

Transactions of the Mathematico-Physical Section of the "Königl. Sächsischen Gessellschaft der Wissenschaften." It is a work of great interest, treating of the causes producing denudation in the Egyptian desert and its results, and is illustrated by many excellent and instructive figures. The chief causes of denudation mentioned are deflation, or the work of the winds directly in denudation by removing whatever is sufficiently loose or has been loosened by decomposition or otherwise, and the work in abrasion by transported sands; 2d, Insolation, or the effects of the sun or heat over the surface of rocks by changes of temperature and especially those of day and night; (3) Decomposition or alteration through any means; (4) The eroding and transporting action of waters, rains being not wholly absent. (5) Vegetation, as a means of modifying results. The results in the formation of deposits are also described. The work is of special value to American geologists.

2. *History of Volcanic Action in the area of the British Isles*, by A. GEIKIE. Anniversary Address before the Geological Society of London, Feb., 1891. Quart. J. G. Soc. xlvii.—More has thus been learned about volcanic action in Paleozoic time from the British Isles than from all the rest of the world. Dr. Geikie, in his Anniversary Address, commences a full review of the interesting subject. Although extending to one hundred pages, the review covers only the earlier part of the history, to the close of the Upper Silurian.

3. *Magnetic Declination in the United States for the Epoch of 1890*.—Mr. CHARLES A. SCHOTT has a paper of seventy-five pages on this subject, in the Report of the Superintendent of the Coast Survey, Prof. T. C. Mendenhall, for 1889, consisting chiefly of tables giving the results of observations reduced to the year 1890.

4. *Telescopic Work for Starlight Evenings*, by WILLIAM F. DENNING, F.R.A.S. 361 pp. 8vo. London, 1891 (Taylor & Francis).—There is a peculiar interest and fascination connected with the subject of Astronomy, which even the comparatively uneducated reader cannot but feel, and hence there exists here a field for popular presentation which is hardly equalled in any other branch of science. The present work is one of this class and is fresh in matter, attractive and popular in style and with its numerous illustrations cannot fail to bring pleasure and instruction to all who use it.

5. *Ostwald's Klassiker der Exacten Wissenschaften*. (Wm. Engelmann, Leipzig). Recent issues of this valuable series include:

No. 21, 23. Ueber die Wanderung der Ionen während der Electrolyse. Abhandlungen von W. Hittorf (1853–1859).

No. 22. Untersuchungen über das Radical der Benzoesäure von Woehler und Liebig (1832).

No. 24. Unterredungen und Mathematische Demonstrationen über zwei neue Wissenszweige, die Mechanik und die Fallgesetze betreffend, von Galileo Galilei. Dritter und vierter Tag (1638).

## APPENDIX.

ART. XVI.—*Restoration of Stegosaurus*; by O. C. MARSH. (With Plate IX.)

IN this Journal, in 1877, the writer described a remarkable extinct reptile from Colorado, under the name *Stegosaurus armatus*,\* and later a much more perfect specimen of another species, *Stegosaurus unguulatus*, from essentially the same horizon, in the Jurassic of Wyoming.† The latter specimen was in fine preservation, and the more important parts of the skull and skeleton, and especially of the remarkable dermal armor, were secured. Subsequently, more than twenty other specimens of these and other species were obtained, so that nearly every part of the osseous structure thus became known, and only portions of the dermal armor were in doubt. A fortunate discovery cleared away most of the doubt in regard to one species, *Stegosaurus stenops*, as the type specimen had the skull, skeleton, and dermal armor together when entombed, and almost in the position they were when the animal died.

With this rich material at hand, an attempt has been made to give a restoration of one of the group, and the type specimen of *Stegosaurus unguulatus* has been selected as the basis. This has been supplemented by a few portions of the skeleton of *Stegosaurus duplex*, apparently a closely allied species from nearly the same locality, while some other parts, especially of the dermal armor, have been placed in accordance with their known position in *Stegosaurus stenops*.

The result is given in Plate IX, which is believed to represent faithfully the main features of this remarkable reptile, as far as the skeleton and principal parts of the dermal armor are concerned. This figure, one-thirtieth natural size, is reduced from a larger restoration, one-tenth natural size, made for

\* This Journal, III, vol. xiv, p. 513, December, 1877.

