RESTORATION OF TRICERATOPS; TRACHODON IN THE DISTANCE.

From painting made under Mr. Hatcher's direction by Charles R. Knight.

Original in Carnegie Museum, Pittsburg, Pa.

DEPARTMENT OF THE INTERIOR

MONOGRAPHS

OF THE

UNITED STATES GEOLOGICAL SURVEY

VOLUME XLIX

WASHINGTON
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1907

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, Director

THE CERATOPSIA

BY

JOHN B. HATCHER

BASED ON PRELIMINARY STUDIES BY

OTHNIEL C. MARSH

EDITED AND COMPLETED BY

RICHARD S. LULL

WASHINGTON
GOVERNMENT PRINTING OFFICE
1907

ERRATA.

[Monograph XLIX of the United States Geological Survey.]

Page 11. Eighth line of text from bottom, for "1871 E" read "4739."
Page 11. Third line of text from bottom, after the word "Type" insert "No. 5457, U. S. National Museum."
Page 12. To list of genera and species add "34. *T. sulcatus* Marsh. Am. Jour. Sci., vol. 39, May, 1890, p. 422. Type No. 4276, U. S. National Museum."
Page 33. In legend of fig. 30, for "2116" read "1201."
Page 37. In legend of fig. 32, for "2065" read "2416."
Page 39. In legend of fig. 34, for "2065" read "2416."
Page 57. Fig. 62, left pubis is not that of type.
Page 65. Nos. 1, 2, and 3 of fig. 74 are of specimen No. 5793, U. S. National Museum.
Page 115. Eleventh line from top, for "1871 E" read "4739."
Page 170. Tenth line from top, for "1871 E" read "4739."

NOTE: Concerning statements on pages 139 and 140 relative to the condition of skull and jaw of specimen No. 4928, it should be said that no record has yet been found of the receipt at the National Museum of the missing parts. They probably became separated from the other material in packing and in their fragmental condition can not now be accurately identified.

CONTENTS.

ILLUSTRATIONS.

FOREWORD TO THE MONOGRAPHS ON VERTEBRATE PALEONTOLOGY.

By Henry Fairfield Osborn.

While vertebrate paleontologist of the United States Geological Survey Prof. Othniel Charles Marsh originated the large conception of a series of paleontological monographs worthy of the remarkable nature and preservation of the ancient life of North America. His plan was to make very complete collections of certain orders and families of vertebrates, to illustrate them in the most artistic manner, and to describe and discuss them in detail. At the time of his death, in 1899, the execution of this great plan was left in the following condition.

1. Odontornithes	Published in 1880.
2. Dinocerata	Published in 1884.
3. Sauropoda	Incomplete; preliminary bulletins published.
4. Ceratopsia	Unpublished; preliminary bulletins published.
5. Stegosauria	Unpublished; preliminary bulletins published.
6. Brontotheriidæ	Unpublished; preliminary bulletins published.

In 1900 the Director of the United States Geological Survey invited me to take general oversight of the preparation of the four incomplete monographs, and all the unpublished work which had been prepared by my distinguished predecessor was put into my hands after revision and report by a special committee. It was found to consist entirely of 204+ carefully prepared lithographic plates, of drawings and wood engravings, some partial bibliographies, and about 100 pages of rough pencil notes and memoranda. The supervision and execution of these illustrations had involved years of labor. There was no manuscript whatever. All record of the numerous and important observations which Professor Marsh had made of these groups of animals he had already published in preliminary bulletins, chiefly in the American Journal of Science and in his two contributions to the Survey publications, "The dinosaurs of North America" (1896), and "Vertebrate fossils of the Denver Basin" (1897).

The entire text of the four monographs therefore remained to be written. To treat exhaustively the materials which had been collected under Professor Marsh's direction and to cover the progress of the many succeeding years of exploration and research by other authors constituted only a part of the work which remained to be done. Many new plates and supplemental illustrations were evidently necessary. Geological as well as paleontological exploration in the field was absolutely needful in order to supplement the very meager data which had been preserved as to the geological conditions and stratigraphic distribution of these animals—data hardly less essential to their philosophical comprehension than the data afforded by the fossils themselves.

After very considerable thought I decided upon the following as the most desirable uniform plan of treatment for each volume and each group:

Section 1. *History of discovery* and of the gradual development of knowledge of the structure and affinities of the group.

Section 2. *Definitions and relationships.* General definition of the group and general morphology or anatomy as compared with that of other groups.

Section 3. *Geological data.* General geological conditions and stratigraphic succession of the stages and horizons in which the remains of the group are found.

Section 4. *Systematic revision.* Systematic revision of the types of each taxonomic rank in the chronological order of their original description, including (1) the parts constituting the type and cotype, if any; (2) the locality and geological level so far as recorded; (3) the present location and museum number of the type; (4) the author's original definitions and descriptions of the type or types. This method of treatment allows little room for originality, but it is the prerequisite of the monographic research of section 5; it disposes once for all of troublesome questions of priority, and if accurately and impartially done is final and furnishes an invaluable reference work for all future research. This section should precede the original morphologic and taxonomic section, instead of following it as arranged by Marsh in his monograph on the Dinocerata.

Section 5. *Morphology and taxonomy.* In this section the animals are rearranged in their natural classification according to the observations and conclusions of the authors; they are treated successively, according to their geological sequence, if ascertained, or if not, according to the sequence indicated by increasing specialization of structure; the orders, families, genera, and species are redefined if necessary; valid forms are distinguished; the synonymous names are eliminated. The entire structure and functions of different parts of the body of each type are considered and carefully discussed.

It is evident that section 5 differs from section 4 in containing a large amount of original matter, consisting of the author's conclusions, which are subject to modification by the opinions of others and by future discovery.

Section 6. *Phylogeny and biology.* In this final original section the phylogenetic history of the group is traced from its probable origin. The phylogenetic relationships of the animals to one another and to other forms are now rendered clearer through the full preceding discussion of their anatomy. Their environment is considered, their habits, their external form and appearance, and finally the rise and fall of the group, and the probable causes of its extinction.

Having thus determined upon this general plan of treatment for these monographs, it remained to decide how they could be most carefully and expeditiously prepared. The experience of my predecessor made it apparent that a division of labor was absolutely essential. I therefore invited Mr. F. A. Lucas to undertake the Stegosauria, and Mr. J. B. Hatcher to undertake the Ceratopsia, I myself to undertake the Sauropoda and Brontotheriidæ.

There could be no question as to either the justice or the wisdom of assigning the present monograph on the Ceratopsia to John Bell Hatcher. His discovery and collection of these animals was, with the exception of his explorations in Patagonia, the greatest single achievement of his remarkable life. Under Professor Marsh's direction, he had devoted four most arduous years to bringing together the magnificent specimens of these horned dinosaurs for the United States Geological Survey and National Museum and for the Yale University Museum.

Mr. Hatcher was delighted to undertake the difficult piece of comparison and research involved in a complete restudy of the Ceratopsia, and entered upon it in July, 1902, with his usual ardor and thoroughness. Except during brief intermissions in the field he worked at this task full time almost daily for two years in addition to discharging his duties during other hours as curator of vertebrate paleontology in the Carnegie Museum. Examining the types, supervising the further preparation of the fossils, visiting all the museums, preparing a very large number of additional drawings, carefully writing and revising his text—this was his occupation for two years. Finally, he was on the very threshold of the pleasantest portion of the work, the conclusion of the systematic and morphological section, and in sight of the rearrangement, classification, and philosophical treatment of the group, when he was stricken down on July 3, 1904.

Much work remained to be done. It was necessary that the monograph should be completed by a third author, and that that author as editor should not alter but should leave the work distinctively Mr. Hatcher's.

Prof. Richard S. Lull, of Yale University, has most sympathetically and successfully accomplished this task. Part I (pp. 1–157) is Mr. Hatcher's, entirely unrevised, the few editor's notes being inserted in brackets. Part II (pp. 159–198) is Professor Lull's, but includes, so far as known, Mr. Hatcher's opinions on the matters treated, as well as very extensive quotations from his writings. It also includes a very considerable amount of original matter by Professor Lull.

I trust that this volume may prove to be a lasting monument to the rare and noble spirit of John Bell Hatcher.

EXPLORATIONS OF JOHN BELL HATCHER FOR THE PALEONTOLOGICAL MONOGRAPHS OF THE UNITED STATES GEOLOGICAL SURVEY, TOGETHER WITH A STATEMENT OF HIS CONTRIBUTIONS TO AMERICAN GEOLOGY AND PALEONTOLOGY.

By Henry Fairfield Osborn.

I. SCIENTIFIC EXPLORATIONS.

While working in the mines of Iowa, John Bell Hatcher[a] had made a small collection of Carboniferous fossils. These he brought to New Haven in 1880 and showed to Prof. George J. Brush, who later introduced him to Prof. Othniel C. Marsh. After graduation from the Sheffield Scientific School he impressed upon Professor Marsh the fact that he wanted to collect and study fossils—that he was willing to work at almost any salary. Marsh recognized his ability and planned to send him at once into the western field. Thus was started Hatcher's career in paleontology.

Hatcher began his first collecting tour on June 25, 1884, near Long Island, Kans. Here he was for a time associated with Mr. Charles H. Sternberg in work in the upper Miocene deposits of the Loup Fork, but after an apprenticeship of a month he began to collect independently. He remained in Kansas until late in November, then traveled south, and spent the winter months until the latter part of March, 1885, around Wichita Falls, Tex., collecting Permian reptiles. These collections are in the Yale Museum.

In 1885 he made a second tour to and about Long Island, Kans., collecting chiefly in the upper Miocene formation as field assistant on the United States Geological Survey. During the two seasons in this region he sent to Professor Marsh, partly for the Yale University Museum and partly for the National Museum, through the United States Geological Survey, a large number of boxes containing chiefly Miocene rhinoceroses. Little or none of this material has yet been described.

In the meantime Professor Marsh was planning his monograph on the lower Oligocene family, the Brontotheriidæ, for which he had already collected some materials. The variety and richness of these animals were still unknown and unsuspected. Marsh assigned to Hatcher the further assembling of material for this monograph, a task which he accomplished with extraordinary success. During the seasons of 1886, 1887, and 1888 he spent fifteen months in the field and collected 105 nearly complete *Titanotherium* skulls and many portions of skeletons and disarticulated bones, besides the remains of many other associated animals. These were collected chiefly for the United States Geological Survey. In 1888 he extended his exploration from Long Pine to Chadron, Nebr., and to the vicinity of Hermosa, S. Dak. Here he laid the

[a] John Bell Hatcher was born at Cooperstown, Brown County, Ill., October 11, 1861. He died July 3, 1904, while engaged in the preparation of this monograph upon the Ceratopsia. Other purely biographical matter will be found in the obituaries by Scott, McGee, Holland, Schuchert, Eaton, and Osborn as follows:

Scott, W. B. John Bell Hatcher. Science, new ser., vol. 20, No. 500, July 29, 1904, pp. 139–142.

Holland, W. J. In Memoriam: John Bell Hatcher. Ann. Carnegie Mus., vol. 2, No. 4, 1904, pp. 597–604.

Eaton, George F. Obituary in Am. Jour. Sci., 4th ser., vol. 18, August, 1904, pp. 163–164.

Schuchert, Charles. John Bell Hatcher. Am. Geologist, vol. 35, No. 3, March, 1905, pp. 131–141.

McGee, W J. Hatcher's Work in Patagonia. Nat. Geog. Mag., vol. 8, No. 11, November, 1897, pp. 319–322.

Osborn, Henry F. John Bell Hatcher, his life and works. In preparation.

The writer is also indebted to Messrs. Charles Schuchert, T. W. Stanton, and O. A. Peterson for their kind revision of the present article.

foundation of his first very exact observations of the stratigraphic succession of the species of titanotheres. This he subsequently made the subject of an important paper in which these beds were subdivided into three levels. In this paper he refers to his work as follows:

> Early in the season of 1886 it became apparent that certain forms of skulls were characteristic of certain horizons in the beds. This fact showed the importance of keeping, so far as possible, an exact record of the horizon from which each skull or skeleton was taken. From actual measurement the vertical range of the Titanotheriidæ was found to be about 180 feet. For convenience in keeping a record of horizons the beds were divided into three divisions of 60 feet each, and each of these three divisions was subdivided into three divisions of 20 feet each. The different skulls and skeletons, when dug out, were each given a separate letter or number, and this letter or number was placed in that subdivision of the beds from which the skull or skeleton was taken.

In 1901 Hatcher again made a tour of these beds in the interests of the Brontotheriidæ monograph, which had been transferred after the death of Professor Marsh to Professor Osborn's hands; he was accompanied by N. H. Darton, of the Geological Survey, and Prof. Eberhard Fraas, of Stuttgart. By means of this second trip practically every species of titanothere was placed in its exact geological level.

During the late autumn and winter months of 1887 Hatcher made collections in the older Tertiary[a] deposits around Washington, D. C., Richmond, Va., and at the Egypt coal mine in North Carolina, searching for the remains of *Belodon* and *Dromatherium* in the upper Triassic beds of that locality, which resulted in the finding of a fine specimen of *Belodon*. In the meantime a new problem came before the Survey; the age of the beds of the so-called Potomac formation had not been satisfactorily determined. Here again Hatcher was successful in procuring considerable dinosaur material, from which Marsh, in a series of papers, attempted to prove that these beds were of Jurassic age.[b]

He concluded the season of 1888 with a trip to the north—to the Cretaceous beds of the Judith River region of Montana. In this region, on the upper Missouri, Cope had explored in 1875 and 1876, finding the remains of *Monoclonius recurvicornis* and other species of the still unrecognized suborder Ceratopsia. Hatcher procured remains of several skulls of related horned dinosaurs, on which Marsh established the new genus *Ceratops*.

In the same autumn—that of 1888—Hatcher's attention was first called to a pair of very large horn cores found 35 miles from Lusk, Wyo., and early in the spring of 1889 this incident led to the discovery of the great locality in Converse County, Wyo., which enabled Marsh to establish and define the great suborder Ceratopsia, and fixed the scene of Hatcher's labors from 1889 to 1892.

Hatcher's very important geological observations, together with his characteristically brief and modest account of his labors, are found in one of his first published papers, entitled "Some localities for Laramie mammals and horned dinosaurs," from which the following is quoted:

> In the nearly four years spent by the writer in working these beds, 31 skulls and several fairly complete skeletons of horned dinosaurs were secured, besides two quite complete skeletons of *Diclonius* (*Claosaurus*), about 5,000 isolated jaws and teeth of Laramie mammals, and numerous remains of other dinosaurs, turtles, lizards, birds, and fishes, as well as extensive collections of fresh-water invertebrates from the same beds. In all, over 300 large boxes of fossils were collected for the United States Geological Survey and are now carefully stored in the Yale Museum, many of them as yet unopened.

This brief summary conveys but a faint idea of the energy, persistence, and skill involved in this work. The great skulls, themselves inclosed in hard sandstone matrices, give the best impression; one huge box (about 10 feet long, 5 feet wide, and 6 feet deep), containing the largest known skull of *Triceratops*, had to be lifted out of a ravine 50 feet deep and hauled for more than 40 miles over a trackless country to the railroad.

Here also he made his important discovery of the remains of Cretaceous mammals in great abundance, only two or three imperfect specimens having previously been found. This discovery he described as follows:

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[a] It is my impression that these collections were mostly from the Eocene.—T. W. S.

[b] The dinosaur material on which these conclusions were based was all from near the base of the Potomac, and the evidence for the Jurassic age of even this portion has been questioned. The upper Potomac beds are now known to be well up in the Cretaceous.—T. W. S.

The small mammals are pretty generally distributed but are never abundant, and on acount of their small size are seen with difficulty. They may be more frequently found in what are locally known as "blow-outs" and are almost always associated with garpike scales and teeth, and teeth and bones of other fish, crocodiles, lizards, and small dinosaurs. These remains are frequently so abundant in "blow outs" as to easily attract attention, and when such a place is found careful search will almost always be rewarded by the discovery of a few jaws and teeth of mammals. In such places the ant-hills, which in this region are quite numerous, should be carefully inspected, as they will almost always yield a goodly number of mammal teeth. It is well to be provided with a small flour sifter with which to sift the sand contained in these ant-hills, thus freeing it of the finer materials and subjecting the coarser material remaining in the sieve to a thorough inspection for mammals. By this method the writer has frequently secured from 200 to 300 teeth and jaws from one ant-hill. In localities where these ants have not yet established themselves, but where mammals are found to be fairly abundant, it is well to bring a few shovelfuls of sand with ants from other ant-hills, which are sure to be found in the vicinity, and plant them on the mammal locality. They will at once establish new colonies, and if visited in succeeding years will be found to have done efficient service in collecting mammal teeth and other small fossils, together with small gravels, all used in the construction of their future homes. As an instance of this I will mention that when spending two days in this region in 1893, I introduced a colony of ants in a mammal locality, and on revisiting the same place last season I secured in a short time from the exterior of this one hill 33 mammal teeth.

In the meantime, in 1891, Hatcher was made assistant to the chair of geology in Yale University. During these highly successful explorations for the remains of Ceratopsia he was in the service partly of Professor Marsh and partly of the United States Geological Survey; so that the collections have been divided between the Yale University Museum and the National Museum in Washington.

He was now at the age of 32, and had been at work nine years without giving any intimation of his original ability as a thinker and writer. He now began his career as a publicist, producing his first paper entitled "The Ceratops beds of Converse County, Wyoming," in the American Journal of Science, February, 1893.

In the spring of 1893 Hatcher accepted a call to Princeton University as curator of vertebrate paleontology and assistant in geology.

For the seven succeeding years he was associated with Prof. W. B. Scott, who has given a full account of his great services to paleontology in Princeton University, which, perhaps, surpassed those he had rendered to his alma mater. His work included three divisions: (1) The exploration of the western Tertiaries, (2) the arrangement of the entire collection of mammalian fossils in the E. M. Museum of Geology, and (3) the expeditions to Patagonia. Professor Scott says:

The most important work which Hatcher undertook during his connection with Princeton was his exploration of Patagonia in the years 1896 to 1899. The plan was all his own and was not proposed to the geological department until everything was nearly ripe for action. He procured the greater part of the necessary funds, and, with characteristic generosity, was himself a liberal contributor. How successful this great undertaking was is very generally known and needs not to be repeated here. Great credit for his success is due to Messrs. Peterson and Colburn, who were associated with Hatcher in the work, but the soul of the enterprise was Hatcher himself. In his "Narrative of the expeditions" he has left an extremely well written and interesting account of these explorations.

In addition to the "Narrative and geography," Hatcher had undertaken to write reports upon the geology and also upon the fossil Litopterna and Marsupialia. How much of this material can be put into shape for publication can not yet be told. In any event he has raised for himself an enduring monument in these volumes, which owe their existence to him, however much or little may be his verbal contribution to their contents.

Hatcher finally returned home in the autumn of 1899, and on February 1, 1900, accepted the position of curator of paleontology and osteology in the museum of the Carnegie Museum of Pittsburg. As soon as he was installed he began to lay out, in consultation with Director W. J. Holland of that museum, plans for very extensive paleontological collections, and for the four succeeding summers he carried on explorations in the Western States and Territories. Through the generosity of Mr. Andrew Carnegie the work begun by Dr. J. L. Wortman in the season of 1899 in the upper Jurassic of Wyoming around Sheep Creek was continued under Hatcher's direction. He initiated renewed exploration in the Upper Cretaceous of Converse County, Wyo., in the Dæmonelix beds of the upper Miocene of Nebraska, and in the Oligocene White River formations of South Dakota and Nebraska. These divisions of the work were organized on a large scale under Messrs. Peterson, Gilmore, Utterback, and Douglass. In the following year he began the further exploration of the Jurassic dinosaur quarries of Marsh and Cope near

Canyon City, Colo., which had already yielded the types of *Camarasaurus*, *Diplodocus*, and many other Sauropoda. Here, as in every other region, Hatcher made not only important discoveries of fossils but invaluable geological observations. In 1902 the Carnegie Museum explorations were continued in Nebraska, in the Jurassic deposits of the Bighorn Mountains in Wyoming, and in the Titanotherium beds of Montana. In the season of 1903 these explorations were continued, and parties were sent also into the chalk or Niobrara deposits of western Kansas.

In 1903 also, the question of the age of the Judith River beds of Montana having come up, Hatcher was employed by the United States Geological Survey for a special expedition with Mr. T. W. Stanton, of the United States Geological Survey, and they finally settled this important problem.

During this period the problem of the sunken continent of Antarctica came to the fore among both geologists and biologists. Two expeditions were projected from Great Britain. Hatcher had carefully studied all the literature pertaining to the South Atlantic and had found notes which convinced him that vertebrate fossils were to be found on one of these islands. He was accordingly fired with the desire to join the proposed Scottish expedition and carried on a long correspondence with the promoters of the project of this expedition, which finally was abandoned. He then developed plans for an Antarctic exploration, which he laid before the Carnegie Institution of Washington.

This was with him a period of great activity. During these four years he published no less than 32 scientific papers, including his most important memoirs on *Diplodocus*, *Haplocanthosaurus*, and the splendid quarto of 314 pages entitled "Narrative and geography," volume 1 of the Reports of the Princeton Expeditions to Patagonia.

During the years 1902–1904 Hatcher was working at the rate of six to seven hours a day on the present monograph on the Ceratopsia, further account of which is given in his own preface to this volume and in the pages by Osborn and Lull.

II. SCIENTIFIC CONTRIBUTIONS.

1. GEOLOGY AND STRATIGRAPHY.[a]

1. The Ceratops beds of Converse County, Wyo., February, 1893.
2. The Titanotherium beds, March, 1893.
4. On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska, with note on the geology of the region, March, 1894.
8. Some localities for Laramie mammals and horned dinosaurs, February, 1896.
11. The Cape Fairweather beds; a new marine Tertiary horizon in southern Patagonia, September, 1897.
12. On the geology of southern Patagonia, November, 1897.
18. Sedimentary rocks of southern Patagonia, February, 1900.
27. The Jurassic dinosaur deposits near Canyon City, Colo., 1901.
33. Origin of the Oligocene and Miocene deposits of the Great Plains, 1902.
37. A correction of Professor Osborn's note entitled "New vertebrates of the mid-Cretaceous," November, 1902.
39. The Judith River beds, March, 1903.
40. L'âge des formations sédimentaires de Patagonie, by Florentino Ameghino. Criticism. June, 1903.
43. Relative age of the Lance Creek (Ceratops) beds of Converse County, Wyo., the Judith River beds of Montana, and the Belly River beds of Canada, June, 1903.
44. The stratigraphic position of the Judith River beds and their correlation with the Belly River beds of Canada. Joint note with T. W. Stanton. August 14, 1903.
46. Osteology of *Haplocanthosaurus*, with description of a new species, and remarks on the probable habits of the Sauropoda and the age and origin of the Atlantosaurus beds, November, 1903.
48. Narrative and geography. Reports of the Princeton University Expeditions to Patagonia, 1896–1899, vol. 1, 1903.
49. An attempt to correlate the marine with the nonmarine formations of the Middle West, 1904.
50. Geology and paleontology of the Judith River beds, by T. W. Stanton and J. B. Hatcher, with a chapter on the fossil plants, by F. H. Knowlton. Bull. U. S. Geol. Survey No. 257, 1905.

A glance at the titles of the eighteen papers cited above gives at once an impression of the breadth and extent of Hatcher's geological observations and of his energy and initiative as a

[a] See citations in full at the end of this sketch, pp. xxv–xxvi.

traveler and explorer. It will be noticed that the series embraces the Jurassic, the Cretaceous, and the Tertiaries of western North America and of the extremity of South America. The reader of these papers is impressed as much with the wealth of detail as with the power of generalization and imagination of past geological conditions, which is especially manifested in his development of the eolian v. the lake-basin theory of deposition in the western Oligocene and Miocene, in his discussion of the stratigraphic relations of the Judith River beds, in his discussion of the geological history of Patagonia, and in his final geological paper, delivered at the anniversary meeting of the Philosophical Society in 1904, "An attempt to correlate the marine with the nonmarine formations of the Middle West."

Fresh from his explorations for the Ceratopsia and Brontotheriidæ were the first two papers which came from his pen, "The Ceratops beds of Converse County," settling their Upper Cretaceous age, and "The Titanotherium beds," establishing the geological and stratigraphical sequence of various species of titanotheres, as well as the thickness and subdivision of the Titanotherium beds into three levels. In 1894 his "Note on the geology of northwestern Nebraska" contained the first of his observations on the relations of the Loup Fork and Equus beds, which were continued during a number of years and were brought to a conclusion in his remarkable paper of 1902, entitled "Origin of the Oligocene and Miocene deposits of the Great Plains," in which he strongly combated the lake-basin theory and advocated the theory of flood-plain and eolian deposition.

The first fruits of the Princeton Patagonian Expedition was a short paper entitled "The Cape Fairweather beds," in which he described this new marine horizon overlying the Santa Cruz deposits. These four years of exploration resulted in his entire rearrangement of the Upper Cretaceous and Tertiary rocks of Patagonia, as set forth in his two papers "On the geology of southern Patagonia" (November, 1897) and "Sedimentary rocks of southern Patagonia" (February, 1900). The latter contains his final conclusions and is of very great importance. In this paper (1) he states that the Eocene was a period of depression, in which there was no fresh-water deposition; (2) he removes the entire series of typical Patagonian beds from the Eocene, where it was formerly placed, and refers it to late Oligocene and early Miocene; (3) he states that the Pyrotherium beds, as that term has been used by Doctor Ameghino, include a series of deposits of varying age from Eocene to Pleistocene—deposits of limited area appearing on eroded surfaces of the Guaranitic Cretaceous beds, and thus producing the confusion which has existed regarding the age of the *Pyrotherium* fauna; (4) he states that the Santa Cruz beds immediately and conformably overlie the Patagonian beds.

The following table exhibits Hatcher's views as to the sequence of the various sedimentary rocks of Patagonia and their age as indicated by paleontologic and stratigraphic evidences:

Sedimentary rocks of Patagonia.

Pleistocene.	Shingle formation.
Pliocene.	Cape Fairweather beds.
Miocene.	Santa Cruz beds.
	Patagonian beds.
Oligocene.	Upper lignites.
	Magellanian beds.
Eocene.	*Wanting.*
Cretaceous.	Guaranitic beds.
	Lower lignites.
	Variegated sandstones.
	Upper conglomerates.
	Belgrano beds.
	Lower conglomerates.
	Gio beds.
	Wanting.
Jurassic?	Mayer River shales.

His observations thus included the Mesozoic section as far down as the Jurassic and, with the exception of a few multituberculate teeth in the Guaranitic beds, completely excluded the mammals from the Upper Cretaceous, where they had been placed.

In 1902 Hatcher again began discussing the Upper Cretaceous vertebrate-bearing horizons of North America, and especially the relations of the Judith River and Laramie beds. Already (American Naturalist, February, 1896) he had affirmed that the Judith River beds were certainly older than the Ceratops beds of Converse County, Wyo., and that the dinosaurs from the Judith River belonged to smaller and less specialized forms than those from the latter locality. Osborn, without observing this note, had subsequently reached the same conclusion. In an animated series of notes and papers Hatcher discussed this question, and finally in June, 1903, accompanied Mr. T. W. Stanton, paleontologist of the United States Geological Survey, in a field study of the Judith River beds and associated formations in Montana and southern Assiniboia. They demonstrated that the Judith River beds represent a fresh-water deposit 600 feet in thickness which is intercalated in the true marine beds of Fort Pierre age, which, therefore, both underlie and overlie the Judith River. This conclusion entirely cleared up this vexed question, explained the discrepancies in the notes of different observers, and established the practical synchronism of these beds with the Belly River deposits of British Columbia, as suggested on geological grounds by Dawson and on faunalistic grounds by Osborn and Lambe.

Hatcher's chief contribution to the Jurassic is his admirable paper published in 1901, "The Jurassic dinosaur deposits near Canyon City, Colo.," in which he shows the sequence in the deposition and evolution of the dinosaurian remains found at this point and clearly states the difficulties which arise in our attempts to correlate these strata with the Upper Jurassic or Lower Cretaceous. His concluding paragraph, while not of final value, is so interesting and suggestive that it may be quoted entire:

The difficulty, it seems to me, lies in the want of a realization of the fact that different conditions prevailed simultaneously over different though often adjacent regions and caused the simultaneous deposition of different materials. Along the streams and about the shores of the greater bodies of water deposits of sandstone would predominate, while in the quieter waters, and especially offshore, the finer materials would be thrown down to form the clays and shales of the same series. Wherever we find these shore deposits constituting the Jurassic strata we encounter the same difficulty in separating the Jura from the Dakota, for sedimentation there seems to have been continuous throughout the two periods, and we are brought to the question as to the equivalents at such localities of the Lower Cretaceous. Could not the rocks of these two formations, in part at least, represent the fresh-water and land equivalents of the marine deposits belonging to the Lower Cretaceous? Fresh-water and marine conditions must have always prevailed, as at present, at the same time over different parts of the earth's surface, though thus far there has been little attempt on the part of geologists and paleontologists to correlate them, each series having as a rule been assigned to a distinct period in the time scale, though it is none the less certain that every marine formation has been accompanied by contemporaneous though more constricted fresh-water deposits, and that remnants, at least, of most of such deposits are still preserved can hardly be doubted; indeed, we may be quite positive that every fresh-water or eolian deposit of whatever age has its marine equivalent, and the writer sees no reason why the lower members of the dinosaur beds of Garden Park should not be the equivalents of the marine Baptanodon beds farther north, while the upper dinosaur beds of the same region and the entire series of dinosaur beds farther north would become the equivalents of the marine Lower Cretaceous. That the lowermost dinosaur beds of Garden Park are of an earlier age than those of Como Bluff, in southern Wyoming, and Piedmont, S. Dak., as well as of the other localities lying to the north, will, I think, be clearly demonstrated when we come to make a comparative study of the dinosaur remains from each. From the foregoing remarks it will readily appear that in the Garden Park region the problem of separating the Jura from the Cretaceous becomes a difficult one; the top of the Dakota becomes the natural dividing line, whether considered lithologically or paleontologically, and I have no doubt that these difficulties will be further enhanced by the discovery of dinosaur horizons throughout the entire upper series of sandstones and shales which we now consider as belonging to the Dakota. This is almost sure to follow as a reward for a patient and careful search in these beds, and will be most welcome as adding one more link in connecting the long gap which at present exists between Jurassic and Laramie dinosaurs.

2. GEOGRAPHY AND NARRATIVE.

14. Patagonia, November, 1897.
15. The third Princeton expedition to Patagonia, October, 1899.
16. Explorations in Patagonia, November 18, 1899.
19. Some geographic features of southern Patagonia; with a discussion of their origin, February, 1900.
20. The Carnegie Museum paleontological expeditions of 1900, November, 1900.
23. The lake systems of southern Patagonia, March, 1901.
36. Field work in vertebrate paleontology at the Carnegie Museum for 1902, November 7, 1902.
45. Vertebrate paleontology at the Carnegie Museum, October 30, 1903.
48. Narrative and geography: Reports of the Princeton University expeditions to Patagonia, 1903.

The explorations in Patagonia afforded Hatcher an opportunity for exhibiting his rare ability as an explorer, geographer, and field naturalist. He published five papers, culminating in his splendid volume entitled "Narrative and Geography." Many portions of this work, with their combination of observations upon nature in all its aspects, remind one strongly, in philosophical method of treatment and in style of presentation, of Darwin's "Voyage of H. M. S. Beagle." It is impossible to briefly summarize this magnificent work.

His preliminary papers, "Some geographic features of southern Patagonia, with a discussion of their origin," "Explorations in Patagonia," and "Lake systems of Patagonia," the last treating of his discovery of several new lakes, are all covered in more extensive form in the Narrative.

The following extract is from an appreciative notice by W J McGee:

Returning from the trip into the interior, Hatcher, with his companion, made a voyage through the Strait of Magellan and about Tierra del Fuego, in the course of which many new observations were made on the natural history, geology, paleontology, and ethnology of the region. The various routes traversed are indicated on Hatcher's map, through which an idea of the extent of the journeys may be gained. He returned to Princeton in July, 1897.

As indicated by his article, Hatcher's energies were by no means limited to the collection of specimens; indeed, he utilized his opportunities for geographic, geologic, and ethnologic study in a notably successful manner. The geographic results are stated summarily, though with excess of modesty, in the paragraphs prepared for this magazine, while the preliminary results of the geologic and paleontologic researches appear in several articles in the American Journal of Science and the American Geologist.

3. PALEONTOLOGY, COMPARATIVE ANATOMY.

3. A median-horned rhinoceros from the Loup Fork beds of Nebraska, March, 1894.

4. On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska, with note on the geology of the region, March, 1894.

5. Discovery of *Diceratherium*, the two-horned rhinoceros, in the White River beds of South Dakota, May, 1894.

6. On a new species of *Diplacodon*, with a discussion of the relations of that genus to *Telmatotherium*, December, 1895.

7. Discovery in the Oligocene of South Dakota of *Eusmilus*, a genus of saber-toothed cats new to North America, December, 1895.

10. Recent and fossil tapirs, March, 1896.

13. *Diceratherium proavitum*, November, 1897.

17. The mysterious mammal of Patagonia, *Grypotherium domesticum*, by Rudolph Hauthal, Santiago Roth, and Robert Lehmann Nitsche. Review, December 1, 1899.

21. Vertebral formula of *Diplodocus* (Marsh), November 30, 1900.

24. Some new and little known fossil vertebrates, 1901.

25. On the cranial elements and the deciduous and permanent dentitions of *Titanotherium*, 1901.

26. *Sabal rigida;* a new species of palm from the Laramie, 1901.

28. *Diplodocus* Marsh; its osteology, taxonomy, and probable habits, with a restoration of the skeleton, July, 1901.

29. On the structure of the manus in *Brontosaurus*, December 27, 1901.

30. A mounted skeleton of *Titanotherium dispar* Marsh, 1902.

31. Structure of the fore limb and manus of *Brontosaurus*, 1902.

32. The genera and species of the Trachodontidæ (Hadrosauridæ, Claosauridæ) Marsh, 1902.

34. Oligocene Canidæ, September, 1902.

35. Discovery of a musk-ox skull (*Ovibos cavifrons* Leidy) in West Virginia near Steubenville, Ohio, October 31, 1902.

38. A new sauropod dinosaur from the Jurassic of Colorado, February 21, 1903.

41. A new name for the dinosaur *Haplocanthus* Hatcher June, 1904.

42. Discovery of remains of *Astrodon* (*Pleurocœlus*) in the Atlantosaurus beds of Wyoming, June, 1903.

46. Osteology of *Haplocanthosaurus*, with description of a new species and remarks on the probable habits of the Sauropoda and the age and origin of the Atlantosaurus beds, November, 1903.

47. Additional remarks on *Diplodocus*, 1903.

50. Geology and paleontology of the Judith River beds, by T. W. Stanton and J. B. Hatcher, with a chapter on the fossil plants, by F. H. Knowlton. Bull. U. S. Geol. Survey No. 257, 1905.

51. Two new species of Ceratopsia from the Laramie of Converse County, Wyo., by J. B. Hatcher. [Edited by Richard S. Lull.] 1905.

52. The Ceratopsia, a monograph, by J. B. Hatcher, based on preliminary studies by Othniel Charles Marsh, edited and completed by Richard S. Lull. [Biographical notice by Henry Fairfield Osborn.] Mon. U. S. Geol. Survey, vol. 49, 1907.

In the decade between 1894 and 1904, crowded as it was with administration, with organization of western parties, with his actual labors as a collector, and his two journeys to Patagonia, Hatcher contributed to vertebrate paleontology no less than 25 papers, varying in length from a page to his monograph of 392 manuscript pages on the Ceratopsia. Although he had had little early training as a comparative anatomist, he exhibits the same keen powers of observation as in geology and exceptional ability in selecting new and important characters. This last quality is especially manifested in his work on the rhinoceroses and titanotheres. The form described by Cope and Osborn as *Aphelops* he soon distinguished as *Teleoceras* by its possession of a terminal horn on the nasals. Similarly he was the first to observe rudimentary horns in *Aceratherium tridactylum*, and to determine that this animal was the ancestor of *Diceratherium*, a point which had been overlooked by Osborn. His independence of mind was illustrated in breaking away from the phylogeny and terminology of the Eocene titanotheres as partly established by Earle, Marsh, and Osborn, and founding a new genus *Dolichorhinus*, showing that this genus was not directly ancestral to the titanotheres, as Osborn had supposed, but was a collateral form, and that the true ancestry was to be sought rather in another genus, *Manteoceras*, which he also established, acting upon a suggestion of Wortman.

Very valuable single papers showing his ability as an osteologist are his "Recent and fossil tapirs" (1896), "Cranial elements of *Titanotherium*" (1901), and "A mounted skeleton of *Titanotherium*" (1902). Of much value also are his papers "Some new and little known fossil vertebrates," including his description of *Trigonias* (1901), and his memoir "Oligocene Canidæ" (1902).

By far his most important paleontological contributions, however, were those which enriched our knowledge of dinosaurs, especially of the group of Sauropoda. He took an active part in the restoration of the splendid skeleton of *Diplodocus carnegiei*, which had been collected for the Carnegie Museum. His observations on this genus resulted in a series of similar papers and culminated in his fine memoir "*Diplodocus* Marsh, its osteology, taxonomy, and probable habits, with a restoration of the skeleton." Similarly he made an important addition to our knowledge of *Brontosaurus*, especially as to the structure of the fore limb and manus, correcting some of the observations of Osborn. The chief opportunity which presented itself to him in this group came with the surprising discovery in Canyon City of an entirely new and very primitive type of sauropodous dinosaurs, to which he gave the name *Haplocanthosaurus*. His final studies on this form are included in a second memoir, "Osteology of *Haplocanthosaurus*." This memoir concludes with a very interesting discussion of the probable habits of the Sauropoda, in which Hatcher strongly contended that they were of amphibious life, and a final discussion of the age and origin of the Atlantosaurus beds.

4. ETHNOLOGY.

22. The Indian tribes of southern Patagonia, Tierra del Fuego, and adjoining islands, January, 1901.

Hatcher's observations on the native Indian tribes of southern Patagonia are succinctly summarized in his "Narrative" (pp. 261–275), where he gives valuable photographs of the big and rather amiable Tehuelches, the so-called giant race of Patagonia.

5. SCIENTIFIC CONTRIBUTIONS OF J. B. HATCHER, IN CHRONOLOGICAL ORDER.[a]

1. The Ceratops beds of Converse County, Wyoming. Am. Jour. Sci., 3d ser., vol. 45, Feb., 1893, pp. 135–144.

2. The Titanotherium beds. Am. Naturalist, vol. 27, Mar., 1893, pp. 204–221, figs. 1–3.

3. A median-horned rhinoceros from the Loup Fork beds of Nebraska. Am. Geologist, vol. 13, Mar., 1894, pp. 149, 150.

4. On a small collection of vertebrate fossils from the Loup Fork beds of northwestern Nebraska, with note on the geology of the region. Am. Naturalist, vol. 28, Mar, 1894, pp. 236–248, figs. 1, 2, pls. i, ii.

5. Discovery of *Diceratherium*, the two-horned rhinoceros, in the White River beds of South Dakota. Am. Geologist, vol. 13, May, 1894, pp. 360, 361.

6. On a new species of *Diplacodon*, with a discussion of the relations of that genus to *Telmatotherium*. Am. Naturalist, vol. 29, Dec., 1895, pp. 1084–1090, figs. 1, 2, pls. xxxviii, xxxix.

7. Discovery, in the Oligocene of South Dakota, of *Eusmilus*, a genus of saber-toothed cats new to North America. Ibid., pp. 1091–1093, pl. xl.

8. Some localities for Laramie mammals and horned dinosaurs. Ibid., vol. 30, Feb., 1896, pp. 112–120, pl. iii.

9. The Princeton scientific expedition of 1895. Princeton Coll. Bull., vol. 8, pp. 95–98.

10. Recent and fossil tapirs. Am. Jour. Sci., 4th ser., vol. 1, Mar., 1896, pp. 161–180, figs. 1, 2, pls. ii–v.

11. The Cape Fairweather beds; a new marine Tertiary horizon in southern Patagonia. Ibid., vol. 4, Sept., 1897, pp. 246–248, 1 fig.

12. On the geology of southern Patagonia. Ibid., Nov., 1897, pp. 327–354, figs. 1–11, and sketch map.

13. *Diceratherium proavitum*. Am. Geologist, vol. 20, Nov., 1897, pp. 313–316, pl. xix.

14. Patagonia. Nat. Geog. Mag., vol. 8, Nov., 1897, pp. 305–319, 2 figs. and map, pls. 35–37.

15. The third Princeton expedition to Patagonia. Science, new ser., vol. 10, Oct. 20, 1899, pp. 580, 581. (Unsigned article.)

16. Explorations in Patagonia. Sci. Am., vol. 81, Nov. 18, 1899, pp. 328, 329, 9 figs.

17. The mysterious mammal of Patagonia, *Grypotherium domesticum*, by Rudolph Hauthal, Santiago Roth, and Robert Lehmann Nitsche. (Revista del Museo de La Plata, vol. 9, pp. 409–474.) Review. Science, new ser., vol. 10, Dec. 1, 1899, pp. 814, 815.

18. Sedimentary rocks of southern Patagonia. Am. Jour. Sci., 4th ser., vol. 9, Feb., 1900, pp. 85–108, pl. i.

19. Some geographic features of southern Patagonia; with a discussion of their origin. Nat. Geog. Mag., vol. 11, Feb., 1900, pp. 41–55, 3 figs., pl. 2.

20. The Carnegie Museum paleontological expeditions of 1900. Science, new ser., vol. 12, Nov. 9, 1900, pp. 718–720.

21. Vertebral formula of *Diplodocus* (Marsh). Ibid., Nov. 30, 1900, pp. 828–830.

22. The Indian tribes of southern Patagonia, Tierra del Fuego, and adjoining islands. Nat. Geog. Mag., vol. 12, Jan., 1901, pp. 12–22, 4 figs.

23. The lake systems of southern Patagonia. Bull. Geog. Soc., Phila., vol. 2, pp. 139–145, map; and Am. Geologist, vol. 27, Mar., 1901, pp. 167–173, pl. xvi.

24. Some new and little known fossil vertebrates. Ann. Carnegie Mus., vol. 1, 1901, pp. 128–144, fig. 1, pls. i–iv.

25. On the cranial elements and the deciduous and permanent dentitions of *Titanotherium*. Ibid., pp. 256–262, fig. 1, pls. vii, viii.

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[a] This bibliography is based on one prepared by Hatcher's brother-in-law, O. A. Peterson.

26. *Sabal rigida;* a new species of palm from the Laramie. Ibid., pp. 263, 264, fig. 1.

27. The Jurassic dinosaur deposits near Canyon City, Colorado. Ibid., pp. 327–341, figs. 1–5.

28. *Diplodocus* Marsh; its osteology, taxonomy, and probable habits, with a restoration of the skeleton. Mem. Carnegie Mus., vol. 1, July, 1901, pp. 1–63, figs. 1–24, pls. i–xiii.

29. On the structure of the manus in *Brontosaurus.* Science, new ser., vol. 14, Dec. 27, 1901, pp. 1015–1017.

30. A mounted skeleton of *Titanotherium dispar* Marsh. Ann. Carnegie Mus., vol. 1, 1902, pp. 347–355, pls. xvi–xviii.

31. Structure of the fore limb and manus of *Brontosaurus.* Ibid., pp. 356–376, figs. 1–14, pls. xix, xx.

32. The genera and species of the Trachodontidæ (Hadrosauridæ, Claosauridæ) Marsh. Ibid., pp. 377–386.

33. Origin of the Oligocene and Miocene deposits of the Great Plains. Proc. Am. Philos. Soc., vol. 41, 1902, pp. 113–131.

34. Oligocene Canidæ. Mem. Carnegie Mus., vol. 1, Sept., 1902, pp. 65–108, figs. 1–7, pls. xiv–xx.

35. Discovery of a musk-ox skull (*Ovibos cavifrons* Leidy) in West Virginia, near Steubenville, Ohio. Science, new ser., vol. 16, Oct. 31, 1902, pp. 707–709, 1 text fig.

36. Field work in vertebrate paleontology at the Carnegie Museum for 1902. Ibid., p. 752, Nov. 7, 1902.

37. A correction of Professor Osborn's note entitled "New vertebrates of the mid-Cretaceous." Ibid., Nov. 21, 1902, pp. 831, 832.

38. A new sauropod dinosaur from the Jurassic of Colorado. Proc. Biol. Soc. Washington, vol. 16, Feb. 21, 1903, pp. 1, 2.

39. The Judith River beds. Science, new ser., vol. 17, Mar. 20, 1903, pp. 471, 472.

40. L' âge des formations sédimentaires de Patagonie, by Florentino Ameghino. (Anales Soc. Cientif. Argentina, pp. 3–231, Buenos Aires, 1903.) Criticism. Am. Jour. Sci., 4th ser., vol. 15, June, 1903, pp. 483–486.

41. A new name for the dinosaur *Haplocanthus* Hatcher. Proc. Biol. Soc. Washington, vol. 16, June 25, 1903, p. 100. [*Haplocanthosaurus.*]

42. Discovery of remains of *Astrodon* (*Pleurocœlus*) in the Atlantosaurus beds of Wyoming. Ann. Carnegie Mus., vol. 2, June, 1903, pp. 9–14, figs. 1–6.

43. Relative age of the Lance Creek (Ceratops) beds of Converse County, Wyoming, the Judith River beds of Montana, and the Belly River beds of Canada. Am. Geologist, vol. 31, June, 1903, pp. 369–375.

44. (With T. W. Stanton.) The stratigraphic position of the Judith River beds and their correlation with the Belly River beds. Science, new ser., vol. 18, Aug. 14, 1903, pp. 211, 212.

45. Vertebrate paleontology at the Carnegie Museum. Ibid., Oct. 30, 1903, pp. 569, 570.

46. Osteology of *Haplocanthosaurus,* with description of a new species and remarks on the probable habits of the Sauropoda and the age and origin of the Atlantosaurus beds. Mem. Carnegie Mus., vol. 2, Nov., 1903, pp. 1–72, figs. 1–28, pls. i–v.

47. Additional remarks on *Diplodocus.* Ibid., pp. 72–75, figs. 1, 2, pl. vi.

48. Narrative and geography. Reports of the Princeton University Expeditions to Patagonia, 1896–1899, vol. 1, 1903, pp. xvi+314, plates and map.

49. An attempt to correlate the marine with the nonmarine formations of the Middle West. Proc. Am. Philos. Soc., vol. 43, No. 178, p. 341.

50. Geology and paleontology of the Judith River beds. By T. W. Stanton and J. B. Hatcher. With a chapter on the fossil plants by F. H. Knowlton. Bull. U. S. Geol. Survey No. 257, 1905.

51. Two new species of Ceratopsia from the Laramie of Converse County, Wyoming, by J. B. Hatcher. [Edited by R. S. Lull.] Am. Jour. Sci., 4th ser., vol. 20, Dec., 1905, pp. 413–419, pls. xii–xiii.

52. The Ceratopsia, a monograph. By J. B. Hatcher. Based on preliminary studies by Professor Othniel Charles Marsh. Edited and completed by Richard S. Lull. [Biographical notice by Henry Fairfield Osborn.] Mon. U. S. Geol. Survey, vol. 49, 1907.

EDITOR'S PREFACE.

Mr. Hatcher was within a few weeks of completing the manuscript of this monograph when his hand was arrested by death. The typewritten manuscript, when placed in the editor's hands, was found to end abruptly in the middle of a sentence in the course of the description of *Triceratops* (*Sterrholophus*) *flabellatus* (p. 147). Diligent search brought to light some more pencil manuscript in Hatcher's hand, carrying the work through the systematic part as far as page 157 of this monograph. This portion, referring to the genera *Diceratops*, *Torosaurus*, and *Nodosaurus*, did not, as a consequence, have the advantage of the author's final revision.

Part II (pp. 159–198) has been prepared by the editor, the labor being increased by the preliminary necessity of mastering Hatcher's ideas and conclusions so far as known. This portion has been actually compiled, whenever possible, from the author's published or written opinions, the editor's purpose being to make the monograph, in so far as possible, Hatcher's own.

In the preparation of the geological portion the joint writings of Hatcher and Stanton, of Stanton and Knowlton, and of L. M. Lambe have been largely used, while in Part II many of the editor's own ideas and conclusions were, perforce, added where Hatcher's views could not be learned from any of his writings.

The author makes frequent reference to a chapter devoted to the revision of the genera and species. This chapter (represented by the generic and specific summary in Part II), so important from the systematic and nomenclatural standpoint, he unfortunately did not write, and the difficult duty of preparing it has devolved upon the editor.

The text figures were virtually completed under the author's supervision, only 12 having been added by the editor. The plates were less complete, however, as several, showing the comparative anatomy, had not been prepared. These have been drawn by Mrs. Lull and, it is hoped, are in accordance with Mr. Hatcher's general plan. The lettering on all the plates except Pls. XVIII–XXV and XLVI was inserted under the direction of the editor.

It should be understood that Hatcher by no means exhausted the possibilities of the subject, a fact which no one appreciated more fully than he. Much remains to be learned concerning material already in the museums but as yet only partially prepared. The need of further exploration and collection in the Judith River beds and their geological equivalent, the Belly River of Canada, where the earliest known Ceratopsia are found, is urgent if we would have an adequate understanding of the group.

The editor has been aided in his undertaking by Professor Schuchert, of Yale University Museum, by Mr. L. M. Lambe, of the Canadian Geological Survey, by Dr. W. D. Matthew, of the American Museum, and by the authorities of the National Museum in Washington. To Prof. Henry Fairfield Osborn especial gratitude is due for his expression of trust in placing so important a task in the editor's hands and for his material aid in the loan of specimens and in the final revision of the manuscript.

RICHARD S. LULL.

PALEONTOLOGICAL LABORATORY, YALE UNIVERSITY MUSEUM,

July, 1906.

AUTHOR'S PREFACE.

When, at the request of Prof. H. F. Osborn, who succeeded the late Prof. O. C. Marsh as chief of the division of vertebrate paleontology of the United States Geological Survey, I undertook to complete Professor Marsh's unfinished volume on the Ceratopsia, it was understood that the work would be attended with certain difficulties that probably would not have presented themselves had Professor Marsh lived to complete the volume himself. The vast collection brought together at New Haven, though in part belonging to the United States Geological Survey, would doubtless, had he lived, have remained intact, for the most part, at least, until such time as he had completed his studies, thus enabling him to study the collection together as a unit instead of separated and divided between two distinct institutions.

Considerable inconvenience has been experienced in the preparation of the present volume by reason of the fact that the material upon which it is based is for the most part scattered in the museums of four different institutions, with none of which the present author is connected, thus necessitating considerable loss of time in travel and rendering it quite impossible to bring together for comparison the types of closely related species. By far the most serious difficulty, however, has been experienced from the lack of sufficient preparation of the large collection of skulls and other material made by the present writer under the direction of the late Professor Marsh, many of which still remain unopened in the original boxes in which they were packed in the field. To render this entire collection fully accessible for purposes of study is a work which of itself would require the services for several years of a considerable force of skilled preparators and would entail an expenditure of both time and money far in excess of that allotted for the preparation of the present volume, which, notwithstanding its title, should be regarded rather as an introduction to the study of the Ceratopsia than as a final report on that interesting group of dinosaurs. It is hoped, however, that in the text and figures not a little new light of interest to the specialist will be thrown on the structure of the Ceratopsia as a group and on the relations of the various genera and species, while at the same time it is believed that those pages relating to the history of the discovery of the Ceratopsia, their probable habits, the conditions under which they lived, the causes which led to their extermination, the causes and conditions of the preservation of their remains, the geology and physiography of the region in which they are found, and the difficulties experienced in collecting such huge fossils, the skulls alone of some of which, when prepared for shipment, having weighed upward of 3 tons, will be of interest to the layman.

Unfortunately only 19 of the lithographic plates planned by the original author for the present volume were completed prior to his death, and, since the Survey has discontinued lithography for illustrations of this character, that uniformity and artistic effect which is shown in the plates of Professor Marsh's other monographs are wanting in the present volume. It is believed, however, that this loss has been at least partially offset by the series of text figures, reproduced from pen-and-ink drawings, which illustrate the text and represent many of the more abstruse anatomical details with possibly greater fidelity than would have resulted from the use of lithographs, where, as too often happens, detail of character is sacrificed for artistic effect.

For aid rendered and for privileges of study in the preparation of the present volume I am indebted to the authorities of various museums. From the late Dr. Charles Emerson Beecher I received every possible aid and opportunity in studying the magnificent collection of Ceratopsia belonging to Yale University. To Dr. George P. Merrill and Mr. Frederick A.

Lucas, of the United States National Museum, I am indebted for many courtesies and for the free use of the large collections of horned dinosaurs belonging to that institution, second only in importance to the collections in the museum of Yale University. To the Canadian Geological Survey I am under obligations for the original drawings and electrotypes used in the illustrations accompanying the memoir by Prof. H. F. Osborn and Mr. L. M. Lambe, entitled "On Vertebrata of the mid-Cretaceous of the Northwest Territory," published as Part II of Volume III of Contributions to Canadian Paleontology of the Canadian Geological Survey. My studies of the collections of the Canadian Survey have been greatly facilitated by Mr. Lambe. To Professor Osborn, of the American Museum of Natural History, New York, I am under obligations for the privilege of studying the collections brought together by the late Professor Cope, which, notwithstanding their fragmentary nature, are of much interest in that they contain a number of types, pertaining more especially to earlier and more primitive forms collected by Professor Cope and his assistants in the Judith River beds of northern Montana.

To the patience and skill of Mr. Sydney Prentice is largely due the excellent series of pen-and-ink figures which accompany and illustrate the text and which set forth with clearness and detail most of the more important cranial and other features, the determination of which is made possible by the large and splendid collection of skulls brought together by the late Professor Marsh and now in the museum of Yale University.

I am indebted to Messrs. C. W. Gilmore, Hugh Gibb, T. A. Bostwick, A. W. Vankirk, and Normann Boss for assistance in preparing certain portions of the material in the Yale and National museums for study.

Above all, however, for whatever of merit there is in the present volume science is mainly indebted to that Nestor of American vertebrate paleontology, the late Prof. Othniel Charles Marsh, whose generosity to a large extent made it possible to bring together the collections upon which the volume is based. Nor did his contributions to the subject end here, for, as appears on the title-page, the present memoir is based on his preliminary studies, and although he left no manuscript aside from his published papers on the Ceratopsia he provided a fund of information in the nature of finished and unfinished drawings, as well as symbols and letters on specimens indicating the character and relations of different parts of the skeleton as he had determined them. These have been of the greatest service, and it is a pleasure to accord the fullest acknowledgment therefor.

The more important collections belonging to the Yale University Museum and the United States National Museum, upon which this volume is chiefly based, were for the most part collected by me, and their value was fully recognized and appreciated by Professor Marsh, as will readily appear from an examination of almost any of his publications. Yet I feel impelled by a sense of justice to give recognition also to others who, as companions or assistants, shared with me throughout at least a portion of the four years spent in bringing together this collection the hardships and vicissitudes of camp life, and who are therefore equally deserving of whatever credit may be due for the accomplishment of that portion of the work. Among these I would mention the late Dr. C. E. Beecher, Messrs. O. A. Peterson, W. H. Utterback, A. L. Sullins, and W. H. Burwell as being especially worthy of recognition.

The lithographic plates were executed by the late Mr. E. Crisand from drawings by Mr. Frederick Berger, also deceased. Both of these gentlemen served Professor Marsh for many years, the former as lithographer and the latter as delineator, materially increasing the value of his publications by their skill and patience. The pencil drawings in the plates and text are also by Mr. Berger. Most of the more important of the pen-and-ink drawings in the text and plates are by Mr. Sydney Prentice; a few, however, representing material now in the American Museum of Natural History in New York, are by Mr. Rudolph Weber, the well-known artist of that institution. Wherever drawings have been reproduced from previous publications full credit is given in the text and plates.

As preparators employed upon this material under the direction of Professor Marsh, Messrs. Adam Hermann and Hugh Gibb rendered especially valuable service.

John B. Hatcher.

PART I

MONOGRAPH ON THE CERATOPSIA

AS COMPLETED BY

J. B. HATCHER

INCLUDING THE HISTORY OF DISCOVERY, THE CLASSIFICATION, THE OSTEOLOGY, AND SYSTEMATIC DESCRIPTIONS OF GENERA AND SPECIES

THE CERATOPSIA.

By John Bell Hatcher.

CHAPTER I.

HISTORY OF THE DISCOVERY OF REMAINS OF THE CERATOPSIA.

FIRST DISCOVERY, BY DR. F. V. HAYDEN.

To Dr. F. V. Hayden is due the credit for the first discovery of remains of this group of horned dinosaurs in North America. In 1855 he made a geological reconnaissance of the badland region lying about the mouth of the Judith River, on the upper Missouri, in what is now the State of Montana. Though some of his observations and conclusions relating to the stratigraphy and correlation of the various geological horizons of that region have since been shown to be erroneous, yet, in view of the great difficulties under which he labored and the pioneer nature of his work, we are forced to admire his ability both as an explorer and as an observer and to reckon the results of his expedition, which he completed while he was yet in his twenty-seventh year and during which he penetrated for several hundred miles a practically unknown wilderness, as second to none in geological and paleontological importance. As an example of the hardships and privations which he and others have at various times undergone for the advancement of that branch of natural science in which they were interested I quote the following from Dr. C. A. White's biographical sketch[a] of Doctor Hayden:

> Not having money enough to carry on independently the explorations upon which he had determined, he sought and obtained permission to travel a part of the time with parties of the American Fur Company on their annual trips for trade and hunting in that country. Starting in the spring of 1854, two years were spent by him in toilsome journeys, traveling largely on foot, often sleeping upon the ground where night overtook him, and occasionally eking out his expenses by working for the few traders who were scattered over that region. In this way he traversed the valley of the Missouri River from the western boundary of the then territory of Iowa to Fort Benton, now a principal town of the State of Montana. He also traversed the valley of Yellowstone River from its mouth to the mouth of Bighorn River. In these journeys his sources of supply and protection were the boats of the American Fur Company which were then ascending those rivers. Their slow progress enabled him to spend much of his time ashore, noting geological structure and collecting fossils. Returning from these long, wild journeyings, Doctor Hayden reached St. Louis, Mo., early in 1856, and for a time made his headquarters there.
>
> The geological notes made by Doctor Hayden during those two years of exploration have served as the basis for constructing a section of the formations of that region which remains with only slight changes to this day, and his geological notes served in part as the basis of subsequent explorations under the auspices of the United States War Department. The large collections of fossils which he then made opened to the scientific world a knowledge of extinct faunas such as had never before been known, and the discoveries which he thus inaugurated have been among the most remarkable in the history of biological geology.

During his explorations in the Judith River badlands he made collections of the fossil plants, invertebrates, and vertebrates of the various geological horizons. The vertebrate remains were submitted to Dr. Joseph Leidy for study and description, and were made the basis of a short communication[b] to the Philadelphia Academy of Natural Sciences, presented

[a] Nat. Acad. Sci., Biographical Memoirs, vol. 3, pp. 399–400.

[b] Notices of remains of extinct reptiles and fishes discovered by Dr. F. V. Hayden in the badlands of the Judith River, Nebraska Territory: Proc. Acad. Nat. Sci. Phila., vol. 8, 1856, pp. 72–73.

for publication at the meeting of the society on March 18, 1856. In this paper Doctor Leidy established four new genera and species of dinosaurs from the remains collected by Doctor Hayden and gave brief descriptions, without figures, of each. In the closing paragraph he provisionally correlated the horizon from which the remains had come with the Wealden of Europe.

Three years later[a] Doctor Leidy described this material more fully and accompanied his descriptions with most excellent figures. In figs. 1–20, Pl. 9, of the publication just cited there are shown a number of teeth of various patterns, all of which were referred by Doctor Leidy to *Trachodon mirabilis*. Of all the teeth represented in figs. 1–20, that depicted in figs. 1–3 formed the basis of his original description of the above-mentioned genus and species, as will readily appear from an examination of the text. This tooth may then be fairly considered as the type of *Trachodon mirabilis*, while the double-rooted tooth shown in figs. 18–20, which, as we now know, pertains to a dinosaur belonging to a genus and species distinct from that of which the single-rooted tooth shown in figs. 1–3 was made the type, must be referred not only to a distinct genus and species, but to another family and suborder. Later discoveries have shown beyond a doubt that the tooth delineated in figs. 18–20 pertained to a species of horned dinosaur of the family Ceratopsidæ, a family which is unique among all known reptiles, both living and extinct, in being provided with teeth having forked roots and with a pair of transversely placed supraorbital horns on the skull. It is thus clearly evident that among this meager and fragmentary collection secured by Doctor Hayden there were remains of the horned dinosaurs, or Ceratopsia, though Doctor Leidy failed to distinguish them from the Trachodontidæ, as he might easily do considering the nature of the material at his command. Leidy's figures of the lateral views of these teeth are reproduced here (figs. 1 and 2) for comparison.

FIG. 1.—Lateral view of type of *Trachodon mirabilis* Leidy. Natural size. After Leidy.

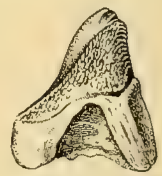

FIG. 2.—Lateral view of tooth of *Monoclonius*, a horned dinosaur discovered by Doctor Hayden. Twice natural size. After Leidy.

DISCOVERY OF TYPE OF AGATHAUMAS SYLVESTRIS BY PROF. F. B. MEEK.

Seventeen years after Doctor Hayden's explorations in the Judith River country, or in 1872, Prof. F. B. Meek discovered a portion of the skeleton of a member of the Ceratopsia near Black Buttes station on the Union Pacific Railroad, not far from the Hallville coal mines, 52 miles east of Green River. The locality was visited the same year by Prof. E. D. Cope, who succeeded in recovering "sixteen vertebræ, including a complete sacrum, caudals, and dorsals, both ilia and other pelvic bones, bones of the limbs, ribs, etc." These were described by Cope[b] and constitute the type of the genus and species *Agathaumas sylvestris*. In his original description he says some limb bones were recovered. In a later publication,[c] however, he says, "There are no bones certainly referable to the limb bones." This material is at present preserved in the collections of the American Museum of Natural History (No. 4000) and consisted originally, according to Cope, of "sixteen vertebræ, including a perfect sacrum, with dorsals and caudals; both ilia and other pelvic bones, those of one side nearly perfect; some bones of the limbs, ribs, and other parts not determined." Of this material there has been accessible to me only the right ilium and a mere fragment of the anterior extremity of the left, one rib nearly complete, and a proximal portion of a second. The sacrum and the dorsals, caudals, and sacro-caudals figured by Cope are also available, although some of the neural arches and spines of the dorsals are missing.

[a] Extinct Vertebrata from the Judith River and Great Lignite formations of Nebraska: Trans. Am. Philos. Soc., 2d ser., vol. 11, 1860, pp. 139–154.

[b] Proc. Am. Philos. Soc., vol. 12, pp. 481–483.

[c] Monographs U. S. Geol. and Geog. Surv. Terr., vol. 2, pp. 55–56.

CERATOPSIA REMAINS DISCOVERED IN COLORADO BY PROF. E. D. COPE.

The next discovery of remains now known to pertain to the Ceratopsia was by Cope.[a] The remains described by him as *Polyonax mortuarius* undoubtedly pertain to a member of the Ceratopsia, and those parts referred provisionally to the ischia are certainly fragments of frontal horn cores of one of the larger members of this group of dinosaurs. This material was discovered by Cope during the summer of 1873 in Colorado (no more definite locality being given) while he was working under the auspices of the United States Geological and Geographical Survey. The remains are now in the American Museum of Natural History, New York, and consist of portions of horn cores and limb bones in an extremely fragmentary condition.

DISCOVERIES BY DR. G. M. DAWSON IN CANADA.

It is also quite possible that some of the dinosaurian remains collected by Dr. G. M. Dawson on Milk River, British America, in the early seventies of the past century, pertained to the Ceratopsia, notwithstanding that all of these remains were referred by Cope to *Hadrosaurus*.[b] A figure of a caudal vertebra from this collection, given by Cope in Pl. VIII, figs. 9, 9*a*, of the volume just cited, appears to pertain to a member of the Trachodontidæ.

EXPLORATIONS IN JUDITH RIVER BEDS BY PROFESSOR COPE.

In 1876 Cope undertook an exploration of the Judith River badlands of the upper Missouri River. On this expedition he was assisted by Messrs. Charles H. Sternberg and John C. Isaac. The expedition was especially successful in securing reptilian remains, including a considerable number of Dinosauria belonging to several new genera and species. Among these were remains of several species of which, on account of the fragmentary condition of the material, Cope was at that time unable to determine the nature, but which are now known to pertain to the Ceratopsia. The first notice of this material appeared in the Proceedings of the Philadelphia Academy of Natural Sciences for 1876,[c] pages 248 to 261, and on pages 255–256 the genus and species *Monoclonius crassus* are briefly described from material belonging partly to the Trachodontidæ and partly to the Ceratopsidæ. From the description given by Cope it is evident that the skeletal material pertains to the Ceratopsia, while the teeth are those of *Trachodon*. Of the skull only the parietals are mentioned, and they are described as the episternum.

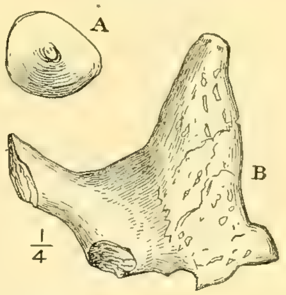

FIG. 3.—Postfrontal, with supra-orbital horn core, of *Monoclonius recurvicornis*. Figured but unidentified by Cope in 1877. A, Superior view; B, lateral view. One-fourth natural size. After Cope.

The following year, 1877,[d] Cope described and figured the supra-orbital horn core and occipital region shown here respectively in figs. 3 and 4. Although Cope was at that time unable to determine the homology of the part shown here in fig. 3 or to refer either bone with certainty to any known dinosaur, we now know that they both pertain to *Monoclonius* or a closely allied genus. They likewise were from the Judith River beds and were found by Professor Cope in 1876 associated with other bones on the north side of the Missouri River, opposite the mouth of Dog Creek.

Thirteen years later,[e] after Professor Marsh had made known the principal characters of the skull in these dinosaurs from the abundant material collected by me in Wyoming and Montana, Cope was able to determine with accuracy the nature of his material, and he then briefly described three additional species from his Judith River collections and referred them to the genus *Monoclonius*. These were *M. recurvicornis*, *M. sphenocerus*, and *M. fissus*. Figures of

[a] Report on the vertebrate paleontology of Colorado: Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873 (pub. 1875), pp. 429–533.
[b] Cretaceous Vertebrata: Rept. U. S. Geol. and Geog. Surv. Terr., vol. 2, 1875, p. 56.
[c] Descriptions of some vertebrate remains from the Fort Union beds of Montana: Proc. Acad. Nat. Sci. Phila., 1876, pp. 248–261.
[d] Report on the geology of the region of the Judith River, Montana, and on vertebrate fossils obtained on or near the Missouri River: Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, pp. 565–597, pls. 30–34.
[e] The horned Dinosauria of the Laramie: Am. Naturalist, 1889, pp. 715–717.

portions of the skulls of the first two of these species were given, and also a figure of the parietal of *M. crassus,* which had previously been described by Cope first as an episternal and later figured and described by him as a sternal.[a]

REMAINS OF CERATOPSIA DISCOVERED BY CANNON, ELDRIDGE, AND CROSS.

In 1887[b] Marsh described and figured a pair of horn cores discovered by Mr. George L. Cannon in the light-colored sandstones of the Denver beds on Green Mountain Creek, near Denver, Colo. These remains were at first referred by Professor Marsh to the bisons and described under the name of *Bison alticornis,* and on this evidence alone the deposits were determined by him to be more recent than the Equus beds (now universally considered Pleistocene), and probably late Pliocene. It is now well known that Professor Marsh erred in referring these remains to the bisons, and that they are in reality the supraorbital horn cores of one of the larger Ceratopsia. Nor is Professor Marsh's error to be wondered at, but on the other hand it is quite excusable, since at that time nothing was known regarding the structure of the skulls of these strange dinosaurs, and in size, surface markings, and form these horn cores more nearly resembled those of certain extinct bisons than of any other known animals, while the very imperfectly petrified nature of the remains might very readily be taken as indicative of the Pliocene or Pleistocene age of the deposits. Indeed, this mistaken identification is a striking example to show how occasionally one may the more readily be led into error through a complete familiarity with his subject, for all that was then known of comparative osteology, as well as the superficial structure and general character of the remains indicated that these horn cores pertained to a very large extinct bison. Had the remains fallen into the hands of any other vertebrate paleontologist probably the same error would have been made, for prior to the discovery of the complete skulls, which occurred a few years later, nothing short of a microscopical examination of the minute structure would have revealed their reptilian nature. Through the later discovery of more perfect material Professor Marsh was able, about two years later, to determine the true nature of these remains, and in 1889[c] provisionally referred them to the horned dinosaurs under the name *Ceratops alticornis.*

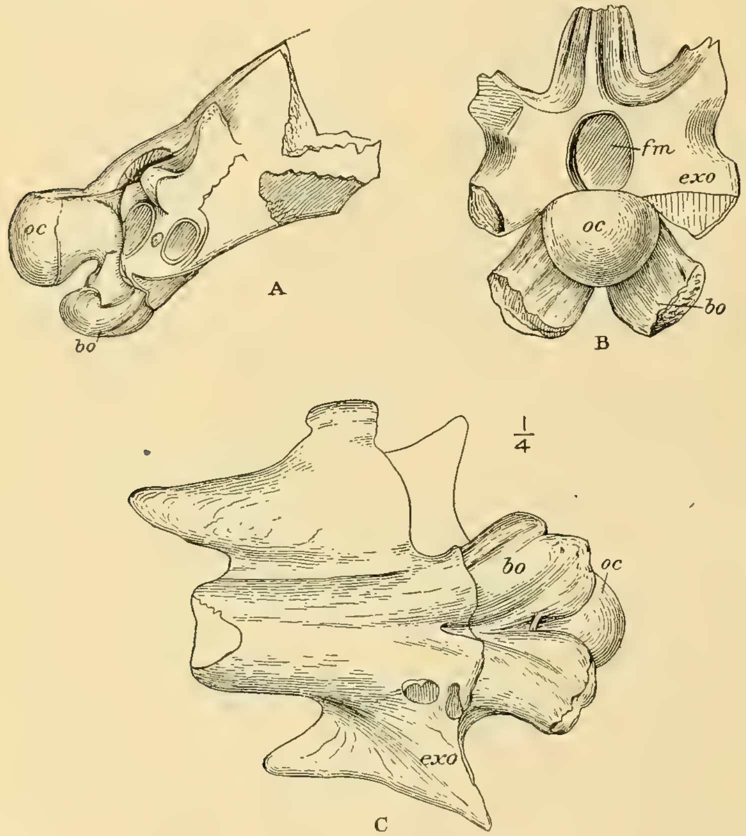

FIG. 4.—Occipital region of *Monoclonius recurvicornis.* Figured but not identified by Cope in 1877. A, Right lateral aspect; B, posterior aspect; C, inferior aspect. *oc,* Occipital condyle; *exo,* exoccipital; *bo,* basioccipital; *fm,* foramen magnum. One-fourth natural size. After Cope.

[a] The sternum of the Dinosauria: Am. Naturalist, 1886, pp. 153–155.

[b] Notice of new fossil mammals: Am. Jour. Sci., 3d ser., vol. 34, October, 1887, pp. 323–324.

[c] Notice of gigantic horned Dinosauria from the Cretaceous: Am. Jour. Sci., 3d ser., vol. 37, August, 1889, pp. 173–175.

For two or three years after the discovery of the type of *Ceratops alticornis* Messrs. George L. Cannon, George H. Eldridge, and Whitman Cross continued to find fragmentary remains of horned dinosaurs in the Denver and Arapahoe (?) beds in the vicinity of Denver, especially on and about the slopes of Green Mountain, an elevation rising about 1,000 feet above the plains, just without the foothills of the main eastern range of the mountains, about midway between Golden and Morrison and just west of the city of Denver. None of these remains were sufficiently complete to permit a determination of even the more important characters of these dinosaurs, and their true nature still remained unknown.

DISCOVERY OF WELL-PRESERVED REMAINS OF CERATOPSIA IN CONVERSE COUNTY, WYO.

In the summer of 1888, under the direction of Prof. O. C. Marsh, I undertook an expedition for the purpose of collecting vertebrate fossils in the Judith River badlands of the upper Missouri River, a locality already rendered classic by the researches of Hayden, Leidy, and Cope. While this expedition was not especially successful, 14 boxes (about a ton) of rather fragmentary material was procured, including the skull fragments figured by Marsh and made the type of the new genus and species *Ceratops montanus*,[a] for which a new family, Ceratopsidæ, was at the same time proposed. Notwithstanding their fragmentary nature the remains demonstrated the presence of horned dinosaurs in these deposits, a fact which had previously been suspected by Cope.[b] At the same time they threw much new light on the affinities of the material previously collected by Hayden, Cope, Cannon, and others.

After passing some two months in the Judith River badlands with very indifferent success, in the early autumn of the same year (1888), at the instance of Professor Marsh, I proceeded to southern Wyoming to investigate the remains of a fossil vertebrate discovered by Mr. Louis Lamotte, just south of the Seminole Mountains, on the west side of the North Platte River, about 1 mile from that stream and 40 miles below Fort Steele. These remains proved to belong to the Ceratopsidæ, although this was not then suspected by me. There were present parts of the skull, vertebræ, ribs, and other portions of the skeleton, all in such a fragmentary and decomposed condition as to render their determination impossible, in the light of what was then known of these dinosaurs.

After spending some time in this vicinity in a fruitless search for more perfect remains, I decided to abandon this locality and proceed to the White River badlands, lying east of the Black Hills in South Dakota, and pass the remainder of the season in making still further collections of the fossil mammalia so abundant in that classic locality. While en route I stopped at Douglas, Wyoming, and there met a former acquaintance, Mr. Deforest Richards, afterwards governor of Wyoming, now deceased, who introduced me to Mr. Charles A. Guernsey. This gentleman, having a general but enthusiastic interest in matters relating to natural history, and especially to geology and paleontology, had, through a long residence in the country as manager and owner of the "Three-Nine" cattle ranch, succeeded in bringing together a considerable collection of fossils. On inspecting this collection, through the kindness and at the request of Mr. Guernsey, I was impressed with its value, for it contained many specimens of great perfection and beauty, and only a glance was needed to show that the entire lot had been brought together with great judgment and discrimination, such as are rarely seen in amateurs and such as might with profit be emulated even in some of our public museums, especially in their exhibition series.

Among the many interesting things in this collection I was at once struck with the fragment of a very large horn core. This fragment was about 18 inches long and perhaps 8 inches in least diameter at the base, which was hollow, the cavity being filled with a hard, brown sandstone closely resembling the sandstone concretions that are so abundant in the Laramie. On inquiry Mr. Guernsey informed me that the specimen had been taken from a skull several feet in length which had been found by his ranch foreman, Mr. Edmund B. Wilson, completely

[a] A new family of horned Dinosauria, from the Cretaceous: Am. Jour. Sci., 3d ser., vol. 36, December, 1889, pp. 477–478.
[b] See Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, p. 592.

embedded in a hard sandstone concretion, weighing not less than 2,000 pounds, that lay in the bottom of a deep canyon about 35 miles north of Lusk, Wyo. Observing my interest in the specimen, Mr. Guernsey very kindly assured me that if I wished to see the skull he would at some future time conduct me to the locality, from the immediate fulfillment of which favor he was then prohibited by pressing business engagements.

Having completed my season's work in the White River badlands, I returned to New Haven on January 3, 1889. In the meantime I had written Professor Marsh several letters concerning this peculiar horn core and he had published, in December, 1888, his description of *Ceratops montanus*, from the material which I had collected in the early part of the season in Montana and which for the first time demonstrated the presence of horned dinosaurs in the Judith River beds. This, together with the fact that Cannon, Eldridge, and Cross had already recovered undoubted dinosaur remains from the Denver beds, where the type of *Bison alticornis* had been found in situ, caused Professor Marsh to doubt the mammalian nature of the pair of horn cores which constituted the type of the latter and of which I had as yet only seen figures. When I examined these horn cores, soon after my arrival in New Haven, I at once recognized the striking similarity between them and the horn core in the collection of Mr. Guernsey. I also expressed an opinion that the latter could have come only from Upper Cretaceous beds. I immediately wrote Mr. Guernsey requesting him to send on his specimens for further examination and comparison. He very kindly and promptly complied with this request, and on its arrival in New Haven Professor Marsh at once recognized the remarkable similarity between the two specimens, and, after his characteristic nature, became immediately possessed with a burning desire to secure the skull and learn the exact geological horizon from which it came. Accordingly, on February 20, 1889, I left New Haven for Lusk, Wyoming, and although long delayed by inclement weather, the season being midwinter, succeeded in securing the remainder of the skull, our party having been conducted to the exact locality by Mr. Wilson, the original discoverer of the specimen. The skull was found embedded in a large sandstone concretion at the bottom of a deep canyon, exactly as had been described by Mr. Guernsey.

