OBITUARY.

GENERAL ANDREW A. HUMPHREYS.—Brigadier-General Andrew Atkinson Humphreys died in Washington, on the 28th of November last, in the seventy-fourth year of his age. General Humphreys was graduated at West Point with the rank of Second Lieutenant on July 1, 1831. After active service in the war against the Cherokee Nation in Florida, and in the Seminole war in 1836, he entered the service of the United States as a civil engineer, to assist Major Bache on the plans for the Brandywine Shoal Light-house and the Crow Shoal Breakwater, Delaware Bay, and he was engaged in this work until July 7, 1838, when he was reappointed to the army with the rank of First Lieutenant, Corps of Topographical Engineers. From 1844 to 1849 he was in charge of the Coast Survey office at Washington. The topographic and hydrographic survey of the delta of the Mississippi River was carried on under his direction in 1849-50, and he had general charge of this work until 1851. After a year spent in Europe in examining the means for protecting deltas from inundation, he was placed in general charge, under the War Department, of the office duties at Washington connected with the explorations and surveys for railroads from the Mississippi River to the Pacific, and geographical explorations west of the Mississippi, a position which he ably filled until the breaking out of the civil war in 1861. During the war of 1861-65, he was in active duty in the field, and was made brevet Brigadier-General, on March 13, 1865, for gallant and meritorious services at Gettysburg, and brevet Major-General, United States Army, on the same day, for his services at Sailor's Creek. On June 27, 1865, he was placed in command of the Military District of Pennsylvania, in the Middle Department, a command which he held until Dec. 9, when he was assigned to his old engineering work, being placed in charge of the examination of the Mississippi levees, a work which occupied him until Aug. 8, 1866, when he was placed in command of the Corps of Engineers and in charge of the Engineer Bureau, in Washington, and promoted to the full rank of Brigadier-General and Chief of Engineers.

General Humphreys remained at the head of the Engineer Bureau of the army until June 30, 1879, when he was retired at his own request, Colonel Horatio G. Wright succeeding him. During his service as commander of the Engineer Corps he also served on many important commissions, among which were the commission to examine into the canal routes across the Isthmus of Panama, from 1872 to 1877, the Board on Washington and Georgetown Improvements, the Revising Boards for Bulkhead and Pier Line of Brooklyn, of Staten Island, and of the Hudson River; the Board for the Survey of Baltimore Harbor and Adjacent Waters, and the Washington Monument Commission. His most important Report is the great work on the "Physics and Hydraulics of the Mississippi," prepared by him in conjunction with Lieutenant H. L. Abbott. He was the author, also, of a volume on the "Campaigns of the Civil War." He received the degree of LL.D. from Harvard, in 1868.

APPENDIX.

ART. XXI.—*Principal Characters of American Jurassic Dinosaurs;* by Professor O. C. MARSH. Part VII. *On the Diplodocidæ, a new family of the Sauropoda.* (With Plates III and IV.)

THE *Sauropoda* are now generally recognized by anatomists as a well-marked order of the Sub-class *Dinosauria.* In the previous articles of this series, the main characters of the two families of this order (*Atlantosauridæ* and *Morosauridæ*) already named by the writer have been given.* A third family is represented by the genus *Diplodocus*, a study of which, more especially of the skull, throws light on the whole group of Dinosaurian reptiles.

THE SKULL.

The skull of *Diplodocus* is of moderate size. The posterior region is elevated, and narrow. The facial portion is elongate, and the anterior part expanded transversely. The nasal opening is at the apex of the cranium, which from this point slopes backward to the occiput. In front of this aperture, the elongated face slopes gradually downward to the end of muzzle, as represented in Plate III, figure 1.

Seen from the side, the skull of *Diplodocus* shows five openings: a small oval aperture in front (*a*), a large antorbital vacuity (*b*), the nasal aperture (*c*), the orbit (*d*), and the lower temporal opening (*e*) (Plate IV, figure 1). The first of these has not been seen in any other Dinosaurs; the large antorbital vacuity is characteristic of the *Sauropoda;* and the other three openings are present in all the known *Dinosauria.*

* This Journal, xvi, 411, Nov., 1878; xvii, 86, Jan., 1879; xxi, 417, May, 1881; xxiii, 81, Jan., 1882; and xxvi, 81, Aug., 1883.

