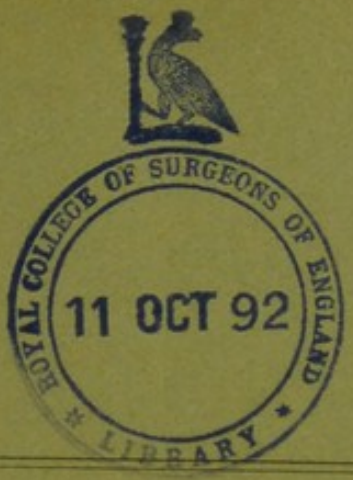
Restoration[s] of Claosaurus and Ceratosaurus ; Restoration of Mastodon americanus / by O.C. Marsh.



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[From the American Journal of Science, Vol. XLIV, October, 1892.]

RESTORATIONS OF CLAOSAURUS AND CERATOSAURUS.

RESTORATION OF MASTODON AMERICANUS.

By O. C. Marsh.

WITH THREE PLATES.

[From the American Journal of Science, Vol. XLIV, October, 1892.]

Restorations of Claosaurus and Ceratosaurus;

by O. C. Marsh. (With Plates VI and VII.)

A number of restorations of Dinosaurian reptiles have been recently made by the writer for the United States Geological Survey, and reduced figures of several of these have already appeared in this Journal; namely, *Brontosaurus* and *Stegosaurus* from the Jurassic, and *Triceratops* from the Cretaceous.* Two others of interest are given in the present article; *Claosaurus* from the Cretaceous, and *Ceratosaurus* from the Jurassic, as shown on Plates VI and VII. The former is a gigantic herbivorous reptile, a typical member of the *Ornithopoda*, and the latter a large carnivorous form of the *Theropoda*, as these orders have been defined by the writer.† Each of these two reptiles is a characteristic example of the great order in which it belongs, but both are highly specialized, and present many features not seen in earlier and more primitive types. Their representatives in the old world are *Iguanodon* and *Megalosaurus*, although each of the four genera may represent a distinct family.

It is especially fortunate that each of the restorations here presented is based upon the remains of a single individual in which both the skull and skeleton were found in position, and in remarkable preservation. Additional remains, apparently identical with each, have also been secured, and these have cleared up several points which otherwise might have been left in doubt. These various remains have already been described by the writer, and the most important parts figured.

* This Journal, vol. xli, p. 339, April, 1891; and vol. xlii, p. 179, August, 1891.
† Ibid., vol. xxi, p. 423, May, 1881; and vol. xxiii, p. 84, January, 1882.

Claosaurus, Marsh, 1890.*

The most important feature in the restoration of *Claosaurus annectens* given on Plate VI is the skull, which will be fully described elsewhere, but its main features may be noticed here. This skull is long and narrow, with the facial portion especially produced. The anterior part is only moderately expanded transversely, thus differing from that of *Hadrosaurus* (*Diclonius*), a nearly allied form. Seen from the side, the skull of *Claosaurus* shows a blunt, rugose muzzle, formed above by the premaxillary and below by the predentary, both probably covered in life with a thick, corneous integument.

Behind the upper part of this muzzle is an enormous lateral cavity, which includes the narial orifice, but was evidently occupied in life mainly by a nasal gland, somewhat like that in the existing Monitor, and also seen in some Birds. This cavity is bounded externally by the nasal bone and the premaxillary. The orbit is very large, and subtriangular in outline. It is formed above by the prefrontal, frontal, and postfrontal, and below mainly by the jugal. There are no supra-orbital bones. A distinct lachrymal forms a portion of the anterior border. The infra-temporal fossa is large, and bounded below by the jugal. There is a thin quadrato-jugal between the jugal and quadrate. The occipital condyle is directed backward and downward.

