

recent years has come through microscopic investigation and the same source still continues to be prolific in the profoundest of discoveries.

Mémoires sur les Terrains Cretacé et Tertiaires préparés par feu ANDRÉ DUMONT, pour servir à la description de la Carte Géologique de la Belgique. edités par MICHEL MOURLON, Conservateur au Muséum d'Hist. Nat. Tome II Terrains Tertiaires, Première Patrie. 440 pp., 8vo. Bruxelles, 1878.

OBITUARY.

THOMAS BELT.—Mr. Thomas Belt, F.G.S., of London, England, died in Kansas City, Missouri, on Saturday, September 28. Mr. Belt had been for some time past actively at work in Colorado, looking after the mining interests of some English company. During the same time he has made some interesting notes of the Drift of that State, and in a letter to the writer in August, he informed him of the discovery of a skull of a human being in the Drift, the details of which he was engaged in studying and working out. He was engaged in preparing a paper to be presented to the American Association at the St. Louis meeting, on the subject of the above-named skull, but did not complete his study in time. He has written many valuable papers on geology, especially on glaciers, and also an interesting volume, entitled "The Naturalist in Nicaragua," continued the result of his observations of over two years in that country. One of his papers is on the retrocession of Niagara Falls.

About two weeks previous to his death he had shown signs of insanity, and it was thought best to remove him to New York. Mr. Silas Lloyd, who had been for a short time associated with him, accompanied him. Just before arriving at Kansas City, Mr. Lloyd had occasion to leave him for a few minutes. On returning, he found the door locked. Mr. Belt refused to let him in, and commenced a furious onslaught on furniture and car. Parties crawled through the broken windows and succeeded in pacifying him. Getting him off the train, he was prevailed upon to drink a glass of milk, and about twenty minutes afterward he died.

G. C. BROADHEAD.

Dr. E. v. ASTEN; M. E. QUETELET; THOMAS GRUBB.—Astronomy has recently lost several able men by death. One of these was Dr. E. von Asten, who was attached to the Pulkowa Observatory, and who has carried on the discussion of the observations and orbit of Encke's comet since Professor Encke's death. He died August 15th, at Kiel, aged 36. Another loss is that of M. E. Quetelet on the 6th of Sept., at Ixelles at the age of 53. He was assistant at the Brussels Observatory for more than twenty years, the direction of which practically fell on him. One of his many important contributions to science was on the proper motions of certain stars. Mr. Thomas Grubb, the maker of the large Melbourne reflector, and of numerous other large reflectors and refractors, died Sept. 19, in the 78th year of his age.

Dr. AUGUST HEINRICH PETERMAN.—Dr. A. H. PETERMANN, the learned geographer, and editor of the "Mittheilungen," died at Gotha, Germany, on the 27th of September, at the age of fifty-six.

APPENDIX.

ART. XLIV.—Principal Characters of American Jurassic Dinosaurs; by Professor O. C. MARSH.
Part I. With seven Plates.

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ON the flanks of the Rocky Mountains, a narrow belt of strata can be traced for several hundred miles, marked always by the bones of gigantic Dinosaurs. Its position is above the characteristic red Triassic beds, and immediately below the hard sandstone of the Dakota group. Hayden, Cope and others have regarded this horizon as Cretaceous, but the abundant vertebrate remains now known from it prove its Jurassic age beyond a reasonable doubt. The writer examined a typical outcrop of this series, on the western slope of the mountains in Wyoming, in 1868, and determined it to be Jurassic; and he has recently named the series the *Atlantosaurus* beds, from the most striking vertebrates they contain. The strata consist mainly of estuary deposits of shale and sandstone, and the horizon is clearly upper Jurassic, as shown in the accompanying section (Plate IV.)*