On the median line, directly over the cerebral cavity of the brain, the type specimen of *Diplodocus* has also a fontanelle in the parietals. This, however, may be merely an individual peculiarity.

The plane of the occiput is of moderate size, and forms an obtuse angle with the fronto-parietal surface.

The occipital condyle is hemispherical in form, and seen from behind is slightly sub-trilobate in outline. It is placed nearly at right angles with the long axis of the skull. It is formed almost wholly of the basi-occipital, the exoccipitals entering but slightly or not at all into its composition. The basi-occipital processes are large and rugose. The paroccipital processes are stout, and somewhat expanded at their extremities, for union with the quadrates.

The parietal bones are small, and mainly composed of the arched processes which join the squamosals. There is no true parietal foramen, but in the skull here figured (Plate III) there is the small unossified tract mentioned above. In one specimen of *Morosaurus*, a similar opening has been observed, but in other *Sauropoda*, the parietal bones, even if thin, are complete. The suture between the parietals and frontal bones is obliterated in the present skull, and the union is firm in all the specimens observed.

The frontal bones in *Diplodocus* are more expanded transversely than in the other *Sauropoda*. They are thin along the median portion, but quite thick over the orbits.

The nasal bones are short and wide, and the suture between them and the frontals is distinct. They form the posterior boundary of the large nasal opening, and also send forward a process to meet the ascending branch of the maxillary, thus forming in part the lateral border of the same aperture.

The nasal opening is very large, subcordate in outline, and is partially divided in front by slender posterior processes of the premaxillaries. It is situated at the apex of the skull, between the orbits, and very near the cavity for the olfactory lobes of the brain.

The premaxillaries are narrow below, and with the ascending processes very slender and elongate. Along the median line, these processes form an obtuse ridge, and above they project into the nasal opening. Each premaxillary contains four functional teeth.

The maxillaries are very largely developed, more so than in most other known reptiles. The dentigerous portion is very high, and slopes inward. The ascending process is very long, thin and flattened, inclosing near its base an oval foramen, and

leaving a large unossified space posteriorly. Above, it meets the nasal and prefrontal bones. Along its inner border for nearly its whole length, it unites with the ascending process of the premaxillary. Each maxillary contains nine teeth, all situated in the anterior part of the bone (Plate III, figure 1).

Along their upper margin, on the inner surface, the maxillaries send off a thickened ridge or process, which meets its fellow, thus excluding the premaxillaries from the palate. Above this, for a large part of their length, the ascending processes of the maxillaries underlap the ascending processes of the premaxillaries, and join each other on the median line.

The orbits are situated posteriorly in the skull, being nearly over the articulation of the lower jaw. They are of medium size, nearly circular in outline, their plane looking outward and slightly backward. No indications of sclerotic plates have been found either in *Diplodocus* or the other genera of *Sauropoda*.

The supra-temporal fossa is small, oval in outline, and directed upwards and outwards. The lateral temporal fossa is elongated, and oblique in position, bounded, both above and below, by rather slender temporal bars.

The pre-frontal and lachrymal bones are both small, the suture connecting them, and also that uniting the latter with the jugal, cannot be determined with certainty.

The post-frontals are tri-radiate bones. The longest and most slender branch is that descending downward and forward for connection with the jugal; the shortest is the triangular projection directed backward, and fitting into a groove of the squamosal; the anterior branch, which is thickened and rugose, forms part of the orbital border above.

The squamosal lies upon the upper border of the par-occipital process. The lower portion is thin, and closely fitted over the head of the quadrate.

The quadrate is elongated, slender, with its lower end projecting very remarkably forward. In front, it has a thin plate extending inward, and overlapping the posterior end of the pterygoid.

The quadrato-jugal is an elongate bone, firmly attached posteriorly to the quadrate by its expanded portion. In front of the quadrate, it forms for a short distance a slender bar, which is the lower temporal arcade.

The palate is very high and roof-like, and composed chiefly of the pterygoids. The basi-pterygoid processes are elongate, much more so than in the other genera of *Sauropoda*.

The pterygoids have a shallow cavity for the reception of these processes, but no distinct impression for a columella.