The nasals are very long and slender, and in front are separated by the narrow superior processes of the premaxillaries. The frontals are short and broad, and somewhat concave above. The parietals are firmly coössified, and very small, forming a thin partition between the supra-temporal fossæ. The latter are bounded posteriorly by the massive squamosals, which contain a deep cavity for the head of the quadrate, and also overlap the exoccipitals.

The striking features of the lower jaw are the massive, rugose predentary, the large and powerful dentary bone with its robust coronoid process, and the very small angular and articular bones.

The teeth are confined entirely to the maxillary and dentary bones. They closely resemble those of *Hadrosaurus*, are arranged in the same manner, and appear to be equally numerous.† They were well adapted to a diet of soft succulent vegetation.

* This Journal, vol. xxxix, p. 423, May, 1890; vol. xliii, p. 453, May, 1892; and vol. xliv, p. 171, August, 1892.

† The description given by Cope of the skull of *Hadrosaurus* (*Diclonius*) *mirabilis*, Leidy, is erroneous in various important points. Among the more serious errors are the following: the predentary bone is mistaken for the dentary, the dentary is regarded as the surangular and as the splenial, while the squamosal is called the parietal. See Proc. Phil. Acad., 1883, p. 97, plates iv–vii.

The main characters of the vertebral column of *Claosaurus* are well shown in the restoration. There are thirty vertebræ between the skull and sacrum, nine in the sacrum, and about sixty in the tail. The whole vertebral column was found in position except the terminal caudals, which are here represented in outline. The cervical vertebræ are strongly opisthocœlian, and the first eleven have short ribs. The dorsals are also opisthocœlian. There are no true lumbar vertebræ, as the last of those in front of the sacrum support free ribs. The anterior caudals are opisthocœlian. The first and second have no chevrons. Behind these, the chevron bones are very long, indicating a powerful, compressed tail, well adapted for swimming.

In the median dorsal region, between the ribs and the neural spines, are numerous rod-like ossified tendons, which increase in number in the sacral region and along the base of the tail, and then gradually diminish in number and size, ending at about the thirty-fifth caudal. These ossified tendons are well shown in the restoration, and are of much interest. They are not unlike those in *Iguanodon* described by Dollo, but as a rule are more elongate, and appear to lack the definite arrangement in rhomboidal figures observed in that genus.*

The fore limbs are unusually small in comparison with the posterior, and the relative size of the two is well shown in the restoration. The scapular arch presents many points of interest. The scapula is large, and so much curved that its shaft is nearly at right angles to the articular faces of its lower extremity. On the anterior margin, above the articulation for the coracoid, is a strong protuberance, with a well-defined facet, adapted to the support of the clavicle, if such a bone were present. The coracoid is very small, and is perforated by a large foramen. The two peculiar bones now generally regarded as belonging to the sternum were not coössified.

The humerus is comparatively short. The radius and ulna are much elongated, the latter being longer than the humerus, and the radius about the same length. The ulna has a prominent olecranon process, and is a stouter bone than the radius. The carpal bones were quite short, and appear to have been only imperfectly ossified. The fore foot, or manus, was very long, and contained three functional digits only. The first digit was rudimentary, the second and third were nearly equal in length, the fourth was shorter and less developed, and the fifth entirely wanting, as shown in Plate VI.

In the functional digits (II, III, IV), the phalanges are elongate, thus materially lengthening the fore foot. The terminal phalanges of these digits are broad and flat, showing

* Archives de Biologie, tome vii, p. 249, Gand, 1886.

that they were covered with hoofs, and not with claws. The limb as a whole was thus adapted to locomotion or support, and not at all for prehension, although this might have been expected from its small size and position.

The elongation of the fore arm and manus is a peculiar feature, especially when taken in connection with the ungulate phalanges. It may, perhaps, be explained by supposing that the animal gradually assumed a more erect position until it became essentially a biped, while the fore limbs retained in a measure their primitive function, and did not become prehensile, which was the case in some allied forms.

The pelvis has already been described by the writer. Its most notable features are seen in the pubis and ischium, the former having a very large expanded prepubis with the postpubis rudimentary, while the shaft of the ischium is greatly elongated.

