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E. D. Cope

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ON THE SAURIANS RECENTLY DISCOVERED IN THE DAKOTA BEDS OF COLORADO.

BY E. D. COPE.

THE formation known as the Dakota was long since characterized by Messrs. Meek and Hayden, from the studies made by the latter gentleman, of the great section exhibited by the Missouri river. Subsequently Dr. Hayden, then as now, the esteemed director of the United States Geological Survey of the territories, observed and defined the same horizon along the eastern flank of the Rocky mountains. Doctor J. S. Newberry, in his reports on the geology of the Colorado basin, has mentioned the same stratum under the name of Lower Cretaceous sandstone, and I have in my report to Lieut. Geo. M. Wheeler identified that part of these sandstones which is seen in northwestern New Mexico, with the Dakota. This formation is then one of great extent and importance. It consists chiefly of sandstones which are sometimes so amorphous as to constitute a quartzite. Among these are interstratified beds of clay, carbonaceous clay, and lignite, some of which may be used as an inferior fuel. These mineral characters show that the formation was, as pointed out by Prof. Newberry, deposited in shallow water during a period of subsidence. He remarks that previous to this subsidence there was an extensive land area; but that it steadily diminished by the encroachments of the ocean. This period of extended dry land, would be regarded by many geologists as a part of the great cretaceous division of time; that occupied in its sinking, and in the deposit of new beds, being now parallelized with the later half of the cretaceous period of the old world scale. In any case the deposit of the sands which became the Dakota rocks, marks the beginning of the cretaceous ocean in North America, and is the No. 1 of Meek and Hayden.

Along both the eastern and western flanks of the Rocky mountains the Dakota beds form a distinctive feature of the landscape. Their hardness has resisted the effects of erosion so that they remain prominent where other beds have been worn away. As all the earlier cretaceous strata lie tilted up against the great central axis, the harder ones form lines of hills or "hog backs," while parallel valleys mark the upturned edges of the softer ones. This role is played by formation No. 2, as has been often shown by Dr. Hayden. The side of the sandstone ridge next the mountains is steep, while the opposite one is sloping, and the summit is is often a narrow ledge. On this elevated perch the ancient Pueblos of New Mexico fixed their rock built houses, courting one peril to escape the greatest of all, the attacks of savage men. To-day these ruined abodes form the resting places of the geologist, the true lover of scenery, who climbs for birds-eye views of his favorite subjects, and for clews to many a knotty problem.

As a shore and shallow water formation, the Dakota should enclose the remains of the plants and animals of the land. And plants have been found in abundance, and have been the theme of an interesting volume of the Hayden series by Mr. Lesquereux, but vertebrate remains were until recently unknown. To ascertain what forms of animal life ranged that unexplored and unexplorable continent, is a problem that stimulated the writer to many excursions among the "hog backs" of Colorado and New Mexico; and many cliffs have been scaled, and many fasts endured without result in this direction.

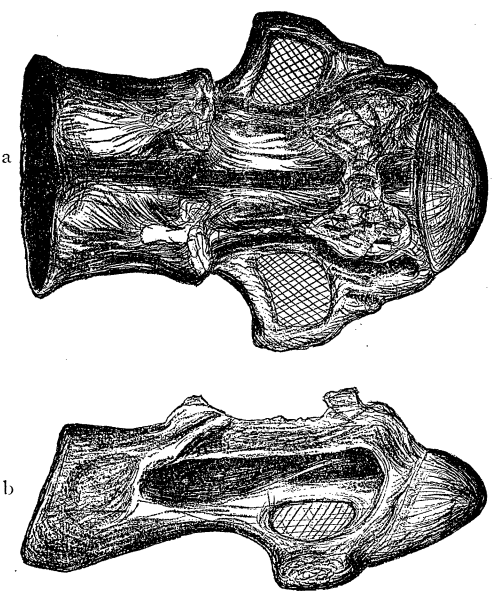

Fig. 1—Cervical vertebra of *Camarasaurus supremus*. *a* from above; *b* from right side. The neural arch is mostly wanting. These figures, like all the others in this paper, are one-tenth natural size.

