MEMOIRS

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY

NEW SERIES, VOLUME III, PART III

CAMARASAURUS, AMPHICŒLIAS, AND OTHER SAUROPODS OF COPE

BY HENRY FAIRFIELD OSBORN AND CHARLES CRAIG MOOK

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PART III. — *CAMARASAURUS, AMPHICŒLIAS*, AND OTHER SAUROPODS OF COPE

ICONOGRAPHIC DESCRIPTION OF THE TYPES AND OTHER MATERIAL OF THE SAUROPODA IN THE COPE COLLECTION OF FOSSIL REPTILES FROM CANYON CITY, COLORADO, IN THE AMERICAN MUSEUM OF NATURAL HISTORY

BY HENRY FAIRFIELD OSBORN AND CHARLES CRAIG MOOK

PLATES LX–LXXXV, AND 127 TEXT FIGS.

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PREFACE

In 1902 the Cope Collection [1] of Fossil Reptiles was presented to The American Museum of Natural History by President Morris K. Jesup, acting upon the urgent advice of Curator Henry Fairfield Osborn. It included all of Cope's types and other dinosaur material of Morrison age from the vicinity of Canyon City, Colorado. Several of these types antedated in establishment and definition Marsh's types from beds of similar age. Cope's descriptions were full but accompanied by few figures; Marsh's came later and were fully illustrated. Marsh also issued, in the publications of the United States Geological Survey, two more or less complete summaries of the characters of these animals; these summaries were fully illustrated and widely distributed. Consequently Marsh's forms became well established in the literature, while Cope's are still unrecognized and imperfectly known. The object of the present memoir is to describe and determine as fully as possible Cope's types, especially of the Sauropoda, the most important genus of which is *Camarasaurus*. This generic name antedates *Morosaurus* Marsh, with which it is considered congeneric, by about one year.

The fugitive descriptions and determinations by Cope, Osborn, Riggs, and Mook, listed in the bibliographies below, may now be replaced by the thorough descriptions and illustrations of the present memoir, in which the characters of the genus *Camarasaurus* are determined in great detail, so far as the nature of the material will permit. All of the type material, including the types of six genera and eleven species, is figured and these animals, practically unknown since their original mention forty years ago, are now brought to light.

The supervision of this research, begun by the senior author in 1904, has been aided by the junior author, upon whom has fallen the burden of the detailed study and measurement, and the preparation of the manuscript. The restoration studies have been made with the coöperation of Dr. William K. Gregory, from the standpoint of musculature and locomotion. Doctor Gregory's coöperation in the solution of some difficult morphological problems has been very valuable. Mr. Walter Granger has assisted in the determination of some of the obscure types. The wash drawings are the work of Mr. Erwin Christman; the line drawings are the work of Mr. Rudolph Weber and of Mr. Christman, assisted by Mrs. Margarette Burchard McMullen and Mr. Wesley Seim. Mr. Charles Christman has rendered valuable assistance in the handling of the very heavy and very fragile bones. Miss Mabel Percy has coöperated in the editing and copying of manuscript. The entire collection is now numbered and stored in such a way as to be accessible to investigators.

The subordinal term *Opisthocœlia* Owen appears in all the descriptions of Cope, who did not adopt the term *Sauropoda* proposed by Marsh. The discussion of this and other questions of nomenclature is deferred to the Monograph now in course of preparation by the authors.

The time, energy, and expenditure, involved in the preparation of this Memoir, chiefly on a single Sauropod, is beyond precedent. At many times the solution of the problems seemed impossible. It is a pleasure to dedicate it to the memory of the former President of the Museum, Mr. Morris Ketchum Jesup, who presented the Cope Collection, and bequeathed the funds by which this elaborate research has been carried on and the hundreds of illustrations have been prepared.

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[1] Professor Cope spent a lifetime in acquiring this collection, in supervising the preparation of portions of it, and also in describing portions of it. In his last will and testament he directed that the collection was to be sold, and the proceeds of the sale were left as a legacy to The Academy of Natural Sciences of Philadelphia.

INTRODUCTION

OCCURRENCE AND COLLECTING OF MATERIAL

Original Discovery and Collecting.— In the spring of 1877 Mr. O. W. Lucas, Superintendent of Public Schools in Canyon City, Colorado, discovered some large fossil bones, which he sent to Professor Edward D. Cope of Philadelphia, Pennsylvania. The date of this discovery is not definitely known, but it appears to have been some time in March. From the first specimens which reached the Cope Museum in Philadelphia, Cope made his original description of *Camarasaurus* and founded the genus; this description was published August 23, 1877. It is believed that most of these specimens came from Quarry No. 1.

The name *Camarasaurus*, or "chambered saurian," was given in reference to the cavernous openings of the centra of the cervical and dorsal vertebræ, namely, the lateral cavities now known as pleurocœlia. After receiving the original bones, Cope employed collectors who gathered together more of the material which is described in the present Memoir.

Subsequent Collecting.— The amount of material collected by Cope's parties was very large. It was not all prepared at once, but a considerable amount of it was cleaned up by Jacob Geismar under Cope's direction. In 1877 a reconstruction of the skeleton of *Camarasaurus* was made by Dr. John Ryder, under the direction of Professor Cope. This reconstruction, the first ever made of a sauropodous dinosaur, was natural size and embodied representations of the remains of a number of individuals; it was over fifty feet in length. This was exhibited at a meeting of the American Philosophical Society on December 21, 1877, and since has been exhibited a number of times at the American Museum (where it is now preserved) and elsewhere. A greatly reduced copy of it was published by the junior author in 1914 (Mook, 1914). A copy of this reconstruction is here reproduced (Plate LXXXII).

After the examination of the material which formed the basis of the above-mentioned reconstruction, Cope's collectors sent in more material. It is very probable that many of the bones of the so-called "yellow series" were included in these later collections. This collecting was done chiefly by Mr. Ira H. Lucas in 1880.

Geological Description of the Canyon City Dinosaur Locality.— All the bones were found in the uppermost beds of the Morrison formation near Garden Park, about eight and one-half miles north to northeast of Canyon City, Colorado. The Morrison in this locality is a member of a triangular block of sedimentary rocks, which is nearly surrounded by the ancient crystallines. The apex of the triangle is toward the north. The crystalline rocks bound the block on the east, north, and west; toward the south the block merges into the sediments of the plains. The block is partly faulted against the crystallines and partly folded down alongside of them. The general distribution of the formations and of the faults is indicated on the accompanying map (Fig. 1). This map is based partly on the Pike's Peak Folio of the United States Geological Survey's Geological Atlas, and partly on the geological map of Colorado published by the Geological Survey of Colorado in 1913. Detailed information regarding the general geology of the region is available in the Pike's Peak Folio.

The Morrison formation is composed lithologically of thin limestone bands, and sandstone beds, usually showing cross-bedding, but chiefly of fine grits known as "joint clays." The formation is one of great areal extent and of comparatively small thickness. It has been interpreted as the result of deposition of sediments, mainly by rivers but partly by wind, upon a broad flat plain of rather low altitude. The conditions of its deposition evidently provided broad areas of marshy country, with lakes, interlacing streams and flat inter-stream areas. Such conditions favored the development of the Sauropoda and

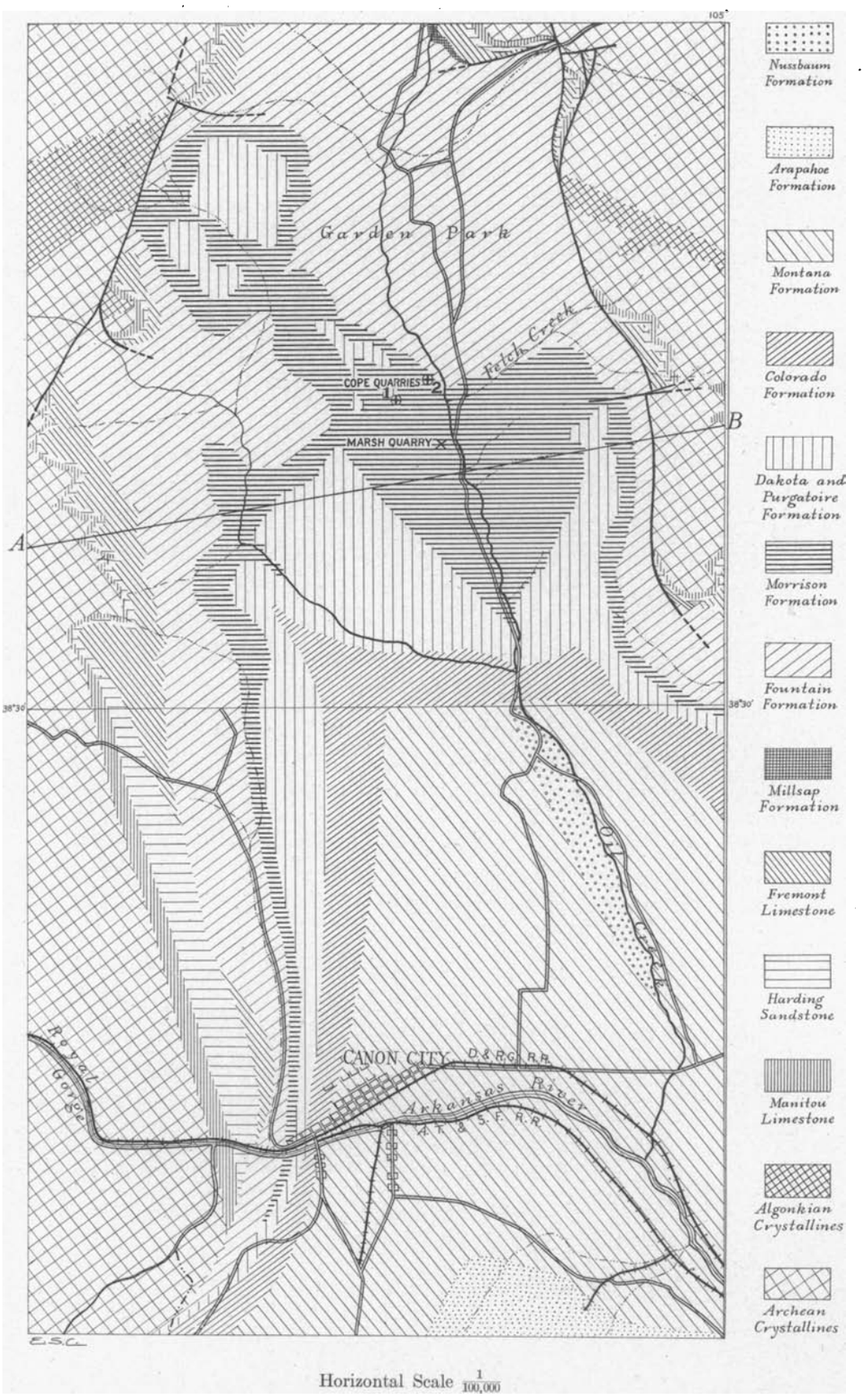

Fig. 1. Geological map of the vicinity of Canyon City, Colorado.

The Morrison formation is indicated in heavy horizontal lines. The material described in the present memoir was collected from the Cope Quarries 1 and 2, west of Garden Park. Horizontal scale $\frac{1}{100,000}$. The line *AB* indicates the position of the geological section (Fig. 2). Adapted from the Pike's Peak Folio of the U. S. Geological Survey and the geological map of Colorado published by the Colorado Geological Survey.

other branches of dinosaurs. The age of the formation has been interpreted variously as Jurassic, Jura-Cretaceous and Comanchean. No opinion, however, upon that subject is stated at the present time. The formation has recently been discussed by Lee, Mook, and Schuchert, to whose articles the reader is referred for further information (Lee, 1915; Mook, 1916; Schuchert, 1918).

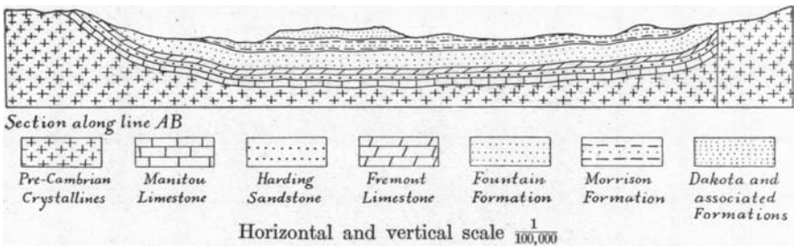

Fig. 2. Geologic section along the line *AB* on the geologic map (Fig. 1).

This section shows the relation of the sedimentary rocks of the Garden Park region to the underlying crystallines, and the relations of the Morrison beds to the other sediments of the region. Horizontal and vertical scale $\frac{1}{100,000}$. (Adapted from Cross, U. S. Geol. Surv. Folio 7.)

The Morrison formation near Canyon City is about 320 feet thick. It occurs in the hogback west of the city and in the valley of Oil Creek northeast of the same. It is exposed in extensive outcrops along Oil Creek and in gullies leading back from the Oil Creek valley. The following section was measured by the junior author in 1913 at the escarpment which forms the western boundary of Garden Park, near the small hillock known as the "Nipple," and near the sites of the dinosaur quarries.

SECTION THROUGH THE "NIPPLE" AND QUARRY NO. 2
(Shown graphically in Fig. 3)

		Feet		Inches
1.	At the summit of the "Nipple" and about 25 feet above the top of the cliff, white sandstone of the Purgatoire series	1		
2.	Brown joint-clay	4		
3.	Brown nodules			4
4.	Brown clay	15		
5.	Gray clay (at the top of the cliff, contains dinosaur bones and is the *productive bed of Cope Quarry 2*)	5		2
6.	Sandstone	1		
7.	Clay	1		
8.	(*a*, *b*, *c*) clay, nodules, and clay	3		
9.	Variegated clay	9		6
10.	Sandstone			4
11.	Clay	6		
12.	Sandstone			3
13.	Variegated clay, gray, purple, and green [1]	204		
14.	Cross-bedded sandstone	8		
15.	Clay	1		
16.	Sandstone	1	to	6
17.	Clay	6		
18.	Sandstone	1		
19.	Clay	40		
20.	Sandstone	1		
21.	Clay	8		
22.	Sandstone	1		
23.	Clay	2		
24.	Sandstone	1		
		319		1
			to	
		319		7
25.	Arkosic conglomerate. This is probably of La Plata age	40 to 50		

[1] The outcrop of this clay series is covered in many places with a thin clay talus, which may conceal some thin beds of limestone or nodules.

The Quarries.— Unfortunately, the quarry records of the Cope Canyon City material have been lost; no quarry diagrams are mentioned in any of Cope's descriptions, and it is unlikely that any were made. Two large quarries are known to have existed and their location is known at the present time. Both of these were excavated in the uppermost beds of the Morrison formation in a general location about eight and one-half miles north to northeast of Canyon City.

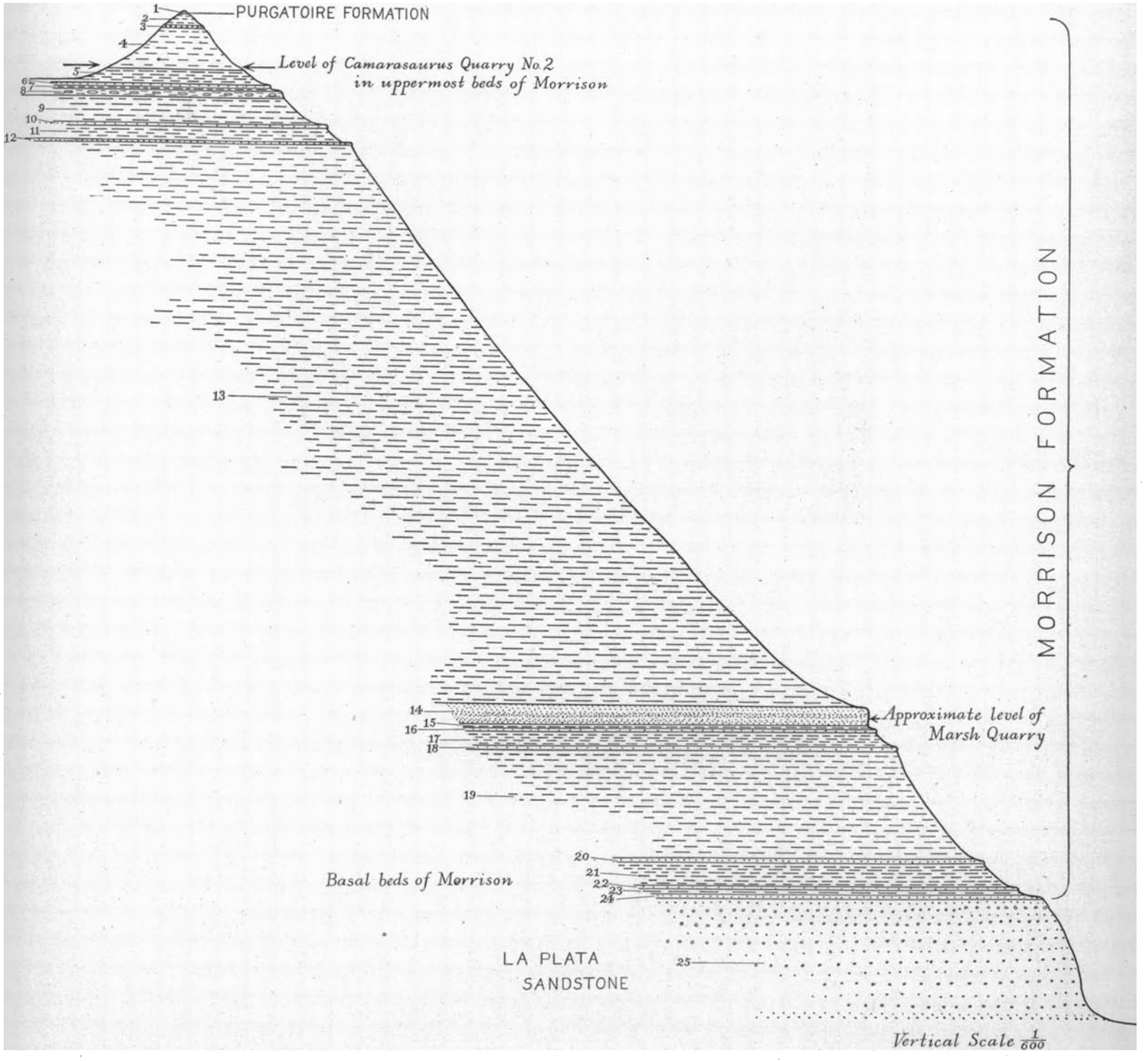

Fig. 3. Morrison formation near Canyon City, Colorado.

Section of the Morrison formation at the escarpment west of Garden Park, and the "Nipple" at its crest. Vertical scale about $\frac{1}{600}$. (Section by C. C. M.)

One large quarry (Fig. 4) is situated about 500 yards west to southwest of the small conical hill, locally known as the "Nipple," a considerable distance from the edge of the escarpment. This quarry is called Cope Quarry No. 1; from it apparently came some of Cope's original types and cotypes, to which the number A. M. 5760 was assigned. Here the Morrison is capped by the Purgatoire sandstone and the quarry site is very definitely marked by a great excavation. The matrix is chiefly reddish to brownish, and probably (?) most of the bones of a reddish color, collectively known as the RED SERIES, came from this quarry.

Fig. 4. Site of one of the Cope dinosaur quarries near Canyon City, Colorado.
It is herein referred to as Cope Quarry No. 1.
This quarry is situated several hundred yards west of the escarpment which forms the western boundary of Garden Park.

Another of these quarries (Figs. 5, 6) is situated almost at the crest of the escarpment which forms the west boundary of Garden Park, and near the base of the "Nipple." It is not very definitely marked, but traces of the work of excavation by Cope's collectors and others mark its site. This quarry is called Cope Quarry No. 2. It may have furnished some of Cope's types. The matrix is largely grayish (it is included in No. 5 in the foregoing section), and it is likely that it furnished most of the bones which are known collectively as the YELLOW SERIES, although this is not certain. Some of the matrix is neither gray nor yellow, and it is possible that certain of the yellow bones may have come from the other quarry. The value, therefore, of the color of the matrix, in determining the field association of the bones, is limited. Variation in color depends upon the condition of the iron oxide of the matrix, and probably also upon the original conditions of decay of the animal tissue. This quarry was reworked by Mr. J. B. Hatcher for the Carnegie Museum in 1901.

There must have been at least one more bone deposit in this vicinity which furnished some of the opisthocœlian material, but the nature and the location of it are not known; indeed, the types of *Amphicœlias altus* and *A. latus* may have come from this deposit, about which no reliable information is available.

All of these quarries are located a short distance north of the quarry worked by Mr. M. P. Felch, subsequently known as the Marsh-Hatcher quarry, which yielded the genotypes *Diplodocus longus* Marsh

and *Haplocanthosaurus priscus* Hatcher, also *H. utterbacki* Hatcher. This Marsh-Hatcher quarry was excavated at a much lower geological level than the Cope quarries.

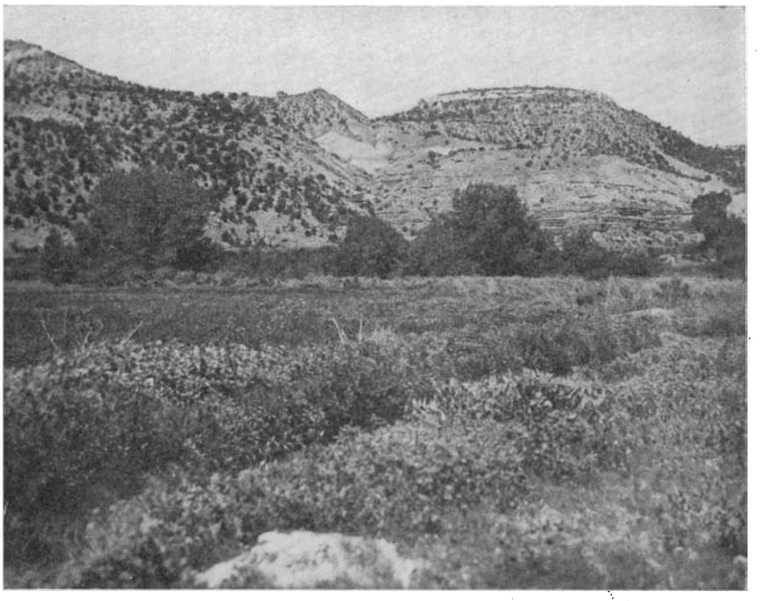

Fig. 5. Site of one of the Cope dinosaur quarries near Canyon City, Colorado. It is herein referred to as Cope Quarry No. 2.

The quarry is situated at the base of the small conical hill, known as the "Nipple," at the crest of the escarpment which forms the western boundary of Garden Park. The view is looking west from Garden Park. It is directly opposite the view in Fig. 6.

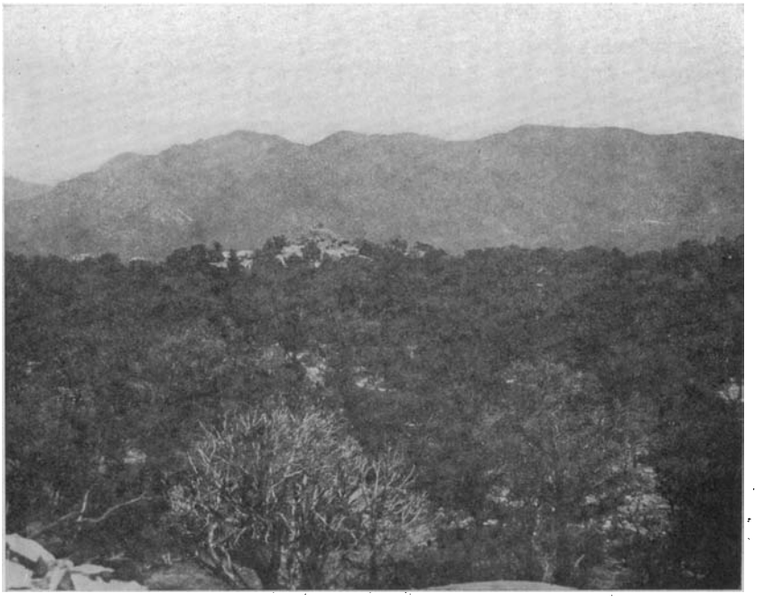

Fig. 6. Site of one of the Cope dinosaur quarries near Canyon City, Colorado. It is herein referred to as Cope Quarry No. 2.

The quarry is situated at the base of the small conical hill in the centre of the figure, known as the "Nipple"; this hill is situated at the crest of the escarpment which forms the western boundary of Garden Park. The view is looking east. It is directly opposite the view in Fig. 5.

List of Cope's Canyon City Types as identified by Dr. W. D. Matthew at the time of cataloguing in the American Museum

A. M. Cope Coll.	5760.	*Camarasaurus supremus* Type Pal. Bull. 25, "Pub. Aug. 23, 1877," see Cope 1878, Am. Phil. Soc. Proc., XVII, 234.	O. W. Lucas
"	5763.	*Camarasaurus leptodirus* Type Should be 3 vertebræ, but only 1 found. [Another found subsequently.]	O. W. Lucas
"	5764.	*Amphicœlias altus* Type Pal. Bull. 27, Dec. 10, 1877. Two dorsals, femur, one tooth. Should be also 2 ribs and part of a pelvic bone.	Found by A. Ripley. Coll. by O. W. Lucas
"	5765.	*Amphicœlias latus* Type Femur and 4 caudal vertebræ (2 missing).	
"	5767.	*Epanterias amplexus* Type Vertebræ and coracoid, etc.	1877–8, O. W. Lucas
"	5768.	*Caulodon diversidens* Type Teeth found alone. Type description "printed Jan. 9, 1878," see p. 193.	Nov. 12, 1877, O. W. Lucas
"	5769.	*Caulodon leptoganus* Type Two teeth [no record, but presumably Colorado].	
"	5770.	*Tichosteus lucasanus* Type Centrum of vertebra (young).	Jan. 9, 1878, O. W. Lucas
"	5771.	*Tichosteus æquifacies* Type Centrum of vertebra, young, small.	Lucas
"	5772.	*Symphyrophus musculosus* Type Vertebra and distal end of humerus. [Now identified as a femur.]	1877, O. W. Lucas
"	5776.	*Brachyrophus altarkansanus* Centra of 4 vertebræ.	O. W. Lucas
"	5777.	*Amphicœlias fragillimus* ?Type Vertebra without centrum. Cope, 1878, Amer. Nat., XII, p. 563.	
"	5780.	*Lœlaps trihedrodon* "No. 2" Eight teeth.	Nov. 2, 1877, O. W. Lucas
"	5766.	*Amphicotylus lucasi* Type Block with several vertebræ, scutes, etc.	1877, O. W. Lucas

The type of *Lœlaps trihedrodon* was the first specimen sent to Cope by O. W. Lucas, and is a "fragmentary lower jaw." It may have been misplaced in some other lot but has not been identified from the measurements and description. Published Aug. 15, 1877, and antedates any of Marsh's *species* of Jurassic megalosauria but does not invalidate any genera.

The type of *Hypsirophus discurus* (Amer. Nat., 1878, p. 188) is generally regarded as a synonym of *Stegosaurus*, Marsh, 1877.

ORIGINAL DESCRIPTIONS OF CANYON CITY DINOSAURS BY COPE

The chronologic sequence of the establishment of the genera and species, with a brief statement of their present determination, may be summarized as follows:

	Genus	Species	Original Date	Present Determination	Ordinal Reference
I.	*Camarasaurus*		August 23, 1877	*Camarasaurus*	Sauropoda
	1. *C. supremus* [1]		August 23, 1877	*C. supremus*	"
	2. *C. leptodirus*		June, 1879	*C. supremus*	"
II.	*Caulodon*		November 21, 1877	Provisionally, *Camarasaurus*	"
	3. *C. diversidens* [1]		November 21, 1877	Provisionally, *C. supremus*	"
	4. *C. leptoganus*		January 12, 1878	Provisionally, *C. supremus*	"
III.	*Tichosteus*		November 21, 1877	Indeterminate	Unknown
	5. *T. lucasanus* [1]		November 21, 1877	Indeterminate	"
	6. *T. æquifacies*		May 3, 1878	Indeterminate	"
IV.	*Amphicœlias*		December 10, 1877	*Amphicœlias*	Sauropoda
	7. *A. altus* [1]		December 10, 1877	*A. altus*	"
	8. *A. latus*		December 10, 1877	Provisionally, *C. supremus*	"
	9. *A. fragillimus*		August, 1878	Provisionally, *A. altus*	"
V.	*Symphyrophus*		January, 1878	Indeterminate	Unknown
	10. *S. musculosus*		January, 1878	Indeterminate	"
VI.	*Epanterias*		June, 1878	Theropod	Theropoda
	11. *A. amplexus*		June, 1878	Theropod	"

[1] Genotype.

PREPARATION AND RESEARCH IN THE AMERICAN MUSEUM

Acquisition.— The Cope Collection of Fossil Reptiles was partly determined in Philadelphia by Dr. W. D. Matthew and was transferred to the American Museum under his direction. The preparation of the material was made by Messrs. Kaison, Charles and Otto Falkenbach, Lang, Christman, Hoover, Brückner, Carr, and Horne.

Separation of Material in the Collection.— The collection includes a large amount of opisthocœlian material. The remains of Sauropoda and other material included in the types of Sauropoda, besides the remains of forms which may represent juvenile sauropods, are listed in the following table. This table is necessarily not precise, owing to the fragmentary character of many of the bones.

Remains		Present Determination
Skull Material		
Brain-case	1	*Camarasaurus*
Maxillary bone	1	"
Quadrate "	1	"
Dentary bones	2	"
Teeth	12 to 15, not including those imbedded in the maxillary and dentaries.	Probably all *Camarasaurus*, includes the types of *Caulodon diversidens* and *C. leptoganus*.
Vertebral Column and Thorax		
Cervical vertebræ (approximately) [1]	24	Mostly referable to *Camarasaurus;* includes part of the type of *Epanterias amplexus*.
Dorsal vertebræ (approximately) [1]	48	Mostly referable to *Camarasaurus;* two are part of the *Amphicœlias* type material, three are included in the *Tichosteus* and *Symphyrophus* types, and two in the *Epanterias* type.
Sacrum	2	One practically complete sacrum of *Camarasaurus*, and one of extremely fragmentary character.
Caudal vertebræ (approximately) [1]	102	Probably all referable to *Camarasaurus*.
Sternal plates	2	Probably *Camarasaurus*.
Chevrons	25	Most of these are referable to *Camarasaurus*, and probably all of them.
Ribs (approximately) [1]	110	Mostly *Camarasaurus*.
Pectoral Girdle		
Scapulæ	7	Six of these are clearly referable to *Camarasaurus*, the other one to *Amphicœlias*.
Coracoids	4	Two of these are distinctly parts of the *Camarasaurus* skeleton, one is referred to *Amphicœlias*, and the other is part of the type of *Epanterias*. It probably represents a theropod.
Fore Limb		
Humeri	2	These humeri clearly belong to *Camarasaurus*.
Ulna	1	Referred to *Amphicœlias*.
Metacarpals	2	Referred to *Camarasaurus*.
Pelvic Girdle		
Ilia	5	The two complete ilia clearly belong to *Camarasaurus;* the three fragmentary ones probably belong to *Camarasaurus*.
Ischia	8	All *Camarasaurus*.
Pubes	7	Six of these are clearly *Camarasaurus;* the seventh is referred to *Amphicœlias*.
Hind Limb		
Femora	7	One of these is a huge femur of *Camarasaurus;* one is part of the type of *Amphicœlias altus*, and another is referred to that form; one is part of the type of *A. latus*, and is probably referable to *Camarasaurus;* the fifth and sixth probably referable to *Camarasaurus;* the seventh a fragment, part of the type of *Symphyrophus musculosus*.
Tibiæ	4	All *Camarasaurus*.
Fibulæ	2	Both *Camarasaurus*.
Astragalus	1	*Camarasaurus*.
Metatarsal	1	*Camarasaurus*.

[1] Approximately, because of the very fragmentary character of some of the material.

Mingling of Types.— The chief difficulty encountered in sorting this collection is the original mingling of the bones of different individuals, brought together from different quarries. Many of the bones referred to certain sauropod genera by Cope prove to belong to other genera, e. g., *Amphicœlias latus* is probably a *Camarasaurus*.

Separation of Series in 1904.— Associate Curator Matthew went over the material, under the direction of Curator Osborn, and catalogued and identified it so far as was possible with the aid of the records available, distinguishing the material (A. M. 5760) obtained in the earlier collecting of 1877 by Superintendent O. W. Lucas from that (A. M. 5761) obtained in the later collecting in 1880 under Mr. Ira H. Lucas. That is, the bones of the earlier collection (O. W. Lucas) were given the number 5760, with variations according to their identification as individuals, such as 5760′ and 5760″; the bones of the later collection (Ira H. Lucas) were given the number 5761, with a modification into 5761*a* for a presumably different individual than the rest of 5761.

Subsequently Professor Osborn and Dr. W. K. Gregory made a further study of the vertebræ and attempted to arrange them provisionally into individual series, using in addition to the previous records the color of the bones, those of the red series apparently having come from a different quarry than those of the yellow series. Most, if not all, of the red bones probably came from Cope Quarry No. 1, and most, if not all, of the yellow bones from Cope Quarry No. 2.

In connection with this work, which was carried on in 1904, Mr. Rudolph Weber, then artist of the Department of Vertebrate Palæontology, made line drawings of many of the vertebræ. In 1906 some wash drawings of the skull material were made by Mr. Erwin Christman. These illustrations were originally prepared for the United States Geological Survey Monograph on the Sauropoda, in course of preparation by Professor Osborn. The cost of preparation of these drawings was borne by the Survey, and they are used in the present Memoir with the permission of the Survey.

Research, 1912–1919.— In 1912 work on the Cope Sauropoda material was renewed as part of the preparation of the Sauropoda Monograph which was being prepared for the Survey by Professor Osborn. This work was undertaken by the present junior author under the direction of the senior author. The entire Cope Collection of Sauropoda from Canyon City was intensively studied and measured with the object of separating the vertebræ and limb bones referable to *Camarasaurus*, *Amphicœlias*, and other Cope genera, and arranging them in individual SERIES SIMILAR IN SIZE, PROPORTIONS, AND COLOR, as well as determining the characters of *Camarasaurus* and *Amphicœlias* and the less-known genera. To a considerable extent, this work consisted in the verification of the previous work by Doctor Matthew and Doctor Gregory; in a few cases, in the modification of their results and in adding to them to meet the present needs.

The composite and multiple nature of the topotype material of *Camarasaurus* is fully described below. Intermingled are the remains of four more or less complete individuals and parts of at least two additional ones. All these series are figured in detail. The coincidence of four series in the neck, back, chest, ribs, pelvis, and tail renders it possible that we have to do with the remains of four complete camarasaur carcasses, entombed in the two quarries. But from total deficiency in the field records it is impossible either to connect them up or to be certain that either series may not belong to the fifth or sixth individuals.

This research has resulted in the arrangement of the vertebræ and ribs in MORPHOLOGICAL SERIES, which may represent originally distinct individuals or may not. The attempt was made to associate the bones of single individuals so far as practicable, partly by size and color, chiefly by anatomical characters and proportions, but in many cases evidence for this was insufficient, and in such cases the attempt was made to assemble series that would be reasonably constituted in a morphological sense. The

arrangement of the bones in these series is as accurate as it could be made, in view of the distorted, sometimes incomplete, and badly mixed character of the material. The pairing of the girdle and limb bones was similarly undertaken, though no attempt was made to pair the ribs. In a few cases it has been possible to determine the relation of some of the girdle and limb bones with the vertebræ, but in most cases the original association is still unknown, though their possible association is very evident.

Intermingled Carnivorous Dinosaur Material and Types.— The type of *Epanterias amplexus* consists of the bones of a large theropod or carnivorous dinosaur. There are some ribs originally placed with *Camarasaurus* which certainly do not agree in characters with the majority of camarasaur ribs, and do resemble those of the Theropoda; there is also a theropodous femur; these bones may be provisionally referred to *Epanterias*.

It is possible, if not probable, that the types of *Tichosteus lucasanus* and *T. æquifacies*, also of *Symphyrophus musculosus*, may be referable to the Theropoda. Cope's types of *Lælaps trihedrodon*, *Brachyrophus altarkansanus*, and *Hypsirophus discurus* were also collected at this locality. The *Lælaps* type is certainly that of a theropod; the positions of the other two genera are uncertain.

I.—HISTORICAL SYSTEMATIC SUMMARY AND COMMENTS ON GENERA AND SPECIES

CAMARASAURUS

Original type reference.

COPE, E. D. On a Gigantic Saurian from the Dakota Epoch of Colorado. Pal. Bull. No. 25, pp. 5–10, "Published, August 23 1877."

Subsequent references.[1]

COPE, E. D. On the Vertebrata of the Dakota Epoch of Colorado. Pal. Bull. No. 28, "Printed Jan. 12, 1878." This article was reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 233–247, March 9, 1878, with nine plates, which consisted of reprints of the figures first published in the American Naturalist.

COPE, E. D. On Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, pp. 71–81, for February, 1878, published January 31, 1878.

OSBORN, H. F. Additional Characters of the Great Herbivorous Dinosaur *Camarasaurus*. Bull. Amer. Mus. Nat. Hist., X, Art. 12, pp. 219–233, June 4, 1898.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 485, 1902.

RIGGS, E. S. The Fore Leg and Pectoral Girdle of *Morosaurus* with a Note on the Genus *Camarosaurus*. Field Col. Mus. Pub. 63, Geol. Ser. 1, No. 10, pp. 275–281, 1901.

MOOK, C. C. The Dorsal Vertebræ of *Camarasaurus* Cope. Bull. Amer. Mus. Nat. Hist., XXXIII, Art. 17, pp. 223–227, March 31, 1914.

HUENE, F. VON. Über die Zweistämmigkeit der Dinosaurier, mit Beiträgen zur Kenntnis einiger Schädel. Neues Jahrb. f. Min. u. Pal., Beilage, XXXVII, pp. 577–589, May 18, 1914. Separates of this were issued somewhat earlier.

MOOK, C. C. Notes on *Camarasaurus* Cope. Ann. N. Y. Acad. Sci., XXIV, pp. 19–22, August 17, 1914.

Type species.— Camarasaurus supremus Cope.

Original type description (COPE).

The vertebræ comprise a cervical, three dorsal and four caudal vertebræ. The dimensions of the animal to which they belong may be inferred from the fact that the first 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 centra of these vertebræ have a ball and socket articulation of the opisthocœlian type, the cups and balls being well pronounced. Just beneath the diapophysis is situated a huge foramen. A broken centrum from which Mr. Lucas removed the matrix, shows that this foramen communicates with a huge internal sinus, which occupies almost the entire half of the body of the vertebra. Those of opposite sides are separated by a septum which is thin medially. Thus the centra of the dorsals are hollow. The neural arches are remarkable for their great elevation, and the great expanse of the zygapophyses. They are more remarkable for the form of the neural spines, which are transverse to the long axis of the centrum. That of one of the vertebræ is strongly emarginate so as to be bifurcate. The widely extended diapophyses support the rib-articulations, and there are no capitular articular facets on the centra, but such are found on the basal region of the diapophyses in some vertebræ.

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[1] Articles which include only passing references to the genus, without description, determination, or discussion, or which deal only with the remains hitherto known as *Morosaurus*, are not included in this list.

The supposed cervical vertebra is depressed, the anterior or convex extremity of the centrum the most so. It is remarkable for its elongate form exceeding the proportions in known *Dinosauria* and *Crocodilia*, and resembling that seen in some fluviatile tortoises. Near the anterior extremity a short, robust parapophysis has its origin, from which it extends outwards and downwards, and soon terminates in a truncate extremity which presents downwards. A deep fossa occupies its upper base, and above this a deep linear foramen extends throughout the greater part of the length of the centrum. If this vertebra possesses a diapophysis it is rudimental.

The caudal vertebræ are amphicœlian, but not deeply so. They are subquadrate in section and not so short as the corresponding ones of *Hadrosaurus*. The most anterior one of the series has short, robust diapophyses, and is more concave anteriorly than posteriorly. The other caudals are more equally bi-concave, but the cavity is very shallow on the most distal of them. The centrum is also relatively more elongate and compressed than those of the others. None of them display the lateral pneumatic fossa which exists in the dorsals, and, where broken so as to permit a view of the internal structure, the latter appears to consist of rather finely spongy tissue. The chevron facets are not very well defined, and the neural spines are of usual forms, and on the anterior two vertebræ, elongate.

Present determination.— This genus is considered as valid, and is fully described below.

Camarasaurus supremus

Original type reference.

COPE, E. D. On a Gigantic Saurian from the Dakota Epoch of Colorado. Pal. Bull. No. 25, pp. 5–10. "Published August 23, 1877."

Subsequent references.[1]

COPE, E. D. The Largest Known Saurian. Amer. Nat., XI, p. 629, October, 1877.

COPE, E. D. On the Vertebrata of the Dakota Epoch of Colorado. Pal. Bull. No. 28, "Printed Jan. 12, 1878." This article was reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 233–247, March 9, 1878, with nine plates, which consisted of reprints of the figures first published in the American Naturalist.

COPE, E. D. On Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, pp. 71–85, for February, 1878, published January 31, 1878.

Original type figures.

COPE, E. D. On Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, pp. 71–85, figs. 1–12, for February, 1878, published January 31, 1878. These figures include some of the bones mentioned by Cope in his original type description, and also some which were not mentioned.

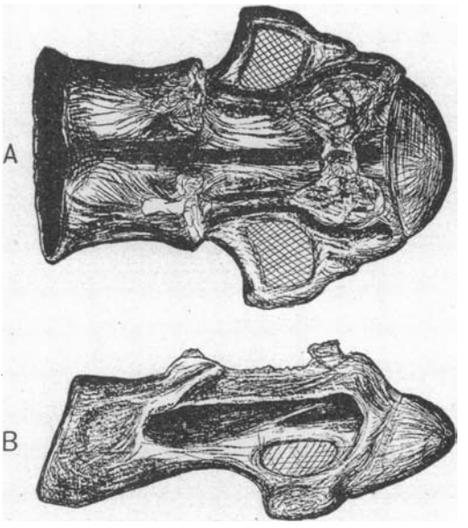

Fig. 7. Cotype cervical vertebra of *Camarasaurus supremus* Cope.

This vertebra is the first bone mentioned in Cope's original description of *Camarasaurus*, as the "chambered saurian." In this memoir it is estimated to be the tenth, or possibly the ninth, cervical. Amer. Mus. Cope Coll. No. $\frac{5760}{X\text{-}C\text{-}7}$. (A) superior view; (B) lateral view, right side; one-tenth natural size. Original type figures, after Cope, rearranged. (Refigured in this memoir, Fig. 32.)

[1] Articles which include only passing references to the species, without description, determination, or discussion, are not embodied in this list.

Types.— Cope mentioned "a cervical, three dorsal and four caudal vertebræ"; these probably did not belong to one individual, and therefore must be considered as cotypes; they are included among the bones of Nos. 5760 and 5760″ of the Cope Collection of Fossil Reptiles of The American Museum of Natural History. The scapula, coracoid, and pelvic bones figured with the cotype must be considered as topotype material, also the vast amount of material included in Nos. 5760, 5760,′ 5760,″ 5761, and 5761*a*, of the Cope Collection of Fossil Reptiles.

Type locality and level.— Uppermost Morrison beds near Canyon City, Colorado.

Original type description (Cope).

Many peculiarities are exhibited by the vertebræ of this species, which are not described in saurians known up to the present time. ....In general, the external walls of the centra are thin, and the processes are composed of laminæ, united by narrow margins. The vertebræ are lighter in proportion to their bulk than in any air-breathing vertebrate.

The anterior extremity of the centrum of the cervical vertebra is prominently convex, and much depressed. The posterior and concave extremity is wider, and of rather greater vertical diameter. The base of the neural arch only occupies half of the length of the centrum, an equal extent of the superior surface extending freely beyond it at its anterior and posterior extremities.

The linear lateral foramen commences a little behind the anterior base of the neural arch, and descending somewhat in its direction, terminates beneath the posterior extremity of the base of the neural arch. The base of the latter overhangs the foramen and the base of the transverse process. The inferior surface of the centrum is concave, the concavity being bounded in front by the inferior convex thickening of the extremity. Behind the middle the surface becomes plane, and is, near the posterior extremity, bounded on each side by a short, angular ridge.

Measurements

	M.
Length of centrum between anterior convexity and posterior lip	.565
Depth of posterior cup	.090
Diameter of cup — Vertical	.310
Diameter of cup — Transverse	.160
Length of parapophysis	.095
Width of neural canal	.063

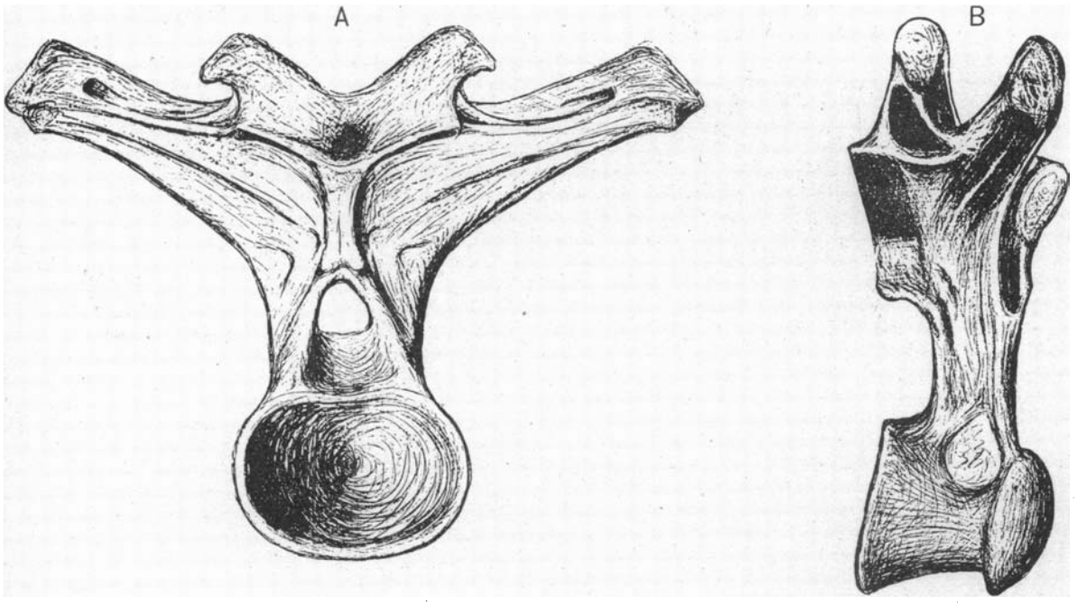

Fig. 8. Cotype dorsal vertebra of *Camarasaurus supremus* Cope.

This vertebra is Dorsal 5. Amer. Mus. Cope Coll. No. $\frac{5760''}{D\text{-}x\text{-}113}$. (A) posterior view; (B) lateral view, right side; one-tenth natural size. Original type figures, after Cope, rearranged. (Refigured in this memoir, Plate LXXI, vertebra 5.)

The dorsal vertebra which I suppose to be the anterior one of those received is characterized by its undivided transverse neural spine. The entire neural arch is of enormous elevation, but as the zygapophyses are above its middle, the neural spine is not as long relatively as in various other genera, or as in the caudals of this one. The sides of the centrum are strongly concave, and the borders

of the cup flaring. The neural arch is everywhere excavated, so as to reduce the bulk, and produce lightness so far as consistent with strength. The diapophyses rise from a point above the neural canal, and are directed upwards as well as outwards. It sends a narrow ridge down to the sides of the centrum, on each side of which its shaft and base are deeply excavated. The posterior of these fossæ is overlooked by the wide zygapophysis; and the roof of the anterior one supports the anterior zygapophysis. The former are separated by another and vertical septum, which bifurcates below, forming two prominent borders of the neural canal. At each side of the base of the neural canal there are two trilateral fossæ, of which the anterior is much the larger, and extends higher up on the lateral edge of the spine. They are separated by a lamina. The diapophysis is not very long, and is subtriangular in section near the extemity. The neural spine is thickened at the extremity as though for the attachment of a huge ligament. At the summit of its posterior basal fossa, at the middle of its height, is an outwardly curved process with a smooth, extero-superior face.

Measurements

	M.
Length of centrum	.275
Total elevation of vertebra	.830
Elevation to posterior zygapophyses	.550
" of superior edge of diapophyses above centrum	.350
" of neural spine above posterior zygapophyses	.295
Length of diapophysis behind	.215
Depth of extremity of do. (restored)	.075
Transverse extent of summit of neural spine	.215
" " " neural spine at middle	.330

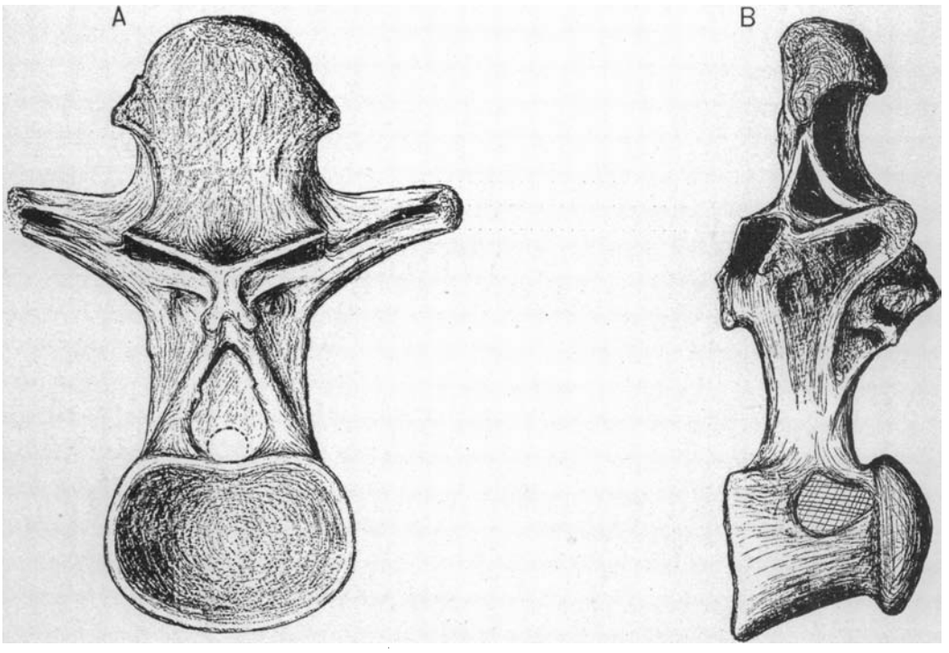

Fig. 9. Cotype dorsal vertebra of *Camarasaurus supremus* Cope.

This vertebra is Dorsal 8. Amer. Mus. Cope Coll. No. $\frac{5760''}{D\text{-}x\text{-}109}$. (A) posterior view; (B) lateral view, right side; one-tenth natural size. Original type figures, after Cope, rearranged. (Refigured in this memoir, Fig. 37 and Plate LXXI, vertebra 8.)

Another dorsal vertebra is better preserved than the last described. It is distinguished by the lack of the median portion of the neural spine and the extension outwards, of the median lateral processes described above. The diapophyses are much larger, and the zygapophyses more extended transversely. The centrum is constricted at the middle, and especially just behind the convex articular extremity, whose circumference forms a prominent rim. The edges of the lip are flared outwards, forming a deep basin, much wider than deep. The fossæ described in the last vertebra are present in this one, but differ in proportions, owing to the greater size and expanse of the superior parts of the neural arch. The fossa posterior to the base of the diapophysis is nearly plane, while that at the anterior base is deeply excavated, is narrower, and extends so far along the inferior side of the process as to give it a semi-circular section near the middle. Distally the diapophysis has a trialate section owing to its three longitudinal ridges, and the articular extremity is large and antero-posterior in direction. The process differs from that of the vertebra already described, in the possession of a facet near the middle of its anterior inferior bounding ridge, which is probably costal, as in the vertebræ of *Crocodilia*. The lateral foramen of the centrum is subround. The general surface is smooth.

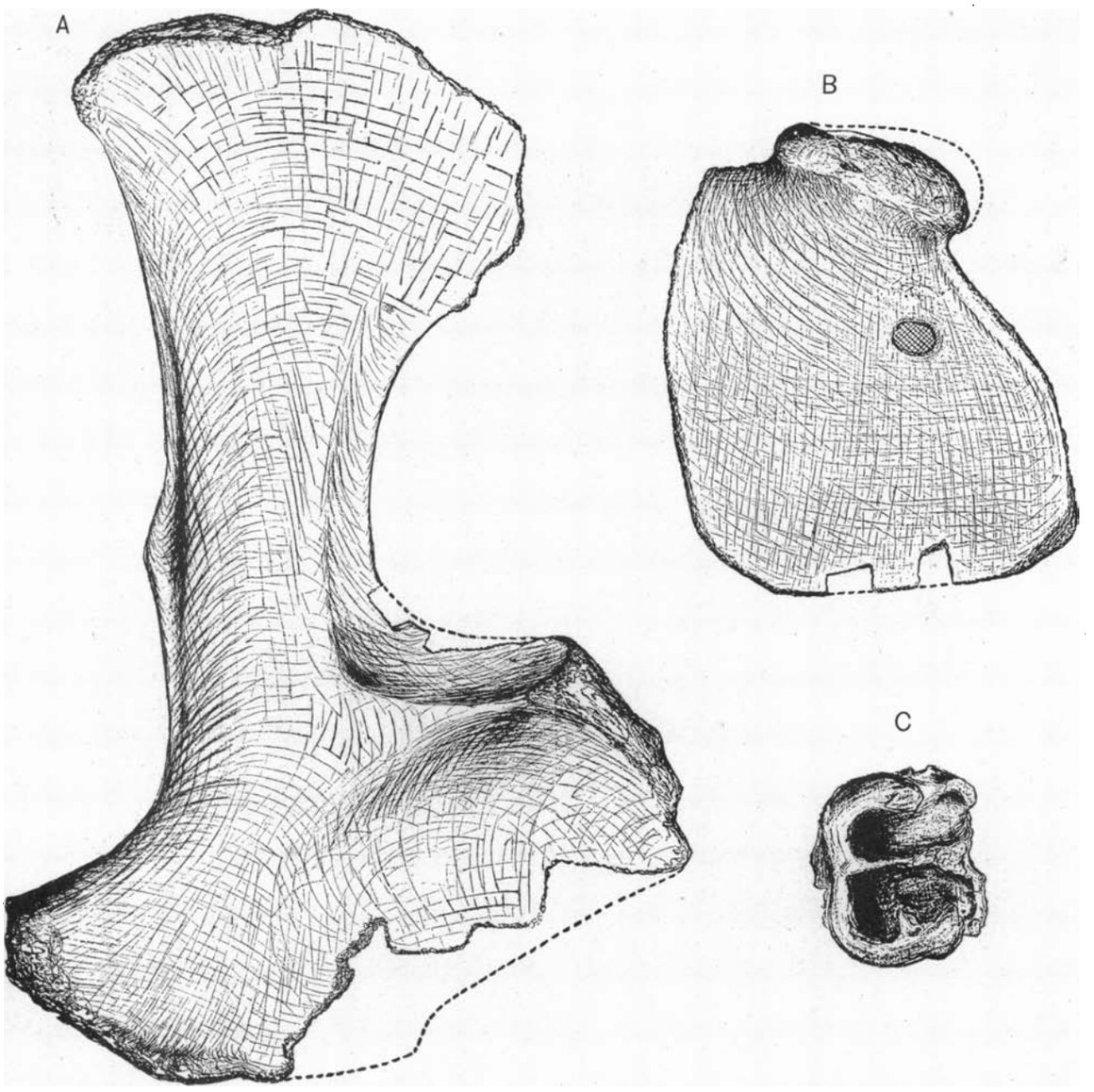

Fig. 10. Scapula, coracoid, and dorsal vertebra of *Camarasaurus supremus* Cope.

These bones were not mentioned in Cope's original description, but were included in the original figures. (A) right scapula (Amer. Mus. Cope Coll. No. $\frac{5760''}{Sc.2}$) external view; (B) right coracoid (Amer. Mus. Cope Coll. No. $\frac{5760''}{Cor.2}$), external view; (C) centrum of a dorsal vertebra (Amer. Mus. Cope Coll. No. $\frac{5760''}{D\text{-}x\text{-}160?}$). According to Cope the latter view is an anterior one, showing the median vertical partition; it is more likely a dorsal view, showing the same partition. The identification of the coracoid as Cor. 2, and of the centrum as D-x-160 is not absolutely certain. All the figures are one-tenth natural size. Original figures, after Cope, rearranged. Refigured in this memoir, Figs. 41, 77, 78, and 82.)

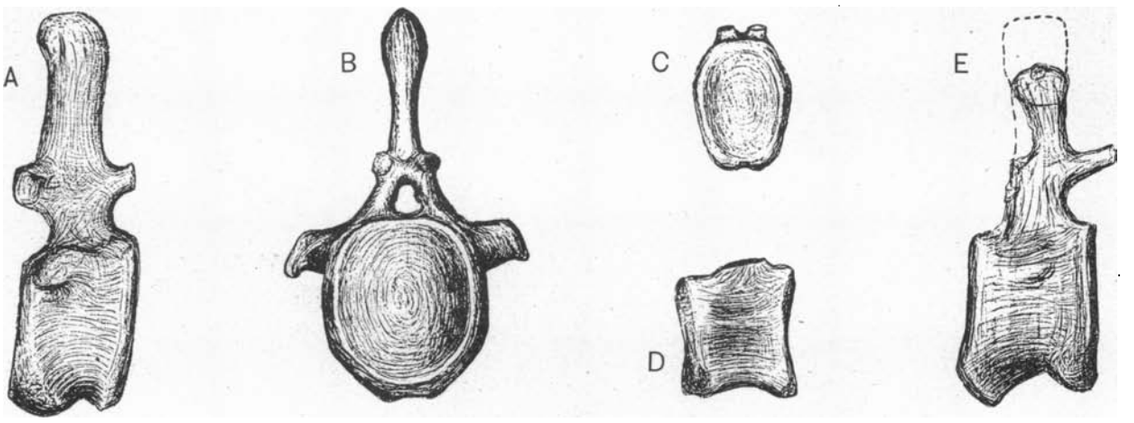

Fig. 11. Cotype caudal vertebræ of *Camarasaurus supremus* Cope.

(A) Caudal 10, estimated (Amer. Mus. Cope Coll. No. $\frac{5760'}{Cd\text{-}y\text{-}3}$), lateral view, right side; (B) the same, anterior view; (C) Caudal 23, estimated (Amer. Mus. Cope Coll. No. $\frac{5760''}{Cd\text{-}o\text{-}23}$), anterior view; (D) the same, lateral view, right side; (E) Caudal 12 or 16 estimated (possibly Amer. Mus. Cope Coll. No. $\frac{5760'}{Cd\text{-}o\text{-}10?}$ or No. $\frac{5760'}{Cd\text{-}o\text{-}24?}$, not positively identified); lateral view, right side. All the figures are about one-tenth natural size. Original type figures, after Cope, rearranged. (Refigured in this memoir, Plate LXXIV, vertebra 10; Fig. 57; and Plate LXXIV, vertebra 12 or Plate LXXV, vertebra 16.)

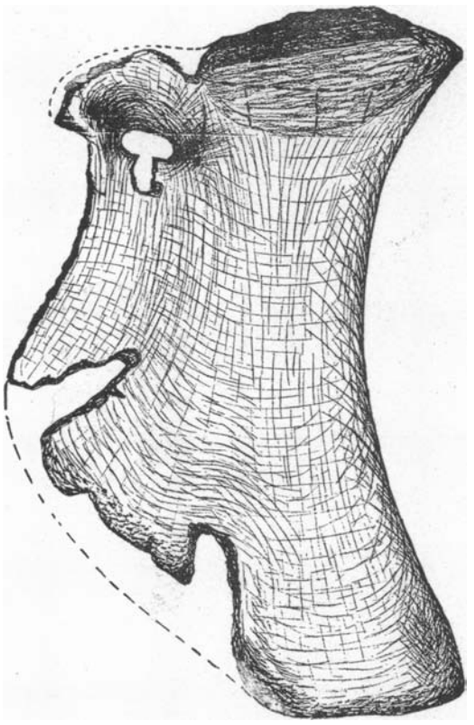

Fig. 12

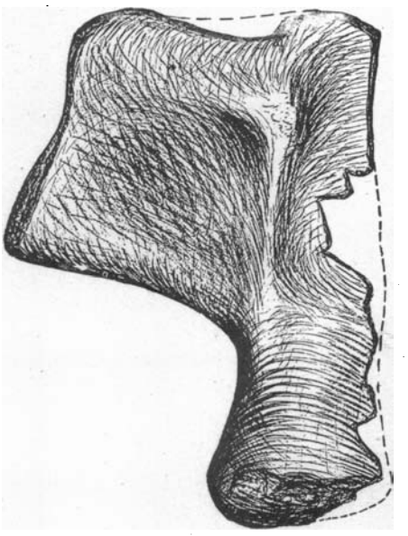

Fig. 13

Fig. 12. Left pubis of *Camarasaurus supremus* Cope.

This bone was not mentioned in Cope's original description, but was included in the original figures (Amer. Mus. Cope Coll. No. $\frac{5760''}{Pb.1}$). Antero-internal view; one-tenth natural size. Original figure, after Cope. (Refigured in this memoir, Fig. 104.)

Fig. 13. Portion of right ilium of *Camarasaurus supremus* Cope.

This bone was not mentioned in Cope's original description, but was included in Cope's original figures. It was evidently considered by Cope as a part of the type (Amer. Mus. Cope Coll. $\frac{5760''}{Il.5?}$). Anterior view; one-tenth natural size. The identification as Ilium 5 is doubtful. Original figure, after Cope. (Refigured in this memoir, Fig. 91.)

Measurements

		M.
Total elevation of vertebra		.770
Total extent of diapophyses		1.010
Diameter of centrum	longitudinal	.300
	vertical of cup	.250
	transverse "	.340
	" at middle	.205
Elevation of zygapophyses above centrum		.310
Diameter of zygapophysis	transverse	.170
	antero-posterior	.090
Width of neural canal		.085
Transverse extent of neural spine		.440
Length of diapophysis from posterior zygapophysis		.320
Antero-posterior width of end of diapophysis		.135
Diameter of centrum of anterior caudal	fore and aft	.170
	vertical	.245
	transverse	.245
Total elevation of do		.545
Elevation of neural canal		.040
Antero-posterior width of neural spine		.075
Diameter of median caudal	fore and aft	.180
	vertical	.200
	transverse	.192
Diameter of posterior caudal	fore and aft	.155
	vertical	.175
	transverse	.145

Besides the characters above-mentioned under the head of the genus, in which the vertebræ of this species differ from those found by Professor Lakes, I may add that they also differ in general proportion. Those of the *Camarasaurus* are relatively shorter and wider, and more depressed, with deeper cup, and less elongate lateral foramen or fossa. The proportions of the caudals differ totally. The dorsal vertebræ are larger than those of the Golden City saurian.

Present determination.— This species, which is the type of the genus, and is based upon adequate material, is considered valid.

Camarasaurus leptodirus

Original type reference.

COPE, E. D. New Jurassic Dinosauria. Amer. Nat., XIII, pp. 402–404, June, 1879.

Subsequent references.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 486, 1902.

Original type figures.

COPE, E. D. New Jurassic Dinosauria. Amer. Nat., XIII, pp. 402–404, figs. 1–3, June, 1879.

Type.— "Three cervical vertebræ, and probably other remains." Amer. Mus. Cope Coll. No. 5763.

Type locality and level.— The uppermost beds of the Morrison formation, at Garden Park, eight miles north to northeast of Canyon City, Colorado.

Original type description (Cope).

The dimensions of these specimens are a little less than that of the largest neck vertebræ of the *Camarasaurus supremus*, but the average length is not very different. The proportions are characteristic. The centrum is little depressed, the vertical and transverse diameters of the cup being nearly equal. The form is thus much more slender than in the *C. supremus*, indicating a neck somewhat like that of the *Trionyches* or *Chelodinæ*.

The parapophyses descend backwards and downwards from the edge of the anterior ball; they are much shorter than the diapophyses, which are decurved. The side of the centrum and coössified base of the neural arch are excavated by a large fossa, which is somewhat subdivided. A smaller fossa is in front of it above the parapophysis. Still another divides the posterior base of the neuropophysis, on each side of the neural arch. The posterior zygapophyses support a strong superior crest, and their superior edges con-

verge to meet at an angle without forming a neural spine at or posterior to the middle of the length of the neural arch, as is the case in *Epanterias amplexus*. The external bases of the zygapophyses are excavated deeply. Length of centrum m. .430; vertical diameter of cup, .140; transverse do., .160; expanse of diapophysis, .380; of posterior zygapophyses, .450; elevation of do., .250; elevation of do. with crest, .360.

Present determination.— The characters mentioned by Cope, and others which may be determined from the type specimen, indicate that this form was not specifically different from *Camarasaurus supremus*. The variations in proportion noted by Cope merely indicate that these bones came from a different part of the neck than those of *C. supremus* which were available at the time. The species therefore is provisionally considered to be conspecific with *C. supremus*.

DISCUSSION OF THE GENUS *Camarasaurus*

Camarasaurus now becomes one of the well-known genera of the Sauropoda. Besides the large amount of material in the topotype specimens, the well-preserved remains in a number of museums identified as *Morosaurus* but which must be considered as belonging to *Camarasaurus* throw light on the structure of the animal.

Confused type material.— As noted in the Introduction and above the GENOTYPE species of *Camarasaurus* (*C. supremus*) was originally described from a small number of bones; the original type material,

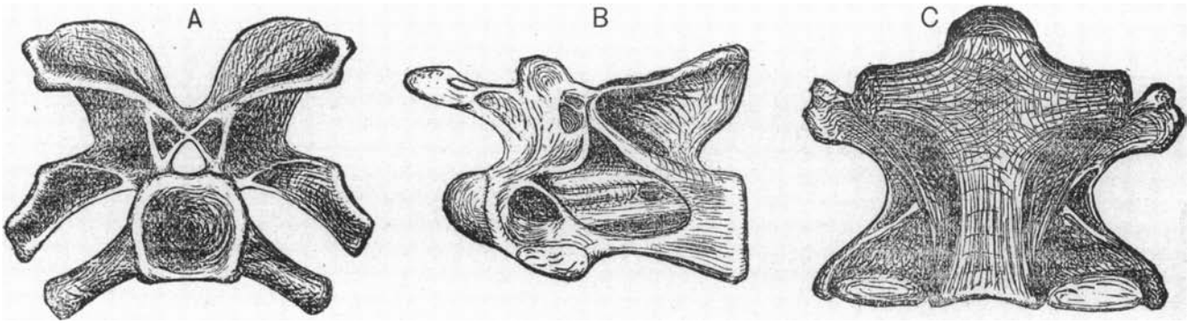

Fig. 14. Type cervical vertebra of *Camarasaurus leptodirus* Cope.

Cervical 7, estimated (Amer. Mus. Cope Coll. No. $\frac{5763}{X\text{-}I\text{-}2}$). (A) posterior view; (B) lateral view, left side; (C) inferior view; one-tenth natural size. Original type figures, after Cope, rearranged. (Refigured in this memoir, Fig. 33.)

including COTYPES, must have consisted of at least two individuals; these bones were collected and associated with a much larger number, which must be considered as TOPOTYPES, and which included several more individuals, as indicated below.

This genotype, cotype, and topotype material, as a whole, consists of portions of the skull and jaws of two individuals; of about twenty-two cervical vertebræ, representing at least three and probably four individuals, possibly more; of about forty-two dorsal and dorso-sacral vertebræ, representing at least four and probably five individuals; of one complete sacrum and fragments of another; of over a hundred caudal vertebræ, representing at least four individuals; of about forty-five ribs of the left side and more of the right, indicating at least five individuals; of two sternal plates; of six scapulæ, indicating at least three individuals; of two coracoids; of two humeri, one right and one left; of two metacarpals; of five ilia; of five pubes; of eight ischia; of one gigantic femur and several smaller ones; of four tibiæ, which belong to opposite sides but are of different length; of two fibulæ; of one astragalus; of one metatarsal; besides a considerable amount of miscellaneous fragmentary material.

Six or more individuals.— There are four individuals represented by the vertebræ alone beyond any possible doubt; more likely there are five, and possibly six. These vertebræ represent animals of approximately, though not exactly, the same size. The vertebræ are almost perfectly preserved in some cases, while in others they are badly distorted, and in still others are little more than fragmentary; they are known to have come from two quarries about a quarter of a mile apart, but there is no reliable record of the exact locality from which any particular specimen came. Those which were collected by Mr. O. W. Lucas in 1877 were given the number 5760; those collected by Ira H. Lucas in 1880 were given the number 5761. These numbers were subdivided into 5760, 5760′, 5760″, 5761 and 5761*a*, to include the remains of distinct individuals so far as these could be determined. In the present studies of these bones the vertebræ were arranged in series, and the position of each bone in the series determined so far as possible. The intention was to place in one series the bones of one individual, but the results in this respect are by no means certain; the series correspond fairly well, however, with the results of the earlier study. It is not possible to say definitely just which vertebræ, or other bones for that matter, came from Quarry No. 1 or which came from Quarry No. 2, and in some cases these bones cannot be separated from those that came from the quarry which yielded the type of *Amphicœlias altus*. The limb bones indicate animals of at least two very distinct sizes. The total number of individuals represented, therefore, must be at least six.

Species of Camarasaurus.— Cope's two species are based upon different parts of the skeleton. The type cervicals of *C. leptodirus* belong much farther forward in the vertebral column than any of the vertebræ described by him as belonging to *Camarasaurus supremus*. When a comparison was made between the *C. leptodirus* type and the vertebræ from the same region of the neck of *C. supremus*, it was found that the two forms could not be separated. There are other variations among the vertebral series which suggest that there are probably two species, and some of the bones of the appendicular skeleton support the suggestion but, unless a further study of the material makes the separation necessary, all the material will be considered as *Camarasaurus supremus* and the skeletal differences as due to individual variation.

CAULODON

Original type reference.

COPE, E. D. On Reptilian Remains from the Dakota Beds of Colorado. Pal. Bull. No. 26, November 21, 1877. This article was reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 193–196, 1878.

Subsequent references.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 484, 1902.

OSBORN, H. F. Additional Characters of the Great Herbivorous Dinosaur *Camarasaurus*. Bull. Amer. Mus. Nat. Hist., X, Art. 12, p. 227, June 4, 1898.

Type species.— *Caulodon diversidens* Cope.

Original type description (Cope).

Fang of the tooth of great length and hollow, and contracted at the base. It is without excavation for successional tooth. Crowns of the teeth of different forms in different portions of the jaw; the posterior are like the bowl of a spoon; others have a similar form but are more compressed, having double lateral ridges, while the crown of another, supposed to be an incisor, is little wider than the root, and has the section an oval with one side less convex than the other. All are coated with an enamel-like layer of considerable thickness which extends on the fang in some of the teeth. None of the crowns present cutting edges.

The characters presented by these teeth are quite distinct from anything hitherto found in North American Saurians. The absence of indication of the successional teeth is remarkable, and in connection with the contraction of the base of the root, suggests that the mode of succession of teeth approximated that exhibited by the *Mammalia*.

Present determination.— This genus is founded upon a species represented by fragmentary remains and cannot be positively identified. The teeth appear, however, to be identical with those of *Camarasaurus supremus*. It is provisionally held, therefore, that *Caulodon* is identical with *Camarasaurus* and that the two names are synonymous, the latter having priority over the former. Subsequent discoveries may necessitate a revision of this determination.

Caulodon diversidens

Original type reference.

COPE, E. D. On Reptilian Remains from the Dakota Beds of Colorado. Pal. Bull. No. 26, pp. 193, 194, November 21, 1877. This article was reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 193–196, 1878.

Subsequent references.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 484, 1902.

OSBORN, H. F. Additional Characters of the Great Herbivorous Dinosaur *Camarasaurus*. Bull. Amer. Mus. Nat. Hist., X, Art. 12, p. 227, June 4, 1898.

Original type figures.— The remains of this species were never figured by Cope. The teeth are figured in this memoir, Plate LX.

Type.— "This large saurian is represented by ten teeth found together, but separated from the cranial bones, and in more or less broken condition. I select four of these exhibiting the characters most clearly." Amer. Mus. Cope Coll. No. 5768.

Type locality and level.— The uppermost beds of the Morrison formation at Garden Park, eight miles north to northeast of Canyon City, Colorado.

Original type description (Cope).

The roots of all the teeth are cylindric. The crown of the posterior tooth is convex on one (the external) side, and concave on the other. The convexity is increased by a contraction of the external surface near and parallel to each border. The concavity is divided by a longitudinal rib which disappears at the base. This edge of the crown is obtuse, as is also the apex. The outline of the apex is rather broadly acuminate. The enamel is closely and strongly rugose, longitudinally on the base, transversely at the edges, and reticulately on the middle portions of the crown.

Measurements

		M.
Length of crown with portion of root		0.120
Diameter of root at middle		.025
Length of crown		.055
Diameter of crown	longitudinal	.030
	transverse	.020

The crown of the second tooth is a little less expanded laterally, and has a greater transverse diameter. The outer side is more convex, and there are two marginal ribs on the basal half of the crown. The interior are not strictly marginal, but are situated within the exterior ribs. Both are very obtuse, and they are separated by a shallow groove. There is no median longitudinal rib.

Measurements

		M.
Diameter of crown at middle	antero-posterior	.026
	transverse	.018

The third type is smaller in all its dimensions, and the crown is equal to the root in long diameter. In my single specimen the distal portion of the crown is lost; the part which remains exhibits neither contraction nor expansion of outline. The borders are very obtuse, and each surface resembles a roll inwards which is bounded by a shallow parallel groove on the inner face of the tooth. Between the grooves the surface is slightly convex. The section is thus an oval with one side very little convex. The enamel is thick and marked with longitudinal rugosities.

Measurements

		M.
Length of fragment		.060
" " root		.030
Diameter "		.014
Diameter of crown at middle	longitudinal	.0135
	transverse	.0085

Present determination.— This species is provisionally considered identical with *Camarasaurus supremus* Cope.

Caulodon leptoganus

Original type reference.

COPE, E. D. On the Vertebrata of the Dakota Epoch of Colorado. Pal. Bull. No. 28, "Printed Jan. 12, 1878." This article was reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 233–247, March 9, 1878.

Subsequent reference.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 484, 1902.

Original type figures.— None; these teeth are figured in this memoir, Plate LXI.

Type.— Cope referred to "a single tooth....Another tooth found with it probably belongs to the same species." Amer. Mus. Cope Coll. No. 5769.

Type locality and level.— The uppermost beds of the Morrison formation near Garden Park, eight miles north to northeast of Canyon City, Colorado. Cope mentioned the type as "a single tooth from a locality distant from that from which the *C. diversidens* was derived." This evidently means some other locality near Garden Park than the Cope Quarry No. 1.

Original type description (Cope).

The best preserved tooth possesses the same general form as that of the *C. diversidens*, but the borders of the spoon-shaped crown are thinner and more acute. The convexity of the convex face of the crown does not commence at these edges, but is separated from them by an open shallow groove. There is a median longitudinal swelling at the middle of the length of the concave face. The striking peculiarity of this species is the very small amount of enamel which invests the crown. It is confined to the inner face, and exists there in a thin layer, not more than half as thick as in the *C. diversidens*, which thins out and disappears towards the edges of the crown. Another peculiarity is seen in its absolute smoothness. In *C. diversidens* the enamel, even when polished by use, shows remains of the grooves.

Measurements

		M.
Diameter of crown at base	fore and aft	.015
	transverse	.019
Diameter of crown at middle	fore and aft	.010
	transverse	.021

Present determination.— The remains of the type of this species are provisionally referred to *Camarasaurus supremus*.