The incidents connected with the procurement of this skull are here thus fully related for the twofold purpose of giving full credit to all concerned and of illustrating the manner in which one of the most important localities for vertebrate fossils was made known, for it was in this immediate vicinity, in Converse County, Wyoming, that the remarkable collection of Ceratopsia and the scarcely less remarkable collection of remains of other reptiles, as well as several thousand isolated jaws and teeth of diminutive mammals, were procured by me and my assistants, Messrs. Peterson, Utterback, and Sullins, during the years 1889–1892, while working in the interests of the United States Geological Survey and under the direction of Prof. O. C. Marsh. As the work of exploration in this newly discovered locality progressed the exact nature of this remarkable group of dinosaurs was rapidly brought to light and the real affinities of those remains, which had for a long time proved so puzzling to both Cope and Marsh, became apparent. The supposed ischia of *Polyonax mortuarius*, described and figured by Cope, were seen to be portions of the supraorbital horn cores, while the element considered by the same author as an episternal of *Monoclonius crassus* proved to be a parietal. The horn cores described by Marsh as pertaining to a bison proved to belong to a dinosaur, and the supposed dermal plates mentioned by him in his description of the type of *Ceratops montanus* became the squamosals of that animal. Nor should these errors in identification be taken as a reflection upon the sagacity of either of these authors, but rather as additional evidence of the remarkable nature of these newly discovered dinosaurs, so different in so many osteological characters from anything hitherto discovered or suspected among representatives of that group. They are, however, striking examples of the many pitfalls that beset the path of the paleontologist when attempting to describe from insufficient or fragmentary material new genera and species—and especially new families—of extinct animals. They are, moreover, striking examples of that axiom so often disregarded in vertebrate paleontology, namely, *that one observed fact is worth any amount of expert opinion.*

Professor Marsh was not slow to recognize the importance of the Converse County locality, and, with the tenacity and enthusiasm that were so characteristic of him, for four years he continued the work in that region, which was carried on for him by me, often under most discouraging circumstances, but which in the end resulted in the accumulation of the splendid collection which forms the basis of the present monograph. This locality has since been visited by collecting parties sent out from the American Museum of Natural History, Princeton, Chicago, and the Kansas State universities, and from the Carnegie Museum. All of these have met with some success.

DISCOVERY OF CERATOPSIA REMAINS IN CANADA BY L. M. LAMBE.

For many years the fresh and brackish water deposits of the Upper Cretaceous on Milk, Red Deer, and Belly rivers in Canada have been known to contain remains of dinosaurs. It was not, however, until after the recent publication by Prof. H. F. Osborn and Mr. L. M. Lambe, based on the material brought together by the latter during the seasons of 1897, 1898, and 1901, through explorations carried on in the interests of the Canadian Geological Survey in the Edmonton and Belly River series of the Red Deer River district, that anything like an adequate knowledge of the nature of these dinosaurs was made known. The publication of this joint memoir by Osborn and Lambe[a] has not only made known a new and highly important locality for the Ceratopsidæ, but has extended their known geographical range and has brought to light a number of new forms.

CERATOPSIA REMAINS DISCOVERED IN THE LARAMIE OF MONTANA.

In 1902 the American Museum party, consisting of Messrs. Barnum Brown and R. S. Lull, discovered a nearly complete skull and other material of one of the larger members of the Ceratopsia in beds belonging to the Laramie on Hell Creek Canyon, 135 miles northwest of Miles City, Mont. The skull was briefly described by Lull.[b]

[a] On Vertebrata of the mid-Cretaceous of the Northwest Territory: Geol. Surv. Canada, Contr. to Can. Pal., vol. 3, pt. 2, 1902, pp. 1–81.
[b] Skull of *Triceratops serratus:* Bull. Am. Mus. Nat. Hist., vol. 19, pp. 685–695.

CHAPTER II.

CLASSIFICATION AND REPRESENTATION OF THE CERATOPSIA.

CLASSIFICATION OF THE CERATOPSIA.

CLASS: Reptilia.
SUBCLASS: Dinosauria Owen.
ORDER: Predentata Marsh
SUBORDER: Ceratopsia Marsh.
FAMILY: Ceratopsidæ Marsh (Agathaumidæ Cope).

In the above scheme of classification I have regarded the Dinosauria as deserving the rank of a subclass, as was proposed by Marsh. While the Dinosauria embraces forms which it appears to the present writer are sufficiently diverse in character to entitle the group to be ranked as a subclass,[a] still, on the other hand, there are a number of important characters common to all dinosaurs which would appear to justify the recognition of the Dinosauria as a natural group, although this has been denied by some authorities, and especially by the late Dr. George Baur, who held that the Dinosauria was not a natural group, but that it was composed of three distinct groups having no characters in common and showing no close relationships. These three groups were, according to Baur, the Iguanodontia (=Predentata Marsh), Cetiosauria (=Sauropoda Marsh), and Megalosauria (=Theropoda Marsh).

In the light of our present knowledge concerning the structure of these extinct animals the position taken by Baur does not seem tenable. Without entering upon an extended discussion of the classification of dinosaurs, which would be quite out of place in this connection, it may be well to state briefly just what are the views held by the author of this monograph and to set forth some of the more important reasons therefor.

The following characters, first pointed out by the late Professor Marsh as possessed in common by all dinosaurs, would seem to be of sufficient importance to warrant their being considered as a natural group distinct from all other reptiles. These are:

1. Teeth with distinct roots, either fixed in more or less distinct sockets or in longitudinal grooves, never ankylosed; no palatal teeth.
2. Skull with superior and inferior temporal arches.
3. Double-headed cervical and thoracic ribs.
4. Sacral vertebræ coossified and more numerous than in other reptilia; seldom less than five.
5. Ilium extended in front of acetabulum, in the construction of which latter the ilium, ischium, and pubis take part.
6. Fibula complete.
7. The reduction in number of digits commences with the fifth.

On the other hand, since we find within this group great diversity in form, structure, and habit, some of its members being carnivorous while others are herbivorous, some quadrupedal and others functionally bipedal, some unarmored while others are heavily armored, with all the many and diverse anatomical characters shown in their osteology which might reasonably be expected from such diversity of habits, there would seem no good reason why they should not form a subclass of the Reptilia comparable, for example, with the Metatheria among the Mammalia, and divisible into three orders, for each of which several names have been proposed by various authors. Of all these those proposed by Marsh appear the most appropriate. These are:

1. The Theropoda, embracing all the carnivorous dinosaurs.
2. The Sauropoda, embracing all the herbivorous forms in which the predentary is wanting.
3. The Predentata, embracing all the herbivorous forms in which the predentary is present.

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[a] Osborn considers the group a superorder within the subclass Diapsida Osborn.—R. S. L.

In accepting the terms Theropoda and Sauropoda rather than Megalosauria and Opisthocœlia or Cetiosauria, I do so out of regard for the more comprehensive nature of those terms as used by Marsh. The latter terms as used originally by Fitzinger (Megalosauri), 1843, Owen, 1859, and Seeley, 1874, respectively, I consider of subordinal rank only. Predentata of Marsh is preferable to Orthopoda Cope, because it is in no sense coordinate with the latter, but is a much more comprehensive term. Cope's Orthopoda and the Ornithopoda of Marsh (not Huxley) are more nearly synonymous.

The Ceratopsia constitute a well-defined and rather compact group, which falls naturally within the Predentata as that order has been defined by Marsh. It embraces forms which in many respects are the most highly specialized representatives of the Dinosauria yet discovered. Marsh has considered the group as a suborder and defined it as follows:

> Premaxillaries edentulous; teeth with two distinct roots; skull surmounted by massive horn cores; a rostral bone, forming a sharp, cutting beak; expanded parietal crest, with marginal armature; a pineal foramen (?). Vertebræ and limb bones solid; fore limbs large, femur longer than tibia; feet ungulate; locomotion quadruped. Dermal armor.

The above characters may be amended and supplemented as follows: Incipient teeth with single roots, which later become completely divided into two branches by replacing teeth; no true pineal foramen; dermal armor exceedingly imperfect; three [four, R. S. L.][a] anterior cervicals coossified; blade of ilium horizontal; post-pubis much reduced; ulna with well-developed olecranon process; rudimentary fourth trochanter on femur.

There is nothing new or original in the above scheme of classification. It is that used by Marsh in his "Dinosaurs of North America,"[b] and may be taken as representing his latest and most mature views on that subject, with which, in the later years of his life, he was most interested. It is used here in preference to the more recent classifications of other authors, because, in my opinion, it represents more nearly than any of these what is at present *actually known* of the structure and relations of the various groups of the Dinosauria to one another and to the Reptilia in general.

All the Ceratopsia at present known pertain to one family, Ceratopsidæ Marsh (=Agathaumidæ Cope). I accept the family name Ceratopsidæ of Marsh rather than Agathaumidæ of Cope, because the former has priority and the genus *Ceratops*,[c] upon which it was founded, can not be shown to be a synonym of any of Cope's genera.

ALPHABETICAL LIST OF GENERA AND SPECIES.

For convenient reference I give below a complete list, arranged alphabetically, of all the various genera and species that have at different times and by different authors been referred to the Ceratopsia, with a reference to the original descriptions of each and present location of the type.

A. *Agathaumas* Cope. Proc. Am. Philos. Soc., vol. 12, 1872, pp. 481–483.
- 1. *A. sylvestris.* Proc. Am. Philos. Soc., vol. 12, 1872, p. 483. Type No. 4000, American Museum Natural History.
- 2. *A. milo* Cope. Bull. 1, ser. 1, U. S. Geol. and Geog. Surv. Terr., p. 10. Type in American Museum Natural History; not identifiable.

B. *Ceratops* Marsh. Am. Jour. Sci., 3d ser., vol. 36, Dec., 1888, pp. 477–478.
- 3. *C.* (*Bison*) *alticornis* Marsh. Am. Jour. Sci., 3d ser., vol. 34, Oct., 1887, pp. 323–324, and Am. Jour. Sci., 3d ser., vol. 37, Aug., 1889, pp. 174–175. Type No. 1871 E, U. S. National Museum.
- 4. *C. horridus* Marsh. Am. Jour. Sci., vol. 37, Apr., 1889, p. 334.—*Triceratops horridus*, Am. Jour. Sci., vol. 38, Aug., 1889, pp. 173–174. Type No. 1820, Yale Museum.
- 5. *C. montanus* Marsh. Am. Jour. Sci., vol. 36, Dec., 1888, pp. 477–478. Type No. 2411, U. S. National Museum.
- 6. *C.* (*Hadrosaurus*) *paucidens* Marsh. Am. Jour. Sci., vol. 37, Apr., 1889, p. 336, and Am. Jour. Sci., vol. 39, Jan., 1890, p. 83. Type in the U. S. National Museum.

C. *Claorhynchus* Cope. Am. Naturalist, vol. 26, p. 757.
- 7. *C. trihedrus* Cope. Am. Naturalist, vol. 26, pp. 757–758. Type No. 3978, American Museum Natural History.

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[a] See p. 47. [b] See Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 237–244. [c] See p. 100.

D. *Dysganus* Cope. Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, p. 250.

8. *D. encaustus* Cope. Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, pp. 250–251. Type No. 5739, American Museum Natural History.
9. *D. haydenianus* Cope. Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, p. 251. Type No. 5738, American Museum Natural History.
10. *D. bicarinatus* Cope. Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, p. 252. Type No. 3975, American Museum Natural History.
11. *D. peiganus* Cope. Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, p. 252. Type No. 3974, American Museum Natural History.

E. *Manospondylus* Cope. Am. Naturalist, vol. 26, pp. 756–757.

12. *M. gigas* Cope. Am. Naturalist, vol. 26, p. 757. Type No. 3982, American Museum Natural History.

F. *Monoclonius* Cope. Proc. Acad. Nat. Sci. Phila., 1876, pp. 255–256.

13. *M. belli* Lambe. Contr. Canadian Pal., vol. 3, pt. 2, pp. 66–67. Type No. 491, Geol. Surv. Canada.
14. *M. canadensis* Lambe. Contr. Canadian Pal., vol. 3, pt. 2, pp. 63–66. Type No. 1254, Geol. Surv. Canada.
15. *M. crassus* Cope. Proc. Acad. Nat. Sci. Phila., 1876, pp. 255–256. Type Nos. 3998, 3998?, 3998d, 3997, American Museum Natural History.
16. *M. dawsoni* Lambe. Contr. Canadian Pal., vol. 3, pt. 2, pp. 57–63. Type Nos. 1173 and 971, Geol. Surv. Canada.
17. *M. fissus* Cope. Am. Naturalist, vol. 23, 1889, p. 717. Type 3988, American Museum Natural History.
18. *M. recurvicornis* Cope. Am. Naturalist, vol. 23, 1889, p. 716. Type No. 3999, American Museum Natural History.
19. *M. sphenocerus* Cope. Am. Naturalist, vol. 23, 1889, p. 716. Type No. 3989, American Museum Natural History.

G. *Nodosaurus* Marsh. Am. Jour. Sci., Aug., 1889, p. 175.

20. *N. textilis* Marsh. Am. Jour. Sci., Aug., 1889, p. 175. Type No. 1552, Yale Museum.

H. *Polyonax* Cope. Bull. U. S. Geol. and Geog. Surv. Terr., 1874, No. 2, pp. 24–25.

21. *P. mortuarius* Cope. Bull. U. S. Geol. and Geog. Surv. Terr., 1874, No. 2, pp. 24–35. Type No. 3950, American Museum Natural History.

I. *Stegoceras* Lambe. Contr. Canadian Pal., vol. 3, pt. 2, pp. 68–69, 1902.

22. *S. validus* Lambe. Contr. Canadian Pal., vol. 3, pt. 2. Type No. 515, Geol. Surv. Canada.

J. *Sterrholophus* Marsh. Am. Jour. Sci., vol. 41, Apr., 1891, p. 340.

23. *S. flabellatus* Marsh. Am. Jour. Sci., vol. 41, Apr., 1891, p. 340. Type No. 1821, Yale Museum.

K. *Torosaurus* Marsh. Am. Jour. Sci., vol. 42, Sept., 1891, p. 266.

24. *T. gladius* Marsh. Am. Jour. Sci., vol. 42, Sept., 1891, p. 266. Type No. 1831, Yale Museum.
25. *T. latus* Marsh. Am. Jour. Sci., vol. 42, Sept., 1891, p. 266. Type No. 1830, Yale Museum.

L. *Triceratops* Marsh. Am. Jour. Sci., vol. 38, Aug., 1889, p. 173.

26. *T. calicornis* Marsh. Am. Jour. Sci., vol. 6, July, 1898, p. 92. Type No. 4928, U. S. National Museum.
27. *T. elatus* Marsh. Am. Jour. Sci., vol. 42, Sept., 1891, p. 265. Type No. 1201, U. S. National Museum.
28. *T. flabellatus* Marsh. Am. Jour. Sci., vol. 38, Aug., 1889, p. 174; *Sterrholophus flabellatus*, Am. Jour. Sci., vol. 41, Apr., 1891, p. 340. Type No. 1821, Yale Museum.
29. *T. galeus* Marsh. Am. Jour. Sci., vol. 38, Aug., 1889, p. 174. Type No. 2410, U. S. National Museum.
30. *T. horridus* Marsh. Am. Jour. Sci., vol. 38, Aug., 1889, pp. 173–174. Type No. 1820, Yale Museum.
31. *T. obtusus* Marsh. Am. Jour. Sci., vol. 6, July, 1898, p. 92. Type No. 4720, U. S. National Museum.
32. *T. prorsus* Marsh. Am. Jour. Sci., vol. 39, Jan., 1890, p. 82. Type No. 1822, Yale Museum.
33. *T. serratus* Marsh. Am. Jour. Sci., vol. 39, Jan., 1890, pp. 81–82. Type No. 1823, Yale Museum.

SUPPOSED EUROPEAN REPRESENTATIVES OF THE CERATOPSIA.

All of the above enumerated genera and species are from the Cretaceous deposits of the United States, and all genera and species are included that have at any time been referred by any authority to the Ceratopsidæ, although some of these, as will be shown later, pertain to families quite distinct from the Ceratopsidæ, belonging even to different suborders.

In addition to the above mentioned American genera and species several European forms have at various times and by various authorities been regarded as pertaining to the Ceratopsia. These are:

A. *Struthiosaurus* Bunzel. Trans. Imp. Royal Geol. Inst. Vienna, 1871.

1. *S. austriacus* Bunzel. Trans. Imp. Royal Geol. Inst. Vienna, 1871.

B. *Cratæomus* Seeley. Quart. Jour. Geol. Soc. London, vol. 37, 1881, p. 637.

2. *C. lepidophorus* Seeley. Quart. Jour. Geol. Soc. London, vol. 37, 1881, pp. 660-667.
3. *C. pawlowitschii* Seeley. Quart. Jour. Geol. Soc. London, vol. 37, 1881, pp. 642–660.

The above mentioned genera and species are from the Gosau beds (Upper Cretaceous) of Austria. In addition to these, various other dinosaurian remains from Europe and elsewhere have at different times been described by various authors as showing characters indicating possible relationships with the Ceratopsia. Among these may be mentioned, as of special interest, (1) the peculiar horn-like dinosaurian bone from the Wealden of the Isle of Wight, described and figured by Richard Lydekker;[a] (2) a fragmentary bone, also from the Wealden of the Isle of Wight, figured and described by J. E. Lee[b] as pertaining to *Polacanthus*, and reprinted in his "Note Book of a Geologist;" (3) the various spines and dermal ossicles that have at different times been figured and described by various authors, usually as pertaining to *Hylæosaurus*, also from the Wealden.[c] Of these, the last all seem without doubt to pertain to *Hylæosaurus* or other allied genera, the affinities of which are with the Stegosauridæ rather than the Agathaumidæ. The same may be remarked, though with somewhat less emphasis, of the element described by Lee, but from the description and figure of the bone referred to by Lydekker it would appear at first glance that that element might very likely have pertained to a member of the Ceratopsia. From an examination of a cast of the specimen kindly sent me by Dr. A. S. Woodward, of the British Museum, I am convinced, however, that the original represented an ungual phalanx from the first or second digit of a large sauropod dinosaur, in which the proximal end with its articular surface had weathered away in such manner that the softer and more cancellous inner portion, by decaying more rapidly than the denser external wall, produced a cavity slightly resembling that found at the bases of the frontal horn cores in the Ceratopsia. The homologies of these various elements and the position which the different genera to which they have been assigned occupy in relation to the Ceratopsia will be more fully discussed in that portion of this volume relating to the revision of the genera and species.

[a] Quart. Jour. Geol. Soc. London, 1890, pp. 185–186.

[b] Ann. and Mag. Nat. Hist., 1843, p. 5.

[c] See Owen, Foss. Rept. Wealden Form., pt. 4, Tables IV and IX.

CHAPTER III.

OSTEOLOGY OF THE CERATOPSIDÆ.

The following rather detailed description of the osteology of the Ceratopsidæ is for the most part based on the genus *Triceratops*. I have selected this genus, both because its osteology is more completely represented in the collections at my disposal than that of any of the other genera of the group, and because it is, on the whole, less divergent and more fairly representative of the family than most of the other genera. While this description of the osteology will in the main be based on remains pertaining to the genus *Triceratops*, reference will occasionally be made to material pertaining to other genera, more especially where striking and important structural or morphological differences are displayed.

THE SKULL.

All the more important elements of the reptilian skull are present in the Ceratopsia, though in many instances they are so much modified as to bear little resemblance to their homologues in the skull of most other members of the Reptilia.

In the Ceratopsia perhaps more than in any other group of reptiles, fossil or recent, the skull has become greatly modified and specialized in certain directions. The chief specialization has been in the direction of affording increased protection and in the development of more efficient organs for procuring food. Specialization along the former line has resulted in the development of the powerful armature seen in the nasal and frontal horns, the enormous expansion of the parietals and squamosals, and the development of the epijugals and epoccipitals. The development of the predentary and rostral bones doubtless increased the animal's ability to obtain food, while they at the same time served as additional protective organs. The compact nature of the skull as a whole is a striking feature in this group of dinosaurs and contrasts strongly with the loose and open structure so characteristic of the theropod and sauropod dinosaurs and of the skulls of most other reptiles, living and extinct, where the different cranial elements are, for the most part, reduced to more or less slender rods, usually separated by large vacuities and loosely attached to one another, the union between the different elements often being only cartilaginous. The inclosed and compact nature of the skull in the Ceratopsidæ was of the greatest value as a means of protection. It parallels that seen in most mammals and is shown, though in a less perfect condition, in most of the Chelonia, as also in *Pareiasaurus* and the anomodont reptiles.

The more striking features just noticed as being present in the skull are well shown in fig. 5, taken from a photograph of the type of *Triceratops prorsus* mounted in the Yale Museum. The broad, hood-like parietal crest; the powerful supraorbital horn cores laterally placed and projecting forward and upward; the somewhat less powerful median nasal horn, projecting almost directly forward; the formidable cutting beak formed by the opposing rostral and predentary bones, borne respectively by the premaxillaries and dentaries; the large laterally placed orbits and narial orifices and the comparatively small laterotemporal fontanelles are conspicuous and striking features, at once distinguishing the skull of the Ceratopsidæ from that of any other known family of reptiles. Seen from above, the skull appears wedge-shaped with the apex directed anteriorly.

THE CRANIUM.

Although the skull in *Triceratops* and the allied genera is larger than that of any other known land animal, living or extinct, the cranium proper, or brain case, is not unusually large, while the brain itself is remarkably small as compared with the size of the animal as a whole or of the skull alone. Only the bones of the occipital and parietal segments take any considerable part in the formation of the brain case proper, and some of these are excluded. The post-frontals do, however, in some cases form a very small part of the anterior portion of the superior wall of that part of the brain case inclosing the olfactory lobe. The different bones of the cranium proper were the first in the skull of the Ceratopsia to become coossified with one another. It thus happens that the anatomy of this region of the skull is somewhat difficult to interpret in adult specimens. Fortunately there are in the Yale Museum collections skulls of a number of young individuals in which the sutures are still sufficiently distinct to show most of the characters of the different bones of this region. One of the skulls (No. 1821), which

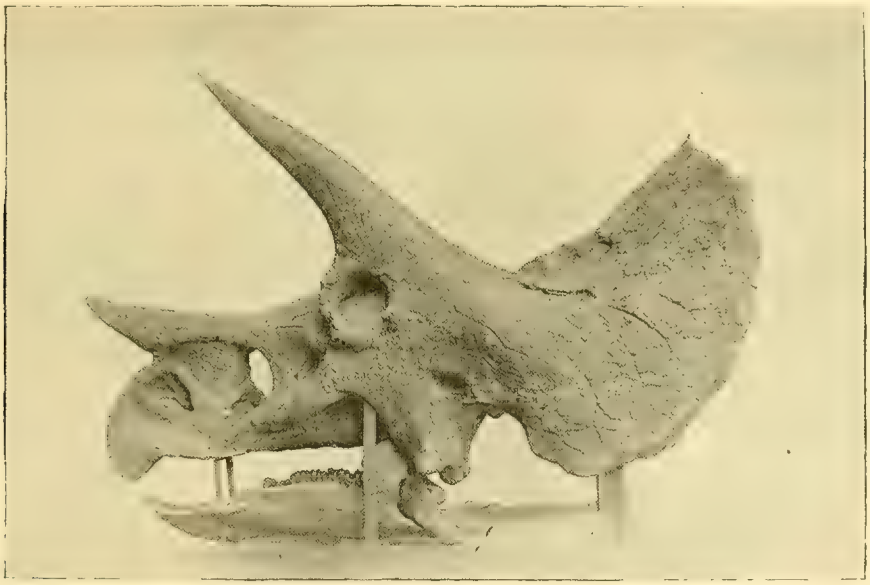

FIG. 5.—Skull of *Triceratops prorsus* (type), No. 1822, Yale Museum, as seen from left side. About one-sixteenth natural size. After Marsh.

was made the type of *Triceratops* (*Sterrholophus*) *flabellatus* by Professor Marsh, is especially valuable in this respect, being essentially a disarticulated skull. Unless otherwise stated in the text, the following description of the skull of *Triceratops* will be based on this specimen.

THE OCCIPITAL SEGMENT.

All the bones of the occipital segment are present, though the supraoccipital is somewhat reduced in size.

In fig. 6 there is shown an oblique posterior view of these bones, with the parietals and squamosals in position as seen from beneath the latter elements.

The basioccipitals coossify early with the exoccipitals and leave no indication of the sutures even in the skulls of comparatively young individuals. This is the case in the type of *T. flabellatus*. In the occipital condyle of a younger individual (No. 1831, Yale Museum) forming the type of *Torosaurus gladius*, however, the sutures are still open and show that the condyle was formed by the union of the basioccipital and exoccipitals. The basioccipital constituted about one-third of the occipital condyle, but formed no part of the border of the foramen magnum. The basioccipital is massive, and the processes are extremely heavy and terminate in broad, rounded, rugose extremities, which have the appearance of articular surfaces, but which in life were doubtless covered with heavy cartilaginous pads. The basioccipital processes are connected distally by a rather thin lamina, and posteriorly there is a deep pit just beneath the occipital condyle. In front they abut against the expanded posterior borders of the processes of the basisphenoid, with which they are united by suture only except in very old individuals, in which they become coossified and the sutures become more or less perfectly obliterated as the age of the animal increases. The basioccipitals are pierced by no foramina.

The exoccipitals are large and massive. They entirely inclose the foramen magnum and expand laterally into greatly elongated processes, which project outward and backward, overlapping the blades of the quadrates and articulating distally with the squamosals by a deep groove on the inferior surface of the latter. The superior border of the distal end of each exoccipital process is expanded and projects into a corresponding notch on the inferior surface of the antero-inferior angle of the parietal. From this notch the suture between the parietals and exoccipitals describes a gentle curve until the supraoccipital is reached, when the superior

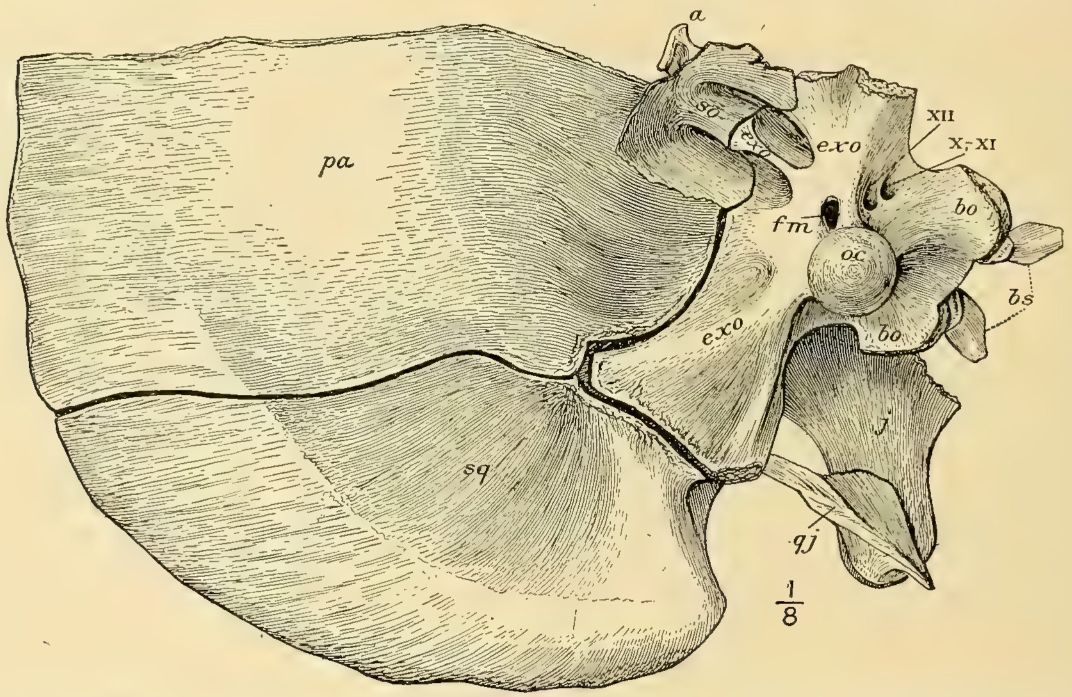

FIG. 6.—Occipital region of *Triceratops flabellatus* Marsh (type), No. 1821, Yale Museum. Inferior view as seen obliquely from behind. *a*, Postfrontal buttress of supraoccipital; *so*, supraoccipital; *pa*, parietal; *sq*, squamosal; *exo*, exoccipital; *fm*, foramen magnum; *oc*, occipital condyle; *bo*, basioccipital; *bs*, basisphenoidal processes; *j*, jugal; *qj*, quadratojugal; X, XI, foramen for exit of tenth and eleventh nerves; XII, foramen for exit of twelfth nerve. One-eighth natural size.

border of the exoccipital is produced into an obtuse angle embraced by the parietal and supraoccipital. The exoccipitals and supraoccipital unite by a nearly horizontal suture. The posterior surface of these bones is deeply excavated, inclosing two deep pockets separated by a thin median partition or keel, which becomes stronger above the supraoccipital suture. On the inferior surface and at the base of the lateral or transverse process of the exoccipital there are two foramina, situated one above the other when the skull is in its normal position. The upper and smaller of these two foramina pierces the exoccipital and enters the foramen magnum just within the external opening of the latter. It doubtless served to transmit the hypoglossal, or twelfth nerve. The more inferior but larger foramen divides, one branch, the posterior, opening into the foramen magnum a little in advance of that for the hypoglossal nerve, probably served for the transmission of the eleventh, or accessory, nerve, while the more anterior branch, which opens into the foramen lacerum posterius, may have served for the passage of the pneumogastric nerve. The sutures between the exoccipitals and alisphenoids evidently were early obliterated. They are not visible in any of the skulls known to me. The foramen lacerum posterius is large, as shown in fig. 8, and is situated at the base of and just anterior to the processes of the basioccipital and exoccipital. It is probable that the basioccipital and exoccipital and the basisphenoid and alisphenoid all took part in inclosing this foramen.

The suture between the supraoccipital and exoccipital remains open until late in life, so that the form and character of the supraoccipital are easily determined. It is proportionally small and composed of two rather thin wing-shaped portions articulating inferiorly on either side with the exoccipitals and alisphenoids. Each of these is produced backward, so as to inclose and overhang the deep cavity already mentioned in describing the exoccipitals, and they unite medially to form the strong superior portion of that keel which divides this cavity vertically into two lateral cavities. Superiorly the supraoccipital sends upward two pillars, one on either side of the median line, to give support to the parietals at their union with the postfrontals, thus contributing to the firm support of the supraorbital horns. In this manner the supraoccipital unites with the widely expanded processes of the exoccipitals in giving support from beneath to the enormous frill-like occipital crest formed by the squamosals and parietals.

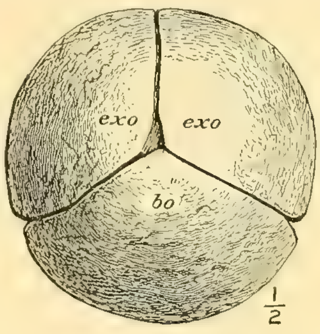

FIG. 7.—Occipital condyle of type of *Torosaurus gladius*, No. 1831, Yale Museum. *bo*, Basioccipital; *exo*, exoccipital. One-half natural size.

The condyle is pedunculate. The peduncle, or neck, is rather short, circular in cross section, and is usually somewhat constricted. The basioccipital and the two exoccipitals enter about equally into its construction, though the former is excluded from the foramen magnum. The articular surface of the condyle has the form of a nearly perfect hemisphere, and indicates considerable freedom of motion, notwithstanding the depth of the cup in the atlas and the enormous posterior projection of the frill. The condyle of the type of *Triceratops prorsus* (No. 1821, Yale Museum) is 91 millimeters in vertical diameter and 102 millimeters in transverse diameter.

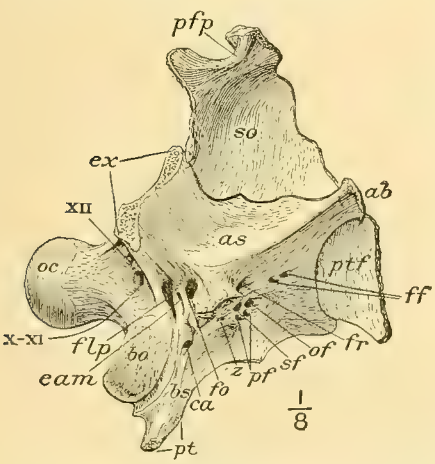

FIG. 8.—Occipital region of skull of *Triceratops flabellatus* (type), No. 1821, Yale Museum, as seen obliquely from beneath, in front. *pfp*, Pillar for support of parietals and postfrontals; *so*, supraoccipital; *ex*, exoccipital process broken away; *as*, alisphenoid; *ab*, alisphenoid buttress for postfrontal; *ptf*, postfrontal; *oc*, occipital condyle; *bo*, basioccipital process; *bs*, basisphenoid; *pt*, surface on basiphenoid process for contact with pterygoid; XII, foramen for twelfth nerve; X-XI, foramen for exit of tenth and eleventh nerves; *flp*, foramen lacerum posterius; *eam*, internal auditory meatus?; *ca*, foramen for carotid artery; *fo*, foramen ovale; *z*, undetermined foramen; *pf*, foramina entering pituitary fossa; *sf*, sphenoidal fissure; *of* optic foramen; *fr*, foramen rotundum; *ff*, small foramina entering brain cavity just back of olfactory lobe. One-eighth natural size.

The foramen magnum is small and somewhat elliptical in outline, the vertical axis being the longer. It has a vertical diameter of 36 millimeters and a transverse diameter of 32 millimeters. The superior border of its exit is somewhat in advance of its inferior, so that it looks upward and backward.

THE SPHENOIDAL SEGMENT.

The basisphenoid is firmly coossified with the alisphenoids. The basisphenoidal processes are produced somewhat beneath the basioccipital processes and present in front at their extremities rugose surfaces for contact with the pterygoids. Anteriorly and superiorly the basisphenoid is compressed, and forms a stout median interorbital septum. The external opening of the middle eustachian canal is situated between and at the base of the basisphenoidal processes, as shown at *mec* in fig. 9 and in Pl. XLVI. It is entirely within the basisphenoid instead of being situated between that bone and the basioccipital, as in the crocodile. Two large foramina, situated one on either side of the skull at the bases of the basisphenoidal processes, pierce the basisphenoid and enter the brain case near the base of the olfactory lobe through a deep fossa, which doubtless lodged the pituitary body. They probably transmitted the carotid arteries. One of these foramina is shown at *ca* in fig 8. Anteriorly the basisphenoidal processes are received into deep pockets on the posterior surfaces of the thin but widely expanded posterior wings of the pterygoids.

The alisphenoids, including also the parasphenoids, with which they are so completely fused, even in young individuals, as to render the latter elements indistinguishable, are extremely irregular in form. They are firmly coossified with one another and with the exoccipitals and the basisphenoid. Together with the latter element they usually form the entire anterior portion of the brain case, save only the extreme anterior portion of the superior border, which in some instances is formed by the anterior projection of the united postfrontals. Supero-posteriorly the alisphenoids articulate with the supraoccipital and supero-anteriorly with the postfrontals. Just beneath the lateral union of the supraoccipital and postfrontals the alisphenoids are developed into a strong lamina or buttress, which gives greater support to this region. Anteriorly the coossified alisphenoids and basisphenoid are embraced by the vomers and the posterior projections of the palatines, as is well shown in fig. 24, from the type of *Triceratops horridus*, No. 1820 of the Yale Museum collections, though not so apparent in the type of *T. flabellatus*, No. 1821 of the same museum, in which these parts are less perfectly preserved. In the type of *T. flabellatus* the olfactory nerves, as shown in fig. 9, leave the brain case by a single large median foramen inclosed entirely by the alisphenoids, while in the type of *T. horridus* this foramen is subdivided by a strong but short median partition of bone, as shown in fig. 27. As will be shown later, however, this difference is probably due to age, and is of no specific or generic importance. In the latter species the alisphenoids are continued forward and form the entire roof of the olfactory lobes, entirely excluding the postfrontals and giving origin to that partition which has just been mentioned as dividing the foramen for the exit of the olfactory nerves into two foramina, conditions well shown in the figure last cited. Near and anterior to the base of the ascending lamina of the alisphenoid two small foramina (*ff*, fig. 8), situated one in advance of the other, pierce the bone and enter the brain cavity just back of the olfactory lobe. At a distance of 38 millimeters behind the more posterior of these two foramina is the anterior opening of the alisphenoid canal, or foramen rotundum. The alisphenoid canal is inclosed externally by a heavy bridge of bone, and is continued posteriorly for 35 millimeters, when it enters the foramen ovale. The latter foramen is large and is separated from the foramen lacerum posterius by a strong bony partition, which is pierced by a small foramen that may possibly represent the external auditory opening. Just beneath the

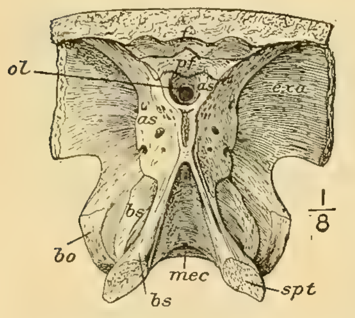

FIG. 9.—Occipital region of type of *Triceratops flabellatus*, No. 1821, Yale Museum, seen obliquely from below. *f*, Frontals; *pf*, postfrontals; *as*, alisphenoids; *exo*, exoccipitals; *bo*, basioccipitals; *bs*, basisphenoids; *spt*, surface for contact with pterygoids; *ol*, exit for olfactory nerve; *mec*, median eustachian canal. One-eighth natural size.

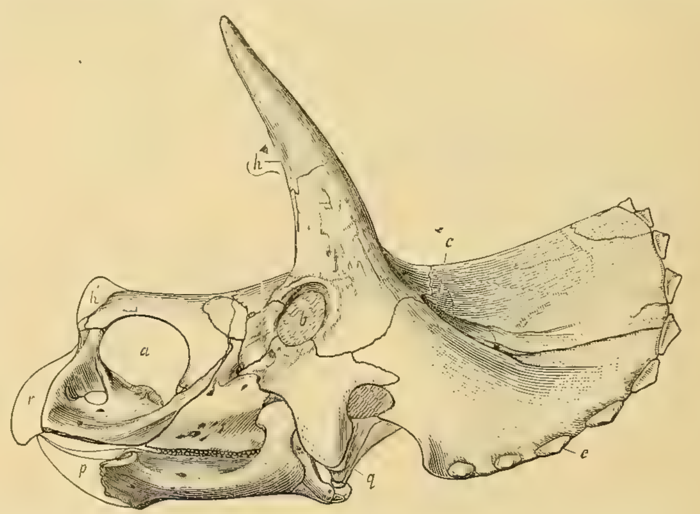

FIG. 10.—Skull of type of *Triceratops flabellatus*, No. 1821, Yale Museum, seen from left side. *h*, Supraorbital horn core; *c*, supratemporal fontanelle; *b*, orbit; *e*, epoccipital; *q*, quadrate and quadratojugal; *a*, anterior nares; *h'*, nasal horn core; *r*, rostral; *p*, predentary. One-twelfth natural size. After Marsh.

anterior opening of the alisphenoid canal there is a rather deep pocket, at the base of which are four foramina. The two larger of these foramina occupy a more elevated position than the two smaller, and are placed one anterior to the other. The anterior and slightly larger of the two is the optic foramen, while the posterior is doubtless homologous with the sphenoidal fissure. The two smaller foramina (*pf*, fig. 8) lead directly into the comparatively deep and elongate pituitary cavity, and their homologies are not definitely known. They may have served to transmit nerves to the large muscles of the orbit. The positions of the various foramina mentioned above are well shown in fig. 8, which represents the right side of the external wall of the brain case with the supraoccipital and postfrontal in position, as seen obliquely from beneath and in front. In so far as I have been able to determine, the position of these foramina is fairly constant in the various genera and species of the Ceratopsidæ.

THE FRILL OR PARIETAL CREST.

The parietals and squamosals are enormously expanded and form a great hood-like frill, which projects far beyond the occipital segment of the skull, entirely inclosing both superiorly and laterally the cervical region. In life the frill doubtless afforded considerable protection to the neck, especially in the genus *Triceratops*, though it could not have been so effective as a protective armor in *Torosaurus*. The specialization which has taken place in the bones of the frill has not been uniform in the different genera and species of the Ceratopsidæ, so that this region of the skull is of the greatest importance in determining genera and species. In *Triceratops* it consisted of a continuous sheet of bone, composed of the closely applied squamosals and parietals. The inferior surface was deeply concave transversely, and the whole projected backward and extended for a distance of nearly or quite a meter behind the occipital condyle, roofing over the entire cervical region above and extending well down on either side. To increase its effectiveness as a protective shield, and perhaps also at the same time to give to it a certain value as an offensive weapon, its external margin or periphery was curved outward and supported a series of elongated, acuminate, triangular ossicles (epoccipitals), which have the appearance of having been covered in life with some hard chitinous substance. When in position, these give to the border of the frill a scalloped or serrated appearance. In the genus *Triceratops* these ossicles are derived from separate centers of ossification and do not ankylose with the squamosals and parietals until late in life. In the type of *T. flabellatus*, which pertained to a young individual, they were for the most part found in position, but free; while in the type of *T. prorsus*, representing an old animal, they are firmly coossified with the squamosals and parietals. They are well shown in figs. 10 and 11, as is also the general form of the frill. In the genera *Monoclonius* and *Torosaurus* there are no epoccipitals, but the margins of the squamosals and parietals each present a series of more or less distinct prominences, giving a serrated appearance to the margin of the frill, similar to that seen in *Triceratops*. In the first-mentioned genera, however, these prominences are not derived from separate centers of ossification, as are the epoccipitals in *Triceratops*, but are present even in young individuals, firmly attached to and forming a part of the squamosals and parietals, as shown in figs. 12 and 13 and in Pls. II and III. The variation in the form and structure of the frill in the various genera and species of the Ceratopsidæ is well shown in Pl. II, where a comparative view of the different types of frill is given.

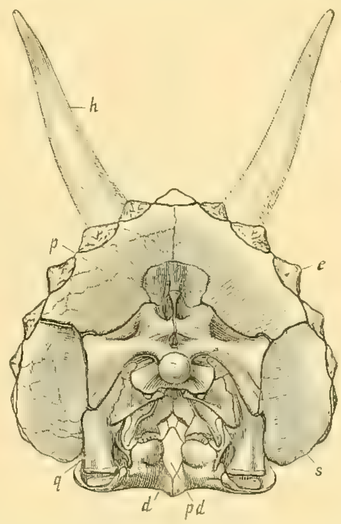

FIG. 11.—Posterior view of skull of *Triceratops flabellatus* (type), No. 1821, Yale Museum. *h*, Supraorbital horn core; *e*, epoccipital; *p*, parietal; *s*, squamosal; *q*, quadrate; *pd*, predentary; *d*, dentary. One-twelfth natural size. After Marsh.

The squamosals vary greatly in form in the different genera and species. In *Triceratops flabellatus* the form of the squamosal is intermediate between that seen in *Ceratops montanus*

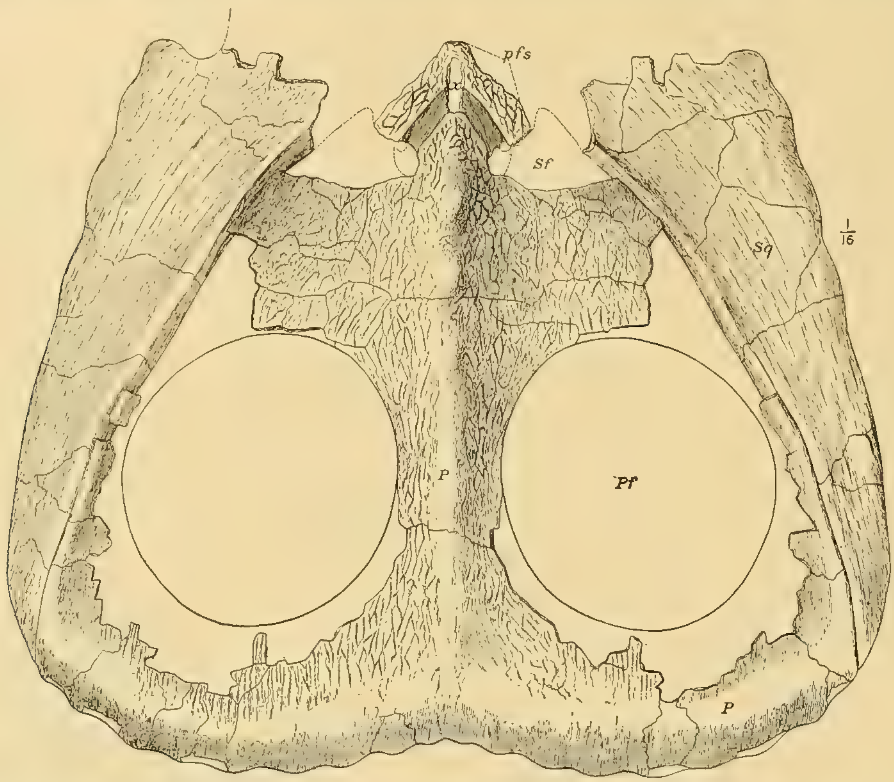

FIG. 12.—Superior view of frill of *Torosaurus gladius* (type), No. 1831, Yale Museum. *p*, Parietal; *sq*, squamosal; *pf*, parietal fontanelle *sf* supratemporal fossa; *pfs*, surface for contact with postfrontal; *x*, foramen analogous to the postfrontal foramen in *Triceratops*. One-sixteenth natural size.

and *Torosaurus latus* or *T. gladius*, as shown in the accompanying figures. It is broad anteriorly and narrows posteriorly. The posterior and inferior border is undulating and supported six small pointed dermal ossicles (epoccipitals), as shown in fig. 10. The external surface for some distance inside this border is very gently concave, but above this it is uniformly convex. The parietal suture is open throughout the entire length of the bone, and the parietal border is heavy. Anteriorly the squamosal is in contact with the quadrate, the exoccipital, the jugal, and the postfrontal, and for a limited extent with the quadratojugal, besides sending a strong process underneath the parietal. It overlaps the external surfaces of all these bones and has a very extended contact, especially with the postfrontal, through which it forms the chief support posteriorly and interiorly to the massive supraorbital horn. On the inner side, near its anterior end, the surface of the squamosal is crossed obliquely by a heavy ridge of bone, presenting anteriorly an abrupt shoulder, against which the distal extremity of the exoccipital process

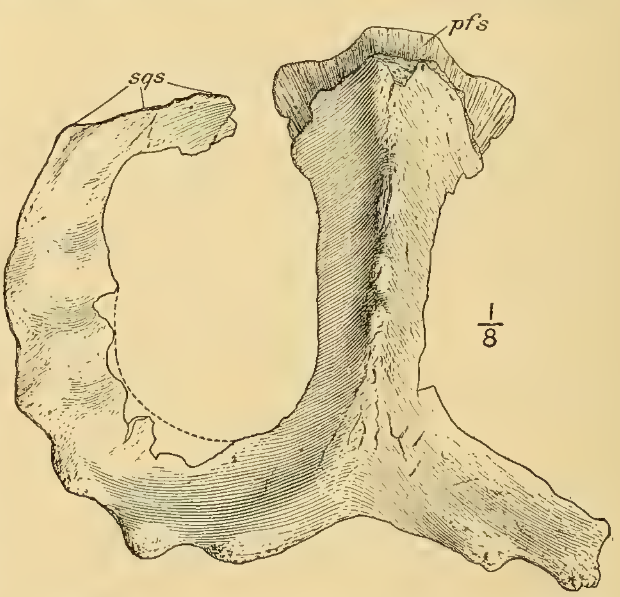

FIG. 13.—Superior view of parietal of type of *Monoclonius crassus*, No. 3998, American Museum of Natural History. *sqs*, Surface for articulation with squamosal; *pfs*, surface for postfrontal. One-eighth natural size.

abuts, while the broad, thin end of the quadrate is wedged in between the exoccipital process and the anterior end of the squamosal and is rather firmly held in a groove on the under surface of the latter. The position occupied by this groove for the quadrate, as well as the form of the squamosal, varies greatly in the different genera and species. On the inferior side of the squamosal, just posterior to the transverse buttress for the exoccipital process, there is a broad, shallow, concave surface, while beyond this the inferior surface of the bone is convex throughout. The line marking the boundary between these convex and concave areas is approximately that which separates the external free portion of the squamosal from the internal portion, which in life was embedded in flesh. The dividing line between these two areas is indicated by a difference in texture and surface markings, that of the external and free area being much more rugose, especially in old individuals, where it was probably covered with a horny substance similar to that which invests the skulls of recent turtles. In the skulls of young individuals like that at present under consideration (No. 1821, Yale Museum), these two surfaces are less distinctly differentiated than in the skulls of older individuals, though still quite apparent, as shown in figs. 6 and 15. Marsh has considered the

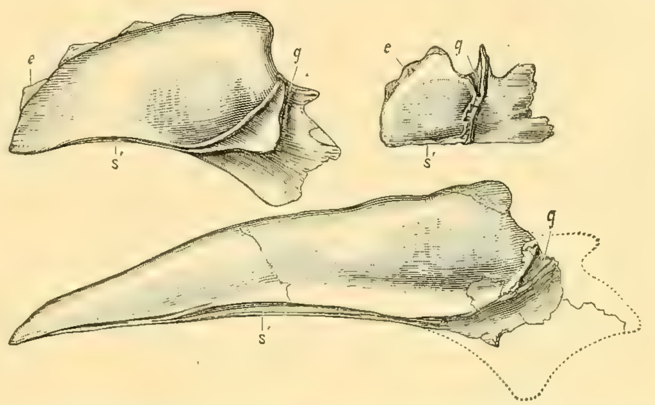

FIG. 14.—1, Right squamosal of *Torosaurus gladius* (type), No. 1831, Yale Museum; inferior view. 2, Right squamosal of *Triceratops flabellatus* (type), No. 1824, Yale Museum; inferior view. 3, Right squamosal of *Ceratops montanus* (cotype), No. 4802, U. S. National Museum; inferior view. *e*, Epoccipital; *s*, parietal surface; *q*, quadrate groove. All one-twentieth natural size. After Marsh.

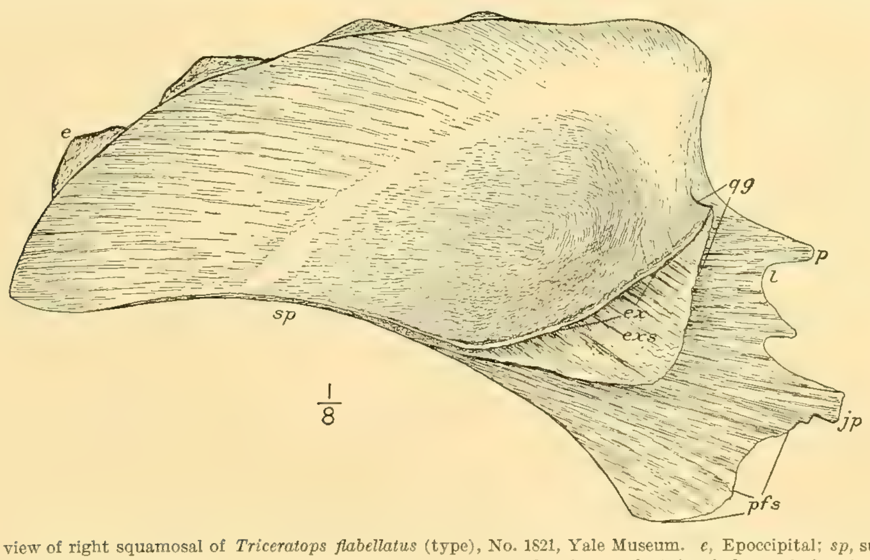

FIG. 15.—Inferior view of right squamosal of *Triceratops flabellatus* (type), No. 1821, Yale Museum. *e*, Epoccipital; *sp*, surface for contact with parietal; *ex*, buttress for exoccipital; *qg*, quadrate groove; *p*, process overlapping quadratojugal; *l*, margin forming posterior border of lateral temporal fossa; *pfs*, postfrontal border; *jp*, process interposed between jugal and postfrontal; *exs*, surface overlapped by exoccipital process. One-eighth natural size.

partial absence of this character as of generic importance, and has made it distinctive of the genus *Sterrholophus*, of which the present specimen was the type. To the present writer it would seem, however, that the difference in the rugosity of the external surface of the squamosal is due rather to a difference in the age of the different individuals, while it may also have been, in part at least, a sexual character. In support of this view it may be mentioned that the rugosities on this surface are less distinct in those specimens where the sutures are less obliterated than in those where they are more perfectly closed, regardless of the genus to which the species may pertain. This is especially noticeable in Nos. 1821 and 1823, Yale Museum, the types, respectively, of *Triceratops* (*Sterrholophus*) *flabellatus* and *Triceratops serratus*, in both of which most of the cranial sutures are still open,indicating that the animal was in each instance comparatively young. The great diversity in size and form displayed by the squamosals in the Ceratopsidæ is well shown in Pl. III.

The parietals, though perhaps separated in extremely young individuals, early became perfectly united, leaving no trace of a suture. They are imperfectly preserved in the type of *Triceratops flabellatus*, but are quite complete in a number of other specimens in the Yale and U. S. National Museum collections, and especially so in the type of *T. serratus*, No. 1823, Yale Museum, as shown in fig. 16 and in Pl. XXVIII. The following description of these elements will be based largely on that skull. Superiorly they are convex laterally and somewhat concave longitudinally, especially along the median line. Together they form about one-half the crest or frill of the skull. Laterally and posteriorly they articulate with the squamosals throughout about two-thirds of their length on the superior surface, when this articulation or contact is interrupted on either side by the large supratemporal foramina or fossæ. On the inferior side or surface the parietals and squamosals are in contact throughout their entire length save at the point where the exoccipital processes are interposed between them, as shown in fig. 6. Anteriorly the parietals are overlapped by the postfrontals and underlapped by the supraoccipitals and exoccipitals. They are much expanded posteriorly but contract rapidly anteriorly. On their superior surface along the median line or crest there is a series of rugose prominences, usually three in number. The posterior border supported seven low pointed epoccipitals, one median and six lateral arranged three on either side. Though there is apparently some variation in the number of these ossicles it hardly seems probable that such variations are of specific importance or that the number was constant in different individuals for any given species. Seven seems also to have been the number present in No. 1822, Yale Museum, the type of *T. prorsus*, though the parietal is not entirely perfect in that specimen and it is therefore impossible to determine the number with certainty.

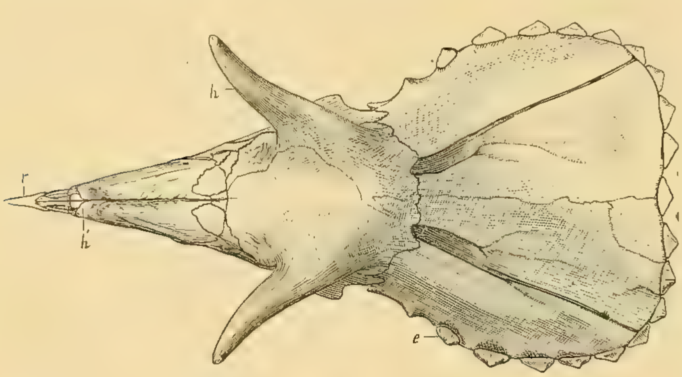

FIG. 16.—Superior view of skull of *Triceratops serratus* (type), No. 1823, Yale Museum. *s*, Squamosal; *p*, parietal; *c*, supratemporal fossa; *e*, epoccipital; *d*, epijugal; *x*, postfrontal foramen; *fp*, postfrontal; *pf*, prefrontal; *f*, frontal; *j*, jugal; *h*, supraorbital horn core; *n*, nasal; *h'*, nasal horn core; *pm*, premaxillary; *r*, rostral. One-twentieth natural size. After Marsh.

THE QUADRATOJUGAL ARCH.

The lower temporal or quadratojugal arch is formed by the jugal, quadratojugal, and quadrate, and these bones are united by suture only even in comparatively old individuals, as shown in fig. 10.

The quadrate, fig. 17, A and B, is triangular in outline. When in position the longer border or base of the triangle is almost parallel with the vertical axis of the skull, though directed somewhat backward and upward. The inferior border is nearly straight and heavy throughout its entire length, and might very appropriately be called the shaft, to distinguish it from the extremely thin angular superior border. The anterior extremity of the quadrate, although much narrower than the posterior, is heavier and presents an elongated and transversely placed articular surface for articulation with the lower jaw. The posterior end of the quadrate is wider but much thinner than the anterior and is overlapped by the squamosal and underlapped by the exoccipital process. On the internal side near the superior border and toward the anterior end of the quadrate there is a deep pocket into which fitted the posterior process of the pterygoid, while the thin posterior blade of the pterygoid overlapped the delicate superior angle of the quadrate when these bones were in position, as shown in fig. 24, from the type of *Triceratops horridus*. The external border of the quadrate anteriorly, throughout half its length, is opposed to the quadratojugal. The latter element sends backward a keeled process, which curves round the inferior border of the thickened shaft of the quadrate and is continued upward and backward along the external surface of that bone, finally coming in contact with and passing beneath a sharp-pointed anterior projection from the squamosal, as is beautifully shown in Pl. XXVII, from the type of *Triceratops serratus*, No. 1823 of the Yale Museum collection. Marsh has stated that the quadratojugal does not articulate with the squamosal in the genus *Ceratops*, and has considered this as a character distinguishing that genus from *Triceratops*, in which genus he states that these two elements are firmly united with one another by sutures. While there is a considerable difference in the character of the union of these elements in these two genera, the union being apparently much stronger in *Ceratops*, it is clear that they do articulate with one another in *Triceratops*.

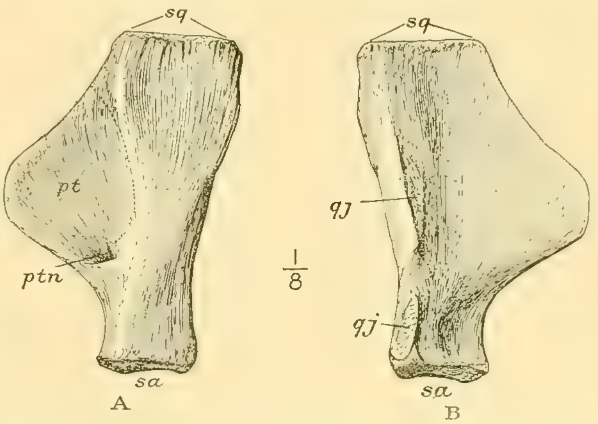

FIG. 17.—A, Internal view of right quadrate of type of *Triceratops flabellatus*, No. 1821, Yale Museum; B, external view of same. *sq*, Surface fitting into quadrate groove of squamosal; *pt*, surface overlapped by pterygoid; *ptn*, notch for process of pterygoid; *sa*, surface for articulation with lower jaw; *qj*, surface for contact with quadratojugal. One-eighth natural size.

The articular surfaces for the lower jaw on the quadrates are in nearly the same vertical plane as the occipital condyle in the Ceratopsia instead of being placed far back as in the crocodile.

The quadratojugal, fig. 18, A and B, is irregularly triangular in outline, very thick medially, but thin about the margins. It is wedged in between the jugal and quadrate and also has, as stated above, a limited contact with the squamosal. The squamosal and quadrate articulations have already been described and need no further mention here. The surface for articulation with the jugal is irregularly elliptical in outline and occupies the anterior half of the external surface of the bone. It bears a number of deep grooves and intervening ridges, which correspond to similar inequalities on the opposing surface of the jugal, thus giving great strength and rigidity to this region. The quadratojugal is the smallest of the three elements which in the Ceratopsia form the quadratojugal arch.

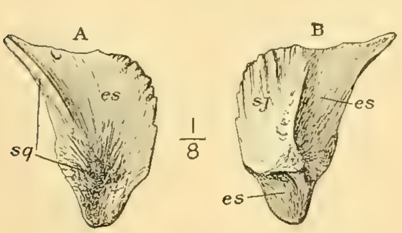

FIG. 18.—A, Internal view of quadratojugal of type of *Triceratops flabellatus*, No. 1821, Yale Museum; B, external view of same. *es*, Free surface; *sq*, surface for quadrate; *sj*, surface for jugal. One-eighth natural size.

The jugal is the largest bone of the three entering into the construction of the quadratojugal arch. Seen from the side when in position it appears T-shaped, the stem being formed by that portion of the bone which overlaps the quadratojugal, as shown in fig. 10 and in Pls. XXVII and XXXIV. The posterior branch of the crossbar at the top sends backward a rather slender bar which interlocks with an anterior projection from the squamosal, as shown in Pl. XLIV, and forms most of the supero-external border of the lateral temporal fossa. Anteriorly and superiorly the transverse portion of the jugal articulates with the maxillary and sends forward a narrow process which is interposed between the lachrymal and the superior border of the maxillary. At the extreme top the jugal forms the antero-inferior border of the orbit, inclosing somewhat less than one-third of that opening. Antero-superiorly it articulates with the lachrymal and postero-superiorly with the postfrontal. The jugal thus forms the external surface of the skull throughout the anterior portion of that area lying between the orbit and the infratemporal or lateral temporal fossa.

The relations of the various elements constituting the quadratojugal arch to one another and to the surrounding bones are well shown in figs. 6, 10, 24, and 26, and in Pl. XLIV.

THE FRONTAL REGION.

The prefrontals, frontals, and postfrontals are all present, though the relative importance of each is somewhat different from that which is usual in the reptilian skull. The characters of these elements are best seen in the type of *Triceratops serratus*, No. 1823 of the Yale Museum collection, and I shall base my description of these elements on that skull.

The frontals are small and become coossified in early life medially with one another, laterally with the prefrontals, and posteriorly with the postfrontals, so that in the skulls of old individuals the sutures between all these bones are completely closed, the whole forming then a single bone roofing over the entire top of the skull between the parietals and nasals, constituting about two-thirds of the orbital borders and culminating in the transversely placed and powerful pair of supraorbital horn cores. In the types of *Triceratops flabellatus* and *T. serratus*, Nos. 1821 and 1823 of the Yale Museum collections, most of the sutures between the different elements of the frontal region are still open, so that in these skulls it is still possible to determine the form of the different frontal bones. The true frontals are abruptly truncated posteriorly in the type of *T. serratus*, No. 1823, but anteriorly they are deeply emarginate and receive the posterior median projection of the nasals. The frontals form no portion of the orbital border, nor do they contribute to the formation of the supraorbital horn cores.

The prefrontals are placed alongside of and external to the frontals, which they about equal in size. Supero-posteriorly they articulate with the postfrontals and immediately beneath the postfrontal suture they form the extremely thick anterior border of the orbit, which in this region is projected far beyond the general surface of the skull. Inferiorly they articulate with the lachrymals, while anteriorly they are in contact with the nasals.

The postfrontals in the Ceratopsia have become of unusual importance. They are several times larger than the frontals and prefrontals combined. They form more than one-half the orbital border and are extremely massive posteriorly. They alone give origin to the so-called frontal horn cores, which might therefore be more appropriately called the postfrontal or supraorbital horn cores. The latter name is preferred by the present author. Anteriorly they are in contact with the frontals and prefrontals, posteriorly with the parietals and squamosals, while immediately beneath the center of the orbits they oppose the jugals. From beneath the postfrontals receive support from both the supraoccipital and the alisphenoid. On the median line and just in advance of the parietal suture a large foramen is usually found piercing the external wall of the postfrontals. It has been called by Professor Marsh the *pineal foramen*.[a] This foramen appears to have communicated with the large cavities in the postfrontals at the base of the horn cores and with certain other smaller cavities in these bones and between them and the supraoccipitals. Its functions are not known, but it is not unlikely that it served for the transmission of nerves and nutrient blood vessels. In some skulls of very old individuals it is almost or entirely closed; the latter is the case in the type of *Triceratops prorsus*, No. 1822, Yale Museum.

The base of the supraorbital or postfrontal horn core is invaded by a very large cavity with comparatively thin walls of bone. Between the horn cores there are a number of smaller cavities situated within the body of the postfrontals, as shown in fig. 24. A number of somewhat larger cavities lie between the supraoccipital and the posterior portion of the postfrontals and anterior portion of the parietals and squamosals. There appears to be considerable individual variation in the number and relative size, form, and position of these various cavities.

[a] This is in no sense a "pineal foramen," as it leads into the postfrontal sinuses and *not* into the brain case. It is a temporary opening, generally closing in older individuals, and hence is analogous to the fontanelle in the skull of the human infant. A more accurate term would be *postfrontal fontanelle*, and as it was evidently not permanent the idea of its transmitting nerves and blood vessels seems hardly tenable. (See fig. 33.)—R. S. L.

The lachrymals form a part of the lower portion of the anterior border of the orbits. This portion of the orbital border is much thinner and is less projected than that immediately above, which is formed by the prefrontals. In front of the orbit the lachrymal is continued forward between the prefrontal above and the jugal and maxillary below. The antero-inferior angle of the lachrymal is lodged between the nasal and the superior branch of the maxillary, and just at the union of these three elements there is in the type of *Triceratops serratus* a foramen which passes between rather than through any of these bones. The position of this foramen varies in the different species; in general it is comparable with that of the infraorbital foramen in the mammalia, and its function may have been similar in the two groups. The internal opening of this foramen is partially bounded by the palatine.

THE NASALS.

In the skulls of old individuals the nasals of opposite sides are firmly united by suture. In the types of *Triceratops flabellatus* and *T. serratus*, however, they are still separate. Along the median line of the skull the sutural border is very thick throughout the entire length of the nasals. The external surface of the nasals is regularly convex. Each nasal consists of a broadly expanded posterior portion, an elongated superior portion closely applied to, and in old age coossified with, that of the opposite nasal, and a shorter inferior branch, as shown in fig. 19, A and B. The elongated superior branches of the nasals form the roof of the nasal passage anteriorly and support the nasal horn, which, however, has its origin in a distinct and single center of ossification that does not coossify with the nasals until late in life. At their anterior extremities the nasals each send downward a short process which overlaps the superior border of the premaxillary. The postero-inferior branch of the nasal is shorter and more slender than the superior. It is directed downward and forward and overlaps the ascending posterior branch of the premaxillary, which is wedged in between this branch of the nasal and the maxillary. The free borders of the nasals form the superior, posterior, and most of the inferior borders of the anterior nares, which open laterally. Posteriorly the nasals are overlapped by the anterior edges of the frontals, prefrontals, and lachrymals. The nasals pass far back under the anterior border of the frontals and prefrontals, but the surface covered over by the lachrymals is more limited.

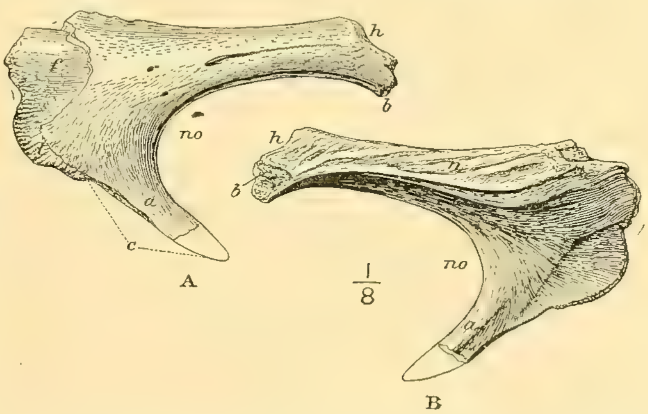

FIG. 19.—A, External view of right nasal of type of *Triceratops flabellatus*, No. 1821, Yale Museum; B, internal view of same. *a*, Inferior process; *b*, process beneath nasal horn overlapping premaxillary; *c*, surface for contact with premaxillary; *l*, surface for lachrymal; *f*, surface for frontal; *no*, anterior nasal opening; *h*, surface for support of nasal horn core; *n*, surface for opposite nasal. One-eighth natural size.

THE MAXILLARIES.

The general outline of the maxillaries, as shown in fig. 22, is that of an irregular triangle, of which the inferior border forms somewhat the longer side. Posteriorly the maxillary is produced into a superior ascending branch and an inferior and horizontal branch. Anteriorly and superiorly the maxillary has an extended articulation with the premaxillary, and supero-posteriorly it is in contact with the jugal, the lachrymal and for a short distance with the nasal, as shown in fig. 10. Internally it has an extended union with the palatine and the lachrymal, as seen in fig. 20. The long inferior and posterior process of the maxillary is embraced at its extremity by the anterior of the two inferior processes of the pterygoid, and supports on its superior and external surface the flat and rather rudimentary transverse, which latter bone, as shown in fig. 21, is also in contact with the inferior process of the palatine for a short distance along its upper and inner margin. The external surface of the maxillary is perforated by a number of smaller and larger foramina, placed rather irregularly; and on the internal side, about 2 inches above the alveolar border, there is a series of small foramina extending throughout the entire length of the dental series. These doubtless served for the transmission of nutrient blood vessels to the teeth.[a]

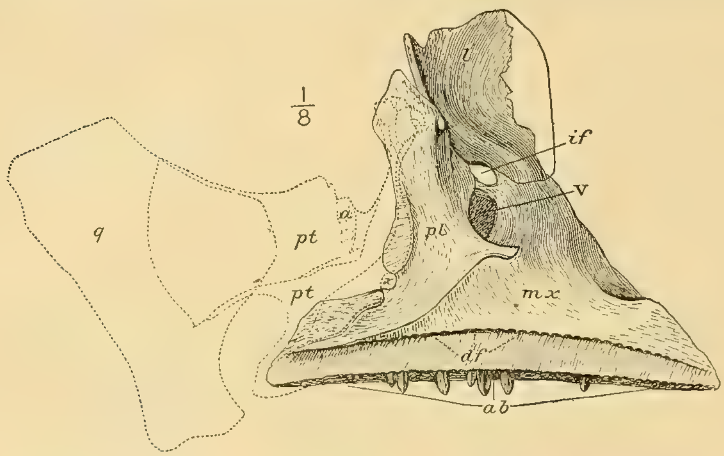

FIG. 20.—Internal view of maxillary, palatine, and lachrymal, with pterygoid and quadrate drawn in in outline. From type of *Triceratops flabellatus*, No. 1821, Yale Museum. *l*, Lachrymal; *if*, infraorbital foramen: v, vacuity between temporal fossa and mouth; *mx*, maxillary; *pl*, palatine; *x*, foramen between pterygoid and palatine; *pt*, pterygoid; *a*, surface for contact with basisphenoid process; *q*, quadrate; *df*, dental foramina; *ab*, alveolar border. One-eighth natural size.

The general form and appearance of the maxillary when detached from the surrounding elements is well shown in fig. 22, drawn from the type of *Triceratops flabellatus*. In this specimen only a few teeth protrude from the alveolar groove, and in this respect the drawing gives a very imperfect idea as to the appearance of the dentition when complete and in position. The position of the infraorbital foramen differs from that in the type of *T. serratus*, where it is located between the superior border of the maxillary and the inferior margin of the nasal.

THE TRANSVERSE BONES.

The transverse bones, or ectopterygoids, are reduced to little more than flattened ossicles on the superior and external surface of the posterior and inferior process of the maxillary, as shown at *tr* in figs. 21 and 24. Above they are in contact with the palatines and below, on the inner side, with the pterygoids. They are very rudimentary, have no contact with the jugals, and serve almost none of the purposes of these elements as represented in the skulls of most recent reptiles.

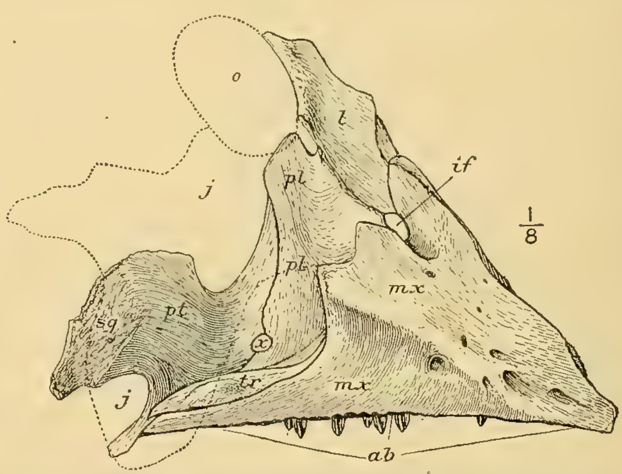

FIG. 21.—External view of right maxillary, palatine, pterygoid, and transverse bones, with jugal drawn in in outline. From type of *Triceratops flabellatus*, No. 1821, Yale Museum. *o*, Orbit; *l*, lachrymal; *pl*, palatine; *if*, infraorbital foramen; *mx*, maxillary; *tr*, transverse; *x*, foramen between palatine and pterygoid; *pt*, pterygoid; *j*, jugal; *sq*, surface for quadrate; *ab*, alveolar border. One-eighth natural size.

THE PTERYGOIDS.

The pterygoids are very irregular in form, as shown in fig. 23. Inferiorly and posteriorly they are broad and thin, the posterior portion being expanded so as to form a broad wing, convex externally and concave internally. The antero-inferior angle of this portion is thick and is lodged in a deep notch on the internal side of the quadrate, while above and posteriorly the

[a] While this view of the function of these foramina is the prevalent one, Doctor Röse has advanced another theory which carries great weight. He believes that the foramina were for the infolding of the mucous membrane from which the tooth papillæ were formed and which could no longer fold in in the ordinary manner because of the great depth of the dental chamber which contains the magazine of teeth. The nerves and blood vessels were within the jaw in their normal position and the use of the foramina for their transmission from the outside would imply the development of an entirely new set of nerves and blood vessels. He also holds that the foramina are much larger than they would be if they were nutrient only. (See F. B. Loomis, Palæontographica, Bd. 46, 1900, p. 250.)—R. S. L.

broad thin wing of the pterygoid overlaps on the inner side the thin angular part of the quadrate, as shown in outline in fig. 20. On the superior portion of the concavity on the inner side of this portion of the pterygoid there is a large rugosity for contact with the anterior face of the distal end of the basisphenoid process. Anterior to this broadly expanded portion of the pterygoid and separated from it by a deep rounded notch is the antero-inferior process of the pterygoid, which is in contact with the transverse and curves round the posterior extremity of the inferior branch of the maxillary, so as to receive a portion of its inner and superior surface into an elongated, rather deep, and rugose cavity. The antero-inferior margin of each of these two inferior processes of the pterygoids are produced into two broad laminæ which run obliquely upward across the inner surface of the bone, the free borders curving toward one another and partially arching over a deep canal, broad below but constricted above, which may have functioned as the eustachian canal. Above the upper limits of these two laminæ the pterygoids are much constricted, and the superior process presents a smooth, flattened, external articular surface for contact with the palatines, while on their internal sides they articulate with one another through short, grooved articular surfaces, which are partially interrupted near their superior borders by a single large median foramen. The sutural surface for contact with the palatine is projected above that which opposes the other pterygoid, and there is a small foramen on the free border between these two surfaces, as shown in fig. 23. The anterior edge of the pterygoid extends forward and forms an elongated plate, crescentic in outline. This articulates with the palatines above and with the maxillary below, as shown in figs. 21 and 24. Just above the maxillary a large foramen passes between the pterygoid and palatine. Anteriorly this foramen is bounded by the posterior border of the palatine and posteriorly by the anterior border of the pterygoid. At the extreme top the pterygoids articulate externally with the palatines and to a slight extent also with inferior lateral projections from the vomers, while medially they are in contact with one another save for the interruption due to the median foramen already mentioned, which doubtless served to transmit the sensory nerves to the palate. These characters are especially well represented in the type of *T. horridus*, No. 1820, Yale Museum collection, and are shown here in figs. 24 and 25, drawn from that skull.

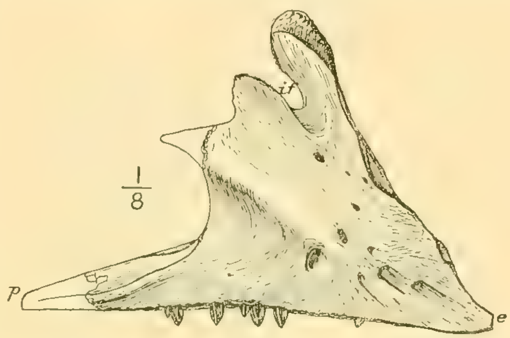

FIG. 22.—External view of right maxillary of type of *Triceratops flabellatus*, No. 1821, Yale Museum. *e*, Anterior end; *p*, posterior end; *if*, infraorbital foramen. One-eighth natural size.

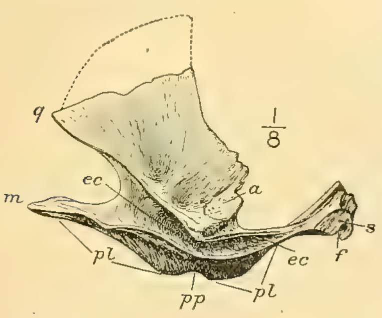

FIG. 23.—Inner view of left pterygoid of type of *Triceratops flabellatus*, No. 1821, Yale Museum. *q*, Angle for articulation with notch in quadrate; *m*, process embracing posterior process of maxillary; *a*, surface for contact with basisphenoid process; *s*, surface for opposite pterygoid; *f*, interpterygoid foramen; *pl*, palatine border; *pp*, pterygo-palatine foramen; *ec*, (?) eustachian canal. One-eighth natural size.

THE PALATINES.

These are broad, thin bones, each consisting of two plates, one vertical and longitudinal, running in a plane nearly parallel with the longer axis of the skull; the other vertical and transverse and occupying a plane extending nearly at right angles to the longer axis of the skull. Along their inferior borders the palatines embrace the superior border of the internal portion of the maxillaries. The vertical and longitudinal portion of the palatines is in contact posteriorly with the pterygoids. The vertical and transverse portion has a thickened, free, inferior border; laterally it gives support to the lachrymal, the superior process of the maxillary, and apparently also to the prefrontals. At the inferior and anterior angle, just where the transverse and longitudinal portions of the palatines meet, they are produced into long, pointed processes which fit nicely into notches on the supero-internal surfaces of the maxillaries, as is well shown in fig. 20.

