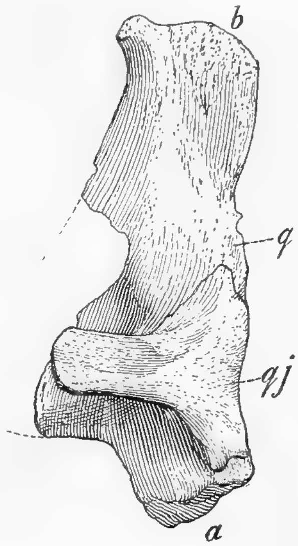

Fig. 6.—Left quadrate and quadratojugal of Stegosaurus stenops? Marsh. Cat. no. 6645, U.S.N.M. ½ Nat. size. Side view. *a*, Articular end for lower mandible; *b*, end which meets the squamosal; *q*, quadrate; *qj*, quadratojugal.

Viewed from the side the quadrate is capped by the squamosal, the truncated top, fitting within a recess on the under side of that bone. On the posterior internal side (shown by the quadrate of No. 6645, see fig. 6), below the squamosal end, a flattened, slightly striated surface rests against the outer anterior face of the paraoccipital process. Near the middle of the quadrate a vertically flattened process is given off, which extends anterior to the longer axis of the bone. This internal process turns slightly inward and unites by a lapping suture with the posteriorly directed process from the pterygoid (see *pt.*, pl. 8).

Fig. 7.—Ventral view of left squamosal of Stegosaurus stenops? Marsh. Cat. no. 6645, U.S.N.M. ½ Nat. size. *a*, Surface for articulation with the quadrate; *b*, sutural surface that unites with parietal; *c*, process which extends forward to meet the postfrontal.

The articular end for the jaw is rectangular in outline. Viewed from behind the articular end is cut off obliquely to the longer axis of the bone (fig. 2, pl. 9). This view also shows on the posterior surface the pronounced longitudinal depression in the shaft of this bone. Text figure 6 is based upon the detached quadrate of No. 6645. In old individuals the quadrate appears to become fixed, as shown by specimens Nos. 4934 and 4936.

Squamosal (*sq*).—The squamosal, as shown in pl. 5, unites by an anterior branch with the postfrontal and by a shorter, heavier, inner process with the parietal. It thus helps to bound the supratemporal fossa posteriorly. Internally the lower posterior edge rests upon the upper border of the paraoccipital process, but more externally it passes below and in front of that bone. (See figs. 4 and 5.) It caps the upper end of the quadrate, which is fitted into a recess on its under side. A ventral view of this bone is shown in figure 7.

Pterygoids (*pt.*).—The pterygoids are irregularly shaped bones, as shown in *pt.*, plate 7. On the latero-posterior borders two diverging processes are developed, which extend backward and outward, and articulate on the inner side by a long, lapping suture, with anteriorly directed processes from the quadrates. On the internal posterior border, where these processes leave the body of the pterygoid, it unites with the descending basisphenoid processes. On the latero-anterior borders two spatulate processes are given off which extend forward and outward. Whether these processes unite with the palatines, or whether there is a transpalatine, as in the crocodile and some other reptiles, can not be determined from this specimen, because of the incomplete and damaged condition of this region. On the median ventral surface of the pterygoids a downwardly directed angular process is developed. This process is strongly braced by vertical lamina extending down on the sides and back (fig. 2, pl. 9). Above and behind this process and at the junction of the pterygoids with the basisphenoid is a large opening that appears to lead forward into a chamber above the pterygoids, and which may represent the posterior narial opening.

From the forward face of the descending process just described is a vertical plate of bone extending well forward in the roof of the mouth. It is likely that a portion of this plate represents the vomers, but the sutural junction of these elements can not be determined from this specimen.

Palatines (*pl.*).—That the palatines are present there can be no doubt, but it is impossible from the present specimens to get anything like an adequate idea of their extent, or relationships to the surrounding elements. The irregularly triangular elements in front of the pterygoids, as represented in plate 7, were identified by Marsh as the palatines. We can not be certain, however, that the openings in the bone and their inner contours exist as depicted.

Vomer (*v.*).—Specimens Nos. 4934 and 4935 (*v.*, pl. 7) show the vomer to have been present in *Stegosaurus*, but it is impossible from available specimens to determine their true extent or relationships.

Epipterygoid.—The damaged condition of this part of the palate in the skull of No. 4934 makes it impossible to positively identify this element.

Measurements of skull of Stegosaurus stenops, No. 4934. Type.

	mm.
Greatest length of skull, taken at center	414
Greatest expanse of paraoccipital processes	142
Greatest expanse above center of orbits	156
Greatest expanse above center of nares	18
Distance from posterior border of orbit to posterior extremity of squamosal	104
Distance from anterior border of orbit to anterior extremity of premaxillae	251
Distance from extremity of premaxillae to distal extremity of quadrate	400
Distance from distal end of quadrate to top of skull	149
Height of skull over center of maxillary (estimated)	71
Height of snout at anterior border of narial opening	40
Height of skull with lower jaw, measurement taken at center of orbit	144
Same measurement taken below posterior border of nares	90
Transverse diameter of occipital condyle	39
Antero-posterior diameter of orbit	91
Antero-posterior diameter of narial opening	75

Lower Jaw.

Plates 5, 7, 8, and 9.

The mandible in *Stegosaurus* consists of 13 elements, and if the coronoid is present there are 15. The dentary, angular, surangular, articular, prearticular, and splenial are paired bones, the predentary being single and articulating with the ends of both rami. The coronoid, a paired element, is probably present, but its presence or absence can not be determined from the available specimens.

The following description of the several elements of the lower mandible is to a great extent based upon the well-preserved jaws of *S. stenops*, No. 4934. It might be well, however, to explain that the jaws were found articulated with the skull, to which they are so closely applied that it has been deemed unwise to attempt their separation.

Dentary (*d.*).—The dentary, as in all dinosaurs, is the largest bone of the mandible. In *Stegosaurus* it is especially remarkable on account of the extreme transverse thinness of the lower half and the wide shelf of bone exterior to the row of teeth on the dorsal border. These features are best shown by the portion of the right dentary pertaining to specimen No. 4935, shown in figure 8. The transverse width of the median lower border of this bone is 7 mm.; the same measurement of the dental border is 21 mm. The external surface is comparatively smooth and flat, and the vertical diameter decreases gradually from back toward the front. Below the anterior border of the orbit, in specimen No. 4934, it has a depth of 68 mm.; below the posterior border of the nares a depth of 41 mm.

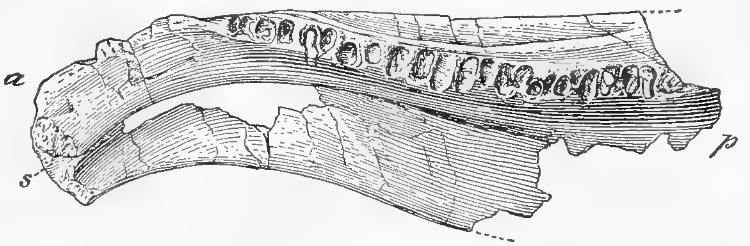

Fig. 8.—Anterior half of right dentary of Stegosaurus sp. Cat. no. 4935, U.S.N.M. ½ Nat. Size. Internal view. *a*, Anterior end; *p*, posterior end; *s*, symphysial surface. Shows the complete dental series of the lower jaw as consisting of 23 functional teeth.

The anterior end curves downward (fig. 8) and inward, the two dentaries forming a "spoutlike" symphysial end as in *Camptosaurus*.

The dorsal border is comparatively wide, the tooth row being placed on the extreme internal border. Along its external border, beginning opposite the first tooth, a ridge gradually rises from this surface until opposite the last tooth it attains a height of 17 mm. above the border of the alveolus. Between this ridge and the dental series is a row of foramina, which evidently correspond to those on the external surface of the *Camptosaurus* dentary, and which doubtless served for the transmission of nerves and nutrient blood vessels to the lips. These foramina lead to a canal traversing the length of the heavier part of the bone and which opens anteriorly near the symphysis. This is the mental foramen through which a branch of the fifth nerve emerges.

The anterior part of the dorsal border where it turns down to meet the predentary, is shallow though broadly grooved. On the internal side of the dentary of No. 4935 (fig. 8) alveoli for 23 teeth can be counted. These occupy a space

114 mm. in length. The tooth row is curved slightly in both the vertical and horizontal aspects. The mandibular fossa is present and on the posterior half extends well up between the thin outer wall and the heavier dentigerous part of the dentary. Inferiorly and latterly this fossa is partially inclosed by the splenial which laps along the inner side to a point below the first tooth. Posteriorly the dentary meets the angular and surangular. In all probability, as mentioned previously, it articulates with the prearticular on the postero-internal side. It appears that these elements do not coössify even in old individuals.

Predentary (*pd.*).—The predentary has been preserved *in situ* in the skull of No. 4934 (*pd.*, fig. 1, pl. 9). Although imperfect in some of its details, it nevertheless gives a good idea of its chief characteristics and manner of articulation with the dentaries. Viewed from the front it appears as a narrow, transversely curved bone, resting upon the beveled ends of the dentaries. On the median ventral border a narrow pointed process is given off which projects downward and backward, being interposed between the ends of the dentaries at the symphysis.

The predentary is wider transversely than the combined premaxillaries, but does not extend so far forward as those bones. (See *pd.*, pl. 8.) The median anterior surface is somewhat flattened and with the forward ends of the dentaries forms the rather truncated end of the mandible. This surface of the predentary is pitted by numerous but irregularly placed pits. In life this bone was probably enveloped by a horny covering and when in contact with the premaxillaries similarly covered must have served as an efficient organ for gathering the plants upon which the animal fed.

Splenial (*s.*).—The splenials are long, thin bones that are closely applied to the internal side of the dentary (*s.*, pl. 8). They reach a point 60 mm. posterior to the symphysial border in front, and posteriorly they inclose internally and inferiorly the mandibular fossa. Posteriorly they extend back to a point 83 mm. from the end of the ramus and lap along the angular and prearticular. Below the junction of the dentary and angular on the infero-lateral border the splenial is visible for a short distance from a lateral view (*s.*, pl. 5).

Angular (*an.*).—The angular is also a long, thin element, which forms the outer and lower part of the posterior portion of the ramus. Dorsally it unites with the surangular by a nearly horizontal suture. In specimen No. 4934, however, as shown in plate 5, the anterior half of this suture has been entirely obliterated and the union of the angular, surangular, and dentary is obscure.

The anterior end appears to be overlapped by the dentary on the outside and by the splenial on the inside. Posterior to the end of the splenial the ventral border of the angular is swollen transversely and underlaps for a short distance the ventral border of the prearticular (see pl. 7), but more posteriorly it returns to the external side of the articular terminating in a sharp end somewhat anterior to the posterior termination of the surangular.

Surangular (*sa.*).—The surangular is a comparatively thin, flat bone, and the largest of the posterior elements of the jaw. Ventrally it sends forward a thin tapering extension which laps along the outside of the dentary. Posteriorly the surangular forms the upper border of the posterior one-third of the ramus. Near the posterior end the upper border is deeply cut out, only a narrow part of the bone extending posterior to the articular end of the quadrate in the articulated jaw. (See *sa.*, pl. 5.) Internally it laps along the articular and also the prearticular. It does not contribute to the formation of the cotylus of the lower jaw, as in *Camptosaurus*. The external mandibular foramen found in the surangular of *Camptosaurus*, *Iguanodon*, and *Triceratops* does not appear to be present in this genus.[1]

Articular (*ar.*).—The articular is a small block-like bone that forms the greater portion of the articular surface for the quadrate. It is embraced below by the prearticular, while on its external surface it is lapped by the angular and surangular. In specimen No. 4934, upon which the present description is based, this element has a transverse width of 35 mm. On the median posterior border it has a vertical depth of 15 mm. On account of the articulating quadrate bones the anterior extent of this element can not be determined. The manner in which the angular, surangular, prearticular, and articular unite is well shown in plates 7, 8, and in plate 9, figure 2, which show all of these bones in their normal relations to one another.

Prearticular (*p. ar.*).—Marsh in his representations of the lower jaw of *Stegosaurus*, did not recognize the presence of the prearticular but called the combined elements[2] the articular (*ar.*). Since this element has recently been found in the jaws of other members of the Predentata, i. e., in *Camptosaurus* by Gilmore[3] and in *Triceratops* by von Huene[4] it was not surprising to find it existing as a separate element in *Stegosaurus*. An examination of the jaws of No. 4934 showed clearly on the posterior ends of both rami the presence of a suture between the articular and an element which embraced it on the inferior surface, and which is identified as the prearticular[5] (*p. ar.*, pls. 7 and 8).

In *Stegosaurus* the prearticular is a moderately long bone, lying internal to the angular which underlaps it for some distance on its median inferior border. The anterior end of the prearticular in the articulated jaw disappears under the overlying splenial.

The anterior half of this element exists as a thin vertical plate of bone applied to the inner side of the jaw, but the posterior portion changes from the vertical to a horizontal plane, gradually widening until its maximum width is reached, where it underlaps the articular.

The truncated posterior end terminates slightly forward of the posterior extremity of the articular. A small portion of the posterior edge of this bone is visible from a side view, just below the angular bone (*p. ar.*, pl. 5).

Coronoid (*c.*).—As mentioned previously on account of the close articulation of the jaws with the skull in specimen No. 4934, the presence of this element can not be positively determined.

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[1] In the English Translation of Zittel's Text-Book on Paleontology, vol. 2, 1902, p. 241, it is said to be present.

[2] Amer. Journ. Sci., ser. 3, vol. 34, 1887, fig. 1, pl. 6.

[3] Proc. U. S. Nat. Mus., vol. 36, 1909, pp. 220–221.

[4] Neues Jahrbuch, Jahrg. 1911 pt. 2, 1912, pp. 160–161.

[5] Since the above was written Huene in an article in Neues Jahrbuch, vol. 37, 1914, p. 581, recognizes and describes a prearticular in the lower jaw of *Stegosaurus*.

Measurements of lower jaw of Stegosaurus stenops, No. 4934. Type.

	mm.
Greatest length	388
Distance between posterior extremities of rami	179
Width across anterior extremities of rami	63
Height of ramus below center of orbit	75
Height of ramus below posterior border of narial opening	41
Width of predentary, estimated	64

Hyoid.—That *Stegosaurus* had a well developed hyoid is clearly shown by specimen No. 4935 in the National Museum, which has the thyrohyals of both sides preserved as shown in figure 9. The better preserved element is a long, flattened, slightly curved bar of bone. Comparing it with the thyrohyal of *Camptosaurus* which was found *in situ*,[1] the expanded end probably represents the forward extremity. Sixty-eight millimeters posterior to this end, the bone reaches its maximum width of 19 mm. From this point it gradually narrows in both directions. Posteriorly it tapers to a small, smooth, rounded end. Dr. F. A. Lucas, in an unpublished manuscript, observes "that judging from their length it seems probable that these reptiles were provided with extensile tongues."

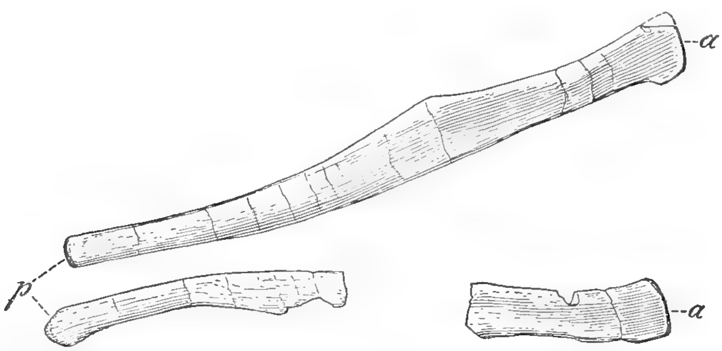

FIG. 9.—THYROHYALS OF STEGOSAURUS SP. CAT. NO. 4935, U.S.N.M. ½ NAT. SIZE. RELATIONS SHOWN AS FOUND IN THE MATRIX. *a, a*, ANTERIOR ENDS; *p*, POSTERIOR ENDS.

The principal measurements are as follows:

	mm.
Greatest length	174
Greatest width of anterior end	18
Greatest width of posterior end	7

EXTERNAL OPENINGS IN THE SKULL.

Supratemporal fossae (*e.*).—The irregularly rounded supraoccipital openings situated one on either side of the parietals are comparatively small in *Stegosaurus*. In *S. stenops* these fossae are bounded anteriorly by an inner branch of the postorbitals and the outwardly curved ends of the parietals. In skull No. 4936, identified by Marsh as *S. armatus*, the frontal also contributes to this boundary (fig. 1, pl. 10). Internally the boundary is formed by the parietals, posteriorly by processes from the parietals and squamosals which meet at the posterior center of the opening, externally by branches of the postorbital and squamosal.

Infratemporal fossae (*c.*).—The infratemporal fossae are vertically elongate, openings with their greatest diameter inclined at an angle of 45° to the longer axes of the skull (*c.*, pl. 5). These fossae are bounded above by the postemporal bar formed by processes of the postorbital and squamosal bones; anteriorly by the

[1] C. W. Gilmore, Proc. U. S. Nat. Mus., vol. 36, 1909, p. 224, pl. 9, fig. 2, *h*.

postorbital bar formed by the united processes of the postorbital and jugal; ventrally by the quadratojugal and quadrate; and posteriorly by the quadrate.

Orbital cavities (*b.*).—The orbits are of large size, suboval in outline, the greatest diameter being antero-posteriorly (*b.*, pl. 5). The length of the orbit is one-fifth of the total length of the skull. Viewed from the side it is bounded above by the supraorbital bones; below by the jugal; anteriorly by the lachrymal and presupraorbital; and posteriorly by the postorbital bar as explained above. Apparently there were no sclerotic plates developed for the protection of the eye. There are no pre- or supraorbital fossae in *Stegosaurus*, as found in *Camptosaurus* and *Iguanodon*.

Anterior nares (*a.*).—The external narial opening is of good size, subelliptical in outline, with its greatest diameter parallel to the longer axis of the skull. Excepting the posterior, and part of the upper boundary formed by the nasals the rest of the orifice is enclosed by the premaxillae.

Posterior nares.—On the median posterior junction of the pterygoids in specimen No. 4934 is a single large foramen which apparently represents the posterior narial opening. The crushing together of the bones anterior to the foramen renders it impossible to trace its course and thus determine its function beyond a question. While it is well within the pterygoids, the basisphenoid forms the upper boundary (pl. 7). It would appear from this specimen that the posterior nares in *Stegosaurus* occupies even a more posterior position than in the recent Crocodilia where the posterior nares are wholly inclosed by the pterygoid bones. From Hatcher's description [1] it would appear that the posterior nares in the Ceratopsia occupy a somewhat similar position in relation to the bones of the palate.

Palatine vacuities.—The crushed and damaged condition of this region of the skull precludes the posssibility of bounding these openings.

Foramen magnum (*fm.*).—Taking into consideration the very small size of the brain in *Stegosaurus*, the foramen magnum is comparatively large. The size of this opening, however, varies considerably in different individuals as may be readily seen by comparing figures 4 and 5. In most skulls it is ovate in outline with the greatest diameter transverse (pl. 9, fig. 2, *fm.*). In specimen No. 6645 the greatest diameter is vertical. As in *Camptosaurus* it is bounded below by the basioccipital, laterally by the exoccipitals, and above by the supraoccipital (fig. 4).

Lesser foramina.—None of the skulls in the National Museum collections are sufficiently well preserved to show clearly the relationships of all of the smaller foramina. However, the five cranii at hand supplement one another to such an extent, that the more important openings have been recognized, and by comparing them with other reptilian skulls of both recent and fossil forms, it is believed they have been identified with a considerable degree of accuracy.

Beginning with the most posterior, it is found that the exoccipital is pierced on its lower external side by two small foramina, one in front of the other, the posterior one being located somewhat more dorsally. The latter represents the exit of the twelfth or hypoglossal nerve (XII, fig. 10). It enters the brain case just within the external opening of the foramen magnum. The next anterior foramen occupies a position essentially that of the anterior condyloid foramen in

[1] Mon. 49, U. S. Geol. Surv., 1907, p. 36.

Triceratops, as identified by Hay,[1] and, as he observes, "probably transmitted a vein."

Anterior to the foramina just described are two larger openings shown in figure 10, IX, XI. In specimen No. 2274, from which the drawing was made, these foramina appear to be separated externally by a thin bony partition, but in specimen No. 6645 they are confluent, forming one large opening into the brain case. From the location of these openings when compared with those of other reptilian skulls, I would identify the anterior one as the fenestra ovalis (fig. 10, VIII) and the posterior one as the foramen lacerum posterius or juglar foramen (fig. 10, IX, XI) through which the pneumogastric, vagus, and glossopharyngeal nerves were transmitted. Whether these foramina enter the brain case by distinct openings, or

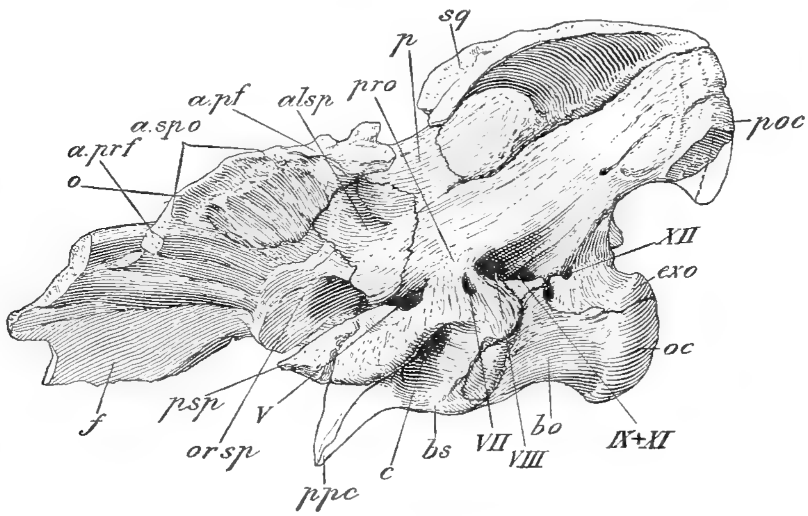

FIG. 10.—OBLIQUE SIDE VIEW OF THE POSTERIOR PART OF THE SKULL OF STEGOSAURUS SP. CAT. NO. 2274, U.S.N.M. ½ NAT. SIZE. *alsp*, ALISPHENOID; *a.pf*, ARTICULAR BORDER FOR POSTORDITAL; *a.prf*, ARTICULAR BORDER FOR PREFRONTAL; *a.spo*, ARTICULAR BORDER FOR POSTFRONTAL; *bo*, BASIOCCIPITAL; *bs*, BASISPHENOID; *c*, EXIT FOR CAROTID ARTERY; *exo*, EXOCCIPITAL; *f*, FRONTAL; *o*, ORBIT; *oc*, OCCIPITAL CONDYLE; *orsp*, ORBITOSPHENOID; *p*, PARIETAL; *poc*, PA A OCCIPITAL PROCESS; *ppc*, PROCESS FOR PTERYGOID; *pro*, PROÖTIC; *psp*, PRESPHENOID; *sq*, SQUAMOSAL; *V*, *VII*, *VIII*, *IX*, *X*, *XI*, AND *XII*, EXITS OF CRANIAL NERVES.

as in *Triceratops* and *Camptosaurus* by a single foramen can not be definitely determined from the available specimens.

In figure 10 the foramen labeled "VII" is the exit of the seventh or facial nerve. It has the same position as in *Triceratops*, *Camptosaurus*, and the alligator, and as in those animals, passes straight through the center of the proötic bone.

The position of the next foramen forward of the seventh, i. e., in front of the proötic and behind the center of the alisphenoid, at once distinguishes it as the foramen ovale, through which the third division of the trigemnial nerve always leaves the skull (V, fig. 10). As in *Camptosaurus*, this opening is largely within the proötic, only the anterior boundary being formed by a descending process of the alisphenoid. Immediately below the foramen ovale is a deep, almost vertical fissure on the side of the basisphenoid and from which a short foramen leads into the

[1] Proc. U. S. Nat. Mus., vol. 36, 1909, p. 100, pl. 2, figs. 1 and 2, *a c f*.

pituitary fossa (fig. 10, *c*). This opening is for the passage of the internal carotid artery. The pituitary fossa is deep, extending well below the brain-case floor, and is wholly within the basisphenoid bone, as shown in plate 10, fig. 3, *pi.*

The foramina anterior to the foramen ovale are only shown in specimen No. 4936 in these collections (pl. 10, fig. 2). The foramina, located near the central posterior border of the orbitosphenoids, represents the exit for the optic nerves (II, fig. 2, pl. 10). This foramen appears to be divided (not shown in the drawing) by a thin filament of bone, which in an uncrushed specimen would be on the median line. As in *Diplodocus*, these foramina appear to lie wholly within the orbitosphenoid bones.

On the posterior margins of the orbitosphenoids at about their middle, where they coössify with the alisphenoids, there are notches (III, fig. 2, pl. 10), which in all probability give exit to the oculomotor nerves.

The olfactory foramen is a V-shaped opening formed by the anterior borders of the coössified orbitosphenoids and bounded above by the frontals, and gave exit to the olfactory nerves. This is an unusually large opening (pl. 10, figs. 2 and 3 *ol*).

Brain.

Plate 10.

A cast of the cranial cavity of *Stegosaurus stenops* shows the small size of the brain of this reptile (fig. 5, pl. 10). Its most striking features were the large size of the optic lobes and the small cerebral hemispheres, the latter having a transverse diameter only slightly in excess of the medulla oblongata. The cerebellum was quite small. The peculiar development of the pituitary body is also noteworthy (*pi.*, fig. 5, pl. 10).

In comparing the brain casts of *Stegosaurus* and *Alligator*, Marsh makes the following interesting comments: [1]

> The contrast in the development of the cerebral region is marked, but in some other respects the correspondence is noteworthy.
>
> In comparing the proportionate size of the brain of this living reptile with that of *Stegosaurus*, as given on the same plate, the result proves of special interest. The absolute size of the two brain casts is approximately as 1 to 10, while the bulk of the entire bodies, estimated from corresponding portions of each skeleton was as 1 to 1,000. It follows that the brain of *Stegosaurus* was only 1 to 100 that of the alligator if the weight of the entire animal is brought into the comparison.

Marsh concludes that *Stegosaurus* had, relatively, one of the smallest brains of any known land vertebrate.

More recently Prof. R. S. Lull makes the following interesting observations on the brain and other parts of the central nervous system.[2]

> The brain is remarkable for its extremely small size, the entire cranial cavity, with a length of 1.05 cm. and a width of 0.30 cm., displacing but 56 cc. of water and having an estimated total weight of but 2½ ounces.
>
> The total weight of the animal must have exceeded that of the greatest of living elephants, the brain of which averages 8 pounds, or over 50 times the weight of that of *Stegosaurus*.
>
> In comparing the relative potential intelligence of the two, one has also to bear in mind the great preponderance of the cerebrum over the other parts of the elephantine brain, while in *Stegosaurus* the

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[1] Dinosaurs of North America, 16th Ann. Rept. U. S. Geol. Surv., pt. 1, 1896, pp. 187–188.

[2] Amer. Journ. Sci., vol. 30, 1910, pp. 371–372, fig. 9.

cerebrum constitutes hardly more than a third of the entire brain weight. The *Stegosaur* brain has a very large olfactory portion, small cerebellum, large medulla, and a hypophysis which is remarkable not only for its size, but also for the peculiar shape. The sense of smell was apparently as well developed as may have been that of sight; the auditory sense I am not yet prepared to discuss.

TEETH.

The teeth in *Stegosaurus* [1] are confined exclusively to the maxillary and dentary bones. They are not differentiated, the form and sculpturing remaining the same throughout the series. Each tooth consists of a laterally compressed, vertically striated crown having denticulate margins, and a long, cylindrical fang. The outer face of the crown is slightly convex vertically, while the inner face is slightly concave. There is a rounded cingulum at the base of the crown, this being more pronounced on the exterior face (fig. 11). The denticles in cross section are rounded with a blunt point. The number of denticles on the teeth of *Stegosaurus stenops* is variable. I have found teeth with as few as four and others with as many as seven on each side of the apical denticle. The apical denticle is always on the median vertical line, not posterior to it as in the teeth of *Ankylosaurus* [2] or *Troödon*.

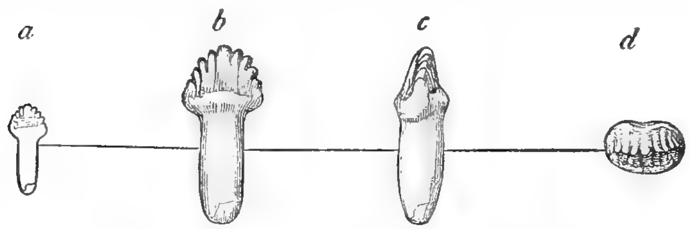

FIG. 11.—TOOTH OF STEGOSAURUS UNGULATUS MARSH. *a*, NATURAL SIZE; *b*, *c*, *d*, TWICE NATURAL SIZE; *b*, OUTER VIEW; *c*, END VIEW; *d*, TOP VIEW. ALL AFTER MARSH.

The teeth are held in distinct sockets. Those worn out or lost through accident are replaced by germ teeth developed in cavities within the jaw. Specimen No. 4934 shows quite clearly the relationship of the germ and functional teeth (fig. 12). The crown of the germ tooth lies on the inside of the base of the functional tooth, the crown resting against the root of the old one, and, as usual among the dinosaurs, ascends or descends according to whether they are in the upper or lower series. It appears that there are not more than two teeth in a vertical series. The teeth of the functional rows present a very regular cutting edge, as contrasted with the irregular series in *Camptosaurus* and *Triceratops*. Many of the crowns in this series (No. 4934) show marks of wear, being obliquely ground.

Twenty-two teeth can be counted in the right maxillary of No. 4934 and the complete maxillary series may have consisted of two or three more. In the dentary of specimen No. 4935 there are aveoli for 23 teeth. With the germ teeth, there were 46 in each jaw or 184 functional teeth in the complete series of the skull. The small weak structure of the teeth is most remarkable when the great size of the animal is taken into consideration. The oblique wear of the teeth would indicate that the bite was shear-like, as in the other predentate dinosaurs. The teeth are invisible from the outside when the jaws are closed. Their weak structure would imply, as Lull [3] has pointed out, a "food of yielding character which did

[1] Marsh in Amer. Journ. Sci., vol. 19, 1880, p. 255, pl. 6, figs. 4 and 5, describes and figures teeth that afterwards were found to pertain to the Sauropod genus *Diplodocus*.

[2] Barnum Brown, Bull. Amer. Mus. Nat. History, vol. 24, 1908, p. 191, figs. 5 and 8.

[3] Amer. Journ. Sci., vol. 30, 1910, p. 367.

not require the forcible mastication of that of *Iguanodon* or more especially of the late Cretaceous *Trachodon,* in which the powerful dental battery of 2,000 teeth reached its highest perfection."

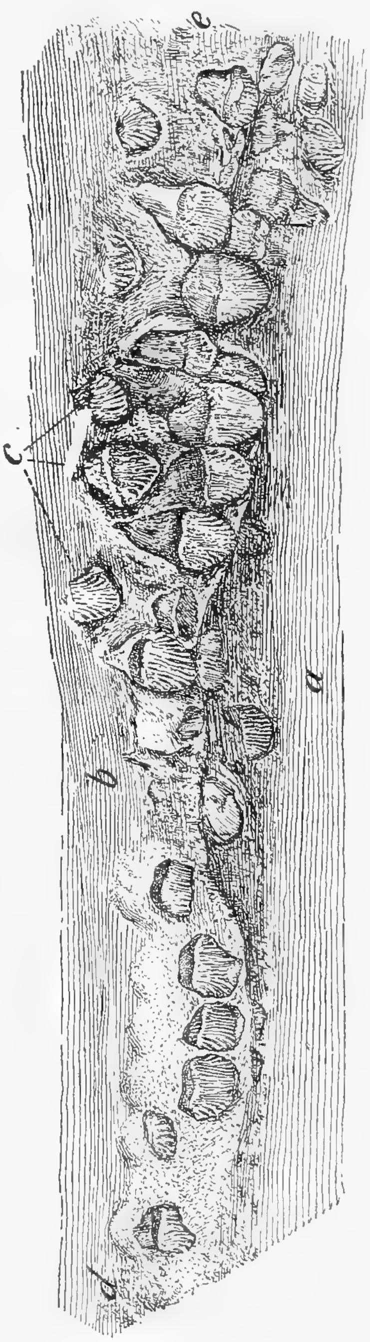

Fig. 12.—Dentition of right maxillary of Stegosaurus stenops Marsh. Type. Cat. No. 4934, U.S.N.M. Slightly larger than natural size. Internal view. *a*, Portion of lower jaw crushed up on outside of maxillary; *b*, maxillary; *c*, germ teeth; *d*, anterior end; *e*, posterior end.

Vertebral Column.

The vertebral formula in *Stegosaurus,* as nearly as can be determined from available material, is as follows: C, 10(?); D, 17(?); S, 3; C, 45 to 47. There are no true lumbars. Some uncertainty exists regarding the exact point of separation between the cervical and dorsal region. Although slightly disarranged, the type of *S. stenops,* No. 4934, shows the entire number of vertebrae in front of the sacrum (including the dorso-sacral) as being 27. Marsh in his first restoration of *S. ungulatus* shows 26 presacrals, 4 sacrals, and 44 caudals.

In regard to the caudal series it would appear that the tail of *Stegosaurus,* as in other dinosaurs, is not made up of a constant number of vertebrae but within limits varies with the individual.

Atlas.—The atlas in *Stegosaurus* consists of the usual four pieces, the intercentrum, neuracentra, and odontoid process. It resembles very closely the corresponding element in *Camptosaurus.*

The intercentrum, as shown by specimen No. 4934, is a subcrescentic block of bone, the concave side being uppermost and with the greatest diameter transverse. The upper posterior part of the transversely concave surface receives the odontoid while the anterior part of this surface is more deeply excavated, forming the lower portion of the cup for articulation with the occipital condyle of the skull.

On either side of this concave portion are the articular surfaces on which the pedicels of the neuracentra rest. Viewed from behind this element presents a nearly straight vertical face for articulation with the axis. On either side of the inferior surface are well-developed facets for the articulation of the single-headed cervical ribs shown in figure 16, r'.

The neuracentra are rather irregularly shaped pieces which form the sides of the neural arch. The articular end which rests upon the intercentrum is expanded antero-posteriorly, having two faces which meet at an obtuse angle. The posterior face rests upon the end of the intercentrum while the anterior and smaller one of the two looks inward and forward and contributes to the formation of the cup for articulation with the occipital condyle. In the collections of the National Museum there are four individuals (Nos. 4934, 4935, 6645, and 7725) which have the atlas preserved. The first three have the neuracentra detached from the intercentrum, but the latter, from which figure 13 was drawn, shows these pieces firmly coössified. Although the upper part of these arches is incomplete (having been restored from the other specimens) this specimen gives a most accurate idea of the manner of the articulation of these lateral pieces in the atlas of *Stegosaurus*, as is clearly shown in figure 13, *A*. Just above the neck-like contraction of the pedicel the neuracentrum gives off two processes, one directed inward and upward, which with the corresponding process of the opposite side forms the covering of the upper part of the neural canal. The neuracentra did not unite on the median line but were probably bound together by ligaments. The postzygapophysial process is more slender than the one just described and is directed upward and backward, its lower internal surface being adapted for articulation with the prezygapophysis of the axis.

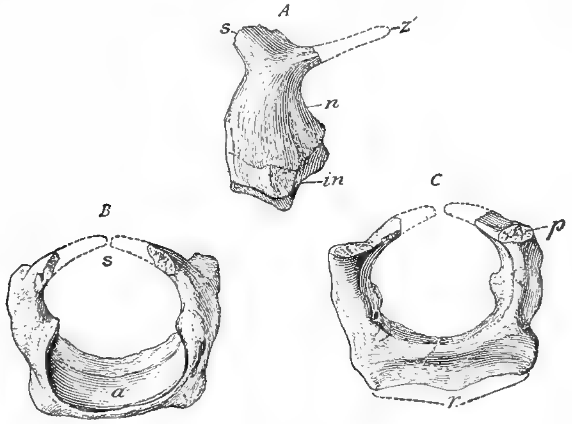

FIG. 13.—ATLAS OF STEGOSAURUS STENOPS ? MARSH. CAT. NO. 6645, U.S.N.M $\frac{1}{3}$ NAT. SIZE. *A*, VIEWED FROM LEFT SIDE; *in*, INTERCENTRUM; *n*, NEURACENTRUM; *s*, NEURAL SPINE; *z′*, POSTERIOR ZYGAPOPHYSIS; RESTORED FROM THE ATLAS OF NO. 4935, U.S.N.M. *B*, VIEWED FROM THE FRONT; *a*, CUP OR ARTICULATING SURFACE FOR THE OCCIPITAL CONDYLE OF THE SKULL; *s*, NEURAL PROCESSES. *C*, VIEWED FROM THE BACK; *p*, BROKEN SURFACES WHENCE POSTZYGAPHYSIAL PROCESS IS GIVEN OFF; *r*, FACETS FOR CERVICAL RIBS.

The odontoid is a small bone (fig. 14, *o*), the upper surface, which is slightly concave transversely, forming the floor of the neural canal. The whole lower part of the bone is rounded transversely. When articulated the anterior part is in contact with the upper concave surface of the intercentrum of the atlas. In position the smooth anterior end abuts against the posterior end of the occipital condyle. The posterior end is slightly concave and is closely applied and in some instances (see axis of No. 4935, fig. 14) is partly coössified with the centrum of the axis.

Measurements of atlases.

	No. 4934.	No. 4935.	No. 6645.
	mm.	*mm.*	*mm.*
Greatest length of intercentrum	22	24	24
Greatest width of intercentrum	55	61	61

Axis.—The description to follow is based almost entirely upon the axis of specimen No. 4935. Although present in No. 4934, it is so badly crushed as to be of little value in determining the characteristics of the bone.

The centrum is plano-concave, constricted medially, with rounded ventral surface without keel. In transverse diameter the ends are expanded, the anterior extremity exceeding the posterior, but unlike the axis of *Camptosaurus* the transverse diameter of the anterior end is less than the total length of the centrum.

The neural arch is composed of two thin parallel plates of bone, which curve in above the neural canal, forming a sharp median longitudinal ridge or crest that rises rapidly toward the back. The posterior portion flares out into an expanded ruff-like process which overhangs the centrum of the next vertebra. Well developed posterior zygapophyses are present on the lower borders of the overhanging portion (fig. 14, *z'*). The anterior zygapophyses are missing from this specimen, but judging from those of the atlas they must have been small and placed forward and well up on the side of the arch.

The articular surfaces for the second cervical rib are situated on the anterior superior part of the centrum and in the center of the neural arch just above the neuro-central suture. The diapophyses extend outward and downward (*d*, fig. 14).

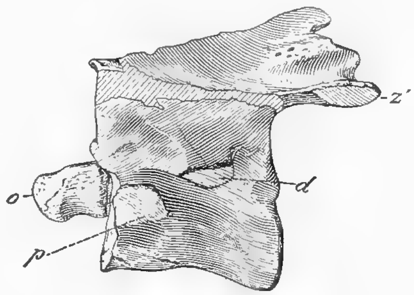

FIG. 14.—AXIS AND PORTION OF ATLAS OF STEGOSAURUS SP. CAT. NO. 4935, U.S.N.M. SIDE VIEW. ⅓ NAT. SIZE. *d*, DIAPOPHYSIS; *o*, ODONTOID; *p*, PARAPOPHYSIS; *z'*, POSTZYGAPOPHYSIS.

The neural canal is exceptionally large, subelliptical in outline, with the longer axis vertical. Neither of the two axes in the National Museum collections show any indication of the presence of a second intercentrum as found [1] in *Camptosaurus*.

The odontoid, shown in figure 14, *o*, is only attached to the axis by matrix, though it may become ankylosed in old individuals, a condition observed by Nopcsa [2] in *Stegosaurus priscus*.

Measurements of axis [3] of No. 4935, U.S.N.M.

	mm.
Greatest length of centrum	71
Greatest width anterior extremity	64
Greatest width posterior extremity	54
Greatest height over all	116

Cervicals posterior to the axis.—Of the cervical series in specimen No. 4934 the first six vertebrae were found articulated as shown in text figure 16, and in plates 2 and 3. Nos. 8, 9, and 10 (see pl. 3), while not connected were so little disarranged that there can be no question but that they represent a continuous series. All of these vertebrae have suffered from crushing, particularly the posterior members of the series, which have the processes so damaged that it is impossible at times to determine their characteristics.

The cervical centra are all without pneumatic or medullary cavities and the same remark applies to the entire vertebral series. The centra increase in length

[1] C. W. Gilmore, Proc. U. S. Nat. Mus., vol. 32, 1907, p. 164.
[2] F. Baron Nopcsa, Geol. Mag., vol. 8, 1911, pp. 110–111, fig. 1 (*a*).
[3] Measurements of the axis of No. 4934 will be found in table on page 53.

from the first to the fifth, the latter equaling the length of the twentieth of the series, and in this diameter exceeding all others.

The first two or three centra might be called platycœlian, though they soon pass into the biconcave type, which continues throughout the dorsal series. The median cervicals have a much deeper concave posterior end than the anterior end, but back of the eighth the concavities of these ends become about subequal.

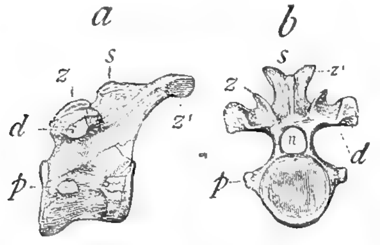

FIG. 15.—MEDIAN CERVICAL VERTEBRA OF STEGOSAURUS UNGULATUS MARSH. $\frac{1}{8}$ NAT. SIZE. *a*, SIDE VIEW. *b*, SAME VERTEBRA, FRONT VIEW. *d*, DIAPOPHYSIS; *n*, NEURAL CANAL; *p*, PARAPOPHYSIS; *s*, NEURAL SPINE; *z*, ANTERIOR ZYGAPOPHYSIS; *z′*, POSTERIOR ZYGAPOPHYSIS. AFTER MARSH.

Viewed from below the ends are expanded, the sides of the centra are pinched together, thus making them concave longitudinally, with a strong angular keel which widens at either end (fig. 16), more especially the anterior, which is roughened by coarse longitudinal striæ. Proceeding toward the dorsals the keel becomes progressively less and less conspicuous.

All of the cervicals have capitular facets on the sides near the anterior end, as shown in figures 15 and 17, *p*. Well-developed diapophyses extend outward from the sides of the neurapophyses. These have heavy, expanded, articular ends, which look more downward than outward. The diapophyses gradually increase in length proceeding posteriorly. On the side of the centra near the posterior end, on a level with the parapophyses, is a roughened

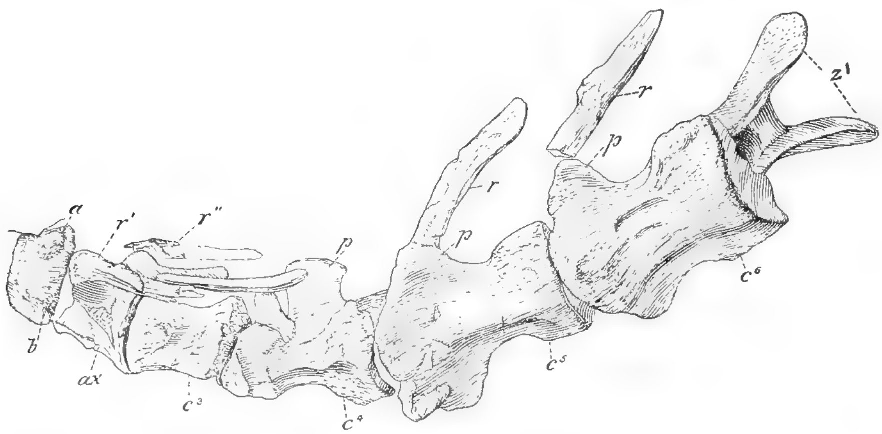

FIG. 16.—ARTICULATED CERVICAL VERTEBRAE OF STEGOSAURUS STENOPS MARSH. CAT. NO. 4934, U.S.N.M. TYPE. $\frac{1}{4}$ NAT. SIZE. INFERIOR VIEW. *a*, ATLAS; *ax*, AXIS; *b*, ARTICULAR FACET FOR CERVICAL RIBS; c^3, c^4, c^5, c^6, CERVICALS THREE TO SIX; *p*, PARAPOPHYSES; *r′*, LEFT CERVICAL RIB TO ATLAS; *r″*, LEFT CERVICAL RIB TO AXIS; *r*, ARTICULATED CERVICAL RIBS BELONGING TO THE FIFTH AND SIXTH CERVICAL VERTEBRAE; *z′*, POSTERIOR ZYGAPOPHYSES.

protuberance which probably indicates the point of insertion of ligaments. These projections are especially pronounced on the cervicals of the posterior half of the neck. The neural canal remains large throughout the cervicals, changing from a pear-shaped outline in the anterior ones to nearly circular openings in the posterior members

The prezygapophyses are wide apart and considerably raised above the diapophyses in the anterior vertebrae, but brought more to their level in the posterior cervicals.

Neural spines are not present, except in the most posterior cervicals, although there is a weak, median, crest-like ridge, which eventually develops into a true spinous process. On account of the damaged condition of these processes I am unable to determine the first vertebrae having such a process.

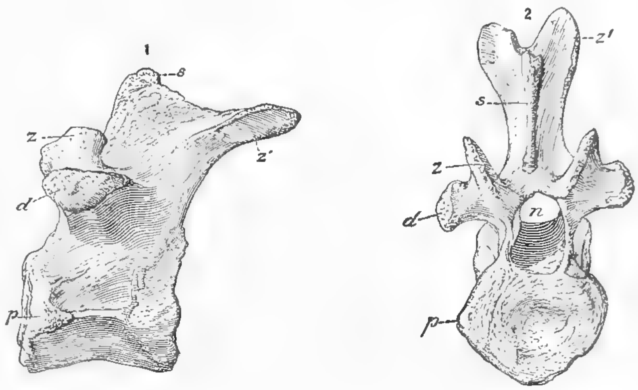

Fig. 17.—Posterior cervical vertebra of Stegosaurus ungulatus? Marsh. Cat. no. 7348, U.S.N.M. ¼ Nat. size. 1, Side view. 2, Oblique front view. *d*, Diapophysis; *n*, neural canal; *p*, parapophysis; *s*, neural spine; *z*, anterior zygapophysis; *z'*, posterior zygapophysis.

Dorsally the neural arch consists of a broad, transversely rounded surface which extends upward and backward, the posterior termination giving off the divergent branches of the post-zygapophyses. The height of the arch gradually increases posteriorly.

Dorsal vertebrae (presacrals 11 to 26).[1]—The dorsal vertebrae of *Stegosaurus* are characterized by the great height of the neural arch and the upward thrust of the transverse processes. The centra of the posterior half of the vertebral column are transversely compressed, being shallowly concave antero-posteriorly and somewhat flattened vertically. All of the vertebrae are without lateral cavities. In the anterior dorsals the depth of the concave articular ends of the centra exceeds that of the posterior ends, but posterior to the median dorsal region the two ends are subequal in this respect.

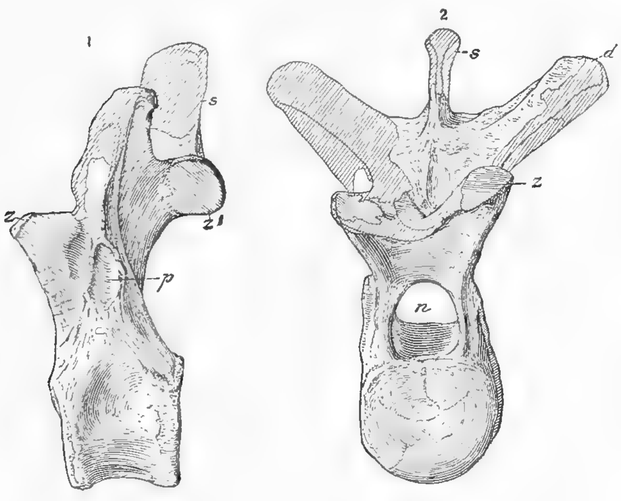

Fig. 18.—Anterior dorsal vertebra of Stegosaurus sp. Cat. no. 6531, U.S.N.M. ¼ Nat. size. 1, Side view. 2, Front view. *d*, Diapophysis; *n*, neural canal; *p*, parapophysis; *s*, neural spine; *z*, anterior zygapophysis; *z'*, posterior zygapophysis.

In the table of measurements on page 53 it will be observed that the centra gradually increase in length from the thirteenth to the twentieth, the latter being the longest of the entire vertebral series in No. 4934. From this point posteriorly they gradually decrease in length to the sacrum.

[1] All through the text and legends to the illustrations, the presacrals are numbered from the skull toward the sacrum, and not from the sacrum forward as is the usual procedure in referring to the vertebrae as presacrals.

There is not a sudden development of the spinous process as in *Camptosaurus*, but rather a gradual growth, beginning with the sharp median ridge on the cervicals and changing gradually into a distinct spine This change takes place at a point anterior to the transition of the parapophyses from the centrum to the side of the neural arch.

Although the type of *S. stenops* has the complete presacral series preserved, the exact point where the change from cervical to dorsal takes place can not be conclusively demonstrated. This transition part of the backbone has been badly damaged by crushing, and it is impossible to determine many of the principal vertebral characters. The eleventh vertebra (counting from the skull) shows plainly that the parapophysis is on the centrum. On the fifteenth it is found on the side of the neural arch at the base of the lamina which rises to support the under side of the transverse process. The position of the parapophyses on the three intermediate vertebrae can not be detected, but one thing is certain, the transition of this facet occurs between the eleventh and fifteenth vertebrae and probably takes place on either the twelfth or thirteenth.