DISCUSSION OF *Caulodon*

It is rather difficult to discuss forms which were based upon teeth alone, particularly since the teeth of the Sauropoda are so little known, there being but two distinct types, namely, the *Diplodocus* and the *Camarasaurus* (*Morosaurus*). The teeth of the types of the two species of *Caulodon* have been well described by Cope and need no further description here. They distinctly resemble the teeth in the maxillary bone of *Camarasaurus supremus* in the topotype material of that form. They also closely

resemble the teeth in the smaller skull of *Camarasaurus* (*Morosaurus*) in the American Museum (Amer. Mus. No. 469), and in the skull of one of the cotypes of *Morosaurus grandis* Marsh in the Yale Museum (Yale Mus. No. 1905). There is no doubt of the close similarity, or even identity, of these teeth but, in view of the fact that there is a possibility of two sauropods having the same type of teeth, though differing in other and more important respects, the reference of *Caulodon* to *Camarasaurus* is made provisional. The teeth are well preserved and are excellent specimens of the larger type of teeth in the Sauropoda.

TICHOSTEUS

Original type reference.

COPE, E. D. On Reptilian Remains from the Dakota Beds of Colorado. Pal. Bull. No. 26, November 21, 1877. This article was reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 193–196, 1878.

Subsequent references.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 493, 1902.
OSBORN, H. F. Additional Characters of the Great Herbivorous Dinosaur *Camarasaurus*. Bull. Amer. Mus. Nat. Hist., X, Art. 12, p. 227, June 4, 1898.

Type species.— *Tichosteus lucasanus* Cope.

Original type description (Cope).

The characters of this genus are derived primarily from the vertebræ. They are nearly amphiplatyan, but one extremity of the articular face is slightly concave, while the other is still more slightly convex or concave. The borders of the former are expanded, while those of the latter are not enlarged. The centrum is hollow, but the chamber does not communicate with the external median by a lateral foramen, as in *Camarasaurus*. The neural arch is attached by suture. There is no capitular articulation on the centrum.

Present determination.— This genus is included in Hay's list of North American Theropoda as a genus of doubtful affinity. It has also been listed as possibly belonging to the Sauropoda. Owing to the fragmentary nature of the type specimen of the genotype, the genus must be considered as indeterminate.

Tichosteus lucasanus

Original type reference.

COPE, E. D. On Reptilian Remains from the Dakota Beds of Colorado. Pal. Bull. No. 26, November 21, 1877. This article was reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 193–196, 1878.

Subsequent references.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 493, 1902.
OSBORN, H. F. Additional Characters of the Great Herbivorous Dinosaur *Camarasaurus*. Bull. Amer. Mus. Nat. Hist., X, Art. 12, p. 227, June 4, 1898.

Original type figure.— Cope never published any figures of this type. It is figured in this memoir, Fig. 15.

Type.— Cope's description mentions vertebræ and speaks of dorsal and lumbar characters. He does not specify exactly what the type comprises. In the Cope Collection the type of *T. lucasanus* appears to consist of one well-preserved vertebral centrum and two fragmentary bones which are probably centra. Amer. Mus. Cope Coll. No. 5770.

Type locality and level.— The uppermost beds of the Morrison formation near Canyon City, Colorado.

Original type description (Cope).

There is no hypapophysis on either dorsal or lumbar vertebræ preserved, and the surface is smooth excepting some delicate longitudinal ridges extending to the border of the expanded extremity. The narrower extremity of a dorsal vertebra is nearly round and presents a slight median tuberosity; the opposite end is wider than deep, and its surface is uniform. The smaller extremity of a lumbar vertebra is slightly concave.

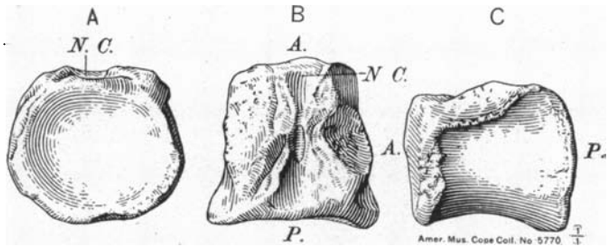

Fig. 15. Type vertebra of *Tichosteus lucasanus* Cope.

Position in vertebral column uncertain (Amer. Mus. Cope Coll. No. 5770). (A) anterior view; (B) superior view; (C) lateral view, left side; natural size. *A.* anterior; *N. C.* neural canal; *P.* posterior. New original figure of type.

Measurements

		M.
Diameter of dorsal centrum	longitudinal	.023
	vertical	.020
	transverse	.025
Width base of neural arch with diapophysis		.010

Present determination.— Owing to the fragmentary nature of the type specimen, and the consequent lack of distinguishing characteristics, the species must be considered indeterminate.

Tichosteus æquifacies

Original type reference.

Cope, E. D. Descriptions of New Extinct Vertebrata from the Upper Tertiary and Dakota Formations. U. S. Geol. and Geog. Surv. Terr., IV, No. 2, May 3, 1878, p. 392.

Subsequent reference.

Hay, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 493, 1902.

Original type figure.— The type of this species was never figured by Cope. Figure 16 of this memoir illustrates the characters of the type specimen.

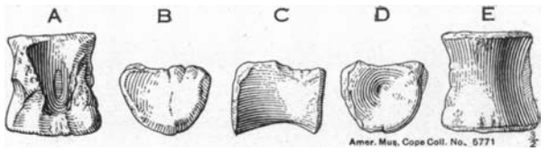

Fig. 16. Type vertebra of *Tichosteus æquifacies* Cope.

Position in vertebral column uncertain (Amer. Mus. Cope Coll. No. 5771). (A) superior view; (B) anterior view?; (C) lateral view, left side?; (D) posterior view?; (E) inferior view; one and one-half times natural size. New original figure of type.

Type.— Cope stated that "This species is indicated by a number of vertebræ, from which I select as the best preserved a probably posterior dorsal or lumbar." This centrum therefore constitutes the type. It is known as No. 5771 of the Cope Collection of the American Museum.

Type locality and level.— The uppermost beds of the Morrison formation near Canyon City, Colorado.

Original type description (Cope).

This species is indicated by a number of vertebræ, from which I select as the best preserved a probably posterior dorsal or lumbar. In accordance with the generic characters, the centrum contains a large median cavity, and the neural arch is freely articulated. The extremities are shallow amphiccelous, and there is no lateral fossa.

The centrum selected has no processes. The diapophyses were probably attached to the neural arch, which is lost. The articular extremities have each a shallow central fossa, and they are nearly similar in the degree of their concavity, which is not the case in the *T. lucasanus*, where one extremity is more concave than the other. They are also more transverse in form than those of the latter species. The centrum is concave inferiorly, but not compressed laterally. The borders next the articular extremity are crimped into short grooves; otherwise the surface is smooth. The floor of the neural canal has a deep longitudinal fossa. The surface of the neuropophysis is nearly as long as the centrum, and is deeply grooved.

Measurements

		M.
Length of centrum		0.010
Diameter of articular face	vertical	0.007
	transverse	0.010

Present determination.— Owing to the fragmentary character of the type specimen and consequent lack of distinguishing characters the species must be considered as indeterminate.

DISCUSSION OF *Tichosteus*

This genus was based upon a species of which the type was a single tiny vertebral centrum and some fragmentary material. It was listed by Osborn among the Sauropoda in 1898, and by Hay in the Theropoda in 1902. The characters of the genotype are so obscure, and the material is incomplete to such an extreme degree, that it is not possible positively to refer the remains to any definite order of the Reptilia, much less to any valid genus or species.

AMPHICŒLIAS

Original type reference.

COPE, E. D. On *Amphicœlias*, a Genus of Saurians from the Dakota Epoch of Colorado. Pal. Bull. No. 27, pp. 1–5, "Published December 10, 1877." This article, with minor changes, was reprinted in Pal. Bull. No. 28, and in the Proceedings of the American Philosophical Society, XVII, pp. 233–247, March 9, 1878.

Subsequent references.

COPE, E. D. On the Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, p. 81, for February, 1878, published January 31, 1878.

BALLOU, WILLIAM H. Strange Creatures of the Past. Century Magazine, November, 1897, pp. 15–23.

OSBORN, H. F. Additional Characters of the Great Herbivorous Dinosaur Camarasaurus. Bull. Amer. Mus. Nat. Hist., X, pp. 227, 229, 230, 232, June 4, 1898.

Type species.— *Amphicœlias altus* Cope.

Original type description (Cope).

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 (Paleontological Bulletin, No. 26, p. 194). They are unequally amphiccelous, the posterior extremity being more concave, and with concave 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.

The manner of the mutual articulation of the neural arches in this genus is peculiar, and is only paralleled in the genus *Camarasaurus*, so far as I can ascertain. 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 the inferior reversed wedge may be

termed, 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 vertebra, 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 two different families in consequence of the different types of vertebral centra, the one opisthocœlous, the other amphicœlous, they may be called *Camarasauridæ* and *Amphicœliidæ* respectively.

The pubis is a stout bone with one slightly concave, thicker border, and an opposite strongly convex, thinner margin. One extremity is truncate; the other presents one transversely truncate and one oblique face. The femur is elongate, and presents a strong postero-external ridge or third trochanter near the middle of the shaft. The head is not separated by a well marked neck, and the great trochanter does not project beyond it.

Present determination.— This genus is considered valid and is described below.

Amphicœlias altus

Original type reference.

COPE, E. D. On *Amphicœlias*, a Genus of Saurians from the Dakota Epoch of Colorado. Pal. Bull. No. 27, pp. 3, 4, "Published December 10, 1877." This article, with minor changes, was reprinted in Pal. Bull. No. 28, and in the Proceedings of the American Philosophical Society, XVII, pp. 233–247, March 9, 1878.

Subsequent references.

COPE, E. D. On Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, p. 81, for February, 1878, published, January 31, 1878.

BALLOU, WM. H. Strange Creatures of the Past. Century Magazine, for November, 1897, p. 22.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 846, 1902.

Original type figures.

COPE, E. D. On Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, pp. 71–85, Figs. 13–15, for February, 1878, published January 31, 1878. These figures were republished in the article in the Proceedings of the American Philosophical Society, mentioned above.

Type.— "Numerous vertebræ. . . . dorsals in which the neural spine is preserved, ... pubic bone. . . . femur." This constitutes Amer. Mus. Cope Coll. No. 5764, which appears to consist of two dorsal vertebræ, a femur, a tooth, a pelvic bone, a scapula, a coracoid, and an ulna.

Type locality and level.— Uppermost beds of the Morrison formation, at Garden Park, eight miles north to northeast of Canyon City, Colorado. This type was evidently collected from a different quarry than either of those which yielded the cotypes of *Camarasaurus supremus*.

Original type description (Cope).

The centrum of the dorsal vertebra of this reptile is contracted both laterally and inferiorly, so that the margins of the articular extremities flare outwards. The sides are flat, and the inferior surface but little convex in the transverse direction. The pneumatic foramen is situated at the bottom of a large lateral fossa which extends nearly the entire length of the superior portion of the centrum. Its inferior border is sunken abruptly, while the superior gradually shallows on the external surface of the base of the neural arch. The foramen is longer than high, in contradistinction to that of the *Camarasaurus supremus*, where it is round or higher than long.

The neural arch is very much elevated to the zygapophyses. It is strengthened by a prominent rib, which extends from the posterior base upwards and forwards to the base of the anterior zygapophysis. The surface above and behind this is occupied by an extensive excavation whose superior border is the line connecting the zygapophyses. The anterior zygapophyses are separated medially by a deep notch which extends to the base of the neural spine. The articular surfaces incline towards each other. Just behind the anterior zygapophysis, a process extends outwards and forwards whose extremity is lost in my specimen. Its posterior face is excavated by the lateral fossa above described. This process is probably the parapophysis which supports the rib. The diapophysis springs from the line connecting the zygapophyses and extends upwards and outwards. Its inferior surface is concave, or longitudinally excavated.

The neural spine is thin, but its anterior and posterior borders are thickened and double, the lateral rib-like edges being separated by grooves which expand at the base. The posterior groove continues to a more elevated point than the posterior [anterior]. Each side of the spine is divided into two shallow wide grooves by a median keel. The apex of the spine is much thickened transversely, its obtuse extremity having the fore and aft and transverse diameters equal.

The pubic bone resembles that of the *Camarasaurus supremus*, but is less robust in all its parts. It is also less extended in antero-posterior width near the proximal extremity. [See text Fig. 124, which probably illustrates this pubis.]

The femur 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 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 of the dorsal vertebra three feet three inches.

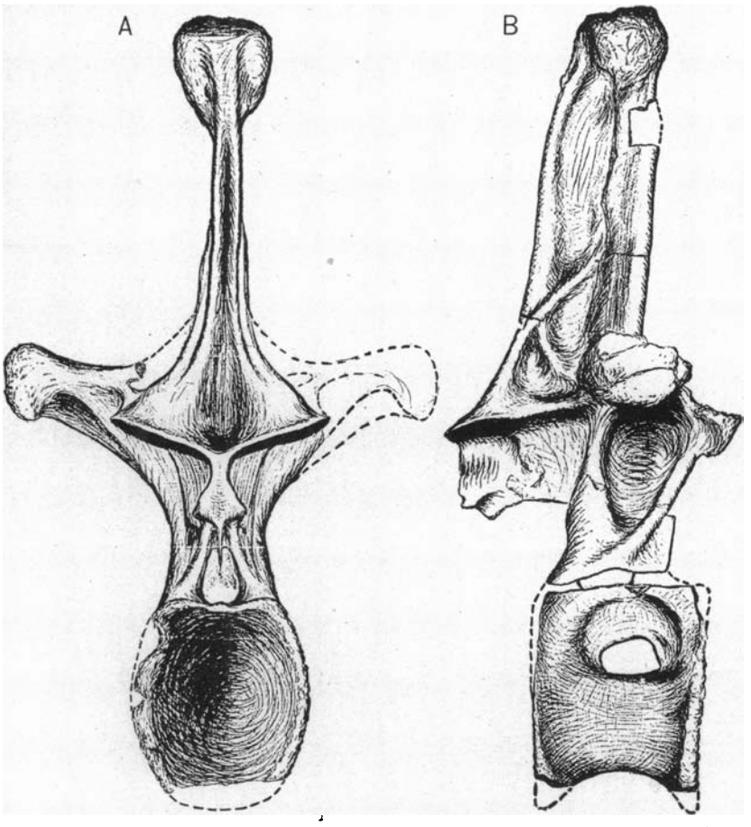

Fig. 17. Type dorsal vertebra of *Amphicœlias altus* Cope.

Estimated to be Dorsal 10 (Amer. Mus. Cope Coll. No. 5764). (A) posterior view; (B) lateral view, right side; one-tenth natural size. Original type figures, after Cope, rearranged. (Refigured in this memoir, Fig. 120.)

Measurements

		M.
Diameter of dorsal centrum	fore and aft	.245
	vertical	.270
	transverse	.265
Total elevation of vertebra		1.100
Length of neural spine		.600
Elevation of anterior zygapophyses		.500
Diameter of neural spine	antero-posterior	.160
	transverse (at middle)	.065
	" at summit	.140
Depth of centrum below pneumatic foramen		.120
Fore and aft diameter of pneumatic foramen		.080
Length of pubic bone		1.060
Thickness of stoutest extremity		.140
Length of femur		1.524
Transverse extent of proximal end		.420
" " " condyles		.320
Diameter of middle of shaft		.220
Distance from head to third trochanter		.665
Diameter of head (compressed)		.260

Present determination.— This species is valid.

Amphicœlias latus

Original type reference.

COPE, E. D. On *Amphicœlias*, a Genus of Saurians from the Dakota Epoch of Colorado. Pal. Bull. No. 27, pp. 4, 5, "Published December 10, 1877." This article, with minor changes, was reprinted in Pal. Bull. No. 28, and in the Proceedings of the American Philosophical Society, XVII, pp. 233–247, March 9, 1878.

Subsequent references.

COPE, E. D. On Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, p. 82, for February, 1878, published, January 31, 1878.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 846, 1902.

Original type figures.

COPE, E. D. On Saurians Recently Discovered in the Dakota Beds of Colorado. Amer. Nat., XII, pp. 71–85, Figs. 16, 17, for February, 1878, published, January 31, 1878.

Type.— "A right femur and four caudal vertebræ which are in good preservation." These constitute Amer. Mus. Cope Coll. No. 5765. Only two of the caudals have been recognized.

Type locality and level. — The uppermost beds of the Morrison formation at Garden Park, eight miles north to northeast of Canyon City, Colorado.

Original type description (Cope).

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 bi-concave; the anterior face more so than the posterior. They all possess diapophyses of depressed form which take their origin below the base of the neural arch. The centra are short in antero-posterior diameter, and do not present lateral angles. They are composed of not very dense osseous tissue. The anterior zygapophyses are rather elongate, and their articular faces are directed steeply inwards. They are received by corresponding shallow excavations, one on each side of the posterior base of the neural spine. The neural spines are compressed and straight, and become very robust towards the apex.

The femur is extraordinarily robust. The great trochanter is low, but the shaft is widest where it expands outward. The third trochanter 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 inter-condylar 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. The articular extremity is marked with irregular pits as in *Dystrophæus* and *Cetiosaurus*.

Measurements

		M.
Diameter of anterior caudal vertebræ	fore and aft	.150
	vertical	.200
	transverse	.260
Elevation to zygapophyses of the same		.250
Total elevation of the same		.480
Length of femur		1.400
Proximal diameter of femur	fore and aft	.165
	transverse	.410
Distal diameter of femur	fore and aft	.360
	transverse	.450
Diameter of middle of shaft of femur		.280

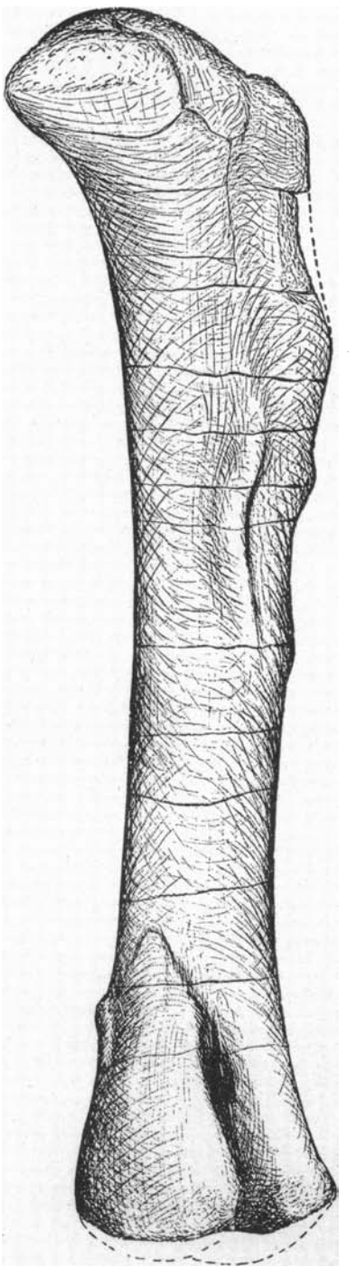

Fig. 18. Type femur of *Amphicœlias altus* Cope.

Right side (Amer. Mus. Cope Coll. No. 5764). Postero-internal view; one-tenth natural size. Original type figure, after Cope. (Refigured in this memoir, Fig. 125.)

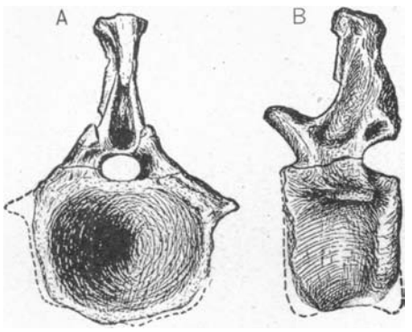

Fig. 19. Type caudal vertebra of *Amphicœlias latus* Cope.

Estimated to be Caudal 15 (Amer. Mus. Cope Coll. No. $\frac{5765}{Cd\text{-}A\text{-}2}$). (A) anterior view; (B) lateral view, left side; one-tenth natural size. Original type figures, after Cope. (Refigured in this memoir, Fig. 55.)

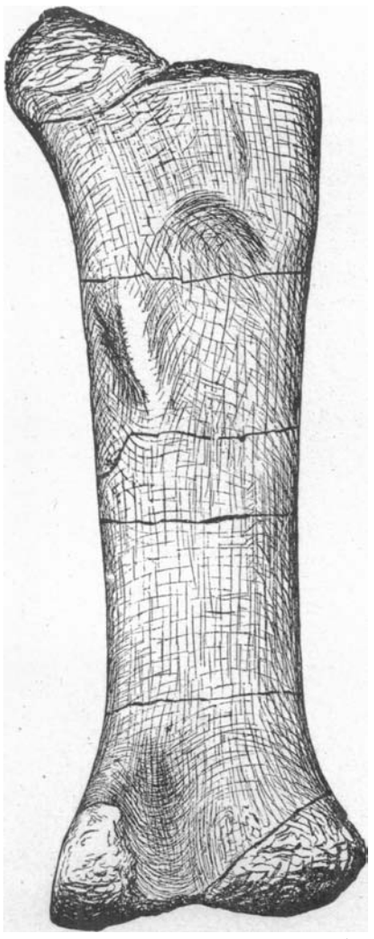

Fig. 20. Type femur of *Amphicœlias latus* Cope.

Right side (Amer. Mus. Cope Coll. No. 5765). Posterior view; one-tenth natural size. Original type figure, after Cope. (Refigured in this memoir, Fig. 109.)

The caudal vertebræ of this species are much more deeply bi-concave than those of the *Camarasaurus supremus;* they also differ in their relatively and absolutely greater breadth of centrum.

Present determination.— This type lacks the slender limb proportions which are characteristic of *Amphicœlias*, and in our opinion represents a young individual of *Camarasaurus*, probably of *C. supremus.*

Amphicœlias fragillimus

Original type reference.

Cope, E. D. A New Species of *Amphicœlias*. Amer. Nat., XII, pp. 563–565, August, 1878.

Subsequent references.

Cope, E. D. Geological News. Amer. Nat., XV, pp. 413, 414, 1881. The species under discussion referred to as *A. fragillisimus.*

Hay, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 486, 1902.

Original type figure.

Cope, E. D. A New Species of *Amphicœlias*. Amer. Nat., XII, pp. 563, 564, Fig. 1, August, 1878.

Type.—"The almost entire neural arch of the vertebra of the largest saurian I have yet seen." This type has not been found.

Type locality and level.—The uppermost beds of the Morrison formation at Garden Park, eight miles north to northeast of Canyon City, Colorado.

Original type description (Cope).

In the extreme tenuity of all its parts, this vertebra exceeds those of this type already described, so that much care was requisite to secure its preservation. It exhibits the general characteristics of the genus *Amphicœlias*, in the hyposphen, anteroposteriorly placed neural spine, and elevated diapophysis for the rib articulation. The diapophyses are compressed and supported by a superior and inferior, and anterior and posterior, thin buttresses, separated by deep cavities. As compared with the *Amphicœlias altus*, this reptile differs in the greater elevation and attenuation of the neural spine, as well as its different form; also in the generally more laminar character of its buttresses and walls. The double rib of the anterior border of the spine of the *A. altus* is here represented by two laminæ which extend on each side, so as to give a horizontal section of the spine a T shape. The posterior zygapophyses have less lateral expanse than in *A. altus*, but they continue as horizontal laminæ with a deep cavity above and below; their superior surfaces contract into two ridges, which are separated by a deep groove. These ridges, unlike the anterior ones, approximate to each other closely on the border of the spine. The summit of the spine is wanting. The measurements are: total elevation of neural arch preserved, 1500 m.; elevation of posterior zygapophyses, 585; transverse expanse of posterior zygapophyses, 190; vertical diameter of base of diapophysis, 390. These figures show that the total elevation of this vertebra, when complete, was not less than six feet, and probably more.

Since in *A. altus* and *C. supremus* the length of the femur is twice the elevation of the dorsal vertebra, we may surmise that the length of the femur of this animal was twelve feet, but this is of course not a necessary consequence of our present knowledge. But so far as the vertebræ are concerned the following rule is without exception among the Saurians of the Dakota epoch: It is, that *the size of the vertebra is in direct proportion to the attenuation of its walls.*

Present determination.— The type of this species has not been found in the Cope Collection, and its characters cannot be clearly determined. Cope's description indicates an animal with the general characters and proportions of *Amphicœlias altus*. It is doubtful, however, if the characters described by Cope warrant the placing of the type in another species different from *A. altus*. The form is therefore provisionally referred to *A. altus*.

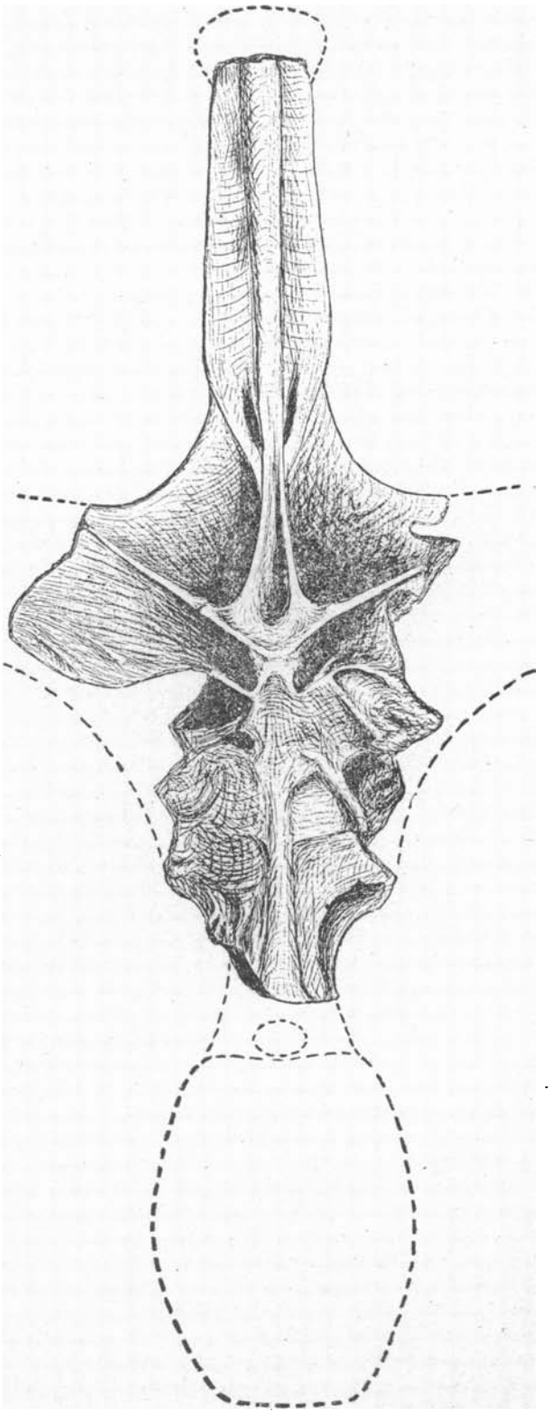

Fig. 21. Type dorsal vertebra of *Amphicœlias fragillimus* Cope.

Estimated to be Dorsal 9 or 10 (type not found). Posterior view; one-tenth natural size. Original type figure, after Cope.

DISCUSSION OF THE GENUS *Amphicœlias*

This is a slender limbed sauropod, with tall and slender vertebral spines which closely resemble those of *Diplodocus* Marsh. The latter genus was founded upon remains discovered in the Marsh Quarry, not far from the Cope Quarries of the Canyon City region.

Amphicœlias was made the type of the family AMPHICŒLIIDÆ by Cope in December, 1877. The family DIPLODOCIDÆ was established by Marsh in 1884, Amer. Jour. Sci., (3) XXVII, p. 166.

The genus is based upon a species represented by fairly recognizable, though incomplete, remains. Its slender form, shown in both vertebræ and femur, together with the extremely thin character of the bony walls of the vertebral laminæ, suggest very strongly the genus *Diplodocus* of Marsh, and so far as the vertebræ are concerned, *Barosaurus* Marsh. There is not enough of the skeleton present in the type to make a complete comparison between these genera possible. As a matter of fact, *Diplodocus* was founded upon fragmentary material so far as the original type is concerned. The characters of that genus are well known from material discovered and described subsequently.

Amphicœlias has been compared with *Apatosaurus* (*Brontosaurus*) of Marsh. The vertebræ and especially the femur are more slender than in that genus, though many of the vertebral elements are similar in construction.

A large scapula resembling that of *Diplodocus* (see Fig. 114), but much larger than any known *Diplodocus* scapula, was found among the *Camarasaurus* topotype material without any record of its association; it is certainly not *Camarasaurus*, and from its characters may well belong to *Amphicœlias*. As the type of *Amphicœlias* was probably found a short distance from the *Camara-*

saurus quarries, it seems reasonable to refer this scapula to *Amphicœlias*. This scapula is larger in proportion to the vertebræ and femur that form the type of *Amphicœlias* than are the corresponding bones in *Diplodocus*, and its size may be of generic value. Besides this scapula, a coracoid and an ulna were found with similar relations to the *Camarasaurus* material (Figs. 115, 116). These are also provisionally referred to *Amphicœlias*. The vertebræ exhibit some slight differences from those of *Diplodocus*.

In view of these facts, and considering also that much of the skeleton of *Amphicœlias* is unknown at the present time, it seems best to consider the genus a valid one, closely related to *Barosaurus* Marsh, and *Diplodocus* Marsh. Its general characters have been summarized above, and its remains are described below.

SYMPHYROPHUS

Original type reference.

COPE, E. D. On the Vertebrata of the Dakota Epoch of Colorado. Pal. Bull. No. 28, "Printed Jan. 12, 1878." Reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 246, 247, March 9, 1878.

Subsequent references.

OSBORN, H. F. Additional Characters of the Great Herbivorous Dinosaur Camarasaurus. Bull. Amer. Mus. Nat. Hist., X, Art. 12, p. 227, June 4, 1898.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 484, 1902.

Type species.— *Symphyrophus musculosus* Cope.

Original type description (Cope).

Vertebral centra moderately elongate, slightly amphicœlous, and composed of uniformly and moderately dense osseous tissue. A narrow deep fossa in the floor of the neural canal. Neural arch coössified to centrum, with a lateral shallow fossa at its base. Neither costal articulation nor process on the centrum.

The coössification of the neural arch of this genus distinguishes it from the few amphicœlous crocodilian genera known from North America, and the fossa at its base is so shallow as to separate it from sauria of the *Pneumatarthrus* and *Ornithopsis* type.

Present determination.—This form is certainly indeterminate generically, and it is not at all certain that it is a member of the Sauropoda. It is probably not a theropod. It thus remains *incertæ sedis*.

Symphyrophus musculosus

Original type reference.

COPE, E. D. On the Vertebrata of the Dakota Epoch of Colorado. Pal. Bull. No. 28, "Printed Jan., 1878." Reprinted in the Proceedings of the American Philosophical Society, XVII, pp. 246, 247, March 9, 1878.

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HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 484, 1902.

Original type figure.— The remains of this species were never figured by Cope. They are figured in this memoir, Figs. 22 and 23.

Type.— A vertebral centrum and the distal end of a humerus according to Cope. Amer. Mus. Cope Coll. No. 5772. The so-called humerus has been identified as a femur.

Type locality and level.— The uppermost beds of the Morrison formation at Garden Park, eight miles north to northeast of Canyon City, Colorado.

Original type description (Cope).

A vertebra of this species is strongly concave laterally and distinctly so inferiorly. The anterior articular facets plane, the posterior slightly concave. The superficial layer of bone is dense and smooth, excepting near the edges of the articular surfaces, where it is rugose. The rugosity is arranged in a line within the articular faces, and consists of numerous small irregular pits and grooves which inosculate. Near the border the grooves assume a transverse direction. There is a nutritive foramen near the middle of each side of the centrum. There are traces of the neurapophysial suture, showing that the neural arch is distinct in young animals.

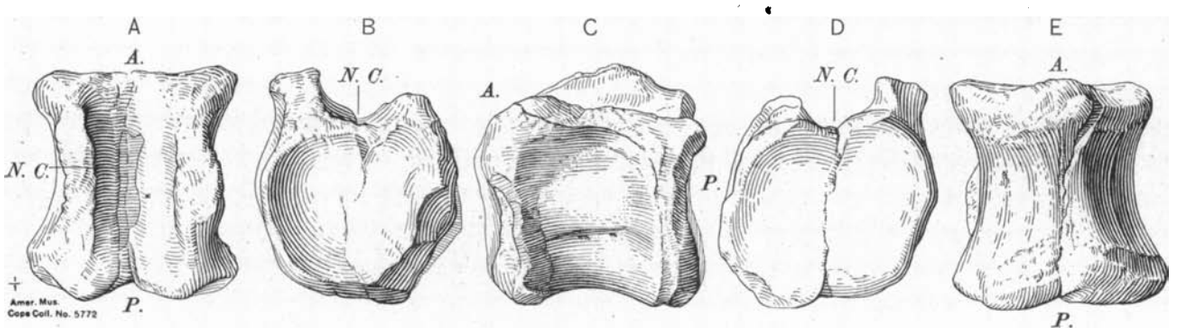

Fig. 22. Type vertebra of *Symphyrophus musculosus* Cope.

Position in vertebral column uncertain (Amer. Mus. Cope Coll. No. 5772). (A) superior view; (B) anterior view?; (C) lateral view, left side?; (D) posterior view?; (E) inferior view; natural size. *A.* anterior; *N. C.* neural canal; *P.* posterior. New original figure of type.

Measurements

		M.
Diameter of centrum	antero-posterior	.032
	vertical	.027
	transverse	.031

The extremity of a humerus is expanded transversely and displays two unequal condyles, separated by a shallow groove. There are no epicondyles on the external face, but fossæ instead.

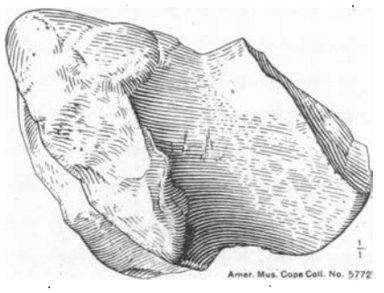

Fig. 23. Type femur of *Symphyrophus musculosus* Cope.

Amer. Mus. Cope Coll. No. 5772. Distal view; natural size. New original figure of type.

Measurements

	M.
Width of distal extremity of humerus	.086
Antero-posterior diameter of larger condyle of the same	.045

Present determination.— Owing to the fragmentary nature of the type specimen, this species is considered as indeterminate. The vertebræ should be compared with the platycœlous *Macrorhynchus*.

DISCUSSION OF *Symphyrophus*

It seems best to consider *Symphyrophus* as not being a member of the Sauropoda at all, but as belonging to some other group of reptiles, possibly to the Crocodilia. This genus was founded upon a small

vertebral centrum and the end of a limb bone. The centrum is small and is almost complete. It evidently belongs to a young individual, as shown by the pedicles at the supero-lateral borders; these pedicles end in sutural surfaces for articulation with the bases of the neural arches. There is no pleurocœl, but a shallow depression on each side of the centrum, slightly above the middle line. About two centimeters below this depression there is on each side another smaller depression, which lodges a single small deep pit on one side and two on the other; the rims of the anterior and posterior surfaces are incomplete, but one end is flat and the other slightly concave. So far as this centrum gives any indication of the characters of the animal to which it belonged, the latter was evidently not a member of the Sauropoda, but of some other group of the Reptilia. It is possible that it belonged to an exceedingly young sauropodous dinosaur, but the characters of the embryonic and young members of the Sauropoda are not sufficiently known to warrant such a reference, especially when the incomplete character of the specimen is taken into consideration. This centrum could only be given such a reference if it were definitely known that the centra of the young Sauropoda differed from the adult in having no pleurocœlia. The end of the limb bone, which Cope identified as the distal end of the humerus, is very incomplete and does not correspond, in the portion which is preserved, with the distal end of the humerus of better preserved specimens. In fact, it does not resemble very closely the end of any limb bone of the Sauropoda, but might be imagined to resemble the distal end of the femur, if the missing parts were restored; even then the resemblance would not be very close.

EPANTERIAS

Original type reference.

COPE, E. D. A New Opisthocœlous Dinosaur. Amer. Nat., XII, p. 406, June, 1878.

Subsequent reference.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 483, 1902.

Type species.— *Epanterias amplexus* Cope.

Original type description (Cope).

The dorsal vertebræ are strongly opisthocœlous, and are without lateral fossa or foramen of the centrum. The arch is freely articulated with the latter, and is not much elevated, and possesses no hyposphen. The neural spine is transverse; the diapophysis is supported on narrow buttresses, and the neural arches generally lightened by fossæ as in the two genera named. A strong parapophysial tubercle near the anterior convexity receives the head of the rib. Each zygapophysis of one side is separated from that of the other by a deep concavity.

Present determination.— This genus was founded upon a species whose remains are clearly referable to the Theropoda and not to the Sauropoda. The genotype is a theropod which at present cannot be separated from *Allosaurus* Marsh.

Epanterias amplexus

Original type reference.

COPE, E. D. A New Opisthocœlous Dinosaur. Amer. Nat., XII, p. 406, June, 1878.

Subsequent reference.

HAY, O. P. Bibliography and Catalogue of the Fossil Vertebrata of North America. U. S. Geol. Surv., Bull. No. 179, p. 483, 1902.

Original type figure.— The remains of *Epanterias amplexus* were never figured by Cope. They are figured in this memoir, Figs. 24–27.

Type.— Two anterior dorsal vertebræ, one including the centrum only, the other most of the neural arch and spine. Several other bones of the same individual appear to have been associated with these, namely: an axis, a vertebra, a coracoid and a fragmentary limb bone which is interpreted to be a metatarsal. These bones together constitute Amer. Mus. Cope Coll. No. 5767.

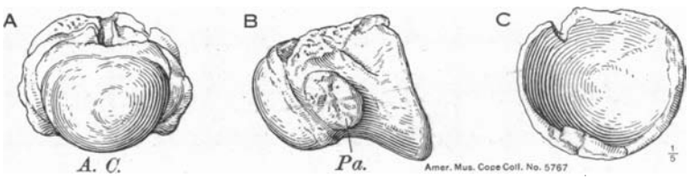

Fig. 24. Vertebra of *Epanterias amplexus* Cope.

This bone is not mentioned in Cope's original description of the type, but it evidently belongs to the same individual. It is the fourth or fifth cervical vertebra of a theropod dinosaur (Amer. Mus. Cope Coll. No. 5767). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-fifth natural size. *A. C.* anterior convexity; *Pa.* parapophysis. New original figure.

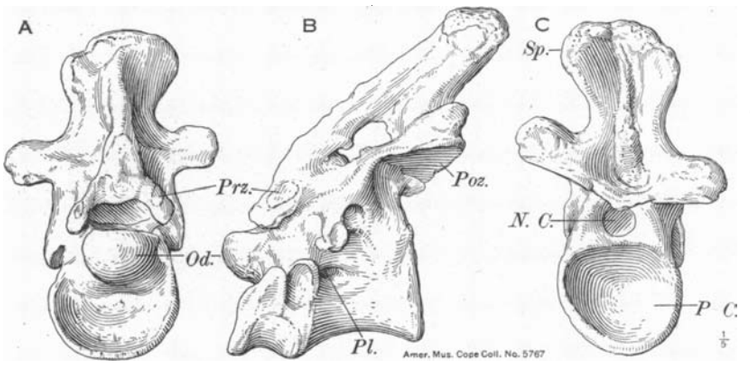

Fig. 25. Cervical vertebra associated with the type of *Epanterias amplexus* Cope.

Axis vertebra, or Cervical 2 (Amer. Mus. Cope Coll. No. 5767). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-fifth natural size. *Di.* diapophysis; *N. C.* neural canal; *Od.* odontoid; *P. C.* posterior concavity; *Pl.* pleurocœl; *Poz.* postzygapophysis; *Prz.* prezygapophysis; *Sp.* spine. New original figures.

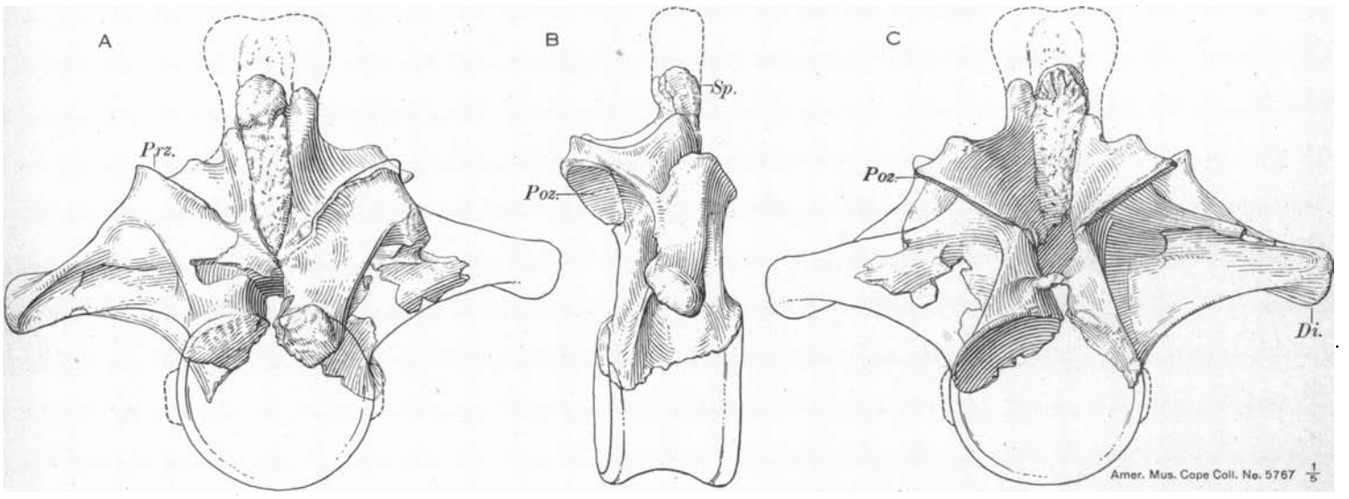

Fig. 26. Type dorsal vertebra of *Epanterias amplexus* Cope.

Dorsal 1 or 2 of a theropod dinosaur (Amer. Mus. Cope Coll. No. 5767). (A) anterior view; (B) lateral view, right side; (C) posterior view; one-fifth natural size. *Di.* diapophysis; *Poz.* postzygapophysis; *Prz.* prezygapophysis; *Sp.* spine. Reconstructed portion in dash lines. New original figure of type.

Type locality and level.— The uppermost beds of the Morrison formation at Garden Park, eight miles north to northeast of Canyon City, Colorado.

Original type description (Cope).

The latter [*E. amplexus*] has a rather low and wide dorsal neural arch with small fore and aft diameter, and with a neural spine divided into three obtuse apices. There are three fossæ at the base of the diapophysis, the anterior one vertical; and a very deep one between the posterior zygapophyses. The cup of the centrum embraces the ball extensively, and the neurapophysis overlaps the side of the centrum behind. Length of centrum m. .115; diameters behind, transverse, .120; vertical, 108. Elevation of neural arch, .290; width of neural spine .083, of both diapophyses .400. This saurian was much smaller than the *Camarasaurus supremus*, and perhaps equal to the *Hadrosaurus foulkei*.

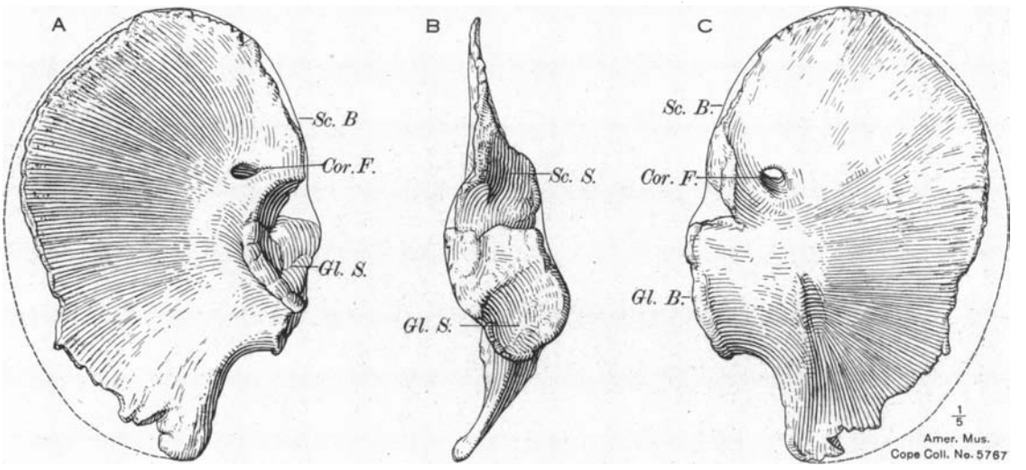

Fig. 27. Coracoid associated with the type of *Epanterias amplexus* Cope.

Right side (Amer. Mus. Cope Coll. No. 5767). (A) internal view; (B) inferior view; (C) external view; one-fifth natural size. *Cor. F.* coracoid foramen; *Gl. B.* glenoid border; *Gl. S.* glenoid surface; *Sc. B.* scapular border; *Sc. S.* scapular surface. Reconstructed portions in dash lines. New original figures.

Present determination.— The species is a member of the Theropoda.

DISCUSSION OF *Epanterias*

This genus was founded upon a species whose type consists of remains of a large theropod. The form is of unusual interest because of the large size of the bones, which are about $\frac{1}{5}$ larger than those of any theropod previously reported from the Morrison formation. These bones have been carefully studied, but the descriptions are not included in the present memoir as they do not belong to a member of the Sauropoda. The form is noted and figured as it was considered a Sauropod by Cope and has been included in lists of the North American Sauropoda.

II.—DETAILED DESCRIPTION OF *CAMARASAURUS* REMAINS

SKULL

Material and Association.— The material of the skull in this collection consists of an incomplete brain-case and occipital region, one nearly complete left maxillary, one right quadrate and two nearly complete right dentary bones. The association of these bones is absolutely unknown. In the type description of *Caulodon diversidens*, Cope mentioned that the teeth which constitute that type were found

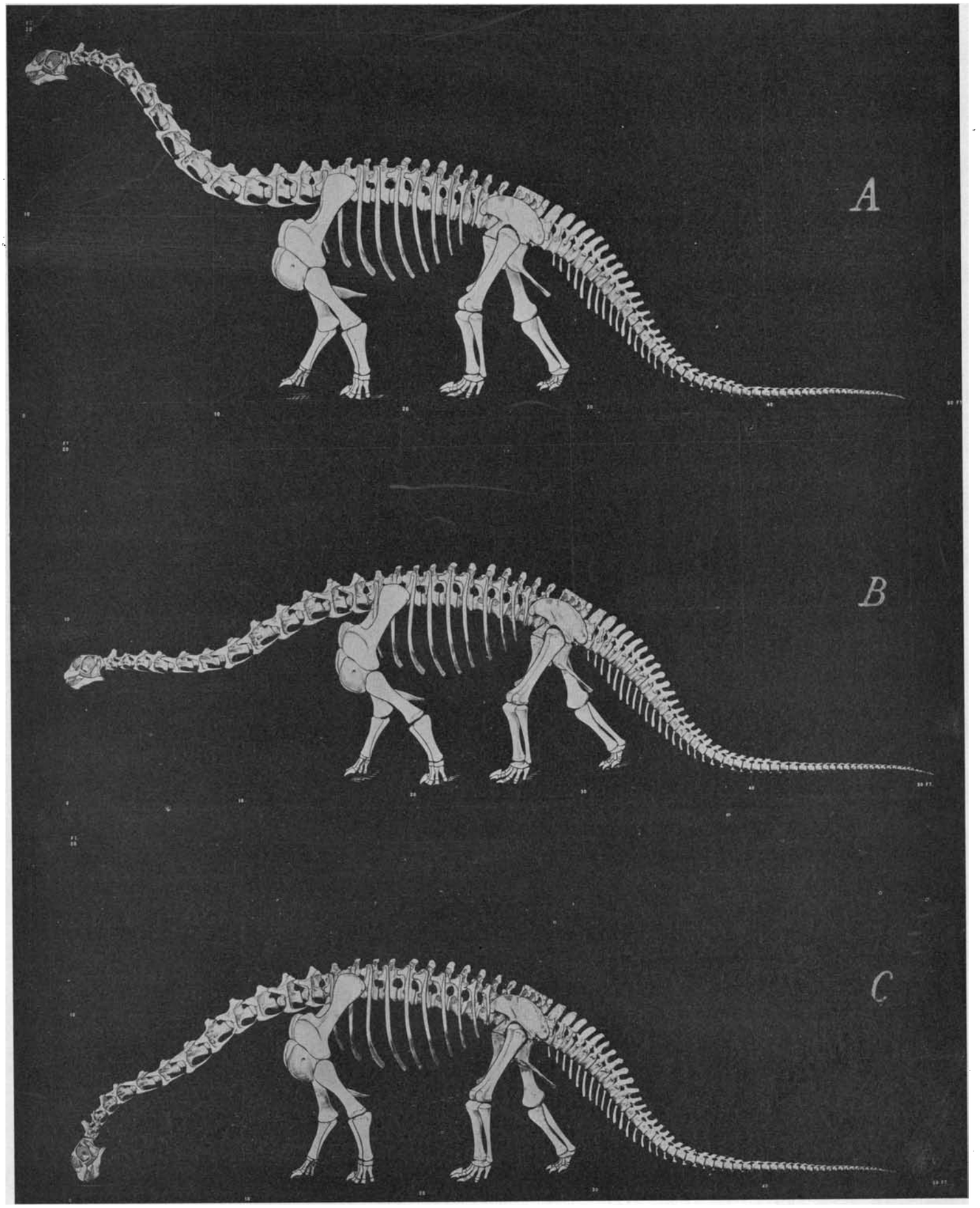

Fig. 28. Three poses of *Camarasaurus* skeleton as mounted in flat cardboard model in 1918.

(A) walking pose, head elevated; (B) walking pose, head and neck horizontal; (C) ground-feeding pose, head depressed. These photographs were made from drawings in which every bone is figured separately to a one-fifth scale and fastened upon a black background. This articulated figure was successively placed in three poses, A, B, and C, and each photographed in turn. In the restoration and reconstruction the structure and arrangement of the phalanges of the feet are purely conjectural. The head of the animal attains a height of 20 feet (A). The maximum length in the extended position (B) is 52 feet. Length of backbone, without curvature, between 54 and 55 feet. These poses do not indicate the usual angle between the head and the neck.

at a considerable distance from the rest of the skull bones. No other skull material has been seen or mentioned in connection with the collection which is under consideration. It is possible, therefore, that the bones mentioned by Cope are the ones herein described. They agree with the skull of *Camarasaurus* (*Morosaurus*) from the Morrison of Wyoming, now in the American Museum, Amer. Mus. No. 467. The portions of the skull preserved are indicated in the accompanying key (Fig. 29). There are also some isolated teeth, whose association with other material is not known, which probably belong with the other remains of the skull. These teeth resemble those of the Wyoming specimen, but are somewhat larger.

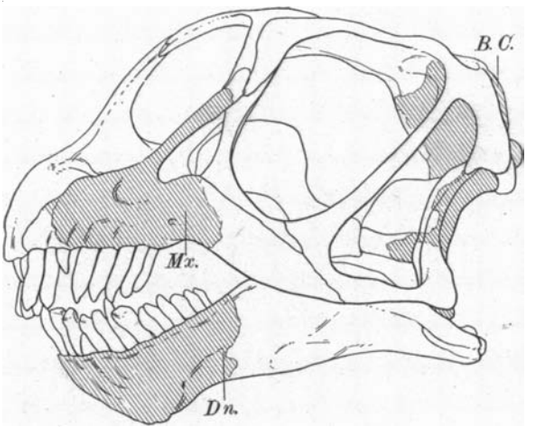

Fig. 29. Key to incomplete skull material (shaded) of *Camarasaurus* in the Cope Collection (Amer. Mus. Cope Coll. No. 5761).

One-tenth natural size. *B. C.* brain-case; *Dn.* dentary; *Q.* quadrate (*Dn.* and *Q.* indicated in this key on the left side, both dentaries in the collection, however, belong to the right side); *Mx.* maxillary. The outline is from a skull of *Camarasaurus* from the Bone Cabin Quarry (Amer. Mus. No. 467).

Characters

The characters of the skull are illustrated in the accompanying figures (Plates LXII to LXVIII). The sutures of the skull are not clearly indicated.

Brain Case.— See Plates LXII and LXIII. The occipital condyle is large, and appears to be composed of a portion of the basioccipital only; it is flat superiorly, and convex posteriorly and inferiorly. The paroccipital process of the left exoccipital is preserved; it is large and stout, and extends downward and outward at an angle of about forty-five degrees. The foramen magnum is moderately large. The vertical diameter of it is considerably greater than the transverse. The basioccipital processes are large and stout. Each one possesses a vertical groove on its posterior surface. The basisphenoid processes are relatively long and slender.

The cavity of the brain-case is small in comparison with the size of the skull. The posterior portion of the cavity is well preserved. It exhibits, besides the space which was occupied by the main mass of the brain and its associated connective tissues, a deep pit which lodged the hypophysis, also foramina which served for the exit of cranial nerves II, III, IV, V, VI, VII, VIII, IX, X, XI, and XII. The positions of these and their combinations with each other are indicated in the accompanying illustrations. There is no trace of a recessus basisphenoidalis comparable to that of *Tyrannosaurus*.

Brain Cast.— See Plate LXIV. The cranial cavity admits of the determination of the form of the connective tissue envelope of the brain. As noted by Dendy (1911) in *Sphenodon* and Osborn (1912)

in *Tyrannosaurus*, the external surface of the dura mater does not correspond with the form of the brain itself, and the size of the cranial cavity is much larger than that of the brain. The same is true of *Camarasaurus*. In spite of this, certain characters of the brain are readily determinable.

The brain is exceedingly small in proportion to the size of the animal. The maximum diameter of the brain-cavity is only very slightly greater than that of the neural canal of the cervical vertebræ; the brain itself must have been lesser in diameter than the spinal cord. The anterior portion of the brain is unknown so far as the specimen described is concerned. A notable character of the brain is the large size of the hypophysis; this occupied a very deep excavation in the floor of the brain-case. The bases of the cranial nerves are for the most part readily identifiable. Their positions are indicated in the illustration of the cast of the cranial cavity (Plate LXIII).

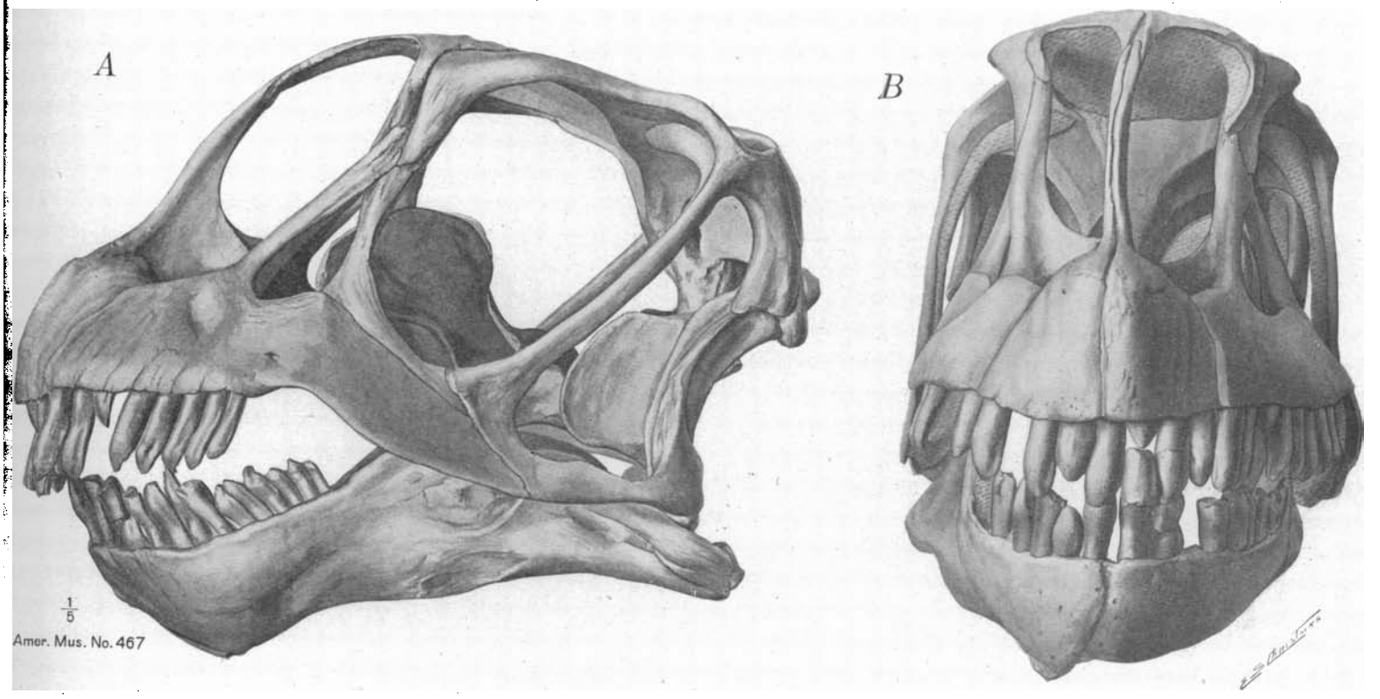

Fig. 30. Skull of *Camarasaurus* species, previously referred to *Morosaurus*.
Amer. Mus. No. 467. (A) lateral view, left side; (B) anterior view; one-fifth natural size. After Osborn.

Quadrate.— See Plate LXII. The single right quadrate bone in the collection is fairly well preserved. The inferior process, which articulated with the lower jaw, is very stout; it is convex on its posterior surface and concave on its anterior one; a broken area on its external surface marks the position of its articulation with the quadratojugal. The anterior process is also moderately stout; its superior flange is not preserved; it is convex inferiorly and deeply excavated above; this excavation evidently lodged a process of the pterygoid. Anterior to this cavity a small process extends downward and outward. The superior process extends upward from the point where the anterior and inferior processes meet; its greatest diameter is in the same plane as the greatest diameter of the anterior process, which plane makes an angle with the greatest diameter of the inferior process; it is moderately high, of medium breadth antero-posteriorly, and very thin laterally; its internal surface is continuous with the corresponding surfaces of the inferior and anterior processes; its external surface is separated, however, from

that of the inferior process by a sharp shoulder, the inferior process being much thicker laterally. The exact form of the junction of the three processes cannot be clearly made out, as a portion of the bone is lacking at this point.

The most characteristic feature of the quadrate is its massive construction, which is more marked in this specimen than in any other known quadrate of the Sauropoda.

Maxillary.— This bone is large. It is broad vertically in its anterior portion and more slender in its posterior portion. The superior bar of the maxillary is stout, compared with the same structure in the skull of *Diplodocus;* it extends upward and very slightly backward from the main mass of the bone. The inferior edge of the maxillary is deflected outward, forming a sort of flange, which protects the immature teeth. The inferior mass of the maxillary exhibits, besides the thin flange mentioned above, a broad irregular dental surface, which lodges the teeth. In the specimen described, five teeth are present, all in an immature stage of development; there are spaces for three more.

Dentary.— See Plates LXV and LXVI. The dentary is massive in each of the specimens in the collection. Near the posterior end in each specimen, varying slightly in position, there is a triangular groove on the external surface. The apex of the triangle points forward and the base is at the posterior end. The external surface of the dentary is dotted with pits; these are spaced rather far apart, not close together as in *Tyrannosaurus*. In the longer of the two dentaries two of the pits appear to extend rather deeply into the bone; they may have functioned as vascular foramina. On the lower portion of the internal surface, near the posterior end of the bone, is a sharply marked acute triangular depression; the apex of the triangle is directed forward; it probably served for articulation with the splenial. These characters are illustrated in the plates.

Measurements

Amer. Mus. Cope Coll. No. 5761

Brain-case		
Breadth across paroccipital processes	26.5 cm. *e.*[1]	
Base of left basisphenoid process to superior border of skull	29.5	
Breadth of occipital condyle	7.4	
Quadrate		
Vertical diameter from glenoid surface to superior end of superior process	27.0	
Posterior border of inferior process to anterior extremity of anterior process (incomplete)	20.5	
Lateral diameter of inferior process	8.0	
Maxillary		
Length of preserved portion	31.0	
Superior end of superior bar to inferior border of bone, oblique direction	30.6	
Dentaries	$\frac{5761}{\text{Dn. 1.}}$	$\frac{5761}{\text{Dn. 2.}}$
Length, maximum	36.0 cm.	35.0 cm.
Length, perpendicular	34.5	33.5
Height, minimum	12.5	12.0

Dentition

Material and Association.— There are two teeth in the collection besides those which constitute the types of *Caulodon diversidens* and *C. leptoganus*, and one which previously was referred to *Amphicœlias*. There are also the five teeth, mentioned above, in the maxillary bone, and two or three in one of the dentaries. The association of these teeth is entirely unknown, except for those in the skull bones, and there is also Cope's statement that the teeth of the *Caulodon* type were found at a considerable distance

[1] Throughout this memoir, *e* means estimated.

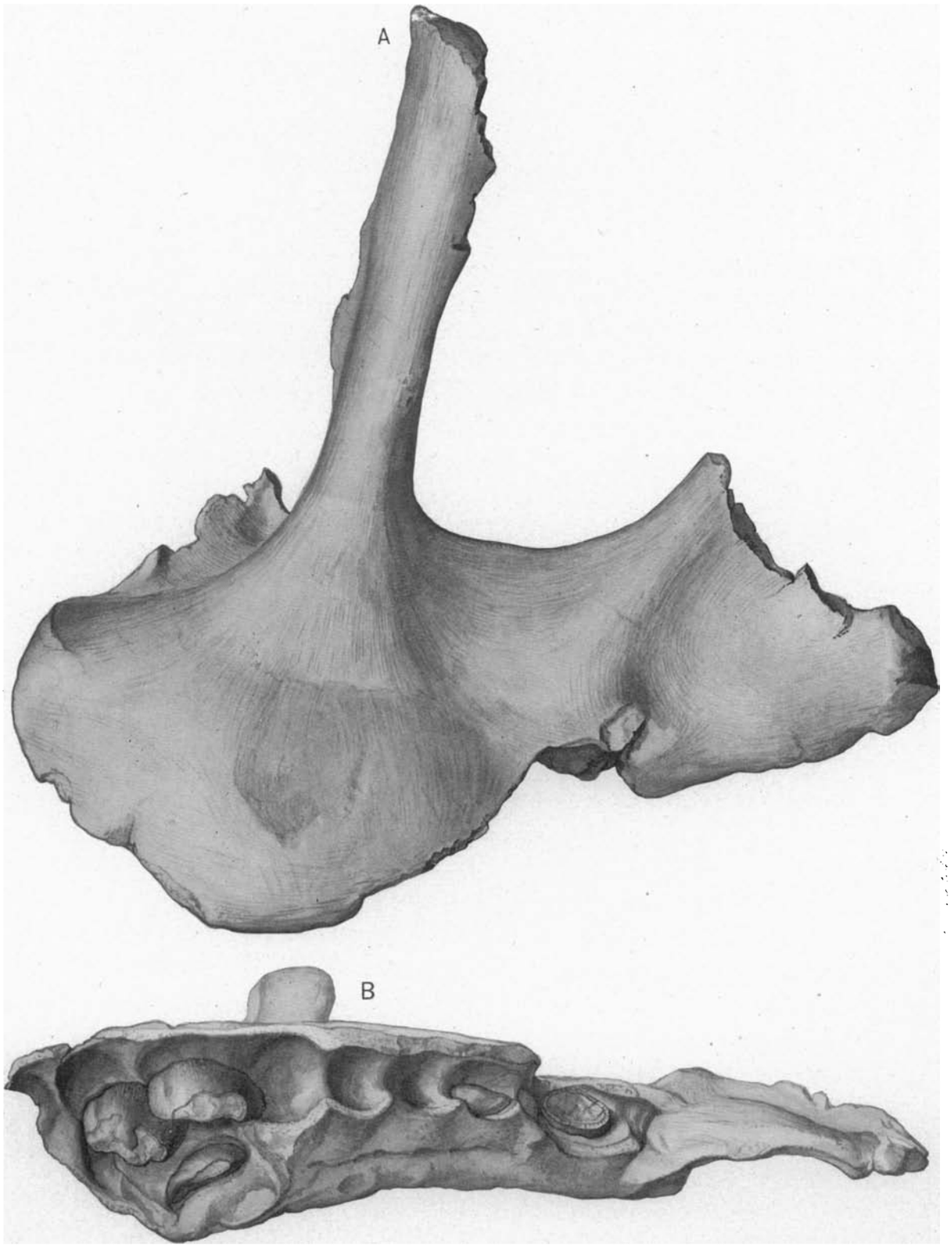

Fig. 31. Left maxillary bone of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. 5761. (A) lateral view, left side; (B) inferior view; one-tenth natural size.

from the skull bones. It is, nevertheless, highly probable that every one of the teeth in the collection belongs to *Camarasaurus*.

Characters

The number of teeth in *Camarasaurus* cannot be determined from the material in the Cope Collection, but it is known from the Wyoming specimen to which reference was made above. In this skull, which may or may not have belonged to the same species, there are twelve teeth in each side of the upper jaw, and thirteen in the lower. It is not improbable that the number of teeth in both the upper and the lower jaw varied slightly among the species of the genus, and possibly among different individuals of the same species.

Of the twelve on each side in the upper jaw, four are in the premaxillary and eight in the maxillary. Besides these teeth, there are several which are not contained in the bones but which have been forced out through the growth of others, yet not completely separated from the rest of the teeth. From the evidence of the Wyoming specimen, the teeth near the posterior ends of the jaws are small and those near the anterior ends are large. Between the two extremes there is a steady gradation from large teeth to small teeth.

The unworn teeth have sharp points, especially in the anterior region of the mouth; they are broadly convex on their external surfaces and concave on their internal surfaces. In some of the teeth there is a vertical ridge on the internal surface, dividing it into two distinct portions. This is especially true of the anterior teeth. The crowns of the teeth are relatively thin. The roots are cylindrical. The borders curve gradually toward the summits; the anterior and, in the front teeth, the median borders are more convex than the posterior or external ones. The single long-used available tooth exhibits three worn surfaces. The surfaces of the teeth are composed of a finely pitted type of enamel; the interiors appear to be composed of cement. See Plates LX and LXI.

Vertebral Column

General Discussion

The vertebral column of *Camarasaurus* possesses the usual characters of the spinal columns of the Sauropoda in general. Among such characters may be listed the large number of cervicals in proportion to the number of dorsals, the absence of lumbars, the great strength of the sacrum, the great length of the tail, the elaborate system of laminar braces, and the opisthocœlous character of the centra in the anterior dorsal region. The *Camarasaurus* vertebral column also agrees with those of most genera of the Sauropoda in having pleurocentral cavities in the cervicals and dorsals, and divided spines in most of the cervicals and in the anterior dorsals. The vertebræ are estimated as follows: cervicals = 13; dorsals = 10–11, sacrals = 5–4; caudals = 53.

The vertebræ of *Camarasaurus* are relatively stout and strongly built. They are more compact than those of *Apatosaurus* and much stouter than those of *Amphicœlias*, *Barosaurus*, and *Diplodocus*. The whole column is much shorter than that of *Diplodocus* and somewhat shorter than that of *Apatosaurus;* it is in some respects more primitive than in these genera, especially *Diplodocus*. The degree of spinal notching in the dorsals and caudals and the tendency toward addition to the cervical series at the expense of the dorsal series, or at any rate the tendency toward impressing the cervical type of structure upon the dorsals, have not gone so far as in *Diplodocus*.

The column is characterized by the typical opisthocœlous combination of strength and lightness, but with strength predominating. It is easily distinguished in the dorsal region from the columns of other genera; the points of distinction will be noted in the discussions of the various structures of the dorsals. The distinction between the cervicals of *Camarasaurus* and *Apatosaurus* is not so marked, although there are certain differences. The larger caudals are easily distinguished from those of other genera of the Sauropoda, though the small posterior caudals have little in the way of distinguishing features. The sacrum of *Camarasaurus* is characteristic and will be discussed at some length.

CERVICAL VERTEBRÆ

General Discussion

Material and Association.— Twenty-seven cervical vertebræ are present in the collection. No field records of the association of these vertebræ with each other and with the other bones of the skeleton are available, and the large number and distorted character of the lot would render such records of slight value if they were available. There are eight cervicals which appear to belong in one consecutive series, representing the neck from Cervical 2 to Cervical 9 inclusive. Several others may have belonged to the same individual as the above-mentioned series. The remainder of the cervicals in the collection appear to fit into smaller series, or to have no relation to any other cervicals.

The bones have been assembled in various ways and in various combinations and their characters were analyzed until the arrangement that seemed most consistent for each series was found. The crushed and broken character of many of the bones and the absence of certain cervicals in some of the series, together with the lack of guiding material, rendered this determination very difficult. The results of the various groupings are indicated in the accompanying tables of measurements and illustrations (Plates LXVII to LXIX, and Figures 32–36). It is by no means certain that these identifications are correct; they are considered, however, to be as nearly correct as the nature of the material will permit of determination. All of the cervicals except the atlas and proatlas are present in one or more of the series.

Number.— The number of cervical vertebræ is not clearly indicated by the topotype material. *Camarasaurus* (*Morosaurus*) *lentus* (Marsh), which is closely related to *C. supremus* Cope, is known to have eleven cervicals posterior to the axis; *Apatosaurus* is known to have thirteen cervicals including the atlas and axis. When the cervicals of the *Camarasaurus supremus* topotype lot are arranged according to the hypothesis that the number is thirteen in this species also, these vertebræ fit into several series, in which the various members match up with each other very well. It is therefore provisionally considered that the number of cervical vertebræ in *Camarasaurus* is thirteen, exclusive of a possible proatlas. The latter is not preserved in the material under discussion, but has been found in a related form, *C.* (*Morosaurus*) *agilis* Marsh, and may have been present in *C. supremus.*

Size and Form.— The size of the cervicals is indicated in the accompanying tables of measurements, and in the illustrations (Plates LXVII to LXIX and Text Figures 32 to 36). The centra gradually increase in length from the axis backward to a maximum in Cervical 8; from 8 to 13 they decrease in length slightly. In breadth and height of centra there is a progressive increase from the axis to the last cervical. The height of the spines increases steadily from Cervical 3 to C. 13. The diapophyses increase in length continuously from the axis to the last cervical.

In form, the cervicals of *Camarasaurus* resemble very closely those of *Apatosaurus* but appear to be slightly more massive. The cervical ribs in *Camarasaurus* are much longer than those of *Apatosaurus*,

and it also appears that the neck was relatively broader than in that genus. The *Camarasaurus* cervicals are much stouter than those of *Barosaurus* and *Diplodocus*, and differ from those of *Haplocanthosaurus* in having divided spines and in being more complexly laminated.

Characters

The Axis

The axis is somewhat different from the remainder of the cervical series, both in structure and in function, and may therefore be discussed separately.

Spine.— The spine of the axis is relatively high. It is triangular in cross-section, with the apex of the triangle directed forward. The anterior border projects rather prominently as a prespinal lamina. This lamina extends from the summit of the spine obliquely downward and forward to a point immediately above the neural canal. The postero-lateral boundaries of the spine are formed by broad plates which extend upward from the postzygapophyses in a manner comparable to that of the suprapostzygapophysial laminæ of the dorsals. The cross-profile of the spine is subacuminate. The superior surface is somewhat rugose, probably in connection with the attachment of a powerful ligament. The posterior surface of the spine is deeply concave, the postero-lateral walls partially enclosing a postspinal cavity. The anterior wall of this cavity, or the posterior surface of the spine, is excavated into two shallow cavities separated by a low vertical ridge. The posterior surface of the spine evidently served as an articulation surface for several large longitudinal muscles.

Prezygapophyses.— The prezygapophyses of the axis are small and indistinct. The atlas is not preserved in this material, but is known from other specimens of the same or a related genus, and the zygapophysial articulation between the atlas and the axis is known to be weak. The prezygapophyses are situated on a level with the upper portion of the neural foramen; they are rather close together and considerably lower than the postzygapophyses. They are supported inferiorly by the infraprezygapophysial laminæ, and posteriorly by the horizontal laminæ.

Postzygapophyses.— The postzygapophyses are large, and were evidently functionally important. They incline rather sharply inward and downward toward the median line, and also incline slightly forward and downward. They are supported superiorly by the postero-lateral edges of the spine, which practically comprise suprapostzygapophysial laminæ. Inferiorly they are supported by strong infrapostzygapophysial laminæ, and anteriorly by the horizontal laminæ. The postzygapophyses are very broad, together constituting the broadest portion of the vertebra.

Diapophyses.— These processes are present in the axis, but they are very small and inconspicuous. They project backward and outward from the horizontal laminæ, and are curved sharply downward near their extremities. They are supported anteriorly and posteriorly by the anterior and posterior branches of the horizontal laminæ respectively, and inferiorly by weak infrapre- and infrapostdiapophysial laminæ. A pair of small cervical ribs may have been attached to them, but these ribs have never been found in *Camarasaurus*, and the articulation surfaces for them are rather obscure. Such ribs have been described in the genus *Diplodocus* by Dr. W. J. Holland (1905, pp. 249, 250). The processes are stronger in the axis herein described than in the one described by Holland, and it is highly probable that *Camarasaurus* possessed them as well.

Parapophyses.— A small process is situated on each side of the anterior portion of the side of the centrum, about midway between the superior and inferior borders of the latter. This is the position

occupied by the parapophyses in the succeeding cervicals, and probably represents these structures. These processes are very small, but their articular surfaces are better developed than those of the diapophyses. Probably a cervical rib was attached to each of these processes, as in the axis of *Diplodocus* described by Holland.

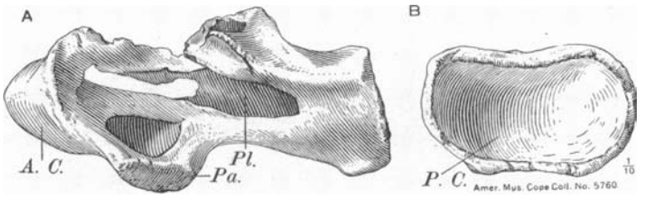

Fig. 32. Cotype cervical vertebra of *Camarasaurus supremus* Cope.

Cervical 10, estimated (Amer. Mus. Cope Coll. No. $\frac{5760}{X\text{-}C\text{-}1}$). (A) lateral view, left side; (B) posterior view; one-tenth natural size. *A. C.* anterior convexity; *Pa.* parapophysis; *Pl.* pleurocœl; *P. C.* posterior concavity. (Compare with original type figures, Fig. 7.)

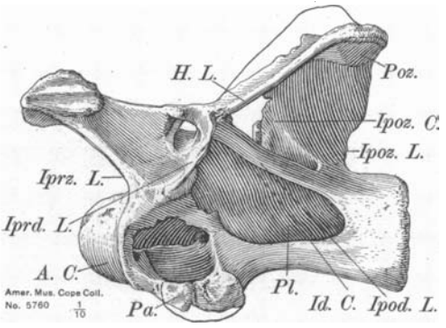

Fig. 33. Type cervical vertebra of *Camarasaurus leptodirus* Cope.

Cervical 6, estimated (Amer. Mus. Cope Coll. No. $\frac{5763}{X\text{-}1\text{-}2}$). Lateral view, left side; one-tenth natural size. *A. C.* anterior convexity; *H. L.* horizontal lamina; *Id. C.* infradiapophysial cavity; *Ipod. L.* infrapostdiapophysial lamina; *Ipoz. C.* infrapostzygapophysial cavity; *Ipoz. L.* infrapostzygapophysial lamina; *Iprd. L.* infraprediapophysial lamina; *Iprz. L.* infraprezygapophysial lamina; *Pa.* parapophysis; *Pl.* pleurocœl; *Poz.* postzygapophysis. Reconstructed portions in outline. (Compare with original type figures, Fig. 14.)