It was therefore a source of no small gratification to have been in receipt of letters from Superintendent O. W. Lucas, of Canyon City, and Professor Arthur Lakes, of Morrison (both in Colorado and one hundred miles apart), at about the same time, informing me of their simultaneous discoveries of vertebrate remains in the beds of Dakota age, near their respective residences. The bones obtained by the former were found in a rather friable bed, and were easily extracted in good condition. Some of those obtained by the latter gentlemen were from a similar or identical formation,

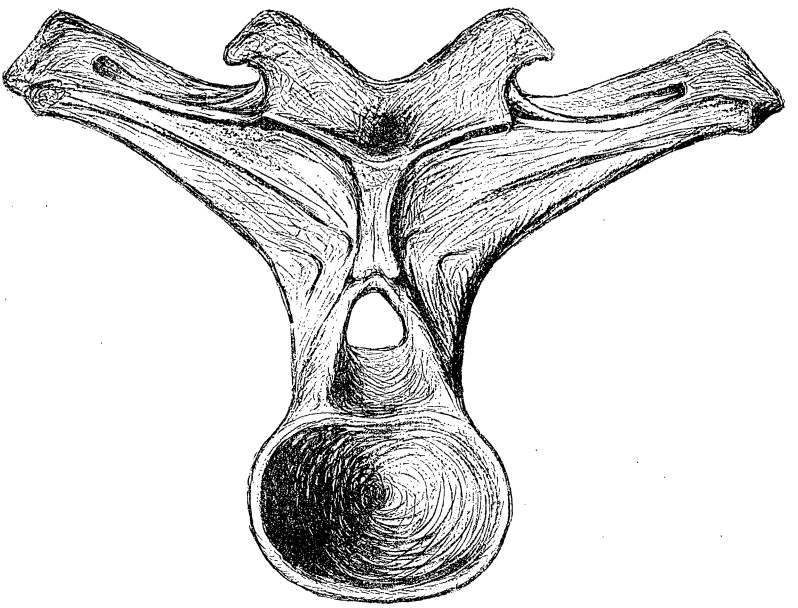

Fig. 2—Anterior dorsal vertebra of *Camarasaurus supremus* from behind.

while others were embedded in the hard sandstone already mentioned. I obtained possession of those from near Canyon city, while those from near Morrison were purchased for the museum of Yale college.

One of the first objects sent by Mr. Lucas is a fragmentary lower jaw of a carnivorous dinosaurian, which he found on the surface of the ground. This fossil was found to belong to a species heretofore unknown, which I referred to the genus *Laelaps*, under the name of *Laelaps trihedrodon*.[1] The second sending included a number of vertebræ, which apparently represent a much more gigantic animal, and I believe the largest or most bulky animal capable of progression on land, of which we have any knowledge. This rep-

[1] Bullet. U. S. Geol. Surv. Terrs. III, 1877, p. 805.

tile I described in my palæontological bulletin No. 26, under the name of *Camarasaurus supremus.* Subsequent sendings included many of the more important bones of the skeleton, which render

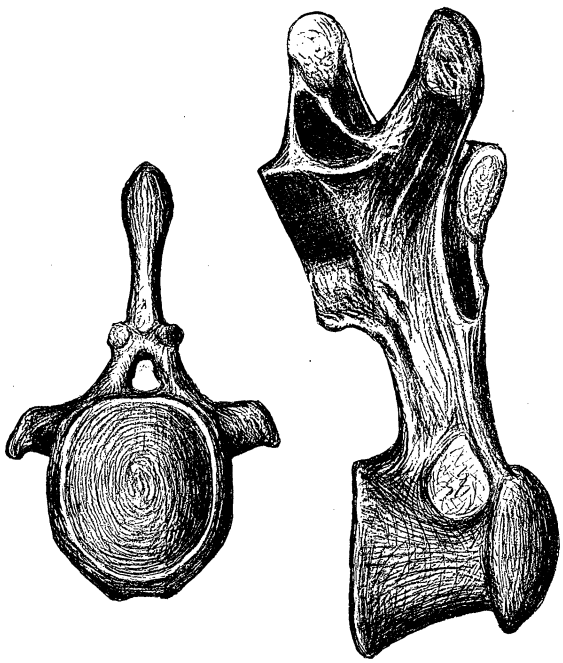

Fig. 4. Fig. 3.

Fig. 3—Dorsal vertebra represented in Fig. 1, the right sight side. Fig. 4—A caudal vertebra viewed from behind.

it comparatively easy to determine the general character of this monster. Later collections received from Mr. Lucas include the teeth of two large species of a new genus which has been characterized under the name of *Caulodon;* and the vertebræ of two genera new to science, which I have named *Tichosteus* and *Symphyrophus.* He also procured remains of two additional forms of gigantic size, fit rivals of the *Camarasaurus,* which I referred to the new genus *Amphicœlias.* A species of tortoise was associated with these saurians, and appears to have been abundant. It is the oldest species of the order yet obtained from American formations, and is not very different from existing forms.

The species of *Camarasaurus* and *Amphicœlias,* which attained to the most gigantic proportions, are remarkable for the light construction of the vertebræ anterior to the tail. In both genera

the centra of dorsal vertebræ are hollow, including two large chambers which are separated by a longitudinal median wall, and communicate with the cavity of the body by a foramen on each side. This is well exhibited by a centrum shown in fig. 6, from which the anterior wall has been removed, and the mineral contents of the chambers extracted. The communication of the latter with the abdominal cavity is seen on the left side, while the foramen of the right side (of the figure) is concealed by its anterior border, which remains.