Besides the Dinosaurs, which are especially abundant, numerous remains of Crocodilia (*Diplosaurus*), as well as Tortoises and Fishes (*Ceratodus*), have been found, and with them a single Pterodactyle (*Pterodactylus montanus*).† The small Marsupial (*Dryolestes priscus*) recently described by the writer was discovered in the same beds.‡

The remains of *Dinosauria* in this series of strata are mostly of enormous size, and indicate by far the largest land animals hitherto discovered. *Atlantosaurus immanis* must have been at least eighty feet in length, and several others nearly equaled it in bulk. With these monsters occur the most diminutive Dinosaurs yet found, one of them (*Nanosaurus*) being about as large as a cat. The herbivorous Dinosaurs now known from these beds are of special interest, and represent two distinct groups, the more important characters of which are given in the present article.

* This section was especially designed to illustrate an Address by the writer, on The Introduction and Succession of Vertebrate Life in America. This Journal, vol. xiv, p. 337, Nov., 1877.

† This Journal, vol. xv, p. 233, Sept., 1878.

‡ This Journal, vol. xv, p. 412, June, 1878.

SAUROPODA.

A well marked group of gigantic Dinosaurs from the above horizon has been characterized by the writer as a distinct family, *Atlantosauridae*, but they differ so widely from typical *Dinosauria*, that they belong rather in a suborder, which may be called *Sauropoda*, from the general character of the feet. They are the least specialized of the order, and in some characters show such approach to the Mesozoic Crocodiles, as to suggest a common ancestry at no very remote period.

The most marked characters of this group are as follows:

1. The fore and hind limbs are nearly equal in size.
2. The carpal and tarsal bones are distinct.
3. The feet are plantigrade, with five toes on each foot.
4. The precaudal vertebræ contain large cavities, apparently pneumatic.
5. The neural arches are united to the centra by suture.
6. The sacral vertebræ do not exceed four, and each supports its own transverse process.
7. The chevrons have free articular extremities.
8. The pubes unite in front by ventral symphysis.
9. The third trochanter is rudimentary or wanting.
10. The limb bones are without medullary cavities.

Of this suborder, *Sauropoda*, four genera are well represented in the Museum of Yale College, and others, apparently closely allied, are indicated by remains from this country and Europe described by various authors. The genera *Atlantosaurus*, (*Titanosaurus*),* *Apatosaurus* and *Morosaurus*, have already been described by the writer, and with the new genus *Diplodocus*, defined below, are the most characteristic American representatives of this group. Of these, *Morosaurus* is known from a large number of individuals, including one nearly complete skeleton, and hence, in the present communication, this genus will be mainly used to illustrate the group.

Morosaurus, Marsh, 1878.

The head in this genus was very small. The skull shows in its fixed quadrates and some other features a resemblance to that in the Crocodiles. The rami of the lower jaw are not united by symphysis. The teeth are numerous, and their general form is shown in Plate V, figures 1 and 2. The neck was elongated, and, except the atlas, all the cervical vertebræ have deep cavities in the sides of the centra, similar to those in birds of flight. (Plate V, figures 3 and 5). They are also strongly opisthocœlous. The atlas and axis are not ankylosed together, and the elements of the atlas are distinct. The supero-lateral pieces unite with the axis by zygapophyses, (Plate V, figure 4, z).

* This Journal, xiv, pp. 87, 514; xv, pp. 241.

The dorsal vertebræ have elongated neural spines, and deep cavities in the sides. They are distinctly opisthocœlous. There are four vertebræ in the sacrum, all with cavities in the centra. Their transverse processes are vertical plates, with expanded ends. The anterior caudal vertebræ are plano-concave, and nearly or quite solid. The tail was elongated, and the chevrons are similar to those in Crocodiles.