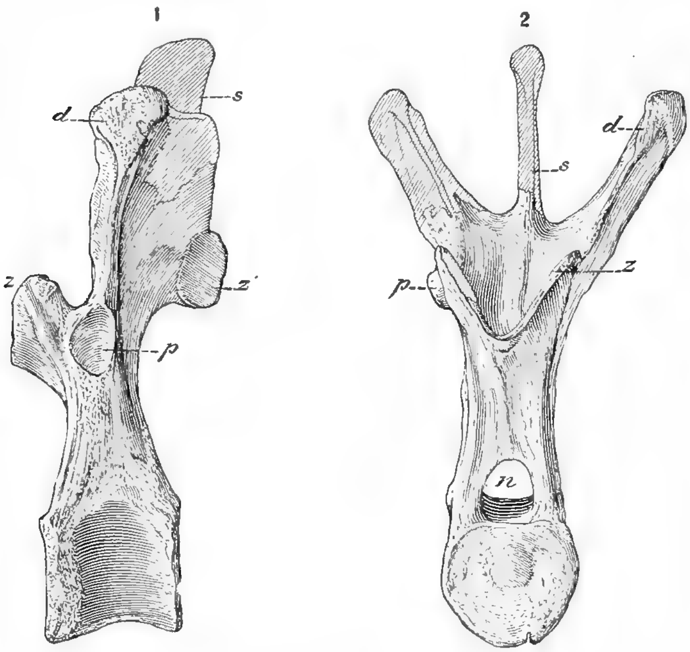

FIG. 19.—ANTERIOR DORSAL VERTEBRA OF STEGOSAURUS SP. SECOND VERTEBRA POSTERIOR TO ONE SHOWN IN FIG. 18. CAT. NO. 6531, U.S.N.M. $\frac{1}{4}$ NAT. SIZE. 1, SIDE VIEW. 2, FRONT VIEW. *d*, DIAPOPHYSIS; *n*, NEURAL CANAL; *p*, PARAPOPHYSIS; *s*, NEURAL SPINE; *z*, ANTERIOR ZYGAPOPHYSIS; *z'*, POSTERIOR ZYGAPOPHYSIS.

The vertical elongation of the neural arch is a somewhat rapid change, beginning with the posterior cervicals and continuing into the anterior dorsal region (figs. 18 and 19). These vertebrae were found articulated, there being one vertebra between them. In *S. stenops* (No. 4934) the maximum height of the dorsals is reached on the twentieth vertebra from the skull. A selection from the vertebral series of one skeleton is given in figures 18, 19, and 20.

The neural canal in figure 18 shows the brachial enlargement, and in the more posterior vertebrae, figures 19 and 20, its decreased size. Unlike *S. ungulatus* (fig. 21), where the neural canal is higher than wide, in this specimen it is subcircular in outline.

The spines gradually increase in height and also in the antero-posterior diameter proceeding posteriorly to the mid-dorsal region. From this point back to the sacrum the neural processes are of about equal dimensions. The summits of all are moderately expanded transversely.

A deep cupped capitular facet is present on all of the vertebrae posterior to the fifteenth, and its position on the side of the arch at the base of the transverse process remains practically unchanged, except on two or more of the posterior dorsals, where it is produced outward on a thick buttress of bone (fig. 20, 1), but to a less degree than in the posterior dorsals of either *Camptosaurus* or *Triceratops*, where it is found more on the anterior border of the transverse process.

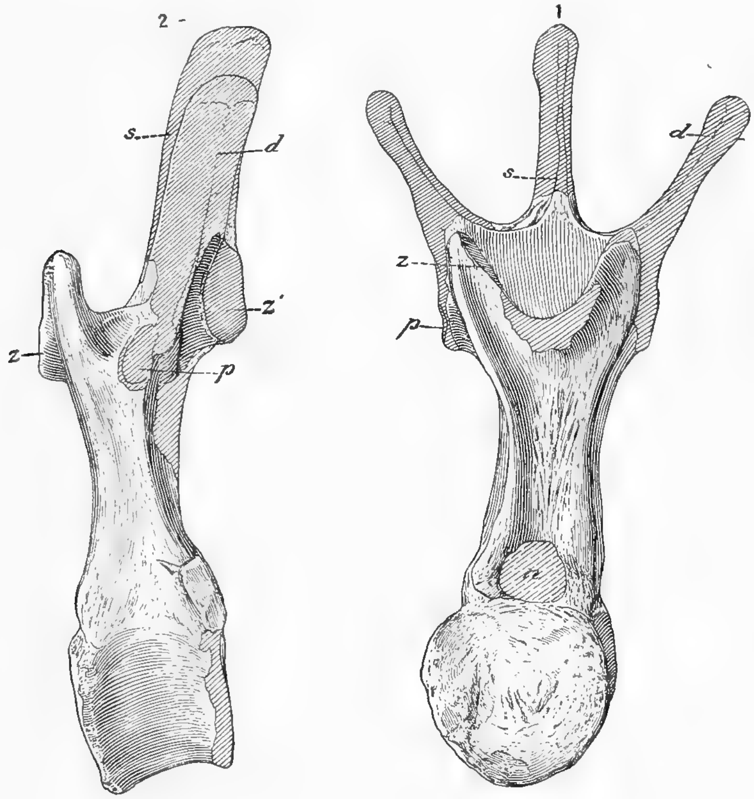

FIG. 20.—POSTERIOR DORSAL VERTEBRA OF STEGOSAURUS SP. CAT. NO. 6531, U.S.N.M. ¼ NAT. SIZE. 1, FRONT VIEW. 2, SIDE VIEW. *d*, DIAPOPHYSIS; *n*, NEURAL CANAL; *p*, PARAPOPHYSIS; *s*, NEURAL SPINE; *z*, ANTERIOR ZYGAPOPHYSIS; *z'*, POSTERIOR ZYGAPOPHYSIS.

The transverse processes are comparatively stout, subtriangular in cross-section, and are rather unique in their great upward inclination from the horizontal, which in the anterior and mid-dorsal region rise to nearly the height of the neural spine. This inclination of the transverse processes of the anterior and mid-dorsal regions is nearly 50° above the horizontal, but as we approach the sacrum they become somewhat more depressed.

The elevation of these processes is considered by Lull[1] "a wonderful adaptation for bearing the great dermal plates with which the back is adorned."

[1] Amer. Journ. Sci., vol. 30, 1910, p. 367.

Nopcsa[1] concurs in this view when he says this upward inclination "is rather due to the increasing weight of the double row of dorsal plates." To me the above reasons do not seem to be the logical explanations for these modifications in the stegosaurian skeleton, particularly since there is no contact between the plates and the vertebrae, and also since there is a very similar elevation of the transverse processes in *Trachodon*, *Triceratops*, and even in the Sauropod dinosaur *Haplocanthosaurus*, all of which are considered to be unarmored animals.

The zygapophyses are large and obliquely placed, those in front looking upward and inward, those behind looking downward and outward, as is well shown in figures 18, 19, 20, and 21. There is no zygosphene articulation of the vertebrae in *Stegosaurus*.

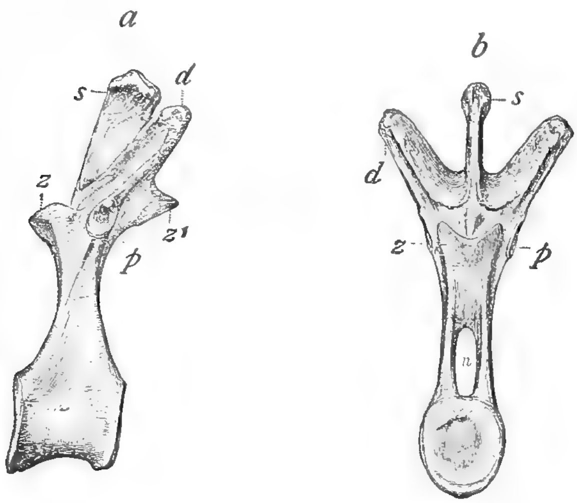

FIG. 21.—DORSAL VERTEBRA OF STEGOSAURUS UNGULATUS MARSH. ⅛ NAT. SIZE. *a*, SIDE VIEW. *b*, FRONT VIEW. *d*, DIAPOPHYSIS; *n*, NEURAL CANAL; *p*, PARAPOPHYSIS; *s*, NEURAL SPINE; *z*, ANTERIOR ZYGAPOPHYSIS; *z'*, POSTERIOR ZYGAPOPHYSIS. AFTER MARSH.

The zygapophysial articulating surfaces are elongated ovals, the longest diameter being transverse. They remain fairly constant in size throughout the series, but narrow antero-posteriorly in the posterior membeıs of the vertebral column.

Dorso-Sacral (*Presacral No. 27*).—The centrum of this vertebra is short, and firmly coössified with both the vertebrae in front and back. (*sd.*, fig. 23.) Likewise the spinous process is firmly cojoined with those of the sacrals.

This vertebra lies distinctly in front of the neck of the ilium, and from the fact that it does not bear a sacral rib, and does have a short, stout dorsal rib, even though that rib is partially metamorphosed, it can very properly be considered the last dorsal (*l'*, fig. 22, and *sd*, fig. 23).

The rib mentioned above is plainly shown on the right side of specimen No. 4934 (*y*, fig. 23). The head is firmly coösified with the diapophysis, the shaft being directed forward and outward to the ilium, with which, in conjunction with a strong upward and forwardly directed process from the first sacral rib, it gives strong support. A narrow transverse slit separates the rib from the outwardly directed bar of the first sacral, although in aged individuals these borders would doubtless be joined.

The transverse process, unlike those of the dorsals more anteriorly, is much depressed, coming out nearly at right angles to the neural spine.

[1] Geol. Mag., vol. 8, No. 3, 1911, pp. 112–113.

Measurements of sacral and presacral vertebrae of Stegosaurus stenops. No. 4934. Type.

Vertebrae.	Greatest length of centra.	Greatest transverse diameter posterior ends.	Greatest height over all.
	mm.	*mm.*	*mm.*
Atlas	32	56	
Axis	56		
3	66		
4	82	61	
5	104	67	
6	96	80	
7	99		135
8	93		
9	84		
10	87		
11	73		
12	74		
13	70		
14	75		
15	82		
16	85		
17			
18			
19	101e		430
20	105		458
21	102	68	430
22	101	76	
23	102		
24	97	86	
25	85	104	
26	70	76	
27 Dorso-sacral	[1] 69		
Sacrals:			
I	72		
II	69		
III	75	102	
Sacro-caudal	78	116	

[1] Estimated.

Sacrum.—The following description of the *Stegosaurus* sacrum is based upon the sacra of five individuals in the National Museum, but more especially upon the well preserved articulated pelvic arch pertaining to the type of *S. stenops*, No. 4934 (fig. 23).

In the sacral region of this specimen there are five coössified vertebrae but for reasons to be given later three only are considered as pertaining to the true or primary sacrum. In describing [1] the sacrum of *S. ungulatus* Marsh found six vertebrae coalesced, four of which he considered as true sacrals (fig. 22). In specimen No. 7346 there are three coössified centra, in Nos. 6531 and 7386 there are four each, and in No. 4936 there are six. From this evidence it would appear that in fully adult animals the pelvic arch may be strengthened by the addition of one or more

[1] Amer. Journ. Sci., vol. 21, pt. 4, 1881, p. 168, fig. 1, pl. 7.

presacral vertebrae and in one species at least (*S. ungulatus*) by the addition of an anterior caudal.

In No. 4934 the first coössified vertebra bears a free rib (see X, fig. 23) which was found still articulated with it, and this vertebra can, therefore, be referred to the presacral series. The next one posteriorly is firmly cojoined to the sacrals by the neural spine and the shortened rib has become firmly coalesced with the diapophyses. This inner end of the rib abuts against the ilium and unites with a process from the first sacral rib, together forming a considerable support to the ilium (*y*, fig. 23). Since this vertebra does not support a sacral rib it may very appropriately be called a dorso-sacral. In the sacrum of this specimen there remain but three coössified elements that may properly be considered as being true sacral vertebrae. The last vertebra, which corresponds to the fourth sacral in *S. ungulatus* (compare fig. 22 with fig. 23), has a process which articulates with the ilium, and is regarded as a modified caudal which will here be called caudo-sacral. The centrum is detached from the third or last sacral and the spine is also free.

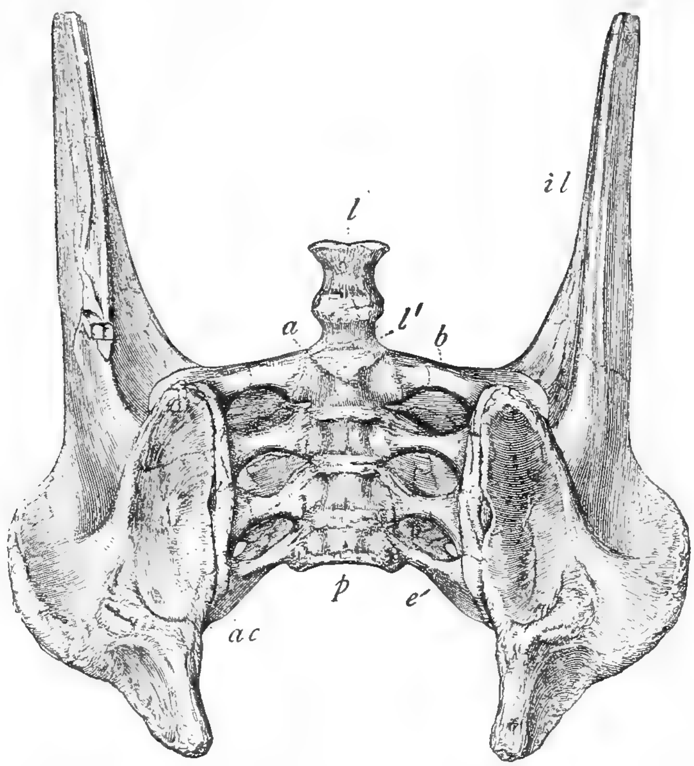

FIG. 22.—SACRUM AND ILIA OF STEGOSAURUS UNGULATUS MARSH SEEN FROM BELOW. $\frac{1}{12}$ NAT. SIZE. *a*, FIRST SACRAL VERTEBRA; *ac*, ACETABULAR SURFACE; *b*, RIB OF FIRST SACRAL VERTEBRA; *e*, RIB OF LAST SACRAL VERTEBRA; *il*, ILIUM; *l*, SECOND DORSAL [illegible] SACRUM OR PRESACRAL NO. 26 COUNTING BACK FROM THE SKULL; *l'*, LAST DORSAL OR 27TH PRESACRAL; *p*, LAST SACRAL VERTEBRA. AFTER MARSH.

The sacral centra, like all others in the vertebral column, are solid, and they gradually increase in size from front to back. In *S. ungulatus*, they are depressed vertically, and transversely have broadly rounded ventral surfaces, without pronounced ventral keel. In *S. stenops*, however, the centra are not depressed, and there is a decided ventral keel. Each centrum supports its own parapophysis (sacral rib), although there is a tendency to overlap the preceding centrum.

The ribs are stout, with expanded proximal and distal ends. In adult specimens the proximal end is firmly ankylosed with the centra and the distal ends coalesce to form what has been called the sacricostal[1] yoke which articulates with the ilium.

[1] E. S. Riggs, Field Columbian Museum, Geol. Series, vol. 2, No. 4, 1903, p. 179.

In *S. ungulatus* and *S. armatus*, No. 4936, as shown in figure 22, the ends of four ribs unite to form this yoke, while in *S. stenops* only three participate in its formation.

Marsh laid considerable stress on the manner of the articulation of the sacral ribs with their respective centra, and even went so far as to establish[1] the species *S. duplex* largely on these differences. He says:

> In the sacrum of this species each vertebra supports its own transverse process or rib as in the Sauropoda, while in *S. ungulatus* the sacral ribs have shifted somewhat forward, so that they touch, also, the vertebra in front, thus showing an approach to some of the Ornithopoda.

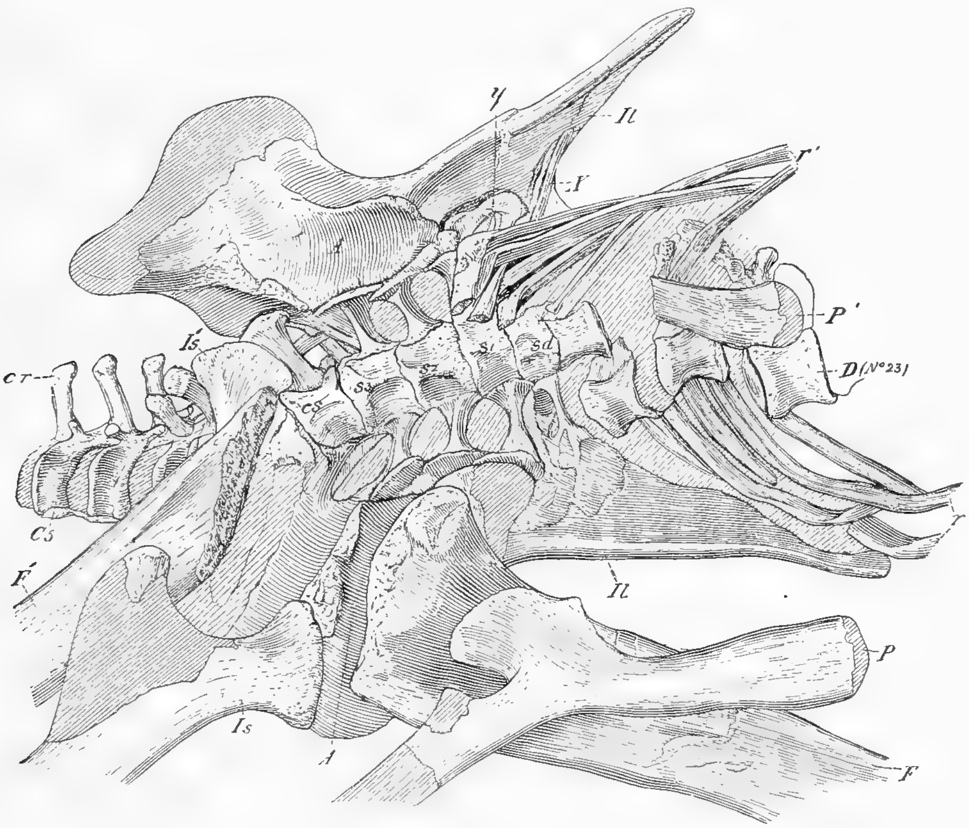

Fig. 23.—Pelvic region of Stegosaurus stenops Marsh. Cat. No. 4934, U.S.N.M. Type. About 1/10 nat. size. Ventral view shown as found in situ. *A*, Acetabulum; *C5*, fifth caudal; *c.r*, caudal rib; *cs*, caudo-sacral; *D*, dorsal vertebra, or presacral no. 23; *F*, left femur; *F'*, right femur; *Il*, ilia; *Is*, left ischium; *Is'*, right ischium; *P*, left pubis; *P'*, right pubis; *r*, ribs of left side; *r'*, ribs of right side; *s1*, *s2*, *s3*, sacral vertebrae one, two, and three; *sd*, dorso-sacral or presacral no. 27; *X*, last free rib articulated with presacral no. 26; *y*, buttress from the first sacral which abuts against ilium. The head of the right femur and portion of the right pubis are removed to better show the sacral vertebrae.

After comparing Marsh's drawing of the sacrum of *S. ungulatus* (fig. 22) with the sacra in the National Museum the actual differences in this respect are so slight it appears to be entirely one of degree which may readily be accounted for on the ground of relative age.

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[1] Amer. Journ. Sci., vol. 34, pt. 9, 1887, p. 416.

The upper surfaces of the diapophyses of the sacrals have an unusual development antero-posteriorly in *Stegosaurus* inasmuch as they coalesce into a continuous sheet of bone which roofs over the entire area between the spinous processes and the ilium with which their outer ends articulate and in adults are usually found firmly coössified. This roof of bone is on a level with the superior flattened surface of the ilium. The diapophyses of all the sacral vertebrae send downward thin vertical lamina that unite suturally with the upper border of the sacral ribs of their respective vertebrae, thus forming bony partitions which separate the large sacral foramina. Internally these foramina are bounded by the sacral centra and externally by the expanded coalesced distal extremities of the sacral ribs, together with the internal surfaces of the ilia. Unlike the Sauropoda, there appear to be no openings leading through these partitions from one foramen to the other.

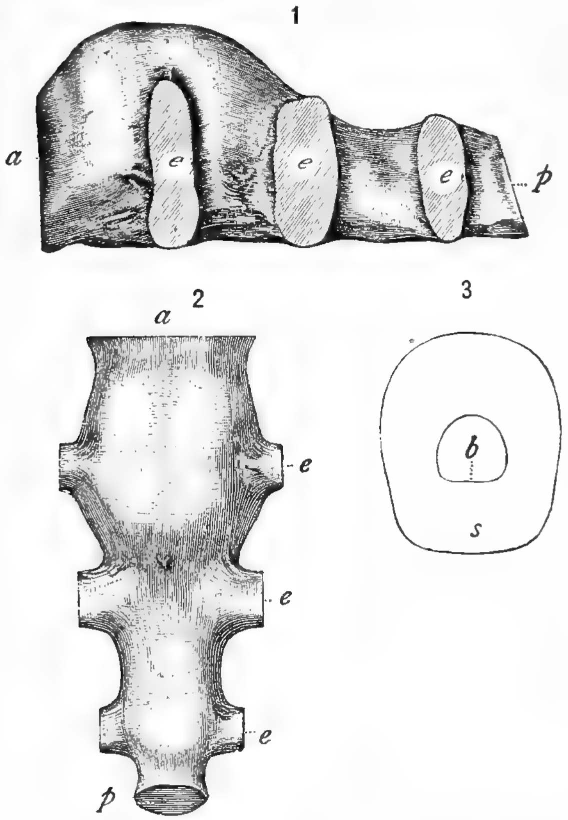

Fig. 24.—Cast of neural cavity in sacrum of Stegosaurus ungulatus Marsh. All figs. ½ nat. size. 1, Side view. 2, Seen from above. 3, Outlines representing transverse sections through brain and sacral cavities. *a*, Anterior end; *b*, brain; *e*, *e*, *e*, foramina between sacral vertebrae; *p*, exit of neural canal in last sacral vertebra; *s*, sacral cavity. All after Marsh.

The neural spines of all the vertebrae giving support to the pelvic arch are comparatively short, with expanded summits. Their height above the level of the ilium in *S. stenops* is fully one-fourth less than in *S. ungulatus*, as figured by Marsh. The spines of the dorso-sacral and three sacral vertebrae are coalesced and form an elongated bony plate, there being a single elongated aperture between the spines of S_2 and S_3 (pl. 4). In *S. ungulatus* the spines of the three sacrals are apparently the only ones to thus become conjoined. The direction of the spines is almost straight upward, there being a slight inclination backward in the spine of the last sacral.

The unusual development of the neural canal is well shown in plate 19, lower figure *c*. of specimen No. 7386. This large cavity appears to lie wholly within the neural processes of the sacrals, and in this specimen has a greatest transverse diameter of 123 mm. The internal surface is comparatively smooth with the widest and deepest point toward the anterior end. The large exits for the nerves leave the chamber through vertically elongated openings leading into the sacral foramina (see fig. 24, *e*, *e*, *e*).

These lie below the level of the diapophyses and between the lower portions of the neural arches.

In describing the nervous system of *S. ungulatus*, Lull[1] makes the following interesting comments on the enlarged neural cavity in the sacrum:

The neural canal in the sacrum is of startling dimensions, having a maximum enlargement of 1.14 cm. and a greatest width of 0.95 cm. and displaces nearly 1,200 cc. of water, thus giving it a mass more than 20 times that of the brain.

The brachial enlargement was the seat of innervation of the powerful fore limbs, while that of the sacrum was mainly the reflex and coördinating center for the control of the mighty muscles of the hind limbs, but more especially of the powerful, active, and aggressive tail, which constituted the principal means of defense.

Marsh says:

It is an interesting fact that in young individuals of *Stegosaurus* the sacral cavity is proportionately larger than in adults, which corresponds to a well-known law of brain growth.

Measurements of sacral vertebrae of Stegosaurus stenops, No. 4934.

	mm.
Total length of three sacral centra	215
Greatest expanse of transverse process of first sacral	145
Greatest expanse of transverse process of last sacral	255
Height of neural spine above zygapophyses, about	155
Length of coössified spines (4 vertebrae)	312
Total length of 5 coössified centra	272

Caudo-sacral (*cs.*).—In specimen No. 4934 the vertebra designated as the first or caudo-sacral is analogous to the vertebra in the *S. ungulatus* sacrum which Marsh considered the last or fourth sacral (fig. 22). That it is a modified caudal appears to be indicated by the low arch; the strong backward slant of the spinous process which is separate from the coössified processes of the sacrals, the noncoössification of the centrum with the sacrum, and the distinctness and manner of articulation of the rib with the ilium.

The rib of the caudo-sacral apparently has an origin similar to those of the true sacrals. It is extended distally, forming a vertical plate of bone with expanded ends. The inner or proximal end unites by suture with the side of the arch and the body of the centrum, while the outer or distal end abuts against the inner, postero-superior border of the ilium, posterior to the inner end of the articular surface for the ischium. The proximal articular end is confined entirely to the centrum of the vertebra and does not meet the rib of the last sacral as in *S. ungulatus*. Likewise the distal end does not, and never could, in this specimen at least, enter into the formation of the sacricostal yoke. This end is entirely distinct from those of the true sacrals and its lower border is considerably above the acetabular border, whereas in *S. ungulatus* (fig. 22), it is firmly coössified with the rib of sacral three and with the other ribs of the sacrum enters subequally into the formation of the yoke. (Compare figs. 22 and 23.)

The centrum of this vertebra in *S. stenops* is distinguished by its broadly rounded inferior surface, as compared with the keeled centra of the sacrals and the blunt wedge-shaped centra of the succeeding caudals when viewed from the side.

[1] Amer. Journ. Sci., vol. 30, 1910, p. 372, fig. 9.

Caudal vertebrae.—In the paleontological collection of the National Museum there are no less than 7 articulated series of caudal vertebrae, in addition to a great number of detached elements. Although none of these series represent a complete tail, they at least supplement one another to such an extent that a very correct idea can be obtained of the entire caudal region of *Stegosaurus*.

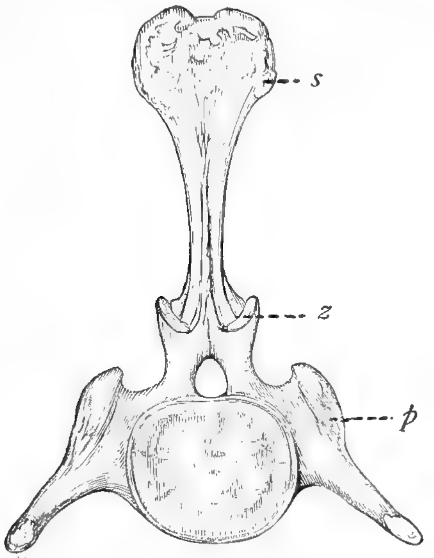

FIG. 25.—SECOND? CAUDAL VERTEBRA OF STEGOSAURUS UNGULATUS MARSH. $\frac{1}{8}$ NAT. SIZE. FRONT VIEW. *p*, TRANSVERSE PROCESS; *s*, NEURAL SPINE; *z*, ANTERIOR ZYGAPOPHYSIS. AFTER MARSH.

With specimen No. 4934 there are 22 caudals preserved, 17 being articulated with the sacrum. The remaining 5 are disarranged, but doubtless represent the next of the series. Specimen No. 4714 has 44 vertebrae in series beginning with the fourth and continuing to the very tip (see fig. 58). A smaller individual, No. 6531, has 40 caudals present, and it appears that 4 or more are missing from the proximal and perhaps an equal number from the distal end of the series. The other specimens have from 22 to 27 vertebrae preserved, all representing the distal half of the tail, and in most instances continuing to the tip. After a careful study of all these specimens, it appears that there are at least 45 vertebrae in the complete caudal series of *Stegosaurus*, and in some individuals as many as 48 or 49 may be found. Marsh, in his restoration of *Stegosaurus*, shows the series as consisting of 46 vertebrae.

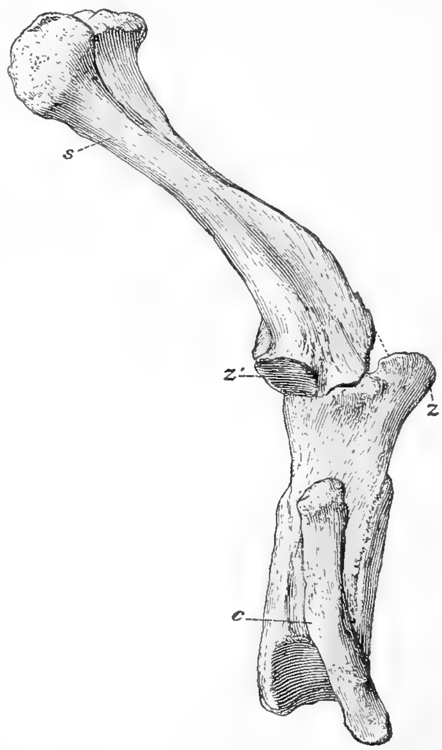

FIG. 26.—ANTERIOR CAUDAL VERTEBRA, PROBABLY THE FOURTH, OF STEGOSAURUS UNGULATUS MARSH. CAT. NO. 6643, U.S.N.M. ABOUT $\frac{1}{4}$ NAT. SIZE. SIDE VIEW. *c*, CAUDAL RIB OR TRANSVERSE PROCESS; *s*, SPINE; *z*, ANTERIOR ZYGAPOPHYSIS; *z′*, POSTERIOR ZYGAPOPHYSIS.

The centra throughout the tail are short and remarkably uniform in length (see table of measurements, pp. 60 and 61) when compared with the caudal series of most other dinosaurs. The centra of the anterior half of the tail are broader than long, but these proportions are reversed in the posterior half, where the vertebrae are more compressed transversely. All of the caudals are constricted medially.

The caudal centra of *Stegosaurus* may be distinguished from those of other American Jurassic dinosaurs by their hexagonal shape when viewed from the ends, as plainly indicated in figure 28.

The anterior caudals are the largest in the whole vertebral column, and have exceptionally high, backwardly directed neural spines, the summits of which terminate in heavy, transversely expanded, rugose heads, as shown in figures 25 and 26. On the anterior third of the tail these processes rapidly decrease in height posteriorly. In specimen No. 4934 the sixteenth is only a little more than half the height of the first caudal. Posteriorly the spinous processes continue to decrease in height and disappear altogether on the thirty-seventh or thirty-eighth vertebrae.

The transversely expanded summits become distinctly bifurcate in the mid-caudal region, a condition prevailing as far back as the twenty-fifth or twenty-sixth caudal. Posterior to this point the transverse expansion of the spine becomes gradually less and less until the last few vertebrae have a spine that consists of a thin, gradually shortening plate of bone without any expansion of the summit. These also differ from those more anteriorly in that they do not overhang the posterior ends of the centra (pls. 15 and 16). The remaining caudals have the neural canal roofed over even to the terminal one, as shown in plate 16.

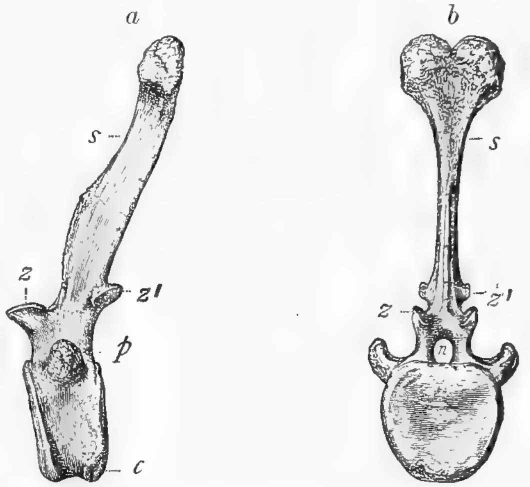

Fig. 27—Anterior caudal vertebra of Stegosaurus ungulatus Marsh. Probably the tenth. $\frac{1}{8}$ nat. size. *a*, Side view. *b*, Front view. *c*, Face for chevron; *n*, neural canal; *p*, transverse process; *s*, neural spine; *z*, anterior zygapophysis; *z'*, posterior zygapophysis. After Marsh.

Excepting the first or caudo-sacral, the nine succeeding vertebrae have vertically elongated transverse processes which may be best described as resembling the "cleats" to which ropes are made fast on board ship (figs. 25 and 26). On the second caudal they appear as a thin vertical plate, springing directly from the superior lateral surface of the centrum, the lower part being produced into an irregularly rounded process which extends outward, downward, and somewhat forward. Unlike the transverse of the caudo-sacral, it is not in contact with the ilium, nor is this plate perforated as in some of the Sauropoda. The third caudal bears the heaviest and longest (vertically) transverse process of any posterior to the first, and in *S. stenops* it is also the first of the series to send a flattened projection above the superior point of attachment to the centrum (see *b*, fig. 27). This type of process decreases rapidly in size, proceeding posteriorly, and in the eleventh caudal, in No. 4934, it has changed to a short, blunt, triangular process which becomes smaller and smaller and finally disappears altogether on either the seventeenth or eighteenth vertebra.

The vertebrae are joined by closely fitting zygapophyses of moderate size. On the anterior half of the tail they overhang at both ends, but posteriorly, especially on the distal portion. The anterior zygapophyses are gradually prolonged anteriorly, the posterior zygapophyses being well within the posterior boundary of the centra. The zygapophyses continue to within three or four of the tip, as shown in plate 16.

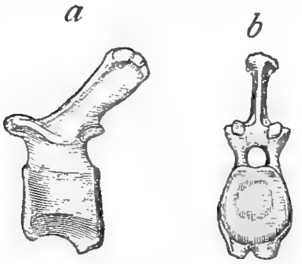

Fig. 28.—Median caudal vertebra posterior to the 26th of *Stegosaurus ungulatus* Marsh. ⅛ nat. size. *a*, Side view. *b*, Front view. After Marsh.

In placing the first chevron on the third caudal, Marsh is probably correct, although I have no positive evidence on this point. The most anterior caudals are without distinct chevron facets. In both No. 4714 and No. 6531 the sixth caudal is the first to show well-defined facets for chevron bones, although they were found articulated in advance of this point.

In the median caudals the facets are placed on prominent tubercles developed on the postero-inferior surface (fig. 28), and although gradually diminishing in size, are present on all except the last few at the tip. In specimen No. 4714 the third caudal from the distal end has a chevron still articulated, as shown in plate 16.

Measurements of caudal vertebrae of Stegosaurus.

No. of vertebrae in series.	Greatest length of centra.							Greatest transverse diameter posterior end of centra.							Greatest height of vertebrae, over all.						
	No. 4288.	No. 4714.	No. 4934.	No. 6099.	No. 6135.	No. 6531.	No. 6629.	No. 4288.	No. 4714.	No. 4934.	No. 6099.	No. 6135.	No. 6531.	No. 6629.	No. 4288.	No. 4714.	No. 4934.	No. 6099.	No. 6135.	No. 6531.	No. 6629.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
1.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3.	.....	46	77	.....	.....	.....	.....	.....	137	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4.	.....	57	66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5.	.....	55	62	.....	.....	52	.....	.....	92	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6.	.....	58	65	.....	.....	49	.....	.....	98	.....	.....	.....	98	.....	.....	320	.....	.....	.....	.....	.....
7.	.....	58	68	.....	.....	52	.....	.....	92	.....	.....	.....	88	.....	.....	305	.....	.....	.....	.....	.....
8.	.....	59	72	.....	.....	55	.....	.....	.....	.....	.....	.....	90	.....	.....	300	.....	.....	.....	265	.....
9.	.....	60	70	.....	.....	55	.....	.....	86	.....	.....	.....	91	.....	.....	285	.....	.....	.....	.....	.....
10.	.....	61	66	.....	.....	56	.....	.....	78	.....	.....	.....	88	.....	.....	255	.....	.....	.....	262	.....
11.	.....	66	66	.....	.....	54	.....	.....	.....	.....	.....	.....	85	.....	.....	245	.....	.....	.....	.....	.....
12.	.....	64	65	.....	.....	54	.....	.....	.....	.....	.....	.....	76	.....	.....	233	.....	.....	.....	.....	.....
13.	.....	63	66	.....	.....	55	.....	.....	.....	.....	.....	.....	76	.....	.....	224	.....	.....	.....	.....	.....
14.	.....	66	63	.....	.....	56	.....	.....	68	.....	.....	.....	72	.....	.....	.....	.....	.....	.....	210	.....
15.	.....	67	64	.....	.....	55	.....	.....	67	.....	.....	.....	68	.....	.....	210	.....	.....	.....	180	.....
16.	.....	65	63	.....	.....	53	.....	.....	65	.....	.....	.....	70	.....	.....	203	.....	.....	.....	.....	.....
17.	.....	71	68	.....	70	52	.....	.....	.....	.....	.....	58	66	.....	.....	.....	.....	.....	.....	178	.....
18.	.....	61	71	.....	68	54	.....	.....	.....	.....	.....	58	64	.....	.....	194	.....	.....	.....	160	.....
19.	.....	65	65	.....	65	54	.....	.....	57	.....	.....	58	.....	.....	.....	175	.....	.....	.....	160	.....
20.	.....	66	60(?)	.....	64	54	.....	.....	55	.....	.....	55	52	.....	.....	175	.....	.....	.....	.....	.....
21.	.....	64	60(?)	.....	64	56	.....	.....	52	.....	.....	55	.....	.....	.....	163	.....	.....	.....	146	.....
22.	.....	61	70(?)	.....	63	55	45	.....	.....	.....	.....	54	56	58	.....	.....	.....	.....	.....	136	.....
23.	.....	62	.....	.....	61	53	44	.....	52	.....	.....	[illegible]	54	.....	.....	.....	.....	.....	160	126	150
24.	.....	62	.....	.....	59	53	46	.....	55	.....	.....	57	56	56	.....	143	.....	.....	.....	125	.....
25.	52	61	.....	67	60	51	46	.....	[illegible]	.....	.....	55	56	.....	.....	135	.....	.....	.....	124	.....
26.	48	61	.....	61	61	51	46	.....	48	.....	.....	55	55	47	.....	120	.....	.....	.....	.....	.....
27.	48	56	.....	60	57	50	45	.....	46	.....	.....	.....	51	45	.....	115	.....	.....	.....	.....	.....
28.	46	54	.....	60	57	49	44	.....	48	.....	60	.....	50	47	.....	109	.....	.....	.....	.....	.....
29.	45	49	.....	55	56	49	43	.....	48	.....	.....	53	52	45	.....	.....	.....	.....	116	.....	88

Measurements of caudal vertebrae of Stegosaurus—Continued.

No. of vertebrae in series.	Greatest length of centra.							Greatest transverse diameter posterior end of centra.							Greatest height of vertebrae, over all.						
	No. 4288.	No. 4714.	No. 4934.	No. 6099.	No. 6135.	No. 6531.	No. 6629.	No. 4288.	No. 4714.	No. 4934.	No. 6099.	No. 6135.	No. 6531.	No. 6629.	No. 4288.	No. 4714.	No. 4934.	No. 6099.	No. 6135.	No. 6531.	No. 6629.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
30.	42	48	....	53	53	48	43	....	46	....	....	46	47	44	....	....	....	....	103	....	....
31.	42	45	....	48	51	48	42	....	43	....	50	48	....	....	....	94	....	....	103	....	91
32.	39	44	....	46	48	47	41	....	43	....	43	47	44	....	....	85	....	....	....	....	....
33.	35	41	....	45	48	44	39	....	38	....	....	....	42	42	....	75	....	....	....	....	....
34.	33	40	....	45	45	42	38	....	39	....	37	39	41	40	....	67	....	....	....	....	73
35.	32	38	....	41	40	40	36	....	....	....	....	....	38	39	....	62	....	....	....	....	....
36.	29	37	....	40	38	37	34	....	....	....	35	37	37	....	....	60	....	....	....	....	....
37.	29	36	....	36	36	35	34	....	....	....	....	35	35	34	....	55	....	....	49	....	....
38.	26	33	....	36	35	33	31	....	....	....	30	28	33	32	....	48	....	....	....	....	....
39.	27	33	....	36	32	33	30	....	....	....	31	25	29	31	....	....	....	....	....	....	....
40.	26	29	....	35	30	30	27	....	....	....	30	23	27	28	....	40	....	....	32	....	....
41.	23	29	....	30	26	29	24	....	....	....	25	28	26	26	....	36	....	....	28	33	....
42.	20	23	....	27	23	26	23	....	....	....	23	27	25	....	....	29	....	....	....	30	....
43.	18	18	....	25	22	24	22	....	....	....	19	21	24	21	....	24	....	....	....	25	....
44.	18	18	....	18	19	21	19	....	....	....	16	16	22	19	....	21	....	....	19	25	....
45.	16	18	....	9+	18	21	19	....	....	....	....	12	19	18	....	18	....	....	13	....	....
46.	14	18	....	....	16	....	17	....	....	....	....	11	....	12	....	18	....	....	11	....	....
47.	14	....	....	....	8+	....	9+	....	....	....	....	....	....	....	....	....	....	....	....	....	....

CHEVRONS.

The chevrons of *Stegosaurus* are noteworthy on account of the great transverse width of their proximal ends, when compared to their short length. They have the usual Y-shape, with expanded articular surfaces. In some individuals (fig. 29) the chevrons of the anterior portion of the tail have these ends united medially by a bridge of bone, thus entirely inclosing the hæmal canal. This condition, however, is variable, for in *S. stenops*, No. 4934, two chevrons, apparently the first and second of the series, have distinct articular ends. In other specimens one chevron will be bridged and the next will show the articular surfaces separate (fig. 30). The above conditions prevail only among the chevrons of the anterior half of the tail, for all specimens agree in having those of the distal portion divided proximally.

The chevrons of the anterior half of the tail, when compared with those of *Camptosaurus*, *Iguanodon*, and *Trachodon*, are short and stout, with especially large hæmal openings. The free or distal end is expanded antero-posteriorly, and excepting a few of the most anterior ones, has a decided backward sweep, which becomes more and more pronounced as the distal end of the tail is approached. The successive changes that take place are well shown in figure 29.

The chevrons articulate intervertebrally and, beginning with the third caudal, continue, as shown in specimen No. 4714, to the next to the last vertebrae of the series (pl. 16).

Marsh has indicated, in his restoration of the skeleton, that the first chevron is between the third and fourth caudals. In this he is probably correct, although the evidence offered by specimens in the National Museum is not altogether conclusive. As mentioned previously, there are no distinct chevron facets on the anterior caudals, and in specimens Nos. 4714, 4934, and 6531, the sixth or seventh centrum from the sacrum is the first to show facets. Two disarticulated chevrons are retained in the rock just below caudals three and four in specimen No. 4934 (pl. 2), and as mentioned above evidently represent the first and second. With specimen No. 4714, chevrons were also found in place in the matrix forward of the

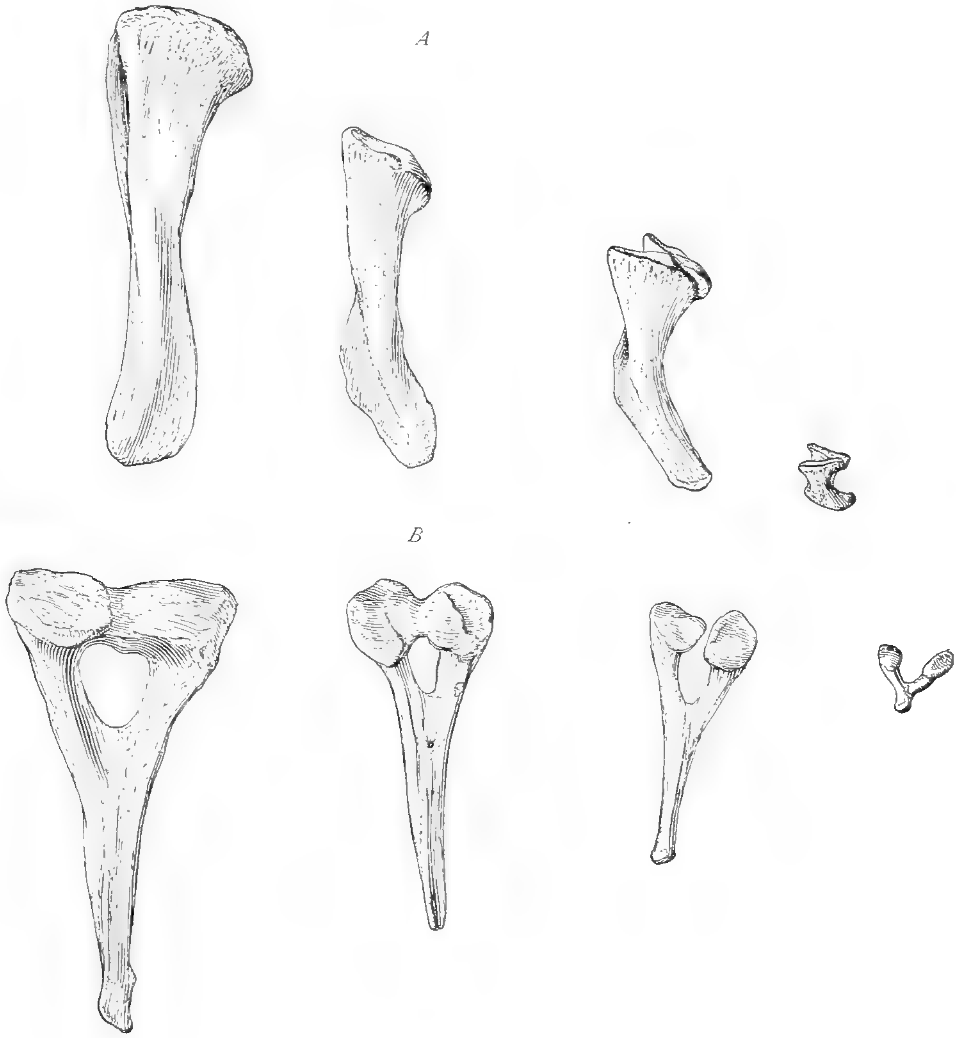

FIG. 29.—CHEVRONS OF STEGOSAURUS SP. CAT NO. 6531, U.S.N.M. ½ NAT SIZE. *A*, SIDE VIEW OF CHEVRONS FROM ANTERIOR, MEDIAN, AND POSTERIOR PARTS OF THE TAIL. *B*, SAME, VIEWED POSTERIORLY.

sixth of the series, so it is certainly known that chevron bones were present forward of the caudals having well defined articulations.

The anterior chevrons of No. 4934 measure 160 and 156 mm. in length, and those articulated with the fourteenth and fifteenth caudals of this same series measure, respectively, 119 and 109 mm. in length.

Ribs.

In *Stegosaurus* there are present cervical, dorsal, sacral, and caudal ribs. Excepting the atlas, all of the other presacral vertebrae bear double-headed ribs.

Cervical ribs.—With specimen No. 4934 there are eight cervical ribs present. Four of these belonging to the left side were found articulated, as shown in figure 16. They pertain to atlas, axis, fifth, and sixth cervicals, respectively. The remaining ribs are from the right side, and, excepting the one for the atlas, the others are disarticulated. There is one crushed against the processes of the twelfth vertebra, counting back from the skull, but it can hardly belong to this vertebra.

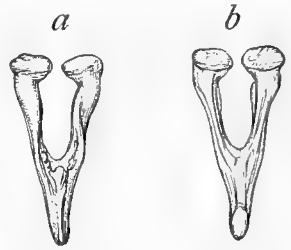

Fig. 30.—Chevron of Stegosaurus ungulatus Marsh. ⅓ nat. size. *a*, Posterior view. *b*, Front view. After Marsh.

The ribs of the atlas and axis are much damaged, but enough of these bones are preserved to show that their arrangement was very similar to that of the living crocodile. They appear to verify the tentative arrangement of these bones in *Diplodocus* by Holland.[1]

The ribs for the atlas are single headed and articulated with the facets on the lower posterior side of the intercentrum. This articular end has a width of 18 mm. The rib for the axis articulates chiefly with the parapophysis and with the diapophysis by a cartilaginous union, as in the crocodile. Both appear to have been long, tapering structures, but of their exact shape little can be determined from the available specimens.

The sixth rib (fig. 31) is a tri-radiate bone formed by the short and stout tubercular and capitular processes with a pointed posterior branch, which is triangular in cross-section. Anteriorly the indentation between the articular process is moderately deep. On the external side, directly below the tubercular process, the ventral surface is produced outward, forming a thin shelf of bone which curves slightly upward and disappears toward the posterior end. This shelf is not present on the posterior ribs of the neck as shown by specimen No. 7616. The posterior cervical ribs are longer and the articular processes are lengthened, especially the tubercular. The articular end of the capitular process in these posterior ribs is much lengthened dorso-ventrally, but compressed antero-posteriorly. The sixth rib has a length of 95 mm.

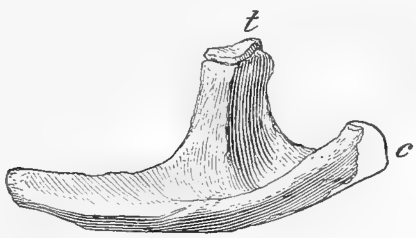

Fig. 31.—Sixth cervical rib, left side of Stegosaurus stenops Marsh. Type. Cat. No. 4934, U.S.N.M. ½ nat. size. Internal view. *c*, Capitulum; *t*, tuberculum.

Dorsal ribs.—All of the dorsal vertebrae bear double-headed ribs, and excepting those of the dorso-sacral all the others are free. From a study of specimen No. 4934 it would appear that there were at least 15, and possibly one or two more, vertebrae carrying thoracic ribs, but of the exact number I am now in doubt.

With the above skeleton there are portions of 25 ribs, most of which are practically entire. Thirteen of these pertain to the left and the remainder to the right

[1] Mem. Carnegie Mus., vol. 2, No. 6, 1909, pp. 249–250, figs. 2–22.

side. Those belonging to the left are retained in the matrix so nearly in their relative positions that they give a fairly correct idea of the changes that occur in their length, shape, and other characteristics. It appears that they represent the series from the thirteenth vertebra back to the sacrum. The fourteenth rib of this side is missing, but is present on the opposite side and still articulated (*X*, fig. 23).

The ribs of this series increase in length and in other dimensions quite rapidly from the first to the fifth, when they continue subequal in length to about the ninth. Posterior to the ninth they shorten rapidly, at the same time becoming more slender throughout the head and shaft. Their gradation in length is well shown by the measurements of the following ribs:

	mm.
Second of series, left side, greatest length about	760
Fifth of series, left side, greatest length	1,040
Seventh of series, left side, greatest length about	1,050
Tenth of series, left side, greatest length about	885
Thirteenth of series, left side, greatest length about	385

The upper external surfaces of the anterior ribs are broad and flat, and posterior to the fifth, produced posteriorly into a rather short blade, and anteriorly into a somewhat shorter projection. Continuing posteriorly these projections become subequal, so that a cross-section near the proximal end would be T-shaped, with the cross of the T formed by the external surface of the rib. The lower half of the rib is flattened and in cross-section would be an elongated oval. Lull[1] comments on the T-shaped cross-section of the ribs in *Stegosaurus* as follows:

> A beautiful mechanical device is shown in that the transverse process is triangular and the rib T-shaped in cross section in the armor-bearing region, giving the maximum of strength, a wide bearing surface, and a minimum expenditure of material.