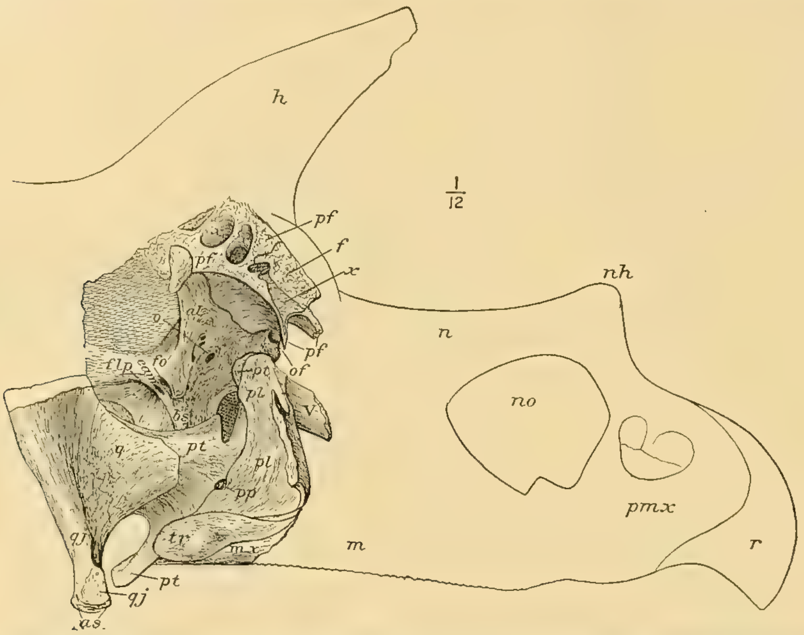

FIG. 24.—Portion of central region of skull of *Triceratops horridus* (type), No. 1820, Yale Museum, as seen from right side with external wall removed, showing relations of the various internal bones of the cranial region to one another. *h*, Supraorbital horn core; *pf*, postfrontal; *x*, cavities in postfrontal; *of*, olfactory foramen; *al*, alisphenoid; *o*, optic foramen; *fo*, foramen ovale; *eam*, external auditory meatus; *flp*, foramen lacerum posterius; *bs*, basisphenoid; *pt*, pterygoid; *pl*, palatine; *tr*, transverse; *q*, quadrate; *qj*, quadratojugal surface; *as*, articular surface for lower jaw; *mx*, *m*, maxillary; *v*, vomer; *n*, nasal; *no*, nasal opening; *nh*, nasal horn; *pmx*, premaxillary; *r*, rostral. One-twelfth natural size.

Just above this process the anterior border of the palatine incloses posteriorly an elongated oval foramen, which is bounded anteriorly by the ascending branch of the maxillary. This foramen passes from the cavity of the mouth to the infratemporal cavity and may be called the maxillopalatine foramen. It is situated, as shown at v, fig. 20, just below the much smaller infraorbital foramen, from which it is separated by a slender process of the maxillary. Above, the palatines approach each other and embrace between them the vomers, the superior extremity of the pterygoids, and the median blade of the alisphenoids. The articulation of these various elements with one another is well shown in the accompanying figures.

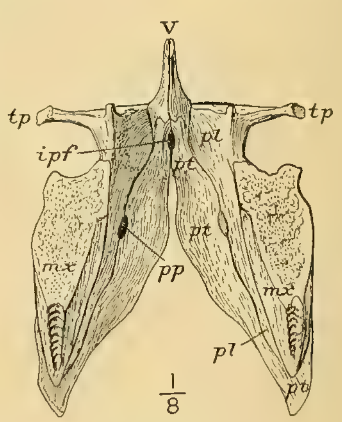

FIG. 25.—Palatine region of type of *Triceratops horridus*, No. 1820, Yale Museum, with anterior portion of skull removed, seen obliquely from below and in front. v, Vomer; *tp*, transverse process of palatine; *ipf*, interpterygoid foramen; *pl*, palatine; *pt*, pterygoid; *pp*, pterygo-palatine foramen; *mx*, maxillary. One-eighth natural size.

THE VOMER.

Only the posterior portion of the vomer is shown in any of the skulls at my disposal, though it is possible that it may be complete in some of the skulls not yet fully prepared.

The vomer is present in a skull, No. 970, of the collections of the American Museum of Natural History, and has been described as follows by Dr. R. S. Lull:[a]

The *vomer* or "*prevomer*" as determined by Broom is a slender, rod-like bone bridging fore and aft the space of the narial fenestra. Anteriorly it is dilated into a flattened rhombic expansion articulating by a squamous suture with the united maxillary bones. Passing backward there appears a median ventral keel, giving the bone in its narrowest part, about the middle, a triangular section. Farther to the rear the lateral edges bend downward to the level of the median keel and then rise again to their former level, where

[a] See "Skull of *Triceratops serratus*," Bull. Am. Mus. Nat. Hist., vol. 19, pp. 685–695.

they give rise to thin, plate-like expansions which are embraced at their posterior end by the pterygoid bones. Dorsally viewed the vomer is seen to become trough-like, the depression being about the width of the shaft of the bone and running the length of the expanded posterior portion. There is no trace of paired elements in the vomer.

I reproduce here Lull's figure of a palatal view of the skull, showing the vomer in position. I can not agree with Lull's statement that "there is no trace of paired elements in the

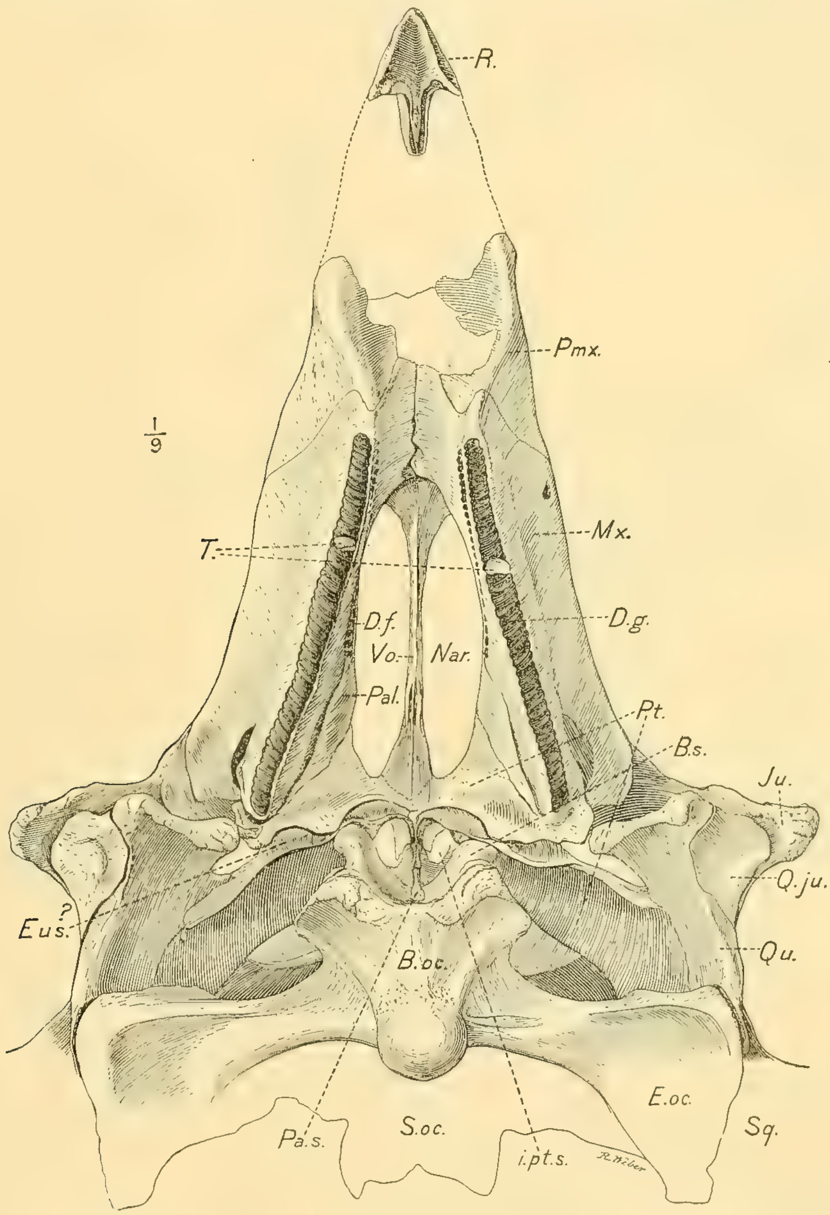

FIG. 26.—Palatal view of skull of *Triceratops serratus* Marsh. Drawn from No. 970, American Museum of Natural History. *R*, Rostral bone; *Nar*, narial vacuity; *i. pt. s*, interpterygoid space; *D. g*, dental groove; *Eus?*, Eustachian groove (?); *Pmx*, premaxillary; *Mx*, maxillary; *Vo*, vomer; *Pa. s*, parasphenoid; *Pal*, palatine; *Pt*, pterygoid. One-ninth natural size. After Lull.

vomer."[a] As shown in figs. 25 and 27, drawn from the type of *Triceratops horridus* Marsh, in the posterior portion the vomer shows on its inferior side a distinct median suture, and the

[a] While the vomer in the specimen cited is the most perfect known, the portions where indications of pairing would be found if present are so badly cracked as to necessitate repairing with plaster. This repair has effectually concealed any indications of a suture, and while Hatcher is probably correct, Lull's statement concerning the absence of indications of paired condition *in this particular specimen* is also true. (See fig. 26.)—R. S. L.

posterior extremity is bifurcated to embrace the compressed median portion of the alisphenoids, as shown in fig. 27, and the lateral processes of the vomer extend a little back of the posterior border of the palatines, by which they are in turn embraced. The inferior border of the bifurcated posterior extremity of the vomer is thickened above the pterygoids, and each process presents on its inferior surface a groove into which fits the short, wedge-shaped superior border of the apex of the pterygoid, and the suture thus formed between the vomer and the pterygoids is W-shaped, as shown in fig. 25. Above their contact with the pterygoids the vomers are firmly inclosed throughout their breadth by the palatines.

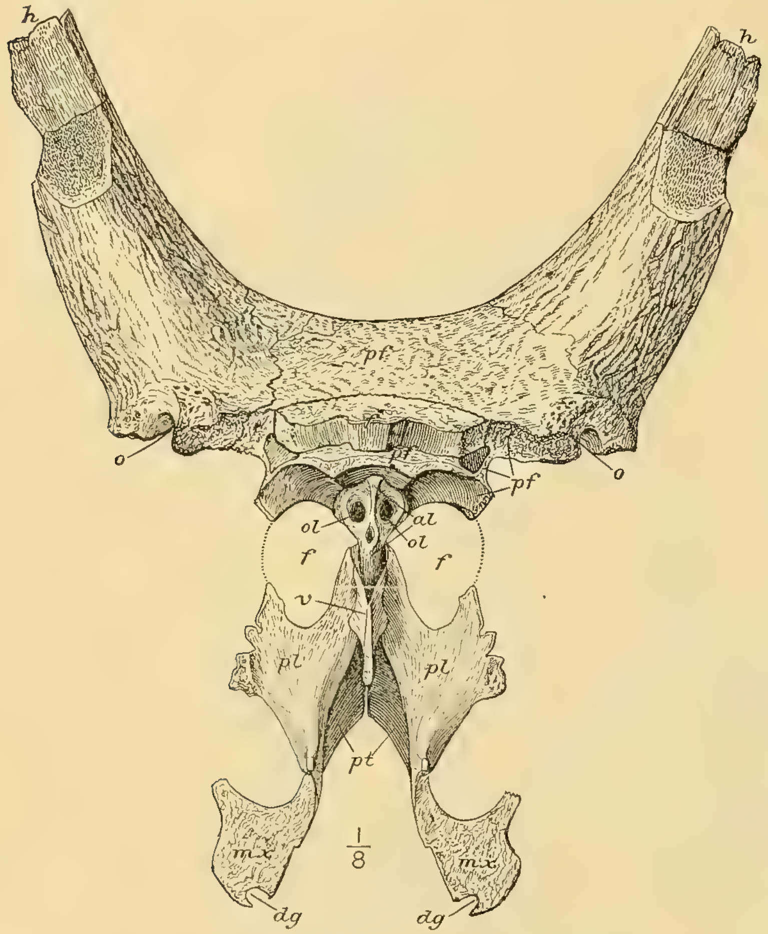

FIG. 27.—Vertical section through skull of *Triceratops horridus* Marsh (type), No. 1820, Yale Museum. Drawn from a fracture just in front of orbits. *h*, Supraorbital horn core; *pf*, postfrontal; *f*, frontal; *o*, orbit; *al*, alisphenoid; *ol*, exit for olfactory nerve; *v*, vomer; *pl*, palatine; *pt*, pterygoid; *mx*, maxillary; *dg*, dental groove; *f*, vacuity between palatines and alisphenoids. One-eighth natural size.

THE PREMAXILLARIES.

The premaxillaries are edentulous. They are much compressed and closely applied to each other. The inferior border is heavy and posteriorly it sends upward and backward a strong process, which is wedged in between the maxillary and the posterior descending branch of the nasal, sending upward a long, slender wedge which is inserted into a deep groove in the latter. The supero-anterior border of the premaxillary describes the arc of a circle. It is thin below, but thickened above where it meets the anterior extremity of the nasals at the base of the nasal horn. At the summit it is embraced externally by a short but stout descending process of the nasal The nasal is supported from beneath by a strong buttress that runs downward and backward. The external border of this bar or buttress is thick and curves forward. It overhangs a broad triangular fossa of which it forms the posterior border. This fossa is confluent below with that of the opposite premaxillary, though they are separated above by a broad, thin median septum. Posteriorly it connects with the narial orifice by a long foramen. Just back of the base of the buttress which gives support to the superior border of the premaxillary a similar buttress runs obliquely backward and upward, supporting laterally the median septum, which in this region forms the imperfect partition between the nasal openings of opposite sides. The posterior opening of the foramen which connects with the triangular fossa mentioned above lies just beneath and at the base of this buttress. Two foramina (sometimes three), situated one behind the other, may be seen on the inferior surface of the premaxillary near the anterior extremity and well within the external border. Anteriorly the premaxillaries are embraced and held rigidly in position by the powerful rostral bone, which extends well backward both superiorly and inferiorly.

THE CRANIAL ARMATURE.

Several elements are present in the cranium of *Triceratops* which seem to have served either wholly or in part as organs of offense and defense. The powerful frontal and nasal horns were most formidable and efficient weapons and must have been of the greatest service to these animals when engaged in resisting the attacks of their enemies, as were also the rostral and predentary bones, which opposed each other and were firmly fixed to the upper and lower jaws, and, like the nasal and frontal horn cores, were in life doubtless insheathed with some horny material which in the latter elements probably resembled very closely the horns of the recent Bovidæ and other cavicorn Mammalia. The rostral and predentary coverings were perhaps not very unlike those enveloping the beaks of the modern turtles, and doubtless served the animal both as organs for procuring food and as weapons. It is probable that the primary function of the enormously expanded parietals and squamosals was to afford protection to the cervical region, while at the same time counterbalancing the weight of the exceedingly

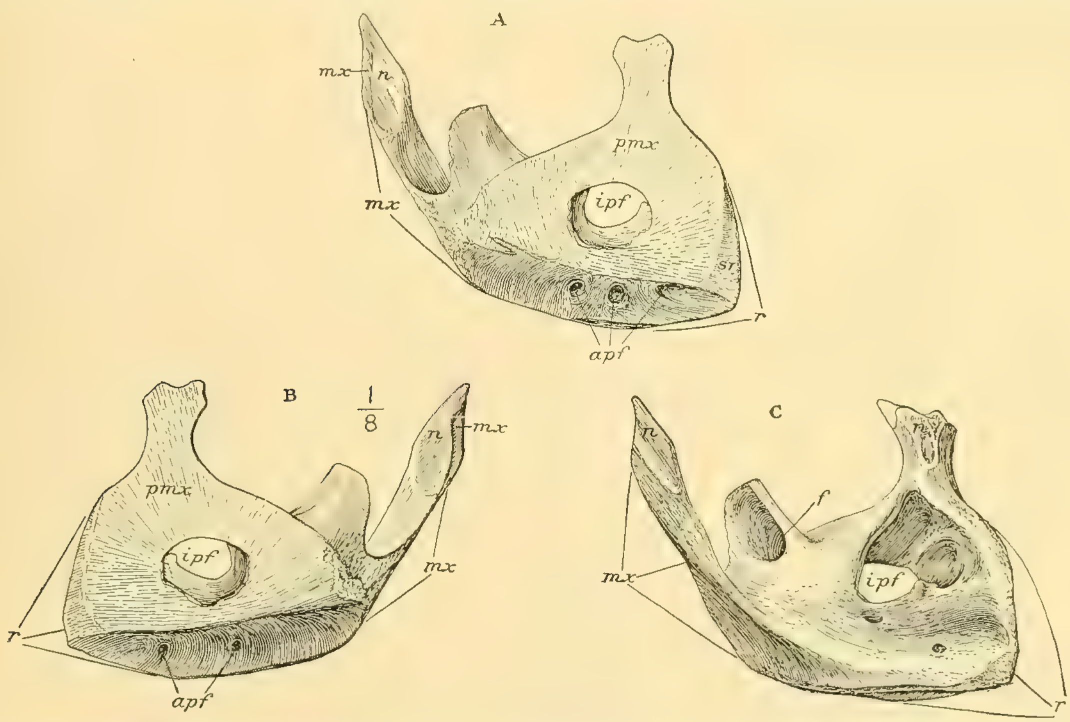

FIG. 28.—A, Internal view of left premaxillary of type of *Triceratops flabellatus* Marsh, No. 1821, Yale Museum; B, internal view of right premaxillary of same; C, external view of right premaxillary. *n*, Surface for nasal; *mx*, surface for maxillary; *pmx*, surface for opposite premaxillary; *r* and *sr*, surface for rostral; *ipf*, interpremaxillary fontanelle; *f*, foramen leading to interparietal fontanelle or fossa; *apf*, anterior palatine foramina. One-eighth natural size.

massive frontal region, including the horns, and giving greater surface for the attachment of those muscles necessary for controlling the movements of the enormous head. In addition there was a series of little, elongated, triangular pointed ossicles (epoccipitals) attached to the free margin of the frill and giving to this border a peculiar undulating appearance, while a similar ossicle, the epijugal, was attached to the external surface of the distal end of each jugal.

In addition to the protective elements already mentioned, many of which, it is clear, were developed primarily for protective purposes, all the elements of the skull are especially heavy and are firmly united with one another by sutures, many of which become closed in the old animal, thus giving a degree of rigidity and strength to the cranium quite unknown in other dinosaurs and affording the greatest possible protection. From the texture of the external surface of all the cranial elements it is evident that they were invested with an integument similar to that which covers the skull in most recent turtles, instead of being deeply embedded in flesh and poorly protected by a thin skin. Such a covering would serve as an additional protection to the animal.

THE SUPRAORBITAL HORN CORES.

Next to the frill the supraorbital horn cores form the most striking feature in the skull of the Ceratopsia. They rise from the superior and lateral surfaces of the postfrontals and may be considered as outgrowths from those bones, the frontals and prefrontals entering but little, if at all, into their composition. They are placed transversely one on either side above the orbits and are directed upward, outward, and forward with a slight curve. They are acutely pointed and vary much in length and form, even in the same genus, and still more so in the different genera. In *Monoclonius* and *Ceratops* they are frequently not more than 15 or 20 centimeters in length, while in some of the species of *Triceratops* they occasionally attain a length of almost or quite a meter. They vary also in form in the different genera and in size as compared with that of the nasal horn core. In *Ceratops* and *Monoclonius* they appear as a rule to have been smaller than the nasal horn core, but in the later and larger forms included in the genera *Triceratops*, *Torosaurus*, etc., they greatly exceed the nasal horn cores in size. The supraorbital horn cores of *Triceratops* are ovate in cross section, the antero-posterior diameter being the longer, the posterior surface broadly rounded and the anterior narrowed so as to form the apex of the ovate figure formed by the cross section. They become more nearly circular toward the apex. The external surface is somewhat flattened, especially near the base. To support the horn cores the postfrontals are extremely thickened behind the orbits, and are supported beneath by the jugals, squamosals, parietals, and supraoccipitals. As with the horn cores in the cavicorn Mammalia, the supraorbital horn cores in the Ceratopsia are hollow at the base, and in some of the larger forms these cavities are very large, being at the base of the horn as much as 15 centimeters in diameter and extending upward, though rapidly diminishing in diameter, for a distance of from 25 to 30 centimeters. These cavities are confluent with other and smaller cavities found in the massive postfrontals at the base of the horn cores. Above the large cavity at the base the central mass of the horn core is very cancellous in structure, while toward the periphery the bone becomes firmer, though continuing somewhat porous throughout its entire thickness. The presence of this cavity at the base of the supraorbital horn core in the Ceratopsia is one of the many examples in the animal kingdom of the application of that mechanical principle which gives the greatest possible increase of strength and superficial area with the least possible weight, and which is most admirably illustrated in the cervical and dorsal vertebræ of the sauropod dinosaurs. The external surface of the supraorbital horn cores is everywhere rugose and marked with deep vascular impressions, probably for the lodgment and protection of the blood vessels and nerves which were inclosed between the bony mass and the sheath of horn with which the former was in life undoubtedly incased. In the type of *T.* (*Sterrholophus*) *flabellatus* (No. 1821, Yale Museum), when discovered, a portion of the investing horny material was still in place about the left horn core, though in such a decomposed condition that it was impossible to preserve it.

THE NASAL HORN CORE.

There is the greatest diversity in the form and size of the nasal horn core in the various genera and species of this group. In some of the earlier, smaller, and more primitive forms of the Judith River beds of Canada and Montana these organs are not only relatively but absolutely longer than in the later, larger, and more specialized forms from the Laramie deposits of central eastern Wyoming. Moreover, while in these later forms the supraorbital horn cores are always much longer and more robust than the nasal horn cores, in the earlier forms, such as *Monoclonius recurvicornis*, and very probably *M. sphenocerus*, the nasal horn cores are absolutely larger than the supraorbital. Among the larger and later forms from the Laramie the nasal horn core seems to attain its greatest length in *Triceratops prorsus*, where, in the type (No. 1822, Yale Museum), it is acute, nearly circular in cross section, and has a length of about 20 centimeters. No nasal horn cores have yet been found associated with any of these later Laramie forms equaling in length that of the type of *Monoclonius sphenocerus* Cope from the Judith River beds of Montana. While these horn cores are supported by the nasals, and in old animals become firmly coossified with them, they nevertheless have their origin in separate and distinct centers of ossification. Moreover, since in young individuals every nasal horn core is seen to have had its origin in a single median center of ossification rather than in two distinct lateral centers placed one beside the other, it is evident that this horn core is in reality morphologically quite distinct from the nasals. In this respect the nasal horn cores differ greatly from the supraorbital horn cores, which are simple outgrowths from the postfrontals, and therefore are morphologically a part of their supporting elements. Unlike the supraorbital horn cores, the nasal horn cores are not hollow at the base, but consist throughout of loose cellular bone. Like the supraorbital horn cores, the external surface of the nasal horn core is marked by numerous vascular impressions, showing that in life they were insheathed with horn. Morphologically the nasal horn cores may be considered as dermal or epidermal ossifications similar to the epijugals, epoccipitals, the rostral, and the predentary, and as quite distinct from the frontal horn cores.

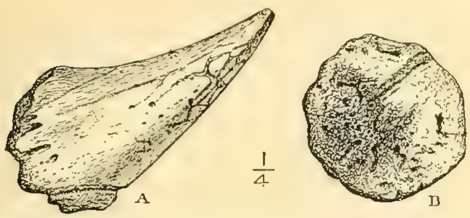

Fig. 29.—A, Nasal horn core (No. 544, University of Chicago collection) of young specimen of *Triceratops prorsus* as seen from right side; B, proximal end of same, showing sutural surface for nasal. One-fourth natural size.

In the collection of the Walker Museum of the University of Chicago there is a detached nasal horn core (No. 544) pertaining to a young individual. The specimen, which apparently belonged to *Triceratops prorsus*, although of a different form from the nasal horn of the type of that species, is in a splendid state of preservation, and shows well the sutural surfaces through which it was attached to the nasals with which, had the animal lived, it would later have become coossified. This horn core is compressed supero-inferiorly, so that its transverse diameter exceeds its vertical. Its principal characters are well shown in fig. 29, which I am able to introduce here through the kindness of Dr. S. W. Williston.

The variation in form and size of the nasal and supraorbital horn cores in some of the various genera and species of the Ceratopsia is well shown in Pls. IV and V, where similar views of a number of such, drawn to the same scale, are reproduced for comparison.

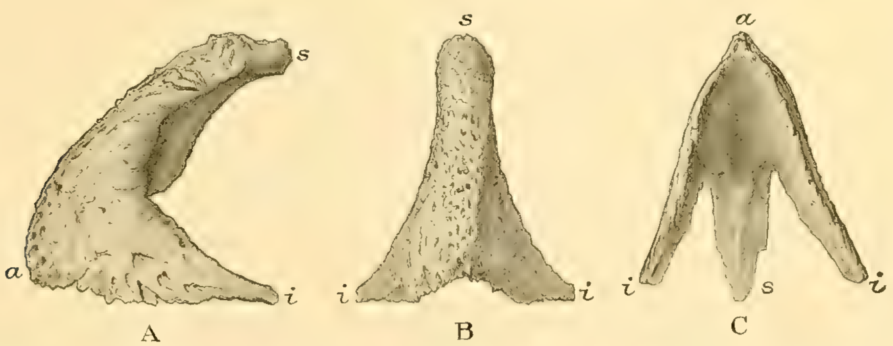

Fig. 30.—Rostral of type of *Triceratops elatus*, No. 2116, U. S. National Museum. A, As seen from left side; B, front view; C, inferior view. *a*, Anterior end; *s*, superior process; *i*, inferior process. After Marsh.

THE ROSTRAL.

This element embraces the anterior extremity of the premaxillaries, and becomes early in the life of the individual firmly united with them. Anteriorly it presents the appearance of a sharp cutting beak, while posteriorly it is triradiate, as shown in C, fig. 30. The median and superior of the three branches is keeled beneath, the keel being wedged in between the anterior extremities of the premaxillaries, which are embraced laterally by rugose folds from the superior and external borders of the same process or branch of the rostral. Inferiorly and laterally the rostral sends backward two rather slender processes, which embrace the inferior surface of the anterior extremities of the premaxillaries. The external surface of the rostral is very rugose, and in life was doubtless covered with a horny sheath which opposed a similar covering on the predentary of the mandible.

THE EPIJUGALS.

These are small, conical dermal ossifications, one on the external side and at the inferior extremity of each jugal. In young animals they are free, but in old age they become firmly coossified with the jugals. They are blunt at the apex and triangular in cross section. The external surface is very rugose, indicating that in life they were incased in a dense horny or dermal covering. Inferiorly and superiorly the epijugals are expanded into thin plates covering over the posterior border of the jugal and overlapping the quadratojugal.

THE EPOCCIPITALS.

Arranged about the periphery of the frill are a series of small, usually elongated triangular ossicles called by Marsh the epoccipitals,[a] though this name does not seem especially appropriate, since they have no connection with any of the occipital bones. They might more appropriately have been called the epiparietals and episquamosals, since they are borne upon and in old age become coossified with these bones. These elements are wanting in the genus *Torosaurus* and perhaps also in some species that have been referred to *Monoclonius*. There is a single large median one at the distal extremity of the parietals, placed transversely to the longitudinal axis of the skull, and the others are arranged at intervals of a few centimeters on either side, along the external borders of the parietals and squamosals. In the type of *Triceratops serratus* (No. 1823, Yale Museum) there were eight of these on either side of the single median one, making seventeen in all, though the number evidently varied in the different species, since in the type of *Triceratops prorsus* there were nine on either side, or nineteen in all. The median of these ossicles is somewhat the larger, but they continue of about equal size until that near the upper border of the squamosal is reached, when they rapidly grow smaller and terminate in a diminutive little ossicle situated on the antero-inferior angle of the squamosal. These ossicles all present a pointed median apex, and from their surface markings they appear in life to have been covered with a horny substance. When in position they give to the border of the frill a peculiar scalloped appearance, which during life was probably even more pronounced, through the presence of the horny coverings. Whether functioning primarily as ornaments or weapons, they must have imparted a very striking appearance to this portion of the animal's anatomy.

EXTERNAL OPENINGS IN CRANIUM.

Although in the Ceratopsia the different bones of the skull are more completely ossified than in most other reptiles and the external wall is as complete and continuous as in most mammals, instead of having the different elements present only in a cartilaginous condition or reduced to mere rods of bone loosely articulated and separated by wide vacuities, as is generally the case among reptiles, nevertheless most of the more important cranial openings found in the reptilian skull are still to be seen in the skulls of this group.

THE SUPRATEMPORAL FOSSÆ.

These are two large openings, situated one on either side at the anterior extremity of the parietal and between that bone and the squamosals. They are elliptical in outline, with the antero-posterior diameter the longer, but are directed inward and forward at an angle of about 45° to the median line of the skull. At the supero-posterior border of each of these foramina a number of deep canals or channels emerge and spread out over the surface of the parietals, forming a complicated system of ramifying channels, while from the postero-inferior angle of the fossa a single deep groove runs along the superior border of the squamosal, giving rise

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[a] Dinosaurs of North America, p. 210.

to a similar series of canals, not so well defined, on the external surface of that element. It is evident, from the manner in which these canals converge and enter the supratemporal fossæ, that the latter gave exit to the nerves and blood vessels that were distributed over the surface of these bones. For greater protection, the larger of these were incased in the series of ramifying canals already described.

THE POSTFRONTAL FORAMEN.

The postfrontal foramen,[a] called by Professor Marsh sometimes the pineal foramen and sometimes the parietal foramen, is usually situated between the postfrontals a little in advance of the anterior extremity of the parietal and on a line with the posterior borders of the supra-orbital horn cores. Since it does not function as a pineal foramen and is usually entirely without the limits of the parietal and within the postfrontals, I have thought best to reject both of the names hitherto applied to it and to call it the postfrontal foramen, from its position in relation to the frontal region of the skull. It is well shown in the type of *Triceratops serratus* (No. 1823, Yale Museum) and in most well-preserved skulls, though in old age, in the genus *Triceratops* at least, it becomes partially or completely closed, as is the case in the type of *Triceratops prorsus* (No. 1822, Yale Museum). A short distance below its exit it branches and connects with that series of large cavities already mentioned as occurring at the base of the frontal horn cores. It is possible that its chief purpose may have been to convey nutrient blood vessels to the growing horn cores and their enveloping horny sheaths, but if so this would fail to explain why they became closed in old individuals, since their function would continue after the horn cores were fully developed, as the horny sheath doubtless continued to grow throughout life. In the type of *Torosaurus latus* (No. 1830, Yale Museum) instead of a single median foramen branching beneath the surface there are two, one in each postfrontal, separated by a distance of 21 millimeters and each apparently running directly to the large cavity at the base of the horn core of its side of the skull. This character is not persistent in this genus, since in the type of *T. gladius* (No. 1831, Yale Museum) there is a single median foramen situated not in the postfrontal as in *Triceratops*, but in the anterior extremity of the parietals. This foramen in this species might very properly be called the parietal foramen, as was done by Marsh.

THE LATERAL TEMPORAL FOSSÆ.

These are two in number, situated one on either side of the skull, with the external openings lying beneath and a little posterior to the orbits. The external openings are subtriangular to ovate in outline and are inclosed anteriorly and superiorly by the jugals, posteriorly by the squamosals, and inferiorly by the quadrates and quadratojugals.

THE ORBITS.

The orbits are large and deep, indicating that the organs of sight were highly developed. The external border of the orbit is very strong and anteriorly it extends outward, well beyond the general external surface of the skull, so as to afford great protection to the eye. Apparently there were no sclerotic plates or other ossicles especially developed for the protection of the eye. The external opening of the orbit is broadly elliptical to nearly circular in some species, with the larger diameter inclined backward at an angle of about 30° from the perpendicular when the skull is in a horizontal position. The external border of the orbits is formed supero-posteriorly and posteriorly by the postfrontals, inferiorly by the jugals, and supero-anteriorly and anteriorly by the prefrontals and lachrymals, respectively. In the type of *Triceratops serratus* (No. 1823, Yale Museum) the orbital fossæ descend to a depth of 23 centimeters into the body of the skull. They are directed downward and slightly forward and are separated by a bony septum which seems to be pierced by a large foramen. Anteriorly the orbital cavities communicate with the narial orifices by large vacuities. The optic foramen enters the orbital

[a] Postfrontal fontanelle.—R. S. L. See footnote, p. 24.

cavity at about the middle of its posterior border. Near the inner border the superior wall of the orbit is supported by three more or less perpendicular pillars. The most posterior, largest, and strongest of these is formed by that buttress-like lamina already described as being present on the superior wing of the alisphenoid and supporting from beneath the postfrontals and the massive supraorbital horn cores.

THE ANTERIOR NARES.

Unlike the anterior nares in crocodiles, alligators, and most recent reptiles, the anterior nares in the Ceratopsia are separated by an imperfect bony partition and open laterally instead of vertically. They are broad, deep incisions between the premaxillaries and nasals. Posteriorly they communicate with the pterygoid fossæ by large vacuities between the palatines and the superior branches of the maxillaries seen at v in fig. 20.

THE POSTERIOR NASAL OPENING.

This is imperfectly closed in front and internally, though it apparently consisted of a single opening near the base of and between the pterygoids and communicated with the narial orifice through the partially inclosed canals situated opposite each other and one on the internal side of either pterygoid. It was not inclosed by the pterygoids as in the crocodiles.

THE POSTERIOR PALATINE VACUITIES.

These are very large and greatly elongated openings between the maxillaries and are divided medially by the slender vomers. They communicate above with the narial orifice and below with the mouth. There is really no ossified false or true palate in the Ceratopsia, such as is seen in most modern reptiles and more especially in the crocodiles and alligators, where the palatines and inferior plates of the maxillaries are greatly developed, forming a continuous roof to the palate, interrupted posteriorly only by the elongated, lateral palatine vacuities, separated by the broad, united palatines. In the Ceratopsia there is really no bony roof to the palate, the oral cavity and narial orifice being confluent throughout almost their entire length.

THE ANTERIOR PALATINE FORAMINA.

There are no true anterior palatine vacuities in the Ceratopsia. The premaxillaries and the anterior portion of the maxillaries meet by their inner borders, entirely roofing over the palate in this region, and the premaxillaries each send upward two strong pillars which give support to their superior branches, the anterior extremity of the nasals and the nasal horn, besides forming a considerable portion of the incomplete median nasal septum already mentioned. Although true anterior palatine vacuities are not present, the inferior surface of each premaxillary is perforated by two (sometimes three) small foramina placed in longitudinal series one anterior to the other. It seems scarcely possible that these small foramina shown in fig. 28 can be remnants of the anterior palatine vacuities.

THE BRAIN AND BRAIN CAVITY.

Considering the size of the skull the brain is smaller in the Ceratopsia than in any other known group of vertebrates. The external opening of the foramen magnum is large when compared with the size of the brain. It is oval in outline, the transverse diameter being a little the shorter. Just within the external opening of the foramen magnum two large foramina (xii, fig. 31) enter the brain cavity, one on either side. These served to transmit the twelfth pair of nerves. A little in front of these is a second and smaller pair of foramina (xi, fig. 31), which I have interpreted as transmitting the eleventh pair of nerves, though Professor Marsh has considered these nerves as entering the brain case together with the tenth through that large foramen which is placed anterior to and a little above this and which I have interpreted as the foramen lacerum posterius. Whatever the function of this foramen may be, it forms the posterior branch of the more anterior of the two foramina that enter the skull behind and at the bases of the basioccipital and exoccipital processes, the anterior branch of which, as previously stated,[a] enters the foramen lacerum posterius just before the latter enters the brain cavity. This anterior branch I have interpreted as having conveyed the tenth nerve to the brain by way of the foramen lacerum posterius. The foramen lacerum posterius is the large oval foramen which enters the brain cavity just in advance of and below the small foramen mentioned above and shown at *flp*, figs. 8 and 31. A little way within the body of cranial wall this foramen branches, so that it has two external exits—one, the larger, in front of the basioccipital and exoccipital, the other, the smaller, having been already mentioned as opening behind the processes of these bones. By some anatomists this foramen, which I have interpreted as the foramen lacerum posterius, may be considered as the auditory, and its external and internal openings as the external and internal auditory meati. Just in front of this large foramen is a small one, *eam*, fig. 32, piercing the heavy bar of bone separating the former from the inner opening of the large foramen ovale. This small foramen I have interpreted as the internal auditory meatus, though I am by no means sure that it functioned as such. It seems, however, at one time to have communicated with three small cavities (III, fig. 31) situated within the bony mass opposite the constriction which marks the division of this portion of the brain cavity into posterior and median cerebral vesicles, while its external opening appears to have been that which I have considered the external auditory meatus. Immediately anterior to this small foramen is the foramen ovale, seen at *fo*, figs. 8 and 32. This is a very large foramen, equaling in size the foramen lacerum posterius. On its anterior border midway between its external and internal openings it receives the posterior opening of the alisphenoid canal, which is likewise of considerable dimensions. Some distance in advance of the inner opening of the foramen ovale the sphenoidal fissure, seen at *sf*, figs. 8, 31, and 32, enters the brain cavity just above and at the side of the entrance to the deep pituitary fossa. A little in advance of this fissure is the

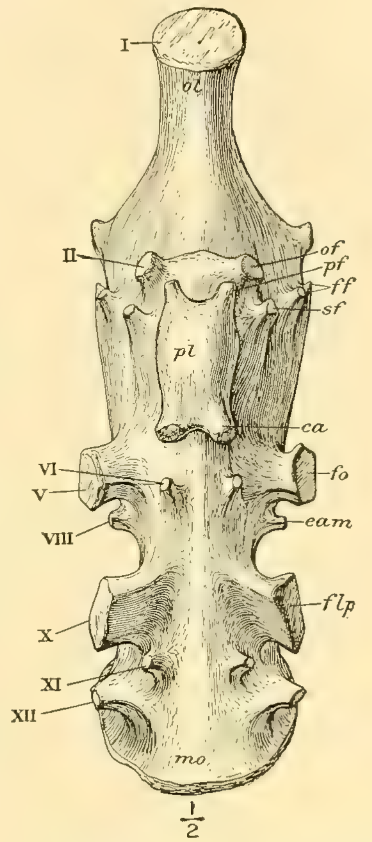

FIG. 32.—Inferior view of brain cast of *Triceratops serratus*, from No. 2065, U. S. National Museum. *mo*, Medulla oblongata; I–XII, cranial nerves; *flp*, foramen lacerum posterius; *eam*, internal auditory meatus?; *fo*, foramen ovale; *ca*, carotid artery; *pl*, pituitary lobe; *pf*, foramen entering anterior extremity of pituitary fossa; *sf*, sphenoidal fissure; *ff*, undetermined foramina; *of*, optic foramen; *ol*, olfactory lobe. One-half natural size.

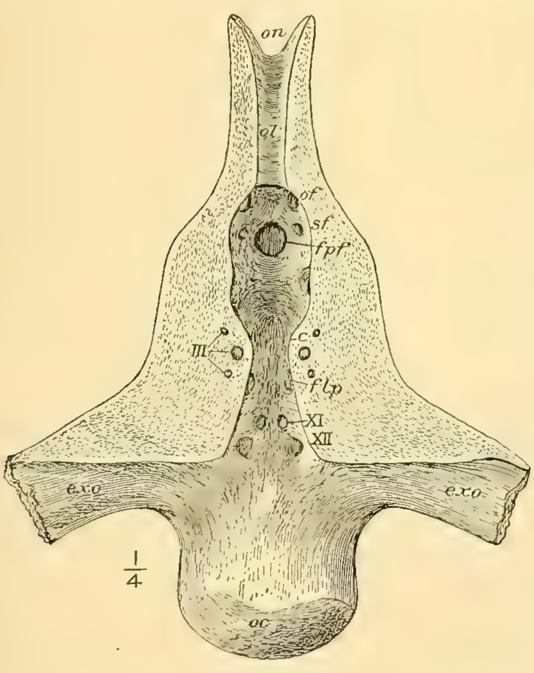

FIG. 31.—Horizontal section of brain case of *Triceratops flabellatus* (type) in the plane of the long axis of the brain, No. 1821, Yale Museum. *oc*, Occipital condyle; *exo*, exoccipital processes; XII, foramen for exit of twelfth nerve; XI, foramen for exit of eleventh nerve; *flp*, internal opening of foramen lacerum posterius; *fpf*, foramen leading to pituitary fossa; *sf*, sphenoidal fissure; *of*, optic foramen; *ol*, olfactory lobe; *on*, exit for olfactory nerves; III, auditory cavities in ? auditory capsules; *c*, constriction between cerebrum and cerebellum. One-fourth natural size.

[a] See p. 16.

somewhat larger optic foramen (*of*, figs. 8, 31, and 32), by which the optic nerve leaves the brain case, while above and a little anterior to this the two small foramina, marked *ff* in fig. 32, enter the brain cavity. The pituitary fossa opens between and a little to the rear of the sphenoidal fissures, as shown in fig. 31. It is deep and extends far back beneath the floor of the median vesicle. The entrance is nearly circular and is constricted just beneath its mouth. Near the anterior end of the pituitary lobe two small foramina (*pf*, fig. 32) enter the pituitary fossa. The foramina for the carotid arteries enter the pituitary fossa at its posterior extremity, as shown in fig. 32. The brain cavity is much constricted just in advance of the optic foramina and this constriction becomes more pronounced anteriorly, separating the cerebrum from the olfactory lobe, which is rather large and much elongated as compared with the size of the brain as a whole. In the type of *Triceratops* (*Sterrholophus*) *flabellatus* (No. 1821, Yale Museum) the olfactory nerves emerge from a single median foramen, as shown in fig. 9 (see p. 18), while in the types of *Triceratops horridus*, fig. 27 (No. 1820, Yale Museum), and *Triceratops prorsus* (No. 1822, Yale Museum) this foramen is divided into two by a median partition or septum. The brain cavity is entirely

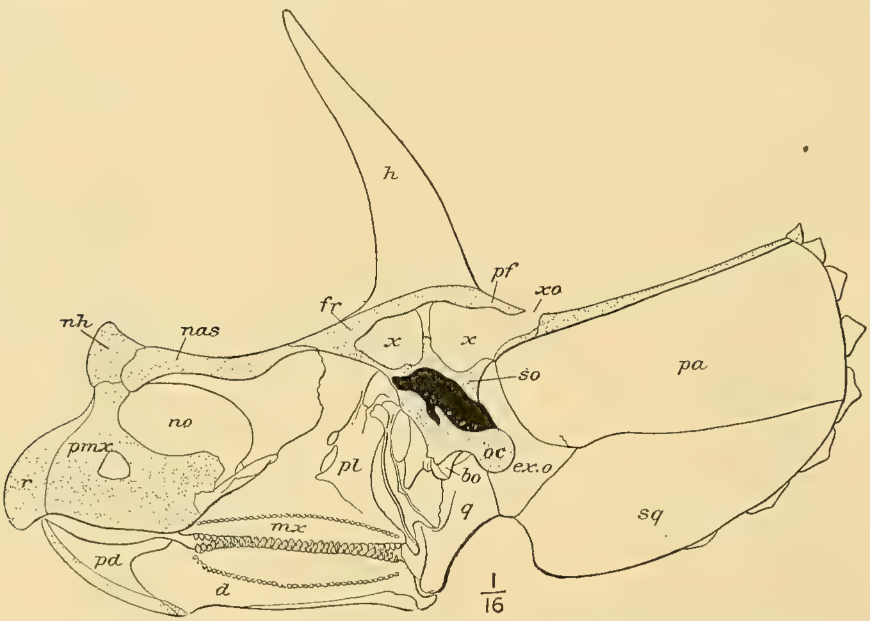

FIG. 33.—Longitudinal section of skull of *Triceratops flabellatus* Marsh, from No. 1821, Yale University Museum, showing the position and extent of the brain cavity. One-sixteenth natural size. Modified by R. S. Lull from an unpublished drawing by Marsh. *bo*, Basioccipital; *d*, dentary; *exo*, exoccipital; *fr*, frontal; *h*, supraorbital horn core; *mx*, maxillary; *nas*, nasal; *nh*; nasal horn core; *no*, nasal opening; *pa*, parietal; *pd*, predentary; *pf*, post frontal; *pl*, palatine; *pmx*, premaxillary; *q*, quadrate; *r*, rostral; *so*, supraoccipital; *sq*, squamosal; *x*, sinuses beneath postfrontal bones; *xo*, postfrontal fontanelle.

inclosed within the basioccipital and exoccipital and the basisphenoid and alisphenoid. The expansion is greatest in the cerebral region and the cavity narrows posteriorly in the region of the cerebellum. There is a marked constriction in the walls of the brain cavity immediately above the internal opening of the foramen lacerum posterius, marking the union of the medulla oblongata with the cerebellum, which is less perfectly separated from the cerebrum by a slight constriction in the walls just in advance of the foramen ovale. The floor of the brain cavity becomes much elevated just in front of the exit of the optic nerve, as is well shown in figs. 31 and 34, while the roof becomes lower and the lateral walls converge, resulting in that decided anterior constriction which separates the olfactory lobe of the brain from the cerebrum.

THE SENSE ORGANS.

Considering the comparative size of the olfactory lobe and the foramen or foramina for the exit of the olfactory nerves, one would judge that the sense of smell was well developed in the Ceratopsia. In the same manner the large and cavernous orbital cavities, with their anterior borders projected well beyond the external surface of the skull, are indicative of large and protruding eyes. These characters, together with the ample dimensions of the optic foramina, suggest that these animals were gifted with keen sight. If we are to judge by the comparative development of the various sense organs, the Ceratopsia would seem to be extremely deficient in the sense of hearing. Properly speaking, there are no auditory capsules in the skull of the Ceratopsia and the otic bones, if present at all, are so completely fused with those forming the cerebral walls that they are entirely unrecognizable. There is a noticeable swelling on either side in the walls of the brain cavity at the point where the auditory capsule should, if present, be located, as shown in fig. 31. But the walls, instead of being thin at this point, are thick, and instead of a capacious auditory bulla on either side there is only a small reniform cavity terminating below in a single median shallow rounded pit and two smaller ones placed one anterior and the other posterior to the median. So far as I can determine two small foramina enter this cavity—one, the smaller, by way of the median round pit mentioned above, the other, the larger, by the anterior of the two smaller of these pits. I am unable to determine the course or the homologies of these two foramina. The former seems, however, to be a rudimentary auditory foramen, while the larger appears to have communicated with the foramen ovale. However this may be, and whatever the homologies of these and various other foramina, it is evident from the structure of the skull in this region that the sense of hearing, unlike the sense of sight and smell, was exceedingly poorly developed in the Ceratopsia. Perhaps this deficiency in hearing may have hastened to some extent at least the extinction of the group.

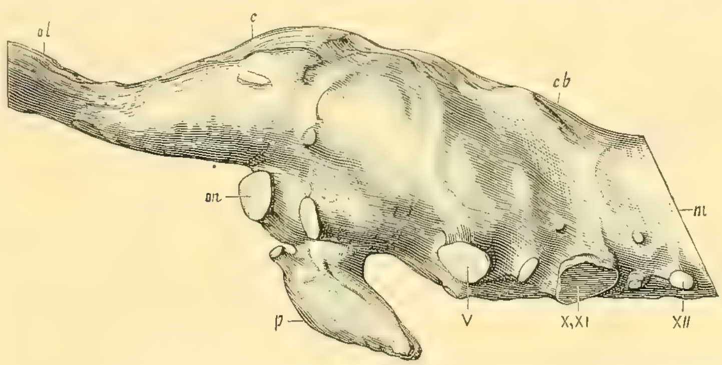

FIG. 34.—Lateral view of brain cast of *Triceratops serratus*, from No. 2065, U. S. National Museum. *c*, Cerebral hemispheres; *cb*, cerebellum; *m*, medulla; *ol*, olfactory lobe; *on*, optic nerve; *p*, pituitary body; V, fifth nerve, or foramen ovale; X, XI, eleventh and twelfth nerves, or foramen lacerum posterius; XII, twelfth nerve. One-half natural size. After Marsh.

THE LOWER JAW.

The mandible in the Ceratopsia is composed of eleven bones. Five of these, the dentary, splenial, angular, surangular, and articular, are paired, while the eleventh, or predentary, is single and median in position, articulating with both rami.

THE PREDENTARY.

The form and principal characters of the predentary are well shown in fig. 35, after Marsh. Seen from below or above it is triangular in outline, deeply excavated superiorly, and with the inferior surface regularly convex. Anteriorly it is compressed, terminating in a median apex, while posteriorly it terminates in three projections, two superior and lateral, each of which overlaps the superior margin of its respective ramus, and one inferior and median, which presents on either side deep grooves into which fit the antero-inferior angles of the rami. The inferior borders of these grooves are projected backward on either side so as to present two posterior branches which overlap the rami and give greater rigidity to the union between the predentary and dentaries. The predentary is wider posteriorly than the rostral but does not extend so far forward as that element, and when in position it is overlapped by the latter, fitting into it as does the lower jaw of a turtle or bird into the upper jaw. It is probable also that the horny coverings with which in life these bones were doubtless enveloped were nicely adjusted to one another and formed efficient cutting organs, serving either as weapons or for procuring food. From the configuration of the rostral and predentary bones it would appear that when closed the rostral sheath fitted over that of the predentary, exhibiting relations similar to those which obtained between the superior and inferior dentitions where, as will be shown later, the external margins of the inferior teeth oppose the internal margin of the superior, the lower jaw fitting within the superior as in mammals.

On the superior surface of each lateral branch of the predentary there is a broad, shallow groove for the reception of the postero-inferior branches of the rostral and the antero-inferior border of the premaxillary. The form and principal characters of the predentary are well shown in fig. 35.

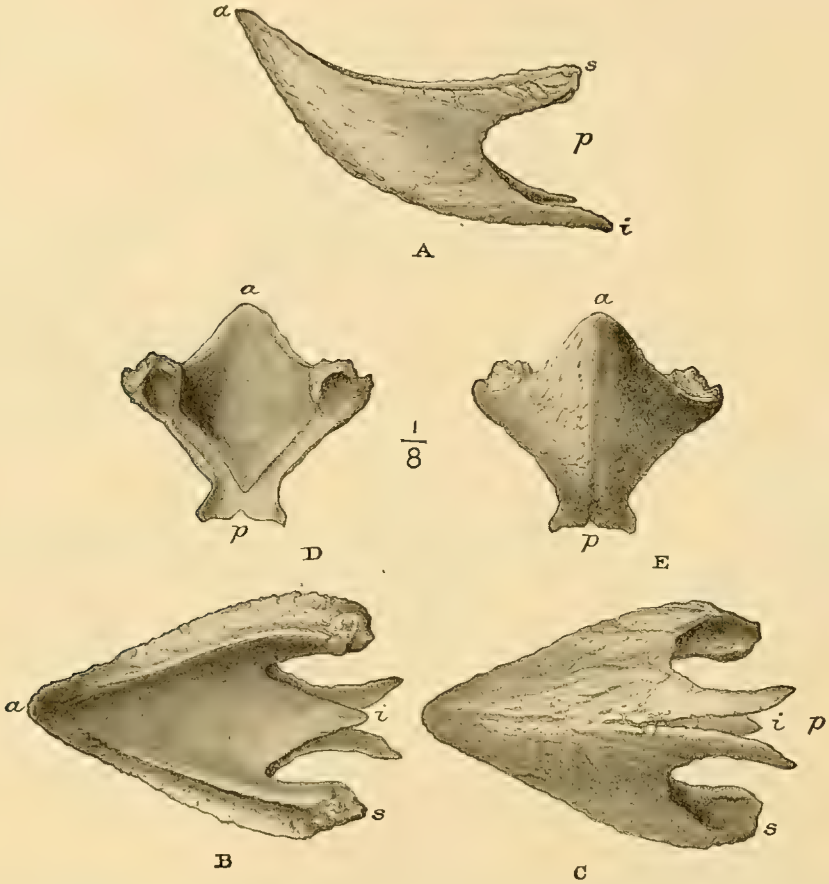

FIG. 35.—A, Side view of predentary of type of *Triceratops prorsus*, No. 1822, Yale Museum; B, superior view of same; C, inferior view; D, posterior view; E, anterior view. *a*, Anterior end; *p*, posterior end; *i*, inferior process; *s*, superior process. One-eighth natural size. After Marsh.

THE DENTARY.

This is much the largest of the bones of the lower jaw. Anteriorly it is much compressed, and it was united with the opposite dentary by cartilage only, through a short, grooved symphysis. A little posterior to the symphyseal surface the transverse diameter of the dentary increases rapidly, and throughout its entire extent it is a strong, heavy bone. Posteriorly on its external surface it sends upward a heavy coronoid process, compressed transversely but much expanded antero-posteriorly at the summit and somewhat resembling the same process in some mammals. The coronoid process is constricted antero-posteriorly below the summit, but thickened transversely. It is exceptionally strong, and the surface of the extremity is rugose and doubtless served for the attachment of the powerful muscles which in life aided in closing the lower jaw. Immediately beneath the base of the coronoid process there is a deep cavity opening on the inferior surface of the dentary throughout about one-half its length. This cavity, which is present in most reptilian rami, is very appropriately called the mandibular fossa. Inferiorly and laterally this fossa is partially inclosed by the splenial, and posteriorly by the angular, surangular, and articular. On the superior border and near the anterior end of this cavity two large foramina pierce the dentary and probably conveyed blood vessels to the interior of that bone. On the inner side of the dentary, about midway between the superior and inferior borders, there is a series of foramina that extends throughout the entire length of the bone. These foramina equal in number the teeth of the vertical series, and doubtless served for the transmission of nerves and nutrient blood vessels to the teeth.[a] Posteriorly the dentary was in contact with the angular, surangular, and articular, though never becoming coossified with them, even in old individuals.

The more important characters of the dentary are well shown in fig. 36, drawn from the right dentary of the type of *Triceratops flabellatus*, No. 1821, Yale Museum.

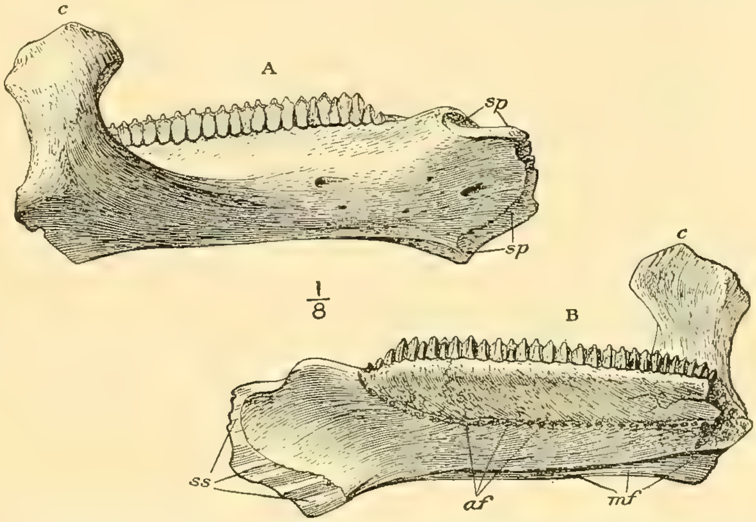

FIG. 36.—A, external view of right dentary of type of *Triceratops flabellatus*, No. 1821, Yale Museum; B, internal view of same. *c*, Coronoid process; *af*, dental foramina; *sp*, surface for predentary; *ss*, symphyseal surface; *mf*, mandibular fossa. One-eighth natural size.

THE SPLENIALS.

These are very long, thin bones, especially slender anteriorly. They reach to the symphyseal border in front, and posteriorly they inclose internally and inferiorly the mandibular fossæ. Throughout their entire length they are closely applied to the dentary, though they seldom, even in the old individuals, become coossified with it. In the middle and posterior region of the splenial the superior margin is expanded and overlaps the internal surface of the dentary above the lateral border of the mandibular fossa. Posteriorly, a little beneath the superior margin, there is a long slit dividing the posterior portion of the splenial into a broad, long inferior branch and a shorter and narrower superior. This slit or fissure is homologous with the internal mandibular foramen in the crocodile. It is inclosed behind by the articular. The inferior and larger of the two posterior branches of the splenial overlaps the angular throughout the entire length of the latter bone.

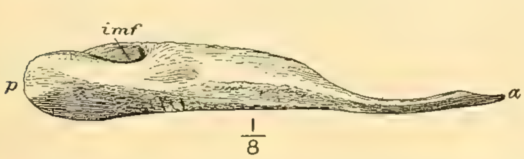

FIG. 37.—Internal view of left splenial of type of *Triceratops prorsus*, No. 1822, Yale Museum. *a*, Anterior end; *p*, posterior; *imf*, internal mandibular foramen. One-eighth natural size.

THE ANGULAR.

This is a broad, thin bone, convex on its inferior or external surface and concave above where posteriorly it receives the articular and surangular, while its thinner and narrower anterior portion overlaps the dentary, passing within the mandibular fossa and forming a portion of its postero-inferior wall. The external border of the angular is the thicker and is in contact throughout with the surangular, while medially it is produced into a rounded angle which fits into a corresponding pocket or groove in the surangular. On its inferior surface it is pierced by a small foramen which leads into the mandibular fossa. It is the smallest of all the elements of the mandible and its form and characters are well shown in fig. 38.

[a] See footnote on p. 26.—R. S. L.

THE SURANGULAR.

This is the largest of the three bones of this region. Its shape is very irregular and it may best be described as consisting of a larger vertical portion expanded antero-posteriorly and a smaller and pointed horizontal portion. The vertical portion is in contact anteriorly with the dentary and at its superior angle it is rounded and thickened, and when in position it fits into a deep pocket in the external wall of the dentary at the base of the coronoid process. Posteriorly and externally on the superior surface it articulates with the quadrate, while internally and superiorly it is overlapped by the articular. Medially on the inner surface there is a long, angular projection, which embraces the antero-external surface of the articular. Inferiorly and internally the surangular is in contact with and overlaps the angular, being wedged in between that bone and the articular. Postero-externally the surangular entirely incloses the mandibular fossa and the external mandibular foramen is reduced to a small hole situated entirely within this bone. Posteriorly the surangular does not extend beyond the articular surface for the quadrate, and just beneath the posterior border of this surface the bone is pierced by a foramen of medium size.

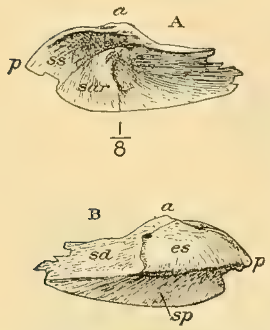

FIG. 38.—A, Superior view of left angular of type of *Triceratops flabellatus*, No. 1821, Yale Museum; B, inferior view of same. *a*, External border; *p*, posterior extremity; *ss*, surface for surangular; *sar*, surface for articular; *sd*, surface for dentary; *es*, exposed surface; *sp*, splenial surface. One-eighth natural size.

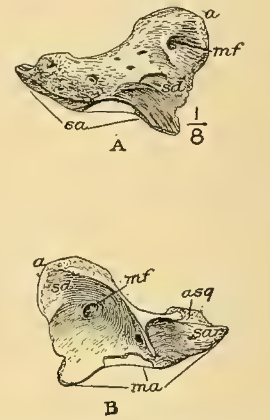

FIG. 39.—A, External view of right surangular of type of *Triceratops flabellatus*, No. 1821, Yale Museum; B, internal view of same. *a*, Supero-anterior angle; *sd*, surface for dentary; *mf*, external mandibular foramen; *asq*, articular surface for quadrate; *sar*, surface for articular; *ma*, margin for contact with angular; *sa*, surface for contact with angular. One-eighth natural size.

THE ARTICULAR.

The articular is embraced below by the angular and surangular, while on its external side it is firmly lodged between the superior and inferior horizontal branches of the latter bone; together with these bones it entirely incloses posteriorly the mandibular fossa. It forms about three-fourths the articular surface for the quadrate and sends backward a triangular process which extends some 50 millimeters beyond the quadrate and is deeply excavated on its superior surface. The antero-internal margin of the articular is produced forward, especially along its superior border, where it forms a sharp process, triangular in cross section, which, when in position, is in contact with the splenial and the posterior internal angle of the dentary. It forms the posterior and a portion of the superior border of the internal mandibular foramen.

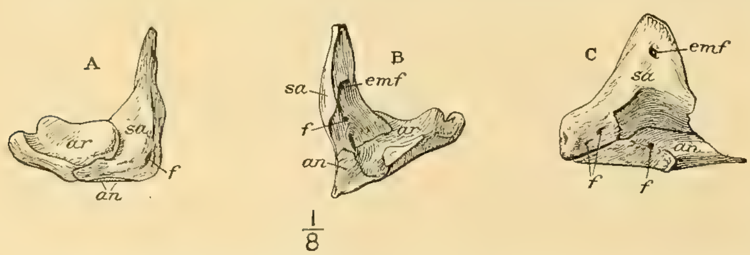

FIG. 40.—A, Posterior view of right angular, surangular, and articular of type of *Triceratops prorsus*, No. 1822, Yale Museum; B, oblique front view of same; C, external view of same. *ar*, Articular; *an*, angular; *sa*, surangular; *f*, foramina; *emf*, external mandibular foramen. One-eighth natural size.

The manner in which the angular, surangular, and articular interlock with one another is well shown in fig. 40, which represents all these bones in their normal position relative to one another.

Although the bones of this region are short and small and are not coossified either with themselves or the dentary, except perhaps in very old individuals, yet when adjusted to each other and the dentary they interlock by such a complicated system of sutures, cavities, and corresponding processes that great rigidity is obtained in this region, where it is absolutely necessary in order to secure perfect control of the mandible.

The relations of the various elements of the lower jaw to one another are well shown in fig. 41 and in Pls. VI, XXVII, and XLI.

THE TEETH.

THE UNWORN TEETH.

The fully adult teeth before being subjected to wear have acutely pointed, conical crowns, as shown in fig. 42. At the base of the crown the transverse diameter exceeds the antero-posterior, while toward the top these dimensions are reversed and the antero-posterior diameter becomes the longer. In each tooth the anterior and posterior edges of the crown are produced so as to form anterior and posterior keels, sharp above but rounded below, and finely serrated along the edges, especially toward the apex. In the superior teeth there is a median vertical keel on the inner surface of the crown extending from the apex quite to the base, while the external surface of the crown bears a vertical keel situated somewhat posterior to the median line and thus dividing the external surface of the tooth into a smaller posterior and larger anterior portion. These conditions are exactly reversed in the teeth of the lower jaw, where the median vertical keel is on the external surface of the crown, while the internal surface is divided by the vertical keel into two unequal areas, the anterior of which is the smaller. As in the superior teeth this vertical keel is sharper and better defined than the median vertical keel of the opposite side of the tooth. The teeth are apparently two-rooted, though in reality there is in the young tooth only a single root, which is early divided into two branches by the peculiar manner in which these teeth replace one another, which will be fully described and illustrated later. In the young tooth the root is single and triangular in cross section. The pulp cavity is large and the walls are extremely thin, especially the anterior and posterior walls of the root just below the crown. In the young tooth the pulp cavity extends well up into the crown, but as the tooth matures the walls thicken and the cavity is confined to the root.

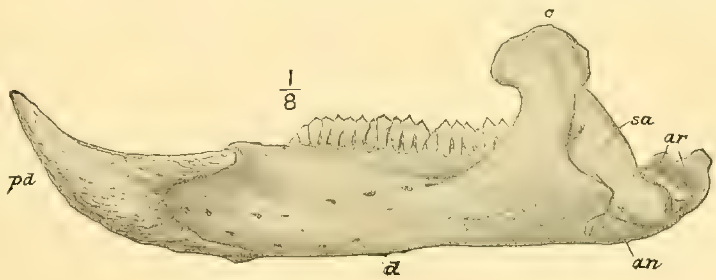

FIG. 41.—External view of left ramus of type of *Triceratops prorsus*, No. 1822, Yale Museum. *c*, Coronoid process; *pd*, predentary; *d*, dentary; *an*, angular; *ar*, articular; *sa*, surangular. One-eighth natural size. After Marsh.

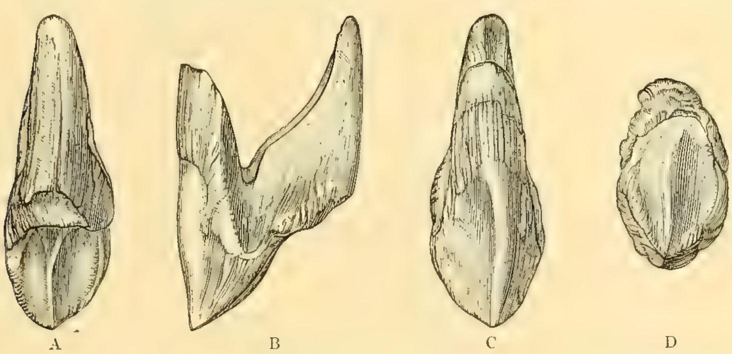

FIG. 42.—A, External view of superior tooth of type of *Triceratops serratus;* B, lateral view of same; C, internal view of same; D, crown view of same. Natural size. After Marsh.

ARRANGEMENT OF THE TEETH IN THE JAW.

In the Ceratopsia the teeth are arranged in longitudinal and vertical series after the manner shown in the accompanying figures, figs. 43 and 44. The number of teeth in each vertical series varies from one in the first at either end of the jaw to perhaps as many as eight near the middle of the jaw, while the number of teeth in each longitudinal series may be upward of forty, varying in number according to the position and perhaps also according to the age of the individual. In a single transverse section through the jaw there is never more than one vertical series of teeth in the Ceratopsia. Thus the number of teeth seen in a transverse section of a jaw at any point will equal the number of longitudinal series of teeth present in that part of the jaw.

REPLACEMENT OF THE TEETH.

The method of replacement of the teeth in the Ceratopsia is somewhat peculiar. If transverse sections be made through the jaw at the bottom of each vertical series of teeth an incipient

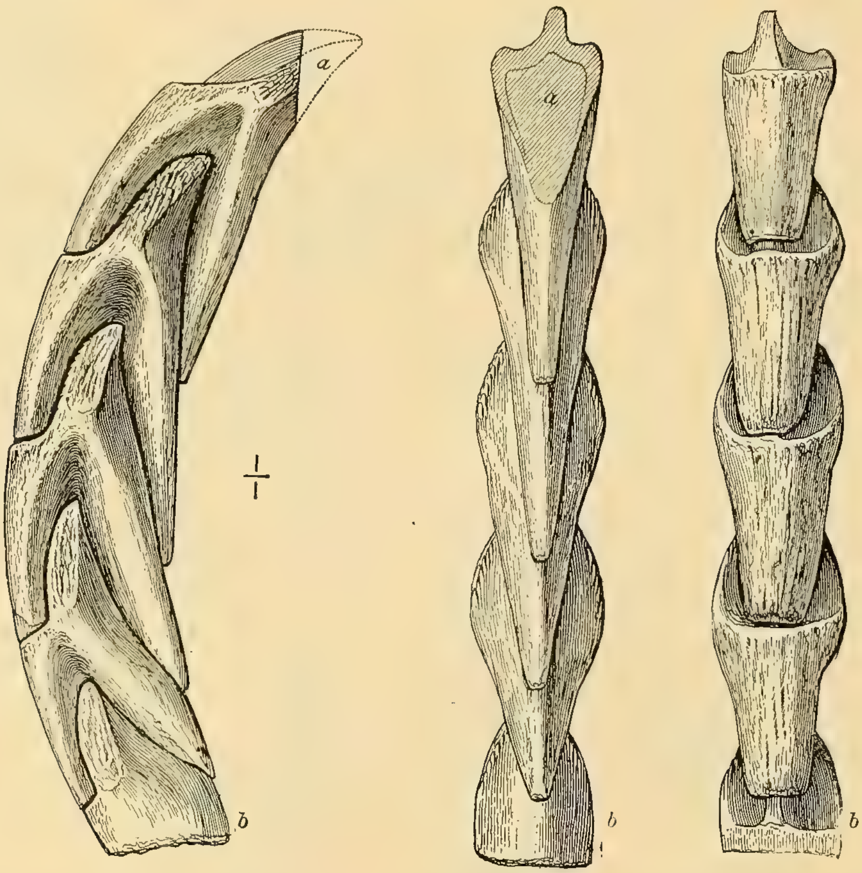

FIG. 43.—A, Back view of single vertical series of inferior teeth of *Triceratops flabellatus*, showing arrangement in jaw and method of replacement; B, external view of same; C, internal view of same. *a*, Worn surface of functional tooth; *b*, incipient tooth. Natural size.

tooth will be seen with the crown fairly well developed, as shown at *b*, fig. 43, with thin walls and a pulp cavity extending quite to the apex, while below the crown there is a single root, widely expanded and with very thin walls, as shown in the cross section at A, fig. 45. The crown of this basal tooth stands nearly vertical and it is inserted into the pulp cavity at the base of the tooth immediately above. The anterior and posterior walls of the pulp cavity in this second tooth have been much constricted, however, by the adjacent anterior and posterior basal angles of the adjacent teeth of the immediately preceding and succeeding vertical series of teeth, as shown at B, fig. 45. The crown of this second tooth in the series instead of occupying a vertical position in the jaw, as does that of the basal tooth, is inclined inward if an upper tooth and outward if a lower. Its apex is inserted into the pulp cavity of the tooth above, the anterior and posterior walls of which have now become entirely obliterated, as shown at C, fig. 45, by the crowding of the crowns of the succeeding tooth of the same vertical series and the adjacent teeth of the immediately anterior and posterior vertical series, and instead of one root there are now two roots, completely separated. The external and stronger branch of the root, if the tooth is an upper, is vertical and incloses the greater portion of what still remains of the pulp cavity. That portion of the pulp cavity adjoining the tooth immediately beneath is without a boundary wall, and the keels of the displacing tooth are inclosed by the lateral walls of the remnants of the pulp cavity still remaining in the two branches of the now completely divided root. The internal branch of the root, if the tooth be a lower, is closely applied to the dorsal surface of the displacing tooth, the keel of which is fitted into the vestigial pulp cavity of the root. The dorsal root of each tooth is projected as a strong buttress far beyond the base of the crown and forms above at its junction with the crown a broad, shallow cavity, into which the extremity of the corresponding root of the tooth above is fitted. The surface of the dorsal root bears a thick covering resembling cementum. In using the terms external and internal I have had reference to the inferior teeth; in the superior teeth the conditions as described above are entirely reversed, as shown in fig. 46. From the above description and the accompanying figures it will be seen that in the Ceratopsia

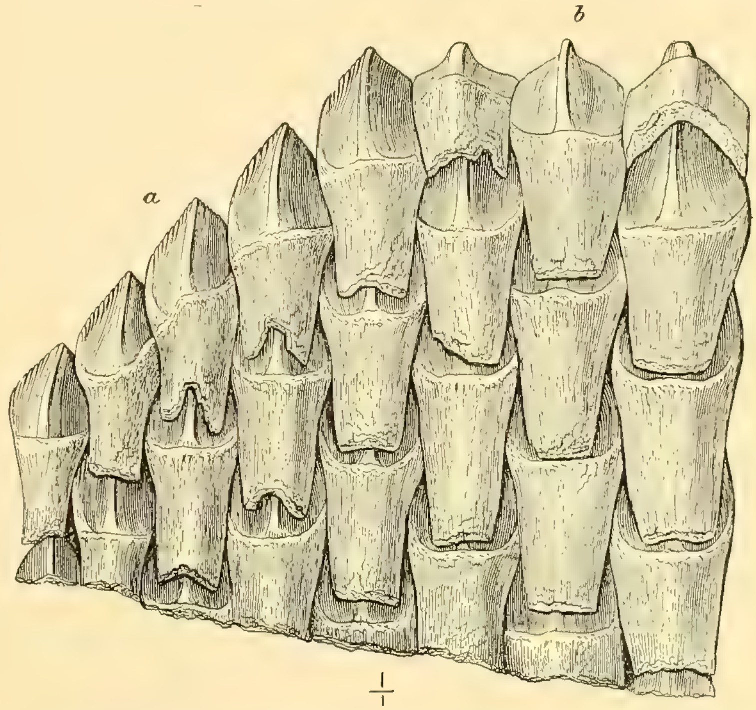

FIG. 44.—Internal view of inferior teeth of type of *Triceratops flabellatus*, as revealed by removing internal wall of right dentary at anterior extremity of dental magazine. *a*, Unworn teeth; *b*, worn teeth. Natural size.

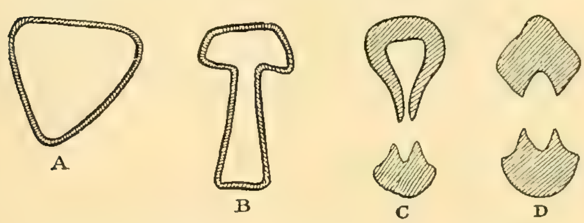

FIG. 45.—A, Transverse section through root of incipient tooth of type of *Triceratops flabellatus;* B, transverse section through root of a slightly older tooth of same; C, transverse section of root after it has become completely bifurcated; D, transverse section through root of fully adult tooth.

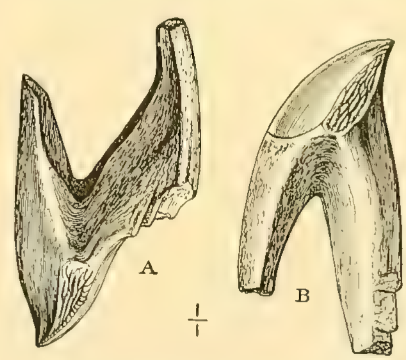

FIG. 46.—A, Superior tooth of *Triceratops*, front view; B, inferior tooth of same, same view. Natural size.

the teeth are replaced from below and that each tooth is carried upward on the crowns of three teeth pertaining to three different vertical series and two different longitudinal series. The median of these three displacing teeth is in the longitudinal series next below that of the other two and this median tooth lies immediately beneath the center of the tooth that is being displaced. The other two displacing teeth lie one anterior and the other posterior to and a little above the median, with the supero-anterior or supero-posterior border of their crowns pushing against the opposing portions of the tooth being displaced. It thus happens that each tooth during its passage upward in the jaw is assisting in pushing forward three teeth, while at the same time being itself pushed upward by three other teeth. As the small embryonic tooth, with single root left widely open, at the bottom of the capacious pulp cavity moves upward toward the alveolar border of the jaw the walls thicken, reducing the capacity of the pulp cavity, the root becomes bifurcated through the pressure brought to bear by the crowns of the teeth immediately beneath and on either side of it and it shifts from the vertical position which it at first occupied in the jaw to the nearly horizontal position which it occupies just before being shed by passing upward or downward in the jaw, as the case may be, along well-defined grooves excavated in the surfaces of the bone within the dental chamber, each groove describing the arc of a circle, as shown in fig. 47, and being opposed by a similar groove on the surface of the bone forming the opposite wall of the dental chamber.

FUNCTIONS OF THE TEETH.

In the Ceratopsia the lower jaw closes inside the upper, and the external borders of the functional lower teeth oppose the internal borders of the superior teeth in such manner that the wear in either series takes place in a vertical plane. When the mouth is closed these surfaces oppose each other laterally, and in the process of opening and closing the mouth they act like the opposing blades of a pair of shears, the teeth functioning as cutting organs rather than as crushing or masticating organs. The structure and arrangement of the teeth and jaws would seem to indicate that these animals may have fed on grasses or the stems, branches, leaves, and twigs of shrubs and trees, and that their food was taken into the mouth in considerable quantities and probably received first into large lateral pouches which lay along the external sides of the maxillaries and dentaries and which the conformation of these bones in this region would indicate were present. From these lateral pouches the food could be readily passed between the jaws, which would act on either side as double-bladed chopping knives, soon reducing it to a condition suitable for its reception into the stomach. The teeth functioned as cutting organs rather than as prehensile or crushing organs, and the food was reduced by cutting into small bits rather than by crushing or grinding into a pulp. The horny sheaths which doubtless incased the predentary and rostral bones would have been very efficient as cropping organs. Their chief function would appear to have been the gathering of suitable food, while at the same time being effective as offensive and defensive organs.

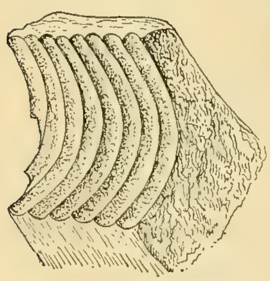

FIG. 47.—Section of maxillary of *Triceratops*, showing interior of dental magazine marked with dental grooves.

THE VERTEBRAL COLUMN.

THE VERTEBRAL FORMULA.