The scapula is elongated and very large, and has a prominent anterior projection. The coracoid is small, suboval in outline, and has the usual foramen near its upper border. These two bones are well represented in Plate VI, nearly in the relative position in which they were found. The humerus is very large and massive, and its radial crest prominent. This bone is nearly solid, and its ends were rough, and well covered with cartilage. This is true also of all the large limb bones in this genus. The radius and ulna are nearly equal in size. The carpal bones are separate, and quite short. The five metacarpals are short and stout, and the first is the largest. The toes were thick, and the unguis phalanges were evidently covered with hoofs. In Plate VII, figure 1, the restoration of the scapular arch and entire fore limb of one species of *Morosaurus*, well illustrates this part of the skeleton.

The pelvic bones are distinct from each other, and from the sacrum. The ilium is short and massive, and shows on its inner side only slight indications of its attachment to the sacrum. More than half of the acetabulum is formed by the ilium, which sends down in front a strong process for union with the pubis, and a smaller one behind to join the ischium (Plate VIII, figure 1, a and b). The acetabulum is completed below by the pubis and ischium. The pubis is large and stout, and projects forward and downward, uniting with its fellow on the median line in a strong ventral symphysis. Its upper posterior margin meets the ischium, and contains a large foramen. The ischium projects downward and backward, and in *Morosaurus* its distal end is not expanded for a symphysis. The relative position and general form of the three pelvic bones in this genus are shown in Plate X, figure 3.

The femur is long and massive, and without a true third trochanter, although a rugosity marks its position. The great trochanter is obtuse, and placed below the head. The ridge which plays between the tibia and fibula is distinct. The tibia is shorter than the femur. It is without a spine or fibular ridge, and its distal end shows that the astragalus was separated from it by a cushion of cartilage. The fibula is stout, its two extremities nearly equal, and its distal end supports the calcaneum. The two tarsal bones of the second row are short, and the five well-developed digits are similar to those in the manus. The first metatarsal is much the largest. (Plate VII, figure 2.)

The largest species of this genus at present known may be called *Morosaurus robustus*. It can readily be distinguished from those already described by its short, helmet-shaped, ilium, which is represented in Plate VIII, figures 1 and 2.

One species of this genus, *Morosaurus grandis*,* is now known by a nearly complete skeleton, and the remains here figured are mainly portions of this individual. They were found together in nearly as perfect preservation as in life, and many of them were in their natural position. The locality was in Wyoming, and the bones were taken out with great care by Mr. S. W. Williston of the Yale Museum.

This animal when alive was about forty feet in length. It walked on all four feet, and in many other respects was very unlike the typical Dinosaur. It must have been very sluggish in all its movements. Its brain was proportionately smaller than in any known vertebrate.

Diplodocus longus, gen. et sp. nov.

This genus includes some Dinosaurs of very large size, and herbivorous in habit. It may be distinguished from the genera already known by the caudal vertebræ, which are elongated, deeply excavated below, and have double chevrons, with both anterior and posterior rami. (Plate VIII, figures 3 and 4). To the last character, the generic name refers. The tibia, also, is a very characteristic bone, as it is deeply grooved above to receive the fibula. The feet in this genus are very similar to those of *Morosaurus*, shown in Plate VII.

The present species is based upon one posterior limb, and the tail, of a single individual. The limb, as extended before removal, measured from the head of the femur to the end of the toes over thirteen feet (4.1^M). The femur was 1645^{mm} in length, and the tibia 1090^{mm}. Four of the median caudal vertebræ measured together thirty-four inches (760^{mm}). The first of these, or the fourteenth in the series, was eight and one-half inches (217^{mm}) long, and five and one-half inches (140^{mm}) across the anterior end.

The peculiar chevron represented in Plate VIII, figure 3, was found attached to the eleventh caudal, and all the remaining chevrons observed were of this character. Figure 4 represents a specimen found at another locality, and perhaps belonging to a different genus.

The above remains indicate a reptile about fifty feet in length. They were found in the upper Jurassic, near Cañon City, Colorado, in 1877, by Mr. S. W. Williston.