The significance of the above interpretation appears to be nullified somewhat when it is known that almost identical conditions are found in *Trachodon*, an unarmored reptile.[2] Some of the Sauropoda also show a T-shaped cross section of certain ribs. From this evidence, therefore, I can see no facts to bear out the theory that this part of the internal skeleton was modified to support the dermal armor. The inner surfaces of all the ribs are convex. The distal ends are never spatulate, though sometimes thickened. Those of the median part of the series are beveled off on the anterior margin. In the posterior part of the series the ends are more truncate.

The tubercle and capitular facets are placed well apart throughout the entire series. The tubercle rises but little above the proximal surface, while the capitular process remains fairly constant in length and is given off nearly at right angles to the shaft, so that when articulated with the vertebra it forms an extremely flat, lank body cavity. In this respect *Stegosaurus* bears a striking resemblance to *Diplodocus* as depicted by Holland.[3]

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[1] Amer. Journ. Sci., vol. 29, 1910, p. 209.

[2] "The oblique T-shaped cross-section that has been specially noticed in *Stegosaurus*, but seems, as far as I am aware, to be present also in other members of the Orthopodous order. Its origin may therefore have to be explained otherwise than through the weight of the dermal armor."—F. Baron Nopcsa, in Geol. Mag., vol. 8, 1911, p. 111.

[3] Amer. Naturalist, vol. 44, 1910, fig. 17 (5).

Sternal bones.—Among the puzzling elements found associated with the skeletal remains of *Stegosaurus* in Quarry 13 were three bones (Nos. 7618, 7619, and 7620) that are here regarded as representing sternal elements. They are of special interest, as this is the first time ossified sternal bones have been found associated with Stegosaurian remains.

These plates are small, triangular, asymmetrical bones. As I interpret these elements (fig. 32), after carefully comparing them with the articulated sternals of *Trachodon annectens* (fig. 34), the broad truncate end is anterior, the pointed end posterior. The transverse width of the anterior end is over one-half the longitudinal length of the bone. This end is truncated with a comparatively

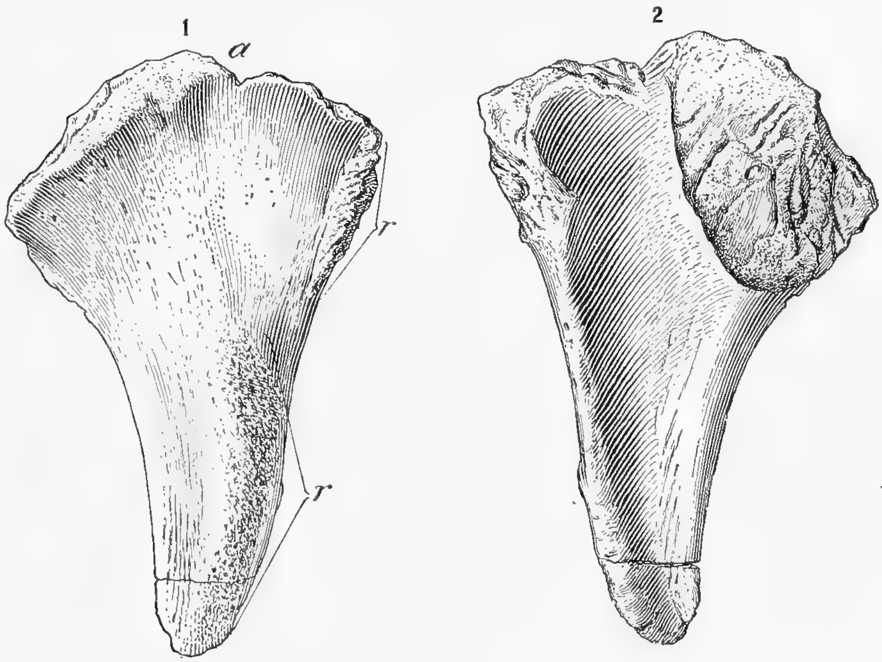

Fig. 32.—Left sternal bone, Stegosaurus sp. Cat. no. 7620. U.S.N.M. ½ nat. size. 1, Ventral view. *a*, Anterior end; *r*, *r*, roughened surfaces for attachment of cartilaginous ribs. 2, Superior view. *c*, Point of cartilaginous union with opposite plate.

thin but roughly rugose border. On the inner side the anterior third presents a thickened area which looks upward and inward and doubtless represents the median union of the plates of opposite sides. The ventral surface is slightly convex transversely, and the dorsal or visceral surface is concave. Both surfaces are comparatively smooth with the exception of roughened areas (*r* and *r*, fig. 32) which probably represent the points of attachment of the sternal ribs. The outer border is somewhat thickened and rounded, while the inner thins out to a sharp edge. Both borders are slightly concave from end to end.

Articulated, the broad truncated ends probably meet the anterior border of the coracoids, and the elements of opposite sides join on the median line at the thickened rugose surface described above. The pointed ends would be directed backward and outward as in *Trachodon* (fig. 34). Although these bones were found widely separated in the quarry and none of the three can be definitely associated with any of the surrounding specimens, yet a comparison of these elements with those of *Trachodon* (compare figs. 33 and 34) show such close general resemblances that there appears to be but little doubt of their correct identification.

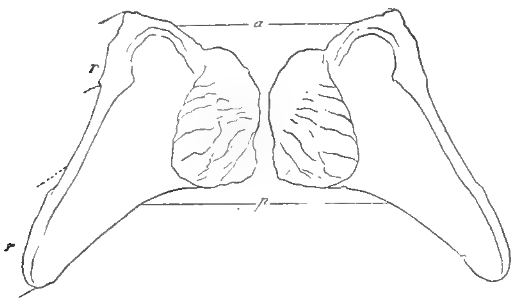

Fig. 33.—Diagram showing probable manner of articulation of Stegosaurus sternal bones. ¼ nat. size. *a*, Anterior ends; *p*, posterior ends; *r*, sternal rib.

Among the predentate dinosaurs, sternal elements were first discovered in *Trachodon* (*Claosaurus*) by Marsh, later in *Triceratops* by Brown,[1] and quite recently by Gilmore [2] in *Thescelosaurus*. That they are present in all members of this group is likely.

Measurements of sternal bones.

	No. 7618.	No. 7619.	No. 7620.
	mm.	*mm.*	*mm.*
Greatest length	170	178	156
Greatest transverse width, proximal end	86	....	65

Shoulder Girdle.

Scapula.—The scapula is comparatively short, and when not flattened by post-mortem causes the inner surface is concave from end to end, rendering it conformable to the convex curve of the body wall when articulated. This curvature of the scapula also tends to throw the articulated coracoid well in front on the chest, as in *Thescelosaurus*, *Trachodon*, *Camptosaurus*, and *Triceratops*.

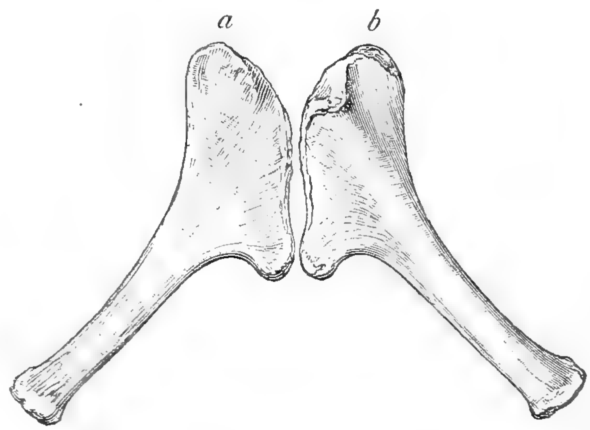

Fig. 34.—Left sternal bone of Trachodon annectens (Marsh). ⅛ nat. size. *a*, Seen from above; *b*, seen from below. After Marsh.

There are seven scapulae in the National Museum collections all showing a downward curve of the bone proximo-distally (pl. 21, fig. 3), and not straight, as Marsh has represented this element in *S. ungulatus*. In this respect they approach the scapula of *Ankylosaurus*, as figured by Brown.[3]

[1] Bull. Amer. Mus. Nat. Hist., vol. 22, 1906, pp. 297-300.
[2] Smiths Misc. Coll., vol. 61, No. 2184, 1913, p. 4.
[3] Bull. Amer. Mus. Nat. Hist., vol. 24, p. 196, fig. 15.

The upper portion of the blade is flattened; about equally expanded fore and aft; upper end cut off at nearly right angles to the shaft, with a slightly thickened rugose border.

Passing toward the articular end the blade gradually contracts antero-posteriorly for two-thirds the length of the bone, while the transverse measurement gradually increases. The progressive thickening of the bone continues to the articular end, which presents a heavy massive surface for the humerus (pl. 21, fig. 3 *g*). In specimen No. 7362 this end has a transverse thickness of 100 mm. and is quite deeply cupped. Approaching the coracoid end the superior border turns upward at slightly more than a right angle to the blade, as in the scapula of *Diplodocus* (see figure by Hatcher [1]), forming a broad, thin expansion of this end. No acromian process is present.

Two of the seven scapulae in the National Museum (Nos. 4934 and 7361) are firmly coössified with the coracoid, forming with it a deep glenoid cavity of good size. This fossa in No. 7361 measures 165 mm. across from lip to lip, its greatest expanse.

Measurements of scapulae.

	S. stenops type No. 4934, left.	*Stegosaurus* sp. No. 7362, right.	*Stegosaurus* sp. No. 7361, right.	*S. stenops.* No. 7371, left.	*S. stenops.* No. 4929, left.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Greatest length	620	670	685	679	687
Greatest breadth, proximal end	226	[1] 215	....	192	215
Greatest breadth, distal end	384	....	380	....	....
Least breadth, shaft	....	138	140	110	135

[1] Estimated.

Coracoid.—The coracoid is a subquadrate bone (pl. 20, fig. 1) which in very old individuals becomes firmly coössified with the scapula. The superior portion of the coracoid is thin, with convex external and concave internal surfaces. The lower portion is much thickened, particularly that part contributing to the glenoid fossa, which in No. 7376 measures 163 mm. in transverse width. The anterior portion of the inferior border is considerably thickened and roughened for ligamentary attachment.

The coracoid foramen is large and its elliptical internal opening is situated just anterior to the coraco-scapula suture, continuing diagonally forward through the coracoid a little below the center of the bone. There are five coracoids in the collection, and all of them show this foramen to be entirely inclosed, and not a notch, as figured by Marsh in his illustrations of this element of *Stegosaurus ungulatus*.

[1] Mem. Carnegie Mus., vol. 1, p. 44, fig. 14, 1901.

Measurements of coracoids.

	S. stenops, type.	*Stegosaurus* sp.	
	No. 4934, left.	No. 7362, right.	No. 7411, right.
	mm.	*mm.*	*mm.*
Greatest length	260	218	285
Greatest height		250	230
Greatest transverse width of glenoid fossa		163	83

Fore Limb and Foot.

The fore limb in *Stegosaurus* was very powerful, as is plainly evident from the robust size of the bones and the great development of the processes of the humerus and lower limb bones. The large size of the olecranon process implies a bent limb of the Ceratopsian type. There were five digits in the fore foot, which was of good size and well adapted for supporting the great weight of this animal.

Humerus.—The humerus is short and massive with widely expanded ends. Below the center of the bone the shaft is greatly constricted and without medullary cavity. The roughened radial crest is well developed and extends from the superior extremity down the antero-external border throughout one-half the length of the bone. The rounded rugose head is situated somewhat internal to the center of the proximal end (pl. 20, fig. 2*h*.) and is produced backward, overhanging the posterior border of the shaft. The head passes on its inner side into an area roughened for the attachment of muscles, which apparently is analogous to the lesser tuberosity in mammalian humeri. The greater tuberosity is apparently represented by a rugose, strongly developed ridge of bone running down from the proximal end on the postero-external border.

The radial and ulnar condyles are well differentiated and separated by a trochlea depression of moderate width and breadth.

The anconeal and trochlear depressions are about subequal, the former perhaps being the better defined. The supinator ridge (pl. 20, fig. 2*s*.) is a prominent feature, and adds much to the transverse expansion of the distal end. In adult individuals both proximal and distal articular ends are roughly rugose.

In the National Museum there are eight humeri. The principal measurements of a number of these will be found in the table below. In *Stegosaurus stenops* the ratio in length of the humerus to the femur is 1:1.9.

Measurements of humeri.

	S. stenops.				*Stegosaurus* sp., No. 7409.	*S. sulcatus*, type No. 4937.	*S. ungulatus*, No. 6646.
	Type, No. 4934.		No. 4929.				
	Right.	Left.	Right.	Left.	Left.	Right.	Left.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Greatest length	572	530	506	512	452	609	610
Greatest breadth proximal end	304	303	315		276		347
Greatest breadth distal end	265		237	227	202	278	283
Least width of shaft	101		102	103	102	118	114

Ulna.—On the proximal end the ulna is expanded and massive, but from above downward it tapers gradually to the very much smaller and little enlarged distal end. There is a heavy olecranon process which is produced far above the articular surface for the humerus (*o.*, fig. 35). The surface of this process is roughened for muscular insertion. In *S. sulcatus* No. 4937 (pl. 20, fig. 3 *A*), an exceptionally large and aged individual, this rugose area is of triangular shape and extends far down on the posterior side of the shaft. In young individuals, as shown by several specimens, the olecranon is truncate and rises only a short distance above the articular surface of this end. (See pl. 20, fig. 3 *B*.) In the great development of the olecranon process the ulna of *Stegosaurus* resembles that of *Triceratops*, where, among dinosaurs, it reaches its maximum development.

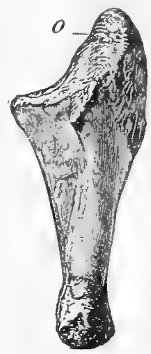

Fig. 35.—Left ulna of Stegosaurus ungulatus Marsh. $\frac{1}{12}$ nat. size. Side view. *o*, Olecranon process. After Marsh.

Viewed proximally the end is subtriangular in outline with a deep transversely concave cavity on the front for the reception of the rounded head of the radius. When these elements are articulated, the ulna completely hides the upper end of the radius from a posterior view. On the inner or radial surface near the distal end is a flattened rugose area, which in an articulated limb is opposed by a similar surface on the outer side of the radius. These doubtless indicate the points of attachment for the ligaments that held these bones in place.

The distal end is comparatively smooth and rounded. In outline it is elliptical, with an area less than that of the radius.

In specimen No. 4934 the ulna exceeds the humerus in length. In adult animals it was found in nearly all instances that the ulna was equal to, if it did not exceed, the humerus in this measurement. In immature specimens, however, on account of the shortness of the olecranon process the ulna is always the shorter of the two bones. (Pl. 20, compare *A* and *B*, fig. 3.)

Measurements of ulnae.

	S. stenops, type No. 4934.	*S. sulcatus*, type No. 4937.
	mm.	*mm.*
Greatest length	540	594
Greatest width proximal end		229
Greatest width distal end		118
Least width of shaft		61
Height of olecranon above humeral articulation		127

Radius.—The radius, although more slender than the ulna, is nevertheless of robust proportions. The shaft is constricted medially, while the ends are expanded, more especially the distal, which exceeds that of the ulna. In uncrushed specimens the shaft of the bone is a little curved, with the convexity forward and inward. The proximal end is subelliptical in outline, with a slightly roughened concave surface.

The posterior convex side of the head of the radius fits nicely into the radial groove on the anterior face of the ulna. On the front of the shaft a shallow groove passes diagonally downward across the front of the bone and doubtless marks the course of one of the larger tendons. It is clearly shown in pl. 20, fig. 4 *A*. In immature specimens this groove is very indistinct.

The heavy expanded distal end is triangular in outline with the apex of the triangle directed outward. This end of the radius of specimen No. 4937 is divided into two unequal faces, which meet one another at an obtuse angle. The larger one articulates with the radiale, but the smaller looks inward and backward and probably represents the attachment of the heavy ligaments which bound the joints together. This conclusion is further strengthened by comparing the surfaces of the two faces, the latter being roughly pitted and lacking the finish of the former.

Measurements of radii.

	S. stenops, type No. 4934.	*S. sulcatus*, type No. 4937.
	mm.	*mm.*
Greatest length	384	463
Greatest width proximal end	....	147
Greatest width distal end	84	158
Least width of shaft	....	67

Fore foot.—A complete fore foot of *Stegosaurus* is as yet unknown, though a considerable number of supplementary specimens give a fairly good idea of its structure, but it yet remains to definitely determine the phalangial formula.

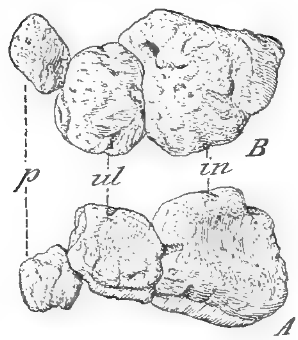

FIG. 36.—CARPUS OF STEGOSAURUS SP. JUVENILE. CAT. NO. 7403, U.S.N.M. ⅓ NAT. SIZE. *A*, FRONT AND *B*, TOP VIEWS. *in*, INTERMEDIUM; *p*, PISIFORM; *ul*, ULNARE.

In young animals the proximal row of the carpus is composed of four bones, but in the adult three of these consolidate to form a single element on the ulnar side. The distal segment of the carpus remains unossified. The digitigrade foot was large, and possessed five well-developed digits which were doubtless inclosed in a muscular mass, the only external evidence of the digits being the flattened hoof-like nails on the first and second toes.

Carpus.—In *Stegosaurus* only the proximal row of the carpus is ossified. This row as now definitely determined is composed of the radiale, intermedium, ulnare, and pisiform. It is only in young specimens that these elements are found separate. In old animals the intermedium, ulnare, and pisiform become ankylosed to form a single element, and in adults where the sutures have become obliterated the carpus would appear to consist of the two block-like bones shown in figure 38, 2, $ul+in+p$, and r. In the collections of the United States National Museum, however, we are fortunate in having preserved *in situ* the radiale, intermedium, and ulnare of one individual (No. 7401, fig. 37) and the intermedium, ulnare, and pisiform of a second specimen (No. 7403, fig. 36).

Both pertain to small, partly grown animals. These supplementary specimens show very clearly the entire *Stegosaurus* carpus, as may be seen by comparing figures 36 and 37.

Professor Marsh recognized three elements in the proximal segment of the carpus and so indicated it in his restoration of the skeleton.[1] Yet later in defining the genus *Diracodon*[2] he observes that "in the fore foot the intermedium and ulnar bones separate, while in *Stegosaurus* these carpals are firmly coössified," evidently overlooking the fact that in plates 48 and 52 of the same article, feet of the genus *Stegosaurus* are shown with these elements separate.

Radiale (*r.*).—The radiale is much the largest bone (see figs. 37 and 38, *r*) of the carpus and is opposed distally by metacarpals I, II, and partly by III. Proximally it articulates exclusively with the radius. It is a block-like bone, wider than long, with upper and lower articulating surfaces roughened, the former being flat, the latter rather angularly convex transversely. The sides are vertical with the exception of the posterior, which has on its outer posterior half a rounded depression of some depth. The principal dimensions of the radiale of an adult and a young specimen are given below:

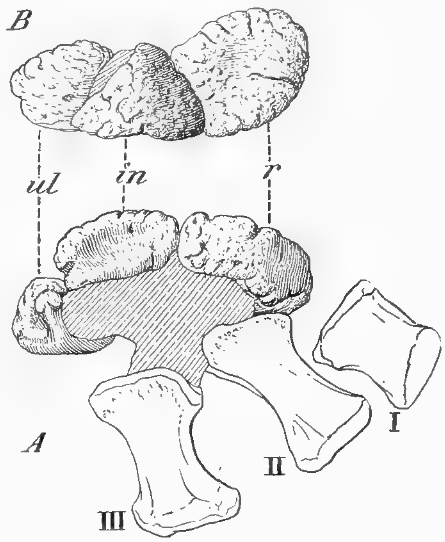

Fig. 37.—Carpus (lacking pisiform) and portion of right fore foot of Stegosaurus sp. Juvenile. Cat. no. 7401, U.S.N.M. ½ nat. size. *A*, Front and *B*, top views. *in*, Intermedium; *r*, radiale; *ul*, ulnare; I, II, III, metacarpals one, two, and three.

Measurements of radiale.

	Juvenile, No. 7401.	Adult, No. 4937.
	mm.	*mm.*
Greatest transverse diameter	72	110
Greatest antero-posterior diameter	62	103
Greatest vertical diameter	50	70

Intermedium (*in.*).—The intermedium will be described from the young specimen bearing catalogue No. 7401. Viewed from above (*in.*, fig. 37, B) this bone is triangular in outline, the front forming the longest side. The anterior face is shallowly concave dorso-ventrally, with an arterial foramen notching the external border. In adult animals all traces of this notch are obliterated.

The upper rugose surface is regularly convex transversely. It articulates with the radiale and ulnare by straight, vertical ends. In an articulated foot it is supported in part by both metacarpals III and IV. Above it meets about equally the distal ends of the radius and ulna.

[1] Amer. Journ. Sci., vol. 21, 1881, pt. 4, p. 170.

[2] Dinosaurs of North America, 1896, p. 193.

Measurements of intermedium.

	Juvenile, No. 7401.	Adult, No. 4937.
	mm.	*mm.*
Greatest transverse diameter	67	97
Greatest antero-posterior diameter	50	94
Greatest vertical diameter	41	69

Ulnare (*ul.*).—In specimen No. 7401 the ulnare is smaller than the intermedium and like that bone is triangular in outline when viewed from above (*B*, fig. 37, *ul.*). It is thinner than the intermedium and articulates dorsally, exclusively with the ulna. Ventrally it probably opposed metacarpal IV and part of V. In specimen No. 4937 the ulnare and intermedium are so closely ankylosed that the suture is almost obliterated.

Measurements of ulnare.

	Juvenile, No. 7401.	Adult, No. 4937.
	mm.	*mm.*
Greatest transverse diameter	46	....
Greatest antero-posterior diameter	55	85
Greatest vertical diameter	30	48

Pisiform (*p.*).—As identified here the pisiform is an irregularly rounded bone, the smallest element of the carpus. In the National Museum material specimen No. 7403 is the only individual which shows this bone as a distinct element (fig. 36, where it is shown as found in the quarry). In none of the adult specimens can this suture be traced.

Measurements of carpus.

[Specimen No. 7403.]

	Interme-dium.	Ulnare.	Pisiform.
	mm.	*mm.*	*mm.*
Greatest transverse diameter	81	52	28
Greatest antero-posterior diameter	69	52	33
Greatest vertical diameter	57	41	24

Metacarpus.—The metacarpus of *Stegosaurus* consists of five bones of about equal though robust proportions. Semi-articulated fore feet in the National Museum collections supplement one another to such an extent that the position of the metacarpals in the foot can be considered as absolutely determined. Specimen No. 7401 (fig. 37) shows metacarpals I, II, and III of the right manus retained nearly in their relative positions to one another as well as to the carpus, and No. 4934 (fig. 40) shows the articulated metacarpals II, III, IV, and V of the left foot. The information furnished by these specimens indicates that the metacarpals differ sufficiently from one another to be easily recognized as to their proper position in the foot when found in a scattered and disarticulated state. (See pl. 21, fig. 2.)

The following detailed description of these bones is based upon the foot of an adult specimen of *Stegosaurus sulcatus*, No. 4937, which is in a beautiful state of preservation:

Metacarpal I (pl. 21, fig. 2, 1) is the shortest and stoutest element of the series and may be distinguished at once by the great breadth of the shaft, being but little constricted at the center when viewed from the front. The ends are about evenly expanded, the proximal being subtriangular in outline with the rather blunt apex directed inward. This end is roughened and slightly concave, with the outer border beveled off where it meets metacarpal II. The transverse diameter of the distal end exceeds the vertical diameter. This end is convex antero-posteriorly, but concave transversely, thus forming a broad groove for articulation with the first phalanx of this digit. The external surface near the upper end is concave antero-posteriorly and roughened for the better attachment of the ligaments which bound the metacarpals together.

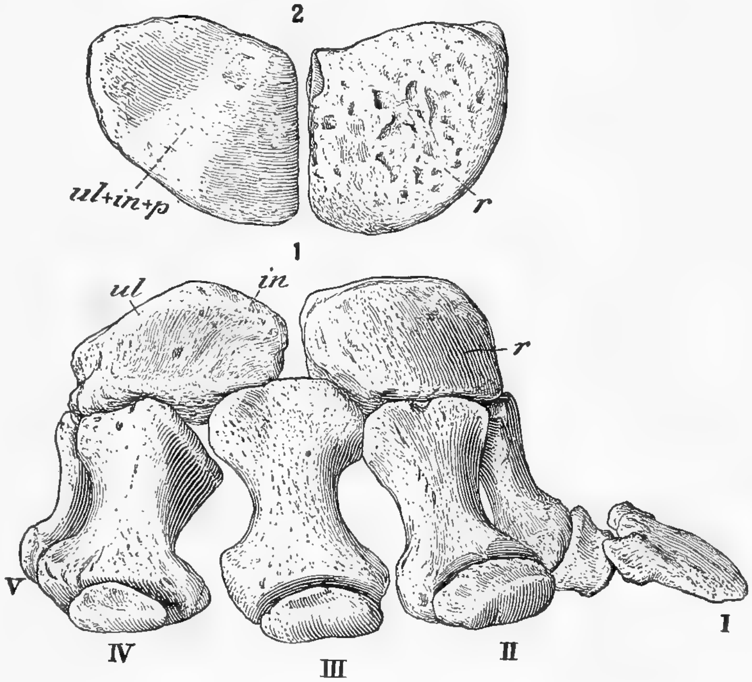

FIG. 38.—RIGHT FORE FOOT OF STEGOSAURUS SULCATUS MARSH. TYPE. CAT. NO. 4397, U.S.N.M. ¼ NAT. SIZE. 1, FRONT VIEW. *in*, INTERMEDIUM; *r*, RADIALE; *ul*, COALESCED INTERMEDIUM, ULNARE, AND PISIFORM; I, II, III, IV, V, DIGITS ONE TO FIVE. 2, PROXIMAL VIEW OF CARPAL BONES, SAME FOOT. *r*, RADIALE; *ul+in+p*, COALESCED ULNARE, INTERMEDIUM, AND PISIFORM.

Metacarpal II is longer and more slender than the preceding. It is constricted medially, both in its lateral and vertical diameters. From the front the ends appear to be about evenly expanded, but viewed laterally the proximal end is especially produced in a posterior direction, giving the bone a wedge-shaped appearance. The proximal end in outline is that of an equilateral triangle, the surface being roughened and slightly concave antero-posteriorly. (See II, fig. 39.)

The distal articular surface is broader than deep, being convex antero-posteriorly and broadly concave transversely.

Metacarpal III is the longest one of the five. Its proximal end is about evenly divided between the distal surfaces of the radiale and intermedium in an articulated foot.

Viewed from the front the proximal and distal ends are about evenly expanded transversely, but the proximal greatly exceeds the distal in the lateral aspect. The constricted shaft of moderate breadth when seen from the front is produced backward, the sides being pinched together, forming a stout ridge which joins the two ends of the bone. The posterior surface of this ridge especially at its center is rugosely roughened.

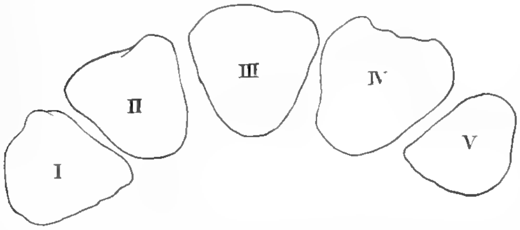

FIG. 39.—OUTLINE OF ARTICULATED PROXIMAL EXTREMITIES OF METACARPALS OF RIGHT MANUS OF STEGOSAURUS SULCATUS MARSH. TYPE. CAT. NO. 4937, U.S.N.M. ⅙ NAT. SIZE.

The distal end has two distinct articular faces, which meet at an obtuse angle on the distal end. The larger of these is shallowly concave transversely and convex vertically for articulation with the first phalanx. This articular surface does not round up on the anterior surface of the bone as in the preceding metacarpals, but the two surfaces meet sharply at right angles. This feature will be discussed later in connection with metacarpals IV and V. The second surface mentioned above looks outward and downward and was probably opposed by an inwardly directed process from the IV metacarpal as shown in 5, plate 21, figure 2.

Metacarpal IV has much the same proportions as metacarpal II, except for the heavier proximal end. The shaft is constricted in both vertical and lateral diameters. The ends are expanded, more especially the distal, and particularly on the inner side of this end. The articular face for the first phalanx is flattened and meets the anterior surface of the shaft at right angles. This feature is even more pronounced than in the preceding metacarpal. These surfaces would appear to indicate the fixed nature of the phalanges which opposed them, and, as will be shown later, probably bore phalanges which did not reach the outside of the muscular mass of the foot. As in metacarpal III, on the outer side of the distal end a second articular surface looks downward and outward and was probably closely connected to an inwardly directed process from the distal end of metacarpal V.

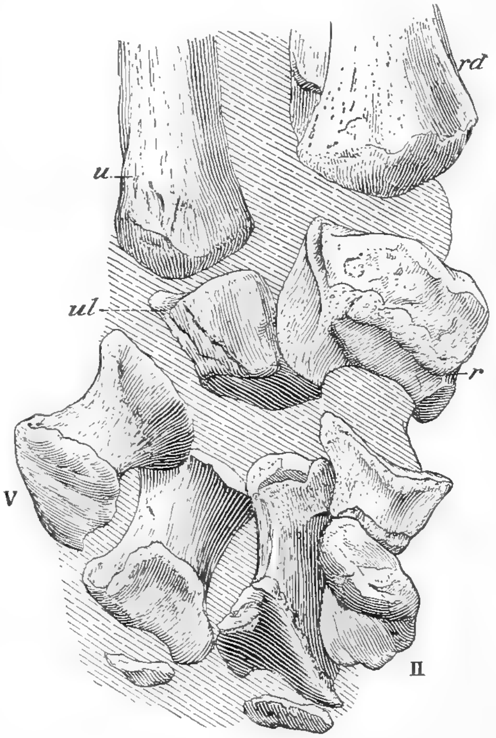

FIG. 40.—LEFT FORE FOOT OF STEGOSAURUS STENOPS MARSH SHOWN AS FOUND ARTICULATED. TYPE. CAT. NO. 4934, U.S.N.M. ⅓ NAT. SIZE. PALMAR VIEW. *r*, RADIALE; *rd*, DISTAL END OF RADIUS; *u*, DISTAL END OF ULNA; *ul*, COALESCED INTERMEDIUM, ULNARE, AND PISIFORM; II, V, METACARPALS TWO AND FIVE.

Metacarpal V (pl. 21, fig. 2) is the weakest element of this series, although this does not imply at all that it is vestigal. It may be recognized at once by the straightness of its outer border and by the hook-like process developed on the internal side of the distal end (*5*, pl. 21, fig. 2). The shaft is moderately constricted; the distal end is rounded antero-posteriorly, widest on the external side, narrowing toward the inner, as does the whole bone. The inner border of the proximal end is slightly concave where it meets metacarpal IV. The posterior side lacks the strong ridge, with roughened surface, which is so prominent a feature in metacarpals II, III, and IV.

An outline drawing (fig. 39) of the proximal ends of the metacarpals shows that when articulated their triangular ends combine to form a compact semi-circular foot well adapted for supporting the great weight of the body. There is no interlocking of the metacarpals as found in the feet of some dinosaurs, but this apparent mechanical weakness is compensated for by the increased size of the muscles and ligaments which bound the foot together, as indicated by the rugosity of the areas for their attachment. In the shortness of the metacarpals, depth of carpus, and arch of the foot, there is a striking superficial resemblance to the foot of the elephant.

Phalanges.—The phalangial formula yet remains to be determined. Of the proximal row of phalanges, only those pertaining to digits I, III, and IV have been found in place. In the left fore foot of specimen No. 4937 the first phalanx of digit I was found attached by matrix to the metacarpal, and in the foot of the same side of *S. stenops*, No. 4934, the first phalanges of digits III and IV were found similarly attached (fig. 40).

This constitutes all of the definite evidence as to the correct placing of the phalangial elements. With specimen No. 7401 (see fig. 37), a disarticulated foot, there are six phalangial bones preserved, two of which are unguals. With the right fore foot of No. 4937 there are five phalanges, one of which is terminal. Four of these have been regarded as constituting the proximal row as shown in figure 38.

The proximal phalanx of the first digit is undoubtedly the largest element of this row. It is wider than long, with posterior articular surface concave and anterior convex in the vertical direction. Both upper and lower surfaces concave longitudinally, the upper being convex, the lower concave transversely. The inner side is longer than the outer, and when articulated makes it appear wedge-shaped with the point directed toward the opposite foot.

In the half-grown animal the inner fourth of this bone is much depressed as shown by specimen No. 7401. The first phalanx of digit II is not certainly known.

The proximal phalanx of digits III and IV will be described from No. 4934 where they were found in place. They are short bones, wider than long, with concave proximal, and convex distal articular ends. The palmar surfaces are flattened and produced posteriorly into a thin sheet which lies under the ends of the metacarpals when articulated. Viewed superiorly the first phalanx of digit IV presents a longer concave surface than the phalanx of digit III, but the distal articulating surface is considerably reduced in size, and with a distinct articular protuberance on the internal side of this surface, reminding one of the homologous element in the *Elephas* foot. It probably represents the articulation for the much reduced and last phalanx of this digit.

The principal measurements of these bones are as follows:

	Proximal phalanges No. 4934.	
	Digit III.	Digit IV.
	mm.	*mm.*
Greatest transverse diameter	44	[1]37
Greatest antero-posterior diameter	19	21
Greatest depth of posterior face	27	25

[1] Estimated.

Of the other phalanges found associated with disarticulated feet, they appear intermediate in form and deserve no especial mention. The fore foot is provided with at least two flattened unguals, and though as yet not found articulated, undoubtedly belong to digits I and II.

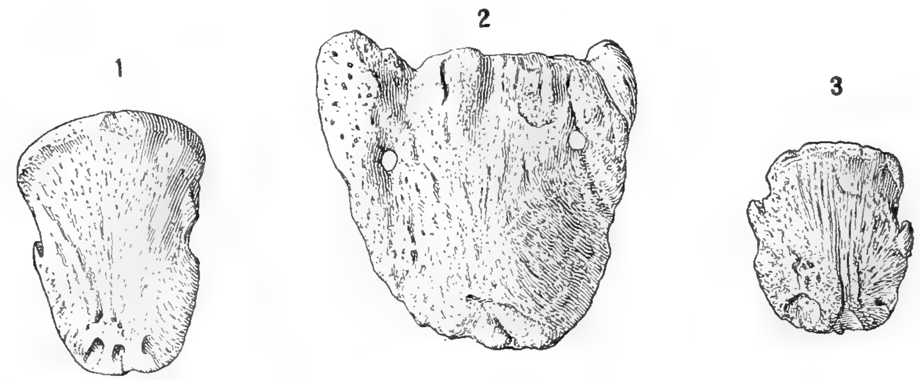

FIG. 41.—DORSAL VIEW OF UNGUALS OF STEGOSAURUS. 1, UNGUAL OF HIND FOOT. CAT. NO. 7419, U.S.N.M. JUVENILE 2, UNGUAL OF DIGIT I, FORE FOOT. CAT. NO. 4937, U.S.N.M. TYPE OF STEGOSAURUS SULCATUS MARSH. 3, UNGUAL OF DIGIT I, FORE FOOT. CAT. NO. 7401, U.S.N.M. JUVENILE. ALL FIGURES ½ NAT. SIZE.

These unguals are flattened, hoof-like bones that during the life of the animal were doubtless incased in a horny nail. The specimens with which two unguals have been found show that they are of two styles, one of which is as broad as long, the other more elongated. The relative shape and size of these unguals are well shown in figure 41. From the position in the rock of the elements pertaining to the right fore foot of No. 4934, I am led to believe that the elongated ungual (1, fig. 41) belongs to digit I.

In old individuals the surfaces of these bones become very much roughened, and the lateral, posteriorly directed points shown in figure 41, 1 and 3, continue to ossify until they project posterior to the articular end as blunt rounded points (fig. 41, 2).

Belonging to the fore foot of No. 7401 are other elements which from their close resemblance to some of the reduced terminal phalanges of *Elephas* are considered the final ones of the remaining digits. Antero-posteriorly these are very short, but long transversely; deep at the proximal end, with narrow and rounded distal end.

It will be observed from the above description that the manus of *Stegosaurus* is entaxonic, as in *Diplodocus* and *Brontosaurus*. Digits I and II were doubtless provided with a full complement of phalanges terminating with flattened unguals, which in life were the only external evidence of their presence. In digits III, IV, and V the number of phalanges was probably successively more and more reduced, each being terminated by a short transversely elongated functionless phalanx, that in life was entirely within the mass of the foot.

Measurements of fore foot elements.

METACARPALS.

	I.		II.		III.		IV.		V.	
	No. 7401.	No. 4937.	No. 7401.	No. 4937.	No. 7401.	No. 4937.	No. 7401.	No. 4937.	No. 7401.	No. 4937.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Greatest length	61	91	84	106	82	126	84	111	64	98
Greatest transverse diameter proximal end	52	80	49	70	53	78	56	80	52	72
Greatest transverse diameter, distal end	51	60	50	71	53	78	55	91	55	79
Least transverse diameter shaft	41	75	28	43	28	40	34	45	35	45

PHALANGES, FIRST ROW.

Greatest length	21	31	13	25	11	20	8	18	....	....
Greatest transverse diameter	42	75	47	67	39	55	41	[1]52	....	....

PHALANGES, SECOND ROW.

Greatest length	51	81	60	....	....	....	....	....	....	....
Greatest transverse diameter	44	84	46	....	....	....	....	....	....	....

[1] Estimated.

PELVIS.

Plates 2, 3, and 4.

The pelvis of *Stegosaurus* is composed of ilium, ischium, and pubis. These all unite to form the acetabulum, which is quite as well closed by bone internally as in the Ceratopsia. Apparently these elements never coössify as is sometimes the case in the adult members of the Sauropoda and Theropoda.

Ilium (*il.*).—The ilium is the largest of the pelvic bones. Its most prominent feature is the great anterior extension and the extreme shortness of the postacetabular part, which is scarcely one-third as long as the anterior portion.

The preacetabular process consists of a long, thickened, wide vertical plate of bone, which terminates anteriorly in a rounded truncate end (fig. 42).

Viewed laterally the superior border of the ilium is curved from end to end, the anterior process being directed outward and downward in the articulated pelvis which overhangs the posterior ribs. Viewed from above the superior crest curves inward and is closely and firmly united with the neural arches of the sacrum. The ilium does not roof over the cavities between the transverse processes as described by Marsh[1] but in adult individuals these cavities are completely covered over, as shown in the sacrum of *S. stenops*, No. 4934, by the coalescence of the antero-posterior expansion of the superior surfaces of the transverse processes. Beginning just anterior to the pubic peduncle the superior surface widens rapidly in a transverse direction posteriorly, particularly on the outer side where the upper portion is produced outward as a heavy shelf of bone with a thickened rounded outer border overhanging the ischiac peduncle. Posterior to the underlying ischiac articulation the ilium contracts rapidly in a transverse direction to a short, thickened, truncate end placed on the inner side of the bone with roughened surfaces, which has a greater vertical than transverse diameter. The greatest vertical thickness of the ilium is through the pubic peduncle and from this point posteriorly the bone is much depressed.

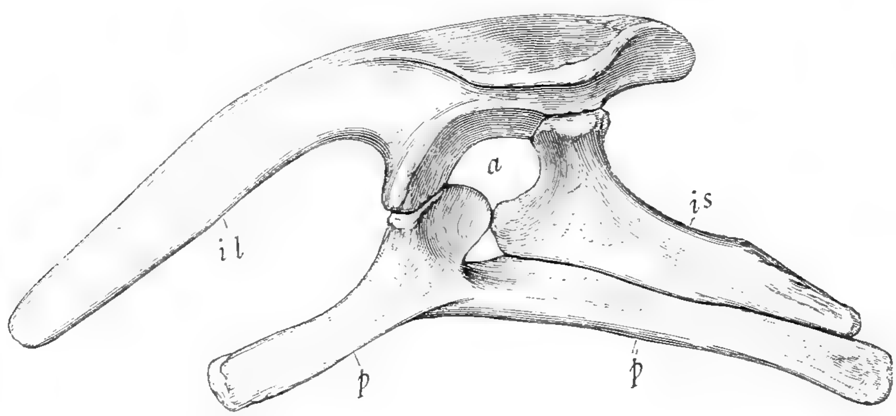

FIG. 42.—PELVIS OF STEGOSAURUS STENOPS MARSH. $\frac{1}{16}$ NAT. SIZE. SIDE VIEW. *a*, ACETABULUM; *il*, ILIUM; *is*, ISCHIUM; *p*, PUBIS; *p'*, POSTPUBIS. AFTER MARSH.

The acetabular portion of the ilium is large and shallow. The surface for articulation with the ischium, while not prominent, is nevertheless of good size, consisting of a roughened transversely elongated triangular area with the point of the triangle directed inward.

The pubic peduncle while not extending far below the acetabular surface is broad and heavy as in *Triceratops*.

On the internal side above the acetabulum the surface is deeply concave vertically with cupped depressions which articulate with the heavy expanded ends of the sacral ribs.

Pubis (*p*.)—The pubis in *Stegosaurus* is composed of a flattened, somewhat spatulate prepubic portion, and a slender, more elongated postpubis. (See fig. 43, *p* and *p'*.) The anterior portion is a thin, vertical blade of bone, terminated usually by a vertically rounded anterior end, although a few specimens show it as being cut off squarely. While this end is not especially thickened, in fully adult specimens there

[1] Amer. Journ. Sci., vol. 21, 1881, p. 168.

is a rugose roughening of the surface, as shown in figure 43. The superior border is broadly concave antero-posteriorly. Near the proximal end it expands transversely and on the outer side a rugose ridge is developed extending nearly across the bone and forming the anterior border of the acetabulum, presenting above a triangular elongated roughened surface which meets the pubic peduncle of the ilium. Posterior to this ridge, the pubis is continued backward as a broad process, with a concave roughened external surface that forms the inner wall of the acetabulum, as in *Triceratops*. On the ventral posterior border of this process is a small surface which articulates with the antero-inferior process of the ischium.

Beneath the rugose ridge described above the somewhat slender postpubis is given off, extending downward and backward at an angle of something less than 45° to the longer axis of the prepubic portion.

The shaft of this portion of the pubis is fairly uniform in vertical width, but the lower longutidinal half is transversely thickened, with a rounded ventral border, while the upper half thins out to a sharp edge, which is slightly roughened.

Marsh [1] shows the postpubis in *S. stenops* as exceeding the ischium in length (see fig. 42), while in the pelvis of *S. ungulatus* it is represented as being somewhat shorter.

I am unable to determine from our material whether this is a constant difference or not. Probably it is not. The pubic foramen in *Stegosaurus* exists always as a notch, the posterior border being open toward the acetabulum. The pubes, as with the ischia, appears to have been in contact only on the median line at their distal extremities.

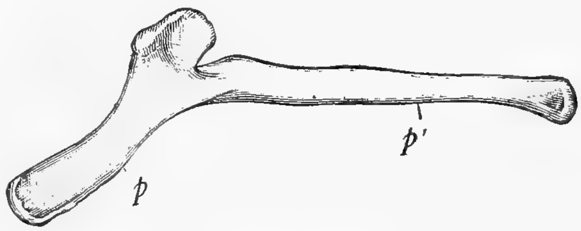

FIG. 43.—LEFT PUBIS OF STEGOSAURUS UNGULATUS MARSH. $\frac{1}{12}$ NAT. SIZE. OUTER VIEW. *p*, PREPUBIS; *p'*, POSTPUBIS. AFTER MARSH.

In *Stegosaurus* the boundaries of the acetabulum are even more completely inclosed by bone than in *Triceratops*, which Hatcher [2] considered as approaching most nearly to the mammalia in this respect.

Specimen No. 7420, a right pubis and the only complete element in the collection, gives the following measurements: Greatest distance from end of pubis to the end of postpubis, in a straight line, 850 mm.; greatest length of prepubic portion, 460 mm.; same measurement of No. 4934, 435 mm.; greatest length of postpubis from anterior edge of notch to distal end, 510 mm.

Ischium (*is.*).—The ischium is a comparatively short, flat, triangular element, showing a concave surface only on the Y-shaped proximal end and gradually tapering toward the distal extremity. The larger of the two articular faces on the proximal end meets the ischiac peduncle of the ilium, while the smaller and transversely compressed surface articulates with the pubis a little forward of the center of the acetabulum, as shown in figure 42.

Viewed from above, the transversely rounded border sweeps downward and backward from the heavy articular surface, with a gentle curve for over half its

[1] Dinosaurs of North America, 1896, pl. 48, figs. 2 and 3.

[2] Mon. 49, U. S. Geol. Surv., 1907, p. 57.

length, where a roughened elevation is met. From this point posteriorly the ischia tapers rapidly to the blunt truncated end (fig. 44), which is triangular in cross-section. The height and rugoseness of this elevation on the superior border of the ischium is more pronounced in fully adult specimens. The inferior border presents a thin, sharp edge, except at the transversely expanded distal extremity, which is flattened and has a roughened surface that appears to have been closely applied to the postpubis. In the restoration of the pelvis of *Stegosaurus* (fig. 42), Marsh[1] has indicated the ischium and postpubis as being in contact along their whole length, but it would appear from the study of specimens in the National Museum collections that there was a longitudinal cleft between them, as in *Omosaurus*.

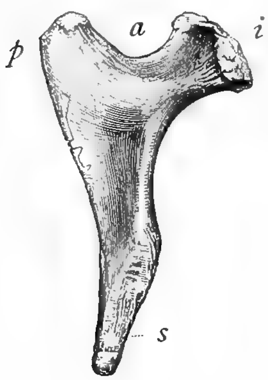

Fig. 44.—Right ischium of Stegosaurus ungulatus Marsh. $\frac{1}{12}$ nat. size. Internal view. *a*, anterior end; *i*, articular end for ilium; *p*, pubic articulation; *s*, symphysial border. After Marsh.

In plate 80, figure 5, Dinosaurs of North America, Marsh shows the distal third of the ischia as meeting on the median line. The shortness of these bones, in conjunction with the great width of the sacrum, appears to make such a union impossible, and in an unpublished plate of the articulated sacrum they are shown only in contact at their ends. Furthermore, none of the seven ischia in these collections shows inner surfaces adapted to or even suggestive of such a cartilaginous symphysis. It is also noted that in the mounted skeleton of *S. ungulatus* in the Peabody Museum of Yale University the ends of the ischia are not in juxtaposition (pl. 36).

Nopcsa[2] lays particular stress on the cleft between the pubis and ischium. He says:

> The longitudinal cleft between the pubis and the ischium, which is present in both species of *Omosaurus* and our *Stegosaurus* [*S. priscus*] is a character found in all primitive Ornithopoda; the closing of this cleft observable in *S. ungulatus* must, therefore, be regarded as a mark of specialization.

In view of what is now known of the manner of articulation of these bones, little weight is to be given Nopcsa's observations.

Measurements of ischia.

	No. 4934.	No. 2111.
	mm.	*mm.*
Greatest length	555	490
Greatest breadth of proximal end	280	262
Greatest breadth of distal end		55
Greatest extent of ilium articulation	195	

Hind Limb and Foot.

Femur The femur of *Stegosaurus* is by far the largest bone in the skeleton. It is remarkably long and slender, with a very straight shaft of nearly uniform width, being somewhat compressed from front to back. The head is not distinct,

[1] Amer. Journ. Sci., vol. 21, 1881, pl. 8, fig. 2.

[2] Geol. Mag., vol. 8, No. 4, p. 151.

although there is a faint constriction connecting it with the shaft of the bone as in *Diplodocus*. The great trochanter is not separated from the head, but as in the Sauropodous dinosaurs the rugose proximal surface of the latter continues uninterruptedly and covers the superior surface of the great trochanter. The head of the femur of *Stegosaurus priscus* Nopcsa is strikingly different from any of the American forms, in having a distinct head and an elevated trochanter major.[1] In these respects it resembles *Triceratops* more nearly than *Stegosaurus*.

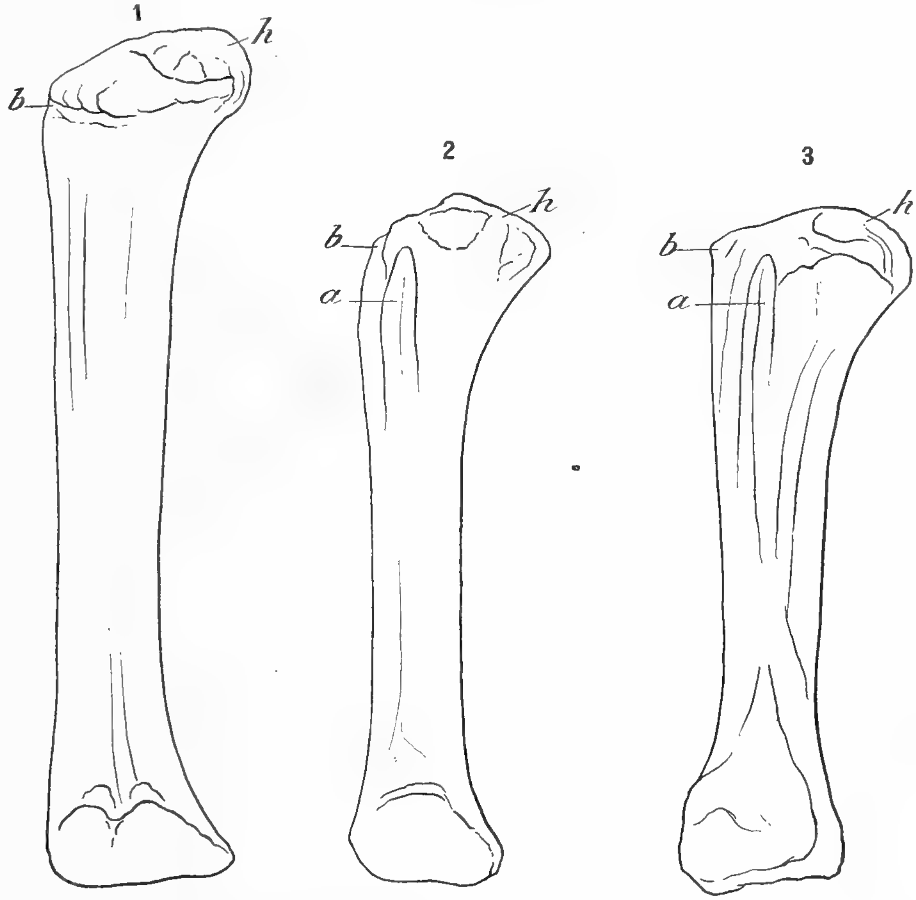

FIG. 45.—COMPARATIVE VIEWS OF STEGOSAURUS FEMORA. VIEWED FROM THE FRONT. ALL 1/12 NAT. SIZE. (1) FEMUR OF S. UNGULATUS MARSH. COTYPE. YALE MUSEUM. (2) FEMUR OF S. ALTISPINUS GILMORE. TYPE. UNIVERSITY OF WYOMING COLLECTION. (3) FEMUR OF S. STENOPS MARSH. TYPE. NO. 4934 U.S.N.M. *a*, LESSER TROCHANTER; *b*, GREATER TROCHANTER; *h*, HEAD.