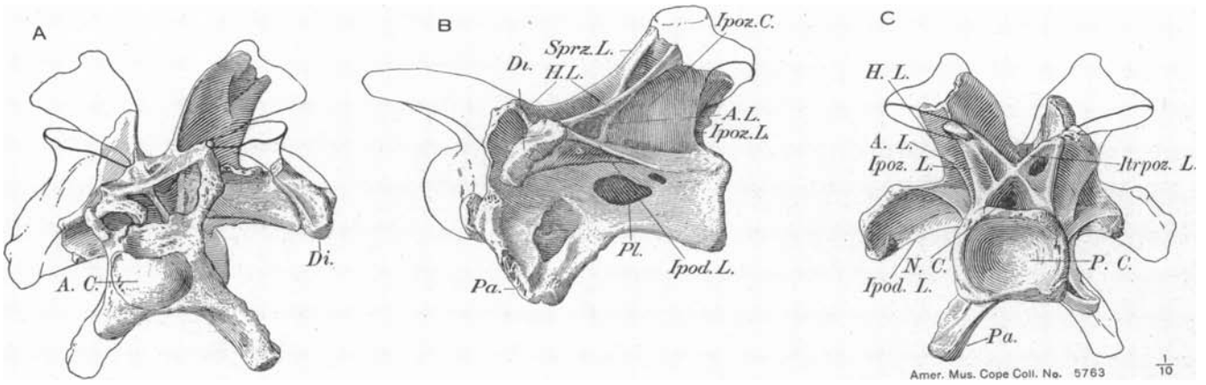

Fig. 34. Type cervical vertebra of *Camarasaurus leptodirus* Cope.

Cervical 7, estimated (Amer. Mus. Cope Coll. No. $\frac{5763}{X\text{-}C\text{-}3}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *A. C.* anterior convexity; *A. L.* accessory lamina; *Di.* diapophysis; *H. L.* horizontal lamina; *Ipod. L.* infrapostdiapophysial lamina; *Ipoz. C.* infrapostzygapophysial cavity; *Ipoz. L.* infrapostzygapophysial lamina; *Itrpoz. L.* intrapostzygapophysial lamina; *N. C.* neural canal; *Pa.* parapophysis; *P. C.* posterior concavity; *Pl.* pleurocœl; *Sprz. L.* supraprezygapophysial lamina. Reconstructed portions in outline. New original figures of type.

Neural Arches.— The neural arches of the axis are relatively simple. They are low at the anterior end of the vertebra and high at the posterior end. The infraprezygapophysial and infradiapophysial cavities are very shallow and simple in form. The infrapostzygapophysial cavities, however, are large. Owing to the rather high positions of the postzygapophyses and the consequent downward slope of the horizontal laminæ these cavities are more above the diapophyses than below them. There is a deep secondary cavity on each side immediately in front of the postzygapophysis.

Centrum.— The centrum of the axis is of moderate length in proportion to its breadth and height; it is narrowest immediately behind the parapophyses. The odontoid process is prominent and is firmly fused with the body of the centrum; this process is composed of two portions, a broad thick basal portion, and a more slender anterior one projecting forwards from it. The anterior surface of the main body of the centrum is practically flat; it inclines slightly forward and downward instead of being vertical. The posterior surface is much larger than the anterior one, and is excavated into a deep concave cup. The pleurocœl occupies about half the length of the centrum; there is no median septum, the pleurocœl extending entirely through the centrum. This cavity is divided into two parts on each side by a slender bar, which is slightly different in form and position on the opposite sides of the bone. The inferior surface of the centrum is marked by a median keel. This structure is sharply elevated near the posterior end of the bone, but is more nearly flat near the anterior end.

Neural Canal.— The neural canal of the axis vertebra is small in size and round in form.

Cervicals 3 to 13 Inclusive

Cervicals 3 to 13 possess characters which are similar in kind, but which differ in degree of development. Most of their component parts and dimensions are progressive in size from 3 to 13. These vertebræ therefore will be discussed as a group rather than singly.

Size.— The cervicals increase steadily in length from C. 3 to C. 8, then decrease gradually to C. 13. In other dimensions they increase steadily from C. 3 to C. 13.

Spines.— The spines are not situated over the middle points of the centra, but over their posterior portions. The spines of Cervicals 5 to 13 inclusive are bluntly rounded at the top on each side, and the longitudinal diameter is greater than the transverse in each metapophysis at its summit.

The spines on Cervicals 3 and 4 are single; they are small, and are flat on their summits. In C. 5 the spine has a very slight median notch. In C. 6 the characters of the spine are obscure owing to the poorly preserved condition of the two specimens of this member of the series. From C. 7 to C. 10, inclusive, the spinal notch increases steadily in depth, the spine of C. 10 being completely divided into two metapophyses. Cervicals 11 to 13 have the spines completely divided as in C. 10.

The height of the spines increases slightly but steadily from C. 3 to C. 13. This fact is somewhat disguised in some of the vertebræ on account of the crushed condition of the specimens. The spine is lowest in proportion to the length of the vertebra in C. 8, and highest in C. 13. The antero-posterior diameters of the spines increase slightly from C. 3 to C. 13.

Throughout the series the spines are braced anteriorly by long slender supraprezygapophysial laminæ, and posteriorly by shorter suprapostzygapophysial laminæ. The anterior surfaces of the spines in Cervicals 3 to 5 are characterized by the presence of narrow, vertical rugose areas. Posterior to C. 5 the anterior surfaces are smooth. The posterior aspects of the spines are characterized by postspinal cavities below and behind the spines and between the postzygapophyses. These are present through-

out the whole cervical series, but are more pronounced in the anterior cervicals with single or slightly divided spines than in the posterior ones with completely divided spines.

Prezygapophyses.— The prezygapophyses are large and flat in the entire cervical series posterior to the axis. They are far apart in each vertebra, and in the anterior portion of the series the diameters across them appear to have been nearly or quite as great as the spread of the diapophyses. It is impossible to determine this point exactly on account of the incomplete preservation of the diapophyses in the only specimens of Cervicals 3 and 4 in the collection. In C. 5 the spread of the diapophyses is slightly greater than that of either the pre- or postzygapophyses. Typically the prezygapophyses are inclined toward each other and toward the median line. The distortion of the bones disguises this character in many of the cervicals.

Support is given the prezygapophyses from a combined superior and posterior direction by the slender supraprezygapophysial laminæ, and from the inferior direction by stout infraprezygapophysial laminæ, from the median line by slender intraprezygapophysial laminæ, and posteriorly by the horizontal laminæ.

Postzygapophyses.— These structures are also large and prominent throughout the series. They are situated higher and slightly further apart than the prezygapophyses, and are inclined similarly. They are supported superiorly and somewhat anteriorly by suprapostzygapophysial laminæ of medium strength, and anteriorly by the horizontal laminæ. They are supported medially and somewhat inferiorly by slender intrapostzygapophysial laminæ, and inferiorly by stout infrapostzygapophysial laminæ.

Diapophyses.— The diapophyses are very short in the anterior cervicals and long in the posterior ones. Those in the only specimens of Cervicals 3 and 4 are broken, so that the exact dimensions are unknown. In C. 5 their spread is slightly greater than those of the zygapophyses. The increase in length of the diapophyses from that point to Cervical 10 is very rapid. From C. 10 to C. 13 this increase is gradual. The diapophyses are situated rather low in the anterior cervical region, and considerably higher back near the dorsals; they are located typically rather far forward on the vertebræ, and bend downward somewhat near their extremities; the tubercular facets face obliquely outward and downward.

The diapophyses are supported anteriorly and posteriorly by the horizontal laminæ, and inferiorly by the anterior and posterior infradiapophysial laminæ.

Parapophyses.— These structures are well developed throughout the series; they are situated on the infero-lateral borders of the centra, immediately posterior to the anterior convexities of the latter; they extend obliquely outward and downward, but more the former than the latter. Their superior surfaces grade into the walls of the centra, and are excavated into broad, shallow cavities. These cavities are in fact subdivisions of the pleurocœlia of the centra; they will be described more fully in connection with the discussion of the pleurocœlia. The parapophyses are rather long in proportion to those of the dorsals. This is especially so in the anterior part of the neck.

Neural Arches.— The neural arches are comparatively low throughout the whole cervical series; they are especially low in the anterior portion of the series, but are somewhat higher in the posterior portion, where they grade into the structure of the dorsals. They are crossed by anterior and posterior infradiapophysial laminæ which separate off infraprezygapophysial, infradiapophysial, and infrapostzygapophysial cavities. The first-mentioned of these cavities, in each side of each vertebra, is the smallest of the three, and is situated near the anterior end of the vertebra in fact in some vertebræ it lies directly over the anterior ball of the centrum, due to the anterior position of the diapophyses and to the

vertical position of the infraprediapophysial laminæ. The infradiapophysial cavity, in each side of each vertebra, is situated immediately below the diapophysis, and is bounded anteriorly and posteriorly by the anterior and posterior branches of the infradiapophysial laminæ. It is deep, especially in the posterior portion of the neck, and is simple in character. In the anterior cervicals it is not sharply separated from the pleurocœl. In the posterior cervical region, however, each side of each cervical has a bar, or plate, which separates the pleurocœl from the infradiapophysial cavity. This bar or plate may be called the *supracentral lamina*. In a side view of a complete cervical this cavity does not appear very large, owing to the downward deflection of the infrapostdiapophysial lamina. In cervicals in which the diapophyses are broken the cavities may be seen to their full extent. The infrapostzygapophysial cavities are situated immediately below the postzygapophyses. They are large and prominent, and their vertical diameters are considerably greater than those of the other two neural arch cavities. They are situated behind the diapophyses, as well as obliquely below and behind them, and occupy a considerable portion of the lateral aspect of each cervical. Usually, especially in the posterior portion of the neck, they are complicated by accessory laminæ and secondary cavities.

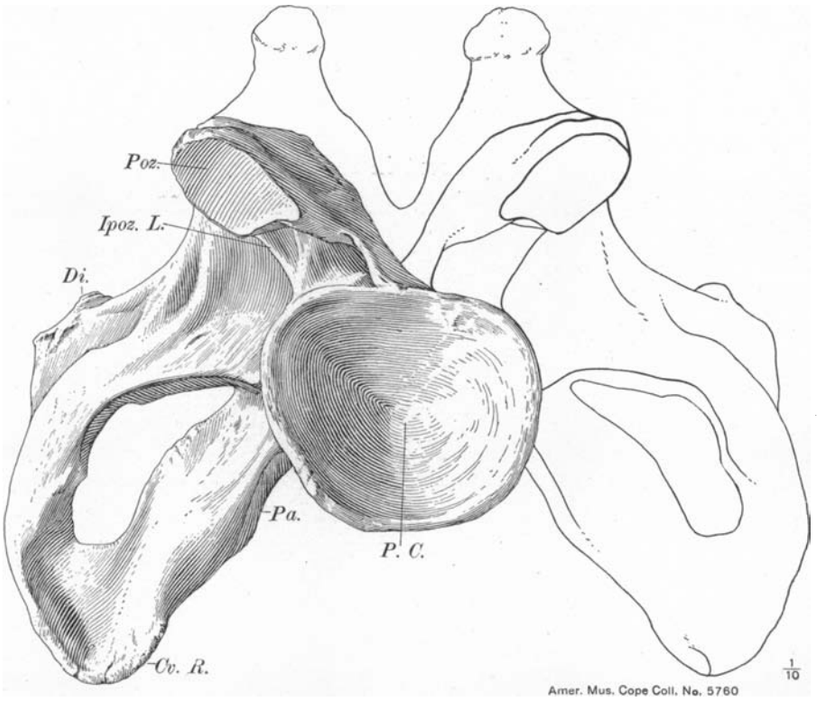

Fig. 35. Cervical vertebra of *Camarasaurus supremus* Cope.

Cervical 13, estimated (Amer. Mus. Cope Coll. No. $\frac{5760}{X\text{-}C\text{-}4}$). Posterior view; one-tenth natural size. *Cv. R.* cervical rib; *Di.* diapophysis; *Ipoz. L.* infrapostzygapophysial lamina; *Pa.* parapophysis; *P. C.* posterior concavity; *Poz.* postzygapophysis. Reconstructed portion in outline.

Centra.— The centra are comparatively short in the anterior cervicals; they increase rapidly in length from Cervical 3 to C. 8, which is the longest in the series, and then they decrease in length to C. 13. In breadth and height of the centra there is a progressive increase from C. 3 to C. 13. The entire series is strongly opisthocœlous, the anterior balls being practically hemispherical throughout, and the posterior cups correspondingly concave. In the anterior cervicals the separations between the centra

and the neural arches are not sharp, but in the posterior cervicals they are marked by the supracentral laminæ mentioned above. The walls of the centra are thin and the pleurocœlia are large, but excavation in this respect has not proceeded to the extent typical of some other genera of the Sauropoda. The pleurocœlia are complex as well as large. The lateral walls of the centra slope upward and inward, while the supracentral laminæ project out laterally. The latter therefore roof over shallow asymmetrical cavities which might be appropriately called *external pleurocœlia*. From these cavities deeper cavities, which may be called *internal pleurocœlia*, extend into the bodies of the centra. The depth, shape and position of these internal cavities vary considerably. Usually there are three of them on each side of each cervical, sometimes only two. The anterior one in each case excavates the proximal portion of the parapophysis; this anterior cavity is comparatively shallow. The other two cavities on each side of each centrum may be considered together, as in some cases they are united into one larger cavity, in others they are separated only by thin bars; in still others they are entirely distinct. Inferiorly the centra are concave in both lateral and longitudinal directions. Small laminæ extend downward and slightly outward from the infero-lateral borders of each centrum.

Neural Canal.— The neural canal in the cervical vertebræ is subcircular in outline. It is small in diameter, and does not vary to any considerable extent in size in the entire length of the neck.

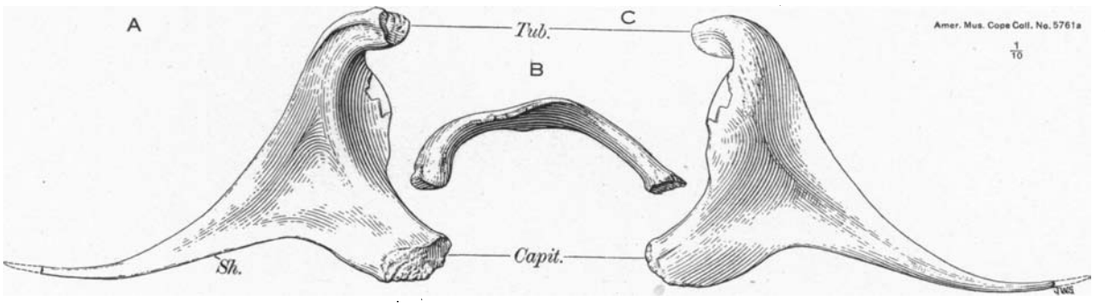

Fig. 36. Cervical rib of *Camarasaurus supremus* Cope.

Left rib of Cervical 12 (Amer. Mus. Cope Coll. No. $\frac{5761\text{-a}}{\text{R-X-A-5}}$). (A) internal view; (B) anterior view; (C) external view; one-tenth natural size. *Capit.* capitulum; *Sh.* shaft; *Tub.* tuberculum. Reconstructed part in outline where definitely known, in dash lines where conjectural.

Cervical Ribs.— The cervical ribs, when they are present, are usually ankylosed by their tubercular processes to the diapophyses of the vertebræ, and by their capitular processes to the parapophyses. With these processes they form a broad loop on either side of each cervical. The tubercular processes extend slightly outward as well as downward from the facets, and in this way increase the total width of the neck. The shafts of the ribs extend backward, practically making right angles with the plane of the capitular and tubercular processes. The shafts, and in fact the entire ribs, are composed of interlocking plates. Near the junction of the shafts and the articular processes the latter are comparatively stout. They are long, and in the few cases in which they are preserved, they extend for considerable distances behind the posterior borders of the centra. They taper rapidly, and at their distal ends are exceedingly slender.

Special Features

The cervical vertebræ of *Camarasaurus*, as shown by this material, have some special features which deserve particular emphasis. One of these is the surface on the superior aspect of the vertebral column

which evidently lodged large muscles; this surface is made up of component portions from each vertebra. In each of these portions it lies between the metapophyses, when the spines are divided, and between the supraprezygapophysial laminæ in front of the spines. The principal cervical attachment of these muscles must have been the posterior surface of the spine of the axis. In the anterior cervical region the spines with shallow notches evidently lodged the narrow ends of these muscles, while in the posterior cervical region the completely divided spines lodged their main mass. The comparatively bulky outline of the cervicals and the great length and slender character of the cervical ribs constitute distinguishing features of the genus *Camarasaurus*. The spread of the diapophyses and cervical ribs, and consequently the breadth of the neck, is relatively greater in *Camarasaurus* than in most other genera of the Sauropoda. In comparison to the bulk of the animal the neck of *Camarasaurus* is comparatively short. In flexibility of the neck *Camarasaurus* had advanced considerably beyond the condition found in *Haplocanthosaurus*, but did not reach the mobile character of the neck of *Diplodocus*.

Measurements[1]

SERIES I (Plate LXVII)

Cervical	Specimen No.	Length of Centrum, Total	Length of Centrum, Base of Cup to End of Ball	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses
2	5761/X–1	23.5 cm.	18.0 cm.	....	....	17.5 cm.
3	5761/X–2	26.5	21.0	....	20.0 cm. *d.*	....
4	5761/X–3	31.0 *e.*	27.5	....	....	23.5
5	5761/X–4	39.5	31.5	....	22.0 *e.*	23.5
6	5761/X–5	Fragmentary	....	....	....	....
7	5761/X–6	55.0	44.5	....	30.5	....
8	5761/X–7	60.5	52.0	55.0 *d.*	27.5 *d.*	31.0 *e.*
9	5761/X–8	54.0 *d.*	41.0	55.0 *d.*	31.5 *d.*	38.0
10	Reconstruction					
11	Reconstruction					
12	5761/X–9	40.0	....	....	41.0	39.5
13	5761/X–10	38.5	24.0	101.0	43.0	46.5

SERIES II (Plate LXVIII)

Cervical	Specimen No.	Length of Centrum, Total	Length of Centrum, Base of Cup to End of Ball	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses
9	5761–*a*/X–a–3	54.5 cm.	45.0 cm.	....	....	....
10	5761–*a*/X–a–4	56.5	45.0	86.5 cm.	....	....
11	5761–*a*/X–a–1	55.0	45.5	96.0	35.0 cm.	40.5 cm.
12	5761–*a*/X–a–5	....	....	98.0+	63.0 *e.*	....
13	5761–*a*/X–a–6	....	....	110.5	....	....

[1] Throughout this memoir, *e.* means estimated; *d.*, distorted; *inc.*, incomplete; and *frag.*, fragmentary.

SERIES III (Plate LXIX)

Cervical	Specimen No.	Length of Centrum, Total	Length of Centrum, Base of Cup to End of Ball	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses
6	5761 / X–B–2	47.0 cm.	41.0 cm.	....	....	....
7	Reconstruction					
8	5761 / X–B–3	61.5	....	....	....	....
9	5761 / X–B–4	....	50.5 *e.*	....	....	....
10	5761–*a* / X–B–5	56.0	42.0	92.0 cm.	43.0 cm.	48.0 cm.
11	5761 / X–B–6	53.5	40.0	....	....	....
12	5761–*a* / X–a–2	50.0 *e.*	37.0	....	....	....
13	5761–*a* / X–B–7	42.5	31.5 *e.*	....	....	41.5

CERVICALS NOT IN SERIES (Text Figs. 7, 32, and 34)

Cervical	Specimen No.	Length of Centrum, Total	Height of Centrum, Anterior	Breadth of Centrum, Anterior	Height of Centrum, Posterior	Breadth of Centrum, Posterior
7	5763 / X–c–3	43.5 cm.	....	....	....	....
10	5760 / X–c–1	56.0	....	27.5 cm. *d.*	16.5 cm. *d.*	31.5 cm. *d.*

DORSAL VERTEBRÆ

General Discussion

Material and Association.— Forty-two or perhaps only forty-one dorsal vertebræ, depending upon the identification of some fragmentary material as belonging to one or two bones, are present in the *Camarasaurus* topotype collection. They belonged to at least four, much more likely five individuals, and perhaps even more. Forty (or forty-one) of these are figured in this memoir, the unfigured one being an incomplete centrum which had no characters worth figuring. Thirty-nine of these have been identified as to their places in the dorsal series, and the figures of them arranged in what appear to be correct morphological series; these arrangements are indicated in Plates LXX to LXXIII. It is not claimed that all the vertebræ figured in each plate actually belonged to the same individual. It is highly probable, however, that each series of dorsals represents a true morphological series, and that the identification of each bone as Dorsal 1, Dorsal 4, etc., is correct, with one or two possible exceptions. This is especially true of the anterior half of the column. In the posterior half, where the resemblance of the dorsals to each other is greater, and where the bones happen to be most poorly preserved, there is more chance of error in exact determination.

Number.— The number of dorsal vertebræ in *Camarasaurus supremus* appears to have been ten, exclusive of a more or less modified dorso-sacral. This has not been determined from the direct evidence of a series of dorsals found in position, or from a single skeleton, but by comparison with a related form, *Camarasaurus* (*Morosaurus*) *lentus* (Marsh), and by a careful study of the material itself, together with an analysis of its characters. When arranged in series of ten dorsals and one dorso-sacral the material appears to constitute a natural series.

Characters

Spines.— The spines of the dorsal vertebræ of *Camarasaurus* are among the most characteristic structures of the genus. They are divided into two metapophyses in the anterior half of the series, and are single in the posterior half. In this respect the dorsal series resembles those of *Apatosaurus* and *Diplodocus*, and differs from those of *Brachiosaurus* and *Haplocanthosaurus*. The division is complete in the

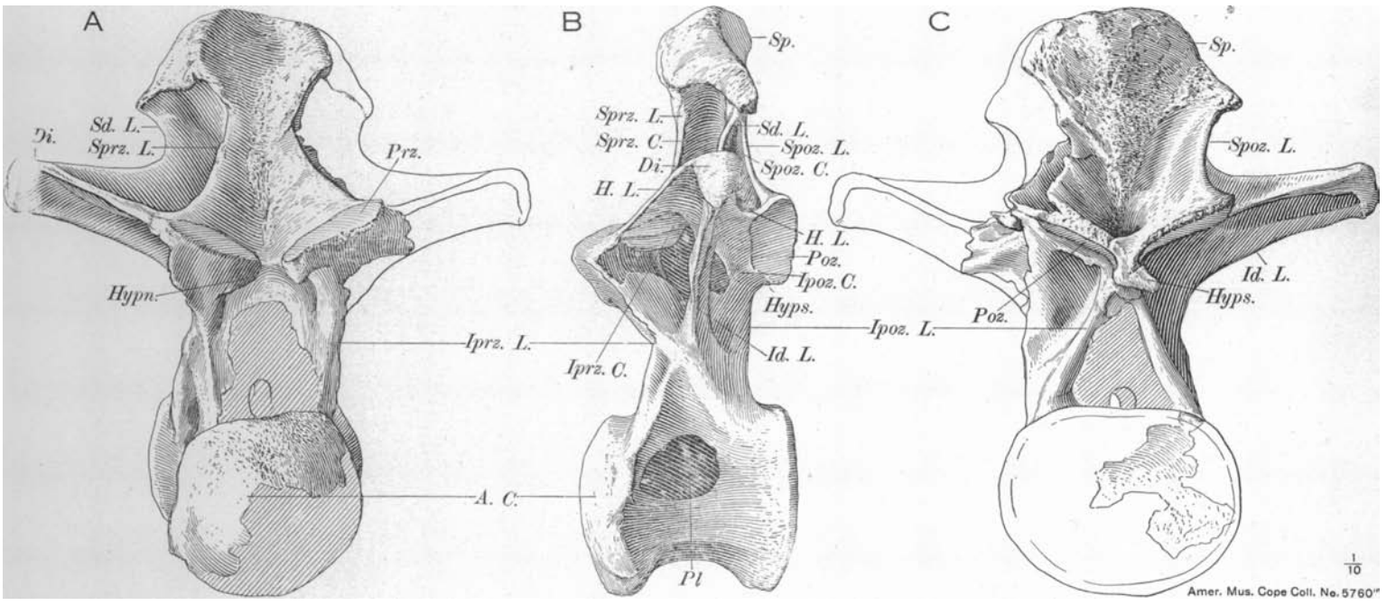

Fig. 37. Cotype dorsal vertebra of *Camarasaurus supremus* Cope.

Dorsal 8, estimated (Amer. Mus. Cope Coll. No. $\frac{5760''}{D\text{-}X\text{-}109}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *A. C.* anterior convexity; *Di.* diapophysis; *H. L.* horizontal lamina; *Hypn.* hypantrum; *Hyps.* hyposphen; *Id. L.* infradiapophysial lamina; *Ipoz. C.* infrapostzygapophysial cavity; *Ipoz. L.* infrapostzygapophysial lamina; *Iprz. C.* infraprezygapophysial cavity; *Iprz. L.* infraprezygapophysial lamina; *Pa.* parapophysis; *Pl.* pleurocœl; *Poz.* postzygapophysis; *Prz.* prezygapophysis; *Sd. L.* supradiapophysial lamina; *Sp.* spine; *Spoz. C.* suprapostzygapophysial cavity; *Spoz. L.* suprapostzygapophysial lamina; *Sprz. C.* supraprezygapophysial cavity; *Sprz. L.* supraprezygapophysial lamina. Reconstructed portion in outline. Compare with the original type figures, Fig. 9, and with Plate LXXI, vertebra 8.

first three dorsals, in Dorsal 4 the spine is very deeply notched, in Dorsal 5 the notch is only slightly less deep, in Dorsal 6 the notch is shallow, and in Dorsal 7 there is only a slight indication of a notch. The division of the spines therefore has not proceeded so far as in *Diplodocus*, in which all of the spines are notched at least to a slight extent. The transition from completely divided to single spines is gradual rather than abrupt, by means of a nodal vertebra, as in *Apatosaurus*. The spines are massive in form and are short; they contrast sharply in form with those of *Apatosaurus*, *Amphicœlias* and *Diplodocus*, and in the posterior region bear more resemblance to those of *Haplocanthosaurus* but are more massive than the latter, and more complex in structure.

The laminar bracings are practically the same in the divided and in the single spines, and may therefore be discussed as a unit, unless special features require special individual treatment. The spines are supported anteriorly by supraprezygapophysial laminæ, and posteriorly by suprapostzygapophysial laminæ. In the posterior region of one series (Series I) and in some vertebræ of other series there is a pair of suprahyposphenal laminæ on the posterior surface of each spine between the suprapostzyga-

pophysial laminæ. The spines are supported laterally by supradiapophysial laminæ. These laminæ extend obliquely upward and backward from the bases of the diapophyses to points near the summits and the posterior borders of the spines; thus they separate anterior and posterior supradiapophysial cavities from each other. The anterior of these cavities in each case lies both in front of, and above the

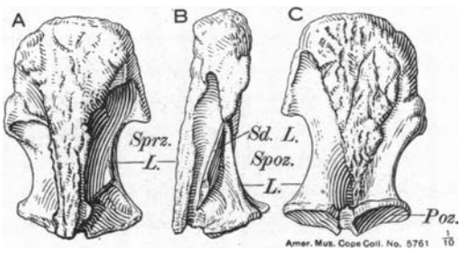

Fig. 38. Spine of dorsal vertebra of *Camarasaurus supremus* Cope.

Position in the series not definitely known; it is between Dorsal 6 and the sacrum (Amer. Mus. Cope Coll. No. $\frac{5761}{D\text{-}X\text{-}153}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *Poz.* postzygapophysis; *Sd. L.* supradiapophysial lamina; *Spoz. L.* suprapostzygapophysial lamina; *Sprz. L.* supraprezygapophysial lamina.

posterior one. A typical section around the center of a single spine is indicated in the accompanying diagram (Fig. 39). Not any of these laminæ extend to the summits of the single spines, but to a point slightly over half way from the zygapophyses to the summits. The latter are rounded or subtriangular in transverse profile; they are thicker antero-posteriorly at the edges than at the median line. The

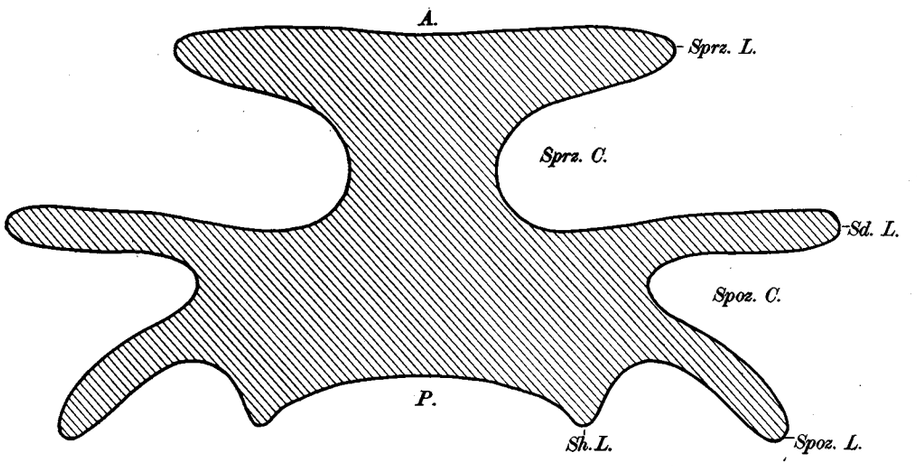

Fig. 39. Horizontal section of a posterior dorsal spine of *Camarasaurus supremus* Cope.

About one-half natural size. *Sd. L.* supradiapophysial lamina; *Sh. L.* suprahyposphenal lamina; *Spoz. C.* suprapostzygapophysial cavity; *Spoz. L.* suprapostzygapophysial lamina; *Sprz. C.* supraprezygapophysial cavity; *Sprz. L.* supraprezygapophysial lamina.

anterior and posterior surfaces of the summits of the single spines, as well as their superior surfaces, are distinctly rugose; from each one of these summits a pair of rugose processes extends outward, backward and downward, meeting the superior extremities of the supradiapophysial laminæ. The anterior and posterior surfaces of the single spines, between the lateral laminæ and below the rugose summits, are covered with rugose areas. These rugosities are broad superiorly where they merge into those of the

summits. Inferiorly they are very narrow, their borders converging in the inferior direction and meeting slightly above the zygapophyses. These conspicuous rugosities evidently served for attachment areas of powerful intervertebral ligaments.

The anterior divided spines, while supported by the same laminæ as the posterior single spines, differ from the latter considerably in structure and function. The summits of the metapophyses are somewhat rugose, but their median surfaces, and the superior surfaces of the parts of the spines between them, are smooth and rounded. The spinal notches, or divisions, are a direct continuation of the same structures in the cervicals; they evidently served as riding-places for large median dorsal muscles. The anterior and posterior surfaces of the spines, below the notches, have small rugosities which probably served as attachment areas for intervertebral ligaments. The small rugosities on the summits of the metapophyses may have served a similar purpose, or may have been attachment areas for muscle strands.

The great breadth of the spines is a distinguishing feature of the genus *Camarasaurus*.

Prezygapophyses.— The prezygapophyses are large in the entire dorsal series, and with the postzygapophyses and the hyposphen-hypantrum articulations, described below, form powerful intervertebral articulations. They are large and are supported superiorly by the supraprezygapophysial laminæ, posteriorly by the horizontal laminæ, and inferiorly, the direction of greatest stress, by stout infraprezygapophysial laminæ.

In the anterior portion of the dorsal series the prezygapophyses are inclined downward toward each other and toward the median line. In the posterior dorsal region they have a tendency to approach horizontality. This is not equally evident in all four of the series of dorsals in the Cope Collection, and may have varied among individuals of the same sex or opposite sexes, or among the different species. The transition from the highly inclined position in Dorsal 1 to the almost horizontal position in the dorso-sacral is very gradual. The effect on the bones of distortion and crushing makes this character very marked and very difficult to evaluate.

In Dorsals 1, 2, and 3 the prezygapophyses are situated far apart; in the remainder of the dorsal series they are very close together. There is no transition from one condition to the other, but an abrupt change. This feature, together with others of a similar character, has a morphological significance which will be discussed below.

Postzygapophyses.— The postzygapophyses resemble their anterior mates in many respects. They are large and strong; they are braced from above by the suprapostzygapophysial laminæ, and in some cases by suprahyposphenal laminæ as well, from in front by the horizontal laminæ, and from below by the stout infrapostzygapophysial laminæ; they are supported from the median direction by the bases of the hyposphens; in the anterior dorsal region they are highly inclined, and in the region near the sacrum, in three of the four series, they approach horizontality. In Dorsals 1 and 2 the postzygapophyses are far apart; in Dorsal 3 and the succeeding members of the series they are close together. The significance of this will be discussed below.

Hyposphen-hypantrum Articulations.— In addition to the zygapophysial articulations, the vertebræ of part of the dorsal series in the Sauropoda are locked together by *hyposphen-hypantrum* articulations. These consist of the *hyposphens*, which are processes extending downward from points between the postzygapophyses, and the *hypantra*, which are processes situated below the prezygapophyses.

The hyposphens are absent on Dorsals 1 and 2. Dorsal 3 has one in a fully developed condition, and each succeeding true dorsal, as shown in the specimens in which preservation is complete, has a similar one. The dorso-sacral appears to have none, or at most, a very weakly developed one. Each

hyposphen extends downward from a point between the postzygapophyses. Immediately below the latter structures the hyposphens are narrow in transverse diameter, but below the narrow parts they expand rapidly, forming massive articular structures. Each hyposphen supports a pair of articular surfaces on its exterior and superior borders. These articular surfaces are continuous with the postzygapophyses. They face outward at the narrow portion of each hyposphen, and obliquely outward and upward below this point.

The hypantra are absent in the first three dorsals, but are present in Dorsal 4 and the succeeding true dorsals; they are faintly developed in the dorso-sacral. Each hypantrum consists of a pair of articular surfaces, situated below the prezygapophyses, usually on thickened portions of the infraprezygapophysial laminæ. The hypantral articular surfaces are continuous with the prezygapophyses, their superior portions facing the median line of each vertebra between these structures. The larger portion of each articular surface, however, faces obliquely downward and inward, approximately at right angles to the prezygapophyses.

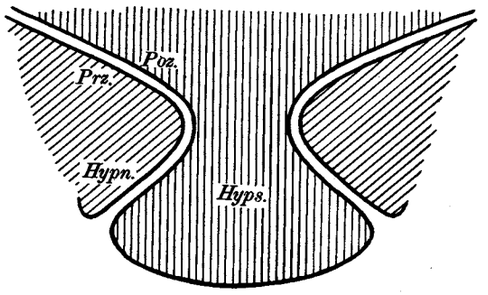

Fig. 40. Articular apparatus of *Camarasaurus* dorsal vertebræ.

Diagrammatic representation of the interlocking articular structures of two dorsal vertebræ, *Hyph.* hypantrum; *Hyps.* hyposphen; *Poz.* postzygapophysis; *Prz.* prezygapophysis. The hypantrum and prezygapophyses of one vertebra interlocking with the hyposphen and postzygapophyses of the next anterior vertebra.

Each hyposphen fits in between the two hypantra of the succeeding vertebra, the narrow portions of the former fitting between the upper portions of the latter, and the superior surfaces of the hyposphen against the inferior surfaces of the hypantrum. This articular complex is illustrated in the accompanying diagram (Fig. 40). The effects of crushing and distortion have modified their appearance in many of the specimens, and they are not always easily identifiable in each figure.

These hyposphen-hypantrum articulations form powerful accessories to the zygapophyses in locking the vertebræ together. In fact they are rather more effective than the latter, as they absolutely prevent lateral motion, and also the anterior vertebra rising with respect to the posterior one. The zygapophyses prevent the posterior one rising with respect to the anterior one. The combination of zygapophysial plus hyposphen-hypantral articulation greatly hinders, or renders impossible except to a very slight extent, any motion other than in an antero-posterior direction. This makes the particular portion of the spinal column where the structures under consideration are located, especially strong and rigid.

Diapophyses.— The diapophyses are especially large and strong in the dorsals; they are rather long throughout the series, especially in the anterior region. In three of the series represented or identified in the collection herein described (Series II, III, and IV), the diapophyses extend outward and only very slightly upward. In the other series (Series I), the diapophyses extend upward at an appreciable angle,

as well as outward. In making this statement due consideration has been given to the effects of crushing. It appears highly probable that the degree of inclination varied among different individuals, and perhaps species, of *Camarasaurus*.

The diapophyses are supported superiorly by the supradiapophysial laminæ, anteriorly and posteriorly by the anterior and posterior blades of the horizontal laminæ, and inferiorly by the infradiapophysial laminæ. The latter are single or double, according to their positions in the column, the anterior ones being double, and the posterior ones single. In some cases additional support is given by accessory laminæ.

The tubercular facets face outward and very slightly downward in the anterior dorsals, and directly outward in the posterior dorsal region. They differ in this respect, to a marked degree, from *Diplodocus*, in which many of these facets face directly downward.

Parapophyses.— The parapophyses, on which are situated the capitular rib facets, are well developed in the *Camarasaurus* dorsals. They vary considerably in position in different members of the dorsal series. In Dorsal 1 they are situated on the sides of the centrum. In this bone in Series I they are poorly preserved, but appear to be situated in front of the pleurocœls, and slightly above them. In Series II Dorsal 1 is not represented. In Series III only the left parapophysis is preserved in Dorsal 1, and it is situated below the pleurocœl, as in the cervicals. In Series IV the parapophyses of Dorsal 1 are situated in front of, and slightly above, the anterior ends of the pleurocœls. This variation indicates different degrees of progress of the process, which is characteristic of the Sauropoda, of cervicalization of the dorsal vertebræ.

In Dorsal 2 the parapophyses are situated slightly higher. They are only represented in two of the series of dorsals (Series III and IV), but in both of these they are shown to be about on a level with the superior borders of the centra. In the second dorsal of Series III the greater portion of each parapophysis is situated above the centrum, but the lower edge is still below the level of the superior border of the centrum. In the second dorsal of Series IV the parapophyses are situated somewhat lower, being mostly below the level of the superior borders of the centrum. In each case they are supported chiefly by the infraprezygapophysial laminæ, and not directly by the centrum. They also receive some support from the infraprediapophysial laminæ.

The parapophyses of Dorsal 3 are characteristic; they are present in this vertebra in Series I, II and III, and by their location and characters make the identification of Dorsal 3 an easy task; they are large and prominent; they are located midway between the level of the superior borders of the centrum and that of the prezygapophyses; they rest upon the infraprezygapophysial laminæ, and in some respects comprise external processes of these structures. Viewed from in front they appear to increase the lateral diameter of the neural arch. The parapophyses are connected with the diapophyses by the infraprediapophysial laminæ. These laminæ therefore support the parapophyses from above as well as the diapophyses from below.

In Dorsal 4 and the succeeding dorsals, up to and including Dorsal 10, the parapophyses are situated on a level with the prezygapophyses. They are supported from the posterior direction by the horizontal laminæ, and from below by the infraprezygapophysial laminæ. They comprise part of the thick masses of bone which are also made up of the bases of the prezygapophyses and of the hypantra. The capitular facets face obliquely outward, downward and slightly forward in the anterior dorsal region, and more nearly directly outward in the vicinity of the sacrum.

The parapophyses are not preserved in any of the dorso-sacrals in the material under discussion.

Judging from other material the dorso-sacral has its parapophyses situated somewhat lower than those of the posterior true dorsals. In the type of *Camarasaurus* (*Morosaurus*) *lentus* (Marsh), (Yale Mus. No. 1910), the parapophyses appear to have been large and to have been composed of elements rising from both neural arches and centrum, similar to the transverse processes of the caudals. This condition is suggested in the dorso-sacral of Series III of the material herein described (Amer. Mus. Cope Coll. No. $\frac{5761}{D-X-138}$). This suggestion is especially strong in the anterior and posterior aspects of the bone (see Plate LXXII, No. 11, *A* and *C*). A study of a sacrum from Wyoming in the American Museum collections (Amer. Mus. No. 690) throws some light on this question. This specimen undoubtedly belongs to *Camarasaurus*, though possibly not to *C. supremus;* it has two dorso-sacrals, one, in front of the primary sacrals, highly specialized as an ilium-supporting vertebra, the other, anterior to this one, retaining most of the structures characteristic of the dorsals. The connection of the latter vertebra with the remainder of the sacrum is very weak. The ribs of this vertebra are attached to it directly by their tubercular processes only. Their capitular processes join the ribs of the other dorso-sacral; their distal extremities are in contact with the ilia. The capitular facets of this vertebra are free, not articulating with the ribs. In the posterior dorso-sacral of this specimen, which is homologous with the dorso-sacrals in the Canyon City Cope material, the parapophyses are low in position, evidently resting directly upon the centrum.

There appears to be a tendency in the dorso-sacrals for the positions of the parapophyses to become lower and lower according to the amount of support given by these vertebræ to the ilia. This tendency is based upon mechanical factors involved in the support of the ilia. These factors will be discussed in connection with the description of the sacrum.

Neural Arches.— The neural arches of the dorsal vertebræ of *Camarasaurus* are comparatively low. They consist, at the anterior borders, largely of the infraprezygapophysial laminæ. These laminæ, in some of the vertebræ, rise a considerable distance above the centra. In a similar manner the arches are largely composed posteriorly of the infrapostzygapophysial laminæ. Broad infradiapophysial laminæ separate from each other cavities on the sides of the arches. In the region from Dorsal 4 to Dorsal 10, inclusive, these laminæ are single, as they are in the dorso-sacral also, when they are present. They do not extend the entire distances from the diapophyses to the centra, but end from 10 to 15 cm. above the latter, leaving the portions of the arches below as slightly convex walls. The cavities are known as infraprezygapophysial or infrapostzygapophysial, according to their positions below the pre- or postzygapophyses, or in other words, anterior or posterior to the infradiapophysial laminæ; they are bounded superiorly by the horizontal laminæ. The latter are usually single, but in some cases, such as Dorsal 5 of Series II (Amer. Mus. Cope Coll. $\frac{5761}{D-X-107}$), they are double in the prediapophysial region. The two cavities on each side are excavated by deep pits in some of the dorsals, but this character is much less pronounced than in some other genera. In some cases accessory laminæ cross the posterior cavities and lend additional support to the diapophyses by providing a means of transmission of stress from the bases of the diapophyses to the powerful infrapostzygapophysial laminæ. In other cases accessory laminæ add strength in various ways, but without any regularity either in the members of one series or among the series.

In the first three dorsals the infradiapophysial laminæ are composed of two blades, anterior and posterior. In Dorsal 1 these blades converge immediately below the diapophyses, but in Dorsals 2 and 3 they meet much farther down. Together they cover deep infradiapophysial cavities. The anterior blades are much shorter than the posterior ones; they extend from the parapophyses upward

and backward to the posterior blades. In this position, in each vertebra, they served to transmit thrusts from the bases of the diapophyses to the infraprezygapophysial laminæ. The posterior blades are longer, and in some cases stouter; they extend the entire distances from the diapophyses to the centra. In the first three dorsals the infrapostzygapophysial laminæ are relatively small and weak, part of their usual functions being performed by the infrapostdiapophysial laminæ.

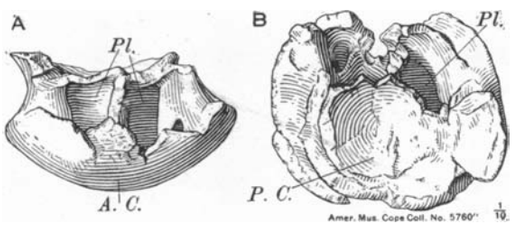

Fig. 41. Centrum of dorsal vertebra of *Camarasaurus supremus* Cope.

Position in the series not definitely known (Amer. Mus. Cope Coll. No. $\frac{5760''}{D\text{-}X\text{-}160}$). (A) superior view, with superior wall removed, (B) posterior view, with part of posterior wall broken away; one-tenth natural size. The character of the interior of the bone is well shown. *A. C.* anterior convexity; *P. C.* posterior concavity; *Pl.* pleurocœl.

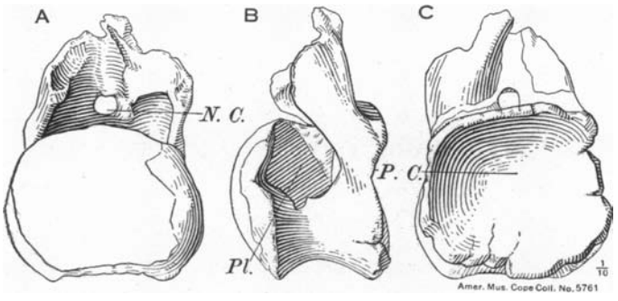

Fig. 42. Fragmentary dorsal vertebra of *Camarasaurus supremus* Cope.

Position in the series not definitely known (Amer. Mus. Cope Coll. No. $\frac{5761}{D\text{-}X\text{-}152}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *N. C.* neural canal; *Pl.* pleurocœl; *P. C.* posterior concavity.

Centra.— The centra of the *Camarasaurus* dorsals are characteristic. They are large, especially in the vertical and transverse diameters, in proportion to those of *Apatosaurus* and *Diplodocus;* they are all opisthocœlous. The anterior balls are present in all the dorsals, but their convexity is greater in the anterior region than back near the sacrum. There is no abrupt change from nearly flat to strongly convex anterior central surfaces as in *Apatosaurus* and *Diplodocus.*

The centra in general are relatively long, especially in Series I. The length is not nearly so great in Dorsals 1 and 2, however, as it is in *Diplodocus.*

Pleurocentral cavities, or pleurocœls, are present in all the dorsals. The external openings vary greatly in size and shape; they are situated on the upper portions of the sides of the centra. Internally they occupy most of the bodies of the centra, the walls of the latter being thin, possibly excepting the anterior balls, which may be solid. The walls are much thicker, however, than those of the corresponding structures in *Barosaurus* and *Diplodocus.*

Neural Canals.— The neural canals in the anterior members of the dorsal series are small and subcircular in outline. Near the sacrum the canal is expanded vertically; the transition from small subcircular outline to elongate oval is gradual.

Special Features

The dorsal region of *Camarasaurus*, considered as a whole, exhibits certain characters which are distinctive of the genus in particular, and some which are shared with other genera. Of the latter characters some illustrate certain mechanical factors in the evolution of the Sauropoda sufficiently well to deserve special discussion.

The notable generic characters of these dorsals have been described above. They may be summarized as follows: short, broad, strong spines, with broad triangular anterior and posterior rugosities, and in some cases suprahyposphenal laminæ, and without pre- or postspinal laminæ; relatively low neural arches; three dorsals with parapophyses below the level of the prezygapophyses; vertical and transverse diameters of the centra very large; length of centra considerable throughout, but not very much greater in the anterior region than in the posterior; general massive and powerful appearance combined with special lightening features.

Several characters illustrating mechanical adaptations appear to be correlated with each other in function. In the evolution of the Sauropoda the cervical series appears to have been increased at the expense of the dorsal series, several of the ancestral anterior dorsals having been taken into the neck. In a similar way the lumbar region has been taken over by the dorsals, so that the latter now articulate directly with the sacrum. In a number of genera of the Sauropoda the process of cervicalization of the dorsals appears to have still been in progress when the group became extinct. In *Barosaurus* and *Diplodocus* this process reached its maximum, in *Apatosaurus* and *Camarasaurus* it had progressed to a considerable degree, while in *Haplocanthosaurus* a more primitive condition was retained.

In *Camarasaurus* Dorsal 1 has the structure of a cervical vertebra rather than that of a typical dorsal. It resembles Cervical 13 far more than it resembles any of the other dorsals. Dorsal 2 is intermediate in structure between D. 1 and D. 3, and Dorsal 3 is intermediate between D. 2 and D. 4. From D. 4 back the gradation in structure is exceedingly gradual, and in Dorsals 8, 9 and 10 it is scarcely noticeable at all. Dorsals 1 and 2 undoubtedly bore dorsal ribs and belonged to the dorsal series; their cervical-like structure therefore requires an explanation. All of the vertebral articular structures anterior to those between Dorsals 3 and 4 are such as will admit of free movement. The large and widely spaced zygapophyses, the absence of great spinal rugosities for the attachment of powerful interspinous ligaments, the absence of hyposphenal articulations, all point toward flexibility rather than rigidity. The low positions of the parapophyses, and consequent wide spaces between the capitular and tubercular facets on the ribs, and also the deeply notched condition of the spines, do not necessarily involve free motion, but they in no way act against it.

The articulation between Dorsals 3 and 4 is firmly fixed, the zygapophyses being close together, and the hyposphenal structures being powerfully developed. Back of this point all the dorsals have this type of articulation, which makes for rigidity rather than mobility. The spines are still deeply notched in Dorsals 3 and 4, but they are slightly shallower than in 1 and 2, and the interspinal rugosities begin to assume considerable proportions. Shortly back of this point the spines are single and the interspinal rugosities cover large areas and are very rough. The capitular as well as the tubercular rib facets are high in this region.

It appears from this that in *Camarasaurus* there were *two distinct presacral regions, one mobile and the other fixed.* The mobile region included the head, the cervicals and the first two dorsals, while the fixed region included the remainder of the dorsals. The great median groove between the metapophyses of the cervicals and of the anterior dorsals evidently lodged a large mass of longitudinal muscles. This

mass was evidently attached to the axis at one end, and Dorsal 8 at the other, with intermediate attachments on the intervening cervicals and dorsals. This muscle mass was thickest in the region from Cervical 10 to Dorsal 3, inclusive, tapering out from this region to its anterior and posterior extremities.

In respect to the cervicalization of the anterior dorsals, and the acquirement of mobility in the anterior dorsal region compared with rigidity in the posterior region, *Camarasaurus* has progressed a considerable amount beyond the condition of *Haplocanthosaurus*, but is slightly primitive with respect to *Apatosaurus*, and very primitive with respect to *Barosaurus* and *Diplodocus*.

Measurements

SERIES I (Plate LXX)

Dorsal	Specimen No.	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses	Height of Vertebra, Total	Length of Centrum, Total	Length of Centrum, Without Ball
1	5760′ / D–X–134	98.5 cm. *e.*	45.0 cm.	38.5 cm.	61.5 cm.	....	....
2	5760′ / D–X–133	Not complete	enough to obtain	measurements			
3	5760′ / D–X–132	97.0 *e.*	47.0	33.0	72.0	28.5 *e.*	18.0 *e.*
4	5760′ / D–X–131	92.0 *e.*	30.0 *e.*	29.5	72.0 *e.*	....	....
5	5761 / D–X–130	76.0 *e.*	28.0	26.5	70.5	....	....
6	5760′ / D–X–129	67.5	27.5 *e.*	23.5	85.0 *e.*	35.0	25.0
7	5760′ / D–X–128	74.0	25.0	25.0	89.0 *e.*	30.5	23.0
8	5760′ / D–X–127	76.5	....	24.0	92.5 *e.*	18.0 *inc.*	....
9	5760′ / D–X–126	63.0	25.5 *e.*	24.0	90.0 *e.*	26.0	19.0
10	5760′ / D–X–125	75.5 *e.*	29.0	24.0	91.0 *e.*	25.5	19.0
D–S	5760′ / D–X–124	67.0 *e.*	....	....	....	25.0 *e.*	17.5 *e.*

SERIES II (Plate LXXI)

Dorsal	Specimen No.	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses	Height of Vertebra, Total	Length of Centrum, Total	Length of Centrum, Without Ball
1	5761–*a* / D–X–105	109.0 cm. *e.*	45.0 cm.	....	....	23.0 cm.	....
2	Reconstruction						
3	5761–*a* / D–X–106	95.0 *e.*	34.0	31.0 cm.	....	23.5 *d.*	....
4	5761 / D–X–119	81.5 *d.*	25.5 *e.*	28.0	74.0 cm. *d. e.*	31.0	....
5	5761 / D–X–107	87.0	32.0 *e.*	34.5	72.0	28.5	....
6	5761 / D–X–108	82.0	32.5	33.5	76.0	24.5	18.0 cm.
7	5760′ / D–X–114	74.0 *e.*	33.5	31.0 *e.*	87.0	29.5	22.5
8	5760″ / D–X–109	73.0 *e.*	32.0	29.5	84.0	30.0 *e.*	23.0 *e.*
9	5761 / D–X–135	....	32.0 *e.*	36.0	92.5	24.0	17.0
10	5761 / D–X–117	63.0 *e.*	31.0	36.0	95.5	21.5	....
D–S	5761–*a* / D–X–118	....	31.0	28.0	100.5	20.0	....

SERIES III (Plate LXXII)

Dorsal	Specimen No.	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses	Height of Vertebra, Total	Length of Centrum, Total
1	5761 / D–X–110	....	50.5 cm. *e. d.*	56.0 cm. *e.*	....	34.0 cm. *e.*
2	Reconstruction					
3	5761 / D–X–112	105.5 cm. *d.*	41.0 *e. d.*	37.5 *d.*	54.0 cm. *d.*	36.0 *e. d.*
4	Reconstruction					
5	5761–*a* / D–X–136	83.5 *e.*	33.0	32.0	....	29.3
6	Reconstruction					
7	5761 / D–X–137	....	35.0	35.0	84.0	24.5 *e.*
8	5761–*a* / D–X–123	77.0	26.0	27.0	93.5 *d.*	....
9	5761 / D–X–116	....	34.0	30.0	91.5	26.0
10	5761 / D–X–150	Too badly broken to measure				
D–S	5761–*a* / D–X–138	....	31.0 *e.*	27.0 *e.*	91.0	23.5 *e.*

SERIES IV (Plate LXXIII)

Dorsal	Specimen No.	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses	Height of Vertebra, Total	Length of Centrum, Total
1	5761–*a* / D–X–104	130.0 cm. *e.*	55.0 cm. *e.*	45.0 cm. *e.*	....	24.0 cm.
2	Reconstruction					
3	5761 / D–X–111	89.0 *e.*	40.0	28.0	66.0 cm.	31.0 *d.*
4	5761–*a* / D–X–102	....	33.0 *e.*	31.5 *e.*	....	25.0
5	5760″ / D–X–113	97.0 *e.*	35.0 *e.*	35.5	78.5	28.0
6	5761–*a* / D–X–120	....	29.0 *e.*	31.5	99.0	24.0
7	5761 / D–X–122	....	26.5	29.5	88.5	26.0
8	5761–*a* / D–X–115	....	35.0	31.0	88.5	25.0
9	5760″ / D–X–103	....	36.0 *e.*	....	....	....
10	5760″ / D–X–101	....	32.0 *e.*	27.5 *e.*	90.0	25.0
D–S	5760′ / D–X–121	84.0 *e. d.*	35.0 *e. d.*	25.5 *d.*	98.0	29.0 *e. d.*

SACRUM

Material and Association.— Only one sacrum is preserved in the *Camarasaurus* material from Canyon City, with the exception of a fragment of a sacral rib attached to one of the ilia. This sacrum is one of the "yellow series" of bones; its association with other material is unknown, but it makes very close fits with the two best preserved ilia in the collection (Amer. Mus. Cope Coll. Nos. $\frac{5761}{\text{II. 1}}$ and $\frac{5761}{\text{II. 2}}$). Its preservation is good; it is somewhat distorted and a few structures are slightly incomplete, otherwise it is in excellent condition.

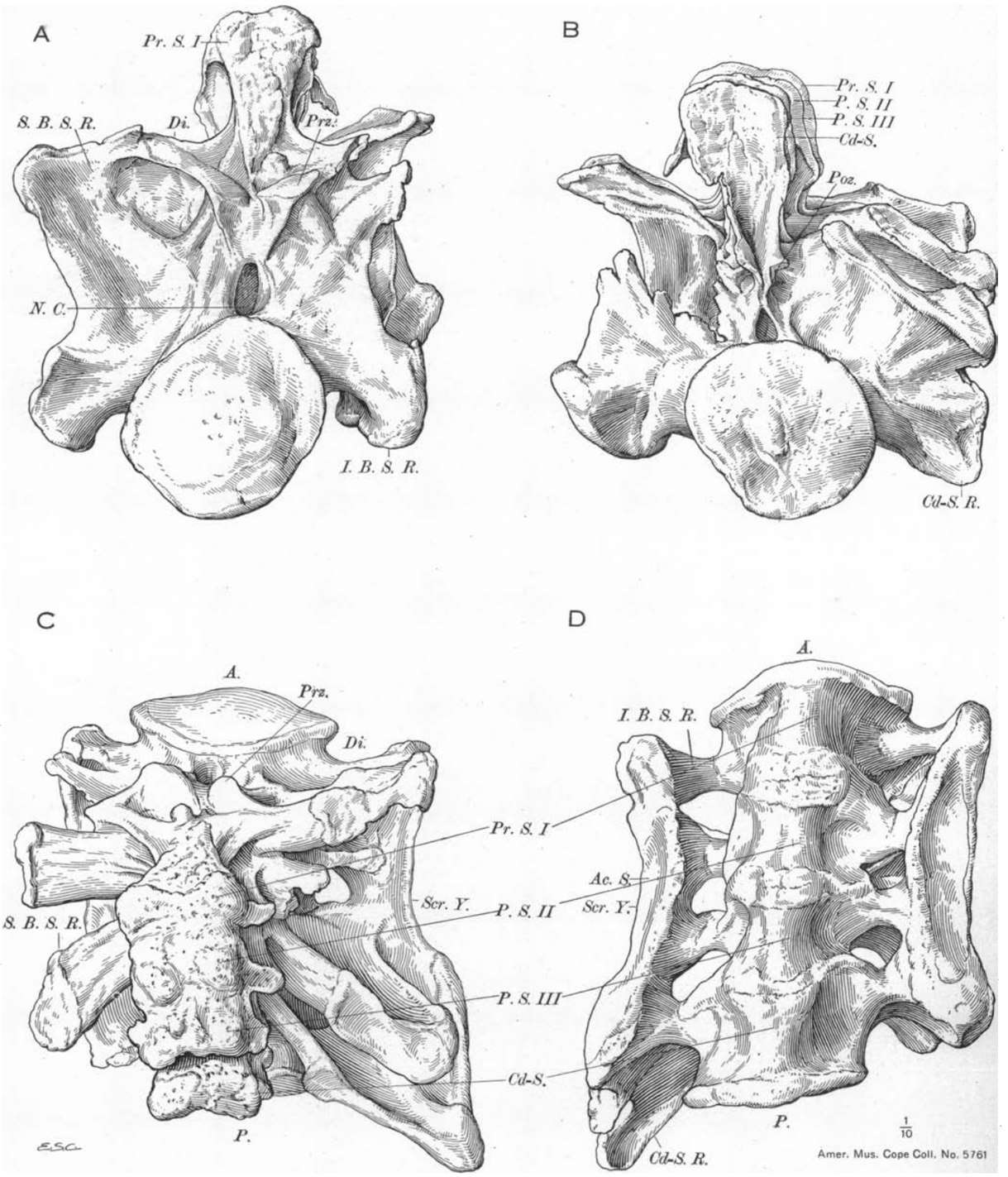

Fig. 43. Sacrum of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. 5761. (A) anterior view; (B) posterior view; (C) superior view; (D) inferior view; one-tenth natural size. *A.* anterior; *Ac. S.* acetabular surface; *Cd-S.* caudo-sacral; *Cd-S. R.* caudo-sacral rib; *Di.* diapophysis; *I. B. S. R.* inferior bar of sacral rib; *N. C.* neural canal; *P.* posterior; *Pr. S. I.* first primary sacral; *P. S. II.* second primary sacral; *P. S. III.* third primary sacral; *Poz.* postzygapophysis; *Prz.* prezygapophysis; *S. B. S. R.* superior bar of sacral rib; *Scr. Y.* sacricostal yoke.

Characters

Composition.— The sacrum in the present specimen is composed of four vertebræ; these include three primary sacrals and one caudo-sacral. A dorso-sacral probably assisted these vertebræ in supporting the ilia, but it was not ankylosed with the first primary sacral, as the anterior articular surfaces of the latter are fully developed and show no indication of having been coössified with the posterior articular surfaces of the vertebra in front of them. The condition of attachment, or ankylosis, of the dorso-sacral with the first primary sacral, in *Camarasaurus*, and probably in all of the Sauropoda, evidently depended upon the age of the individual animal. The presence of but four vertebræ in the sacrum is therefore not a generic character distinguishing *Camarasaurus* from other sauropodous genera, but rather a character indicating incomplete individual development. It is possible that this character taken in connection with size may indicate species in the genus.

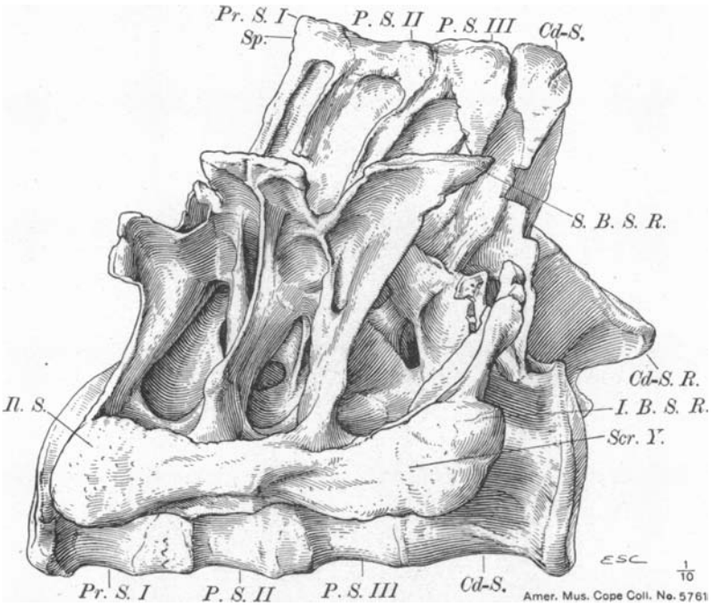

Fig. 44. Sacrum of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. 5761. Lateral view, left side, one-tenth natural size. *Cd-S.* caudo-sacral; *Cd-S. R.* caudo-sacral rib; *I. B. S. R.* inferior bar of sacral rib; *Il. S.* iliac surface; *Pr. S. I.* first primary sacral; *P. S. II.* second primary sacral; *P. S. III.* third primary sacral; *S. B. S. R.* superior bar of sacral rib; *Sp.* spine; *Scr. Y.* sacricostal yoke.

Spines.— The spines of the three primary sacrals (Sacrals 1, 2, and 3), are coössified from their bases to their summits. The spine of the first primary sacral has a prominent anterior rugosity, also strong supraprezygapophysial laminæ. Both of these structures are absent on the other two primary sacrals. All three of the primary sacrals have prominent suprapostzygapophysial laminæ; these laminæ join the summits in elongated laminar processes which extend outward and downward from the latter as in the dorsals. The primary sacral spines do not have supradiapophysial laminæ. The fused summits present a broadly rounded superior surface, which is highest at the anterior end. The exposed portion of the posterior surface of the third primary sacral spine is rugose.

The spine of the caudo-sacral is free superiorly, but is ankylosed, in its inferior half, with the spine of Primary Sacral 3. The resemblance between the spine of the caudo-sacral and the spines of the anterior

members of the caudal series is very close. The anterior surface of the caudo-sacral spine is concave laterally, and rugose; the superior surface is rounded. There are no well-developed supraprezygapophysial laminæ, but there is a pair of faint elevations which may represent such laminæ in a vestigial condition.

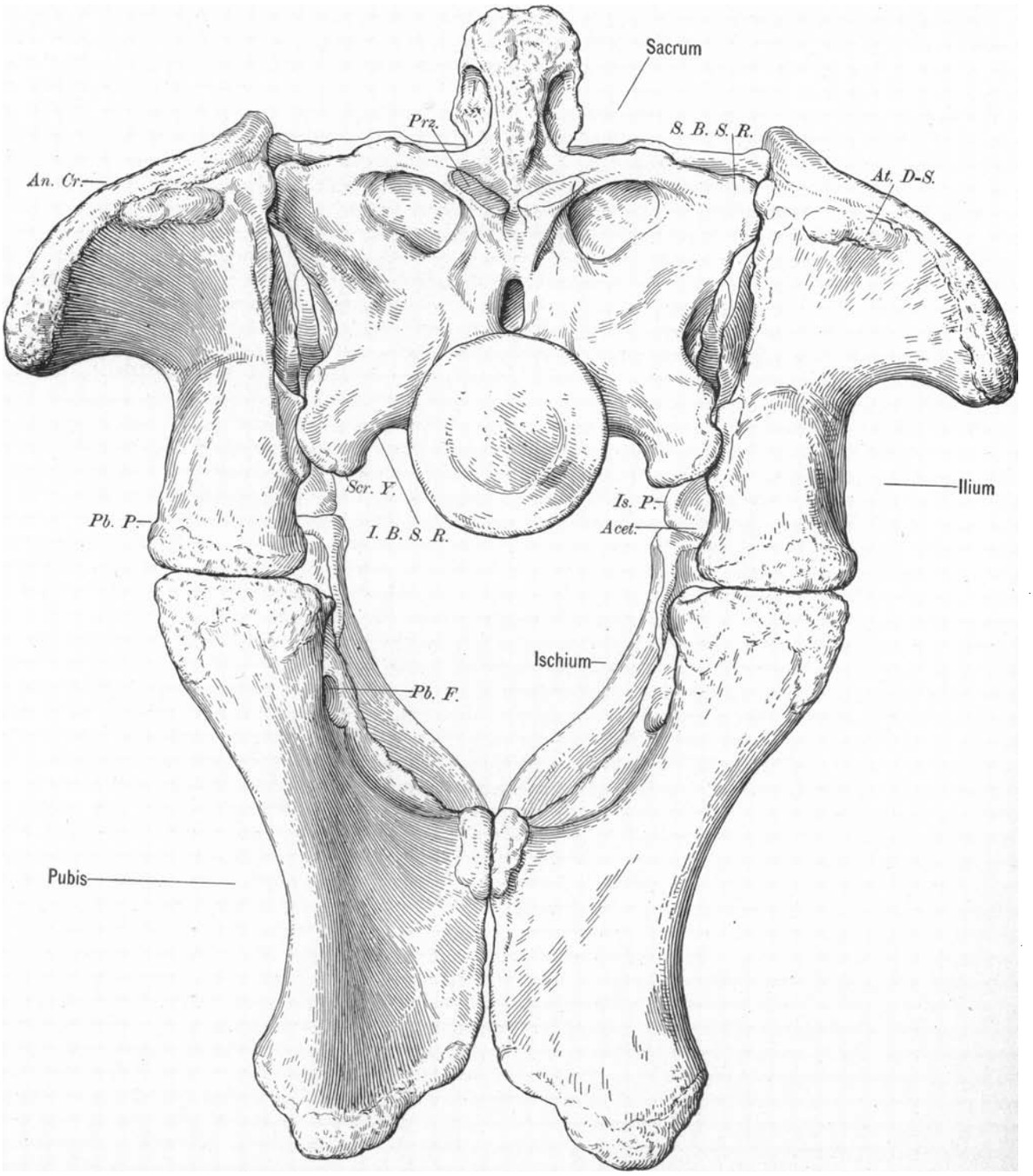

Fig. 45. Pelvis and sacrum of *Camarasaurus supremus* Cope.

The material upon which this reconstruction is based may have belonged to one, two, or three individuals (sacrum, Amer. Mus. Cope Coll. No. 5761; ilia, $\frac{5761}{Il.1}$, $\frac{5761}{Il.2}$; pubes, $\frac{5761}{Pb.1}$, $\frac{5761}{Pb.2}$; ischia, $\frac{5761}{Is.1}$, $\frac{5761}{Is.3}$). Anterior view; one-tenth natural size. *An. Cr.* anterior crest; *Acet.* acetabulum; *At. D-S.* attachment area of dorso-sacral; *I. B. S. R.* inferior bar of sacral rib; *Is. P.* ischiadic peduncle; *Pb. F.* pubic foramen; *Pb. P.* pubic peduncle; *Prz.* prezygapophysis; *S. B. S. R.* superior bar of sacral rib; *Scr. Y.* sacricostal yoke. (Compare with Figs. 87 and 88.)

There is also a pair of laminæ which occupy the same position as the supradiapophysial laminæ of the dorsals; these support the caudal ribs from above. The suprapostzygapophysial laminæ are very large and strong; they constitute lateral boundaries to a deep postspinal cavity.

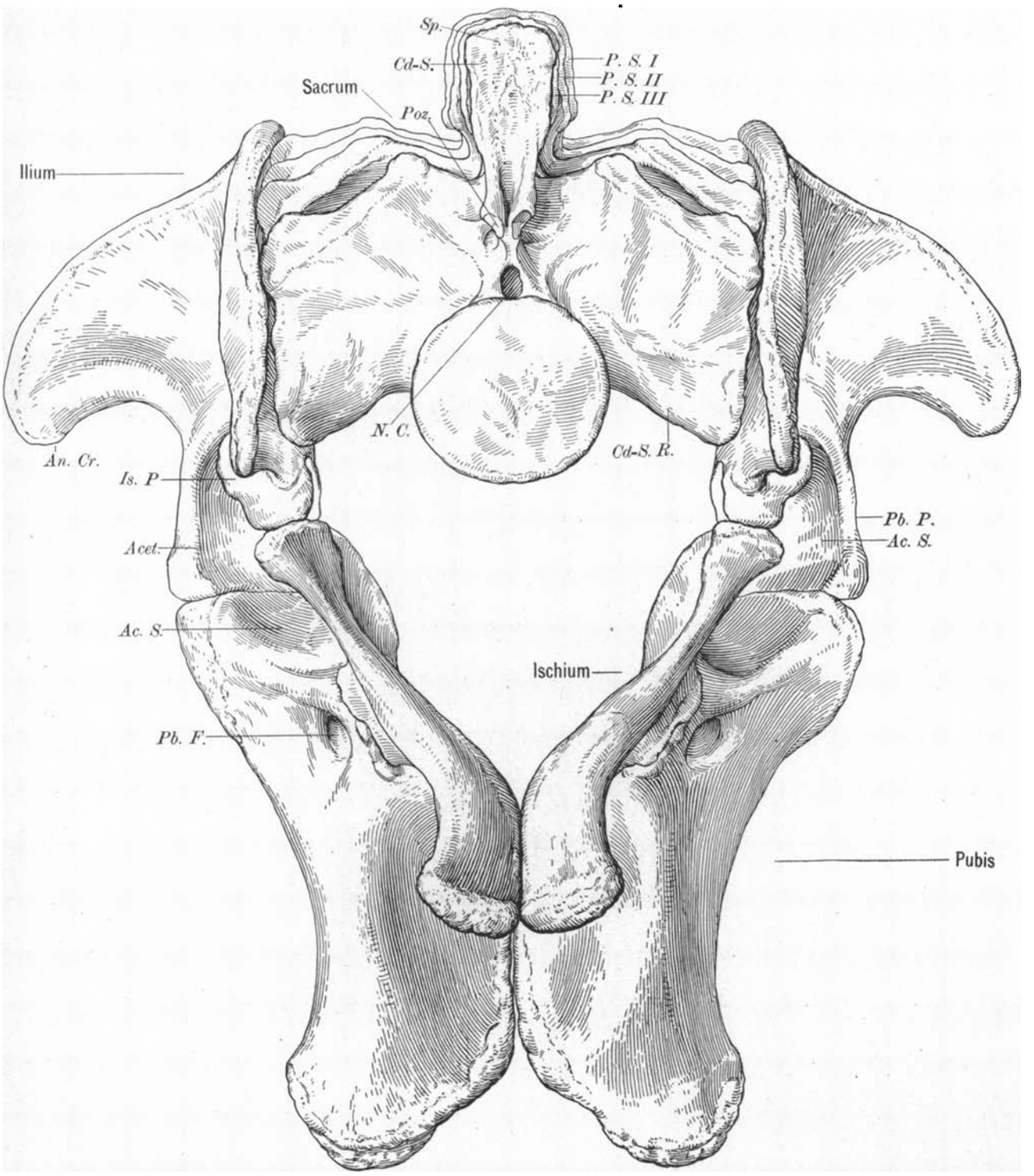

Fig. 46. Pelvis and sacrum of *Camarasaurus supremus* Cope.

The material upon which this reconstruction is based may have belonged to one, two, or three individuals (sacrum, Amer. Mus. Cope Coll. No. 5761; ilia, $\frac{5761}{Il.1}$, $\frac{5761}{Il.2}$; pubes, $\frac{5761}{Pb.1}$, $\frac{5761}{Pb.2}$; ischia, $\frac{5761}{Is.1}$, $\frac{5761}{Is.3}$). Posterior view; one-tenth natural size. *Ac. S.* acetabular surface; *Acet.* acetabulum; *An. Cr.* anterior crest; *Cd-S.* caudo-sacral; *Cd-S. R.* caudo-sacral rib; *Is. P.* ischiadic peduncle; *N. C.* neural canal; *P. S. I.* first primary sacral; *P. S. II.* second primary sacral; *P. S. III.* third primary sacral; *Pb. P.* pubic peduncle; *Pb. F.* pubic foramen; *Poz.* postzygapophysis; *Sp.* spine. (Compare with Figs. 87 and 88.)

Prezygapophyses and Hypantra.— The prezygapophyses are retained complete in the first primary sacral. In this vertebra they are of medium size and are situated close together. The hypantral surfaces are small but distinct. The prezygapophyses are supported by laminæ which are homologous with the same structures in the dorsals, viz., superiorly by supraprezygapophysial laminæ, posteriorly by small horizontal laminæ, and inferiorly by infraprezygapophysial laminæ.

In the other sacrals the prezygapophyses are absent, having been lost in connection with the process of ankylosis of the vertebræ. The position of the zygapophysial articulation between the first and second

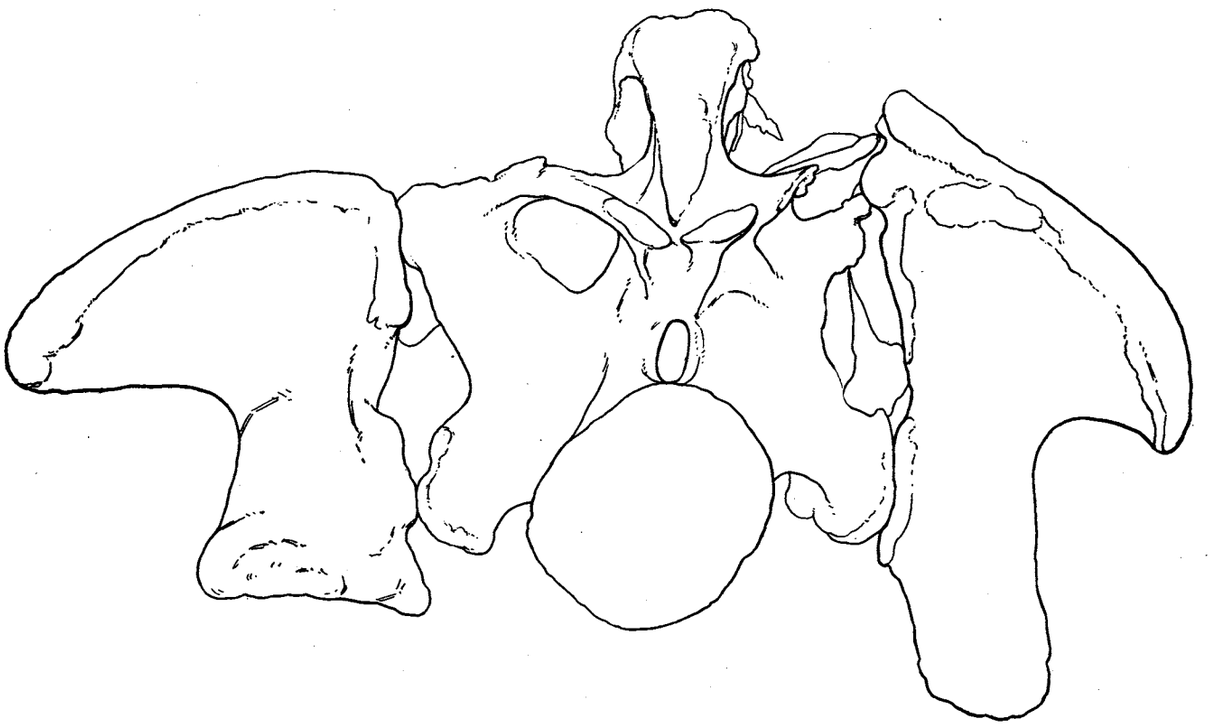

Fig. 47. Ilia and sacrum of *Camarasaurus supremus* Cope.