* This species, when described by the writer, was referred provisionally to the genus *Apatosaurus*. This Journal, vol. xiv, p. 515.

Laosaurus Marsh, 1878.

Another well marked group of herbivorous Dinosaurs, mostly of small size, occur in the same deposits with the gigantic forms above described. These belong to a separate suborder, and among the typical *Ornithoscelida*, as defined by Huxley. They belong also to the *Iguanodontidae*, and most nearly resemble the genus *Hypsilophodon*, from the Wealden of England. All the specimens known from the *Atlantosaurus* beds appear to come under the genus *Laosaurus*, several species of which have already been found, represented by numerous individuals. One of the species hitherto undescribed may be called *Laosaurus altus*, and its remains, with those of the smaller *Laosaurus celer*,* are here used to define the characters of the genus.

The skull is of medium size, and, so far as its structure has been made out, resembles that of *Hypsilophodon*. The teeth, also, are very similar (Plate IX, figures 2 and 3.) The rami of the lower jaw are edentulous in front, and apparently were not united by symphysis. The dorsal and caudal vertebræ have their extremities nearly plane, and the neural arches are united to the centra by suture. The chevrons have their articular ends joined together, as in *Iguanodon* and most Dinosaurs.

The fore limbs were quite small, less than half as long as the hind limbs, and evidently were not much used in locomotion. The humerus is slender, and considerably curved. The radius and ulna are nearly of the same size. In this species, the humerus is 190^{mm} long, and the radius 150.

The bones of the pelvis are distinct. The outline of the ilium is not known, but the pubes and ischia of several individuals have been determined, and prove of great interest. The pubis forms the antero-inferior part of the acetabulum, and the ischium completes the lower portion. The pubis extends downward and inward in front, and terminates in a broad spatulate free extremity. It unites with the ischium below the acetabulum, and sends backward and downward a long slender ramus, which is clearly homologous with the so-called pubic bone in birds (Plate X, figure 2). There is a large foramen near the ischiadic margin. This foramen is closed behind by suture only, and in some specimens becomes a notch. The posterior, rodlike, ramus ossifies from an independent center, and, to distinguish it from the true reptilian pubis in front, may be called the post-pubic bone. A comparison of the three pelves represented together in Plate X (*Hesperornis*, *Laosaurus* and *Morosaurus*), will make clear the intimate relation existing between the pubic bones of Birds and Dinosaurian reptiles.† If this series be extended by adding

* This Journal, xv, 244, March, 1878.

† After these figures were made, showing the position of the Dinosaurian pubis, which has caused so much discussion since Cuvier, I found that Dr. J. W. Hulke had already suggested the true solution of one difficulty. (Journal Geological Society of London, vol. xxxii, p. 334.)