In the collections of the National Museum there are 10 Stegosaurian femora, but on none do I find a rugose area extending down any appreciable distance on the superior external surface, such as noted by Osborn [2] in *Diplodocus*, although on some specimens there is a rugose area running down on the outer anterior surface as in *Mastodon* and *Elephas*.

A small finger-like proximal or lesser trochanter, called great trochanter by Owen in *Iquanodon*, is present in *S. stenops* (3, fig. 45.*a*.) and on all the other femora

[1] F. Baron Nopcsa, Geol. Magazine, vol. 8, No. 4, 1911, p. 147, fig. 6 (c).
[2] Mem. Amer. Mus. Nat. Hist., vol. 1, pt. 5, 1899, p. 211, fig. 14 (*a*), *tr. I*.

before me, although it appears to be absent in *S. ungulatus* (fig. 46) and the allied European forms. The presence of this atrophied trochanter, which is such a prominent feature of all bipedal dinosaurian femora, apparently represents the remnant of a much larger process, which has been handed down from a bipedal ancestry.

FIG. 46.—LEFT FEMUR OF STEGOSAURUS UNGULATUS MARSH. $\frac{1}{12}$ NAT. SIZE. FRONT VIEW. *c*, INNER CONDYLE; *s*, SHAFT SHOWING ABSENCE OF FOURTH TROCHANTER; *t*. GREAT TROCHANTER. AFTER MARSH.

With the exception of having the trochanter just described, the whole proximal end of the femur of *Stegosaurus* is remarkably like those of the Sauropodous dinosaurs, especially that of *Diplodocus*.

Marsh[1] has pointed out the absence of the third trochanter (now recognized as the fourth) in *S. ungulatus* and I find it absent in *S. stenops*. The origin of the caudo-femoral muscle is nevertheless usually indicated by an obtuse longitudinal swelling, which fades out rapidly both above and below. As shown by Nopcsa in *S. priscus* "it must be considered as the last trace of this trochanter." In specimen No. 7380, of which we have both femora preserved, the vestigal fourth trochanter is roughly rugose. In the American *Stegosaurus* the fourth trochanter appears always to be more vestigal than in *Triceratops*.

The distal end of the femora is more expanded transversely than antero-posteriorly. The external condyle, as usual, is larger than the internal. The intercondylar notch is wide and moderately shallow. The external condyle has on its outer side a shallow groove which probably transmitted one of the strong tendons.

Nopcsa[2] has contributed some interesting observations on the *Stegosaurus* hind limb, which are given herewith:

I wish to emphasize the fact that in this genus [*Stegosaurus*] the amount of cartilage on both ends of the femur was decidedly much greater than in the Ornithopodidæ, and that the shape of the proximal and distal end of the bone must have been originally somewhat different from the present shape. The lack of a trochlea on the distal end of the femur of *Stegosaurus* can give us a clue to the amount of cartilage missing, for *Stegosaurus*, being a terrestrial animal, can not have walked, and especially sat down without bending its knees sometimes for more than 90°, while as shaped in the fossil the tibia would become dislocated if forced to make an angle of more than 45° with the femur. This tends to show that the cartilage on the distal end of the femur must have been at least 4 cm. thick, and this is certainly not too much when we consider that the distal femoral cartilage of the macerated *Gallus* figured above had a thickness of 4.5 mm., while the femur itself measured 94 mm. in length. It becomes evident that just as we could never try to bring the macerated femur of *Gallus* into correct juxtaposition to the acetabulum without allowing for a great amount of cartilage, so we can not base any conclusion as to the position or direction of the femur in *Stegosaurus* exclusively on the shape of its articular surface. * * *

Even by those who hold the contrary view of the amount of cartilage in Diplodocus it is thought to be correlated with the aquatic habits of this monster, but this theory can not apply to the heavily

[1] Dinosaurs of North America, 1896, p. 191.

[2] Geol. Mag., vol. 8, No. 4, 1911, pp. 147–148.

armored *Stegosaurus*. I quite believe that the feeble ossification of the sternal apparatus and the low degree of ossification of the distal carpals and tarsals in most Dinosaurs are much more likely to explain the great cartilage caps on the femora of the Stegosauridæ and similar animals than the hypothetical aquatic habits. These features and the coarse structures of the bones indicate a low degree of ossification in the whole body, and the great masses of cartilage were probably needed to ensure the continuous increase of size throughout life.

Lull[1] says:

The loss of this trochanter [the fourth] together with the slight development of the pubic peduncle of the ilium precludes the possibility of a bipedal gait, though doubtless *Stegosaurus* is derived from a bipedal ancestry, quadrupedalism being secondarily acquired as in the Ceratopsia, owing to the immense weight of the creature's armament.

A comparative study of the series of femora in the National Museum collections shows the existence of two types of animal—one a distinctively slender, long-limbed form, the other a short-limbed type. The former reaches its maximum development in *S. ungulatus* as shown in the mounted skeleton (fig. 46 and pl. 36). The latter is represented by a hind limb, No. 7380. The femur of this specimen is of a fully adult animal, as evidenced by the rugose nature of the articulations and areas of attachment for the more important muscles. The articular ends and condyles are especially well defined and in every way have a more finished appearance than any of the longer femora in the collection. A small humerus, No. 7409, but not associated with the hind limb mentioned above, also exhibits characteristics similar to those of the femur described above.

Whether these bones represent an undescribed species, I am not prepared to decide at this time, but that there are long and short limbed forms of the genus *Stegosaurus*, the evidence before me appears most conclusive.

The femora of *S. stenops* and *S. longispinus* show these species to be classed as long-limbed animals. It is quite possible that when the femora of the other described species are known it will be found that these short-limb bones pertain to one of them. There is also the possibility that the matter of sex may account for the difference in the size of the limbs.

Measurements of femora.

	S. stenops, type No. 4934.		*S. ungulatus.*	*Stegosaurus* sp.				*S. longispinus*, type.
	Right.	Left.	No. 6646, right.	No. 7370, left.	No. 7380, right.	No. 7380, left.	No. 7385, right.	Right.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Greatest length	1,080	1,010	1,200	977	908	895	860	1,082
Greatest breadth at proximal end	283	307	329	....	245	268	225	275
Greatest breadth at distal end	276	269	263	227	246	242	192	242
Least width of shaft	145	140	147	130	128	128	117	132

[1] Amer. Journ. Sci., vol. 30, 1910, p. 367.

Tibia (*t.*).—In *Stegosaurus stenops*, the tibia is very much shorter than the femur, the ratio being as 1:1.68.

The tibia of *Stegosaurus* may at once be distinguished by the unusual angulation of the expanded ends; that is, the greatest diameter of these extremities lies in about the same plane, while in the Ceratopsia and Camptosauridæ these diameters occupy planes nearly at right angles to one another. Articulating the proximal end of the tibia with the femur as in *Camptosaurus*, *Triceratops*, or *Trachodon* tends to throw the articulated foot out at right angles to the longer axis of the body. This at once raises the question as to the correctness of the interpretation of the articulation of the limb as shown by various figures and illustrations.

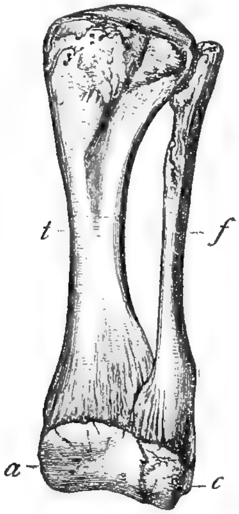

FIG. 47.—LEFT TIBIA AND FIBULA OF STEGOSAURUS UNGULATUS MARSH. 1/12 NAT. SIZE. FRONT VIEW. *a*, ASTRAGALUS; *c*, CALCANEUM; *f*, FIBULA; *t*, TIBIA. AFTER MARSH.

The proximal end shows on the posterior side two comparatively small condyles which overhang the posterior surface of the tibia. The external border of this end is shallowly concave antero-posteriorly for the reception of the proximal end of the fibula. On the anterior side is a broadly rounded, blunt cnemial crest. The least diameter of the constricted shaft is below the middle. The distal end is widely expanded antero-posteriorly, but without marked expansion transversely. On the anterior face of this end the surface is unequally divided by a broad, shallow, longitudinal groove, which probably transmitted the tendons of the flexor muscles of the foot. The smaller or external part represents, in function at least, the external malleous of the mammalian tibia. It extends below the internal surface with which the astragalus unites, and articulates on its inner side with that bone. The anterior surface of this part is flattened and articulates closely with the fibula (fig. 47).

The articular surface for the astragalus is cupped. This surface is irregularly gouged out (fig. 48), into which fit corresponding projections on the proximal end of the astragalus. This union renders the bones immovable upon one another and brings about a condition favorable to their early coössification, as evidenced by the ankylosis of these bones in four of the six tibia preserved in the National Museum collections.

A front view of the tibia is shown in figure 47.

Measurements of tibia.

	S. stenops, type No. 4934, right.	*S. ungulatus*, No. 6646, right.	*Stegosaurus* sp.		
			No. 7379, left.	No. 7380, right.	No. 7387, right.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*
Greatest length	643	696	602	565	570
Greatest width proximal end	265	275	230	210	210
Greatest width distal end	....	245	217	185	232
Least width shaft	85	98	87	77	79

Fibula (*f*.).—The fibula is slender, with the proximal end heavier than the distal. The tibial side of the upper end is hollowed out in order to better conform to the surface of the tibia, with which it articulates. An obtuse thickened ridge passes diagonally across the inner surface, about 70 mm. below the proximal end, and serves to distinguish the fibulae of *Stegosaurus* from those of other known dinosaurs. The proximal articular surface is rounded and rugose and quite on a level with that of the tibia.

The surface next to the tibia is plain, while the opposite side is irregularly convex. The distal end, much flattened and expanded antero-posteriorly, was closely applied to the flattened surface of the tibia.

A somewhat roughened area for muscular attachment passes diagonally across the outer surface just above the center of the bone. The distal end when articu-

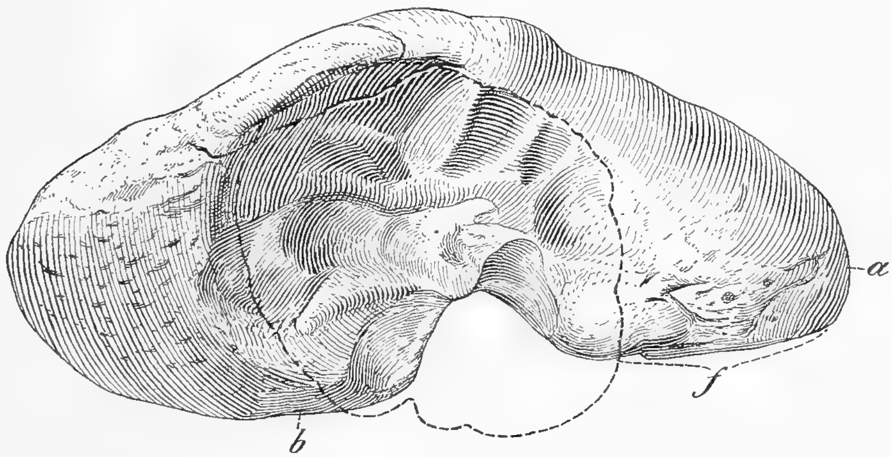

FIG. 48.—DISTAL END OF RIGHT TIBIA OF STEGOSAURUS SP. CAT. NO. 7387 U.S.N.M. ½ NAT. SIZE. *a*, EXTERNAL BORDER, *b*, ANTERIOR BORDER; *f*, SURFACE FOR FIBULA. DOTTED LINE SHOWS POSITION OF ASTRAGALUS WHEN ARTICULATED.

lated rests upon the very small calcaneum. In some individuals it has been found to coalesce with the calcaneum, these in turn with the astragalus and tibia, forming a smooth convex articulation for the ankle joint. The principal features of the fibula are shown in figures 47 and plate 25, fig. 5.

Measurements of fibulae.

	S. stenops. Type.	*Stegosaurus* sp.				
	No. 4934.	No. 7389.	No. 7380.	No. 7390.	No. 6644.	No. 7384.
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Greatest length	610	515	518	548	579	550
Greatest width proximal end	109	78	81	71	82	72
Greatest width distal end	74	90	79	68	99	95
Least width of shaft	....	38	38	47	38	41

Hind foot.—The proximal row of the tarsus is composed of the astragalus and calcaneum, the distal row apparently remaining unossified. In adult individuals the astragalus usually coössifies with the tibia; calcaneum generally remaining as a distinct element, although in two instances it was found ankylosed with the fibula.

A complete articulated hind foot of *Stegosaurus* is as yet unknown, although associated foot bones enable me to determine the chief features of the structure of the pes.

In the hind foot there are three functional digits, with the rudiment of a fourth. The latter, as first determined by O. C. Marsh, was thought to represent a remnant of digit one, but, as I shall attempt to show, probably represents the fourth. The fifth appears to be entirely wanting.

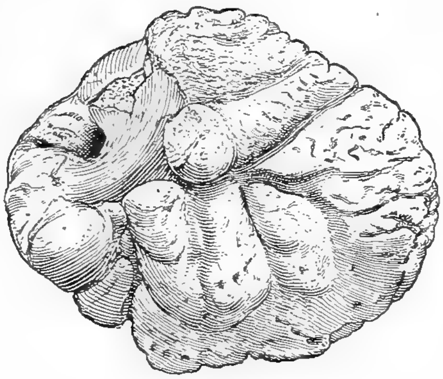

FIG. 49.—ASTRAGALUS OF STEGOSAURUS SP. CAT. NO. 7387, U.S.N.M. ½ NAT. SIZE. PROXIMAL VIEW.

In the first restoration of the hind foot[1] Marsh showed five digits, evidently drawn from a fore foot, but this error was corrected by him in a later restoration.[2]

Astragalus (*a.*).—The astragalus in *Stegosaurus* is reduced to a flattened, disk-like bone, having a regular concave plantar surface and an irregular convex proximal surface. Viewed from above it is suboval in outline, the longer diameter being transverse. When articulated, the end of the tibia more than covers it (see fig. 48). Externally it meets the inner border of the calcaneum, with which it is often ankylosed.

The median superior surface is covered with rounded protuberances (fig. 49), which fit into corresponding depressions in the cupped surface of the distal end of the tibia, thus rendering the two bones immovable upon one another. This joint, as mentioned previously, is most favorable for their early coössification, a condition observed in nearly all fully adult individuals.

Although Marsh included this character in all of his definitions of the family Stegosauridæ, he was apparently well aware of its being an age characteristic, as evidenced by the following: "In the Stegosauridæ alone, among known dinosaurs, is the astragalus coössified with the tibia. This, however, is not a character of much importance." [3]

Measurements of astragali.

	Stegosaurus, sp.			
	No. 7378.	No. 7387, right.	No. 6646, right.	No. 7380.
	mm.	*mm.*	*mm.*	*mm.*
Greatest diameter antero-posteriorly	104	95	122	76
Greatest diameter transversely	110	112	115	87

[1] Amer. Journ. Sci., vol. 21, 1881, p. 169, pl. 8, fig. 2. [2] Idem., vol. 42, 1891, p. 180, pl. 9. [3] Idem, vol. 23, 1884, p. 336.

Calcaneum (*c.*).—The calcaneum is represented in the Museum collections by five specimens, of which three are articulated with the tibiae. Viewed externally it is a small angularly rounded element, with the greatest diameter supero-inferiorly. The external surface is comparatively smooth, being slightly concave vertically. The tibial side is deeply concave from above downward, this surface in the articulated limb closely uniting with the distal portion of the external malleolus. The bone thins out posteriorly, but thickens anteriorly. The internal border for articulation with the astragalus is much roughened. The anterior border is regularly rounded from above downward and conforms closely with the convex surface of the astragalus. The proximal end presents a roughened beveled articular surface for the fibula, the bevel being toward the tibial side. The chief features of this bone are well shown in figure 50.

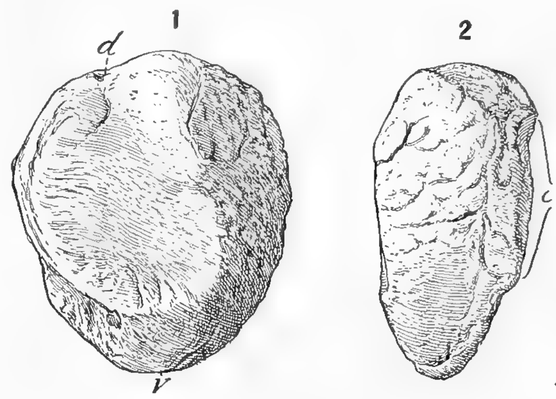

Fig. 50.—Right calcaneum of Stegosaurus sp. Cat. no. 7367, U.S.N.M. ½ nat. size. (1) Lateral view; (2) front view; *c*, border articulating with the astragalus; *d*, dorsal border which meets the fibula; *V*, ventral border.

Measurements of calcanea.

	No. 7397, right.	No. 7398, left.	No. 6646, right.	No. 7368, left.
	mm.	*mm.*	*mm.*	*mm.*
Greatest antero-posterior border	67	65	75	71
Greatest transverse diameter	34	30	38	41
Greatest height	76	80	103	87

Metatarsus.—The metatarsus of *Stegosaurus* consists of four bones, of which three are large and support functional toes, and one is rudimentary (figs. 52 and 53).

The functional metatarsi are exceedingly stout, robust elements, the median one being the longest of the three. Their proximal ends were evidently bound together by strong ligaments, there being no interlocking articular facets as found on the metatarsals of many of the bipedal Ornithopoda.

The foot of specimen No. 4280, shown as found *in situ*, in plate 21, figure 1, appears to have one digit preserved in its entirety. This digit has two phalanges, and on the analogy of other dinosaurian hind feet, as shown in the table below, would indicate that it represents the innermost or first digit. On the evidence of this one foot it was so regarded when the drawing for figure 52 was made.

Phalangial formula of known dinosaurian hind feet:

	Digits—				
	I	II	III	IV	V
Scelidosaurus harrisonii Owen	2	3	4	5	0
Camptosaurus dispar Marsh	2	3	4	5	0
Thescelosaurus neglectus Gilmore	2	3	4	5	0
Brachyceratops montanensis Gilmore	2	3	4	5	0
Iguanodon bernissartensis Boulenger	0	3	4	5	0
Trachodon annectens (Marsh)	0	3	4	5	0
Diplodocus carnegii Hatcher	2	3	4	2	1
Brontosaurus excelsus Marsh	2	3	4	2	1

The more recent discovery of an articulated limb (No. 4936) throws considerable doubt on the above interpretation, and I am now inclined to the opinion that the ungual does not belong to the digit as shown in figure 52, III, but was shifted into its present position from one of the other toes, as shown in plate 21, figure 1. The evidence for this is, first, the great resemblance of the short metatarsal to metatarsal I of Sauropodous dinosaurs, and, second, the finding of a disarticulated foot in the rock near and around the distal ends of a tibia and fibula which were articulated with the femur. If this association is correct, it shows the short metatarsal to be on the inside of the foot, and would therefore be metatarsal I as indicated in figure 52. Upon other evidence Marsh has given this bone a similar position in the hind foot, as shown in his restoration (pl. 32, upper figure). From the great resemblance of this short metatarsal to the homologous element in the hind foot of *Brontosaurus* and *Diplodocus*, I regard it as representing metatarsal I, and the rudimentary metatarsal I would consider as the remnant of Digit IV.

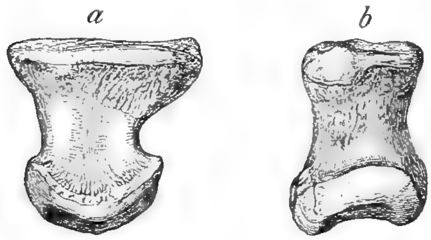

FIG. 51.—METATARSAL II OF RIGHT HIND FOOT OF STEGOSAURUS UNGULATUS MARSH. ½ NAT. SIZE. *a*, SIDE VIEW; *b*, FRONT VIEW. AFTER MARSH.

The loss of the fifth digit and the reduction of the fourth to a vestigal metatarsal shows that the reduction in the pes of *Stegosaurus* has taken place from the outside of the foot as in the Sauropodous dinosaurs rather than from both outer and inner sides, as in some of the Ornithopoda.

It may be that there is a progressive increase in the number of phalanges in Digits I to III so characteristic of nearly all dinosaurian reptiles, but I am inclined to believe that when the complete formula is known it will be found that Digit III lacks the ungual and perhaps one or more of the phalanges.

Metatarsal I is an exceedingly short, stout element, the width about equaling the length. The proximal end is wider than deep, thus reversing the measurements of the median metatarsal. Viewed from the front the whole bone is beveled off toward the outside. The chief characteristics of this element are shown in plate 21, figure 1, I.

Metatarsal II may at once be recognized by the transversely compressed proximal end and the greatly lengthened antero-posterior diameter of this end (fig. 51).

The slightly concave proximal articular surface does not reach the back but the bone develops a strong, roughened, overhanging tuberosity for ligamentary attachment. The shaft is constricted, the distal end about evenly expanded, with broad, shallow median groove. The distal articular surface extends well up on the anterior face of the shaft, as it does in all three metatarsals. On the external side of the anterior surface, below the center, a vertically elongated, tuberosity with roughened surface is developed, as shown in figure 52, *t*.

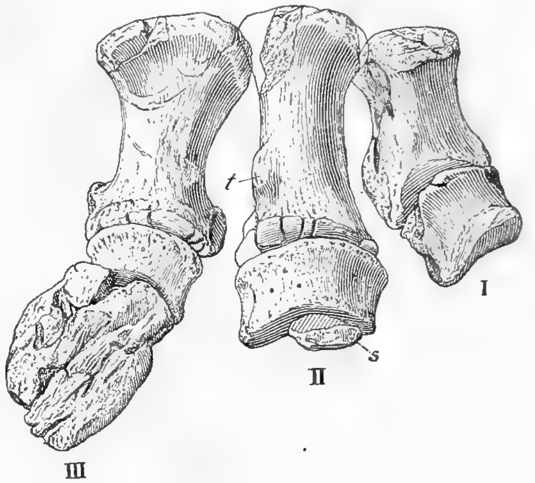

FIG. 52.—RIGHT HIND FOOT OF STEGOSAURUS SP. CAT. NO. 4280, U.S.N.M. ABOUT ¼ NAT. SIZE. DRAWN ARTICULATED. *s*, SESAMOID; *t*, TUBEROSITY; I, II, III, DIGITS ONE, TWO, AND THREE. UNGUAL ON DIGIT III PROBABLY PERTAINS TO DIGIT ONE.

Metatarsal III has an irregularly rounded proximal end, with slightly concave, roughened articular surface. The shaft is constricted in all diameters, but more especially the transverse.

The distal end has two surfaces which meet at an obtuse angle on the internal third of this end. The rounded internal surface articulates with the first phalangial, while the external surface turns somewhat backward, remaining free.

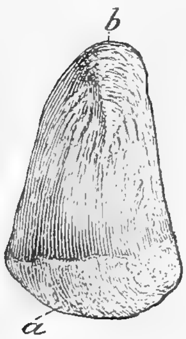

FIG. 53.—VESTIGAL METATARSAL OF STEGOSAURUS SP. CAT. NO. 7419, U.S.N.M. NATURAL SIZE. *a*, ARTICULAR END; *b*, PINCHED OFF PROXIMAL END.

Metatarsal IV consists of a small, slightly flattened element, with rounded distal and a pinched-off proximal end, the latter without articular surface. If my interpretation of the respective ends is correct, then this digit would have one or more phalanges; but on the other hand, if they have been reversed it would represent all that remains of this digit. The upper end is somewhat roughened, as shown in figure 53.

Phalanges.—The complete phalangial formula of the hind foot of *Stegosaurus* is unknown. The partially articulated foot (No. 4280) shown in plate 21, figure 1, has the proximal row of phalanges of digits I, II, and III preserved in their proper relations to the metatarsals, and is the only specimen in the collection in the United States National Museum furnishing positive evidence as to their proper arrangement.

The proximal phalanges in all of the digits are short and broad, relatively much heavier than those of the manus. Their proximal ends are shallowly concave from above downward and slightly roughened. Their distal ends are convex from above downward, with a broad, concave transverse median depression.

The proximal phalanx of digit I is a short, broad bone which articulated with a broad, depressed, hoof-like ungual (fig. 54) with roughened surface, which in life was doubtless incased in a horny hoof. Marsh, in the restoration of *Stegosaurus ungulatus* (pl. 32, upper figure), regarded this digit as the second, and on that account it has been given three phalanges.

The proximal phalanx of digit II (fig. 52) may be recognized at once when viewed from above on account of its bilateral symmetry. In this aspect the proximal phalanges of digits I and III are wedge-shaped, with the least antero-posterior diameter away from the center of the foot.

The first phalanx of digit II (fig. 52) had a small flattened discoidal element attached by matrix to its distal end. This element either represents a rudimentary second phalanx of this toe or a sesamoid bone. I am inclined to believe it to be the latter. A similar element was found with the disarticulated foot bearing the number 7415. These probably represent phalangial sesamoids such as Hatcher[1] found in the manus of *Brontosaurus*.

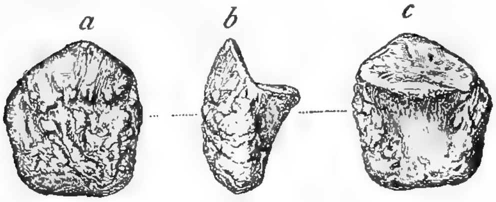

FIG. 54.—TERMINAL PHALANX OF STEGOSAURUS SP. ½ NAT. SIZE. *a*, FRONT VIEW; *b*, SIDE VIEW; *c*, POSTERIOR VIEW. AFTER MARSH.

Nothing is known of the positive arrangement of the other phalangials or unguals, and we must await the discovery of more complete material for the determination of the digital formula.

The pes, as in the manus, is digitigrade. The roughened articular ends of the metatarsals and phalanges indicate the presence of thick pads of cartilage between the joints.

That the foot was well arched is shown by the wedge-like proximal end of metatarsal II and the oblique proximal phalanges of digits I and III.

The ungual of digit I if articulated would turn obliquely inward toward the median line of the body. Other unassociated unguals show the ends to be obliquely truncated toward the mesial line, as the one shown in digit III (fig. 52) of No. 4280. There are one or two others which are more symmetrical, and probably represent the terminal phalanx of the median toe (Mt. II). With the associated hind-foot bones of No. 4936 there were two disarticulated unguals present, but whether digit III bears a flattened claw remains to be determined.

The general character of the bones of the hind foot suggests that the feet of *Stegosaurus* were much like those of a large tortoise, club-like, with the toes turned well downward.

Measurements of the elements of the pes.

METATARSALS.

	No. 4280.		
	I	II	III
	mm.	*mm.*	*mm.*
Greatest length	76	117	100
Greatest transverse diameter proximal end	55	....	76
Greatest transverse diameter distal end	68	....	76
Least transverse diameter shaft	50	34	43

PHALANGES, FIRST ROW.

Greatest length	33	35	31
Greatest transverse diameter	60	61	55

[1] Ann. Carnegie Museum, vol. 1, 1902, p. 373, fig. 13, pl. 19.

Dermal Armor.

Plates 2, 3, 4, 11, 12, 13, 14, 15, 16, 17, 18, 22, 23, 24, and 25.

The exoskeleton of *Stegosaurus* consists primarily of four types of structure; the so-called gular or throat scutes covering the neck and possibly the head (pl. 22, figs. 2 and 3); the isolated rugose ossicles which have not been placed but probably were scattered over the skin (fig. 56); the series of erect plates forming two rows along the neck, back, and tail (pl. 14); and the elongated, spike-like spines placed near the end of the caudal series (pls. 15 and 16).

Dermal ossicles (*o.*).—The first type, consisting of small, depressed, angularly rounded ossicles, was found in the rock near the skull and neck of No. 4934 (pl. 2, also pls. 3 and 4, *o*). These ossicles are of irregular sizes, but none exceeds 35 mm. in diameter (see fig. 55). It might be mentioned that similar ossicles were found with the skeletons of three other individuals, Nos. 4936, 7615, and 7947, in the collection of the National Museum. (See two of these in pl. 22, figs. 2 and 3.)

Nearly all of these structures have one flattened side with a sculptured surface, but without distinct pattern. The pits and grooves forming the sculpture are most pronounced in the center of each ossicle. From the position of some few of these that still remain attached to the cervical vertebrae by matrix, I am led to believe that the flat, sculptured face represents the external side shown in plate 22, figure 2. If this be correct the patches of ossicles present on either side of the neck, as shown in plates 2 and 3, *o*, have their internal surfaces uppermost (pl. 22, fig. 3). There is no positive evidence to show that they were confined to the under side of the jaws and throat as indicated by Marsh in his restoration of *Stegosaurus* (pl. 32, upper figure). From the position of those found with No. 4934, it would appear more probable that they covered the sides of the neck from the base of the erect plates downward, scattering, if at all, on the ventral areas, this region being protected by softer skin without bony scutes as in most modern reptiles.

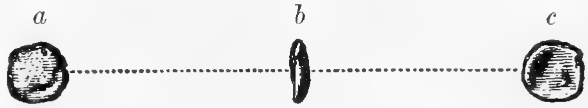

Fig. 55.—Dermal ossicle of Stegosaurus ungulatus Marsh. $\frac{1}{6}$ nat. size. *a*, Superior view; *b*, side view; *c*, inferior view. If the scale is correctly given this is an exceptionally large ossicle. After Marsh.

After a careful comparison of the *Heloderma* skull and its investing skin tubercles (compare figs. 1, 2, and 3, pl. 22) with those of *Stegosaurus*, it appears probable that these ossicles formed a similar investiture of the superior portion of the Stegosaurian cranium. There may have been evidence bearing on the above suggestion, but when the skull came into my hands it had been entirely divested of its matrix, thus destroying all traces of closely associated ossicles.

That these extended to other parts of the body is shown by ossicles found near the tenth and eleventh vertebrae and still others attached to the sixteenth vertebra, and more posteriorly two were found at the base of the tenth plate near its posterior border. That they did not form a continuous investiture of the sides of the animal is shown by their absence from the matrix between the ribs of the left side and the underlying dorsal armor, for surely the skin must have been present here when the carcass was entombed.

None of the isolated dermal structures figured by Marsh have been recognized with any National Museum specimen (fig. 56).

Nuchal plates.—The plates borne upon the neck immediately posterior to the skull are small, thin, vertically elongated, with roughened basal ends, without material transverse expansion, except in very old individuals. In specimen No. 4934 there are five of these small elongated plates as shown in plate 14. These gradually increase in height from front to back. As shown by No. 7615 (pl. 23, figs. 2 and 3), they are flattened on one side, probably the external, and slightly convex antero-posteriorly on the opposite side. The depth of the insertion of these plates in the skin appears to be indicated by an abrupt transverse constriction some 40 mm. above the basal end, well shown in figure 57, *g*. The character of the surface of this portion is also changed, inasmuch as the vascular grooves of the upper surfaces end abruptly at the point of contraction. In other specimens this surface is roughened with fine interrupted ridges of bone, their general trend being antero-posteriorly. In some of the above plates there is a slight transverse beveling of the lower end, and all agree in having one large foramen leading up into the interior of the bone.

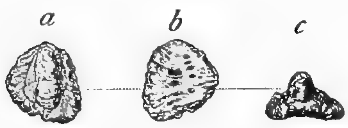

Fig. 56.—Tubercular spine of Stegosaurus ungulatus Marsh. $\frac{1}{12}$ nat. size. *a*, Superior view; *b*, inferior view; *c*, end view. After Marsh.

Dorsal plates.—The small elongated plates are succeeded by larger more or less oval plates, with transversely expanded bases, of very short fore and aft extent as compared with the longitudinal diameter of the upper portion, apparently a provision for greater freedom of movement such as would be required in the region of the shoulders (pl. 23, figs. 4, 5, and 6). In specimen No. 4934 there are four of these oval plates with bases cleft longitudinally. These increase rapidly in size, as is shown in plate 14, Nos. 6 to 8. The bases of these plates are somewhat asymmetrical, with exterior and interior surfaces about equally rugose. The asymmetry of the bases would indicate that the plates were inclined slightly outward from the perpendicular when held in the skin. As in those plates on the anterior portion of the neck the external side is flattened, while the internal is slightly convex antero-posteriorly. Other specimens, as No. 7584 (pl. 23, fig. 5), show similar plates to have transversely enlarged bases, but without median cleft.

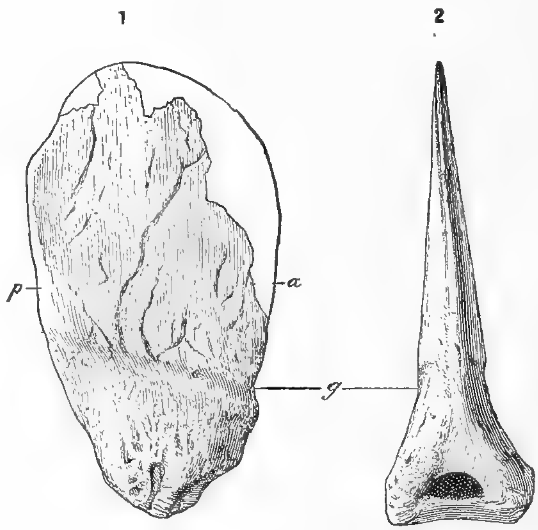

Fig. 57.—(1) Side and (2) posterior views of nuchal plate of Stegosaurus sulcatus Marsh. Type. Cat. no. 4937, U.S.N.M. $\frac{1}{3}$ nat. size. *a*, Anterior border; *g*, groove showing depth of insertion in the integument; *p*, posterior border.

The oval plates are succeeded by two or more of a subrectangular outline with rugose bases having but little transverse thickening, but not cleft longitudinally except in young individuals. Their approximate shape is shown well in plate 14, although some of the upper portion is missing from plates 10 and 11 (pl. 14); these are in turn followed by the thin subtriangular plates of the sacral and anterior caudal region. Good examples of this latter style are shown in plate 24, figures 3 and 4. In these plates I am unable to find differences that would enable one to determine the exterior from the interior surfaces. The bases are symmetrical, both surfaces equally rugose and evenly covered with vascular grooves.

Caudal plates.—In the consideration of the remaining dermal structures of the tail a second specimen, No. 4714, in the National Museum supplements the one just described to such an extent that it is possible to give an accurate account of the entire dermal series.

This specimen consists of an articulated series of 44 caudal vertebrae with the plates of one row and the dermal spines in sequential position (fig. 58). The relative positions of these elements as found was determined from an accurately drawn map (fig. 58, also Diagram 5, map of quarry 13, pl. 37) made at the time the fossil was collected.

A comparison of these vertebrae with those of the articulated skeleton (No. 4934) indicates that between 5 and 7 vertebrae are lacking from the proximal end to complete the caudal series. It was also observed that the largest plate occupied the same relation to the tail as the corresponding plate in the *Stegosaurus stenops* skeleton. (Compare p_{14}, pl. 3, with pl. 13.) This apparently establishes the position of the largest plate to be above the base of the tail, as correctly placed by Marsh in his first restoration (pl. 32, upper figure), and not, as in later conceptions, above the sacral region.

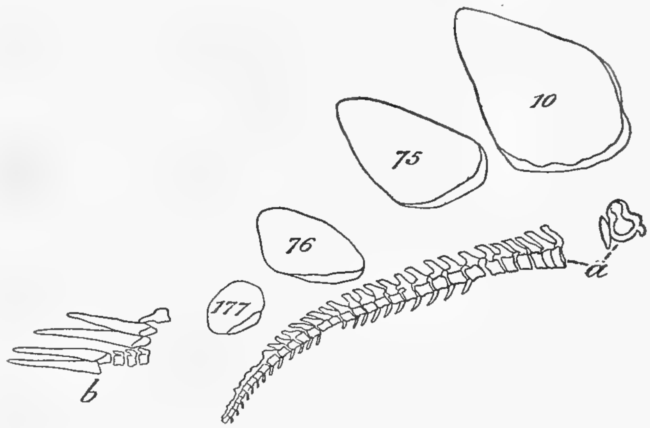

Fig. 58.—Sketch from diagrams 5 and 7 of map of quarry 13 showing relative positions of dermal plates and caudal vertebrae in tail of Stegosaurus stenops. Cat. no. 4714, U.S.N.M. *a*, Anterior caudal vertebrae; *b*, dermal spines with tip of tail (see plate 14). 10, 75, 76, and 177 original quarry numbers of dermal plates.

Posterior to this plate and in regular order are three other plates of diminishing dimensions, as in No. 4934. (Pl. 24, figs. 4, 3, 2, and 1; compare with caudal plates No. 4934, pl. 2.)

Measurements demonstrated the fact that the length of the remaining articulated caudals, i. e., to a point where the dermal spines attach, exceeded by 8 inches (206 mm.) only, the total longitudinal diameter of the three plates, barely enough to account for the interspaces between the plates. This would appear to show that there were only three plates posterior to the largest of the series, or six for the two rows. Adding this number to the 14 actually shown in position more anterior to them would give us 20 as the total number of these flat plates, whereas Marsh, in his first restoration, has 12 in a single row (pl. 32, upper figure), Lucas 30, 24 and 22, respectively, in his restorations (pls. 33 and 34), and Lull 28 in the latest conception (pl. 36).

It is of interest to note that the plates of specimens Nos. 4714 and 4934 when correlated on the basis of their relative positions as found in the field (compare pl. 2 and fig. 58) agree very closely in measurements and in general contours. This correlation is shown below:

Correlation of plates of the tail in two specimens.

	No. 4714.			No. 4934.	
	Greatest longitudinal diameter.	Greatest vertical diameter.		Greatest longitudinal diameter.	Greatest vertical diameter.
	mm.	*mm.*		*mm.*	*mm.*
No. 95	650	580	P. 13	695	....
No. 10	770	700	P. 14	785	760
No. 75	660	620	P. 15	630	627
No. 76	420	320	P. 16	410	335
No. 177	295	210	P. 17	290	225

On the evidence of these two individuals it would appear that there were only two of the sharp-edged overhanging distal plates (pl. 24, figs. 1 and 2) on the tail, whereas the Yale mount shows six. In the first restoration by Marsh none of this type were indicated (pl. 32, upper figure). Had such a plate been inserted by him it would have necessitated the removal of the two anterior pairs of spines in order to make room for it, but such a change would have been in accord with the sequential order of these bones, as shown by the evidence presented here. That the diminution in the size of the plates from the largest to the smallest was a regularly graduated change and not an abrupt transition, as seen in the Yale mount (pl. 36), is abundantly shown.

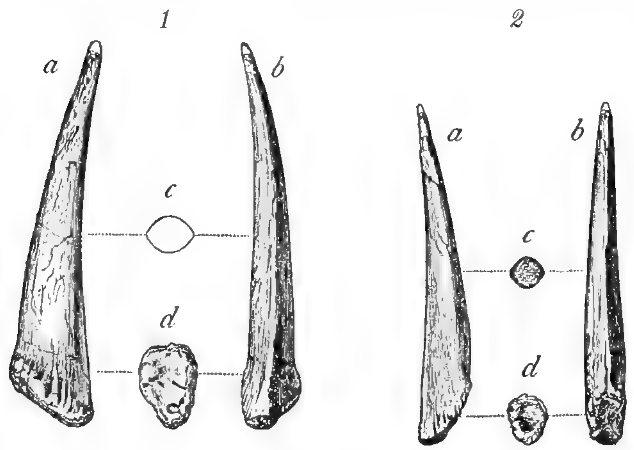

FIG. 59.—(1) LARGE DERMAL SPINE OF STEGOSAURUS UNGULATUS MARSH. 1/12 NAT. SIZE. *a*, SIDE VIEW; *b*, FRONT VIEW; *c*, SECTION; *d*, INFERIOR VIEW OF BASE. (2) SMALLER CAUDAL SPINE OF SAME. *b*, POSTERIOR VIEW; OTHER LETTERS SAME AS IN NO. 1. AFTER MARSH.

I can not accept Lull's[1] statement, when, in discussing the distal plates of the tail, he says "the base being embedded in the muscles between the neural spines and

[1] Verhandlungen des VIII. Internationalen Zoologen-Kongress zu Graz, 1912, p. 676.

the vertebral centra," for surely were they so attached the function of these muscles would be destroyed. Like all the other dermal structures of this animal, I believe these bases were embedded entirely within the thick skin.

Dermal spines.—Of the remaining dermal structures only the spike-like spines, situated near the end of the tail, are yet to be considered. The number of these spines, with the possible exception of *S. ungulatus*, appears not to have exceeded four, arranged in two pairs. Lucas was the first to reach this conclusion from the evidence of two specimens which showed them in place (pls. 15 and 16).

That four is the correct number is now substantiated by the evidence shown by six individuals, five of which are in the National Museum. The foremost pair is always the larger of the two. I have before me 30 of these spines, representing at least 10 individuals. These specimens exhibit a considerable variety of shapes and sizes, ranging from 7 inches (175 mm.) long in a young individual (pl. 25, fig. 2) to more than 3 feet (985 mm.) in the type of *S. longispinus*, an adult specimen (fig. 60, *A*). All agree in having oblique bases, but in the expansion of this end they vary from the nonexpanded ends of *S. longispinus* and *S. stenops* to the exceedingly large bases of *S. sulcatus* (fig. 60). The spines of the young individuals (pl. 25, figs. 1 and 2) are without rugose roughening of the bases, but the adults are very rough, reaching their maximum development in *S. sulcatus* (pl. 18).

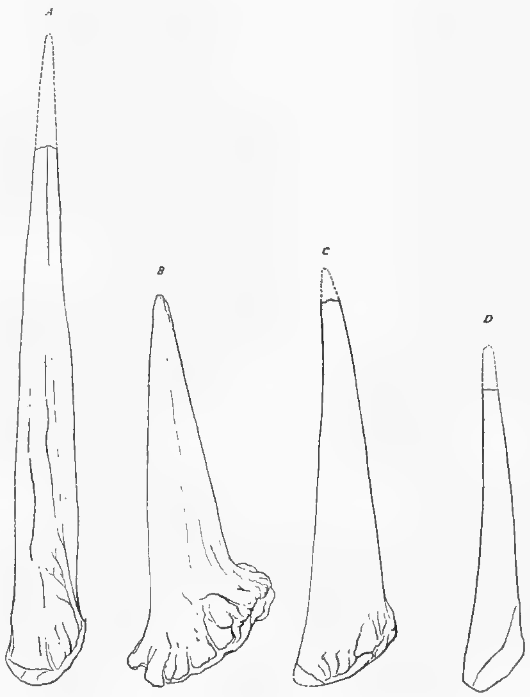

Fig. 60.—Dermal tail spines. *A*, Stegosaurus longispinus. Type. D 54, University of Wyoming collection. *B*, Stegosaurus sulcatus. Type. Cat. no. 4937, U.S.N.M. *C*, Stegosaurus ungulatus. Cat. no. 6099, U.S.N.M. *D*, Stegosaurus stenops. Type. Cat. no. 4934, U.S.N.M. All figures $\frac{1}{15}$ natural size.

All of the spines have the surface of the oblique end shallowly concave dorso-ventrally. On this end there is always one large pit, which leads up into the interior of the shaft. (See *f*, fig. 65.) It probably transmitted a blood vessel supplying nourishment to cells, which, as shown by various cross-sections, is very cancellous, implying a bone of light weight. The spines gradually taper, except in *S. longispinus*, from the expanded bases to the subacute apex, the lower two-thirds being characterized by sharp edges fore and aft; but in many of the specimens the upper third is subcircular in cross-section (fig. 59, *c*). Like the flat plates, the external surfaces are covered by vascular impressions (pls. 16 and 17).

The anterior pair in all instances give evidence of having been more deeply embedded in the skin than the posterior pair. That these spines were often broken or injured in life is shown by three specimens, two of which have the top broken off and healed, while the third (No. 6646) appears to have suffered other injury, as shown by the curved and thickened condition of the shaft.

The bases of the posterior pair in an articulated tail, as shown by two individuals (pls. 15 and 16),[1] would be subadjacent to the seventh, eighth, and ninth caudals, counting back from the tip of the tail, while the anterior pair would be above the twelfth, thirteenth, and fourteenth vertebrae.

The relative difference in length between an anterior and posterior spine of the same individual is shown in the table of measurements below:

Measurements of spines.

	Greatest length.	
	Anterior spine.	Posterior spine.
	mm.	*mm.*
No. 4937, *Stegosaurus sulcatus* Marsh	635	522
No. 6099, *Stegosaurus ungulatus* Marsh	598	577
No. ...., *Stegosaurus* sp.	446	384
No. 4288, *Stegosaurus stenops* Marsh	300	280

Arrangement of the Armor.

The most striking fact concerning the arrangement of the armor and one convincingly demonstrated by this specimen (No. 4934) is that the plates of opposite sides are not arranged in pairs, but those of one side alternate with those of the other (pl. 14).[2] This feature has been the subject of considerable speculation and discussion among vertebrate paleontologists and is one upon which directly opposite views are held.

Marsh, in 1891, made the first pictorial restoration[3] of *Stegosaurus* (pl. 32, upper figure) and placed the series of plates in a single row along the median line of the neck, back, and tail, with four pairs of spines near the end of the tail. Lucas, in 1901, published the next restoration,[4] and was the first to show the plates arranged in pairs (pl. 33, lower figure). Later, in a statuette prepared under his direction, the plates were made to alternate along the back and the caudal spines were reduced from four to two pairs. (See pl. 34, lower figure.)

The latest conception, as exemplified by a recently mounted skeleton[5] in the Peabody Museum of Yale University (pl. 36, lower figure), reconstructed under the direction of Prof. R. S. Lull, and a small model of the animal in the flesh has been made after this mount (pl. 36, upper figure).[6] In this a return to the paired

[1] The positive evidence given by specimens in the National Museum as to the proper position of the spike-like spines near the end of the tail in Stegosaurian dinosaurs would indicate that Nopcsa was in error in placing similar spines of *Stegosaurus priscus* in an upright position on the scapular region of that animal. (See F. Baron Nopcsa, Geol. Mag., vol. 8, No. 4, 1911, p. 152, fig. 9.)

[2] Lucas was the first to recognize this arrangement. In his Animals Before Man in North America, 1902, p. 171, he says of the plates: "They were placed far enough apart to permit freedom of motion and appear to have been arranged alternately and not in pairs."

[3] Amer. Journ. Sci., vol. 42, 1891, pp. 179–181, pl. 9.

[4] Animals of the Past, 1901, fig. 24.

[5] Amer. Journ. Sci., vol. 30, 1910, pp. 361–377, figs. 2, 3, and 4.

[6] Idem, pl. 11.

arrangement of the plates is shown and the original idea of four pairs of spines retained.

The type of *Stegosaurus stenops* (No. 4934) corroborates most conclusively Lucas's interpretation of the arrangement of the dorsal armor, and, except in one or two points, I would indorse his restoration (pl. 34, lower figure) as being in accord with the evidence shown by the specimens in the United States National Museum collections.

The reasons given by Lucas for the alternating position, as stated in an unpublished manuscript, were twofold: First, that the plates *did* alternate as they lay embedded in the rock, and, second, that no two of them were precisely similar in shape or dimensions. Opposed to this argument, Lull has advanced the opinion "that the position of the plates in the rock is hardly conclusive, for the series might easily have shifted forward or backward slightly during maceration or in the subsequent movement of the rock."

A careful study of this series of plates leads to the belief that such a shifting has not taken place. For example, part of this series, as shown in plates 2, 4, and 14, has fallen to the left and lies under the body of the animal, while the posterior plates are approximately in position above the pelvic region, yet both sections show the same alternating arrangement. Moreover, there is a remarkable uniformity of the overlapping of plates of one side upon those of the opposite row—that is, the middle point of the underlying plates, taken longitudinally, is, in nearly all instances, in the center of the interspace between the plates of the uppermost series (pl. 14). This exact spacing of the plates would indicate that they remained attached to the skin until becoming fixed in the position in which we now see them. If this be true, it is difficult to explain the possibility of bringing the plates of opposite sides into alignment, since in order to do so, it would be necessary to shift the small anterior ones only a few inches, while the larger plates would need to be moved a foot or more. Certainly, if remaining attached to the skin in sequential order, as the evidence appears to show, had the plates of one side shifted, all would have moved in the same direction and approximately similar distances.

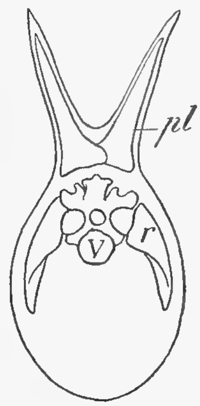

Fig. 61.—Section of the neck of Stegosaurus. *pl*, Dermal plate; *r*, cervical rib; *V*, vertebra. Modified from Lull.

As to the argument that the shifting took place by the movement of the rock—that view seems absolutely untenable, since nowhere, either in the specimen or in attached rock, is there any indication of lateral shearing.