The femur is long, and the shaft nearly straight. The great trochanter is well developed, while the third trochanter is large and near the middle of the shaft. The external condyle of the distal end is projected well backward, indicating great freedom of motion at the knee.

The tibia is shorter than the femur, and has a prominent cnemial crest. The distal end is much flattened, and the astragalus is closely adapted to it. The fibula is very straight, with its lower end flattened and closely applied to the front of the tibia. The calcaneum is large, with its concave upper surface closely fitted to the end of the fibula. Of the second row of tarsals, only a single one appears to be ossified, and that is very small and thin, and placed between the calcaneum and the fourth metatarsal, nearly or quite out of sight.

The hind foot, or pes, had but three digits, the second, third, and fourth, all well developed and massive. The terminal phalanges were covered with broad hoofs. The first and fifth digits were entirely wanting.

All the limb bones in *Claosaurus* are solid, thus distinguishing it from *Hadrosaurus*. The separate ischium, not coössified with the pubis, the absence of a fourth digit in the hind foot, and other marked characters, also make the genus distinct from *Pteropelyx*, the skull of which is not known.

The reptile here restored was nearly thirty feet in length when alive, and about fifteen in height in the position represented in Plate VI. The remains were obtained by Mr. J. B. Hatcher and Mr. A. L. Sullins, in the Ceratops beds of the Laramie, in Wyoming. Among the associated fossils are the gigantic *Triceratops* and *Torosaurus*, which were also herbivorous Dinosaurs, and with them were found the diminutive Cretaceous mammals recently described by the writer.

Ceratosaurus, Marsh, 1884.*

In the same horizon of the Jurassic in which *Brontosaurus* and *Stegosarus* were found, the skeleton restored in Plate VII was likewise discovered. It is a typical carnivorous Dinosaur of moderate size, and doubtless was one of the various enemies of the large herbivorous forms. The restoration represents the reptile one-thirtieth natural size, and in a position it must have frequently assumed.

The skull of *Ceratosaurus nasicornis* is very large in proportion to the rest of the skeleton. The posterior region is elevated, and moderately expanded transversely. The facial portion is elongate, and tapers gradually to the muzzle. Seen from above, the skull resembles in general outline that of a crocodile. The nasal openings are separate and lateral, and are placed near the end of the snout, as shown in Plate VII.

Seen from the side, this skull appears Lacertilian in type, the general structure being light and open. From this point of view, one special feature of the skull is the large, elevated, trenchant horn-core situated on the nasals. Another feature is the large openings on the side of the skull, four in number. The first of these is the anterior nasal orifice; the second, the very large triangular antorbital foramen; the third, the large oval orbit; and the fourth, the still larger lower temporal opening.

The parietal bones are of moderate size, and there is no parietal foramen. The median suture between the parietals is obliterated. The frontal bones are rather short, and are closely united on the median line. The nasal bones are more elongate than the frontals, and are firmly coössified. These bones support the large, compressed, elevated horn-core, on the median line. The lateral surface of this elevation is very rugose, and furrowed with vascular grooves. It evidently supported a high, trenchant horn, which must have formed a most powerful weapon for offense and defense.

The premaxillaries are separate, and each contained three functional teeth. The maxillary bones are large and massive, as shown in Plate VII. They are provided each with fifteen functional teeth, which are large, powerful, and trenchant, indicating clearly the ferocious character of the animal when alive. These teeth have the same general form as those of *Megalosaurus*, and the dental succession appears to be quite the same. Above the antorbital foramen on either side is a high elevation composed of the prefrontal bones. These protuberances would be of service in protecting the orbit, which they partially overhang.

* This Journal, vol. xxvii, p. 329, April, 1884; and vol. xxviii, p. 161, August, 1884.

The lower jaws of *Ceratosaurus* are large and powerful, especially in the posterior part. In front, the rami are much compressed, and they were joined together by cartilage only. There were fifteen teeth in each ramus, similar in form to those of the upper jaws.