† Ibid., vol. xviii, p. 504, December, 1879. See also, vol. xix, p. 253, March, 1880; vol. xxi, p. 167, February, 1881; and vol. xxiv, p. 413, November, 1887.

a lithographic plate to accompany the monograph of the *Stegosauria*, prepared by the writer for the U. S. Geological Survey.

In this restoration, the animal is represented as walking, and the position is adapted to that motion. The head and neck, the massive fore limbs, and, in fact, the whole skeleton, indicate slow locomotion on all four feet. The longer hind limbs and the powerful tail show, however, that the animal could thus support itself, as on a tripod, and this position must have been easily assumed in consequence of the massive hind quarters.

In the restoration as here presented, the dermal armor is the most striking feature, but the skeleton is almost as remarkable, and its high specialization was evidently acquired gradually as the armor itself was developed. Without the latter, many points in the skeleton would be inexplicable, and there are still a number that need explanation.

The small, elongated head was covered in front by a horny beak. The teeth are confined to the maxillary and dentary bones, and are not visible in the figure here given. They are quite small, with compressed, fluted crowns, and indicate that the food of this animal was soft, succulent vegetation. The vertebrae are solid, and the articular faces of the centra are bi-concave or nearly flat. The ribs of the trunk are massive, and placed high above the centra, the tubercle alone being supported on the elevated diapophysis. The neural spines, especially those of the sacrum and anterior caudals, have their summits expanded to aid in supporting the massive dermal armor above them. The limb bones are solid, and this is true of every other part of the skeleton. The feet were short and massive, and the terminal phalanges of the functional toes were covered by strong hoofs. There were five well-developed digits in the fore foot, and only three in the hind foot, the first toe being rudimentary, and the fifth entirely wanting.

In life, the animal was protected by a powerful dermal armor, which served both for defense and offense. The throat was covered by a thick skin in which were imbedded a large number of rounded ossicles, as shown in the figure. The gular portion represented was found beneath the skull, so that its position in life may be regarded as definitely settled. The series of vertical plates which extended above the neck, along the back, and over two-thirds of the tail, is a most remarkable feature, which could not have been anticipated, and would hardly have been credited had not the plates themselves been found in position. The four pairs of massive spines characteristic of the present species, which were situated above the lower third of the tail, are apparently the only part of this

peculiar armor used for offense. In addition to the portions of armor above mentioned, there was a pair of small plates just behind the skull, which served to protect this part of the neck. There were also, in the present species, four flat spines, which were probably in place below the tail, but as their position is somewhat in doubt, they are not represented in the present restoration.