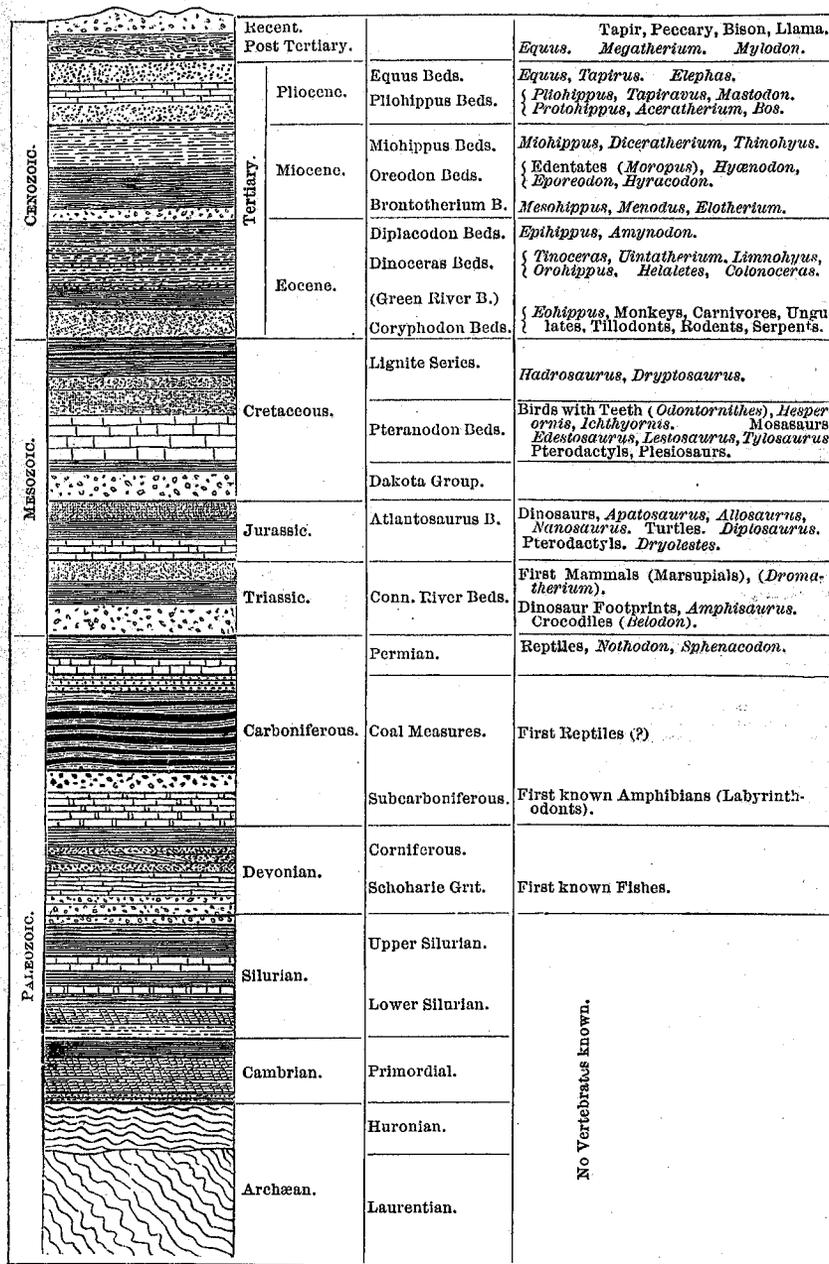
the pelves of some existing birds (for example *Geococcyx*), and of a few other reptiles, it will become still more evident that the bone called "pubis" in a bird, is a different bone from the pubis of a crocodile. The ischium in *Laosaurus* is a slender bone, extending backward parallel with the post-pubic. It has a distinct obturator process, which laps over the latter bone.

The limb bones in this genus have a distinct medullary cavity. The femur has a prominent great trochanter, the extremity of which is separated from the neck by a fissure. The third trochanter is long, and curved outward. The tibia slightly exceeds the femur in length, the proportions in *Laosaurus altus* being 393 to 360^{mm} (Plate IX, figure 3). The fibula is slender, and the distal smaller than the proximal end. The astragalus is distinct from the tibia, and the calcaneum supports the fibula. There are but two tarsals in the second row. There are three well developed digits in the pes (II, III and IV). The outer, or fifth, is wanting, and the first, or hallux, is represented only by a remnant of the metatarsal. The phalanges are rather short, and the unguis ones are pointed. (Plate IX, figure 3.)

The remains of this genus at present known are all from the *Atlantosaurus* beds of Colorado and Wyoming. Those here described were found in Wyoming by Mr. S. W. Williston. They represent an animal of slender proportions, and about ten feet in length.

Yale College, New Haven, October, 1878.

[To be continued.]



SECTION OF THE EARTH'S CRUST.

TO ILLUSTRATE VERTEBRATE LIFE IN AMERICA.