Fig. 7.

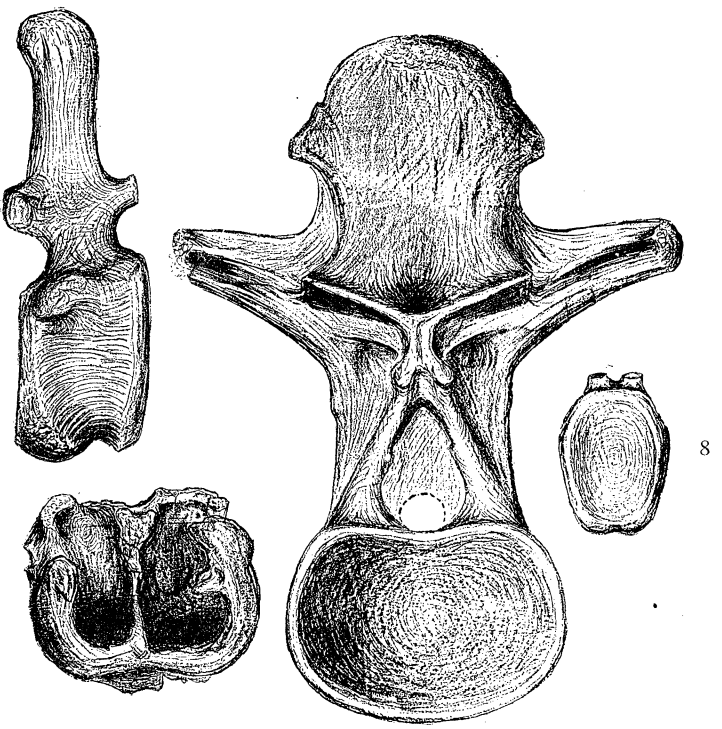

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Fig. 6. Fig. 5.

Fig. 5—A median dorsal vertebra seen from behind, showing the hyposphen. Fig. 6—Centrum of a dorsal vertebra without anterior wall. Fig. 7—Caudal vertebra shown in fig. 4, from the right side. Fig. 8—A more posterior caudal, end view of the centrum.

They are also remarkable for the enormous elevation of the superior arches, and diapophyses, the result of which is to give the ribs an unusually elevated basis, and the cavity of the body much space above the vertebral axis on each side. On the other

hand the bones of the tail and limbs are solid or nearly so, in great contrast with some of the *Dinosauria* of later geological periods.

The manner of the mutual articulation of the arches of the vertebræ in the genera *Camarasaurus* and *Amphicœlias* is very peculiar, and has not been observed in any other animals.

The anterior zygapophyses are separated by a deep fissure, while the posterior zygapophyses are united on the middle line. From the latter from the point of junction, there descends a vertical plate which rapidly expands laterally, forming a wedge whose base looks downward. The supero-lateral faces are flat, and articulate with corresponding facets on the inferior side of the anterior zygapophyses, which look downward and inward, on each side of the fissure above described. When in relation, the anterior zygapophyses occupy a position between the posterior zygapophyses above, and the *hyposphen*, as I have termed the inferior reverse wedge, below. This arrangement accomplishes the purpose effected by the zygosphenal articulation, that is the strengthening of the articulation between the neural arches, but in a different way. The additional articulation is placed at the opposite extremity of the vertebræ, and it is the anterior zygapophysis instead of the posterior one which is embraced. This structure entitles the genera which possess it to family rank, and as the two genera mentioned above belong to different families in consequence of the different types of vertebral centra, the one opisthocœlous, the other amphicœlous, they have been called *Camarasauridæ* and *Amphicœlidæ* respectively.

This structure is readily seen by reference to Figs. 5 and 13, where it is represented in the vertebræ of the two genera from behind. In Fig. 2 it is replaced by a stouter vertical plate of bone, which spreads out a little below. It is seen in profile in Fig. 3. It is not present in the vertebræ of the tail.

The characters of the genus *Camarasaurus* are derived from nearly all portions of the skeleton excepting the skull and ungues. The bones are generally in good preservation.

The vertebræ of the cervical, dorsal and lumbar region are all opisthocœlous or reversed ball and socket. The centra of the cervicals are very elongate, but those which follow them diminish rapidly in length, until in the lumbar region they have but a small anteroposterior diameter. The anterior caudal vertebræ are also

very short and wide; but the length of the centra gradually increases, so that the distal ones are quite elongate. The caudal centra are all moderately amphicœlous.

The sacrum is short and consists of only four vertebral centra, thoroughly coössified. The anterior articular extremity is convex; that of the posterior extremity slightly concave. Its transverse processes are, like those of the other vertebræ, much elevated, although they spring from the centra. The external face of their bases is not prominent, and the spaces between their projecting portions are deeply excavated. The centra are like those of the caudal vertebræ, composed of dense bone. The extremities of the adjacent transverse processes are united, thus enclosing large foramina.