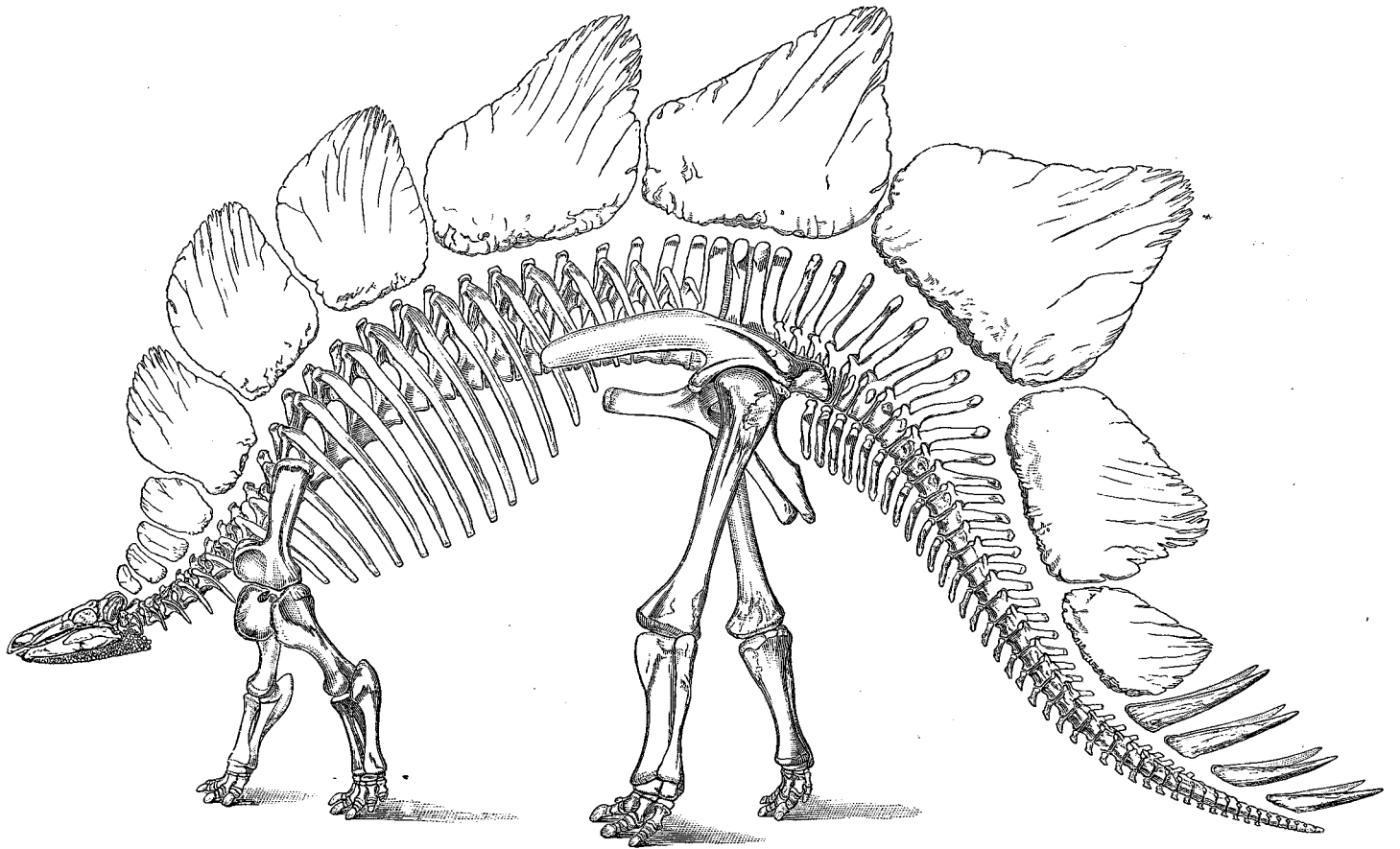
All these plates and spines, massive and powerful as they now are, were in life protected by a thick, horny covering, which must have greatly increased their size and weight. This covering is clearly indicated by the vascular grooves and impressions which mark the surface of both plates and spines, except their bases, which were evidently implanted in the thick skin.

The peculiar group of extinct reptiles named by the writer the *Stegosauria*, of which a typical example is represented in the present restoration, are now so well known, that a more accurate estimate of their relations to other Dinosaurs can be formed than has hitherto been possible. They are evidently a highly specialized sub-order of the great group which has the typical *Ornithopoda* as its most characteristic members, and all doubtless had a common ancestry. Another highly specialized branch of the same great order is seen in the gigantic *Ceratopsia*, of the Cretaceous, which the writer has recently investigated and made known. The skeleton of the latter group presents many interesting points of resemblance to that of the *Stegosauria*, which can hardly be the result of adaptation alone, but the wide difference in the skull and in some other parts indicates that their affinities are remote. A comparison of the present restoration with that of *Triceratops*, recently published by the writer,\* will make the contrast between the two forms clearly evident.

All the typical members of the *Stegosauria* are from the Jurassic formation, and the type specimen used in the present restoration was found in Wyoming, in the *Atlantosaurus* beds of the upper Jurassic. *Diracodon*, a genus nearly allied to *Stegosaurus*, occurs in the same horizon. *Omosaurus* of Owen, from the Jurassic of England, is the nearest European ally now known, but whether it possessed a crest of dermal plates like that of *Stegosaurus* is doubtful, although caudal spines were evidently present.

New Haven, Conn., July 15th, 1891.

\* This Journal, vol. xli, p. 339, April, 1891.



Restoration of *STEGOSAURUS UNGULATUS*, Marsh. One-thirtieth natural size.