Immediately in front of this cavity, the pterygoids begin to expand, and soon form a broad, flat plate, which stands nearly vertical. Its upper border is thin, nearly straight, and extends far forward. The anterior end is acute, and unites along its inferior border with the vomer. A little in front of the middle, a process extends downward and outward for union with the transverse bone. In front of this process, uniting with it and with the transverse bone, is the palatine.

The palatine is a small semi-oval bone fitting into the concave anterior border of the pterygoid, and sending forward a slender process for union with the small palatine process of the maxillary.

The vomer is a slender, triangular bone, united in front by its base to a stout process of the maxillary, which underlaps the ascending process of the premaxillary. Along its upper and inner border, it unites with the pterygoid, except at the end, where for a short distance it joins a slender process from the palatine. Its lower border is wholly free.

The Brain.

The brain of *Diplodocus* was very small, as in all Dinosaurs from the Jurassic. It differed from the brain of the other members of the *Sauropoda*, and in fact from all other known reptiles, in its position, which was not parallel with the longer axis of the skull, as is usually the case, but inclined to it, the front being much elevated, as in the Ruminant mammals. Another peculiar feature of the brain of *Diplodocus* was its very large pituitary body, enclosed in a capacious fossa below the main brain case. This character separates *Diplodocus* at once from the *Atlantosauridæ*, which have a wide pituitary canal connecting the brain cavity with the throat. In the *Morosauridæ*, the pituitary fossa is quite small.

The posterior portion of the brain of *Diplodocus* was diminutive. The hemispheres were short and wide (Plate IV, figure 1), and more elevated than the optic region. The olfactory lobes were well developed, and separated in front by a vertical osseous septum. The very close proximity of the external nasal opening is a new feature in Dinosaurs, and appears to be peculiar to the *Sauropoda*.

The Lower Jaws.

The lower jaws of *Diplodocus* are more slender than in any of the other *Sauropoda*. The dentary especially lacks the massive character seen in *Morosaurus*, and is much less robust than the corresponding bone in *Brontosaurus*. The short dentigerous portion in front is decurved (Plate III, figure 1), and its greatest depth is at the symphysis. The articular, angular, and subangular bones are well developed, but the coronary and splenial appear to be small.

The Teeth.

The dentition of *Diplodocus* is the weakest seen in any of the known *Dinosauria*, and strongly suggests the probability that some of the more specialized members of this great group were edentulous. The teeth are entirely confined to the front of the jaws (Plate III, figure 1), and those in use were inserted in such shallow sockets that they were readily detached. Specimens in the Yale museum show that entire series of upper or lower teeth could be separated from the bones supporting them without losing their relative position. In Plate IV, figure 2, a number of these detached teeth are shown. This series of teeth was found with the remains of *Stegosaurus*, and hence was at first referred to that genus, as was also the specimen represented in figure 3 of the same plate.* The teeth of *Stegosaurus* are now known to be of a different type, somewhat resembling those of *Scelidosaurus*.

The teeth of *Diplodocus* are cylindrical in form, and quite slender. The crowns are more or less compressed transversely, and are covered with thin enamel, irregularly striated. The fangs are long and slender, and the pulp cavity is continued nearly or quite to the crown. In the type specimen of *Diplodocus*, there are four teeth in each premaxillary, the largest of the series; nine in each maxillary; and ten in each dentary of the lower jaws. There are no palatine teeth.

The jaws contain a single row only of teeth in actual use. These are rapidly replaced, as they wear out or are lost, by a series of successional teeth, more numerous than is usual in these reptiles. Plate IV, figure 3, represents a transverse section through the maxillary, just behind the fourth tooth. The latter is shown in place (1), and below it is a series of five immature teeth (2 to 6), in various stages of development, preparing to take its place. These successional teeth are lodged in a large cavity (*c*), which extends through the whole dental portion of the maxillary. The succession is also similar in the premaxillary teeth, and in those of the lower jaws.

The Vertebræ.

The vertebral column of *Diplodocus*, so far as at present known, may be readily distinguished from that of the other *Sauropoda* by both the centra and chevrons of the caudals.

* This Journal, xix, p. 255, March, 1880.