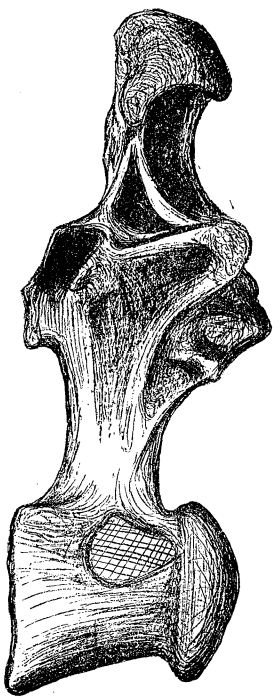


Fig. 9—View of the right side of the dorsal vertebra of *Camarasaurus supremus*, represented in Fig. 5.

The scapula is relatively of large size. It is rather elongate, and the superior extremity is expanded. There is a very large mesoscapular process, which is wanting in *Cetiosaurus*, according to Phillip's figures. It appears to resemble the scapula in *Dystrophæus*.[1] (See Fig. 10.)

The coracoid bone is of proportionately small size. It is of an irregularly quadrate form, with the proximal extremity the shortest. The articular face is large, and is presented obliquely away from the long axis of the plate. There are no emarginations nor intermediate processes, and the perforating foramen is well removed from the border.

Pelvic bones of two forms are present. Neither of them resembles pelvic bones of *Dinosauria*, and are least of all similar to the forms of ilium which are known in that order. One of them is a robust L-shaped bone, one limb of which is expanded into a wide fan-shaped plate; and the other is stouter and of subequal width, terminating in a stout sub-triangular articular extremity.

[1] See Report Lt. Wheeler, Vol. IV, pl. LXXXIII, p. 31.