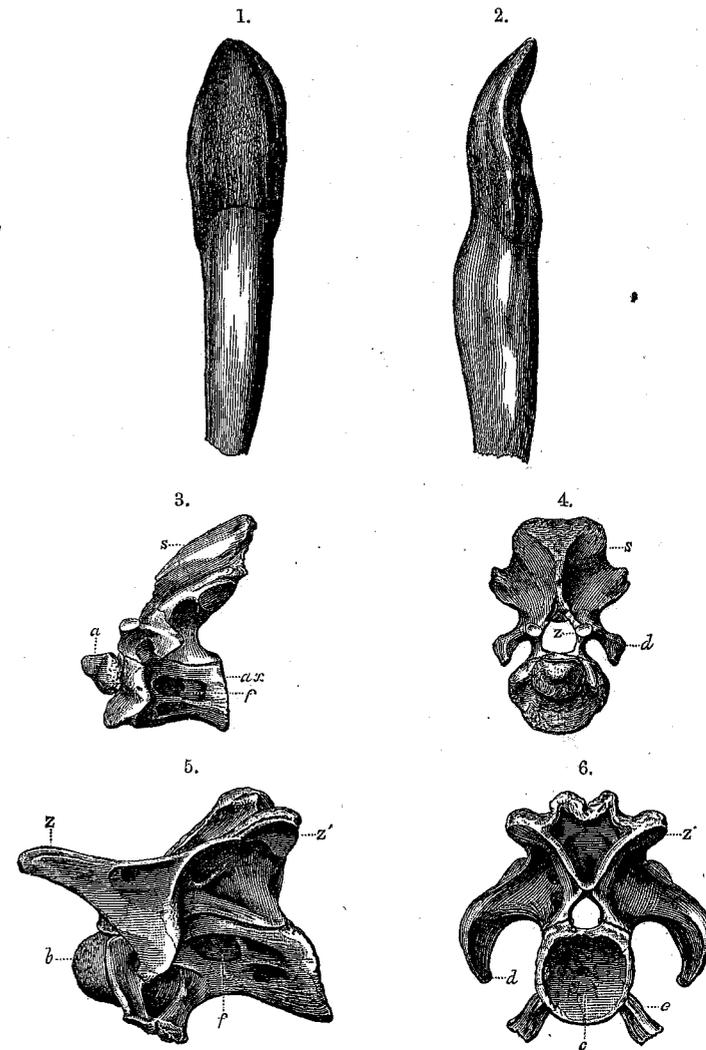


Figure 1.—Tooth of *Morosaurus grandis* Marsh; side view.

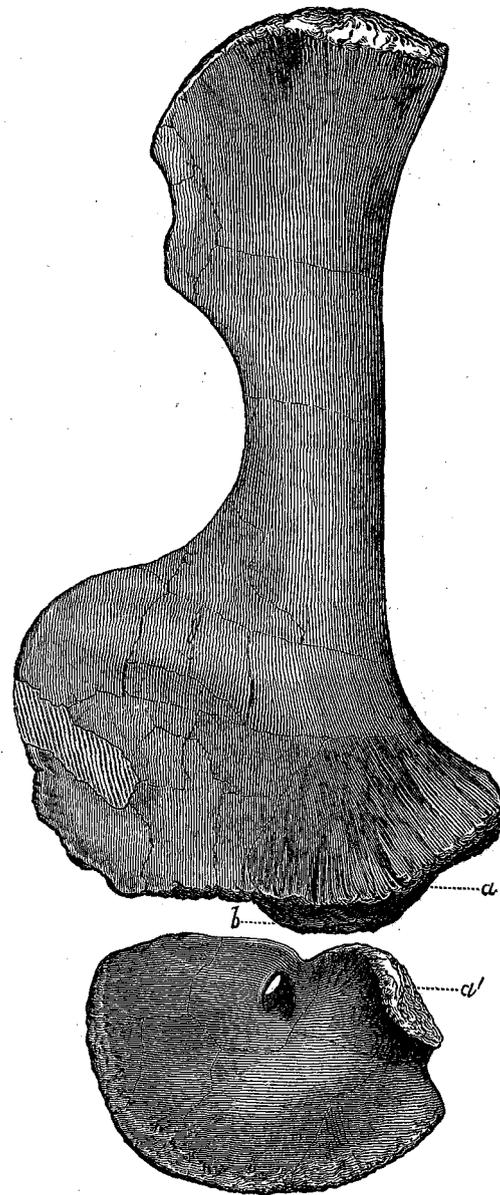
Figure 2.—The same; front view. Both one-half natural size.