As nearly as can be determined the vertebral formula in *Triceratops* is as follows: Cervicals, 7 [8, R. S. L.];[a] dorsals, 14; sacrals, 10; caudals ?. There are no true lumbars. In giving the vertebral formula as above I have considered as sacrals all those vertebræ in the sacral region that are coossified by their centra. Some of these give no support to the ilia, and the anterior might perhaps better be called a sacro-lumbar, since it is in fact but a modified lumbar, while the last four are in reality sacro-caudals, representing the first four caudals which have become somewhat modified and firmly attached to the sacrum. In the type of *Triceratops brevicornus* (No. 1834, Yale Museum) the entire presacral series of vertebræ were found in position and interlocked by their zygapophyses, but unfortunately just at the junction with the sacrum the vertebræ and the

[a] See footnote, p. 47.

concretion in which they were embedded are so weathered that it is not possible to determine with certainty all the characters of this region, though it can be stated with considerable certainty that there were not more than 21 vertebræ [22] in the presacral series. The number of caudals is entirely conjectural, since in no skeleton yet found is this region sufficiently complete to make possible even a fairly probable estimate of the number of caudals. The number of cervicals is

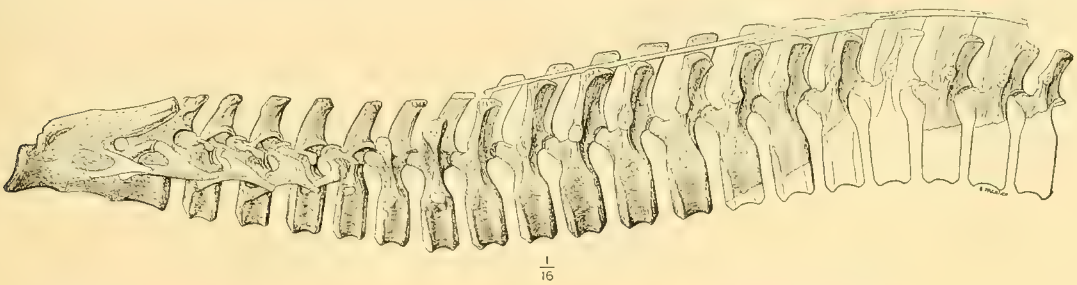

FIG. 48.—Presacral vertebral series of type of *Triceratops brevicornus*, No. 1834, Yale Museum

placed at 7 [8], and the division between the cervical and dorsal series is indicated not so much by differences in the vertebræ themselves as by the differences in the ribs which they support. These were fortunately in position in this region of the vertebral column in the type of *Triceratops brevicornus*, and the rib of the eighth [ninth] vertebra is unquestionably a thoracic rib with a strong lateral curve and differing greatly from the straight cervical ribs of the sixth [seventh] and seventh [eighth] cervicals. Between the last cervical and the first dorsal vertebræ the change is great, though far less marked than between the second and third dorsals, and were it not for the presence of the ribs, which in all herbivorous dinosaurs offer a more certain guide for distinguishing between the vertebræ of these two regions, one might very naturally be brought to the erroneous conclusion that the division between the cervical and dorsal series was between the ninth and tenth [tenth and eleventh] presacral vertebræ rather than the seventh and eighth [eighth and ninth]. The most marked difference between the ninth and tenth [tenth and eleventh] vertebræ is noticeable in the position of the capitular rib facets. The transverse process of the seventh [eighth] cervical is much more slender than that of the first dorsal. These characters are well shown in fig. 48.

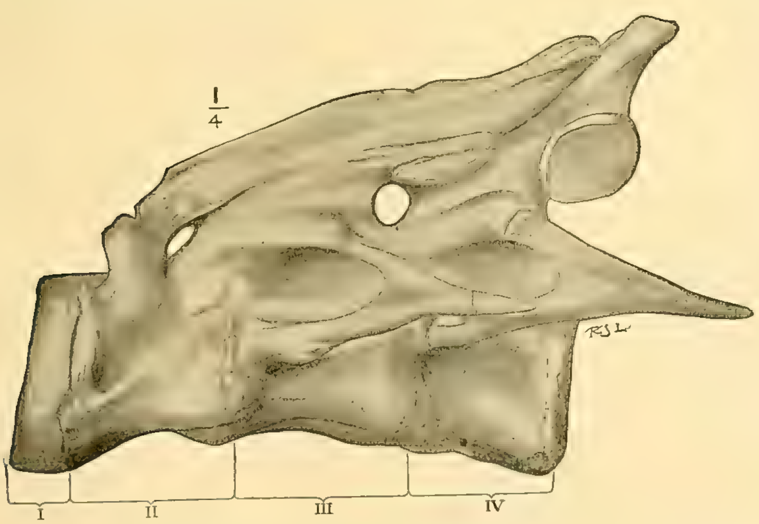

FIG. 49.—Anterior cervicals of *Triceratops prorsus*, No. 1822, Yale Museum. Drawn by R. S. Lull. One-fourth natural size.

THE ANTERIOR CERVICALS.[a]

As above stated, there are 7 [8] cervicals in the vertebral column of *Triceratops*, and it is probable that the number is constant for the different genera and species in the group. To give greater rigidity to the

[a] In a specimen, No. 1822, Yale Museum, the type specimen of *Triceratops prorsus*, a distinct suture is seen 3 to 4 mm. behind the anterior margin of the atlas measured on its inferior face and extending upward some distance on either side, indicating that the so-called atlas of Hatcher's above description is in reality the *atlas and axis*, while the axis of Hatcher represents the third and the third the fourth cervical. The atlas is therefore reduced to a ring-like bone of somewhat greater fore and aft extent inferiorly than toward its dorsal side. The *axis* bears the neural arch and spine as described above for the atlas. On the axis of *Monoclonius crassus* (p. 76, fig. 78) there are distinct facets, evidently lacking in *Triceratops* for the articulation of the first cervical rib; otherwise the anterior cervicals are quite similar in the two genera.—R. S. L.

anterior cervical region and better support to the enormous head the 3 [4] anterior cervicals are fused together by their centra, neural arches, and spines. The cup on the anterior extremity of the atlas for the reception of the occipital condyle is deep and circular. In the type of *Triceratops prorsus* (No. 1822, Yale Museum) it has a depth of 35 millimeters and a diameter of 87 millimeters. The atlas [axis] bears no cervical rib, but midway between its anterior and posterior extremities on either side on its superior border it sends upward, backward, and inward a broad, thin process. These converge and unite medially with the neural spine, forming the anterior border of the neural canal and arching over superiorly the elongated vertebrarterial canals. The anterior opening of the neural canal is large and triangular in outline with the apex of the triangle at the top. Posterior to the vertebrarterial canal the neural arch and spine are completely fused with those of the axis [third cervical], leaving no trace of the anterior zygapophyses of the axis [third cervical] or the posterior zygapophyses of the atlas [axis].

The neural spine of the axis [third cervical] is much compressed anteriorly, where, with that of the atlas [axis], it forms a sharp ridge, sloping gently backward and upward. Posteriorly it is higher, and in the type of *Triceratops prorsus* (No. 1822, Yale Museum) somewhat flattened antero-posteriorly and expanded transversely, while in the type of *Triceratops brevicornus* (No. 1834, Yale Museum) the neural spine of the axis [third cervical] continues compressed to the very summit. In the types of both species the posterior zygapophyses of the axis [third cervical] are coossified with the anterior zygapophyses of the third [fourth] cervical. Beneath and in front of the coossified zygapophyses a large circular foramen passes quite through from one side to the other and affords a means of exit for the spinal nerves given off between these vertebræ. Above and posterior to the zygapophyses the neural spine of the axis [third cervical] is closely applied to though not coossified with that of the third [fourth] cervical. Just at the middle of the base of the neural arch of the axis [third cervical] there is on either side a prominent diapophysis, and some distance below and a little anterior to this a strong parapophysial process springs from the lateral border of the centrum at a point about midway between its superior and inferior borders. These processes, which together represent the superior and inferior branches of the transverse processes, give support to the first pair of cervical ribs. They are separated by a rather deep, long cavity in the external border of the centrum.

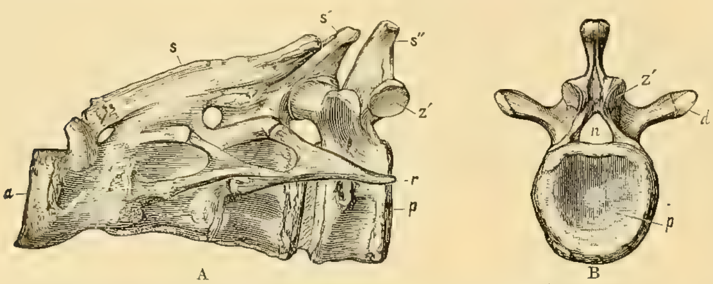

FIG. 50.—A, Anterior cervicals of type of *Triceratops prorsus*, No. 1822, Yale Museum; B, posterior view of fourth [fifth] cervical of same. *a*, Anterior face of atlas; *d*, diapophysis; *n*, neural canal; *p*, posterior face of fourth [fifth] vertebra; *r*, rib; *s*, neural spine of axis; *s′*, neural spine of third [fourth] cervical; *s″*, neural spine of fourth [fifth] cervical; *z*, posterior zygapophyses. One-eighth natural size. After Marsh.

The centrum of the third [fourth] cervical is a little shorter than that of either the atlas [atlas and axis] or axis [third cervical], and it is firmly coossified with that of the latter. The neural arches of these two vertebræ are likewise firmly coossified, as are also their opposing zygapophyses. Above the zygapophyses the spines are free, though closely applied to one another. The neural spine of the third [fourth] cervical is a little higher than that of the axis [third cervical] and has the summit much expanded transversely and slightly emarginate. The diapophysis occupies a rather more elevated position than in the axis [third cervical]. It is both longer and stronger than in that vertebra. It is directed forward and arches downward and bears at its extremity an articular facet for the tuberculum of the second cervical rib. At its base it is separated from the parapophysis by a concave surface which is not so deep as the corresponding one on the axis [third cervical]. The parapophysis is placed rather more anterior than that of the axis [third cervical] and is not so prominent, being reduced to a small round articular surface on the anterior portion of the body of the centrum. From the parapophysis a strong round ridge runs backward to the posterior end of the centrum separating the concavity already mentioned as being present below the diapophysis from the deeper one beneath the parapophysis. The inferior surface of the centrum of the third [fourth] cervical is flat but narrow, while that of the axis [third cervical] is narrow but deeply excavated, and the atlas [and axis] is broad and comparatively flat in this region. The centrum of the third [fourth] cervical is both broader and deeper than that of either the atlas [and axis] or axis [third cervical], and this is especially true of its posterior extremity.

The fourth [fifth] cervical is free and not coossified in any way with the third. Its centrum is a little broader and deeper than that of the preceding cervical; it is concave posteriorly and perhaps also anteriorly, though I can not be certain as to this since in the two instances in which we have it in position (Nos. 1822 and 1834, Yale Museum) it has not been detached from the preceding vertebra. Since, however, the centra of the immediately succeeding vertebræ are biconcave it is quite probable that that of the fourth [fifth] cervical is also. The rudimentary parapophysis is represented by a round capitular rib facet situated near the anterior extremity of the centrum and midway between its superior and inferior surfaces. There is no well-defined ridge dividing the side of the centrum into superior and inferior concavities. The diapophysis, which in this and all the succeeding presacral vertebræ may be considered as alone representing the transverse process, is situated well up on the side of the neural arch, somewhat anterior in its position to that of either of the two preceding cervicals. It is much flattened supero-inferiorly and expanded antero-posteriorly. It is directed outward and upward and presents on the posterior angle at its extremity an articular surface for the tuberculum of its cervical rib. The anterior and posterior zygapophyses are much produced and overhang respectively the anterior and posterior ends of the centrum. The neural spine rises more directly upward than in the preceding cervicals; it is more pointed and not so robust as that of the third cervical. It is much compressed near the base, where its antero-posterior dimension exceeds by several diameters the transverse, but at the summit it is much contracted antero-posteriorly and slightly expanded transversely, the latter diameter becoming the greater at the apex. The neural canal is somewhat smaller in this region of the neck than in the atlas [third cervical], and it is more nearly circular in outline. The inferior border of the centrum is a little broader than that of the third [fourth] cervical and there is a shallow and narrow median concavity which is deepest posteriorly.

THE FIFTH, SIXTH, AND SEVENTH[a] CERVICALS.

The centra of these vertebræ are subequal in length and a little shorter than the centra of the anterior cervicals. These vertebræ do not differ materially from that last described save that the inferior surfaces of the centra are broader and flatter, the capitular rib facets are successively more elevated in the posterior cervicals, and the spines are somewhat broader antero-posteriorly. The transverse processes are slightly more expanded in the posterior cervicals and the tubercular facets face backward and outward, indicating that the cervical ribs were directed backward and a little outward.

The above description of the cervical vertebræ is based on the type of *Triceratops prorsus* (No. 1822, Yale Museum), except that of the seventh, which is wanting in that specimen but is present and in its natural position in the type of *Triceratops brevicornus* (No. 1834, Yale Museum), as are also the preceding cervicals, though not in so good a state of preservation as in No. 1822, in which all the cervicals save the last are present and in an almost perfect state of preservation.

THE DORSAL VERTEBRÆ.

There are fourteen dorsals in the vertebral series of No. 1834, Yale Museum. These are all interlocked by their zygapophyses and are united in front with the complete cervical series. The anterior seven dorsals are complete. The centrum of the eighth is injured on

[a] Sixth, seventh, and eighth.—R. S. L.

its inferior border, while the centrum of the ninth is still more imperfect, and those of the succeeding dorsals have entirely weathered away. The impressions of these centra with fragments of the bone adhering are preserved in regular series in the matrix and the spines, transverse processes, and neural arches interlocked by their zygapophyses are still intact in the matrix, most of them in a perfect state of preservation, as shown in fig. 48. Posterior to the fourteenth dorsal the hard sandstone concretion in which the skeleton was found embedded was much fractured by surface weathering. Impressions of the first and second sacral centra are also preserved, together with the impression of the transverse process of the first sacral and a considerable portion of the strong parapophysis or sacral rib, given off from the point of union between the second and third sacrals and abutting against the base of the pubic process of the ilium. Most of the right ilium is represented either by the actual bone or by impressions of it in the matrix and the proximal portion of the right pubis is in position. In this skeleton we are for the first time able to fix with certainty the number of presacral vertebræ in this genus.

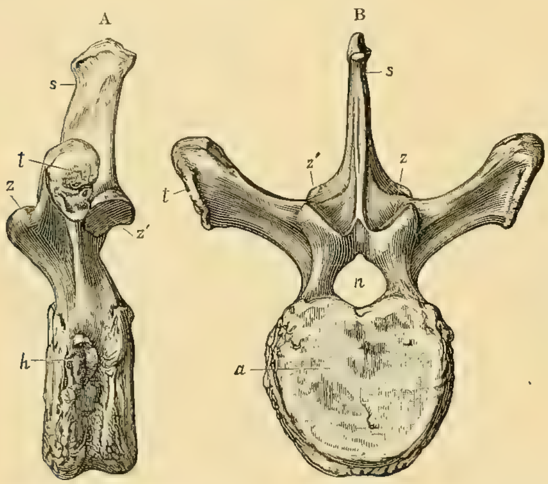

FIG. 51.—A, Anterior dorsal of *Triceratops prorsus* (No. 4842, U. S. National Museum, second dorsal of mounted skeleton), side view; B, anterior view of same. *s*, Neural spine; *t*, transverse process; *h*, capitular rib facet; *z*, anterior zygapophyses; *z'*, posterior zygapophyses; *n*, neural canal; *a*, anterior end. One-eighth natural size. After Marsh.

THE FIRST DORSAL.

The chief difference between the first dorsal and the last cervical is noticeable in the transverse process and the tubercular rib facet. The transverse process in the first dorsal is longer, not so flat, more triangular in cross section, and is inclined more directly upward, rising above the level of the zygapophyses. The tubercular rib facet is much larger and looks downward and outward in conformity with the shape and position of the first thoracic rib, instead of forward and slightly outward as in the cervicals. The capitular facet is situated at the base of the transverse process and on the superior border of the centrum, as in the last cervical. The neural spine is somewhat broader anteroposteriorly than in the last cervical. In fig. 51 there is shown a disarticulated anterior dorsal of *Triceratops prorsus*. The short and broad centrum, stout and somewhat elevated transverse processes, deeply incised posterior zygapophyses, and low neural arch are conspicuous features.

THE SECOND DORSAL.

This differs from the preceding vertebra chiefly in its more elevated and more robust transverse process and the increased size of the tubercular rib facet, which, as in the preceding vertebra, looks outward and downward. The capitular facet continues to occupy a position on the superior border of the centrum at the base of the transverse process. There is a deep cavity in the side of the centrum not seen in the succeeding dorsals and less emphasized in the preceding.

THE THIRD DORSAL.

This differs from the second dorsal, especially in the altered position of the capitular rib facet, which has now shifted from its position at the superior border of the centrum, as seen in the posterior cervicals and dorsals 1 and 2, to a position high up on the side of the neural arch and between the anterior and posterior zygapophyses. The tubercular facet also is somewhat reduced in size and faces upward and outward instead of outward and downward, as in the preceding dorsals. The transverse processes, which with the first dorsal began to increase in length and to pass from the nearly horizontal position they occupy in the cervicals to the more elevated positions which they assume in the median and posterior dorsals, are now inclined upward at an angle of about 45° from the neural spines and rise nearly on a level with the summits of the latter.

DORSALS 4 TO 14.

The structure of the succeeding dorsals is so similar that they may best be described together by calling attention to those characters wherein they differ from one another and from the preceding dorsals. The capitular facet, which, as already noticed, suddenly shifted to a more elevated position on dorsal 3, gradually continues to move upward on the succeeding dorsals until in the fifth it is seen to be leaving the neural arch and moving out on the inferior surface of the transverse process. This continues until in the posterior dorsals it occupies a position midway between the apex and base of the transverse processes, which are a little shorter and somewhat weaker in this region than in the middorsal series. The antero-posterior diameter of the neural spines is also somewhat greater in the posterior and middorsal regions, and the transverse processes increase both in length and strength until about the tenth, when they become a little more slender and somewhat shorter as we proceed posteriorly. The neural arches are throughout of about equal height. Every dorsal vertebra has two rib facets, a capitular and tubercular, showing that the ribs were double headed throughout. In the middorsal region there are a number of long, flat, ossified tendons lying on either side of the neural spines near their summits and closely applied to them, as shown in fig. 48.

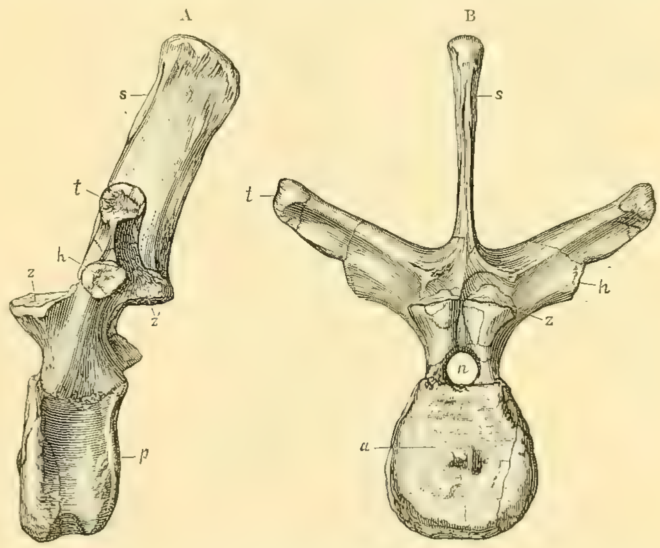

FIG. 52.—A, Lateral view of posterior dorsal of *Triceratops prorsus*, No. 4842, U. S. National Museum, last dorsal of mounted skeleton; B, anterior view of same. *s*, Neural spine; *t*, transverse process; *h*, capitular facet; *z*, anterior zygapophyses; *z'*, posterior zygapophyses; *n*, neural canal; *a*, anterior; *p*, posterior. One-eighth natural size. After Marsh.

In fig. 52 there is shown a detached posterior dorsal of *Triceratops prorsus*. As will be noticed by a comparison of this figure with fig. 51, the neural spine is much broader, the incisions of the neural arch for the anterior and posterior zygapophyses are much deeper, the capitular rib facet has moved far out on the inferior surface of the transverse process, the centrum has become proportionally higher and narrower, the neural canal is smaller, and the neural arch is more constricted.

THE SACRUM.

The sacrum is composed of ten coossified vertebræ. The centra of the median sacrals are somewhat compressed, but the centra of both the anterior and posterior sacrals are heavier and more expanded. Although ten vertebræ are firmly united by their centra to form the sacrum, not all of these should be regarded as true sacrals. The first of these ten coossified vertebræ should be more properly regarded as a sacro-lumbar or dorso-sacral, and Marsh considered the two anterior sacrals as such, while four or perhaps five of the posterior of these coossified vertebræ should be regarded as sacro-caudals, thus reducing the number of true sacrals to four or five according to the number that have been eliminated as dorso-sacrals and sacro-caudals.

Seen from below, as shown in fig. 53, the sacrum presents a strong median bar formed by the united sacral centra, each of which gives rise on either side to a transverse process or sacral rib. The extremities of these transverse processes form together the periphery of an oval, so that the outline of the sacrum is an oval with the antero-posterior diameter much the longer. The inferior border of the sacrals is marked by a broad, shallow groove commencing with the centrum of the third sacral and extending to that of the tenth. The first sacral, or that vertebra which I have interpreted as a dorso-sacral, supports a short, flat diapophysial process, which curves backward at its distal end and is firmly united with a similar but somewhat longer process from the second sacral. These two processes inclose between them an elongated foramen. The diapophyses of the three succeeding vertebræ are likewise united at their extremities and inclose elongate foramina, as shown in fig. 55, where a superior view of the same sacrum is shown. Neither the first nor the second sacral gives off parapophysial processes, and it might therefore be better to regard both these vertebræ as dorso-sacrals, as Marsh suggested. At the union of the second and third sacrals a very strong parapophysis is given off. This process arises quite as much from the second sacral as from the third, and it is from this fact that I have regarded this vertebra as a true sacral rather than a dorso-sacral. The unusually strong parapophysial process springing from the union of the second and third sacral centra is directed backward and outward. It is much expanded at its distal extremity, where it unites with similar processes springing from the union of the three succeeding sacral centra to form the strong acetabular bar of the sacrum constituting the superior and inner wall of the acetabulum. This acetabular bar is formed by the union of the distal extremities of the four anterior parapophyses, which inclose a series of three large, elongated foramina, larger than those inclosed by the anterior diapophyses. Back of the acetabulum the transverse processes are simple and decrease in length from the seventh to the tenth sacral, the transverse process of the latter being greatly reduced in length.

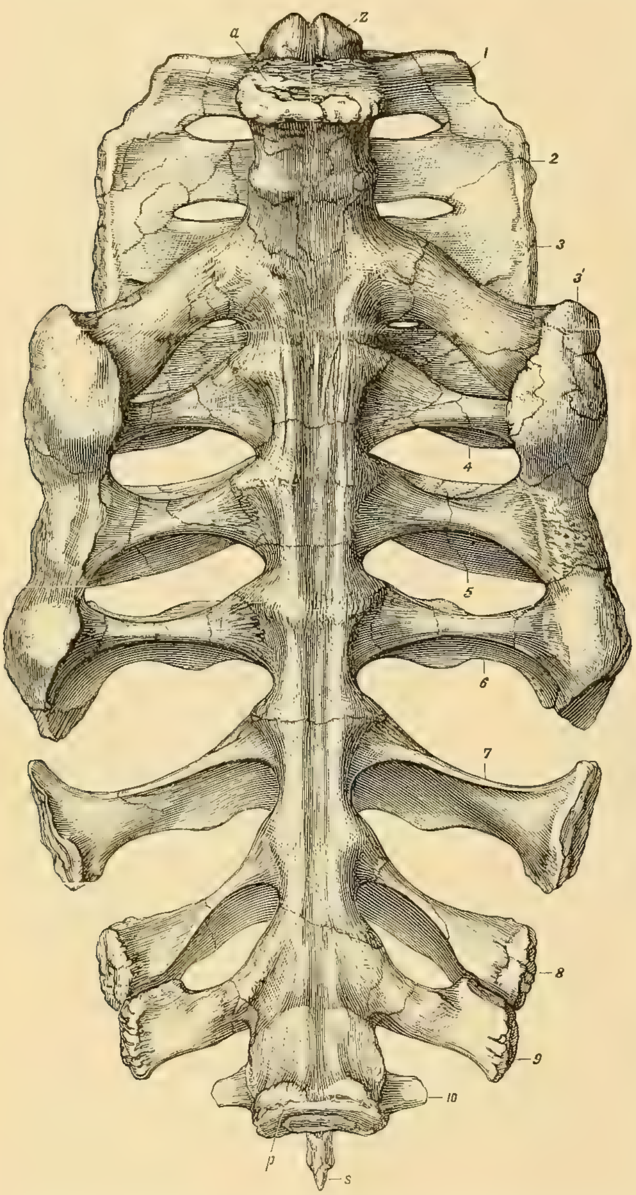

FIG. 53.—Inferior view of sacrum of *Triceratops prorsus*, No. 4842, U. S. National Museum, in mounted skeleton. *a*, Anterior sacral; *p*, posterior sacral; *s*, neural spine of last sacral; *z*, anterior zygapophyses of first sacral; *1* to *10*, transverse processes of left side. One-eighth natural size. After Marsh.

Only four of the sacrals bear diapophyses and parapophyses. These are the third, fourth, fifth, and sixth, and it would perhaps be better to consider these four vertebræ as the only true sacrals. The transverse processes of the eighth and ninth sacrals are in contact, though not coossified at their extremities, and inclose a large and elongate foramen. The transverse process of the seventh sacral is expanded at its extremity, but it is widely separated from the transverse processes of the preceding and succeeding sacrals.

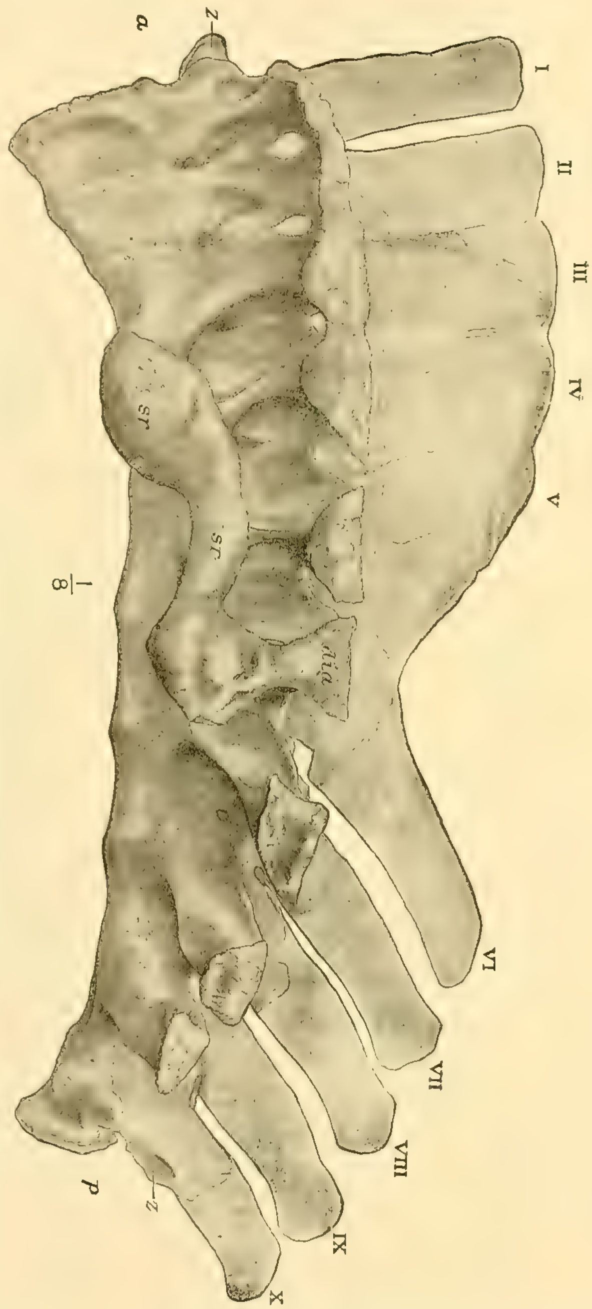

Fig. 54.—Side view of sacrum of *Triceratops prorsus*, No. 4842, U. S. National Museum, in mounted skeleton. *a*, Anterior; *p*, posterior; *dia*, diapophysis; *sr*, fused ends of parapophyses, or sacral ribs; *z*, zygapophysis. Drawn under the direction of Professor Marsh. One-eighth natural size.

Seen from the side the sacrum is strongly arched upward with the neural spines of the true sacrals coossified and forming a strong bony plate. Beginning with the second sacral and continuing to the ninth the extremities of the diapophyses are expanded and present rugose surfaces for contact with the ilium, as shown in figs. 54 and 55.

Viewed from above the neural spines appear much compressed. The anterior diapophyses are shorter than the parapophyses and broader and thinner than the diapophyses of the posterior sacrals. As shown in fig. 55, all the diapophyses are in contact with and give support to the ilium, save those of the first and last sacrals.

There is an enlargement of the spinal cord in the anterior portion of the sacrum, as shown in fig. 56, though it is not so pronounced as in *Stegosaurus*. Between each pair of sacral vertebræ a pair of nerve branches are given off from the spinal cord, and there was a marked constriction in the spinal cord just at each of the points where these branches have their origin.

THE CAUDAL VERTEBRÆ.

Unfortunately only a few scattered caudal vertebræ of *Triceratops* are known, and it is quite impossible to determine the exact number of vertebræ in the tail.

The first caudal, as shown in fig. 57, has the centrum broader than long. The neural spine is strong, expanded at the apex, and is directed upward and backward at an angle of about 45°. The transverse processes are rather short and are directed outward at right angles to the centrum. The centrum is flat beneath and is broader than deep. The neural arch is low and is not so deeply incised for the zygapophyses as in the presacrals, more especially the dorsals.

The median caudals, as shown in fig. 58, have slightly biconcave and short centra. The vertical and transverse diameters are nearly equal. The transverse processes are shorter and less elevated, and the neural arches are proportionally somewhat higher than in the first caudal.

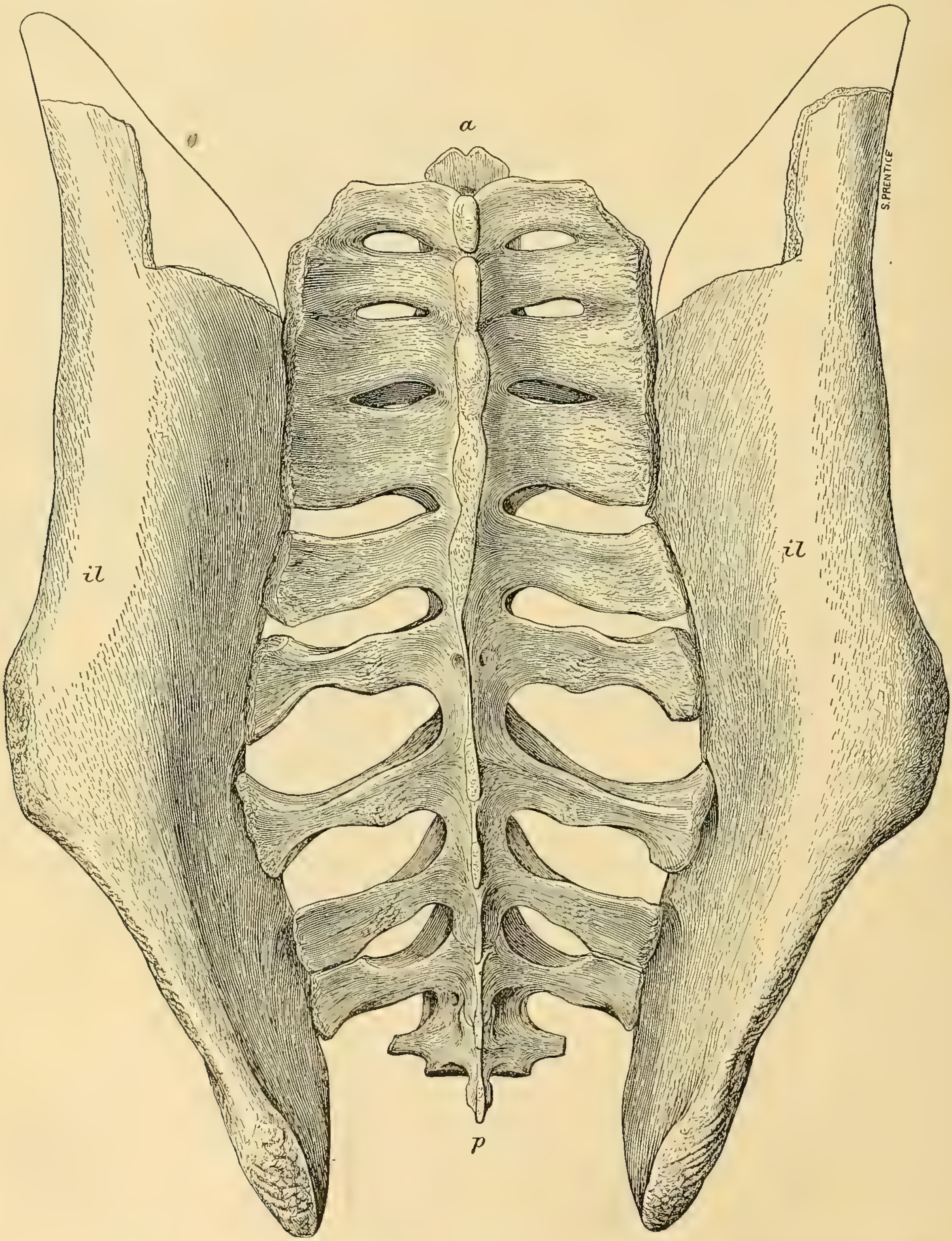

FIG. 55.—Superior view of sacrum, with ilia in position, of *Triceratops prorsus*, No. 4842, U. S. National Museum, in mounted skeleton. *a*, Anterior; *p*, posterior; *il*, ilium.

There are facets on the inferior surface of the centrum for the articulation of the chevrons, each of which articulated with two centra.

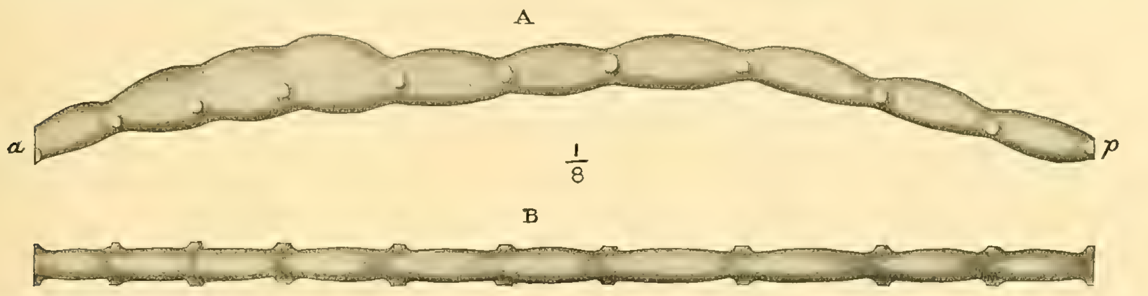

FIG. 56.—Spinal cord of sacrum of *Triceratops prorsus*, No. 4842, U. S. National Museum. A, Lateral view; B, superior view. *a*, Anterior; *p*, posterior.

The distal caudals are longer than broad, have nearly circular extremities, and are slightly biconcave. The neural arches are proportionally higher and there are no transverse processes, as shown in fig. 58.

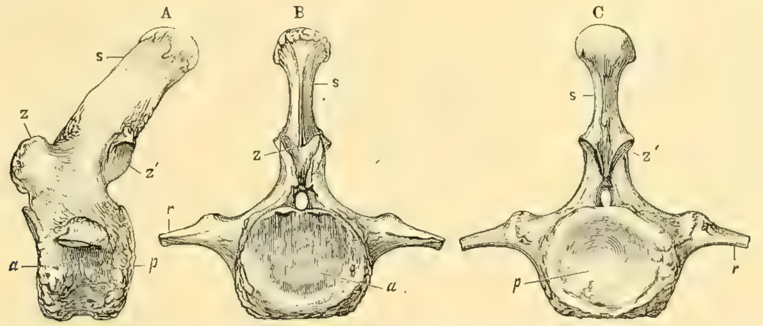

FIG. 57.—First caudal of *Triceratops prorsus*, No. 4842, U. S. National Museum, mounted skeleton. A, Side view; B, anterior view; C, posterior view. *a*, Anterior; *p*, posterior; *s*, neural spine; *z*, anterior zygapophyses; *z'*, posterior zygapophyses; *r*, rib borne on the transverse process. One-eighth natural size. After Marsh.

OSSIFIED DORSAL TENDONS.

In the type of *Triceratops brevicornus*, No. 1834, Yale Museum, there are preserved a number of flattened and elongate rod-like ossified tendons, commencing with the third dorsal and continuing on either side of the neural spines as far back as the posterior dorsals. It is probable that these ossifications were present also in the sacral and anterior caudal region, although from the imperfect condition of the material at hand it is impossible to determine this point with certainty. These ossifications are shown in fig. 48. In cleaning the type of *T. calicornis* Mr. C. W. Gilmore has found these ossifications along the sacrum.

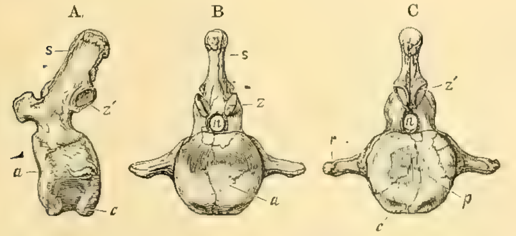

FIG. 58.—Median caudal of *Triceratops prorsus*, No. 2580, U. S. National Museum, seventh caudal of mounted skeleton. A, Lateral; B, anterior; C, posterior views. *n*, Neural canal; *c*, facet for chevron; other letters as in fig. 57. One-eighth natural size. After Marsh.

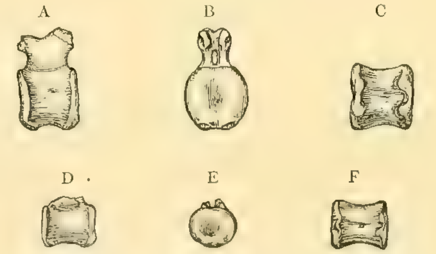

FIG. 59.—Distal caudals of *Triceratops*. A, B, C, Lateral, anterior, and inferior views; D, E, F, same views of a more posterior caudal. One-eighth natural size. After Marsh.

THE PELVIS.

As shown in fig. 60, the pelvis in the Ceratopsia is very characteristic. All three of the elements usually found in the pelvis of the Dinosauria are present and enter into the construction of the acetabulum, which is more nearly closed internally than is common in that group.

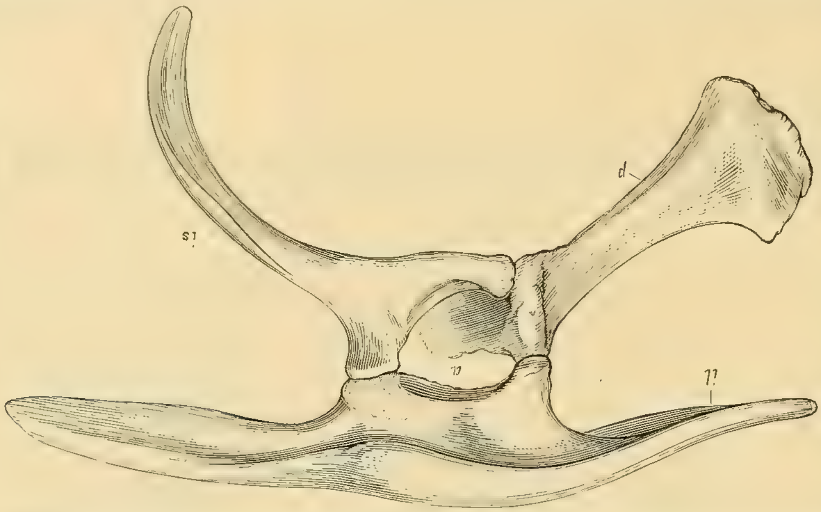

FIG. 60.—Pelvis of *Triceratops flabellatus* Marsh, No. 1821, Yale Museum, as seen from left side. *il*, Ilium; *p*, pubis; *is*, ischium; *a*, acetabulum. One-twelfth natural size. After Marsh.

THE ILIUM.

The ilium is the largest of the pelvic bones. It consists of a broad and elongate plate much expanded anteriorly, but more pointed and somewhat thickened posteriorly. When in position this iliac plate occupies a horizontal rather than a vertical or inclined plane, thus differing materially from that position which this element assumes in other members of the Dinosauria. Externally it presents throughout its entire length a rather thin and smooth edge or border, but the internal border, save near the anterior extremity, is thick and presents rugosities for contact with the transverse processes of the sacrum, as shown in fig. 55. The anterior and posterior wings or blades of the ilium are nearly equal in length. Near the middle the internal border of the ilium is greatly thickened and produced downward to form the superior border of the acetabulum and the ischiac and pubic peduncles. The ischiac peduncle is broader than the pubic, but not so much produced beneath the superior border of the ilium.

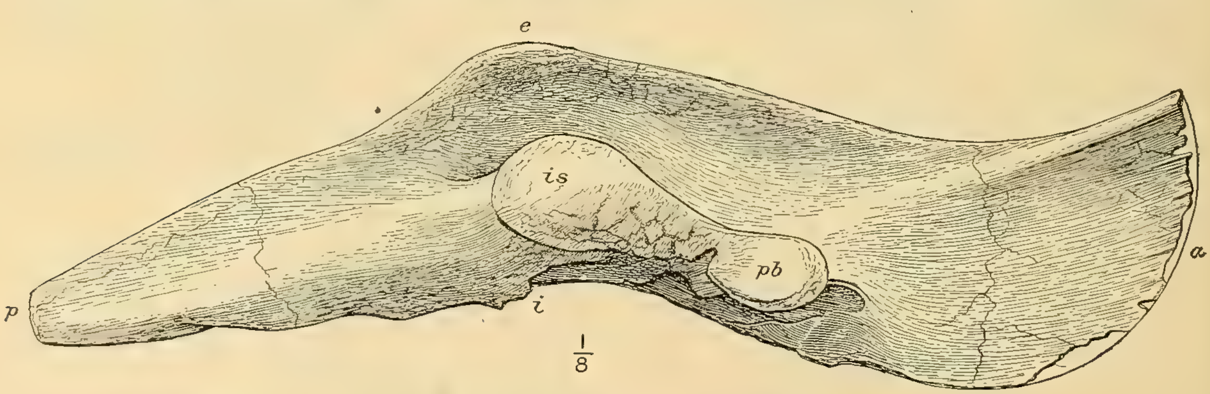

FIG. 61.—Inferior view of right ilium of *Triceratops flabellatus* Marsh, No. 1821, Yale Museum. *a*, Anterior end; *p*, posterior; *i*, internal border; *e*, external border; *is*, ischiac peduncle; *pb*, pubic peduncle. One-eighth natural size.

In fig. 61 there is given an inferior view of the ilium of the type of *Triceratops flabellatus* Marsh, No. 1821, Yale Museum. This shows well the characteristic form of the ilium in the

Ceratopsia. The external and internal borders each describe a sigmoid curve. The anterior end of the ilium is broad, the posterior narrow. The width of the ilium continues uniform from the anterior extremity to a point just back of the ischiac peduncle.

THE PUBIS.

As shown in fig. 62, the pubis in *Triceratops* is composed of a well-developed prepubic element and a rudimentary postpubis. The shaft is constricted medially and rather flat, the vertical diameter being the longer. It expands distally into a rather broad blade and is directed downward and forward, but not inward. The distal extremities of the pubis were not in contact. Near the proximal end of the pubes the external surface is produced into a projecting rugose ridge, which extends entirely across the bone and forms the anterior border of the

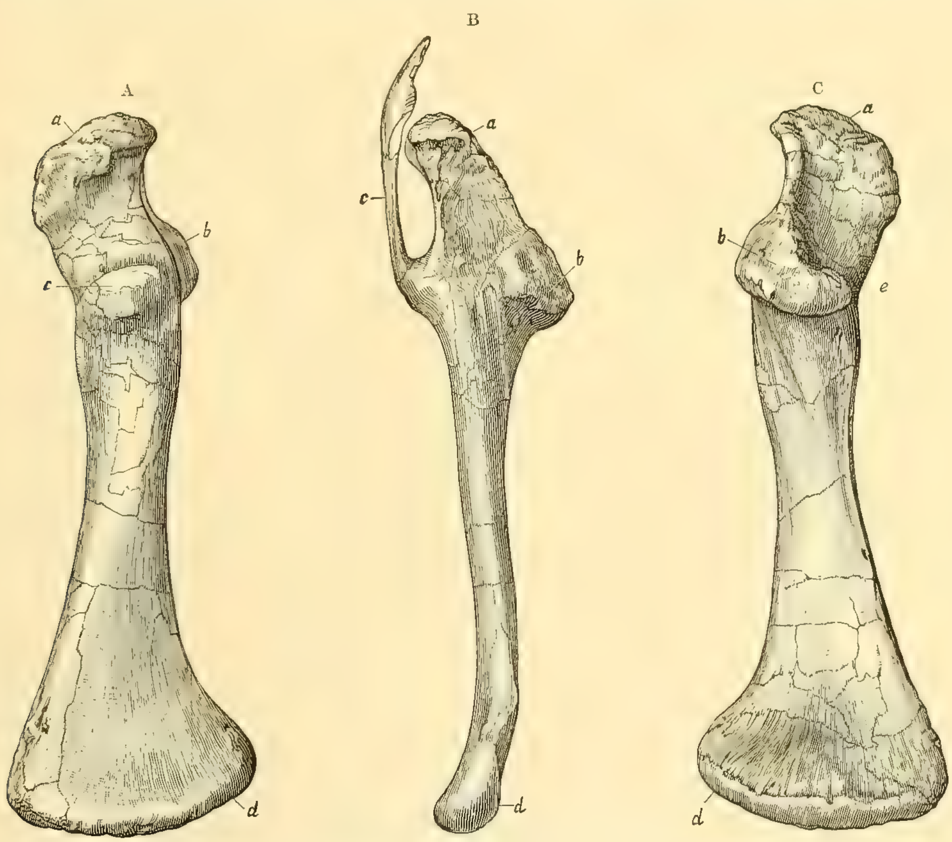

FIG. 62.—Left pubis of *Triceratops prorsus* Marsh, No. 4842, U. S. National Museum, in mounted skeleton; B, superior view; C, external view. *a*, Proximal end; *b*, surface for pubic peduncle; *c*, postpubis, broken away in A and C; *d*, distal end; *e*, surface for contact with ischium. One-eighth natural size. After Marsh.

acetabulum, presenting above an articular surface for contact with the pubic peduncle of the ilium, and beneath another for contact with the antero-inferior projection of the proximal end of the ischium. Posterior to this ridge the pubis is developed into a broad process, which is rugose on its external surface and forms the internal wall of the acetabulum, which is more nearly closed in the Ceratopsia than in any of the other herbivorous dinosaurs. In this respect these dinosaurs approach those conditions which prevail in the Mammalia.

THE ISCHIUM.

This is the most slender of the bones of the pelvis. As shown in figs. 60 and 63, it consists distally of a slender, rod-like shaft, which curves downward and inward and meets that of the opposite side medially in an extended cartilaginous symphysis, as shown in fig. 63.

Proximally it is expanded and presents a rugosity for articulation with the ischiac peduncle, while sending downward and forward a process which articulates at its extremity with the pubis. The proximal end of the ischium forms the inferior and most of the posterior border of the acetabulum.

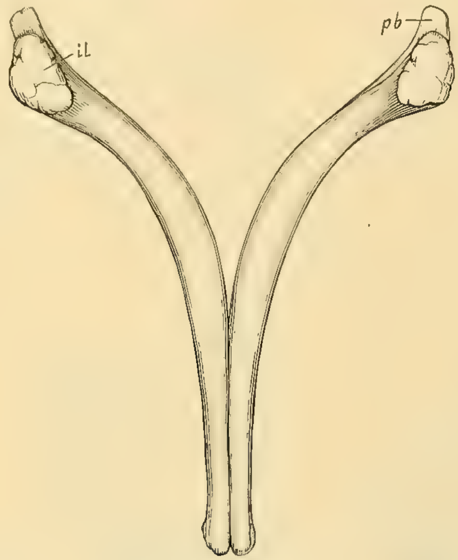

FIG. 63.—Posterior view of ischia of *Triceratops prorsus* Marsh, No. 1822, Yale Museum. *pb* Pubic surface; *il*, iliac surface.

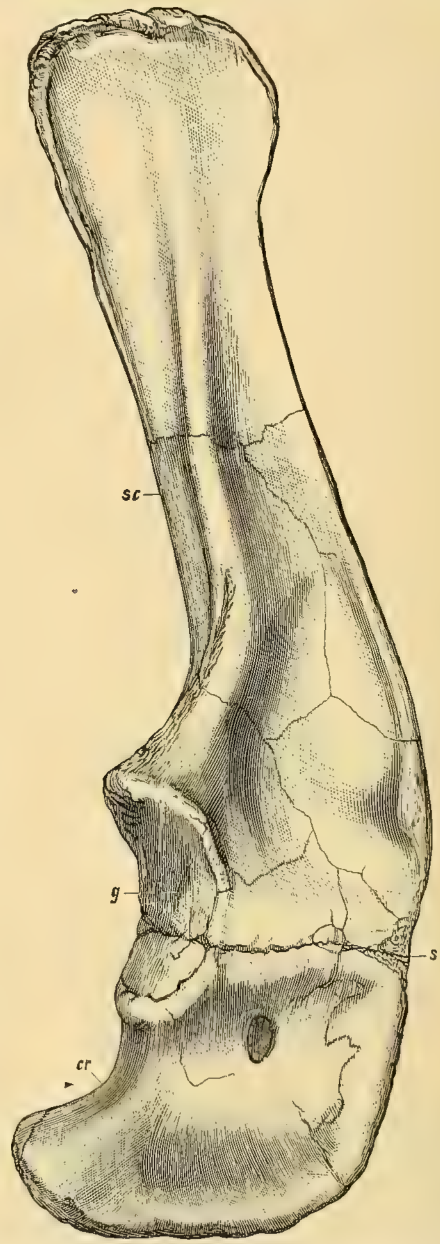

FIG. 64.—External view of right scapula and coracoid of *Triceratops prorsus* Marsh, No. 4800, U. S. National Museum, in mounted skeleton. *sc*, Scapula; *g*, glenoid cavity; *cr*, coracoid; *s*, suture between scapula and coracoid. One-eighth natural size. After Marsh.

THE SHOULDER GIRDLE.

So far as at present known the scapula and coracoid were the only elements preserved in the pectoral arch. Nothing representing either a clavicle or a sternal has yet been found. It is more than probable, however, that sternals were present.

THE SCAPULA.

As shown in fig. 64, the scapula is long and flat, especially at the upper extremity, which is thin and somewhat expanded antero-posteriorly. Just below the upper end of the scapula a ridge appears at about the middle of its outer surface and continues downward throughout about two-thirds of the length of the bone, gradually approaching the posterior border of the blade of the scapula, when it rapidly becomes more elevated and is directed more abruptly backward, extending beyond the posterior border of the blade of the scapula and giving support to the glenoid cavity. This is doubtless homologous with the spine of the scapula in mammals, and, like that element, it divides the blade of the scapula into a smaller prescapula and a larger postscapula, with prescapular and postscapular fossæ, as in the Mammalia. The scapula is broadest and thickest at the superior border of the glenoid cavity, which is rather high and of moderate depth and is formed by both the scapula and the coracoid, the former contributing rather more than the latter to its construction.

THE CORACOID.

The coracoid is united by suture with the scapula and forms the inferior portion of the glenoid cavity. The anterior and inferior borders of the coracoid are turned inward and describe together a nearly complete semicircle. This border is much thickened at the postero-inferior angle, and this thickening might be considered as indicative of the presence of sternals. There is a rather deep notch between the inferior border of the coracoid and the glenoid cavity. The coracoid foramen is large, and its elliptical internal opening is situated some distance below the coraco-scapular suture and midway between the anterior and posterior borders of the bone.

THE RIBS.

Besides the so-called sacral ribs borne by the sacrals in the Ceratopsia all regions of the vertebral column bear ribs. These begin with the axis and continue to the anterior caudals. There are therefore present in the Ceratopsia cervical, dorsal, and caudal ribs.

THE CERVICAL RIBS.

All the cervical vertebræ except the atlas [and axis] bear double-headed cervical ribs, as shown in fig. 48. The ribs of the posterior cervicals are longer than those of the anterior, but are straight and not arched, as are the ribs of the dorsal region. They are thin, flat bones, pointed distally, but at their proximal extremities they branch and form tubercular and capitular processes, the indentation being more marked than in the ribs of the dorsal region.

THE DORSAL RIBS.

Commencing with the eighth [ninth] presacral vertebra the ribs assume a different form and position. Instead of being straight and directed backward, as in the cervical region, they are curved with the arch outward and are directed downward, so as to inclose the thorax and to some extent also the abdomen. These are the ribs of the dorsal region. They are all double headed, and in the anterior ribs the tuberculum and capitulum are well separated, as would be expected from the positions of the tubercular and capitular facets, which are situated, respectively, on the extremity of the transverse process and the sides of the centra. In the posterior ribs, however, the capitulum is not so far removed from the tuberculum, since in this region of the vertebral column the capitular facet has shifted its position from the side of the centrum to the anterior and inferior surface of the transverse process midway between the extremity of that process and its point of union with the neural arch. The anterior and median dorsal ribs are stout and much arched, while the posterior are more slender and straighter.

THE CAUDAL RIBS.

These are reduced to short, straight, pointed ossicles at the extremities of the transverse processes, with which they early become coossified, though leaving a distinct trace of the suture, as shown in fig. 57. The ribs soon disappear in the more posterior caudals. The caudal ribs differ from the presacral ribs in being single headed.

THE FORE LIMB AND FOOT.

All three of the elements of the fore limb are present in the Ceratopsia. The limb as a whole is proportionally shorter than the hind limb and the individual bones are somewhat more robust than are the corresponding bones of the hind legs. Thus the animal was not so high at the shoulders as at the hips. This shortening of the fore limbs and feet in the Ceratopsia is correlated with the abbreviated cervical region, which, as we have already seen, consists of seven [eight] short vertebræ. These conditions enabled the animal readily to bring the anterior extremity of the head on a level with the feet, facilitated the necessary movements of the head by reducing the range of possible motion, and gave increased power to the muscles controlling those movements by bringing the fulcrum nearer the weight, conditions absolutely necessary considering the enormous weight of the skull and its investing musculature. Anterior and posterior views of the humerus are shown here in figs. 65 and 66, while external and internal lateral views of the fore limb may be seen in the restoration of the skeleton in Pl. XLIX.

THE HUMERUS.

The humerus is greatly expanded at either extremity, but much constricted just below the radial crest, which is exceptionally well developed and extends from the superior extremity down the antero-internal border throughout about two-thirds the length of the bone. The head is situated in about the middle of the proximal end and is produced only a little backward beyond the posterior border of the shaft of the humerus. At the distal end the radial and ulnar condyles are well differentiated and separated by broad and deep trochlea.

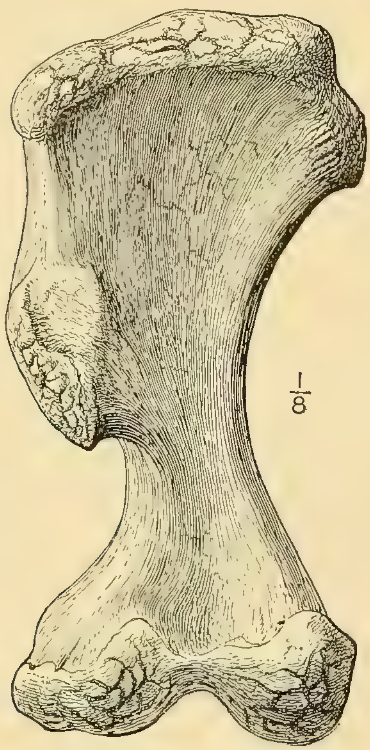

FIG. 65.—Anterior view of right humerus of *Triceratops prorsus* Marsh, No. 4842, U. S. National Museum, in mounted skeleton. One-eighth natural size.

FIG. 66.—Posterior view of right humerus of *Triceratops prorsus* Marsh, No. 4842, U. S. National Museum, in mounted skeleton. *h*, Head; *r*, radial crest; *rc*, radial condyle; *uc*, ulnar condyle. One-eighth natural size. After Marsh.

The anconeal fossa is shallow, scarcely exceeding in depth the cavity situated directly opposite on the anterior face of the humerus. The humerus is proportionally somewhat longer when compared with the femur than are the bones of the fore arm as compared with the tibia and fibula. The general form of the humerus is well shown in figs. 65 and 66.

THE ULNA.

The ulna is extremely massive above, but smaller below. There is a slight constriction in the shaft a little above the distal extremity. The olecranon is massive and is produced far above the proximal end of the radius, as in most mammals, conditions differing materially from those which obtain in this element in most dinosaurs.

THE RADIUS.

The radius is slender when compared with the ulna. It is of moderate strength, however, and somewhat expanded at either extremity. The shaft is subcircular in cross section, and continues rather uniform throughout its entire length. The form is well shown in fig. 68.

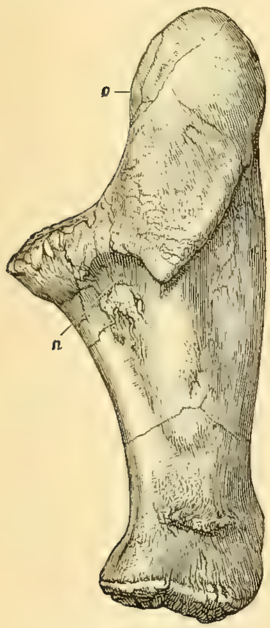

FIG. 67.—Anterior view of ulna of *Triceratops prorsus* Marsh, No. 4842, U. S. National Museum, in mounted skeleton. *o*, Olecranon process; *r*, surface for proximal end of radius. One-eighth natural size. After Marsh.

THE CARPUS.

Nothing is known of the structure of the carpus in the Ceratopsia, and I refrain from offering any suggestions as to what elements entered into its construction or the probable character of any of them. Future discoveries will doubtless make known its structure.

THE METACARPUS.

This was composed of four well-developed metacarpals, as shown in fig. 69. The metacarpals were much shorter than the metatarsals. Metacarpal III was the largest of the series, but was nearly equaled in size by II and IV, while metacarpal I was smaller than the others. All the metacarpals were functional. Their form is well shown in fig. 69 and in Pl. XVII. In all the metacarpals the shafts were constricted, with the extremities much expanded.

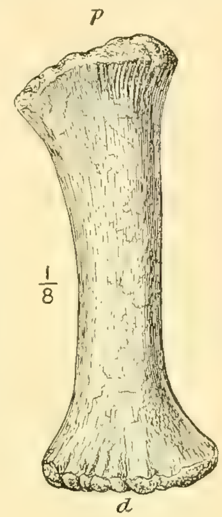

FIG. 68.—Radius of *Triceratops serratus* Marsh, No. 970 American Museum of Natural History. *d*, Distal extremity; *p*, proximal extremity. One-eighth natural size.

THE PHALANGES.

Nothing is definitely known of the number or arrangement of phalanges in the manus of the Ceratopsia. From the nature of the metacarpals, however, there can be no reasonable doubt that the manus was mesaxonic in structure, and that the phalanges of the third digit were larger than those of the lateral digits, while it is quite possible, also, that the middle digit may have borne one phalanx more than digits II and IV and perhaps two more than did the first digit, though these are mere conjectures and have not as yet been confirmed by direct observations. No manus even fairly complete has as yet been discovered. The phalanges of the proximal series are of moderate length, with the longitudinal diameter exceeding the transverse. The intermediate phalanges are short, the transverse diameter exceeding the longitudinal. The unguals are broad and depressed. They are laterally expanded distally and constricted proximally. They exhibit a coarse cancellous structure, and during the life of the animal were evidently incased in a horny substance resembling hoofs. The form and character of the various phalanges are well shown in fig. 70.

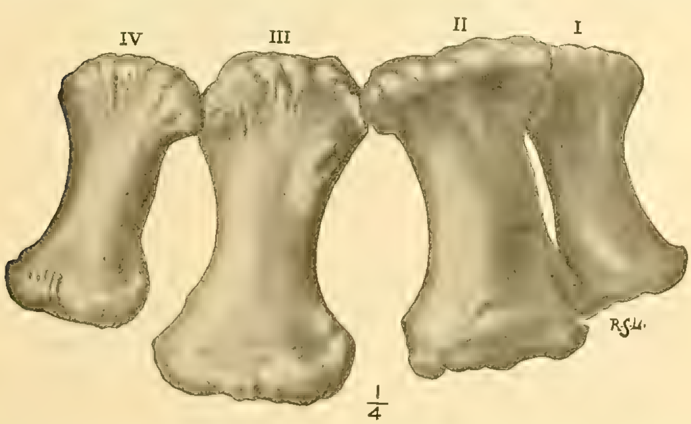

FIG. 69.—Anterior view of metacarpals of *Triceratops serratus*, No. 970, American Museum of Natural History. One-fourth natural size. Drawn by R. S. Lull.

THE HIND LIMB AND FOOT.

The hind limb and foot in *Triceratops* is longer than the fore limb and somewhat more slender, though it also may be regarded as robust.

THE FEMUR.

The femur is half as large again as the tibia. The shaft is constricted and somewhat elliptical in cross section, with the transverse diameter the longer. It is much expanded at either extremity. Proximally the head is well differentiated from the shaft and the greater trochanter by a marked constriction or neck. It is directed upward and inward at an angle of about 45° to the longitudinal axis of the femur. The articular surface of the head is rugose and exhibits a convoluted structure, which is continued out upon the superior surface of the greater trochanter. The latter is expanded antero-posteriorly, inclosing externally a deep digital fossa. About midway between the head and the distal end of the femur there is a rudimentary fourth trochanter situated on the postero-internal border of the bone. The distal end of the femur is rather more expanded transversely than antero-posteriorly. The external condyle is larger than the internal. The intercondylar notch is very deep and narrow. The external condyle sends backward a considerable projection, which is narrow and constricted just opposite the bottom of the intercondylar notch. The principal characters of the femur are well shown in fig. 71 and Pls. XIV and XV.

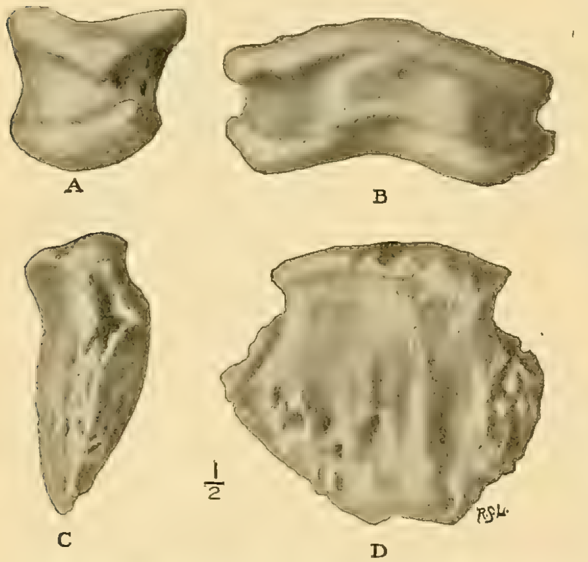

FIG. 70.—Phalanges of the manus of *Triceratops serratus*, No. 970, American Museum of Natural History. A, B, Intermediate phalanx, viewed from the front and side; C, D, ungual phalanx, viewed from front and side. One-half natural size. Drawn by R. S. Lull.

THE TIBIA.

The tibia is short, much constricted medially, but greatly expanded at either extremity. At the distal extremity this expansion is almost entirely in a transverse direction, there being no marked antero-posterior expansion. There is no well-defined internal malleolus on the inner side, but the external border is developed into a very prominent process, forming somewhat less than one-half the distal extremity of the tibia. This process falls a little below the inferior border of the astragalus and closely embraces that element on its external surface. It may be regarded as having performed the same functions as did the external malleolus or distal end of the fibula in the Mammalia. Its anterior surface was in contact with the distal extremity of the fibula. The principal characters of the tibia are shown in fig. 71 and Pl. XVI.

THE FIBULA.[a]

I have not observed this bone in the genus *Triceratops* or any of the Laramie forms of the Ceratopsia. It was doubtless present, however, though much reduced. In describing the genus *Triceratops* Marsh[b] says of it: "The fibula is very slender and the distal end was closely applied

[a] An admirably preserved fibula was found with the skull (No. 970, American Museum of Natural History) described by Lull as pertaining to *Triceratops serratus* Marsh. This bone, which is here figured (fig. 72), is long and very slender, with a subcylindrical shaft and flattened, expanded extremities. Proximally the bone is crushed so as to exaggerate the flattening to some extent. The face which was applied to the tibia is plane, while the outer surface is convex. The articular face is rounded and rugose. The distal articular extremity is much flattened and was evidently closely applied to the front of the tibia. The articular face is concave and oblique with reference to the long axis of the shaft. A somewhat roughened area of considerable size, for muscular attachment, occurs on the outer surface of the shaft about one-third the length of the bone from the distal end.—R. S. L.

[b] Dinosaurs of North America, p. 214.

to the front of the tibia." This is probably correct, though I am unable to ascertain that this description was based upon an actual specimen of the bone in question. In *Monoclonius*, an earlier and smaller form, the fibula was present but rather slender, as shown in fig. 88.

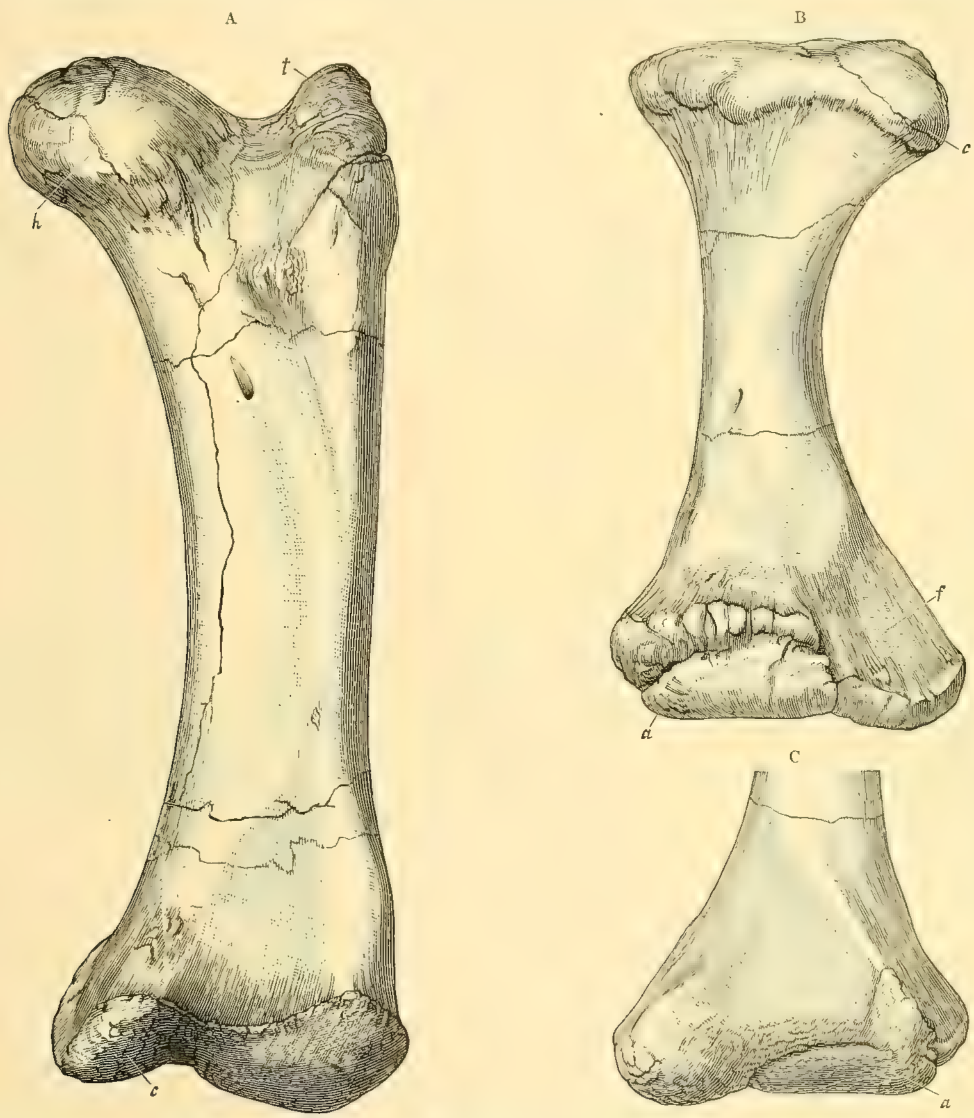

FIG. 71.—A, Anterior view of left femur of *Triceratops prorsus* Marsh, No. 4842, U. S. National Museum, in mounted skeleton: *h*, Head; *t*, greater trochanter; *c*, internal condyle. B, Front view of left tibia of same. No. 4842, U. S. National Museum, in mounted skeleton: *c*, Cnemial crest; *f*, surface for fibula; *a*. astragalus. C, Distal end of same: *a*, Astragalus. All one-eighth natural size. After Marsh.

THE TARSUS.

The astragalus is the only element of the tarsus known to the present writer, though others were doubtless present. It was closely applied and early became coossified with the tibia, covering over the internal two-thirds of the distal extremity of that bone, as shown in fig. 71 and Pl. XVI. I am unable to say anything further regarding the structure of the tarsus in the Ceratopsia, no elements other than the astragalus referable to it being known to me.

THE METATARSUS.

Three functional metatarsals were present in the pes of *Triceratops*. These were the second, third, and fourth. It is possible also that vestiges of the first and fifth were present, but as yet no pes has been discovered sufficiently complete to determine this point. The metatarsals are much longer and stronger than the metacarpals. They interlock with one another at their proximal ends and are closely applied throughout most of their length in order to give greater rigidity and strength to the foot. The median or third is the largest of the three, but the second and fourth are also quite well developed; their shafts are somewhat constricted, but they expand at the extremities. At the distal end the lateral expansion is greatest, while at the proximal end they are expanded most antero-posteriorly. Their form is well shown in fig. 73.

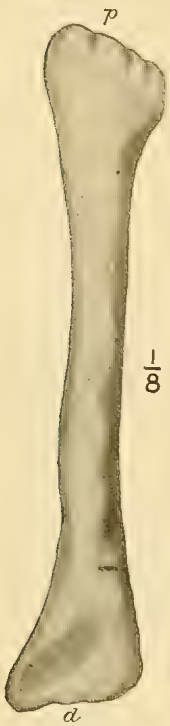

FIG. 72.—Fibula of *Triceratops serratus*, No. 970, American Museum of Natural History, anterior view. One-eighth natural size. Drawn by R. S. Lull.

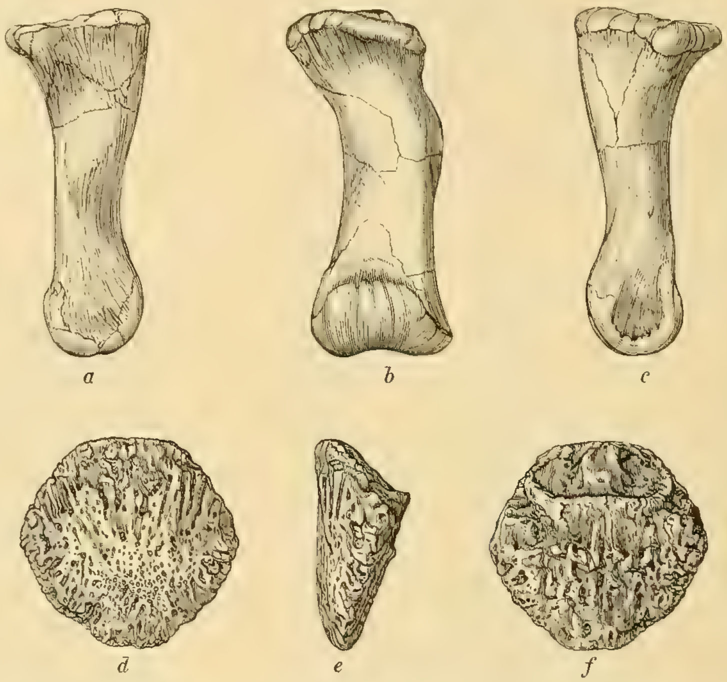

FIG. 73.—*a, b, c,* External, posterior, and internal views of metatarsal of *Triceratops prorsus*, U. S. National Museum. *d, e, f,* Dorsal, lateral, and palmar views of ungual phalanx of the pes of *Triceratops horridus*, U. S. National Museum. All one-eighth natural size. After Marsh.

THE PHALANGES.

The phalanges of the pes are very similar to those of digits II, III, and IV in the manus, though somewhat larger. The proximal phalanges are rather long, but the intermediate ones are very short and broad. The terminal phalanges are broad and rugose or cancellous. They were incased in flat hoofs instead of compressed claws as in the sauropod and theropod dinosaurs. It is probable that the third digit was provided with four or five phalanges, while the second and fourth digits would each have had one less than the third.

THE EXOSKELETON.

Various spines and dermal plates have been found, more especially in the Laramie, associated with remains of the Ceratopsia and other dinosaurs. None of these have yet been found in such association as would demonstrate conclusively that they pertained to any member of the Ceratopsia, and nothing is positively known as to the positions occupied by any of these ossifications in the anatomy of the animal. A few of these are shown here in fig. 74, but considering the limited knowledge we at present possess concerning them it seems scarcely worth while to speculate as to the positions they occupied. The asymmetrical spines, one of which is shown in fig. 74, 1, 2, 3, may have been arranged in pairs at the base of the tail, and it is not impossible that the plates shown in 4–10 and others similar to them may have been so embedded in the skin as to have formed a cuirass or armor about the throat and over certain regions of the back. The curious group of little ossicles coossified about a common base, shown in 11 and 12, were found associated with a considerable portion of a skeleton of a member of the Trachodontidæ, though not in such manner as to demonstrate conclusively that it pertained to that skeleton. No Ceratopsia remains were found with it, however, and it would seem probable that it pertained to the associated skeleton were it not for the fact that no such ossifications were found associated with the two nearly complete skeletons of that trachodont collected by the writer in the same deposits.

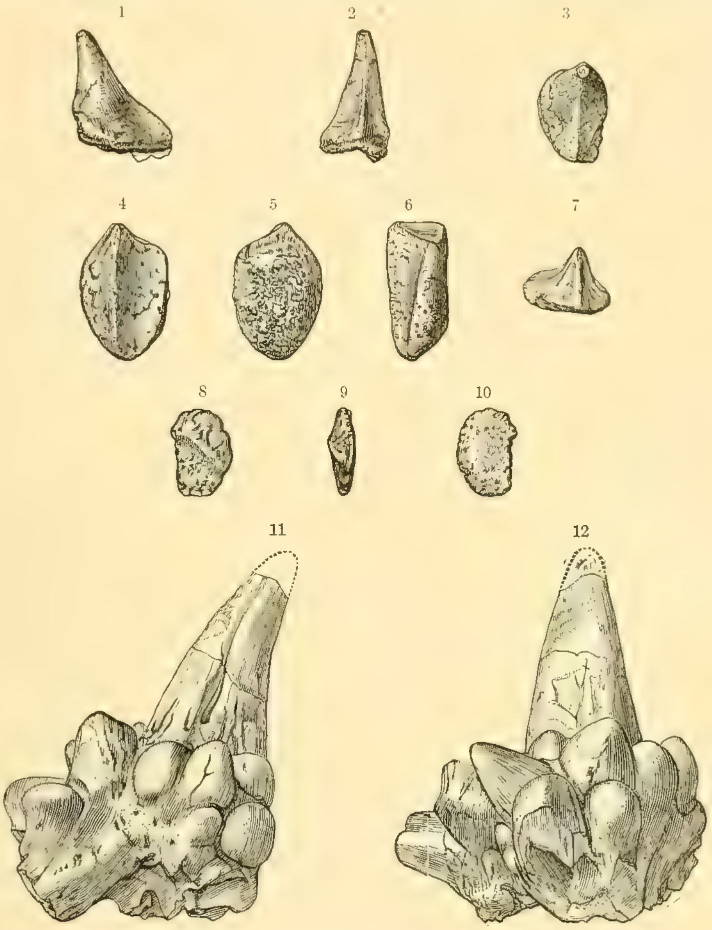

Fig. 74.—1–3, Side, front, and top views of dermal spine; 4–7, top, bottom, side, and end views of dermal plate; 8–10, top, side, and bottom views of dermal plate. All the above figures are one-eighth natural size. 11–12, Side and front views of dermal ossifications found with portion of skeleton of *Diclonius*. One-half natural size. After Marsh.

CHAPTER IV.

SYSTEMATIC DESCRIPTIONS OF GENERA AND SPECIES.

METHOD OF TREATMENT.

In the following systematic descriptions all the various genera and species that have at any time been referred to the Ceratopsia will be included, and all specimens that have ever been used either as types of new genera and species or as pertaining to hitherto unknown portions of forms previously described will likewise be included, regardless of the present author's opinion relative to the synonymy of the various generic and specific names or of the correct identification or reference of any of the elements that have at various times been described by different authorities from materials found in such isolated position as to render their correct reference uncertain or largely, at least, a matter of individual opinion. In all such instances the original descriptions and figures of the various authors will first be given in full, even at the risk of tediousness, and will be followed by a presentation of the present author's views.