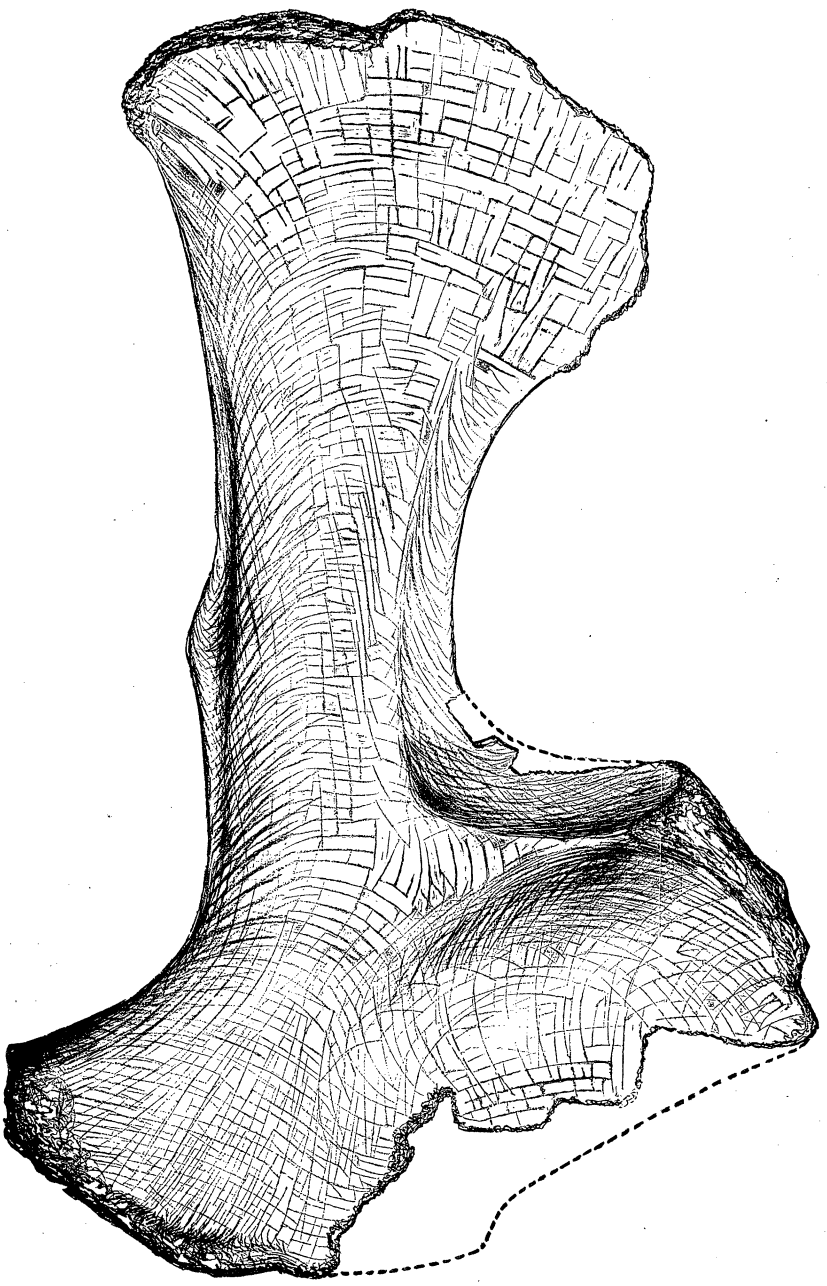
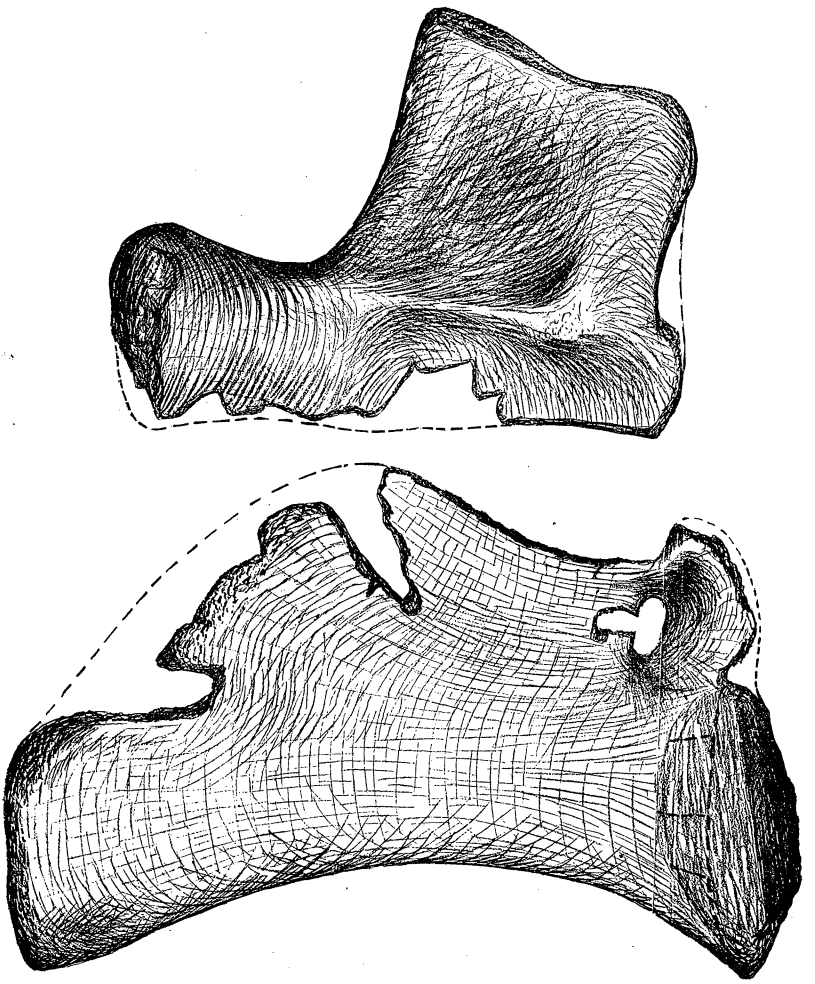


Fig. 10—The right scapula of *Camarasaurus supremus*, external view.

But one species of *Camarasaurus* has as yet been discovered. This I have named *C. supremus*, in allusion to its huge size. The bones, so far discovered by Mr. Lucas, are: a cervical and twenty dorsal and lumbar vertebræ, with twenty caudals. Both scapulæ and coracoids were recovered, with one-half of the sacrum, and two pairs of pelvic bones. Of the hind limb I have the femur, with



Figs. 11, 12—Pelvic bones of *Camarasaurus supremus*.

a tibia less certainly belonging to the same animal, although found among the other bones. There is one metapodial. There are many other bones which I have not yet reconstructed or determined.

The dimensions of this animal may be inferred from the fact that the cervical vertebra is twenty inches in length and twelve in transverse diameter; and that one of the dorsals measures three and a half feet in the spread of its diapophyses, two and a half feet in elevation, and the centrum thirteen inches in transverse diameter. Another dorsal is two feet ten inches in elevation.