The former are elongated, and deeply excavated below, as shown in Plate IV, figures 4 and 5. The chevrons are especially characteristic, and to their peculiar form the generic name *Diplodocus* refers. They are double, having both anterior and posterior branches, and the typical forms are represented in figures 6 and 7 of the same plate.

The Pelvic Girdle.

The most characteristic bone of the two families of *Sauropoda* previously described is the ischium. In the *Atlantosauridæ*, the ischia are massive, and directed downward, with their expanded extremities meeting on the median line. In the *Morosauridæ*, the ischia are slender, with the shaft twisted about 90°, directed backward, and the sides meeting on the median line, thus approaching this part in the more specialized Dinosaurs. The ischia referred to the genus *Diplodocus*, representing the new family here established, are intermediate in form and position between those above mentioned. The shaft is not expanded distally, nor twisted, and was directed downward and backward, with the ends meeting on the median line.

Size and Habits.

The type specimen of *Diplodocus*, to which the skull here figured apparently belongs, indicates an animal intermediate in size between *Atlantosaurus* and *Morosaurus*, probably 40 or 50 feet in length, when alive. The teeth show that it was herbivorous, and the food was probably succulent vegetation. The position of the external nares indicates an aquatic life.

The remains of the above specimen were found by S. W. Williston and M. P. Felch in the upper Jurassic beds, near Cañon City, Colorado. A second and smaller species is represented by remains found by Arthur Lakes near Morrison, Colorado. This species, which may be called *Diplodocus lacustris*, has much more slender jaws than the one above described. A maxillary bone contains eight teeth, and at the premaxillary suture measures 26^{mm} in thickness. The series of teeth occupy a space of 70^{mm}. A second specimen of apparently the same species has since been found in Wyoming.

The geological horizon of all the *Sauropoda* from the Rocky Mountain region is in the Atlantosaurus beds of the upper Jurassic. No Cretaceous forms of this group are known.

Classification.

The main characters of the order *Sauropoda*, and of the three families now known to belong to it, are as follows:

Order SAUROPODA.

Premaxillary bones with teeth. Large antorbital opening. Anterior nares at apex of skull. Post-occipital bones. Anterior vertebræ opisthocœlian; pre-sacral vertebræ hollow; each sacral vertebra supports its own transverse process. Fore and hind limbs nearly equal; limb bones solid. Feet plantigrade, unguligate; five digits in manus and pes; second row of carpal and tarsal bones unossified. Sternal bones parial.* Pubes projecting in front, and united distally by cartilage; no post-pubis.

(1.) Family *Atlantosauridæ*. A pituitary canal. Ischia directed downward, with expanded extremities meeting on median line. Sacrum hollow. Anterior caudals with lateral cavities.

(2.) Family *Diplodocidæ*. Dentition weak. Brain inclined backward. Large pituitary fossa. Two antorbital openings. Ischia with straight shaft, not expanded distally, directed downward and backward, with ends meeting on median line. Caudals deeply excavated below. Chevrons with both anterior and posterior branches.

(3.) Family *Morosauridæ*. Small pituitary fossa. Ischia slender, with twisted shaft, directed backward, and sides meeting on median line. Anterior caudals solid.

The *Sauropoda* are the order of Dinosaurs having the nearest affinities with the *Crocodilia*, especially through some of the extinct forms. *Diplodocus*, for example, resembles *Belodon* of the Triassic, particularly in the large antorbital vacuities of the skull, the posterior position of the external nasal aperture, as well as in other features. The genus *Aetosaurus*, from the same formation, is an intermediate form, and represents a distinct order, which may be called *Aetosauria*. The nearer relations of these groups will be discussed by the writer elsewhere.

Yale College, New Haven, Jan. 21, 1884.

* *Ceteosaurus* has been figured with a single sternal bone by Phillips and other authorities. The writer recently examined the original specimen at Oxford, and found portions of two of these bones, which strongly resemble the sternal plates of American *Sauropoda*.

EXPLANATION OF PLATES.

PLATE III.

FIGURE 1.—Skull of *Diplodocus longus*, Marsh; side view.

FIGURE 2.—The same skull; front view.

FIGURE 3.—The same skull; top view.

All the figures are one-sixth natural size.

PLATE IV.