This specimen is surely another example of the truth so aptly put by the late Prof. Charles E. Beecher[1] when he observes that "*the positive information conveyed by the finding of a foot or of any other portion of a skeleton, with the bones in a sequential position in the rock, is of far greater anatomical value than any number of expert opinions.*"

That the bases of the plates of opposite rows, anterior to the sacrum, were nearer together on the median line of the back (fig. 61) than has been represented in any of the restorations of *Stegosaurus* is indicated by the evenness of the bases

[1] Trans. Conn. Acad. Sci., vol. 11, 1902, p. 311.

of the plates of No. 4934, as shown in plate 14. Had there been considerable space between them in folding back, the plates of one side would have their bases projecting beyond those of the other, a distance approximately equal to the space between the bases in life.

The internal lip of the transversely expanded bases of the plates of opposite rows on the neck and anterior dorsal region, in specimen No. 4934, appear to have overlapped the median line of the back as shown in figure 61. In other words, the expanded portion of the plates of one row are in the center of the interspace of those of the opposite side, so that the point where the plates emerged from the thick skin of the back must have been but very little off the middle line of the back.

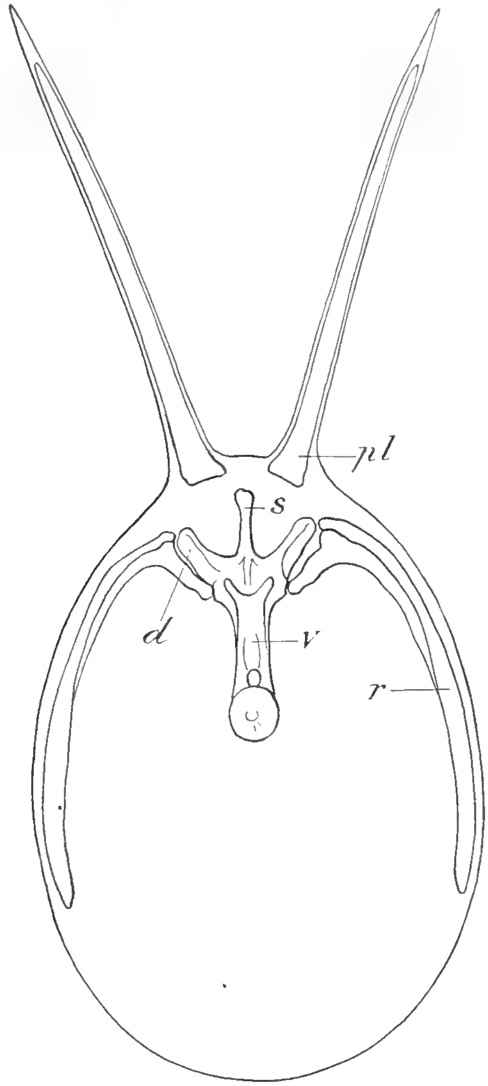

FIG. 62.—SECTION OF THE TRUNK OF STEGOSAURUS. *d*, DIAPOPHYSIS; *pl*, DERMAL PLATE; *r*, RIB; *s*, SPINE; *V*, VERTEBRA. MODIFIED FROM LULL.

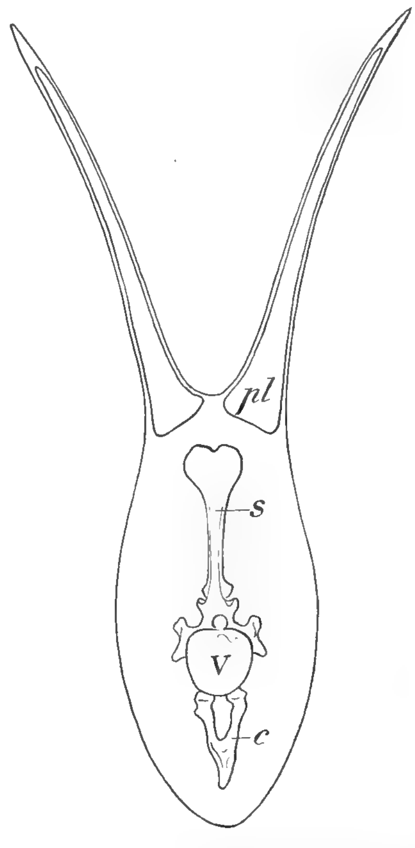

FIG. 63.—SECTION OF THE PROXIMAL PART OF THE TAIL OF STEGOSAURUS. *c*, CHEVRON; *pl*, DERMAL PLATE; *s*, SPINE; *V*, VERTEBRA. MODIFIED FROM LULL.

The evidence in favor of an erect rather than a procumbent position for the plates, is shown by the fact that both surfaces are covered with blood-vessel impressions and no indication of either having been in contact with the creature's flesh. On the other hand, the base is extremely rugose and the only part adapted for insertion in the skin or for the attachment of other connective tissues. Furthermore, specimen No. 4934 shows (pl. 2) the plates above the pelvic region retained in the rock in such an erect posture, while those more anteriorly are folded back underneath the skeleton, a thing manifestly impossible in plates naturally procumbent on either side.

The rugose character of the bases of the plates, as well as of the spines, implies an extremely thick skin in which these were embedded. The ossicles, plates, and spines are all strictly dermal structures, for in no instance is there indication of articulation with subadjacent bones. The vasicular grooves and impressions which mark the surfaces of both plates and spines indicate that they were inclosed by a horny covering which in life would somewhat increase their size, as shown in figures 61, 62, 63, and 64.

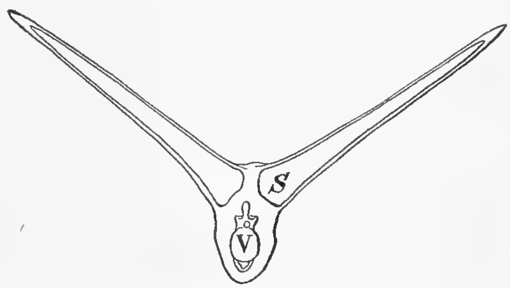

Fig. 64.—Section of distal portion of the tail of Stegosaurus. *S*, Dermal spine; *V*, vertebra. Modified from Lull.

The primary function of this armor must have been that of defense, not, perhaps, in the sense of use as actual defensive instruments, but protective to the extent of giving the animal a most formidable appearance. It is true that the spines near the end of the tail may have been of some use as defensive weapons, but they could have been of comparatively little value for offensive purposes, although it has been contended that this was their chief function. To be effective in such a capacity, the tail should be flexible to a considerable degree, and this does not appear to have been the case. In the first place, the caudal vertebrae are joined by closely fitting zygapophyses, which are present nearly to the distal end of the tail; moreover, the articular ends of the centra are rather abruptly truncated, not rounded or beveled, as in those animals having a flexible tail. These structural details, combined with the series of plates along the dorsal side, must have made the tail of *Stegosaurus a heavy, stiff appendage, incapable of more than cumbersome lateral movements and wholly unsuited for use on an active enemy.*

The facts relating to the dermal armor which now appear to be established from this study of the Stegosaurian remains in the United States National Museum are:

(1) **That the armor of the neck, back, and tail was formed by two rows of erect plates, the elements of one row alternating with those of the other.**

(2) **That the total number of plates in the two rows was not less than 20 and not more than 22.**

(3) **That the position of the largest plate of the series appears to be above the base of the tail and not over the pelvis.**

(4) **That the usual number of dermal spines on the tail is four, arranged in two pairs.**

Measurements of dermal plates of Stegosaurus stenops No. 4934. Type.

Plate No. (counting backward from the skull).	Greatest height.	Greatest diameter anteroposteriorly.	Greatest length anteroposterior of roughened base.	Greatest transverse width of roughened base.	Plate No. (counting backward from the skull).	Greatest height.	Greatest diameter anteroposteriorly.	Greatest length anteroposterior of roughened base.	Greatest transverse width of roughened base.
	mm.	*mm.*	*mm.*	*mm.*		*mm.*	*mm.*	*mm.*	*mm.*
[1] 1	97	60	....	....	10	[2] 610+	535	423	40
2	119	45	36	17	11	....	560	....	55
3	134	82	....	....	12	....	610	590	....
4	172	75	55	....	13	....	695	590	....
5	185	76	60	....	14	760	785	720	87
6	....	191	96	....	[3] 15	627	630	450	105
7	....	[2] 323	205	105	[3] 16	335	410	300	....
8	....	430	180	....	[3] 17	225	290	220	50
9	[2] 610+	....	....	....	[4] 18	537	....	115	65

[1] Plates with odd numbers pertain to left row, even to the right row.
[2] Estimated.
[3] Dermal elements not in sequence.
[4] Dermal spine.

Position of plate centers in relation to underlying vertebrae.

Plate No. (counting backward from the skull).	Vertebrae in vertebral column.	Plate No. (counting backward from the skull).	Vertebrae in vertebral column.	Plate No. (counting backward from the skull).	Vertebrae in vertebral column.
1	Atlas.	6	Sixth and seventh (between).	10	Seventeenth.
2	Axis.	7	Eighth.	11	Twentieth.
3	Third and fourth (between).	8	Tenth.	12	Twenty-fourth.
4	Fourth and fifth (between).	9	Thirteenth and fourteenth (between).	13	Second caudal.
5	Fifth and sixth (between).			14	Eighth caudal.

Morphology of Plates.

Lull [1] has given the following interesting explanation of the development of the dermal plates:

Upon comparing a given plate with a scute of a crocodile or that of such a dinosaur as *Ankylosaurus* or *Stegopelta* it at once becomes apparent that the great expanse of the first represents merely an enormous hypertrophy of the median ridge or carina of the latter. This expanse is practically alike on both sides, with blood-vessel impressions and no indication that either one side or the other was in contact with the creature's flesh. On the other hand, the base, the morphological equivalent of the body of the scute in crocodile or *Ankylosaur*, is always somewhat asymmetrical, even when divided into two portions by the longitudinal cleft of those of the cervical region. This base in the great dermal plates particularly is extremely rugose, implying either a heavy pad of cartilage or a very thick connective tissue between the plate and its underlying skeletal support. There is in no instance any indication of a true articulation with the subadjacent bones.

[1] Amer. Journ. Sci., vol. 29, 1910, pp. 204-205.

THE GENUS STEGOSAURUS.

In a paper published in 1877 [1] Prof. O. C. Marsh proposed the genus and species *Stegosaurus armatus*, referring it to the new order Stegosauria, which was not defined.

In 1878,[2] Prof. E. D. Cope, on meager material, proposed the genus *Hypsirophus* and briefly described the species *H. discursus*, and in 1879 [3] described a second species, *H. seeleyanus*. Both of these species were based upon specimens from the Jurassic of Colorado and later were referred by Marsh and other authorities to the genus *Stegosaurus*.

In 1879 [4] Marsh briefly described the species *S. ungulatus*. In 1880,[5] without comment, he refers to the Stegosauria as a suborder and for the first time defines the genus *Stegosaurus* as follows:

(1) All the bones of the skeleton are solid.

(2) The femur is without a third trochanter.

(3) The crest on the outer condyle of the femur, which in birds separates the heads of the tibia and fibula, is rudimentary or wanting.

(4) The tibia is firmly coössified with the proximal tarsals.

(5) The fibula has its larger extremity below.

Marsh briefly described the skull, brain, limbs, dermal spines, and plates. Teeth were also described, but were afterwards [6] discovered to pertain to the Sauropod dinosaur *Diplodocus*.

In February, 1881,[7] Marsh recorded additional information concerning the brain, pelvic arch, and limbs. In the same communication the species *S. affinis* was named, but inadequately defined. In a paper published in May of the same year [8] the following classification was proposed by him for the genus *Stegosaurus:*

Suborder Stegosauria.

Family Stegosauridæ.

Genus Stegosaurus.

In 1882,[9] Marsh again raised the rank of the Stegosauria to an order and at the same time defined it, placing under it two families, the Stegosauridæ and the Scelidosauridæ. His definition is as follows:

Order STEGOSAURIA

Herbivorous; feet plantigrade, ungulate; five digits in manus and pes; second row of carpals unossified. Pubes projecting free in front; postpubis present. Forelimbs very small; locomotion mainly on hind limbs. Vertebræ and limb bones solid. Osseous dermal armor.

(1) Family Stegosauridæ. Vertebræ biconcave. Neural canal in sacrum expanded into large chamber; ischia directed backward, with sides meeting on median line. Astragalus coössified with tibia; metapodials very short.

Genera: *Stegosaurus* (*Hypsirhophus*), *Diracodon*, and, in Europe, *Omosaurus* Owen.

(2) Family Scelidosauridæ. Astragalus not coössified with tibia; metatarsals elongated; four functional digits in pes. Known forms all European.

Genera: *Scelidosaurus*, *Acanthopholis*, *Crataeomus*, *Hylaeosaurus*, *Polacanthus*.

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[1] Amer. Journ. Sci., vol. 14, 1877, p. 513.
[2] American Naturalist, vol. 12, 1878, pp. 188, 189.
[3] Idem, vol. 13, 1879, pp. 401, 402.
[4] Amer. Journ. Sci., vol. 18, 1879, p. 504.
[5] Idem, vol. 19, 1880, pp. 251-259, pls. 6-11.
[6] Amer. Journ. Sci., vol. 26, 1883, p. 85.
[7] Idem, vol. 21, 1881, pp. 167-170, pls. 6-8.
[8] Idem, vol. 21, 1881, p. 423.
[9] Idem, vol. 23, 1882, pp. 83, 84.

In 1884 [1] this classification was republished, without change except in the definition of the order the additional character "cervical ribs free" was inserted.

In 1887 [2] the discovery of additional specimens enabled Marsh to contribute further to the knowledge of the skull and dermal armor. In the same paper the three new species *Stegosaurus stenops*, *S. sulcatus*, and *S. duplex* were briefly designated. The close relationship of the Stegosauria with the Ornithopoda was recognized and a list of important characters wherein they differ was given.

The first restoration of *Stegosaurus* was published by Prof. Marsh in 1891 [3] and additional characters relating to the osteological structure and life appearance of the animal were noted.

In 1893 [4] Lydekker republished Marsh's restoration of *Stegosaurus* and inadvertently referred it to the genus *Hypsirophus*. Later in the same publication (p. 438), Marsh calls attention to this error.

In 1895 [5] Marsh published a revised definition of the Stegosauria, here again called a suborder. With a few emendations these definitions were repeated in 1896 [6] in his Dinosaurs of North America.

In 1900 [7] Lydekker referred the two British species *Omosaurus armatus* and *O. hastiger* to the genus *Stegosaurus* quite oblivious of the fact that the genus already contained an American species *S. armatus*. Lucas in 1901 [8] described the species *S. marshi* and in the following year it was referred by him to the new genus *Hoplitosaurus*,[9] and in the same article the generic name *Dacentrurus* was proposed for Owen's genus *Omosaurus*, preoccupied.

In the same year Lucas [10] contributed further to our knowledge of *Stegosaurus*, particularly as to the life appearance of the animal, presenting a restoration by Charles R. Knight.

In 1902 [11] Hay created the superfamily Stegosauridea and under the genus *Stegosaurus* the following species were recognized: *S. affinis*, *S. armatus*, *S. discursus*, *S. duplex*, *S. seeleyanus*, *S. stenops*, *S. sulcatus*, and *S. ungulatus*.

In that year Lucas [12] announced for the first time the "probable" alternating arrangement of the dermal plates of opposite rows.

Zittel [13] defined the genus *Stegosaurus* thus:

Skull narrow and depressed, relatively very small, and brain cavity in proportion to size of the body more diminutive than in any other land vertebrate. Orbits small; laterally directed; supratemporal vacuities small and rounded; nasals nearly half as long as the skull. Mandibular ramus deep, pierced by a lateral foramen. Teeth very numerous, bluntly pointed, more or less spatulate in form, loosely socketed in a single functional series. Vertebræ slightly amphicœlous or with flat ends, the cervicals with short ribs and dorsals with much elevated neural arches, on which the stout dorsal ribs

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1 Nature, vol. 31, 1884, p. 68.
2 Amer. Journ. Sci., ser. 3, vol. 34, 1887, pp. 413–417, pls. 6–11.
3 Idem, ser. 3, vol. 42, 1891, pp. 179–181 with pl. 9: also Geol. Mag., ser. 3, vol. 8, 1891, pp. 385–387, pl. 10.
4 Nature, vol. 48, 1893, p. 304, fig. 3.
5 Amer. Journ. Sci., ser. 3, vol. 50, 1895, pp. 496–497.
6 16th Ann. Rept. U. S. Geol. Surv., pt. 1, 1894–95.
7 Cat. of Fossil Reptiles and Amphibia, vol. 4, 1900, p. 252.
8 Proc. U. S. Nat. Mus., vol. 23, 1901, pp. 591, 592, pls. 23, 24.
9 Science, vol. 16, 1902, p. 435.
10 Animals of the Past, 1901, pp. 106, 107, fig. 24.
11 Bull. 179, U. S. Geol. Survey, 1902, pp. 495, 496.
12 Animals before Man in North America, 1902, p. 171.
13 Text-book Paleontology, English Translation, vol. 2, 1902, pp. 241, 242.

are borne. Sacrum of four fused vertebræ, sometimes with one or more lumbars added on in front; thin neural canal enlarged to ten times the capacity of brain cavity. Anterior caudal vertebra the largest in the column, and with strong chevron bones. Forelimb short and stout, ulna with large olecranon process. Manus short, apparently pentadactyl. Femur large and straight, without inner trochanter; tibia and fibula much shorter. Astragalus and calcaneum fused with opposing bones of the crus; pes tridactyle, digit No. I rudimentary and No. V wanting. Dermal armour consisting of two rows of flattened bony plates extending from the back of the head well down the tail, the largest plates situated immediately over the pelvis. Four spines on the tail, and throat protected by a shield of irregular ossicles.

In 1910[1] Lull contributed an article on the Armor of Stegosaurus, in which he concluded that the plates were arranged in two rows, but in pairs. Later, in the same year,[2] he published a picture of the first mounted skeleton of the genus and a life restoration based upon the mount. The actual assembling of the bones brought about several changes from the previously accepted conceptions of the animal. It was also shown that the species *S. duplex* is not valid, and that the type-specimen of that species is one of the cotypes upon which Marsh founded the species *S. ungulatus.*

Zittel,[3] in 1911, included all of the armored Dinosauria under the family Stegosauridæ and redefined the genus *Stegosaurus.*

As shown by the recent study of the extensive collection of Stegosaurian remains in the United States National Museum, the earlier definitions of the genus, as briefly reviewed above, are in several respects in error. Such inaccuracies as have been detected can be attributed in most instances to the incompleteness of the material at the command of the earlier authors.

In the light of new and better preserved specimens, the genus *Stegosaurus* may now be characterized as follows:

Generic characters.—**Skull relatively very small and brain cavity in proportion to size of the body more diminutive than in any other land vertebrate. Supraorbital region composed of two separate bones. Ramus deep and without lateral foramen. Dentition $\frac{23+}{23}$. Teeth extremely small and weak. Vertebrae slightly amphicœlus, or with flat ends; dorsals with much elevated neural arches. Neural canal in sacrum enlarged to many times the capacity of the brain. Sacrum and lateral processes entirely roofed over by bone. Anterior caudal vertebra largest in the column. Ulna (in adults) as long as humerus, with large olecranon process. Manus short, pentadactyle. Phalangial formula of digits III and IV apparently reduced. Femur long, straight, fourth trochanter vestigal, with or without lesser trochanter. Tibia having greatest diameter of two ends in the same plane. Pes tetradactyle, digit IV consisting of a vestigal metatarsal, digit V wanting. Dermal armor consisting of two rows of erect, flattened plates extending from back of head to distal fourth of tail. Plates of opposite rows alternating. Four dermal spines near end of tail.**

Stegosaurus armatus is the type-species of the genus, and was founded upon a specimen from the Morrison beds near Morrison, Colorado. Fourteen species have

[1] Amer. Journ. Sci., vol. 29, 1910, pp. 201–210, figs. 1–11.
[2] Idem, vol. 30, 1910, pp. 361–377, figs. 1–10.
[3] Grundzüge der Palaeontologie, vol. 2, 1911, pp. 293–295.

been referred to this genus, ten of which are American and four European. Of these, one appears to be a *nomen nudum*, one is a synonym of a species already described, and three others have been referred to other genera. Now only nine valid species are recognized, and a revision of these will probably bring about a further reduction.

An alphabetical list of the species, location of the type, and its catalogue number is given below:

Stegosaurus affinis Marsh, 1881 (*nomen nudum*) (Yale University Museum).

Stegosaurus armatus Marsh, Dec., 1877 (No. 1850, Yale University Museum).

Stegosaurus (*Omosaurus*) *armatus* (Owen), 1876 (No. 46013, British Museum)=*Dacentrurus armatus* (Owen).

Stegosaurus (*Hypsirophus*) *discurus* (Cope), Mar., 1878 (Amer. Mus. Nat. Hist.).

Stegosaurus duplex Marsh, Nov., 1887 (No. 1858, Yale University Museum)=*S. ungulatus*.

Stegosaurus durobrivensis Hulke (British Museum).

Stegosaurus (*Omosaurus*) *hastiger* (Owen), 1877 (Nos. 46320, 46321, 46322, British Museum)=*Dacentrurus hastiger* (Owen).

Stegosaurus longispinus Gilmore, 1914 (No. D54, Univ. of Wyo.).

Stegosaurus marshi Lucas, Feb., 1901 (No. 4752, U. S. Nat. Mus.)=*Hoplitosaurus marshi* (Lucas).

Stegosaurus priscus Nopcsa, Mar., 1911 (No. R. 3167, British Museum).

Stegosaurus (*Hypsirophus*) *seeleyanus* (Cope), June, 1879 (Amer. Mus. Nat. Hist.).

Stegosaurus stenops Marsh, Nov., 1887 (No. 4934, U. S. Nat. Mus.).

Stegosaurus sulcatus Marsh, Nov., 1887 (No. 4937, U. S. Nat. Mus.).

Stegosaurus ungulatus Marsh, Dec., 1879 (No. 1853–1858, Yale Univ. Museum).

Description of Species.

With one exception the following descriptions are based on type-specimens in the United States National Museum. The reference to the original description is followed by citations of the more important literature which further elucidates the species under consideration.

The parts of the skeleton constituting the type are listed, and the locality, geological horizon, name of the collector, and catalogue number are given in each case, so that a permanent record of the type material will hereafter be available.

In the discussion of the species the original description will be quoted in its entirety, followed by a historical account of the specimen and a further description of such parts of the skeleton as seems necessary to supplement the original text.

STEGOSAURUS STENOPS Marsh.

Plates 2–9 and 11–17, 19; 22, fig. 3; 23, figs. 2, 3, 4, 6; 24.

Stegosaurus stenops Marsh, Amer. Journ. Sci. (3), vol. 34, 1887, pp. 414, 415, pl. 6; Geol. Mag. (3), vol. 5, 1888, pp. 11–15, pl. 1.—Lydekker, Cat. of Fossil Reptilia and Amphibia in the British Museum, pt. 1, 1888, p. 176, fig. 31.—Zittel, Handbuch der Palaeontologie, vol. 1, 1890, p. 745, figs. 650, 654.—Marsh, Amer. Journ. Sci (3), vol. 39, 1890, p. 426, pl. 7, fig. 2; vol. 42, 1891, p. 179.—Cope, Trans. Amer. Philos. Soc., vol. 17, 1892, p. 18 (*Hypsirophus*).—Marsh, 16th Ann. Rept. U. S. Geol. Surv., pt. 1, 1896, p. 186, pls. 43 and 47, fig. 3; Mon. 27, U. S. Geol. Surv., 1897, p. 499, fig. 52.—Woodward, Outlines of Vertebrate Paleontology, 1898, p. 212, fig. 131.—Nopcsa, Földtani Kózlöny, Budapest, vol. 31, 1901, p. 215.—Hay, Bull. 179, U. S. Geol. Survey, 1901, p. 496.—Lull, Amer. Journ. Sci., vol. 29, 1910, pp. 206, 208; vol. 30, 1910, p. 373; Verhandlungen des VIII. Internationalen Zoologen-Kongresses zu Graz, 1910, p. 677.—Zittel, Grundzüge der Palaeontologie, pt. 2, 1911, p. 293, fig. 442.—Huene, Neues Jahrbuch, vol. 37, 1914, pp. 580, pl. 10.

Diracodon laticeps Marsh, Amer. Journ. Sci., vol. 24, 1887, p. 416, pl. 9; Geol. Mag. (3), 1888, pp. 11–15, pl. 3; 16th Ann. Rept. U. S. Geol. Surv., pt. 1, 1896, p. 193, pl. 51. (Not *D. laticeps* Marsh, 1881.)

Type-specimen.—Cat. No. 4934, U. S. N. M. A comparatively complete articulated skeleton. The parts preserved are listed below.

Skull.
Lower jaws.
Atlas.
Axis.
Twenty-five presacral vertebrae.
Three sacral vertebrae.
Twenty-two caudal vertebrae.
Five cervical ribs.
Twelve thoracic ribs (right).
Thirteen thoracic ribs (left).
Four chevron.
One scapula (left).
One coracoid (left).
Two humeri.
Two ulnae.
Two radii.
Four metacarpals (II, III, IV, V of left fore foot).
Two phalanges (proximal row digits III, IV, left fore foot).
One carpus (left).
One radiale (right).
Three metacarpals (right).
Five ? phalanges (right).
Two femora.
One tibia (right).
One fibula (right).
One astragalus (right).
One calcaneum (right).
Two ilia.
Two ischia.
Two pubes.
Seventeen dermal plates.
One dermal spine.
Numerous dermal ossicles.

Collected by Mr. M. P. Felch, 1885–1886.

Type-locality.—Quarry No. 1, Garden Park, near Canon City, Fremont County, Colorado.

Horizon.—Morrison, Upper Jurassic.

The original description, by Marsh, is as follows:

The skull of *Stegosaurus* is long and slender, the facial portion being especially produced. Seen from the side, with the lower jaw in position, it is wedge-shaped, with the point found by the premaxillary, which projects well beyond the mandible. The anterior nares are large and situated far in front. The orbit is very large and placed well back. The lower temporal fossa is somewhat smaller. All these openings are oval in outline and are on a line nearly parallel with the top of the skull. In this view the lower jaws cover the teeth entirely.

Seen from above, the wedge-shaped form of the skull is still apparent. The only openings visible are the supratemporal fossæ. The premaxillary bones are short above, but send back a long process below the narial orifice. The nasal bones are very large and elongate. They are separated in front by the premaxillaries and behind by anterior projections from the frontal bones. The prefrontals are short and externally join the postfrontals. The parietals are small and closely coössified with each other. Viewed from in front the skull and mandible present a nearly quadrate outline [pl. 9, fig. 1] and the mutual relations of the facial bones are well shown. In this view is seen also the predentary bone, a characteristic feature of the mandible in this genus. The lateral aspect of this bone is shown in figure 6 [pl. 5]. The teeth in this genus are entirely confined to the maxillary and dentary bones and are not visible in any of the figures here given. They are small, with compressed, fluted crowns, which are separated from the roots by a more or less distinct neck. The premaxillary and predentary bones are edentulous.

The present skull belongs to the type-specimen of a new and very distinct species, which may be called *Stegosaurus stenops*. The skull and nearly complete skeleton of this specimen, with nearly all the dermal armor in place, were found in almost the position in which the animal died.

This animal was much smaller than those representing the other species of this genus. Its remains were found by Mr. M. P. Felch, in the Atlantosaurus beds of the Upper Jurassic, in southern Colorado. In this geological horizon all the known American forms of *Stegosaurus* have been discovered.

History of the specimen.—The skeleton was collected by Mr. M. P. Felch during the years 1885 and 1886 from quarry No. 1 (pl. 1, lower figure) in Garden Park, Fremont County, Colorado. That Mr. Felch recognized the importance of the specimen is clearly shown by the carefully made diagrams, notes, etc., which he prepared in order to facilitate the fitting together of the blocks of sandstone and broken pieces when it should be assembled in the laboratory.

The specimen was shipped to Prof. O. C. Marsh at New Haven, Connecticut, where it was partially assembled and the rock covering was removed from what was the lower side in the quarry, as shown in plate 4. The skull was the only part worked out free from the matrix. In this condition the specimen was studied and in 1887 [1] briefly described by Prof. Marsh as the type of the species *S. stenops*. It was then sent to storage, where it remained until after the death of Professor Marsh. In 1899 all of the vertebrate fossils at New Haven belonging to the Government (comprising five carloads) were shipped to the United States National Museum, the present specimen forming a portion of that collection. In 1904, under the direction of Mr. F. A. Lucas, the specimen was unpacked and sufficiently assembled to obtain the necessary data for the life restoration made in that year by Mr. C. R. Knight (pl. 33, lower figure). The drawing of the dermal plates shown in plate 14 was also made at that time. It was again placed in storage and remained there until September, 1911, when its final preparation was begun. So that now, after a period of 28 years since it was first discovered, this most perfect specimen of a *Stegosaurus* is at last available for exhibition and study purposes, and it will long serve as a standard for interpretating and coördinating the scattered parts of others of its kind.

Position of the skeleton.—The specimen as assembled and as now exhibited in the United States National Museum (pl. 2) shows the skeleton in the position it occupied in the quarry. Every bone occupies the precise relative position it did when found. In order to show the series of dermal plates that were folded back beneath the body of the animal a large mirror was installed in such a manner as to display these plates to the observer. A second mirror was likewise placed below the overturned skull, so that it reverses the head to its normal position and at the same time shows the elements composing the top of the cranium.

The adaptation of mirrors to the better display of large fossil specimens, here used for the first time, is most gratifying in the results obtained.

When the skeleton was found it lacked the greater portion of the posterior half of the tail, the hind feet, and some other minor portions. The animal lies on its left side [2] with the bones so closely connected that there can be no question raised as to their belonging to this one individual.

The vertebral column is largely intact and to a great extent articulated—at least it is so little disturbed that the axial skeleton appears to be complete from the tip of the nose to the seventeenth caudal. The distal half of the tail, as mentioned above, is largely missing, although five caudal vertebrae, three plates, and

[1] Amer. Journ. Sci., vol. 34, 1887, pp. 414–415, pl. 6.

[2] In a letter to Professor Marsh, dated June 23, 1886, Felch says:

The animal here lay on its left side and up against the bank of our old river bed, bringing its left [right] hip the highest, the right [left] hip and some bones having slid downhill toward the bottom of the bed. Most all of the plates along here lay up and on the outside of this bank, resting on the marl bed.

one of the dermal spines are scattered about beyond the last of the articulated series. (See pl. 2.)

The presacral vertebrae, with the exception of the mid-dorsal region, retain their relative positions. In the middle of the series three vertebrae have been pushed up and out of position, but the combined length of these vertebrae is sufficient to fill the gap between the posterior and anterior articulated series. This would appear to indicate that none are missing. The head and neck are articulated and curve backward toward the fore feet, lying ventral side up in a death-like attitude. The femora are nearly in place in the acetabulum with their distal ends wide apart as if at the end of a long stride. The tibia and fibula of the right leg is doubled back along the front of the femur, but the foot as well as the lower limb bones of the left leg are missing. Both articulated fore limbs, with considerable portions of both fore feet, occupy their relative positions, one lying on top of the other. The thoracic ribs of the right side have been pushed up into a heap along the front of the right ilium and above the posterior portion of the vertebral column. Those of the opposite side are largely retained in their relative positions, their free ends curving upward and to some extent showing the natural curve of this portion of the body cavity.

The pelvic bones are all present, though slightly disarranged; the ilia, however, remain firmly coössified with the sacral vertebrae and show plainly the great breadth of the hips.

The dermal plates, which in life stood erect along the back, are present to a point back of the pelvis and are retained in the rock in their mutual relationships. The eleven plates forming the armor of the anterior part of the animal are turned back in under the body and neck, forming a continuous sheet of bone upon which the anterior parts of the skeleton lay. Three large plates over and back of the sacral region occupy much the same position as during the life of the animal, their bases being just above the spinous processes of the associated vertebrae. There are three other plates present from the caudal region, as mentioned above, and although disarranged they show the relative decrease in size posteriorly. The little disturbed condition of the specimen appears to indicate that it was found in a place not far removed from where the animal died. The position is that of an animal which died a natural death, for such disarrangement as exists can be attributed to the natural shifting of the bones rather than to their having been torn apart by any of the contemporary carnivora.

Theory of fossilization.—The story of the entombment of this specimen, as read from the position of the various parts of the skeleton, would appear to be as follows:

The animal died in the water or along the banks of one of the large streams that traversed that portion of Colorado in those ancient days. In the event of death having occurred along the banks, before decomposition had set in a freshet floated the carcass and it was carried downstream, and, as the water subsided was stranded upon an old river bar. Before reaching the bar the soft tissues commenced to relax and allowed the projecting plates along the top of the back to droop, and upon coming into shallow water their points were caught in the sand and the current acting against the carcass forced it over and upon the plates, folding them back underneath the ribs of the lower side. The larger plates of the series, those above the hips and base of the tail, which were doubtless most strongly attached, retained their natural positions. As decomposition progressed the other bones of the skeleton either settled into the sand, as is true of those of the lower or left side where the ribs of the body are found spaced much as in life, while those of the right side have been carried into a pile above the backbone and against the upstanding hip bones. That these elements were piled up by the action of the current appears to be indicated by the fact that the longer axes of the bones of this side all lie in the same general direction. In other words, the direction of the force of the current was diagonally across the longer dimensions of the skeleton, as indicated by an arrow on the diagram (pl. 3). Thus were the bones laid down, and the final part of the story necessitates a rapid covering of the skeleton by sand in order to make the condition right for the petrifaction and preservation of the specimen. This sand in the many years following was covered by other sediments until many thousands of feet had accumulated. The great pressure brought about by the accumulated weight of the overlying strata consolidated the loose sand into the hard sandstone that until recently completely enveloped the fossil.

Discussion.—Since this specimen is the basis for that part of the present paper devoted to the osteology of *Stegosaurus*, where the skeletal parts have been described in detail, it is only necessary to discuss here those characteristics wherein it differs from the other known species. On account of the inadequate descriptions of the type-specimens upon which the other American species are based and which are preserved elsewhere, I am unable to contrast these species to the best advantage, but such differences as have been found appear to indicate that other and more important specific characters will be disclosed when those types are more fully known and available for comparison.

Typically the skeleton of *Stegosaurus stenops* represents an adult animal of medium proportions, being less robust than the specimens upon which *S. ungulatus* and *S. sulcatus* are based. From *S. ungulatus* this species may at present be distinguished chiefly by characters found in the sacrum and femur.

In *S. stenops* the sacrals have a decided ventral keel, as compared with the broad, rounded, keel-less centra of *S. ungulatus;* the nonparticipation of the caudosacral rib in the formation of the sacracostal yoke and the much shorter spinous processes of the sacrals are other distinguishing characters.

The presence of a rudimentary finger-like lesser trochanter (*a*, fig. 45) on the outer anterior face of the proximal end of the femur of *S. stenops*, and its relatively shorter length distinguish it at once from the slender, elongate femur of *S. ungulatus* where the lesser trochanter has entirely disappeared. (Compare 1 and 3, fig. 45.)

From *S. sulcatus* this species may be distinguished by its smaller size and differences displayed in the dermal tail spines, as shown in figure 60.

The genus *Diracodon* [1] was founded by Marsh upon two imperfect maxillary bones (No. 1885, Yale University Museum). Later, from the study of additional material, other characters were assigned this genus and a figure of the distal end of the tail with spines *in situ* (No. 4288, United States National Museum) was published (pl. 15).

[1] Amer. Journ. Sci., vol. 21, 1881, p. 421.

Marsh says of these specimens: "Aside from the form of the skull [meaning maxillae] these specimens have in the fore foot the intermediun and ulnar bones separate, while in *Stegosaurus* these carpals are firmly coössified." As shown by specimens in the National Museum (fig. 36), all small individuals have the intermedium, ulnare, and pisiform separate, while in large individuals these are completely fused. Another character assigned to *Diracodon* is the freedom of the astragalus and calcaneum from tibia and fibula. This is also an age characteristic, as abundantly shown by National Museum specimens. The caudal vertebrae and spines ascribed to *D. laticeps* by Marsh (pl. 15) agree in shape and size with those belonging to *Stegosaurus*, and are here referred to *S. stenops* (compare pls. 15 and 16). From this brief review it will be seen that this genus and species rests entirely upon the characters displayed by the teeth and maxillary bones, and these, according to the description by Marsh, agree in nearly all respects with those of *Stegosaurus*. In 1902 Zittel's Text-book of Paleontology (vol. 2, p. 242) says: "Is probably founded on the young of this species," referring to *S. ungulatus*. It appears that at the time *Diracodon laticeps* was founded the homologous parts of *Stegosaurus* were unknown, which would account for Marsh's statement that the genus is most nearly related to *Laosaurus*, and also for its reference to the Family Camptosauridæ (Camptonotidæ), an assignment corrected later.

Although I have not had an opportunity of examining the type-specimen, it would appear that the genus, and probably also the species, are invalid and should be abandoned.

STEGOSAURUS SULCATUS Marsh.

Plates 18; 20, figs. 3 and 4; 21, fig. 2; 23, fig. 1; 25, fig. 3.

Stegosaurus sulcatus MARSH, Amer. Journ. Sci., vol. 34, 1887, p. 415, pl. 8, figs. 4–6; Geol. Mag., ser. 3, vol. 5, 1888, pl. 2, figs. 4–6; Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pl. 50, figs. 4–6.—NOPCSA, Földtani Közlony, Budapest, vol. 31, 1901, p. 215.—HAY, Bull. 179, U. S. Geol. Survey, 1901, p. 496.—LULL, Amer. Journ. Sci., vol. 29, 1910, pp. 209, 210, fig. 11.

Type-specimen.—Cat. No. 4937, U.S.N.M. Consists of 4 dermal spines, 2 dermal plates (one pertaining to the neck, the other to the mid-dorsal region), right humerus, right ulna, two radii, both fore feet, portions of both scapulae, parts of femora, fibula, ischium, and caudal vertebrae. Collected by Mr. J. L. Kenney in 1883.

Type-locality.—Quarry 13 near Como, Albany County, Wyoming.

Horizon.—Morrison, Upper Jurassic.

Description.—This species has never been adequately defined, and it is only recently that the type-specimen was assembled and prepared for study. Marsh confined his first observations to a study of one of the dermal spines of the anterior pair. Two grooves or sulci (pl. 18, fig. 2) on the inner face suggested the specific name, but, as will be shown later, these grooves are not present on the opposite spine, and this character, therefore, does not serve to distinguish the species.

The original description is as follows:

In one large species, which may be called *Stegosaurus sulcatus*, there is at present evidence of only one pair of spines. These are the most massive of any yet found, and have two grooves on the inner face, which distinguish them at once from all others known.

In some trays of unprepared material in the United States National Museum there was found, together with other parts of the skeleton, three dermal tail spines, one of which (*b*, fig. 65) bore a striking resemblance to the spine figured and described by Marsh as the type of *S. sulcatus*, its chief difference from the type being the absence of the "two grooves on the inner face." In the same tray was a box label, on which was written, with other information, evidently by the collector, "four spines in this box." Since only three were found, it occurred to me that perhaps the fourth might be the one described by Professor Marsh, and upon comparing the original labels found with each the above conclusion was verified. Both labels had the accession number 1650, and they also showed that all four of the spines had been packed in "box 8" when shipped from the field. This information, together with the fact that of the 30 dermal spines now before me, there is only one (this in the "box 8" lot) showing a resemblance to the type spine of *S. sulcatus* through the great development of the basal end. There was also the additional

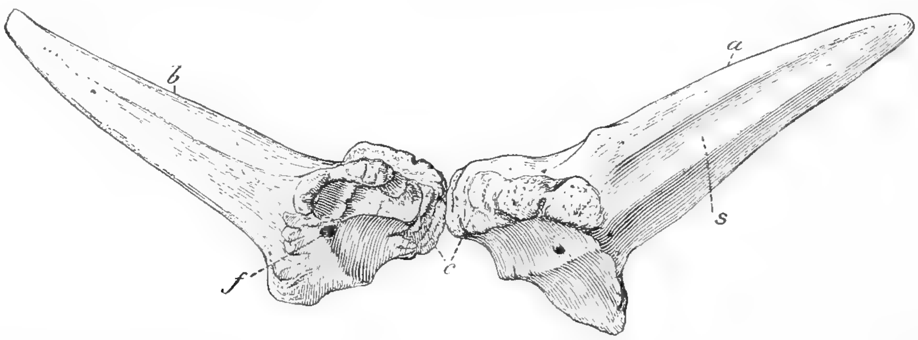

FIG. 65.—ANTERIOR PAIR OF DERMAL TAIL SPINES OF STEGOSAURUS SULCATUS MARSH. TYPE. CAT. NO. 4937 U.S.N.M. ABOUT $\frac{1}{10}$ NAT. SIZE. VIEWED FROM THE FRONT. *a*, TYPE SPINE; *b*, SPINE RECENTLY FOUND; *c*, RUGOSE SURFACE FOR CARTILAGIOUS UNION OF THE TWO SPINES ABOVE THE CAUDALS; *f*, FORAMEN PASSING INTO INTERIOR OF SPINE; *s*, SULCI, PRESENT ONLY ON RIGHT-HAND SPINE.

evidence of this being the proper association of these bones from the fact that these two spines are opposites, as shown in figure 65. The posterior dermal spines lack the greatly enlarged bases of the anterior pair, are without sulci (pl. 25, fig. 3), and indistinguishable from those of an adult specimen of *S. ungulatus*.

The type of *S. sulcatus* is a large and evidently a very old individual. The few bones of this specimen sufficiently complete to be compared with those of other species show no good distinguishing characters except for their very large size, so that for the present this species must rest upon the greatly expanded bases of the anterior pair of spines, and this feature may be found to be an age characteristic. In that event this species would represent a very large and old individual of *S. ungulatus*. The sulci mentioned by Marsh and so plainly shown in plate 18, figures 2 and 3, are not present on the opposite spine, and in the Stegosauria this feature is probably as inconstant as it has been found to be in the Ceratopsia, where sulci are present on one supraorbital horn-core but absent on the other. These spines are fully illustrated in plate and text and further description appears unnecessary. The radius, foot, and ulna are shown in plate 20, figures 3A, 4A, plate 21, figure 2, and nuchal plate in plate 23, figure 1, also in text figure 57.

Measurements of caudal spines No. 4937.

	Anterior pair.		Posterior pair.	
	Right.	Left.	Right.	Left.
	mm.	*mm.*	*mm.*	*mm.*
Greatest length	....	623	370	520
Greatest extent antero-posteriorly	274	275	150	160
Greatest extent transversely	180	170	80	80

STEGOSAURUS LONGISPINUS, new species.

Type-specimen.—No. D54 Museum of the University of Wyoming. Collected by W. H. Reed and Prof. A. C. Dart in 1908.

Type-locality.—About 1½ miles east of Alcova, Natrona County, Wyoming.

Horizon.—Morrison Beds, Upper Jurassic.

The type-specimen consists of 42 vertebrae from all parts of the backbone, fragmentary sacrum, two ischia, portion of one pubis, right femur, several ribs and four dermal tail spines, two of which are fairly complete.

Distinctive characters found in the dermal spines and posterior caudal vertebrae make it necessary to create a new species, and I therefore propose the name *Stegosaurus longispinus*, the specific name being suggested by the slender elongated nature of the dermal tail spines.

Detailed description.—The dermal spines of *S. longispinus* are the longest so far recorded. The most complete spine of the four present measures 860 mm. in length and the tip is missing. It is estimated that the complete length of this bone would be about 3 feet 3 inches (985 mm.). This species is unique in the uniform development of the basal portion of the spines, whereas in all other described forms, where the spines are known, the bases of the anterior pair greatly exceed those of the posterior pair. This feature reaches its maximum development in *S. sulcatus*.

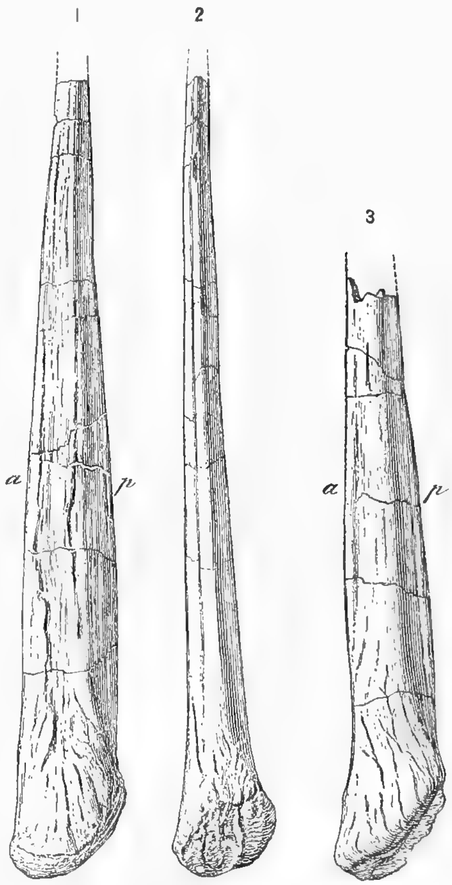

FIG. 66.—ANTERIOR PAIR OF DERMAL TAIL SPINES OF STEGOSAURUS LONGISPINUS. TYPE. D 54, UNIVERSITY OF WYOMING COLLECTION. ⅛ NAT. SIZE. (1) LATERAL VIEW; (2) POSTERIOR VIEW OF SAME; (3) LATERAL VIEW OF OPPOSITE SPINE. *a*, ANTERIOR BORDER; *p*, POSTERIOR BORDER.

The base of the spine shown in figure 66 has an antero-posterior diameter of 145 mm. and a transverse diameter of 110 mm. Like measurements of the other three do not vary 5 mm. in either of these dimensions.

These spines have the usual oblique ends, so that in life they would be directed outward and backward at a considerable angle from the perpendicular (see fig. 65). The lower ends of the anterior pair are rugosely roughened with weakly developed, asymmetrically placed longitudinal keels; the posterior pair is smooth and without keel.

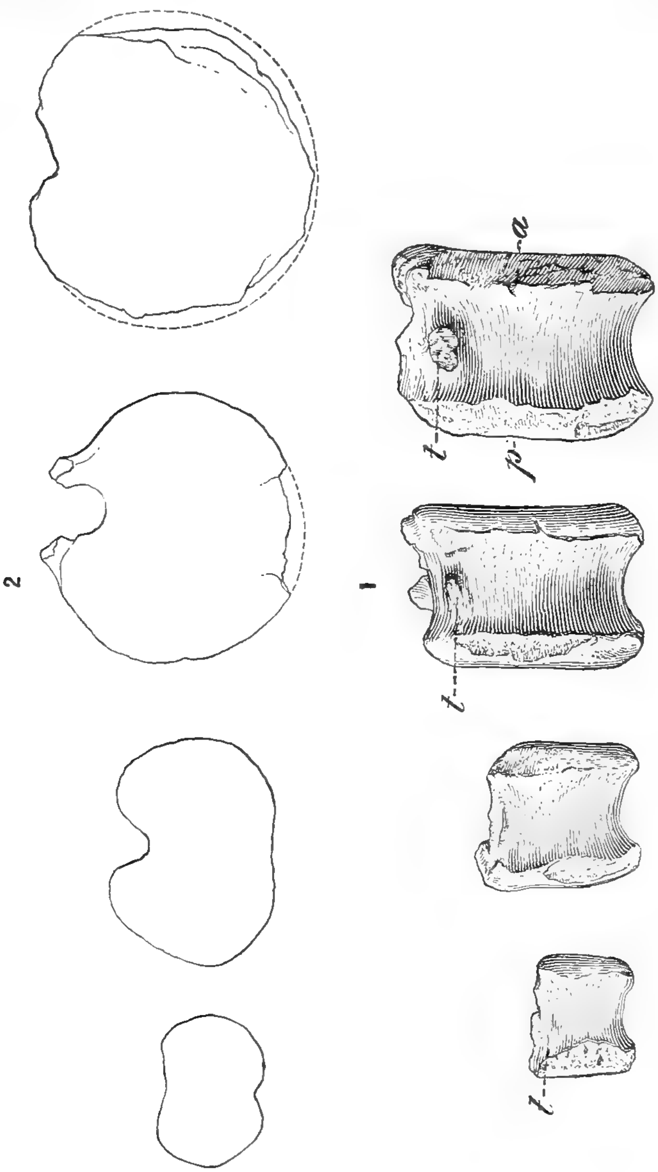

FIG. 67.—CAUDAL VERTEBRAE OF STEGOSAURUS LONGISPINUS GILMORE. TYPE. D 54, UNIVERSITY OF WYOMING COLLECTION. ¼ NAT. SIZE. 1, SIDE VIEW; 2, END VIEW OF SAME. *a*, ANTERIOR END; *p*, POSTERIOR END; *t*, VESTIGAL TRANSVERSE PROCESSES.

The spines are unusually flat and slender with sharp edges fore and aft throughout their entire length. The lower part of the shaft is slightly constricted antero-posteriorly so that the widest portion of the blade is some 200 or 250 mm. above the basal end. In all other species the spines gradually taper from the base to the very tips (see fig. 60).

The long, slender, flattened shafts with sharp edges; the constriction of the shaft above the bases; and the uniformity in the development of the bases of the spine series are a combination of characters which will at once separate the tail spines of *S. longispinus* from other described species. The principal features of these spines are well shown in figure 66.

Turning now to the caudal vertebrae we find that the anterior members of the series have the usual short centra and robust spines with expanded summits; the median caudals are more elongated with hexagonal centra, and appear indistinguishable from those of the type of *S. stenops*.

Coming to the caudals of the distal portion of the tail, of which there are 10 present, these show such distinctive differences from those of the other species, (fig. 67) that the question of their proper association with this specimen was at once raised. In reply to my inquiry, Mr. Reed assures me that there can be no question but that they belong to the type-specimen, as this skeleton was found isolated, that is, there were no bones of other animals found in the same quarry with it.

The characters by which these vertebrae differ from those of the other species of *Stegosaurus* are contrasted in the two parallel columns below.

S. longispinus.	*Other species.*
Centra depressed.	Centra compressed laterally.
Centra rounded when viewed from end.	Centra hexagonal when viewed from end.
Sides of centra deeply concave.	Sides of centra moderately concave.
Vestigal transverse process.	Process wanting.
Centra mushroom headed.	Heads of centra without special expansion.