The femur already mentioned is six feet, and the scapula five

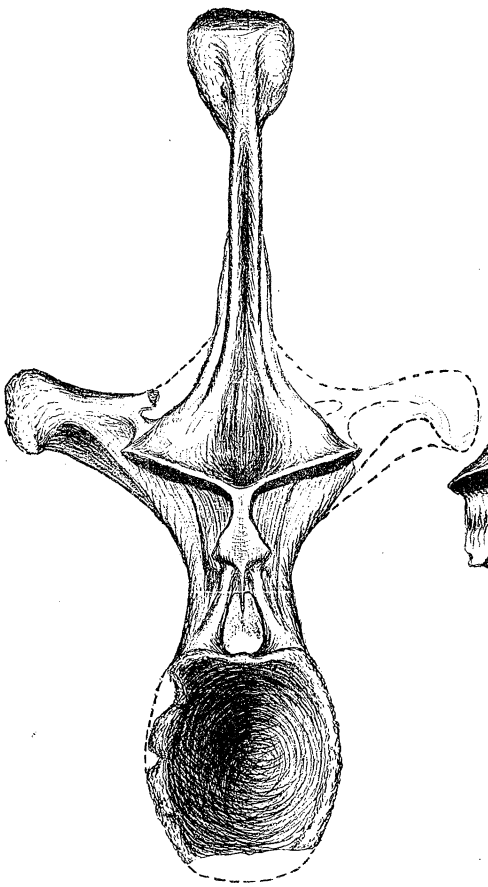


Fig. 13.

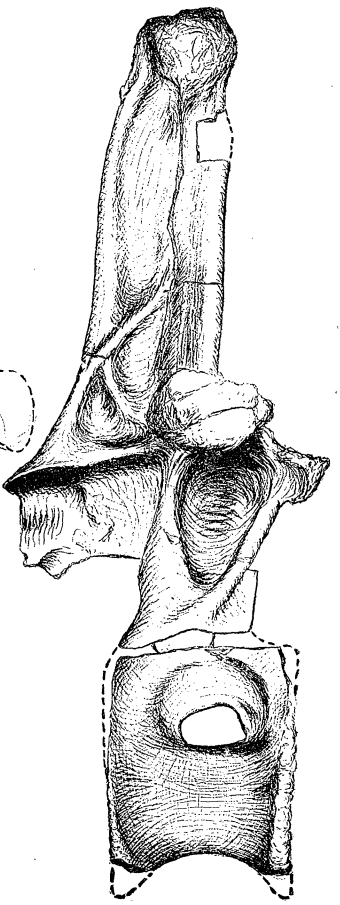


Fig. 14.

Fig. 13—Dorsal vertebra of *Amphicœlias altus* seen from behind, exhibiting the hyposphen.

Fig. 14—The vertebra represented in Fig. 13 seen from the right side, displaying the excavations of the neural arch and spine, and the pneumatic foramen of the centrum.

and a half feet in length. The posterior dorsal vertebræ exceed

in dimensions those of any known saurian, equaling those of the right whale. The centra measure sixteen inches in transverse diameter. The neck was probably ten feet in length.

That this species was capable of and accustomed to progression on land, is certain from the characters of the bones of the limbs and their supports above described. The extraordinary provision for lightening the weight of a portion of the skeleton has more than one significance. It must be borne in mind that the caudal vertebræ retain the solid character seen in those genera which stood habitually on their hind limbs. That the present species was herbivorous is suggested simply by its huge dimensions, and the natural difficulty of supplying itself with animal food.

The scapula is enormous as compared with the pelvic bones. The sacrum is also small and short, showing that the weight was not borne on the hinder limbs. The great length of the humerus in the probably allied genus *Dystrophæus*, from the Trias of Utah, adds to the probability that the same bones were large in *Camarasaurus*. This character, taken in connection with the remarkably long neck possessed by that genus, suggests a resemblance in form and habits between those huge reptiles and the giraffe. While some of the later *Dinosauria* elevated themselves on their hind limbs to reach the tree-tops on which they fed, the general form of the body in some of these earlier types enabled them to reach their food without the anterior limbs leaving the earth.

The vertebræ from all parts of the column of *Camarasaurus* are known, and those of the dorsal and lumbar regions present the extraordinary character, of which a trace is seen in *Cetiosaurus*, of neural spines expanded transversely to the axis of the column. Numerous vertebræ of *Amphicœlias* are known, and in the dorsals in which the neural spine is preserved, the latter displays the usual form, that is, it is compressed in the direction of the axis of the column. The centra differ from those of *Camarasaurus* in the form of their articular extremities, resembling more nearly in this respect the genus *Tichosteus* Cope (Palæontological Bulletin, No. 26, p. 194). They are unequally amphicœlous, the posterior extremity being more concave, and with prominent margins; while the opposite one is less expanded, and is but slightly concave. The neural arch is coössified to the centrum, and there is no capitular costal articulation on the latter.