Outline of bones in position (sacrum, Amer. Mus. Cope Coll. No. 5761; ilia, $\frac{5761}{\text{II.1}}$, $\frac{5761}{\text{II.2}}$). Anterior view, one-tenth natural size. (Compare with Figs. 45 and 46.)

primary sacrals is indicated by a pair of faint ridges, having the outlines of zygapophyses. Between the second and third primary sacrals, and between the third primary sacral and the caudo-sacral, there are no traces of zygapophyses whatever.

Postzygapophyses.— The postzygapophyses are preserved in the caudo-sacral, but have been lost in the primary sacrals. They are relatively small and distinctly curved, their upper portions facing almost directly downward, and their lower portions facing directly outward; they bear a very close resemblance to the postzygapophyses of the caudals. Large suprapostzygapophysial laminæ support them from above, small horizontal laminæ from in front, and the pedicles of the neural arch from below.

Transverse Processes and Ribs.— The articulation of the sacrum with the pelvis exhibits the same degree of complexity as in other sauropodous genera. The first primary sacral has transverse processes which are clearly derivable from the diapophyses of the dorsals. The same is true, though not so clearly, in the case of the second primary sacral and possibly of the third. The transverse processes of the caudo-sacral are clearly homologous with the corresponding structures of the caudals.

The articular processes of the sacrum of the Sauropoda have been discussed by Marsh, Cope, Osborn, Williston, Hatcher, Riggs, and others, and various interpretations of these structures have been suggested. Marsh repeatedly stated that the sacral vertebræ had no ribs. Osborn considered the processes to be partly diapophysial and partly costal. Hatcher considered the superior processes to be diapophyses and the inferior ones to be true ribs. The nature of the articulations is indicated by the sacra of two young individuals, one the type of *Camarasaurus* (*Morosaurus*) *lentus* (Yale Mus. No. 1910), and the other a specimen of *Camarasaurus* (*Morosaurus*), in the Field Museum (Field Mus. No. 5384).

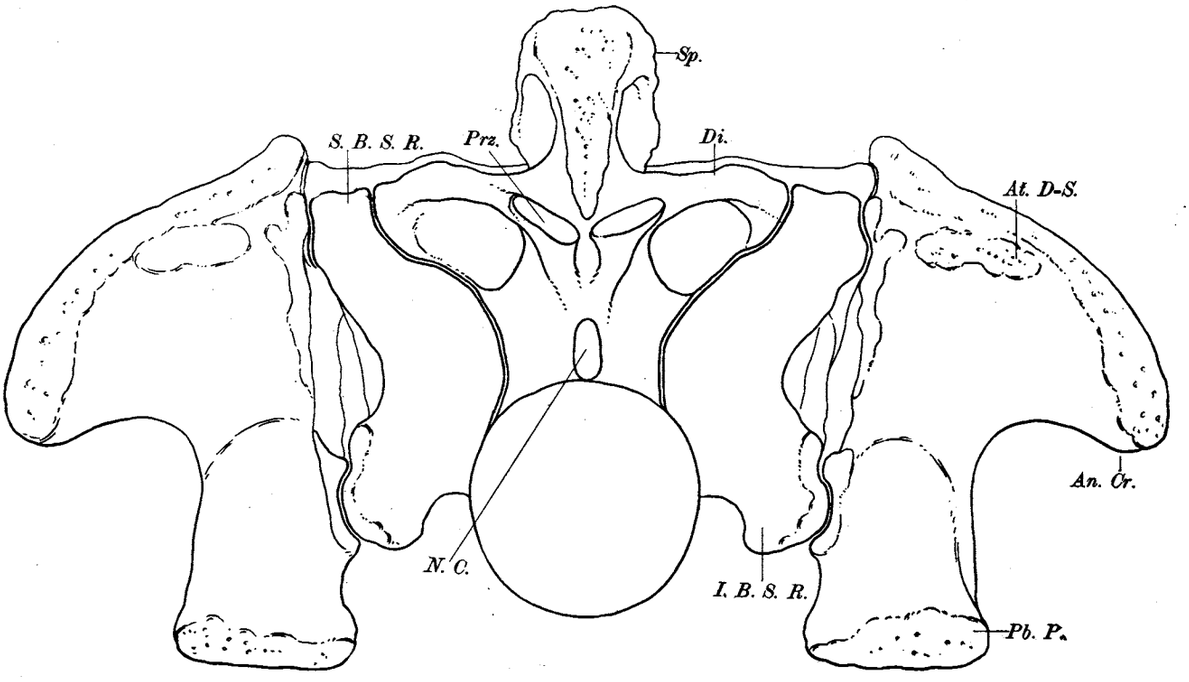

Fig. 48. Ilia, sacrum and sacral ribs of *Camarasaurus supremus* Cope.

Diagrammatic key of sacro-iliac components (based on sacrum, Amer. Mus. Cope Coll. No. 5761; ilia, $\frac{5761}{\text{II. 1}}$, $\frac{5761}{\text{II. 2}}$). Anterior view, one-tenth natural size. *An. Cr.* anterior crest; *At. D-S.* attachment area of dorso-sacral on ilium; *Di.* diapophysis; *I. B. S. R.* inferior bar of sacral rib; *N. C.* neural canal; *Pb. P.* pubic peduncle; *Prz.* prezygapophysis; *S. B. S. R.* superior bar of sacral rib; *Sp.* spine.

It has been figured by Riggs. (1903, plate XLIX.) These young sacra prove conclusively that the inferior processes of the sacral articular apparatus are morphologically ribs. The nature of the superior articular processes is not proven by these specimens, but they point toward a combination of diapophyses plus ribs in the composition of these processes. The articulations between the ribs and the diapophyses have become entirely obliterated in the first primary sacral. The position of this articulation on the right side, in the Cope Canyon City specimen, is indicated by a concavity below the diapophysis, in the position occupied in the dorsals by the foramen between the capitulum and tuberculum of the rib on the one hand, and the vertebra on the other. The same is true of the articulation between the infradiapophysial lamina and the rib. In the second and third primary sacrals the positions of these articulations are not indicated at all. The posterior surfaces of the infradiapophysial laminæ near their inferior borders may possibly locate the position of former boundaries between ribs and vertebræ. The interpretation given the specimen herein described is indicated in the diagram (Fig. 48).

The articular processes of the caudo-sacral are different from those above described. On the right

side there is a single process, which articulated with the ilium throughout its entire distal end. The left process is incomplete; enough of it is preserved to indicate a slightly greater contrast between the upper plate-like portion and the lower massive portion which articulates with the lower ends of the other left sacral ribs to form the left sacricostal yoke. The homology of these processes of the caudo-sacral and the ribs of the caudals is beyond doubt. That they are morphologically ribs is indicated by the young specimen of *C. lentus* above mentioned; in that specimen the processes are entirely distinct from the vertebræ, having been united with them by suture only.

The inferior, or capitular, portions of the ribs are completely coalesced with the centra in all four sacrals and the positions of articulation obliterated. They are broad near the centra, somewhat constricted slightly farther out, and then greatly expanded and fused with each other, forming a pair of stout sacricostal yokes. The lower surfaces of the inferior portions of the sacral ribs are flattened slightly, and not twisted as in *Apatosaurus*. The sacricostal yokes are stout; they articulate with the ilia externally, and inferiorly present a pair of smoothly rounded concave surfaces, which are continuous with the acetabular surfaces of the ilia, and which form the inner portions of the superior boundaries of the acetabula.

The superior portions of the sacral ribs represent the tubercular elements, and the inferior portions the capitular elements.

Neural Arches.— The neural arches are simple. In the primary sacrals they are crossed by vertical infradiapophysial laminæ which extend from the inferior bars of the sacral ribs upward to the diapophyses, and outward to the tubercular portions of the ribs. In the caudo-sacral the neural arch surfaces are largely occupied by the bases of the upper portions of the sacral ribs. The neural arches are firmly fused together, but have slit-like openings leading into internal cavities. These openings indicate the boundaries of the respective vertebræ.

Centra.— The centra of the four sacrals are about equal in length. Those of the first primary sacral and the caudo-sacral are about equal in height and breadth. The second and third primary sacrals have centra which are apparently of the same height as the first primary sacral and the caudo-sacral, but of lesser width.

The sides of the centra are largely covered by the capitular portions of the sacral ribs. There are no external pleurocœlia. In an early description Cope described this sacrum as being solid. Marsh attacked this statement, and said that the sacra of the Sauropoda were always hollow. No sections have ever been made of these centra, so it is at present impossible to confirm or deny either of these statements.

The inferior surfaces of the centra are broadly rounded, contrasting with the sharply keeled centra of *Diplodocus*.

Neural Canals.— The neural canals in the first primary sacral and the caudo-sacral agree in size and shape with those of the dorso-sacrals and the anterior caudals. The small openings between the neural arches of the various sacrals lead to internal cavities of relatively large size. The sacral portion of the spinal cord was evidently larger than any other portion of the neural system. The shape of the sacral nerve cavity is not determinable to any degree of exactness, but it is apparently similar to that of *C.* (*Morosaurus*) *lentus* as figured by Marsh.

Measurements

Amer. Mus. Cope Coll. No. 5761 (Text Figs. 43 and 44)

Diameter of four spines, antero-posterior	41.5 cm.
Length of right sacricostal yoke	62.0
Length of left sacricostal yoke	62.5
Length of four centra	79.5
Breadth across sacricostal yoke, anterior end	67.5
Breadth across sacricostal yoke, posterior end	79.0
Height of Primary Sacral I, anterior end (measured obliquely)	93.5

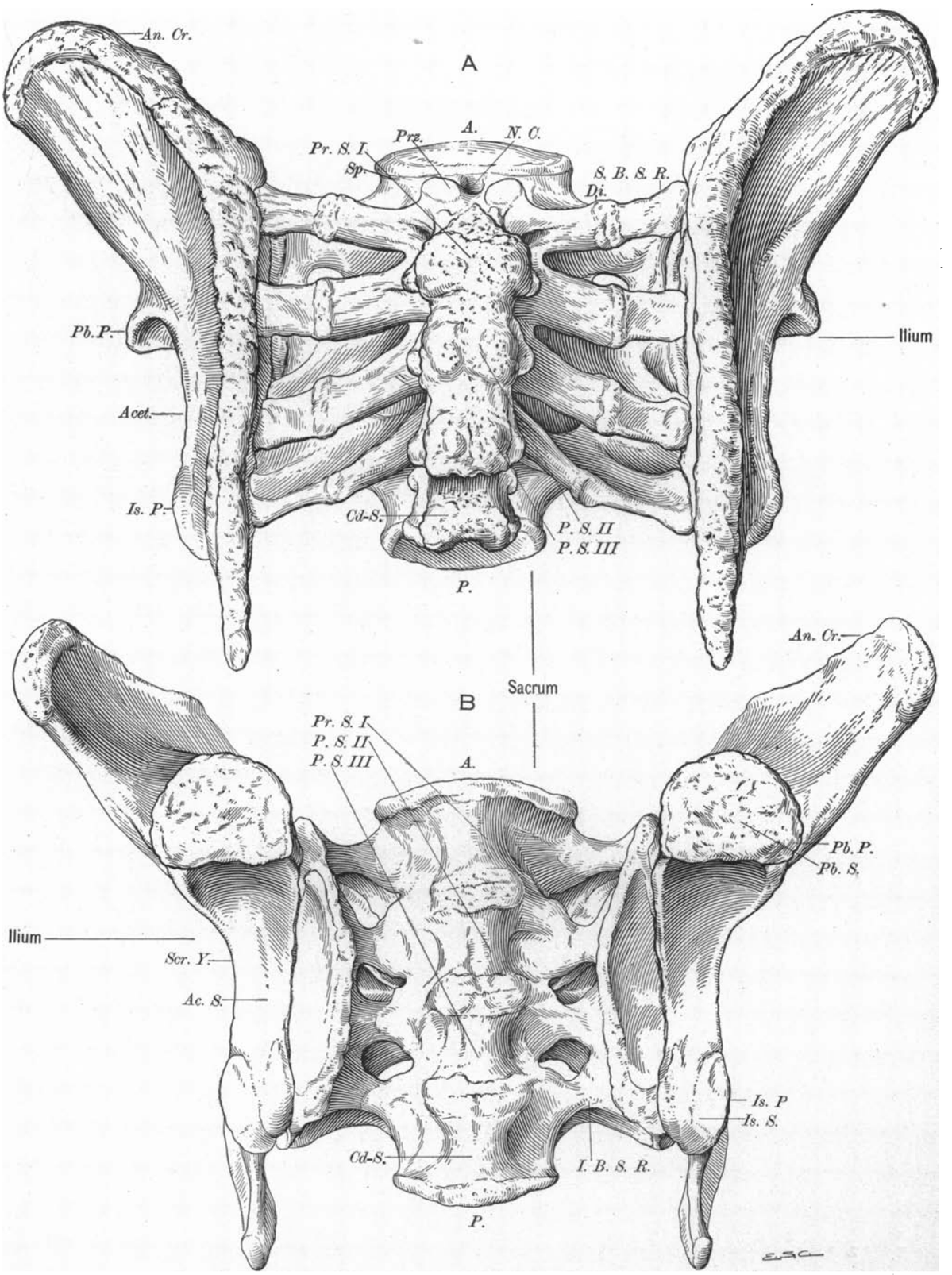

Fig. 49. Sacrum and ilia of *Camarasaurus supremus* Cope.

Reconstructions (based on sacrum, Amer. Mus. Cope Coll. No. 5761; ilia, $\frac{5761}{\text{Il. 1}}$, $\frac{5761}{\text{Il. 2}}$). (A) superior view; (B) inferior view; one-tenth natural size. *A.* anterior; *Ac. S.* acetabular surface; *Acet.* acetabulum; *An. Cr.* anterior crest; *Cd-S.* caudo-sacral; *Di.* diapophysis, *I. B. S. R.* inferior bar of sacral rib; *Is. P.* ischiadic peduncle; *Is. S.* ischiadic surface; *N. C.* neural canal; *P.* posterior; *Pb. P.* pubic peduncle; *Pb. S.* pubic surface; *Pr. S. I.* first primary sacral; *P. S. II.* second primary sacral; *P. S. III.* third primary sacral; *S. B. S. R.* superior bar of sacral rib; *Scr. Y.* sacricostal yoke; *Sp.* spine.

CAUDAL VERTEBRÆ

General Discussion

Material and Association.— About one hundred caudal vertebræ are present in the collection. They clearly belong to at least four individuals and probably they represent at least two more. No assistance was available from field records. The bones were evidently badly scattered, so a field map would have helped little if one had been available. When the caudals are arranged in four series they take their places quite naturally, in a manner comparable to that of the dorsals. The broken and distorted character of these bones has made the problem of their identification especially difficult. It is highly probable that the identifications are very nearly correct in every case, and absolutely correct in many cases. It is of course entirely possible that some of the vertebræ included in these series may belong to a fifth individual, and it is very likely that all of the vertebræ in one series do not belong to the same individual. It is considered that these series represent, as nearly as it is reasonably possible, true morphological series, and as such, give a fairly accurate idea of the tail of *Camarasaurus*. The discussion and arrangement are made provisional upon the possible future discovery of a complete *Camarasaurus* tail in place. The caudals are illustrated in Plates LXXIV–LXXVII.

Number.— The number of vertebræ in the *Camarasaurus* tail is not definitely known. The material in the collection now described contains one caudal vertebra which appears to be Caudal 46, and several which have been estimated to belong in the region from C. 40 to C. 45. The tail of one of the cotypes of *Camarasaurus* (*Morosaurus*) *grandis* (Marsh), (Yale Mus. No. 1901), has a long, but incomplete series of caudals, the last of which is evidently at least as far back as C. 50, and perhaps further. A well preserved section of a *Camarasaurus* tail in the American Museum collections (Amer. Mus. No. 825) has thirty-two caudals which appear to be a continuous series. The first of these caudals has a small transverse process, and is the only vertebra in the lot which does have such a process. It is therefore estimated as being anywhere from Caudal 10 to C. 14, inclusive. This would make the last one C. 41 to C. 45. This has the appearance of being a terminal caudal, as its posterior end differs considerably from its anterior one. This tail appears to have belonged to a relatively young individual, and may possibly not have attained its full number of caudals. Then again, the number may have varied considerably among the various species of the genus, and to a certain extent among the individuals of one species. The presence of a long, slender whip-lash, like that of *Diplodocus*, is doubtful. From the characters of the Yale specimen, and from the material under discussion, it seems highly probable, however, that *Camarasaurus* may have had a more primitive whip-lash, of moderate length. An estimate of fifty-three as the number of caudals in the tail of *Camarasaurus* would probably be very close to the true number. Such an estimate is provisionally made.

Characters

Size and Shape.— The first caudal is very large, being practically the same size as the last sacral. From this vertebra back to the end of the tail there is a steady decrease in the vertical and transverse diameters. The last caudal represented in any of the series, which appears to be C. 46, is extremely small. The antero-posterior diameters decrease much more gradually. For about half the length of the tail they appear to be of uniform length, although the mid-caudal vertebræ are slightly shorter than the uncrushed anterior ones. From the middle of the tail back they decrease gradually but steadily

until Caudal 44 is between one-third and one-fourth the length of Caudal 1. The centra are relatively broad and high in proportion to their length, and the neural arches are very low.

Spines.— The spines are of moderate height in the anterior caudal region, and they gradually decrease in the posterior direction until they disappear as separate structures in the vicinity of Caudal

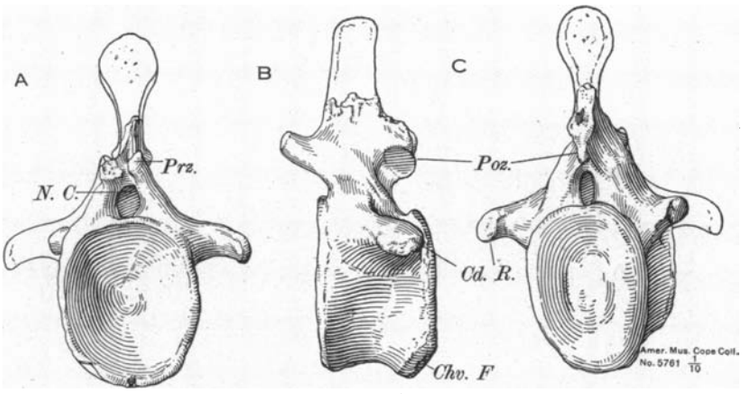

Fig. 50. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 10, estimated (Amer. Mus. Cope Coll. No. $\frac{5761}{Cd\text{-}X\text{-}5}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *Cd. R.* caudal rib; *Chv. F.* chevron facet; *N. C.* neural canal; *Poz.* postzygapophysis; *Prz.* prezygapophysis. Reconstructed parts in outline.

30. They are supported anteriorly and posteriorly by suprapre- and suprapostzygapophysial laminæ in the anterior caudal region. These laminæ disappear in the region about Caudal 20. In the anterior caudal region the spines are broader at their summits than at their bases. The transverse profiles of the summits are in some cases broadly rounded, in other cases subacuminate. In the region from Caudal 13 to C. 30 the spines are narrow. The antero-posterior diameters of the anterior spines are not great; they increase relatively in the posterior direction, so that the posterior spines are flat and plate-like,

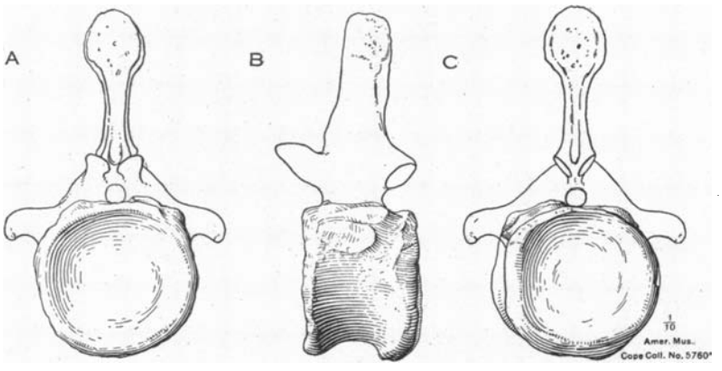

Fig. 51. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 11, estimated (Amer. Mus. Cope Coll. No. $\frac{5760'}{Cd\text{-}Y\text{-}5}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. Reconstructed parts in outline.

instead of being equidimensional longitudinally and transversely. The antero-posterior profile in the anterior caudal region is roughly rounded. Further back the spines are bounded superiorly by straight horizontal lines, the spines projecting backward slightly behind the postzygapophyses.

In the anterior caudal spines the anterior, posterior, and superior surfaces are strongly rugose, probably in connection with the attachment of strong interspinous and supraspinous ligaments. The superior rugosities die out quickly in the posterior direction, while the anterior and posterior rugosities gradually decrease and die out in the vicinity of Caudal 25. The first two caudal spines, and in Series I the third as well, have lateral rugosities as well as those just mentioned. These probably served for the attachment of muscles which extended back from the dorsal region and sacrum.

The anterior spines of the caudal series are practically vertical in position, while those farther back are inclined slightly backward. Throughout most of the series the caudal spines overhang the centra posteriorly.

Prezygapophyses.— The prezygapophyses are fairly well developed throughout the tail of *Camarasaurus*, at least as far back as Caudal 38, and were probably functional as far back as the region of C. 45; they decrease in size regularly from the anterior region to the posterior; they are all situated on pedicles which extend forward beyond the anterior borders of the centra; they face upward and inward throughout the entire series; they are supported superiorly by supraprezygapophysial laminæ and inferiorly by the walls of the neural arches. There are no horizontal laminæ as in the cervicals and dorsals.

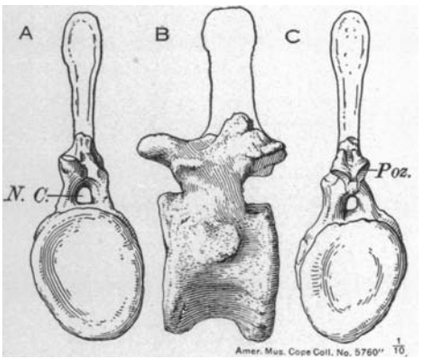

Fig. 52.

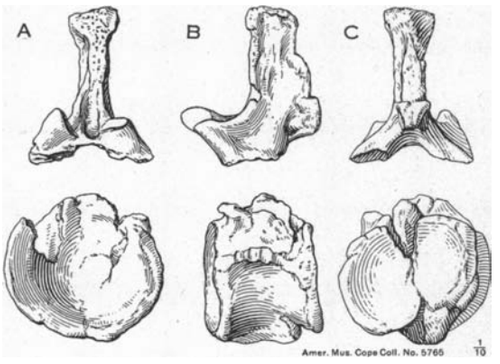

Fig. 53.

Fig. 52. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 12, estimated (Amer. Mus. Cope Coll. No. $\frac{5760''}{Cd\text{-}o\text{-}2i}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *N. C.* neural canal; *Poz.* postzygapophysis. Reconstructed portions in outline.

Fig. 53. Caudal vertebra, referred to *Camarasaurus supremus* Cope, originally part of the type of *Amphicœlias latus* Cope.

Caudal 13, estimated (Amer. Mus. Cope Coll. No. $\frac{5765}{Cd\text{-}A\text{-}i}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. New original figure of *A. latus* type.

Postzygapophyses.— These structures are situated at the bases of and slightly beneath the spines. They face downward and outward. In the posterior caudal region, in which the spines are absent, the postzygapophyses are supported on pedicles which extend upward and backward from the neural arches, one pedicle for each pair of postzygapophyses. Throughout the series of at least forty, probably forty-four or forty-five, caudals which have these structures, the postzygapophyses overhang the posterior surfaces of the centra. In the first two caudals they are supported inferiorly by median vertical plates which may be called INTRASPINOUS LAMINÆ. Posterior to Caudal 2 they are supported merely by the posterior edges of the walls of the neural arches.

Transverse Processes.— The transverse processes are present from Caudal I to the vicinity of Caudal 13. They differ fundamentally from the processes of the cervicals and dorsals in being neither dia-

pophyses nor parapophyses, nor combinations of the two. Morphologically they are single-headed ribs which have become ankylosed with their respective vertebræ. This is not indicated directly by the material herein described, but is clearly shown by the type of *Camarasaurus* (*Morosaurus*) *lentus* (Yale Mus. No. 1910). In Caudal 1 they are highly modified, functioning to a certain extent as ilium-supporting structures. This vertebra therefore might be considered as a second caudo-sacral. The processes in this vertebra are preserved in three specimens; they are longer than those of the succeeding caudals, and are very much stouter, especially at their distal extremities. These extremities are very massive, and are directed or curved sharply forward. They evidently assisted in supporting the ilia.

These transverse processes, or ribs, are much smaller in the vertical diameter in the first caudal than in the caudo-sacral, but are much larger than in any other caudal. In Caudals 1 and 2, and to a slight extent in C. 3, the superior supports of the processes have horizontal superior, as well as obliquely sloping, borders. These superior borders in every case make angles with the upward sloping borders, the intersection of the borders making prominent shoulders. These shoulders are absent in the caudals posterior to C. 3. The caudal ribs, or transverse processes, posterior to C. 3 are simple in character and gradually decrease in size; they die out in the vicinity of Caudal 13, the point varying slightly in different individuals.

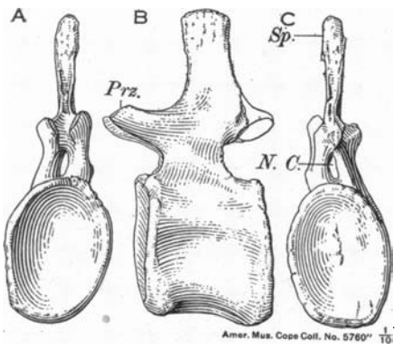

Fig. 54.

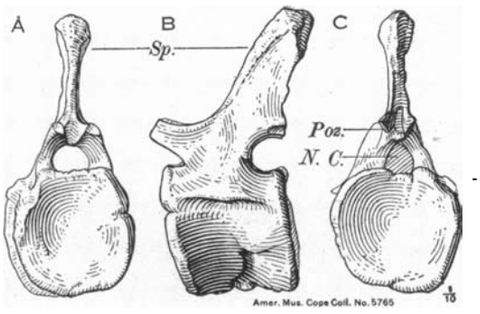

Fig. 55.

Fig. 54. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 14, estimated (Amer. Mus. Cope Coll. No. $\frac{5760''}{Cd\text{-}o\text{-}15}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *N. C.* neural canal; *Prz.* prezygapophysis; *Sp.* spine. Reconstructed portion in outline.

Fig. 55. Caudal vertebra referred to *Camarasaurus supremus* Cope, originally part of the type of *Amphicœlias latus* Cope.

Caudal 15, estimated (Amer. Mus. Cope Coll. No. $\frac{5765}{Cd\text{-}A\text{-}2}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *N. C.* neural canal; *Poz.* postzygapophysis; *Sp.* spine.

Neural Arches.— The neural arches of the entire caudal series are low and simple in structure. The arches are not divided into separate portions as in the dorsals and cervicals, there being no diapophyses nor the supporting laminæ usually associated with them. The walls of the arches themselves form the only inferior supports to the zygapophyses. It is not known exactly how far back in the tail the neural arches extend. There are broken borders in the caudal estimated as C. 42 in Series III. From evidence exhibited by remains of closely related forms (Yale Mus. No. 1901 and Amer. Mus. No. 825), it appears that they must have extended to a point within two or three vertebræ from the end of the tail. The last four or five of these arches, however, were probably vestigial in form, being merely pairs of elevations on the superior surfaces of the centra, without osseous connecting roofs.

Centra.— The centra are broad and high, and of medium length in the anterior caudal region. They gradually decrease in breadth and height until in the terminal caudal they are small rod-like structures; they remain practically constant in length from Caudal 1 to the region between C. 30 and C. 36; from that point back they decrease gradually until at the end of the tail they are estimated to be about one-third as long as in Caudal 1. In the last caudal in this material, which is estimated to be C. 46, the length of the centrum is about two-fifths as long as that of C. 1. The centra in the anterior caudals are slightly procœlous, or amphicœlous, that is, they have anterior concavities and posterior convexities or

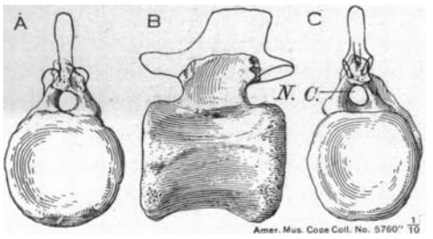

Fig. 56.

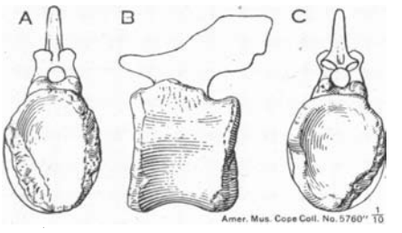

Fig. 57.

Fig. 56. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 22, estimated (Amer. Mus. Cope Coll. No. $\frac{5760''}{Cd\text{-}o\text{-}17}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. *N. C.* neural canal. Reconstructed portion in outline.

Fig. 57. Cotype caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 23, estimated (Amer. Mus. Cope Coll. No. $\frac{5760''}{Cd\text{-}o\text{-}28}$). (A) anterior view; (B) lateral view, left side; (C) posterior view. Reconstructed portion in outline. (Compare with Fig. 11.)

anterior and posterior concavities. None of these characters are very pronounced, the modifications of *Camarasaurus* in this respect being primitive compared with *Apatosaurus* and *Diplodocus*.

Inferiorly each centrum presents a concave antero-posterior profile. The chevrons articulate between successive caudals, and small articular surfaces are occasionally observable at the angles between the anterior and inferior, and posterior and inferior surfaces, respectively. The first two or three, possi-

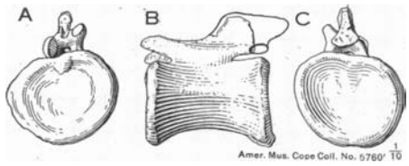

Fig. 58

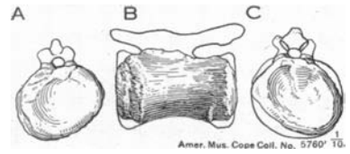

Fig. 59

Fig. 58. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 28, estimated (Amer. Mus. Cope Coll. No. $\frac{5760'}{Cd\text{-}Y\text{-}8}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. Reconstructed portions in outline.

Fig. 59. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 30, estimated (Amer. Mus. Cope Coll. No $\frac{5760'}{Cd\text{-}Y\text{-}11}$). (A) anterior view; (B) lateral view, left side (from right side reversed); (C) posterior view; one-tenth natural size. Reconstructed portions in outline.

bly four, caudals were probably without chevrons. From this region back for a considerable distance chevrons were present, but their posterior limit is unknown. They are described below.

Neural Canals.— The neural canals of the caudal vertebræ are small and gradually decrease in size in the posterior direction. The last four or five vertebræ, perhaps more, probably lodged the spinal cord in grooves rather than in completely enclosed canals.

Special Features

The bones of the tail of *Camarasaurus* are massive rather than light, they differ greatly in this respect from the corresponding bones of *Diplodocus*. The caudals are characterized by expanded summits on the spines, rather weak development of the caudal ribs, or transverse processes (except in Caudal 1), an entire absence of pleurocœls in the centra, and lack of excavation and complex lamination on the neural arches and caudal ribs. The tail is flat, being much higher than wide, but not to the same extent

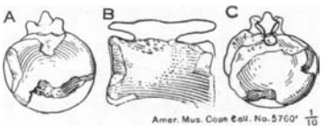

Fig. 60.

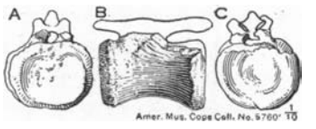

Fig. 61.

Fig. 60. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 32, estimated (Amer. Mus. Cope Coll. No. $\frac{5760'}{Cd\text{-}Y\text{-}18}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. Reconstructed portion in outline.

Fig. 61. Caudal vertebra of *Camarasaurus supremus* Cope.

Caudal 33, estimated (Amer. Mus. Cope Coll. No. $\frac{5760'}{Cd\text{-}Y\text{-}16}$). (A) anterior view; (B) lateral view, left side; (C) posterior view; one-tenth natural size. Reconstructed portion in outline.

as in *Diplodocus*. The rugosities on the sides of the spines of the first two or three caudals evidently served as attachment areas for large muscles which extended from this point forward, and probably for muscles which extended backward as well. The anterior and posterior rugosities, and those upon the summits of the spines, probably anchored strong intervertebral ligaments. Muscles were probably also attached to the ends of the caudal ribs. The chevrons must also have served for the attachment of longitudinal muscles.

The procœlous character of the centra is not so pronounced in the caudals of *Camarasaurus* as in those of *Diplodocus*. This indicates a somewhat lesser degree of flexibility in the tail of the former genus than in that of *Diplodocus*.

Measurements

SERIES I (Plate LXXIV)

Caudal	Specimen No.	Height of Vertebra, Total	Spread of Caudal Ribs	Length of Centrum, Total	Width of Centrum, Anterior	Height of Centrum, Anterior	Width of Centrum, Posterior	Height of Centrum, Posterior
1	5760″ Cd–O–1	87.5 cm. *e.*	....	18.0 cm.	32.0 cm.	....	34.5 cm.	....
2	Reconstruction							
3	5760″ Cd–O–2	77.5	66.0 *e.*	15.5	33.5	35.0	30.5	32.5
4	5760″ Cd–O–3	78.0	59.5	12.5	28.0	29.0	29.5	32.0
5	5760″ Cd–O–4	71.5	58.0	13.5	28.0	29.5	27.0	28.0
6	Reconstruction							
7	5760″ Cd–O–5	....	55.0	14.5	29.5	24.5	27.0	21.5
8	5760″ Cd–O–6	....	48.0 *e.*	11.5	29.0	29.0 *e.*	26.0	25.0 *e.*
9	5760″ Cd–O–9	64.0 *d.*	....	18.5	19.0 *e. d.*	29.0 *e. d.*	16.0 *d.*	26.0 *e. d.*
10	5760′ Cd–Y–3	57.5	52.0	12.0	24.5	25.0	27.5	23.0
11	5760′ Cd–Y–4	....	33.0 *e.*	16.5	24.5	20.0 *d.*	23.0	17.5 *d.*
12	5760″ Cd–O–10	....	....	17.0	20.5	23.0	20.5	21.0
13	5760″ Cd–O–18	....	....	17.0	....	20.5 *d.*	18.5 *d.*	21.5 *d.*
14	Reconstruction							
15	5760″ Cd–O–14	44.5	....	16.5	15.0 *d.*	20.5 *d.*	13.5 *d.*	20.0 *d.*
16	5760″ Cd–O–16	42.0 *e.*	....	16.5	18.0	20.0 *e.*	16.5	19.0 *e.*
17	5760″ Cd–O–23	....	....	17.0 *e.*	17.0 *e. d.*	17.5 *d.*	18.0	17.5 *d.*
18	Reconstruction							
19	5760″ Cd–O–21	....	....	17.5	15.5 *d.*	18.5	14.0 *d.*	18.0
20	5760″ Cd–O–22	....	....	17.0	15.0	19.0 *d.*	14.5	19.0 *d.*
21	Reconstruction							
22	5760″ Cd–O–26	30.5	....	20.0	15.0	17.0	14.5	15.7
23	Reconstruction							
24	5760″ Cd–O–29	....	....	17.5	14.0	17.0	14.0	19.5 *d.*
25	Reconstruction							
26	Reconstruction							
27	5760′ Cd–Y–13	17.0	....	15.5	12.5	11.0	12.5	10.5
28	5760′ Cd–Y–12	....	....	16.5	12.5	11.5	13.5	10.5
29	Reconstruction							
30	Reconstruction							
31	5760′ Cd–Y–19	....	....	12.5	7.5	....	7.0	....

SERIES II (Plate LXXV)

Caudal	Specimen No.	Height, Total	Spread of Caudal Ribs	Length of Centrum, Total	Width of Centrum, Anterior	Height of Centrum, Anterior	Width of Centrum, Posterior	Height of Centrum, Posterior
1	5760′ Cd–Y–X	....	....	....	....	....	....	....
2	Reconstruction	Fragmentary						
3	Reconstruction							
4	5760′ Cd–Y–1	69.5 cm.	56.0 cm.	13.0 cm.	31.0 cm.	31.0 cm.	27.5 cm.	28.5 cm.
5	5760′ Cd–Y–2	64.5	52.0 *e.*	13.0	28.0 *e.*	29.0	25.5	25.5
6	5760′ Cd–Y–III	Very incomplete						
7	Reconstruction							
8	5760″ Cd–O–7	58.0	39.0 *e.*	13.0 *d.*	23.5	25.0	22.0 *d.*	22.0
9	5760″ Cd–O–8	52.5	40.5	12.0	23.0	21.5	21.5	21.0
10	5760′ Cd–Y–6	....	....	16.5	24.5 *d.*	22.0 *d.*	21.5 *d.*	21.0 *d.*
11	5760″ Cd–O–12	50.5 *d.*	25.5 *d.*	16.0	16.5 *d.*	21.5 *d.*	15.5 *d.*	20.0 *e.*
12	5760″ Cd–O–11	48.5	23.0	16.0	18.0 *d.*	18.0	18.0 *d.*	18.5
13	5760″ Cd–O–13	....	....	15.5	20.0	22.5 *d.*	19.5	21.5
14	5760′ Cd–Y–7	....	....	19.0	21.5	20.0 *e.*	21.5	20.0 *e.*
15	5760″ Cd–O–19	45.0	....	14.5	20.5	19.0	18.0	....
16	5760″ Cd–O–24	37.0	....	14.5 *d.*	17.5	18.0	17.5	18.0
17	5760″ Cd–O–25	....	....	14.0	19.0	....	17.5	....
18	5760″ Cd–O–30	....	....	13.0	18.0	....	18.0	....
19	Reconstruction							
20	5760″ Cd–O–27	....	....	18.0	14.5 *d.*	14.0 *d.*	15.0 *d.*	15.0 *d.*
21	5760′ Cd–Y–9	....	....	19.5	....	15.5	14.0	16.0
22	5760″ Cd–O–32	27.0	....	17.0	16.5	15.0	16.0	14.5
23	5760″ Cd–O–31	....	....	17.0	17.0	15.5	16.5	....
24	Reconstruction							
25	Reconstruction							
26	Reconstruction							
27	Reconstruction							
28	5760′ Cd–Y–14	....	....	16.0	11.5	11.5 *d.*	....	10.5
29	5760′ Cd–Y–15	....	....	16.0	11.0	....	....	....
30	Reconstruction							
31	Reconstruction							
32	Reconstruction							
33	Reconstruction							
34	Reconstruction							
35	5760′ Cd–Y–20	....	....	11.5	7.5	....	7.0	....
36	5760′ Cd–Y–21	....	....	11.0	8.0	8.0	7.0	7.0
37	5760′ Cd–Y–22	....	....	12.5	8.0	....	7.5	....
38	5760′ Cd–Y–23	....	....	12.5	....	....	....	....

SERIES III (Plate LXXVI)

Caudal	Specimen No.	Height of Vertebra, Total	Spread of Caudal Ribs	Length of Centrum, Total	Width of Centrum, Anterior	Height of Centrum, Anterior	Width of Centrum, Posterior	Height of Centrum, Posterior
1	5761 Cd–1	81.0 cm. *d.*	73.0 cm. *d.*	25.0 cm.	26.0 cm. *d.*	36.0 cm. *d.*	23.5 cm. *d.*	36.5 cm. *d.*
2	5761 Cd–X–2	84.0	63.0	12.0 *d.*	38.0	38.0	30.5	34.0
3	5761 Cd–3	73.0 *d.*	54.0 *d.*	17.5	31.5 *d.*	33.0	26.0 *d.*	31.5
4	5761 Cd–4	73.5	46.5	15.5	31.0 *d.*	35.0	25.5 *d.*	30.0
5	5761 Cd–5	68.0	49.5	14.0	34.0	31.0	29.5	30.5
6	5761 Cd–6	66.5	....	14.5	27.0	30.0	22.5	26.0
7	5761 Cd–7	63.5	46.0 *d.*	15.0	28.5	30.5	26.5	28.5
8	5761 Cd–8	56.5 *d.*	55.5 *d.*	15.5	38.0 *d.*	27.0 *d.*	34.0 *d.*	26.5 *d.*
9	Reconstruction							
10	5761 Cd–10	....	....	....	....	26.5	....	25.0
11	5761 Cd–11	51.5 *d.*	32.5 *d.*	14.0	29.5	23.5 *d.*	26.0	21.0 *d.*
12	Reconstruction							
13	Reconstruction							
14	5761 Cd–X–11	45.5	....	16.5	19.5	20.5 *e. d.*	17.5	19.0
15	5761 Cd–X–12	40.5	....	16.5	17.0	17.0	17.5	18.0
16	5761 Cd–X–15	....	....	16.5	17.0	16.0	17.0	17.0
17	5761 Cd–X–14	....	....	17.0	17.5	17.5	17.5	17.0
18	Reconstruction							
19	5761 Cd–X–17	30.0	....	15.0	15.0	17.0	15.0	16.0
20	Reconstruction							
21	Reconstruction							
22	5761 Cd–X–19	....	....	16.0	14.5	....	14.5	....
23	5761 Cd–X–20	24.0	....	15.5	13.0	....	12.5	....
24	5761 Cd–X–22	21.5	....	15.5	13.5	13.5	13.0	13.5
25	5761 Cd–X–21	22.0	....	15.0	13.0	13.5	11.5	....
26	Reconstruction							
27	Reconstruction							
28	5761 Cd–X–23	....	....	15.5	12.5	....	12.0	....
29	5761 Cd–X–25	18.0	....	16.5	13.0	12.0	12.5	12.0
30	5761 Cd–X–24	17.5	....	15.5	14.0	....	12.0	....
31	Reconstruction							
32	Reconstruction							
33	Reconstruction							
34	5761 Cd–X–26	15.5	....	13.5	12.0	....	9.5	....
35	Reconstruction							
36	Reconstruction							
37	Reconstruction							
38	Reconstruction							

Caudal	Specimen No.	Height of Vertebra, Total	Spread of Caudal Ribs	Length of Centrum, Total	Width of Centrum, Anterior	Height of Centrum, Anterior	Width of Centrum, Posterior	Height of Centrum, Posterior
39	5761 Cd-X-27	....	....	15.5	12.5	....	12.0	....
40	Reconstruction							
41	Reconstruction							
42	5761 Cd-X-28	....	....	12.0	8.0	....	8.0	....
43	5761 Cd-X-29	....	....	11.0	7.0	....	6.0	....
44	5761 Cd-X-30	....	....	9.5	....	....	....	....

SERIES IV (Plate LXXVII)

Caudal	Specimen No.	Height of Vertebra, Total	Spread of Caudal Ribs	Length of Centrum, Total	Width of Centrum, Anterior	Height of Centrum, Anterior	Width of Centrum, Posterior	Height of Centrum, Posterior
1	5761 Cd-X-1	....	92.0 cm. *e.*	17.5 cm.	35.5 cm.	37.0 cm.	38.0 cm.	35.0 cm.
2	5761 Cd-X-2	77.5 cm. *e.*	69.0 *e.*	10.5	41.5	31.5	40.0	33.5
3	5761 Cd-X-3	81.5 *d.*	61.5	10.0	39.5	37.5	34.5	36.0 *d.*
4	5761 Cd-X-4	81.0	57.5	10.5	38.5	38.5	33.5	36.0
5	Reconstruction							
6	5761 Cd-X-5	70.0	40.0 *e.*	15.5	27.0	36.0 *d.*	21.5	31.5 *d.*
7	5761 Cd-X-6	64.5	42.5	12.5	32.0	27.0	28.0	24.0
8	5761 Cd-9	....	....	....	....	26.5	....	25.0
9	5761 Cd-X-7	60.5	32.0	15.5	21.0 *d.*	27.0	18.0 *d.*	25.0 *d.*
10	Reconstruction							
11	Reconstruction							
12	5761 Cd-X-9	56.0 *d.*	....	17.5	20.5 *d.*	26.5 *d.*	15.5 *d.*	27.0 *d.*
13	5761 Cd-X-10	51.0	....	15.0	23.5 *d.*	23.0	21.0 *d.*	21.0
14	5761 Cd-12	....	....	17.0	16.5 *d.*	23.0 *d.*	18.0 *d.*	22.5 *e.*
15	5761 Cd-X-13	41.5	....	16.5	17.0	19.0	17.0	19.0
16	5761 Cd-13	38.5	....	15.5	16.5	19.0	15.0	18.5
17	5761 Cd-14	....	....	16.5	....	....	....	....
18	5761 Cd-X-16	36.0	....	15.5	16.0	16.5	15.5	16.0
19	Reconstruction							
20	Reconstruction							
21	Reconstruction							
22	Reconstruction							
23	Reconstruction							
24	5761 Cd-X-18	....	....	17.0	15.5	....	15.5	....
25	Reconstruction							
26	Reconstruction							
27	Reconstruction							
28	5761 Cd-15	....	....	17.0	....	....	....	....

EXTRA CAUDALS (Text Figs. 50–52, 54–58, 60, 61)

Caudals	Specimen No.	Height, Total	Spread of Caudal Ribs	Length of Centrum, Total	Breadth of Centrum, Anterior	Height of Centrum, Anterior	Breadth of Centrum, Posterior	Height of Centrum, Posterior
10	5761 Cd–X–8	....	30.0 cm. *e.*	16.5 cm. *d.*	21.5 cm. *d.*	....	16.5 cm. *d.*	....
11	5760′ Cd–Y–5	....	....	16.5	26.0 *d.*	22.0 cm.	24.5 *d.*	21.5 cm.
12	5760″ Cd–O–20	....	....	16.5	17.0	17.0	16.5	16.5
14	5760″ Cd–O–15	46.0 cm. *d.*	....	16.5	15.0 *d.*	20.5 *d.*	13.5 *d.*	20.0 *d.*
15	5765 Cd–A–2	41.0	....	15.5 *d.*	18.5	19.0 *d.*	19.5 *d.*	18.0 *d.*
22	5760″ Cd–O–17	....	....	19.5	17.5	16.5	16.5	16.5
23	5760″ Cd–O–28	....	....	....	....	18.5 *d.*	14.5	17.0 *d.*
28	5760′ Cd–Y–8	....	....	18.5	16.5	12.5	16.0	13.0
32	5760′ Cd–Y–18	....	....	15.0	....	....	....	....
33	5760′ Cd–Y–16	....	....	15.5	12.5	9.5	12.5	....

CHEVRONS

Material and Association.— The chevrons of *Camarasaurus* are represented in the collection by twenty-five specimens, besides some fragments; their original association is unknown. It is possible that some of these may belong to *Amphicœlias;* if so, they are not identifiable. There are no undoubted caudal vertebræ of that genus in the collection, those of the *A. latus* type belonging to *Camarasaurus*, and it is rather unlikely that chevrons would be preserved when caudals were not. The chevrons in the collection therefore are all provisionally referred to *Camarasaurus.* These chevrons have been arranged in four series according to their characters, and no attempt has been made to identify the chevrons of particular individuals, but to combine the material available into reasonable sequences.

Number.— Thirty-five chevrons are estimated to have been present in the skeleton of *Camarasaurus.*

Characters

The chevron bones preserved were all situated in the anterior portions of the various caudal series. They are all stout compared with the corresponding chevrons of *Diplodocus.* The positions assigned to the individual bones are more or less arbitrary, as there is no known completely preserved chevron series of a closely related form which could be used as a guide. Various skeletons of *Apatosaurus* and *Diplodocus* indicated chevrons from C. 3 to C. 7 as the longest in the series. At the present time it is provisionally estimated that the sixth chevron is the longest.

The first two or three chevrons are distinctly Y-shaped, and the inferior blade is no longer than the superior V. The increase in the length of the inferior blade is gradual from the first chevron to the sixth, according to the present estimate; from the sixth backward the length of the blade diminishes steadily to the last chevron in the collection, which is estimated to be C. 16. The articular ends are considerably expanded. The blades are curved backward, in the best preserved specimens. Their anterior and posterior edges are extended into thin laminar flanges, which evidently served for the attachment of caudal muscles.

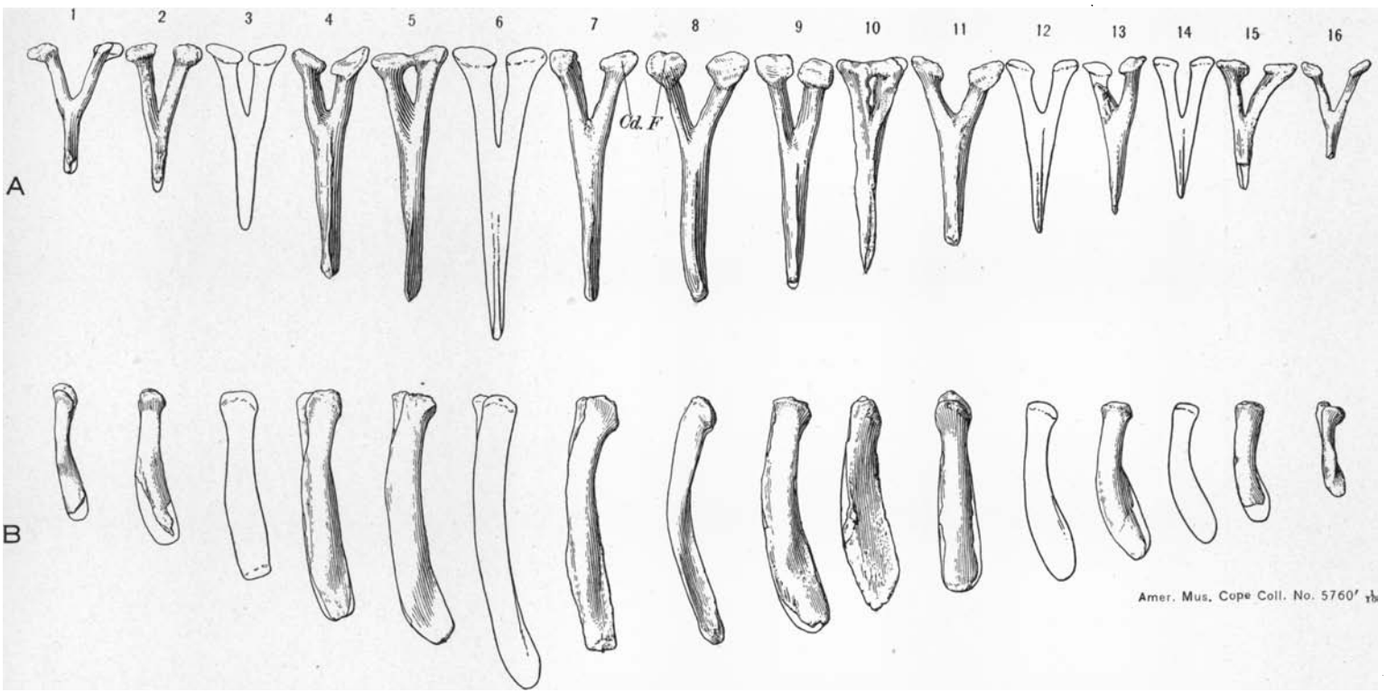

Fig. 62. Chevrons of *Camarasaurus supremus* Cope. Series I.

Amer. Mus. Cope Coll. No. 5760′. (A) posterior views; (B) lateral views, left side; one-tenth natural size. *Cd. F.* caudal facet. Reconstructed chevrons and portions in outline.

Number of chevron in series:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Specimen number:	5760′ Cv. 1	5760′ Cv. 2	Reconstruction	5760′ Cv. 3	5760′ Cv. 5	Reconstruction	5760′ Cv. 9	5760′ Cv. 6	5760′ Cv. 4	5760′ Cv. 12	5760′ Cv. 13	Reconstruction	5760′ Cv. 14	Reconstruction	5760′ Cv. 15	5760′ Cv. 16

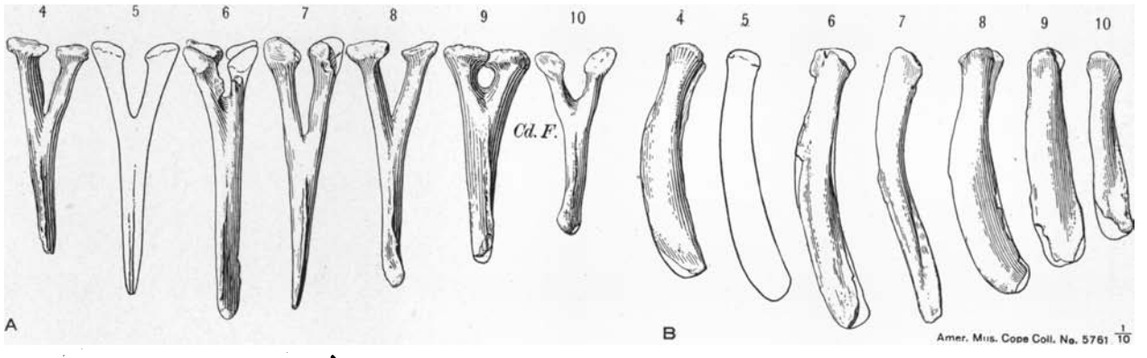

Fig. 63. Chevrons of *Camarasaurus supremus* Cope. Series II.

Amer. Mus. Cope Coll. No. 5761. (A) posterior views; (B) lateral views, left side; one-tenth natural size. *Cd. F.* caudal facet. Reconstructed chevron and portions in outline.

Number of chevron in series:	4	5	6	7	8	9	10
Specimen number:	5761 Cv. 20	Reconstruction	5761 Cv. 22	5761 Cv. 23	5761 Cv. 21	5761 Cv. 24	5761 Cv. 25

Measurements

SERIES I (Text Fig. 62)

Chevron	Specimen No.	Length, Total	Breadth, Proximal End
1	5761 Cv.1	....	14.0 cm.
2	5761 Cv.2	....	11.5
3	Reconstruction		
4	5760′ Cv.3	36.5 cm.	12.0
5	5761 Cv.5	40.5	12.0
6	Reconstruction		
7	5761 Cv.9	40.5	11.5
8	5760′ Cv.6	39.5	16.0
9	5760′ Cv.4	35.5 *inc.*	12.5
10	5761 Cv.12	33.5	9.5
11	5760′ Cv.13	30.5 *inc.*	13.5
12	Reconstruction		
13	5760′ Cv.14	25.0 *inc.*	15.0
14	Reconstruction		
15	5760′ Cv.15	....	13.5
16	5760′ Cv.16	15.0	11.5

SERIES II (Text Fig. 63)

Chevron	Specimen No.	Length, Total	Breadth, Proximal End
4	5761 Cv.7	....	....
5	5761 Cv.8	41.0 cm. *inc.*	....
6	5761 Cv.10	44.5 cm.	13.5 cm.
7	5761 Cv.11	41.5	13.5

SERIES III (Text Fig. 64)

Chevron	Specimen No.	Length, Total	Breadth, Proximal End
5	5761 Cv.17	....	....
6	5761 Cv.18	42.5 cm.	13.5 cm.
7	5761 Cv.19	36.0	14.0

SERIES IV (Text Fig. 65)

Chevron	Specimen No.	Length, Total	Breadth, Proximal End
4	5761 / Cv.20	34.5 cm.	13.5 cm.
5	Reconstruction		
6	5761 / Cv.22	44.5	....
7	5761 / Cv.23	42.5	....
8	5761 / Cv.21	39.5	15.0
9	5760′ / Cv.24	33.0 *inc.*	13.5
10	5761 / Cv.25	21.5	13.0

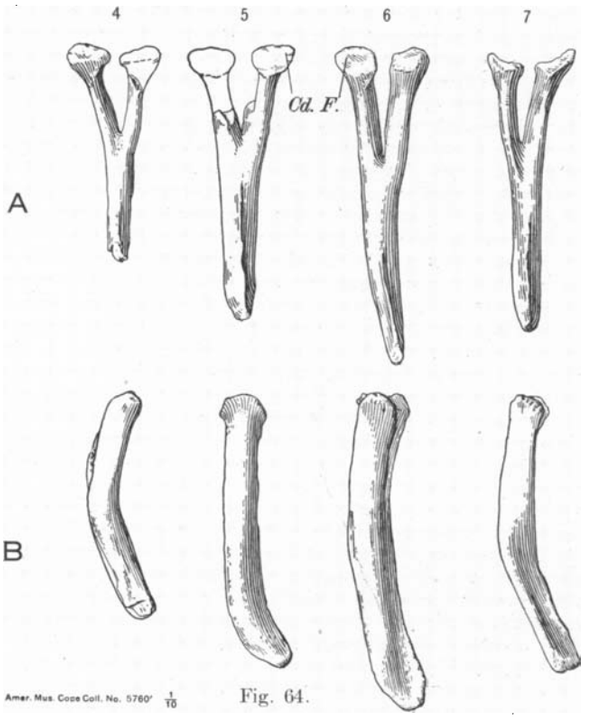

Fig. 64.

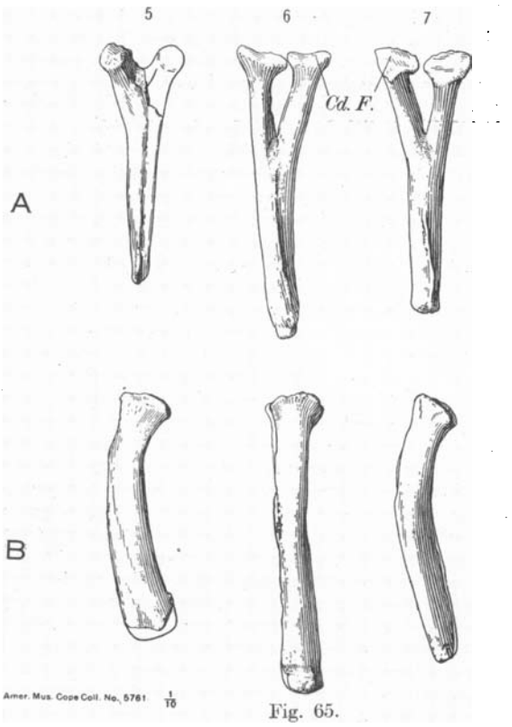

Fig. 65.

Fig. 64. Chevrons of *Camarasaurus supremus* Cope. Series III.

Amer. Mus. Cope Coll. No. 5760′. (A) posterior views; (B) lateral views, left side; one-tenth natural size. *Cd. F.* caudal facet. Reconstructed portions in outline.

Number of chevron in series:	4	5	6	7
Specimen number:	5760′ / Cv.7	5760′ / Cv.8	5760′ / Cv.10	5760′ / Cv.11

Fig. 65. Chevrons of *Camarasaurus supremus* Cope. Series IV.

Amer. Mus. Cope Coll. No. 5761. (A) posterior views; (B) lateral views, left side; one-tenth natural size. *Cd. F.* caudal facet. Reconstructed portions in outline.

Number of chevron in series:	5	6	7
Specimen number:	5761 / Cv. 17	5761 / Cv. 18	5761 / Cv. 19

Sternal Plates

Material and Association.— Two sternal plates are the only representatives of the sternal region of the skeleton in the collection; both are incomplete, being eroded on the edges, but one is much better preserved than the other. They belong to opposite sides and may represent a pair. The color of both plates is reddish, which may indicate that they came from the same quarry as most of the other red bones. Aside from this there is no information whatever as to the association of the plates.

Characters

The better preserved of the two plates is suboval in outline. At one end there is a thickened process; throughout the rest of the bone the thickness is very slight. One border, which is probably the mesial, is nearly straight; the other border converges toward the first at the thin end of the bone; about two-thirds of the distance from the middle of the bone to the thick end, this border makes a rather large angle with the longitudinal axis of the bone. The point of maximum thickness of the thick end is nearer the internal than the external border.

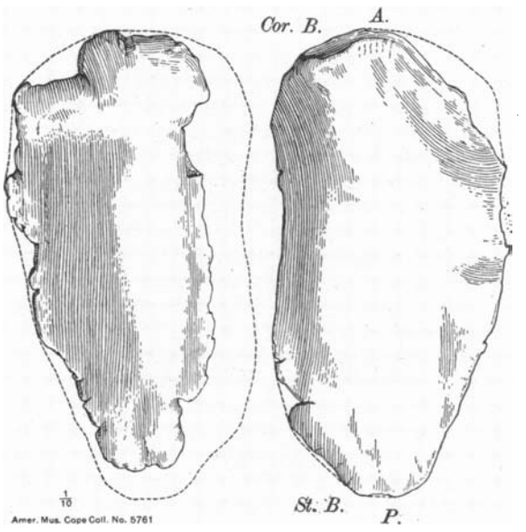

Fig. 66. Sternal plates of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. 5761. Dorsal, or internal, views, estimated; one-tenth natural size. *A.* anterior end; *Cor. B.* coracoid border; *P.* posterior end; *St. B.* sternal border which articulated with other portions of the sternal apparatus, estimated.

It is not possible at the present time to determine with certainty the orientation of the bone in the skeleton. The median and external borders are ascertainable, also the dorsal and ventral surfaces. The identification of the anterior and posterior ends, and consequently of the right and left plates, is uncertain. Various workers on the Suaropoda have differed in placing the thick or the thin borders of the plates anteriorly. In this memoir the thick ends of the plates are provisionally considered to be anterior and the thin ends posterior. The thick anterior processes evidently served for attachment with the coracoids, either directly or through intercalated cartilage. The better preserved plate (Amer. Mus. Cope Coll. No. $\frac{5761}{St.1}$) is then the right, and the other (Amer. Mus. Cope Coll. No. $\frac{5761}{St.2}$) is the left.

Measurements

(Text Fig. 66)

Sternal Plate	Specimen No.	Length, Total	Breadth, Total
Right	5761 St.1	67.5 cm.	33.0 cm.
Left	5761 St. 2	64.5 cm. *inc.*	31.0 cm. *inc.*

Dorsal Ribs

Material and Association.— A large quantity of ribs are preserved in the collection; their original association is unknown. The left ribs are better preserved than the right ones. From forty to sixty-five right ribs and forty-six left ones, which are well enough preserved to be readily identified as to right or left, are present in the collection. Besides these there are numerous ribs which are provisionally referred to carnivores, and a number of small ribs, more or less fragmentary in character. The left ribs exhibit the characters of the costal series so well that the right ones are neither described nor figured, nor are measurements of them given. Most of the left ribs have been arranged in four series, and have been so figured. Several of them did not fit in any of the series, or appeared to duplicate some of the ribs in these series; these have been figured separately. See Plates LXXVIII to LXXXI.

Number.— The number of dorsal ribs in *Camarasaurus* appears to be slightly variable; there are ten besides the rib of the dorso-sacral vertebra. In some cases the latter rib may be counted among the dorsal ribs, and in other cases it may not; this depends upon the degree of modification of the dorso-sacral vertebra. If the latter has progressed far in the process of sacral modification, its rib is no longer a part of the dorsal series but is a part of the sacrum. In two of the series of dorsal vertebræ, as assembled at present, the dorso-sacral is but slightly modified; in another of the series it is somewhat more so, and in the fourth one it is considerably modified. Accordingly the costal series is estimated to consist of ten ribs in two cases, and eleven in the other two. There is no specimen of a highly modified dorso-sacral rib in the collection, but the ilium shows an area of attachment for one. The ribs of the collection appear to indicate that at least six individuals are represented.

Characters

The tuberculum and capitulum are situated far apart in the first rib, and approach each other in the successive members of the series. This approach is rapid in the first four ribs, and then is more gradual.

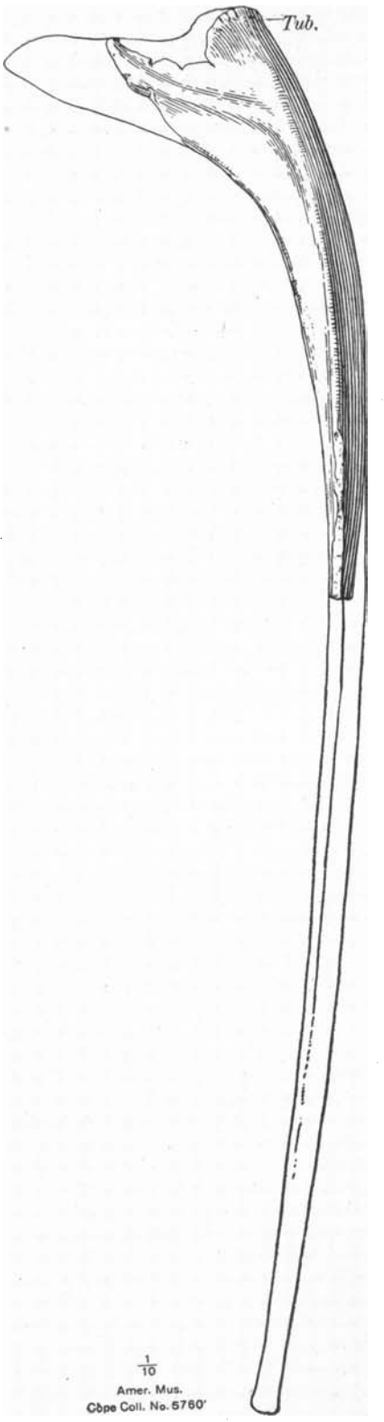

Fig. 67. Rib of *Camarasaurus supremus* Cope.

Left rib No. 9, estimated (Amer. Mus. Cope Coll. No. $\frac{5760'}{R\text{-}a\text{-}15}$). External view; one-tenth natural size. *Tub.* tuberculum. Reconstructed parts in outline.

The tubercular facets articulate with the diapophyses of the dorsal vertebræ, which are constant in position. The capitular facets articulate with the parapophyses, which vary somewhat in their positions. In the first dorsal vertebra and rib the articulation is on the side of the centrum; in the second it is near

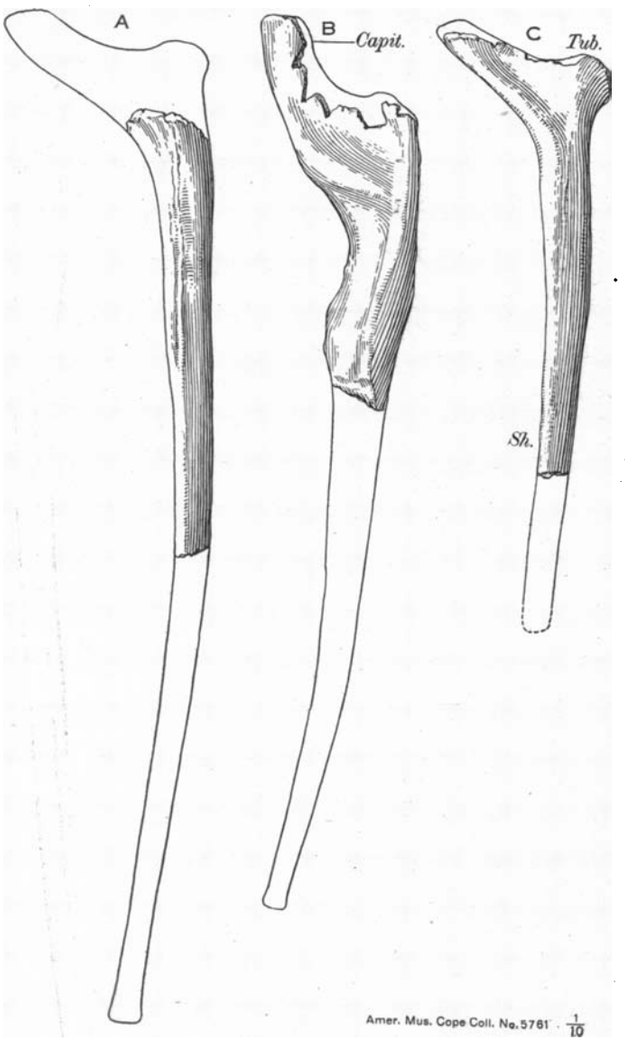

Fig. 68.

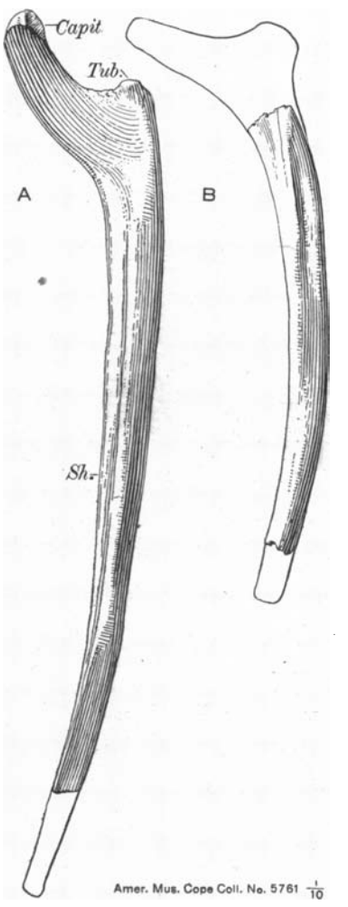

Fig. 69.

Fig. 68. Ribs of *Camarasaurus supremus* Cope.

Left ribs Nos. 9, 10, and Dorso-sacral, estimated (Amer. Mus. Cope Coll. Nos. 5760′ and 5761). (A) No. 9; (B) No. 10; (C) Dorso-sacral; external views; one-tenth natural size. *Capit.* capitulum; *Sh.* shaft; *Tub.* tuberculum. Reconstructed parts in outline.

Rib number in series:	9	10	Dorso-sacral
Specimen number:	5761 R-A-41	5761 R-A-45	5761 R-A-20

Fig. 69. Ribs of *Camarasaurus supremus* Cope.

Left ribs Nos. 9 and 10, estimated (Amer. Mus. Cope Coll. No. 5761). (A) No. 9; (B) No. 10; external views; one-tenth natural size. *Capit.* capitulum; *Sh.* shaft; *Tub.* tuberculum.

Rib number in series:	9	10
Specimen number:	5761 R-A-48	5761 R-A-43

the superior border of the centrum. In both D.R. 1 and D.R. 2 the positions of the articulations are slightly variable. In the third vertebra and rib the capitular articulation is about midway between the level of the prezygapophyses and that of the superior border of the centrum. In this vertebra the posi-

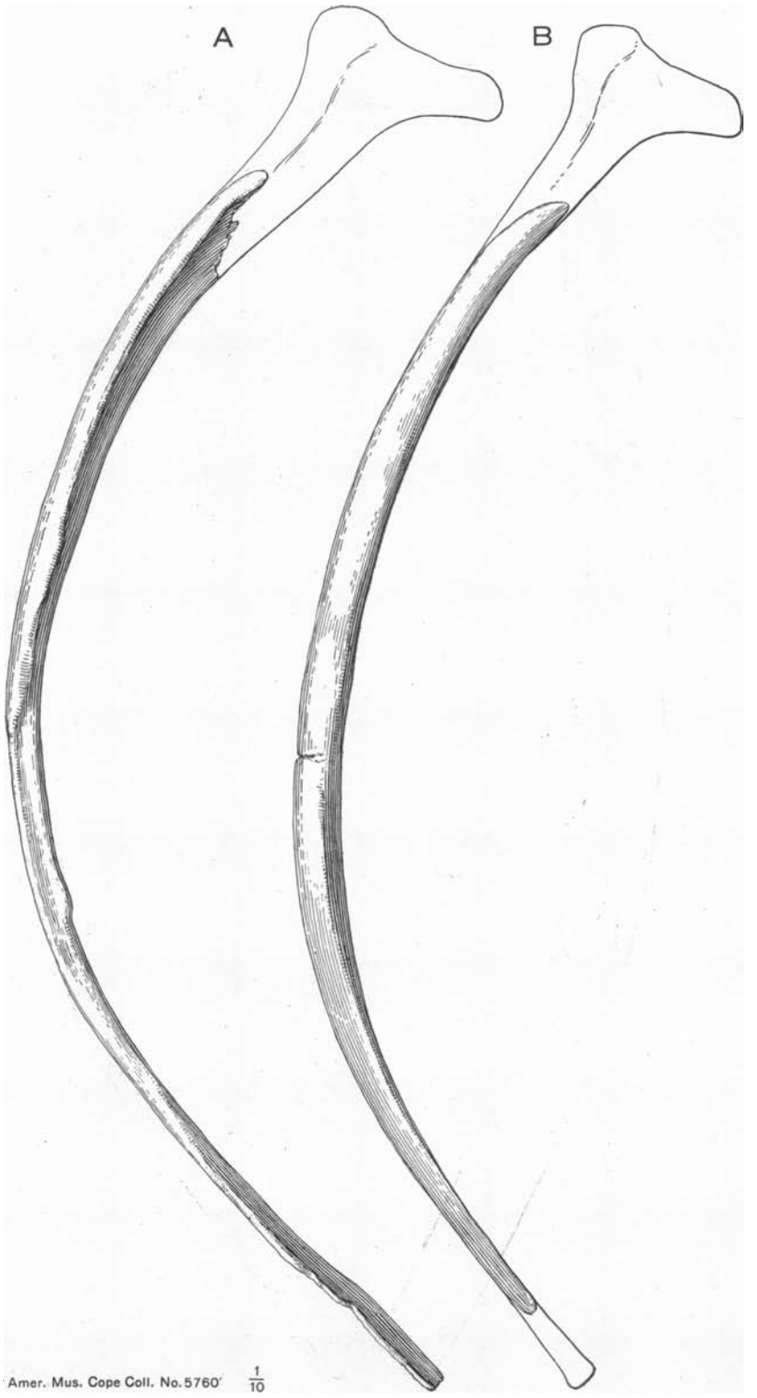

Fig. 70. Left ribs of *Camarasaurus supremus* Cope.

Rib 5, estimated (Amer. Mus. Cope Coll. No. $\frac{5760'}{R\text{-}A\text{-}14}$, $\frac{5760'}{R\text{-}A\text{-}3}$). (A) R–A–14; (B) R–A–3; posterior views showing maximum curvature; one-tenth natural size. Reconstructed parts in outline. (Compare with Plate LXXIX, rib 5, and Plate LXXXI, rib 5.)

tion is constant. In the fourth and succeeding vertebræ and ribs the capitular articulation is situated slightly below the level of the prezygapophyses, and slightly posterior to them.

The shaft of the ribs is always twisted, so that the surface which is posterior at the proximal end of the bone is external at the distal end. The longest of the ribs is D.R. 5; from this they decrease gradu-

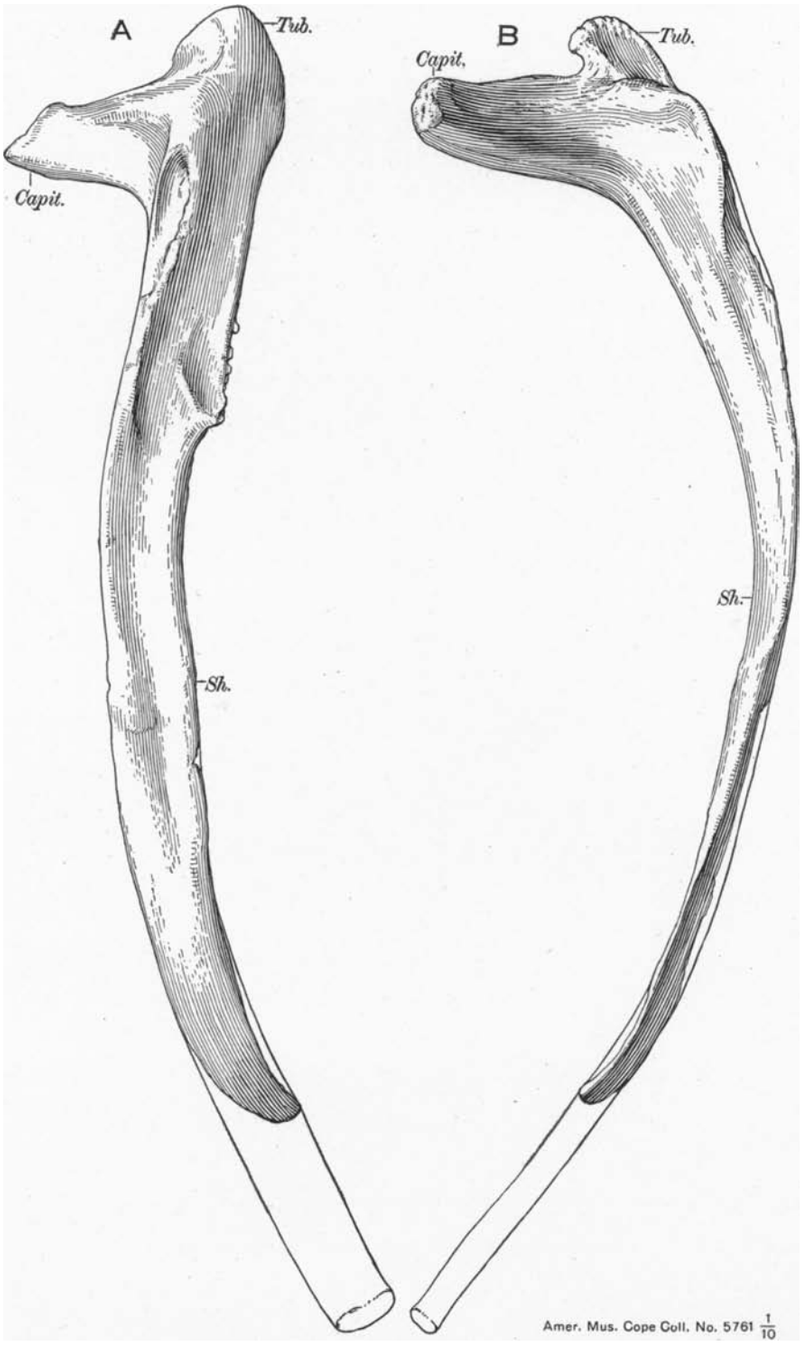

Fig. 71. Left rib of *Camarasaurus supremus* Cope.