The spinous processes are missing from all of the distal caudals. Measurements taken of the centra show the transverse diameter to always exceed the vertical, whereas in the distal caudals of other species the vertical always equals if it does not exceed the transverse diameter.

Although there are considerable portions of the sacrum present it is too fragmentary to be compared to advantage.

Such dorsal vertebrae as are preserved show the usual elongated neural processes, with upwardly directed diapophyses, and small laterally compressed centra. These show no distinctive features.

The cast of the sacral cavity is depressed and considerably more expanded laterally than in *S. ungulatus*. How much of this flattening may be attributed to crushing it is impossible to say.

The ischia are of the same size as those of *S. stenops*, and differ only in minor details (pl. 25, fig. 4).

The femur in its general proportions closely resembles those of the type-specimen of *S. stenops* (fig. 45), as in that species the femur may be distinguished from those of *S. ungulatus* by the presence of the finger-like lesser trochanter on the external anterior face of the proximal end (*a*, fig. 68). The condyles are illy defined, being wide apart, with articular surfaces confined almost exclusively to the distal view. It has a greatest length of 1,082 mm.; other measurements are given in table on page 83.

FIG. 68.—RIGHT FEMUR OF STEGOSAURUS LONGISPINUS. TYPE NO. D 54, UNIVERSITY OF WYOMING. $\frac{1}{12}$ NAT. SIZE. FRONT VIEW. *a*, LESSER TROCHANTER; *b*, GREATER TROCHANTER; *h*, HEAD.

The few ribs present show the usual T-shaped cross-section of the proximal portion.

Family SCELIDOSAURIDAE Huxley.

Genus HOPLITOSAURUS Lucas 1902.

HOPLITOSAURUS MARSHI (Lucas) 1901.

Plates 26–30.

Stegosaurus marshi Lucas, Proc. U. S. Nat. Mus., vol. 23, 1901, pp. 591, 592, pls. 23–24.
Hoplitosaurus marshi (Lucas) Science, new ser., vol. 16, No. 402, 1902, p. 435.—Lull, Amer. Journ. Sci., vol. 29, 1910, p. 30, fig. 7.—Zittel, K. A. Grundzüge der Palaentologie, pt. 2, 1911, p. 294.

Type-specimen.—Cat. No. 4752 U.S.N.M. Consists of the right femur, proximal half of left humerus; distal half of right humerus. Proximal portion of right scapula and coracoid, one dorsal centrum, caudal centra, numerous dermal plates of the spined, keeled, flattened, and rounded shapes; fragments of ribs and other elements. Collected by N. H. Darton in 1898.

Type-locality.—"Calico Canyon," near Buffalo Gap Station, South Dakota.

Horizon.—Lakota, Lower Cretaceous.

In 1901 Lucas first described this specimen as a new species of *Stegosaurus*, but a year later, recognizing its affinities as being nearer the Wealden *Polacanthus*, and therefore distinct from the former genus, he proposed the name *Hoplitosaurus* for its reception. Since 1901 four genera and as many species of armored dinosaurs have been described from the Cretaceous of this country; but in none of these articles is there reference made to the present form. It would appear on account of the closeness of the geological horizons in which some of these specimens were found that, when a comparative study is made, they will be found to be closely allied, if not identical, with the present genus.

The family attribution of *Hoplitosaurus* in all probability lies within the Scelidosauridae of Huxley, an assignment which I believe will eventually include other genera of American ridge-scuted dinosaurs.

The original description by Lucas follows:

The name *Stegosaurus marshi* is proposed for a new species of Stegosaur represented by a number of plates, spines, and portions of the nuchal and gular armature, as well as by some vertebræ and bones of the limbs, obtained by Mr. N. H. Darton in South Dakota from beds considered by him to be of Lower Cretaceous age.

This material, which is in the United States National Museum and is the type of the species, is numbered 4752 in the catalogue of fossil vertebrates. It was found associated with remains of another dinosaur of moderate size, probably related to Camptosaurus.[1] The species is characterized by the general massive appearance of the plates and spines, the comparatively large extent of their basal surfaces, their abrupt taper, and sharp edges. In these respects they are quite different from the corresponding portions of any other Stegosaur yet discovered, and coming, as they do, from the highest horizon in which remains of Stegosaurs have been found they may be considered as representing the latest developments in the dermal armature of this remarkable group of dinosaurs.

A dermal spine found by Mr. J. B. Hatcher, in conjunction with remains of Triceratops, and regarded at the time as belonging to that genus, may very likely have come from the species under consideration.

A spine, shown on plate [28], presumably from near the posterior end of the caudal series, has a long and comparatively wide basal portion and then tapers rapidly to a spike-like form.

A plate, shown on plate [29], apparently from the caudal series somewhat in advance of the spine just described, is triangular in section, slightly rounded on one surface, while on the other it tapers abruptly from the base with a concave curve.

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[1] Type-specimen of *Camptosaurus depressus* Gilmore—C. W. Gilmore.

Another plate, probably from the dorsal series, is much more compressed than either of the two already noted, and seen in profile has the form of a rather narrow high triangle.

None of the large flattened plates so characteristic of Stegosaurs hitherto described are present, and while the material available is too scanty to warrant any positive assertion regarding them, yet it seems probable that in the species under consideration all the plates were small and heavy.

The nuchal armor consists of small, thick, irregularly quadrilateral plates slightly keeled, and these, save for their smoothness, are suggestive of the nuchal and dorsal plates of crocodiles.

The throat was protected by rounded ossicles varying from 3 to 25 mm. in diameter, and many of these are present on the slab containing the nuchal plates. It is entirely probable that this species represents a distinct genus of Stegosaurs; but in the absence of material on which to base a generic diagnosis it seems best not to bestow upon it a new generic name.

This specimen was recognized by the late Prof. O. C. Marsh as representing a new form, and as it was almost the last specimen to be studied by him it seems particularly appropriate to name the species in honor of one who did so much to make the Stegosaurs known.

The following are the measurements of the spine and plates described: Caudal spine, shown on plate 20, 370 mm. high and 252 in antero-posterior diameter; caudal plate, shown on plate 21, 304 mm. high and 155 in antero-posterior diameter; width of articular face 148 mm.; dorsal plate 380 mm. in greatest height, and 198 in antero-posterior diameter.

Scapula and coracoid.—The scapula as in *Ankylosaurus* is especially thick and massive. Thickest above the humeral articulation and narrowest just posterior to that point, where it measures 108 mm. across the shaft.

The upper portion of the blade is missing, but from the proximal portion it would appear to have been decidedly concave from end to end on the inner surface. A heavy oblique ridge rises from the median external surface of the shaft just posterior to the glenoid cavity and continues forward and upward, terminating at the acrominal border. The forward termination of this ridge overhangs the lower external surface of the bone. It appears very similar to the outwardly curved superior borders of this portion of the *Ankylosaurus* scapula as described by Brown,[1] and resembles somewhat the process found on the scapula of *Hylaeosaurus*.[2]

The coracoid is firmly coössified with the scapula and with it forms a shallow but extensive glenoid cavity. The coracoid foramen passes almost straight through the bone, not diagonally as in *Stegosaurus* and *Ankylosaurus*. The coracoid is a flattened discoid bone, its general proportions being well shown in plate 26, figure 3. At the articulation with the scapula it has a vertical measurement of 190 mm.

Humerus.—The humerus of *Hoplitosaurus* is represented by the distal half of the right and the proximal portion of the left (pl. 26, figs. 1 and 2). These pieces show it to have been a short bone, with widely expanded ends, that are much flattened anteroposteriorly. The deltoid ridge, although broken, appears to have been well developed, and as in *Stegosaurus* extended well down on the side of the shaft. The radial and ulnar condyles are feebly developed, being separated by a very shallow trochlear depression.

The supinator ridge is much more prominent than in *Stegosaurus*, and its great transverse development adds much to the width of the distal end of the bone. On the posterior side the olecranon fossa of the mammalian humerus is represented by a broad and very shallow depression. The head is less robust than in *Stegosaurus* and does not overhang to any appreciable extent the posterior surface of the shaft.

[1] Bull. Amer. Mus. Nat. History, vol. 24, 1908, p. 196.
[2] Owen, Wealden, and Purbeck Reptilia, Mon. Pal. Soc., 1858, pt. 3, pl. 4.

From these two parts of opposite humeri it is estimated the total length of the humerus in this individual would be about 385 mm. The greatest transverse measurement of the distal end is 165 mm.

In the considerable expansion of the ends and the contraction at the center the humerus in *Hoplitosaurus* resembles those of *Polacanthus* and *Acanthopholis*.

Femur.—The right femur is almost perfectly preserved, lacking only a portion of the fourth trochanter. It was found in the matrix of the lower side of the block containing the dermal ossifications shown in plate 27. Although only little more than one-half the length of the shortest *Stegosaurus* femur in the National Museum collections, the proportions of these bones are remarkably similar. The

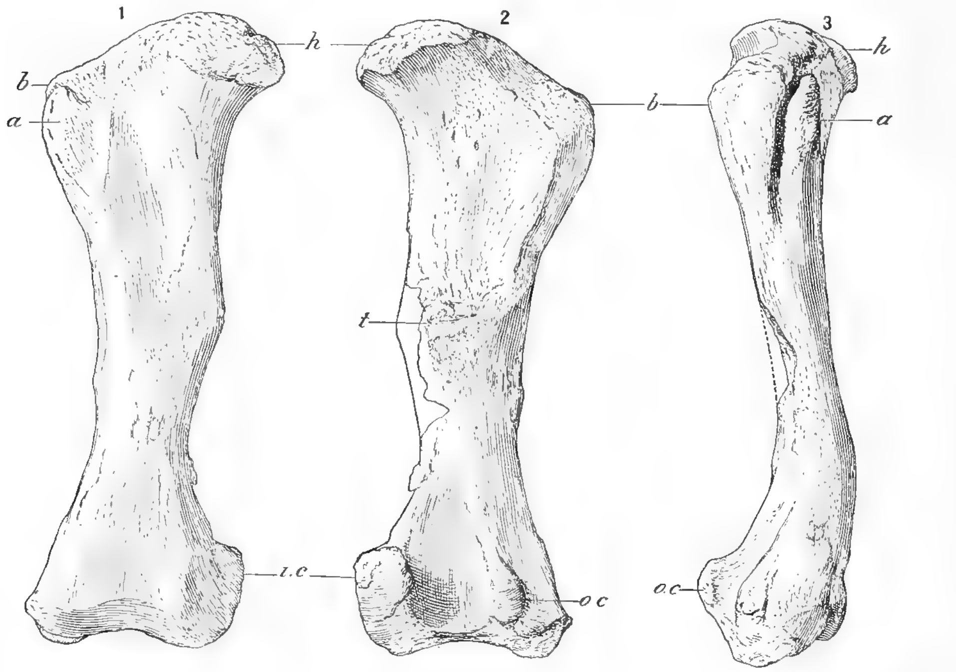

FIG. 69.—RIGHT FEMUR OF HOPLITOSAURUS MARSHI (LUCAS). TYPE. CAT. NO. 4752, U.S.N.M. ⅓ NAT. SIZE. (1) FRONT VIEW. (2) BACK VIEW. (3) EXTERNAL VIEW. *a*, LESSER TROCHANTER; *b*, GREATER TROCHANTER; *h*, HEAD; *i. c.*, INTERNAL CONDYLE; *o. c.*, OUTER CONDYLE; *t*, FOURTH TROCHANTER.

articular parts of the proximal and distal ends are in general aspect typically Stegosaurian. The head is not as distinctly separated from the rest of the proximal end as in *Polacanthus*, but resembles more nearly the conditions found in *Stegosaurus;* the rugose proximal surface continues uninterruptedly over the entire proximal end to the external border. The lesser trochanter (*a*, fig. 69) is relatively more strongly developed in *Hoplitosaurus* than in *Stegosaurus*. It is characterized by its compression in the direction of the bone; it is roughened externally and divided by a narrow fissure from the neck of the femur. The flattened nature of this trochanter and its external position, on the proximo-anterior face, would at once serve to distinguish it from other femora pertaining to the armored dinosauria.

The external border continuing down from the proximal end is rugosely roughened, and with the process here called the great trochanter was probably the point of insertion of the gluteal muscles. It appears that with the retrogression of this trochanter, which is vestigal in *Stegosaurus*, the point of insertation of these muscles gradually changed, until, in *S. ungulatus* and in the Sauropod dinosaurs, with the disappearances of this trochanter, the superior outer border functions as the trochanter major, as first correctly determined by Osborn in *Diplodocus*.

The shaft is slightly bowed from end to end, the arcuation of the center being forward. The bone is flattened antero-posteriorly being wider than deep.

The fourth trochanter is present, and placed above the middle on the postero-internal border of the shaft, and although broken as mentioned above, appears to have been more prominently developed than in *Stegosaurus*.

The external condyle (see *oc*, fig. 69) as in other dinosaurs is larger than the inner, both rounding up well on the back. They are separated by a wide but shallow intercondylar notch. The internal condyle is weak and much compressed transversely, and has on its internal side the usual longitudinal groove.

Measurements of Femur No. 4752.

	mm.
Greatest length	495
Greatest breadth proximal end	190
Greatest breadth distal end	170
Least width of shaft	65

Dorsal vertebrae.—The dorsal region of the backbone is represented by a solitary dorsal centrum, which is considerably distorted by pressure. Making due allowance for distortion, the centrum would be deeper than wide, with flattened sides and slightly expanded ends, having concave articular surfaces. Neural canal large; pedicels of neural arch contracted antero-posteriorly as they rise from the centrum, suggestive of a high neural process. The principal measurements of this centrum are: Greatest length 74 mm.; greatest height 63 mm.; greatest transverse diameter 50 mm.

Caudal vertebrae.—Six caudal vertebrae were found with this specimen, but the great size of three of these precludes the possibility of their pertaining to this individual. This also renders the association of the remaining three somewhat problematical.

The better preserved one from the median caudal region has a massive centrum being as wide as long; articular ends slightly biconcave; chevron facets well developed on posterior end; diapophyses leave the centrum on a level with the neural canal, the latter comparatively small, with greatest diameter transverse; spinous process missing, though the fractured base indicates that it was thickened.

This centrum has the following dimensions: Greatest length 80 mm.; greatest width 80 mm.; greatest height 65 mm. A caudal from the distal end of the tail is relatively more elongated; without transverse process; centrum somewhat compressed transversely; with biconcave ends. It has a length of 50 mm.

Ribs.—The ribs, with the exception of the proximal portion shown in plate 27, are all fragmentary. Many of these fragments are triangular in cross section. From these pieces it would be inferred that none of the ribs were very massive.

Dermal armor.—As in *Polacanthus, Hylæosaurus, Acanthopholis, Nodosaurus, Stegopelta, Ankylosaurus,* and *Hierosaurus,* the dermal armor of *Hoplitosaurus* is of a complex character, combining as it does scutes of at least five different forms; (1) simple flattened; (2) rounded ossicle-like; (3) keeled; (4) triangular plate-like, and (5) spined.

(1) Those of the first kind are thin, rectangular scutes with rounded corners and without surface sculpture or ornamentation. Two of these, shown in plate 27, have the surface gently concave across the shortest diameter.

(2) The ossicle-like scutes are the most numerous of those preserved. They vary greatly in size and shape, being rounded, oblong, elliptical, and subrectangular forms, that measure from 10 mm. to 50 mm. in the longest diameter. The block of sandstone shown in plate 27 is thickly studded with them, in some instances three and four being found one above another.

These are undoubtedly the scutes to which Lucas refers as representing the gular armature, a decision reached, no doubt, on account of the resemblance of many of the scutes to ossicles forming the throat investiture of *Stegosaurus.* Since the femur was found attached to the lower side of this block of sandstone, there is reason for thinking that these ossicles in conjunction with other dermal structures may have formed a carapace-like covering over the pelvic region, as is known to be the case in *Polacanthus* and *Stegopelta.*[1]

(3) There are numerous keeled scutes preserved, and they also vary much in size and shape. Some are buttonlike, being raised in the center as a blunt cone-like projection (*d* and *d'*, fig. 70), but the greater number are elongated, angularly rounded, with a sharp keel on the dorsal surface, asymetrically placed. In all of the examples before me this ridge is highest in the center, gradually sloping toward both ends. None show a projecting spur such as found by Wieland [2] in similar scutes of *Hierosaurus.* One of the better preserved measured through the center has a thickness of 32 mm. One or more scutes are almost flat, with an obtuse ridge (*c* and *c'*, fig. 70), very similar to those found with the remains of *Acanthopholis,* as described by Huxley.[3] The ventral side of some of these scute plates show the same texture of coarsely woven cloth, as described by Marsh in *Nodosaurus,* and the dorsal surfaces of a few are scrobiculate as in *Stegopelta.*[4]

(4) The large subtriangular, plate-like structures, closely resemble those of *Polacanthus,* which Nopcsa [5] upon the evidence of associated material assigned to the caudal region in two rows along the top of the tail (fig. 72). Doubtless from their close resemblance they will eventually be found to occupy a similar position in *Hoplitosaurus.* The base is hollowed out as in the tail plates of *Scelidosaurus* and *Hylæosaurus,* and as in the case in many of the dermal plates of *Stegosaurus.*

A well-preserved example of this style gives the following measurements: Greatest diameter antero-posterior, 210 mm.; greatest vertical diameter, 175 mm.; greatest transverse diameter, 65 mm. As in nearly all the larger plates the lateral surfaces are covered with blood-vessel impressions.

[1] S. W. Williston, Science (n. s.), vol. 22, 1905, p. 504.
[2] Amer. Journ. Sci., vol. 27, 1909, p. 252.
[3] Geol. Mag., vol. 4, 1867, p. 65, pl. 5, fig. 1.
[4] R. L. Moodie, Science Bull., vol. 13, 1911, p. 267.
[5] Geol. Mag., vol. 2, 1905, pp. 246–249, fig. 6, pl. 12.

(5) Of the spined scutes there are portions of eight present, five of which are nearly perfect. The form of all when viewed laterally may be roughly described as triangular, and nearly all are elongated and asymetrical. For convenience of description these may be subdivided into the following:

(*a*) Scutes with median, transversely expanded, oblique bases; above base greatly expanded antero-posteriorly, contracting rapidly to a rounded spine which rises from near the center of the plate, tapering to blunt upper extremity. What I take to be the external side is angularly convex antero-posteriorly, the inner

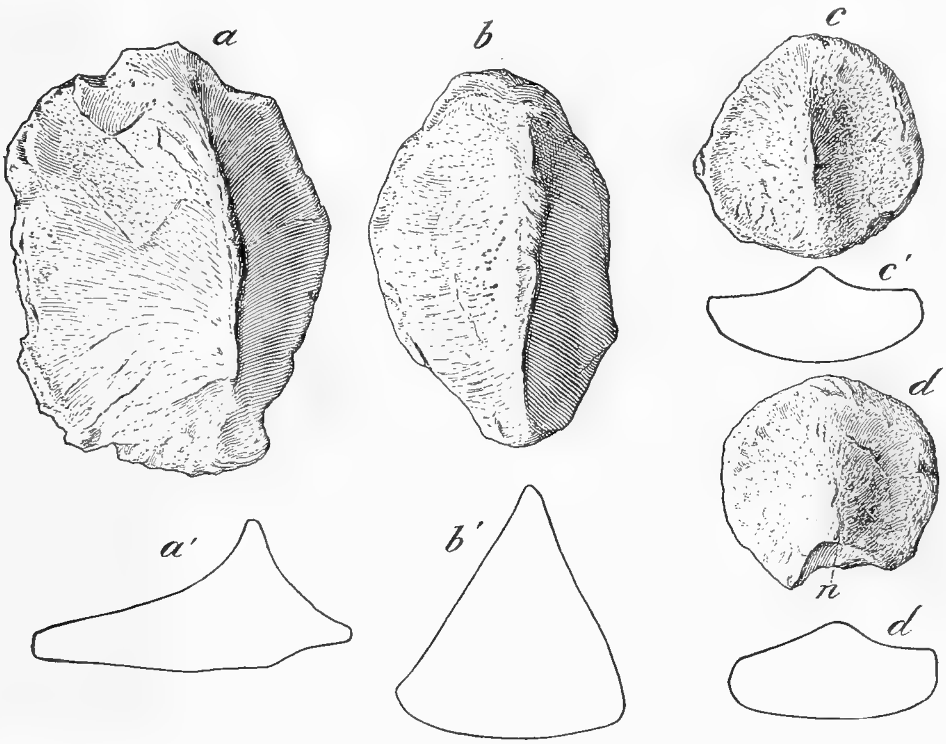

FIG. 70.—DERMAL SCUTES OF HOPLITOSAURUS MARSHI (LUCAS). TYPE. CAT. NO. 4752, U.S.N.M. ½ NAT. SIZE. *a*, RIDGED SCUTE; *a′*, CROSS-SECTION OF SAME; *b*, TRIANGULAR SCUTE; *b′*, CROSS-SECTION OF SAME; *c*, CIRCULAR RIDGED SCUTE; *c′* CROSS-SECTION OF SAME; *d*, CIRCULAR NODED SCUTE; *d′*, CROSS-SECTION OF SAME; *n*, NODE-LIKE ELEVATION.

side being less so. The anterior and posterior edges of the lower third of the plate present sharp borders, becoming more obtuse as they pass into the spine. Correcting the measurements given by Lucas of the spine shown in plate 28, the greatest length is over 390 mm.; and the greatest length antero-posteriorly is 280 mm. If Nopcsa is correct in the placing of the dermal armor in the restoration of the English *Polacanthus*, these spines would pertain to the anterior half of the animal, as shown by the close resemblance of the present spines as compared with those of that genus. (Compare pl. 28 with fig. 72.) Lucas in his description considered them as belonging to the distal caudal region. A modification of this type is shown in figure 71. There is not the sudden development of a rounded spine as shown in the scute described above. The edges fore and aft, from top to bottom, are sharp and the triangular spine is compressed transversely. Along the inner side of the base of both this and the preceding spine there is a longitudinal depression as if for its insertion in the skin. Greatest height of this spine is 290 mm.; greatest length antero-posteriorly, 190 mm.; greatest width of base about 55 mm.

(*b*) Dermal elements with compressed grooved bases and spine; longitudinally grooved on posterior borders. Throughout the entire length of the bone, a cross-section would be triangular in outline, with the base resting on a level surface, the spine continuing upward, outward, and backward, overhanging the posterior border of the base (pl. 29, figs. 1 and 2). The anterior or convex edge is sharp throughout its entire length. The body of the bone is moderately convex longitudinally on one side and correspondingly concave on the opposite side. In its general form it resembles most nearly dermal elements found with the skeleton of *Hylæosaurus*.[1] The principal features of this plate are well shown in plate 29. The greatest height is 330 mm.; greatest length antero-posteriorly, about 210 mm.

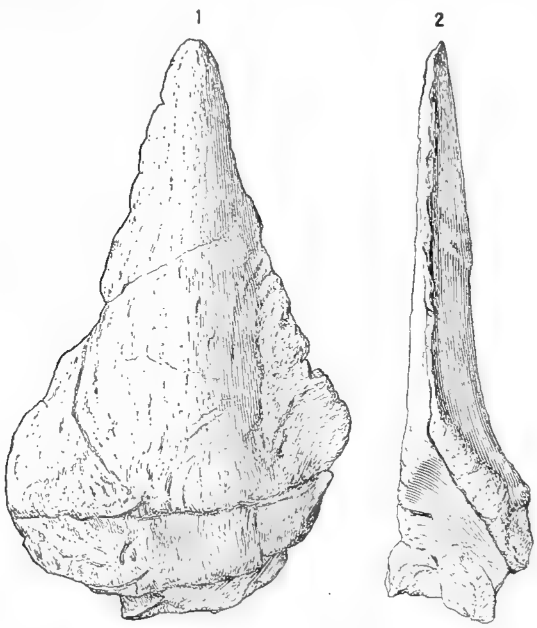

FIG. 71.—DERMAL PLATE OF HOPLITOSAURUS MARSHI (LUCAS). TYPE. NO. 4752, U.S.N.M. ½ NAT. SIZE. 1, LATERAL VIEW; 2, END VIEW OF SAME.

(*c*) These have heavy, massive, expanded bases, spines compressed with edges, sharp both fore and aft; base somewhat obliquely beveled, spine curved outward; greatest height more than 270 mm.; greatest length antero-posteriorly, 175 mm.; greatest width of base, 150 mm. A modification of this type is shown in plate 30, figures 1 and 2. The spinous part is reduced to a mere sharp ridge of bone rising from a massive base. It has the proportions of those placed by Nopcsa just in front of the pelvic shield in *Polacanthus* (fig. 72). Greatest height, 122 mm.; greatest length antero-posteriorly, 140 mm.; greatest width of base, 100 mm.

As may be readily seen from an inspection of the figures, these skin ossifications in *Hoplitosaurus* present far more variety of form than do those obtained with the remains of any American dinosaur known at the present time.

They vary all the way from small, rounded tubercles to plates of good size, and from simple flattened scutes to those with sharp ridgings and spines.

[1] See *d*, *d*, *d*, pl. 4, Fossil Reptilia of the Wealden and Purbeck, 1858, p. 25.

As to the position of these various shaped skin scutes, the present specimen offers but few suggestions, and anything that can be said regarding them is largely a matter of conjecture, since all were mixed up in somewhat of a disassociated manner and mingled with various other parts of the skeleton.

Judging from the length of the femur the present dinosaur in life was of low stature, with a height at the hips of about 4 feet, and that it was quadrupedal in gait appears to be indicated by the robust character of such parts of the pectoral girdle and fore limbs as have been preserved.

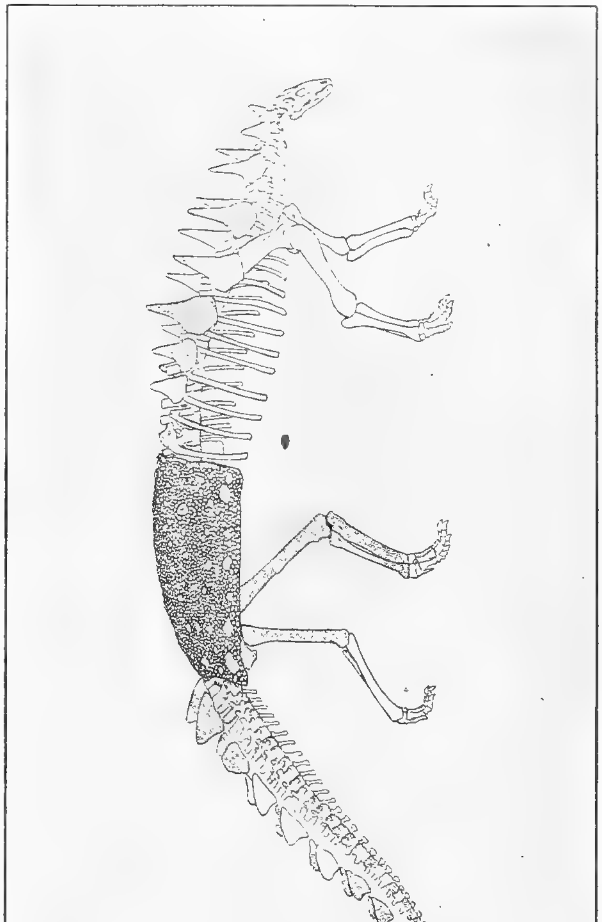

Fig. 72.—Skeletal restoration of *Polacanthus foxi* Hulke. After Nopcsa.

Dinosaur Armor from the Lance Formation.

In 1911 Wieland figured[1] and described a number of dinosaurian dermal plates from the Lance formation of Wyoming that are now preserved in the paleontological collections of Yale University. While none of these were so associated with other bones as to be positively identified, they are of interest as showing a great diversity of shapes, and they especially emphasize the paucity of our knowledge concerning the animals to which they belong. Complying with Wieland's suggestion that "it would be of very considerable interest to know the actual number and proportion of these elements in the collections, and especially their associations," I have prepared a brief account of those in the United States National Museum, with figures of the more characteristic plates.

Cat. No. 5793 is the dermal element (fig. 73) figured by Marsh[2] as the dermal spine of *Triceratops* and of which Hatcher[3] says "may have been arranged in pairs

[1] Amer. Journ. Sci., vol. 31, pp. 119–122, figs. 4–7.
[2] Dinosaurs of North America, 1896, pl. 70, figs. 1–3.
[3] The Ceratopsia, Mon. 49, U. S. Geol. Survey, 1907, p. 65, figs. 74 1–3.

at the base of the tail [*Triceratops*]." In general it bears a striking resemblance to the dermal spine of *Hoplitosaurus marshi* shown in plate 30, and on the analogy of the dermal armor of *Polacanthus* (fig. 72), to which *Hoplitosaurus* appears to be closely allied, I would say that spines of the character of these would belong to the armor in front of the sacrum over the middorsal region rather than to the caudal series, the position assigned it by Hatcher.

From available records I am unable to say anything of its association with other bones in the field. Collected by J. B. Hatcher in Converse County, Wyoming.

Cat. No. 7243, a thickened subrhombic plate with heavy obtuse median ridge, lower surface concave across the shortest diameter (pl. 31, fig. 3). No other bones or fragments associated. Collected by G. L. Wait at Dovetail Butte, about 1 mile west from ranch of E. J. Sanford, Valentine, Fergus County, Montana.

Cat. No. 7724, a single heavy curved plate resembling somewhat Wieland's figure 4 (pl. 31, fig. 4). It was associated with fragments of dinosaur bones, but none were sufficiently complete to be identified. Collected by A. L. Beekley in Carbon County (SE. ¼ sec. 14, T. 24 N., R. 84 W.), Wyoming. From the Lance formation.

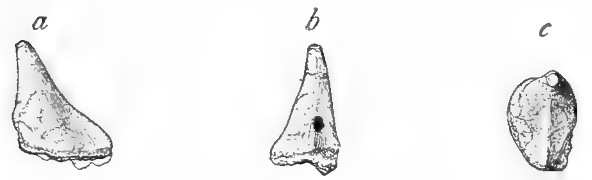

FIG. 73.—DERMAL SPINE OF A CERATOPSIAN? DINOSAUR. CAT. NO. 5793, U.S.N.M. ABOUT $\frac{1}{7}$ NAT SIZE. *a*, SIDE VIEW; *b*, FRONT VIEW; *c*, TOP VIEW. AFTER MARSH.

Cat. No. 7726. Some half dozen rounded and elliptical plates with spinal node and ridged forms (pl. 31, fig. 2), which undoubtedly pertain to the same species as those figured by Wieland in figure 5 of the article cited above. These were collected by D. F. Hewett near Cody (NE. ¼ sec. 23, T. 50 N., R. 100 W.), Big Horn County, Wyoming.

Nos. 7804–7805. Two pointed spine-like ossifications (*A* and *B*, fig. 1, pl. 31). Collected by J. B. Hatcher in Converse County, Wyoming. From the Lance formation.

RESTORATIONS OF STEGOSAURUS.

Since Prof. O. C. Marsh published the first pictorial restoration of *Stegosaurus ungulatus*, in 1891,[1] there have appeared, from time to time, various pictures and statuettes depicting the life appearance of this curious reptile.

These show a considerable variety of interpretations and are of interest as exhibiting the diverse opinions held regarding its probable appearance in the flesh and especially as to the arrangement of the dermal armor. In plates 32 to 36 and arranged in chronological order are some of the more striking of these restorations. Some comments upon the more important structural differences displayed in these restorations are given below.

As mentioned above, Marsh made the first restoration of *Stegosaurus* shown here in plate 32, upper figure. It was based upon the cotypes[2] of *S. ungulatus* (Nos. 1853 and 1858, Yale Museum), "while some other parts, especially of the dermal armor, have been placed in accordance with the known position in *Stegosaurus stenops*" (No. 4934, U.S.N.M.). It will be observed that notwithstanding the positive evidence

[1] Amer. Journ. Sci., vol. 42, 1891, pl. 9.
[2] R. S. Lull, Amer. Journ. Sci., ser. 4, vol. 30, 1910, pp. 363–364.

furnished by the *S. stenops* skeleton as to the existence of two parallel rows of 14 dermal plates, Marsh placed the series in a single row of 12 along the median line of the neck, back, and tail, with four pair of spines near the end of the tail.

In 1893 [1] the Rev. H. N. Hutchinson published the first life restoration by T. Smit, shown in plate 32, lower figure. It was evidently based upon Marsh's restoration, as indicated by the position, shape, and arrangement of the armor, although the tail spines were reduced by the artist to slender pin-like affairs, occupying a nearly vertical position. The pose was changed from an upright quadrupedal gait to that of a bent-limbed, crawling reptile of the crocodile type. This attitude is opposed to all of the generally accepted ideas of the normal mode of locomotion of this animal.

The restoration shown in plate 33, upper figure, published for the first time, was drawn by Mr. Frank Bond, in 1899, under the direction of the late Prof. W. C. Knight of the University of Wyoming. It is of interest as showing the plates arranged in procumbent positions, a view not alone held by Knight. All of the evidence, however, is opposed to such an arrangement of the armor.

In 1901 [2] Lucas published the next restoration (pl. 33, lower figure), a painting by Mr. Charles R. Knight. This was the first to show the plates arranged in pairs. In the same year a second restoration (pl. 34, upper figure) was made by Mr. G. E. Roberts, under the direction of Mr. Lucas, and the first showing the alternation of the plates of opposite rows, and the reduction of the tail spines from four to two pairs. The proportions here shown are extremely bad, the body being too long, and the limbs especially crude in form and pose. The only use made of this restoration, so far as I am able to learn, was in a popular magazine article by Mr. R. I. Geare.[3]

In 1903 a statuette (pl. 34, lower figure) was prepared by Knight under the direction of Lucas, in which the arrangement of the armor is practically the same as in the previous restoration by Roberts, although the inaccurate proportions of the body and limbs were corrected. From this small model a life-size restoration was made and formed a part of the exhibit at the World's Fair held in St. Louis in 1904. It is now displayed in the hall of fossil vertebrates in the United States National Museum. Although according to our present knowledge it is now known to be inaccurate in several details, yet, taken all in all, it probably comes nearer the truth than any representation yet produced.

In 1905 Lankester[4] published the restoration of *Stegosaurus* shown in plate 35, lower figure, and was the first to depict the animal with a color pattern of irregularly rounded black spots upon a lighter body color. The hooked raptorial bird-like beak, the puffed-up proportions of the body, and the increased number (10) of dermal spines are without warrant. In fact, there is but little to commend in it. It may be of interest to know, however, that Sir Arthur Conan Doyle used this restoration as an illustration in his story of The Lost World.

A second restoration [5] by Smit is shown in plate 35, upper figure. In this representation there was a return to the upright quadrupedal pose (compare pls. 32,

[1] Extinct Monsters, 1893, 2d ed., pl. 10.
[2] Animals of the Past, 1901, fig. 24, Smithsonian Report, 1901, pl. 4.
[3] Outdoor Life, July, 1910, p. 6.
[4] Extinct Animals, 1905, p. 208, fig. 150.
[5] H. N. Hutchinson, from a revised edition, 1911, of Extinct Monsters and Creatures of Other Days, pl. 26.

lower figure, and 35, upper figure) and a general rearrangement of the plates of the dermal armor. The alternation of the plates of opposite rows is shown, but the median part of the tail was bereft of its dermal adornment. The reason for the latter change is difficult to conjecture unless it were reasoned that it allowed greater freedom of movement and thus facilitated the use of the tail as an offensive instrument so that the dermal spines near the tip could be brought into action. At best it is more fantastic than in accord with the known facts.

The latest conception (pl. 36, lower figure), as exemplified by a recently mounted skeleton [1] in the Peabody Museum of Yale University, erected under the direction of Prof. R. S. Lull, and after which he has prepared a small model[2] (pl. 36, upper figure) of the animal as he appeared in the flesh, shows a return to the paired arrangement of the plates and the retention of four pairs of spines on the tail.

Since the mounted skeleton and life restoration by Lull embody all of the latest ideas (up to the year 1912) regarding the articulation of the bones of the skeleton and the life appearance of *Stegosaurus*, it only becomes necessary for me to point out wherein they differ from the facts revealed during this more recent study of a large series of Stegosaurian remains. I appreciate only too well the difficulties encountered in mounting for the first time the skeleton of one of these huge and grotesque creatures, and in justice to Professor Lull I would say that he now recognizes the correctness of some of the observations recorded below.

It is in the dermal armor that the greatest alterations are now to be made, and since the evidence for these changes is discussed in detail in the descriptive part of this paper, it is only necessary to enumerate them here.

1. The plates of opposite rows alternate, not paired as shown in the restoration.
2. There are not more than 22, and perhaps only 20, in the complete series of flat plates, whereas the restored skeleton shows 28. It is quite possible, however, that the number of these plates may vary, within limits, with the individual.
3. The largest plate of the series, as shown by the two individuals found *in situ*, is above the base of the tail, not over the sacrum.
4. Dermal spines number four, based on the evidence of association in six individuals.
5. Number of overhanging spine-like caudal plates to be reduced from six to two, on the evidence of two individuals.
6. First plate of the series above the atlas, not over the fourth cervical, as shown in the mounted skeleton. It is of interest to note that Owen figures the first pair of dermal elements in *Scelidosaurus* (as found in the matrix) immediately above the atlas.
7. Bases of the plates of opposite rows throughout the series, comparatively close together on either side of the middle line of the back. Not supported by the upwardly directed transverse processes of the dorsals.
8. Although the evidence is not conclusive, there is every probability that the small rounded, so-called gular ossicles covered the top and sides of the head and neck, rather than the throat, as represented in restorations (pl. 32, upper figure).

[1] Amer. Journ. Sci., vol. 30, 1910, figs. 2, 3, and 4.

[2] Idem, pl. 2, and fig. 10.

A study of the crania in the National Museum shows that in all the occipital condyle is deflected downward in such a way from the longer axis of the skull as to cause the anterior portion of the cranium to be carried low in front if the condyle is to be in line with the cervicals. While the articulation is such as to allow of further depression and also of elevation, it would seem that the normal pose would be much as in *Camptosaurus*, *Trachodon*, *Triceratops*, and *Diplodocus*. All of the pictorial restorations shown in the preceding pages, with the exception of Knight's (pl. 33, lower figure), show the head with an extreme elevation of the nose.

In the fore feet, as shown by the articulated limb of *S. stenops* (fig. 40), there is but a single row of ossified carpals, and it appears from the evidence of other feet that the third, fourth, and fifth digits carried a reduced number of phalanges—not a full complement as shown in the Yale skeleton.

As Lull[1] has pointed out, "The feet are large as though to support the creature's weight on yielding soil, the hand evidently possessing five, while the foot bore three, well-developed digits (and one which is vestigal). The semi-digitigrade feet were doubtless inclosed in a fleshy mass as in the modern elephants, while the external indications of the digits were mainly the hooflike nails." It seems most probable that in life only two of these digits (I and II) were in evidence.

The body is lank, but I can not agree with Lull that the hips are narrow, for while they do not have the great breadth of the *Triceratops* pelvis, they are nevertheless of good width.

I would question somewhat the proportions of the skeleton shown in plate 36, lower figure, as being typical of the Stegosaurian dinosaurs. The great elevation of the trunk and tail above the ground is evidently brought about by the unusual length of the femora used in this composite mount. The stilted appearance of this specimen, I am sure, would not be attained by any of the individuals in the National Museum collections. The difference in length between the exceedingly long femora used in the *S. ungulatus* skeleton and the longest ones before me is well shown in figure 45.

The great height of the hips brought about a corresponding elevation of the shoulder region which in this specimen necessitated the straightening of the fore limbs almost to their limits in order to articulate them with the skeleton. This does not seem to me to be the normal standing pose, for the presence on the ulna of a large olecranon process and the development of strong rugose processes on the humerus are features implying a bent, strongly flexed limb of the Ceratopsian type. With shorter femora such a pose could be easily brought about in the mounted skeleton with the resulting advantage of bringing the head nearer the ground, obviously a more natural position, for in the present pose, on account of the short neck, the animal's nose could only have reached the ground with the greatest difficulty.

The mounting of this skeleton shows the animal as being somewhat shorter than Marsh's estimated length of 25 feet. Lull gives the total length of this specimen between perpendiculars as 19 feet 5 inches and the greatest height from the base to the top of the highest plate as 11 feet $10\frac{1}{2}$ inches. The latter measurement

[1] Amer. Journ. Sci., ser. 4, vol. 30, 1910, p. 367.

will be somewhat less when the plates are properly placed. The average *Stegosaurus* would probably measure somewhat less in length, for this skeleton is based upon the remains of old and very large individuals. The present weight of the fossil bones is 1,917 pounds, and Lull has estimated the live weight of the animal as being between 7 and 10 tons.

As in nearly all dinosaurs the articular surfaces of the limb bones give but little positive evidence as to their exact manner of articulation, and any statement as to their normal pose largely resolves itself into a matter of personal opinion.

I had hoped to present at this time an illustration of a mounted skeleton of *Stegosaurus stenops* that it is proposed to erect in the United States National Museum, and which would graphically portray the ideas set forth here as to the articulation of the bones of the skeleton. Work of a more urgent nature, however, has delayed the mounting of this skeleton and it has been deemed inadvisable to longer postpone the present paper pending its completion.

The skin covering of *Stegosaurus* is at this time wholly conjectural, although in the light of recent discoveries we may yet hope to have definite knowledge as to its character. Lambe[1] has recently described impressions of the dermal covering of a Ceratopsian as consisting of "nonimbricating plate-like and tubercle-like scales." Based upon this evidence and from what is known of the integument of the Trachodont dinosaurs it is reasonable to expect the covering of *Stegosaurus* to be scale-like, with numerous bony skin ossicles scattered over the entire body, instead of the smooth leathery elephant-like texture which has so often been represented.

The exceedingly small and feeble teeth would appear to indicate that *Stegosaurus* must have fed upon the most succulent of terrestrial plants. The structure of the feet suggests that they were land haunting, doubtless of low swampy regions rather than the upland, but they suggest the probability of being adaptations from a group highly specialized for locomotion upon land. There is every reason to believe that *Stegosaurus* was descended from a bipedal ancestry as first suggested by Dollo. Increasing bulk and development of the armor caused them to lose celerity of movement, and they became sluggish, slow-moving creatures of low mentality, only sufficient, perhaps, to direct the mere mechanical functions of life

[1] The Ottawa Naturalist, vol. 27, 1914, pp. 129–135.

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EXPLANATION OF PLATES.

PLATE 1.

Upper figure quarry "No. 1," Garden Park, Fremont County, Colorado.

From a photograph taken in 1901, showing the quarry as worked by the Carnegie Museum of Pittsburgh, Pennsylvania. See p. 24.

Lower figure quarry "No. 1," Garden Park, Fremont County, Colorado.

From a photograph by I. C. Russell, taken at the time Felch was working here for Professor Marsh. The man in the foreground is standing on the level from which the fossils have been removed. See p. 24.

PLATE 2.

View of the upper or right side of the skeleton of *Stegosaurus stenops* Marsh. Type. Cat. No. 4934, U.S.N.M. About $\frac{1}{20}$ natural size. Shows the bones of the animal just as they were found and as now exhibited (p. 106).

The nonshaded portions represent restored parts.

PLATE 3.

Outline of the skeleton of *Stegosaurus stenops* Marsh. Designed as a key to plate 2. Scale about $\frac{1}{20}$ natural size (p. 106).

Ac, acetabulum.
At, atlas.
C4, fourth caudal.
C17, seventeenth caudal.
Ca, carpus.
Cer 9, ninth cervical.
Ch, chevron.
Co, coracoid.
DS, dorso-sacral (No. 27).
F, femur.
Fb, fibula.
H, humerus.
Il, ilium.
Is, ischium.
O, dermal ossicles.
P3 to *P17*, dermal plates, three to seventeen.
PS, presacrals (numbered from head toward sacrum).
Pu, pubis.
R, radius.
S, dermal spine.
Sc, scapula.
T, tibia.
U, ulna.
II, *V*, metacarpals two and five.
→, indicates direction of water current that washed over the specimen.

PLATE 4.

View of the lower or left side of the skeleton of *Stegosaurus stenops* Marsh. Type. Cat. No. 4934, U.S.N.M. About $\frac{1}{20}$ natural size. Shows the position of the dermal plates in relation to the other parts of the skeleton. Since this drawing was made the contacts of many additional parts have been found, which will account for various inconsistencies when compared with plates 2 and 3.

C_2, second caudal.
C17, seventeenth caudal.
Ca, carpus.
Cer 6, sixth cervical.
CS, caudo-sacral.
Ch, chevron.
F, femur.
H, humerus.
Is, ischium.
Il, ilium.
O, dermal ossicles (improperly placed. See *O*, plate 3, for correct position).
P_{13} to P_{16}, dermal plates, one to sixteen.
R, radius.
R′, ribs.
S, sacrum.
S_3, third sacral vertebra.
Sc, scapula.
Sc,? (may represent fragment of the right scapula).
T, tibia.
U, ulna.
II, V, metacarpals two and five.

PLATE 5.

Skull of *Stegosaurus stenops* Marsh. Side view. Type. Cat. No. 4934, U.S.N.M. ½ nat. size. *a*, anterior nares; *an*, angular; *ar*, articular; *b*, orbit; *c*, infratemporal fossa; *d*, dentary; *j*, jugal; *l*, lachrymal; *m*, maxillary; *n*, nasal; *oc*, occipital condyle; *p. ar*, prearticular; *pd*, predentary; *pf*, prefrontal; *pm*, premaxillary; *p.o*, postorbital; *p. oc*, paraoccipital process; *po. so*, postsupraorbital; *p. so*, presupraorbital; *q*, quadrate; *qj*, quadratojugal; *s*, splenial; *sa*, surangular; *sq*, squamosal. See p. 27.

PLATE 6.

Skull of *Stegosaurus stenops* Marsh. Top view. Type. Cat. No. 4934, U.S.N.M. ½ nat. size. *e*, supratemporal fossa; *f*, frontal; *l*, lachrymal; *m*, maxillary; *n*, nasal; *p*, parietal; *pf*, prefrontal; *pm*, premaxillary; *po*, postorbital; *p. oc*, paraoccipital process; *po. f*, postfrontal; *po. so*, postsupraorbital; *p. so*, presupraorbital; *q*, quadrate; *qj*, quadratojugal; *so*, supraoccipital *sq*, squamosal. See p. 27.

PLATE 7.

Skull of *Stegosaurus stenops* Marsh. Type. Cat. No. 4934, U.S.N.M. ½ nat. size. Inferior view. *an*, angular; *ar*, articular; *d*, dentary; *oc*, occipital condyle; *p. ar*, prearticular; *pd*, predentary; *pl*, palatine; *pm*, premaxillary; *p. oc*, paraoccipital process; *pt*, pterygoid; *s*, splenial; *v*, vomer.

Drawn under the direction of Prof. O. C. Marsh, with slight modifications. See p. 27.

PLATE 8.

Skull of *Stegosaurus stenops* Marsh. Longitudinal section. Type. Cat. No. 4934, U.S.N.M. ½ nat. size. *a*, anterior nares; *an*, angular; *ar*, articular; *d*, dentary; *f*, frontal; *f.m*, foramen magnum; *m*, maxillary; *n*, nasal; *oc*, occipital condyle; *p*, parietal; *p. ar*, prearticular; *pd*, predentary; *pm*, premaxillary; *p. oc*, paraoccipital process; *pt*, pterygoid; *q*, quadrate; *s*, splenial.

Drawn under the direction of Prof. O. C. Marsh, with slight modifications. See p. 27.

PLATE 9.

Skull of *Stegosaurus stenops* Marsh. Cat. No. 4934, U.S.N.M. ½ nat. size. Type. (1) Front view; (2) back view. *a*, anterior nares; *an*, angular; *ar*, articular; *d*, dentary; *f*, frontal; *fm*, foramen magnum; *l*, lachrymal; *n*, nasal; *oc*, occipital condyle; *p*, parietal; *p. art*, prearticular; *pd*, predentary; *pf*, prefrontal; *pm*, premaxillary; *po*, postorbital; *p. oc*, paraoccipital; *po. f*, postfrontal; *po. so*, postsupraorbital; *p. so*, presupraorbital; *pt*, pterygoid; *q*, quadrate; *sa*, surangular; *so*, supraorbital, *sq*, squamosal. Both figures after Professor Marsh, with slight modifications. See p. 27.

PLATE 10.

Skull of *Stegosaurus armatus* Marsh.? Cat. No. 4936, U.S.N.M. 1. Top view; *e*, supratemporal fossa; *f*, frontal; *fm*, foramen magnum; *ns*, sutural surface for nasals; *oc*, occipital condyle; *p*, parietal; *po*, postorbital; *ps*, sutural surface for prefrontal; *so*, supraoccipital. 2. Ventral view; *al. sp*, alisphenoid; *b*, orbit; *e*, supratemporal fossa; *oc*, occipital condyle; *ol*, olfactory region of the brain case; *or. sp*, orbitosphenoid; *pp*, paraoccipital process. II, III, and IV exit of second, third, and fourth cranial nerves. 3. Longitudinal section through brain case; *f*, frontal; *f′*, exit of II cranial nerve; *fm*, foramen magnum; *oc*, occipital condyle; *ol*, exit of olfactory nerve; *op*, for optic lobe; *p*, parietal; *pi*, pituitary fossa; *ps*, presphenoid; *so*, supraoccipital. 4. Outline of skull of *Stegosaurus armatus* with brain cast in position; seen from above; *c*, cerebral hemispheres; *cb*, cerebellum; *e*, supratemporal fossa; *m*, medulla; *ol*, olfactory lobes. 5. Brain cast of the same; *c*, cerebral hemispheres; *cb*, cerebellum; *m*, medulla; *ol*, olfactory lobes; *on*, optic nerves; *op*, optic lobes; *pi*, pituitary body. All figures are ½ nat. size. Drawn under the direction of Prof. O. C. Marsh with slight modifications. The species identification is that of Professor Marsh. See p. 41.

PLATE 11.

Cervical vertebrae and nuchal plates of *Stegosaurus stenops* Marsh. Type. Cat. No. 4934, U.S.N.M. About ½ nat. size. *at*, atlas; c_6, sixth cervical; *p. 1* to *p. 5*, dermal plates one to five, inclusive. Shows the relations of these bones as found in the matrix. From a photograph. See p. 92.

PLATE 12.

Fig. 1. Posterior dorsal plate of *Stegosaurus stenops* Marsh. Cat. No. 4714, U.S.N.M. ¼ nat. size. Viewed from the side. This plate can probably be correlated with No. 13 of No. 4934. This is plate No. 95, diagram 5, quarry 13. See also plate 37. *a*, anterior border; *b*, posterior border. See p. 93.