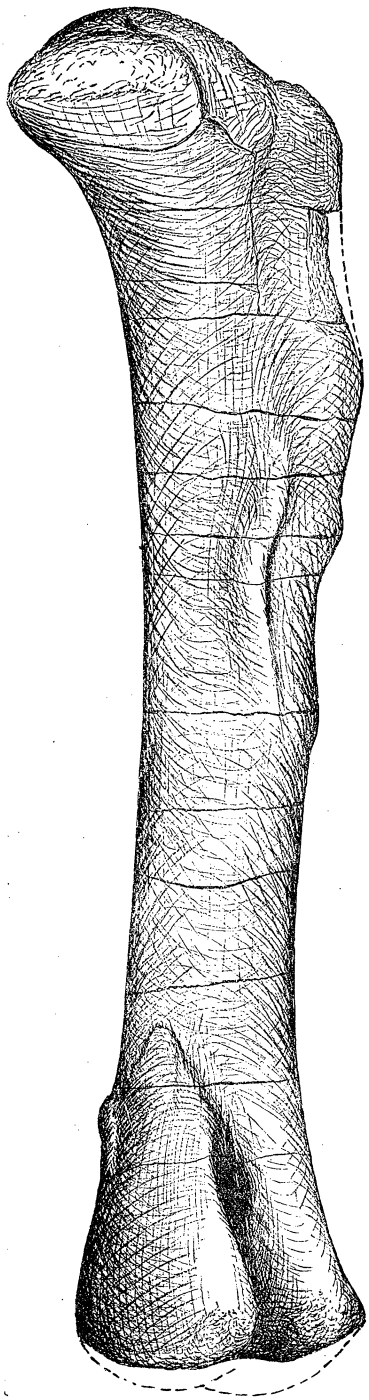


Fig. 15—Femur of *Amphicœlias altus*, seen from the inner posterior direction.

The lightness of construction of the vertebræ of this genus is as remarkable as in the *Camarasaurus*, but is differently exhibited. The greater fore and aft extent is seen in the fossæ, which are therefore not so deeply excavated as in that genus, but the osseous walls are not less lightened and attenuated. The elevation of the middle line of the back must have been extraordinary in the *Amphicœlias altus* (Figs. 13, 14), and the huge knob at the summit of the neural spine indicates the strength of the longitudinal ligament which connected the vertebræ with each other and with the head.

The femur of *Amphicœlias altus* is remarkable for its slender form. It is a few inches longer than that of the *Camarasaurus supremus*, but is not so robust. The shaft is nearly round and somewhat contracted at the middle, where it is slightly convex backwards. It is slightly curved inwards at the great trochanter. Here the shaft is moderately grooved on the posterior face. This trochanter is only a prominent ledge below the head. The third trochanter is situated a little above the middle of the shaft; it is a prominent obtuse ridge directed backwards. The condyles are extended well posteriorly, and are separated by a deep popliteal groove, which originates on the

inferior portion of the shaft. They are also separated anteriorly by a shallow open groove. The external condyle is rather more robust than the internal.

The length of the femur is six feet four inches; the elevation

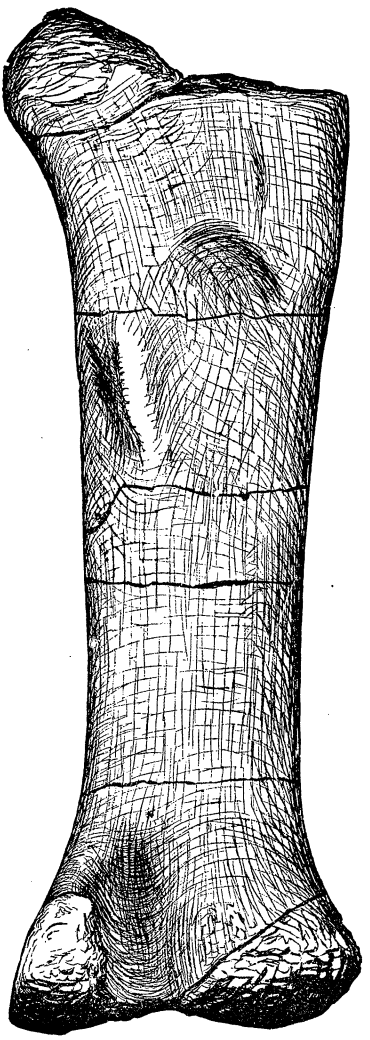
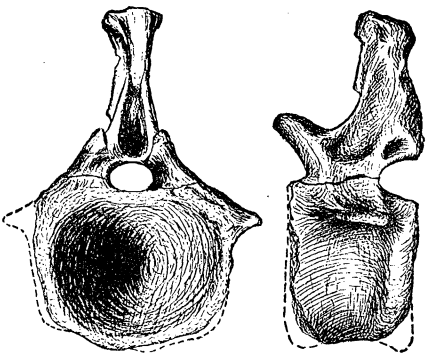


Fig. 17—Left femur of *Amphicœlias latus*, from behind.



a *b*

Fig. 16—A caudal vertebra of *Amphicœlias latus; a* from before, *b* from the left side.

of the dorsal vertebra three feet three inches. The animal, if proportioned anteriorly like the *Camarasaurus supremus*, must have been able to elevate itself to a height of thirty feet. Its length cannot yet be conjectured.