Rib 4 (Amer. Mus. Cope Coll. No. $\frac{5761}{R\text{-}A\text{-}24}$). (A) direct external view when placed as in position in the body; (B) direct anterior view, when placed as in position in the body; one-tenth natural size. *Capit.* capitulum; *Sh.* shaft; *Tub.* tuberculum. Reconstructed portion in outline. (Compare with Plate LXXX, rib 4.)

ally in length in both anterior and posterior directions; Dorsal Rib 4 is the stoutest in the series. If the shafts are placed in a vertical position the level of the capitular facets is below that of the tubercular facets in each of the first three ribs. In the fourth and fifth ribs the two processes are typically at about the same level. Posterior to D.R. 5 the capitular facets are typically higher than the tubercular ones. These positions are frequently modified in the fossil specimens through distortion of the bones.

There is in nearly every rib a prominent ridge extending from a point on the postero-external border near the tuberculum, to a point on the antero-external border about midway between the proximal and distal ends.

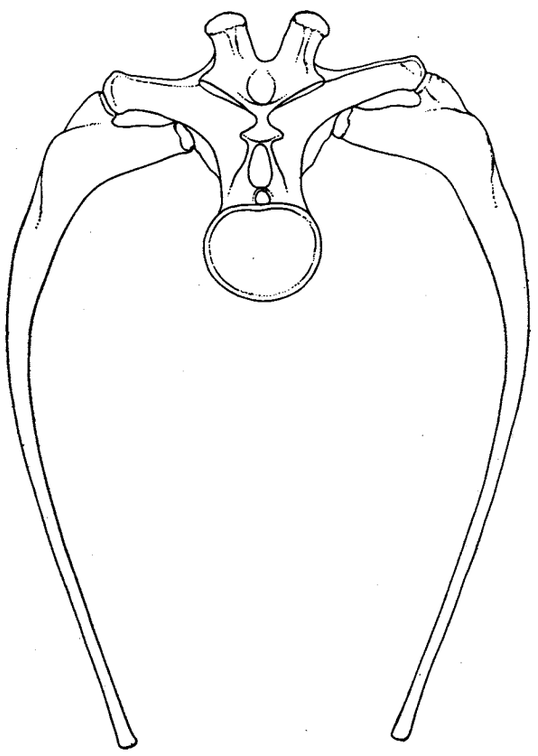

Fig. 72. Reconstruction of cross-section of thorax of *Camarasaurus supremus* Cope.

The vertebra is Dorsal 4, posterior view, with ribs attached.

Measurements

SERIES I (Plate LXXVIII)

Rib No.	Specimen No.	Length, Perpendicular	Length, Curve	Distance between Capitulum and Tuberculum	Breadth, Proximal End, Maximum	Circumference, Shaft
1	Reconstruction					
2	5761 / R-a-31	135.5 cm.	136.5 cm.	33.0 cm.	56.0 cm.	24.0 cm.
3	5761 / R-a-32	151.5 *inc.*	149.0 *inc.*	....	....	21.0
4	5761 / R-a-33	197.0 *inc.*	198.0 *inc.*	23.0	45.0	22.0
5	5760′ / R-a-34	....	82.0 *frag.*	21.0	40.0	....

SERIES I (*Continued*)

Rib. No.	Specimen No.	Length, Perpendicular	Length, Curve	Distance between Capitulum and Tuberculum	Breadth, Proximal End, Maximum	Circumference, Shaft
6	5761 R-a-35	130.0 *inc.*	122.0 *inc.*	20.0	35.0	26.0
7	5761 R-a-37	54.5 *e. inc.*	....	18.5 *e.*	29.5 *e.*	23.0
8	5761 R-a-36	153.5	153.0	16.0	30.0	20.0
9	5761 R-a-38	Very fragmentary				
10	5760′ R-a-42	Very fragmentary		10.0 *e.*	24.5 *e.*	....
D-S	5760′ R-a-39	47.0 *inc.*	36.0 *inc.*	15.0	22.0	20.0

SERIES II (Plate LXXIX)

Rib No.	Specimen No.	Length, Perpendicular	Length, Curve	Distance between Capitulum and Tuberculum	Breadth, Proximal End, Maximum	Circumference, Shaft
1	5761 R-a-11	111.5 cm. *inc.*	121.0 cm. *inc.*	36.0 cm.	58.0 cm.	21.0 cm.
2	5760′ R-a-12	166.0 *inc.*	164.0 *inc.*	42.0 *e. inc.*	52.0 *e. inc.*	19.0
3	5760′ R-a-13	188.5 *inc.*	193.5 *inc.*	....	....	22.0
4	Reconstruction					
5	5760′ R-a-14	187.5 *inc.*	216.0 *inc.*	....	....	21.5 *inc.*
6	5760′ R-a-16	75.0 *frag.*	73.0 *frag.*	20.0	25.0 *inc.*	19.5
7	5760′ R-a-17	131.0 *inc.*	125.0 *inc.*	18.0	31.0	....
8	5760′ R-a-18	112.0 *inc.*	100.5 *inc.*	15.0	29.0	18.0
9	5760′ R-a-19	120.0	112.0	13.0	18.0	18.5
10	5761 R-a-44	102.5 *inc.*	99.0 *inc.*	16.0	23.0	15.0

SERIES III (Plate LXXX)

Rib No.	Specimen No.	Length, Perpendicular	Length, Curve	Distance between Capitulum and Tuberculum	Breadth, Proximal End, Maximum	Circumference, Shaft
1	5760′ R-a-1	89.5 cm. *inc.*	98.0 cm. *inc.*	37.0 cm.	56.0 cm.	25.0 cm.
2	5760′ R-a-2	167.0 *inc.*	168.0 *inc.*	....	....	21.0
3	5760′ R-a-5	Very fragmentary				
4	5760′ R-a-4	Very fragmentary				
5	5760′ R-a-3	169.0 *inc.*	184.0 *inc*	....	....	20.0
6	5760′ R-a-6	197.5 *inc.*	190.0 *inc.*	21.0	35.0	24.0
7	5760′ R-a-8	57.0 *frag.*	47.0 *frag.*	17.5	29.5	19.0
8	5760′ R-a-7	86.0 *inc.*	77.0 *inc.*	20.0	31.0	18.0
9	5760′ R-a-9	132.0 *inc.*	123.5 *inc.*	....	....	17.0
10	5760′ R-a-46	89.0 *inc.*	72.0 *inc.*	18.5 *inc.*	30.0 *inc.*	19.0

SERIES IV (Plate LXXXI)

Rib No.	Specimen No.	Length, Perpendicular	Length, Curve	Distance between Capitulum and Tuberculum	Breadth, Proximal End, Maximum	Circumference, Shaft
1	5761 R-a-21	70.0 cm. *inc.*	74.0 cm. *inc.*	41.0 cm.	62.0 cm.	....
2	5761 R-a-22	155.0 *inc.*	161.0 *inc.*	35.0	52.0	18.5 cm.
3	5761 R-a-23	146.0 *inc.*	152.0 *inc.*	26.0	51.0	24.0
4	5761 R-a-24	165.5 *inc.*	180.0 *inc.*	27.0	51.0	27.0
5	5761 R-a-25	101.0 *inc.*	107.0 *inc.*	....	41.5	24.0
6	5760′ R-a-26	Very fragmentary				
7	5760′ R-a-27	131.5 *inc.*	116.0 *inc.*	20.0	31.0	23.0
8	5761 R-a-28	138.0 *inc.*	133.5 *inc.*	18.0	31.0	19.0
9	5760′ R-a-29	121.5 *inc.*	116.0 *inc.*	14.0	28.0	19.0
10	5761 R-a-30	69.5 *inc.*	91.0 *inc.*	14.5	....	25.5
D–S	5761 R-a-40	26.5 *frag.*	30.0 *frag.*	15.5 *e.*	24.5	37.5

EXTRA RIBS (Text Figs. 67–69)

Rib	Specimen No.	Length, Perpendicular	Length, Curve	Distance between Capitulum and Tuberculum	Breadth, Proximal End, Total	Circumference, Shaft
5	5760′ R-a-15	91.0 cm. *inc.*	91.0 cm. *inc.*	14.5 cm.	....	25.5 cm.
9	5761 R-a-48	114.0 *inc.*	109.5 *inc.*	15.0	23.0 cm.	21.0
9	5761 R-a-45	54.8 *inc.*	45.0 *inc.*	....	28.0	....
10	5761 R-a-43	65.5 *inc.*	.....	....	....	....
D–S	5761 R-a-20	66.0 *inc.*	61.0 *inc.*	16.0	24.0	19.0

VENTRAL RIB

Material and Association.— One exceedingly slender bone in the collection has proved very difficult to identify. The most satisfactory determination is that the bone is a sternal rib.

Characters

The bone is of medium length, and is flat in cross-section. It tapers slightly in breadth from one end to the other; the broader end is also the thicker; most of the bone is straight, but the thicker end curves sharply in one direction, while the thinner end curves somewhat in the opposite direction; this curving may be due, either wholly or in part, to distortion after burial of the bone. The orientation in the skeleton is not readily determinable.

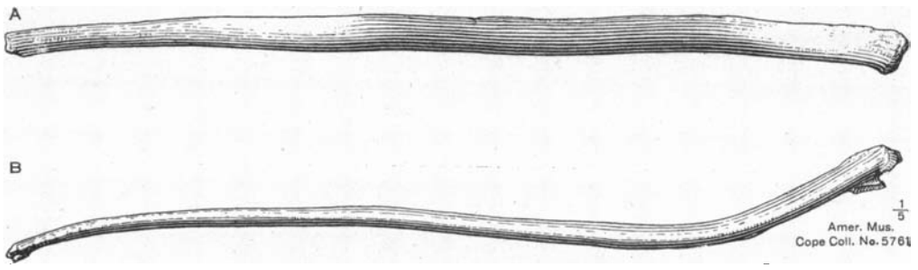

Fig. 73. Probably ventral rib of *Camarasaurus supremus*.

(A) superior (?) or inferior (?) view; (B) lateral view; one-fifth natural size.

Measurements

Amer. Mus. Cope Coll. No. 5761 (Text Fig. 73)

Length, maximum	66.0 cm.
Breadth, maximum	3.0
Breadth, minimum	1.9 *inc.*
Thickness	1.4

Pectoral Girdle

Scapula

Material and Association.— Seven scapulæ are present in the Cope Canyon City collection. One of these is different in a number of respects from the other six; it resembles the scapula of *Diplodocus* in form, but is much larger and thicker than any known *Diplodocus* scapula. The resemblance between the known bones of *Amphicœlias* and those of *Diplodocus* is marked, though in each case the *Amphicœlias* bone is larger. The scapula under discussion (Amer. Mus. Cope Coll. No. 5764a) is therefore referred to *Amphicœlias* provisionally. The other six scapulæ resemble each other in most characters, although they differ slightly from each other. Two pairs are clearly recognizable. Each scapula in each pair resembles its mate closely, but differs slightly from the scapulæ of the other pair. The remaining two scapulæ are opposites, one being a right and the other a left (Amer. Mus. Cope Coll. Nos. $\frac{5760''}{Sc.\ 3}$ and $\frac{5761}{Sc.\ 2}$ respectively), and they agree in characters so far as the latter are ascertainable. One of them is badly crushed, however, so that its characters are obscure in some respects. The size of the two bones appears to be different. Provisionally they are considered as belonging to different individuals. The association of the various scapulæ in the field is unknown.

The original association of the various scapulæ with the coracoids in the collection is not definitely known. It appears probable from the character of the borders that Cor. 1 belonged with Sc. 1, or possibly with Sc. 4, and that Cor. 2 might have belonged with either Sc. 5 or Sc. 6, but not with Sc. 3.

Characters

The scapulæ in this collection agree in most characters with those of the *Camarasaurus* (*Morosaurus*) *grandis* cotype material (Yale Mus. No. 1905) and of the *C.* (*Morosaurus*) *lentus* type (Yale Mus. No. 1910), but differ from these in some details.

The scapula of *Camarasaurus* is massive and heavy; its length is not greatly in excess of its greatest breadth. The superior end is greatly expanded in the anterior direction, and slightly so in the posterior

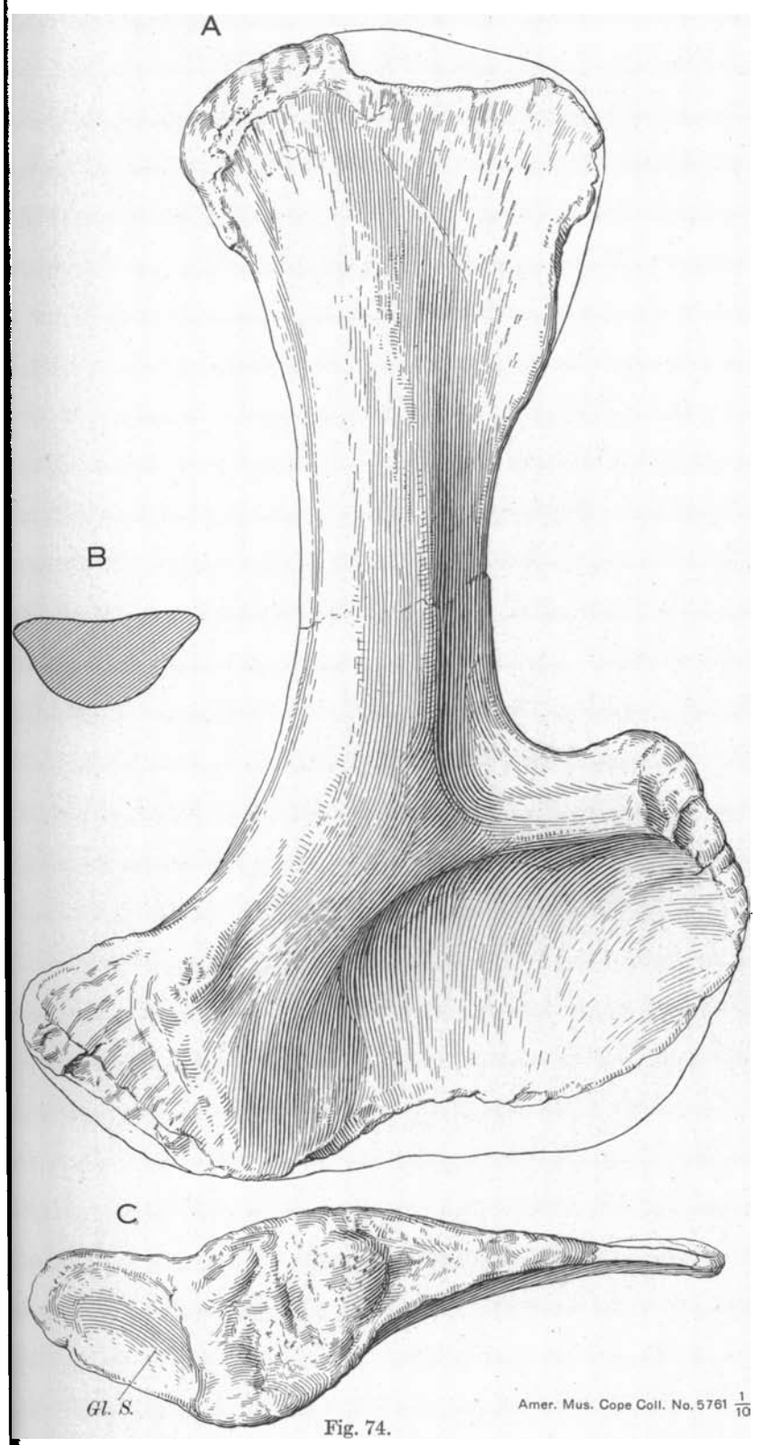

Fig. 74.

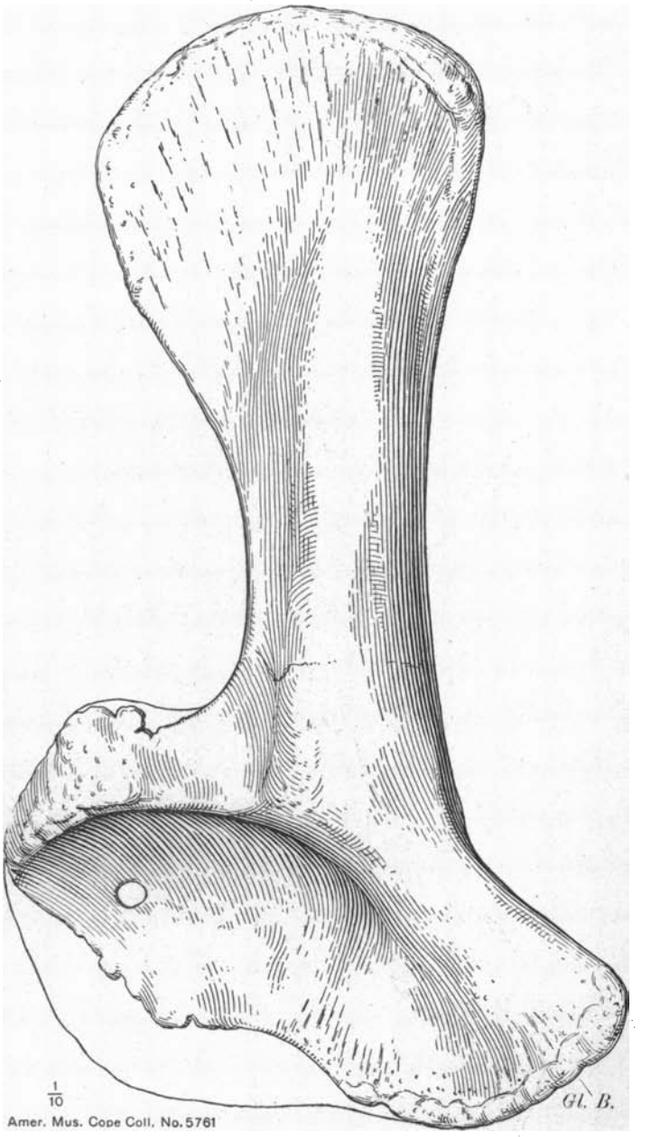

Fig. 75.

Fig. 74. Right scapula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Sc.5}$. (A) external view; (B) section of shaft; (C) inferior surface; one-tenth natural size. *Gl. S.* glenoid surface. This scapula is considered to be the opposite of Sc. 1 (Fig. 75); it may have belonged to the same individual as Cor. 2.

Fig. 75. Left scapula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Sc.1}$. External view; one-tenth natural size. *Gl. B.* Glenoid border. The foramen is accidental. This scapula is considered to be opposite to Sc. 5 (Fig. 74). It probably belonged to the same individual as Cor. 1. Reconstructed parts in outline.

direction. The anterior expansion is not limited strictly to the superior end, but extends down the shaft for a considerable distance. The superior end is flattened out, but is much thicker than the corresponding ends of the scapulæ of other sauropod genera, so far as the latter are known. The superior border is strongly rugose, probably in connection with the attachment of a large mass of suprascapular cartilage. The shaft has considerable breadth, though this varies somewhat among the different specimens; it is also very thick; the external surface is irregularly convex, and the internal surface is somewhat concave;

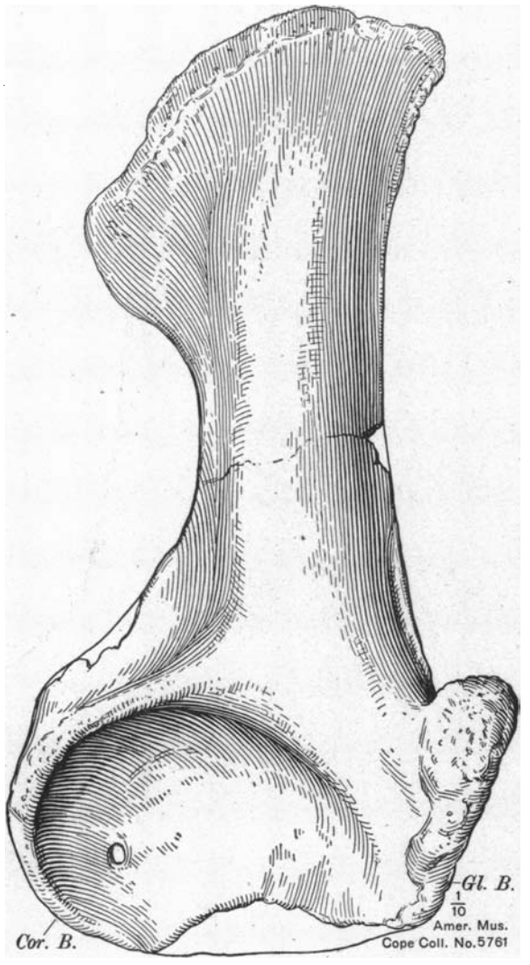

Fig. 76.

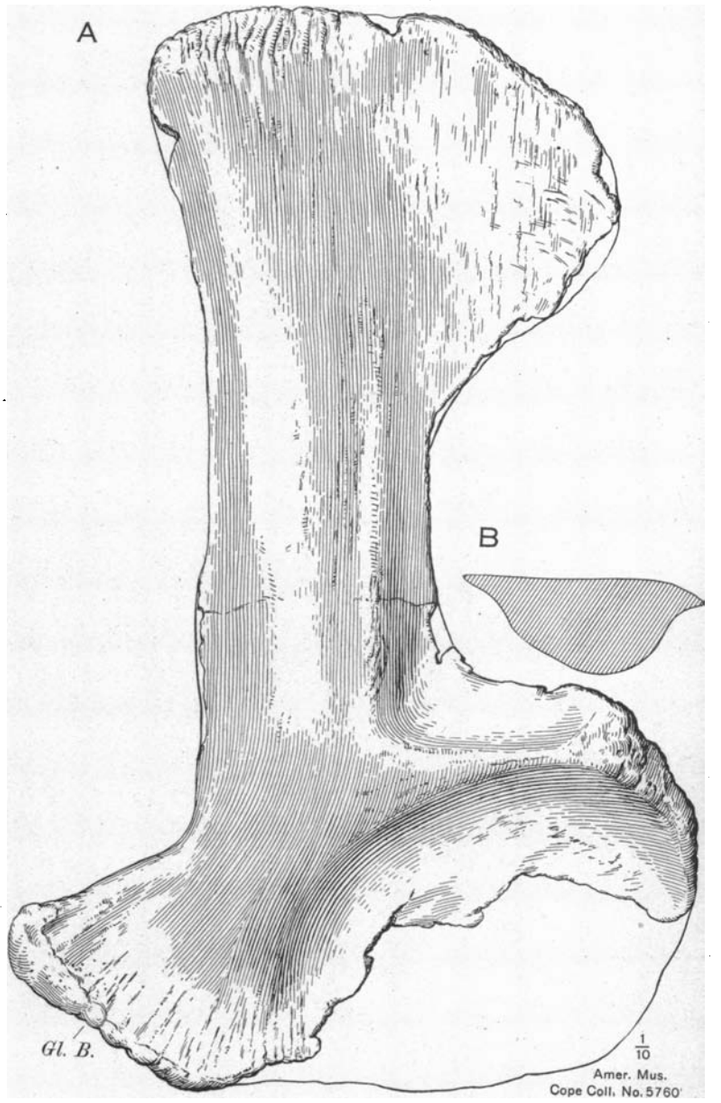

Fig. 77.

Fig. 76. Left scapula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Sc.2}$. External view; one-tenth natural size. *Cor. B.* coracoid border; *Gl. B.* glenoid border. The foramen is accidental. This scapula may belong to the same individual as Sc. 3 (Figs. 9, 69, 70); it is badly crushed. Reconstructed parts in outline.

Fig. 77. Right scapula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760''}{Sc.3}$. (A) external view; (B) section of shaft; one-tenth natural size. *Gl. B.* glenoid border. This scapula may be the opposite of Sc. 2 (Fig. 76); it is nearly normal, uncrushed. Reconstructed parts in outline. (Compare with the original figure, Fig. 10A, and with Fig. 78.)

the anterior and posterior edges project beyond the central mass of the shaft as prominent ridges. The inferior ends are greatly expanded, both in anterior and posterior directions; the anterior expansion is large in areal extent, but comparatively thin; the posterior expansion is bordered inferiorly by the scapular portion of the glenoid surface, and is massively constructed in connection with the support of the humerus.

The great muscle fossa on the inferior portion of the external surface is deep and extensive. The

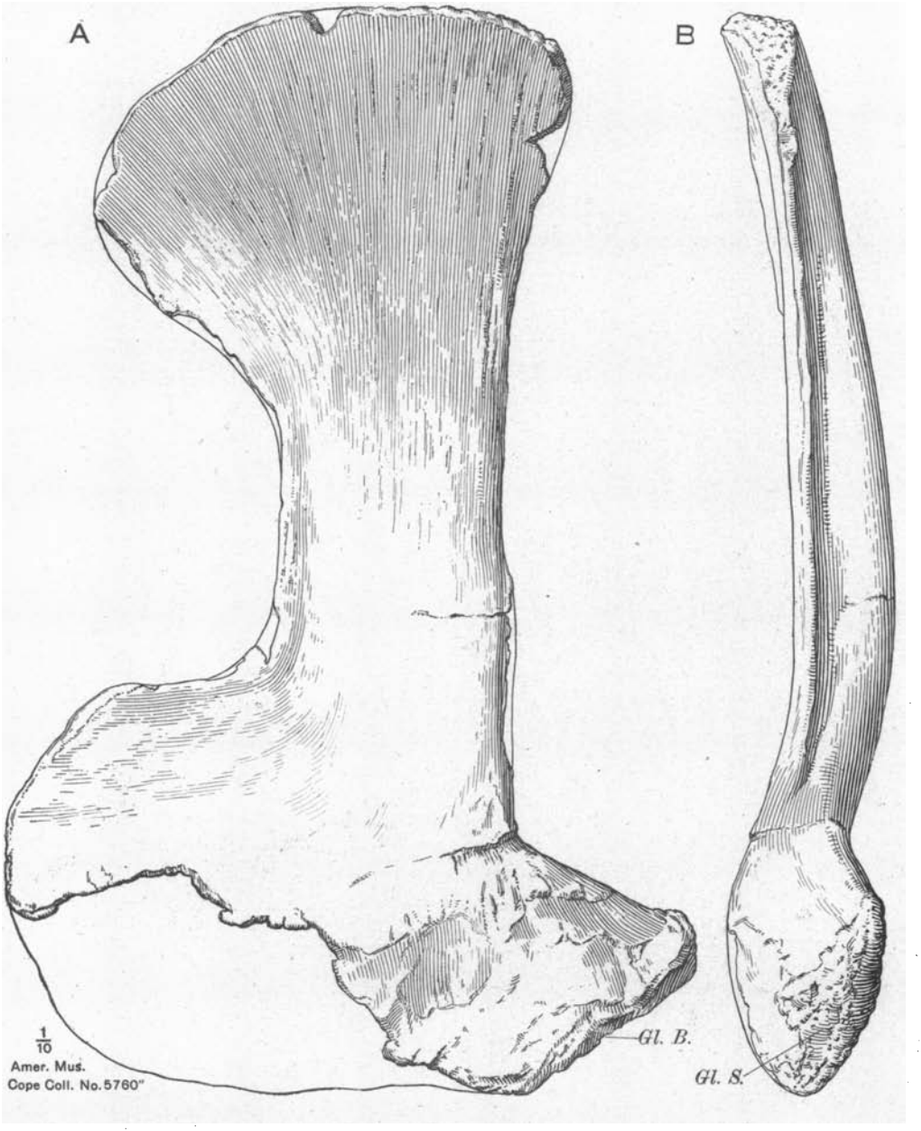

Fig. 78. Right scapula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760}{Sc.3}$. (A) internal view; (B) posterior view; one-tenth natural size. *Gl. B.* glenoid border; *Gl. S.* glenoid surface. This scapula may belong to the same individual as Sc. 2 (Fig. 76). Reconstructed parts in outline. Compare with the original figure, Fig. 10A, and with Fig. 77.)

superior fossa, which is partly on the shaft and partly on the antero-inferior process, is also prominent. The ridge separating these fossæ is distinct, but is not greatly elevated. This ridge extends from the base of the shaft in an anterior and also superior direction to the antero-superior border of the anterior

process, and also from the base of the shaft posteriorly and inferiorly to the infero-posterior corner of the posterior process. It constitutes, therefore an oblique ridge, which has the greatest measurable transverse diameter in the scapula; hence it may be termed the *axis of greatest breadth.* In the *Camarasaurus* scapula this axis makes a broad open angle with the longitudinal axis. The angle between the

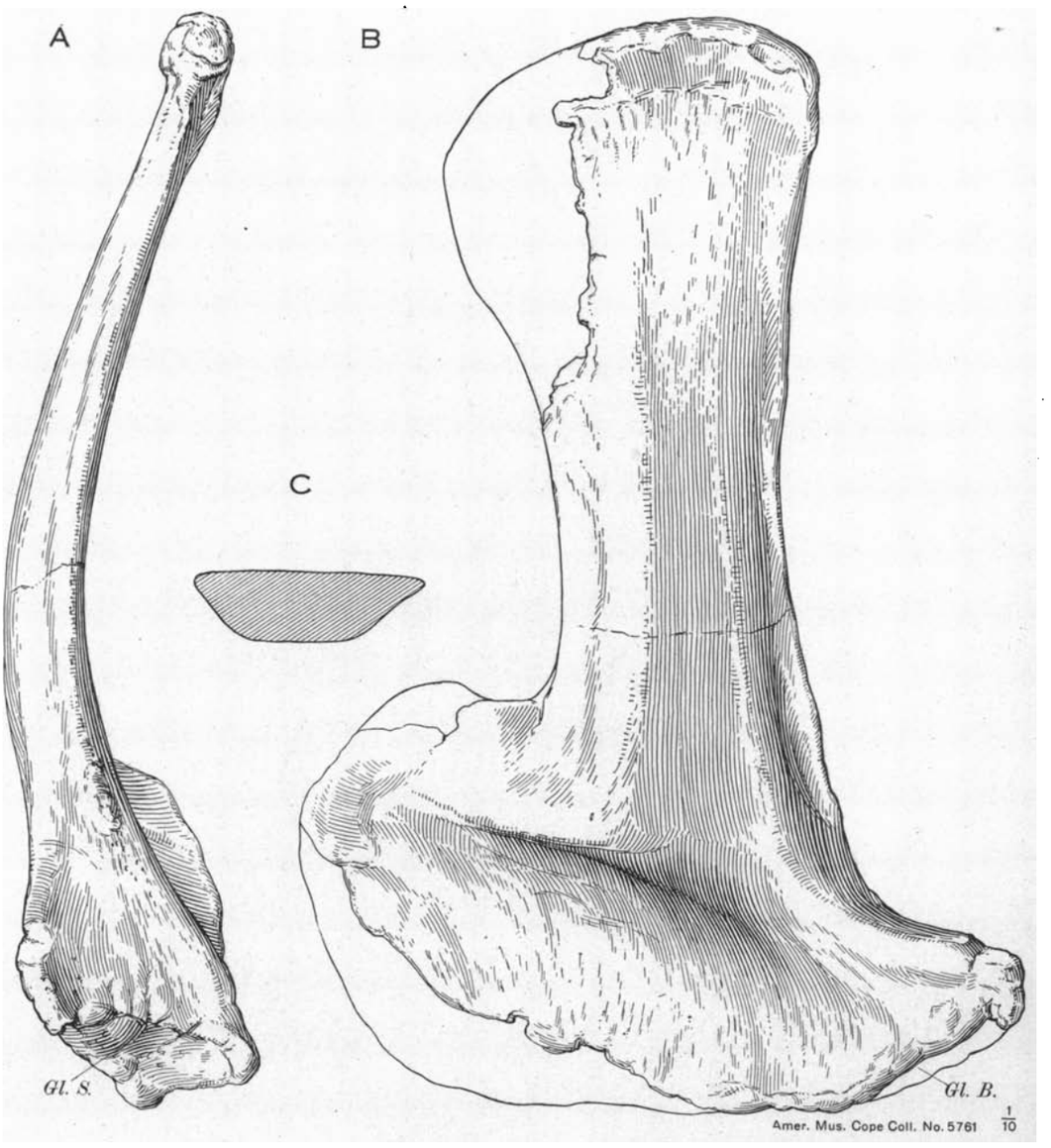

Fig. 79. Left scapula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Sc.4}$. (A) posterior view; (B) external view; (C) section of shaft; one-tenth natural size. *Gl. B.* glenoid border; *Gl. S.* glenoid surface. This scapula is considered to be the opposite of Sc. 6 (Fig 80). It is possible that it belonged to the same individual as Cor. 1. Reconstructed parts in outline.

two axes approaches ninety degrees, contrasting strongly with *Diplodocus*, in which the angle is acute. The angles in the various scapulæ of *Camarasaurus* in the collection herein described are as follows:

Scapula	$\frac{5761}{Sc.1}$	62°
"	$\frac{5760''}{Sc.2}$	distorted
"	$\frac{5760''}{Sc.3}$	67°
"	$\frac{5761\text{–}a}{Sc.4}$	64°
"	$\frac{5761}{Sc.5}$	69°
"	$\frac{5761\text{–}a}{Sc.6}$	70°

The curvature of the scapula is considerable.

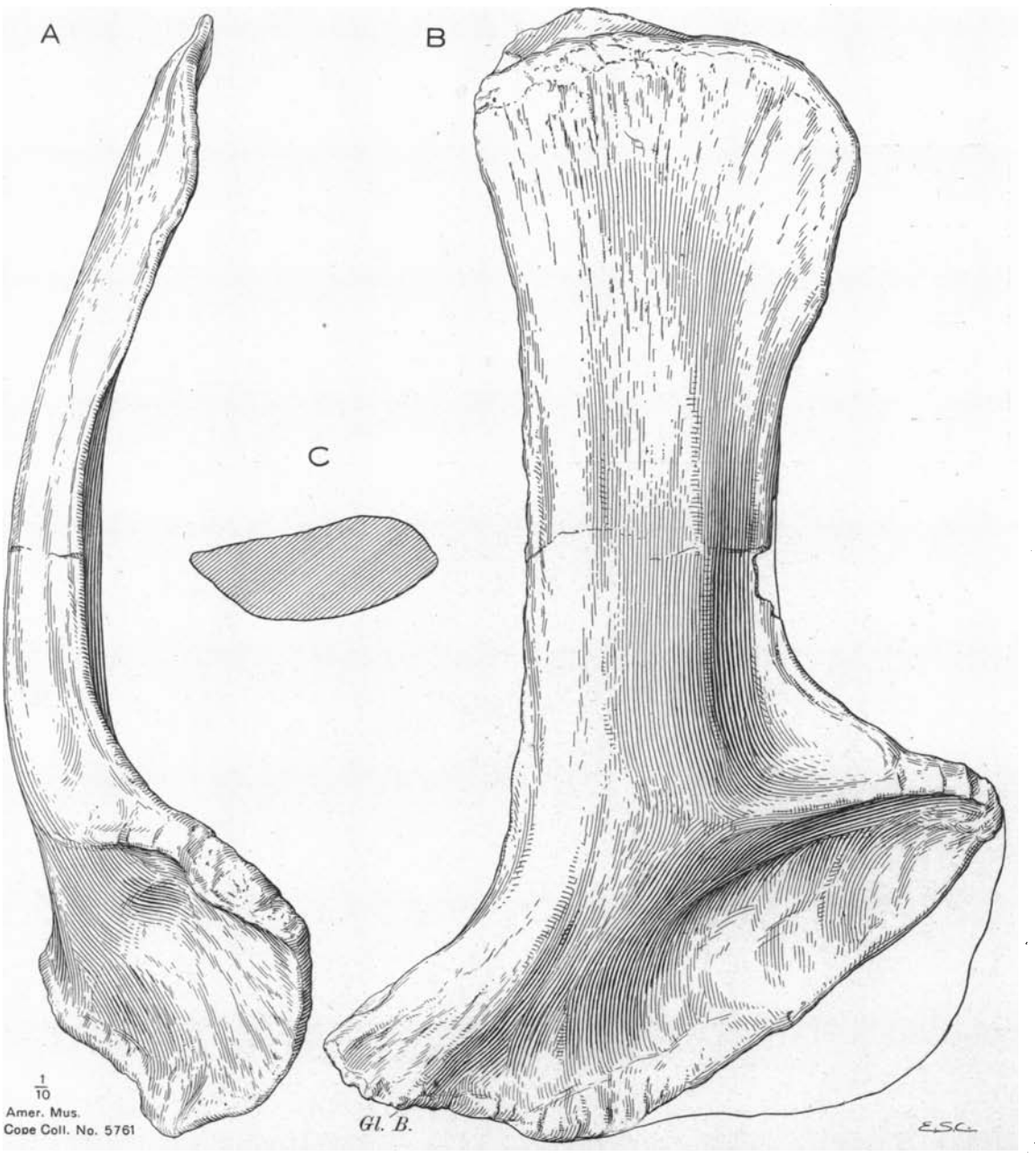

Fig. 80. Right scapula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Sc.6}$. (A) anterior view; (B) external view; (C) section of shaft; one-tenth natural size. *Gl. B.* glenoid border. This scapula is considered to be the opposite of Sc. 4 (Fig. 79). It may have belonged to the same individual as Cor. 2. Reconstructed parts in outline.

Special Features

The great size and thickness of the scapula is a distinctive feature of the genus *Camarasaurus*, at least of the species *C. supremus* which is represented in this collection. The scapulæ of *Apatosaurus* and *Diplodocus* are considerably thinner; the scapula of *Amphicœlias*, if the above-mentioned identification is correct, is more slender, that of *Brachiosaurus* is similar, but probably somewhat thinner, and that of *Haplocanthosaurus* is much smaller and has a very different outline.

The nearly rectangular relation between the longitudinal axis and the axis of greatest breadth, the relatively great breadth in proportion to the length, and the great expansion of the superior end, are also distinctive characters.

Measurements

(Text Figs. 74–80)

Scapula	Specimen No.	Length, Total	Length, over Curve	Breadth, Superior	Breadth, Inferior, (oblique)	Breadth of Shaft	Thickness of Shaft
Left	5761 Sc.1	166.5 cm.	178.0 cm. *e.*	59.0 cm.	97.0 cm.	34.0 cm.	13.0 cm.
Left	5761 Sc.2	143.0	156.0 *e.*	49.5	71.0 *d.*	26.5	11.0
Right	5760″ Sc.3	161.0	....	69.0	101.0	30.5	14.0
Left	5761 Sc.4	164.0	173.0	....	112.0	33.0	11.5
Right	5761 Sc.5	163.5	....	61.5	104.5	27.0	12.5
Right	5761 Sc.6	161.0	175.0	56.0	100.0	33.5	12.5

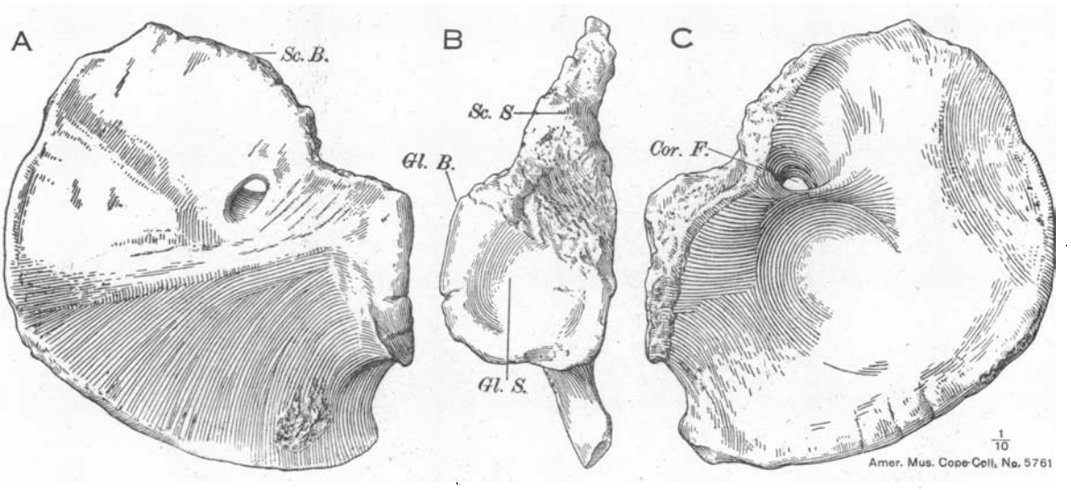

Fig. 81. Left coracoid of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Cor.1}$. (A) external view; (B) postero-superior view; (C) internal view; one-tenth natural size. *Cor. F.* coracoid foramen; *Gl. B.* glenoid border; *Gl. S.* glenoid surface; *Sc. B.* scapular border; *Sc. S.* scapular surface. It may have belonged to the same individual as Sc. 1 or Sc. 4.

CORACOID

Material and Association.— Three large coracoids are present in the collection, besides the small one in the type of *Epanterias amplexus*. One of these differs considerably from the other two in outline

and proportions; it resembles that of *Diplodocus*, but is larger and stouter than any known *Diplodocus* coracoid. It is here provisionally referred to *Amphicœlias*, and is described below, pages 381, 382. The other two coracoids undoubtedly belong to *Camarasaurus;* they are opposites, but whether they belonged to one individual is impossible to determine; they are similar in size and characters, and may well belong to the same individual. Cor. 1 fits very well with Sc. 1, but may possibly have been originally associated with Sc. 4; Cor. 2 fits very well with Sc. 5 and with Sc. 6.

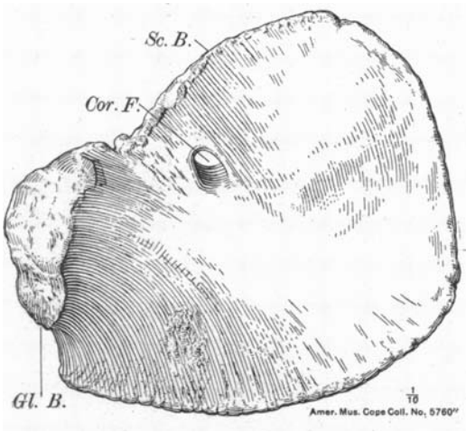

Fig. 82. Right coracoid of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760''}{Cor.2}$. External view; one-tenth natural size. *Cor. F.* coracoid foramen; *Gl. B.* glenoid border; *Sc B.* scapular border. This is possibly the same bone as the coracoid figured by Cope (see Fig. 10 B). It may have belonged to the same individual as Sc. 5 or Sc. 6.

Characters

The coracoid of *Camarasaurus* is subrectangular in outline, and its vertical and longitudinal diameters are subequal; the external surface is irregularly convex, and the internal surface irregularly concave. The entire bone is very thick, the glenoid portion being very massive. The free edges are rounded; they are very slightly indented by pits and grooves, but are too smooth to be considered rugose. The broad glenoid surface is smooth. The articular surface for contact with the scapula is rough. The coracoid foramen is irregular in form. A slight rugosity, evidently for muscle attachment, is present on the external surface of the left of the two coracoids, near the inferior border. There is a sharp angle between the inferior border and the lower portion of the posterior border.

Measurements

(Text Figs. 81, 82)

Coracoid	Specimen No.	Inferior Angle to Anterior End of Scapular Surface (maximum diameter)	Scapular Surface to Antero-inferior Border	Perpendicular to Glenoid Surface
Left	$\frac{5761}{Cor.1}$	72.5 cm.	49.5 cm.	60.5 cm.
Right	$\frac{5761}{Cor.2}$	70.0	50.5	63.5

Fore Limb

HUMERUS

Material and Association.— Two humeri are present in the Cope *Camarasaurus* material. One belongs to the right side and the other to the left. They are almost identical in size, their characters are similar, likewise their color. It is probable that they belong to the same individual, but there is no way in which such a relation may be definitely proven. The right humerus is well preserved, but the left one is incomplete. The description is based principally upon the characters of the right humerus.

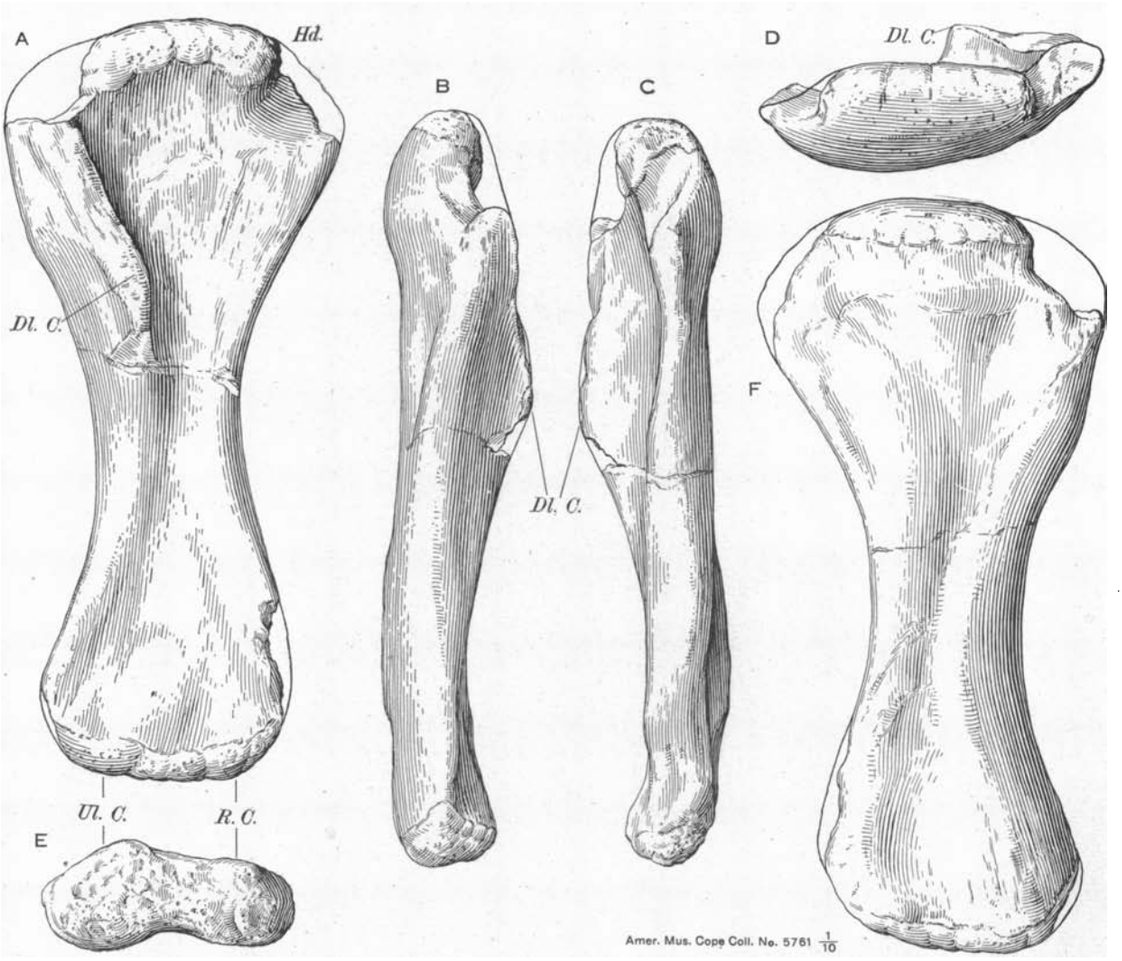

Fig. 83. Right humerus of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{H.1}$. (A) anterior view; (B) external view; (C) internal view (D) superior view; (E) posterior view; (F) inferior view; one-tenth natural size. *Dl. C.* deltoid crest; *R. C.* radial condyle; *Ul. C.* ulnar condyle. Reconstructed parts in outline. This humerus is considered to be the opposite of H. 2 (Fig. 84.)

Characters

The humerus of *Camarasaurus* resembles that of *Apatosaurus* of Marsh. The bone is stout and strongly built. The superior and inferior articular surfaces are rather smooth, but have slight pits and grooves indenting them. The proximal end has a very slight inclination in the posterior direction. The deltoid crest is prominent, and the antero-superior muscle fossa is of moderate depth. The shaft is of

medium width; it is relatively thicker than the shafts of *Brachiosaurus* and *Diplodocus*, and has about the same thickness as the shaft of the *Apatosaurus* humerus, possibly being very slightly less massive. The distal end has a slight inclination forward. The condyles are not especially prominent.

Measurements

(Text Figs. 83, 84)

Humerus	Specimen No.	Length, Total	Breadth, Proximal End	Breadth, Distal End	Circumference	Index
Right	$\frac{5761}{H.\ 1}$	113.5 cm.	50.0 cm.	36.0 cm.	60.0 cm.	.528
Left	$\frac{5761}{H.\ 2}$	111.0	48.0 *e.inc.*	*frag.*	53.0 *inc.*	.477

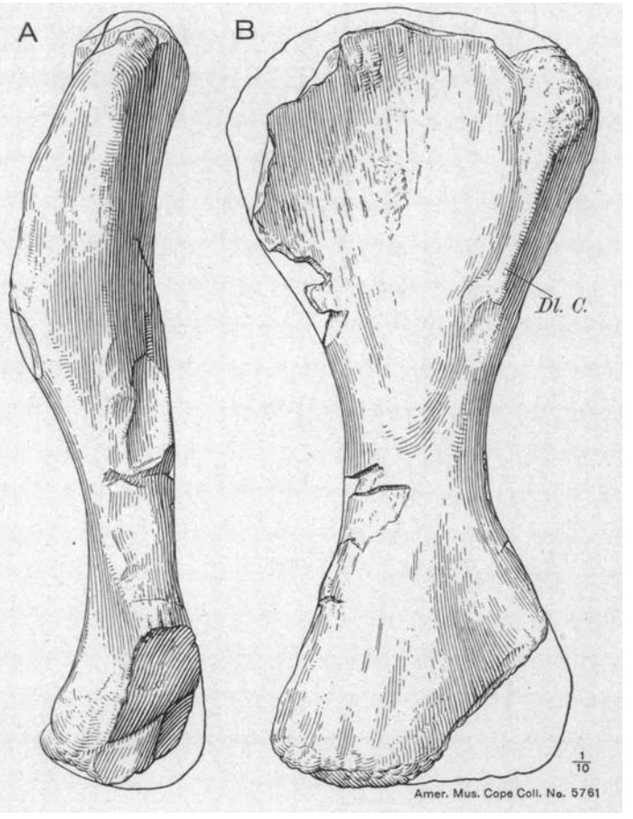

Fig. 84. Left humerus of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{H.\ 2}$. (A) external view; (B) anterior view; one-tenth natural size. *Dl. C.* deltoid crest. This bone is probably the opposite of H. 1 (Fig. 76). Reconstructed parts in outline.

METACARPALS

Material and Association.— Two metacarpals are preserved in the *Camarasaurus* topotype collection. One of these is well preserved, but is slightly crushed; this one is identifiable as Mtc. II of the left side. The other metacarpal is incomplete; it appears to be Mtc. I of the left side.

Characters

The Mtc. I. is moderately long in proportion to its breadth. Its lateral or right, surface is smoothly rounded; its anterior surface is smooth, except near the distal end, where it has been roughened by erosion; the infero-medial border is not preserved, the anterior surface being, therefore, incomplete. The superior portion of the medial surface is slightly concave in connection with the articulation with Mtc. II; the inferior portion of this surface is missing; the posterior surface is smooth where the original surface of the bone is preserved, but the greater part of it has been roughened by erosion. The proximal and distal ends of the bone are not well preserved, the proximal being smooth and the distal lacking its medial process.

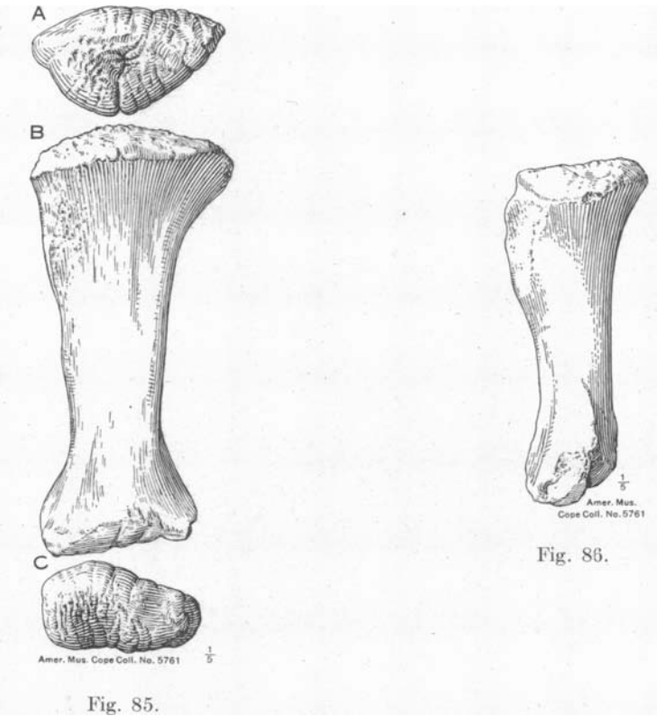

Fig. 86.

Fig. 85.

Fig. 85. Left metacarpal II of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. 5761. (A) superior view; (B) anterior view; (C) inferior view; one-fifth natural size.

Fig. 86. Left metacarpal I of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. 5761. Anterior view; one-fifth natural size.

The Mtc. II is relatively long in proportion to its breadth as compared with the same bone in *Apatosaurus*. It is smooth on its anterior surface, rounded on its supero-lateral margin, and expanded into a subacuminate process on its supero-mesial margin; its inferior end is expanded in both lateral and mesial directions. The mesial border of the shaft is relatively thin, but the lateral one is thicker. The posterior surface is smooth for the most part, but is characterized by a prominent rugosity near the proximal end, which extends from the median line to the lateral border and around this so as to occupy the proximal half of the lateral surface. The proximal and distal articular surfaces are deeply rugose.

Measurements

(Text Figs. 85, 86)

Metacarpal	Specimen No.	Length, Total	Circumference	Index
Left I	5761 Mp. 2	24.5	20.0	.816
Left II	5761 Mp. 1	31.0 cm.	17.5 cm.	.564

Pelvic Girdle

ILIUM

Material and Association.— Five ilia are represented in the Cope Canyon City material. Two of these are practically complete, though somewhat distorted; one is a right ilium, the other a left. These ilia articulate with the single well-preserved sacrum, described above. The other three ilia, of which two belong to the right side and one to the left, are very incomplete; they each consist of the anterior crest and the pubic peduncle; their association with the rest of the material is unknown; they are reddish in color, in contrast with the complete pair which is yellowish, and they may have originally belonged with the reddish vertebræ (Series I and II of the dorsals, and Series I and II of the caudals), but there is no direct evidence for this.

Characters

The characters of the ilium of *Camarasaurus* have been determined from the complete pair, of which the left is the nearest perfect, but it has been slightly flattened by crushing. This flattening has reduced the amount of lateral flare of the anterior crest, has increased the length of the pubic peduncle and has decreased the thickness of the latter. The right ilium has been crushed differently; in it the amount of flare has been increased, the pubic peduncle shortened and thickened, and the posterior portion of the superior border has been pressed down. The original iliac flare seems to have been retained more closely in the three fragmentary ilia than in the complete ones. The original angle of this flare must have been considerable. The superior border of the ilium is rugose. The acetabular surface is smooth. The pubic peduncle is convex anteriorly and slightly concave posteriorly. The internal surface of the ilium possesses slight elevations at the points of articulation with the sacrum. Both of the complete ilia bear articulations of this sort, for contact with the dorso-sacral as well as the other sacrals. The ilium resembles that of *Apatosaurus*, but is, perhaps, slightly smaller in proportion to the size of the scapula and limb bones.

Measurements

(Text Figs. 13, 89–93)

Ilium	Specimen No.	Length, Total	Height, Acetabulum to Superior Border	Height, Pubic Peduncle to Superior Border	Length of Acetabulum
Left	5761 Il. 1	115.0 cm.	46.0 cm.	68.0 cm.	52.0 cm.
Right	5761 Il. 2	118.5	30.5	60.5	43.0

ISCHIUM

Material and Association.— Eight ischia are preserved in the collection; four of them belong to the right side and four to the left; some of them are red and some are yellow; no data are available regarding their original association. They appear to match each other fairly well in pairs. One pair is some-

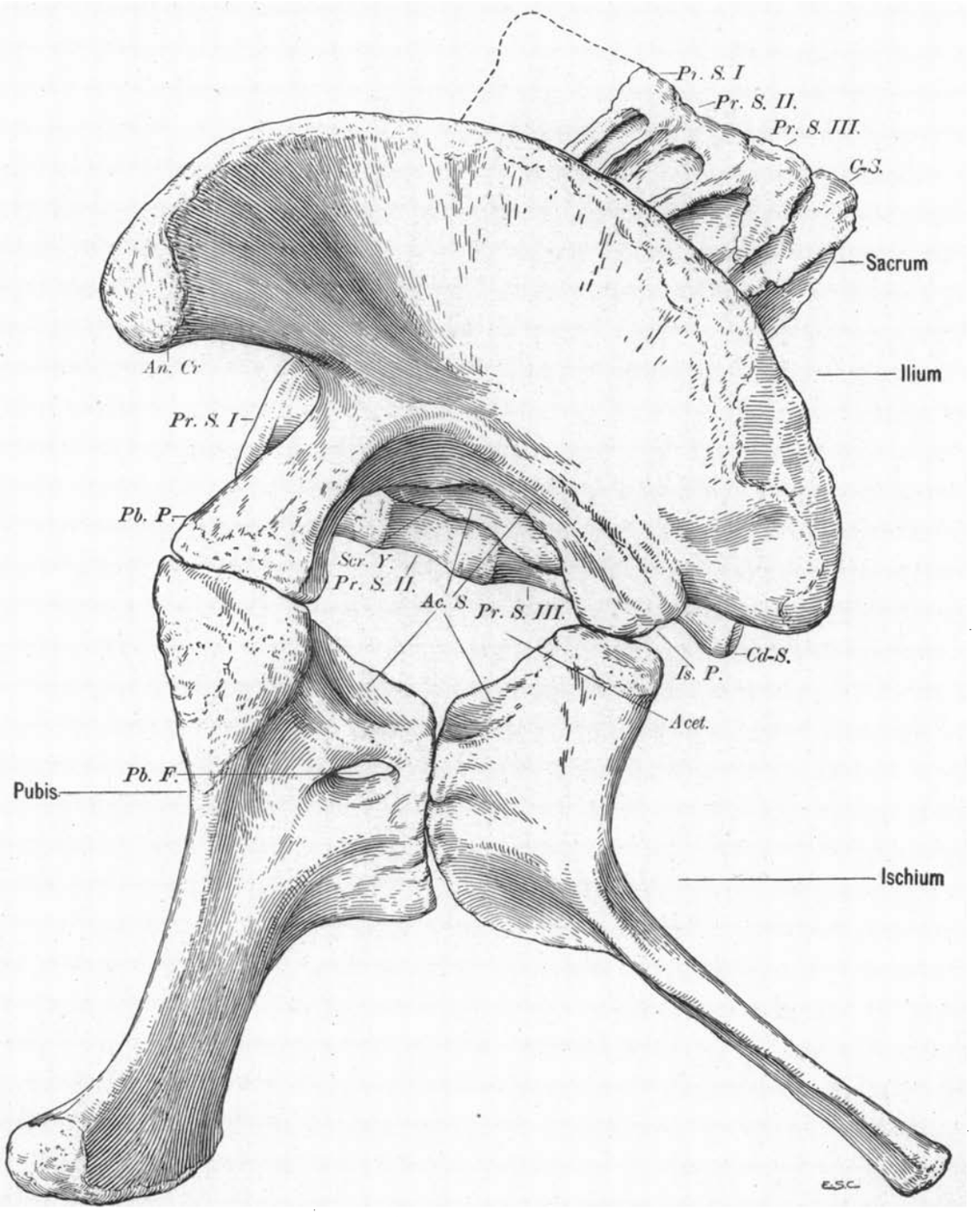

Fig. 87. Reconstruction of sacrum and pelvis of *Camarasaurus supremus* Cope. Composition of one or two individuals. (Based upon Amer. Mus. Cope Coll. No. 5761.)

External view; one-tenth natural size. *Acet.* acetabulum; *Ac. S.* acetabular surface; *An. Cr.* anterior crest of ilium; *C-S.* caudo-sacral spine; *Cd-S.* caudo-sacral centrum; *Is. P.* ischiadic peduncle; *Pb. F.* pubic foramen; *Pb. P.* pubic peduncle; *Pr. S. I.* primary sacral I; *Pr. S. II.* primary sacral II; *Pr. S. III.* primary sacral III; *Scr. Y.* sacricostal yoke. Sacral spines crushed backwards; dotted line indicates normal position. Compare with Figs. 45, 46, and 88.

what different in proportions from the other three, and it is possible that it may belong to *Amphicœlias;* its proportions are more like those of *Diplodocus*, which resembles *Amphicœlias* in many respects, than are the other three pairs; it does not possess the distal expansions which are characteristic of the ischia of *Diplodocus*, though, of course, *Amphicœlias* may not have had them either. The resemblance to the other ischia is rather greater than the differences between them. It seems probable, therefore, that this

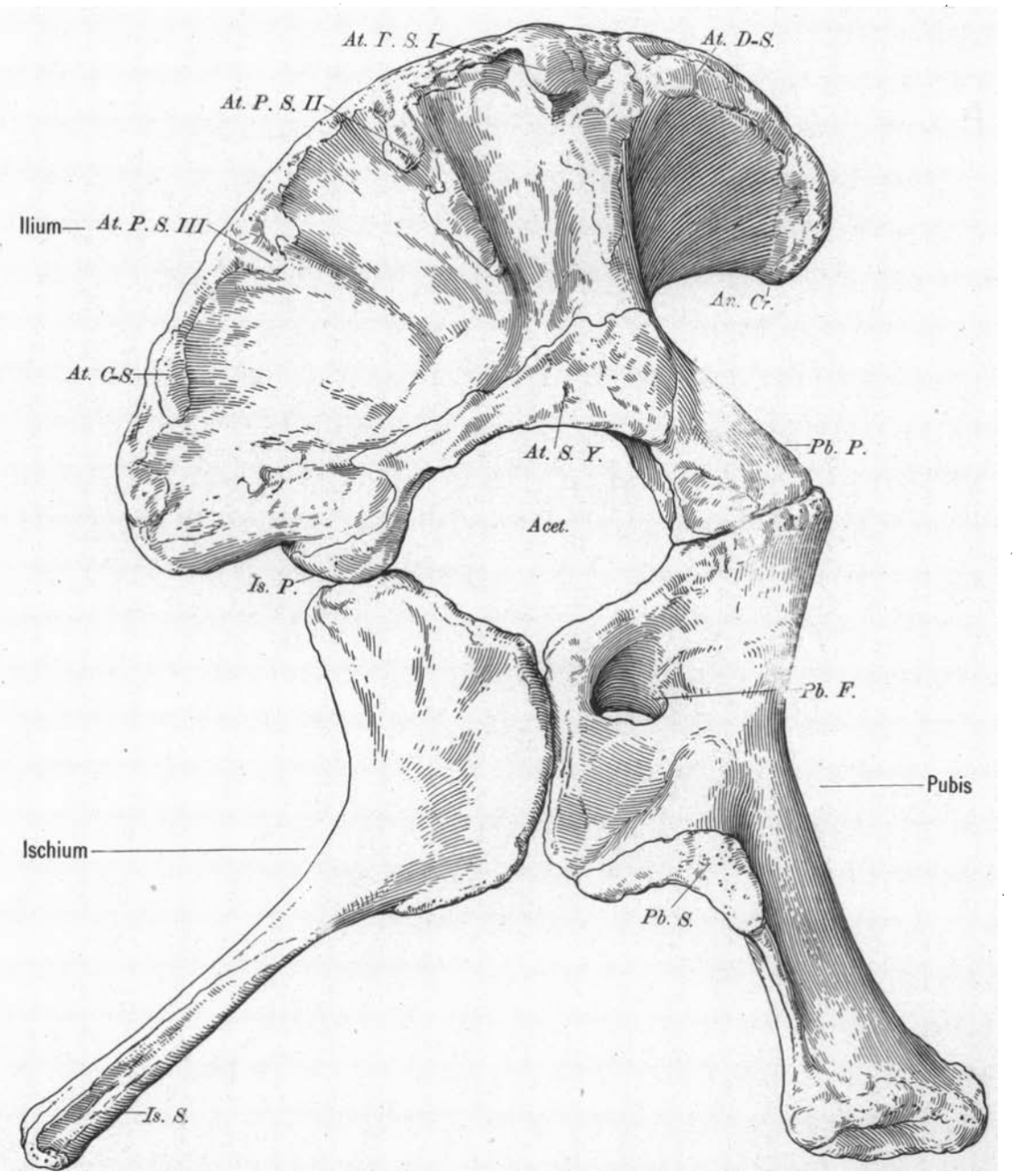

Fig. 88. Reconstruction of pelvis of *Camarasaurus supremus* Cope. (Based on Amer. Mus. Cope Coll. No. 5761.)

Internal view; one-tenth natural size. *Acet* acetabulum; *An. Cr.* anterior crest of ilium; *At. C-S.* attachment area of caudo-sacral; *At. D-S.* attachment area of dorso-sacral; *At. P. S. I.* attachment area of Primary Sacral I; *At. P. S. II.* attachment area of Primary Sacral II; *At. P. S. III.* attachment area of Primary Sacral III; *At. S. Y.* attachment area of sacricostal yoke; *Is. P.* ischiadic peduncle; *Is. S.* ischiadic surface; *Pb. F.* pubic foramen; *Pb. P.* pubic peduncle; *Pb. S.* pubic surface. Compare with Fig. 87.

pair of ischia belongs to *Camarasaurus* along with the other three pairs. The differences may be due to the presence of two species in the material; it is possible that they represent sexual differences; they may even be individual differences, although they appear to be too great for that.

Characters

In most respects the ischia of *Camarasaurus* resemble those of other genera of the Sauropoda. They differ from all other known sauropod ischia in having long slender shafts and no expansions at the distal ends.

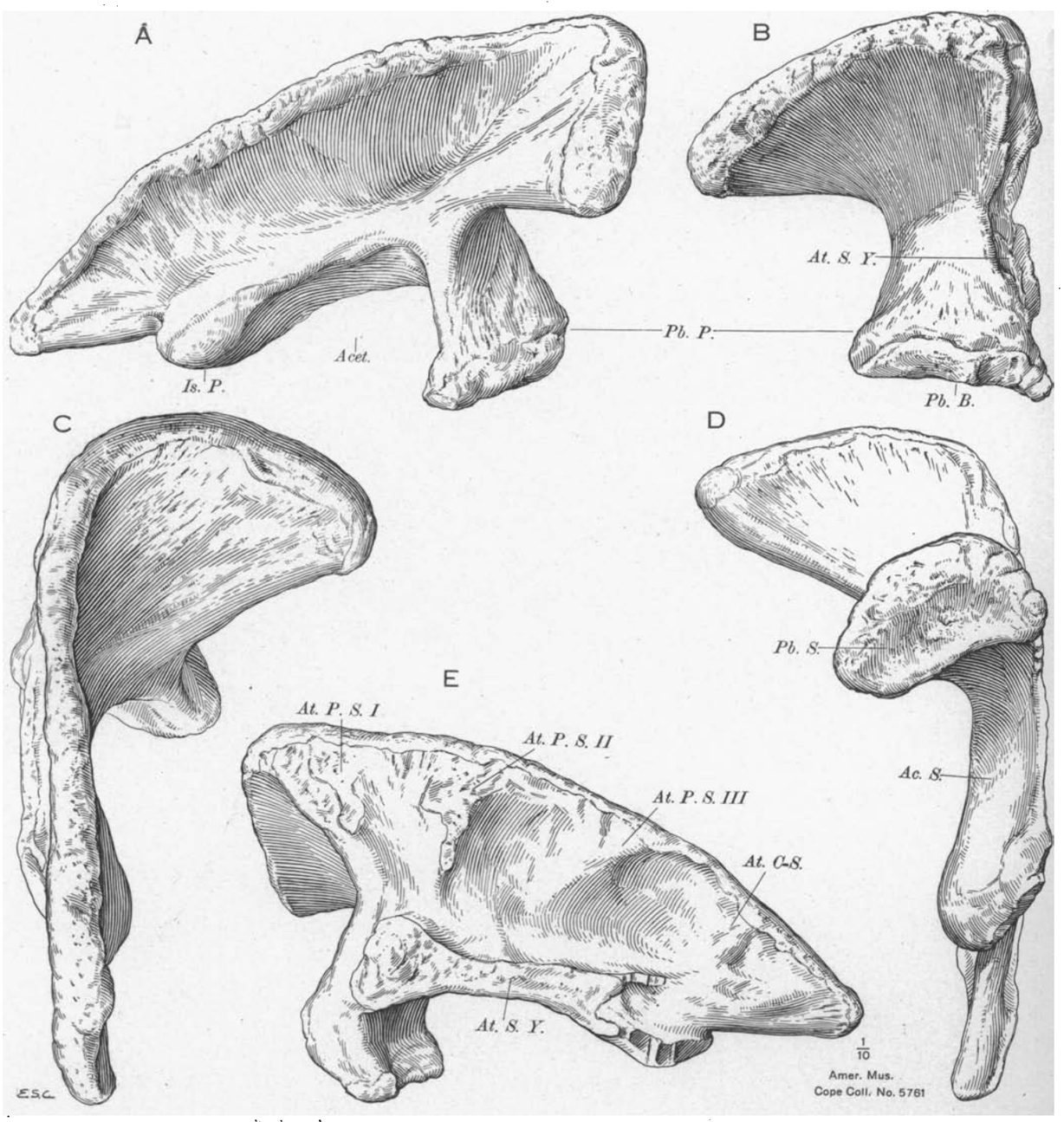

Fig. 89. Right ilium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{II.1}$. (A) external view; (B) anterior view; (C) superior view; (D) inferior view; (E) internal view; one-tenth natural size. *Acet.* acetabulum; *Ac. S.* acetabular surface; *At. C-S.* attachment of caudo-sacral vertebra; *At. P. S. I.* attachment area of Primary Sacral I; *At. P. S. II.* attachment area of Primary Sacral II; *At. P. S. III.* attachment area of Primary Sacral III; *At. S. Y.* attachment area of sacricostal yoke; *Is. P.* ischiadic peduncle; *Pb. B.* pubic border; *Pb. P.* pubic peduncle; *Pb. S.* pubic surface. This ilium is probably the opposite to Il. 2 (Fig. 90), and is part of the basis of the reconstructions of the pelvis (Figs. 45, 46, 47, 48, 49, 87 and 88).

The acetabular surfaces of the ischia are smooth. The surfaces which articulated with the ilia and the pubes are slightly roughened. The surface which articulated with the corresponding surface of the opposite ischium is sharply set off from the rest of the shaft. A cross-section of the shaft resembles a distorted triangle.

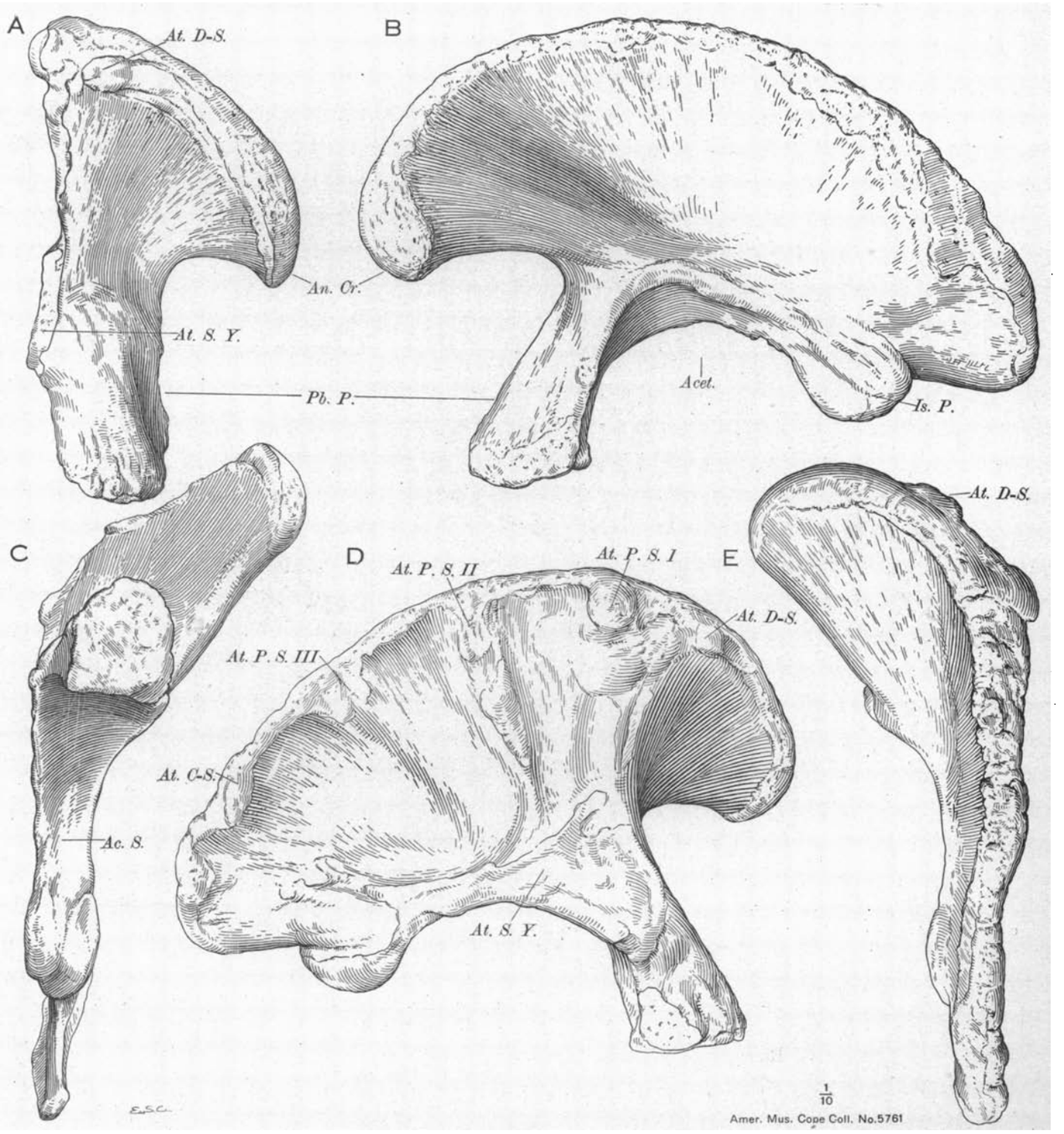

Fig. 90. Left ilium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{II.1}$. (A) anterior view; (B) external view; (C) inferior view; (D) internal view; (E) superior view; one-tenth natural size. *Acet.* acetabulum; *Ac. S.* acetabular surface; *An. Cr.* anterior crest; *At. C-S.* attachment area of caudo-sacral; *At. D-S.* attachment area of dorso-sacral; *At. P. S. I.* attachment area of Primary Sacral I; *At. P. S. II.* attachment area of Primary Sacral II; *At. P. S. III.* attachment area of Primary Sacral III; *At. S. Y.* attachment area of sacricostal yoke; *Is. P.* ischiadic peduncle; *Pb. P.* pubic peduncle. This ilium is probably the opposite of Il. 1 (Fig. 89), and is part of the basis of the reconstructions of the pelvis (Figs. 45, 46, 47, 48, 49, 87 and 88).