2. Ventral view of the same.

Drawn under the direction of Prof. O. C. Marsh.

PLATE 13.

Fig. 1. Anterior caudal plate of *Stegosaurus stenops* Marsh. Cat. No. 4714, U.S.N.M. ¼ nat. size. Viewed from the side. This is the largest plate of the series and is correllated with No. 14 of No. 4934. This is plate No. 10, diagram 5, quarry No. 13. See plate 37, also same as fig. 4, plate 24. *a*, anterior border; *b*, posterior border. See p. 93.

2. Ventral view of the same.

Drawn under the direction of Prof. O. C. Marsh.

PLATE 14.

Series of dermal plates of *Stegosaurus stenops* Marsh. Type. Cat. No. 4934, U.S.N.M. Plates 1 to 14 in sequence. The even numbers represent plates pertaining to the row of the right side; the odd to those of the left. About ⅛ natural size.

Drawn by Mr. George E. Roberts, under the direction of Dr. F. A. Lucas with additons. Published by permission of the United States Geological Survey. See p. 93.

PLATE 15.

Caudal vertebrae and spines of *Stegosaurus stenops* Marsh. Cat. No. 4714, U.S.N.M. ⅛ nat. size. Seen from the right side. *a*, right anterior spine; *b*, left anterior spine; *c*, left posterior spine; *d*, right spine of posterior pair; *d′*, basal half of same spine, removed in order to show underlying caudals; *e*, chevron; *f*, terminal vertebra; *g*, twelfth caudal from distal end. Drawn under direction of Prof. O. C. Marsh. See p. 95.

PLATE 16.

Caudal vertebrae, spines and plates of *Stegosaurus stenops* Marsh. Cat. No. 4288, U.S.N.M. Seen from the left side. ⅛ nat. size. After Marsh. *a*, right spine of anterior pair; *b*, left spine of anterior pair; *c*, small caudal plate; *d*, chevron bones; *e*, right spine of posterior pair; *f*, left spine of posterior pair; *g*, terminal vertebra; *h*, twenty-third caudal vertebra from distal end.

The bones represented here are essentially in the position in which they were found. Identified and figured by Prof. O. C. Marsh as *Diracodon laticeps* Marsh. Drawn under the direction of Prof. O. C. Marsh. See p. 95.

PLATE 17.

Dermal tail spine of *Stegosaurus stenops* Marsh. Cat. No. 6135, U.S.N.M. ½ nat. size. (1) and (2) side views; (3) posterior view. It undoubtedly belongs to the anterior pair. From quarry No. 13, diagram 5; No. 31½. See map, plate 37. Drawn under the direction of Prof. O. C. Marsh. See p. 95.

PLATE 18.

Dermal tail spine of *Stegosaurus sulcatus* Marsh. Cat. No. 4937, U.S.N.M. Type. ¼ nat. size. (1) external view; (2) internal view; (3) anterior view; (4) section taken at first fracture above the base in figure 2; (5) section taken at second fracture above the base, shown in figure 2. *a*, anterior sulci; *b*, ridge dividing the basal surface; *p*, posterior sulci; *r*, ridge between sulci; *s*, roughened surface for cartilaginous union with spine of opposite side. Drawn under the direction of O. C. Marsh. See p. 109.

PLATE 19.

Skull and sacral cavity of *Stegosaurus*.

Fig. 1. Skull of *Stegosaurus stenops* Marsh. Viewed from the right side. Type. Cat. No. 4934, U.S.N.M., about 1/4 nat. size. Reproduced from a photograph. See p. 27.

2. Sacral cavity of *Stegosaurus* sp. Cat. No. 7386, U.S.N.M. 1/4 nat. size. Ventral view. *a*, anterior; *c*, sacral cavity; *p*, posterior end. See p. 56.

PLATE 20.

Right coracoid, humerus, ulnae, and radii of *Stegosaurus*.

Fig. 1. Right coracoid of *Stegosaurus stenops* Marsh. Cat. No. 7411, U.S.N.M. 1/4 nat. size. Viewed externally. *a*, anterior border; *b*, glenoid fossa; *c*, coracoid foramen. See p. 67.

2. Right humerus of *Stegosaurus stenops* Marsh. Cat. No. 4929, U.S.N.M. 1/6 nat. size. Front view. *h*, head; *r*, radial crest; *s*, supinator ridge. See p. 68.

3. Right ulna of *Stegosaurus*. *A*, Cat. No. 4937, U.S.N.M. Type of *Stegosaurus sulcatus* Marsh. Adult: *B*, Cat. No. 7401, U.S.N.M. Juvenile. Comparative side views to show the great difference in the development of the olecranon process. Both 1/6 nat. size. See p. 69.

4. Right radii of *Stegosaurus*. *A*, Cat. No. 4937, U.S.N.M. Type of *Stegosaurus sulcatus* Marsh. Adult: *B*, Cat. No. 7401, U.S.N.M. Juvenile. Comparative front views. Both 1/6 nat. size. See p. 70.

PLATE 21.

Scapula of *Stegosaurus stenops*, metacarpals of *Stegosaurus sulcatus*, and hind foot of *Stegosaurus*.

Fig. 1. Right hind foot of *Stegosaurus*. sp. Cat. No. 4280, U.S.N.M. About 1/4 nat. size. Shown as found *in situ*. I, II, III, digits one, two, and three. *S*, sesamoid. See p. 88.

2. Metacarpals of *Stegosaurus sulcatus* Marsh. Cat. No. 4937, U.S.N.M. Type. 1/4 nat. size. Right fore foot, front view. 1, 2, 3, 4, and 5 metacarpals one to five. See p. 72.

3. Left scapula of *Stegosaurus stenops* Marsh. Cat. No. 7371, U.S.N.M. 1/6 nat. size Outer view. *g*, glenoid fossa. See p. 66.

PLATE 22.

Skull of *Heloderma suspectum* and dermal ossicles of *Stegosaurus stenops* Marsh.

Fig. 1. Tuberculated upper surface of the skull of *Heloderma suspectum*, the Gila monster, for comparison with the dermal tubercles of *Stegosaurus*. About nat. size. After Osborn. See p. 91.

2. Dermal ossicles of *Stegosaurus stenops* Marsh. Cat. No. 7615, U.S.N.M. 1/2 nat. size. External view. Shown as found *in situ*. See p. 91.

3. Dermal ossicles of *Stegosaurus stenops* Marsh. Cat. No. 4934, U.S.N.M. Type. 1/4 nat. size. Internal side of ossicles. Portion of those shown in plates 2 and 4. See p. 91.

PLATE 23.

Dermal plates of *Stegosaurus stenops* Marsh, and *Stegosaurus sulcatus* Marsh.

Figs. 1, 2, and 3. Nuchal plates of *Stegosaurus* showing the change in shape and comparative sizes from the skull posteriorly. (1) Cat. No. 4937. Belongs to the type of *Stegosaurus sulcatus* Marsh; (2) and (3) Cat. No 7615. All in the U. S. National Museum. All 1/4 nat. size. See p. 92.

4. Posterior nuchal plate of *Stegosaurus stenops* Marsh. Cat. No. 7584, U.S.N.M. 1/4 nat. size. See plate 37, map of quarry 13, diagram 4, No. 211. This plate is correlated with No. 6 of No. 4934. See also plate 14. See p. 92.

5. Dermal plate from region of shoulder of *Stegosaurus stenops* Marsh. Inner view. Cat. No. 7584, U.S.N.M. 1/8 nat. size. See plate 37, map of quarry 13, diagram 4, No. 209. This plate is correlated with No. 8 of No. 4934. See also plate 14. See p. 92.

6. Dermal plate from sacral region of *Stegosaurus stenops* Marsh, Cat. No. 4714, U.S.N.M. 1/8 nat. size. See plate 37, map of quarry 13, diagram 5, No. 95. This plate is correlated with No. 13 of specimen No. 4934. See also plate 14. See p. 93.

PLATE 24.

Dermal plates from tail of *Stegosaurus stenops* Marsh.

FIG. 1. Distal tail plate of *Stegosaurus stenops* Marsh. Cat. No. 4714, U.S.N.M. About $\frac{1}{8}$ nat. size. Plate 37, map of quarry 13, No. 177, quarry 13, diagram 5; also 177, fig. 58. This plate is correlated with No. 17 of specimen No. 4934, plate 3. See p. 93.

2. Dermal tail plate of *Stegosaurus stenops* Marsh. Cat. No. 4714, U.S.N.M. $\frac{1}{8}$ nat. size. See plate 37, map of quarry 13, diagram 5, No. 76; also 76, fig. 58. This plate is correlated with No. 16 of specimen No. 4934, plate 3. See p. 93.

3. Dermal plate of *Stegosaurus stenops* Marsh. Cat. No. 4714, U.S.N.M. $\frac{1}{8}$ nat. size. See plate 37, map of quarry 13, diagram No. 75. This plate is correlated with No. 15 of specimen No. 4934. See plate 3; also 75, fig. 58. See p. 93.

4. Dermal tail plate of *Stegosaurus stenops* Marsh. Cat. No. 4714, U.S.N.M. $\frac{1}{8}$ nat. size. See plate 37, map of quarry 13, diagram 5, No. 10; also 10, fig. 58. This plate is correlated with No. 14, specimen No. 4934, plate 3. See p. 93.

PLATE 25.

Fibula, ischium, and dermal tail spines of *Stegosaurus*.

Fig. 1. Anterior dermal tail spine of *Stegosaurus stenops* Marsh. Cat. No. 6629, U.S.N.M. $\frac{1}{2}$ nat. size. Lateral view. Juvenile. See p. 95.

2. Posterior tail spine of *Stegosaurus stenops* Marsh. Cat. No. 6629, U.S.N.M. $\frac{1}{2}$ nat. size. Oblique lateral view. Juvenile. See p. 95.

3. Posterior dermal tail spine of *Stegosaurus sulcatus* Marsh. Type. Cat. No. 4937, U.S.N.M. $\frac{1}{5}$ nat. size. Viewed from the side. See p. 110.

4. Left ischium of *Stegosaurus longispinus* Gilmore. Type D 54, University of Wyoming collection. $\frac{1}{6}$ nat. size. *b*, process which meets the pubis; *i*, iliac articulating border; *s*, symphysis. See p. 113.

5. Left fibula of *Stegosaurus* sp. Cat. No. 7389, U.S.N.M. $\frac{1}{4}$ nat. size. Internal view. See p. 85.

PLATE 26.

Scapula, coracoid, and humerus of *Hoplitosaurus marshi* (Lucas).

Fig. 1. Distal half of humerus of *Hoplitosaurus marshi* (Lucas). Type. Cat. No. 4752, U.S.N.M. About $\frac{1}{3}$ nat. size. See p. 115.

2. Proximal half of the left humerus of *Hoplitosaurus marshi* (Lucas). Type. Cat. No. 4752, U.S.N.M. About $\frac{1}{3}$ nat. size. Front view. See p. 115.

3. Portion of right scapula and coracoid of *Hoplitosaurus marshi* (Lucas). Type. Cat. No. 4752, U.S.N.M. $\frac{1}{3}$ nat. size. Lateral view. *a*, acromion process; *c*, coracoid; *g*, glenoid fossa. See p. 115.

PLATE 27.

Dermal elements of *Hoplitosaurus marshi* (Lucas). Type. Cat. No. 4752, U.S.N.M. Mass of dermal scutes and ossicles shown as found *in situ*. Less than $\frac{1}{2}$ nat. size. See p. 118.

PLATE 28.

Dermal plate of *Hoplitosaurus marshi* (Lucas). Type. Cat. No. 4752, U.S.N.M. $\frac{1}{2}$ nat. size. External view, probably represents the type of spine adjacent to the shoulder region. See p. 119.

PLATE 29.

Dermal plate of *Hoplitosaurus marshi* (Lucas). Type. Cat. No. 4752, U.S.N.M. (1) lateral view; (2) posterior view of same. Both figs. $\frac{1}{3}$ nat. size. See p. 120.

PLATE 30.

Dermal plate of *Hoplitosaurus marshi* (Lucas). Type. Cat. No. 4752, U.S.N.M. (1) lateral view; (2) posterior view of same. Both figs. $\frac{1}{3}$ nat. size. See p. 120.

PLATE 31.

Dermal bones of unidentified reptiles.

Fig. 1. Dermal ossifications of unidentified reptiles. (*a*) Cat. No. 7804, U.S.N.M.; (*b*) Cat. No. 7805, U.S.N.M. Lateral view. Both natural size. Both from Lance formation of Wyoming. See p. 122.

2. Dermal scutes of *Hierosaurus* ?. Cat. No. 7726 U.S.N.M. $\frac{1}{2}$ nat. size. Dorsal view of all. From Big Horn County, Wyoming See p. 122.

3. Dermal scute of unidentified dinosaur from the Lance formation of Montana. Cat. No. 7724, U.S.N.M. $\frac{1}{2}$ nat. size. Dorsal view. See p. 122.

4. Dermal scute of unidentified dinosaur from the Lance formation of Wyoming. Cat. No. 7243, U.S.N.M. $\frac{1}{2}$ nat. size. Dorsal view. See p. 122.

PLATE 32.

Restorations of *Stegosaurus*.

Upper figure. Restoration of *Stegosaurus ungulatus* Marsh, 1891. $\frac{1}{45}$ nat. size. After Marsh. See p. 122.

Lower figure. Life restoration of *Stegosaurus ungulatus* Marsh. By J. Smit, 1893. After Rev. H. N. Hutchinson. See p. 123.

PLATE 33.

Restorations of *Stegosaurus*.

Upper figure. Life restoration of *Stegosaurus*. By Frank Bond, 1899. Drawn under the direction of Prof. W. C. Knight. See p. 123.

Lower figure. Life restoration of *Stegosaurus ungulatus* Marsh. By Charles R. Knight, 1901. After F. A. Lucas. See p. 123.

PLATE 34.

Restorations of *Stegosaurus*.

Upper figure. Life restoration of *Stegosaurus ungulatus* Marsh. By G. E. Roberts, 1901. See p. 123.

Lower figure. Statuette of *Stegosaurus stenops* Marsh. By Charles R. Knight, 1903. After model in U. S. National Museum. See p. 123.

PLATE 35.

Restorations of *Stegosaurus*.

Upper figure. Restoration of *Stegosaurus ungulatus* Marsh, by T. Smit. After Rev. H. N. Hutchinson, 1911. See p. 123.

Lower figure. Life restoration of *Stegosaurus*, 1905. After E. Ray Lankester. See p. 123.

PLATE 36.

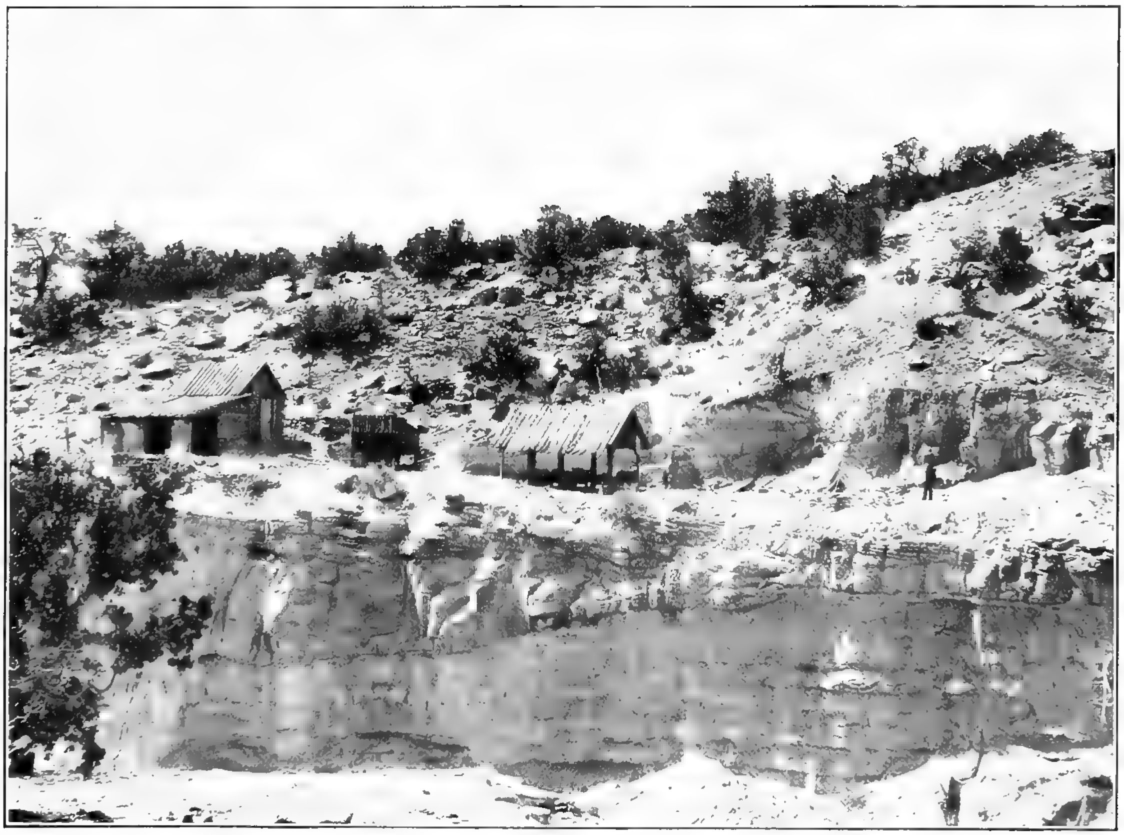
Restorations of *Stegosaurus*.

Upper figure. Life restoration of *Stegosaurus ungulatus* Marsh, by R. S. Lull, 1910. After R. S. Lull. See p. 124.

Lower figure. Mounted skeleton of *Stegosaurus ungulatus* Marsh, in the Peabody Museum, New Haven, Conn. (Cat. Nos. 1853 and 1858), oblique front view. 1910. Length, 19 feet 5 inches. After R. S. Lull. See p. 124.

PLATE 37.

Map of quarry 13, near Como, Albany County, Wyoming. Worked under the direction of Prof. O. C. Marsh, from 1879 to 1887, inclusive. Scale about $4\frac{1}{2}$ feet to the inch. This map shows the relative positions of all the bones found in diagrams 1, 2, 3, 4, 5, 7, 8, 11, 12, and 13, each bone or group of bones being designated by the original quarry numbers. Compiled from quarry maps made by Mr. Fred Brown. See p. 4.



QUARRY, GARDEN PARK, FREMONT COUNTY, COLORADO.

FOR EXPLANATION OF PLATE SEE PAGE 131.

Skeleton of Stegosaurus stenops.

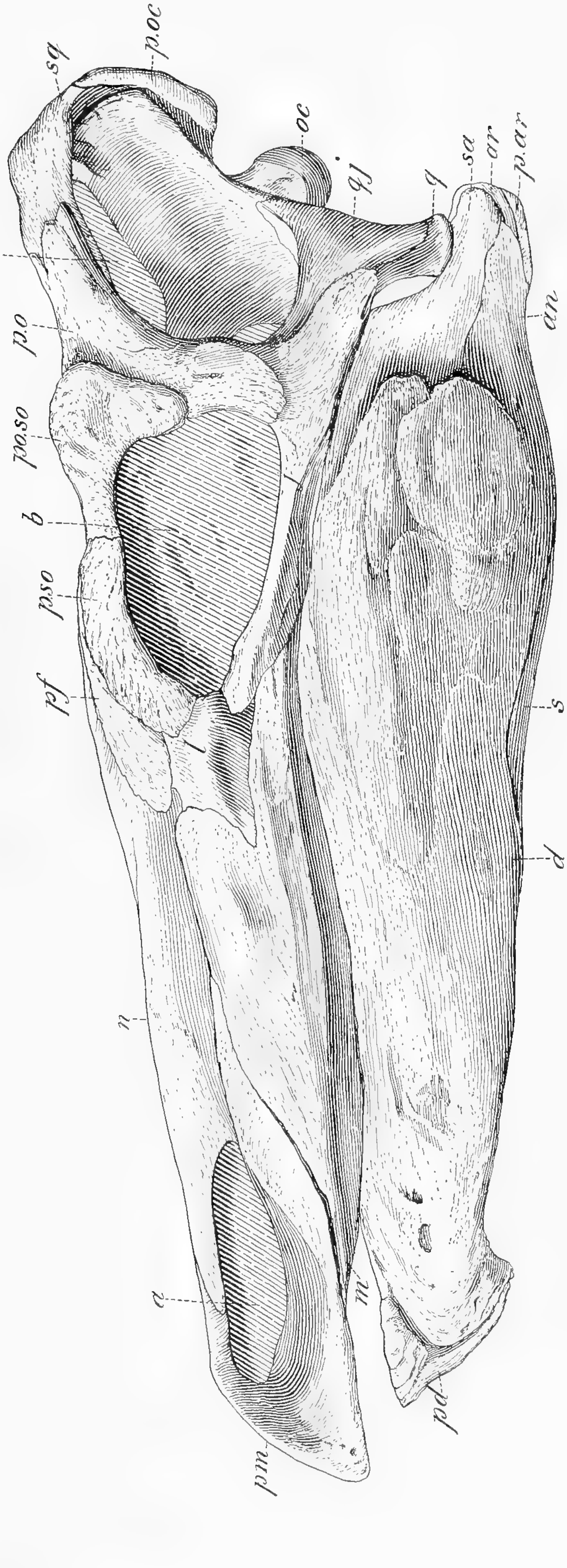
For explanation of plate see page 131.

KEY TO SKELETON OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 131.

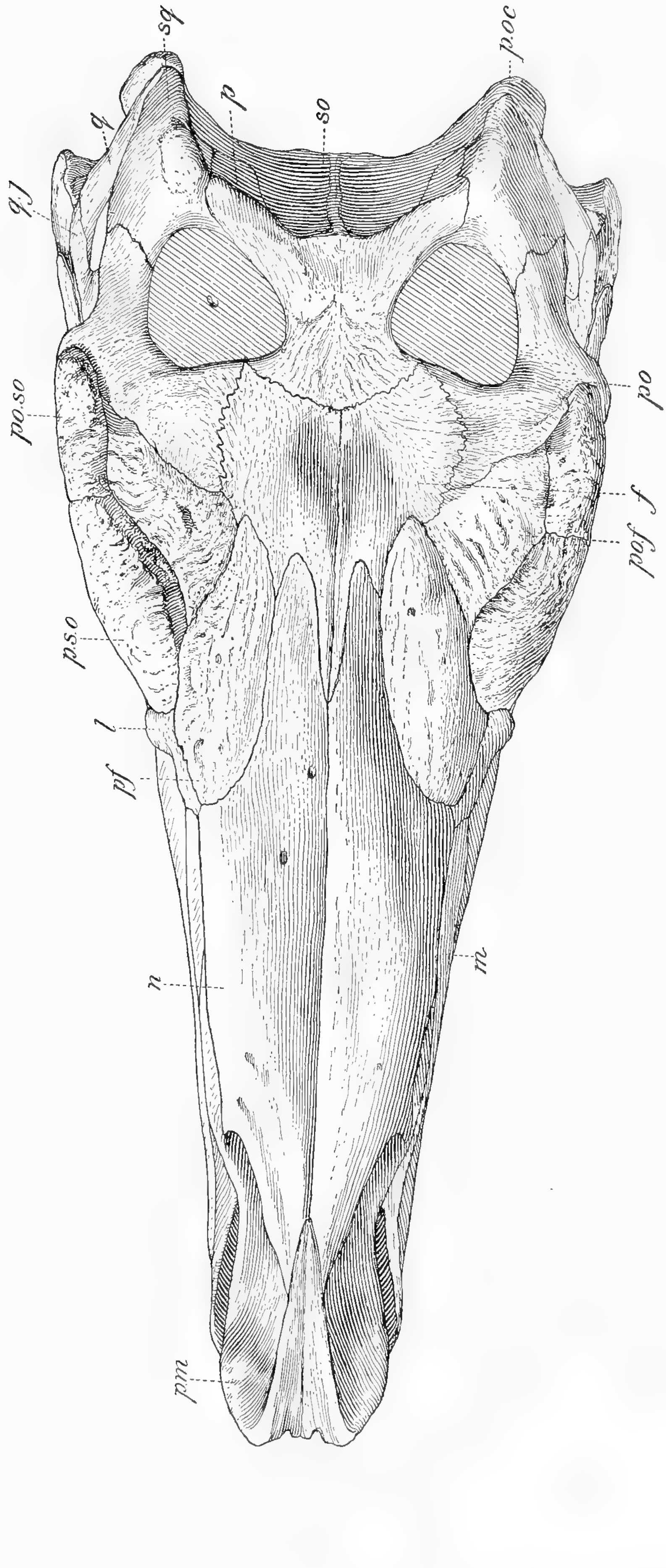
SKELETON OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 131.



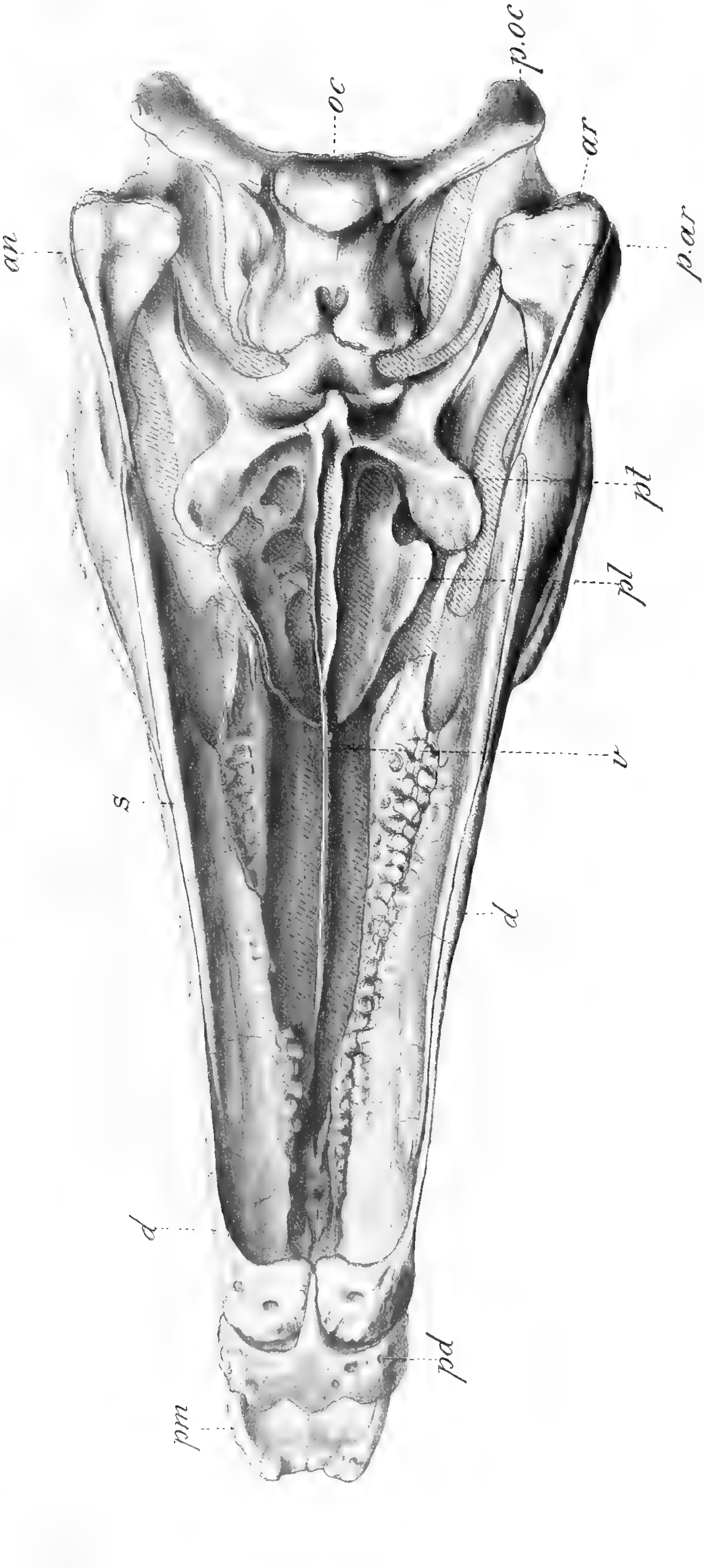
SKULL OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 132.



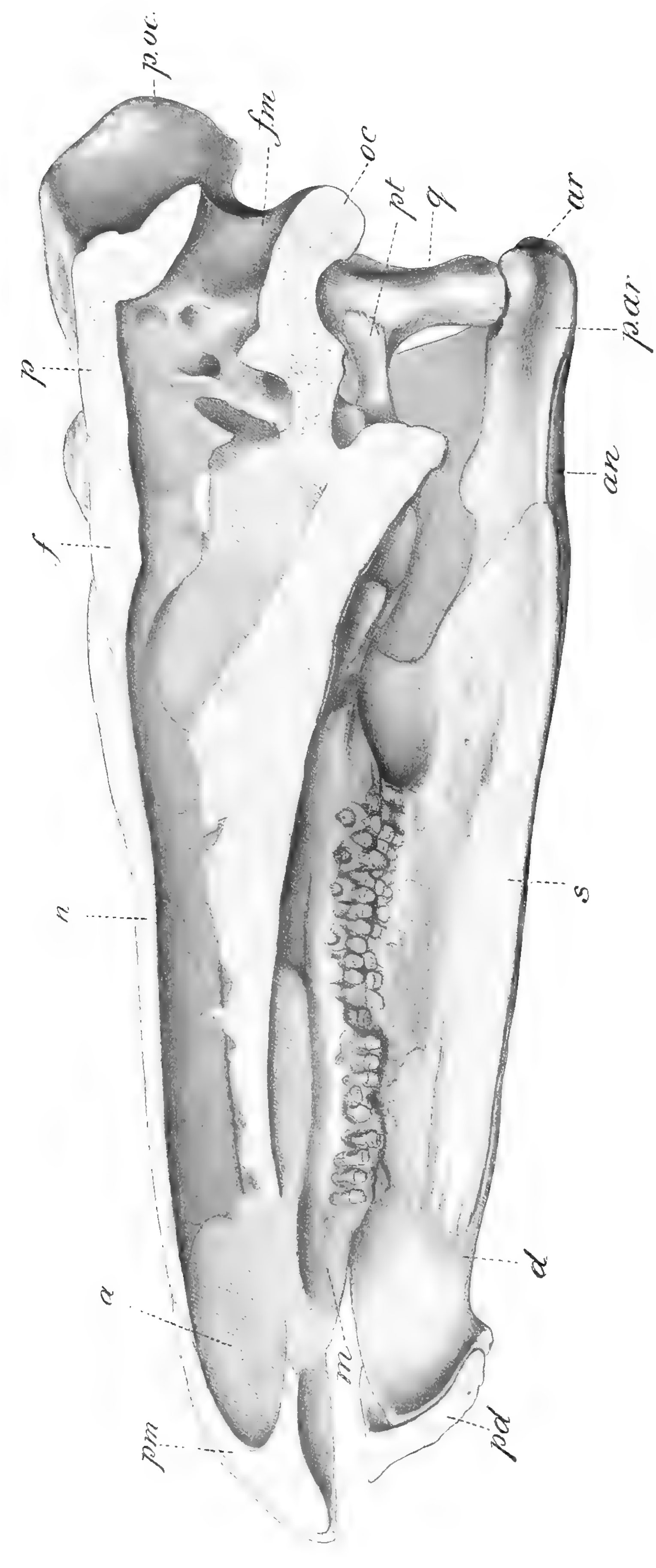
SKULL OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 132.



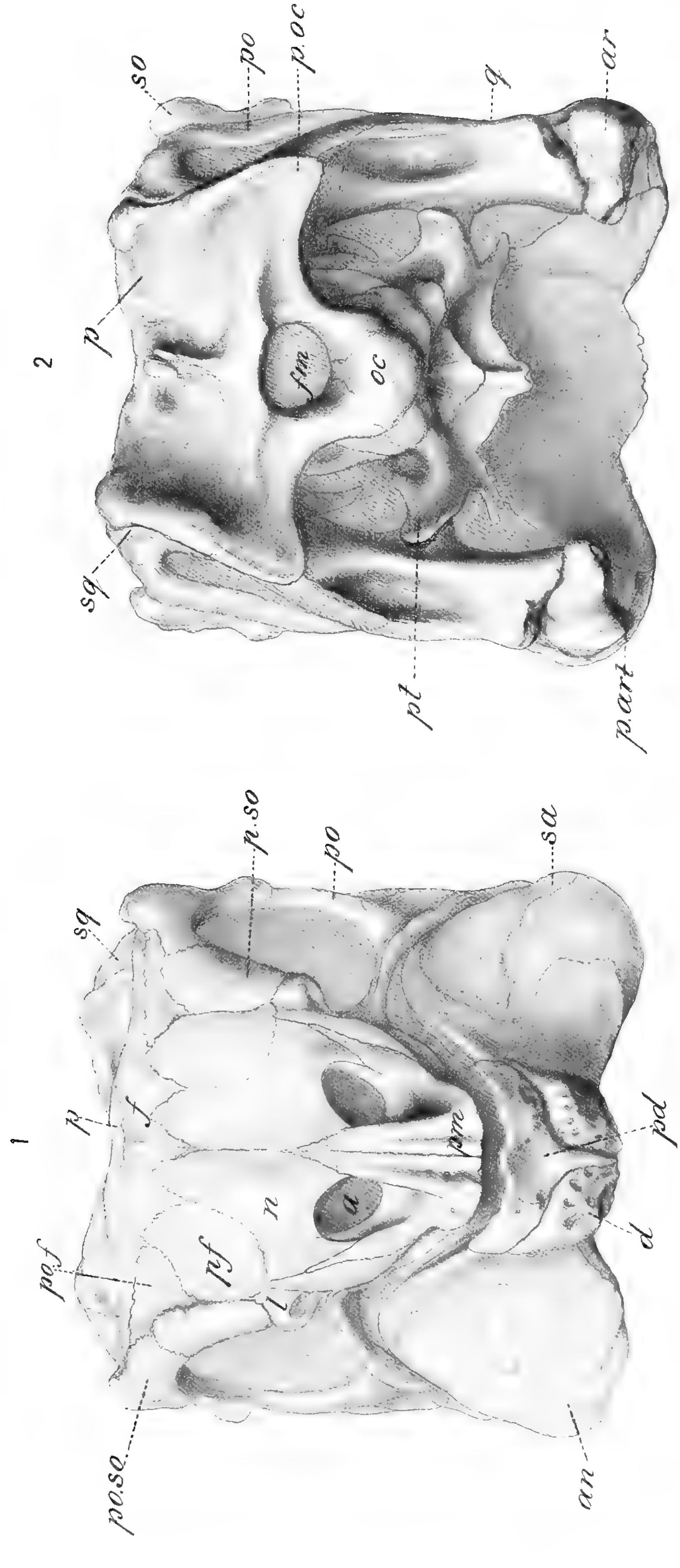
SKULL OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 132.



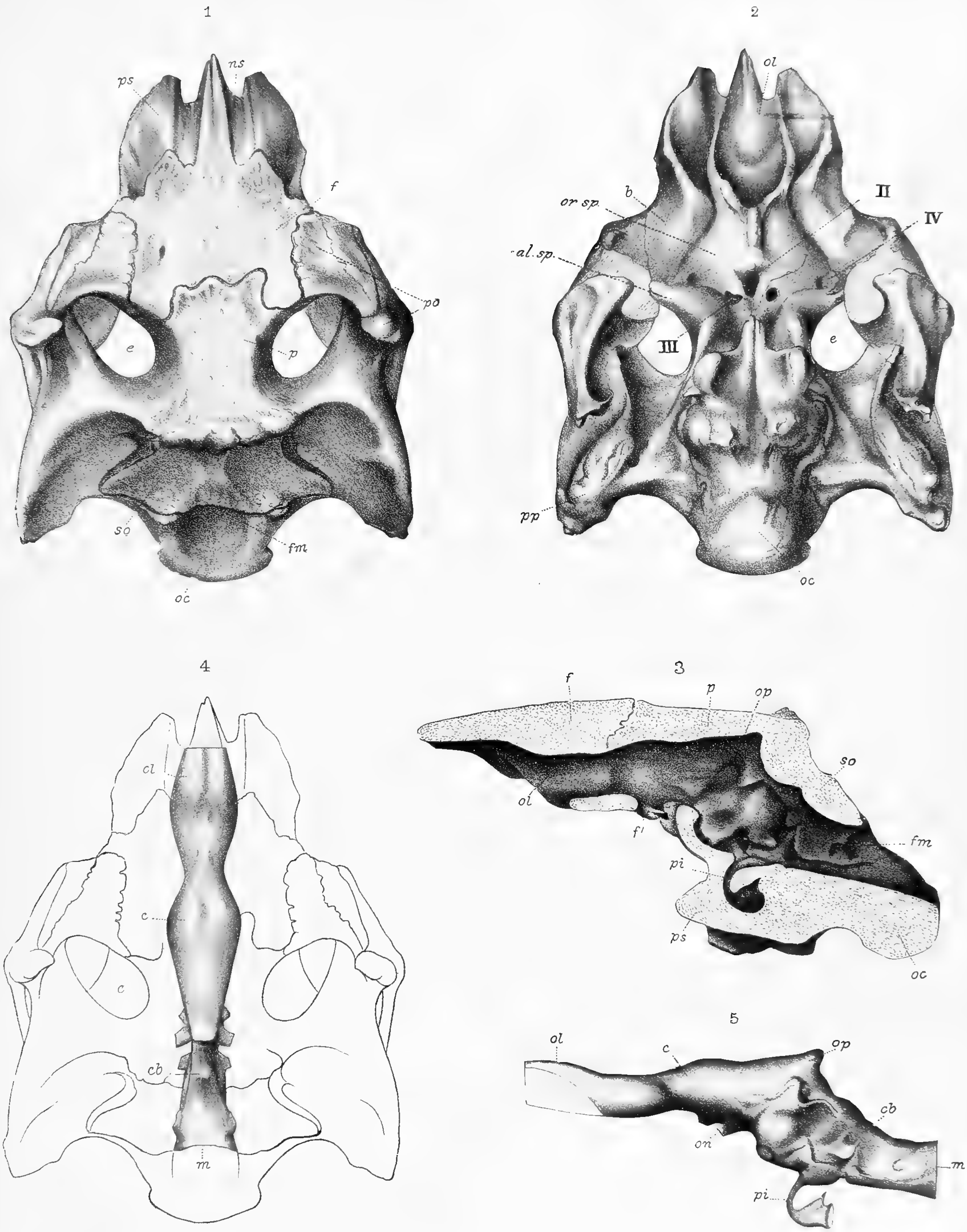
SKULL OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 132.



SKULL OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 132.



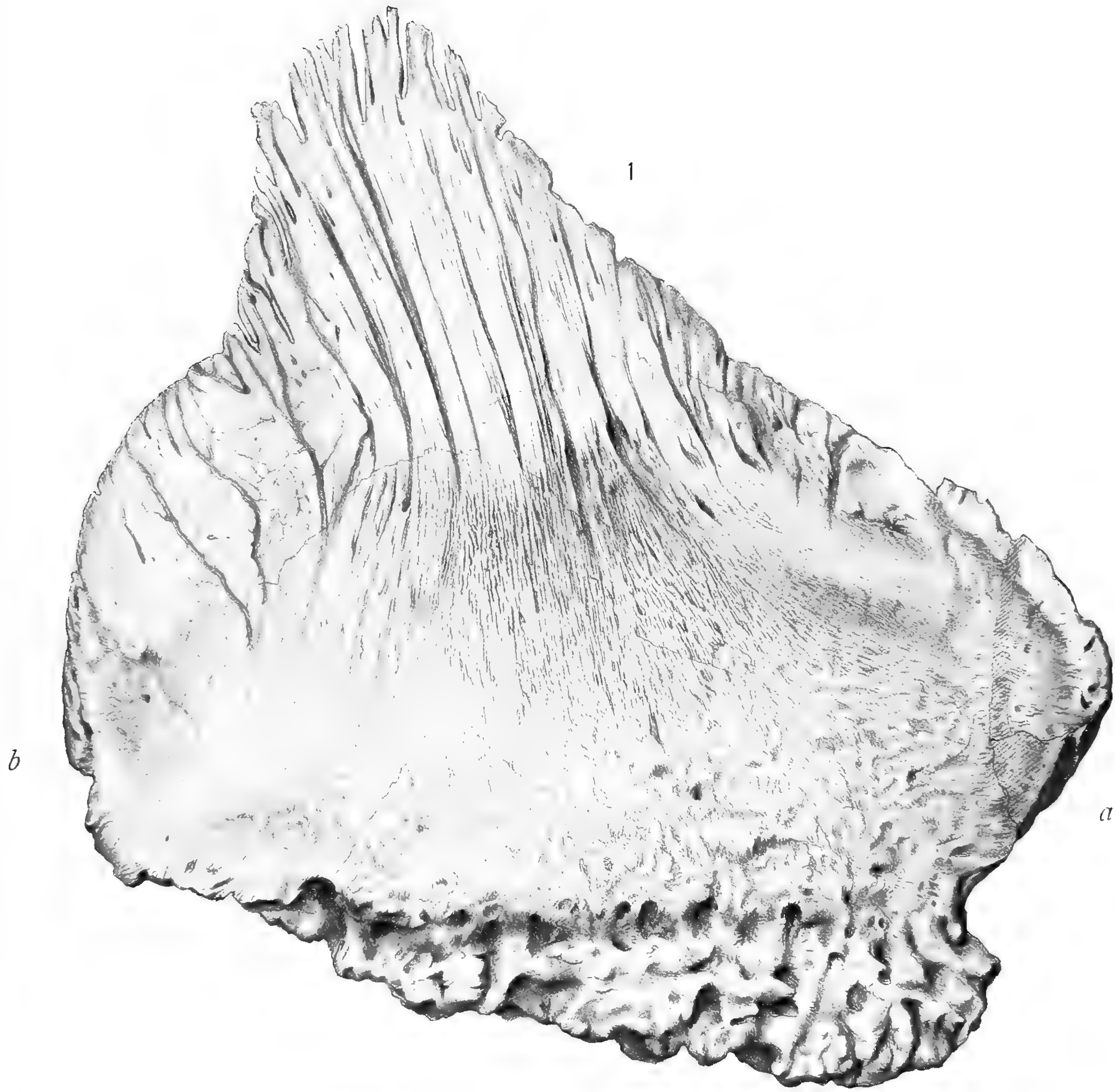
Skull and Brain of Stegosaurus armatus?

For explanation of plate see page 132.

CERVICAL REGION OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 133.

1



2

PLATE OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 133.

1

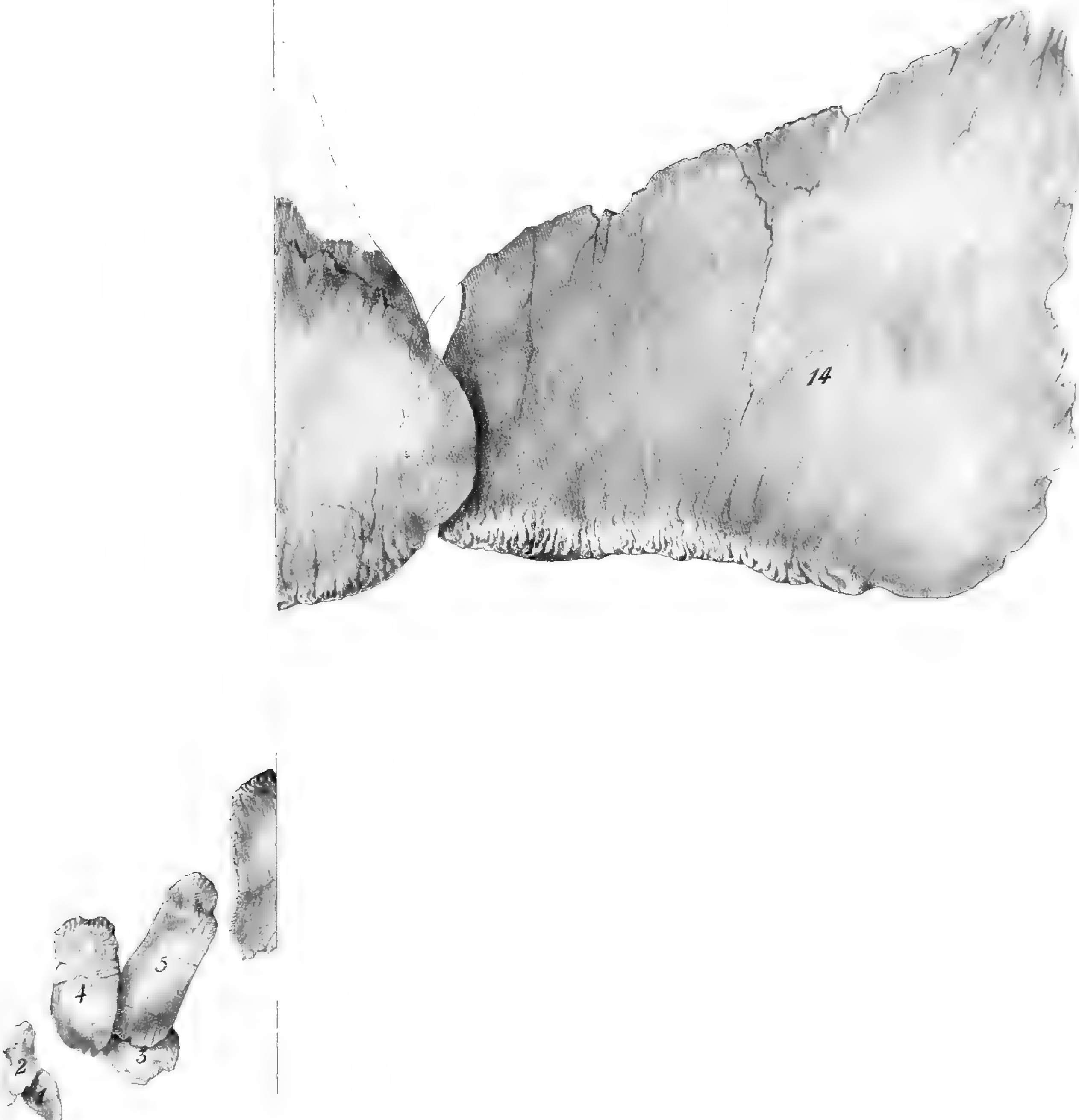
a

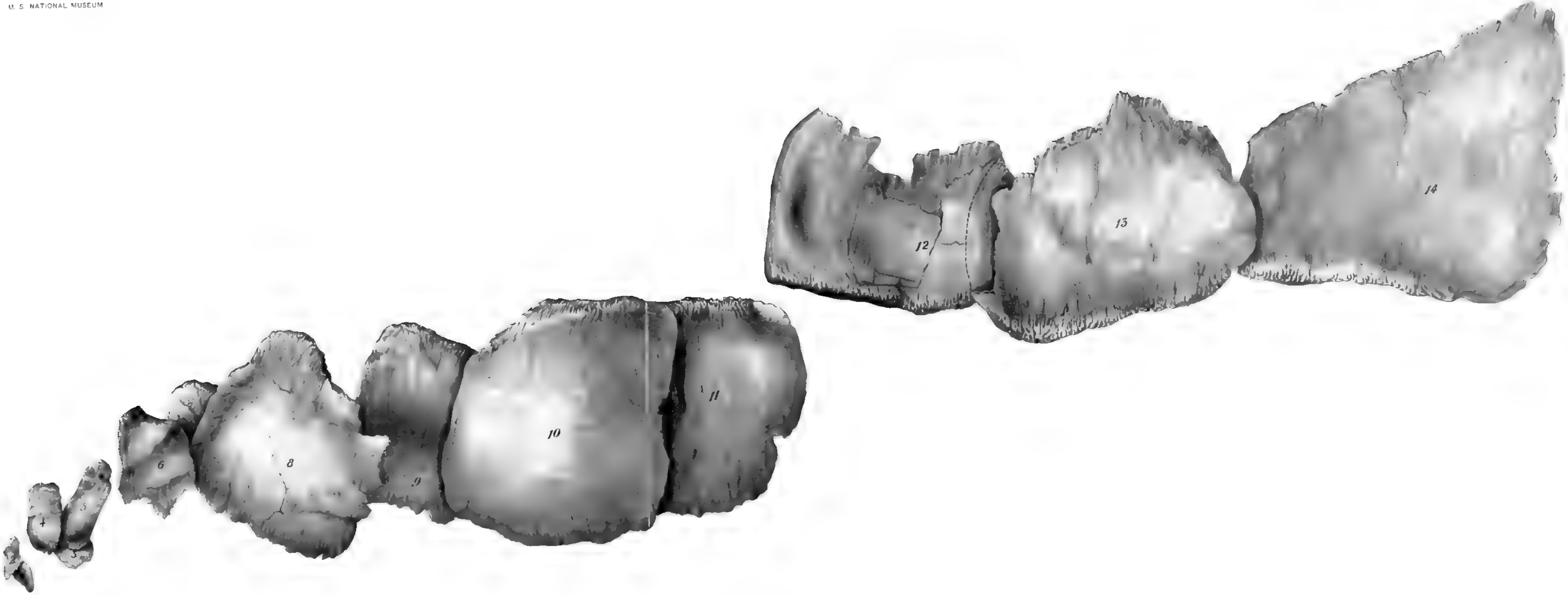
b

2

Plate of Stegosaurus stenops.