In the diagnoses and descriptions of the various genera and species a reference will first be given to the original description of each. This will be followed by references to all later publications by the original author in which a further elucidation of the characters of the genus or species under consideration may have been undertaken, based either on the subsequent discovery of new and more perfect material or on a more complete description of the original type. A reference will also be made to the more important literature by other authors.

In the treatment of each genus and species, when possible, the parts forming the original type will be listed and definitely located, and the name of the museum to which each now belongs will be given, as well as the distinctive numbers which have been assigned to them in such museums, so that in each instance a permanent record may be available as to the character and location of all types which have served as the basis for new genera or species.

In the descriptions of genera and species the *original description* of each will be given verbatim. This will be followed by such additional extracts from subsequent publications, either by the founder of the genus or species under discussion or by other authorities, as shall appear to the present author to be important. All original descriptions of type specimens will be given as quotations and all types accessible to the present author will be carefully figured regardless of his opinion as to synonymy, the aim being to put the reader in possession of all the facts upon which the opinions of the present and all previous contributors have been based, so that each student may be able intelligently to arrive at his own conclusions wherever differences of opinion may exist.

While the distinctive characters of the various genera and species must of necessity be very largely based on the original types, yet wherever a genus or species is accepted as valid no opportunity will be omitted further to elucidate its characters by the introduction and description of such additional material as may appear to the writer to be referable to the same, care always being taken, however, to state distinctly that such material does not pertain to the type and definitely to locate it by its appropriate number and a reference to that museum to which it belongs.

Although the very large collections brought together by the late Prof. Othniel Charles Marsh will serve as the basis of the present volume, free use will also be made of the material collected by the late Prof. Edward Drinker Cope, as well as of that brought together by the

Canadian Geological Survey, chiefly through the efforts of the vertebrate paleontologist, Mr. Lawrence M. Lambe. The more recently collected materials of the American Museum of Natural History in New York, of the Carnegie Museum at Pittsburg, the Museum of the University of Chicago, and the Museum of the State University of Kansas have also been freely placed at the disposal of the writer.

The earlier, smaller, more primitive, and less specialized mid-Cretaceous forms from the Judith River and Belly River beds will be first considered, followed by a description of the larger and more specialized forms from the later Laramie deposits of Converse County and Black Buttes, Wyoming, and from the Denver beds of Colorado, which latter have been considered by some as of post-Laramie age.

REVISION OF SPECIES OF JUDITH RIVER CERATOPSIA.

GENERA AND SPECIES DESCRIBED BY PROFESSOR COPE.

DYSGANUS Cope. 1876.

Type species, *D. encaustus*.

Original description in Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, p. 250.

Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, pp. 572, 596; Proc. Acad. Nat. Sci. Phila., 1883, p. 99; Am. Nat., vol. 24, 1890, p. 571.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 20.

This genus was proposed by Professor Cope in 1876, when he also gave brief descriptions of four supposedly new species (*D. encaustus*, *haydenianus*, *bicarinatus*, and *peiganus*) which he considered as pertaining to it. Neither in his original nor in any subsequent description did Cope state definitely what he considered the affinities of the representatives of this genus. Hay, in his Bibliography and Catalogue of the Fossil Vertebrata of North America, has placed this genus in the Trachodontidæ, while Nopcsa, in his Synopsis und Abstammung der Dinosaurier, has considered it as pertaining to the Ceratopsidæ. Since the specimens upon which was based the type species of the genus and the types of any of the other species are no longer determinable [a] in the Cope collection, we have now to rely entirely upon his descriptions for the determination of those characters which might throw light upon the question of the relationship of this genus. Before discussing it further, therefore, it would seem advisable to quote in full Professor Cope's original description of the genus and its several species.

DYSGANUS ENCAUSTUS Cope. 1876.

Type (No. 5739, American Museum of Natural History) consists of detached teeth.

Original description in Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, pp. 250–251.

Cope, Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, p. 572.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, p. 14.

Char. gen.—A large number of teeth exhibit the characters of this genus, which is a peculiar form of herbivorous Dinosauria. The crowns are compressed so that the fore-and-aft diameter much exceeds the transverse. The body of the crown is a flattened shaft of dentine, one face of which is the denser and produces the cutting edge. This face is flat or weakly keeled, while there are two other faces uniting at an open angle, thus giving a subtriangular section. On each of these faces is adherent a shaft of cementum-like material of a dense character, whose external face is longitudinally concave. These inclose between them on the median line a deep groove, which expands below into a wide concavity, which appears to be enlarged as the age of the tooth increases preparatory to shedding. The other parts of the base of the crown below the cutting face are inclosed in a rather thick deposit of rugose cementum, which rises a distance on the sides of the tooth.

The method of replacement of the teeth in this genus appears to resemble that of *Cionodon*, except that there is no indication of the existence of as many series in the transverse direction. The longitudinal grooves in the anterior and posterior cement columns are probably occupied by the borders of the apices of successional teeth. The presence of these columns, etc., distinguishes this genus from that and other allied genera.

Char. specif.—The cutting face is more or less concave and is impressed or sunken, its lateral borders and the cement of the basis projecting beyond it. The inferior border is also usually oblique, that of one of the sides rising diagonally. In the same proportion a weak keel is also unsymmetrically placed, lying close to the opposite border and dividing the face into a wide and a narrow concavity. The oblique border is also incurved, the edge of the posterior cement column curving round

[a] All types of Ceratopsia in the American Museum of Natural History, except that of *Agathaumas milo*, have now been identified.—R. S. L.

the cutting face of the dentine. The latter is delicately rugose in unworn specimens. The external basal cementum rises highest on the incurved border of the crown; its surface is minutely rugose, the rugosity being generally punctiform. It is also of a different color from the dentine in the specimens as preserved, and is occasionally found nearly worn away. The edge of unworn teeth is not serrate.

Measurements.

	M.
Length of basis of tooth	0.012
Diameter of crown, antero-posterior	.009
Diameter of crown, transverse	.004
Transverse diameter below crown	.008

The teeth are rather smaller than those of *Hadrosaurus foulkei.* The borders present no indication of the crenation seen in that and other species, either in worn or unworn specimens.

Dysganus haydenianus Cope. 1876.

Type (No. 5738, American Museum of Natural History) consists of detached teeth.

Original description in Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, pp. 251–252.

Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, pp. 572, 594, 596.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

Represented by a number of teeth found in such relation that they are supposed to belong to two individuals.

They differ materially in form from those of the *D. encaustus* and exceed any of them in size.

The base of the tooth possesses the thick investment of rough cementum, and has a slope away from the base of the crown. The form of the crown is peculiar in possessing a lateral face placed at a strong angle to the usual face, and separated from it by a strong protuberant angular ridge. This angular cutting face would resemble that of the *Diclonii* were it not that the body of the dentine of which it is composed is a flat plate instead of a triangular segment of a subquadrate prism. Each face has a separate plate, which is separated from the other by a suture. A solid mass fills the angle between them, which is divided by a groove produced by the pressure of the angle of the face of the succeeding tooth which fits it. The wider of the "front" faces is divided by a low longitudinal ridge. Both of the faces are bounded by an external incurved ridge, which causes them to have a concave surface.

A tooth of a size equal to that of the one just described, and found with it, has a form more nearly like that of *D. encaustus* in the less degree of prominence of the lateral angle. It displays but a single posterior cementum-like mass, which presents considerable lateral faces as well as a posterior one, as in the first-described tooth.

Measurements.

	M.
Length of base of crown	0.010
Elevation of remaining part of crown	.006
Diameter of crown, antero-posterior	.015
Diameter of crown, transverse, total	.010
Diameter of crown, transverse dentine	.004

Dedicated to Dr. F. V. Hayden, U. S. Geologist.

Dysganus bicarinatus Cope. 1876.

Type (No. 3975, American Museum of Natural History) consists of detached teeth.

Original description in Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, p. 252.

Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, p. 572.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

This dinosaurian is represented in the collections by some of the teeth of three individuals. Two of the teeth represent immature stages, while the others are worn by continued use. They all present characters not found in the *D. encaustus.* from which they differ in a direction the opposite of that which characterizes the *D. haydenianus.*

The crowns present a nearly flat face without incurved lateral angles nor prominent median keel. The basis is wide, projects in a rim beyond the face, and is invested with rough cementum. The face is peculiar in being divided into three planes by two low angular ridges, and its surface is smooth. The dentinal column is triangular, and there are two posterior columns separated by a fissure in mature teeth.

The absence of the lateral incurved angle and the presence of the two median ones distinguish this species from the *D. encaustus.*

Measurements.

	M.
Length of basis	0.009
Width of basis	.011
Length of worn face	.006
Diameter of crown, antero-posterior	.011
Diameter of crown, transverse	.007

Dysganus peiganus Cope. 1876.

Type (No. 3974, American Museum of Natural History) consists of detached teeth.

Original description in Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, p. 252.

Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, p. 572.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

In the typical tooth of this species the form approaches the genus *Palæoscincus* Leidy, in the compression of the crown and the contraction of the base; it is a limital species of *Dysganus* if really properly placed in that genus.

The widest portion of the crown is above the base; from this expansion it contracts in both directions, and in the unworn tooth forms an angular median apex. This is not the case in *D. encaustus*, which is regularly rounded. The margin of the crown is narrowed, expanding but little toward the expansion, and is quite rugose. From these rugosities low ridges descend on the face of the tooth, whose surface is also minutely rugose. The face is divided by a prominent median rib, which extends to the apex. No cementum is visible on the basis in the only specimen in which this part is preserved.

Measurements.

	M.
Length of crown	0.008
Diameter of crown, transverse	.005
Diameter of crown, antero-posterior, at base	.008
Diameter of crown, antero-posterior, greatest	.011

From the above descriptions of this genus and the various species placed in it by Professor Cope it will readily appear that he included in it teeth pertaining both to the Ceratopsidæ and to the Trachodontidæ, while the type of *D. peiganus* should be considered from his description as pertaining to some member of the Stegosauridæ, and perhaps not specifically different from the tooth figured by Lambe on page 57 of his Vertebrate Fauna of the Mid-Cretaceous of the Northwest Territory, and provisionally referred by him to *Stereocephalus tutus*.

In attempting to determine the affinities of the genus, however, we should rely chiefly upon the characters presented by the types of the typical species, *D. encaustus*. Since, however, these types are no longer available, we have to rely upon their characters, as described by Cope. If, as Professor Cope has stated in his definition of the genus, in the teeth "the body of the crown is a flattened shaft of dentine" and "the crowns are compressed, so that the fore-and-aft diameter much exceeds the transverse," then these teeth can not pertain to the Ceratopsia, for in no member of that group known to the present writer have the teeth either the form or the proportionate diameters given by Cope. Neither am I acquainted with any species of the Ceratopsidæ in which there are no crenulations on the margins of either the worn or unworn teeth, as is stated to be their condition by Cope in *D. encaustus*, the type species. Neither does the method of replacement of the teeth in any of the Ceratopsidæ resemble that of *Cionodon*, as the latter has been described by Cope on page 448 of his Report on the Vertebrate Paleontology of Colorado, which is as follows:

The teeth are rod-like, the upper portion subcylindric in section, with the inner face flattened from apex to base, while the lower half is flattened externally by an abrupt excavation to the middle for the accommodation of the crown of the successional tooth. The inner face of the tooth, from apex to base, is shielded by a plate of enamel, which is somewhat elevated at the margins and supports a keel in the middle, thus giving rise to two shallow longitudinal troughs. The remainder of the tooth is covered with a layer of some dense substance, possibly cementum, which overlaps the vanishing margins of the enamel. The outer inferior excavation of the shaft presents a median longitudinal groove to accommodate the keel of the closely appressed crown of the successional tooth. The apex of the tooth being obtusely wedge-shaped, the functional tooth is pushed downward and transversely toward the inner side of the jaw. The tooth slides downward in a closely fitting vertical groove of the outer alveolar wall. The inner wall is oblique, its section forming, with that of the outer, a V; it is furrowed with grooves similar and opposite to those of the outer wall, but entirely disconnected from them. The base of the shank of the functional tooth, on being displaced by the successional, slides downward and inward along the groove of the inner side, each lateral movement being accompanied by a corresponding protrusion. At the most, three teeth form a transverse line, namely, one new apex external, one half-worn crown median, and the stump or basis of a shank on the inner. The new crowns are, however, protruded successively in series of three, in the longitudinal direction also. Thus, when an apex is freshly protruded, the shank in front of it is a little more prominent, and the third stands beyond the alveolar border. As each shank increases somewhat in diameter downward in the *C. arctatus*, the section increases in size with protrusion; hence, before the appearance of a new crown outside of it, there are but two new functional teeth in a cross row. Thus, in the outer longitudinal row, only every third tooth is in functional use at one time; in the middle series all are in use, while in the inner, every third one is simultaneously thrown out in the form of a minute stump of the shank, if not entirely ground up.

From the order in which he took up and described the various genera of dinosaurs in his original description of this genus it is clear that Cope did not at that time regard *Dysganus* as being closely related to *Monoclonius,* for in the text we find it separated from that genus by *Diclonius* and the three new species of that genus, then proposed by Cope. We might infer, therefore, that at that time Cope considered *Dysganus* as more closely related to *Diclonius* than to *Monoclonius.* Indeed, the only character mentioned by Professor Cope in his original description of the genus which in the present writer's opinion might be considered as indicating for this genus any relationships with the Ceratopsia is the indefinite statement that "the longitudinal grooves in the anterior and posterior cement columns are probably occupied by the borders of the apices of successional teeth," conditions similar to those which are known to obtain in the Ceratopsia.

In a critical note published by Professor Cope in the American Naturalist of June, 1890, page 571, he would seem, however, to have considered *Dysganus* as pertaining to the Ceratopsidæ. For in referring to the "two-rooted teeth," described by Marsh as peculiar to that family of dinosaurs, he remarks:

> The "two-rooted teeth," described by Professor Marsh * * * are not such in point of fact. The appearance of two roots is produced by the absorption of the middle part of a single root by the crown of the successional young tooth. * * * Teeth of this kind were figured by Leidy as belonging to *Trachodon,* and were described by me as representing the new genus *Dysganus.*

In his list of the species of the family Ceratopsidæ (Agathaumidæ), published on pages 715–717 of the American Naturalist for August, 1889, Cope makes no mention of the genus *Dysganus* nor of any of its included species.

Hay, in his Bibliography and Catalogue of the Fossil Vertebrata of North America, remarks that it is a genus of uncertain affinities, though, as we have already remarked, he placed it in the Trachodontidæ, while Nopcsa has, as we have pointed out, referred it without question to the Ceratopsidæ.

After a careful study of all the literature on the genus and its included species I am convinced that the genus *Dysganus* was based on teeth pertaining to two or more genera belonging in part to the Trachodontidæ and in part to the Ceratopsidæ.

In view of this and the absence of the type specimens[a] and the imperfect nature of the material upon which the genus was based, as well as the lack of any figures or sufficiently exact description of the particular teeth, considered by Cope as the type of the genus, to fix their true nature, I feel warranted in excluding it from the recognizable genera of the Ceratopsidæ. It should, I believe, be considered as a nomen nudum.

MONOCLONIUS Cope. 1876.

Type species, *M. crassus* Cope.

Original description in Proc. Acad. Nat. Sci. Phila., vol. 28, 1876, pp. 255–256.

Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, p. 573; Proc. Acad. Nat. Sci. Phila., 1883, p. 99; Am. Naturalist, vol. 23, 1889, pp. 715–717 and 906, and vol. 26, 1892, p. 757; Am. Geol., vol. 8, 1891, p. 56.

Baur, G., Science, vol. 17, 1891, pp. 216–217; Am. Naturalist, vol. 24, 1890, p. 570; Am. Naturalist, vol. 25, 1891, pp. 448, 450.

Dana, J. D., Manual of Geology, 1895, p. 847.

Hatcher, J. B., Am. Naturalist, vol. 30, 1896, p. 113.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 9, 20, 21.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 41, Feb., 1891, p. 176; 3d ser., vol. 43, Jan., 1892, pp. 83–84; 3d ser., vol. 50, Dec., 1895, p. 497; Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 217, 243.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Woodward, A. S., Outlines of Vertebrate Palæontology, p. 213.

Zittel, K. A. von, Text-book of Palæontology, English translation by C. R. Eastman, vol. 2, p. 245.

The chief distinctive characters of this genus are its small size, the diminutive supraorbital horn cores pointing directly upward; the short, broad, and widely fenestrated parietals; the short squamosals, as indicated by the squamosal border on the parietals in the type.

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[a] See footnote on p. 67.

MONOCLONIUS CRASSUS Cope. 1876.

Type (No. 3998, American Museum of Natural History) consists of teeth?, sacrum, anterior dorsals, and parietal.

Original description in Proc. Acad. Nat Sci. Phila., vol. 28, 1876, pp. 255–256.

Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, pp. 573, 594; Am. Naturalist, vol. 14, 1880, p. 511; ibid., vol. 20, pp. 153–154; vol. 23, 1889, pp. 715–717, 905.

Lambe, L. M., Contr. to Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 68.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, F. H., Contr. to Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 14, 20.

ORIGINAL DESCRIPTION.

Cope's original definition of this genus and species was as follows:

Char. gen.—Teeth with obliquely truncate face and distinct root, which is grooved for the successional tooth on the front. No external cementum layer, caudal vertebræ biconcave, and brim narrow. Fore limbs large and massive.

The teeth of this genus resemble those of *Hadrosaurus*, and like them are replaced from the "front," an arrangement which precludes the possibility of more than one series of teeth being in functional use at one time. The robust fore limbs and elongate ilium distinguish *Diclonius* [a] from *Hadrosaurus*. From *Trachodon* it differs in the absence of the rough cementum layer on the back of the tooth.

Char. specif.—The faces of the teeth are acuminate oval in form and are divided by an elevated keel, which is median above, but turns to one side at the base. Margin crenate, the grooves extending more or less on the crown "back," which is otherwise smooth.

Sacrum with ten vertebræ, the last centrum much compressed, the diapophyses extending horizontally from the neural arch above, and connected by a vertical lamina with the iliac supports; length, 27.33 inches. The bones of the limbs are robust, the hinder the longer, but not so much so as in some other genera. Length of femur, 22 inches; width, proximally, 7.4 inches; distally, 6 inches. Length of tibia, 20 inches; greatest diameter, proximally, 8 inches; distally, 7.25 inches. The three anterior dorsal vertebræ are coossified, and the first exibits a deep cup for articulation with the preceding vertebra. The episternum is a T-shaped bone, thin and keeled on the median line below. Length of transverse portion, 21 inches.

Subsequent discoveries have shown that the above description is erroneous in many particulars. First, Cope's description of the teeth seems to have been based, not on the teeth of *Monoclonius*, but on those of *Trachodon*, since he says that they resemble those of *Hadrosaurus* and are replaced in a similar manner from in "front," while we now know that they differ from the teeth of both *Hadrosaurus* and *Trachodon* in that they are fixed in the jaw by two roots inserted transversely instead of by one root, as in both the latter genera, and that they are replaced from below in much the same manner as the deciduous teeth are replaced by the permanent set in the Mammalia; second, the statement that "the three anterior dorsal vertebræ are coossified" has been shown by subsequent discoveries to apply to the three [four] [b] anterior cervicals, Cope having mistaken the cervicals for dorsals; third, the T-shaped bone, described as an episternum, we now know to be the coossified parietals.

Notwithstanding these errors, which, owing to the pioneer nature of the work and the rather fragmentary material upon which it was based, we may excuse, the size and form of the parietals, squamosals, and supraorbital horn cores and the characters of the sacrum and the relative proportions of the fore and hind limbs, as described by Cope, may be considered as fairly diagnostic of the genus and as placing it on a valid foundation, while little difficulty will be found in identifying the species (*M. crassus*), either from the original and subsequent descriptions by Professor Cope or from actual comparisons of other material with that of the type, which latter method should always be the final course of arbitration in determining the synonymy of all closely related and apparently identical forms.

LITERATURE.

In 1886 [c] Cope described and figured as a probable sternal element the parietal of *Monoclonius crassus*, and discussed at some length the structure of the sternum in the Dinosauria.

Two years later,[d] after Professor Marsh had described and figured the type of *Ceratops montanus*, Cope identified as a frontal horn core the element figured by him in 1877.[e] He also

[a] This is certainly a misprint. Cope undoubtedly meant to say *Monoclonius*. See also Proc. Acad. Nat. Sci. Phila., 1883, p. 100.

[b] See footnote on p. 76.

[c] Am. Naturalist, vol. 20, Feb., 1886, pp. 153–155.

[d] Am. Naturalist, vol. 22, Dec., 1888, pp. 1108–1109.

[e] Pl. 34, fig. 8, Bull. U. S. Geol. and Geog. Surv. Terr.

at that time (December, 1888) was inclined to the opinion that *Ceratops* Marsh was a synonym of *Polyonax* Cope, which latter had been founded in 1874 on material collected in the Laramie of Colorado.

The following year,[a] in a note entitled "The horned Dinosauria of the Laramie," which did not appear, however, until early in the year 1890 (hence the apparent conflict in dates), Professor Cope was enabled, through the publication by Professor Marsh of a paper (with figures) entitled "The skull of the gigantic Ceratopsidæ,"[b] to determine definitely the homologies of certain bones pertaining to the type of *Monoclonius crassus* and to define further that genus and species. In this paper Cope proposes the family name Agathaumidæ to take the place of Ceratopsidæ, previously proposed by Marsh and based on the genus *Ceratops*, which Cope considered a synonym of some one of the previously established genera pertaining to the family. He concludes this paper by giving a list of the genera and species already known, adding three new species, *Monoclonius recurvicornis*, *M. sphenocerus*, and *M. fissus*, all of which he describes with more or less detail, unfortunately omitting, however, to include the various forms already described by Marsh. The additional characters then given as diagnostic of the present genus and species, *Monoclonius crassus*, are so important that I can not refrain from quoting him in full in this connection.

After giving due credit to Professor Marsh for the assistance rendered by the latter's article just referred to, Cope continues:

> The most complete skeleton in my collection is that of the *Monoclonius crassus* Cope. This includes representatives of all the elements except the bones of the feet. The posterior part of the skull is preserved, including the left frontal bone. This bears a horn over the middle of the orbit, of small dimensions, and with the apex antero-posteriorly compressed. The parietal bones are enormously expanded and are interrupted on each side of the middle line by a huge foramen, which causes the remaining parts of the bone to resemble the corresponding parts of *Chamæleo*, depressed in a horizontal plane. The squamosals are lateral, and consist of a wide plate with convex external border with a slightly undulating outline. The ilium is remarkably elongate both anterior and posterior to the acetabulum, appropriate to the ten vertebrae which constitute the sacrum. It and the sacrum resemble very closely those of the *Agathaumas sylvestre* Cope, which fact, with the evidence derived from the other vertebræ, leaves no doubt that the *Agathaumas* is to be referred to the horned herbivorous Dinosauria, with *Monoclonius* and *Polyonax*. This family is called by Marsh the Ceratopsidæ, but as it is not certain that *Ceratops* Marsh is distinct from one of the genera previously named I shall call it the Agathaumidæ (or hellenice Agathaumantidæ) from the longest known genus *Agathaumas*.

In a later article entitled "Notes on the Dinosauria of the Laramie,"[c] Cope considers *Ceratops* Marsh a synonym of *Monoclonius* Cope, and distinguishes this genus from *Polyonax* Cope (*Triceratops* Marsh, according to Cope) by the relative lengths of the frontal and nasal horn cores, *Monoclonius* being characterized by short frontal and elongate nasal horns and *Polyonax* by long frontal and comparatively short nasal horns. In this paper Cope also identifies as cervicals the three coossified vertebræ which he had described in 1876 as anterior dorsals. He also here announces for the first time the presence of a postpubis, which had been supposed by Professor Marsh to be absent in these dinosaurs.

DESCRIPTION OF TYPE SPECIMEN.

With this brief historical review of the synonymy and original and subsequent descriptions of *Monoclonius*, I will proceed to a detailed description of the type specimen (No. 3998) as it now exists in the collections of the American Museum of Natural History, New York City. In Cope's original description of this genus and species he mentions the teeth, caudal vertebræ, the three anterior dorsals (now known to be the cervicals), the fore limbs, the femur, tibia, ilium, sacrum, and the episterum (now known to be the parietals).

Owing to the fact that Professor Cope failed to employ any definite marks or symbols for distinguishing type specimens, and the confusion existing in his collection prior to its removal from Philadelphia to New York, I am unable to identify all the material mentioned by him as pertaining to the type of the present species. In his remark that the most complete skele-

[a] Am. Naturalist, vol. 23, Aug., 1889, pp. 715–717.
[b] Am. Jour. Sci., vol. 38, Dec., 1889, pp. 501–506, Pl. XII.
[c] Am. Naturalist, vol. 23, Oct., 1889, pp. 904–906.

ton in his collection included representatives of all the elements except the feet, I am convinced that he had in mind material pertaining to more than one individual. Moreover, it does not seem at all unlikely, but, on the other hand, from a study of the material it appears quite probable, that the actual type material described by Cope was of a composite nature and pertained to two or more individuals. In the following detailed description of the type I shall include only such material as I can positively identify as having been associated by Cope with the type either in his original or subsequent descriptions:

The skull.—Those parts of the skull preserved and at present identifiable as certainly associated by Cope with the type consist of the greater portion of the parietals (first described and later figured by Cope as the episternal) and the left frontal. Among the several squamosals in the Cope collection from the Judith River beds I am absolutely unable to identify that mentioned by Cope in the passage quoted above; neither am I able to determine positively that any squamosal in the collection pertains to this species.

The *parietals* are preserved almost entire. Their general form is well shown in fig. 75. They are firmly united along the median line, and may be described as consisting of a straight, broad median portion, somewhat expanded in front and presenting throughout the anterior three-fourths of its length a markedly convex superior surface supporting three low, rounded, rugose, median prominences appearing at intervals of about 75 millimeters. The inferior surface of this median bar is concave throughout the anterior one-half of its length, but plane posteriorly. The anterior extremity shows sutural markings, and its inferior portion is more expanded than the superior, both anteriorly and laterally, for articulation with the postfrontals, and perhaps also to some extent laterally with the squamosals. The specimen distinctly shows that the union between these two cranial elements, the parietals and postfrontals, was by overlap and underlap, like the shingles of a roof, the inferior border of the parietals being overlapped by the superior border of the frontals. Such an articulation would permit a continuous growth of the skull to an almost indefinite age. Posteriorly this median bar expands laterally, giving rise on either side to two broad bars, which curve first outward, then forward, and at last inward toward the anterior lateral extremity of the median bar, with which, however, it probably never came in actual contact, although its present imperfect condition does not permit this character to be determined with certainty. These lateral parietal bars have an average width of about 10 cm., though they are decidedly more slender anteriorly than posteriorly. They describe about one-half the circumference of an ellipse, and, together with the median bar, they inclose on either side a large parietal foramen, elliptical in outline, perhaps not entirely inclosed anteriorly, with the longer diameter directed antero-posteriorly and having a dimension of about 315 mm., while the shorter transverse diameter is about 220 mm. in length. Posteriorly and medially the parietal border is broadly emarginate, and at a distance of 10 cm. on either side of the median line there is located the first of a series of undulations which continue at intervals all along the periphery of the parietal, decreasing in prominence anteriorly and becoming almost obsolete just before the squamosal suture commences. The squamosal suture occupies the external (anterior) border of the anterior portion of the lateral

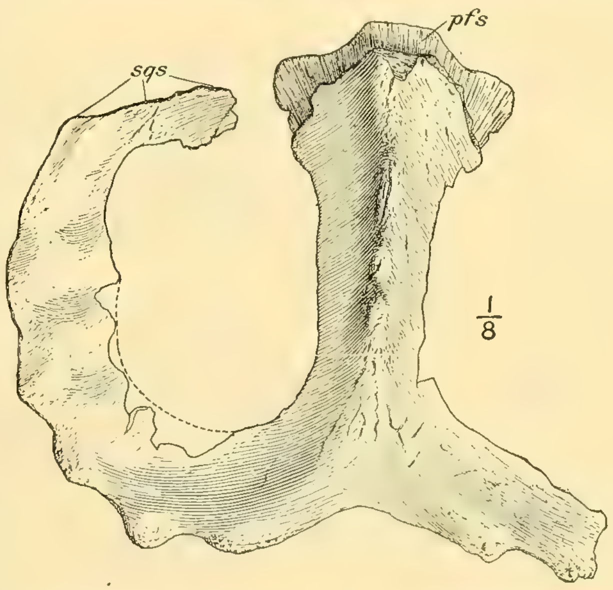

FIG. 75.—Superior view of parietal of type of *Monoclonius crassus*, No. 3998, American Museum of Natural History. *sqs*, Surface for articulation with squamosal; *pfs*, surface for postfrontal. One-eighth natural size.

bar of the parietal. It is but 170 mm. in length, and indicates that the squamosals were short, not very broad, and rather inconspicuous as compared with the same elements in some other contemporaneous and later forms. Among the latter may be mentioned more especially *Triceratops*. Cope's description of the squamosals is somewhat indefinite and does not appear to have been based on any material pertaining to the type.

The left *frontal* bone (No. 3997, American Museum of Natural History) mentioned by Cope does not, I am satisfied, belong to the same but to a smaller and younger individual than the parietals just described. This conclusion is borne out by the fact that Cope made no mention of this remarkably characteristic element in his original description of the species, and only associated it with the type in his subsequent paper published thirteen years later. Not only is the border for contact with the parietal shorter than that in the parietals, but the color, texture, surface markings, and general conformation of the bone all indicate that it pertained to an individual distinct from that to which the parietals pertained. I believe that any characters it may present should not be considered as certainly diagnostic of the present species, for its specific identity must, for the present at least, remain uncertain. I describe and figure this element in this connection not out of regard for any certain additional characters it may furnish distinctive of the present genus and species, but rather for the information which it affords relative to the homologies of certain cranial elements in the Ceratopsia as a group. It may be described as consisting of both those elements which have been described and figured by Marsh[a] as the frontals and postfrontals, but without the slightest indication of a fronto-postfrontal suture, although the sutures for the parietal, squamosal, jugal, prefrontal, and opposing frontal appear in their proper positions on the different margins of the bone. In general form it is triangular, with the apex of the triangle directed anteriorly. Posteriorly its superior surface is broad, flat, and elevated. Anteriorly it curves sharply downward and terminates in a narrow-pointed projection, which was interposed between the opposite frontal and the left prefrontal. Externally it is much deflected posteriorly, and medially it forms the superior two-thirds of the circumference of the orbit. Immediately above the orbit, at the external border of the postfrontal, there rises a low horn core, broad below and pointed above, with the antero-posterior diameter considerably exceeding the transverse. The external lateral surface of this prominence is plane, the internal strongly convex, giving to the horn core the form of one-half of the apex of a cone that has been longitudinally bisected. The orbital border is thick and rugose. The inner border throughout the anterior one-half of its length presents a suture for articulation with the frontal of the opposite side. Posteriorly, however, this border is somewhat emarginate, and instead of presenting a sutural margin it shows a thin, free edge, which formed the lateral border of an elongate foramen, homologous with that which Marsh has designated as the pineal foramen. This expands below into a large cavity, partially inclosed laterally by a vertical septum but apparently communicating with the orbit by one or more small foramina. The posterior border presents an irregular margin for articu-

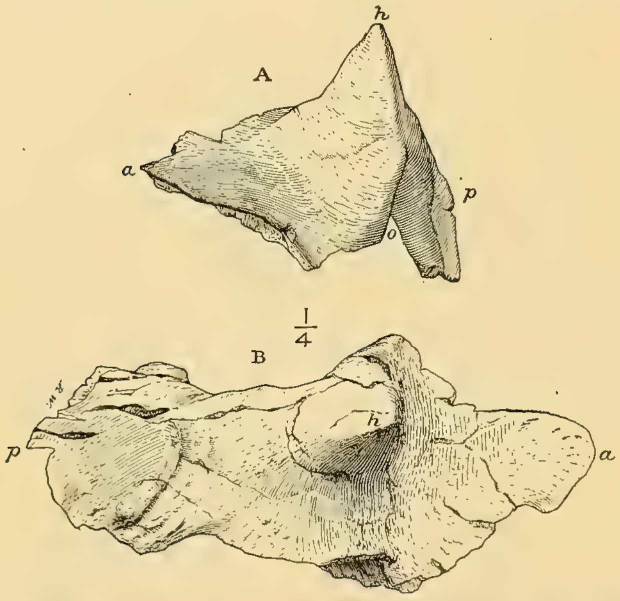

FIG. 76.—A, Oblique front view of frontal and postfrontal (No. 3997, American Museum of Natural History) of *Monoclonius crassus?*, with supraorbital horn core; B, superior view of same. *a*, Anterior end; *p*, posterior; *h*, supraorbital horn; *o*, orbit. Both figures are one-fourth natural size.

[a] Am. Jour. Sci., 3d ser., vol. 44, 1891, pp. 167–168, Pl. I.

lation with the parietal. Externally this assumes the nature of a wide, deep pocket formed by the posterior extension of the superior and inferior walls of the bone. Into this pocket the lateral angle of the median bar of the parietal fitted. At about the middle of the posterior margin of the postfrontal for a very short distance it presents a free, thin border, indicating the presence of a small foramen opening into a large cavity beneath the surface of the postfrontal, which is here comparatively thin. The posterior margin of the deflected lateral portion of this bone presents in part a fractured surface and in part a suture for articulation with the squamosal. Inferiorly there is a short sutural surface for articulation with the jugal, though for the most part this is not shown. The usual articulation between this bone and the parietal, squamosal, and jugal seems to have been by overlap and underlap rather than by direct interlocking sutural contact. The antero-external border of the frontal is thin and presents a free edge, which appears to have overlapped the prefrontal.

The sacrum.—This (No. 3998*a*, American Museum of Natural History) is composed of 10 vertebræ, if we include all those coossified with the true sacrals. If, however, we determine the number of sacrals by the number of sacral ribs there are but 8 sacrals, and of these only 4

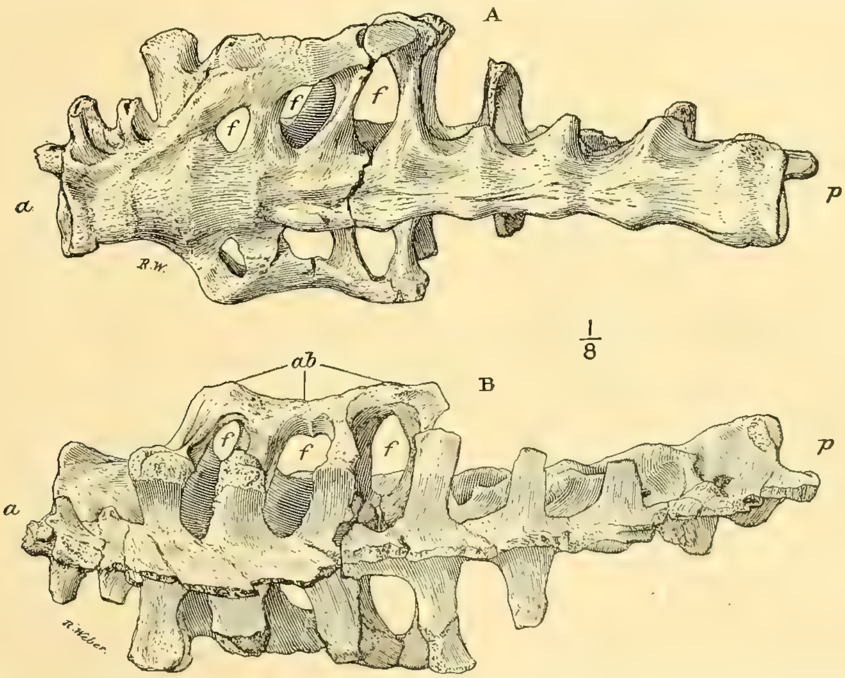

FIG. 77.—A, Oblique inferior view of sacrum of type of *Monoclonius crassus* Cope (No. 3998*a*, American Museum of Natural History); B, oblique superior view of same. *a*, Anterior end; *p*, posterior; *ab*, acetabular bar; *f*, foramina between sacral ribs, centra, and acetabular bar. One-eighth natural size.

or perhaps 5 had the sacral ribs united distally into a longitudinal bar, both giving support to the ilium and entering into the construction of the acetabulum. The general form of the sacrum is much obscured by distortion, due to crushing. The posterior sacral ribs are for the most part incomplete, and none of the neural spines are entire. Many of the diapophyses are also injured, but otherwise the sacrum is complete and in a good state of preservation for a dinosaurian sacrum. The centra are all of medium length and somewhat constricted medially. Commencing with the fourth and terminating with the ninth, the inferior surface is broad and shows a median shallow groove somewhat more marked at the junctions of the several centra. Save the first and last all the centra have the vertical diameter exceeding the transverse, though these proportions have undoubtedly been materially affected by crushing. The first three centra are decidedly heavier than any of the succeeding ones, and the last is much compressed and proportionately stouter than those immediately preceding it. The first two sacrals do not bear ribs, although the first sacral rib springs jointly from the second and the third sacrals, and all the succeeding sacral ribs spring from the point of union of the succeeding centra except the last, which is given off directly from the middle of the centrum of the tenth sacral; while the next preceding springs jointly from the eighth and ninth centra, it is for the most part borne by the ninth. The diapophyses of the first and second vertebræ are short and weak, much more so than in *Triceratops*, and are without inferior plates. Those of the succeeding vertebræ are longer, stouter, much expanded superiorly, while inferiorly they are united throughout their length with the corresponding sacral ribs by thin, bony plates, which in the region of the acetabulum give a firm support to the longitudinal bar mentioned above, formed by the expansion and union of the extremities of the sacral ribs of this region and constituting a portion of the wall of the acetabulum. This bar, together with the coalesced sacral ribs and diapophyses, incloses three foramina which are left open both above and below.

Next to the skull the most important distinctive characters in the Ceratopsidæ are to be found in the sacrum. It is unfortunate that as yet the best sacra have been found either isolated or at most associated with only fragmentary or indifferent skull material, so that for the most part it has been difficult to correlate the various forms of sacra and crania. The same may be said of the present specimen, for although Cope in his description has referred it to the same skeleton with the parietals and postfrontal described above, there would seem from such general characters as size, color, degree of petrifaction, etc., to be little doubt that all three pertained to as many different individuals. Moreover, associated with them in the same lot (designated Lot II by Cope) are representatives of many different individuals pertaining not only to various species, but to genera, families, orders, and even classes of reptiles, and almost without exception unaccompanied by any distinctive marks or labels giving data as to their association or as to the geological horizon or geographical position in which they were found, other than the Judith River beds of Montana.

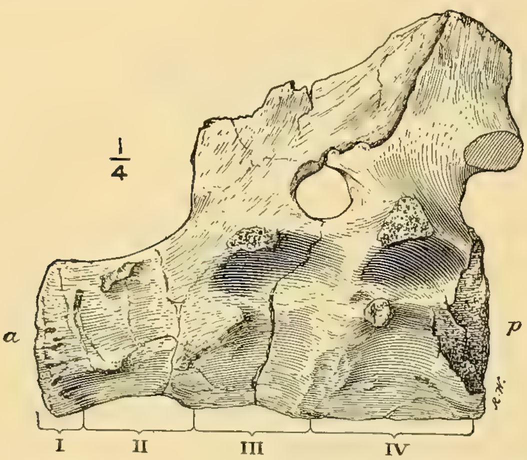

FIG. 78.—Atlas, axis, and third and fourth cervical of type of *Monoclonius crassus* Cope (No. 3998, American Museum of Natural History), as seen from left side. *a*, Anterior end; *p*, posterior. One-fourth natural size. (Drawing altered under the direction of R. S. Lull.)[c]

The cervicals.[a]—Only the three [four][b] anterior cervicals are known. The three coalesced vertebræ described by Cope as anterior dorsals are in reality the atlas, axis, and third [and fourth] cervical. All of these [except the atlas] bore double-headed cervical ribs. They are firmly coossified by their centra. The atlas [and axis] has the lateral and vertical diameters nearly equal, it bears no spine, and at its anterior extremity there is a deep cup for the reception of the condyle of the skull. The vertical diameter of the second [third] and third [fourth] cervicals exceeds the transverse, although in the present specimen the proportions have evidently been much altered by crushing. Both these vertebræ bear spines, and that of the axis [third cervical] is much extended antero-posteriorly. These spines are closely applied to one another, though not coossified, save at the base, where they are separated by a large circular foramen 28 millimeters in diameter.

The dorsals.—There are in the collection a number of dorsals, all incomplete and evidently found isolated, and there is at present no record available as to their associations. In size

[a] The coalesced anterior cervicals of *Monoclonius crassus*, as in *Triceratops*, undoubtedly consist of four bones, the atlas being reduced to a narrow ring-like element, the line of demarcation being indicated by a series of pit-like depressions ranging from the inferior surface of the bone upward and fading out a little beyond the mid-distance to the summit. The fore and aft diameter of the atlas as thus indicated is much greater inferiorly.

[b] Numbers in brackets added by R. S. Lull.

[c] Fig. 78 as prepared under Mr. Hatcher's direction failed to indicate these depressions. The drawing has been subsequently corrected to agree with the specimen. The axis, Hatcher's atlas, is rendered thus somewhat less in anterior extent, though its posterior limitations are as before. The anterior margin of the spine, which rises abruptly above the suture between the axis and the third cervical, extends forward in a gentle curve fading out on the dorsal portion of the axis. The axis also bears two distinct rib facets as indicated in the figure. Herein it differs from that of *Triceratops*, in which no ribs are borne in the axis. (Compare fig. 50, p. 47.)—R. S. L.

and general characters they agree well with what we might expect to obtain in *M. crassus*, and some of them may pertain to the same skeleton as the type. The centra of all are short, somewhat constricted medially, with nearly plane or slightly biconcave extremities. The neural arches are of moderate height and somewhat constricted just above the neural canal, which is of only moderate dimensions. The neural spines are of moderate length and compressed. The transverse processes are triangular in cross section. There is a tubercular rib facet at the extremity of each transverse process and a capitular facet situated on the side of the centrum in the anterior dorsals, on the neural arch in the median dorsals, and on the inferior side of the transverse processes in the posterior dorsals.

The anterior and posterior zygapophyses of opposite sides are distinct, though not widely separated in the vertebræ of the anterior and middorsal regions. In the posterior dorsals, however, they are confluent.

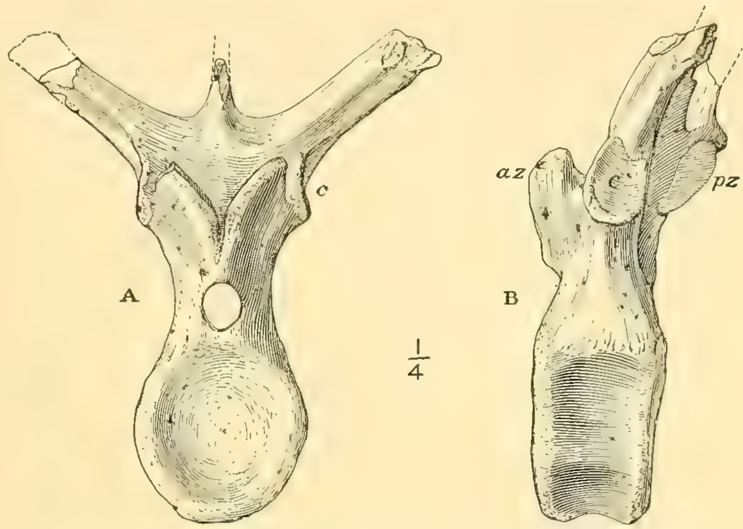

FIG. 79.—A, Anterior view of posterior median dorsal of type of *Monoclonius crassus* Cope, No. 3998, American Museum of Natural History; B, side view of same. *c*, Capitular rib facet; *az*, anterior zygapophysis; *pz*, posterior zygapophysis. Both one-fourth natural size.

The caudals.—In the collection there is a single caudal, which, though not the first of the series, I refer to the anterior caudals. It is biconcave, with a small transverse process springing from near the middle of the side of the centrum. The centrum is short and constricted medially below the transverse processes. The neural arch is low and the zygapophyses of opposite sides well separated. The spine is wanting in the present specimen.

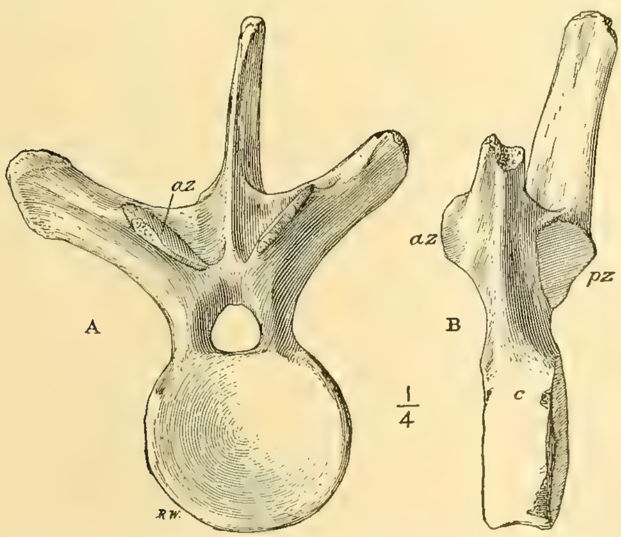

FIG. 80.—A, Anterior view of anterior dorsal of type of *Monoclonius crassus* Cope, No. 3998, American Museum of Natural History; B, side view of same. *az*, Anterior zygapophysis; *pz*, posterior zygapophysis; *c*, capitular rib facet. Both figures one-fourth natural size.

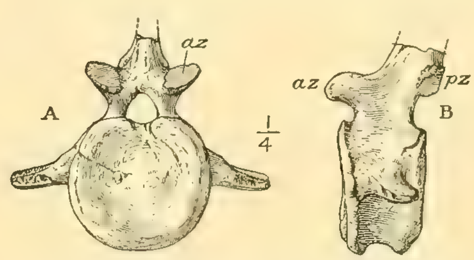

FIG. 81.—A, Anterior view of an anterior caudal of type of *Monoclonius crassus* Cope, No. 3998, American Museum of Natural History; B, side view of same. *az*, Anterior zygapophysis; *pz*, posterior zygapophysis. Both figures one-fourth natural size.

The pelvis.—In his original description of the genus and species Cope simply mentions the ilium as being elongate. There are in the collections from the Judith River beds two ilia. The larger of these is nearly complete, and although a little small in comparison with the sacrum described above, it corresponds very well in character and state of preservation with the parietals; hence I have referred it to the same skeleton, though with a query. It differs little from the same bone in *Agathaumas*, except in its smaller size. It is proportionally longer and more slender in the present genus

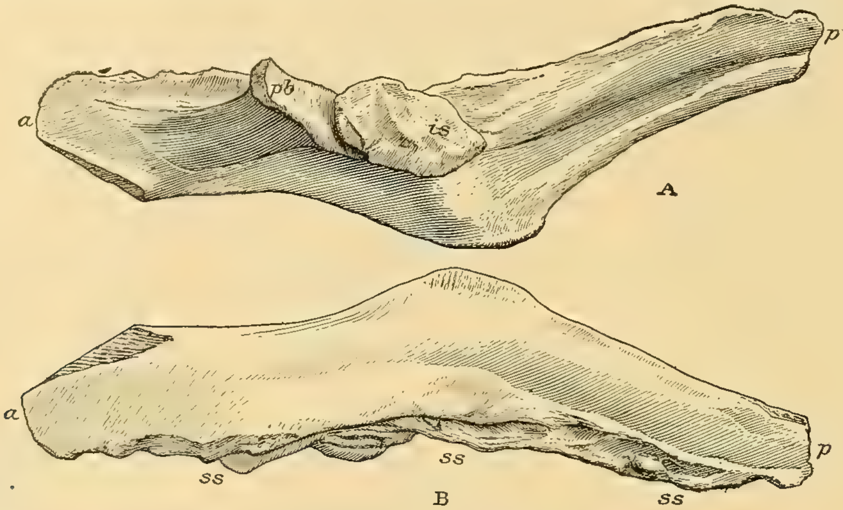

FIG. 82.—A, Inferior view of right ilium (No. 3998? American Museum of Natural History) of *Monoclonius crassus* Cope; B, superior view of same. *a*, Anterior extremity; *p*, posterior; *is*, ischiac peduncle; *pb*, pubic peduncle; *ss*, surface for contact with sacrum. One-eighth natural size.

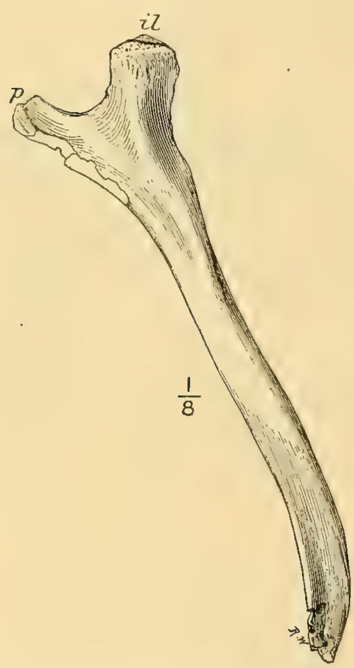

FIG. 83.—External view of ischium of *Monoclonius crassus* Cope, No. 3998, American Museum of Natural History. *il*, Process for contact with ilium; *p*, process for contact with pubis. One-eighth natural size.

and has the deflected external margin posterior to the ischiac peduncle more marked and produced into a somewhat angular prominence. The extreme anterior end of the blade is wanting, but otherwise the bone is essentially complete.

Superior and inferior views of this ilium are given here in fig. 82.

I have been unable to detect any portion of either pubis among the collections from the Judith River beds. There is a left ischium nearly complete, but lacking the extremity of the anterior process with the articular surface for the pubis and the extreme distal end of the shaft. This agrees very well in size and general characters with the other material that has been referred by Cope to *M. crassus*. I therefore describe and figure it in this connection. In general form the ischium in the Ceratopsia is not very unlike a rib, and after a casual glance it might be mistaken for one of those elements. More careful study, however, will at once reveal its identity. Proximally it presents a moderately expanded subcircular articulation for contact with the ischiac peduncle of the ilium. Just below this it sends forward a rather slender process for articulation with the pubis. The extremity of this is wanting in the present specimen. The shaft of the ischium is subcircular in cross

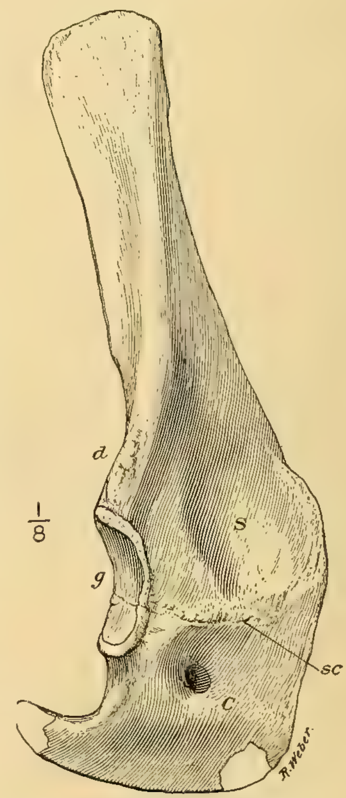

FIG. 84.—External view of right scapula and coracoid of *Monoclonius crassus* Cope, No. 3998*a*, American Museum of Natural History. *S*, Scapula; *C*, coracoid; *g*, glenoid cavity; *d*, rugosity for attachment of deltoid muscle; *sc*, scapulo-coracoid suture. One-eighth natural size.

section throughout most of its length, becoming somewhat triangular toward its distal extremity. It is directed downward and backward, but distally it curves inward and slightly forward in such manner as to bring the inner surface of the extremities of the ischia in contact for a considerable distance. It is evident, however, that the union between the ischia was only cartilaginous. In fig. 83 there is given a side view of this imperfect ischium. Unfortunately the draftsman has made no attempt to eliminate the distortion in the bone due to crushing.

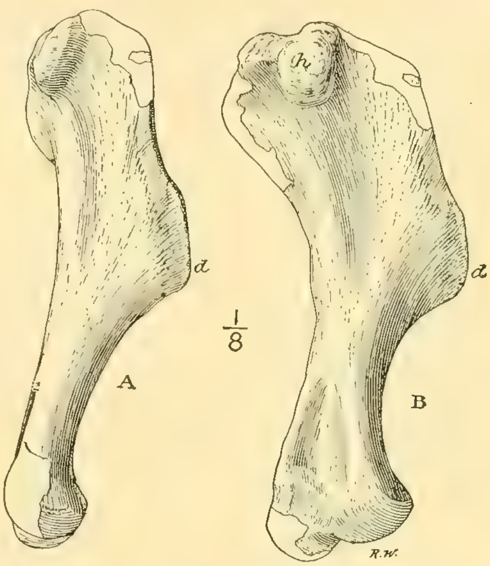

FIG. 85.—A, External view of right humerus of *Monoclonius crassus* Cope, No. 3998, American Museum of Natural History; B, posterior view of same. *h*, Head; *d*, deltoid ridge. One-eighth natural size.

The scapula.—There is a right scapula and coracoid, nearly complete, which may be referred to the present genus and species. The glenoid cavity is almost exactly bisected by the scapulo-coracoid suture, though from foreshortening this does not appear to be the case in the accompanying figure (fig. 84). The external surface of these bones is regularly but gently convex longitudinally; the inner surface is concave. The anterior margin of the coracoid is convex, with the inferior angle produced into an acute angular process, bent backward and inward. Between this process and the lower border of the glenoid cavity there is a deep notch or emargination of the inferior or posterior border of the coracoid. The external opening of the foramen is midway between the anterior and posterior borders of the coracoid and directly opposite the point where the coraco-scapular suture joins the surface of the glenoid cavity. Internally the foramen opens at the coraco-scapular suture. In general the external surface of the coracoid is regularly convex, while the internal is concave. The scapula is comparatively stout and heavy toward its lower extremity, but thin, flat, and somewhat expanded at its upper extremity. On the external inferior margin a rugose surface extends for some distance above the glenoid cavity and probably served as a surface for the attachment of the long abductor or deltoid muscle. From this rugosity a prominent ridge extends upward obliquely across the external surface of the scapula to its anterior margin.

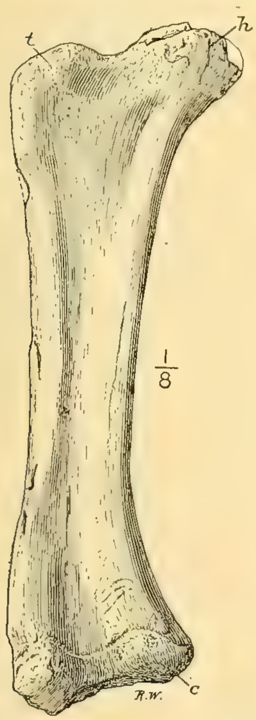

FIG. 86.—Anterior view of right femur of *Monoclonius crassus* Cope, No. 3998? American Museum of Natural History. *h*, Head; *t*, great trochanter; *c*, internal condyle. One-eighth natural size.

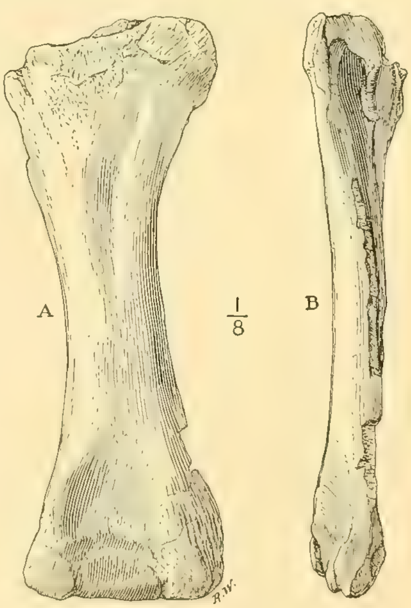

FIG. 87.—A, Posterior view of tibia of *Monoclonius crassus* Cope, No. 3998, American Museum of Natural History; B, lateral view of same, much distorted by crushing. *as*, Astragalus. One-eighth natural size.

The limbs.—Of the bones of the fore limbs I find in the collection only a right humerus. It was doubtless upon the evidence afforded by this bone that Cope based his remark that the fore limbs were robust. Proximally the humerus is much expanded transversely, the deltoid ridge being continuous throughout about one-half the length of the bone and turning backward inferiorly. The head is restricted to the median half of the proximal end of the humerus and it is produced forward. The shaft of the humerus is very broad proximally, with the transverse diameter several times greater than the fore and aft. Below the deltoid ridge the transverse diameter of the shaft is more restricted and the antero-posterior somewhat increased, so that the bone becomes elliptical in cross section, with the transverse diameter still the greater.

Most of the more important characters of the humerus are shown in fig. 85.

I do not find in the collections from the Judith River beds either a femur or tibia agreeing with the measurements given by Cope for those bones in his original description of the genus and species. There are two femora, both of which are much too long. There are also two complete tibiæ in the collection, and the smaller of these, though longer and with the proximal end broader than given by Cope, may perhaps be the one referred to in his original description. It is much crushed and distorted, but was evidently comparatively strong and heavy, and in this respect it seems somewhat out of proportion with either of the femora mentioned above. The astragalus is still in position at the distal extremity, as shown in fig. 87.

A fibula in the collection is of the same length as that given for the tibia, and may perhaps pertain to the same skeleton as the type, although there is no other evidence as to this association. It is much compressed throughout its entire length, but is antero-posteriorly expanded at the extremities and more especially at the proximal extremity, as shown in fig. 88.

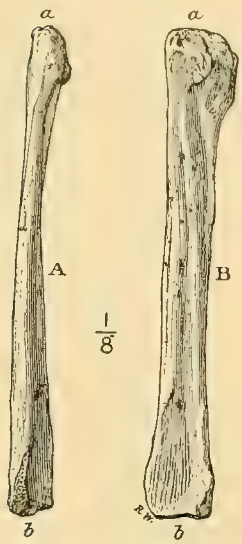

FIG. 88.—A, Anterior view of fibula of *Monoclonius crassus* Cope, No. 3998, American Museum of Natural History; B internal view of same. *a*, Proximal end; *b*, distal end. One-eighth natural size.

Principal measurements of Monoclonius crassus.

	Mm.
The parietals:	
Estimated length of parietals (type 3998) along median line	500
Greatest expanse of parietals	716
Depth of median posterior emargination	64
Antero-posterior diameter of parietal foramen	310
Transverse diameter of parietal foramen	205
The frontal, No. 3997:	
Greatest length of frontal	301
Height of horn above superior border of orbit	75
Antero-posterior diameter of orbit	91
Width of skull between orbits as determined by doubling distance from orbital border to frontal suture	254
Three [four] anterior cervicals, No. 3998:	
Combined length of three [four] coossified centra	234
Transverse diameter of cup for condyle	72
Vertical diameter of cup for condyle	77
Depth of cup for condyle	28
Length of sacrum (3998*a*)	746
Expanse of diapophyses of fifth and sixth sacrals	303
Estimated length of ilium (3998)	850
Depth of same just back of ischiac peduncle	177
Combined length of scapula and coracoid (3998*a*)	820
Length of scapula alone	660
Length of coraco-scapular suture	183
Greatest diameter of coracoid foramen in same	31
Greatest length of humerus (3998)	560
Transverse diameter at proximal end as restored	205
Transverse diameter at point of greatest constriction	85
Greatest length of shorter of two femora mentioned in text (3998?)	625
Greatest length of shorter of two tibiæ mentioned in text (3998?)	538
Greatest length of fibula mentioned in text (3998?)	505

MONOCLONIUS FISSUS Cope. 1889.

Type (No. 3988, American Museum of Natural History) consists of poorly preserved pterygoid.
Original description on page 717, vol. 23, Am. Naturalist, 1889.
Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 14, 20.

Founded on a right pterygoid mistaken by Cope for a squamosal (No. 3988, American Museum of Natural History). This bone is very incomplete. I shall only quote Cope's original description and give figures of the type, since the species is based on very insufficient and unsatisfactory material.

Founded on a squamosal bone of an individual of much smaller size than those above described [*M. crassus*, *recurvicornis*, and *sphenocerus*]. The suture with the parietals is relatively shorter than in the *M. crassus*, occupying only the distal third of the margin. The plate anterior to the transverse suture for the quadrate is more nearly in one plane, is wider in relation to its length, and has a squamosal sutural surface and a transverse groove not seen in the *M. crassus*. The excavation posterior to the process which joins the quadrate is deeper. External border mostly lost. Total length, 180 mm.; length in front of quadrate suture, 50 mm.; width in front of same, 87 mm.; width at postquadrate concavity, 62 mm.

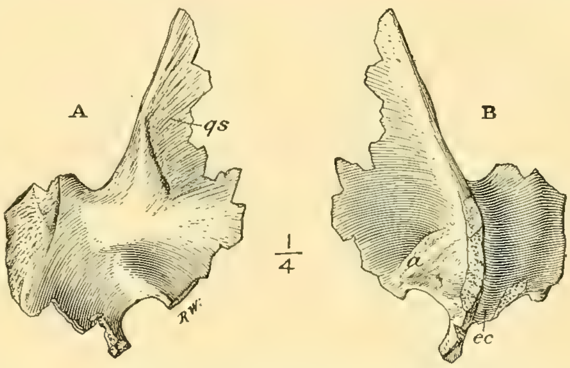

FIG. 89.—A, External view of right pterygoid, type of *Monoclonius fissus* Cope, No. 3988, American Museum of Natural History; B, internal view of same. *qs*, Surface for quadrate; *a*, surface for pterygoid process; *ec*, eustachian canal (?). One-fourth natural size.

Fig. 89 shows the extremely fragmentary and unsatisfactory nature of the type of this species. It also indicates the diminutive size of the animal to which it pertained when compared with the more gigantic forms from the Laramie of Converse County, Wyo. Owing to the fragmentary nature of the type, I am quite unable to add anything additional to the specific characters given by Cope, and the species must remain practically as a nomen nudum, which it would not be amiss to relegate to the paleontological wastebasket.

MONOCLONIUS RECURVICORNIS Cope. 1889.

Type (No. 3999, American Museum of Natural History) consists of portions of skull, including frontal and nasal horn cores.
Original description on page 716, vol. 23, of American Naturalist.
Hatcher, J. B., Am. Naturalist, vol. 33, 1896, p. 113.
Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 68.
Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 14, 20.

The type of the present species consists of the occipital region of the skull, both supraorbital horn cores, a portion of the frontals, the nasal horn core coossified with a fragment of the nasals, a fragment of the jugal, and a fragment of the parietal showing about 10 inches of the periphery with two epoccipital bones in place.

The specimen was discovered by Prof. E. D. Cope in 1876, in a bluff on the north side of the Missouri River, nearly opposite the mouth of Dog Creek, in Montana. According to Cope, the geological horizon was near the base of the Judith River beds as these are represented at this locality.

The material upon which the present species was based was first described in great detail, without, however, being named by Cope, in volume 3 of the Bulletins of the U. S. Geological and Geographical Survey of the Territories under Hayden, pages 588–594. His description was as follows:

1. *Cranial bones of a dinosaurian.*—A number of the bones of the skull of a large dinosaurian reptile were found in the second bed of lignite above the lower bed of sandstone represented in fig. 3 as belonging to the Judith River beds, or Cretaceous No. 6. The locality where they are found is on the north side of the Missouri River, nearly opposite to the mouth of Dog Creek. The bones were lying in immediate contact, and with them was found a fragment consisting of two teeth and

part of a third tooth. These present the characters of the genus *Diclonius* and of either the species *D. calamarius* or *D. perangulatus*, or one not described.

These bones exhibit anomalous characters and with one exception their identification presents a difficult problem. They were numbered in the order of their discovery from 1 to 12, but I commence the description with No. 8, as the one which furnishes the basis for the determination of the others. This portion of the skull includes the united occipital and sphenoid regions, with some lateral elements in close contact with them. The sutures separating the basioccipital and basisphenoid, the exoccipital and prootic, and the prootic and basisphenoid are distinct and squamosal in character. Other sutures are not visible. The bones are generally thin, especially their superficial dense layer.

A remarkable peculiarity of the basal axis of the cranium is its obliquely ascending direction, as its plane makes with that of the posterior occipital surface an angle of 40°. The latter plane was also directed forward, as indicated by the position of the occipital condyle, so that the posterior portion of the skull rose like the abutment of an arch from the vertebral column. This structure also contracts the space occupied by the brain, a deficiency which is compensated by its elongation forward.

The basioccipital is, in its axial portion, exceedingly short, the condyle and its peduncle including two-thirds of its length. In front of this is a considerable expansion, consisting of two huge cup-shaped postero-inferior processes, which spread out laterally and inferiorly from the neck of the condyle, partially concealing it from an inferior view. They are separated by a deep emargination immediately below the condyle. These processes are doubtless the insertions of powerful muscles and appear to be homologous with those found on each side of the basis cranii anterior to the occipital condyle in the emeu. Their borders are separated from those of the exoccipitals by a deep notch on each side. This element may be the true sphenoid, although sutural distinction from the basioccipital is not clear. [See fig. 4, A, B, and C, this monograph.]

The exoccipitals have an aliform lateral expansion, which extends beyond the lateral walls of the brain case. Each one consists of two principal ribs, which terminate in projections which are separated by a concave thin margin. The anterior is curved forward. The posterior is straighter and is directed outward and a little backward. The supraoccipital is narrow and is bounded by an elevated ridge on each side, which approach each other upward. The postero-superior face is deeply concave and is divided by a strong median carina or crest of the same elevation as the lateral crests. The foramen magnum is relatively large and is a little higher than wide. It is probable that the supraoccipital bone does not form part of its border, although, a very small portion having been broken from its posterior edge, the question is not positively decided. The occipital condyle is relatively large and consists exclusively of the basioccipital bone. It is a portion of a globe, the superior convexity being interrupted by a small plane. It is supported on a short neck, on the superior face of which are two lateral shallow concavities.

The presphenoid or sphenoid bone is simple and of remarkable length, resembling that of a bird or snake rather than that of a lizard. It has no posterior lateral processes corresponding to those in front of the basioccipital bone, but embraces the base of the former equally all round by a squamosal suture. The notch separating the occipital processes is continued as a wide groove, which rapidly contracts to an acute termination on the posterior part of the basisphenoid bone. It is bounded on each side by an elevated ridge. These are bounded externally by an open groove on each side, which unite farther forward on the basisphenoid. These are in turn bounded on the outer side by an obtuse ridge, which are not continued on the sphenoid. The median portion of the basisphenoid is convex from side to side. The anterior portion is narrower, and the cranial cavity is here strongly compressed.

Four foramina are situated on the posterior part of the walls of the cranial cavity. These probably represent the fenestra ovalis, the foramen lacerum posterius, and the foramen carotideum. The first named is quite large and perforates the posterior part of the exoccipital bone, a part of its posterior border being formed by the crested sphenoid and a small part of its interior lower margin being probably contributed by the basisphenoid. An inferior tongue-like prolongation of the exoccipital bone separates it from a large foramen in front of it, which it bounds in conjunction with the presphenoid and prootic. This foramen is oval, with the long axis directed upward. Between it and the fenestra ovalis the exoccipital is pierced by a much smaller round foramen at a point below the middle of the former. The prootic bone is prolonged forward and at a point much anterior to the exoccipitals, and the remaining part of the supraoccipitals bounds another foramen of not large size. This, perhaps, gave exit to one of the branches of the trigeminus. The anterior extremity of this part of the skull is very peculiar. The sphenoid, from an ascending direction, turns horizontally, while the supraoccipital rises apparently as a median ascending process free from the inferior walls. The latter acquires another roof, which incloses an open cavity with the supraoccipital, which expands forward and has its lateral borders composed of the united produced lateral angles of the inferior and superior bounding surfaces. The brain chamber turns forward and the superior part of it terminates rather abruptly. The inferior part of the cast of the matrix, which occupies it, is continued with a subtriangular section, resembling the hypophysis or the united peduncles of the olfactory lobes. The roof of this chamber rests on an osseous mass in front, which is concave above from side to side; below, its broken section is transverse, its vertical diameter small and least in the middle.

There is some uncertainty attending the determination of the elements which compose the mass above described. It is possible, as already observed, that the recurved, cup-shaped basal bone is the sphenoid, and not the basioccipital. This interpretation receives some countenance from those offered in explanation of the few crania of Dinosauria hitherto found. These are two, or perhaps three, viz, one described by Mr. Hulke, and a second by Prof. H. G. Seeley in the Quarterly Journal of the Geological Society of London, and another published near the same time by Doctor Bunzel in the quarto of the K.-K. Mineralogische Anstalt of Vienna.

In all of these the basicranial axis is deflected immediately in front of the occipital condyle, in Doctor Seeley's specimen to a very great extent, as much as in the Crocodilia of later periods. In the other two crania the deflection is less marked, and it terminates in an angle, from which the axis continues forward. In Mr. Hulke's specimen it rises somewhat, as in the Montana animal. In none of the crania is the element in front of the condyle recurved as in the latter, though they display in their angle a rudiment of the prominent crest above described. In none of the European crania is the supraoccipital region directed obliquely forward, as in the *Diclonius*, but the lateral constriction is seen in Doctor Seeley's specimen.

It is then possible that the bone which I have called a downward prolongation of the exoccipital is the prootic, although I can not certainly detect any suture separating it from the former. In that case the large foramen in front of it becomes the foramen ovale, the bone in front of it the alisphenoid, and the anterior foramen the foramen opticum. In view of the form of the brain this identification is not without probability.

The cast of the brain does not display any median fissures. Its vertical depth is greatest a little anterior to the foramen magnum, where it is compressed, the sides being shallowly concave and separated from the superior surface by a longitudinal angle. In front of this position it is subcylindric and the anterior extremity comes to an obtuse termination, which is convex in cross section and concave in the vertical sense, the lower portion continuing downward and forward, possibly to the hypophysis.

Before describing the remaining cranial bones the significance of the characters above recorded may be considered. As regards the form of the brain, the superior elevation of the posterior region above the anterior is a point of resemblance to birds rather than to reptiles. The apparent absence of prolongation of the hemispheres into the olfactory lobes is also a character of birds rather than of reptiles. The brain cavity is in fact closed in front above, as in Mr. Hulke's skull already mentioned, which also presents no prolongation for the olfactory lobes. This is present even in those reptiles where the chamber is closed in front—e. g., Ophidia—while it is absent in birds. When viewed from above there are other affinities indicated. The absence of indication of lateral optic lobes points to reptiles and not to birds, while the small diameter of the hemispheres is not like either class, but resembles more the state of things in Batrachia and fishes. The characters of the osseous structure present some avian affinities. Such are the simple semiglobular occipital condyle, the infero-posterior processes of the basioccipital, and the short, thin, lateral processes of the exoccipital bones. The great prolongation of the basisphenoid, the lack of lateral processes of that bone, and the absence of overhanging lateral margin of the superior cranial walls may be looked upon as ophidian or avian characters. Lacertilian characters are completely wanting. The anterior termination of the brain case and its basis resembles nothing else.

In close contact with the side of the mass above described was found a bone of peculiar form, which doubtless belongs to the suspensorium. There could be no doubt of this were the bone suturally united with the cranial element proper. It is, however, only applied to it by the intervention of a body of hardened matrix, of the peculiar color of that which occupies the cranial chamber and which differs much from the lignite in which I found the bones embedded. Almost in contact I found a corresponding piece of the opposite side of the skull, but with a more extensive attachment of an adjoining bone. I therefore describe this bone in preference to the first named. It consists of two bones, one a tabular mass, the other a projecting body resembling a horn core, standing on one of the extremities of the table and at right angles to its plane. The tabular part of the bone is thick, and its free border (opposite to the horn-like bone) is excavated, so as to be double. The two plates are connected by crosspieces, which inclose three fossæ. Both the marginal and inferior faces of the bone display smooth surfaces, as though for synovial articulations. The external surface is roughened with tubercles. The horn-like bone rises from the probably exterior border of the tabular bone, which embraces part of its base in a fixed articulation. It is a rather short and stout cone, with a subtriangular section, much rounded on the inner side. The apex is rather abruptly contracted from the inner and from what I suppose to be the superior sides. Its base is continuous with that of the tabular bone, and terminates externally—i. e., on the side away from the tabular bone—in a thick projecting rim. The surface of the horn-like portion is deeply grooved and scored, probably for nutritive vessels, as the grooves are continuous. The texture of these bones is for some distance dense, but is more spongy in the center. The corresponding bone of the opposite side does not differ from it.

These bones are evidently lateral; but little can be asserted as to their true nature. The position in which one of them was found would lend support to the view that they are the united opisthotic and squamosal, or either of those bones plus the quadrate. Certain it is that none of those bones are attached suturally to the posterior part of the cranium in this animal, in which it differs from all other reptiles. The infero-anterior surface of the exoccipital resembles much more that of the same region in birds, and the proximal faces in the anomalous bones described are of similarly smooth character. One result is certainly derived from this examination, viz, that the Dinosauria (if this genus belong to that order) do not pertain to the division of Reptilia with fixed os quadratum. This is a realization of an anticipation published in 1870 in the following words: "Those (Reptilia) which consolidate the periotic elements, but retain the partial freedom of the quadrate, on the other hand, lead to the avian class. These are the Ornithosauria and, perhaps, when we come to know the cranium, the Dinosauria. At least this may be predicted if the structure of the foot and ear bones are correlated in this group as they are elsewhere." It is probable that the horn-like processes were directed forward, and also, if the position in which the attached one was found be normal, in a line extending below that of the sphenoid. This position would relate it to the quadrate. This subject may be considered in connection with the structure of the mandible, discussed further on.

The next bones, marked as Nos. 1 and 2 in my notes, are from the median line of the skull, and of very peculiar form. They were found in contact, but it is very doubtful whether the relation they present to each other is the normal one. No. 1 is an L-shaped bone, the short limb of the L being recurved, and with the extremity pointing nearly in the direction of the longer limb. The region at the junction of the L is the thickest, being very massive and solid, and the limbs contract regularly to their extremities. The shorter limb becomes compressed toward the end. The longer narrows more gradually and is convex transversely on the face next the shorter limb. The other face of the long limb exhibits two longitudinal excavations, separated by a vertical septum. The opposite face of the short limb is transversely truncate. The posterior part of the inferior face of the long limb is also flat, and joins that of the short limb at a transverse solid angle, which is a little less than right. In profile the adjacent faces of the two limbs of the L form a deep rounded sinus. These and the adjacent lateral surfaces are roughened with grooves, some of them of large size, apparently for blood vessels. The convex side of the long limb is still rougher, being transversely wrinkled and pierced by numerous pores. Its distal third is equally divided by a strong median groove.

Bone No. 2 is composed of two elements, one of them entire, the other incomplete. The former consists of two triangular plates, united by their longest borders so as to give a V on section and to inclose together a deep groove whose sides are elevated at one end and gradually descend to the other. The line of junction is a narrow obtuse keel, and the external surface is furrowed by grooves which are parallel to the shortest sides. This sheath bone incloses a slightly curved longitudinal element, which extends freely from it at its long angle, as a rod with an oval section, and is nearly continuous with the keeled angle of the embracing bone. In the other direction it becomes wider and deeper to the posterior border of the broken sheath bone. Here it does not fill the sheath bone, but roofs over the inclosed space, which forms a conical axial cavity of the mass, which is now filled with matrix. The surface away from the sheath bone is gently concave and is divided longitudinally by the base of a septum or keel. The opposite surface of the free part of the median bone is equally divided by a longitudinal groove.

Positive determination of these elements is at present impracticable, as they do not resemble the corresponding bones in any animal known to me. No. 1 approximates in form the ethmoid of the gull (*Larus*), but appears, in part at least, to have been a bone of the external surface. The long limb has nearly the appearance of those parts of the bird's skull which are inclosed in a horny sheath. The inferior septum is not appropriate to that element. Its proper position at the front of the basicranial axis is less probable, because bone No. 2 is more appropriately placed there. If we then suppose No. 1 to be the septum narium and adjacent part posterior to it, we are met with the anomalous recurved short limb of the bone, which thus becomes a horn-like projection directed upward and forward at the base of the muzzle. This may be considered in connection with the rising projection of the supraoccipital bone, and with the fact that this short limb is entirely filled with moderately coarse cellular tissue. As to bone No. 2, its sheath-like portion may be parasphenoid, and the axial part presphenoid or sphenoidal rostrum, or the former may be the vomer and the latter the septum nasi or basitrabecular.

From the preceding it is evident that the only comparisons which throw any light on the probable positions of these bones are those made with cranial elements of birds.

Bone No. 3 was found in contact with No. 2. It is flat and subparallelogrammic in shape. One side (the thickest) is excavated by a regular arch, with smooth free border at right angles to the other surfaces. A part of the opposite side exhibits a free narrow edge. All the other borders are sutural, generally partly squamosal, without serrature or roughness. This bone is lateral, and the segment of a circle may be a portion of the orbit. There are several other bones belonging to this series, but their description is postponed until their identification is practicable. No elements of the skeleton not cranial were found, excepting a rib, a humerus, and a portion of the transverse border of the episternum. The latter resembles the corresponding piece in the *Monoclonius crassus* Cope, and a similar fragment of large size was found with the remains of the *Agathaumas sylvestre* in Wyoming.

Owing to the fragmentary nature of this material, Cope was unable to determine with accuracy the homologies of the different parts preserved, and the species remained unnamed until after Marsh's publications on the Ceratopsia made known their true nature, when they were referred to the above species, which was briefly described as follows in the American Naturalist of August, 1889, page 716, published December 17, 1889:

Monoclonius recurvicornis Cope, sp. nov. Dinosaurian Cope (Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, 1877, p. 588; pl. 34, figs. 7 and 8).