Measurements

(Text Figs. 94–101)

Ischium	Specimen No.	Length, Total	Breadth, Proximal End	Breadth, Distal End	Circumference, Shaft
Right	5761 Is. 1	116.0 cm.	greatly distorted	18.5 cm.	33.5 cm.
Right	5760′ Is. 2	108.0	65.0	19.0 *inc.*	39.0
Left	5761 Is. 3	104.0	60.0	14.0	31.5
Left	5760′ Is. 4	115.0	64.5	19.0	39.0
Right	5761 Is. 5	103.5	63.5	14.0	31.0
Left	5760′ Is.6	120.0	....	16.5	45.5
Left	5761 Is. 7	....	59.0	....	....
Right	5760′ Is. 8	....	....	....	....

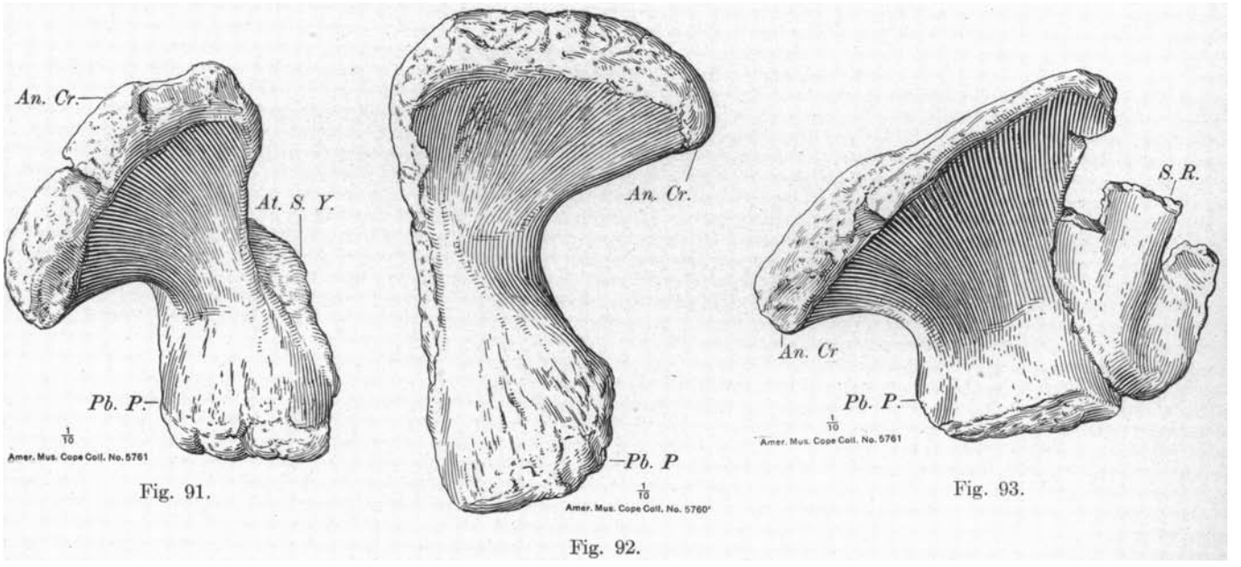

Fig. 91. Fig. 92. Fig. 93.

Fig. 91. Right ilium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{II.5}$. Anterior view; one-tenth natural size. *An. Cr.* anterior crest; *At. S. Y.* attachment border of sacricostal yoke; *Pb. P.* pubic peduncle. (Compare with original figure, Fig. 13.)

Fig. 92. Left ilium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760'}{II.3}$. Anterior view; one-tenth natural size. *An. Cr.* anterior crest; *Pb. P.* pubic peduncle.

Fig. 93. Right ilium and fragment of sacrum of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{II.4}$. Anterior view; one-tenth natural size. *An. Cr.* anterior crest; *Pb. P.* pubic peduncle; *S. R.* sacral rib. Crushed vertically.

PUBIS

Material and Association.— Six pubes are present in the collection. One of these is evidently part of the type of *Amphicœlias*. Two of the five pubes referable to *Camarasaurus* belong to the right side

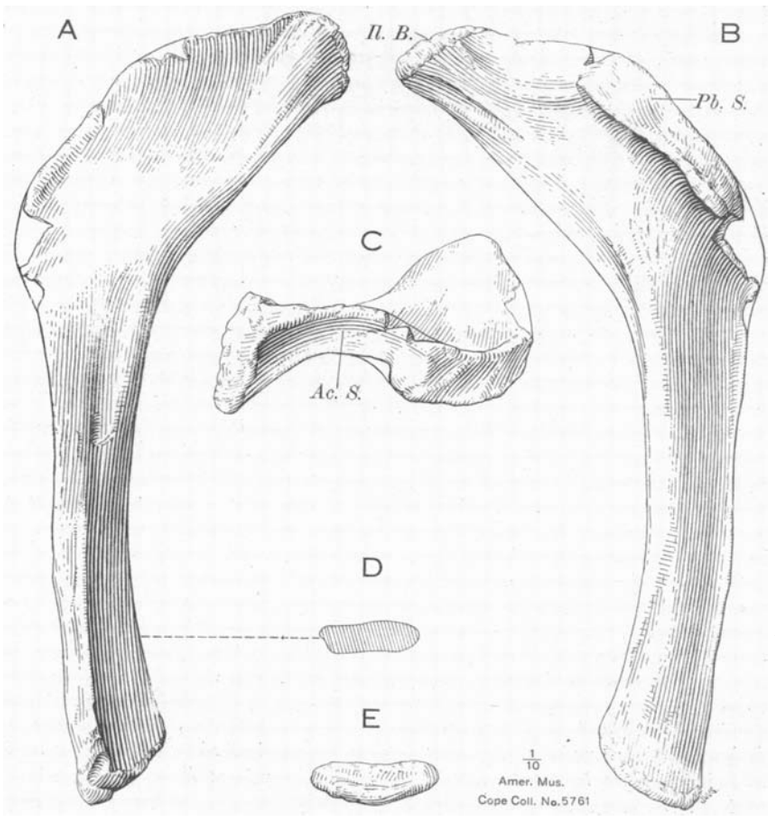

Fig. 94. Right ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Is.1}$. (A) internal view; (B) external view; (C) proximal view; (D) section of shaft; (E) distal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Pb. S.* pubic surface. Reconstructed parts in outline.

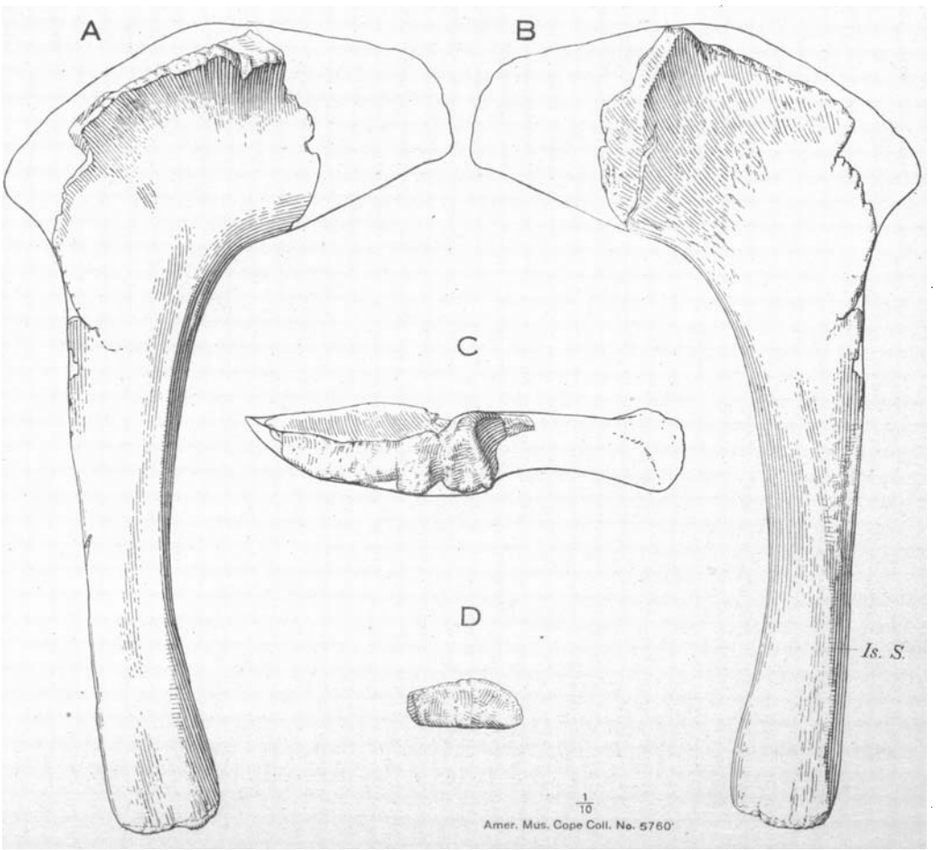

Fig. 95. Left ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760}{Is.6}$. (A) internal view; (B) external view; (C) proximal view; (D) distal view; one-tenth natural size. *Is. S.* ischiadic surface. Reconstructed parts in outline.

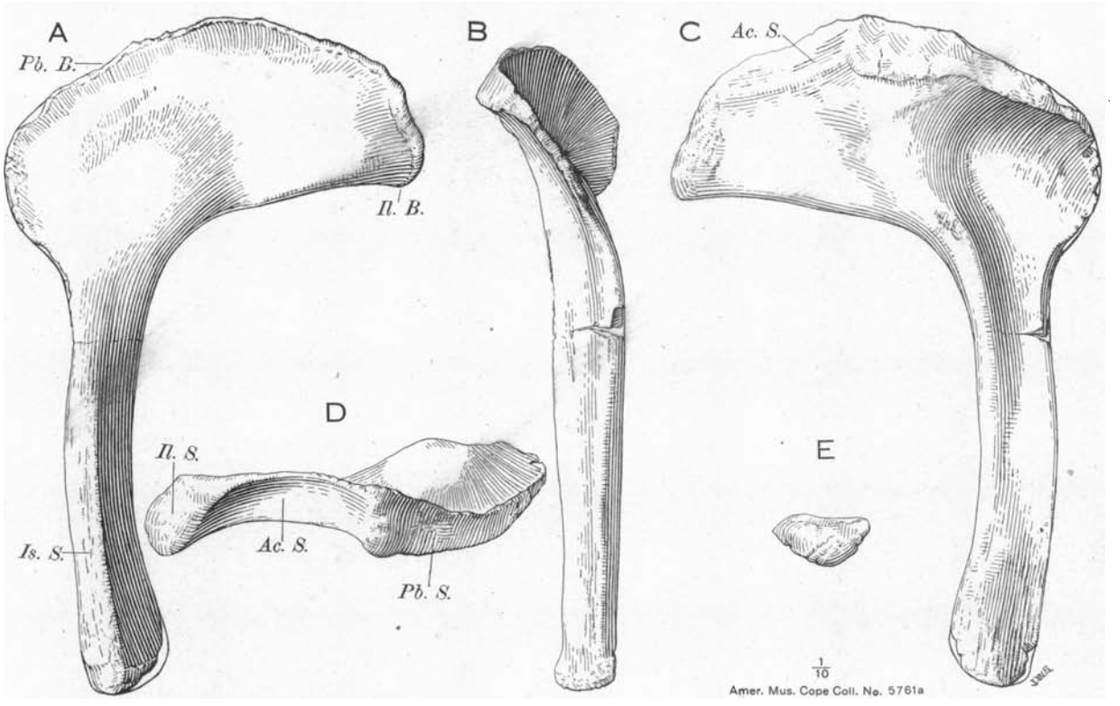

Fig. 96. Right ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761\text{-}a}{Is.\,5}$. (A) internal view; (B) inferior view; (C) external view; (D) proximal view; (E) distal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Il. S.* iliac surface; *Is. S.* ischiadic surface; *Pb. B.* pubic border; *Pb. S.* pubic surface. Probably the opposite of Is. 5 (Fig. 97). Reconstructed parts in outline.

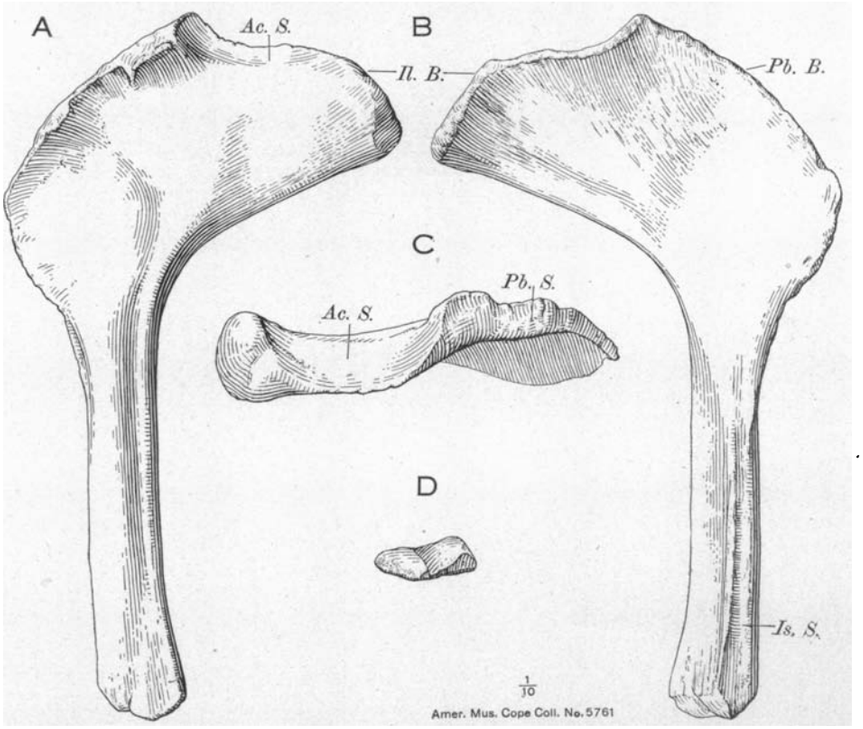

Fig. 97. Left ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Is.\,3}$. (A) external view; (B) internal view; (C) proximal view; (D) distal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Is. S.* ischiadic surface; *Pb. B.* pubic border; *Pb. S.* pubic surface. Probably the opposite of Is. 3 (Fig. 96).

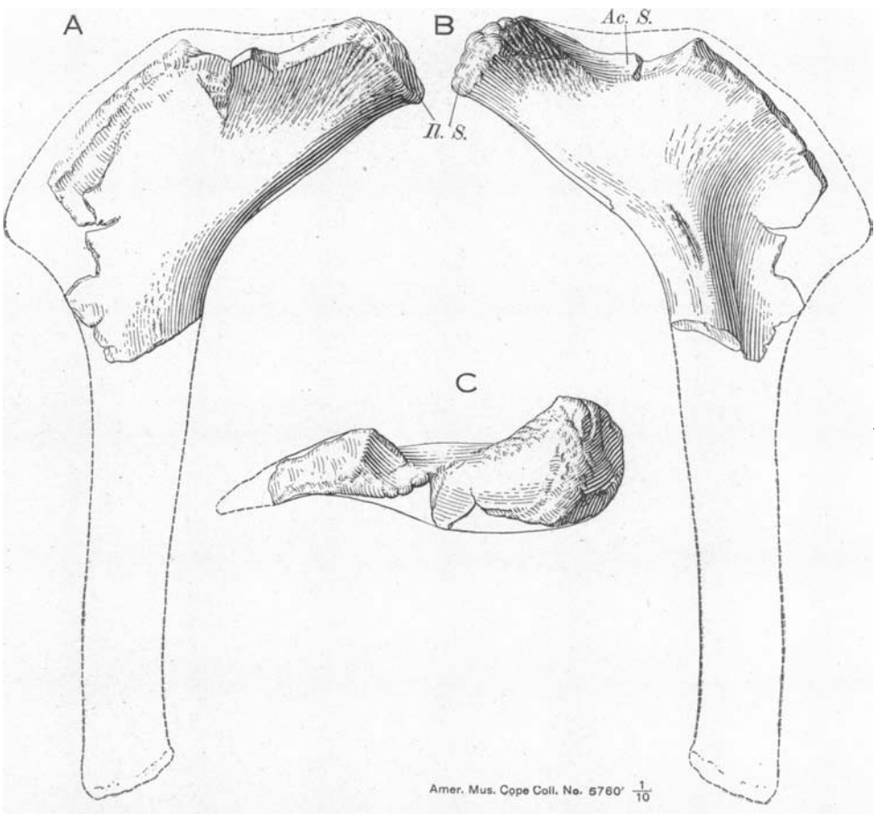

Fig. 98. Right ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760'}{Is.8}$. (A) internal view; (B) external view; (C) proximal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. S.* iliac surface. Probably the opposite of Is. 7 (Fig. 99). Reconstructed parts definitely known in outline; inferred, in dash lines.

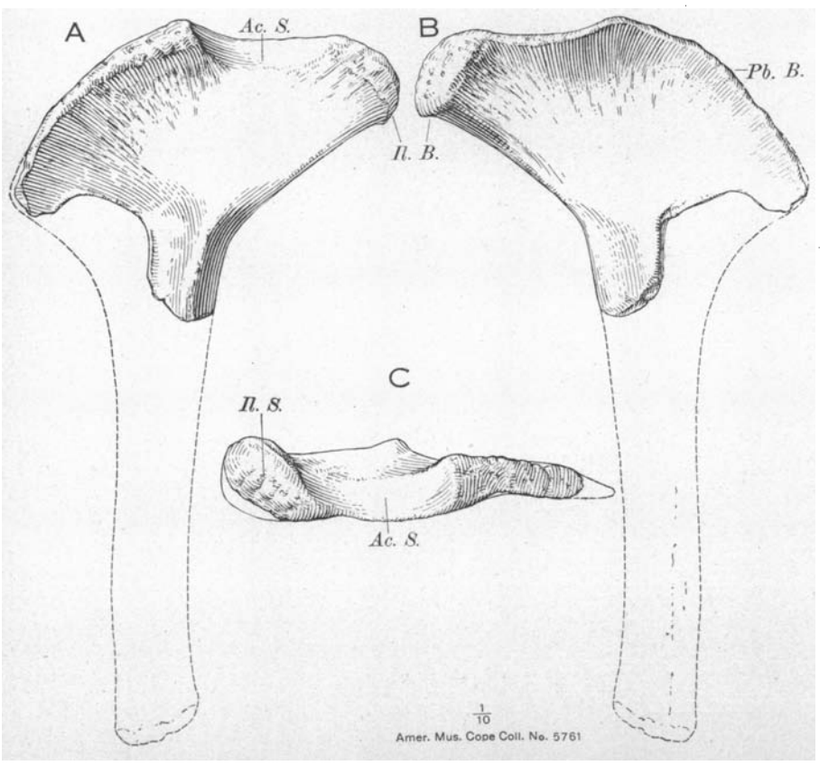

Fig. 99. Left ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Is.7}$. (A) external view; (B) internal view; (C) proximal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Il. S.* iliac surface; *Pb. B.* pubic border. Probably the opposite of Is. 8 (Fig. 98). Reconstructed portion, inferred, in dash lines.

and three to the left. The association of these bones with each other and with other material in the collection is unknown. They vary slightly in color, but not definitely enough for the variation to be of any use in determining association.

Characters

The *Camarasaurus* pubis is thick and massively constructed. The acetabular surface is broad, also the surface which articulated with the ilium; the acetabular surface is smooth, and the iliac surface fairly so; the internal surface, which articulated with the pubis of the opposite side, is considerably roughened. The internal border is very sharply twisted; the upper portion is concave anteriorly, and

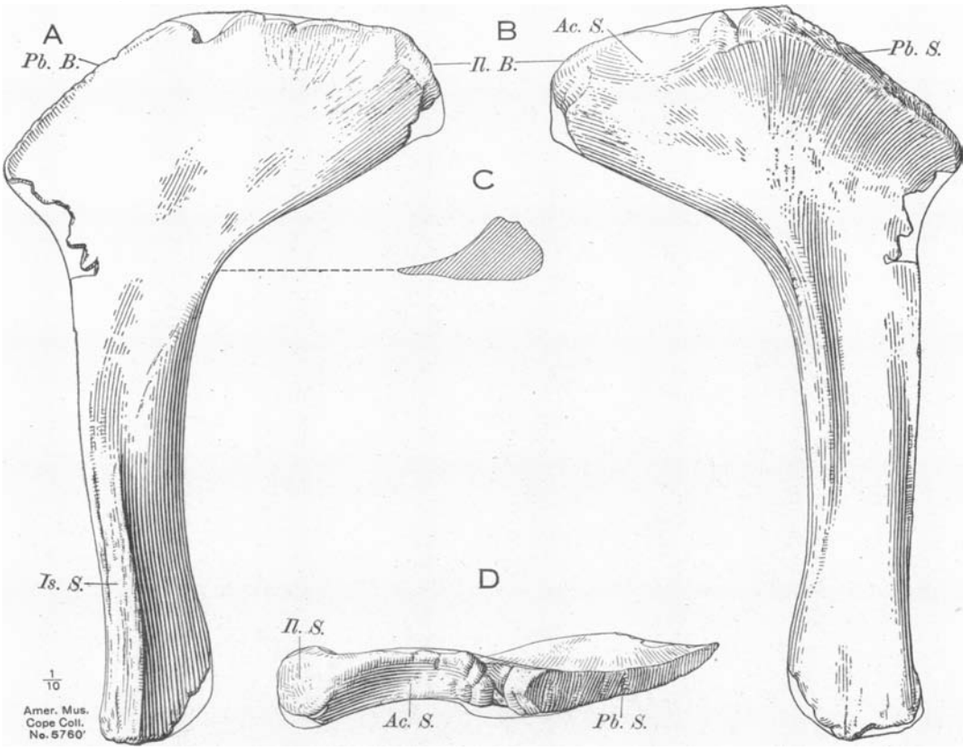

Fig. 100. Right ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760}{Is.2}$. (A) internal view; (B) external view; (C) section of shaft; (D) proximal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Il. S.* iliac surface; *Is. S.* ischiadic surface; *Pb. B.* pubic border; *Pb.* pubic surface. Probably the opposite of Is. 4 (Fig. 101). Reconstructed parts in outline.

the middle portion is concave posteriorly; the lower portion of the internal border does not articulate with the opposite one, and it is straight. The shaft is somewhat flattened, and is also very thick. The distal end is not rounded, as in *Apatosaurus*, but flattened, or irregular; it was evidently capped with cartilage.

The position of the two pubes when in place is such that the greatest breadth of each pubis is nearly parallel with the transverse axis of the animal.

Measurements

(Text Figs. 102–106)

Pubis	Specimen No.	Length, Total	Breadth, Proximal End	Breadth, Distal End
Right	5761 / Pb. 1	98.0 cm.	41.5 cm.	46.0 cm.
Left	5761 / Pb. 2	102.5	41.5 *e.*	38.5
Right	5760′ / Pb. 3	....	....	....
Left	5760″ / Pb. 4	100.0	....	31.5
Left	5761 / Pb. 6	105.5	....	....

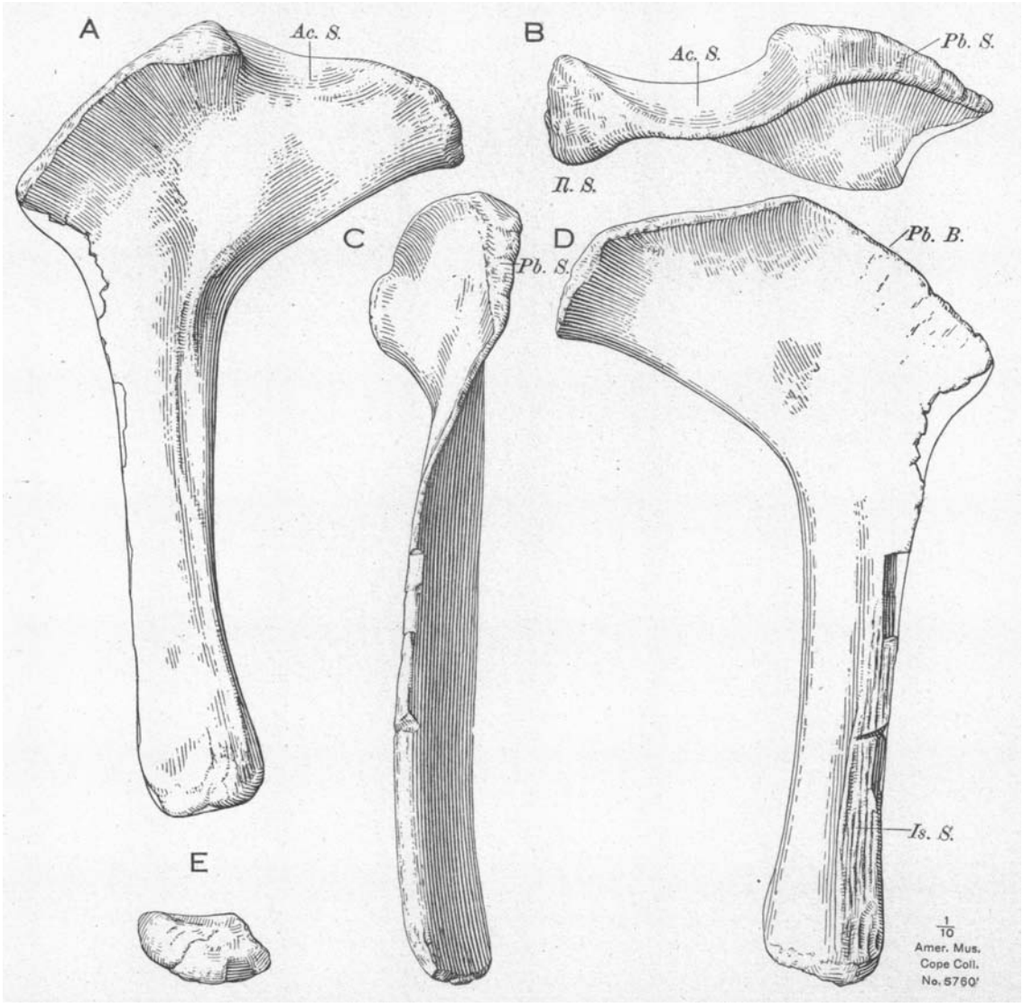

Fig. 101. Left ischium of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760'}{Is.\ 4}$. (A) external view; (B) proximal view; (C) inferior view; (D) internal view; (E) distal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. S.* iliac surface; *Is. S.* ischiadic surface; *Pb. B.* pubic border; *Pb. S.* pubic surface. Probably the opposite of Is. 2 (Fig. 100). Reconstructed portion in outline.

Hind Limb

FEMUR

Material and Association.— Five femora are present in the collection. One of these is part of the type of *Amphicœlias altus*, and is described below. Another constitutes the principal element in the type of *A. latus;* it is altogether different in proportions from the above-mentioned femur and very clearly belongs to a different genus; it agrees with the known *Camarasaurus* femora in being stout and short; it is here referred provisionally to a small, possibly a young, individual of the latter genus. These femora probably came from a different quarry than those which yielded the larger quantity of the *Camarasaurus* bones.

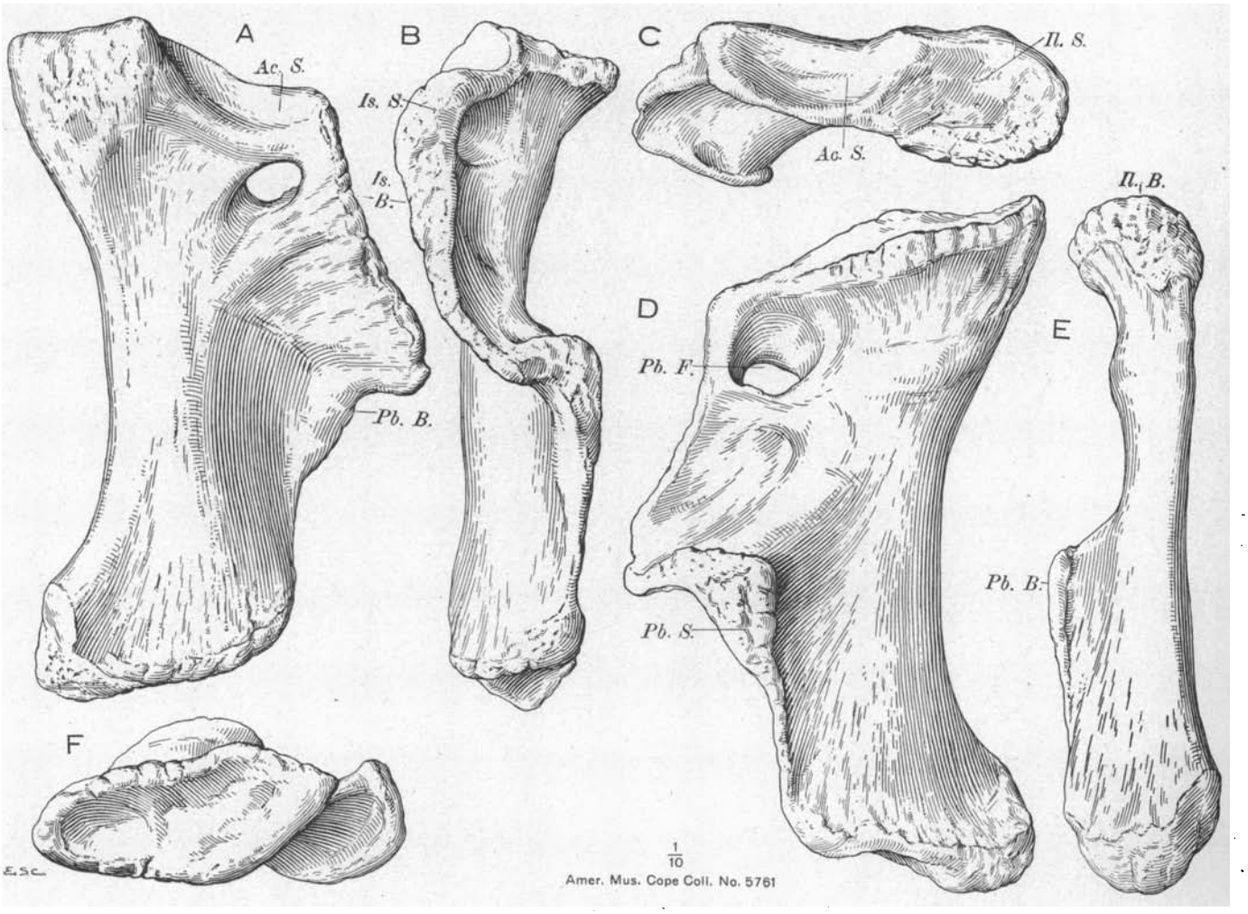

Fig. 102. Left pubis of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Pb.2}$. (A) external view; (B) posterior view; (C) proximal view; (D) internal view; (E) distal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Il. S.* iliac surface; *Is. B.* ischiadic border; *Is. S.* ischiadic surface; *Pb. B.* pubic border; *Pb. F.* pubic foramen. This bone served as part of the basis of the reconstructions of the pelvis (Figs. 45, 46, 87, 88).

There is a huge left femur, which is incompletely preserved, and two smaller femora, one a left and one a right. The great left femur is the only one which can be considered as belonging with one of the fully grown *Camarasaurus* skeletons. Of the other two the shorter, or right, may well belong to a young individual of *Camarasaurus*, not represented by other bones. The left one corresponds with the lower portion of the type femur of *Amphicœlias altus*, and is provisionally referred to that form.

Characters

The characters of the femur are chiefly taken from the great left femur mentioned above; the entire external half of the specimen is lacking; the internal half is complete except for part of the distal end; the long broken surface exhibits the interior structure of the bone; the femur is not solid, neither is it hollow; it is filled with a mass of coarse-grained spongy bone; the internal border of the bone is strongly curved longitudinally, and the head is very large and massive. These facts lead to the conclusion that

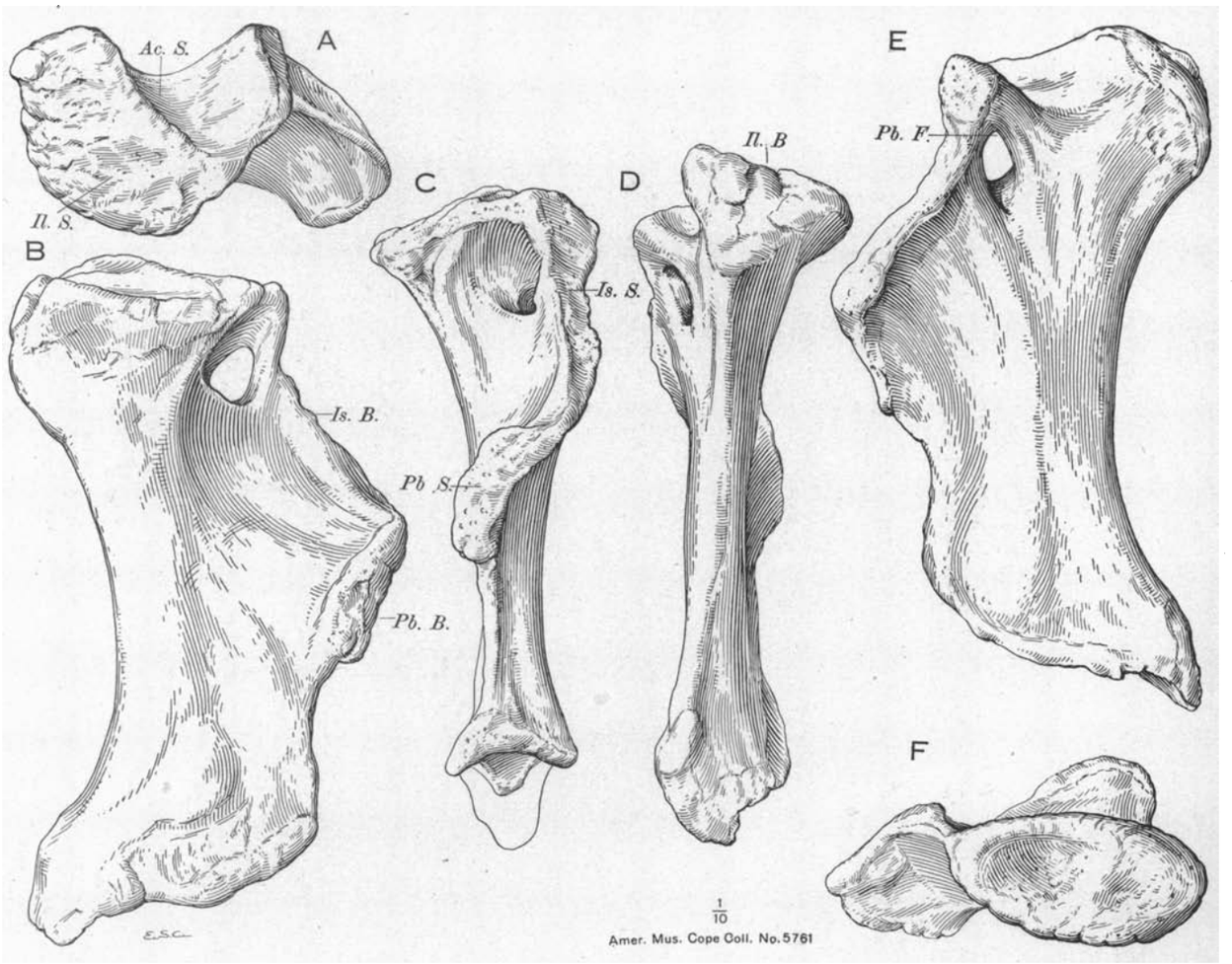

Fig. 103. Right pubis of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Pb.1}$. (A) proximal view; (B) internal view; (C) posterior view; (D) anterior view; (E) external view; (F) distal view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Il. S.* iliac surface; *Is. B.* ischiadic border; *Is. S.* ischiadic surface; *Pb. B.* pubic border; *Pb. F.* pubic foramen; *Pb. S.* pubic surface. Reconstructed portion in outline. (This pubis is part of the basis for the reconstruction of the pelvis (Figs. 45, 46, 87, and 88).

the breadth of the femur was very great. The broad lateral curvature supports this inference. The femur therefore has been restored as very massive in its proportions. The head is somewhat roughened by small pits; it is not strongly rugose, however, as in some sauropod genera; this may be due to incomplete preservation of the original rugose surfaces. The superior portion of the shaft is well preserved; it is thick antero-posteriorly; the inferior portion of the shaft has been distorted; the antero-posterior

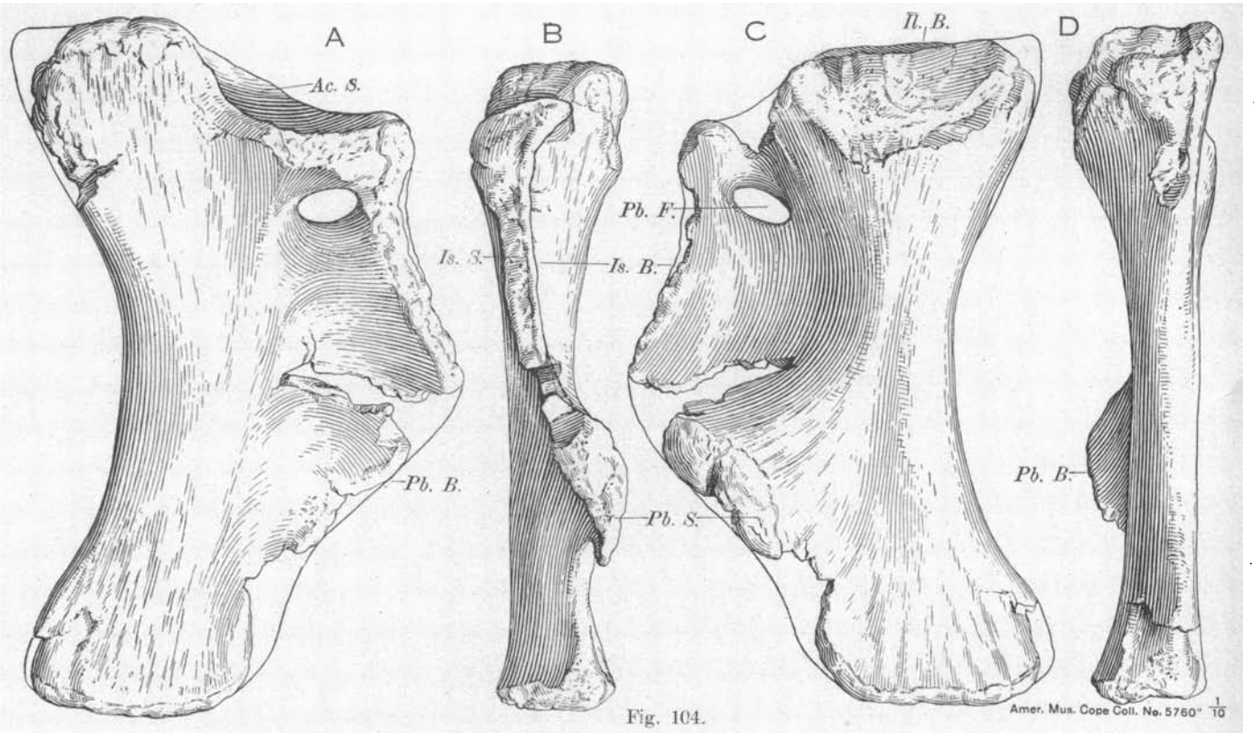

Fig. 104.

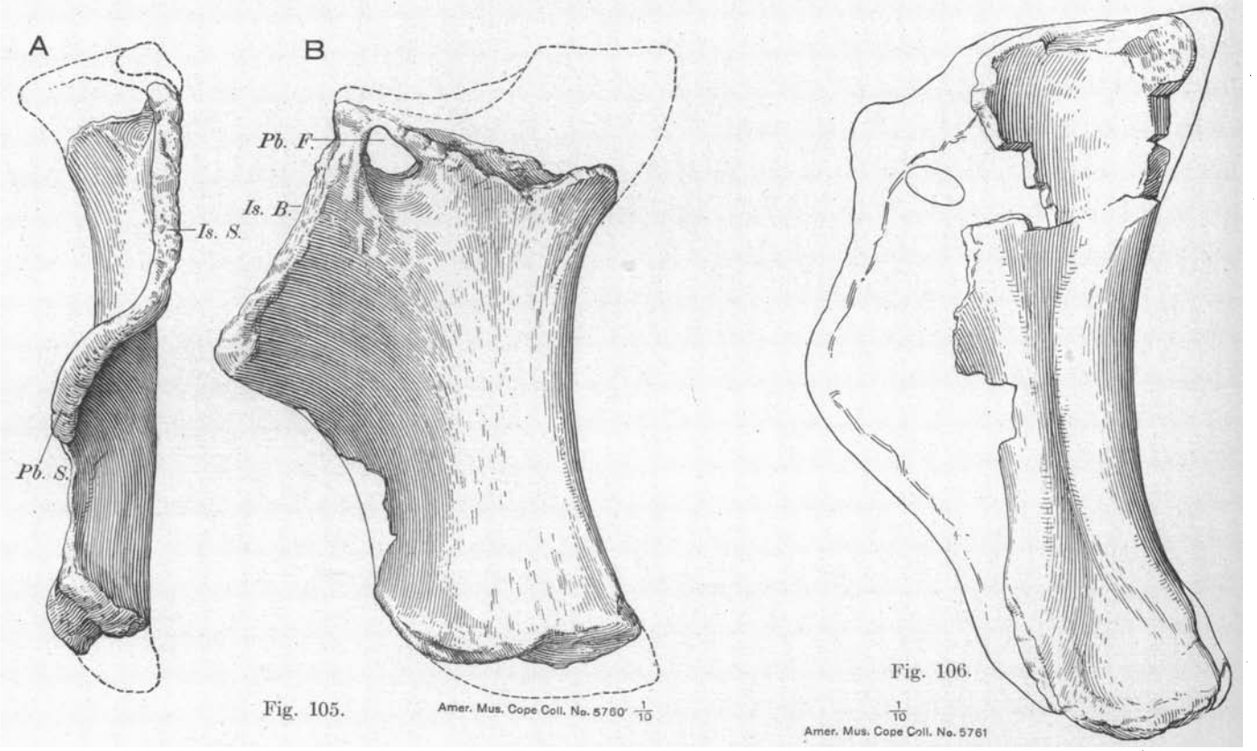

Fig. 105.

Fig. 104. Left pubis of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760''}{Pb.4}$. (A) external view; (B) posterior view; (C) internal view; (D) anterior view; one-tenth natural size. *Ac. S.* acetabular surface; *Il. B.* iliac border; *Is. B.* ischiadic border; *Is. S.* ischiadic surface; *Pb. B.* pubic border; *Pb. F.* pubic foramen; *Pb. S.* pubic surface. Reconstructed parts in outline. This pubis is one of the bones originally figured by Cope. (See Fig. 12).

Fig. 105. Right pubis of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760'}{Pb.3}$. (A) posterior view; (B) external view; one-tenth natural size. *Is. B.* ischiadic border; *Is. S.* ischiadic surface; *Pb. F.* pubic foramen; *Pb. S.* pubic surface. Reconstructed parts which are certain in outline; inferred in dash lines.

Fig. 106. Left pubis of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Pb.6}$. Internal view; one-tenth natural size. Reconstructed parts in outline.

diameter has been increased abnormally. This distortion has resulted in the anterior border of the femur, and to a lesser extent the posterior border, becoming convex instead of straight or very slightly concave, as in undistorted sauropod femora. This bulging has made the internal aspect of the bone seem clumsy in appearance.

The fourth trochanter is prominent and rather rugose; it is remarkable in that its apex is situated exactly halfway between the proximal and distal ends of the bone. All other known sauropod femora have the trochanter slightly nearer the proximal end than the distal. This may be a specific, or perhaps an individual character; it cannot be considered as a generic character.

Measurements

(Text Figs. 107–109)

Femur	Specimen No.	Length, Total	Breadth, Proximal End	Breadth, Distal End	Circumference	Index
Left	$\frac{5761a}{\text{Fm. 1}}$	180.0 cm. *e.*	....	....	....	....
Left	$\frac{5765}{\text{Fm. 4}}$	127.0 *inc.*	45.0 cm. *inc.*	44.0 cm.	71.0 cm.	.559

TIBIA

Material and Association — Four tibiæ are present in the collection. Two of these belong to the right side and two to the left. One of the left tibiæ is much larger than the other. The distal end of this large tibia is incompletely preserved. The other left tibia is considerably distorted and badly eroded. One of the right tibiæ is well preserved and the other one is incomplete. There is no record of the association of these bones. The right tibiæ are yellow, and the left are red. The dimensions and characters, as well as the color, suggest that all of these tibiæ are from different individuals. The complete right tibia (Amer. Mus. Cope Coll. No. $\frac{5761}{\text{Tb. 1}}$) fits very accurately with one of the fibulæ (Amer. Mus. Cope Coll. No. $\frac{5761}{\text{Fb. 1}}$ and the two bones probably came from the same individual. The only preserved astragalus was probably also a part of this hind limb.

Characters

The tibia is massive in form and is considerably shorter than the femur. An exact ratio cannot be determined, owing to lack of knowledge of the association of the bones. The superior end is very broad transversely. The external flange, which partially locks the fibula in position, is thick. The shaft is comparatively thick, but is considerably constricted with respect to the ends; the transverse diameter of the shaft is considerably greater than the antero-posterior diameter; it is possible that this is partly due to crushing of a similar nature in all of the specimens, but it is probable that it is essentially a relaible character. The shaft is slightly twisted, resulting in a non-parallel arrangement of the superior and inferior portions of the anterior surface. The distal end is expanded, but not to the extent of the proximal end. The inferior border is even, but inclines upward and outward toward the fibula. There is a slight notch on the inferior surface, which lodged the astragalus. The external border articulates closely with the fibula. The tibia resembles very closely that of *Apatosaurus*.

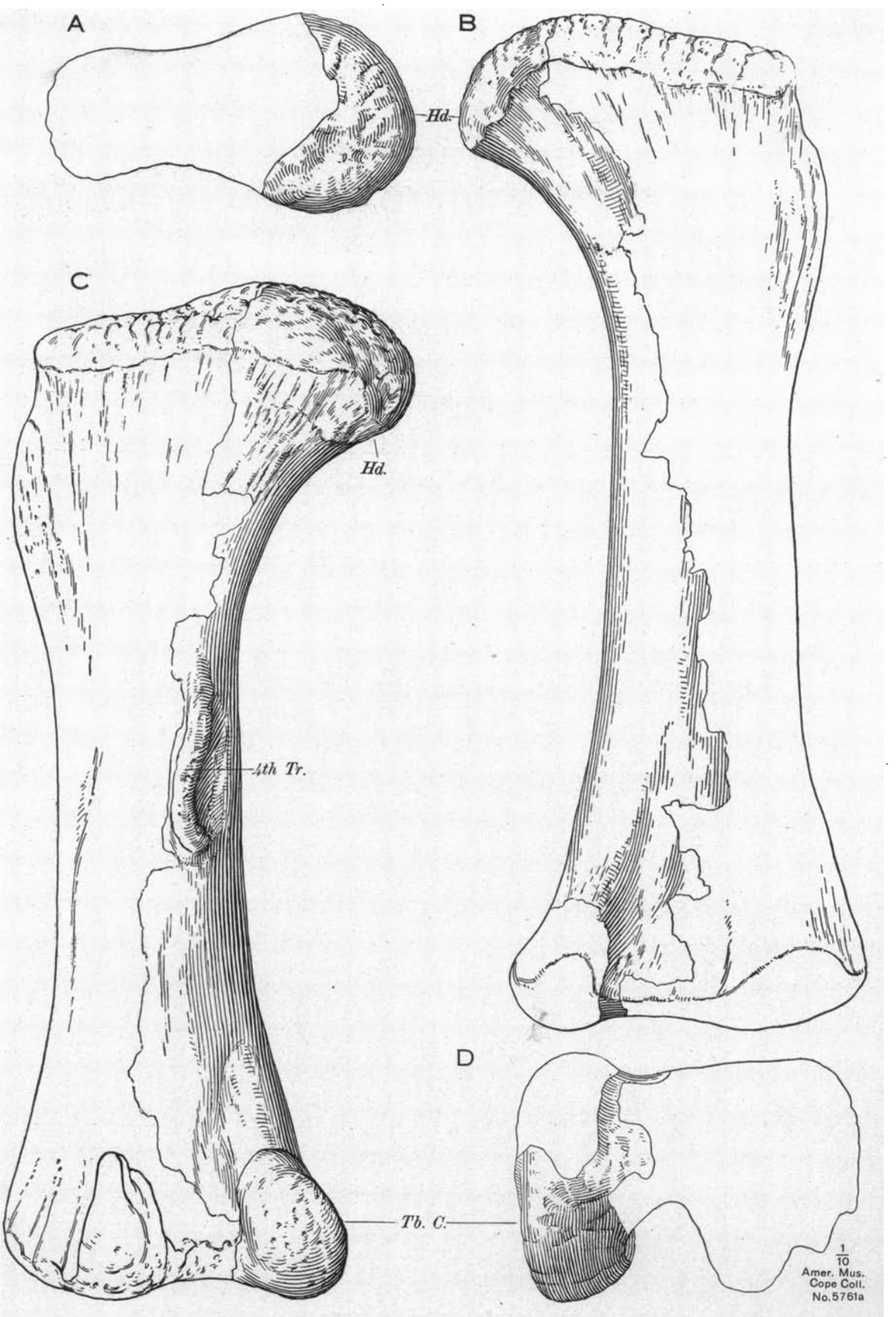

Fig. 107. Left femur of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761\text{-}a}{Fem.1}$. (A) proximal view; (B) anterior view; (C) posterior view; (D) distal view; one-tenth natural size. *Hd.* head; *Tb. C.* tibial condyle; *4th Tr.* fourth trochanter. Reconstructed parts in outline. (See Fig. 108.)

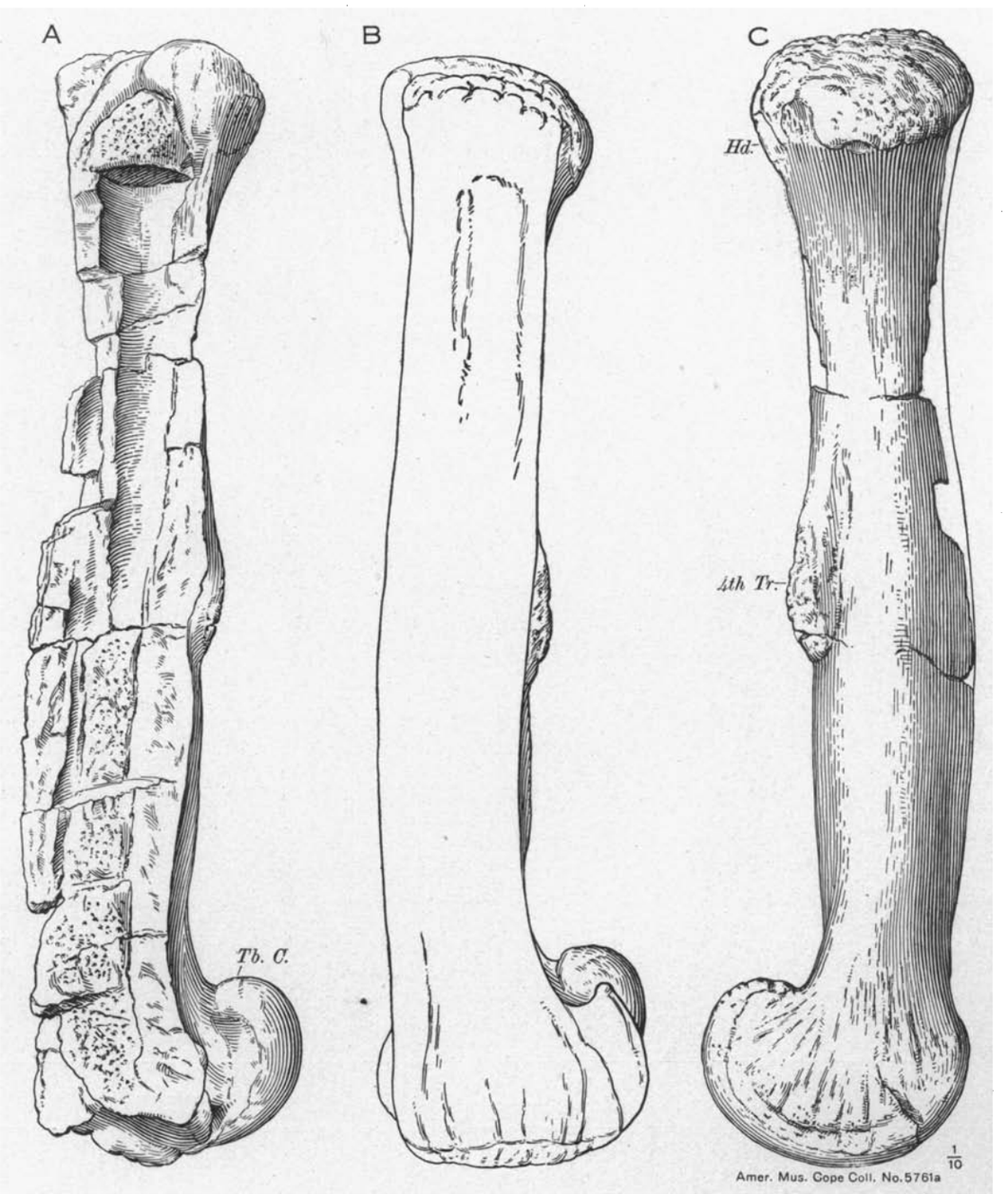

Fig. 108. Left femur of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761\text{-}a}{Fem.1}$. (A) broken surface, showing interior structure; (B) external view; (C) internal view; one-tenth natural size. *Hd.* head; *4th Tr.* fourth trochanter; *Tb. C.* tibial condyle. Reconstructed parts in outline. (See Fig. 107.)

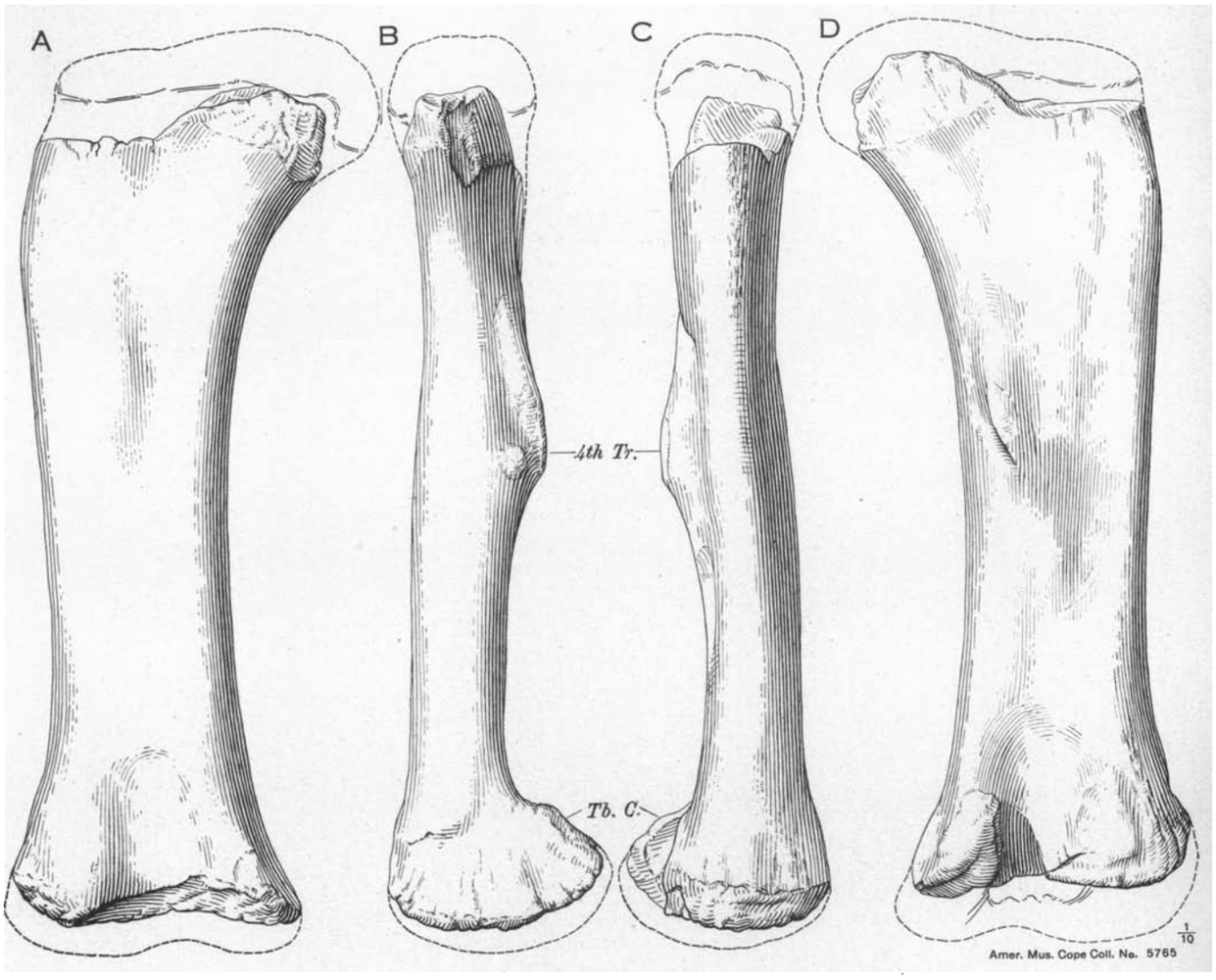

Fig. 109. Right femur of *Camarasaurus* species.

Amer. Mus. Cope Coll. No. 5765. (A) anterior view; (B) internal view; (C) external view; (D) posterior view; one-tenth natural size. *Tb. C.* tibial condyle; *4th Tr.* fourth trochanter. Reconstructed parts in outline. This is part of Cope's type of *Amphicœlias latus*. (Compare with original type figure, Fig. 20.)

Measurements

(Text Figs. 111–113)

Tibia	Specimen No.	Length	Breadth, Proximal End	Breadth, Distal End	Circumference	Index
Right	5761 / Tb. 1	104.0 cm.	41.5 cm.	35.5 cm.	55.0 cm.	.528
Left	5760′ / Tb. 2	126.5	47.0	33.5	64.0	.505
Right	5760″ / Tb. 3	109.5	42.5 *d.*	30.5	54.0	.493

FIBULA

Material and Association.— Only two fibulæ are present in the *Camarasaurus* cotype material, both of which belong to the right side. The better preserved of the two belongs to the "yellow series" and fits

closely with the right tibia described above. The other one is incompletely preserved; it cannot be associated with either "red series" or "yellow series" by color, and its association with other bones is unknown.

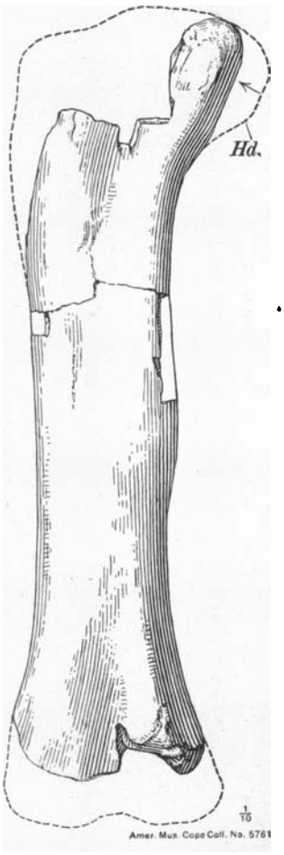

Fig. 110. Left femur of a sauropod dinosaur, probably a young *Camarasaurus*.

Amer. Mus. Cope Coll. No. $\frac{5761}{\text{Fem. 2}}$. Anterior view; one-tenth natural size. *Hd.* head. Reconstructed parts certain in outline; inferred, in dash lines.

Characters

The fibula of *Camarasaurus* is scarcely distinguishable from that of *Apatosaurus*. The antero-posterior diameter is considerably greater than the transverse; it is much greater near the proximal than near the distal end. The internal surface is twisted so that the anterior margin is broadly rounded near the proximal end, and is a thin edge near the distal end; this thin edge faces obliquely forward and outward. The ends are rounded and are slightly rugose. There is one prominent rugosity on the external surface, slightly nearer the proximal end than the distal, and slightly nearer the anterior border than the posterior; it is elevated on a low process, and evidently served for the attachment of powerful muscles. A less prominent rugosity is situated near the proximal end on the external border.

Measurements

(Text Figs. 111 and 115)

Fibula	Specimen No.	Length	Breadth, Proximal End	Breadth, Distal End	Circumference	Index
Right	$\frac{5761}{\text{Fb. 1}}$	111.0 cm.	26.0 cm.	19.0 cm.	35.0 cm.	.315
Right	$\frac{5760'}{\text{Fb. 2}}$	114.0	....	....	39.0	.342

ASTRAGALUS

Material and Association.— There is only one astragalus in the collection; it belongs to the right side, is yellow in color, and corresponds in size and shape with the astragalar articular surfaces of the well-preserved tibia and fibula described above. These facts indicate that the astragalus was probably originally associated with this tibia and fibula, but it is by no means certain. The field association is unknown.

Characters

The astragalus is a broad flat bone. Viewed from above, the anterior border is irregularly convex. The posterior border is nearly straight. The anterior and posterior borders converge internally, consequently the internal border is short; it is also convex. The internal half of the superior surface is flat;

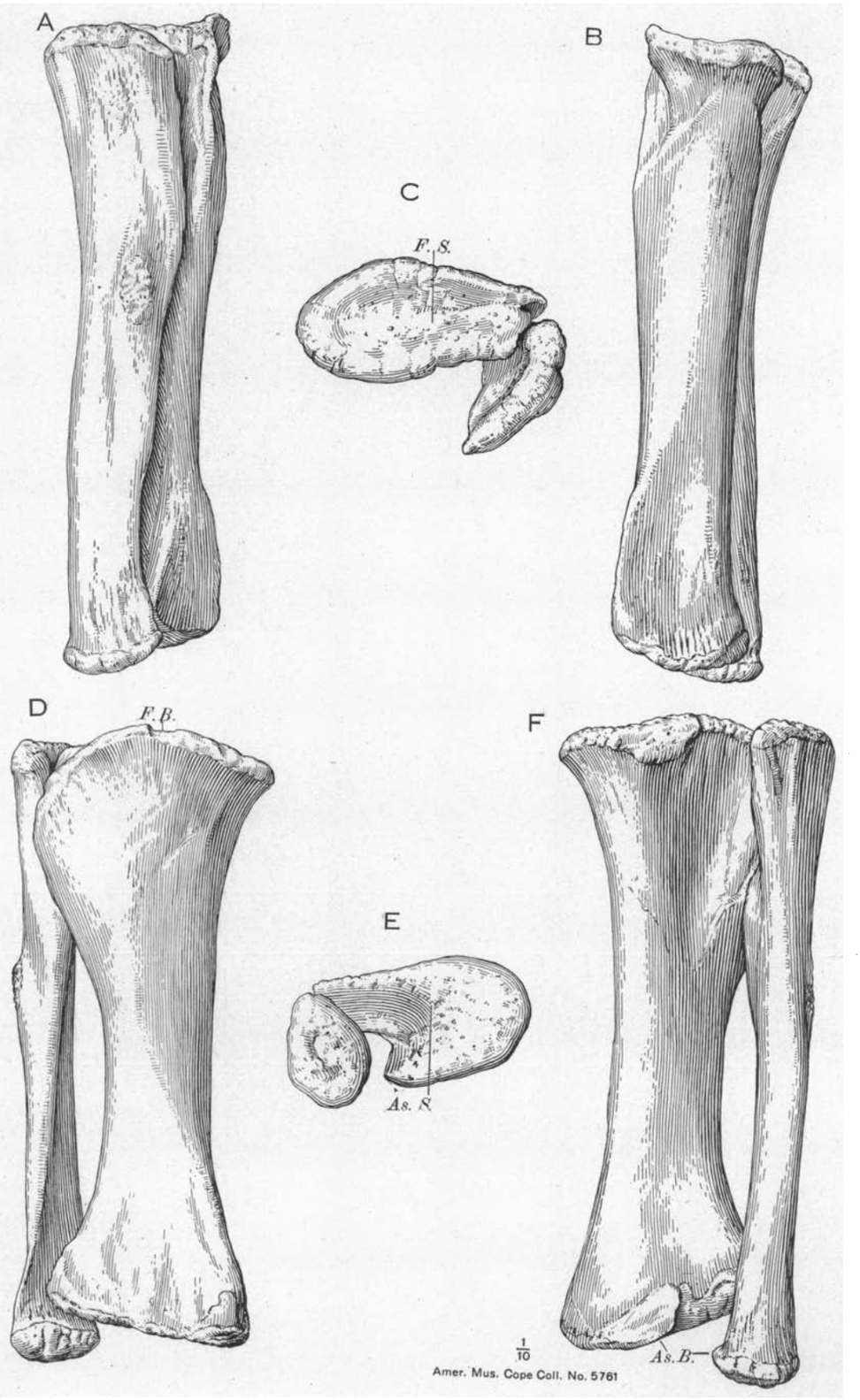

Fig. 111. Right tibia and fibula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Tb.1}$ and $\frac{5761}{Fb.1}$. (A) external view; (B) internal view, (C) proximal view; (D) anterior view; (E) distal view; (F) posterior view; one tenth natural size. *As. B.* astragalar border; *As. S.* astragalar surface; *F. B.* femoral border; *F. S.* femoral surface.

the external half is irregular. Of this external half the anterior portion is excavated into a pit, and the posterior portion is elevated into a prominent process. These structures correspond with similar, but alternately placed structures on the inferior surface of the tibia. The external surface is excavated into a deep longitudinal groove, which is overhung by the tibial process above mentioned. This groove corresponds with the internal ridge at the distal end of the fibula, the two bones locking tightly together when in position. The inferior, or distal tarsal surface is slightly and irregularly convex. The degree of convexity has evidently been reduced by crushing.

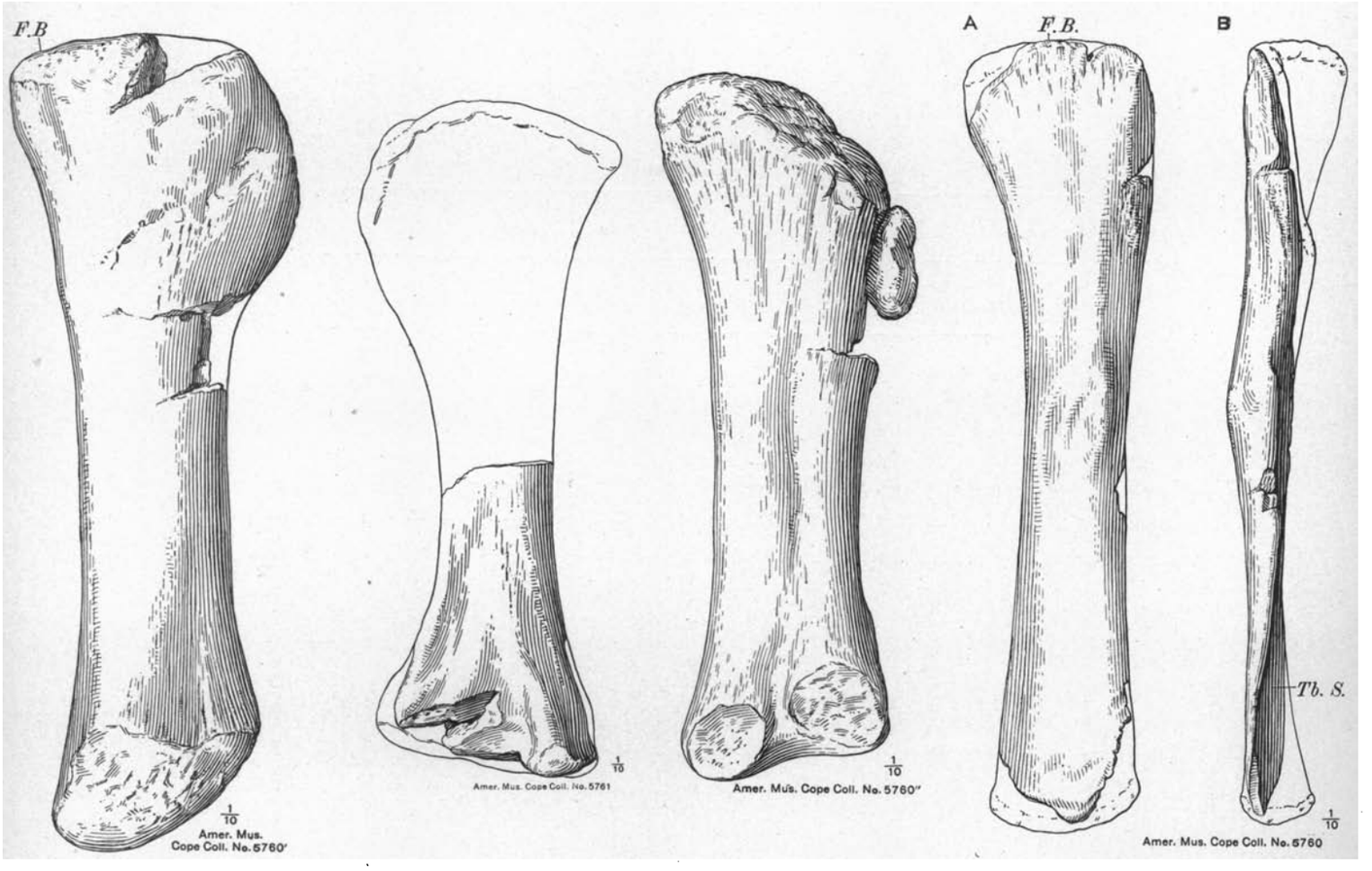

Fig. 112. Fig. 113. Fig. 114. Fig. 115.

Fig. 112. Left tibia of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760'}{Tb.2}$. Anterior view; one-tenth natural size. *F. B.* femoral border. Reconstructed parts in outline.

Fig. 113. Right tibia referred to *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{Tb.4}$. Anterior view; one-tenth natural size. Reconstructed parts in outline.

Fig. 114. Right tibia of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760''}{Tb.3}$. Posterior view; one-tenth natural size.

Fig. 115. Right fibula of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5760'}{Fb.2}$. (A) lateral view; right side; (B) anterior view; one-tenth natural size. *F. B.* femoral border; *Tb. S.* tibial surface. Reconstructed parts in outline.

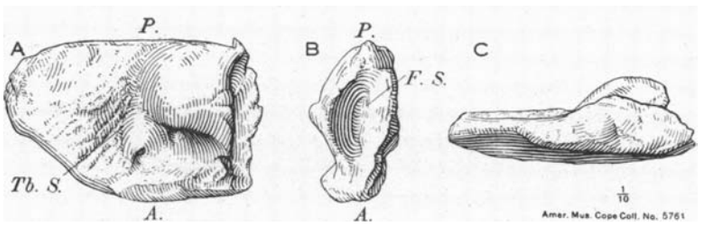

Fig. 116. Right astragalus of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. 5761. (A) superior view; (B) lateral view, left side; (C) anterior view; one-tenth natural size. *A.* anterior; *F. S.* fibular surface; *P.* posterior; *Tb. S.* tibial surface.

Measurements

(Text Fig. 116)

Astragalus	Specimen No.	Length, Maximum	Breadth, Maximum	Thickness, Vertical, Maximum
Right	5761 / As. 1	23.0 cm.	38.0 cm.	13.0 cm.

METATARSAL

Material and Association.— Only one metatarsal is preserved in the collection; it is identifiable as a Mtt. III of the right side. Its association with other bones is unknown; it is yellowish in color, and may have been originally associated with other yellow bones.

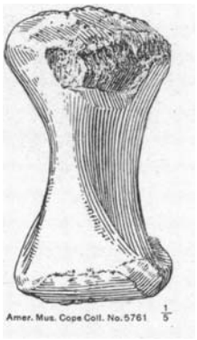

Fig. 117. Right metatarsal III of *Camarasaurus supremus* Cope.

Amer. Mus. Cope Coll. No. $\frac{5761}{\text{Mtp. 3}}$. Anterior view; one-fifth natural size.

Characters

This bone is short and stout. Its most striking characteristic is the twisted form, the greatest diameter across the proximal end making an angle of about 40° with the transverse diameter of the distal end. The anterior and posterior surfaces are smooth, also the lateral borders. Both the superior and the inferior extremities are expanded laterally. On the posterior border of the distal end is situated a pair of articular processes whose articular surfaces merge into that of the distal end.

Measurements

(Text Fig. 117)

Metatarsal	Specimen No.	Length	Circumference	Index
Right III	5761 / Mp. 3	22.5 cm.	22.0 cm.	.977

Restorations and Reconstructions

Restoration of the Head

The restoration of the head is based upon the skull bones in this collection, the Wyoming skull of *Camarasaurus* (*Morosaurus*) (Amer. Mus. No. 467), and upon photographs of recent lizards and *Sphenodon*. Fig. 118 *b* and *c* indicates the head in its normal position, i. e., with its longitudinal axis at an angle with the longitudinal axis of the neck. In Fig. 118*a* the head is indicated in an elevated position, with the axis of the head in line with that of the neck.

The position of the supraorbital ridge is accurately indicated by the skull mentioned above; the positions of the nares, orbits, and temporal membranes are indicated approximately. These structures are probably correctly placed, or if they are at all incorrect, only to a very slight extent.

Restorations and Reconstructions of the *Camarasaurus* Skeleton

Ryder's Restoration.— It would be hardly justice to the very able comparative anatomist, Dr. John A. Ryder, to publish, without explanation, his reconstruction (Plate LXXXII), roughly drawn, life size, and exhibited before the American Philosophical Society December 21, 1877.

The reconstruction was obviously made after one series of bones was exposed, but before Professor Cope had had time to give them much study. It would not appear that Professor Cope himself seriously studied the reconstruction, from the false arrangement of the teeth on the malar arch and from the placing of consolidated spines like those of the sacrum opposite the massive scapula.

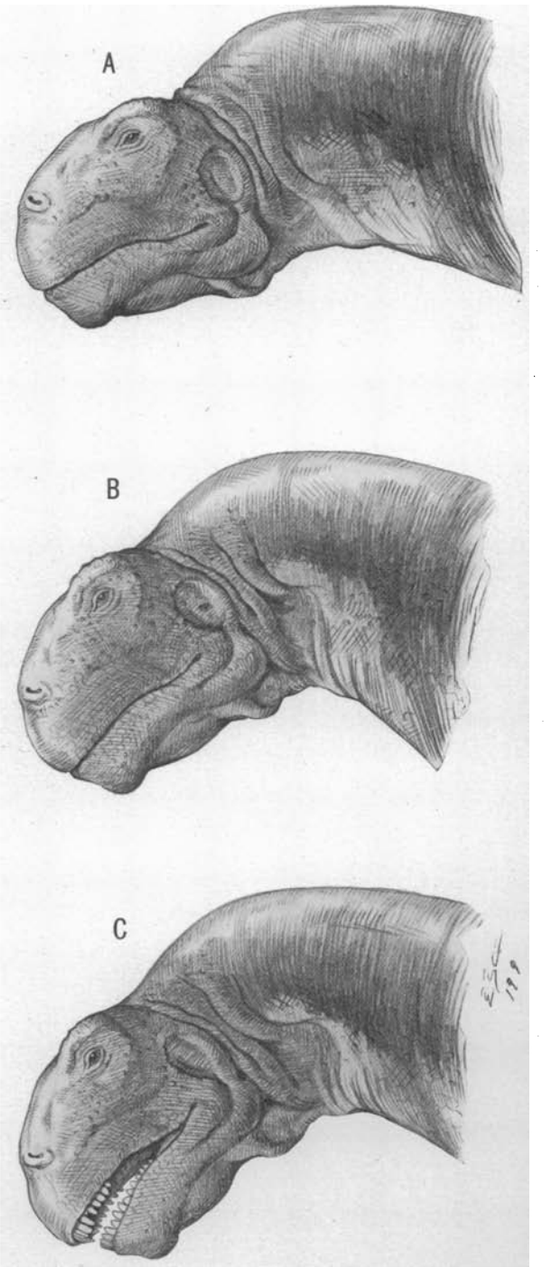

Fig. 118. Three studies of head of *Camarasaurus*.