Figure 3.—Axis and part of atlas of *Morosaurus grandis*; side view, one-eighth natural size. *a*. odontoid process, or centrum of atlas; *ax*. centrum of axis; *f*. foramen in centrum; *s*. neural spine.

Figure 4.—The same; front view. *d*. diapophysis; *z*. zygapophysis.

Figure 5.—Fourth cervical vertebra of *Morosaurus grandis*; side view, one-eighth natural size. *b*. ball on anterior end of centrum; *f*. foramen in centrum; *z*. anterior zygapophysis; *z'*. posterior zygapophysis.

Figure 6.—The same; back view. *c*. cup on posterior end of centrum; *d*. diapophysis; *e*. parapophysis; *z'*. posterior zygapophysis.



Left scapula and coracoid of *Morosaurus grandis* Marsh; side view; one tenth natural size. *a.* scapular face of glenoid cavity; *b.* rugose surface of scapula for union with coracoid; *a'* coracoidean part of glenoid cavity.

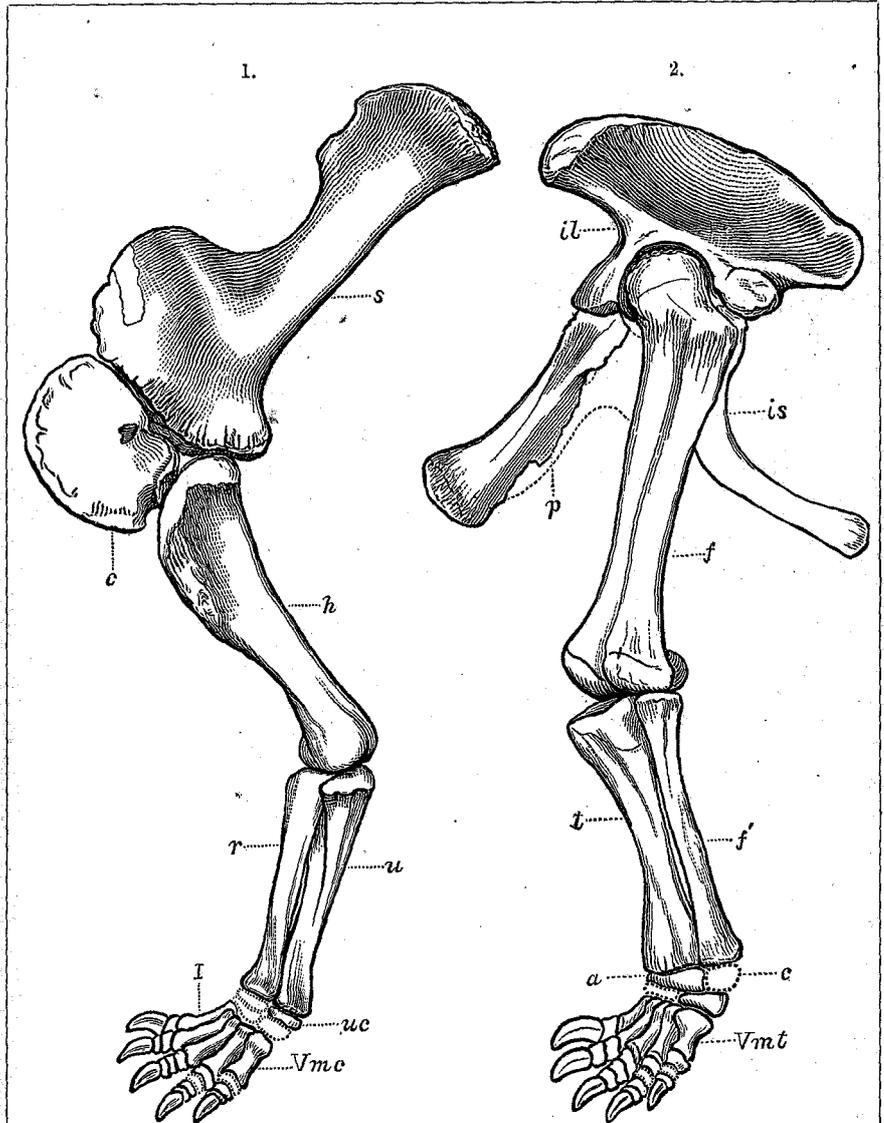


Figure 1.—Bones of left fore leg of *Morosaurus grandis* Marsh; one-twentieth natural size; *s.* scapula; *c.* coracoid; *h.* humerus; *r.* radius; *u.* ulna; *uc.* ulnar carpal; *I.* first metacarpal; *Vmc.* fifth metacarpal.