FIGURE 1.—Skull and brain-cast of *Diplodocus longus*, Marsh; seen from above, one-sixth natural size; *a*, aperture in maxillary; *b*, antorbital opening; *c*, nasal opening; *c'*, cerebral hemispheres; *d*, orbit; *e*, lower temporal fossa; *f*, frontal bone; *f'*, fontanelle; *m*, maxillary bone; *m'*, medulla; *n*, nasal bone; *oc*, occipital condyle; *ol*, olfactory lobes; *op*, optic lobe; *p*, parietal bone; *pf*, pre-frontal bone; *pm*, pre-maxillary bone; *q*, quadrate bone; *qj*, quadrato-jugal bone.

FIGURE 2.—Maxillary teeth of *Diplodocus longus*, Marsh; side view, one-half natural size; *e*, enamel; *r*, root.

FIGURE 3.—Section of maxillary of *Diplodocus longus*, Marsh; one-half natural size, showing functional tooth (fourth) in position, and five successional teeth in dental cavity; *a*, outer wall; *b*, inner wall; *c*, cavity; *f*, foramen.

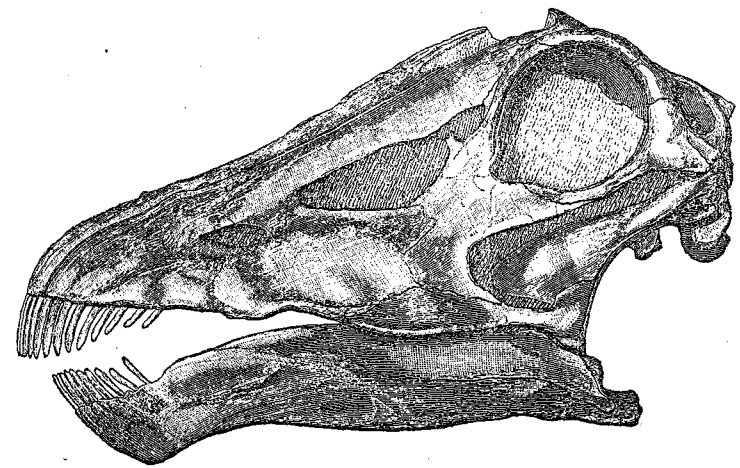
FIGURE 4.—Twelfth caudal vertebra of *Diplodocus longus*, Marsh; side view, one-sixth natural size; *c*, anterior face for chevron; *c'*, posterior face for chevron; *s*, neural spine; *z*, pre-zygapophysis; *z'*, post-zygapophysis.

FIGURE 5.—The same vertebra; bottom view; size and letters as in Fig. 4.

FIGURE 6.—Chevron found attached to tenth and eleventh vertebræ of *Diplodocus longus*, Marsh; top and side views, one-tenth natural size; *a*, anterior end; *p*, posterior end; *v*, faces for articulation with vertebræ.

FIGURE 7.—Chevron of another individual; top and side views; size and letters as in Fig. 6.

1.



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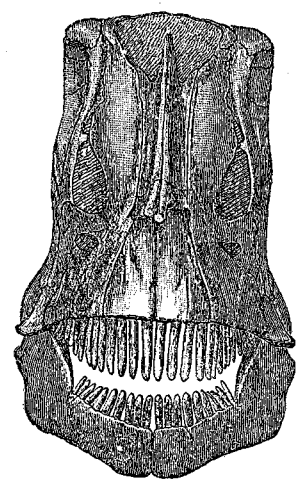