The cervical vertebræ of *Ceratosaurus* differ in type from those in any other known reptiles. With the exception of the atlas, all are strongly opisthocœlian, the cup on the posterior end of each centrum being unusually deep. In place of an equally developed ball on the anterior end, there is a perfectly flat surface. The size of the latter is such that it can only be inserted a short distance in the adjoining cup. This peculiar articulation leaves more than three-fourths of the cup unoccupied by the succeeding vertebra, forming, apparently, a weak joint.

The dorsal and lumbar vertebræ are bi-concave, with only moderate concavities. The sides and lower surface of the centra are deeply excavated, except at the ends. All the presacral vertebræ are very hollow, and this is also true of the anterior caudals.

There are five well coössified vertebræ in the sacrum of the present specimen of *Ceratosaurus nasicornis*. The transverse processes are very short, each supported by two vertebræ, and they do not meet at their distal ends. The caudal vertebræ are bi-concave. All the anterior caudals, except the first, supported very long chevrons, indicating a high, thin tail, well adapted to swimming. The tail was quite long, and the distal caudals were very short.

The scapular arch of *Ceratosaurus* is of moderate size, but the fore limbs are very small. The humerus is short, with a strong radial crest. The radius and ulna are also very short, and nearly equal in size. The carpal bones were only imperfectly ossified. There were four digits in the fore foot, and all were armed with sharp claws. The second and third digits were much larger than the first and fourth, and the fifth was entirely wanting.

The pelvic arch of *Ceratosaurus* is of special interest. In the type specimen here restored, the ilium, ischium, and pubis, on each side, are firmly coössified. The ilia, moreover, are attached to the sacrum, which was in place in the skeleton. The ilia have the same general form as in *Megalosaurus*. The ischia are comparatively slender. They project well backward, and for the last half of their length the two are in close apposition. Their distal ends are coössified and expanded, as shown in Plate VII.

The pubes have their distal ends coössified, and expand into an elongate, massive foot, which is one of the most characteristic parts of the skeleton. It is probable that this foot in connection with the distal ends of the ischia served to support the body in sitting down. That some Triassic Dinosaurs sat down on their ischia is proved conclusively by the impressions in the Connecticut River sandstone. In such cases, the leg was bent so as to bring the heel to the ground. The same action in the present reptile would bring the foot of the pubes to the ground, nearly or quite under the center of gravity of the animal. The legs and ischia would then naturally aid in keeping the body balanced. Possibly this position was assumed habitually by these ferocious biped reptiles, in lying in wait for their prey.

The femur is much curved, and the shaft very hollow. The tibia is shorter than the femur, nearly straight, and has a large cnemial crest. The astragalus is not coössified with the tibia, and has a strong ascending process. The fibula is well developed, and nearly straight, its distal end fitting into the calcaneum. The tarsals of the second row are very thin, and united to the metatarsals below them.

The most interesting feature in the extremities of this Dinosaur is in the metatarsal bones, which are completely ankylosed, as are the bones of the pelvis. There are only three metatarsal elements in each foot, the first and fifth having apparently disappeared entirely. The three metatarsals remaining, which are the second, third, and fourth, are proportionally shorter and more robust than in the other known members of the *Theropoda*, and being firmly united to each other, they furnish the basis for a very strong hind foot. The phalanges of the hind feet are of moderate length, and most of them are quite hollow. The terminal phalanges evidently supported strong and sharp claws.

The unique cervical vertebræ, the coössification of the pelvic bones, and the union of the metatarsals, as in modern Birds, distinguish *Ceratosaurus* widely from all other Dinosaurs, and make it the type of a well-marked family, the *Ceratosauridæ*. The nearest allied form is apparently *Ornithomimus*, from the Laramie, recently described by the writer.