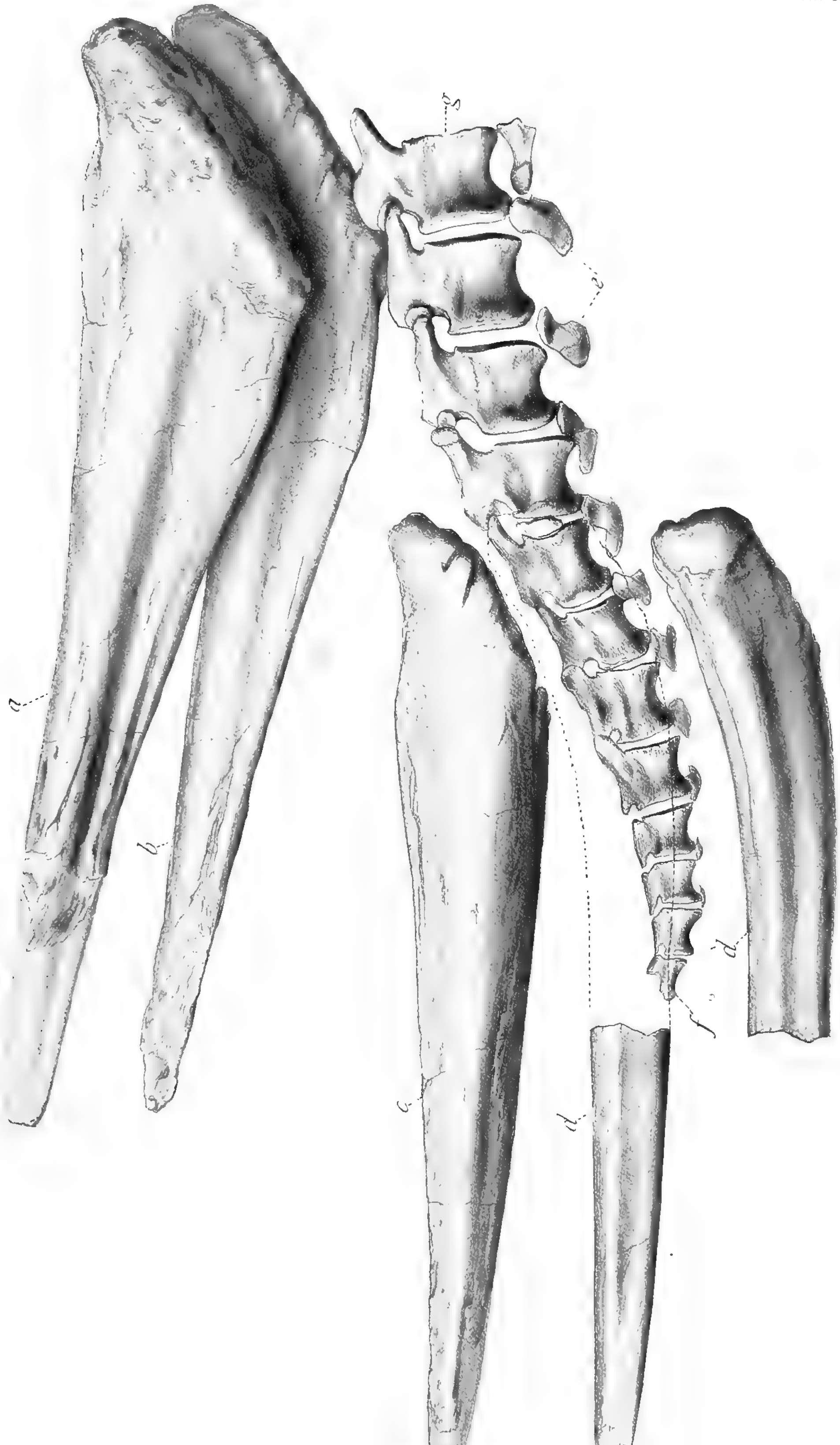
For explanation of plate see page 133.


14
5
4
3
2
1



DERMAL PLATES OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 133.

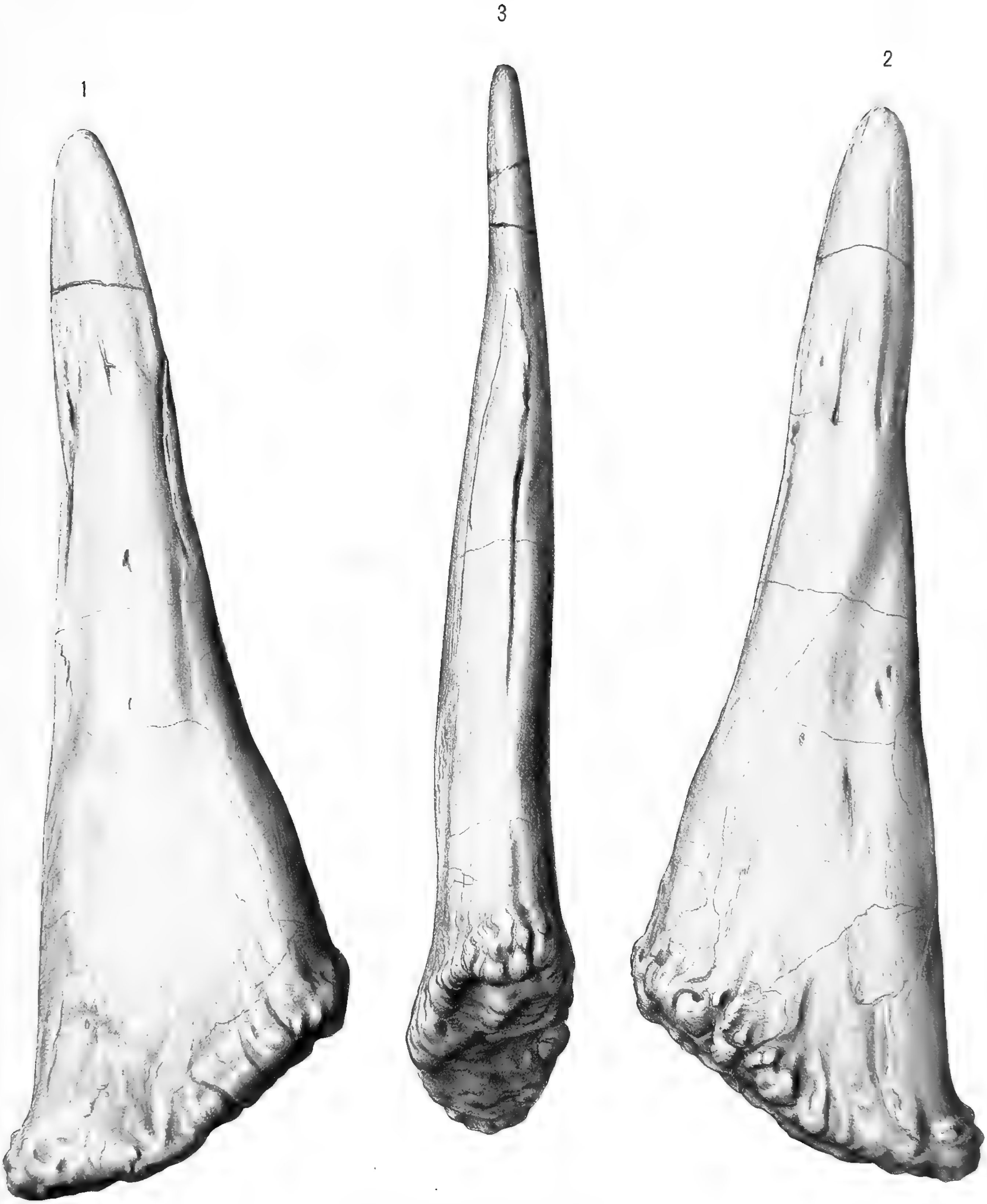


TIP OF TAIL OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 133.

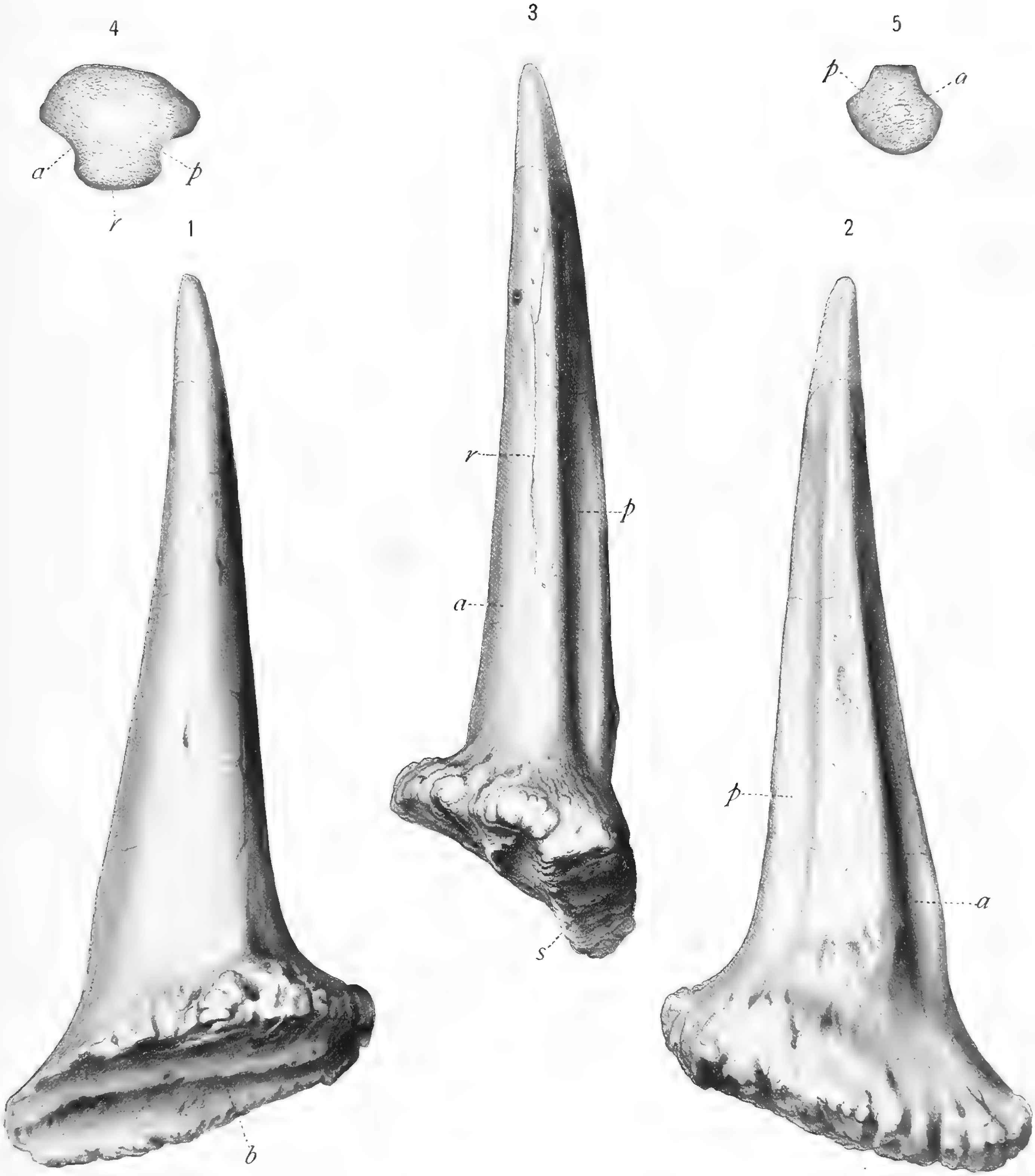
TIP OF TAIL OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 133.



DERMAL SPINE OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 133.

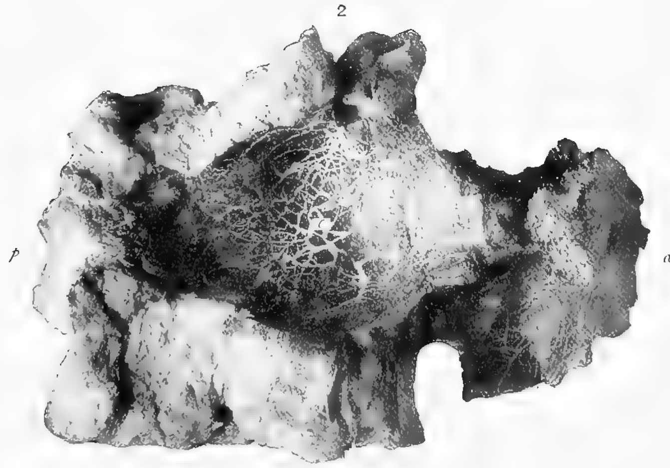


DERMAL SPINE OF STEGOSAURUS SULCATUS.

FOR EXPLANATION OF PLATE SEE PAGE 133.

1

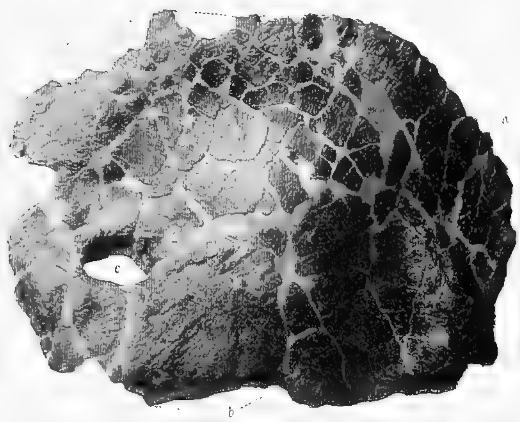
2



SKULL AND SACRAL CAVITY OF STEGOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 134.

1



2

3

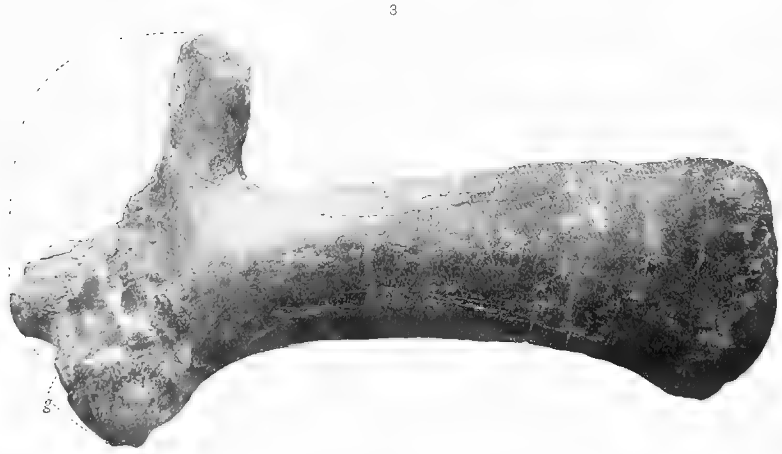
Coracoid, Humerus, Ulna, and Radii of Stegosaurus.

For explanation of plate see page 134.

1

2

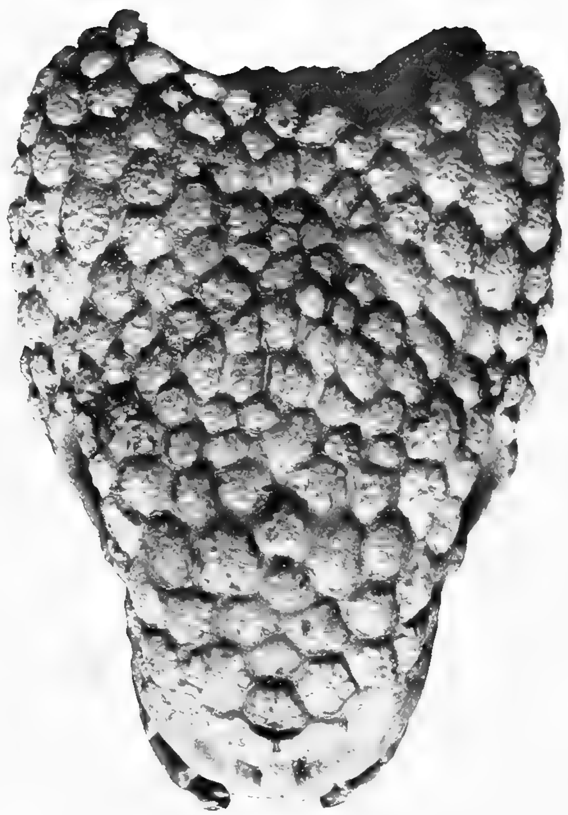
3



SCAPULA, FORE AND HIND FOOT OF STEGOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 134.

1



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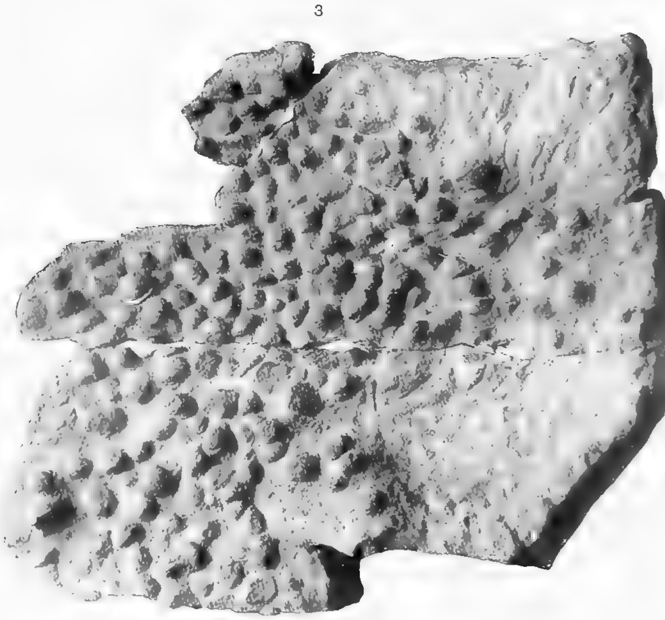
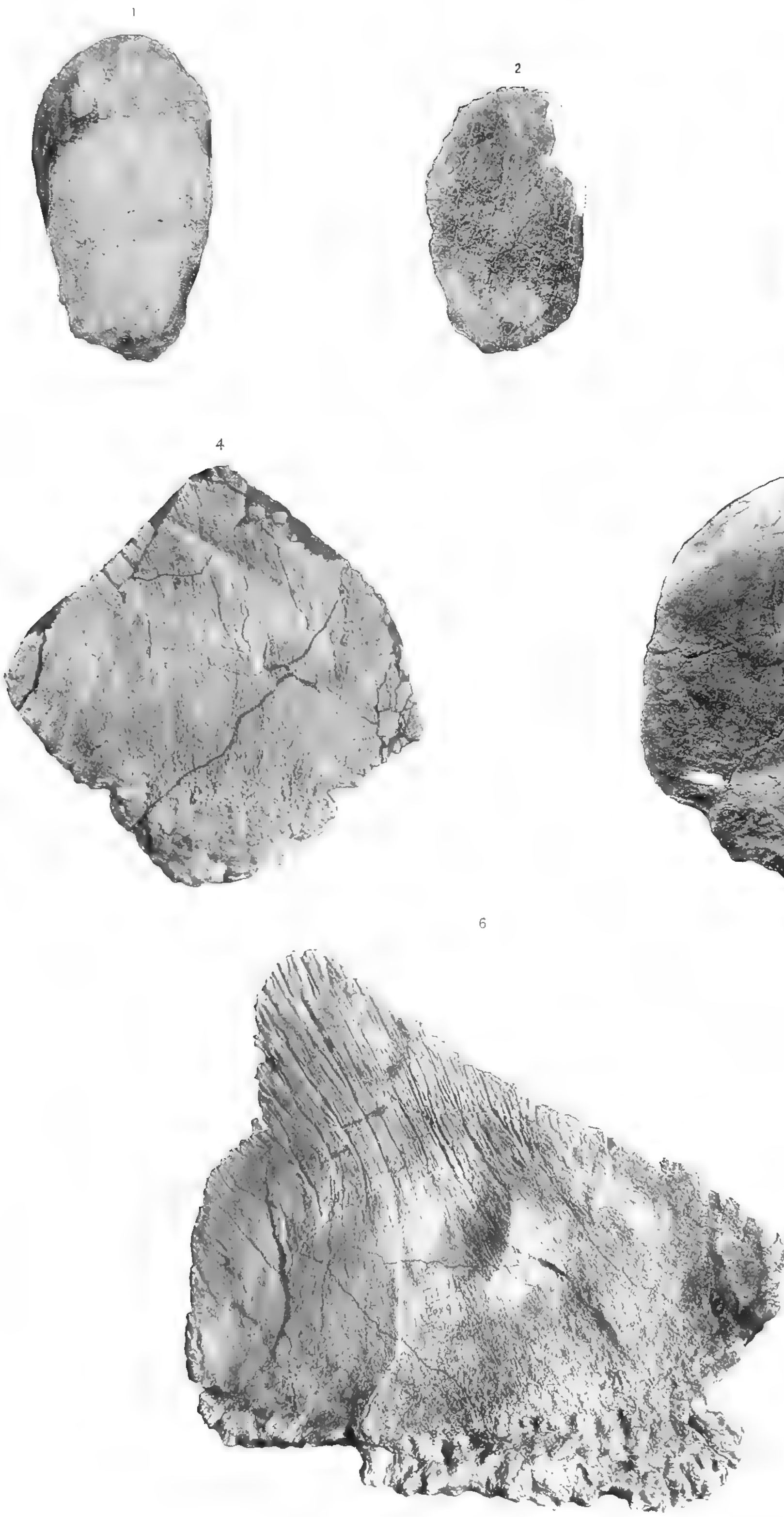


2

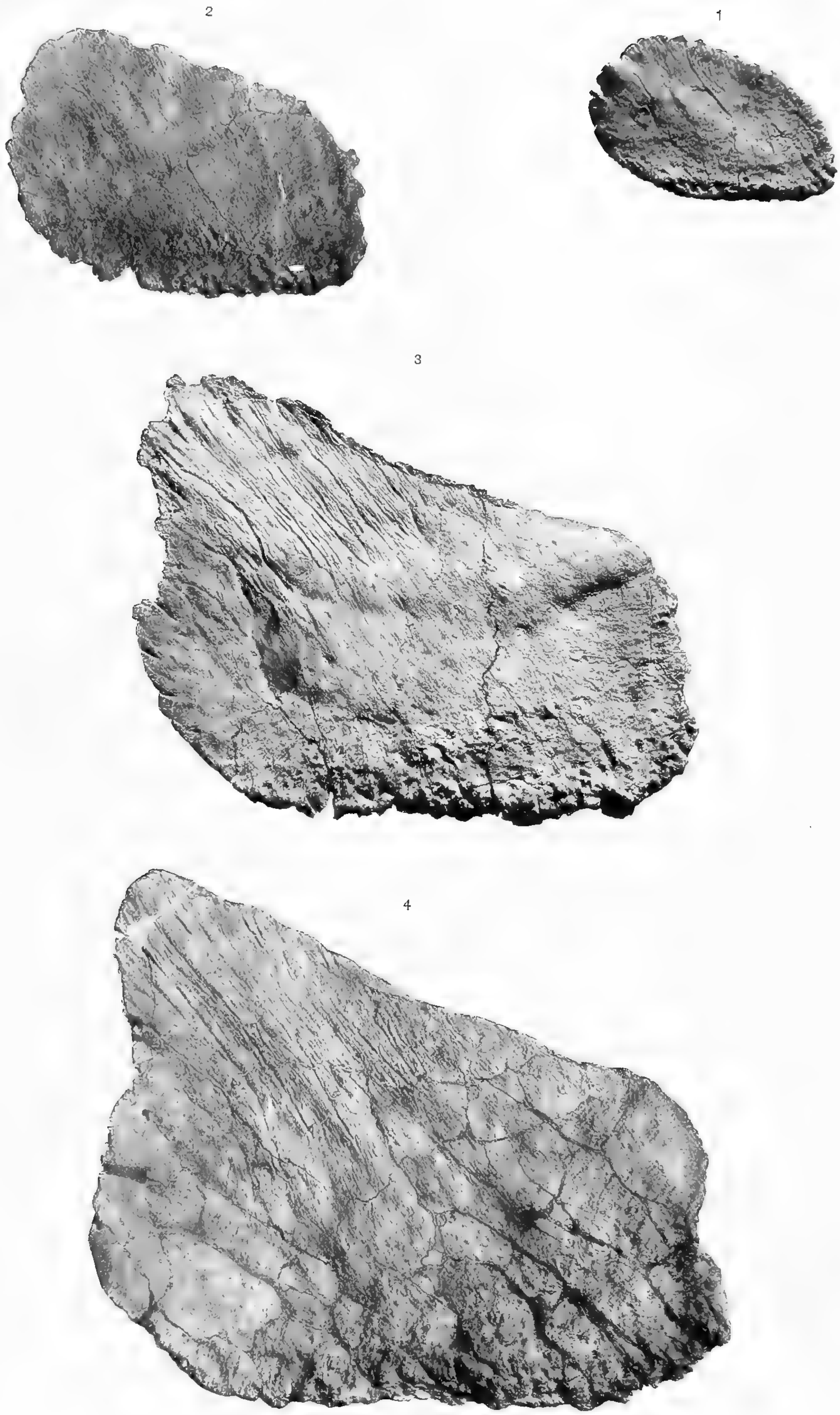
SKULL OF HELODERMA SUSPECTUM AND OSSICLES OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 134.



DERMAL PLATES OF STEGOSAURUS STENOPS AND S. SULCATUS.

FOR EXPLANATION OF PLATE SEE PAGE 134.



DERMAL PLATES OF STEGOSAURUS STENOPS.

FOR EXPLANATION OF PLATE SEE PAGE 135.

FIBULA, ISCHIUM, AND DERMAL TAIL SPINES OF STEGOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 135.

SCAPULA, CORACOID, AND HUMERUS OF HOPLITOSAURUS.

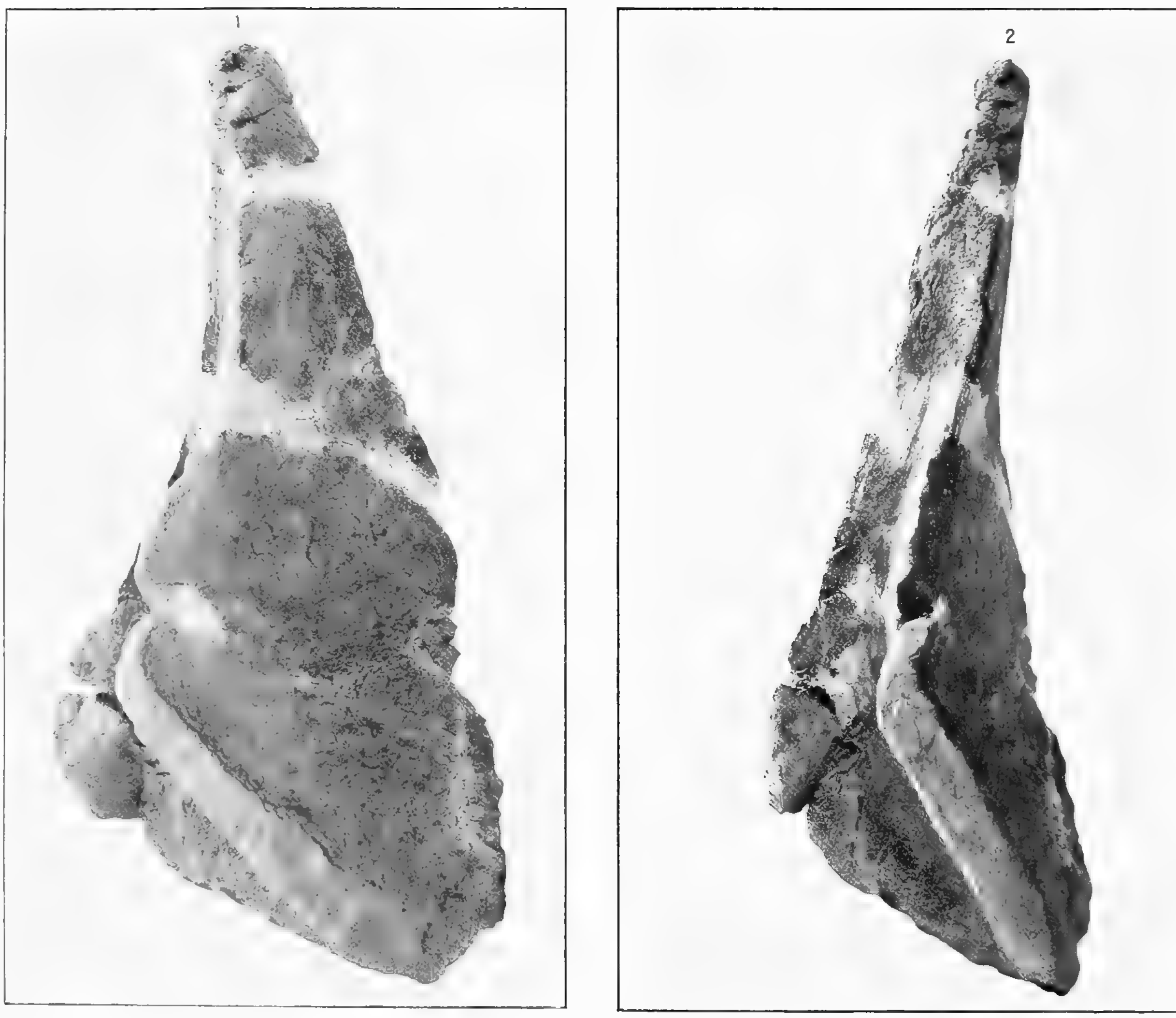
FOR EXPLANATION OF PLATE SEE PAGE 135.

DERMAL BONES OF HOPLITOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 135.

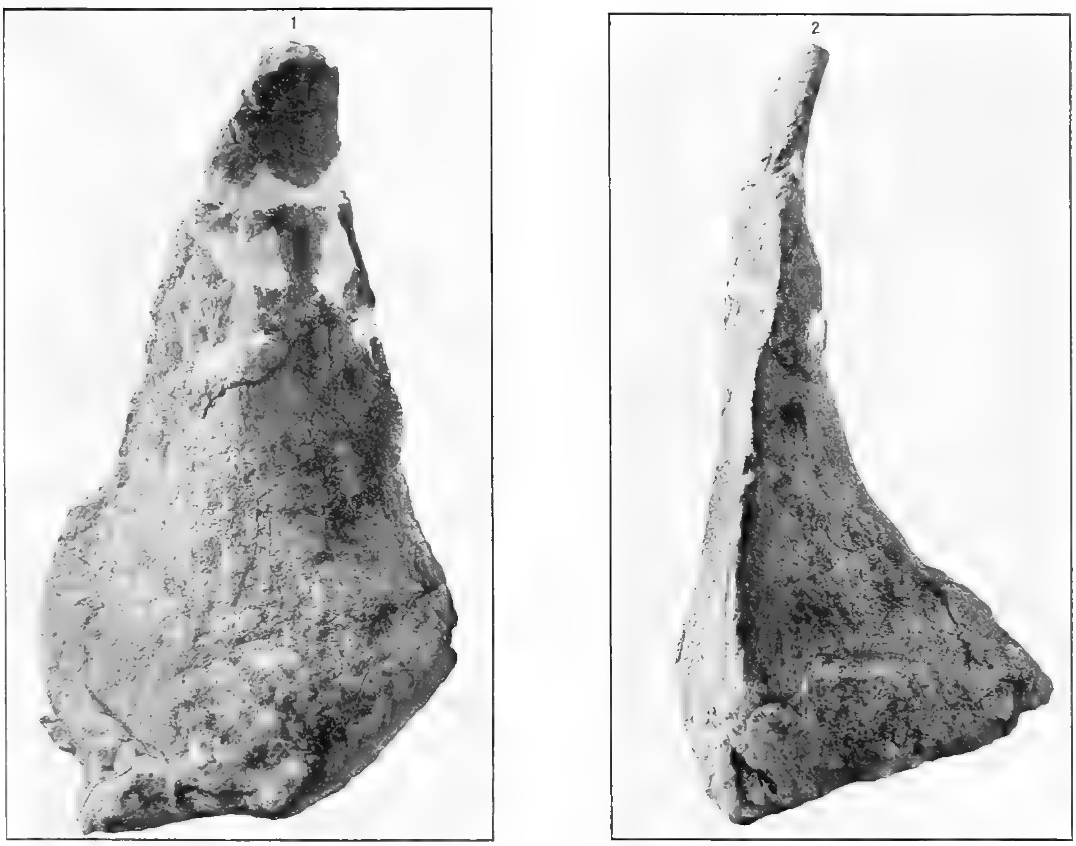
Dermal Plate of Hoplitosaurus.

For explanation of plate see page 135.



DERMAL PLATE OF HOPLITOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 135.



DERMAL PLATE OF HOPLITOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 135.

1

a *b*

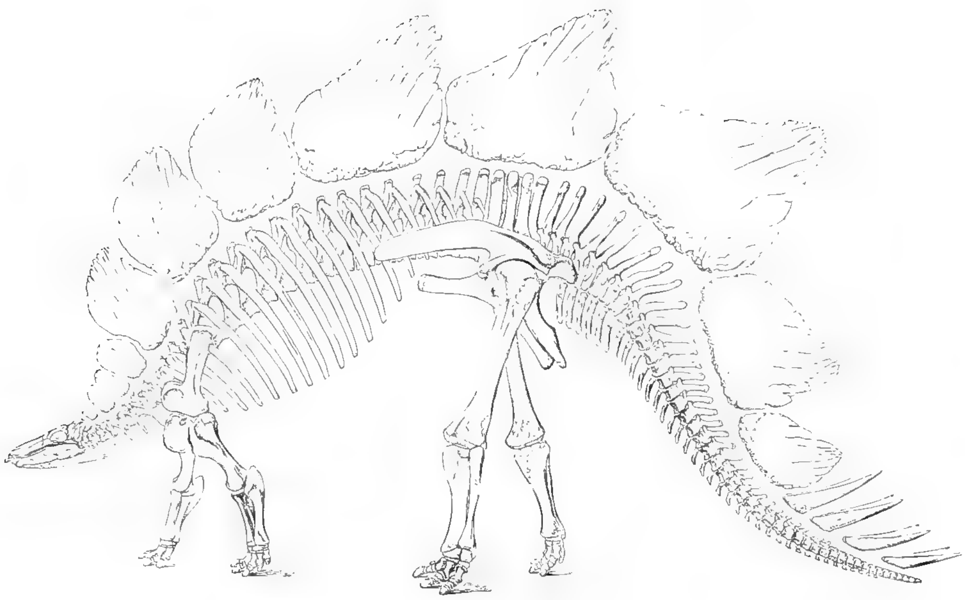
2

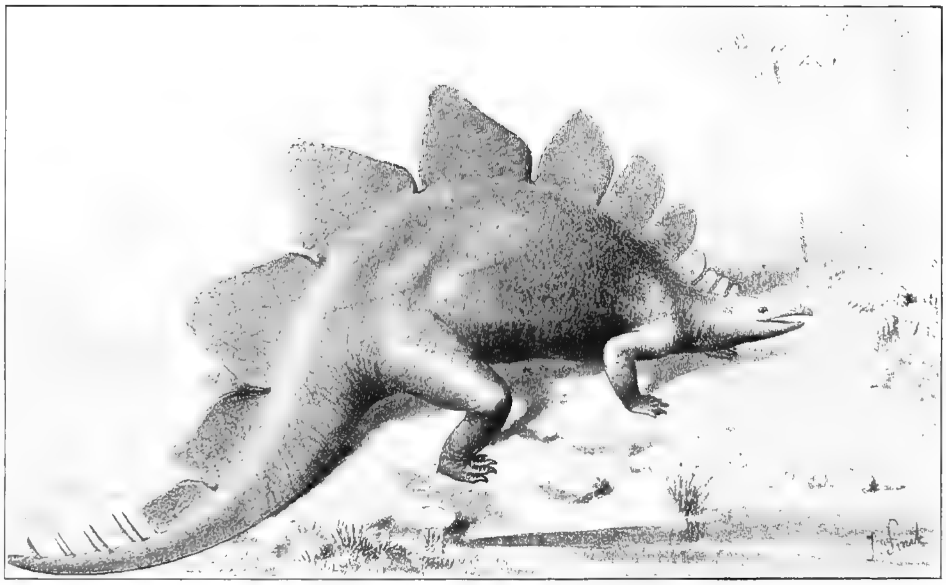
3

4

DERMAL BONES OF UNIDENTIFIED REPTILES.

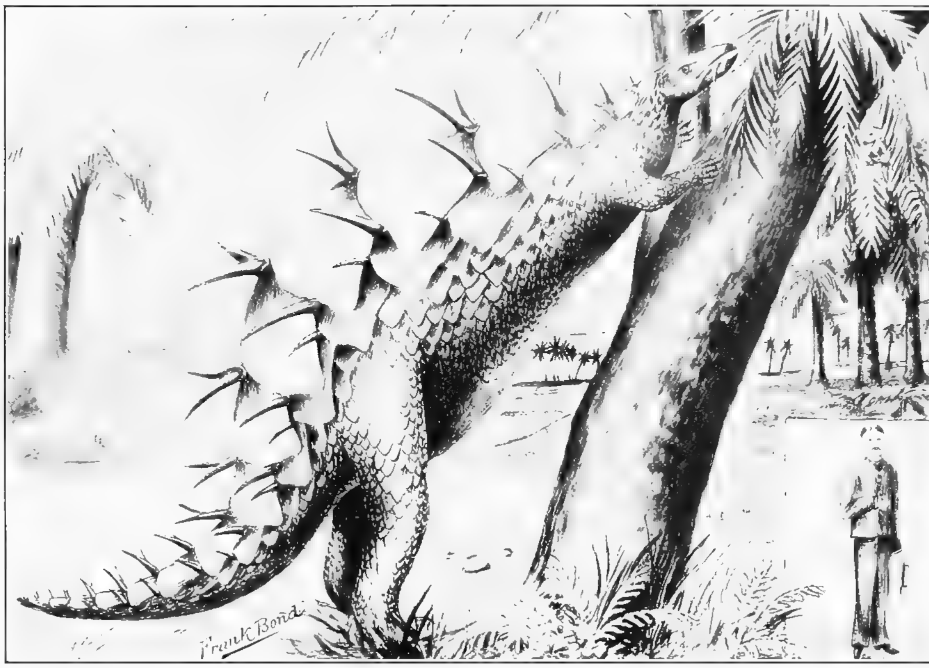
FOR EXPLANATION OF PLATE SEE PAGE 136.





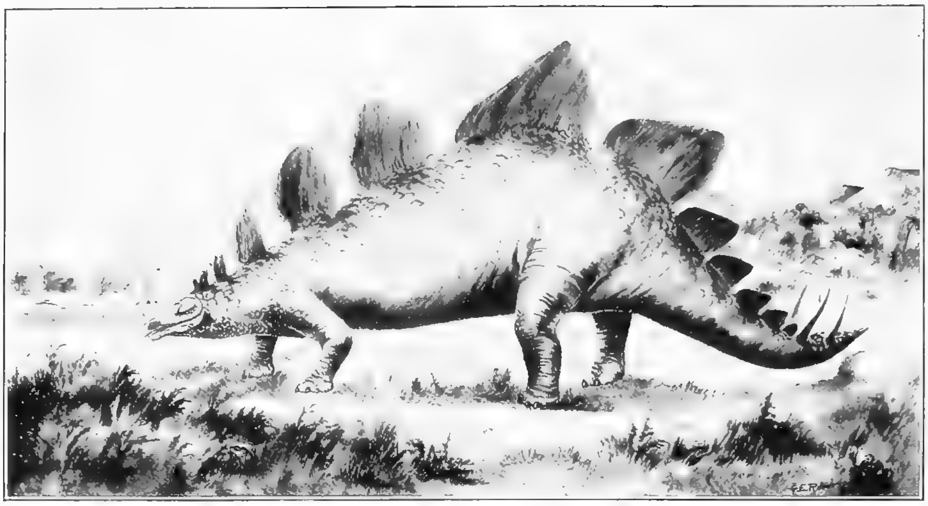
RESTORATIONS OF STEGOSAURUS.

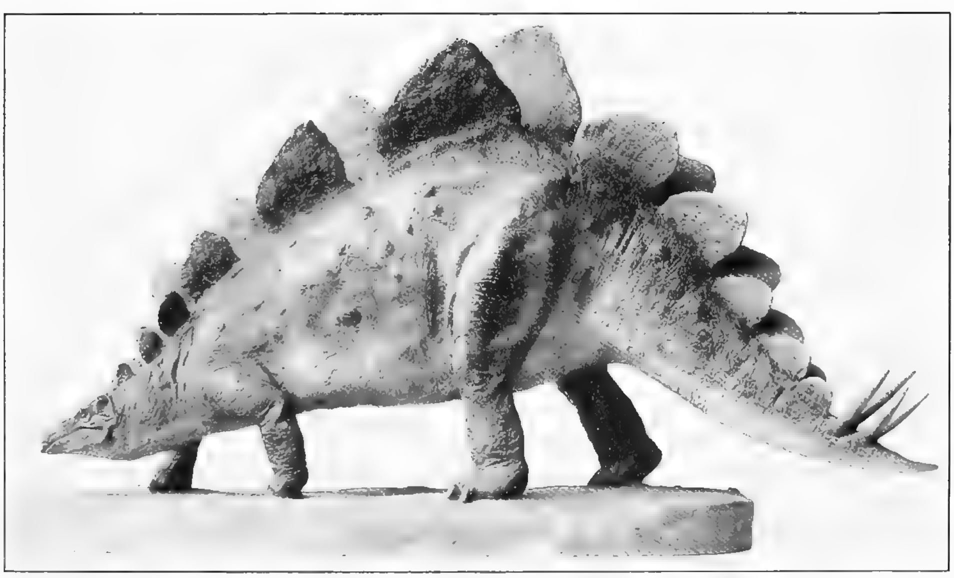
FOR EXPLANATION OF PLATE SEE PAGE 136.



RESTORATIONS OF STEGOSAURUS.

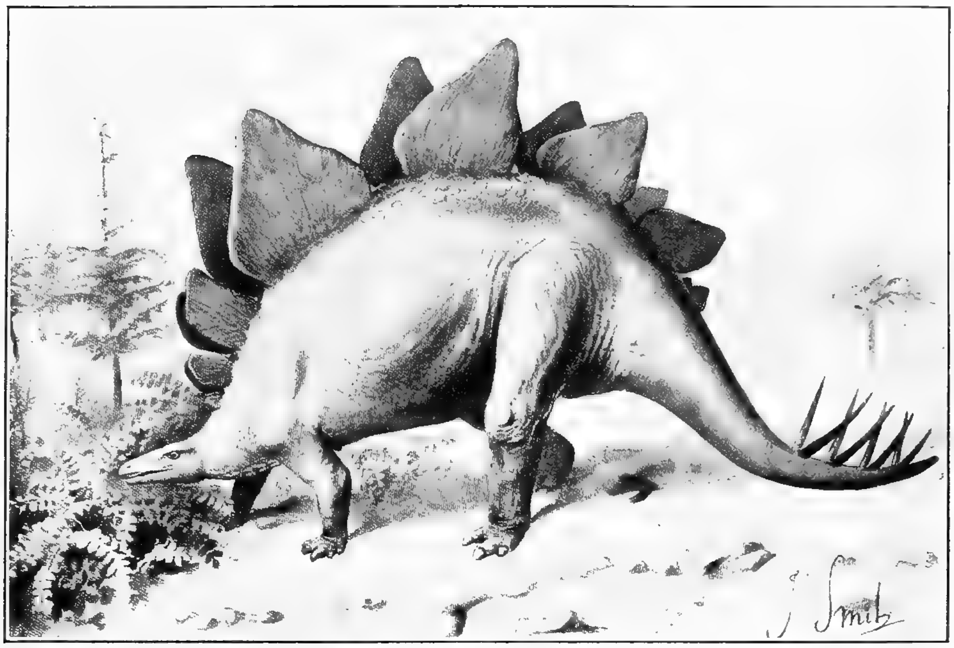
FOR EXPLANATION OF PLATE SEE PAGE 136.

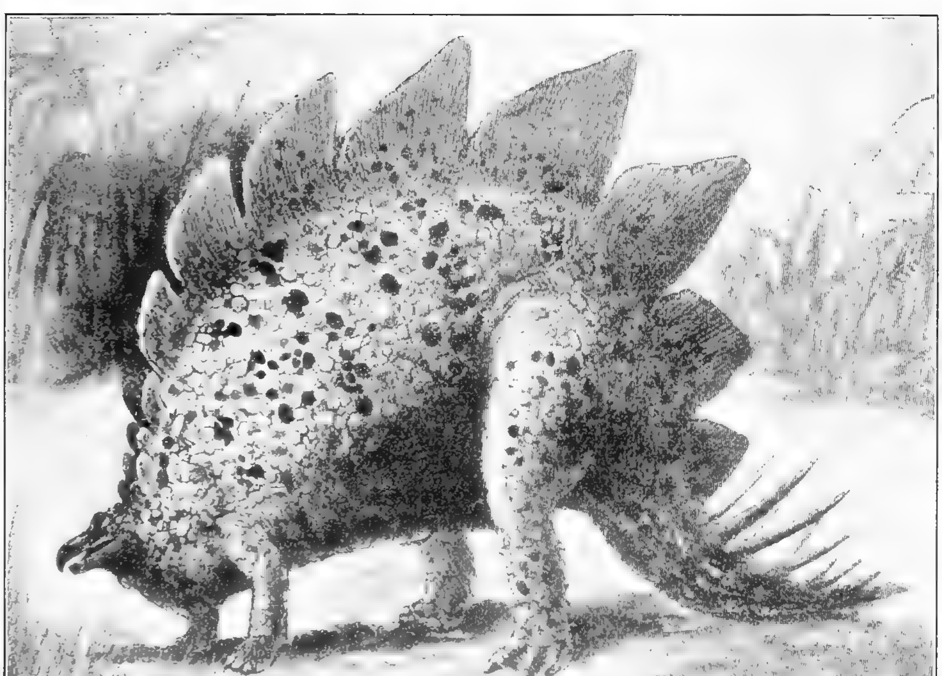




RESTORATIONS OF STEGOSAURUS.

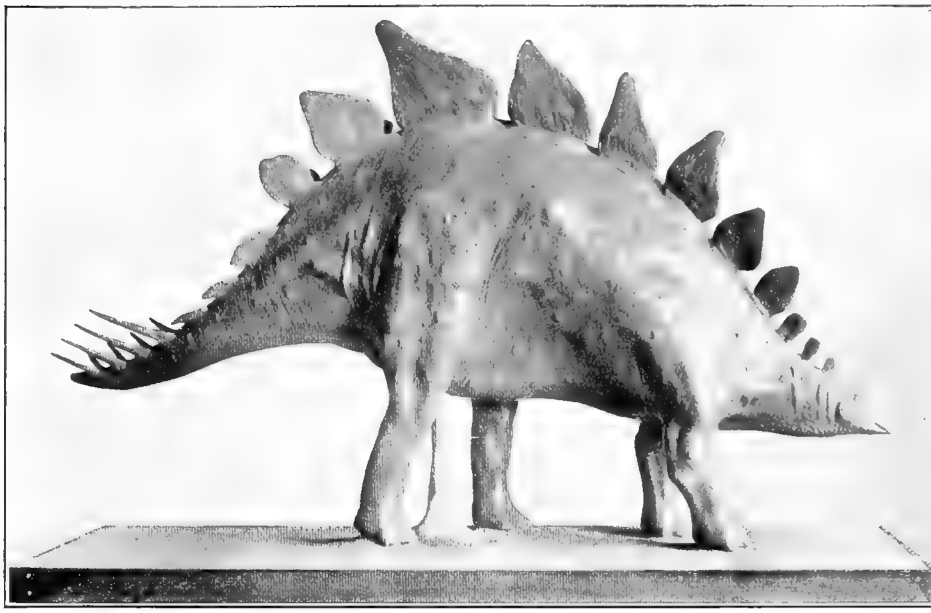
FOR EXPLANATION OF PLATE SEE PAGE 136.

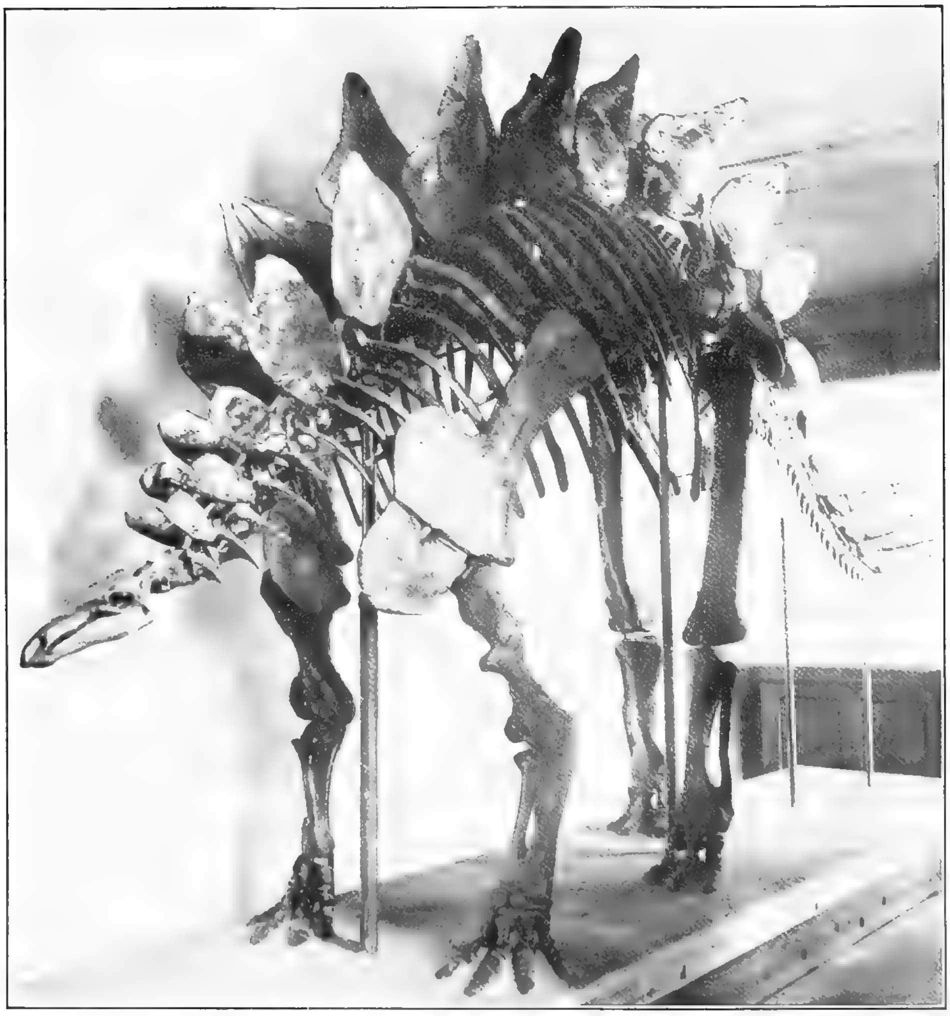




RESTORATIONS OF STEGOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 136.





RESTORATIONS OF STEGOSAURUS.

FOR EXPLANATION OF PLATE SEE PAGE 136.

MAP OF QUARRY No. 13.

FOR EXPLANATION OF PLATE SEE PAGE 136.

INDEX.

[Figures in BLACK-FACE type indicate descriptions.]

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