I excavated the bones of the skull of this species in Montana and described them as above, but suspecting that they might belong to some of the species already known, I did not name them. The fortunate discovery by Professor Marsh enables me to determine them. The supraorbital horns are robust, straight, and rather short. Their section is an antero-posterior oval at base and at the middle rounded subquadrate. The nasal bones are wedge-shaped and much narrowed forward. They support a coossified median septum below. Superior face rounded, very rugose. Some distance posterior to the apex they support a very robust horn, which is compressed and turned abruptly forward at the apex. Posterior face injured. Length of supraorbital horn 210 mm.; long diameter at base, 115 mm.; width of nasal bone at base of horn, 100 mm.; diameter of nasal horn at base (transverse), 95 mm.; elevation (on curve) to broken apex, 115 mm. Between the supraorbital horns on each frontal bone a low tuberosity. This was a colossal animal and of peculiar characters. The squamosal is narrower than in *M. crassus* and had marginal tuberosities.

In the original type a considerable portion of the basioccipital region is preserved, showing the occipital condyle formed by the coalesced basioccipital and exoccipitals which surround and inclose the foramen magnum. The occipital condyle may best be described as pedunculate and hemispherical in form. Its articular surface describes in fact an almost perfect hemisphere. I have already stated that the occipital condyle in the Ceratopsia is formed by the united basioccipital and exoccipitals. In the present specimen these elements are so firmly united as to show no trace of the sutures; in several other instances, however, in younger individuals, the sutures are open, thus affording conclusive proof as to the structure of the condyle, and there can be no doubt that, as Marsh has stated, the basioccipital and exoccipitals unite to form the occipital condyle, and that it is not formed by the basioccipital alone, as stated by Cope.

The peduncle of the condyle is somewhat constricted in front of the articular surface, and it is subcircular in cross section. The foramen magnum is small, compared with the size of the condyle, and circular in outline; it is inclosed by the exoccipitals and supraöccipitals. I am unable to determine the character or position of the other foramina mentioned by Cope in his description of this specimen.[a]

The supraorbital horn cores are short, stout, and abruptly pointed at the apex. Near the base they are subtriangular, becoming somewhat compressed near the apex. Cope asserted that the base of the horn core is solid, but I find that it is cavernous, the cavities being filled with matrix which in color and texture resembles the surrounding bone. The right horn core is somewhat more slender and a little longer than the left. In proportion to the nasal horn the frontal horns are small when compared with those of later genera of Ceratopsia from the Laramie of Wyoming, Montana, and Colorado. Just in front of the right supraorbital horn core there is on the frontal a prominence with the apex missing, presenting the characters of a diminutive horn core. Unfortunately the frontal of the opposite side is wanting, so that it is impossible to determine whether a similar prominence was present on the opposite side. This prominence is subtriangular in cross section, it is directed anteriorly, and its form and surface markings would indicate that it also bore a horn.

The L-shaped bone described by Cope is in reality the nasal horn core and a portion of the nasals with which the horn core is coossified, as was suggested by Cope in his original description and definitely stated and figured by him in his later diagnosis of the species. The nasal horn core is massive and curves strongly forward, thus suggesting the very appropriate specific name. It is split throughout its entire length. The line and place of fracture seem to have been determined by a suture. This is especially suggested by the character of the surface near the base of the fractured area, and it would seem to indicate that the nasal horn core in the present specimen was made up in part by the nasals and in part by a bone derived from a separate center of ossification instead of by the nasals alone, as has very generally been believed. Assuming that this nasal horn core did spring jointly from the nasals and a distinct ossification, only that portion represented by the latter element has been preserved in the present specimen. The portion preserved shows that the nasal horn core was somewhat more massive than the frontal horn cores and that it was much compressed distally and with the antero-posterior diameter exceeding the transverse throughout its entire length. The external surface, like that of the supraorbital horn cores, is marked by deep grooves, indicating that in life these elements were insheathed by some substance, which most likely partook of the nature of horns, often assuming large and formidable proportions. From the base of this horn core the nasals narrow rapidly in front, and thus appear acutely wedge-shaped when viewed from above. The narial septum is strong, and there is on either side on the inferior surface of the nasals just beneath and in front of the base of the nasal horn core a smooth, shallow, concave area. Posterior to these concavities the roof of the nasal aperture presents a broad, flat surface without a narial septum, the narial apertures of either side being confluent from this point backward.

Associated with the type is a considerable fragment of bone which I have identified as the proximal portion of the left jugal, showing a considerable portion of the orbital border and of the opposite free border of this bone, as seen just below its union with the squamosal. The external surface of this bone is very rugose, and just below the inferior border of the orbit there is quite a prominent tuberosity.

A fragment of the margin of the posterior border of the right squamosal is preserved. It shows three distinct emarginations separated by four prominences, and two of the latter bear epoccipitals. One of these is very small, and both show distinct sutural connections with the bone itself. The portion preserved suggests that the squamosal was very stout and of considerable size. Neither the superior nor inferior surfaces present the vascular grooves to be seen on the squamosals of most other members of the Ceratopsia, but are quite smooth, indicating that the bone was embedded in flesh or, what appears to me more probable, that it pertained

[a] Bull. U. S. Geol. and Geog. Surv. Terr., vol. 3, pp. 588-594.

to a young individual. In this respect this element resembles very closely the same portion of the squamosal in Marsh's type of *Sterrholophus flabellatus*, founded on a very complete skull of a young individual, and I am inclined to the opinion that the smooth surface of the squamosals and parietals upon which Marsh largely based his generic distinctions was due rather to the immature age of the individual than to generic differences.

The supraorbital horns in the type of the present species appear to be attached by suture to their supporting elements and to have been developed from distinct and separate centers of ossification, much as the horn cores in the giraffe. In other words, they seem to have an origin independent of the other elements of the skull, which serve them simply as supports. In each supraorbital horn core in the present instance there appears at the base a distinct ridge, well shown in the accompanying figures, entirely encircling the base of the horn and giving the appearance of a suture which has not yet been fully obliterated, owing, perhaps, to the somewhat immature age of the individual. This latter condition is further indicated by the somewhat imperfect union of the epoccipitals already referred to. Certain characters just referred to in the present skull would seem to suggest that the supraorbital horn cores in the earlier Ceratopsia at least were developed independently of the other cranial elements, while the nasal horn was derived in part also from a distinct center of ossification.

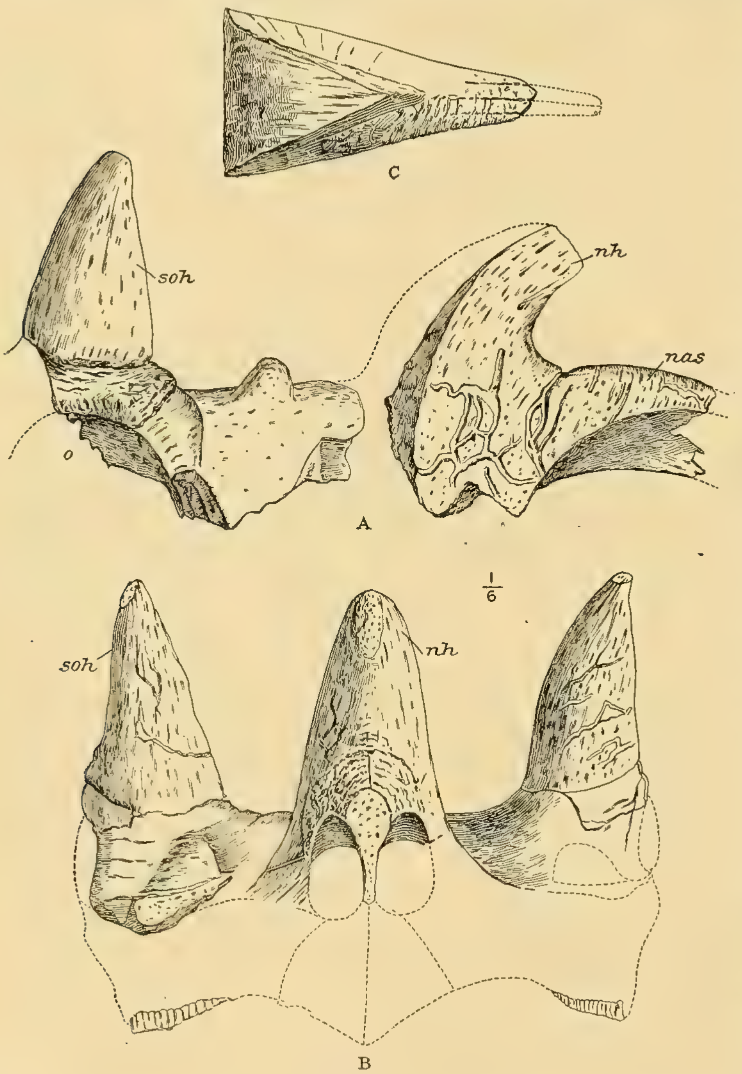

FIG. 90.—A, Lateral view of type of *Monoclonius recurvicornis* Cope, No. 3999, American Museum of Natural History; B, front view of same; C, top view of nasal horn of same. *nas*, Nasal; *nh*, nasal horn core; *o*, orbit; *soh*, supraorbital horn core. All one-sixth natural size. After Cope.[a]

The material above described, which forms the type of the present species, represents an animal of considerable dimensions. Though smaller than any of the Ceratopsia from the Laramie of Wyoming, Montana, or Colorado, it was nevertheless decidedly larger than most of those known from the Judith River beds. In the development of the supraorbital horn cores it shows a very decided advance over *M. crassus*, the type species of the genus, provided the supraorbital horn referred to by Cope really pertained to that species. The fragment of squamosal preserved also shows a very marked modification in the direction shown in the genera *Ceratops*, *Triceratops*, and *Sterrholophus* of Marsh. It is so different and distinct from that of the type species of the genus *M. crassus* that when it is considered in connection with the other structural differences found in other portions of the skull, more especially the horn cores, I do not hesitate to refer it to a distinct genus, *Ceratops* of Marsh, founded on very similar

[a] From Am. Naturalist, vol. 23, Pl. XXXIV.

material from the same region. Fig. 90 shows side, front, and top views of the type of *Monoclonius recurvicornis* Cope.

The similarity in form exhibited by the supraorbital horn cores in *Ceratops montanus* and *Monoclonius recurvicornis* will be apparent to all, while the dissimilarity between them and the same element in the cotype of *Monoclonius crassus*, the type species of the genus, is even more striking. This, together with the accessory horn in front of the larger horn shown in the type of *M. recurvicornis*, along with several other characters to be noticed later, would seem to warrant the removal of the last-mentioned species from the genus *Monoclonius* and the placing of it in the genus *Ceratops*, with which it agrees very well in so far as the characters of this latter genus are at present known. These questions will be discussed in greater detail in that chapter devoted to a revision of the genera and species.

Principal measurements of the type.

	Mm.
Transverse diameter of occipital condyle	76
Vertical diameter of occipital condyle	70
Height of right frontal horn	166
Antero-posterior diameter of same at base	117
Transverse diameter of same at base	99
Transverse diameter of nasal horn at base	112
Transverse diameter of nasal horn near summit	35
Antero-posterior diameter of nasal horn near summit	58
Transverse diameter of nasals at base of nasal horn	133
Transverse diameter of nasals at distal extremity of part preserved	49
Height of nasal horn above superior border of nasals	175

Monoclonius sphenocerus Cope. 1889.

Type (No. 3989, American Museum of Natural History) consists of portion of premaxillary nasals and nasai horn. Original description pp. 716–717, vol. 23, Am. Naturalist, 1889.

Cope, E. D., Am. Naturalist, vol. 26, 1892, p. 757.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 68.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., (Agathaumas) Science, new series, vol. 7, 1893, pp. 842, 844; Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 14, 20.

The type (No. 3989, American Museum of Natural History) of the present species consists of the nasals and left premaxillary, representing a very large individual, found by Charles H. Sternberg on the Missouri River near Cow Island, Montana, in 1876. No definite horizon is given. Cope's original description was as follows:

Monoclonius sphenocerus Cope, represented by numerous parts of the skeleton, including parts of the skull, which were found by Charles H. Sternberg, on the Missouri River, near Cow Island, in 1876. The end of the muzzle is preserved, and presents characters which show that the species is quite different from the one last described. The nasal bones are greatly produced to form a slender, compressed, decurved apex, with a prolongation of the inferior median ethmoid septum. The superior face is round in the transverse section, and is rugose. At a long distance behind the apex the nasal horn rises. It is compressed and vertical in direction, and was not less than 250 mm. in length, but the apex I have not yet found in the packages. Supraorbital horns unknown. The nasal bones are narrower at the base of the horn than in the *recurvicornis*, and the horn is of different form. The anterior border converges regularly to the posterior, and its anterior edge is acute for the distal half. Length of nasals in front of horn, 255 mm.; transverse diameter of nasals below at base of horns, 70 mm.; diameters of base of horn, antero-posterior, 160 mm.; transverse, 60 mm.

The *Monoclonius sphenocerus* is an animal of large size, exceeding the rhinoceros in height, and the nasal horn is the most formidable weapon I have observed in a reptile.

From the above description and the figures which accompanied it it will be seen that the species must rest on the nasals and premaxillary mentioned above. The numerous portions of the skeleton mentioned by Cope are now no longer determinable, not having been distinctively marked by Cope, and I shall base my description and diagnosis of the species on the nasals and premaxillary alone.

The nasals are massive and indicate an animal of large size. The sutures for the frontals and premaxillaries are distinct and indicate that the individual was scarcely adult. Superiorly and about midway between their anterior and posterior extremities the nasals support a large and powerful horn. This is compressed and pointed, with the anterior margin acute and the posterior rounded. It was straight and was directed upward and backward. Just in front of the nasal horn there is on the inferior side of the nasals a median septum. The extremity of this is broken away, so that it is impossible to determine its extent. The narial passage is both wide and deep. The nasals are very narrow anteriorly, but wide posteriorly, where they present an underlapping suture for contact with the frontals. Inferiorly and posteriorly they present an underlapping plate which was overlapped by the premaxillary, and this articulation is made more rigid by the median notch shown in the figure. The premaxillary is much constricted medially but moderately expanded posteriorly for union with the nasals, while anteriorly it is much expanded in order to give efficient support to the rostral, which is wanting in the present specimen. Together with the nasals the premaxillaries on either side inclose

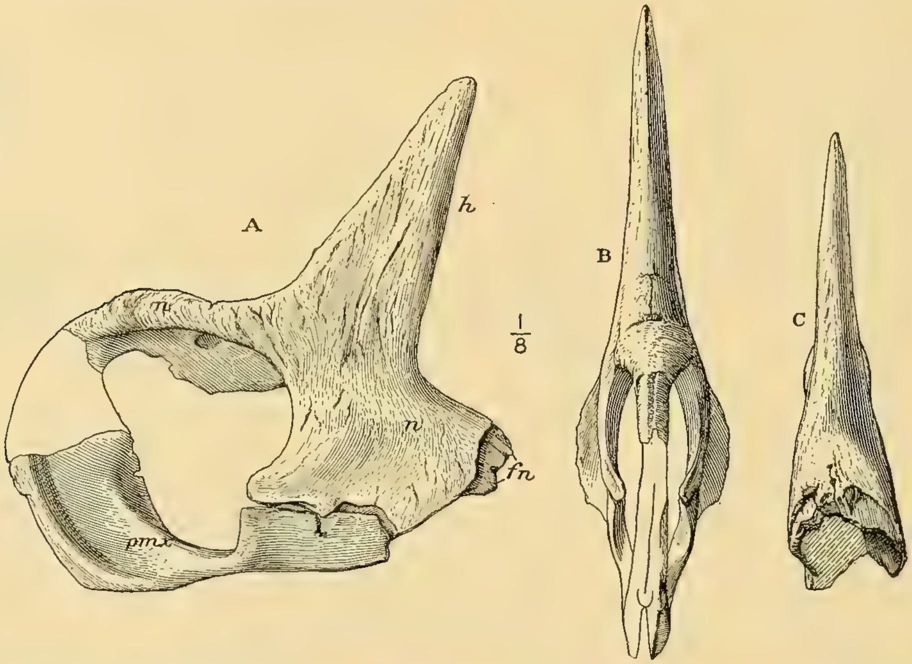

FIG. 91.—A, Lateral view of nasal horn and beak of *Monoclonius sphenocerus* Cope, type, No. 3989, American Museum of Natural History; B, front view of same; C, posterior view of same. *h*, Nasal horn core; *n*, nasals; *fn*, fronto-nasal suture; *pmx*, premaxillary. All one-eighth natural size.

a large heart-shaped foramen. The anterior extremities of both the nasals and premaxillary are wanting in the present specimen.

Principal measurements of the type (No. 3989).

	Mm.
Estimated total length of nasals	505
Greatest length of nasal horn core	302
Transverse diameter of horn core at base	80
Antero-posterior diameter of horn core at base	160
Height of apex of horn above premaxillary suture	465

GENERA AND SPECIES OF CERATOPSIA FROM THE JUDITH RIVER BEDS OF CANADA, DESCRIBED BY LAMBE.

Having concluded this review of the different species of *Monoclonius* that have been proposed by Cope upon remains of these dinosaurs from the Judith River beds of northern Montana, I will next consider the forms described by Prof. H. F. Osborn and Mr. Lawrence M. Lambe and based, for the most part at least, on material collected by the latter in the Belly River beds of the Northwest Territory, Canada.

The treatment of this material by the above-mentioned authors forms part 2 of volume 3 (quarto) of Contributions to Canadian Paleontology, published by the Geological Survey of Canada and entitled "On Vertebrata of the Mid-Cretaceous of the Northwest Territory." This memoir, consisting of 81 pages of descriptive matter, with 21 plates and numerous text figures, is divided into two parts. The first of these, entitled "Distinctive Characters of the Mid-Cretaceous Fauna," pages 7–21, is by Professor Osborn, and is devoted largely to a discussion of the relations of the vertebrate fauna of the supposed Belly River beds to those of the Judith River beds of Montana and the Laramie of Converse County and central southern Wyoming, and of the Denver beds in Colorado. The second part of this memoir, "New Genera and Species from the Belly River Series (Mid-Cretaceous)," is by Mr. Lambe, and is for the most part purely descriptive. Three new species of Ceratopsidæ are recognized and described as pertaining to the genus *Monoclonius*. These are *Monoclonius dawsoni*, *canadensis*, and *belli*. A new genus and species, *Stegoceras validus*, is also described, and erroneously referred to the Ceratopsidæ. The species described by Lambe will now be considered.

MONOCLONIUS DAWSONI Lambe. 1902.

Type (Nos. 1173 and 971,[a] Geol. Surv. Canada) consists of parts of two skulls from Red Deer River, Canada.
Original description in Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 57–63.
Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 68, 75, 76, 81.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 14, 20.

The type of the present species was collected by Mr. Lambe in 1901, in the Judith River beds on Red Deer River between Berry Creek and Dead Lodge Canyon, Alberta, no more exact locality or horizon being given by that author.[b] Mr. Lambe's description is as follows:

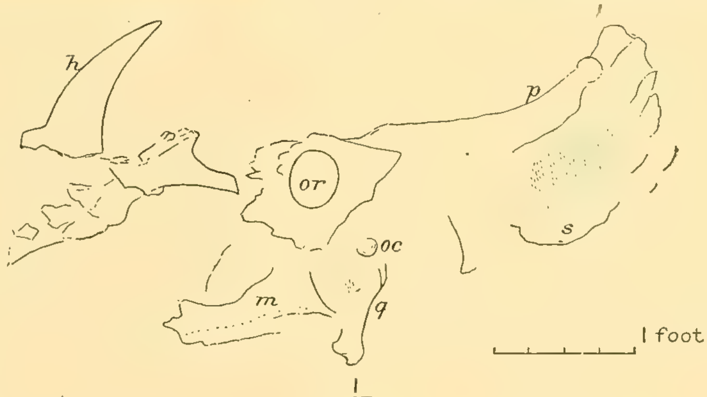

FIG. 92.—Head of *Monoclonius dawsoni*, from a sketch in the field. One-sixteenth natural size. *p*, Parietal; *or*, orbit; *oc*, occipital condyle; *q*, quadrate; *m*, maxilla (inner side showing a row of foramina); *h*, nasal horn core; *s*, squamosal. After Lambe.

> The remains of an apparently undescribed species of this genus, consisting of the skull of one individual and the posterior crest of another, are of especial interest. The skull when found lay on its right side, and although very much crushed, certain parts of it supply definite information as to its structure and size. The two orbits, the right maxilla, a quadrate, and the occipital condyle, were conspicuous and apparently in place, with a large posterior crest extending to the rear. Somewhat in advance of the orbits a horn core, of large size and apparently symmetrical form, occupied a position suggestive of a nasal origin, the nasal bones and the frontals being probably represented by the fragments filling the space between the orbit and the horn core (see fig. 14 [fig. 92], from a measured drawing made before the parts of the skull were removed).
>
> The large posterior crest forms the back part of the skull above. Its exact shape is fortunately supplied by the admirably preserved specimen shown in outline, from beneath, in fig. 15 [fig. 93]. The surface of the bone, above the orbit and from there inward for a short distance toward the median line of the skull, is moderately smooth and shows no trace of a horn core.
>
> With the separate posterior crest was found a horn core, similar in shape to, although not as well preserved as, the one belonging to the skull.
>
> The posterior crest is composed of the parietals and squamosals coalesced. The former are represented by a flat, thin, smooth median portion that expands laterally both in front and behind. Anteriorly it is deeply concave below and broadly convex above, but posteriorly it thickens gradually, and dividing to either side is continued forward as the squamosals in a broad curve to meet the anterior expansion. On either side of the median element is included a large supratemporal vacuity or fontanelle.

[a] This specimen, No. 971, here figured (fig. 93) and described has since been made the type of a new genus and species. See footnote, p. 93.—R. S. L.

[b] See p. 179.

The posterior crest is somewhat saddle-shaped. Its sides are wavy, with a slight thickening of the bone in the posterior five of the seven corresponding convexities of the periphery, while a pair of inwardly directed spurs of bone, with their points turned slightly downward, are developed on its posterior border, one on each side of the median line. The intervacuital element is thickened along its median length and a more decided strengthening of the bone occurs along the posterior border, resembling in this respect the corresponding part of *Monoclonius belli*, described farther on. In all other parts of the crest the bone is thin, more particularly near and at the margin of the fontanelles, whilst along the sinuous curves of the sides the edge is sharp, except in the emarginations, where it is rounded. Vascular markings occur on both surfaces, more particularly on the peripheral projections.

Measurements.	Mm.
Height of orbit	0. 110
Width of orbit	.095
Height of horn core	.331
Circumference at base of horn core	.343
Antero-posterior diameter of base of same	.135
Transverse diameter of base of same	.092
Diameter of occipital condyle	.060
Length of maxilla, approximate	.350
Height of same, approximate	.120
Long diameter of lower face of quadrate	.080
Short diameter of lower face of quadrate	.036

The skull and the posterior crest were collected on Red Deer River in 1901.

With this species are provisionally associated a scapula and coracoid, a sacrum, an ilium, a rostral bone, and a predentary bone, described or referred to in the next succeeding pages.

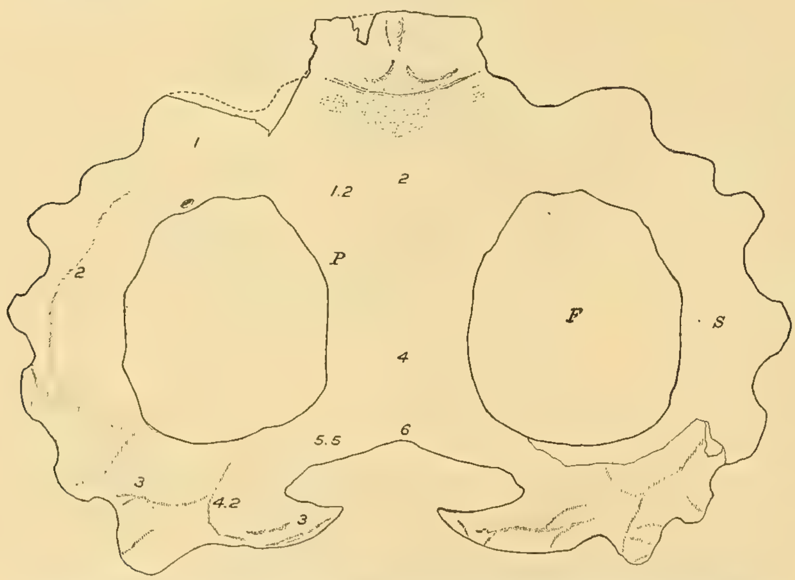

FIG. 93.—Posterior crest [a] referred by Lambe to *Monoclonius dawsoni*, probably pertaining to a distinct species; viewed from beneath. Slightly less than one-eighth natural size. The numbers give the thickness of the bone, in centimeters, at the points indicated. *P*, Parietal; *S*, squamosal; *F*, fontanelle. After Lambe.

The scapula with coracoid is figured on Pl. XIX, fig. 4 [Pl. XX, fig. 1], viewed from its inner side.

The scapula is long and narrow, slightly concave inward in the direction of its length, stout below, thinning rapidly upward, upper end terminating squarely, breadth decreasing toward mid-length, slightly expanded above, front margin thin, back margin broad below, narrowing to its mid-length, then continuing thin upward. A rounded ridge extends upward, on the outer surface, diagonally across from the upper end of the glenoid cavity to the front margin, continuing as a decided thickening of the front margin above.

The coracoid is broader than high, emarginated below the glenoid cavity and produced backward below, lower border turned inward, inner surface decidedly concave, back border at emargination thick, border elsewhere rather thin, rounded. Foramen traversing thickness of upper part directed obliquely downward and outward with an enlarged outer opening. A small foramen occurs, below the glenoid cavity, in the emargination of the posterior border. Glenoid cavity higher than broad, its curve forming almost a semicircle.

In the specimen figured the coracoid was probably firmly united with the scapula, the suture between them, extending from the mid-height of the glenoid cavity forward, being only slightly indicated. The union of the two bones may be regarded as an evidence of age in the individual.

The left scapula and coracoid from the Red Deer River district, so similar, in most respects, to that of *Triceratops prorsus* Marsh, as figured in Sixteenth Report of the United States Geological Survey, differs in one important particular, viz, in having the lower border of the coracoid turned inward instead of outward.

[a] This is the type of *Centrosaurus apertus* Lambe. See Pl. XXIV and footnote on p. 93.

Measurements of scapula and coracoid.

	Mm.
Scapula with coracoid (left). Cat. No. 506:	
Extreme length of scapula with coracoid in line with back edge of shaft	0.879
Length of scapula	.711
Length across glenoid cavity	.150
Length of glenoid cavity along curve	.204
Breadth of glenoid cavity at suture between scapula and coracoid	.078
Breadth of glenoid cavity near either end	.096
Breadth of scapula at junction with coracoid, inner surface	.175
Breadth of scapula at junction with coracoid, outer surface	.149
Breadth of scapula at upper end of glenoid cavity	.238
Breadth of scapula at mid-length	.113
Breadth of scapula at upper end	.184
Breadth of coracoid at lower end of glenoid cavity	.223
Thickness of scapula at upper end near front border	.025
Thickness on base of ridge above upper end of glenoid cavity	.060
Thickness at lower end of glenoid cavity	.060
Thickness of coracoid in concavity below foramen	.020
Width of foramen, inner end	.014
Height of same, inner end	.030
Width of same, outer end	.025
Height of same, outer end	.040

The rostral bone figured on Pl. XX and the small predentary bone (Pl. XIX, figs. 5 and 6) [Pl. XX, figs. 2 and 3] were found separately, and may with some probability of correctness be referred to this species. A large ilium is figured toward the end of this report.

This species is named in honor of Dr. George M. Dawson, C. M. G., late director of the Geological Survey of Canada.

From the above description it will readily appear that the fragmentary skull (No. 1173, Geol. Surv. Canada) must be considered as the actual type of the present species, on which alone we must depend for the determination of its distinctive characters. The posterior crest and associated horn core, as well as the scapula and coracoid, ilium, rostral, and predentary bones provisionally associated with the type may have pertained to the same species, but of this we can not be certain, and since they were all found disassociated they may possibly have pertained to one or more different species. However this may prove to be, any characters which this collateral material may show can not be taken as certainly diagnostic of the species until such time as the discovery of additional and more complete material shall conclusively demonstrate that these particular types of parietal crest, scapula, etc., were associated with that pattern of skull shown in the actual type.

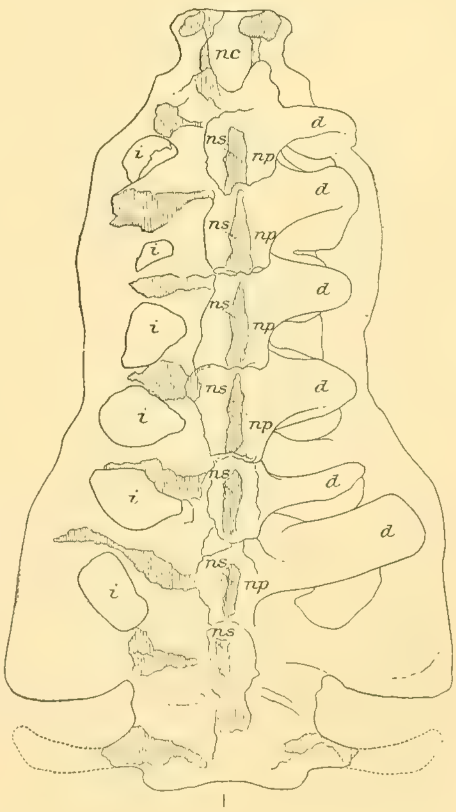

FIG. 94.—*Trachodon* sacrum provisionally associated with *Monoclonius dawsoni* by Lambe; superior view, less than one-seventh natural size. *nc*, Neural canal; *d*, diapophysis; *np*, neural platform; *ns*, neural spine; *i*, interspace. After Lambe.

The type (No. 1173, Geol. Surv. Canada) consists of a very fragmentary skull with large and somewhat compressed nasal horn core curved backward, ovate in cross section, with the broad end of the oval directed anteriorly. The orbit is nearly circular, and there still remains in the type the base of a small rudimentary supraorbital horn core. This rudimentary horn core is flattened on its external surface as in the cotype of *Monoclonius crassus* Cope. About 1 inch of the apex of this horn is wanting in the present specimen. A fragment of the parietal is preserved showing three or four of the marginal undulations. These resemble those seen in the type of *Monoclonius crassus* Cope, and I am inclined to regard the present species as closely allied to if not identical with the *M. crassus* of Cope. The nasal horn and orbit are very large when compared with the occipital condyle, the maxillaries, and quadrate.

The peculiar parietal (see footnote *b*, p. 93) associated by Lambe with the type of *M. dawsoni* I regard as pertaining to a distinct species and perhaps also to a distinct genus. The median parietal bar is very heavy and deeply emarginate posteriorly, where on either side it gives off an elongated process which is pointed and curves inward and slightly downward. The bases of these processes are separated from one another by a distance of 300 mm. They are each 109 mm. in length, have a breadth of 112 mm. at the base, and a thickness of 30 mm. They are acutely pointed, have rugose surfaces with deep vascular grooves, and in life were evidently insheathed in horn. The posterior border of the parietal between the bases of these processes is very thick and round. On the superior surface, in the middle just in front of the posterior border, there is a rather deep concavity. The median bar of the parietal is very thick throughout its entire length. Its superior surface is marked by a number of very gentle elevations; it is rugose and shows shallow vascular impressions. Beside the processes already mentioned as present on the posterior portion of the parietals, there is on either side a series of seven emarginations on the parietal borders separated by as many prominences. The

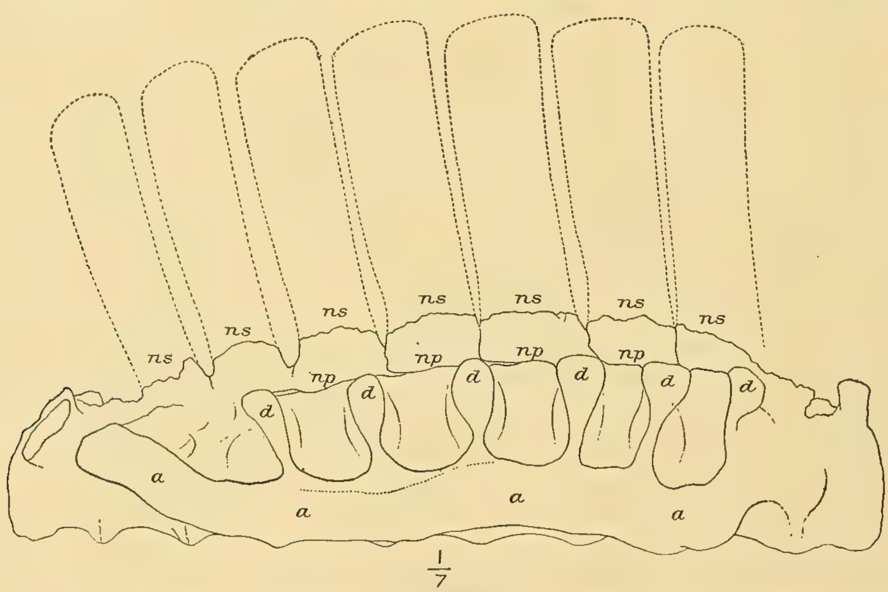

FIG. 95.—The same sacrum as in fig. 94; right lateral aspect, about one-seventh natural size. *a, a*, Facet for ilium; *d*, diapophysis; *np*, neural platform; *ns*, neural spine. After Lambe.

posterior of these prominences are the larger, and each bears evidence of having supported a distinct epoccipital bone during the life of the animal, save perhaps the two anterior, which appear to have been overlapped by the squamosal, since the parietal in this region presents a rather distinct sutural surface for contact with the squamosal. The parietals on either side of the median bar present a large fontanelle, and the margin of bone inclosing this is very thin. These fontanelles have a length of 292 mm. and a breadth of 254 mm. The parietal bar is concave on its inferior surface, especially anteriorly. At its anterior extremity it presents a number of cavities and articulates with the postfrontals.[a]

The sacrum described and figured by Lambe and provisionally associated with the present species does not belong to the Ceratopsia. It is clearly the sacrum of one of the Ornithopoda and belongs without doubt to some species of *Trachodon*.

The nasal horn (No. 190, Geol. Surv. Canada) figured by Lambe and reproduced here in Pl. XVIII, figs. 1 and 2, though referred by him with a query to *M. dawsoni*, resembles more nearly the same element in *M. recurvicornis* Cope. It differs from that element in *M. dawsoni* by curving forward as in *M. recurvicornis* instead of backward as in the type of *M. dawsoni*.

[a] See fig. 93 and Pl. XXIV.

It is extremely massive and only moderately compressed. It curves rather more strongly forward than does the nasal horn of *M. dawsoni* in the opposite direction or backward.

One half of a horn core, split longitudinally[a] and found with the peculiar parietal (No. 971, Geol. Surv. Canada) referred by Lambe, though I think erroneously, to *M. dawsoni*, appears to represent one half of a nasal horn of the type described by Cope as *M. sphenocerus*. Owing to the imperfect nature of this specimen it is not possible to determine positively whether it represents a nasal or a supraorbital horn core. It seems more than probable that the type of parietal shown in fig. 91 was associated with a nasal horn similar to that of *M. sphenocerus*. If this horn core should prove to be a supraorbital the evidence would be equally in favor of excluding it and the associated parietals from the present species in which the supraorbital horn core is very rudimentary. It seems quite probable that this peculiar parietal may pertain to *M. sphenocerus*. From the nature of the associated horn core it can not pertain to *M. dawsoni*.[b]

MONOCLONIUS CANADENSIS Lambe. 1902.

Type (No. 1254 a, b, c, d, e, Geol. Surv. Canada) consists of anterior dorsal and fragments of skull.

Original description in Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 63–66.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 68, 81; Ottawa Naturalist, vol. 18, pp. 81–84; Trans. Roy. Soc. Canada, 2d series, vol. 10, sec. 4, pp. 3–9.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 14, 20.

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[a] When Mr. Hatcher saw this horn core it was partially embedded in the matrix; on being entirely removed from the latter, the bone was found to be complete and not split longitudinally, as both Hatcher and Lambe supposed. (See Pl. XXIV, fig. 3.)—R. S. L.

[b] CENTROSAURUS APERTUS Lambe. 1904.

Type No. 971, Canadian Geological Survey, consisting of a parietal crest and nasal horn core.

Original description in Ottawa Naturalist, vol. 18, July, 1904, pp. 81–84.

Lambe, L. M., Trans. Royal Soc. Canada, 2d ser., vol. 10, 1904, sec. 4, pp. 3–9.

The material upon which this genus and species is based was originally referred to *Monoclonius dawsoni* and was described and figured as such by Lambe in Contributions to Canadian Paleontology, vol. 3, pt. 2, 1902, pp. 58–59. The type was found in the Belly River (Judith River) series of Red Deer River, Alberta. The author's original description is as follows:

"The crest of *C. apertus* is composed principally of the coalesced parietals which form an expansion having somewhat the shape of a saddle, broader than long and much more robust posteriorly than in front where the bone is decidedly thin. The squamosal is not known. The parietal part of the expansion, figs. 1 and 2, Pl. I [Pl. XXIV], is longitudinally ridged in the median line, is broadly expanded laterally on either side, and ends posteriorly in a robust transverse bar that is concave in outline behind as viewed from above. The fontanelles occur one on either side of the median line and are of large size; they are bounded behind by the transverse bar that forms the posterior border of the crest, and laterally and in front by the thin side extensions. Along the median line the bone is transversely concave beneath. The separate ossifications, named by Marsh epoccipitals, are well developed in four pairs, with, in addition, the pair of hooked processes, already mentioned, which are regarded as specially developed epoccipitals. The alar extensions are referred to in the original description as the squamosal portion of the crest, the squamosals being then regarded as having coalesced with the parietals. Near the anterior border of the right extension, however, there is a definite line of demarcation, *a*, figs. 1 and 2, which can be considered only as the suture for the squamosal. * * * The postfrontal suture, *b*, figs. 1 and 2, extends from the inner side of the anterior end of the fontanelle obliquely forward and inward to the median line in front. Numerous impressions of blood vessels are present on and in the neighborhood of the epoccipitals and hooked processes and on the upper surface along the median ridge.

"The horn core, fig. 3, found with the crest is presumably a nasal one. It is straight and laterally compressed so as to be lenticular in cross section, presenting a sharp edge to the front and rear. A somewhat similarly shaped nasal horn core has been described by Cope under the name *Monoclonius sphenocerus*. One side, that figured, is deeply channeled longitudinally; the other is more regularly convex; vascular markings are conspicuous on both sides. There is apparently no great distortion, if any, of the specimen, which is 30 centimeters long and imperfect at the tip and below.

"We may conclude from the above that *Centrosaurus apertus* had a broadly expanded squamoso-parietal crest composed mainly of the coalesced parietals, the squamosals being confined to the antero-lateral edge of, and taking but little part in the formation of, the frill; that the large oval fontanelles were included entirely within the parietal part of the expansion and that the epoccipital bones were well developed, of which the hinder pair were greatly modified so as to form large hooks or spurs of bone on the hinder border; that a closely fitting integument was present, as is indicated by the many impressions of blood vessels on the upper surface, with the probability that the projections of the periphery at the sides and behind were sheathed with horn."

In his second paper on this species Lambe gives the following:

Principal measurements.

	Mm.
Extreme length from anterior end of crest (imperfect), medially, to line touching posterior edge of specimen on either side	616
Length on median line, from anterior end to posterior border	486
Semibreadth of specimen on curve of under surface	470
Semibreadth of specimen horizontally	439
Vertical drop of lateral edge of specimen below median line of upper surface at mid-length	186
Antero-posterior diameter of fontanelle	296
Transverse diameter of fontanelle	248
Circumference of base of left posterior spur	172

Mr. Lambe's description of this interesting type is mainly due to Hatcher's suggestion that it represents a distinct genus and species from *Monoclonius dawsoni*.—R. S. L.

Red Deer River, Alberta, between Berry Creek and Dead Lodge Canyon. Lambe's original description is as follows:

This species is founded on a squamosal, part of a parietal, a jugal, a supraorbital horn core, the left ramus of the lower jaw, and an anterior dorsal vertebra, with some other parts of the skull, not yet fully determined, of one individual. A right ramus of another individual is shown on Pl. XVIII [XIX] and a separate horn core on Pl. XVII [XVIII].

A right mandibular ramus, referred to this species on account of its resemblance in form to the one shown above, is described further on.

The horn core (fig. 18 [fig. 96, Pl. XVIII]) rises above the orbit from the postfrontal, of which it forms a part. The postfrontal unites behind, by suture, with the squamosal and below with the jugal. The orbit is oval, with the longer diameter vertical, its upper curve lying close under the base of the horn core, its margins not ridged. The horn core is small, about 21.6 centimeters long from the upper edge of the orbit to its summit and 22.8 centimeters in circumference near the base, circular in section, and solid.

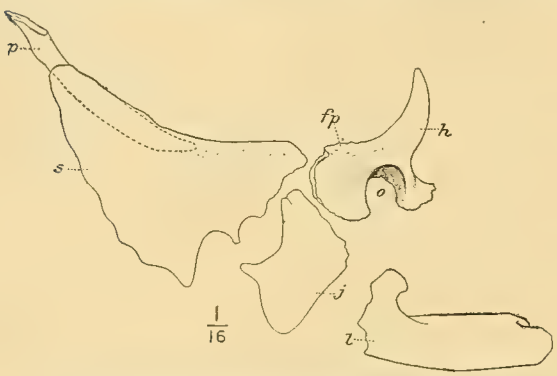

FIG. 96.—*Monoclonius canadensis;* part of the skull from the right lateral aspect. One-sixteenth natural size. *fp*, Postfrontal; *h*, horn core; *o*, orbit; *s*, squamosal; *p*, right lateral extension from parietal; *j*, jugal (misplaced nasal[a]); *l*, lower jaw. After Lambe.

Squamosal [Pl. XXIII], somewhat triangular in shape, flat, moderately thin, its outer edge smooth, rounded, wavy in outline, so as to produce six minor convex curves. Shorter and more pronounced near the front. Its outer front edge is deeply emarginated, with a shallower concavity limiting the outer termination of the jugal suture (see fig. 18 [fig. 96]), inside of which is the suture for the union with the postfrontal. The inner border is slightly concave. The lower surface near and parallel to the inner posterior end is broadly and shallowly grooved for the reception of a long, slender bone, triangular in section, that projects backward and inward, its outer edge continuing the curve of the squamosal. Probably this slender bone represents the anterior end of a forward bent side extension of the parietal, such as occurs in the species *Monoclonius belli*, in which case a fontanelle of moderate size might be expected on the inner side of the squamosal.

In fig. 18 [fig. 96] the underlying bone (imperfect posteriorly) is indicated by a dotted outline under the squamosal, beyond which it projects; its outer free edge shows a round-edged convexity in continuation of the sinuosities of the squamosal. The proximal inner margin of the squamosal is bent at right angles to the plane in which the remainder of the bone lies and its under surface is deeply excavated in its inner front part for some distance back from the postfrontal suture.

Measurements of squamosal, etc.

	Mm.
Length on curve of outer border	0.576
Length on curve of inner border	.573
Length from posterior end to center of front margin	.533
Thickness near outer border at mid-length	.028
Breadth across front margin	.355
Thickness near inner border at mid-length	.038
Length of bone underlying the squamosal (imperfect)	.502
Breadth of same at mid-length	.064
Greatest thickness at mid-length	.030

With the parts of the head shown in fig. 18 [fig. 96] was also found an anterior dorsal vertebra, fig. 19 [fig. 97], of rather small size. The faces of the centrum of this vertebra are slightly concave.

Next following is the description of a right mandibular ramus, found separately in 1897, but agreeing in size with the one depicted in fig. 18 [fig. 96].

Ramus of lower jaw (right), Cat. No. 284.

Ramus of lower jaw (Pl. XVIII [XIX], figs. 1 and 2) stout, with an inward bend at mid-length, low and thick behind, elevated and laterally compressed in front where the inner surface is shallowly concave. Excavated posteriorly below for nearly one-third of its length, the excavation extending upward along the back surface of the coronoid process and anteriorly as the mandibular canal leading forward to the mandibular groove in the lower border. The dentary canal between the outer alveolar wall and the outer surface enters from the upper and anterior part of the excavation by a large opening. Coronoid process stout, upright, hooked forward and flattened laterally above, its outer upward surface rugosely striated. A broad, low ridge, least defined toward the center, runs at about mid-height along the outer side, the surface, in a general way, above and below, retreating obliquely inward. The dental chamber, straight, starting at a low level behind, inclined strongly upward and slightly outward toward the front, its lower edge making an angle of about 20° with the lower border. Alveolar

[a] Referred to as a nasal by Lambe in Trans. Roy. Soc. Canada, 2d ser., vol. 10, sec. 4, p. 7.

grooves in outer wall of dental chamber deeply impressed toward their upper ends by a second series of groove terminations, an evidence of two roots in the teeth belonging to this jaw, such as are characteristic of some of the species of the Ceratopsidæ (Agathaumidæ). Height of dental chamber much reduced forward. A number of large foramina present in the outer surface. Front border, as viewed from the side, sinuous, rugose for its union with the predentary bone. Twenty-three alveolar grooves are present in the dental chamber (imperfect posteriorly) of the specimen figured. A small symphyseal surface is present in the front lower border.

Measurements of ramus of lower jaw.

	Mm.
Extreme length at mid-height	0.398
Depth at mid-length	.116
Distance from upper border, a little in advance of front end of dental chamber to lower posterior border of symphyseal surface	.137
Height of facet for articulation of predentary bone	.096
Distance from top of coronoid process to lower border	.193
Breadth of coronoid process from point of anterior hook backward	.097
Thickness at center of upper coronoidal expansion	.024
Thickness of coronoid process at its mid-height	.038
Antero-posterior diameter of symphyseal surface	.055
Height of same	.025
Width of larger alveolar grooves at middle of dental chamber	.009
Six grooves in a space of	.072
Height of grooves from their base to upper edge of outer alveolar wall, at middle of dental chamber	.028
Height of same anteriorly	.044

A maxillary bone (not figured) with teeth that are double fanged is referred to this species. One of the teeth is shown on Pl. XVIII [XIX], figs. 3 and 4.

A separate tooth, presumably from the lower jaw, is also figured on Pl. XVIII [XIX]. It was found separately, but on account of its having two roots, agreeing thus with the evidence of the alveolar grooves of the mandibular ramus just described, it is likewise referred to *M. canadensis*.

The discovery of this specimen is of the greatest importance, since it affords the first definite information regarding the character of the parietals and squamosals that are associated with the type of frontal horn cores shown in Marsh's type of *Ceratops montanus*. A comparison of the frontal horn of the type of the present species with that of Marsh's type of *C. montanus* makes it apparent that they are essentially the same, and I do not hesitate to remove the present species from the genus *Monoclonius* Cope and place it in that of *Ceratops* Marsh. Whether or not it should be regarded as specifically distinct from *C. montanus* I am unable to say without further study, and this question will be left for that portion of the present volume devoted to a revision of the genera and species. It is true that Professor Marsh had referred the broad squamosal shown in Pl. III, fig. 1, to *Ceratops montanus*, but since that specimen was found at a place about 15 miles distant from the locality that yielded the type, Marsh's correlation, though possibly correct, is purely conjectural, and to Lambe's fortunate discovery we are indebted for positive knowledge concerning the actual association of these important elements of the skull in this type of the Ceratopsia.

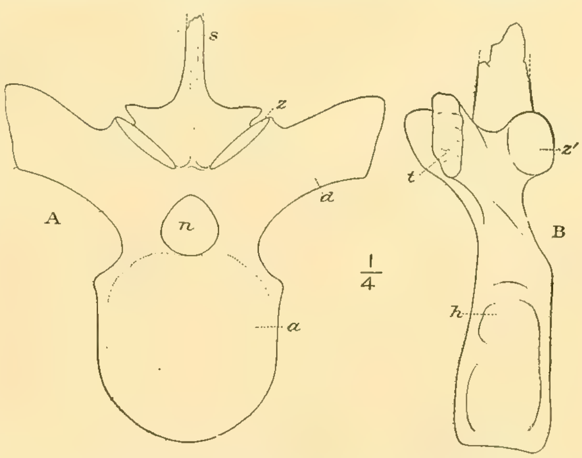

Fig. 97.—Anterior dorsal vertebra of *Monoclonius canadensis*. One-fourth natural size. A, Front view; B, left side view. *a*, Anterior face of centrum; *d*, diapophysis; *h*, facet for head of rib; *n*, neural canal; *s*, neural spine; *t*, facet for tubercle of rib; *z*, prezygapophysis. *z′*, postzygapophysis. After Lambe.

The squamosal (No. 1254a, Geol. Surv. Canada) found associated with the type of the present species exceeds in length that of any squamosal yet found from the Judith River beds. The portion posterior to the quadrate groove is more than twice the length of the anterior portion. Posteriorly it is much contracted and elongated and is already clearly assuming the form shown by the squamosals in the later genus *Torosaurus*, from the Laramie. The quadratojugal notch is deep and the inferior border of the squamosal posterior to this notch is produced downward and forms a rather acute triangular projection. Back of this the external border of the squamosal presents six gentle prominences separated by intervening sinuosities. These are more pronounced and less separated from one another in the anterior region than in the posterior. The border throughout is rather heavy. [See Pl. XXIII, figs. 1, 3.]

On its internal and inferior border throughout the posterior one-half of its length the squamosal presents a deep and broad groove for the reception of the slender bone shown by Lambe and seen here in fig. 96. [Also in Pl. XXIII, figs. 2, 4.] This bone is imperfect at the posterior extremity, but it is clear that it represents a portion of the external bar of the parietal. Its general form is very similar to that element as seen in the type of *Torosaurus gladius* Marsh, and it articulates with the squamosal in the same manner. The distal portion of that part of this element preserved in the present specimen presents on its external margin beyond the surface for contact with the squamosal an elongated prominence which, when the bone is placed in its proper position relative to the squamosal, is seen to form a continuation of that series of prominences already described as being present on the border of the squamosal. The internal margin of this external bar of the parietal is very thin throughout most of its length and evidently formed the external border of the parietal fontanelle. I have little hesitancy in asserting that the squamosal and frontal horn cores of the present species were associated with a parietal of the same general type as that described by Lambe and referred to *Monoclonius belli*, and I am of the opinion that the two may be specifically identical, although from the material at hand it is impossible to determine this point with certainty. The supraorbital horn core and postfrontal found associated with the other remains are similar in form to those which formed the type of *Ceratops montanus* Marsh and distinct from those associated with the type of *Monoclonius crassus* Cope.

The bone figured and described by Lambe (see fig. 96) as a jugal[a] proves on examination to be a right nasal. It shows posteriorly the proper articular surfaces for contact with the frontals and prefrontals, and sends downward a process for articulation with the ascending branch of the maxillary and premaxillary. Anteriorly it sends downward a process for contact with the premaxillary. Superiorly on its inner surface it presents a broad and elongated articular surface for contact with the opposing nasal. The nasal horn was detached, indicating that the animal was not fully adult. The inferior border is concave and describes a nearly complete semicircle which formed the superior border of the nasal opening.

In the present species the anterior portion of the squamosal may be described as being composed of a broad vertical portion and a narrower horizontal portion. The horizontal portion, together with that of the opposite squamosal, formed most of the superior surface of the skull in this region, reducing the anterior extremity of the parietals to a narrow point, as in *Torosaurus*. The angle formed by the union of the vertical and horizontal plates at the anterior extremity of the squamosal is produced into a strong ridge and shows a series of rugose prominences separated by concave surfaces. One of these latter is very deep. Posterior to these the superior margin of the squamosal is deeply emarginate, and this emargination probably led to the supratemporal fontanelle.

MONOCLONIUS BELLI Lambe. 1902.

Type (No. 491, Geol. Surv. Canada) consists of a parietal.

Original description, Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 65–67.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 59, 64, 68, 81.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 14, 20.

The type (No. 491, Geol. Surv. Canada) of the present species consists of the greater portion of the coalesced parietals, as shown in Pl. XXI. The bone was found by Mr. Lambe in 1898 in the Belly River series on the Red Deer River.

[a] See footnote, p. 94.

His original description is as follows:

The bone, figured on the above plate [Pl. XXI], is interpreted as representing the coalesced parietals of the posterior crest of an undescribed species of *Monoclonius*, probably ancestral to such later forms as *Torosaurus latus* and *T. gladius* of Marsh from the Laramie of Wyoming.

To facilitate an understanding of the view held as to the position the parietals probably occupied relative to other bones of the head, a drawing of the bone has been applied to the figure, slightly modified, of the skull of *T. gladius*, as given by Marsh in the Sixteenth Annual Report of the United States Geological Survey.

The parietal element from Red Deer River is symmetrical, T-shaped, with a subcylindrical shaft expanding rapidly both in front and behind. Anteriorly the expansion is concave below, strengthened above by a median, rounded ridge in continuation of the central shaft, and thinning out laterally. Posteriorly the shaft divides, nearly at right angles to itself, to either side, so as to form a strong transverse bar slightly concave at mid-length above and convex below, thin at its front edge and thickest behind. The posterior border is angularly rounded.

The space on either side of the shaft represents the inner halves of the supratemporal fontanelles. The bone missing from the specimen would complete the outer border of the fontanelles and effect a union with the inner margins of the squamosals. The lower face of the anterior expansion, on either side of the median line, is striated by distinct furrows that follow down the lower lateral sides of the shaft as deep grooves and curve outward on to the transverse bar. The anterior upper surface also exhibits similar grooves that do not, however, pass beyond the mid-length of the shaft.

The parietal, imperfect at its anterior end, is about one-third the size of that of *T. gladius*, and would probably represent a proportionately smaller animal, an earlier and more generalized form of the genus with larger fontanelles than its later Laramie successors.

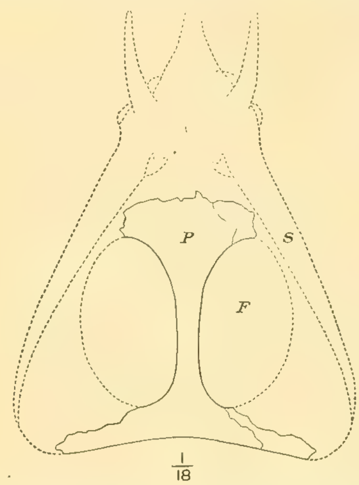

FIG. 98.—Posterior crest of *Monoclonius belli*, from Red Deer River. One-eighteenth natural size. The dotted lines are from a drawing of the head of *Torosaurus gladius* Marsh, as seen from above. *P*, Parietal; *S*, squamosal; *F*, fontanelle. After Lambe.

Measurements of parietal bone.

	Mm.
Extreme length of specimen (imperfect anteriorly) along median line	0. 584
Breadth of front expansion from median line to left edge of specimen	. 173
Breadth of posterior border from median line to left edge of specimen	. 305
Circumference of shaft at mid-length	. 180
Breadth of same at mid-length	. 065
Thickness of same at mid-length	. 053
Thickness of anterior expansion at center on median line	. 041
Thickness at anterior end of specimen on median line	. 018
Thickness on median line midway between posterior border and narrowest part of shaft	. 035
Antero-posterior diameter of fontanelles	. 416

Belly River series, Red Deer River, 1898.

This species is dedicated to Dr. Robert Bell, the administrative head of the Canadian Geological Survey.

After a careful study of the type of the present species, together with that of *M. canadensis* Lambe, one can not avoid being convinced as to their generic identity with *Ceratops montanus* Marsh, while at the same time the great dissimilarity shown in the parietals and squamosals of these species when compared with the same elements in *Monoclonius dawsoni* Lambe affords evidence additional to that already pointed out as obtaining in the frontal horn cores, in favor of the generic distinction of the three former species from that of the last-mentioned species.

STEGOCERAS Lambe. 1902.

Type species, *S. validus*.

Original description in Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 68 and 69.

Nopcsa, F. Baron, Centralblatt für Mineralogie, 1903, p. 266.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 3, 1902, p. 21.

This genus was founded by Lambe on some problematical reptilian remains from the Judith River beds of Canada. Although they are probably not referable to the Ceratopsidæ they will be considered here for the reason that Lambe referred them to that family.

STEGOCERAS VALIDUS Lambe. 1902.

Type (Nos. 515[a] and 1423, Geol. Surv. Canada) consists of two cranial fragments pertaining certainly to different species and possibly to different genera.

Original description in Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 68–69.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 81.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 15.

The present genus and species are based upon the fragmentary remains of three different individuals. Unfortunately Lambe failed to designate any one of these remains as the type of the genus or species,[a] and he remarks in speaking of the two better preserved specimens that they may pertain to different species. His description is as follows:

The two symmetrical, compact bones, represented on Pl. XXI [XXII], were found separately. The lower portions of their sides, as well as their ends, consist of sutural surfaces, indicating that other bones were firmly united to them and completely surrounded them. A transverse suture divides each almost equally into an anterior and a posterior half. On the lower surface there is evidence of a line of coalescence in a longitudinal direction and extending from end to end. The upper surface of each specimen is dome shaped.

In the larger specimen (Cat. No. 515)[a] the anterior end is produced forward and is slightly elevated, terminating in two projections; the surface is here distinctly nodose. In the lateral posterior upper surface a similar rugosity is apparent. The surface of the central convexity is smooth. In the smaller specimen (Cat. No. 1423) the upper surface is smooth and pitted throughout. It is trilobed posteriorly and is not produced forward in front, where, however, two small nodes occur, one on each side of the median line.

The structure of the lower surface is marked by a number of smooth, concave areas, as represented in the reproductions, from photographs of the specimens, in figs. 2 and 5 of Pl. XXI [XXII].

It is probable that these bones were situated in the median line of the head, in advance of the nasals. They may have belonged to a species of dinosaur not otherwise represented in the collections from Red Deer River and, judging from the difference in shape of the two specimens, more than one species may be indicated. Marsh in his figure of the head of *Triceratops serratus* shows a nasal horn core (divided both transversely and longitudinally by sutures)[b] that may correspond to the specimens from Red Deer River.

A third specimen (Cat. No. 1594), similar to the anterior half of the larger of the two bones, was collected in 1901. It has separated from its posterior half along the line of the transverse suture.

For these bones the name *Stegoceras validus* is proposed with the hope that future discoveries may aid in a clearer understanding of their affinities. (See also Cat. No. 1075.)

Belly River series, Red Deer River. 1898, 1901.

After a careful study of the materials upon which the present genus and species were based I am fully convinced that they pertain to a reptile hitherto unknown. I can not, however, agree with Lambe's determination as to the position which these elements occupied in the skull,[c] nor do I believe that they pertain to any member of the Ceratopsia. And it has yet to be shown that they belong to any dinosaur. I should not be surprised if, when the true nature of the animal to which they pertain is known, it would prove to belong to some other reptilian order. As suggested by Lambe I am inclined to the opinion that the two better preserved specimens belong to different species, but I can not agree with him in interpreting them as prenasals. They appear to me rather as representing the superior portion of the occipital, parietal, and frontal segments of the skull of some reptile in which, as shown in fig. 99, the different bones of this region have been greatly reinforced from above by the coalescence of dermal ossifications which rise in a dome-shaped mass above the brain case, completely enveloping the cranial elements of this region and thus giving great additional strength to the cranium. This ossified dermal covering, as it might be called, differs in structure from the ordinary membrane bones forming the roof of the brain case to which it is attached in being extremely dense and in exhibiting a columnar structure, so that about the margins this dome-like mass of bone, overlying and firmly coossified with the ordinary cranial elements, is seen to be composed of innumerable

[a] Mr. Lambe considers No. 515 as the type.—R. S. L.

[b] These sutures separate the nasals and premaxillaries; the horn core is absent.—R. S. L.

[c] In a paper published since the death of Hatcher (Trans. Roy. Soc. Canada, 2d ser., vol. 10, sec. 4, p. 24), Mr. Lambe says: "*Stegoceras validus* is based on portions of the skull from the median line of the head, with indications on the upper surface of the presence of an unpaired horn. These parts were supposed to be prenasal, but, as pointed out by Nopcsa (Ueber Stegoceras und Stereocephalus, von Franz Baron Nopcsa, jr., Centralblatt für Mineralogie, etc., No. 8, 1903, Stuttgart), they probably represent the frontal and nasal elements of the skull. In *Stegoceras* we have an entirely new type, a unicorn dinosaur remarkable in that it bore a horn springing from the fronto-nasal region, recalling a somewhat similar development in the mammals *Aceratherium incisivum* and *Elasmotherium sibiricum*."—R. S. L.

minute columns of bone arranged perpendicular to and radiating from the external surface of the various bones of the roof of the skull, with which they are firmly coossified at their bases, as shown in fig. 100.

If my interpretation, which differs only in a few unimportant particulars from that of Nopcsa, is correct, Lambe was not only wrong in considering these elements as prenasals,[a] but he also possibly mistook the anterior for the posterior extremities. I would interpret the large median cavity shown on the inferior surface in fig. 99 as the upper portion of the brain cavity, while the transverse suture which divides it into anterior and posterior moieties I would consider the parieto-frontal suture, rather than the fronto-nasal, as believed by Nopcsa.

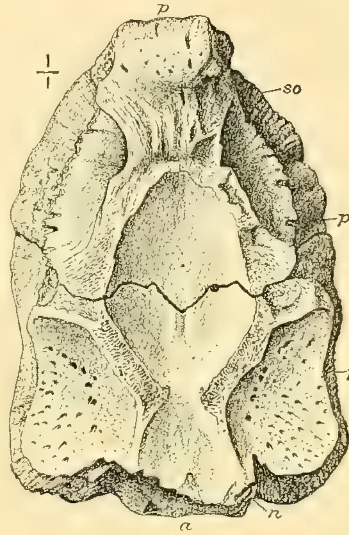

FIG. 99.—Inferior view of *Stegoceras validus* Lambe, No. 1423, Geol. Surv. Canada. *a*, Anterior; *p*, posterior; *n*, nasal; *f*, frontal; *pe*, parietal; *so*, supraoccipital. Natural size.

Thus the bone in front of the suture becomes, according to my interpretation, the frontal rather than the nasal, as regarded by Nopcsa, though faint lateral sutures just in advance of the interorbital constriction may mark the posterior borders of the nasals. Like Nopcsa, I regard the lateral cavities as orbital. Posteriorly in the larger of the two specimens there are two deep lateral cavities which opened externally by a small circular foramen, only the internal border of which latter is represented in either specimen. The deep lateral cavities I interpret as infratemporal fossæ, while the circular foramina opening into them may possibly represent the supratemporal fossæ, though from the position of these foramina this interpretation appears hardly probable. On the larger of the two more complete specimens just behind that cavity which I have considered the brain cavity there is a broken or sutural surface, followed by a rather deep median excavation terminating anteriorly in two shallow pits separated by a median septum. This may have formed the roof of the foramen magnum.

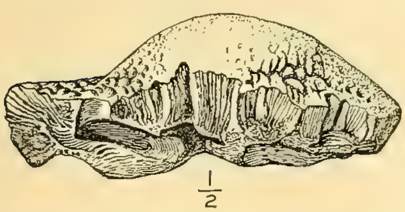

FIG. 100.—Side view of type specimen, No. 515, Geol. Surv. Canada, showing columnar structure of dermal ossification. One-half natural size.

Without more perfect material it is quite impossible to determine definitely either the homologies of these elements or the nature of the animal to which they pertained. In the present writer's opinion, however, there is no good reason for considering them as horn bearing, or the animals to which they belonged as pertaining to the Ceratopsidæ. I, therefore, do not include them in that group.

Principal dimensions of bones of Stegoceras validus.

	Mm.
For the larger (type specimen No. 515, Geol. Surv. Canada):	
Greatest length	106
Greatest breadth	60
Greatest depth	41
For the smaller (No. 1423, Geol. Surv. Canada):	
Greatest length	64
Greatest breadth	44
Greatest depth	31

Taken as a whole the collection of Ceratopsia made by Lambe from the Belly River beds is a most important one, since it furnishes much valuable evidence not only regarding the distinctly generic characters of these earlier and less specialized members of the family, but relating also to the ancestry and phylogeny of the later, more highly specialized, and much better known

[a] See footnote c, p. 98.

forms from Converse County, Wyo. The affinities of *Monoclonius*, as shown in the type species *M. crassus* Cope and in *M. dawsoni* of Lambe, are apparently with the later genus *Triceratops* of Marsh, while *Ceratops montanus* Marsh, *C. recurvicornis* Cope, *C. canadensis*, and *C. belli* Lambe would seem to be ancestral to *Torosaurus*. These questions will be more fully discussed when we come to treat of the phylogeny and taxonomy of these dinosaurs.

GENERA AND SPECIES DESCRIBED BY PROFESSOR MARSH FROM THE JUDITH RIVER BEDS.

CERATOPS [a] Marsh. 1888.

Type species, *C. montanus*.

Original description in Am. Jour. Sci., 3d ser., vol. 36, Dec., 1888, pp. 477–478.

Marsh, O. C., ibid., Apr., 1889, pp. 327, 334–335; Aug., 1889, p. 175; Dec., 1889, pp. 505, 506; Jan., 1890, pp. 81–83; Feb., 1891, pp. 171, 176; Apr., 1891, pp. 340–341; Sept., 1891, p. 266; Jan., 1892, p. 83; Dec., 1895, p. 497; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, pp. 145, 206, 210, 216, 219, 243.

Ed. Am. Geologist, vol. 8, 1891, p. 56.

Baur, G., Science, vol. 17, 1891, p. 216; Am. Naturalist, vol. 24, 1890, p. 570; Am. Naturalist, vol. 25, 1891, p. 450.

Hatcher, J. B., Am. Naturalist, vol. 30, 1896, p. 113.

Lydekker, R., Nature, vol. 48, 1893, p. 304.

Nicholson and Lydekker, Manual Pal., 1889, vol. 2, p. 1163.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 9, 20.

Woodward, A. S., Outlines Vert. Pal., pp. 213, 216.

Zittel, K. A. von, Text Book Pal., trans. by C. R. Eastman, vol. 2, p. 245.

The present genus may be distinguished from *Monoclonius* Cope, based on material from the same beds in Montana, by the greater development of the supraorbital horn cores, the longer and narrower squamosals, the enlarged fontanelles, by which the parietals are reduced to slender median and lateral bars. The nasal horn cores are very probably quite different also in the two genera, though we can not as yet be certain as to their character in *Ceratops*. From our present knowledge of the skull of *Ceratops* it seems to have been a precursor of *Torosaurus* Marsh, while *Monoclonius* Cope appears to have been ancestral to *Triceratops* Marsh.

CERATOPS MONTANUS Marsh. 1888.

Type (No. 2411, U. S. National Museum) consists of occipital condyle and pair of frontal horn cores.

Original description in Am. Jour. Sci., 3d ser., vol. 36, 1888, pp. 477–478.

Hatcher, J. B., Am. Naturalist, vol. 30, 1896, p. 113.

Marsh, O. C., Am. Jour. Sci., vol. 37, Apr., 1889, p. 327; Jan., 1890, p. 83; vol. 43, 1892, p. 84; Sixteenth Ann. Rept. U. S Geol. Survey, pt. 1, p. 216.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 9, 14, 18, 20.

Walcott, C. D., Science, new ser., vol. 11, 1900, p. 23.

In December, 1888, Professor Marsh described the new genus and species *Ceratops montanus*. The type (No. 2411, U. S. National Museum) consists of an occipital condyle and a pair of frontal horn cores, found together and pertaining to the same skull. These remains were found by me in 1888. The horizon was near the top of the Judith River beds, and the exact locality was on the northwestern slope near the summit, about 300 yards from the point of the first hogback that projects into the valley of Cow Creek from the west, just below where the old Cow Island and Fort Benton freight road descends into the valley of Cow Creek, about 10 miles above the confluence of that stream with the Missouri River.

Marsh's original description of the above genus and species was as follows:

> The present genus appears to be nearly allied to *Stegosaurus* of the Jurassic, but differs especially in having had a pair of large horns on the upper part of the head. These were supported by massive horn cores firmly coossified with the occipital crest. The latter are probably attached to the parietal bones, but, as the sutures in this region are obliterated, they may be supported in part by the squamosals.

[a] The name *Ceratops* was used by Rafinesque in 1815 to designate a genus of birds. As no description of the genus was published, and as no forms were mentioned as pertaining to it, it becomes a nomen nudum. Should expert nomenclaturists decide that Rafinesque preoccupied the name *Ceratops* I have suggested that the term *Proceratops* be used in its stead. (See Am. Jour. Sci., 4th ser., vol. 21, p. 144.)—R. S. L.

The horn cores in the type specimen are subtriangular at base, but nearly round in section in the upper half. Their position is represented approximately in the figures of the accompanying plate [shown here in fig. 100]. These horn cores are slightly hollowed at the base, but are otherwise solid. The exterior texture and markings show that they were evidently covered with true horns, and these must have formed large and powerful offensive weapons. In position and direction these horn cores are somewhat similar to the large posterior pair of protuberances in *Meiolania*,[a] one of the extinct Testudinata, and to the corresponding ones of the existing *Phrynosoma*. The only known example of similar structure in the Dinosauria is the single median horn core on the nasals of *Ceratosaurus*, from the Jurassic. It is not improbable that there were other horn cores on the skull in the present genus, but of this there is at present no positive evidence. A detached median prominence resembling a horn core was found with some similar remains, but may pertain to an allied genus.

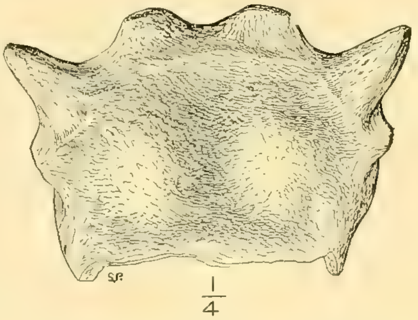

Fig. 101.—Upper view of cranium of *Meiolania platyceps* Owen, drawn from a cast (No. 208) in the U. S. National Museum. One-fourth natural size.

The resemblance in form and position of the posterior horn cores to those of some of the ungulate mammals is very striking, and, if detached, they would naturally be referred to that group.

The basioccipital found in place with these horn cores and represented in Pl. XI [fig. 104, 1 *b* and 2 *b*,] is much elongated, and formed the entire occipital condyle. Its exact position with reference to the horn cores could not be determined.

Teeth, vertebræ, and limb bones, which probably belonged to the present genus, were all secured in the same horizon. They indicate a close affinity with *Stegosaurus*, which was probably the Jurassic ancestor of *Ceratops*.

Among other remains referred to the present reptile, but not found with the type specimen, are some peculiar large dermal plates, in pairs, that indicate a well-ossified armor. These plates show indications of being covered, in part, at least, with scutes, as in turtles. Their position can not at present be determined.

The type specimen on which the present genus and species are based was found in place, in the Laramie deposits of the Cretaceous in Montana, by Mr. J. B. Hatcher, of the U. S. Geological Survey. Other specimens, apparently pertaining to the same species, were secured in the same horizon of the same region.

Remains of the same reptile, or one nearly allied, had previously been found in Colorado in deposits of about the same age by Mr. G. H. Eldridge, also of the U. S. Geological Survey.

The associated fossils found with the present specimens are remains of other dinosaurs, crocodiles, turtles, and fishes, mostly of Cretaceous types. The mollusks in the same beds indicate fresh-water deposits.

The fossils here described indicate a reptile of large size, 25 or 30 feet in length, and of massive proportions. With its horned head and peculiar dermal armor, it must have presented in life a very strange appearance.

The remains at present referred to this genus, while resembling *Stegosaurus* in various important characters, appear to represent a distinct and highly specialized family that may be called the Ceratopsidæ. They will be described more fully in a later number of this journal.

As is now well known, the above description is erroneous in many particulars. The beds were not Laramie, but Judith River, a distinctly older formation. The horn cores in the Ceratopsidæ are not firmly coossified with the occipital crest, and they were not directly attached to either the parietals or squamosals. Marsh's suggestion that there were probably other horn cores on the skull proved correct. The basioccipital does not form the entire condyle, but that element is made up of the coossified basioccipital and exoccipitals. The large plates mentioned by Marsh as dermal plates are in reality squamosals. The size of the animal indicated by the type material was considerably overestimated by Marsh, and his suggestion that *Stegosaurus* was the Jurassic ancestor of *Ceratops* might at present be questioned by many.

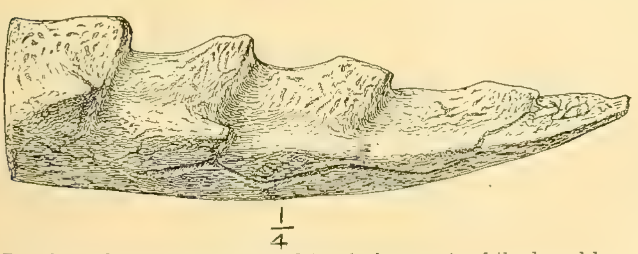

Fig. 102.—Side view of the coalesced terminal segments of the dermal bony tail sheath of *Meiolania platyceps* Owen, from a cast (No. 207) in the U. S. National Museum. One-fourth natural size.

[a] *Meiolania platyceps* was described and figured by Sir Richard Owen in the Philosophical Transactions of the Royal Society, 1888, B, pp 181–191, pls. 31–37. *Meiolania* is a turtle, one of the Cryptodira, found on Lord Howes Island in the Pacific, and in at least two features is suggestive of the Ceratopsia. The superior view of the hinder portion of the cranium here shown (fig. 101) exhibits, in addition to the low hindermost pair of horns, "larger cores, which rise in advance of and exterior to these; the length of this core is 2 inches" (Owen). These cores are the ones to which Marsh refers as being similar to those of *Ceratops montanus*, and, like those of the dinosaur, were evidently sheathed with horn. Fig. 102 shows the osseous tail sheath of *Meiolania*, which also bears vascular markings similar to those borne on the ceratopsian frill.—R. S. L.

I can add nothing of importance to Professor Marsh's original description of the type, except to give the more important measurements. These are as follows:

Measurements of Ceratops montanus.

	Mm.
Height of frontal horn core	220
Antero-posterior diameter of same at base	93
Transverse diameter of same at base	88
Transverse diameter of occipital condyle	71

The principal characters of the type material are well shown in figs. 103[a] and 104,[a] and from these and the above description it is clear that the genus *Ceratops* must rest on the characters displayed by the occipital condyle and the frontal horn cores, neither of which elements are represented in the actual type of the genus *Monoclonius* of Cope. If the frontal shown in fig. 75, bearing the diminutive horn core which was subsequently associated by Cope with the type, though evidently pertaining to a much smaller individual, be admitted as a cotype, and therefore to some extent, at least, diagnostic of the genus *Monoclonius*, there would still be good reasons for considering *Ceratops montanus* as both generically and specifically distinct

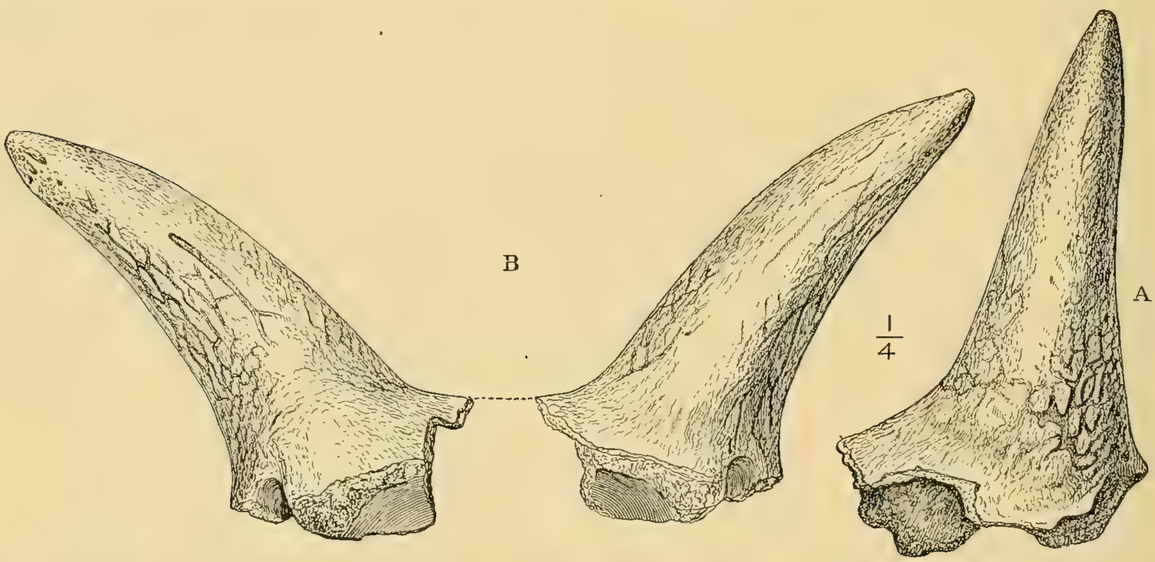

FIG. 103.—Supraorbital horn cores of the type of *Ceratops montanus* Marsh (No. 2411, U. S. National Museum) in their proper position. A, O blique back view; B, anterior view. One-fourth natural size.

from *Monoclonius crassus*, for such striking differences as are shown in these two types of frontal horn cores are certainly suggestive of other and even more important structural differences in the skull and other portions of the skeleton. However, the full discussion of such questions must be left for that portion of this volume devoted to a revision of the genera and species.