The type specimen of *Ceratosaurus* was about twenty-two feet long when alive, and twelve feet high as here restored. It was found by Mr. M. P. Felch, in the Atlantosaurus beds of the upper Jurassic in Colorado. The associated fossils were mainly other Dinosaurs, especially *Sauropoda* and *Ornithopoda*, together with various small mammals.

New Haven, Conn., September 22, 1892.

Restoration of Mastodon Americanus, Cuvier; by O. C. Marsh. (With Plate VIII.)

The great abundance and good preservation of the remains of the American *Mastodon* have led to various restorations of the skeleton. The best known of these is that made by Prof. Richard Owen, in 1846, based upon a skeleton from Missouri now in the British Museum.* Another restoration was made a few years later by Dr. J. C. Warren, based mainly on a very perfect skeleton from Orange county, New York.† This skeleton is now preserved in the Warren Museum in Boston. A third restoration was made by Prof. James Hall, from a skeleton found at Cohoes, New York, and now in the State Museum of Natural History, in Albany.‡ These restorations are all of importance, and taken together have made clear to anatomists nearly all the essential features of the skeleton of this well-known species.

Additional discoveries have since brought to light more perfect specimens, one of which, now in the Yale Museum, is perhaps in the best preservation of any skeleton of the American *Mastodon* yet discovered, and this has been used by the writer in the restoration, one thirty-second natural size, given on Plate VI, which is reduced from a large drawing made for the United States Geological Survey.

The position chosen in this restoration is one which seems especially fitted to bring out the massive proportions of the animal, and, at the same time, to show nearly all the characteristic features of the entire skeleton. The animal as thus represented was, when alive, about twelve feet in height, and perhaps twenty-four feet in length including the tusks.

This animal was fully adult, as the last molars above and below are in place and somewhat worn. The epiphyses of the vertebræ, moreover, are nearly all coössified with the centra, and in some of them, the sutures are obliterated. The epiphyses are also firmly united to the limb bones.

The tusks were very large, and considerably divergent. There were no inferior tusks, and no traces of their alveoli remain. The penultimate and last molars are present above and below in fine preservation, the former considerably worn.

Other features of this skeleton, and especially the various new anatomical points it discloses, will be discussed by the writer in another communication.

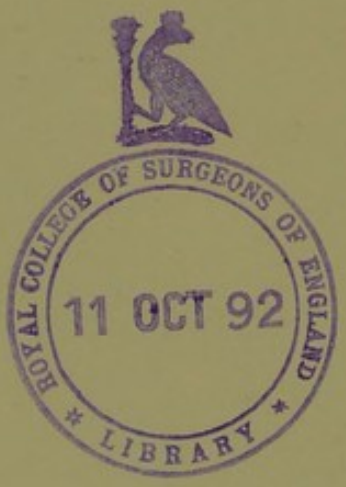
New Haven, Conn., September 23, 1892.

* British fossil Mammals and Birds, figure 102, p. 298, London, 1846.

† Description of a skeleton of the *Mastodon giganteus* of North America, plate xxvii, Boston, 1852.

‡ Report of the New York State Cabinet of Natural History for the year 1867 plate vi, Albany, 1871.