If in this fauna, the *Camarasaurus supremus* was preëminent in general proportions, and the *Amphicœlias altus* was the tallest, the *Amphicœlias latus* was the most robust. It is represented in Mr. Lucas' collection by a right femur and four caudal vertebræ which are in good preservation. They reveal the existence of another saurian of huge dimensions, and of great mass in proportion to its height.

The caudal vertebræ are apparently from the anterior part of the series. They are all strongly biconcave; the anterior face more so than the posterior. They are much more deeply bicon-

cave than those of the *Camarasaurus supremus;* and also differ in their relatively and absolutely greater breadth of body.

The femur is extraordinarily robust. The great trochanter is low, but the shaft is widest where it expands outward. The third trochanter is a ridge, is above the middle, and is short and little prominent. It is on the inner edge of the posterior aspect of the shaft, and looks backwards and inwards. The shaft in its present state is compressed so as to reduce the antero-posterior diameter. It is not however crushed or cracked. The condyles have much greater transverse than antero-posterior extent. They are moderately produced backward, and are separated by a deep popliteal groove, while the anterior trochlear groove is wide and well marked. The inner condyle is narrowed posteriorly, while the external one is obtuse and robust. Their articular faces are marked with irregular pits as in *Dystrophæus* and *Cetiosaurus.*

The length of this bone is fifty inches and the thickness fourteen inches. The body of the caudal vertebra is ten inches in transverse diameter.

The character of the articular surfaces of the bones of the limbs already mentioned is a peculiarity of *Camarasaurus* as well as of the genera named. It indicates a thick cartilaginous cap of the bones, which, if ossified, would be an epiphysis like that of the *Mammalia.* I first observed this character in the *Dystrophæus viæmalæ*, a huge saurian discovered by Prof. J. S. Newberry in the red rocks of the Painted Canyon, near the Sierra La Sal, in south-eastern Utah, and described by myself in Lieut Wheeler's final report. The bed from which it was derived is supposed to be of Triassic or Jurassic age. It had an enormous scapula like *Camarasaurus*, and a long straight humerus; its toes were short. It was probably a predecessor of the gigantic forms from the Dakota formation, and an inhabitant of a more ancient continent. It did not reach the dimensions of either of the species of the genus above-named, or of *Amphicœlias*, having been only as large as an elephant.

The genus *Tichosteus* included a species not larger than an alligator. Its vertebræ were hollow, but the internal chamber did not communicate with the body cavity. The only known species of *Symphyrophus* was of similar size, but the vertebral bodies were solid. Some of the numerous crocodile-like teeth found by Mr. Lucas probably belong to species of these genera.

Dr. Hayden visited the locality of Mr. Lucas' excavations, and informs me that the formation from which the *Camarasaurus* was obtained, is the Dakota. Prof. Marsh has attempted to identify what is, according to Prof. Mudge, the same horizon, one hundred miles north of Canyon City, with the Wealden of England. Specimens from the northern locality which I have examined render it certain that the horizon is that of Mr. Lucas' excavations. Of this I may say that there is no palæontological evidence of its identity with the Wealden. The resemblance of the vertebrate fossils to those of the English Oolite is much greater, but not sufficient as yet for identification.

The discovery of *Vertebrata* in the strata of the Dakota epoch is an important addition to the geology and palæontology of North America. Credit is due to Superintendent O. W. Lucas for this discovery, and also in an especial manner for the skill and care he has exercised in taking out and shipping the ponderous specimens.

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THE DISCOLORED WATERS OF THE GULF OF CALIFORNIA.

BY THOS. H. STREETS, M.D., U. S. N.

ONE of the earliest names given by the old Spanish navigators to the body of water that lies between the peninsula of Lower California and the western coast of Northern Mexico was the Vermilion sea. It was also known in the earlier times as the Mar de Cortez, and Mar Laurentano; or the Mar Vermiglion, Mar Rojo, and Mar Vermijo, on account of the reddish color of its waters; and more recently as the Mar, or Gulfo, de California.

The names Vermiglion, Vermijo, and Rojo seem to have been applied as early as between the years 1537 and 1540, after the explorations of Ulloa and Alarcon, and from the accounts given of it by Nuño de Guzman and his officers, who were the conquerors and rulers of Sinaloa, a state bordering on the gulf.

In all these narratives, however, it is well to note that two entirely distinct causes of discoloration are confounded. Father Consag and Ugarte, in particular, speak of the brick-colored corrosive water of the gulf-head, which is altogether different from the more vermilion-colored patches at the mouth of the gulf, which were, doubtless, what suggested the name Vermilion sea.