The squamosal figured by Marsh[b] as pertaining to *Ceratops montanus*, but originally described in the above quotation as a dermal plate, was found by the present writer many miles from the locality which furnished the type. It may or may not pertain to that genus and species. Judging, however, from the character of the squamosal in *Ceratops* (*Monoclonius*) *canadensis* Lambe, where the supraorbital horn cores are strikingly similar to those of the present species, it seems probable that Marsh was in error in referring this squamosal to *C. montanus*.

[a] In figuring the type of *Ceratops montanus*, Marsh mistook the external lateral view of the supraorbital horn core for the posterior. Fortunately a portion of the orbit is present, making it possible to determine the position of the horn cores with certainty. In fig. 103 these horn cores are shown in their proper positions, which is somewhat different from that assigned them by Professor Marsh.

[b] Am. Jour. Sci., vol. 43, 1892, pl. iii, fig. 3. This monograph, Pl. I, fig. 1.

Ceratops paucidens Marsh. 1889.

Type consists of left maxillary and a premaxillary (in U. S. National Museum), Judith River beds, Dog Creek, Montana.

Originally described as *Hadrosaurus paucidens* in Am. Jour. Sci., 3d ser., vol. 37, Apr., 1889, p. 336. Later placed in the genus *Ceratops* (Am. Jour. Sci., 3d ser., vol. 39, Jan., 1890, p. 83).

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

The type of this species (now in the U. S. National Museum), a left maxillary and a premaxillary, was found by the present writer in the upper Judith River beds, on Dog Creek, Montana. The exact locality was on the western slope, very near the summit, of a rounded badland hill about 20 rods east of the spring situated about one-quarter of a mile east of the freight road running from Judith to Maiden, Mont. The locality is locally known as the "Bad Place" by freighters, having acquired this name from the nature of the road, which here follows the winding divide between Dog Creek and the Judith River. The divide at this place is both narrow and crooked. It is inclosed on either side by badlands which extend on either side to the neighboring streams. It is distant about 12 miles from Judith post-office, on the Missouri River, and, on account of the spring mentioned above, during certain seasons of the year the locality is a favorite camping place for freighters bound to and from either Judith or Big Sandy, a station on the Great Northern Railway.

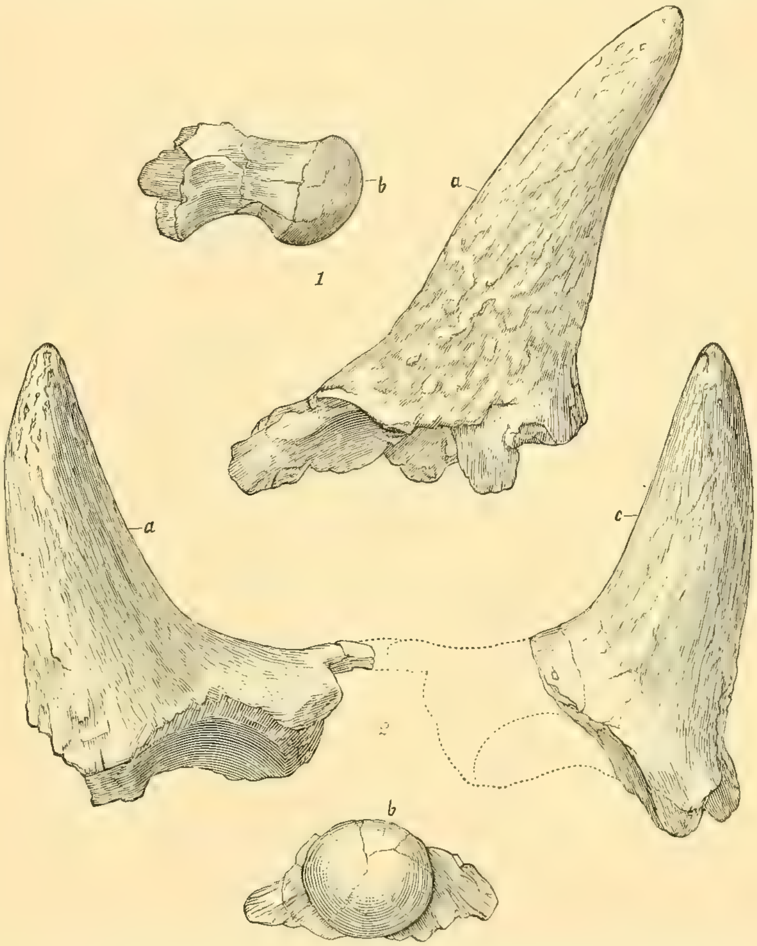

Fig. 104.—1, Supraorbital horn core and occipital condyle of type (No. 2411, U. S. National Museum) of *Ceratops montanus* Marsh, side view: *a*, Horn core; *b*, condyle. 2, Posterior views of occipital condyle and supraorbital horn cores of same: *a*, Left horn core; *c*, right; *b*, condyle. One-fourth natural size. After Marsh.

In his original description[a] Professor Marsh referred this species to the genus *Hadrosaurus;* the year following, however, he placed it in the genus *Ceratops*. His original description is as follows:

In strong contrast with the species above described (*Hadrosaurus breviceps*) is another from the same region and same formation. The best preserved specimen that now represents it is a left maxillary, nearly complete. With this was found some other portions of the skull, but the maxillary affords the best distinctive characters. All, however, indicate a skull of extreme lightness and delicacy of build for one of the Ornithopoda. The maxillary is especially slender, and the anterior and posterior extremities are pointed. The middle of the bone is more massive, but yet very light for this portion of the skull. The teeth are of the general type of those in this genus, but are comparatively few in number and only one row appears to have been in service.

The maxillary preserved is about 10 inches in length, and 3 inches high near the center. The row of teeth in use contains about thirty.

The remains on which the present species is based were found in 1888, in the Laramie formation of Montana, by Mr. J. B. Hatcher, of the United States Geological Survey.

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[a] Am. Jour. Sci., vol. 37, 1889, p. 36.

The following year[a] Marsh recognized the true affinities of this species and placed it in the genus *Ceratops*. His remarks at this time were as follows:

The specimen recently described by the writer under the name *Hadrosaurus paucidens* should probably be referred to the genus *Ceratops*, as a comparison with more perfect specimens indicates a much closer affinity with that genus than at first supposed. In addition to the maxillary described, one of the premaxillaries is in good preservation. This agrees in general features with the corresponding bone in *Triceratops*, but is less specialized. Its inner surface is deeply concave, showing that the two premaxillaries did not meet each other closely, as in *Triceratops*, but apparently only in front. This species, as well as the type of the genus *Ceratops montanus*, represents smaller, less specialized forms of the family, and may be from a lower geological horizon than the gigantic reptiles which the writer has recently made known.

It is not at all unlikely that the type of the present species pertained to one of the several species of Ceratopsidæ already described as from the Judith River beds. Since, however, the teeth, the maxillaries, and the premaxillaries of all these are imperfectly known, it is at present impossible to determine to which of them this specimen should be referred. Marsh's statement that this species, as well as the type of the genus *Ceratops montanus*, represents smaller, less specialized forms, from a possibly lower geological horizon than the gigantic Ceratopsidæ from the Laramie of Converse County, Wyo., is significant, considering that the present type was recovered from near the summit of the Judith River beds, and should be taken as additional evidence in favor of the view long held by the present author, that the Judith River beds represent a horizon decidedly older than the beds of Converse County, Wyo., the correctness of which was conclusively demonstrated in 1903 by the stratigraphic work of Messrs. T. W. Stanton and J. B. Hatcher.[b]

SPECIES ERRONEOUSLY REFERRED TO CERATOPS.

The two species *Ceratops* (*Bison*) *alticornis* and *C. horridus*, although originally referred by Marsh to *Ceratops*, certainly do not pertain to that genus. Their affinities are more nearly with *Triceratops*, in which genus the latter was subsequently placed by Professor Marsh, though for some reason unknown to the present writer, or perhaps by oversight, the former was left by Marsh in the genus *Ceratops*. In the present volume they will be considered as belonging to the genus *Triceratops*, and their description will be deferred until we come to treat of the species of that genus.

From the above description of these earlier, smaller, and more primitive forms from the Judith River beds we will pass on to the larger, later, and more specialized forms from the Laramie of southern Wyoming and of Converse County in east-central Wyoming, from northwestern South Dakota, eastern Montana, and from the possibly later deposits, known as the Denver beds, of Colorado.

REVIEW OF THE SPECIES OF LARAMIE CERATOPSIA.

GENERA AND SPECIES DESCRIBED BY PROFESSOR COPE.

AGATHAUMAS Cope.

Type species is *A. sylvestris*.

Original description of genus, Proc. Am. Philos. Soc., vol. 12, pp. 481–483.

Baur, G., Science, vol. 17, 1891, pp. 216–217; Am. Naturalist, vol. 25, 1891, pp. 448, 450, 452.

Cope, Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873, pp. 435, 438, 442, 444–446; Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, 1st ser., pp. 16, 17; Rept. U. S. Geol. and Geog. Surv. Terr., vol. 2, 1875, pp. 41, 53–54, 248; Am. Naturalist, vol. 12, 1878, p. 246; Proc. Acad. Nat. Sci. Phil., 1883, p. 99; Am. Naturalist, vol. 23, 1889, p. 715; Syl. Lectures on Pal., Univ. of Pennsylvania, 1891, p. 43; Am. Naturalist, vol. 26, 1892, pp. 757–758.

Dana, J. D., Manual of Geology, 1895, p. 847.

Editor Am. Geologist, Am. Geologist, vol. 8, 1891, p. 56..

Lydekker, R., Nature, vol. 48, 1893, p. 304.

Lambe, L. M., Sum. Rept. Geol. Surv. Canada, 1898, p. 187.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 41, Feb., 1891, p. 176; vol. 43, Jan., 1892, pp. 83 and 84; vol. 50, Dec., 1895, p. 497; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, pp. 217, 243.

Nopcsa, F. Baron, Földtani Közlöny, vol. 31, Budapest, 1901, p. 270.

[a] Am. Jour. Sci., vol. 39, 1890, p. 83.

[b] Bull. U. S. Geol. Survey No. 257, 1905.

Osborn, H. F., Bull. Am. Mus. Nat. Hist., vol. 5, 1893, p. 326; Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 9, 20.
Woodward, A. S., Outlines Vert. Pal., p. 213.
Zittel, K. A. von, Text-book Pal., trans by C. R. Eastman, vol. 2, p. 244.

This, the earliest known genus of the Ceratopsidæ, represents one of the larger of these horned dinosaurs. Unfortunately nothing is known of the skull in this genus. This is especially unfortunate in the present instance, since in this group of dinosaurs the skull affords by far the best generic and specific characters, and most of the genera and species are based very largely and often entirely upon cranial characters. From the material at hand it would be hard to distinguish the present genus from any one of the several genera that have been proposed for the reception of these later Laramie Ceratopsidæ.

AGATHAUMAS SYLVESTRIS Cope. 1872.

Type (No. 4000, Am. Mus. Nat. Hist.) consists of about sixteen vertebræ, including the sacrum, the right ilium, fragments of ribs, etc.

Originally described in Proc. Am. Philos. Soc., vol. 12, pp. 481–483.
Marsh, O. C., Am. Jour. Sci., 1873, pp. 230–231.
Baur, G., Science, vol. 17, 1891, p. 217.
Cope, E. D., Am. Naturalist, 1872, p. 670; Proc. Acad. Nat. Sci. Phila., vol. 24, 1872, p. 279; Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873, pp. 435, 438, 442, 444–446, 447; Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, 1st ser., pp. 9, 11, 16–18, 20; Rept. U. S. Geol. and Geog. Surv. Terr., vol. 2, 1875, pp. 31, 34, 40, 54–56, 57, 248; Bull. U. S. Geol. and Geog. Surv., vol. 3, 1877, p. 594; Am. Naturalist, vol. 12, pp. 245–246; Am. Naturalist, vol. 23, 1889, pp. 715–717; Syl. Lectures on Pal., Univ. Pa., 1891, p. 43; Am. Naturalist, vol. 26, 1892, p. 758.
Dana, J. D., Manual of Geology, 1895, p. 847.
Hatcher, J. B., Am. Naturalist, vol. 30, 1896, p. 113.
Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

The first of these larger and more specialized members of the Ceratopsia to be discovered and described was the *Agathaumas sylvestris*[a] of Cope. Indeed this was the first of all the genera and species of this group of dinosaurs to be described and named.

LOCALITY.

The type (No. 4000, Am. Mus. Nat. Hist.) of the present genus and species was discovered in 1872 by F. B. Meek, of Dr. F. V. Hayden's Geological and Geographical Survey of the Territories. It was found in southern Wyoming, not far from Black Buttes station on the Union Pacific Railroad, 52 miles east of Green River. According to Professor Cope, who unearthed the remains, they were taken from a bed of sandstone occupying a stratigraphic position just above the thinner or lower stratum of the Bitter Creek series of coals and overlain by two other coal seams. This bed of sandstone in which the bones were found "crops out high on the bluffs" lying east of Black Buttes station. Dr. T. W. Stanton, who is well acquainted with the country about Black Buttes, writes me as follows:

I can not say that I have ever identified the exact spot from which the bones were taken, but the horizon and the general location within 200 or 300 yards is easily found. Meek, who discovered the bones, and Cope, who collected and described them in 1872, were not very definite in their statements as to the locality, though they gave its exact position in the section. The only natural inference from Cope's description is that the place is east of the railroad, which for a short distance here has a course almost south. In 1873 Lesquereux visited the locality and gave its position as follows:[b] "The Saurian bed, as it is now called, is at the top of the ridge facing the depot, at a short distance, half a mile, east from it. The débris taken out in digging the bones of the animal is still mixed with a quantity of fragments of those bones, and some of the specimens are remarkably interesting, bearing, as they do, fragments of bones on one side and fossil leaves on the other." White evidently overlooked this definite statement when he published his belief that the type locality of *Agathaumas sylvestris* is probably about a mile south of Black Buttes station and about 100 feet above the principal horizon for invertebrate fossils.[c]

The Black Buttes section was examined by Messrs. Stanton and Knowlton in 1896, who described[d] it as follows:

"The most prominent feature of the section at Black Buttes is the massive bed of sandstone somewhat over 100 feet thick at the base of the exposure, forming steep hills and cliffs northeast of the railroad opposite the station and passing

[a] The original spelling was *Agathaumas sylvestris*, later variations by Cope were *Agathaumus* for the genus and *sylvestre* and *silvestre* for the species.
[b] Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873, p. 373.
[c] Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1877, p. 223.
[d] Bull. Geol. Soc. America, vol. 8, p. 143.

beneath the surface by its dip of 9 or 10 degrees near the coal mine. The upper portion of it is also exposed on the south side of Bitter Creek Valley, about a mile from the station. All of the Laramie fossils, whether plants, invertebrates, or vertebrates, that have hitherto been described or listed as coming from Black Buttes were obtained from the overlying beds within about 100 feet of the top of this massive sandstone. The original specimen of *Agathaumas sylvestris* was found about 20 feet above it, and the plants that have been described came from the same horizon and from several higher bands up to the bed overlying the principal coal, some 60 or 75 feet higher. The invertebrates from this locality have about the same range. Most of the beds vary considerably in character and thickness within short distances, but the fossiliferous and overlying portions of the section may be described in general terms as a series of variable sandstones, clays, and coal beds exposed in low hills and ridges with a dip of 9 or 10 degrees eastward at the base, but decreasing in the upper portions to 5 or 6 degrees, which is about the same as the dip of the overlying Wasatch beds."

DESCRIPTION BY COPE.

Cope's original description of the present genus and species is as follows: [a]

During the present season F. B. Meek, of Dr. F. V. Hayden's Geological Survey of the Territories, discovered some large bones near Black Buttes station, on the Union Pacific Railroad, 52 miles east of Green River and near the Hallville coal mines. Shortly afterwards I visited the spot with a branch expedition, and commenced excavations with a view to the recovery of the remainder of the animal. The position was discovered to be between the thinner or lower strata of the Bitter Creek series of coal, which at this point, occupy a position of elevation and crop out high on the bluffs. Two strata appear above the sandstone in which the bones occur and one below it. The portion of the skeleton found rested in the midst of vegetable débris, as sticks and stems, and was covered with many beautiful dicotyledonous leaves, which filled the interstices between the bones. The plant bed gradually passed into a shell bed, containing numerous thin dimyaria, and close by some oysters were found. The whole question as to geologic age and aqueous conditions during which these beds were deposited being unsettled, I gave especial attention to the recovery of the bones, with the view of reaching a definite conclusion on these points.

We succeeded in recovering 16 vertebræ, including a perfect sacrum, with dorsals and caudals; both iliac and other pelvic bones, those of one side nearly perfect; some bones of the limbs, ribs, and other parts not determined.

The vertebræ are large. The dorsals are short, with vertically oval centra and small neural canal. The diapophyses originate well above the neural canal, diverge upward, and are triangular in section. The neural spine is very much elevated and the arch short antero-posteriorly. The zygapophyses are close together in both directions, those of the same aspect being separated by a narrow keel only. They do not project, but consist of articular surfaces cut into the solid spine. The latter is flat and dilated distally. The articular faces are nearly plane with a slight median prominence.

The ribs have two articular surfaces, but I found no capitular pit on the dorsal centra.

Elevation of centrum 7.5 inches; width of same, 5 inches 7.5 lines; length of same, 3 inches 8.5 lines. Total elevation of a dorsal vertebra, 28 inches 3 lines. The sacrum consists of five vertebræ, the anterior centrum not depressed. They give out huge diapophyses which are united by suture. They are themselves united distally in pairs, each pair supporting a longitudinal convex articular face for the ilium. Each pair incloses a perforation with the centra. The first diapophysis goes off from the point of junction of the first and second vertebræ, the second from the third only, and is more slender. The total length is 25 inches, and the width 30 inches. Its vertebræ are flat below, with latero-inferior angles. The last centrum gives off a simple diapophysis.

Another vertebra exhibits a diapophysis as low as the floor of the neural canal and united by coarse suture. Others posterior to the sacrum are more elongate, with slightly compressed centrum and with diapophysis opposite floor of canal and not united by suture. Centra flat below; no chevron bones discoverable. Length of centrum, 4 inches 4 lines; depth of articular face, 4 inches; width of same, 4 inches 3 lines.

The iliac bone is extended antero-posteriorly. One extremity is thick and rather obtuse, but of little depth. There is a large protuberance above the acetabular sinus. The other extremity is dilated into a flat, thin plate of rather greater length than the stouter extremity. From one of its margins a rod-like element projects. Its total length is about 4 feet, of which the acetabular sinus measures about 8.10 inches.

A short bone pertaining to the limbs has the articular surfaces at a strong angle to each other, hence the shaft is twisted. It is deeply grooved on one side near the extremity. The other extremity bears a rather flattened hourglass-shaped articular face, and below it on one angle is a crest. The convexity of the surface is not great, and this extremity resembles that of a dinosaurian or crocodilian reptile. Its length is, however, only $8\frac{1}{4}$ inches; apparently too small for a humerus, though this is not certain, while it is decidedly too small for a metatarsal of such an animal.

From the above description it is evident that the animal of Black Buttes is a dinosaurian reptile, the characters of the sacral and iliac bones alone sufficing to demonstrate this point. If the reader will compare the measurements given for species of this group already known he will observe that those of the present animal exceed those yet described from North America. It is possible that if the corresponding parts of *Hadrosaurus tripos* Cope, or *Thespesius occidentalis* Leidy, are discovered, they may approach it.

It is thus conclusively proven that the coal strata of the Bitter Creek Basin of Wyoming Territory, which embraces the greatest area yet discovered, were deposited during the Cretaceous period, and not during the Tertiary, though not long preceding the latter. It appears that the forests that intervene between the swamps of epochs during which the coal was

[a] Proc. Am. Philos. Soc., vol. 12, pp. 481-483.

formed were inhabited by these huge monsters; that one of them lay down to die near the shore of probably a brackish-water inlet, and was soon covered by the thickly fallen leaves of the wood; that continued subsidence of the level submerged the bones, which were then covered with sand.

The form of the ilium differs very materially from that of *Hadrosaurus* and the vertebræ are plane, thus differing from *Thespesius*. The limb bone is distinct from anything in *Lælaps*, which, moreover, probably resembles *Thegalosaurus* in its ilium. The present form recalls rather *Cetiosaurus*. As it is evidently new to our system, it may be called *Agathaumas sylvestris*.

In his Cretaceous Vertebrata Cope describes and figures the type in detail. His description is as follows: [a]

The characters of this genus are derived from the typical species *A. sylvestris*, which is represented by dorsal and lumbar vertebræ and an entire sacrum, with the ilia, one nearly entire, ribs, and a number of other bones the characters of which have not yet been positively ascertained. One of these resembles the proximal part of a pubis, others portions of the sternum, etc.

On eight (and perhaps nine) vertebræ, anterior to the sacrum, there is no indication of the capitular articular facet for the rib. This facet is found, as in Crocodilia, at or near the base of the elongate diapophyses. The centra are slightly concave posteriorly, and still less so on the anterior face, with gently convex margins. The neural canal is very small, and the neural arch short and quite distinct from the centrum, having scarcely any suture. The neural arch has a subcubical form, partly truncated above by the anterior zygapophyses. In like manner the base of the combined neural spine and diapophyses are truncated below by the square-cut posterior zygapophyses. The diapophyses are long, and directed upward; they are triangular in section.

There are eight (and perhaps nine) sacral vertebræ, which exhibit a considerable diminution in the diameters of the centra. The diapophyses and neural arches are shared by two centra, the anterior part of a centrum bearing the larger portion of both. The diapophyses are united distally in pairs, each pair inclosing a large foramen. The anterior is the most massive and rests on the ilium; the posterior pair the most expanded; the superior margins of its posterior edge form an open V, with the apex forward on the neural arch of the fifth vertebra. On the last sacrals the diapophyses rise to the neural arch again. The exits of the sacral spinal nerves are behind the middles of the centra, and continue into grooves of the sides in all but the last vertebra. The reduced and rather elongate form of the last sacral vertebra induces me to believe that this animal did not possess such large and short caudal vertebræ as are found in the genus *Hadrosaurus*, and that the tail was a less massive organ.

The ilium is much more elongate than the corresponding element in *Hadrosaurus*, *Cetiosaurus*, or *Megalosaurus*. Its upper edge is turned and thickened inward above the anterior margin of the acetabulum, and here the middle of the conjoined diapophyses of the second and third sacral vertebræ was applied when in place. In front of this point the ilium is produced in a straight line and a stout flattened form with obtuse end. Posterior to it its inner face is concave to receive the second transverse rest of the sacrum, and the superior margin is produced horizontally toward the median line like the corresponding bone in a bird. The posterior part of the bone is the widest, for it is expanded into a thin plate and produced to a considerable length. From one of the margins (my sketch, made on the ground, represents it as the upper) a cylindric rod is produced still farther backward. This it is believed is only the shaft of a displaced rib. The base of the ischium is coossified with the ilium and is separated behind its base from the iliac portion of the acetabulum. There is no facet nor suture for the pubis at the front of the acetabulum.

The ribs are compressed. There are no bones certainly referable to the limbs.

The form of the ilia distinguishes this genus from those known heretofore.

The last nine dorsal vertebræ have rather short centra, the most posterior the shortest. They are higher than wide; the sides are concave, the inferior face somewhat flattened. The neural arch is keeled behind from the canal to between the posterior zygapophyses, and a similar keel extends from the base of the neural spine to between the anterior zygapophyses. The neural spine is elevated and compressed, the diapophysis is convex above and concave along the two inferior faces, most so on the posterior. The articular face of the first sacral vertebra is wider than deep. The eight sacral vertebræ are flattened below, in all except the first, by a plane which is separated from the sides by a longitudinal angle. The neural spines of the anterior five sacral vertebræ are mere tuberosities. A large sutural surface for attachment of a transverse process is seen on the posterior third of the eighth sacral vertebra, which descends nearly as low as the plane of the inferior surface. On the ? tenth sacral there is no such process, but its neural arch and that of the ? ninth support transverse processes. These are more like those of the dorsals in having three strong basal supporting ribs, the anterior and posterior extending for some distance along the arch.

Either naturally or in consequence of distortion, the plate of the ilium is at a strong angle to the vertical axis of the acetabulum, and at the posterior part of it its plate presents a free margin on the outside as well as the inside of the femoral articulation.

[a] Pp. 53–56; also Bull. No. 2, U. S. Geol. and Geog. Surv. Terr., pp. 17–19.

Measurements.

	Mm.
Length of the nine posterior dorsal vertebræ	0.880
Length of the nine sacral vertebræ (36¾ inches)	.930
Length of right ilium (2 pieces, 0.84–0.22), (41 inches)	1.060
Length of eighth dorsal from the sacrum	.090
Length of the base of the neurapophysis	.085
Depth of the articular face	.153
Width of the articular face	.123
Length of the second from sacrum	.070
Depth of the articular face	.155
Width of the articular face	.137
Elevation of the neural canal	.045
Width of the neural canal	.028
Elevation of the face of the zygapophyses	.104
Elevation of the base of the neural spine	.150
Length of the diapophysis from the lower base	.200
Length of the diapophysis from the capitular articulation	.125
Antero-posterior width above	.050
Antero-posterior width of the base of the neural spine	.070
Antero-posterior width at the zygapophysis	.078
Length of the neural spine (fragment)	.200
Width of centrum of the first sacral	.160
Depth of the centrum of the first sacral (to the neurapophysis)	.145
Length of the centrum of the first sacral	.100
Length of the centrum of the seventh sacral	.100
Depth of the centrum of the seventh sacral (behind)	.085
Width of the centrum of the seventh sacral (behind)	.100
Expanse of the second sacral transverse support (22 inches)	.560
Length of the ilium anterior to the acetabulum	.470
Length of the acetabulum	.200
Length of the ilium posterior to the acetabulum	.390
Width of the ilium at the anterior extremity	.140
Width of the ilium at the front of the acetabulum	.210
Width of the ilium at the posterior expansion	.250
Thickness above the acetabulum	.060
Width of the acetabulum	.105
Width of the bases of the ischium	.085
Width of the shaft of a rib	.062

Other bones, not yet determined, will be included in the description in the final report.

This species was no doubt equal in dimensions to the largest known terrestrial saurians or mammals.

MATERIAL NOW AVAILABLE.

Of this material there remains accessible only the right ilium and a mere fragment of the anterior extremity of the left, one rib nearly complete but lacking the capitulum and the distal extremity, a proximal portion of a second rib without either capitulum or tuberculum. The sixteen vertebræ mentioned by Cope consist of the nine posterior dorsals, for the most part represented only by centra. There are, however, three complete but detached neural arches. One of these still supports the transverse process of the left side and this shows at its extremity the tubercular rib facet, while the capitular rib facet may also be seen on the inferior border, near the point where the transverse process unites with the neural arch. There is also preserved a left one-half of a fourth neural arch, which likewise bears a transverse process, complete except at the very extremity, where the tubercular facet is wanting. In the second from the anterior dorsal of the series figured by Cope the neural arch is still in position. It shows only a sutural union with the centrum, being held in position by the inclosing matrix. Both transverse processes, as well as the neural spine, are wanting in this and the three posterior dorsals figured by Cope. The sacrum which he has described as being perfect and consisting of five, sometimes eight or perhaps nine, vertebræ is also present. The three centra of the anterior caudals or sacro-caudals are present in identically the same condition as figured by Cope, as is also the fragmentary coossified neural arch shown by him in Pl. IV, fig. 18, of his Cretaceous Vertebrata. The undetermined bones shown by him in Pl. IV, figs. 19, 19a, and 20, are also present. No pelvic bones, other than the ilium mentioned above, and no limb bones pertaining to the type are to be found, and since they have nowhere been described by Cope it is doubtful whether they were ever recovered except, perhaps, in an extremely fragmentary and hopeless condition.

DETAILED DESCRIPTION.

The ilium.—This, after the sacrum, is the most important element of the original type. The right ilium is present and complete save the anterior and posterior extremities and a portion of the pubic peduncle, which are wanting.

The blade of the ilium is much extended, both anterior and posterior to the acetabulum. The anterior extremity appears broad and somewhat truncated when compared with the pointed, narrow, and elongate posterior extremity. When adjusted to the sacrum the expanded blade of the ilium is more nearly horizontal than vertical, just the opposite from that which obtains in the sauropod dinosaurs and more closely resembling that of the Mammalia. In this position the external edge, when viewed from above, presents a compound curve, gently concave anteriorly and more decidedly convex throughout the posterior two-thirds of its length. When viewed from in front the external border continues in the same horizontal plane until just above and a little posterior to the ischiac peduncle, when it bends abruptly downward. This, the external margin, is moderately thick throughout its entire length, but it is greatly thickened near the posterior and anterior extremities and in the deflected region just above the ischiac peduncle. The broad superior surface of the ilium is convex transversely throughout its middle region, but concave at either extremity; antero-posteriorly it is gently convex throughout its entire length. The internal margin is rather thin at either extremity, but considerably thickened and otherwise modified medially for contact with the sacrum. The inferior surface of the ilium gives origin to the ischiac and pubic peduncles, which spring from near its internal margin. From the base of the pubic peduncle a broadly convex ridge of bone extends diagonally across the anterior blade of the ilium to its antero-external angle, inclosing in front the deep concavity which occupies the inferior surface of this bone just external to the acetabulum. The inferior surface of the posterior blade is a nearly flat surface. The ischiac peduncle is low, broad, and much expanded both transversely and antero-posteriorly. The articular surface of the pubic peduncle is wanting; that portion of the base remaining indicates, however, that this element, although more slender, was actually longer than the ischiac peduncle. In the Ceratopsia the ilia are never coossified with the sacrum, and in the present specimen the surface for attachment with the sacrum is but poorly indicated. In Cope's description of this ilium he mistook the anterior for the posterior extremity, erroneously described the base of the ischium as coossified with the ilium, and stated that there was no facet for the pubis. Some of these errors he corrected after the descriptions of more complete material by Professor Marsh.

The vertebræ.—The nine posterior dorsals figured by Cope are all accessible. These, save the second from the first of the series, are represented only by the centra, for the most part in a much damaged condition. The exact association of the detached neural arches mentioned above is uncertain. With the second, held in place by the surrounding matrix, there is the neural arch, but without the spine or transverse processes. This arch, as well as those of the other vertebræ represented in the series, were united only by suture with their respective centra, thus indicating that the individual had not yet reached maturity. All the dorsal centra are short, deeper than broad, plano-concave or slightly biconcave, constricted medially and obovate in cross section. The neural canal is small, its vertical diameter exceeding the transverse, and is nearly inclosed by the neural arches, but inferiorly it is bounded by the superior surfaces of the centra. The neural arch is rather high, rising about 85 mm. above the neural canal before giving origin to the transverse processes. Of the detached neural arches, each bearing a transverse process, mentioned above as still associated with the type material, one has been referred by Cope to the eighth and another to the ninth of the series. These transverse processes are triangular in cross section and bear, near their union with the neural arches, capitular rib facets, while the one best preserved shows at its extremity a portion of the tubercular rib facet. The capitular facets are each supported inferiorly by a single strong vertical lamina or buttress, which springs from the posterior lateral border of the neural arch. The zygapophyses on either side are placed very close together, both anterior and posterior, those of one side being separated from those of the other by a very narrow median ridge or keel. The articular surface of each occupies a single horizontal plane, the anterior looking upward, the posterior downward. The remarkable simplicity exhibited in the articulation of these vertebræ contrasts strongly with the complicated condition which obtains in the same region of the vertebral column of the Sauropoda. I can not understand Cope's reason for describing the neural arch as "short and with scarcely any suture," save that he meant antero-posteriorly.

The sacrum.—The sacrum as figured and described by Cope is in a fair state of preservation. The three sacro-caudals figured by him as Nos. 15, 16, 17 of the vertebral series are evidently posterior sacrals or sacro-caudals and represent 7, 8, and 10 of the functional sacrals, 1 and 9 being wanting, not having been preserved. In one of these the neural arch is preserved, but in the other two only the centra remain, though fortunately in a better state of preservation than are those of the dorsal region. They are somewhat more elongate than the dorsal centra and have the vertical and transverse diameters more nearly equal. The inferior surface of each is broad and slightly concave. Superiorly they expand laterally at either extremity in order to give support to transverse processes, which, however, are wanting in the present specimens. These centra are not so regularly constricted medially as are those of the dorsals, and this is especially true of that centrum numbered 17 in Professor Cope's figures. The neural arch is compressed and low when compared with that of the dorsals. The two coossified neural arches referred to and figured by Cope as sacrals are present and appear to have occupied a position in the vertebral column similar to that shown in Cope's figure. I believe they pertain to two of the posterior sacrals or sacro-caudals.

The five true sacrals are present and decrease regularly in size from the first to the last, as shown in Pl. XXV. The centra of the first and second of these vertebræ are comparatively broad and short; those of the three posterior are more elongate. All the sacral ribs or transverse processes spring more directly from the union of the centra in the present sacrum than in that of *Triceratops*, as will be seen from a comparison of the figures, a condition apparently somewhat intermediate between that which obtains in *Monoclonius* and *Triceratops*. In the latter genus, as has already been pointed out, only the anterior of the sacral ribs takes its origin about equally from two vertebræ, the three posterior pairs of sacral ribs taking their origin almost entirely from the anterior half of a single centrum. The sacral ribs are strong and they unite distally to form a strong bar, which articulates with the ilium and forms a portion of the acetabular wall. Together the four sacral ribs inclose three large foramina. It would perhaps be better to consider only the four posterior of these vertebræ as true sacrals and treat the anterior as a sacro-lumbar. It is probable also that had the animal been fully adult there would have been attached to this still another sacro-lumbar, as in the sacrum of *Triceratops*. The total number of vertebræ united in the sacrum would then be 10, as in the last-mentioned genus. There are represented in the type 18 instead of 16 vertebræ, as stated by Cope, and his figures show 17 centra and portions of 18 vertebræ.

The undetermined bone shown by Cope in figs. 19 and 19*a*, Pl. IV, of his Cretaceous Vertebrata I believe to be a lateral metapodial, though somewhat crushed and distorted.

The ribs.—Only portions of two ribs pertaining to the type specimen are to be found. One of these consists of a fragment about a foot long, representing the proximal portion of a rib from the mid-dorsal region, with both the head and tubercle wanting. It is much flattened proximally, but becomes triangular in cross section beyond the tubercle. The other rib is nearly complete and is from the posterior region, though not the last of the series. The head and extreme distal end are both wanting. It is flattened proximally, becoming subovate beyond the tuberculum and subelliptical toward the distal extremity.

Principal measurements of the type.

	Mm.
Greatest length of portion of ilium preserved	1,142
Estimated length of ilium when complete	1,392
Antero-posterior expanse of ischiac and pubic peduncles	342
Greatest transverse diameter of ischiac peduncle	150
Distance from superior border of ilium to extremity of ischiac peduncle	212
Transverse diameter of eighth dorsal from sacrum	132
Vertical diameter of same	167
Length of same	91
Height of anterior zygapophyses above suture for centrum	111
Height of base of neural spine above suture for centrum	155
Distance from capitular to tubercular facets	130

The above description of the type of *Agathaumas sylvestris*, together with the original and later descriptions by Professor Cope, makes it clear that the generic and specific distinctions must rest on such characters as are to be found in the ilium, sacrum, posterior dorsals, and ribs, and it will be well to bear this point in mind when we come to a discussion of the synonymy, which will be taken up in that part of the present volume devoted to a revision of the genera and species.

Agathaumas milo Cope. 1874.

Type (No. ?, American Museum of Natural History) consists of a sacral centrum and fragment of proximal end of tibia, no longer determinable.

Original description Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 1, 1874, 1st ser., p. 10, footnote.

Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, 1st ser., p. 21; Rept. U. S. Geol. Surv. Terr., vol. 2, 1875, p. 58.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

In a brief footnote on page 10 of Bulletin No. 1, first series of the Bulletins of the U. S. Geological and Geographical Survey of the Territories, published in 1874, Professor Cope names, without any description whatever, this and a number of other supposedly new Mesozoic Reptilia. His remarks in this connection are as follows:

> In examining a collection from this formation, made by one of my assistants, I find a series of Mesozoic genera of vertebrates as follows: Dinosauria, *Cinodon* [a misprint for *Cionodon*] *arctatus*, gen. et sp. nov.; *Polyonax mortuarius*, gen. et sp. nov.; *Agathaumas milo*, sp. nov.; * * *

On page 21 of Bulletin No. 2, first series, United States Geological and Geographical Survey of the Territories, Professor Cope identifies the very fragmentary material constituting the type of the present species as pertaining to *Hadrosaurus occidentalis*. His remarks in this connection were as follows:

> Remains of species of Dinosauria were obtained at two localities in Colorado not many miles apart, the greater number at one of them, from which also the crocodilian and turtle remains were derived. Those from other deposits consist of portions of limb bones apparently of a single individual of gigantic size. The more abundant fragments are referable to three species. A fragment of limb bone is very similar to portions from the other locality, and associated is a sacral vertebra of appropriate size and characters. All of these were therefore referred provisionally to a single species under the name of *Agathaumas milo*, but are here described under *Hadrosaurus occidentalis*.

It is thus clear that, according to Cope, *Agathaumas milo* Cope became a synonym of *Hadrosaurus occidentalis* Leidy. Whether or not this latter determination was correct the fact remains that *A. milo* is a nomen nudum, and the fragmentary nature of the type is such as to preclude an adequate description. The species should therefore be discarded.

POLYONAX Cope. 1874.

Type species *P. mortuarius*.

Original description Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 1, 1874, p. 10, footnote.

Baur, G., Science, vol. 17, 1891, p. 217.

Cope, E. D., Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873 (pub. 1875), pp. 448, 451–452; Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, 1st ser., 1874, pp. 7, 21, 24; Rept. U. S. Geol. and Geog. Surv. Terr., vol. 2, 1875, pp. 58, 63–64; Am. Naturalist, vol. 22, 1888, p. 1109; Science, vol. 13, 1889, p. 290; Am. Naturalist, vol. 23, 1889, p. 715.

Dana, J. D., Manual of Geology, 1895, p. 847.
Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 68.
Marsh, O. C., Am. Jour. Sci., January, 1892, p. 83; December, 1895, p. 497; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, pp. 217, 243.
Nicholson and Lydekker, Manual Pal., 1889, vol. 2, p. 1163.
Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 9, 20.
Woodward, A. S., Outlines Vert. Pal., p. 213.
Zittel, K. A. von, Text-book Pal., trans. by C. R. Eastman, vol. 2, p. 244.

This genus, like the last-mentioned species of *Agathaumas*, was proposed but not described in the footnote a portion of which is quoted above.[a] The genus is described as follows:

Char. gen.—A species considerably larger than the last (*Cionodon arctatus*), represented by vertebræ and numerous fragments of limb bones. The most characteristic of the former are two probably from the posterior dorsal region, which are somewhat distorted by pressure. The more anterior is shorter than the other and exhibits both anterior faces slightly concave, the one more so than the other. They are higher than wide and the border is scalloped above for the capitular articulation for the rib. There are numerous nutrient foramina and some ligamentous pits on the articular surfaces. The inferior face is rounded. In the larger vertebra both faces are more strongly concave, and at each end of the lower side there is an obtuse hypopophysial tuberosity. The sides of the centra of both vertebræ are concave. The neural canals are relatively small and the neurapophyses coossified. A third vertebra without arches is similar in specific gravity, though without the white surface layer of the others. It is appropriate in size and form to this species, and is peculiar in its flat form, resembling the anterior dorsals of the *Hadrosaurus*. In this respect it is related to the shorter vertebra of the two above described as the latter is to the longer. The surface of the posterior articular surface is damaged; it was not concave, and is now slightly convex; the anterior is preserved and is concave.

Only one species of *Polyonax* has been described, namely, *P. mortuarius* Cope. This will now be noticed.

Polyonax mortuarius Cope. 1874.

Type (No. 3950, American Museum of Natural History) consists of fragments of horn cores, vertebræ, etc.

Original description in Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 1, 1st ser., 1874, p. 10, footnote.

Cope, E. D., Ann. Rept. U. S. Geol. and Geog. Surv. Terr. for 1873 (pub. 1875), pp. 448, 451–452; Bull. U. S. Geol. and Geog. Surv. Terr., vol. 1, No. 2, 1st ser., 1874, pp. 7, 21, 25; Rept. U. S. Geol. Surv. Terr., vol. 2, 1875, pp. 26, 59, 64–65; Am. Naturalist, vol. 23, 1889, p. 715, 716.
Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 21, p. 270.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

This species, like the genus to which it was referred, was first named without being described in the footnote mentioned and in part quoted above in connection with our remarks on *Agathaumas milo*. In Bulletin No. 2, United States Geological and Geographical Survey of the Territories, page 25, after the diagnosis of the genus *Polyonax* just quoted, Cope defines the present species as follows:

The articular faces are deeper than wide in the vertebræ; the sides are smooth; the lower faces narrow and probably keeled.

Measurements.

	Mm.
Anterior dorsal, length of centrum	0.048
Anterior elevation of neural canal	.094
Anterior width	.094
Median dorsal, length of centrum	.057
Median elevation to neural canal	.117
Median width	.083
Posterior dorsal, length of centrum	.092
Posterior dorsal, elevation	.104
Posterior dorsal, width	.083
Posterior dorsal, diameter of neural canal	.015

The measurement of the neural canal is made near the base of the neurapophyses and is probably a little affected by pressure.

The limb bones embrace portions of tibia, fibula, and some others not yet determined. The portion of tibia is from the base of the cnemial crest, so that one extremity is trilobate, the other transverse oval. The former outline indicates two posterior tuberosities. The bone is solid and the superficial layer, for 3 mm. or less, is so dense and glistening as to

[a] Bull. No. 2, U. S. Geol. and Geog. Surv. Terr., 1st ser., 1874, pp. 24 and 25.

resemble cementum. Portions referred to fibulæ have a subcrescentic section, with narrowed width in one direction. Two fragments of shafts of long bones I can not determine either as belonging to the limbs or pelvis. They belong to opposite sides; each is oval in section, and the diameter regularly contracts to one end. One side is slightly convex in both directions; the other is less convex transversely and gently convex longitudinally. A peculiarity consists of a central cavity present in both at the fractured large end, which is bordered by a layer of dense bone like the outside.

Measurements.

	Mm.
Transverse diameter of tibia fragment below cnemial crest	0.125
Antero-posterior diameter of tibia fragment at base of crest	.095
Width of fragment of fibula	.073
Thickness of fragment of fibula	.035
Length of fragment of unknown bone	.145
Proximal diameter of unknown bone	.088
Distal view of unknown bone	.065

The above measurements indicate a much larger animal than the *Cionodon arctatus* and one not very different in size from the *Lælaps aquilunguis*.

In his Cretaceous Vertebrata, pages 63–65, Cope repeats his original description of the present genus and species, accompanying it with illustrations of the type material, Pl. II, figs. 3–5, and Pl. III, figs. 1–4. Cope's description and figures demonstrate conclusively the extremely fragmentary and totally inadequate nature of the material upon which the genus and species were based. The fragments supposed by Cope to pertain to the ischia are now known to have been portions of the frontal horn cores. The "paleontological wastebasket" would be a fit receptacle for what still remains of the type material, while the name should be dropped from paleontological literature. It was perhaps a premonition of this which suggested to Professor Cope the specific appellation *mortuarius*. Unfortunately vertebrate paleontology is burdened with too many genera and species founded, as in the present instance, on fragmentary and insufficient material.

MANOSPONDYLUS Cope. 1892.

MANOSPONDYLUS GIGAS Cope.

Type (No. 3982, American Museum of Natural History) consists of two dorsal vertebræ.
Original description in Am. Naturalist, vol. 26, 1892, p. 757.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 15.

The type (No. 3982, American Museum of Natural History) of the present genus and species, which Cope provisionally referred to the Ceratopsidæ (Agathaumidæ), consisted originally of two dorsal vertebræ. No locality was given by Cope, but he stated verbally to the present writer that they were from South Dakota. I have been able to discover only one of these vertebræ in the Cope collections of fossil vertebrates. This is shown in fig. 105.

Cope's original description was as follows:

Manospondylus gigas.—Char. gen.—Dorsal vertebræ with short antero-posterior diameter, and gently concave articular faces. Neurapophyses coossified. At the superior part of the centrum, a deep entering fossa; surfaces of circumference otherwise uninterrupted. Tissue of centrum at borders of articular faces coarsely vesicular. The form of these vertebræ indicates that this genus is allied to the Agathaumidæ rather than the Hadrosauridæ. No genus of either family known to me possesses the fossæ at the base of the neural arch.

Char. specif.—Dorsal centrum a little deeper than wide. Lateral surfaces smooth.

Diameters of centrum.

	Mm.
Articular face, vertical	205
Articular face, transverse	200
Antero-posterior	90

Two dorsal vertebræ are the only remains which I can refer to this species, which is the most gigantic of the Dinosauria of the Laramie known to me. In the same neighborhood, but several hundred yards distant, I discovered a huge supratemporal bone, which differs from those of some of the allied genera in having a simple undulate free border, without tuberosities or processes. Its form is similar to that of *Agathaumas*,[a] i. e., as broad as long posterior to the quadrate suture. There is no evidence that it belongs to this species.

[a] This must be an error, as no cranial bones of *Agathaumas* are known.—R.S.L.

A comparison of the vertebra still preserved with others from the same region in the vertebral column, but belonging to the skeleton of a large carnivorous dinosaur, probably pertaining to some species of *Dryptosaurus*, from the Laramie of Converse County, Wyo., and now in the collections of the Carnegie Museum, demonstrates conclusively that the remains upon which the present genus and species were based belonged to the Theropoda rather than the Predentata, and that it was therefore not a member of the Ceratopsidæ. Its likeness to the carnivorous genus *Dryptosaurus* is seen in the general form of the dorsal centrum, the coarsely cancellated internal structure of the bone, and the deep fossa on the superior lateral surface of the centrum. The similarity of structure shown by the type and a vertebra from the Carnegie Museum skeleton is remarkable, and I may remark in this connection that there can be no doubt that the latter pertained to a member of the Theropoda, since it was found associated with the skull and a considerable portion of the skeleton. The present genus and species is therefore not a member of the Ceratopsidæ and needs no further consideration in this connection.

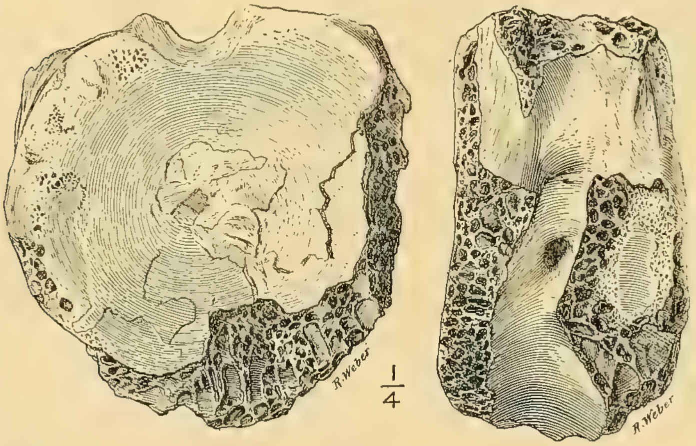

FIG. 105.—Vertebral centrum of *Manospondylus gigas* Cope, type, No. 3982, American Museum of Natural History. One-fourth natural size.

CLAORHYNCHUS Cope. 1892.

Type species, *C. trihedrus*.

Original description in Am. Naturalist, vol. 26, 1892, pp. 757–758.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 19, 20.

The genus and the species were founded on a rostral and predentary bone, neither of which I have been able to discover in the Cope collections. No locality or definite horizon other than Laramie was given by Cope. It was presumably from South Dakota. Cope's original description is as follows:

CLAORHYNCHUS TRIHEDRUS Cope. 1892.

Type (No. 3978, American Museum of Natural History) consists of a rostral and a predentary.

Original description in Am. Naturalist, vol. 26, 1892, pp. 757–758.

Osborn, H. F., Contr. Canadian Pal., vol. 3, pt. 2, 1902, p. 15.

Char. gen.—This genus is established on a rostral and predentary bones of a species of the Agathaumidæ, which were found together and with the fragments of a massive supratemporal bone. They are distinguished by their absolutely flat inferior faces, there being no alveolar ridges as in the forms described by Marsh. They are not compressed but are as wide as long. They are not adapted to the muzzle of *Monoclonius*, where the rostral bone is compressed (*M. sphenocerus*).

Char. specif.—Rostral and predentary bones as wide as long, with flat inferior face and rounded superior median angle. Transverse diameter rather exceeding the vertical. Sides convex. All the surfaces furrowed by coarse grooves which terminate in foramina.

The short, wide form of this species differs from that seen in the species of the family Agathaumidæ which have been yet described. The extremity of the beak had apparently a horny sheath and was adapted for crushing comparatively hard substances.

The comparative dimensions of the rostral and predentary bones given by Cope suggested to me that Professor Cope had mistaken the exact homology of the former element and that these bones may have pertained to a member of the Trachodontidæ, and in a recent paper on the genera and species of that family I have included the present genus and species in the Trachodontidæ.[a] In the absence of the type material for direct comparison it is impossible to determine the affinities of the present genus and species with certainty.[b] If, however, as Professor Cope states, they are without alveolar ridges, have absolutely flat inferior faces, and are as wide as long, they would seem, unless these characters are due to crushing, to pertain to a member of the Trachodontidæ rather than the Ceratopsidæ.

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[a] Annals Carnegie Mus., vol. 1, pp. 377–386.

[b] The type has recently been identified by Dr. Matthew.—R. S. L.

GENERA AND SPECIES DESCRIBED BY MARSH AND HATCHER, CHIEFLY FROM CONVERSE COUNTY, WYO.

I will next consider those representatives of the larger and more specialized members of the Ceratopsidæ made known by Professor Marsh. The greater portion of these were obtained by me from the Laramie deposits of Converse County in central eastern Wyoming. A few, however, are from the Denver beds, in the vicinity of Denver, Colo., and were collected by Messrs. Whitman Cross, G. H. Eldridge, and George L. Cannon.

CERATOPS Marsh. 1888.

CERATOPS ALTICORNIS Marsh. 1889.

Syn., *Bison alticornis* Marsh. Transferred to genus *Ceratops*, Am. Jour. Sci., vol. 38, Aug., 1889, pp. 174–175.
Type consists of supraorbital horn cores (No. 1871 E, U. S. National Museum) from Denver beds, Colorado.
Original description in Am. Jour. Sci., vol. 34, Oct., 1887, pp. 323–324.

Marsh, O. C., Am. Jour. Sci., vol. 38, 1889, pp. 174–175; Mon. U. S. Geol. Survey, vol. 27, 1897, pp. 512, 527.
Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 9, 14.
Walcott, C. D., Science, new ser., vol. 11, 1900, p. 23.

FIG. 106.—1, Part of skull with horn cores of *Triceratops* (*Ceratops. Bison*) *alticornis* Marsh, front view; 2, the same specimen, seen from the left. Both figures are one-eighth natural size. After Marsh.

The earliest of these largest forms of the Ceratopsidæ to be described by Professor Marsh was the type of the present species. This comprised a portion of the cranium consisting for the most part of the pair of frontal horn cores shown in fig. 106. Owing to the very close resemblance between these horn cores and those of certain members of the Bovidæ, and more especially of some of the extinct bisons, Professor Marsh quite naturally overlooked their real nature, and in his first description he referred them to the genus *Bison*, making them the type of the new species *alticornis*. His original description, as published in the American Journal of Science of October, 1887, was as follows:

This species of *Bison* is represented by various remains, the most important of which is the portion of a skull figured below. This specimen, which may be regarded as the type, indicates one of the largest of American bovines, and one differing widely from those already described. The horn cores, instead of being short and transverse, as in the existing bisons, are long and elevated, with slender, pointed ends. They have large cavities in the base, but in the upper two-thirds are nearly or quite solid. Their position is well shown in the cuts below [fig. 106]. The frontal region between the horn cores is broad, somewhat convex, and very rugose.

The remains of this species are found in the sandstones of the Denver group, at the eastern base of the Rocky Mountains, where they indicate a well-marked horizon, which may be called the Bison beds. These deposits are more recent than the Equus beds, and are probably late Pliocene.

The locality of the type specimen is on the banks of Green Mountain Creek, near Denver, Colo., where it was found by George L. Cannon, jr., of Denver. Portions of the same specimen were subsequently secured by Whitman Cross, of the U. S, Geological Survey. Other remains were obtained by G. H. Eldridge, of the Survey, and all were sent to the writer for examination.

To the erroneous determination of the nature of these remains is due the error made by Marsh in determining the age of the deposits constituting the Denver group, which are now known to be late Cretaceous instead of late Pliocene.

Nearly two years later[a] Professor Marsh recognized the real affinities of these remains and removed them from the genus *Bison* to *Ceratops*. His remarks in this connection at that time were as follows:

The bison-like horn cores figured in this journal (Am. Jour. Sci., vol. 34, p. 324) probably belonged to a member of this group (the Ceratopsidæ), as already suggested by the writer.[b] They were sent to him from a locality in which he had himself collected Mastodon remains and other Pliocene fossils. As they agreed in all anatomical characters with the remains of cavicorn mammals from that formation, they were referred to the genus *Bison*, under the name *B. alticornis*. The writer has since learned that they were found in the Denver beds, which, although regarded as Tertiary, are probably Cretaceous. Under these circumstances this well-marked species may be known as *Ceratops alticornis* until additional remains make certain its true nature.

The previous suggestion referred to by Marsh in the quotation just given certainly does not make it clear that he at that time considered *B. alticornis* as a member of the Ceratopsidæ or as a dinosaur; and since, in his original description of the species already quoted, he clearly states that it was found "in the sandstones of the Denver group," it is clear that he was not misled by the collectors as to its stratigraphic position. The error was clearly one of erroneous determination of the nature of the animal to which the remains pertained, and was entirely excusable, considering the little that was then known concerning this remarkable group of dinosaurs. All that was at that time known concerning the comparative osteology of the vertebrata suggested its relations with the bisons among the Mammalia and, without making a microscopical examination he would have been a daring anatomist who would have ventured to suggest from any external anatomical characters alone that these horn cores pertained to a dinosaur or other member of the Reptilia. In the article last cited, in speaking of the resemblances between these horn cores and those of the Bovidæ, Marsh aptly concludes with the following remark: "This accurate repetition in later and still existing forms of the highly specialized weapons of an extinct group of another class is a fact of much interest." He might very properly have added, with no reflection upon himself, that in the present instance it has led to an unfortunate error both as to the determination of the nature of the remains themselves and of the age of the deposits in which they were found.

Why Professor Marsh should have referred this species to *Ceratops* rather than *Triceratops* is not at all clear. Its affinities are certainly with the latter genus, as will appear when we come to discuss the synonymy of the various genera.

TRICERATOPS Marsh. 1889.

Type species, *T. horridus*.

Original description in Am. Jour. Sci., vol. 38, August, 1889, p. 173.

Baur, G., Science, vol. 17, 1891, pp. 216-217; Am. Naturalist, vol. 25, 1891, p. 450.

Ed. Am. Geologist, Am. Geologist, vol. 8, 1891, p. 56.

Lambe, L. M., Sum. Rept. Geol. Surv. Canada, 1898, pp. 184, 187.

Lydekker, R., Nature, vol. 48, 1893, p. 304.

[a] Am. Jour. Sci., vol. 38, August, 1889, pp. 174-175.

[b] Am. Jour. Sci., vol. 37, April, 1889, p. 335.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 38, Aug., 1889, p. 174; vol. 38, Dec., 1889, pp. 501–506; vol. 39, Jan., 1890, pp. 81–83; vol. 39, May, 1890, pp. 418–426; vol. 40, Feb., 1891, pp. 168–177; vol. 40, Apr., 1891, pp. 339–342; vol. 42, Aug., 1891, p. 181; vol. 42, Sept., 1891, pp. 265 and 266; vol. 43, Jan., 1892, pp. 82–84; vol. 44, Oct., 1892, pp. 343 and 346; Mar., 1894, p. 245; vol. 50, Nov., 1895, p. 412; vol. 50, Dec., 1895, pp. 485–498; 4th ser., vol. 6, July, 1898, p. 92; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, pp. 145, 208–214, 218, 227–228, 243; Mon. U. S. Geol. Survey, vol. 27, 1897, pp. 510–516.

Nicholson and Lydekker, Manual Pal., 1889, vol. 2, p. 1163.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 271.

Osborn, H. F., Bull. Am. Mus. Nat. Hist., vol. 5, 1893, p. 326; Science, new series, vol. 7, 1898, p. 844; Contr. Canadian Pal., vol. 3, pt. 2, 1902, pp. 9, 20, 21.

Steinman and Döderlein, Elements Pal., 1890, p. 665.

Walcott, C. D., Science, new series, vol. 11, 1900, p. 22.

Woodward, A. S., Outlines Vert. Pal., pp. 213, 216.

Zittel, K. A. von, Text-book Pal., trans. by C. R. Eastman, vol. 2, p. 244.

The type species of the present genus was founded on the greater portion of a skull (No. 1820, Yale Museum) from the Laramie of Converse County, Wyo. The genus is represented by a number of species. All the representatives are of large size, and the skull is less fenestrated than in any other genera. The genus may be characterized as follows: *Supraorbital horns directed forward and upward at an angle of 45°; nasal horn of moderate length and directed nearly straight forward; no parietal fontanelles; squamosal short and broad.*

TRICERATOPS (CERATOPS) HORRIDUS Marsh. 1889.

Type consists of skull from the Laramie of Converse County, Wyo. (No. 1820, Yale Museum).

Original description in Am. Jour. Sci., vol. 37, Apr., 1889, pp. 334–335.

Marsh, O. C., Am. Jour. Sci., vol. 38, Aug., 1889, p. 173, where it is made the type of the genus *Triceratops*.

DISCOVERY.

The type of the present genus and species consists of the greater portion of a skull (No. 1820, Yale Museum), with portions of the lower jaws. It is that from which the horn core first seen by the present writer in the collection of Mr. C. A. Guernsey at Douglas, Wyo., was taken. It is therefore of considerable historical importance as having led to the discovery of that important locality in Converse County, Wyo., which has yielded so many and such interesting remains of these and other Laramie dinosaurs, mammals, turtles, fishes, invertebrates, and plants. Unfortunately the skull was incomplete when found, a considerable portion of it having already weathered away, and such portions as did remain are now separated and preserved in two different collections. The major portion is in the Yale collection, while the base of the right supraorbital horn core is in the private collection of Mr. C. A. Guernsey.

This skull was discovered by Mr. E. B. Wilson, and was collected by the present writer. It was found embedded in a hard calcareous sandstone concretion which had weathered out of a stratum of soft, light, yellow, heavily bedded sandstone, about 20 feet thick, near the middle of that series of fresh-water sandstones and shales which in this region are interposed between the marine Fox Hills sandstones below and the leaf-bearing Fort Union beds above. The locality is shown approximately at + 1 in Pl. LI. The exact location of this skull was on the south side and about 5 feet above the bottom of the canyon which enters Buck Creek from the west. It was about 100 yards above the springs now locally known as Hatchers Springs, where Johnson Brothers' sheep ranch is now located. About 150 yards below and on the north side of this canyon is a small "blow-out," or "badland area," about half an acre in extent, situated just below the mouth of a small tributary from the north and directly opposite the ranch buildings just referred to. From the same stratum of soft, light-colored sandstone from which had weathered the concretion containing the skull found 150 yards above, at this lower locality I obtained the type of *Trachodon longiceps* Marsh[a] and a considerable number of isolated teeth of small Laramie mammals, as well as various remains of fishes, reptiles, and amphibians. This mammal-bearing locality is shown at o 3 in Pl. LI, while

[a] Am. Jour. Sci., 4th ser., vol. 39, May, 1890, p. 422.

at o 2 in the same plate, half a mile to the southwest, on the crest of the ridge that forms the watershed between this and the next tributary to the south, emptying into Buck Creek from the west, there is another "blow-out" of about equal area in a similar sandstone layer, but at a horizon estimated as 80 feet higher, from which were obtained bones of *Trachodon* and numerous teeth of Laramie mammals, fishes, and reptiles, including representatives of both the Ceratopsidæ and Trachodontidæ.

ORIGINAL DESCRIPTION.

In his original description Marsh placed the present species in the genus *Ceratops*. His description as given in the American Journal of Science for April, 1889 (3d ser., vol. 37, pp. 334–335), was as follows:

The strange reptile described by the writer as *Ceratops montanus* proves to have been only a subordinate member of the family. Other remains received more recently indicate forms much larger and more grotesque in appearance. They also afford considerable information in regard to the structure of these animals, showing them to be true Stegosauria, but with the skull and dermal armor strangely modified and specialized just before the group became extinct.

The vertebræ and the bones of the limbs and of the feet are so much like the corresponding parts of the typical *Stegosaurus* from the Jurassic that it would be difficult to separate the two when in fragmentary condition, as are most of those from the later formation. The latter forms, however, are of much larger size, and nearly all the bones have a peculiar rugosity much less marked in the Jurassic species. In the form here described this feature is very conspicuous and marks almost every known part of the skeleton.

In the type specimen of the present species, the posterior horn cores are much larger than these appendages in any other known animal living or extinct. One of them measures at the base no less than twenty-seven inches, and about sixteen inches around, halfway to the summit. Its total height was about two feet. In general form these horn cores resemble those of *Ceratops montanus*, but the anterior margin is more compressed, showing indications of a ridge.

The top of the skull in the region of the horn cores is thick and massive and strongly rugose.

This skull as a whole must have had at least fifty times the weight of the skull of the largest Sauropoda known, and this fact will give some idea of the appearance of this reptile when alive.

As previously stated, the posterior pair of horn cores of this family are hollow at the base, and in form and surface markings are precisely like those of the Bovidæ. The resemblance is so close that, when detached from the skull, they can not be distinguished by any anatomical character. This accurate repetition, in later and still existing forms, of the highly specialized weapons of an extinct group of another class is a fact of much interest.

The present specimen is from the Laramie formation of Wyoming, but fragmentary remains which may be referred provisionally to the same species have been found in Colorado.

As is now well known, and as was soon after recognized by Professor Marsh, the Ceratopsidæ are not nearly so closely related to the Stegosauria as he then supposed. There are many important structural differences, not only in the skull but in almost every portion of the skeleton.

CERATOPS HORRIDUS MADE THE TYPE OF THE NEW GENUS TRICERATOPS.

Shortly after this Professor Marsh recognized the generic distinction existing between *Ceratops montanus* and *C. horridus*, and made the latter the type of a new genus, *Triceratops*. His remarks in this connection, as published in the American Journal of Science, August, 1889 (vol. 38, pp. 173–174), were as follows:

The animal described by the writer as *Ceratops horridus* possesses some remarkable characters not before known in the Dinosauria. In addition to the pair of massive horn cores on the top of the skull, there is a third horn core on the nose. This is median, as in the rhinoceros, and is placed on the end of the nasals, which are firmly coossified to support it.

The edentulous premaxillaries are compressed anteriorly and are strongly coossified with each other and with a third bone in front, which corresponds to the predentary bone below, the whole forming a projecting beak, like that of a tortoise. Over all there was, evidently, a huge horny covering, like the beak of a bird.

The bone in front of the premaxillaries has apparently not before been observed in any vertebrate, and may be called the rostral bone (os rostrale). It is analogous to the prenasal ossification of the pig and of the Dinocerata.

Other portions of the skull show features not before seen in the Dinosauria. There is a huge occipital crest, extending backward and outward. In the present specimen this is bent downward at the sides, like the back part of a helmet, thus affording in life strong protection to the neck.

The lower jaws are massive and were united in front by a strong predentary bone. This is pointed anteriorly and its surface marked by vascular impressions, showing that it was covered with horn and fitted to meet the beak above.

The skull appears to have been at least two meters in length, aside from the horny beak. It represents a genus distinct from the type of the family, which may be called *Triceratops*. This interesting specimen, which has recently been received at the Yale Museum, was discovered by Mr. Charles A. Guernsey and Mr. E. B. Wilson in the Laramie formation of Wyoming.

In this paper Marsh calls attention to the presence of a number of characters hitherto unknown in this or any other group of dinosaurs—such as the strong nasal horn, the os rostrale and the huge occipital crest functioning as a shield for the cervical region—but does not state by just what characters this genus is to be distinguished from *Ceratops*, nor is this distinction easy to make, considering the material on which the last-mentioned genus was founded. Nevertheless, when we consider the diminutive size of *Ceratops* in comparison with that of *Triceratops* and the differences observable in the characters of the frontal horns (compare figs. 5 and 103), it is evident that they may have pertained to distinct genera and that if, in the types of each species, more parts in common had been preserved it would be possible to establish other differences of still greater importance. Moreover, the difference in the geological horizons from which the types of the two genera were derived is so great as to preclude the probability, not to say possibility, of their having pertained to a common genus. The type of *Triceratops horridus* came from about the middle of the upper half of the Laramie deposits as they are represented in Converse County, Wyo. The type of *Ceratops montanus* was found near the summit of the Judith River beds in Montana. Between these two series of deposits are intercalated the Bearpaw shale and the true Fox Hills sandstone, the actual combined thickness of which has yet to be determined, but which, from observations made by the writer on Willow Creek, Montana, could not have been much, if any, less than 2,000 feet. To this should be added the 1,500 feet of sediment lying between the horizon at which the type of *T. horridus* was found and the top of the Fox Hills, so that a series of deposits aggregating approximately 3,500 feet in thickness separated the strata from which the types of these two genera were obtained—a series representing an enormous time interval, too long, it is believed, for any single genus of so highly specialized dinosaurs as were the Ceratopsia to have persisted. Considering the difference in time at which they lived and their difference in size and structure, there can be little doubt but that they were generically distinct and that this distinction will be still further emphasized when more is known of the structure of the genus *Ceratops*, which is as yet only known from fragments.

DETAILED DESCRIPTION OF TYPE.

The type (No. 1820, Yale Museum) of the present genus and species pertained to a fully adult and apparently very old individual. When first seen by the present writer the central mass of the cranium lay embedded in a large concretion of hard, gray sandstone lying on the weathered slope a few feet above the bed of the rather picturesque canyon in which it was found. It had probably rested in its present position for more than a century subjected to the destructive action of wind and weather. Although numerous fragments of the anterior and posterior portions of the skull lay scattered about over the slope and others were recovered from the loose sand at the bottom, no inconsiderable portion of it had been swept away and irretrievably lost by the torrents of water that in spring and summer rush madly down the usually dry beds of all the canyons of this semiarid region after each recurring storm. It thus happens that in the type of this genus, the most prolific in species and individuals of any of the Laramie Ceratopsia at least, many interesting characters are not shown.

Although the skull is badly injured by weathering, these injuries are not wholly without their advantages, since they reveal many points in the anatomy of the skull which it would be difficult to determine from a more perfect specimen without duplicating in part, at least, the injury which the present skull has already suffered.

By weathering, a transverse section of the skull is given just in advance of the orbits, a view of which is seen in fig. 27 (p. 30), which shows well the relations of the frontals, postfrontals, alisphenoids, palatines, pterygoids, maxillaries, and vomers in this region. The frontals and prefrontals are seen to rest on top of a forward prolongation of the postfrontals which reaches forward in advance of the alisphenoids, probably extending as far as the anterior border of the orbits. Medially in this region the frontals and postfrontals are in contact, but laterally the postfrontals are separated from the overlying frontals and prefrontals by two large cavities, which in fig. 24 (p. 28) are represented as filled with matrix.

The alisphenoid differs materially in the type of the present genus from that in the type of *Sterrholophus*,[a] as will be readily seen by a comparison of figs. 9 and 27. Instead of stopping a little short of the anterior opening of the olfactory foramen as in the last-mentioned genus, it is carried considerably in advance of that opening, which in the present specimen is divided by a strong median septum into two openings, the olfactory nerves leaving the brain case by two lateral foramina in the type of *Triceratops* instead of by a single median one as in the type of *Sterrholophus*,[a] differences which should certainly be regarded as of generic importance if both skulls were adult. Since, however, the type of *Sterrholophus* pertained to a young individual it is probable that the median septum was present as cartilage and was lost in maceration. It is very unlikely that there was in any of these dinosaurs a single olfactory nerve.

The posterior portion of the vomers appears in position wedged in between the vertical plates of the palatines, while at their extreme posterior end they divide and embrace the anterior and inferior edge of the alisphenoid, which shows a small median foramen just beneath the olfactory foramina. Beneath and posteriorly the vomers join the ascending branches of the pterygoids in a W-shaped articulation, as shown in fig. 25 (p. 28). Only the posterior portion of the vomers is preserved.

The palatines are each composed of two broad, thin vertical plates of bone, one directed antero-posteriorly, and the other transversely. The transverse plates are well shown in fig. 27, while the longitudinally directed plates are better seen in fig. 24. Posteriorly the longitudinal plates of the palatines join the pterygoids and together they form the posterior lateral walls of the palate. Beneath, the palatines overlap a considerable portion of the posterior and inner surface of the maxillary concealing a number of the dental foramina. There is a large circular foramen between the palatines and pterygoids just above the superior border of the maxillary. The function of this I have been unable to determine. Above, the longitudinal blades of the palatines overlap the vomers, the superior branches of the pterygoids and clasp between them the inferior edge of the alisphenoid, while the external portions of the superior borders of the transverse blades are produced upward until they nearly or quite meet two opposing dependent processes from the anterior extremity of the postfrontals and surround two large vacuities shown at *f* in fig. 27, placed one on either side, which afford direct communication between the narial orifices and the lateral temporal fossæ.

On the right side the entire external wall of the skull had weathered away, and when the matrix filling the capacious lateral temporal fossa was removed the relations of those elements that form the internal walls of that fossa were clearly revealed, as shown in fig. 24. The broad superior and posterior blade of the pterygoid is seen to curve outward and backward and to pass beneath the thin superior blade of the quadrate, while, as shown in the same figure, the slender inferior posterior blade runs backward along the inner surface of the maxillary, curving quite around the posterior extremity of the inferior branch of the latter and articulating with the rudimentary transverse bone or ectopterygoid. The latter element is reduced to an elongated flat plate of bone, broad and rounded behind and pointed in front, thickened in the middle and thin at either end and fixed to the upper external surface of the inferior branch of the maxillary.

Above and in front the postfrontals appear intercalated between the alisphenoids and the frontals and prefrontals. In front there is a large cavity filled with matrix between the prefrontals and postfrontals and behind this the postfrontals are much thickened and are invaded by a number of large cavities separated by strong partitions of bone. These postfrontal cavities are present in all the larger members at least of the Ceratopsia, and they doubtless had their origin in the application of that well-known mechanical principle or device, so often exhibited in the organic world, by which strength is combined with lightness. Posteriorly and superiorly the alisphenoid sends upward and outward a powerful buttress-like blade which acts as a strong pillar, giving support to the postfrontals and the enormous supraorbital horn cores. At the base of this pillar the optic foramen and foramen rotundum are seen separated from the foramen ovale by a conspicuous prominence, while in front of these are the other smaller foramina shown in the figure, the functions of some of which are at least doubtful.

[a] *Triceratops flabellatus*, No. 1821, Yale Museum.

The anatomy of the occipital region may be well seen from behind, as shown in fig. 107. The frill is for the most part wanting and the large hemispherical occipital condyle appears in the center, which gives origin above to the elongated exoccipital processes, greatly expanded distally and below to the short, stout basioccipital processes, while just in front of these may be seen only the extremities of the basisphenoid processes resting against the broad plates of the pterygoids, which diverge and give rise below to two processes, the broader and thinner of which gives support to the quadrate from within, while the longer and more slender passes downward and forward to meet the inferior branch of the maxillary. Above the occipital

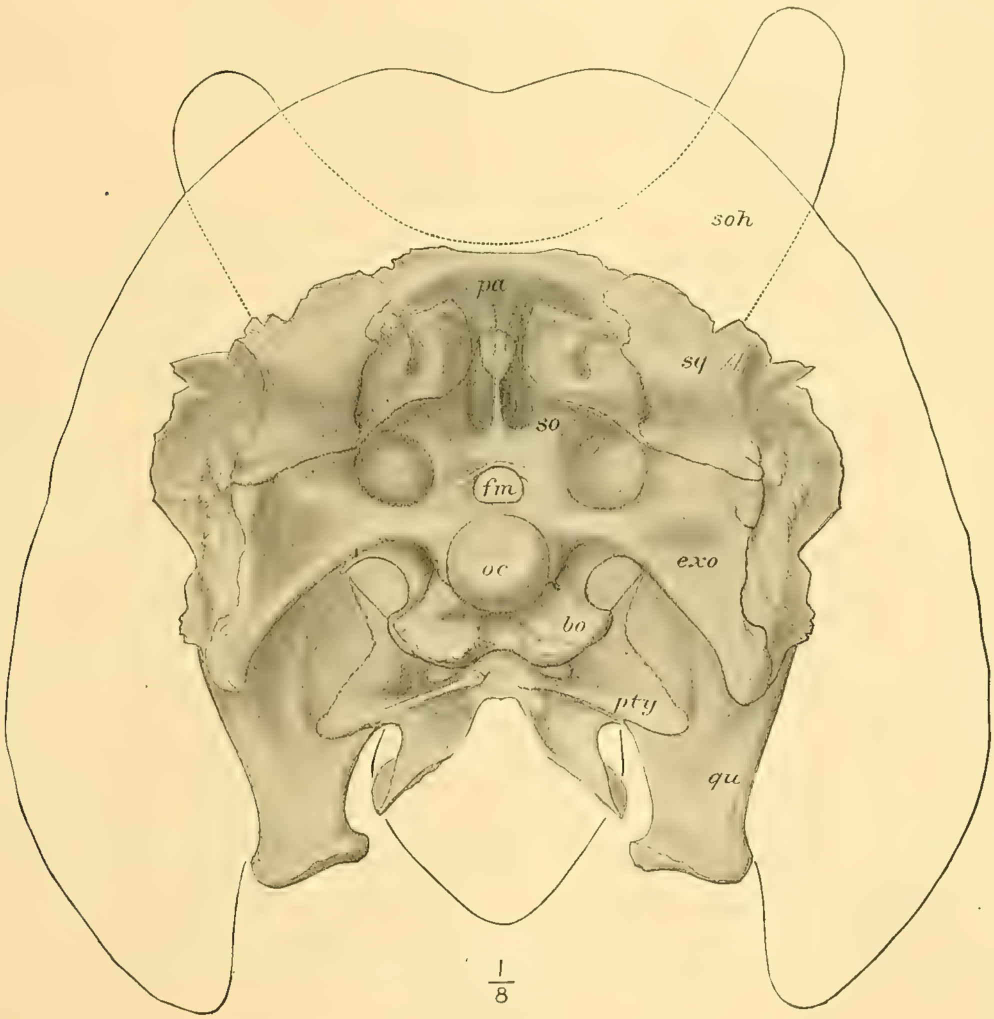

FIG. 107.—Posterior view of type of *Triceratops horridus*, No. 1820, Yale Museum. Drawn under Professor Marsh's supervision. *bo* Basioccipital; *exo*, exoccipital; *fm*, foramen magnum; *pa*, parietal; *pty*, pterygoid; *qu*, quadrate; *so*, supraoccipital; *soh*, supraorbital horn core; *sq*, squamosal. One-eighth natural size.

condyle is the foramen magnum, situated entirely within the exoccipitals. Above this the posterior surface of the exoccipitals shows two deep pockets or cavities situated one on either side of a strong, vertical, median bar which expands somewhat just below the suture for the supraoccipital. Laterally and superiorly the exoccipitals articulate with the squamosals.

The supraorbital horn cores appear exceedingly massive. The rostral bone is also very heavy and not so sharp along its infero-anterior border as in most other species where that element is known. The nasal horn is very broad at the base and quite short and blunt. The jugals, quadratojugals, and quadrates appear as usual.

On Pl. XXVI is given a view of the skull as seen from the left side, with such of the detached fragments placed in their proper positions as we were able to locate. This drawing shows at a glance the very close relationship existing between the present species and *T. prorsus* and *T. brevicornus*. From the former, however, it is readily distinguished by the form of the supraorbital horn cores and the shortness of the nasal horn core, while its greater size should perhaps be taken as distinguishing it from both these species. The principal dimensions of the type are as follows:

Principal measurements.

	Mm.
Diameter of occipital condyle	116
Expanse of quadrates	536
Fore and aft diameter of supraorbital horn core at base	245
Transverse diameter of supraorbital horn core at base	172
Transverse diameter of supraorbital horn core 10 inches above base	127
Fore and aft diameter of supraorbital horn cores 10 inches above base	155
Height of nasal horn core	130
Transverse diameter of nasal horn core at base	125

TRICERATOPS SERRATUS Marsh. 1890.

Type consists of nearly perfect skull with lower jaw (No. 1823, Yale Museum), from Laramie of Converse County, Wyo. Original description in Am. Jour. Sci., 3d ser., vol. 39, Jan., 1890, pp. 81–82.

Dana, J. D., Manual of Geology, 1895, p. 846.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 69.

Lull, R. S., Bull. Am. Mus. Nat. Hist., vol. 19, art. 30.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 41, Feb., 1891, p. 177; vol. 43, Jan., 1892, p. 84; Mon. U. S. Geol. Survey, vol. 27, 1897, p. 512.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 271.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

Woodward, A. S., Outlines Vert. Pal., p. 214.

Zittel, K. A. von, Text-book Pal., trans. by C. R. Eastman, p. 244.

LOCALITY AND HORIZON.