(A) Head extended and bent upwards with reference to the neck; (B) head in normal relation to neck; (C) normal position of head, with mouth open, exposing teeth. The head of *Camarasaurus* is extremely short and deep. The nostrils and eyes are elevated. The tympanum leaves a space behind the quadrate.

Twelve to thirteen vertebræ are consigned to the neck, close to the true number. Eighteen vertebræ are consigned to the back, eight too many. Fifty-seven vertebræ are consigned to the tail, not far from the correct number. A complete set of claws are consigned to both the fore and the hind feet.

Still Unknown Parts of *Camarasaurus*

(1) In the accompanying restorations and reconstructions, Figure 118 and Plates LXXXIII and LXXXIV, it is observed that our knowledge of this animal is still very incomplete regarding the structure of the pes, the dotted lines being based on our knowledge of the pes of *Apatosaurus* or *Brontosaurus*.

(2) It is also unknown or uncertain whether these animals possessed a set of abdominal ribs. One rib (Fig. 73) has been found which may possibly represent a member of the abdominal rib series.

(3) The vertebral formula is still uncertain, although it is probable that the number was as follows: cervicals 13; rib-bearing dorsals 10, dorso-sacral, 1; consolidated primary sacrals, 3; caudo-sacrals, 1; caudals 53.

Present Reconstructions and Restorations

As detailed in the introduction and in the text, Plates LXXXIII and LXXXIV represent both a *reconstruction* and a *restoration*, based upon the topotype materials of four or more individuals of *Camarasaurus*.

The *skull* characters are partly based upon the *Camarasaurus* topotype skull bones and largely upon the nearly complete skull originally referred to *Morosaurus* by Osborn; it is probable but not certain that this reference is correct.

It is very important to note that the four chief skeletons and two of the remaining skeletons are of approximately the *same linear measurements*, but *differ slightly in proportions*.

Chief Proportions of the Skeleton

(1) The *enlargement and elevation of the shoulder* above the relatively depressed and reduced sacro-pelvic region is one of the most surprising features of this reconstruction. This proportion cannot be considered as actually *demonstrated*, because only two complete ilia were found with the four skeletons, and they belong to the same individual. It is possible that these ilia and the other bones of the pelvis which appear to belong with them (Figs. 45, 46, 47, 87, 88, 89, 90) represent another individual than those individuals represented by the massive scapulo-coracoid bones. The other pubes and ischia are of the same size as in the pelvis figured in the restoration.

This makes the highest point in the backbone between the shoulders, as contrasted with the previous restorations of *Brontosaurus* and *Diplodocus* by Osborn, in which the pelvic region is made the high point. Recent studies of *Apatosaurus* by Osborn, Gregory, and Mook make the shoulders higher than the sacrum.

(2) The neck is rather massive and the neck and shoulders bore the chief weight. The heaviest portion of the chest was at the fourth rib, where the relatively immobile hyposphen-hypantrum articulation of the dorsal vertebræ begins.

(3) The linear proportions of the various segments of the axial skeleton may be roughly indicated as follows:

	M.	In.
Skull and jaws	1.195	47.07
13 cervical vertebræ	5.000	196.85

	M.	In.
10 to 11 dorsal vertebræ	3.200	125.98
4 sacral vertebræ	.800	31.49
53 caudal vertebræ	7.300	287.40
Length of combined axial skeleton, head and vertebral column	17.495	688.79

(4) As shown in the articulated skeleton (Fig. 28) the total length and height of the animal, with the spinal curvatures and in the walking pose, were as follows:

Elevation of the head above the ground ..... 20 to 22 feet
Total length from the front of the head to the tip of the tail ..... 50 to 52 feet
Height of the backbone at the shoulder ..... 12 to 13 feet
Maximum depth of chest from the summit of the neural spines to the sternal plates ..... 8 feet

(5) The head in the Sauropoda, as pointed out by Holland, has been mistakenly represented as parallel with the long axis of the neck, whereas it should be *flexed* or at an angle with the neck. In this respect our reconstruction gives a somewhat misleading impression, as the head should be bent down as in Figure 118 B, C. It is correctly indicated in the restoration model, Plate LXXXV.

COMPARISON WITH OTHER SAUROPODA

As compared with the two other Sauropoda, in which the skeleton is now fully known, namely, *Diplodocus* and *Apatosaurus*, *Camarasaurus* is relatively the most massive, the most elevated at the shoulder, the least elongated over all, and the most ponderous in its proportions. It was apparently not provided with the whip-like terminal tail vertebræ so characteristic of *Apatosaurus* and *Diplodocus;* the vertebræ steadily lessen in longitudinal diameter and would indicate that the tail came to a rather abrupt point.

EXTERNAL APPEARANCE OF *Camarasaurus*

The external appearance of the head is shown in Fig. 118. The head is extremely short and deep in its proportions, contrasting with the elongate head of *Diplodocus*. The animal as a whole is indicated in Plate LXXXV. This represents an animal terrestrial in gait but adapted to an amphibious life. In the present drawing the fore and hind limbs may be too rounded and not of sufficiently elongate oval section. Studies of the limb motions of the larger reptiles are now being made with a view to correctly portraying the surfaces of the limbs in action. In general the present drawing (Plate LXXXV) only partly expresses the opinions of the authors on the external appearance of these animals. After a careful study of the musculature had been made, a complete model, based on the muscular anatomy, was made, in order to gain an approximate portrayal of the external appearance.

SUMMARY OF CHARACTERS OF THE GENUS *CAMARASAURUS*

The results of the present investigations include determinations of the generic characters of *Camarasaurus* so far as these characters are determinable from the material in the collection. The genus *Camarasaurus* includes animals of massive proportions. Throughout the skeleton, with the single exception of the ischium, the bones are stoutly constructed.

The CERVICAL VERTEBRÆ have divided spines, otherwise they are not characteristic. They resemble very closely the cervicals of *Apatosaurus* (*Brontosaurus*).

The DORSAL VERTEBRÆ are characteristic. In addition to their general stoutness the dorsals possess a number of diagnostic characters. The spines are low and broad; they possess a distinct type of lamination of their own, somewhat different from that of any of the other sauropod genera; those of the anterior dorsals are divided as in *Apatosaurus* and *Diplodocus*, and the posterior dorsal spines are single as in those genera. There is a gradual transition from completely divided spines to single spines, contrasting with the relatively abrupt change in *Apatosaurus*. The spine of Dorsal 7 is single or very slightly notched in *Camarasaurus*, whereas in the column of *Diplodocus* the division persists, to an appreciable extent, as far back as Dorsal 9. The zygapophyses are large; in the anterior dorsal region they are far apart; they are close together in the articulation of Dorsal 3 with Dorsal 4, and in the succeeding dorsals. The diapophyses, especially in the anterior region, are long. The parapophyses are low in position in the first three dorsals, posterior to which they are high and situated at a constant level. The dorsal centra are all of medium length, the anterior ones being little longer than those nearer the sacrum; all of them are distinctly opisthocœlous, contrasting with *Apatosaurus* and *Diplodocus*, in which there is an abrupt change from strongly opisthocœlous anterior dorsal centra to distinctly platycœlous centra farther back.

The SACRUM is characterized by short spines and by a tendency toward retardation in the inclusion of the vertebra immediately posterior to Dorsal 10 in the sacrum itself as a functional dorso-sacral.

The CAUDALS are distinguished from those of other sauropod genera by their short spines with expanded summits, the relatively slight development of the caudal ribs, and probably, but not certainly, by the absence of a distal whip-lash.

The SCAPULA is large and massive and is expanded at both ends. The coracoid is subcircular in outline; it is more distinctly rounded than that of *Apatosaurus*, but less so than that of *Diplodocus*.

The fore-limb is not especially characteristic except in small details; it resembles that of *Apatosaurus*.

The ISCHIUM is one of the characteristic bones of the genus. In contrast with the rest of the skeleton it is slender in form, and has a long shaft, differing in regard to the latter character from *Apatosaurus* and *Diplodocus*. The PUBIS is very massive; it is somewhat more angular in outline than that of *Apatosaurus*, and its median border involves a greater degree of twisting.

The vertebral formula is not definitely known. It is probably slightly variable. One interpretation in the present memoir is: cervicals 13, dorsals 10, sacrum 5 (dorso-sacral + 3 primary sacrals + caudo-sacral), caudals 53. Another interpretation used in the memoir is: cervicals 13, dorsals 11, sacrum 4 (3 primary sacrals + caudo-sacral), caudals 53.

SYNONYMY OF *Camarasaurus* COPE AND *Morosaurus* MARSH.— In 1898 the synonymy of *Morosaurus* Marsh with *Camarasaurus* Cope was suggested by Osborn (1898); in 1901 this view was favored by Riggs (1901); in 1914 it was definitely adopted by Mook (1914). In the present memoir *Morosaurus* is considered to be a synonym of *Camarasaurus*, Cope's term having priority and therefore being valid.

The basis for this conclusion is the following group of facts: both the remains of *Camarasaurus* herein described and those of the type specimens of Marsh's various species of *Morosaurus* are massive in proportions, though different in size, and have similar outlines in the bones of the skull so far as these are available for comparison; the teeth are likewise similar; the cervical, vertebræ, especially the axis, are practically identical in form; the dorsal vertebræ have similar outlines and proportions, are composed of essentially the same laminar elements and cavities, and have short spines, the division of which is similar, also the centra exhibit the same kind of opisthocœlous articulation; the sacrum in each possesses short spines of similar form and composition, as well as a tendency toward retardation in the inclusion

of the dorso-sacral in the sacrum; the caudal vertebræ have similar spines, similar centra, and similar slightly retarded development of caudal ribs; the scapulæ and coracoids are almost identical in outline and arrangement of parts; the ischia are slender, both actually and in proportion to other parts of the skeleton, having little resemblance to other sauropod ischia; the pubes are very angular in outline and exhibit a similar form of twisting on the median borders; the limb bone proportions are similar, so far as direct comparison is possible.

The difference in size between the *Camarasaurus* remains now described and those of the Marsh species is largely due to age distinctions. See discussion of *Camarasaurus*, pp. 268, 269.

III.—DETAILED DESCRIPTION OF THE REMAINS OF *AMPHICŒLIAS*

Amphicœlias is represented in the collection by the two dorsal vertebræ, the pubis, and the femur of the holotype. Other material belonging to this collection, provisionally identified as *Amphicœlias*, consists of a scapula, a coracoid, and an ulna. A tooth is included in the material designated Amer. Mus. Cope Coll. No. 5764, but it is not mentioned in Cope's original description, and it does not resemble the teeth of *Diplodocus* which is probably the nearest well-known relative of *Amphicœlias*.

Vertebral Column

Material and Association.— Two dorsal vertebræ are present in the type of *A. altus*. The species *A. fragillimus* was founded on a dorsal vertebra which has not been found in the Cope Collection; it was figured by Cope, and the figure is reproduced in this memoir (Fig. 21). Four caudal vertebræ are mentioned in the type description of *A. latus*. Two of these have been identified; they are clearly referable to *Camarasaurus*, and need no particular description.

Characters

The two dorsal vertebræ of the type of *Amphicœlias altus* (Amer. Mus. Cope Coll. No. 5764) resemble very closely the dorsals of *Diplodocus*. The anterior of the two dorsals is very incompletely preserved; it resembles the sixth dorsal of *Diplodocus* and has been restored from that bone. The spine is not preserved except at the base; it possesses pre- and postspinal laminæ. The right prezygapophysis is preserved; it is of medium size and is situated close to the median line. The right postzygapophysis is also of medium size and close to the median line. A vestige of a portion of the hypantrum is preserved. The diapophyses are not preserved. The right parapophysis is partially preserved, but the capitular facet at the end of it is absent; the process is situated somewhat lower in position than the stump of the diapophysis. There is a single infradiapophysial lamina. The infraprezygapophysial cavity is shallow in general, but has a small deep excavation in its center. The infrapostzygapophysial cavity has only partially complete borders. The infraprezygapophysial lamina is prominent, but the infrapostzygapophysial lamina is not preserved. The anterior and posterior ends of the centrum are not preserved. The pleurocœl is small externally.

The other dorsal vertebra is much better preserved; it resembles Dorsal 10 of *Diplodocus*, but is slightly more robust. The spine is very tall; its summit is expanded, and is somewhat rugose; it possesses prominent prespinal laminæ which are separate throughout most of their lengths, but which unite

superiorly. There are two postspinal laminæ which are entirely separate, though they are close together. The supraprezygapophysial laminæ are absent; they may have been present but not preserved. The suprapostzygapophysial laminæ are prominent, but are short; they incline forward superiorly and join the prominent supradiapophysial laminæ midway between the summit and the base of the spine. The horizontal lamina is preserved on the right side; it is very prominent. There is a small accessory lamina extending from the horizontal lamina to the suprapostzygapophysial lamina.

The prezygapophyses are well preserved; they are fairly large, and are considerably inclined toward each other, though they are close together. The hypantral surfaces are rather prominent and are

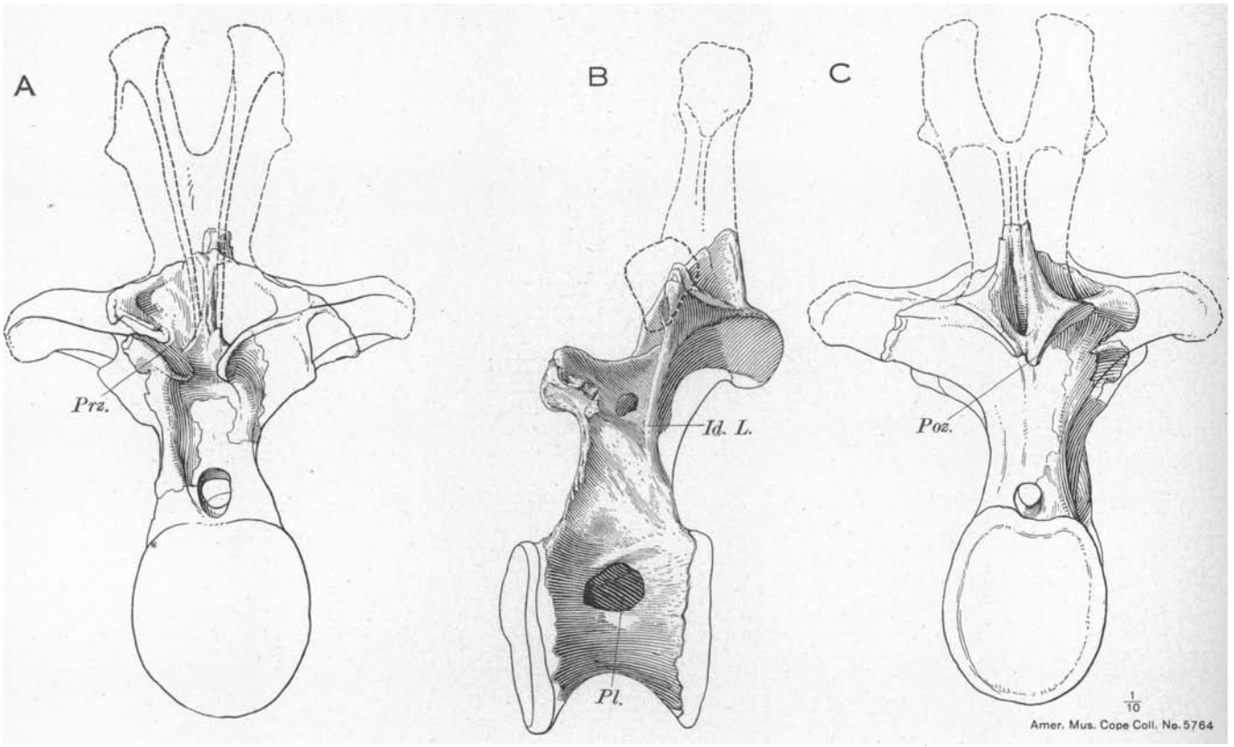

Fig. 119. Type dorsal vertebra of *Amphicœlias altus* Cope.

Dorsal 6, estimated (Amer. Mus. Cope Coll. No. 5764). (A) anterior view; (B) lateral view, left side (reversed from right side); (C) posterior view; one-tenth natural size. *Id. L.* infradiapophysial lamina; *Pl.* pleurocœl; *Poz.* postzygapophysis; *Prz.* prezygapophysis. Reconstructed parts certain in outline; inferred, in dash lines.

strongly supported, though they have not the strength of the corresponding structures of *Camarasaurus*. The postzygapophyses are much larger than the prezygapophyses; they are slightly inclined toward each other and are close together. The hyposphen is large and prominent; its articular surfaces are confluent with the postzygapophyses.

The right diapophysis is preserved; it is short and stout, and is situated nearer the prezygapophyses than the postzygapophyses; its articular surface faces directly outward. The right parapophysis is incompletely preserved; it is situated considerably below the level of the diapophysis.

The infraprezygapophysial laminæ are only moderately developed. The right lamina is partly obscured by a strong oblique lamina which extends downward and backward from the parapophysis to a point immediately above the posterior end of the centrum. The infrapostzygapophysial laminæ are

short and stout. The right lamina sends off a small accessory lamina which supports the upper border of the postzygapophysis.

The centrum is well preserved; its anterior surface is very slightly convex superiorly, but is concave inferiorly; its posterior surface is distinctly concave. These two concavities suggested the name *Amphicœlias* for the genus. The length and height of the centrum are about equal. The breadth of the posterior end is about the same, but that of the anterior end is considerably less. The pleurocœl is small externally.

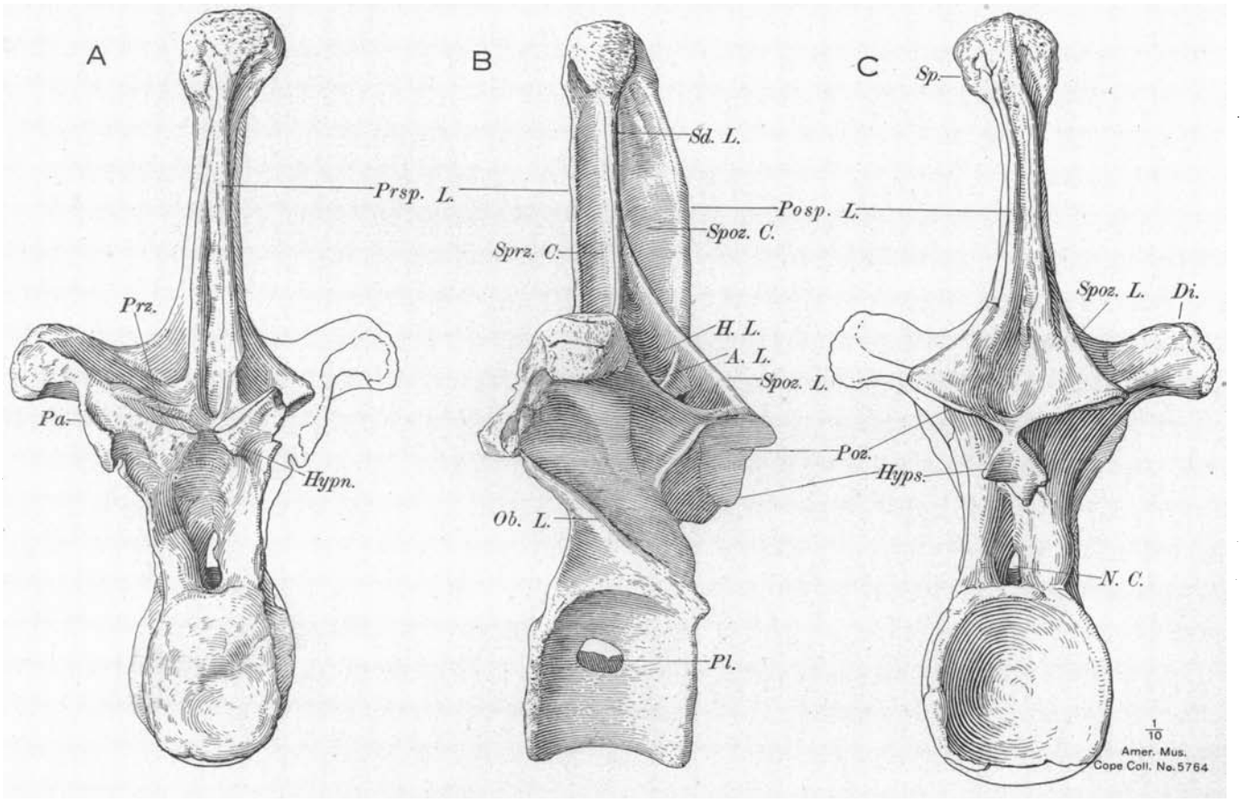

Fig. 120. Type dorsal vertebra of *Amphicœlias altus* Cope.

Dorsal 10, estimated (Amer. Mus. Cope Coll. No. 5764). (A) anterior view; (B) lateral view, left side (from right side, reversed); (C) posterior view; one-tenth natural size. *A. L.* accessory lamina; *Di.* diapophysis; *H. L.* horizontal lamina; *Hypn.* hypantrum; *Hyps.* hyposphen; *N. C.* neural canal; *Ob. L.* oblique lamina; *Pa.* parapophysis; *Pl.* pleurocœl; *Posp. L.* postspinal lamina; *Poz.* postzygapophysis; *Prsp. L.* prespinal lamina; *Prz.* prezygapophysis; *Sd. L.* supradiapophysial lamina; *Sp.* spine; *Spoz. C.* suprapostzygapophysial cavity; *Spoz. L.* suprapostzygapophysial lamina; *Sprz.* C. supraprezygapophysial cavity. Reconstructed portion in outline. (Compare with original type figures, Fig. 17.)

Measurements

(Text Figs. 17, 119, and 120)

Dorsal	Specimen No.	Height, Total	Spread of Diapophyses	Spread of Prezygapophyses	Spread of Postzygapophyses	Length of Centrum, Total	Height of Centrum
6?	5764 / Ds–a–1	Too fragmentary to measure					
10?	5764 / Ds–a–2	107.5 cm.	59.0 cm. *e.*	....	29.5 cm.	24.5 cm.	8.0 cm.

Pectoral Girdle

SCAPULA

Material and Association.— No scapula is mentioned in Cope's descriptions of the type, but there is one left scapula in the Canyon City material the structure and proportions of which are very different from those of the scapula of *Camarasaurus*, and are in keeping with those of other bones of *Amphicœlias*. Whether or not it came from the same quarry as the type material of *Amphicœlias* is not known. The scapula is here provisionally referred to *Amphicœlias*.

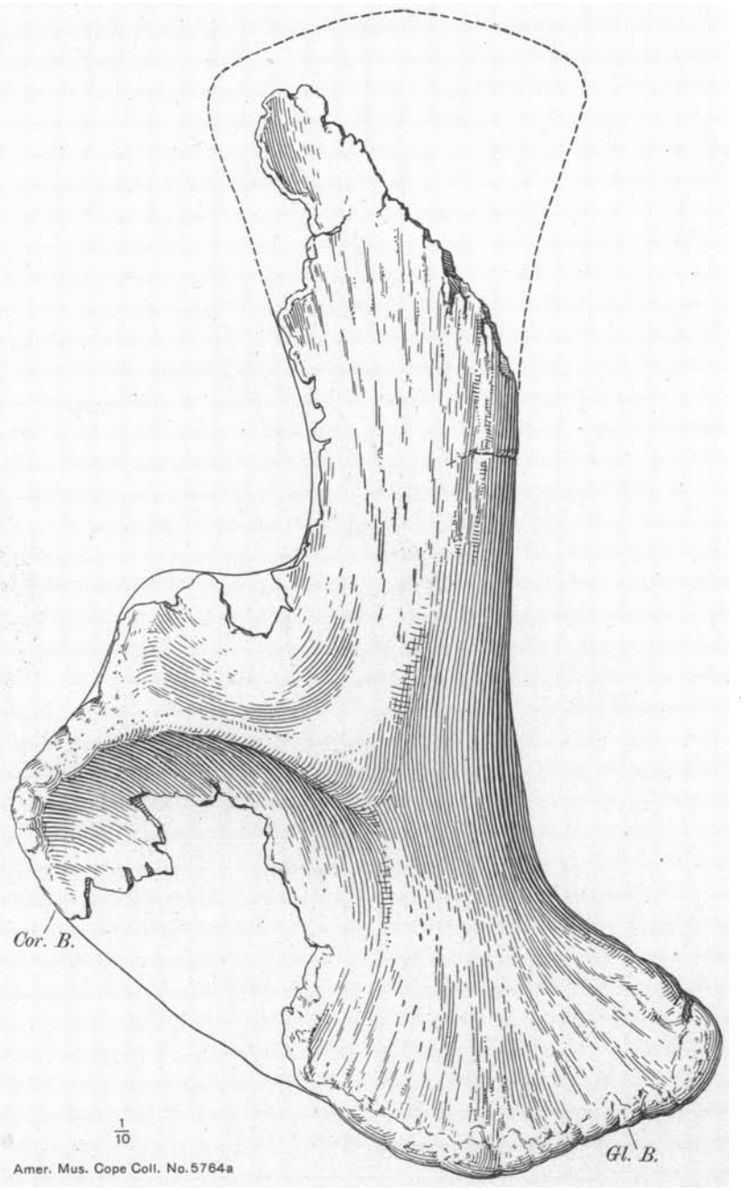

Fig. 121. Left scapula referred to *Amphicœlias altus* Cope.

Amer. Mus. Cope Coll. No. 5764-*a*. External view; one-tenth natural size. *Cor. B.* coracoid border; *Gl. B.* glenoid border. Reconstructed parts certain in outline; inferred, in dash lines.

Characters

This scapula resembles that of *Diplodocus* in form, but is larger and much more massive. It is incomplete at the superior end, but was evidently about as long as the scapulæ of *Camarasaurus* described above. The superior end was evidently less expanded than in *Camarasaurus*, but more expanded than in *Apatosaurus*. In this respect the scapula resembles that of *Diplodocus*. The shaft is moderately broad and is very thick; in the latter character it differs from the scapula of *Diplodocus;* the inferior end is expanded, but not to the extent of the *Camarasaurus* scapula. The posterior process, which supports the glenoid surface, is very thick, as in *Camarasaurus*. The anterior process is longest near its lower border and is less expanded above. The diameter from the extremity of the anterior process to that of the posterior process, or the axis of greatest breadth, makes a much more oblique angle with the longitudinal axis of the bone than in *Camarasaurus*, but somewhat less than in *Diplodocus;* this angle is 51°. The great inferior concavity, on the external surface of the anterior process, extends, in the posterior direction, only as far back as the median vertical axis of the bone.

Measurements

(Text Fig. 121)

Scapula	Specimen No.	Length, Total	Breadth, Inferior (oblique)
Left	5764-*a* / Sc. 7	161.0 cm. (for part preserved)	97.0 cm.

CORACOID

Material and Association.—There is no coracoid in the original type material of *Amphicœlias* according to Cope's descriptions and the available records. There is a left coracoid in the collection, however, which is different from the coracoid of *Camarasaurus*; it resembles the coracoid of *Diplodocus* in

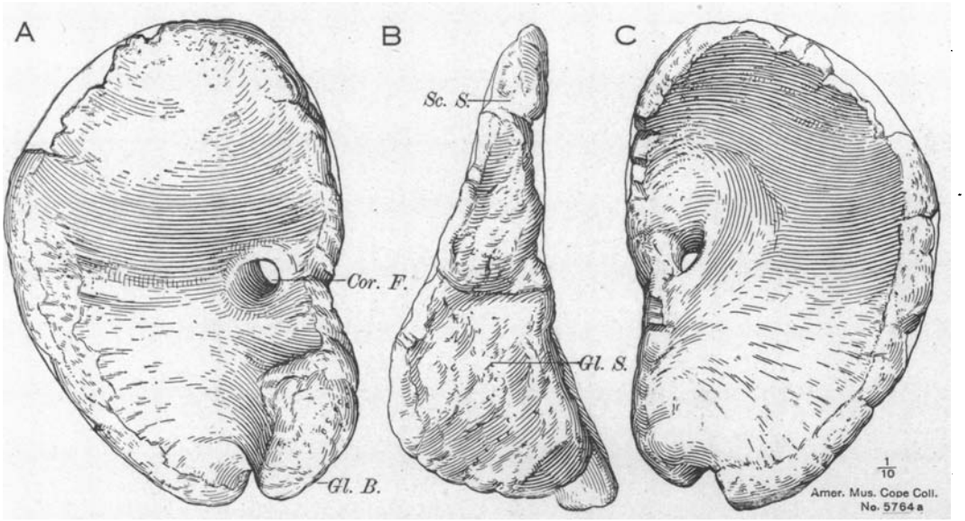

Fig. 122. Left coracoid referred to *Amphicœlias altus* Cope.

Amer. Mus. Cope Coll. No. 5764-*a*. (A) external view; (B) superior view; (C) internal view; one-tenth natural size. *Cor. F.* coracoid foramen; *Gl. B.* glenoid border; *Gl. S.* glenoid surface; *Sc. S.* scapular surface Reconstructed parts in outline.

form, and its scapular surface corresponds very well with the coracoid surface of the left scapula described above, so far as the latter surface is preserved. This coracoid is provisionally referred to *Amphicœlias*.

Characters

The antero-posterior diameter of this coracoid is considerably greater than its vertical diameter; in this respect the coracoid resembles that of *Diplodocus;* This coracoid is much larger, and especially much thicker, than any known *Diplodocus* coracoid, however. The process which supports the glenoid surface is massive. The coracoid foramen is large; it is situated near the scapular border, nearly equidistant from the anterior and posterior ends of the bone, but is very slightly nearer the posterior than the anterior end. The external surface is gently convex and the internal surface slightly concave.

Measurements

(Text Fig. 122)

Coracoid	Specimen No.	Breadth, Total	Height, Total
Left	5764–*a* / Cor. 3	72.0 cm.	43.0 cm.

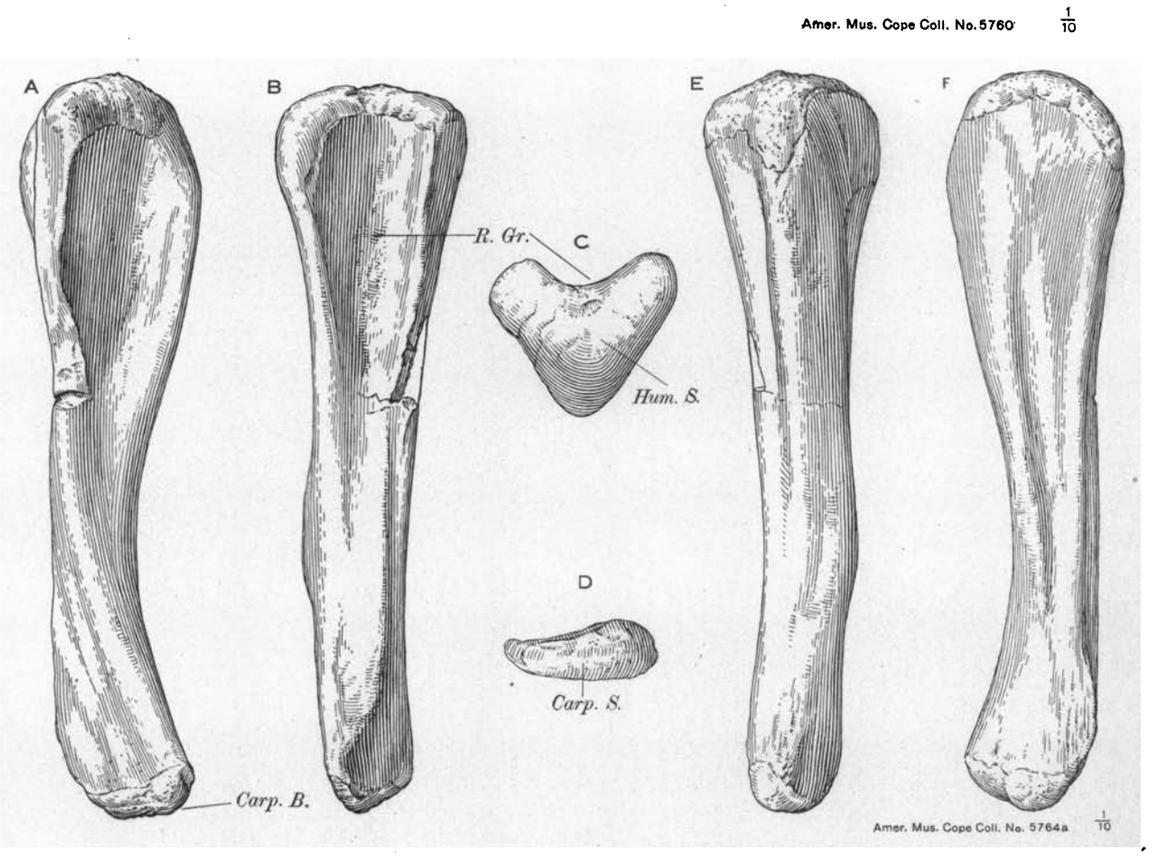

Fig. 123. Right ulna referred to *Amphicœlias altus* Cope.

Amer. Mus. Cope Coll. No. 5764–*a*. (A) external view; (B) anterior view; (C) proximal view; (D) distal view; (E) posterior view; (F) internal view; one-tenth natural size. *Carp. B.* carpal border; *Carp. S.* carpal surface; *Hum. S.* humeral surface; *R. Gr.* radial groove. Reconstructed portion in outline.

Fore Limb

ULNA

Material and Association.— The ulna is not known from the type, nor from any other positively identifiable specimen. There is a left ulna in the collection, however, which does not agree in proportions with the limb bones of *Camarasaurus*. It is in accord with the proportions of the known bones of *Amphicœlias*. This ulna is therefore provisionally referred to the latter genus.

Characters

The bone is unusually long for an ulna; it is also very massive; its flange-like edges do not project very far outward; the radial groove on the proximal portion of the anterior surface is shallow; the proximal posterior ridge is bluntly rounded; the external surface at the proximal end is flat, while the corresponding internal surface is slightly concave; the thickness of the bone diminishes toward the distal end; the shaft is distinctly twisted in accommodation to the radius; the distal surface of the bone is incomplete.

Measurements

(Text Fig. 123)

Ulna	Specimen No.	Length, Total	Breadth, Proximal End	Breadth, Distal End	Circumference	Index
Left	5764–*a* / Ul. 1	105.5 cm.	26.0 cm.	19.0 cm.	41.0 cm.	.388

Pelvic Girdle

PUBIS

Material and Association.— The pubis belonging to the type of *Amphicœlias* is not positively identifiable. There is one incomplete left pubis in the Canyon City material, however, which differs considerably from the various pubes of *Camarasaurus* in the collection, and which agrees with Cope's original description. This bone resembles other bones of *Amphicœlias* in proportions and is identified provisionally as the type pubis of that genus.

Characters

The most characteristic feature of this bone is its great length compared with its transverse diameter, combined with a considerable thickness of bone; the iliac surface was evidently small; the inferior end is somewhat expanded and is rugose. The incomplete condition of the bone renders a detailed description of it impossible.

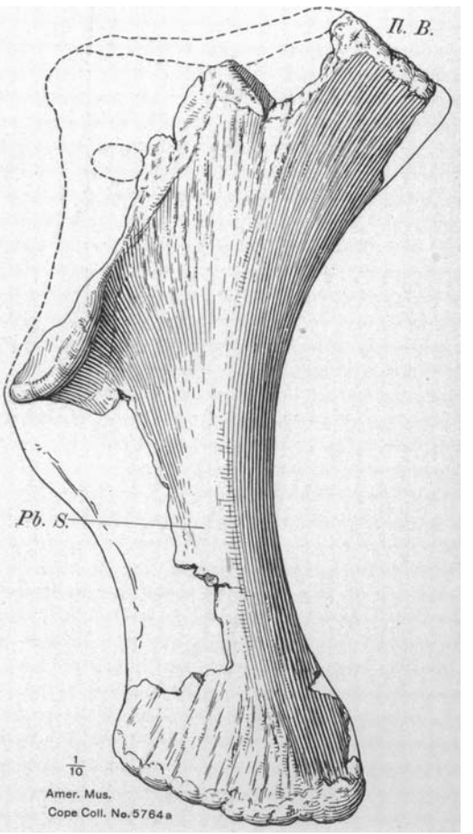

Fig. 124. Left pubis referred to *Amphicœlias altus* Cope.

Amer. Mus. Cope Coll. No. 5764–*a* / Pb 5. Internal view; one-tenth natural size. *Il. B.* iliac border; *Pb. S.* pubic surface. Reconstructed parts certain in outline; inferred, in dash lines.

Measurements

(Text Fig. 124)

Pubis	Specimen No.	Length, Total
Left	5764 / Pb. 5	117.0 cm.

Other measurements could not be made owing to the incomplete character of the specimen.

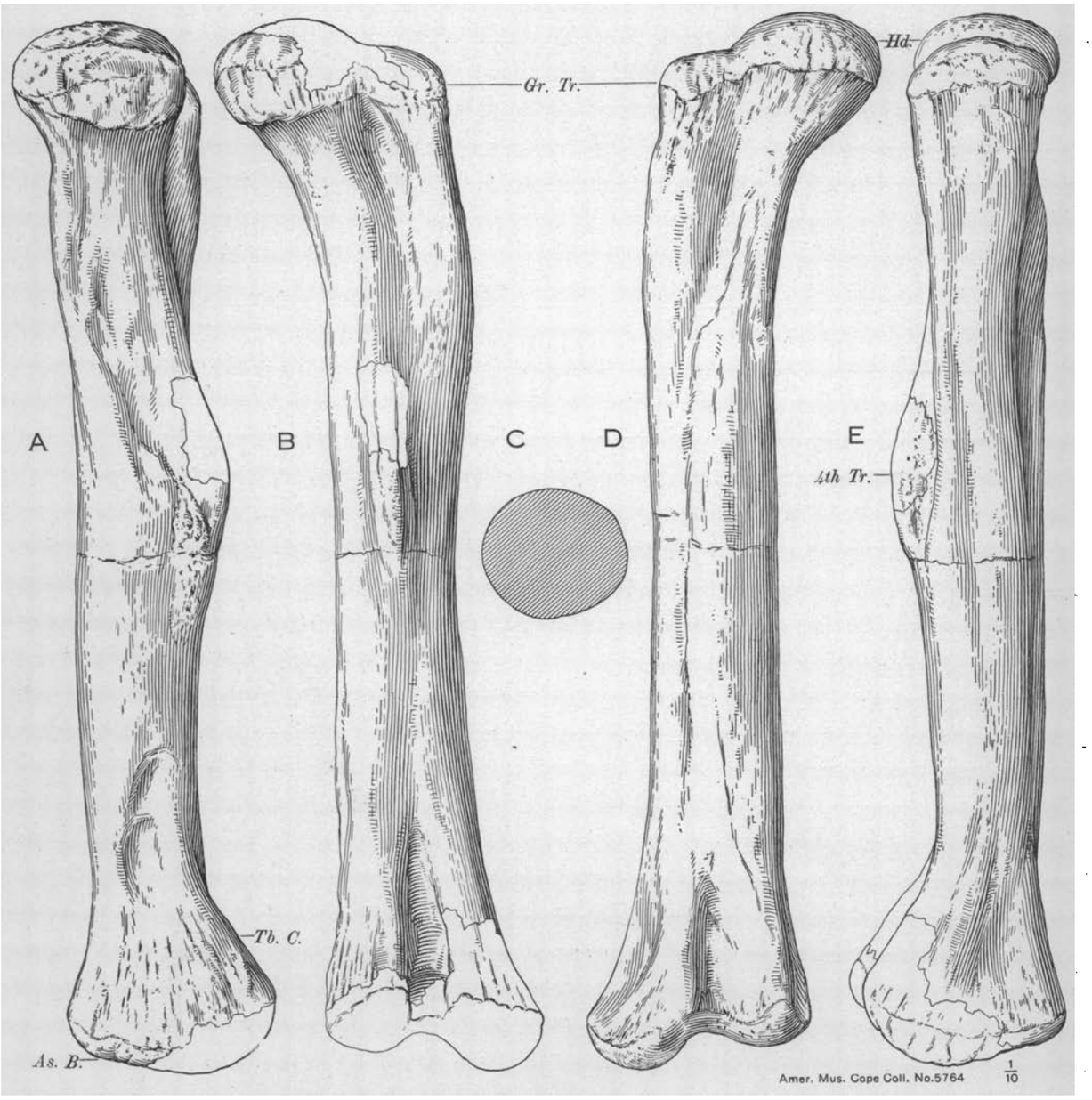

Fig. 125. Type right femur of *Amphicœlias altus* Cope.

Amer. Mus Cope Coll. No. 5764. (A) internal view; (B) posterior view; (C) section of shaft; (D) anterior view; (E) external view; one-tenth natural size. *As. B.* astragalar border; *Gr. Tr.* great trochanter; *Hd.* head; *Tb. C.* tibial condyle; *4th Tr.* fourth trochanter. Reconstructed parts in outline. (Compare with original type figure, Fig. 18.)

Hind Limb

Femur

Material and Association.— A right femur constitutes part of the type of *Amphicœlias altus*, and a left femur part of the type of *A. latus*. The latter bone is clearly referable to a different genus than the *A. altus* type; its characters agree more closely with those of the femur of *Camarasaurus* than with those of the type femur of *A. altus*. This bone is referred provisionally to a young *Camarasaurus*. There is another femur, of the left side, in the collection; its association with other bones is unknown; it is incompletely preserved, but the lower portion of it, which is preserved, is altogether different from the femur of *Camarasaurus*, and agrees very closely with the femur of the *A. altus* type. This femur is referred provisionally to *Amphicœlias altus*. It is possible, in fact not at all improbable, that it is the mate to the type femur of *A. altus*.

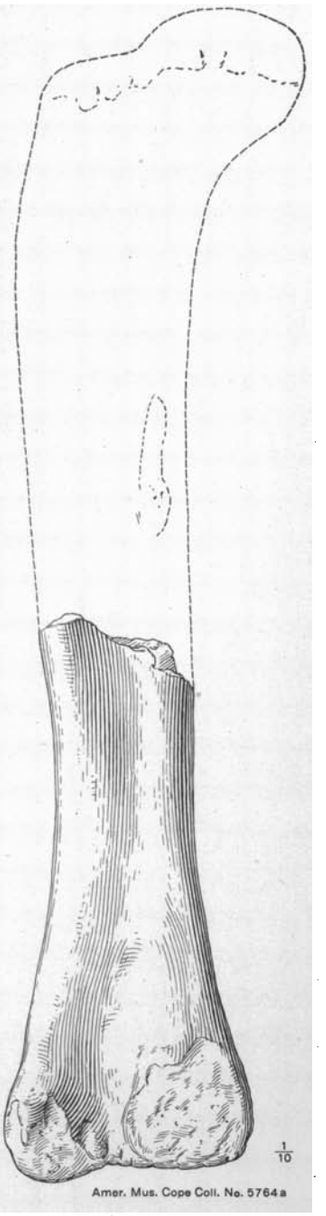

Fig. 126. Left femur referred to *Amphicœlias altus* Cope.

Amer. Mus. Cope Coll. No. 5764 *a*. Posterior view; one-tenth natural size. Reconstructed parts in dash lines.

Characters

The characters may be described from the type femur. The bone is very long and slender; the proximal and distal ends are only slightly expanded transversely; the head is distinctly elevated above the supero-external angle of the bone; the shaft is nearly circular and is slender; the condyles are not preserved; the rugosity of the great trochanter is not prominent; the fourth trochanter is prominent and is decidedly nearer the proximal than the distal end of the bone.

Measurements

Amer. Mus. Cope Coll. No. 5764 (Right Femur, Text Figs. 18, 125, and 126)

Length, Total	177.0 cm.
Circumference	73.5
Breadth, Proximal End	42.5
Breadth, Distal End	
Index	.415
Proximal End to Center of Fourth Trochanter / Distal End to Center of Fourth Trochanter	.766

Summary of Characters of the Genus *Amphicœlias*

Amphicœlias is more slender than *Camarasaurus;* its known remains resemble those of *Diplodocus*, but are somewhat larger than any known *Diplodocus* and somewhat more strongly constructed.

The anterior dorsal vertebræ possess divided spines; the spines of the posterior dorsals are single; the latter possess double pre- and post-spinal laminæ. The posterior dorsal centra are platycœlous to amphicœlous, contrasting with the opisthocœlous centra of the posterior dorsal

vertebræ of *Camarasaurus*. The pubis is very long; it is longer and more slender than that of *Camarasaurus*, and larger and more robust than that of *Diplodocus*. The femur is long and slender.

The following characters are inferred from material provisionally referred to the genus: scapula very large, resembling that of *Diplodocus* in outline, but much more massive; the angle between the longitudinal axis and the axis connecting the anterior and posterior inferior processes is oblique as in *Diplodocus*. The coracoid resembles that of *Diplodocus* in having its antero-posterior diameter much greater than its vertical one; it is much larger, and especially much thicker, however, than any known *Diplodocus* coracoid. The ulna is long and relatively slender, though actually stout.

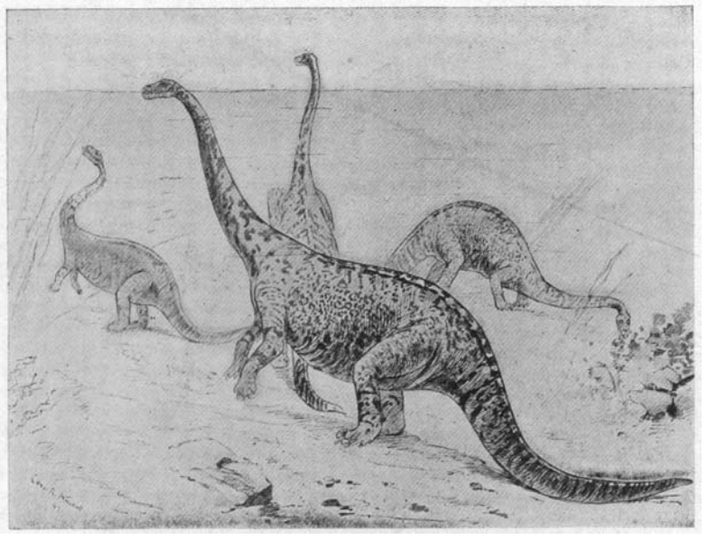

Fig. 127. Restoration of *Amphicœlias altus* Cope.

This restoration was made under the direction of Prof. Cope by Mr. Charles R. Knight. It was published in 1897, and is of particular interest in being the first published restoration of the external appearance of a sauropod dinosaur. After Wm. H. Ballou, 1897.

As shown in the geological introduction the type of *Amphicœlias* was probably found on a geological level 250 feet higher than that of *Diplodocus;* but this level is not certainly known. Pending this knowledge it is best to regard *Amphicœlias* as a somewhat more recent type geologically than *Diplodocus*. If the inferred characters are correct, *Amphicœlias* has advanced further in the process of elongation of the fore limbs than *Diplodocus*. This also remains to be demonstrated. See discussion of *Amphicœlias*, page 279.

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Plate LX

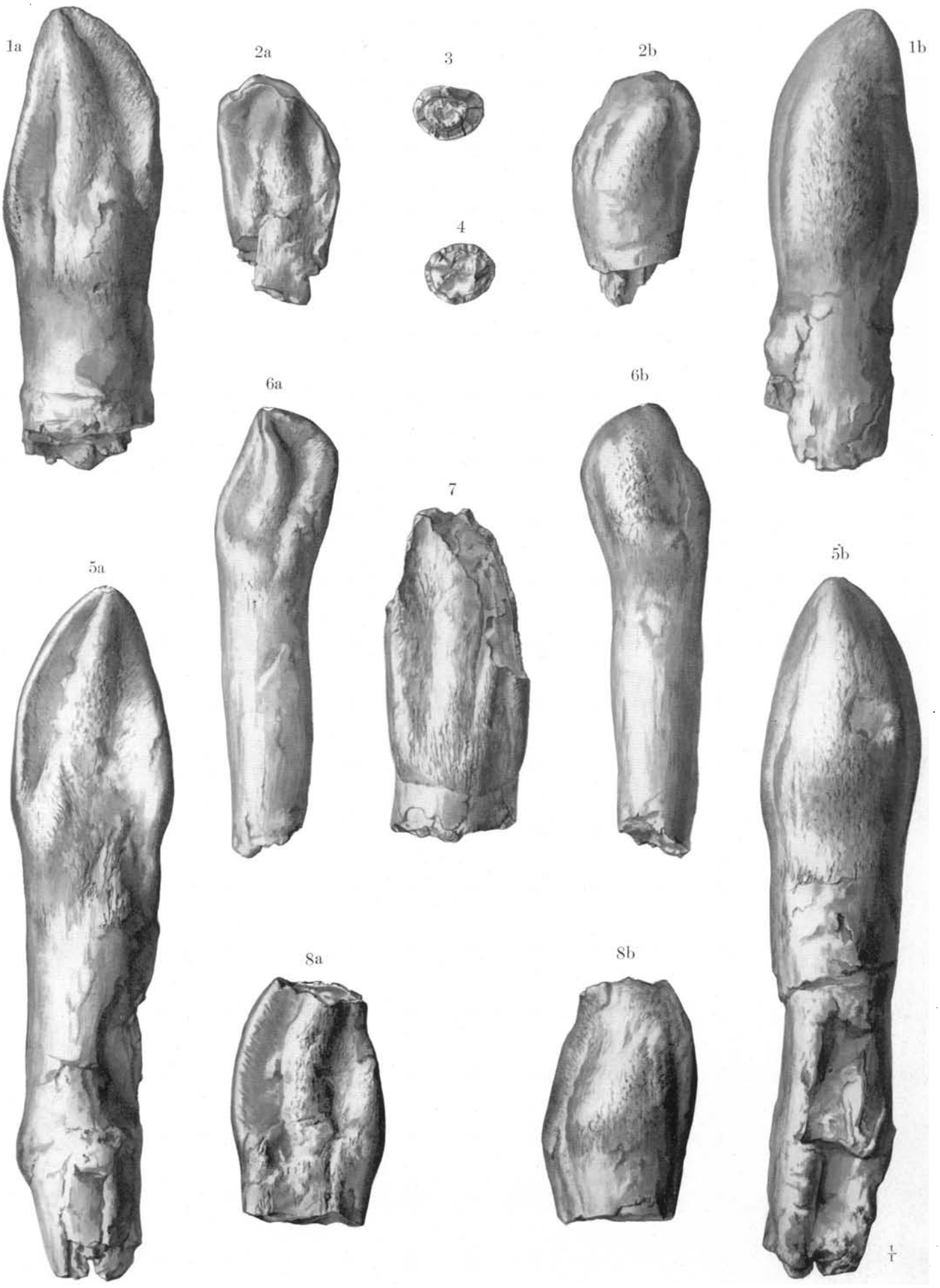
Teeth of type of *Caulodon diversidens* Cope

Natural size

All teeth provisionally referred to *Camarasaurus supremus*.

Amer. Mus. Cope Coll. No. 5768

Fig. 1a Anterior tooth, internal view.
1b The same, external view.
Fig. 2a Posterior tooth, internal view.
2b The same, external view.
Fig. 3 Small posterior tooth, broken section.
Fig. 4 Small posterior tooth, broken section.
Fig. 5a Anterior tooth, internal view.
5b The same, external view.
Fig. 6a Posterior tooth, internal view.
6b The same, external view.
Fig. 7 Anterior tooth, internal view.
Fig. 8a Anterior tooth, internal view.
8b The same, external view.



Amer. Mus. Cope Coll. No. 5768

Plate LXI

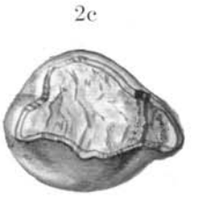
Teeth of type of *Caulodon leptoganus* Cope and one tooth previously referred to *Amphicœlias altus* Cope

Natural size

All teeth provisionally referred to *Camarasaurus supremus.*

Amer. Mus. Cope Coll. No. 5764 and No. 5769

Fig. 1a Anterior tooth of *Caulodon leptoganus* type (Amer. Mus. Cope Coll. No. 5769), internal view.
1b The same, external view.
Fig. 2a Posterior tooth previously referred to *Amphicœlias altus* (Amer. Mus. Cope Coll. No. 5764), internal view.
2b The same, lateral view.
2c The same, crown view.
2d The same, lateral view, opposite to that of 2b.
2e The same, external view.
Fig. 3a Anterior tooth of *Caulodon leptoganus* type (Amer. Mus. Cope Coll. No. 5769), external view.
3b The same, crown view, internal surface above, external surface below.
3c The same, internal view.



Amer. Mus. Cope Coll. Nos. 5764 and 5769

Plate LXII

Brain-case and right quadrate bone of *Camarasaurus supremus* Cope

One-half natural size

This is the only brain-case preserved in the Cope Canyon City Collection; its association with the other material in the collection is uncertain; this is also true of the quadrate.

Amer. Mus. Cope Coll. No. 5761

Fig. 1 Posterior portion of cranium, posterior view.
Fig. 2a Right quadrate, external view.
2b The same, posterior view.
2c The same, internal view.
2d The same, inferior view.

Bo. P. basioccipital process.
Bs. P. basisphenoid process.
F. M. foramen magnum.
O. C. occipital condyle.
Par. P. paroccipital process of exoccipital.
Pt. surface which articulated with the pterygoid.
Q. J. surface which articulated with the quadrato-jugal.

1

F.M.

O.C.

Par.P.

Bo.P

Bs.P.

2a

2b

2c

2d

½

Amer. Mus. Cope Coll. No. 5761

Plate LXIII

Section of brain-case of *Camarasaurus supremus* Cope, with outline key

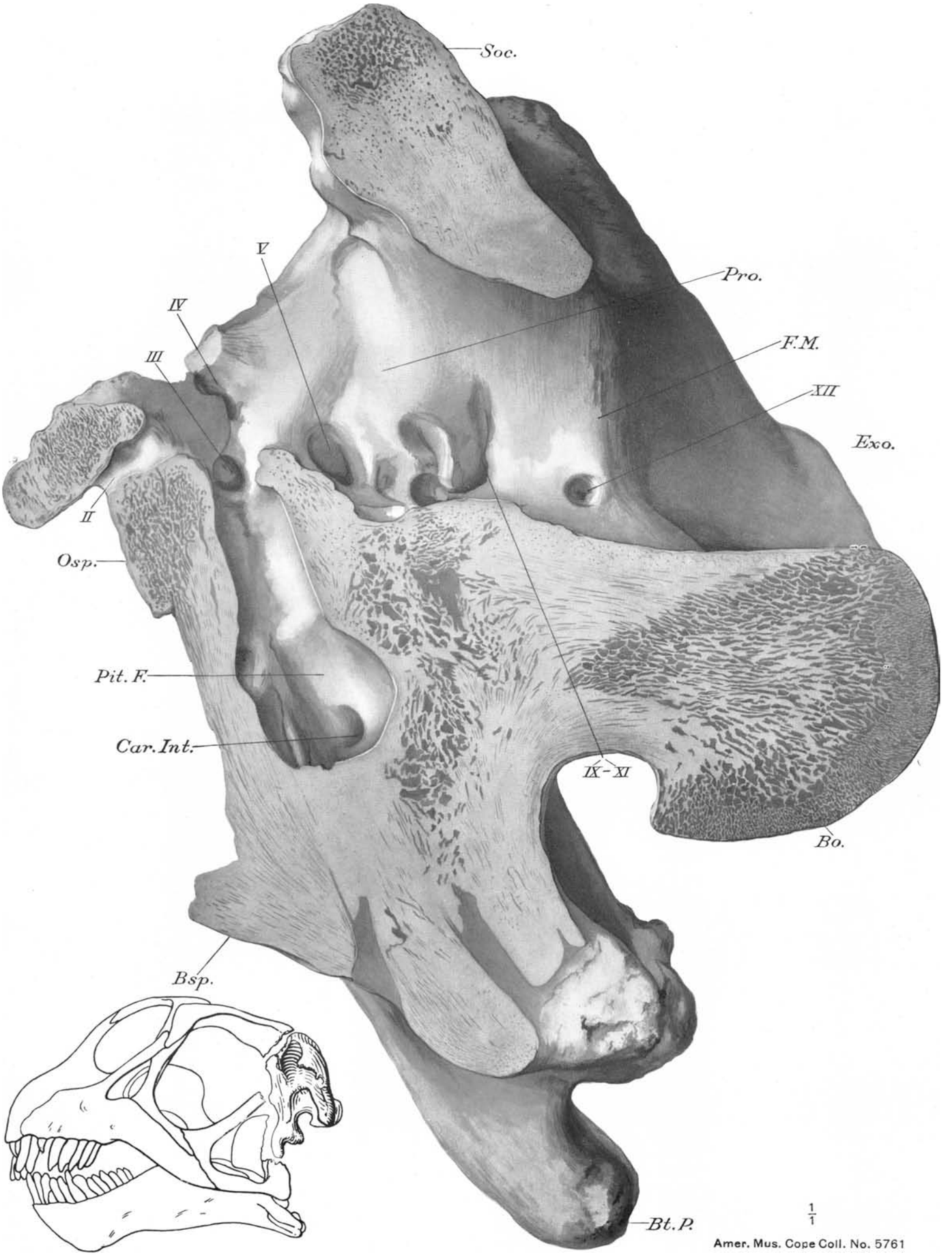
Section total height $\frac{9}{32}$ inch less than natural size, key one-twentieth natural size

This median section illustrates the characters of the posterior portion of the cranial cavity.

Amer. Mus. Cope Coll. No. 5761

Bo.	basioccipital.
Bsp.	basisphenoid.
Bt. P.	basipterygoid process.
Car. Int.	foramen of internal carotid artery.
Exo.	exoccipital.
F. M.	foramen magnum.
Osp.	orbitosphenoid.
Pit. F.	pituitary fossa.
Pro.	proötic.
Soc.	supraoccipital.
II	foramen of second cranial nerve.
III	foramen of third cranial nerve.
IV	pit and foramen of fourth cranial nerve and the cranial process at its base.
V	foramina of fifth cranial nerve.
IX–XI	foramina of ninth, tenth, and eleventh cranial nerves.
XII	foramen of twelfth cranial nerve.

The shaded portion of the key drawing of the *Camarasaurus* skull, indicates the location of the exterior of the brain-case figured in the section.



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Amer. Mus. Cope Coll. No. 5761

Plate LXIV

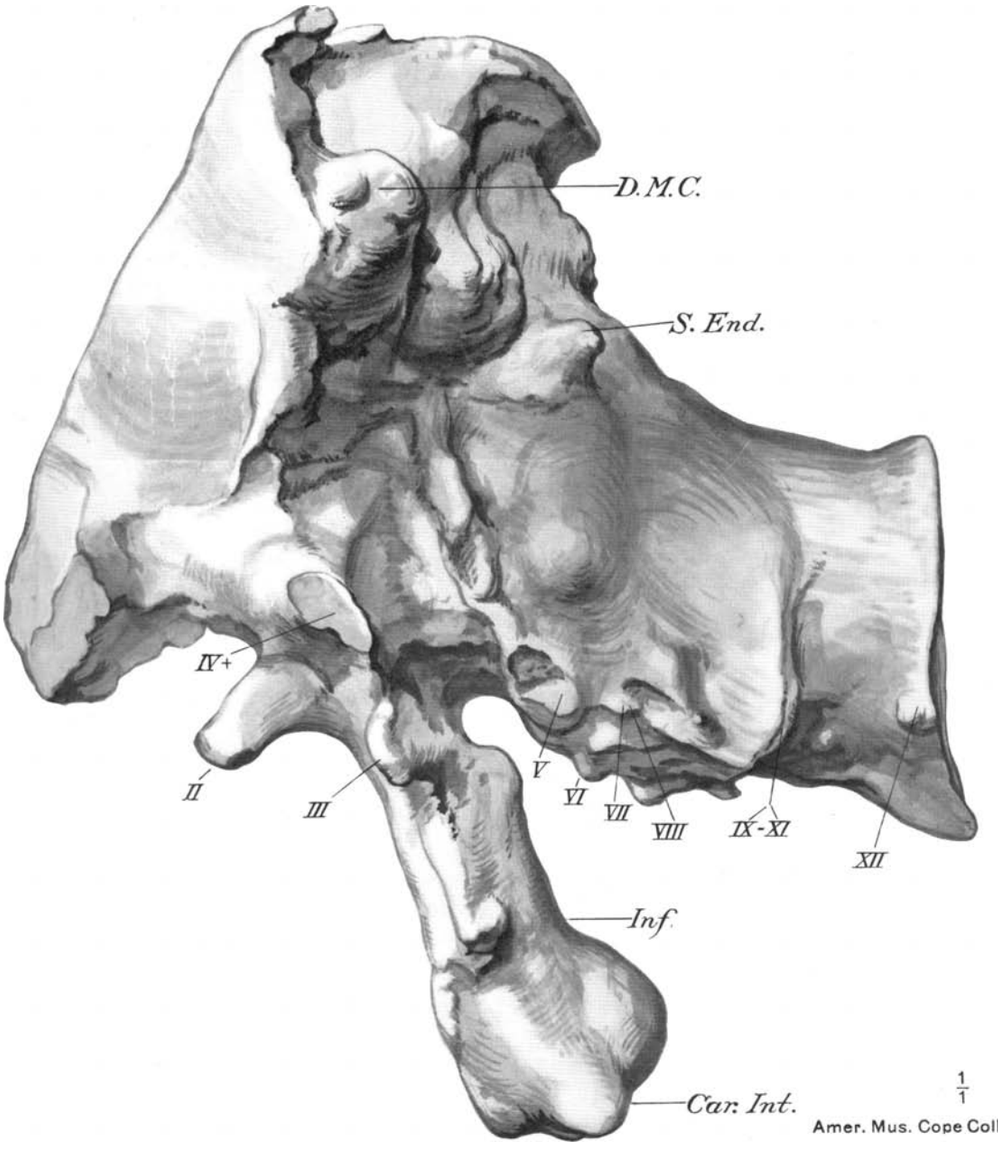
Cast of posterior portion of cranial cavity of *Camarasaurus supremus* Cope

Natural size

The anterior portion of the cranial cavity is not preserved in the specimen. Lateral view, left side.

From brain-case figured in Plate LXII, Amer. Mus. Cope Coll. No. 5761

Car. Int.	internal carotid artery.
D. M. C.	cast of dura mater.
Inf.	infundibulum.
S. End.	saccus endolymphaticus.
II	second cranial nerve.
III	third cranial nerve.
IV	expansion of brain envelope at base of fourth cranial nerve.
V	fifth cranial nerve.
VI	sixth cranial nerve.
VII	seventh cranial nerve.
VIII	eighth cranial nerve.
IX–XI	ninth, tenth, and eleventh cranial nerves.
XII	twelfth cranial nerve.



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Amer. Mus. Cope Coll. No. 5761

Plate LXV

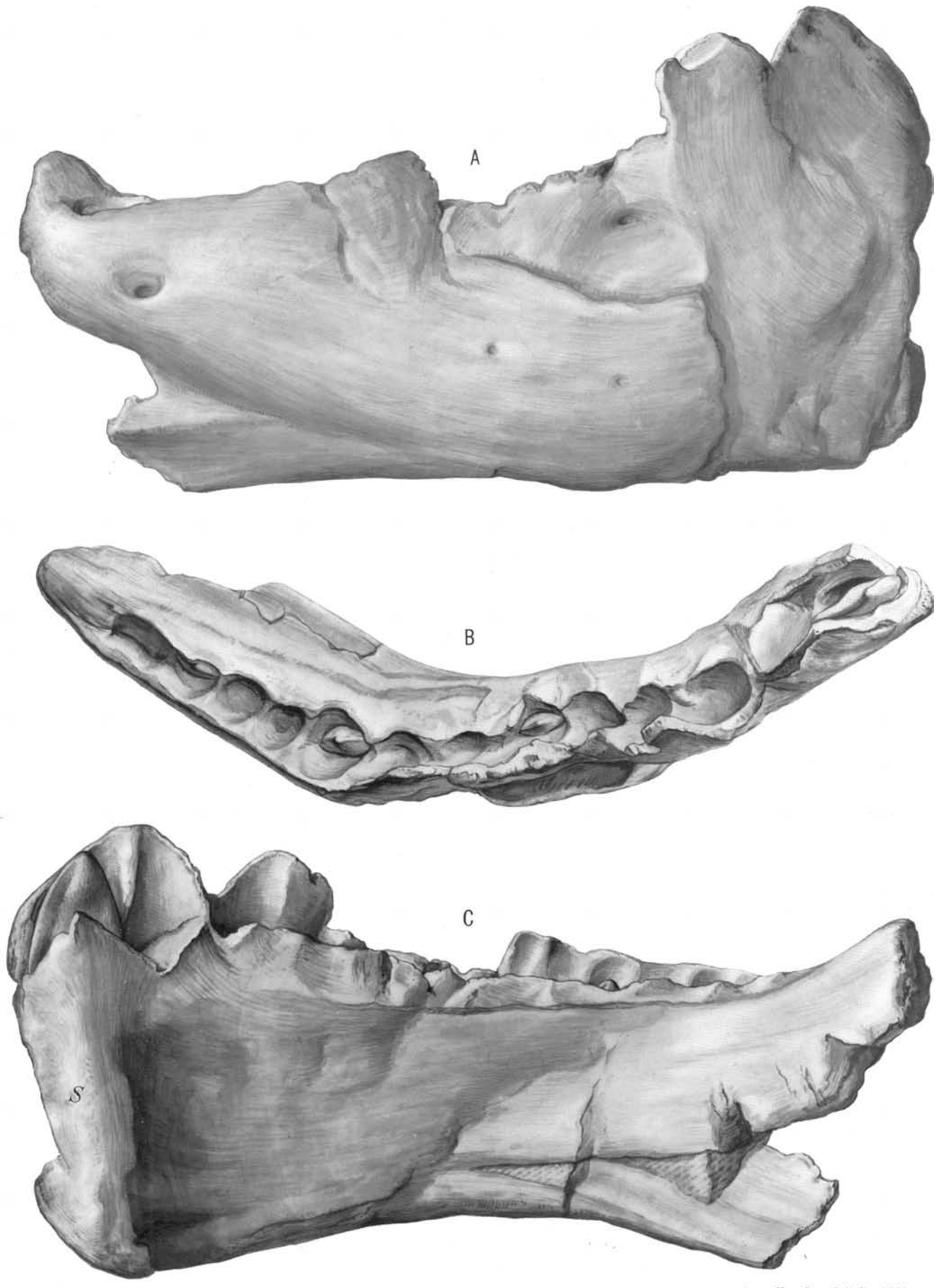
Right dentary of *Camarasaurus supremus* Cope

One-half natural size

The association of this dentary with the other skull material is certain.

Amer. Mus. Cope Coll. No. 5761

Fig. A Lateral view, right side.
Fig. B Superior view.
Fig. C Internal view.
S median symphysis.



Amer. Mus. Cope Coll. No. 5761

Plate LXVI

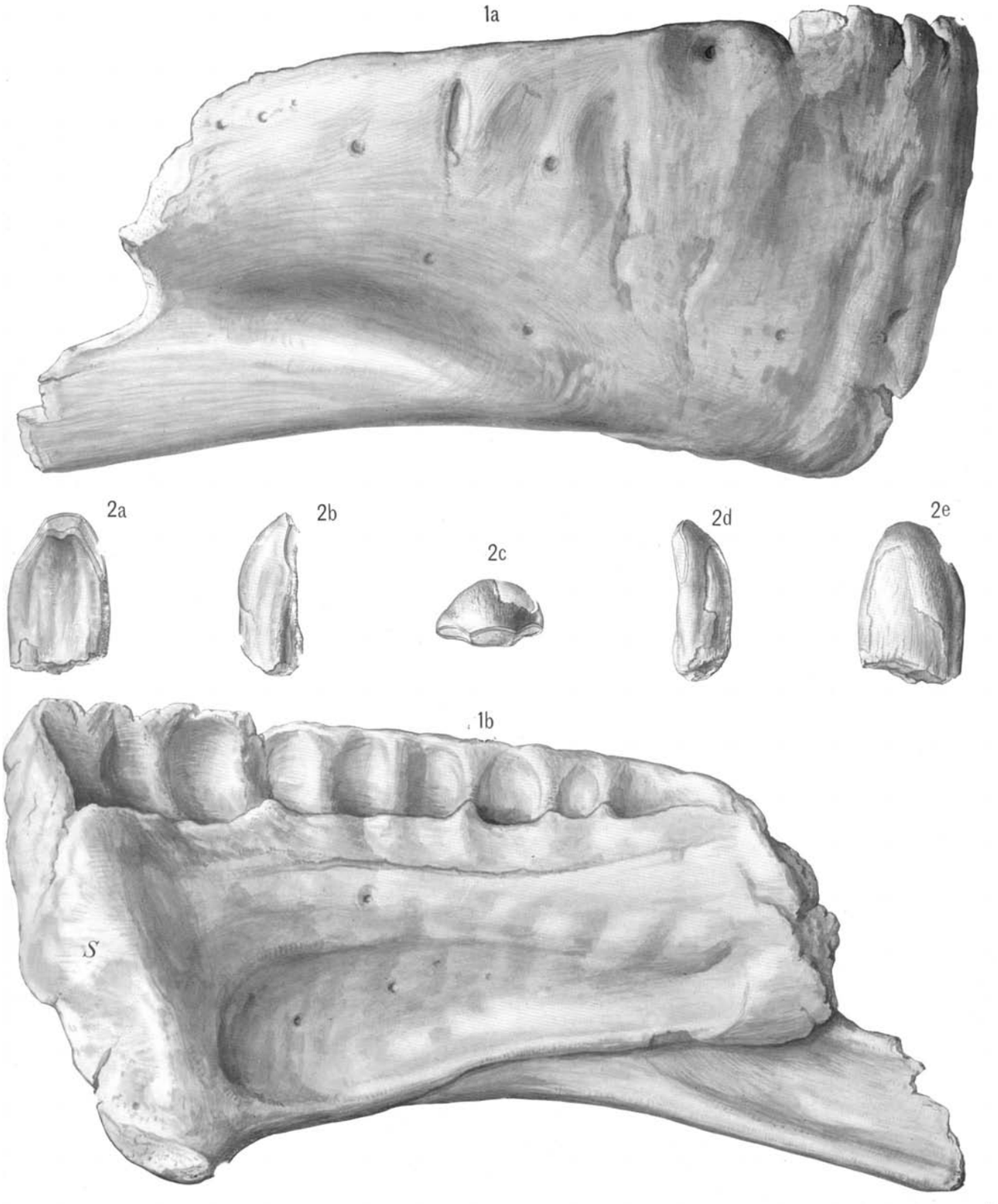
Right dentary and tooth of *Camarasaurus supremus* Cope

One-half natural size

The association of the tooth with the dentary, and of either with other material of the skull, is uncertain.

Amer. Mus. Cope Coll. No. 5761

Fig. 1a Right dentary, lateral view, left side.
1b The same, internal view.
S median symphysis.
Fig. 2a Anterior tooth, internal view.
2b The same, lateral view.
2c The same, end view.
2d The same, lateral view, opposite to that of 2b.
2e The same, external view.



Amer. Mus. Cope Coll. No. 5761 $\frac{1}{1}$

Plate LXVII

Cervical vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The association of these vertebræ with each other is not definitely determined. They comprise a consistent morphological series.

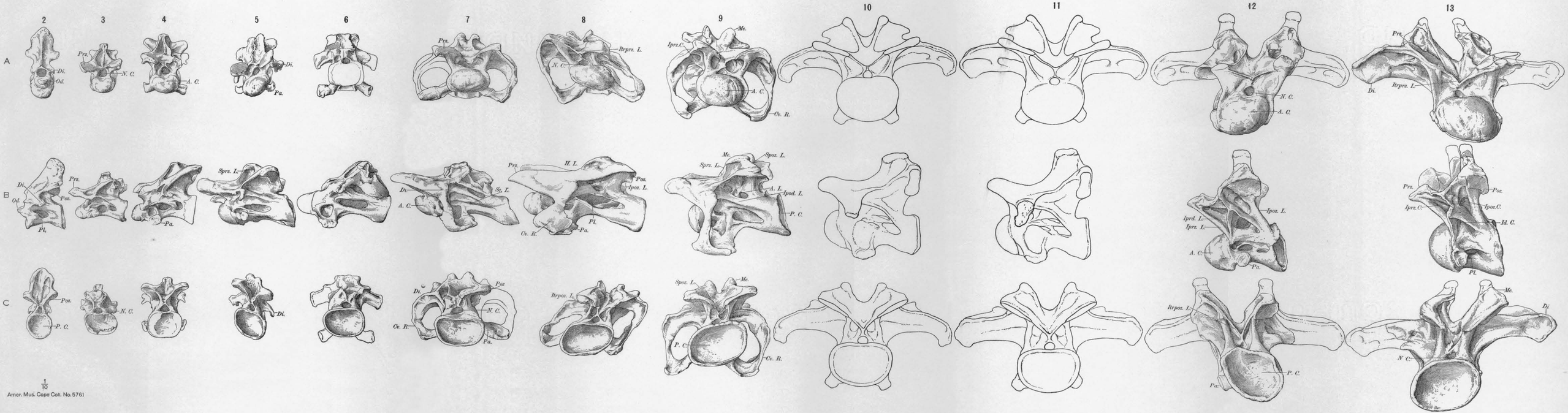
Cervical Series I. Cervical Vertebræ 2–13

Amer. Mus. Cope Coll. No. 5761

Cervical	Museum Number	Cervical	Museum Number
2	$\frac{5761}{X-1}$	8	$\frac{5761}{X-7}$
3	$\frac{5761}{X-2}$	9	$\frac{5761}{X-8}$
4	$\frac{5761}{X-3}$	10	Reconstruction
5	$\frac{5761}{X-4}$	11	Reconstruction
6	$\frac{5761}{X-5}$	12	$\frac{5761}{X-9}$
7	$\frac{5761}{X-6}$	13	$\frac{5761}{X-10}$

The figures 2–13 indicate to Cervicals 2 to 13 respectively. A, anterior views; B, lateral views, left side; C, posterior views.

A. C.	anterior convexity.
A. L.	accessory lamina.
Cv. R.	cervical rib.
Di.	diapophysis.
H. L.	horizontal lamina.
Id. C.	infradiapophysial cavity.
Ipod. L.	infrapostdiapophysial lamina.
Ipoz. C.	infrapostzygapophysial cavity
Ipoz. L.	infrapostzygapophysial lamina.
Iprd. L.	infraprediapophysial lamina.
Iprz. C.	infraprezygapophysial cavity.
Iprz. L.	infraprezygapophysial lamina.
Itrpoz. L.	intrapostzygapophysial lamina.
Itrprz. L.	intraprezygapophysial lamina.
N. C.	neural canal.
Od.	odontoid process of axis.
Pa.	parapophysis.
P. C.	posterior concavity.
Pl.	pleurocœl.
Poz.	postzygapophysis.
Prz.	prezygapophysis.
Sc. L.	supracentral lamina.
Spoz. L.	suprapostzygapophysial lamina.
Sprz. L.	supraprezygapophysial lamina.



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Amer. Mus. Cope Coll. No. 5761

Plate LXVIII

Cervical vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The association of the vertebræ is not definitely known. They are arranged to form a consistent series in size and morphological characters.