Restoration of CLAOSAURUS ANNECTENS, Marsh. One-fortieth natural size.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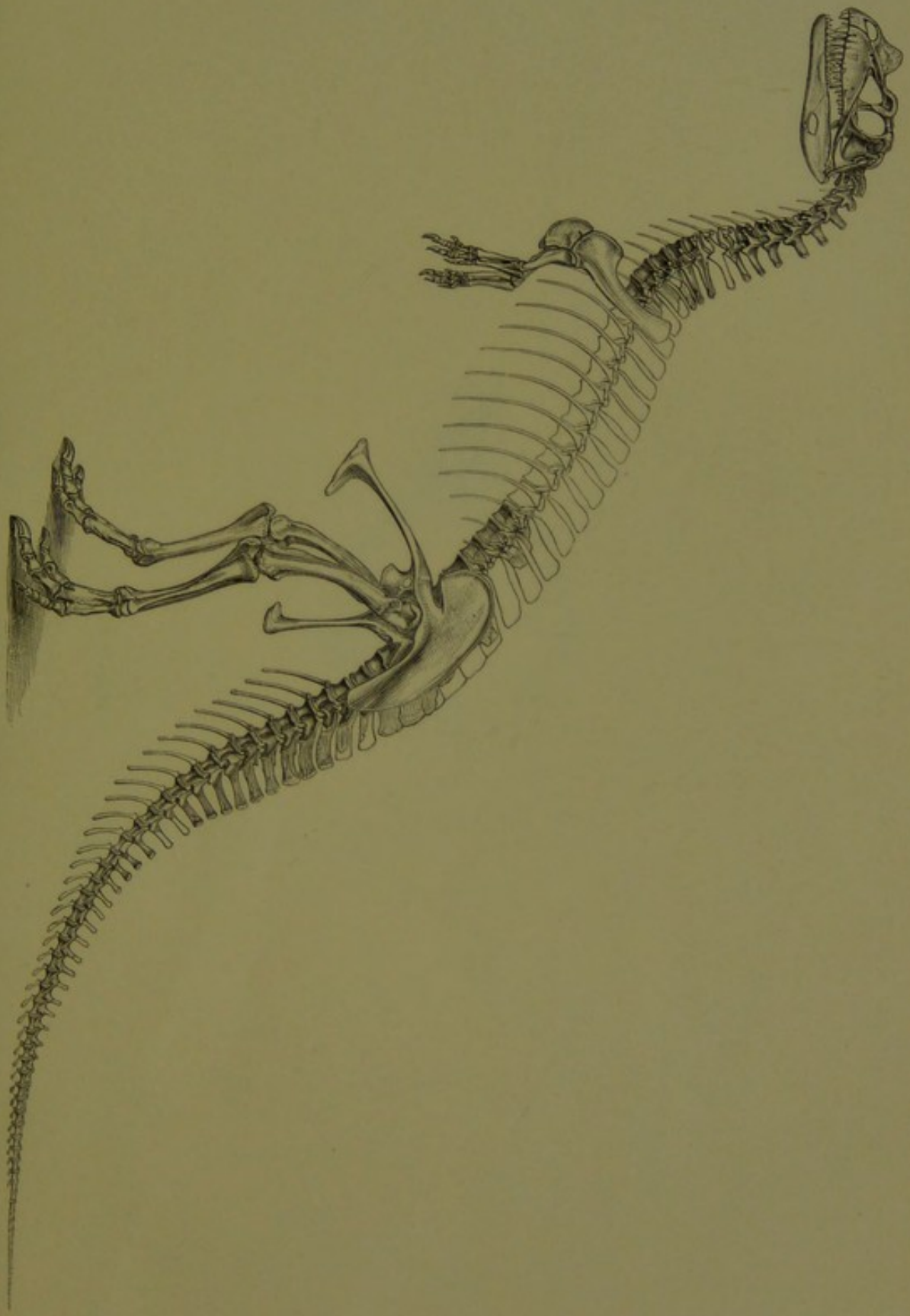

Restoration of CERATOSAURUS NASICORNIS, Marsh. One-thirtieth natural size.