Figure 2.—Bones of left hind leg of *Morosaurus grandis*; one-twentieth natural size. *il.* ilium; *is.* ischium; *p.* pubis; *f.* femur; *t.* tibia; *f'.* fibula; *a.* astragalus; *c.* calcaneum; *Vmt.* fifth metatarsal.

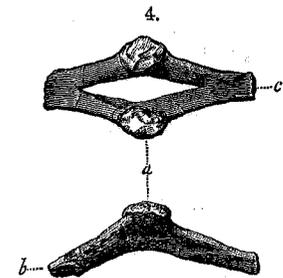
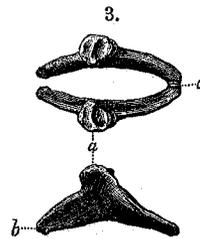
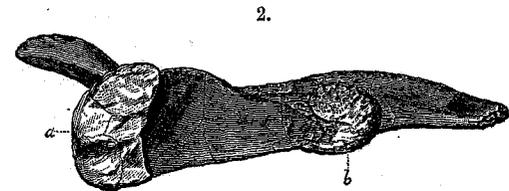
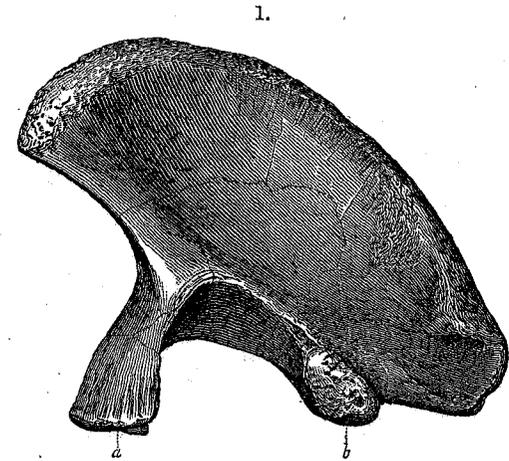


Figure 1.—Left ilium of *Morosaurus robustus* Marsh; side view. *a.* anterior, or pubic, articular surface; *b.* posterior, or ischiadic, articular surface.

Figure 2.—The same; inferior view. *a.* anterior, or pubic, articulation; *b.* posterior, or ischiadic, articulation. Both figures one-tenth natural size.

Figure 3.—Chevron of *Diplodocus longus* Marsh; top and side views. *a.* articular surfaces; *b.* anterior process; *c.* posterior process.

Figure 4.—Chevron of another individual; letters the same as in figure 3. All the figures are one-tenth natural size.