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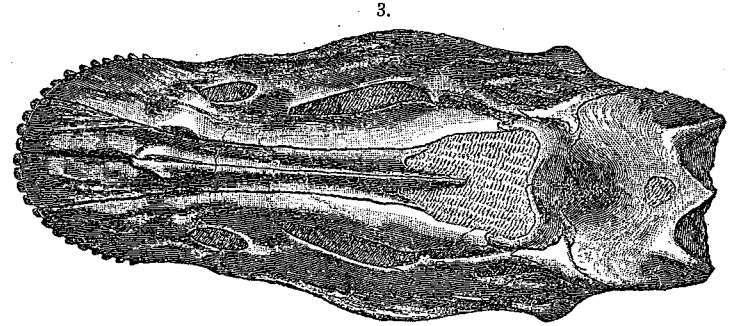
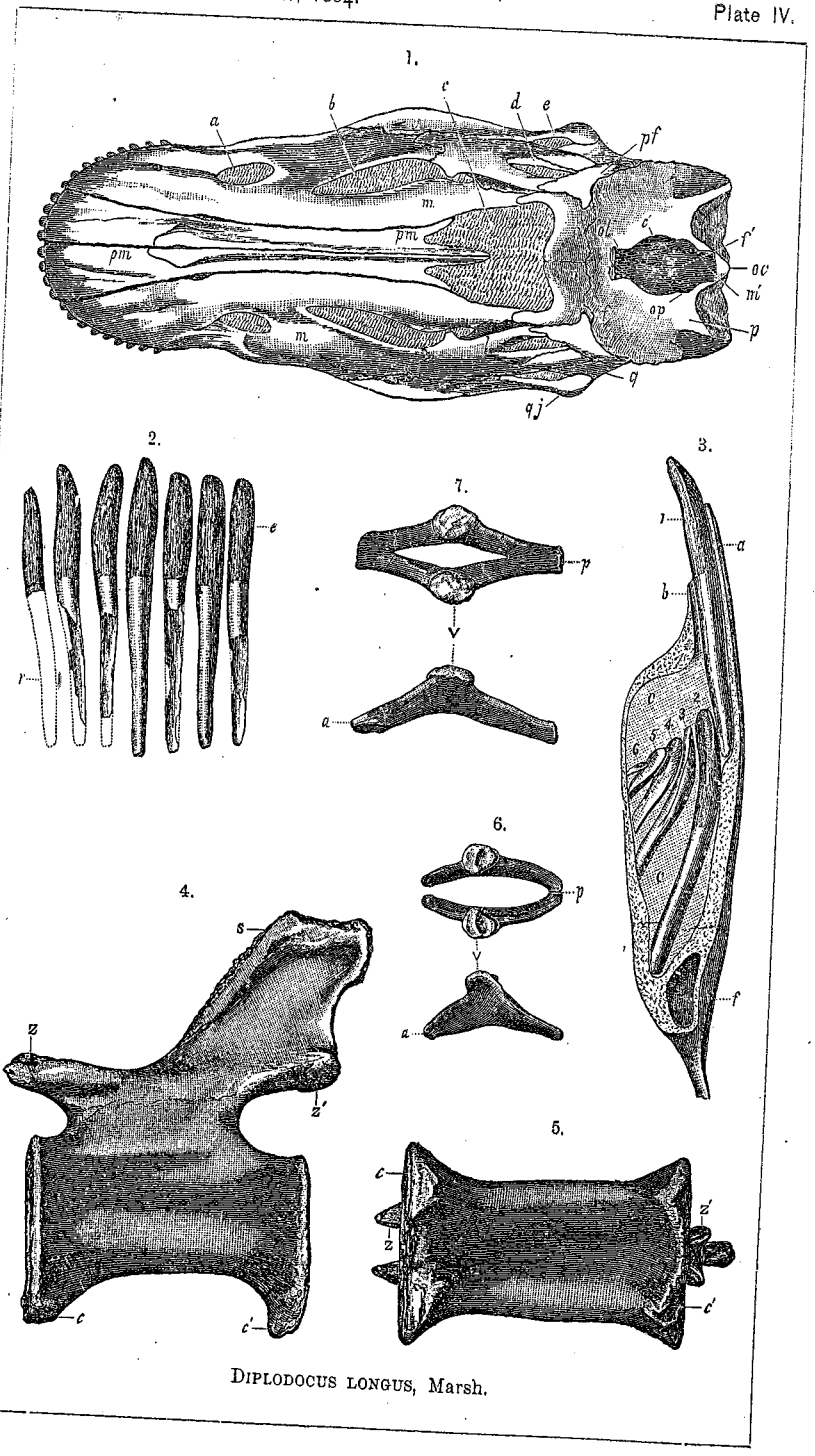


SKULL OF DIPLODOCUS LONGUS, Marsh. One-sixth natural size.



DIPLODOCUS LONGUS, Marsh.