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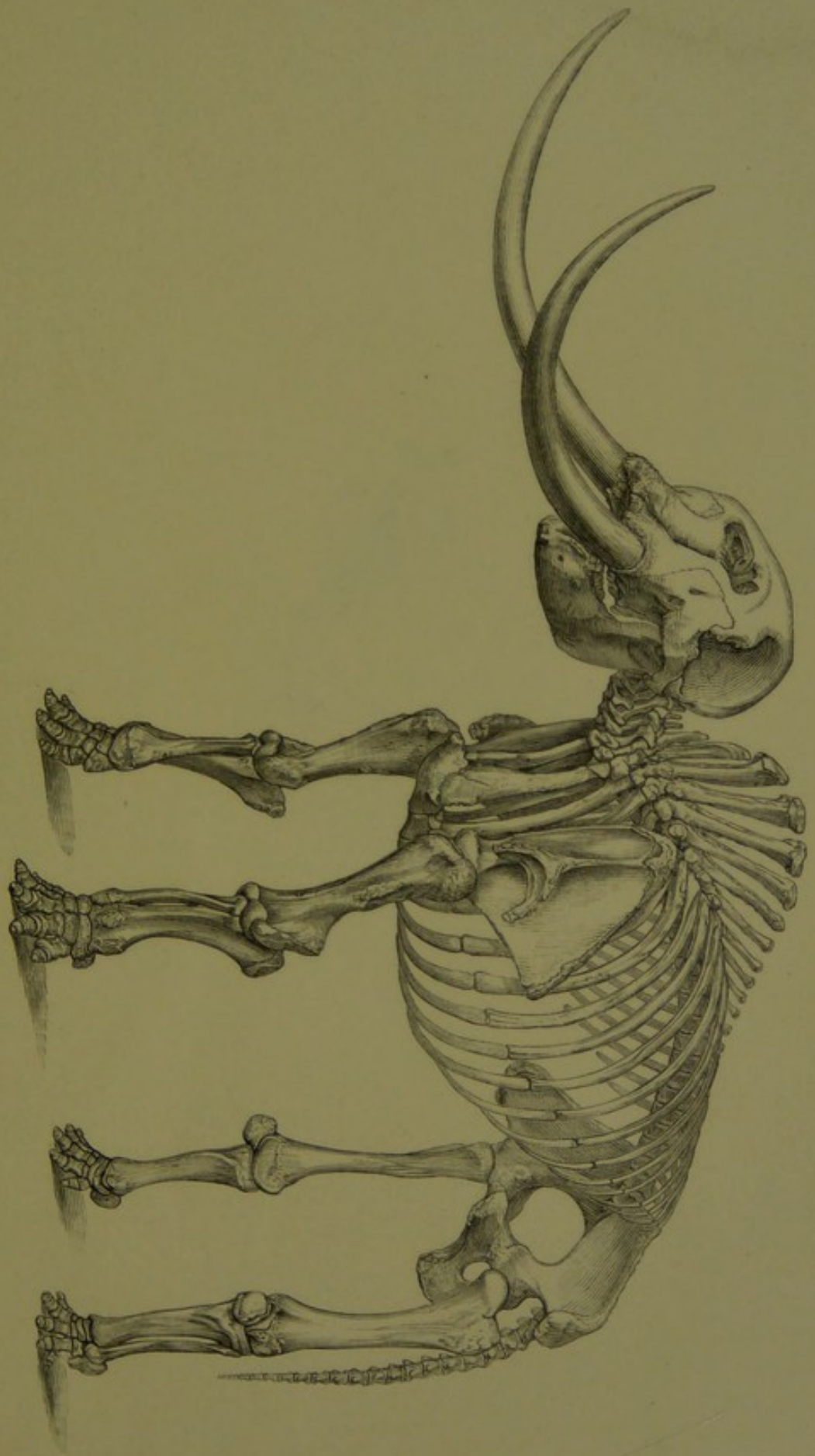
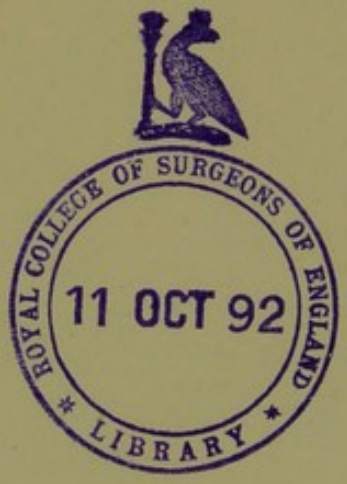


Restoration of MASTODON AMERICANUS, Cuvier. One thirty-second natural size.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