Cervical Series II. Cervical Vertebræ 9–13 [1]

Amer. Mus. Cope Coll. No. 5761-*a*

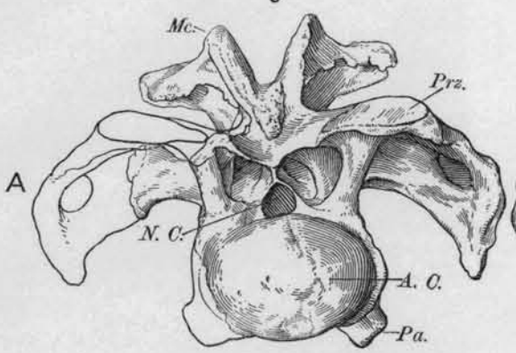
Cervical	Museum Number	Cervical	Museum Number
9	$\frac{5761\text{–}a}{\text{X–a–3}}$	12	$\frac{5761\text{–}a}{\text{X–a–5}}$
10	$\frac{5761\text{–}a}{\text{X–a–4}}$	13	$\frac{5761\text{–}a}{\text{X–a–6}}$
11	$\frac{5761\text{–}a}{\text{X–a–1}}$		

The figures 9–13 indicate to Cervicals 9 to 13 respectively. A, anterior views; B, lateral views, left side; C, posterior views.

A. C.	anterior convexity.	*Me.*	metapophysis.
Cv. R.	cervical rib.	*N. C.*	neural canal.
Di.	diapophysis.	*P. C.*	posterior concavity.
Ipod. L.	infrapostdiapophysial lamina.	*Pa.*	parapophysis.
Ipoz. C.	infrapostzygapophysial cavity.	*Pl.*	pleurocœl.
Ipoz. L.	infrapostzygapophysial lamina.	*Poz.*	postzygapophysis.
Iprz. L.	infraprezygapophysial lamina.	*Prz.*	prezygapophysis.
Itrpoz. L.	intrapostzygapophysial lamina.	*Spoz. L.*	suprapostzygapophysial lamina.
Itrprz. L.	intraprezygapophysial lamina.	*Sprz. L.*	supraprezygapophysial lamina.

[1] Cervicals 12 and 13 of this series are coalesced by centra and zygapophyses.

9



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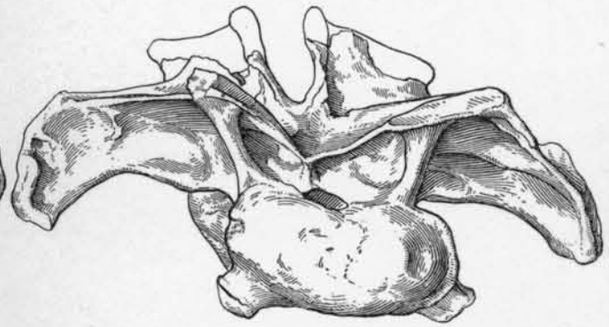

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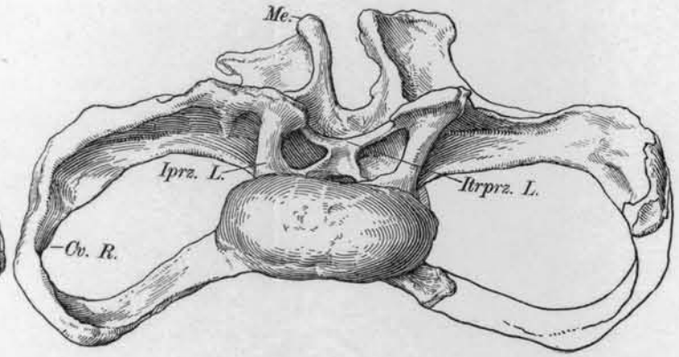
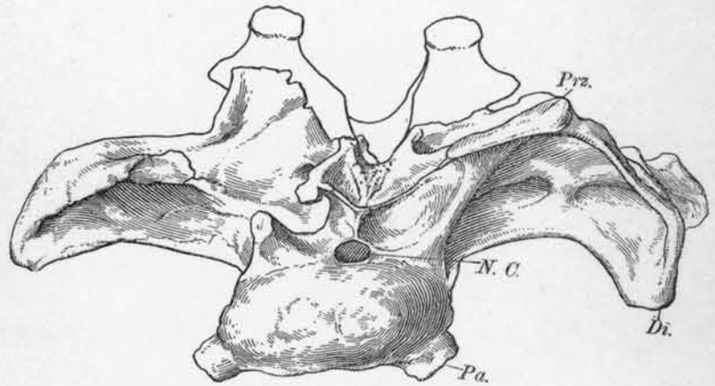
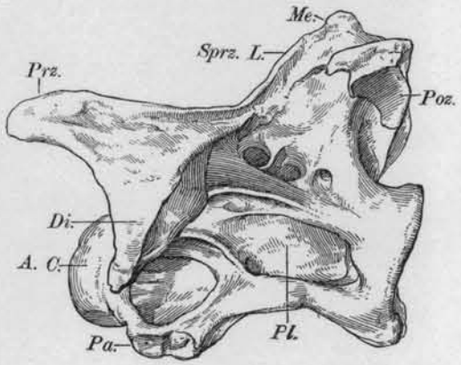


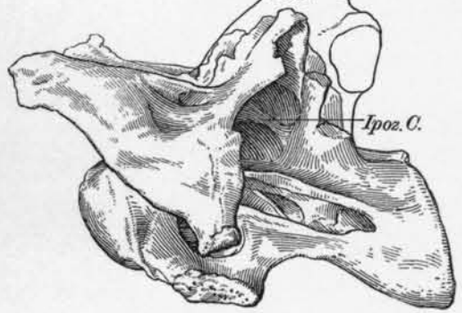
12 13

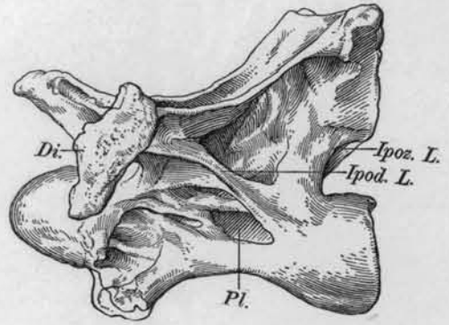


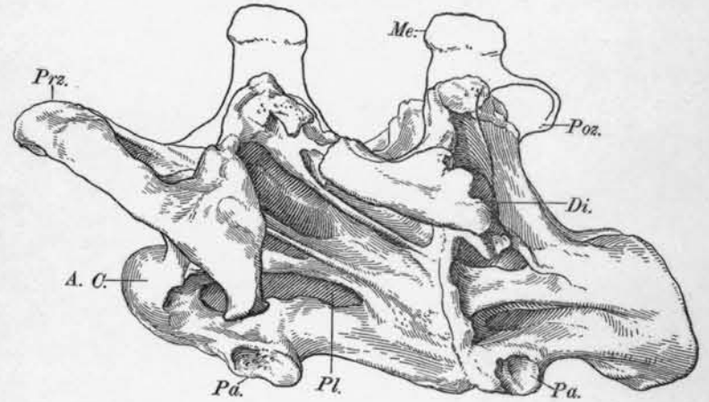
A

B

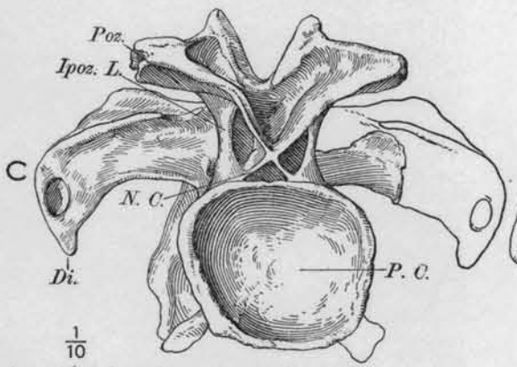


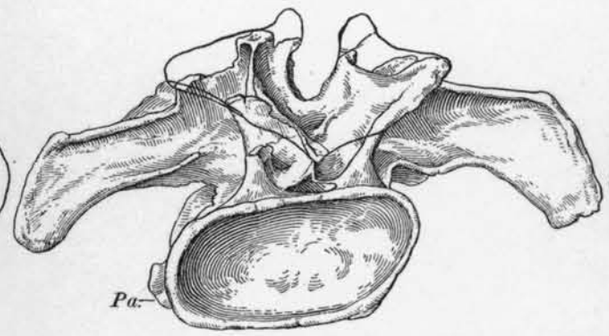


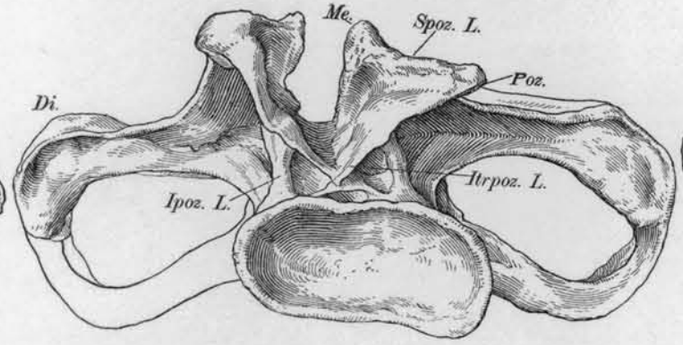


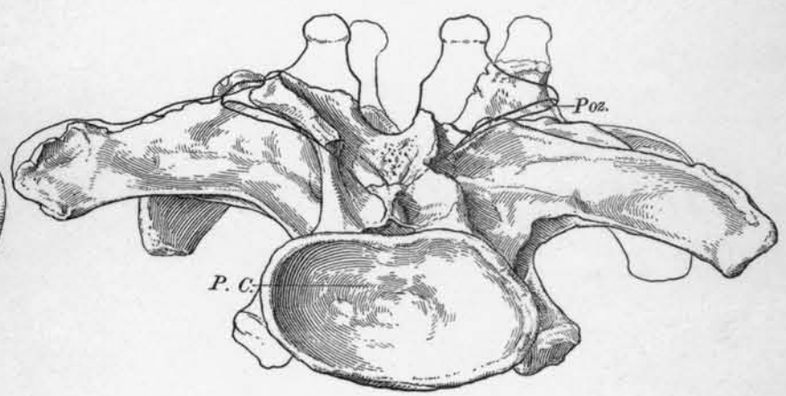


C









1/10

Amer. Mus. Cope Coll. Nos. 5761 and 5761a

Plate LXIX

Cervical vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of these vertebræ is uncertain. They have been arranged according to their morphological characters.

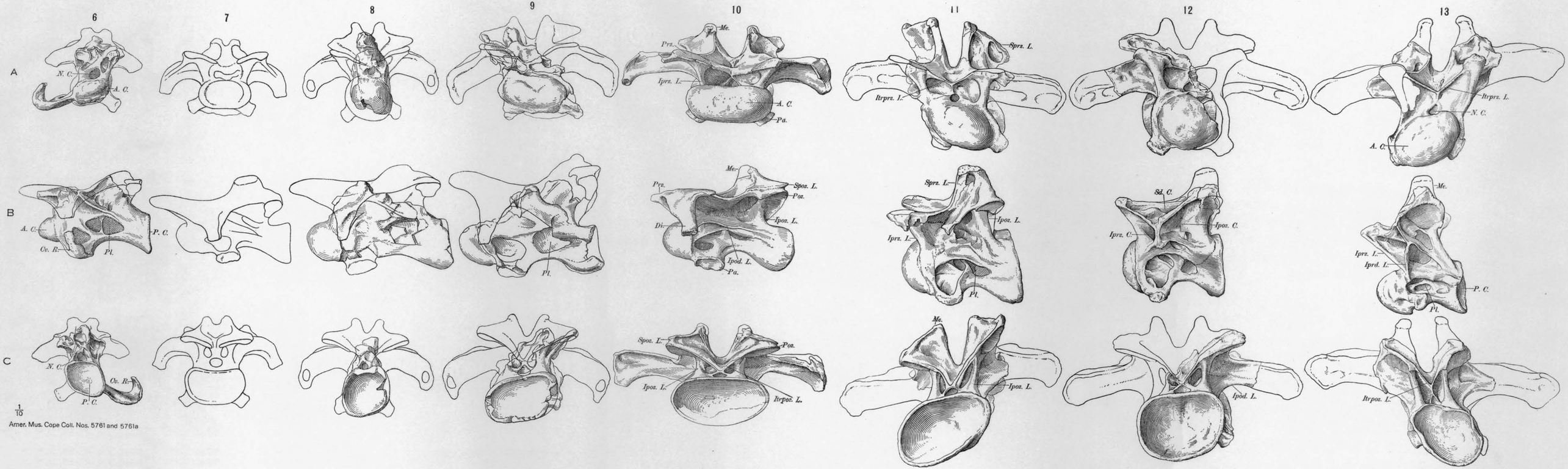
Cervical Series III. Cervical Vertebræ 6–13

Amer. Mus. Cope Coll. Nos. 5761 and 5761-*a*

Cervical	Museum Number	Cervical	Museum Number
6	$\frac{5761}{X\text{–}b\text{–}2}$	10	$\frac{5761\text{–}a}{X\text{–}b\text{–}5}$
7	Reconstruction	11	$\frac{5761}{X\text{–}b\text{–}6}$
8	$\frac{5761}{X\text{–}b\text{–}3}$	12	$\frac{5761\text{–}a}{X\text{–}a\text{–}2}$
9	$\frac{5761}{X\text{–}b\text{–}4}$	13	$\frac{5761\text{–}a}{X\text{–}b\text{–}7}$

The figures 6–13 indicate to Cervicals 6 to 13 respectively. A, anterior views; B, lateral views, left side; C, posterior views.

A. C.	anterior convexity.
Cv. R.	cervical rib.
Di.	diapophysis.
Ipod. L.	infrapostdiapophysial lamina.
Ipoz. C.	infrapostzygapophysial cavity.
Ipoz. L.	infrapostzygapophysial lamina.
Iprd. L.	infraprediapophysial lamina.
Iprz. C.	infraprezygapophysial cavity.
Iprz. L.	infraprezygapophysial lamina.
Itrpoz. L.	intrapostzygapophysial lamina.
Itrprz. L.	intraprezygapophysial lamina.
Me.	metapophysis.
N. C.	neural canal.
P. C.	posterior concavity.
Pa.	parapophysis.
Pl.	pleurocœl.
Poz.	postzygapophysis.
Prz.	prezygapophysis.
Sd. C.	supradiapophysial cavity.
Spoz. L.	suprapostzygapophysial lamina.
Sprz. L.	supraprezygapophysial lamina.



1/10

Amer. Mus. Cope Coll. Nos. 5761 and 5761a

Plate LXX

Dorsal vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The association of these vertebræ is uncertain. They differ slightly from those of the other series in having somewhat longer centra, and greater development of the suprahyposphenal laminæ.

Dorsal Series I. Dorsal Vertebræ 1–10 and Dorso-sacral Vertebra [1]

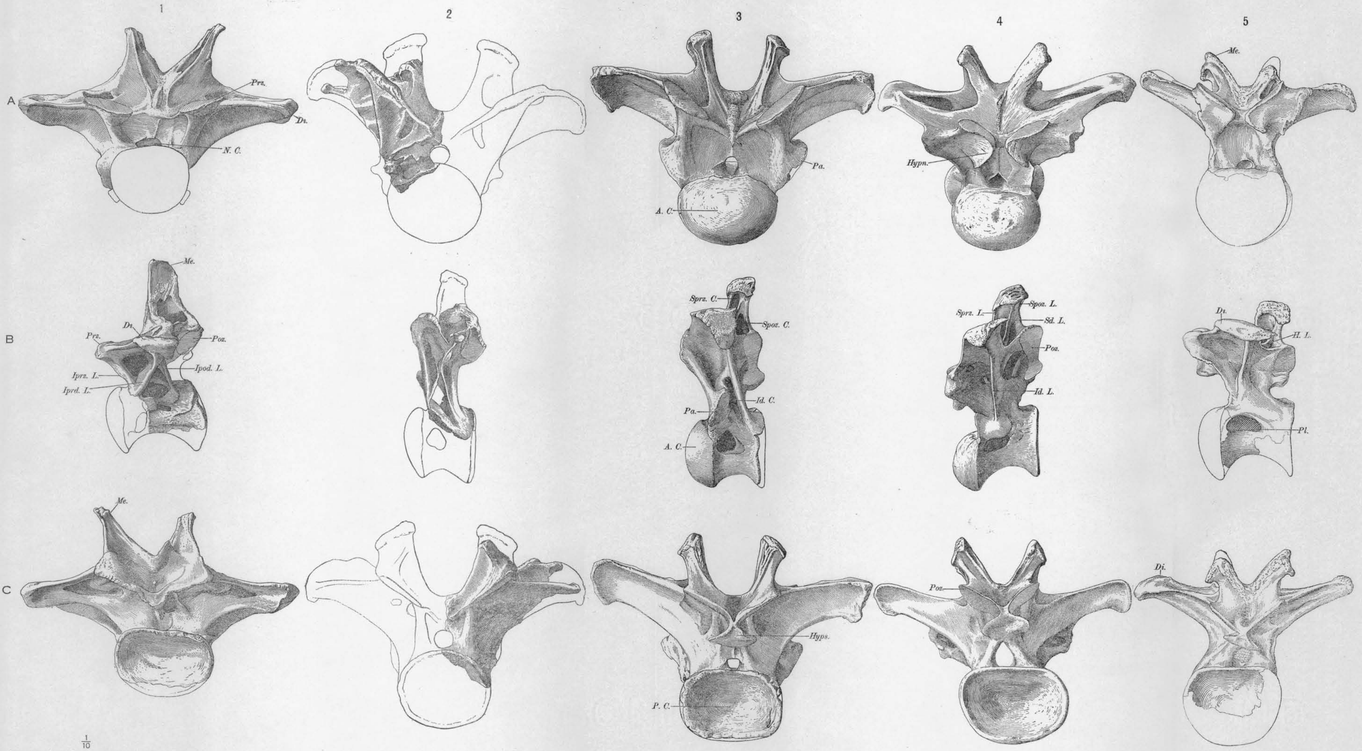
Amer. Mus. Cope Coll. Nos. 5760′ and 5761

Dorsal	Museum Number	Dorsal	Museum Number
1	5760′ / D–X–134	7	5760′ / D–X–128
2	5760′ / D–X–133	8	5760′ / D–X–127
3	5760′ / D–X–132	9	5760′ / D–X–126
4	5760′ / D–X–131	10	5760′ / D–X–125
5	5761 / D–X–130	Dorso-sacral	5760′ / D–X–124
6	5760′ / D–X–129		

The figures 1–10 indicate to Dorsals 1 to 10 respectively; D-S. indicates the Dorso-sacral. A, anterior views; B, lateral views, left side; C; posterior views.

A. C.	anterior convexity.
A. L.	accessory lamina.
Di.	diapophysis.
H. L.	horizontal lamina.
Hypn.	hypantrum.
Hyps.	hyposphen.
Id. C.	infradiapophysial cavity.
Id. L.	infradiapophysial lamina.
Ipod. L.	infrapostdiapophysial lamina.
Ipoz. C.	infrapostzygapophysial cavity.
Ipoz. L.	infrapostzygapophysial lamina.
Iprd. L.	infraprediapophysial lamina.
Iprz. C.	infraprezygapophysial cavity.
Iprz. L.	infraprezygapophysial lamina.
Me.	metapophysis.
N. C.	neural canal.
P. C.	posterior concavity.
Pa.	parapophysis.
Pl.	pleurocœl.
Poz.	postzygapophysis.
Prz.	prezygapophysis.
Sd. L.	supradiapophysial lamina.
Sh. L.	suprahyposphenal lamina.
Sp.	spine.
Spoz. C.	suprapostzygapophysial cavity.
Spoz. L.	suprapostzygapophysial lamina.
Sprz. C.	supraprezygapophysial cavity.
Sprz. L.	supraprezygapophysial lamina.

[1] All of these drawings except those of Dorsal 5 were made by Mr. Rudolph Weber for the U. S. Geological Survey.



1/10

Amer. Mus. Cope Coll. Nos. 5760 and 5761

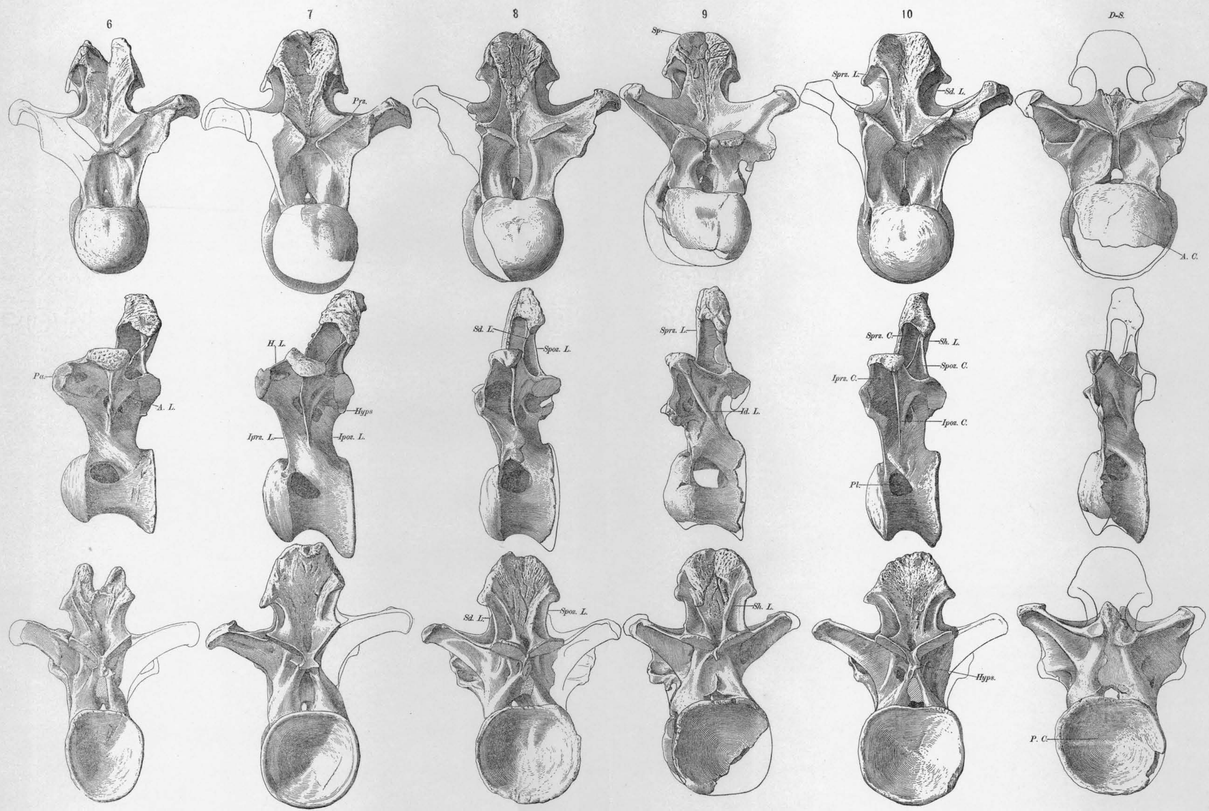


Plate LXXI

Dorsal vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The association of these vertebræ is uncertain. The dorso-sacral appears to be only slightly modified as an ilium-supporting vertebra.

Dorsal Series II. Dorsal Vertebræ 1–10 and Dorso-sacral Vertebra [1]

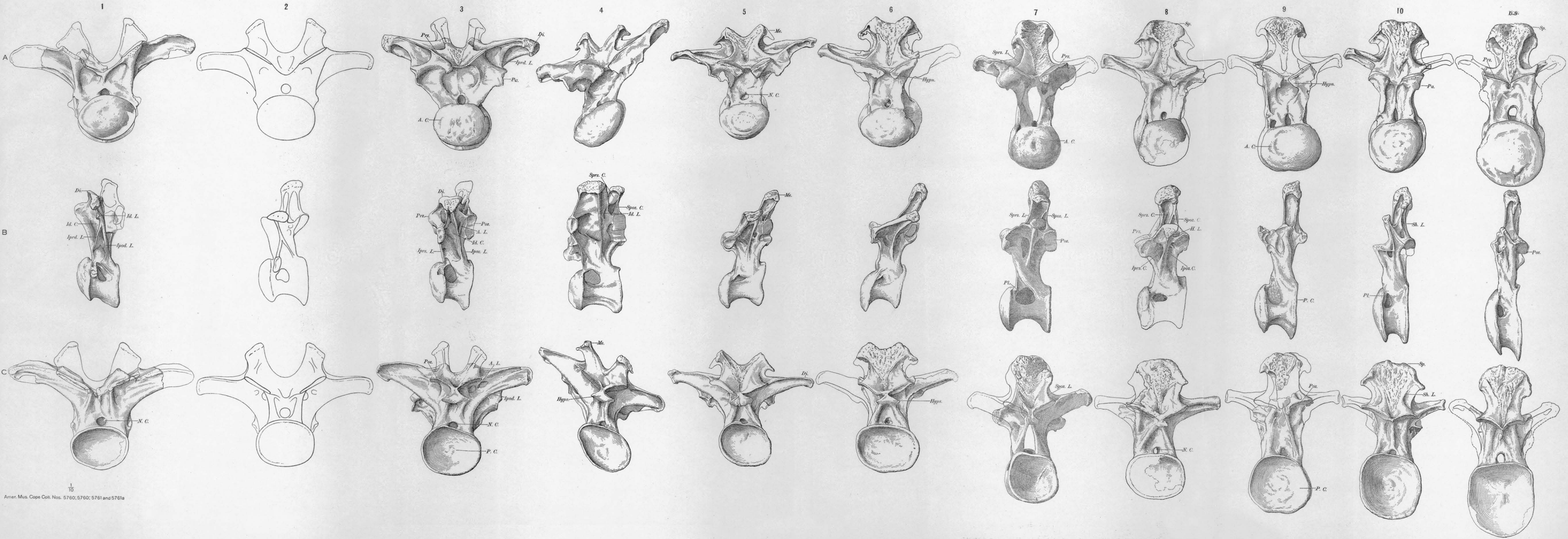
Amer. Mus. Cope Coll. Nos. 5760′, 5760″, 5761, and 5761-*a*

Dorsal	Museum Number	Dorsal	Museum Number
1	5761-*a* / D–X–105	7	5760′ / D–X–114
2	Reconstruction	8	5760″ / D–X–109
3	5761-*a* / D–X–106	9	5761 / D–X–135
4	5761 / D–X–119	10	5761 / D–X–117
5	5761 / D–X–107	Dorso-sacral	5761-*a* / D–X–118
6	5761 / D–X–108		

The figures 1–10 indicate Dorsals 1 to 10 respectively; D-S. indicates the Dorso-sacral. A, anterior views; B, lateral views, left side; C, posterior views.

A. C.	anterior convexity.
A. L.	accessory lamina.
Di.	diapophysis.
H. L.	horizontal lamina.
Hypn.	hypantrum.
Hyps.	hyposphen.
Id. C.	infradiapophysial cavity.
Id. L.	infradiapophysial lamina.
Ipod. L.	infrapostdiapophysial lamina.
Ipoz. C.	infrapostzygapophysial cavity.
Ipoz. L.	infrapostzygapophysial lamina.
Iprd. L.	infraprediapophysial lamina.
Iprz. C.	infraprezygapophysial cavity.
Iprz. L.	infraprezygapophysial lamina.
Me.	metapophysis.
N. C.	neural canal.
P. C.	posterior concavity
Pa.	parapophysis.
Pl.	pleurocœl.
Poz.	postzygapophysis.
Prz.	prezygapophysis.
Sh. L.	suprahyposphenal lamina.
Sp.	spine.
Spoz. C.	suprapostzygapophysial cavity.
Spoz. L.	suprapostzygapophysial lamina.
Sprz. C.	supraprezygapophysial cavity.
Sprz. L.	supraprezygapophysial lamina.

[1] The drawings of Dorsal 7 were made by Mr. Rudolph Weber for the U. S. Geological Survey.



1/10

Amer. Mus. Cope Coll. Nos. 5760; 5760; 5761 and 5761a

Plate LXXII

Dorsal vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The association of these vertebræ is uncertain. The dorso-sacral in this series is highly modified as an ilium-supporting vertebra.

Dorsal Series III. Dorsal Vertebræ 1–10 and Dorso-sacral Vertebra [1]

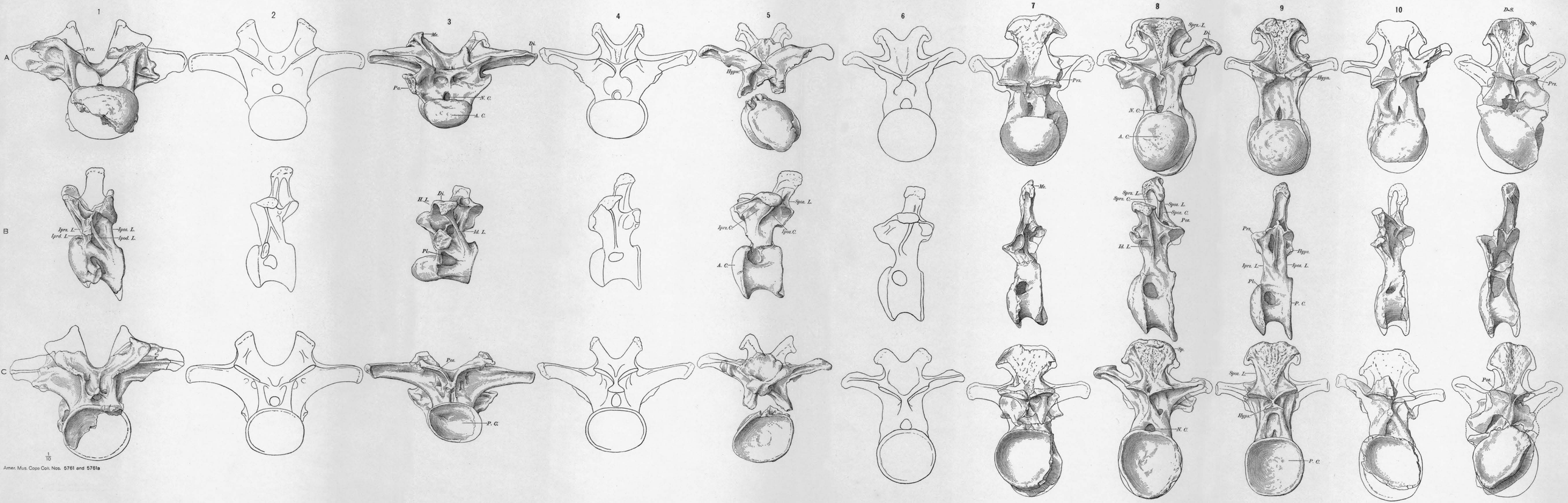
Amer. Mus. Cope Coll. Nos. 5761 and 5761-*a*

Dorsal	Museum Number	Dorsal	Museum Number
1	5761 / D–X–110	7	5761 / D–X–137
2	Reconstruction	8	5761-*a* / D–X–123
3	5761 / D–X–112	9	5761 / D–X–116
4	Reconstruction	10	5761 / D–X–150
5	5761-*a* / D–X–136	Dorso-sacral	5761-*a* / D–X–183
6	Reconstruction		

The figures 1–10 indicate Dorsals 1 to 10 respectively; D-S. indicates the Dorso-sacral. A, anterior views; B, lateral views, left side; C, posterior views.

A. C.	anterior convexity.
Di.	diapophysis.
H. L.	horizontal lamina.
Hypn.	hypantrum.
Hyps.	hyposphen.
Id. L.	infradiapophysial lamina.
Ipod. L.	infrapostdiapophysial lamina.
Ipoz. C.	infrapostzygapophysial cavity.
Ipoz. L.	infrapostzygapophysial lamina.
Iprd. L.	infraprediapophysial lamina.
Iprz. C.	infraprezygapophysial cavity.
Iprz. L.	infraprezygapophysial lamina.
Me.	metapophysis.
N. C.	neural canal.
P. C.	posterior concavity.
Pa.	parapophysis.
Pl.	pleurocœl.
Poz.	postzygapophysis.
Prz.	prezygapophysis.
Sp.	spine.
Spoz. C.	suprapostzygapophysial cavity.
Spoz. L.	suprapostzygapophysial lamina.
Sprz. C.	supraprezygapophysial cavity.
Sprz. L.	supraprezygapophysial lamina.

[1] Drawn by Mr. E. S. Christman and assistants.



Amer. Mus. Cope Coll. Nos. 5761 and 5761a

PLATE LXXIII

Dorsal vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of these vertebræ is uncertain.

DORSAL SERIES IV. DORSAL VERTEBRÆ 1–10 AND DORSO-SACRAL VERTEBRA [1]

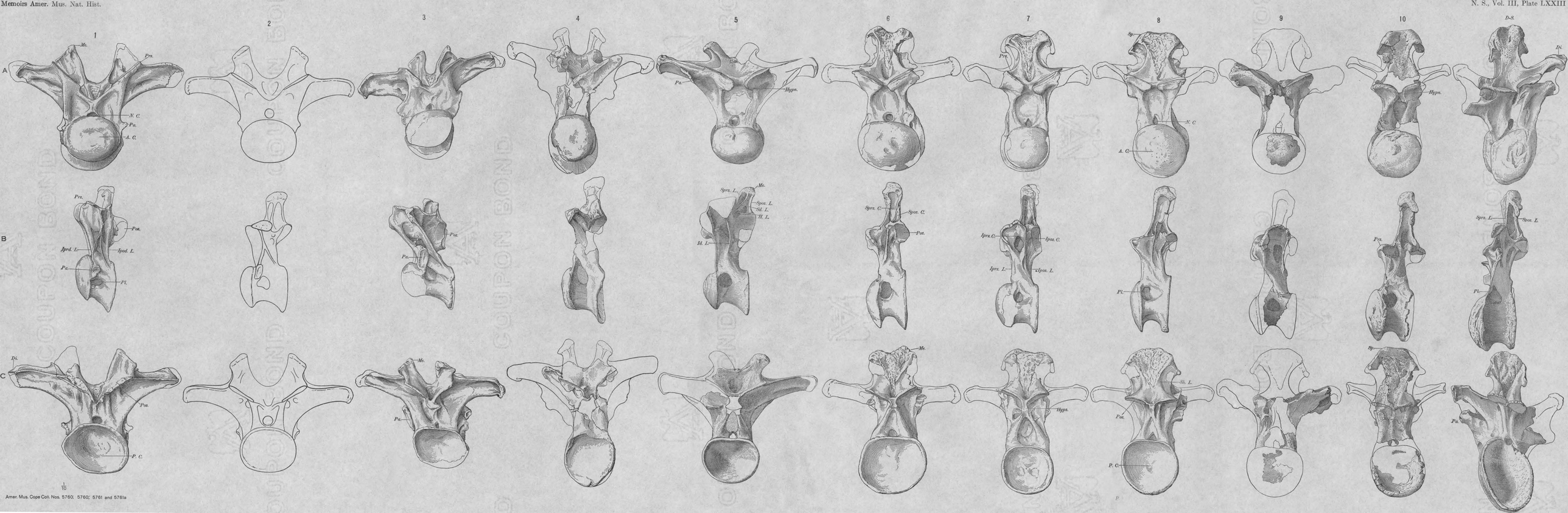
Amer. Mus. Cope Coll. Nos. 5760′, 5760″, 5761, AND 5761-*a*

Dorsal	Museum Number	Dorsal	Museum Number
1	5761–*a* / D–X–104	7	5761 / D–X–122
2	Reconstruction	8	5761–*a* / D–X–115
3	5761 / D–X–111	9	5760″ / D–X–103
4	5761–*a* / D–X–102	10	5760″ / D–X–101
5	5760″ / D–X–113	Dorso-sacral	5760′ / D–X–121
6	5761–*a* / D–X–120		

The figures 1–10 indicate Dorsals 1 to 10 respectively; D-S. indicates the Dorso-sacral. A, anterior views; B, lateral views, left side; C, posterior views.

A. C.	anterior convexity.
Di.	diapophysis.
H. L.	horizontal lamina.
Hypn.	hypantrum.
Hyps.	hyposphen.
Id. L.	infradiapophysial lamina.
Ipod. L.	infrapostdiapophysial lamina.
Ipoz. C.	infrapostzygapophysial cavity.
Ipoz. L.	infrapostzygapophysial lamina.
Iprd. L.	infraprediapophysial lamina.
Iprz. C.	infraprezygapophysial cavity.
Iprz. L.	infraprezygapophysial lamina.
Me.	metapophysis.
N. C.	neural canal.
P. C.	posterior concavity.
Pa.	parapophysis.
Pl.	pleurocœl.
Poz.	postzygapophysis.
Prz.	prezygapophysis.
Sd. L.	supradiapophysial lamina.
Sh. L.	suprahyposphenal lamina.
Sp.	spine.
Spoz. C.	suprapostzygapophysial cavity.
Spoz. L.	suprapostzygapophysial lamina.
Sprz. C.	supraprezygapophysial cavity.
Sprz. L.	supraprezygapophysial lamina.

[1] The drawings of Dorsals 5, 9, 10 and the Dorso-sacral were made by Mr. Rudolph Weber for the U. S. Geological Survey.



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Amer. Mus. Cope Coll. Nos. 5760; 5760; 5761 and 5761a

Plate LXXIV

Caudal vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of the vertebræ is uncertain.

Caudal Series I. Caudal Vertebræ 1–53 as Provisionally Determined [1]

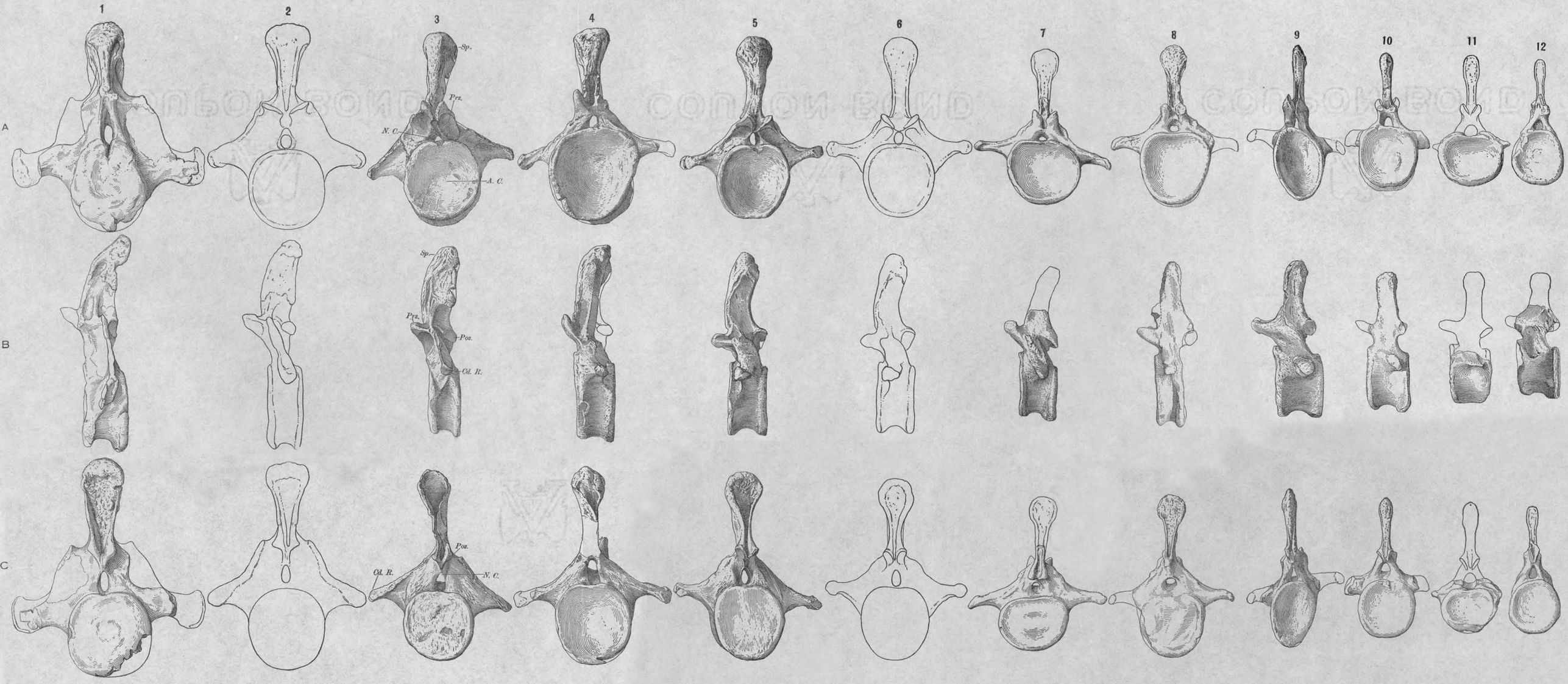
Amer. Mus. Cope Coll. Nos. 5760′ and 5760″

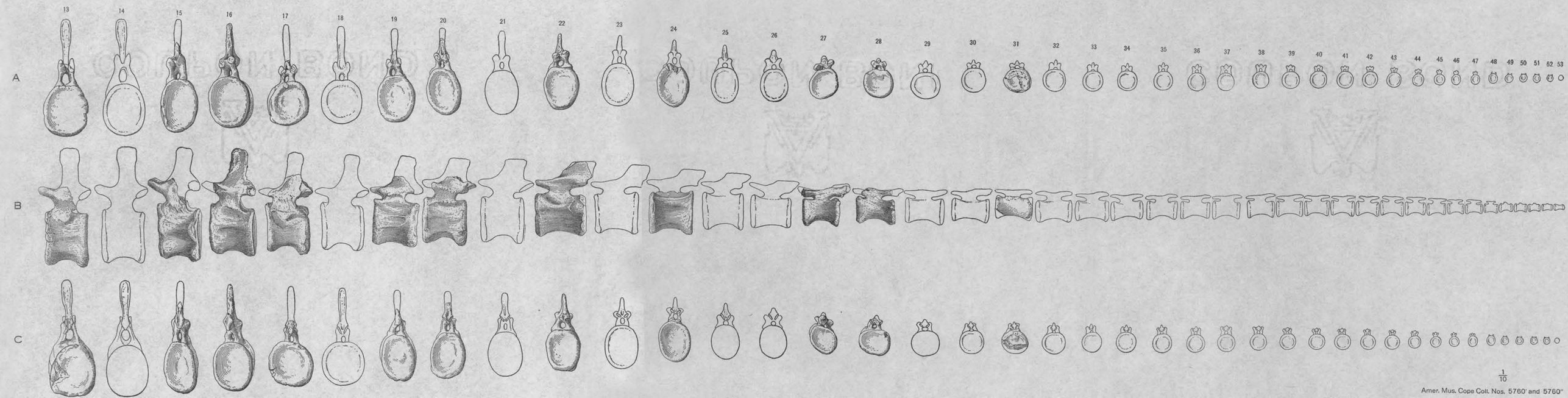
Caudal	Museum Number	Caudal	Museum Number	Caudal	Museum Number
1	5760″ / Cd–0–1	11	5760′ / Cd–Y–4	21	Reconstruction
2	Reconstruction	12	5760″ / Cd–0–10	22	5760″ / Cd–0–26
3	5760″ / Cd–0–2	13	5760″ / Cd–0–18	23	Reconstruction
4	5760″ / Cd–0–3	14	Reconstruction	24	5760″ / Cd–0–29
5	5760″ / Cd–0–4	15	5760″ / Cd–0–14	25	Reconstruction
6	Reconstruction	16	5760″ / Cd–0–16	26	Reconstruction
7	5760″ / Cd–0–5	17	5760″ / Cd–0–23	27	5760′ / Cd–Y–13
8	5760″ / Cd–0–6	18	Reconstruction	28	5760′ / Cd–Y–12
9	5760″ / Cd–0–9	19	5760″ / Cd–0–21	29	Reconstruction
10	5760′ / Cd–Y–3	20	5760″ / Cd–0–22	30	Reconstruction
				31	5760′ / Cd–Y–19
				32 to 53	Reconstructions

The figures 1–53 indicate Caudals 1 to 53 respectively. A, anterior views; B, lateral views, left side; C, posterior views.

A. C. anterior concavity.
Cd. R. caudal rib.
N. C. neural canal.
Poz. postzygapophysis.
Prz. prezygapophysis.
Sp. spine.

[1] Many of these drawings were made by Mr. Rudolph Weber for the U. S. Geological Survey.





$\frac{1}{10}$

Amer. Mus. Cope Coll. Nos. 5760' and 5760''

Plate LXXV

Caudal vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of these vertebræ is uncertain.

Caudal Series II. Caudal Vertebræ 1–53 as Provisionally Determined[1]

Amer. Mus. Cope Coll. Nos. 5760′ and 5760″

Caudal	Museum Number	Caudal	Museum Number	Caudal	Museum Number
1	5760′ / Cd-Y-X	14	5760′ / Cd-Y-7	26	Reconstruction
2	Reconstruction	15	5760″ / Cd-0-19	27	Reconstruction
3	Reconstruction	16	5760″ / Cd-0-24	28	5760′ / Cd-Y-14
4	5760′ / Cd-Y-1	17	5760″ / Cd-0-25	29	5760′ / Cd-Y-15
5	5760′ / Cd-Y-2	18	5760″ / Cd-0-30	30	Reconstruction
6	5760′ / Cd-Y-III	19	Reconstruction	31	Reconstruction
7	Reconstruction	20	5760″ / Cd-0-27	32	Reconstruction
8	5760″ / Cd-0-7	21	5760′ / Cd-Y-9	33	Reconstruction
9	5760″ / Cd-0-8	22	5760″ / Cd-0-32	34	Reconstruction
10	5760′ / Cd-Y-6	23	5760″ / Cd-0-31	35	5760′ / Cd-Y-20
11	5760″ / Cd-0-12	24	Reconstruction	36	5760′ / Cd-Y-21
12	5760″ / Cd-0-11	25	Reconstruction	37	5760′ / Cd-Y-22
13	5760″ / Cd-0-13			38	5760′ / Cd-Y-23
				39 to 53	Reconstructions

The figures 1–53 indicate Caudals 1 to 53 respectively. A, anterior views; B, lateral views, left side; C, posterior views.

A. C. anterior concavity.
Cd. R. caudal rib.
N. C. neural canal.
Poz. postzygapophysis.
Prz. prezygapophysis.
Sp. spine.

[1] Several of these drawings were made by Mr. Rudolph Weber for the U. S. Geological Survey.

A

B

C

1 2 3 4 5 6 7 8 9 10 11 12

Sp.
Prz.
A. C.
Poz.
Cd. R.
Chv. F.
N. C.

13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53

$\frac{1}{10}$

Amer. Mus. Cope Coll. Nos. 5760 and 5760

Plate LXXVI

Caudal vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The exact original association is uncertain. In many cases, however, the characters and the directions of distortion indicate the relative positions of the vertebræ.

Caudal Series III. Caudal Vertebræ 1–53 as Provisionally Determined

Amer. Mus. Cope Coll. No. 5761

Caudal	Museum Number	Caudal	Museum Number	Caudal	Museum Number
1	5761 Cd–1	15	5761 Cd–X–12	30	5761 Cd–X–24
2	5761 Cd–X–2	16	5761 Cd–X–15	31	Reconstruction
				32	Reconstruction
3	5761 Cd–3	17	5761 Cd–X–14	33	Reconstruction
4	5761 Cd–4	18	Reconstruction	34	5761 Cd–X–26
5	5761 Cd–5	19	5761 Cd–X–17	35	Reconstruction
		20	Reconstruction	36	Reconstruction
6	5761 Cd–6	21	Reconstruction	37	Reconstruction
7	5761 Cd–7	22	5761 Cd–X–19	38	Reconstruction
				39	5761 Cd–X–27
8	5761 Cd–8	23	5761 Cd–X–20	40	Reconstruction
9	Reconstruction	24	5761 Cd–X–22	41	Reconstruction
10	5761 Cd–10	25	5761 Cd–X–21	42	5761 Cd–X–28
11	5761 Cd–11	26	Reconstruction	43	5761 Cd–X–29
12	Reconstruction	27	Reconstruction	44	5761 Cd–X–30
13	Reconstruction	28	5761 Cd–X–23	45 to 53	Reconstructions
14	5761 Cd–X–11	29	5761 Cd–X–25		

The figures 1–53 indicate Caudals 1 to 53 respectively. A, anterior views; B, lateral views, left side; C, posterior views.

A. C. anterior concavity.
Cd. R. caudal rib.
Chv. F. chevron facet.
N. C. neural canal.
Poz. postzygapophysis.
Prz. prezygapophysis.
Sp. spine.

A

B

C

1 2 3 4 5 6 7 8 9 10 11 12 13

Sp. *Prz.* *N. C.* *Cd. R.* *A. C.*

Sp. *Prz.* *Poz.* *Cd. R.*

N. C. *Poz.*

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53

Sp. *Prz.* *Poz.*

Poz. *N. C.*

Chv. F.

$\frac{1}{10}$

Amer. Mus. Cope Coll. No. 5761

Plate LXXVII

Caudal Vertebræ of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of these vertebræ is uncertain.

Caudal Series IV. Caudal Vertebræ 1–53 as Provisionally Determined

Amer. Mus. Cope Coll. No. 5761

Caudal	Museum Number	Caudal	Museum Number	Caudal	Museum Number
1	5761 / Cd–X–1	10	Reconstruction	19	Reconstruction
		11	Reconstruction	20	Reconstruction
2	5761 / Cd–X–2	12	5761 / Cd–X–9	21	Reconstruction
				22	Reconstruction
3	5761 / Cd–X–3	13	5761 / Cd–X–10	23	Reconstruction
4	5761 / Cd–X–4	14	5761 / Cd–12	24	5761 / Cd–X–18
5	Reconstruction	15	5761 / Cd–X–13	25	Reconstruction
6	5761 / Cd–X–5			26	Reconstruction
7	5761 / Cd–X–6	16	5761 / Cd–13	27	Reconstruction
8	5761 / Cd–9	17	5761 / Cd–14	28	5761 / Cd–15
9	5761 / Cd–X–7	18	5761 / Cd–X–16		

The figures 1–53 indicate Caudals 1 to 53 respectively. A, anterior views; B, lateral views, left side; C, posterior views.

A. C. anterior concavity.
Cd. R. caudal rib.
Chv. F. chevron facet.
N. C. neural canal.
Poz. postzygapophysis.
Prz. prezygapophysis.
Sp. spine.

A

B

C

1 2 3 4 5 6 7 8 9 10 11 12 13

Sp.
Prz.
N. C.
A. C.
Poz.
Cd. R.

14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53

Chv. E.
Chv. F.

Plate LXXVIII

Dorsal Ribs of *Camarasaurus supremus* Cope

One-tenth natural size

The original association with each other and with the vertebræ is uncertain.

Dorsal Rib Series I. Dorsal Ribs 1–10 and Dorso-sacral Rib

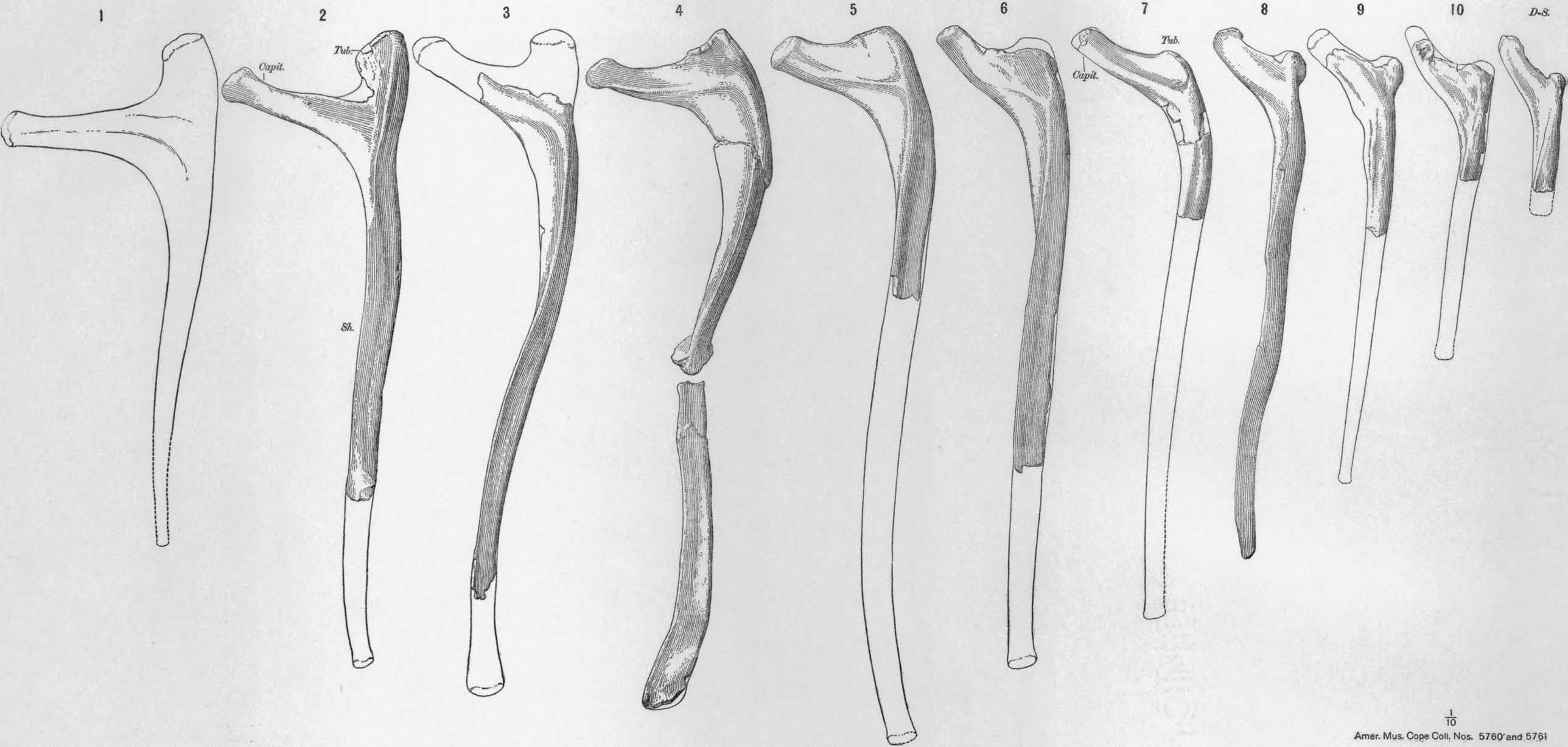
Amer. Mus. Cope Coll. Nos. 5760′ and 5761

Rib	Museum Number	Rib	Museum Number
1	Reconstruction	7	5761 / R-a-37
2	5761 / R-a-31	8	5761 / R-a-36
3	5761 / R-a-32	9	5761 / R-a-38
4	5761 / R-a-33	10	5760′ / R-a-42
5	5761 / R-a-34	Dorso-sacral	5760′ / R-a-39
6	5761 / R-a-35		

External views, left ribs.

The figures 1–10 indicate Dorsal Ribs 1 to 10 respectively; D-S. indicates probable Dorso-sacral Rib.

Capit. capitulum.
Sh. shaft.
Tub. tuberculum.



$\frac{1}{10}$

Amer. Mus. Cope Coll. Nos. 5760 and 5761

PLATE LXXIX

Dorsal Ribs of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of these ribs with other bones is uncertain.

DORSAL RIB SERIES II. DORSAL RIBS 1–10

Amer. Mus. Cope Coll. Nos. 5760′ and 5761

Rib	Museum Number	Rib	Museum Number
1	5761 / R–a–11	6	5760′ / R–a–16
2	5760′ / R–a–12	7	5760′ / R–a–17
3	5760′ / R–a–13	8	5760′ / R–a–18
4	Reconstruction	9	5760′ / R–a–19
5	5760′ / R–a–14	10	5761 / R–a–44

External views, left ribs.

The figures 1–10 indicate Dorsal Ribs 1 to 10 respectively.

Capit. capitulum.
Sh. shaft.
Tub. tuberculum.

$\frac{1}{10}$

Amer. Mus. Cope Coll. Nos. 5760 and 5761

Plate LXXX

Dorsal Ribs of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of the ribs is uncertain.

Dorsal Rib Series III. Dorsal Ribs 1–10

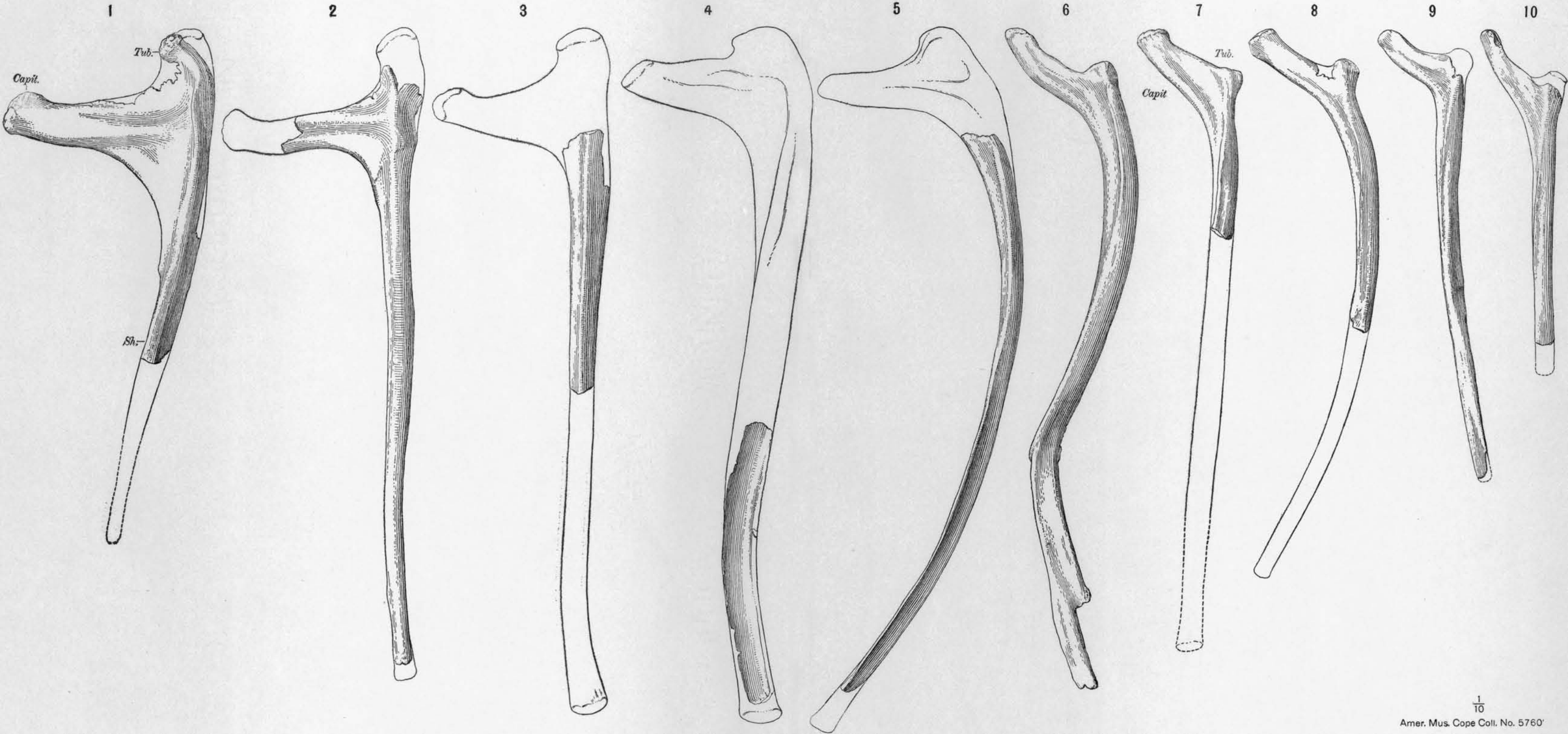
Amer. Mus. Cope Coll. No. 5760′

Rib	Museum Number	Rib	Museum Number
1	$\frac{5760'}{\text{R-a-1}}$	6	$\frac{5760'}{\text{R-a-6}}$
2	$\frac{5760'}{\text{R-a-2}}$	7	$\frac{5760'}{\text{R-a-8}}$
3	$\frac{5760'}{\text{R-a-5}}$	8	$\frac{5760'}{\text{R-a-7}}$
4	$\frac{5760'}{\text{R-a-4}}$	9	$\frac{5760'}{\text{R-a-9}}$
5	$\frac{5760'}{\text{R-a-3}}$	10	$\frac{5760'}{\text{R-a-46}}$

External views, left ribs.

The figures 1–10 indicate Dorsal Ribs 1 to 10 respectively.

Capit. capitulum.
Sh. shaft.
Tub. tuberculum.



$\frac{1}{10}$

Amer. Mus. Cope Coll. No. 5760

PLATE LXXXI

Dorsal Ribs of *Camarasaurus supremus* Cope

One-tenth natural size

The original association of these ribs with other bones is uncertain.

DORSAL RIB SERIES IV. DORSAL RIBS 1–10 AND DORSO-SACRAL RIB

Amer. Mus. Cope Coll. Nos. 5760′ and 5761

Rib	Museum Number	Rib	Museum Number
1	5761 / R–a–21	7	5760′ / R–a–27
2	5761 / R–a–22	8	5761 / R–a–28
3	5761 / R–a–23	9	5760′ / R–a–29
4	5761 / R–a–24	10	5761 / R–a–30
5	5761 / R–a–25	Dorso-sacral	5761 / R–a–40
6	5760′ / R–a–26		

External views, left ribs.

The figures 1–10 indicate Dorsal Ribs 1 to 10 respectively; D-S. indicates the probable Dorso-sacral Rib.

Capit. capitulum.
Sh. shaft.
Tub. tuberculum.

$\frac{1}{10}$

Amer. Mus. Cope. Coll. Nos. 5760, 5761

Plate LXXXII

Ryder's Reconstruction of Skeleton of *Camarasaurus supremus* Cope

About one-twenty-fifth natural size

This reconstruction was made in 1877 by Dr. John A. Ryder under the direction of Prof. E. D. Cope. The original drawing was natural size; it was first exhibited at a meeting of the American Philosophical Society in Philadelphia, Pennsylvania, on December 21, 1877; since that time it has been exhibited a number of times at The American Museum of Natural History and elsewhere. It is still preserved in the American Museum as an historic document of great interest.

Based upon Amer. Mus. Cope Coll. Nos. 5760, 5760′, and 5760″.

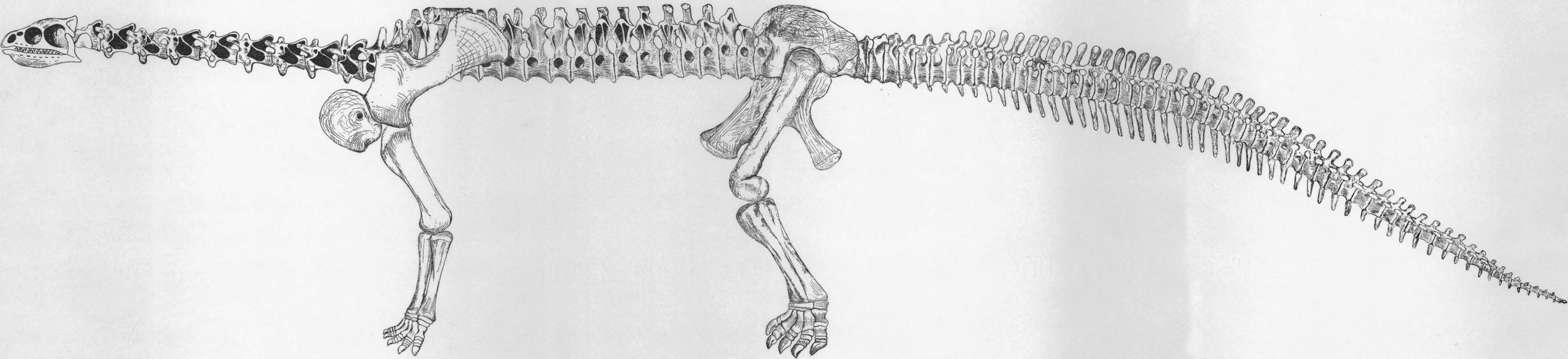


Plate LXXXIII

Reconstruction of Skeleton of *Camarasaurus supremus* Cope

One-thirtieth natural size

This reconstruction was drawn in 1918 under the direction of the authors, by Mr. Erwin S. Christman. It is based for the most part upon the drawings of the material in the collection, and upon the determinations of parts indicated in the present memoir; it embodies the results of studies of poses by Prof. W. K. Gregory. The drawing of the skull was based largely upon Amer. Mus. No. 467, originally described as *Morosaurus*.

In the present pose the left manus is represented as descending, while the left pes is about to be raised from the ground. The head is slightly raised with respect to the neck, the axes of the skull and of the neck being continuous instead of making a marked angle, which is the normal relation between head and neck in the Sauropoda.

The dotted lines represent the supposed extent of the suprascapular cartilage. The dash lines represent reconstructions from other material.

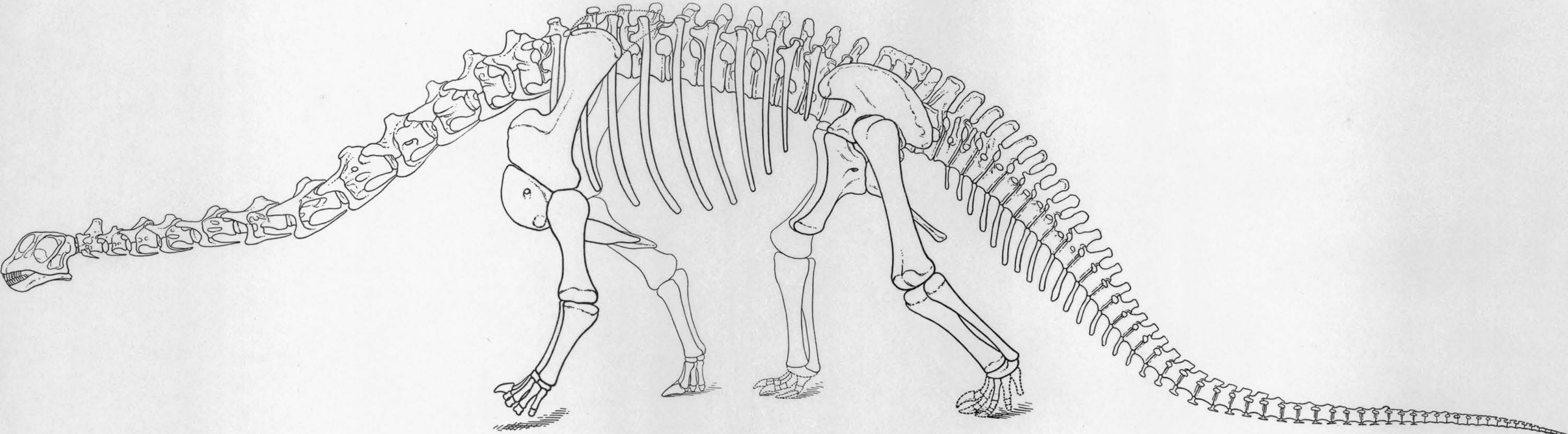


Plate LXXXIV

Reconstruction of Skeleton of *Camarasaurus supremus* Cope

One-thirtieth natural size

This reconstruction was drawn in 1918 under the direction of the authors by Mr. Erwin S. Christman.

As in the reconstruction, LXXXIII, it is based upon the four chief skeletons of *Camarasaurus*. The feet are restored from Osborn's figure of *Morosaurus*. The restoration of the manus is probably correct. The restoration of the pes is highly conjectural. The restoration of the skull is based upon Osborn's figure of *Morosaurus*. With the exception of the feet and of a possible error in the proportions of the limbs and between the shoulder and the pelvic region, this restoration is approximately correct.

Known and unknown parts uniformly shaded.

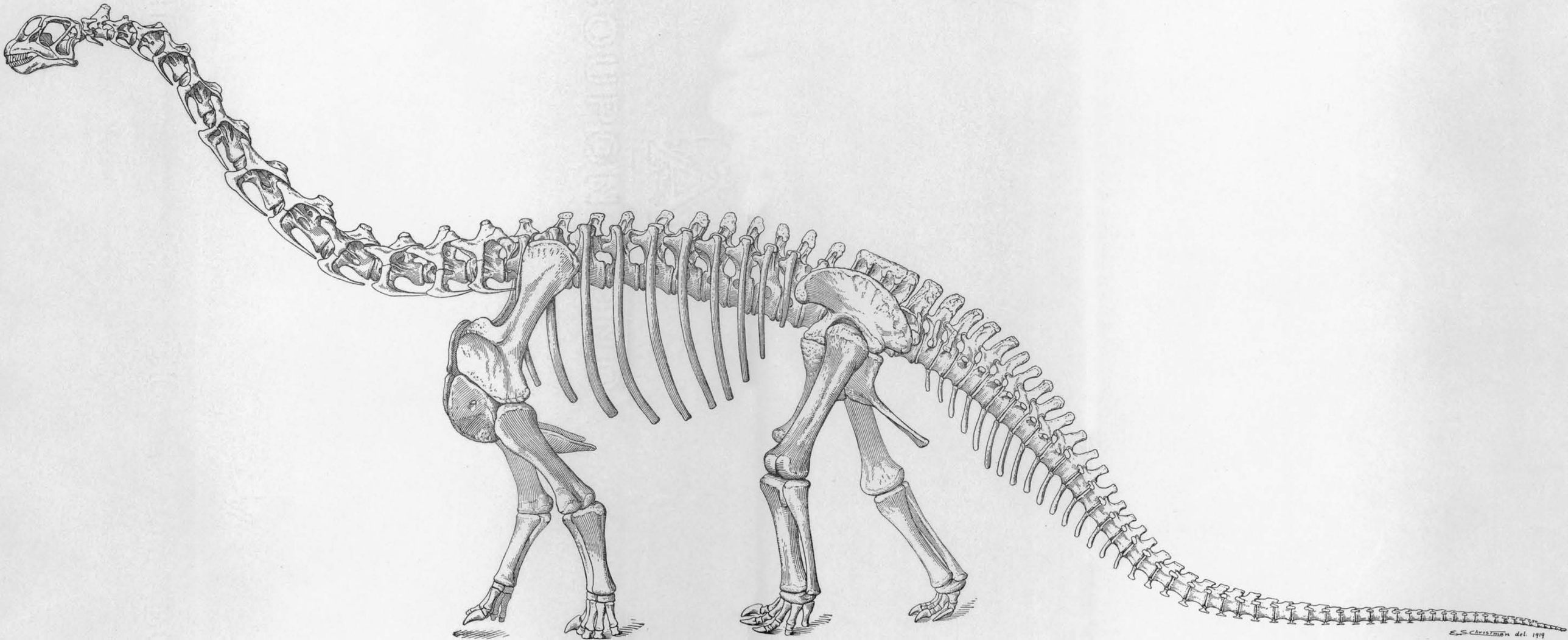

E. S. Christman del. 1919

Plate LXXXV

Restoration of *Camarasaurus supremus* Cope

Fig. 1. Lateral view of model, left side.
Fig. 2. Oblique view of model, from in front and part of the left side.
Fig. 3. Oblique view of model, showing rear and part of right side.
Fig. 4. Lateral view of model, right side.

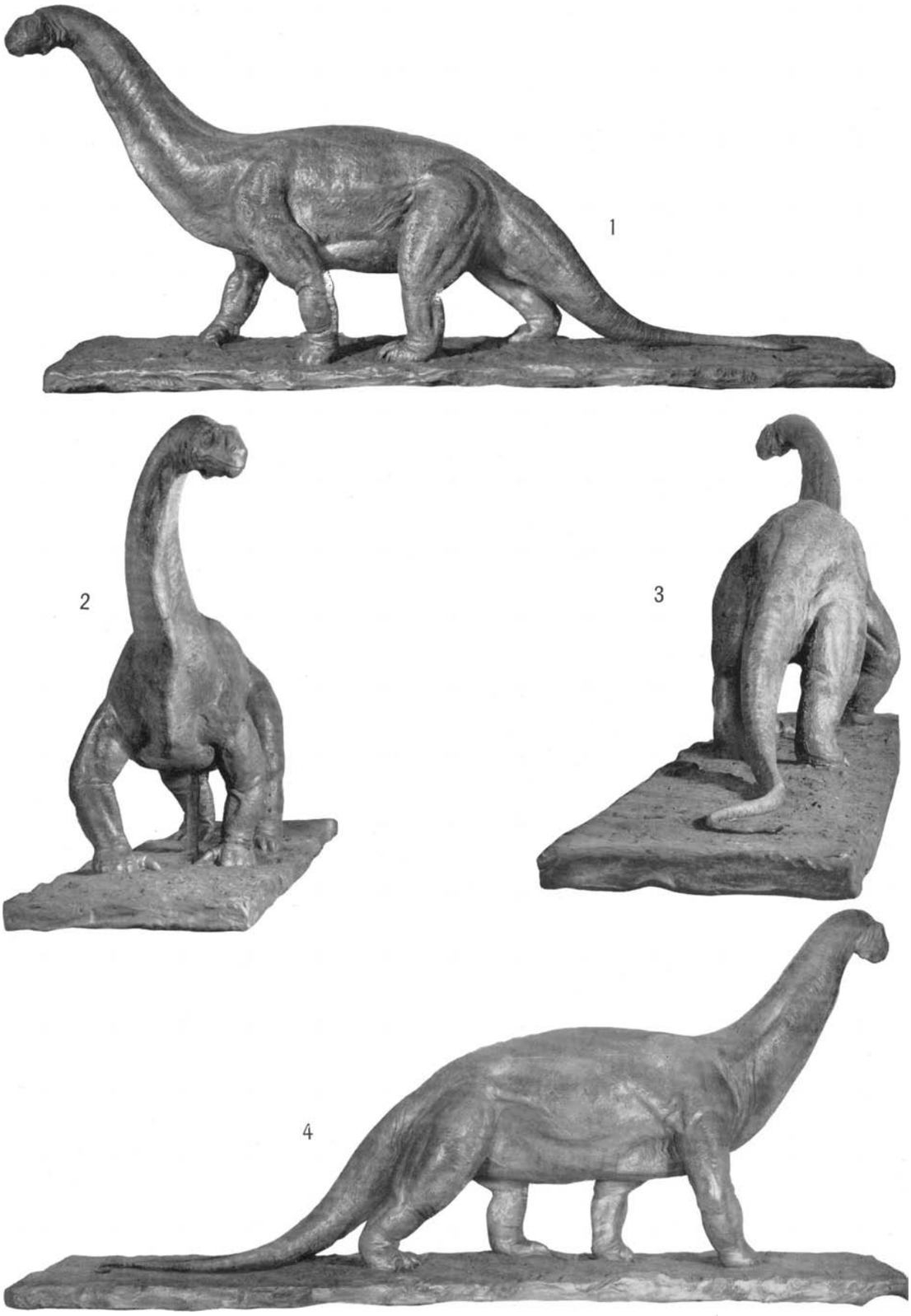
These figures are photographs of a life model of *Camarasaurus* made by Mr. E. S. Christman under the direction of Professor W. K. Gregory, with the coöperation of the authors. The animal is represented in a walking pose, so far as it could be worked out from the forms and positions of the facets on the limb bones and upon much other data.

Among Recent reptiles the Crocodilia raise the body well off the ground when moving rapidly and afford numerous hints as to the movement of the limbs in the sauropods. It is the opinion of Professor Gregory and of the authors that *Camarasaurus* neither crawled like a lizard nor walked with fully straightened limbs like an elephant.

The head is bent sharply downward upon the neck. The shoulder region is high, differing from most other restorations of sauropods; the thigh is extraordinarily massive, as shown by the muscle areas on the pelvis; the tail is relatively small as compared with *Diplodocus*. The lateral curvature of the spinal column is suggested by the series of figures, although it is not clearly shown in any one.

The skin pattern is highly conjectural.

Careful researches in comparative myology, carried on for several years by Professor Gregory and his associates, were applied to the problem of the restoration of the flesh; photographs, enlarged from moving-picture films of moving reptiles, furnished by Mr. R. L. Ditmars, were of great value in determining the pose; valuable suggestions were made by Mr. Charles R. Knight.


1
2
3
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