In the American Journal of Science for January, 1890, Professor Marsh proposed the present species. The type (No. 1823, Yale Museum) consists of a well-preserved skull, with lower jaw, pertaining to an animal apparently not fully adult, discovered by the late Dr. C. E. Beecher in 1889. It was found incased in a hard calcareous sandstone concretion in the locality designated as +4, Pl. LI. The exact locality was on the north side of the middle fork and about 3 miles above the mouth of the draw of Dry Creek, which empties into Lance Creek from the west, immediately below the U–L cattle ranch, then long abandoned, but now occupied as a sheep ranch by Mr. Jacob Mills. The horizon was at the base of a stratum of sandstone about 20 feet above the bottom of the draw, which here assumes the appearance of a narrow but not deep canyon. I should judge the actual horizon to be somewhat above that which furnished the type of *T. horridus*.

ORIGINAL DESCRIPTION.

Marsh's original description of the species was as follows:

First in importance of the new discoveries is a nearly perfect skull of the genus *Triceratops*, a typical example of which (*T. flabellatus*) was described and figured by the writer in the last number of this journal. The present skull is more perfect than any hitherto found and exhibits admirably the strongly marked characters of the genus. It is likewise of gigantic size, being nearly 6 feet in length (1.8 m.), although the animal was not fully adult.

A striking peculiarity of this skull, which has suggested the specific name, is a series of bony projections on the median line of the parietal crest. The latter is elevated along this line to support them, and the sides descend rapidly to their union with the squamosals. There is a second series of elevations along the middle of the squamosal bone as it falls away from the base of the horn core, but these are much less prominent.

The orbit is nearly circular in form instead of oval and is situated above and forward of its position in the species referred to. The quadratojugal meets the anterior process of the squamosal, forming a closer union than in the skull previously figured. In this respect and in the elevations on the squamosal it approaches a much smaller specimen, at present referred to the genus *Ceratops*.

The nasal horn core is wanting in the present specimen, as it was not ossified with the nasals. It projected upward and forward. The nasal bones extend outside the superior branch of the premaxillaries, the lateral suture uniting the two being nearly vertical.

The present specimen is from the Ceratops beds of Wyoming in essentially the same horizon of the Laramie as the skull of *Triceratops flabellatus*, to which reference has been made.

FURTHER DESCRIPTION.

This splendid skull may be further described as follows, and in the beginning I may state that the character which has suggested the specific name is probably possessed in common, to a greater or lesser degree, by all the species of the genus, or even of the family, and can not therefore be considered as in any way distinctive.

Notwithstanding its size, the skull pertained to an individual not fully adult, as shown by the cranial sutures, most of which are still open, thus making it possible to determine with accuracy the form and position of the various elements of the skull. The skull is complete, except the nasal horn, the extremity of the predentary, a portion of the rostral, and the summits of the supraorbital horn cores, which are wanting.

The *nasals* are in contact medially throughout their entire length, save at the extreme anterior end, where they each send downward a short process. These downward-projecting processes diverge and embrace the elevated anterior portions of the premaxillaries. Posteriorly the nasals pass beneath the anterior borders of the frontals, prefrontals, and lachrymals, with which elements they articulate by underlapping and overlapping sutures, the posterior border of the nasals being overlapped by the anterior borders of the elements mentioned. Inferiorly and posteriorly the nasals each send downward and forward a rather strong process, which articulates below with the superior border of the maxillary for a short distance posteriorly and for a longer distance anteriorly with the posterior projection of the premaxillary. Anteriorly this inferior process of the nasal forms the posterior, and for a short distance the inferior, border of the nasal opening. Posteriorly it forms the external superior border of the lachrymal foramen. The nasal horn is wanting, and its characters are therefore not determinable. Only the sutural surface on the nasals is preserved, and from this it would appear to have been considerably compressed transversely, with the antero-posterior diameter exceeding the transverse, conditions somewhat similar to those that obtain in the nasal horn of *Monoclonius sphenocerus* of Cope.

The *rostral* is rather small, with a strong median keel posteriorly separating two rather deep pockets located one on either side for the reception of corresponding processes from the premaxillaries. The rostral is lighter and less rugose than is usual in other skulls, but this may be due to the immature age of the individual.

The *premaxillaries* anteriorly are suturally united with the rostral and with each other, while above they are embraced by short descending processes of the nasals, with which they are also united by suture. Immediately beneath the nasal horn they each send upward a very strong buttress. These support the nasals from beneath and give to this region the rigidity that is essential to insure the most effective use of the nasal horn as an offensive and defensive weapon. As in other genera and species, the premaxillaries form but an imperfect median septum and the external nasal openings are confluent. There are the usual number of laminæ and foramina in this region, which seem, however, to be subject to considerable individual variation. They are best understood by a reference to Pl. XXVII, where a side view of the skull is shown. Posteriorly the premaxillaries articulate with the maxillaries, and superiorly they send upward and backward a long, slender process, which is wedged in between the maxillary and nasal, extending almost or quite to the anterior border of the lachrymal foramen, which in the present species is situated between the nasal and maxillary instead of entirely within the maxillary, as in *Sterrholophus flabellatus*.

The *maxillary* has the usual form. Its articulation with the premaxillary has already been described. Supero-posteriorly the maxillary articulates with the jugal and forms the inferior border of the lachrymal foramen. Owing to the imperfectly prepared condition of the type specimen it is impossible to determine the exact relations of the pterygoids and the palatines to the posterior portion of the maxillary. It is quite probable, however, that they do not differ materially from those shown in the types of *T. horridus* and *Sterrholophus flabellatus*, but are quite different from those figured by Dr. R. S. Lull as pertaining to a skull, No. 970, in the collections of the American Museum of Natural History and described by that author as belonging to the present species. A careful study of the New York specimen would doubtless show that both Doctor Lull's figure and description of this region are erroneous and that the pterygoids do not form the postero-lateral borders of the narial fenestræ, but that these borders are formed by the palatines, the anterior limits of the pterygoids being much more reduced than shown by Lull.[a]

The *frontals* are small, somewhat rectangularly shaped bones. Anteriorly they overlap the nasals, and together they present a deep median emargination. Medially or internally they are in contact with each other throughout their length, while posteriorly they articulate with the postfrontals and externally or laterally with the prefrontals. The right frontal is pierced at its posterior border by a large foramen, the posterior border of which is formed by the postfrontal. This foramen is absent on the opposite side, and it is probably pathologic.

The *prefrontals* occupy a position just external to the frontals and articulate with the latter throughout their entire length. Posteriorly they are broad and flat and oppose the anterior extremities of the postfrontals. Anteriorly they articulate with the nasals, curve downward to form the convex external wall of the skull, and meet below in a straight suture the superior borders of the lachrymals. Posterially their external lateral borders are much thickened where they form the supero-anterior borders of the orbits and give support to the supraorbital horn cores from beneath and in front.

The *lachrymals* are the smallest of the three bones that articulate with the posterior extremities of the nasals. They articulate with the prefrontals above and the jugals below. Posteriorly they form the median portion of the anterior border of the orbit, which is not so thick and does not project so far outward as that portion immediately above, which is formed by the prefrontal. Anteriorly, at its inferior angle, the lachrymal sends forward a long projection, which is continued along and within the inferior border of the nasal and with the latter forms the superior border of the elongated lachrymal foramen, which appears to have communicated with the orbit through a large opening confluent also with the narial orifice.

The *jugal* has the usual triradiate form commonly seen in the Ceratopsia. Anteriorly it articulates with the lachrymal above and the maxillary below, and sends forward a long, slender process which lies just within the superior border of the maxillary and, together with that bone, forms the inferior border of the lachrymal foramen. Beneath the lachrymal foramen the jugal overlaps externally the superior branch of the maxillary. Above, the jugal forms the antero-inferior border of the orbit, while posteriorly it articulates with the postfrontal and sends backward a broad, thin process which overlaps the external wall of the squamosal and forms the greater portion of the superior border of the lateral temporal foramen, which is bounded in front by the dependent spatulate process of the jugal. The latter overlaps the quadratojugal and supports at its distal extremity the epijugal.

The *quadratojugal* has the usual irregularly wedge-shaped form, broad in front and thin and pointed behind. It is firmly fixed between the quadrate and the jugal and sends backward along the superior and external wall of the quadrate a triangular process which passes beneath a smaller but similar process that extends forward from the squamosal. These two processes, together with the quadrate, form the inferior temporal arch and inclose below the lateral temporal foramen, which is triangular in outline and is inclosed behind by the squamosal.

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[a] This question of disagreement has been referred for arbitration to Dr. W. D. Matthew, of the American Museum, who writes (June 6, 1905) as follows: "As to the pterygoids and palatines on our *Triceratops* skull (No. 970), I have compared your figure and photograph with the original as carefully as possible, and there can be no question as to their being correct. The only possible doubt would be as to the correctness of your interpretation, the alternative supposition being that what you call palatine is a refolded plate of the maxilla (the fissure between for nutrition of the dental row) and what you call pterygoid is palatine. Looking over the specimen, this appears to me an improbable, but not impossible, explanation. I note, however, that Marsh's interpretation, judging from his description of *Triceratops* in 'Dinosaurs of North America," agrees with yours; it also harmonizes better with the form and arrangement in the Theropoda."—R. S. L.

Owing to the state of preparation of the type it is not possible to determine accurately the characters of the quadrate, though it is hardly probable that it differs materially from that element in other species of the genus.

The *postfrontals* are much the most massive elements of the frontal region of the skull. They give rise to the supraorbital horn cores and form the posterior half of the orbital border. Anteriorly they articulate with the frontals and prefrontals above and the jugals below; inferiorly they are in contact with the jugals and squamosals, and posteriorly with the squamosals and parietals. In the median line, just back of the horn cores, they are perforated by a large foramen,[a] the pineal of Marsh, which in other skulls is known to communicate with certain large cavities in the postfrontals situated back of the orbit, some of which, at least, are confluent with the large cavities at the bases of the supraorbital horn cores. The floors of these large cavities are formed in part, at least, by the supraoccipital, and their purpose seems to have been to combine strength with lightness by that mechanical adaptation so frequently resorted to in the animal kingdom, which finds its most perfect development among the Dinosauria in the vertebræ of the more highly specialized Sauropoda. Anteriorly the postfrontals are overlapped by the frontals and prefrontals, but posteriorly they overlap the parietals, and a median projection of the latter element is inserted into a broad emargination of the prefrontals. Only the bases of the supraorbital horn cores are preserved in the type, the upper half of both being entirely wanting. The portions preserved show that these horns in the present specimen were comparatively somewhat more slender than those of most other species of this group. It is possible that this character may have been of sexual rather than specific importance and that the type may represent the skull of a young female, since it would not seem improbable to suppose that the horns would be less robust in the females than in the males. At the base of each horn core on the posterior surface of the postfrontal just above the squamosal border there is an elevated rugosity which is a continuation of that series of similar rugosities described and figured by Marsh as being present on each squamosal.

The *squamosals* are comparatively broad, short, and stout. The inferior border of each describes the arc of a circle with a regularly sculptured peripheral border. The anterior extremity presents an irregular border for contact with the postfrontal, jugal, quadrate and quadratojugal, as shown in Pl. XXVII. The surface throughout is rugose and grooved, presenting an intricate system of shallow, ramifying channels, which doubtless lodged and gave protection to that system of nutrient blood vessels which lay between the bone and a closely fitting horny covering with which in life it was probably insheathed.

The *parietals*, if ever separate, are now firmly coossified, demonstrating that these elements became fused very early in the life of the animal. Taken together the parietals are very broad behind and narrow in front, where on either side they present an elongated supratemporal foramen which in other individuals is known to have communicated both with the temporal fossa and with the cavities at the base of the horn cores. The median line of the parietals is elevated antero-posteriorly and presents a series of four rugose prominences. The superior surface of the parietals is convex transversely and concave antero-posteriorly. The external surface of these bones, like that of the squamosals, is rugose throughout and presents an intricate system of shallow grooves for the lodgment and protection of blood vessels. The more important of these are seen to emerge from the posterior borders of the supratemporal foramina as larger and deeper canals, whence they branch and spread out over the surface of the bone, becoming smaller and less marked with each successive ramification. As with the squamosals, in life these channels doubtless lodged and gave protection to that system of blood vessels which gave nourishment to the parietals and their insheathing substance, whether composed of horn or other material. The sutures between the parietals and squamosals and the parietals and postfrontals have remained open.

The frill.—Taken together the squamosals and parietals form a broad frill, with the transverse diameter nearly double the fore and aft, deeply concave below and broadly convex above,

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[a] See footnote on p. 24.

so as to form a complete covering and efficient armor for the short cervical region restricted in the Ceratopsia, as in most Mammalia, to the seven [eight, R. S. L.] anterior presacral vertebræ. The periphery of this frill bore seventeen triangular epoccipital bones. The broader of these occupied a median position relative to the parietals, while the remaining sixteen were arranged in pairs, eight on either side, diminishing in size as they recede from the median. The third of these laterally paired epoccipitals is supported about equally by the parietals and squamosals, while the first two pairs are borne by the parietals and the five remaining pairs are borne by the squamosals. The last two pairs of the latter five, instead of being borne on the extreme margin of the frill as are the others, are shifted to the superior surface of the squamosals and are much smaller than those located between them and the single median ossicle. The number of these epoccipital bones appears to vary from seven lateral on either side and one median, or fifteen in all, in the type of *Triceratops prorsus* as figured by Marsh, to nine lateral and one median, or nineteen in all in the type of *Sterrholophus flabellatus* as figured by that author. The number of epoccipitals may, however, have varied in different individuals and can hardly be considered as diagnostic of the different genera or species.

The lower jaw was proportionately long and slender and the predentary seems to have been somewhat elongated, though the anterior portion is wanting. There is a marked protuberance near the middle of the inferior border, and above this are a number of foramina, the three larger of which are arranged in a series one behind the other and in the same horizontal plane. The coronoid process is strong and moderately expanded above. As nearly as can be determined the articular, angular, and surangular do not differ materially from the same elements in *Triceratops prorsus*.

Seen from the side with the lower jaws in place, as they were found, the skull appears long, broad, and low. The superior surface between the midfrontal region and the median epoccipital is deeply concave antero-posteriorly, much more so than is shown in Pl. XXVII. The superior surface of the nasals, prefrontals, and frontals is slightly concave. The orbits are large and irregularly elliptical in outline, not "nearly circular" as originally described by Marsh. The hard sandstone matrix in which the skull when found was embedded has not yet been removed from the under surface, so that I am unable to describe the palatal view.

The characters which at present seem most distinctive of this species are (1) *the position of the lachrymal foramen, which lies between the maxillary and nasal instead of within the maxillary;* (2) *the structure of the inferior temporal arch;* (3) *the comparatively slender supraorbital horn cores;* (4) *the narrow and elongated lateral temporal foramen.* The number of epoccipitals and the rugosities mentioned by Marsh as present on the squamosals may also prove to be of specific importance.

Principal measurements of type of T. serratus (No. 1823, Yale Museum).

	Mm.
Greatest length of skull	1,710
Greatest breadth of frill	1,150
Expanse of jugals	630
Expanse of frontal region at anterior border of orbits	369
Greatest diameter of orbit	136
Least diameter of orbit	110
Greatest diameter of lateral temporal fossa	108
Least diameter of lateral temporal fossa	45
Distance from posterior border of orbit to posterior border of frill	828
Thickness of postfrontal behind orbit	159
Antero-posterior diameter of supraorbital horn core immediately above orbit	173
Antero-posterior diameter of supraorbital horn core 200 mm. above orbit	115
Transverse diameter of supraorbital horn core immediately above orbit	132
Transverse diameter of supraorbital horn core 200 mm. above orbit	95
Greatest length of squamosal	785
Greatest breadth of squamosal	400
Length of parietals along median line	652
Distance between squamosal sutures at posterior border of frill	900
Distance between squamosal sutures at junction with postfrontals	297

	Mm.
Distance from anterior border of orbit to posterior border of nasal opening	266
Distance between orbit and lateral temporal foramen	145
Distance between lateral and supratemporal foramina	259
Distance from lateral temporal foramen to posterior extremity of squamosal	780
Circumference of supraorbital horn core at base	490
Circumference of supraorbital horn core 200 mm. above base	345

TRICERATOPS PRORSUS Marsh. 1890.

Type consists of nearly perfect skull with lower jaw (No. 1822, Yale Museum), Laramie of Converse County, Wyo. Original description in Am. Jour. Sci., vol. 39, Jan., 1890, p. 82.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 41, Feb., 1891, pp. 177–178; Apr., 1891, pp. 339 and 342; vol. 43, Jan., 1892, p. 84; Nature, vol. 48, Sept. 7, 1893, p. 337; Am. Jour. Sci., 3d ser., vol. 48, July, 1894, p. 90; Mon. U. S. Geol. Survey, vol. 27, 1897, p. 516; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, pp. 218.

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Woodward, A. S., Outlines Vert. Pal., p. 213, 216.

Zittel, K. A. von, Text-book Pal., trans. by C. R. Eastman, vol. 2, p. 244.

ORIGINAL DESCRIPTION.

The present species was based on a nearly complete skull (No. 1822, Yale Museum), with lower jaw and the six anterior cervicals of an individual fully adult. Marsh's original description of this species was as follows:

A second skull of this genus, fully adult, and of nearly equal dimensions, was secured at the same time as the specimen last described. It is in excellent preservation, although somewhat distorted, and evidently belongs to a different species.

The nasal horn core and the rostral bone are in position, and perfect. The former is very large and is directed straight forward, its upper surface being nearly on a line with the superior face of the nasals. It is somewhat oval in transverse section, and pointed in front, the apex being directly above the anterior extremity of the rostral bone. It is so firmly coossified with the nasals that no trace of a suture can be observed. Its external surface is rugose from vascular impressions, indicating that it was covered by horn, thus forming a most powerful weapon.

The huge frontal horn cores are more massive and less slender than in the species above described.

The parietal crest is not so broad as in the two species last described, but appears to resemble more closely that of *Triceratops horridus*, its sides being inclined downward, as if to protect the neck.

The rostral bone likewise is very similar to that in the last species, but is somewhat more compressed. The two forms may be readily distinguished by the nasal horn core, for in *T. horridus* this is comparatively small and points directly upward, instead of straight forward, as in the present species.

With this skull were found several cervical vertebræ and some other portions of the skeleton. The atlas, axis, and the third vertebra are firmly anchylosed with each other, and their ribs, also, are coossified in the same mass. This union, unknown hitherto among the Dinosauria, was evidently rendered necessary to afford a firm support for the enormous skull. The remaining cervical vertebræ are short and massive, and the articular faces of the centra are concave or nearly flat.

The present specimen is from the Laramie of Wyoming, and was found in the same vicinity as the skull above described.

LOCALITY.

The type of the present species, as already stated, consisted of the skull, lower jaw, and the six [seven] anterior cervical vertebræ (No. 1822, Yale Museum). They were found by me on July 4, 1889, incased in a hard concretion of calcareous sandstone, which had nearly weathered out of a thick stratum of rather soft and almost white sandstone. The locality, shown at + 3 in Pl. LI, was situated about 100 yards above and on the same side of the canyon as that at which the type of the species last described was obtained. When discovered, the skull lay a few feet above the bottom of the canyon and at a slightly lower horizon than the type of *T. serratus*. Between the position occupied by these two skulls on the opposite side of the canyon there extends for a distance of perhaps 200 feet a perpendicular wall, perhaps 20 feet in height, near the summit of which, at the point marked O B sp., Pl. LI, a considerable portion of the skeleton (Burwell specimen) of a species of the Trachodontidæ was found.

In several subsequent papers Professor Marsh referred material from other localities to the present species, thereby furnishing additional specific characters. Of first importance among such supplementary material was a considerable portion of the skeleton of a single individual, now in the collection of the U. S. National Museum (No. 4842).[a] The remains of this skeleton, which included several vertebræ and ribs, the sacrum, pelvis, scapula, representations of all the limb bones except the radius and fibula, several foot bones, a portion of a horn core, etc., were found by me at the place marked + sk. c. in Pl. LI. The locality is near the head and on the north side of a small draw (not shown on the map) which empties into Lance Creek from the east, about 1½ miles below the U–L ranch. About 100 yards above the point where the skeleton was found is a small cottonwood grove by a spring, near which my party camped while engaged in taking up the bones. In dry seasons, however, this spring ceases to flow. The horizon is a ledge of sandstone at about the same level, I should judge, as that which furnished the type of *Triceratops horridus*, and I should judge it to be considerably lower than that from which the skull that forms the type of the present species was obtained. In view of the probable difference in the horizons at which the two specimens were found, and the fact that a fragment of a supraorbital horn core is all that the two specimens have in common for direct comparison, as well as the fact that this more nearly resembles the same element in the type of *T. elatus*, as will be seen by a comparison of fig. 108 and Pl. XLIII, their specific identity can hardly be considered as demonstrated or as even being capable of demonstration, and I prefer to limit the definition of the present species to the type specimen, which may now be described in detail.

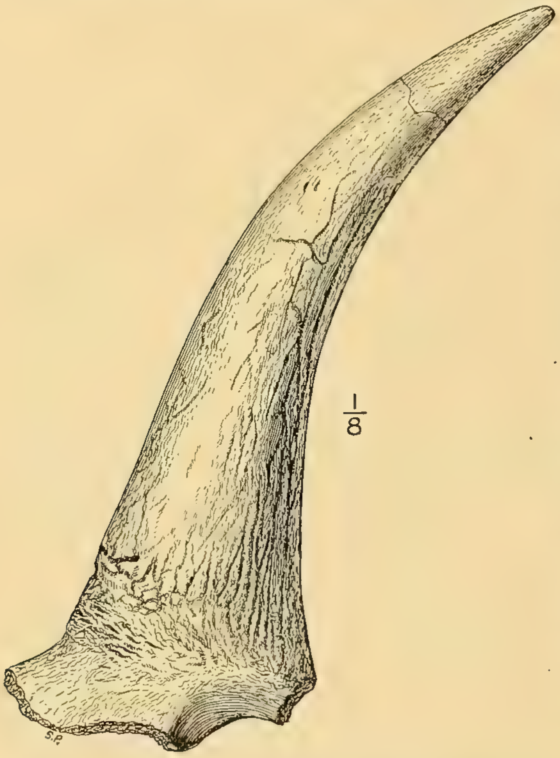

FIG. 108.—Right supraorbital horn core found with skeleton (No. 4842, U. S. National Museum) referred by Marsh to *Triceratops prorsus*. It resembles more nearly the same element in *T. elatus*. Compare with Pl. XLIII. One-eighth natural size.

DETAILED DESCRIPTION OF THE TYPE SPECIMEN.

The type (No. 1822, Yale Museum) consists of the six [seven] anterior cervical vertebræ, with the skull and lower jaws complete, save the summit of the left supraorbital horn core and the median posterior portion of the parietal, which had weathered away and were lost before the specimen was discovered. The parts recovered indicate that the animal was fully adult and perhaps in advanced old age when it met death. Most of the cranial sutures are closed. The epoccipitals and epijugals are firmly coossified with their respective elements, while the entire external surface of the skull is rugose and marked with a multitude of deep vascular impressions or canals, especially conspicuous on the squamosals and parietals, where they present a labyrinth of ramifying branches, most of which converge about and lead into the large supratemporal fossæ.

The present species, which includes nearly the smallest if not the very smallest representatives of the family known from the Laramie formation, is readily distinguished by the following characters: (1) The long and anteriorly directed nasal horn core; (2) the slender supraorbital horn cores directed upward, forward, and outward throughout about one-half their length, when they begin and continue to curve gently inward from thence to the summit; (3) the

[a] This is the mounted skeleton. See pages 189–192; fig. 124; Pl. XLIX.—R. S. L.

nearly circular orbit; (4) the position of the infraorbital foramen below the superior border of the ascending branch of the maxillary, as in *Sterrholophus flabellatus*.

Viewed from the side, the facial region of the skull of the present species appears long and the parietal crest proportionally abbreviated, presenting the opposite conditions from those which obtain in the genus *Torosaurus*, where the parietal crest is greatly elongated and the frontal region much abbreviated. The superior surface of the region between the supraorbital horn cores and the posterior border of the frill is strongly concave, though this condition has doubtless been somewhat accentuated by crushing. A rather sharp and elevated ridge marks the middle lines, displaying a series of three small rugose elevations. The jugal is directed downward and slightly backward and is firmly coossified with the epijugal. The union between these elements and the quadratojugal is less complete, though these are coossified below, while the suture between the jugal and quadratojugal is left open above throughout fully two-thirds of its length. The quadratojugal notch is deep and narrow, more so than in any other skull known to the writer. The squamosal is proportionally broad and short and bears seven epoccipitals. The smallest of these is at the antero-inferior angle, which is rather less prominent than in most other species of the family. The posterior border of the frill is incomplete and it is therefore impossible to determine with accuracy the number of epoccipitals borne by

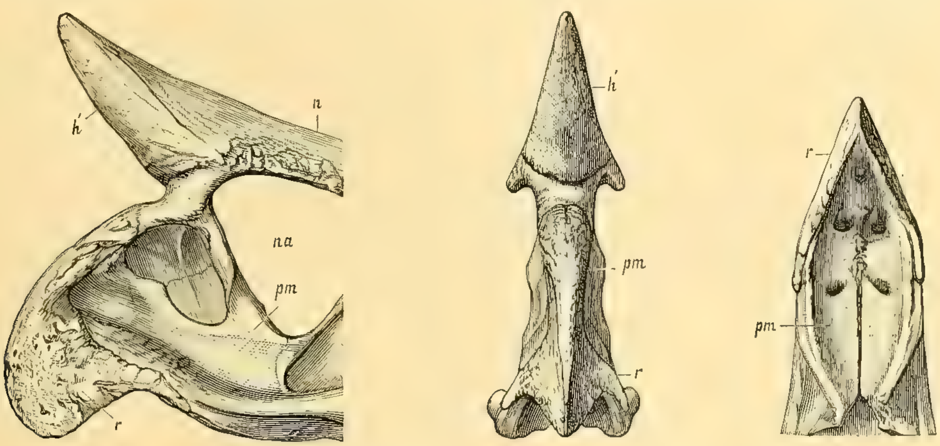

FIG. 109.—Anterior part of skull of type of *Triceratops prorsus* Marsh (No. 1822, Yale Museum). 1, Side view; 2, front view; 3, inferior view. *h'*, Nasal horn core; *n*, nasal bone; *na*, narial aperture; *pm*, premaxillary; *r*, rostral. One-eighth natural size. After Marsh.

the parietals, though the number seems to have been five, one median and four lateral, arranged two on either side, making nineteen in all, as figured by Marsh and shown here in Pls. XXXII and XXXIV. There is no postfrontal (pineal) foramen.[a]

Owing to the advanced age of the individual, it is impossible to determine to just what extent the various cranial elements enter into the construction of the orbital borders. The powerful supraorbital horn cores are directed forward and upward at an angle of about 45° from the perpendicular. The long and pointed nasal horn is directed nearly straight forward and only very slightly upward. The superior surface of the nasals and nasal horn core are in nearly the same plane. The nasal horn reaches as far forward as the short and compressed rostral, which embraces the premaxillaries anteriorly and is completely fused with them. The rostral is deeply excavated beneath and presents on either side a sharp, cutting edge. It is very rugose and was doubtless in life incased in a heavy sheath of horn or other substance resembling, on a large scale, the beak of modern birds and turtles. With a similar beak borne by the predentary of the lower jaw, which fitted into and opposed from beneath that borne on the rostral, these elements afforded the most effective means for procuring the food necessary for the sustenance of the individual and at the same time must have served as very efficient

[a] See note on p. 24.—R. S. L.

offensive and defensive weapons. The form and character of the rostral bone are well shown in fig. 109.

The *predentary*, fig. 110, is longer and more slender than the rostral. It is pointed anteriorly and posteriorly and is triradiate, presenting two superior lateral processes which overlap the antero-superior margins of the dentaries and a single inferior median process which is bifurcated distally and passes beneath the antero-inferior borders of the dentaries.

The *dentary* is short and shows a number of large and small foramina arranged in a somewhat irregular longitudinal series on the external surface of the bone, as shown in fig. 41, midway between the inferior and alveolar borders and commencing just in advance of the base of the coronoid process. Between the base of the coronoid process and the anterior extremity of the dentary the external surface is deeply concave antero-posteriorly instead of nearly straight, as in some of the larger forms.

The *coronoid process* curves strongly outward at the base. It is rather slender, of moderate height, and much expanded antero-posteriorly at the summit.

The *articular*, *angular*, and *surangular*, fig. 40, are closely applied to and interlocked with one another in a somewhat complicated manner. They are not, even in the present specimen, which represents a rather old individual, coossified either with the dentary or with one another. The free condition of these elements, taken in connection with the open symphysis and the free quadrate and shallow articular cup, might be taken as indicative at least of the possibility of some lateral and fore-and-aft motion in the lower jaws. However this may have been, it is quite certain that the jaws were not absolutely rigid, though the manner in which wear has

FIG. 110.—Predentary of type of *Triceratops prorsus* Marsh, No. 1822, Yale Museum. 1, Side view; 2, superior view; 3, inferior view. *a*, Anterior end; *b*, upper border; *d*, groove for dentary; *s*, symphysis. One-eighth natural size. After Marsh.

taken place on the teeth both in the upper and lower series is proof positive that in the process of mastication there was little or no lateral movement of the jaws one upon the other.

From the inner side the dentary presents a regular longitudinal series of dental foramina on its median surface, numbering one for each of the vertical series of teeth in the dental magazine, which in the present instance amounts to thirty-two.

Posteriorly the dentary is invaded by the deep and elongated mandibular fossa, which is closed behind by the angular, surangular, and articular, and internally by the long and slender splenial. Near the anterior extremity of the mandibular fossa two rather large foramina pierce the walls of the dentary.

The *splenials*, fig. 37, are very long and quite slender anteriorly, but broader behind, where they form the inner walls of the mandibular fossæ and are each pierced by a large internal mandibular foramen which communicates with the mandibular fossa.

The *premaxillaries* have the usual form. They send upward and forward two strong buttress-like pillars which give support from beneath to the superior arm of the rostral and the nasal horn core. A shorter buttress, not so stout, is directed upward and backward. This reaches only about halfway to the nasals, and with its anterior and posterior projecting laminæ forms an imperfect median nasal septum.

The *narial orifice* is large and opens externally by two very large lateral openings bounded above by the nasals and behind by the inferior processes of the nasals and the postero-superior processes of the premaxillaries. The narial orifice is confluent below with the mouth. The palatines and pterygoids did not form a closed palate. The *vomers* probably formed a long narrow median bridge, as shown in a skull (No. 970, Am. Mus. Nat. Hist.) lately described and figured by R. S. Lull[a] (see fig. 26), who refers it to *Triceratops serratus* of Marsh.

These elements are not preserved in the present specimen, and it is not possible to determine their nature. Posteriorly the narial orifice is confluent with the orbits, and the lachrymal or infraorbital foramen opens directly into the narial orifice, doubtless having communicated through it with the orbit.

Seen from behind (Pl. XXXIII), the supraorbital horn cores appear close together and the great hood-like frill is deeply arched, extending far beyond the occipital condyle and describing nearly three-fourths of the circumference of a complete circle. For a distance of about 20 centimeters from the posterior border the inferior surface of the frill presents the same rugose and grooved appearance as the upper surface, showing that this portion of the frill was covered below also with horn or some other dense substance. Within this external area, which has an average width of about 20 centimeters, the lower surface of the bone presents a smooth surface and has the appearance of having been covered with the muscles and softer tissues. Far forward, beneath the great frill, in the center, the occipital condyle is seen, its articular surface presenting the appearance of an almost perfect hemisphere. It is borne on a short peduncle, and just above it is the foramen magnum with a subtriangular opening. On either side of the occipital condyle opposite the foramen magnum the exoccipital processes are given off. These extend backward and outward and their distal extremities are expanded into broad, thick blades, the extremities of which abut against low but strong buttresses running diagonally across the inner surfaces of the squamosals near their anterior ends. The inferior angle of the exoccipital process protrudes a little below the inferior border of the squamosal in the present specimen, as in the type of *T. brevicornus*. Beneath and a little in front of the exoccipital processes the short, stout basioccipital processes are seen. These are exceptionally short in the present species, and in front they are in contact with the basisphenoidal processes. The latter are longer and more slender than the basioccipitals and articulate distally with the inner of the two posterior branches of the pterygoids, while the much broader external branch of the pterygoids laps over and articulates, by a peg and notch arrangement, with the quadrates, which are continued downward and expanded transversely to form the condyle for articulation with the shallow cup on the superior surface of the articular and surangular. Distally the quadrates converge so that their inner inferior angles are separated only by a distance of 185 millimeters from one another.

As in the type of *T. horridus*, the olfactory nerves leave the brain by two foramina in the present specimen.

The principal measurements of the skull and lower jaws are as follows:

Measurements of skull and lower jaws of Triceratops prorsus.

	Mm.
Length of skull from apex of nasal horn core to middle of parietal as restored	1,383
Greatest length of skull	1,523
Greatest width of frill	944
Expanse of antero-inferior borders of squamosals	556
Expanse of epijugals	532
Distance from orbit to apex of rostral	712
Distance from orbit to apex of nasal horn core	660
Expanse of orbits	245
Thickness of postfrontals back of orbit	155
Distance from inferior border of orbit to lower extremity of jugal	340
Greatest diameter of orbit	128
Least diameter of orbit	122
Antero-posterior diameter of supraorbital horn core at base	195
Transverse diameter of supraorbital horn core at base	150
Transverse diameter of supraorbital horn core 25 cm. above base	75
Antero-posterior diameter of supraorbital horn core 25 cm. above base	105
Circumference of supraorbital horn core 25 cm. above base	290

[a] Bull. Am. Mus. Nat. Hist., vol. 19, pp. 685-695.

	Mm.
Circumference of supraorbital horn core at base	540
Distance from orbit to apex of supraorbital horn core	550
Distance from apex of supraorbital horn to apex of nasal horn	650
Length of nasal horn core measured along lower side	210
Vertical diameter of nasal horn core at base	114
Transverse diameter of nasal horn core at base	100
Circumference of nasal horn core at base	330
Distance from orbit to posterior border of nasal opening	250
Diameter of occipital condyle	84
Length of dentary	505
Length of predentary	304
Length of splenial	508
Greatest width of splenial	85
Combined length of first six [seven] cervicals	550
Combined length of first three [four] cervicals	297
Transverse diameter of anterior end of atlas	105

TRICERATOPS GALEUS Marsh. 1889.

Type consists of a nasal horn core (No. 2410, U. S. Nat. Mus.), Denver beds of Colorado.

Original description in Am. Jour. Sci., vol. 38, Aug., 1889, pp. 174.

Marsh, O. C., Mon. U. S. Geol. Survey, vol. 27, 1897, p. 527.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

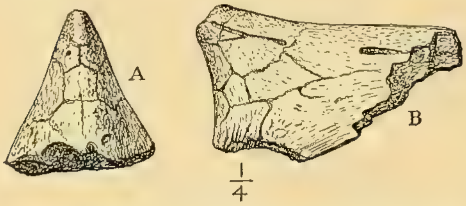

FIG. 111.—Type of *Triceratops galeus* Marsh, No. 2410, U. S. National Museum, consisting of nasal horn core. A, Anterior view; B, as seen from left side. One-fourth natural size.

In the same paper[a] in which Professor Marsh proposed the genus *Triceratops* he named and described very briefly the present species. After describing the new species *Triceratops flabellatus*, which he subsequently made the type of a new genus, he continues as follows:

> A much smaller species is represented by various remains, probably from the same horizon, in Colorado. In this species the nasal horn core is especially characteristic. It is compressed longitudinally, and its apex is pointed and directed well forward. It is on the extremity of the nasals and is thoroughly coossified with them. In front, at the base, it shows indications of union with the premaxillaries, but this connection was slight.
>
> The type specimen was found in Colorado by Mr. G. H. Eldridge, of the U. S. Geological Survey. The known remains indicate an animal about 25 feet in length.

The extremely fragmentary nature of the material upon which this species was based precludes the possibility of defining it adequately. As will readily appear from an examination of Marsh's brief description, the nasal horn core must be considered as the type of the species. The "various remains" by which according to Marsh the species was represented were undescribed by him. The nasal horn core was the only portion of the skeleton in any way described by Marsh in naming the species. It was sent in with a considerable number of fragmentary dinosaur bones collected by Mr. G. H. Eldridge near Brighton, Colo. The field labels accompanying these bones state that some of the different fragments, at least, were found separated as much as a mile from one another, and there is no information stating just which, if any of them, were found with the nasal horn core. It is clear, therefore, that the diagnosis of the species must rest solely upon the latter element. This is shown here in fig. 111. In form and general character it resembles much more closely that element in *Torosaurus gladius* Marsh than in any known species of *Triceratops*, and it appears quite possible that it may have pertained to that genus and species. From the fragmentary nature of the specimen, however, this is incapable of demonstration. The species should be abandoned. The principal measurements of the type are: Height of horn core, 71 mm.; breadth of same at base, 60 mm.

[a] Am. Jour. Sci., vol. 38, Aug., 1889, p. 174.

TRICERATOPS SULCATUS Marsh. 1890.

Type consists of a fragmentary skull, vertebræ, etc. (No. 4276, U. S. National Museum), from Laramie of Converse County, Wyo.

Original description in Am. Jour. Sci., vol. 39, May, 1890, p. 422.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 271.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

Walcott, C. D., Science, new ser., vol. 11, 1900, p. 23.

The type (No. 4276, U. S. National Museum) of this species was found by me at a somewhat higher horizon in the Laramie of Converse County, Wyo., than any remains yet mentioned. Professor Marsh's original description was as follows:

> One of the largest skulls of *Triceratops* secured during the past season was not in good preservation, although nearly the whole was recovered, and with it various vertebræ and other portions of the skeleton. The animal was fully adult, as shown by the ossification of the epoccipital and epijugal bones with the portions of the skull on which they rest. The epijugal bones are especially prominent and rugose, and the sutures uniting them with the jugals are nearly obliterated
>
> The most distinctive character of the skull is seen in the horn cores of the frontal region, which are very large and elongate. On the posterior surface of the upper half of each horn core there is a deep groove, which has suggested the specific name. The horn cores are narrow in front, and in the upper portion become distinctly ridged.
>
> The antero-posterior diameter of the horn cores at the base is about 9 inches, and above, where the groove begins, about $4\frac{1}{2}$ inches.
>
> The caudal vertebræ in this species are unusually short, and the median caudals have a deep longitudinal groove on the bottom of the centra.
>
> This type specimen was found in the Ceratops beds, in Wyoming, by Mr. J. B. Hatcher.

The exact locality at which the type of this species was found is shown at +5, Pl. LI. It consisted of a fragmentary skull with lower jaw, humerus, several vertebræ, and other portions of the skeleton. The lower jaw is in a good state of preservation, but the other portions of the skull are for the most part in a very fragmentary condition. External, internal, and superior views of the left ramus are shown in Pl. VI. These show the animal to have been fully adult. The splenial is firmly coossified with the dentary, and the angular, surangular, and articular are in position. The ramus is massive. The inferior border is nearly straight and the coronoid process rises upward, slopes backward, and curves inward. It is pointed at the apex and is only moderately expanded antero-posteriorly. I am unable to detect the presence of a distinct coronoid bone, this element, if it existed, having become completely fused with the coronoid process of the dentary.

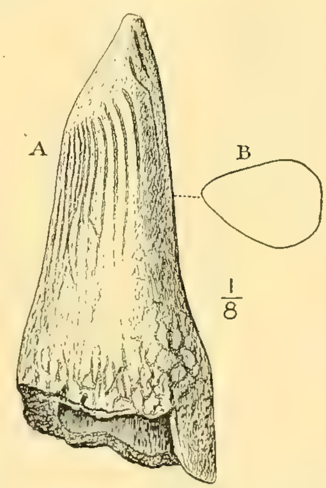

FIG. 112.—Supraorbital horn core of *Triceratops sulcatus* Marsh, type, No. 4276, U. S. National Museum. A, Side view; B, cross section. One-eighth natural size.

Thirty-two foramina enter the dental magazine from the inner side of the ramus. All the teeth in use during the life of the animal have fallen out and are wanting, but the crowns of a number of unused teeth may be seen in the dental chamber. These are of the usual pattern and of moderate size, not nearly so large as in the cotype[a] of *Triceratops elatus* Marsh (No. 4805, U. S. National Museum).

Only one of the supraorbital horn cores is at present accessible, and this does not agree very well with Marsh's statement:

> The most distinctive character of the skull is seen in the horn cores of the frontal region, which are very large and elongate. On the posterior surface of the upper half of each horn core there is a deep groove, which has suggested the specific name.

It seems quite likely that Professor Marsh based his description of the horn cores in the present species on that one of the two supraorbital horn cores pertaining to the type which is at present unavailable and that the two differ materially in size and form, this difference apparently having been due to an injury received by the one now available during the life of the animal. This horn core is very stout, but not elongate. It is truncated above in a peculiar wedge-shaped manner, as though the superior portion had been broken off in life and the injured bone had

[a] See footnote on p. 136. R. S. L.

healed without exhibiting any exostosis or malformation. Its present form does not appear to be due to erosion after entombment. Near its distal extremity the surface is marked by a number of rather deep grooves. The horn is ovate in cross section. The humerus and vertebræ found associated with the skull show no distinctive characters. It is very unfortunate that the opposite of this horn core can not at present be found anywhere among the collections of the U. S. National Museum, since it evidently afforded the principal characters for distinguishing the species. There are in the collections of that museum, however, two other skulls, No. 4286 and Nos. 1203 and 1206–1210, more or less incomplete, that exhibit grooves on the supraorbital horn cores very similar to those mentioned as shown in the type of the present species.

One of these, No. 4286, is shown here in fig. 113, which represents an anterior view of that portion of the skull preserved. In this skull the supraorbital horn cores were large and elongate and bore each a broad and deep groove on the anterior and inner surface, as shown in the figure, instead of on the posterior surface, as was described by Marsh in the type of this species.

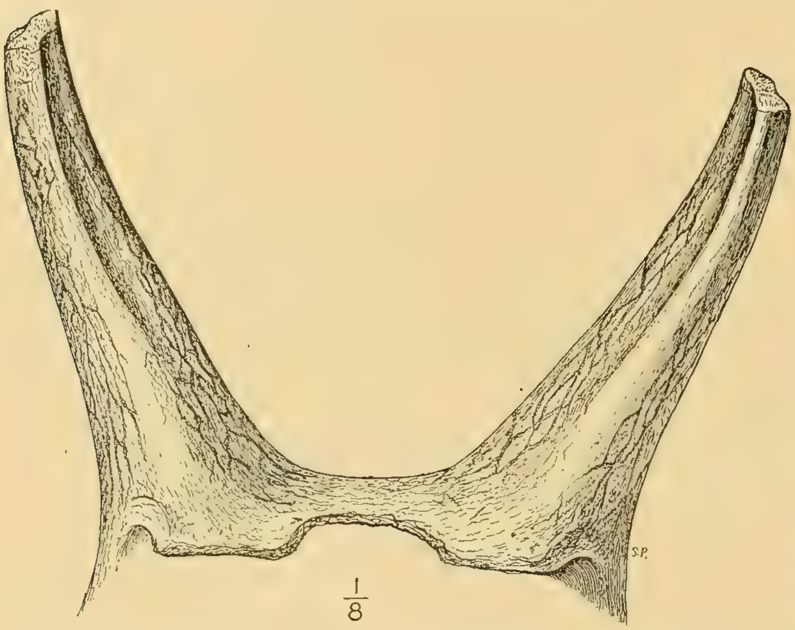

FIG. 113.—Anterior view of frontal region of *Triceratops* skull, No. 4286, U. S. National Museum. Referred to *T. sulcatus* Marsh. One-eighth natural size.

The other skull (Nos. 1203 and 1206–1210) mentioned above is nearly complete, though disarticulated. Posterior and anterior views of the frontal region are shown in Pl. XXXVII. These show the horn cores as marked by long grooves, both on their anterior and posterior surfaces, similar to those described by Marsh as obtaining in the type of the present species on the posterior surfaces of the horn cores.

In view of the fact that as shown above, grooves similar to those described by Marsh as characteristic of the present species may occur at various places on the supraorbital horn cores of the Ceratopsidæ, it does not seem advisable to consider either the presence or the position of such grooves as of specific importance. It is probable that such grooves have, in most instances at least, had their origin in an infolding or thickening of the horny sheath with which in life the horn core was incased, and that their position, form, and depth were determined by the place, nature, and amount of the thickening or infolding of the horny substance. Such being their origin, as appears not improbable, they are likely to appear in any of the various genera and species, and should not be considered as of specific importance.

TRICERATOPS ELATUS Marsh. 1891.

Type (No. 1201, U. S. National Museum) consists of skull, from Laramie of Converse County, Wyo.

Original description in Am. Jour. Sci., vol. 42, September, 1891, p. 265.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

LOCALITY.

The type (No. 1201, U. S. National Museum) of the present species was found by the writer in a loose bed of arenaceous shale on the east side of Lance Creek. It lay on the gently sloping hillside, about a quarter of a mile from the creek and directly opposite the mouth of Lightning Creek. The locality is shown at +16, in Pl. LI. The horizon I should judge to be about the middle of the Laramie series, although owing to the absence of exposures of either the underlying or overlying deposits in this immediate vicinity it is difficult to determine exact horizons with even moderate precision, and this difficulty is augmented by the frequency with which the sandstones and shales of these deposits replace one another, both vertically and laterally, making it extremely difficult to trace any given stratum for any considerable distance. Immediately in front and removed about 8 feet from the skull on the same horizon was the lower jaw shown in fig. 114. This may have belonged to the type, although fragments of another skull were found lying about at the same locality.

ORIGINAL DESCRIPTION.

Professor Marsh's original description of this species was as follows:

One of the largest members of the Ceratopsidæ, representing a distinct species, is at present known from the skull only, which was procured during the past year. Although this skull is about 6½ feet in length, it belonged to an animal scarcely adult, as indicated by some of the cranial sutures. The rostral bone is not coossified with the premaxillaries as in old animals, and the superior branch of the former bone has its extremity free. The nasal horn core, however, is firmly coossified with the nasals. It is of moderate size, with an obtuse summit directed upward. The main horn cores were quite long, with their extremities pointed and directed well forward. These horn cores are compressed transversely, the section being oval in outline.

One of the most striking features of the skull is the parietal crest, which was quite elongate and much elevated, more so than in any of the species hitherto discovered, and this has suggested the specific name.

The length of this skull from the front of the rostral bone to the back of the parietal crest was about 78 inches, and the greatest transverse expanse of the posterior crest was about 40 inches. The summit of one of the frontal horn cores was about 28 inches above the orbit and 53 inches from the base of the quadrate.

This interesting specimen was found in the Ceratops beds of the Laramie in Wyoming by Mr. J. B. Hatcher, of the U. S. Geological Survey, whose previous discoveries are well known.

SPECIFIC FEATURES.

The type consists of a very complete left side of a skull, showing all the more important cranial characters. When found it lay on its left side, and the upper or right side had weathered away.

The anterior portion of the skull and the left half of the middle and posterior regions are exceptionally well preserved, making it possible to determine most of the more important cranial characters, and these are well shown in Pl. XLIII.

The most striking specific characters are to be seen in the nasal and supraorbital horn cores and the jugal, as will appear from comparison of the figures of the type of the present species with those of the other species of Ceratopsia found in the Laramie. The orbit also is exceptionally large, having a vertical diameter of 175 mm. and an antero-posterior diameter of 150 mm. The infratemporal fossa is much elongated antero-posteriorly and is triangular in outline. Its greatest antero-posterior diameter measures 145 mm. and its greatest vertical diameter has a length of 85 mm.

Epoccipitals were borne only on the posterior margins of the parietals and the posterior half of the squamosals. The antero-external border of that portion of squamosal back of the groove for the quadrate is rather sharp edged, regular in outline, and presents neither that series of undulations noticed in several other species of the Ceratopsia nor surfaces for the support of epoccipitals. Each squamosal supported four epoccipitals, and there were six on the parietals, three on either side of the median line. Apparently there was no median epoccipital as in *T. prorsus* and other species.

The *supraorbital horn core* is long and massive and curves strongly forward. Throughout most of its length it is much compressed laterally, but at the extremity it is subcircular in outline.

The *nasal horn core* is very short and stout, rising but little above the superior surface of the nasals and projecting a little in front of the anterior border of the superior processes of the premaxillaries, which formed its chief support. Although in the present specimen the suture between the nasal horn core and the nasals is closed, it is still distinguishable, and the nasal horn core is seen to have originated from a center of ossification distinct both from the nasals and the premaxillaries. In a second specimen belonging to a younger individual, which I shall consider as a cotype,[a] No. 4805, U. S. National Museum, found on the same horizon and only a few feet from the type, the nasal horn core is disarticulated and the sutural surfaces at the base for contact with the premaxillaries and nasals are very distinct. The form and characters of this nasal horn core are well shown in fig. 115.

The *jugal* is especially characteristic in the present species. The inferior process, instead of descending vertically beneath the orbit as in most other species of the Ceratopsia, is directed downward and backward at an angle of about 45°, and the distal end is produced far back of the posterior border of the orbit. The posterior border of the inferior process of the jugal is regularly but gently convex, the anterior concave.

The external surface of the maxillary is very rugose and the bone in this region appears to have been diseased. It is not possible to trace with accuracy the suture between the maxillary and the jugal.

On the parietal crest, just posterior to the supratemporal fontanelle, the squamosal presents two indentations, which may perhaps be interpreted as malformations resulting from injuries. One of these, the anterior, is very pronounced, the bone being completely perforated. I am inclined to consider this as due to some injury received during the life of the animal rather than as a persistent structural character of specific importance.

Principal measurements of the type.

	Mm.
Greatest length of skull	1,934
Distance from posterior border of orbit to posterior extremity of squamosal	963
Distance from anterior border of orbit to extremity of nasal horn core	520
Distance from anterior border of orbit to extremity of rostral	833
Distance from extremity of rostral to extremity of quadrate	1,025
Height of extremity of supraorbital horn core above inferior margin of maxillary	1,154
Distance in straight line from apex of supraorbital horn core to superior border of orbit	740
Length of supraorbital horn core measured along posterior surface	940
Length of supraorbital horn core measured along anterior surface	690
Antero-posterior diameter of supraorbital horn core at base	310
Transverse diameter of supraorbital horn core at base, somewhat reduced by crushing	150
Greatest circumference of supraorbital horn core at base	840
Circumference of supraorbital horn core at middle	380
Circumference of supraorbital horn core at apex	128
Thickness of postfrontal back of orbit	220
Greatest length of squamosal	950
Greatest expanse of squamosals, estimated	1,000
Greatest expanse of jugals, estimated	500
Diameter of occipital condyle	106

DESCRIPTION OF COTYPE [PLESIOTYPE].

On the same horizon, and at a distance of about 10 feet from the type of the present species, remains of a second skeleton were found, which I shall consider as the cotype [plesiotype] of the present species, although it possesses some characters which might be considered as of specific importance. The remains of this second specimen consist of a right dentary with the surangular and coronoid, a portion of the left surangular, the occipital condyle, nasal horn core, an imperfect pterygoid, several epoccipitals, and some other portions of the skull and skeleton not now accessible.

[a] More properly a plesiotype. This is a term defined by Schuchert and Buckman (Science, n. s., vol. 21, June 9, 1905, p. 900) as follows: "*Plesiotype.* Any specimen identified with an already described and named species, but not selected by the nomenclator himself." The word is further defined (p. 899) as referring to "material upon which supplementary descriptions of species are based."—R. S. L.

The specimen under consideration furnishes the first example of a free coronoid yet observed in the Ceratopsia, although this element is doubtless present in all the other genera and species of the group, usually, however, being so completely fused with the coronoid process of the dentary as to appear a portion of that element, more especially in old individuals. Its general form and position relative to the surangular and the coronoid process of the dentary are well shown in fig. 114. It is triangular in outline, terminating below in a sharp, spout-like process which clasps about the posterior border of the base of the coronoid process. Its anterior border is produced into a sharp edge, which overlaps the inner surface of the coronoid process; the superior and posterior borders are thick and strong.

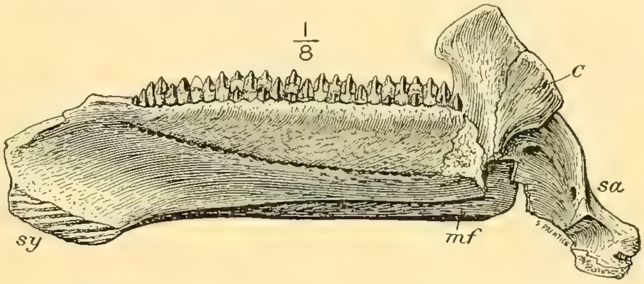

FIG. 114.—Internal view of right mandible (No. 4805, U. S. National Museum) of *Triceratops elatus*, cotype [plesiotype]. *C*, Coronoid; *sa*, surangular; *mf*, mandibular fossa; *sy*, symphysis. One-eighth natural size.

As in other members of the Ceratopsia, the posterior border of the coronoid process presents a deep vertical groove for the reception of the anterior extremity of the surangular. The mandibular fossa is deep, and at its anterior extremity a large foramen enters the dental chamber. There appear to have been four teeth in place in each vertical series, so that the number of longitudinal series of teeth in the jaw would be eight.

The surangular is not entirely complete. It is rather elongate, and is heavier than in *Triceratops prorsus*. Near its anterior extremity it is pierced by a large external mandibular foramen. On its inner side, just in advance of the projection in front of the articular, there is the opening of a large foramen. A short distance beneath the surface this foramen branches; one branch, the anterior, runs forward and opens on the external surface of the bone at a point midway between the internal openings of this foramen and that of the anterior external mandibular foramen mentioned above. The other or posterior branch of this foramen has its external opening on the posterior border of the surangular near the external border. Near the inferior border of the external surface of the bone there are two foramina opening near together, and it is probable that these also connect with the large foramen already mentioned as opening on the inner surface of the bone.

As shown in fig. 115, the nasal horn core is of peculiar form, and was derived from a center of ossification distinct from either the nasals or premaxillaries. It is short and stout, somewhat

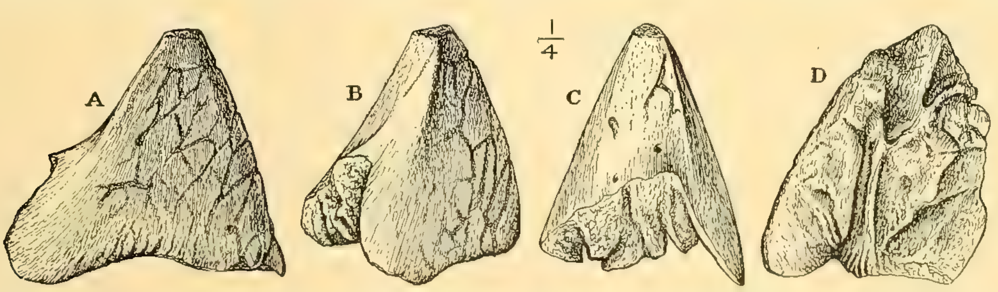

FIG. 115.—Nasal horn core of *Triceratops elatus*, cotype [plesiotype], No. 4805, U. S. National Museum. A, Right side view; B, oblique back view; C, posterior view; D, sutural surface for contact with nasals. One-fourth natural size.

compressed laterally, and shows distinct sutural surfaces for contact with the nasals and premaxillaries. Posteriorly on either side it sends downward and backward a thin blade of bone which clasps over the anterior extremities of the nasals. The posterior surface of the nasal horn core is rather smooth and slightly excavated, the anterior is convex, very rugose, and presents a number of deep vascular grooves, one of which runs continuously from the apex to the base of the horn core. The character of this nasal horn core differs somewhat from that of the type of the species, though at the same time presenting certain similarities not seen in the same element in most other species. It appears to be intermediate in character between that of the type of the present species and the nasal horn core of the type of *Triceratops calicornis*, a nearly related if not identical species.

Measurements of the cotype [*plesiotype*].

	Mm.
Length of dentary from base of coronoid to predentary	560
Greatest depth of dentary	180
Greatest length of surangular	213
Greatest antero-posterior diameter of coronoid	70
Antero-posterior diameter of nasal horn core at base	145
Transverse diameter of nasal horn core at base	110
Length of nasal horn core	140
Diameter of occipital condyle	99

Triceratops calicornis Marsh. 1898

Type (No. 4928, U. S. National Museum) consists of skull and portion of skeleton from Laramie beds of Converse County, Wyo.

Original description in Am. Jour. Sci., 4th ser., vol. 6, July, 1898, p. 92.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 271.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

Walcott, C. D., Science, new ser., vol. 11, 1900, p. 23 (*T. californis*).

LOCALITY.

The type (No. 4928, U. S. National Museum) of this species was found by the writer about 1 mile nearly due south of the locality which yielded the skeleton (No. 4842, U. S. National Museum) referred by Marsh to *T. prorsus*. The location is shown in Pl. LI at +29. When found, the skull lay embedded with a considerable portion of the skeleton in a stratum of rather hard sandstone, from which the frill, as well as a considerable number of the bones of the skeleton, protruded, and had already suffered much from weathering. On the whole, however, it is fairly complete, and it is possible to determine many of the most important of the cranial and other skeletal features of this supposedly new species from the type specimen alone.

ORIGINAL DESCRIPTION.

Professor Marsh's original description of this species was as follows:

One of these, which may be called *Triceratops calicornis*, is of special importance, as not only the skull, but the greater part of the skeleton of the animal, is in good preservation, forming one of the most instructive specimens now known of this group of extinct reptiles. The skull, as a whole, shows the well-marked features of the genus *Triceratops*. A specific character is seen in the nasal horn core, which is in perfect preservation. It is directed well forward, and, unlike any hitherto described, is concave above, which fact has suggested the specific name. The upper or posterior surface of this horn core somewhat resembles the bottom of a horse's hoof.

Some of the principal dimensions of this skull are as follows: Length from front of beak to back of parietal crest, about 6 feet 5 inches; from front of beak to end of occipital condyle, 3 feet 5 inches; distance from occipital condyle to back of parietal crest, 4 feet; from front of beak to point of nasal horn core, 23 inches; height of postfrontal horn core, 29½ inches, and antero-posterior diameter of same horn core at base, 12 inches.

The type (No. 4928, U. S. National Museum) of the present species consists of a skull with lower jaw, eleven dorsal vertebræ, several ribs, a considerable portion of the pelvis and sacrum, and other portions of the skeleton. The material constituting the type has been very much neglected since its arrival at the U. S. National Museum, and some of it is no longer available. Of the lower jaw, only the predentary and a small portion of the anterior part of the left dentary remain, while a considerable portion of the frill of the skull has been lost.

DESCRIPTION OF TYPE.

The skull.—The skull pertaining to the type of the present species is very similar to that which forms the type of *T. elatus* (No. 1201, U. S. National Museum). Most of the characters seen in that skull which might be considered of specific importance are shown also in the type of the present species, though somewhat more emphasized. This is especially true of the nasal horn, which, as will appear from a reference to Marsh's original description quoted above, furnished the chief specific distinction. The jugal differs from that in the type of *T. elatus* in that it falls directly below the orbit instead of being directed strongly backward as in the last-mentioned species. It is more than probable, however, that this is due to the different manner in which the two have been affected by pressure.

In the type of the present species the skull is large, with elongate supraorbital horn cores curved strongly forward. The orbits are large and elliptical, with the longer diameter inclined slightly backward from the vertical. The nasal horn core is low and rises almost directly upward. It is pointed above, convex in front, and concave behind, where it is overlapped by an anterior prolongation of the nasals, with a convex and rugose superior surface which may be considered as having formed part of the nasal horn core. The nasal horn core proper is supported in part by the nasals and in part by the premaxillaries, but is an ossification distinct from either.

The premaxillaries are very long and deep, but do not differ materially in form from those of other members of the group. The rostral shows no peculiar characters, but the sutures between it and the premaxillaries are open, indicating that the animal was young. The squamosal is broad and elongate. At present only a small portion of the parietal is intact, though more than half of it was originally preserved. The epoccipitals were not coossified with the squamosals and parietals. The principal characters are well shown in Pls. XXXVIII and XXXIX.

The lower jaw.—When discovered the lower jaw was complete and in an excellent state of preservation. Among the material in the National Museum I have been able to discover only the predentary, with the anterior extremity of the left dentary. The latter shows a freshly fractured surface, and it is more than probable that the remainder of this element at least is buried somewhere among the Museum collections.

The vertebral column.—The dorsal series is complete save for the eighth, ninth, and tenth dorsals, which are wanting. The only marked character in the dorsals in the present species is to be seen in the three posterior dorsals, where the neural spines are much broader and thinner than in the same vertebræ in *T. prorsus* or *T. brevicornus*. The centra of the anterior dorsals are short and nearly circular in outline, while farther back in the series the centra become longer and the vertical diameter considerably exceeds the transverse. (See Pl. XL, figs. 2 and 3.)

There are preserved portions of the cervicals and caudals, but they are not accessible. The greater portion of the sacrum is present also, but this has not yet been prepared for study.

The pelvis.—An ilium and pubis are nearly complete, but in the present state of preparation show no special characters, save that the postpubis is rather better developed than in other species.

Principal measurements of type.

	Mm.
Distance from anterior end of rostral to posterior end of squamosal	2,180
Distance from anterior end of rostral to anterior border of orbit	1,010
Distance from anterior end of nasal horn core to anterior border of orbit	635
Distance from anterior end of rostral to postfrontal foramen	1,375
Distance from inferior border of orbit to lower end of jugal	430
Distance from superior border of orbit to apex of supraorbital horn core	780
Distance between orbits	440
Longest diameter of orbit	185
Shortest diameter of orbit	125
Distance from posterior border of orbit to posterior surface of supraorbital horn core	262
Circumference of supraorbital horn core at base	960
Circumference of supraorbital horn core 300 mm. above orbit	450
Antero-posterior diameter of supraorbital horn core at base	370
Transverse diameter of supraorbital horn core at base	175
Transverse diameter of nasal horn core at base	110
Altitude of nasal horn core	110
Distance from posterior border of nasal opening to extremity of beak	605

TRICERATOPS OBTUSUS Marsh. 1898.

Type (No. 4720, U. S. National Museum) consists of portion of skull from Laramie beds of Converse County, Wyo.

Original description in Am. Jour. Sci., vol. 6, July, 1898, p. 92.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 271.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

Walcott, C. D., Science, new ser., vol. 11, 1900, p. 23 (*T. obtusa*).

Professor Marsh described this species as follows:

A second new species, which may be called *Triceratops obtusus*, is represented by a large skull belonging to the same genus. The nasal horn core of this skull is very short and obtuse and so well preserved that it indicates the normal form and size. The entire length of this horn core is only 1 inch. Its summit is 3½ inches behind the premaxillary suture. The width of the nasals beneath the horn core is 5½ inches. The length of the squamosal from the quadrate groove to the posterior end is about 36 inches and its greatest width is 19 inches.

These two skulls (types of *T. calicornis* and *T. obtusus*) were both found by J. B. Hatcher in the Ceratops beds of Converse County, Wyo.

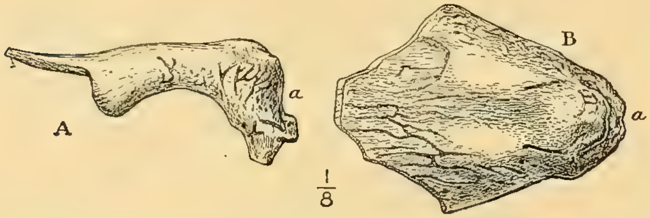

FIG. 116.—Anterior portion of nasals of type of *Triceratops obtusus* Marsh (No. 4720, U. S. National Museum). A, Side view; B, superior view; *a*, anterior. One-eighth natural size.

The type (No. 4720, U. S. National Museum) of the present species consists of a pair of mandibular dentaries and the anterior portion of the nasals, a left maxillary, a squamosal, parts of a pterygoid, and a vertebra. The specific name was suggested by the character of the nasal horn core. The nasals, as shown in the accompanying figures, are extremely broad, and the nasal horn core is reduced to a broad, rounded, and rugose prominence, marked with a number of deep vascular grooves.

The dentary is exceptionally deep and the teeth are unusually large. Below the base of the coronoid process on either dentary the external surface of the bone presents a very sharp ridge that extends continuously throughout about one-third of its length. The posterior portion of the alveolar region of the left dentary bears evidence of having been affected by disease and presents extensive malformations. The mandibular fossa extends rather farther forward than is common in other species of the Ceratopsia. The dentary is exceptionally massive and the teeth are very large. There are a number of foramina on the external surface of the dentary, as shown in the accompanying figure.

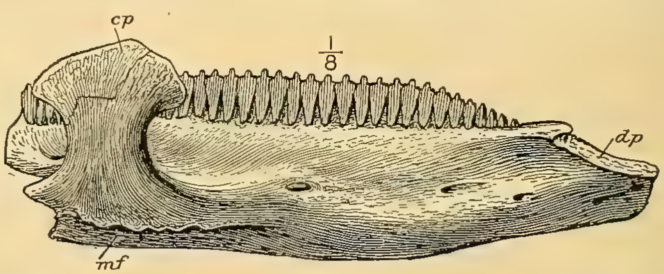

FIG. 117.—External view of right dentary of type of *Triceratops obtusus* Marsh, No. 4720, U. S. National Museum. *cp*, Coronoid process; *dp*, face for articulation with the predentary; *mf*, mandibular fossa. One-eighth natural size.

Notwithstanding the scanty and fragmentary material upon which the present species is based, it would seem to be a valid one, as indicated alike by the characters of the dentary, the teeth, the nasal horn core, and that part of the nasals still preserved.

The type of the present species was found in Converse County, Wyo., about 1 mile east of Lance Creek and 2 miles southeast of the U–L ranch. The horizon would be about the middle of the Laramie, as those deposits are represented in this region. The locality is shown at + 9, Pl. LI.

Principal measurements of the type.

	Mm.
Greatest length of dentary	670
Greatest depth of dentary	228
Length of dental series	535
Breadth of nasals at base of horn core	140
Distance from top of nasal horn core to inferior surface of nasals	75

I have been unable to find in the collections of the U. S. National Museum the squamosal mentioned by Marsh as pertaining to the type, and hence can say nothing concerning the form of this important element. The other portions of the skeleton preserved show no peculiarities worthy of note.

Triceratops brevicornus Hatcher.

Type (No. 1834, Yale Museum) from Laramie of Converse County, Wyo.

Original description in Am. Jour. Sci., 4th ser., vol. 20, p. 413.

Char. specif.—Supraorbital horn cores short and stout, not much compressed, nearly circular in cross section. Nasal horn core short and stout with the anterior border perpendicular instead of being directed upward and forward at an angle of 30°. Vertical and longitudinal diameters of lateral temporal foramen nearly equal. Orbit irregularly elliptical in outline with the longer axis running from above downward and forward. Postfrontal fontanelle open, even in old individuals.

The type (No. 1834, Yale Museum) of the present species consists of a nearly perfect skull with lower jaw and a complete series of presacral vertebræ, together with a number of ribs more or less complete, and portions of the pelvis, including a portion of the right ilium and a nearly complete pubis.

LOCALITY AND HORIZON.

The skeleton was discovered by Mr. W. H. Utterback, and the exact locality was about 3 miles above the mouth of Lightning Creek and about 1½ miles south of that stream, in Converse County, Wyoming. The locality is indicated by +22, in Pl. LI. The horizon was near the summit of the Laramie, and the specimen was collected by the present writer assisted by Messrs. W. H. Utterback, A. L. Sullins, and T. A. Bostwick. When discovered the skeleton lay embedded in a hard sandstone concretion and was much shattered and weathered about the pelvic region. The vertebral series lay in position with the vertebræ interlocked by their zygapophyses from the axis to the last dorsal, though portions of some of the vertebræ had weathered away when found. Behind the posterior dorsal, impressions of the centra of the first two sacrals were preserved in the hard sandstone in which the skeleton was embedded. None of the limb bones and no part of the tail were recovered.

DESCRIPTION OF TYPE.

THE SKULL.

The extremely rugose nature of the skull, together with the closed condition of the sutures, many of which are almost or entirely obliterated, make it certain that the type of the present species pertained to an old individual.

The cranium.—The chief distinctive features of the cranium are as follows: The supraorbital horn cores are unusually short and stout, especially at the base. They are less compressed and more nearly circular in cross section than in most other species. The nasal horn is short and very stout, the antero-posterior diameter much exceeding the transverse. Its anterior border is directed upward in a line perpendicular with the longer axis of the skull instead of forward and upward at an angle of about 30° to that axis as in the type of *T. prorsus.* The lachrymal foramen, as in *T. serratus,* lies between the maxillary and the nasal, but in the present species its anterior half is entirely inclosed by the maxillary, that bone sending upward a short process alongside the premaxillary process and forming the anterior one-half of the superior border of the foramen. The orbit is elliptical in outline, the longer diameter being inclined backward from the perpendicular at an angle of about 10°. The lateral temporal fossa is triangular in outline, its respective borders describing nearly an equilateral triangle, the fore-and-aft diameter only slightly exceeding the vertical. The rostral bone is heavy and very deeply excavated beneath. The epijugal is rather acutely pointed and regularly triangular in cross section. The infratemporal arch, as in *T. serratus,* is formed by the quadrate with overlapping processes from the jugal and squamosal, that from the latter element occupying a slightly more elevated position in the type of the present species than in that of *T. serratus.* The exoccipital process extends distally beyond the quadrate and projects as a small angular process. There are six epoccipitals, borne wholly on the squamosal, and at least three more between the last of these and the single median one situated at the median parietal region. Though the frill is not sufficiently perfect in this region to determine the number of epoccipitals with accuracy, there can not be fewer than nineteen. The postfrontal fontanelle is large and circular in outline. The median longitudinal crest of the parietals is well defined and bears the usual rugosities. Near the apex the right horn core has been worn into a peculiar form by the long-continued action of wind, sand, and water while it protruded from the sandstone concretion in which it was found. The palatal view shows no characters essentially different from those of other species of this genus. In the region of the supraoccipitals and parietals the sutures are so obliterated by age and obscured by distortion and crushing that it is quite impossible to determine their nature.

The lower jaw.—The lower jaws with the predentary were in position and in a splendid state of preservation. The predentary is rather longer than is common. On the superior surface of the mandibular fossa near the anterior end two large foramina pierce the wall and pass upward toward the dental chamber. The splenial is very broad posteriorly and entirely incloses the mandibular fossa, except at the opening of the internal mandibular foramen. The coronoid process is low and stout, and superiorly it is produced forward into a broad and somewhat decurved projection. At its greatest expansion the superior border of the splenial covers over for a short distance the series of dental foramina on the inner side of the dentary. The principal characters of the skull are well shown in Pls. XLI and XLII.

THE VERTEBRÆ.

The vertebræ have been fully described in that portion of the present volume relating to the osteology of the genus *Triceratops* (pp. 46–51). Their more important characters are well shown in Pl. XL, fig. 1.

Principal measurements of type of T. brevicornus (No. 1834, Yale Museum).

	Mm.
Greatest length of skull	1, 652
Greatest breadth of frill	1, 120
Expanse of jugal	600
Expanse of frontal region at anterior border of orbits	357
Greatest diameter of orbit	168
Least diameter of orbit	120
Fore-and-aft diameter of lateral temporal fossa	105
Vertical diameter of lateral temporal fossa	85
Distance from posterior border of orbit to posterior border of frill	840
Thickness of postfrontal behind orbit	130
Least antero-posterior diameter of horn core immediately above orbit	175
Antero-posterior diameter of horn core 6 inches above orbit	117
Transverse diameter of horn core immediately above orbit	140
Transverse diameter of horn core 6 inches above orbit	97
Greatest length of squamosal	870
Greatest breadth of squamosal	433
Length of parietals along median line	712
Distance between squamosal sutures at posterior border of frill	874
Distance between squamosal sutures at junction with postfrontals	330
Distance from anterior border of orbit to posterior border of nasal opening	228
Distance between orbit and lateral temporal foramen	142
Distance between lateral and supratemporal foramina	285
Distance from lateral temporal foramen to posterior border of squamosal	705
Distance from occipital condyle to posterior margin of crest	650
Distance from occipital condyle to interior border of rostral	975
Distance from posterior border of anterior nares to anterior border of rostral	525
Distance from postfrontal foramen to extremity of nasal horn	750
Greatest expanse of exoccipital processes	550
Distance from inferior border of orbit to bottom of jugal	343
Diameter of occipital condyle	88
Distance from mid-frontal region to apex of supraorbital horn	500
Length of splenial	503
Length of predentary	255
Greatest breadth of predentary	142
Combined length of dentary and predentary	681
Combined length of dentary and articular	620
Total length of presacral vertebral series	2, 290
Total length of dorsal series	1, 490

STERRHOLOPHUS Marsh. 1891.

Type species, *S. flabellatus*.

Original description in Am. Jour. Sci., 3d ser., vol. 41, April, 1891, p. 340.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 43, Jan., 1892, pp. 83 and 84; vol. 50, Dec., 1895, p. 497; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, pp. 216–217, 243.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, pp. 20, 21.

Woodward, A. S., Outlines Vert. Pal., pp. 213, 216.

Zittel, K. A. von, Text-Book Pal., transl. by C. R. Eastman, vol. 2, p. 245.

In publishing his restoration of *Triceratops* in the American Journal of Science of April, 1891, Marsh proposed the new genus *Sterrholophus*. He based this genus on the skull of a young individual which he had previously (Am. Jour. Sci., 4th ser., vol. 8, Aug., 1899, p. 174) made the type of a new species of *Triceratops* (*T. flabellatus*). This now became the type of the genus *Sterrholophus*. The following paragraph by Marsh relating to the generic distinctions between the genera *Triceratops*, *Ceratops*, and *Sterrholophus* is worth quoting in this connection. He says:

> This restoration gives a correct idea of the general proportions of the entire skeleton in the genus *Triceratops*. The size in life would be about 25 feet in length and 10 feet in height. The genus *Ceratops* so far as at present known is represented by individuals of smaller size and, in some instances, at least, of quite different proportions. A third genus, which may be called *Sterrholophus*, can be readily distinguished from the other two by the parietal crest, which had its entire posterior surface covered with the ligaments and muscles supporting the head. In *Ceratops* and *Triceratops* a wide margin of this surface was free and protected by a thick, horny covering.

In writing the above lines Professor Marsh appears to have forgotten that the parietal crest of *Ceratops* was quite unknown, and that therefore it was uncertain as to whether in that genus the parietal crest was free and protected by a horny covering or covered over with ligaments and muscles. Another point which does not seem to have been sufficiently considered by Marsh in establishing this genus is the immature nature of the skull upon which it is based. Considering the youth of the individual it does not appear at all improbable that if the parietal crest had been free, as in *Triceratops*, it would have shown those rugosities and other features so prominent on the surface of these bones in the skulls of older and more mature individuals. Then, again, if these characters are present in some and absent in other skulls of adult animals should they be considered as of generic or even specific importance or as sexual characters? These questions will be discussed more in detail in the revision of the genera and species.

Sterrholophus flabellatus Marsh. 1889.

Type (No. 1821, Yale Museum) consists of a nearly complete but disarticulated skull associated with several vertebræ, a few limb bones, etc.

Original description of type in Am. Jour. Sci., 3d ser., vol. 38, Aug., 1889, p. 174, where it is referred to *Triceratops*. Made the type of the genus *Sterrholophus* in Am. Jour. Sci., 3d ser., vol. 41, April, 1891, p. 340.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 43, Jan., 1892, p. 84; Mon. U. S. Geol. Survey, vol. 27, 1897, p. 511.

Nopcsa, F. Baron, Földtani Közlöny, Budapest, 1901, vol. 31, p. 270.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, 1902, p. 14.

Woodward, A. S., Outlines Vert. Pal., p. 215.

Zittel, K. A. von, Text-Book Pal., transl. by C. R. Eastman, vol. 2, p. 245.

ORIGINAL DESCRIPTION.

Professor Marsh's original description of this species was as follows:

> Triceratops flabellatus, sp. nov.
>
> A second specimen of still greater dimensions has since been found at another locality of the same formation by Mr. J. B. Hatcher. The skull, lower jaws, and a considerable portion of the skeleton were found together. A striking peculiarity of this skull is the occipital crest, which extends upward and backward, like an open fan. Its margin was armed with a row of horny spikes, supported by separate ossifications, some of which were found in position.
>
> The skull as it lay in the rock measured more than 6 feet in length, 4 feet in width, and the horn cores about 3 feet in height. These dimensions far surpass any of the Dinosauria hitherto known, and indicate to some extent the wonderful development these reptiles attained before their extinction at the close of the Cretaceous.

As already noted, two years later Marsh removed this species from the genus *Triceratops* and made it the type of the new genus *Sterrholophus*.

LOCALITY AND HORIZON.

The type (No. 1821, Yale Museum) of the present genus and species was found by me at the locality marked +2 on Pl. LI. It lay in a bed of arenaceous shale, at the summit and at the extreme western point of a high and rocky ridge about half a mile in length, running westward from the main divide between Buck Creek and Lance Creek. At the same locality I procured a considerable number of teeth of small Laramie mammals and other fossils, both vertebrates and invertebrates, while at a distance of about 1 mile directly south, on the summit of a high ridge and on the opposite side of a deep canyon emptying westward into Lance Creek, at the point marked ⧫ 1, Pl. LI, and at about the same horizon, is the locality at which I first discovered Laramie mammals.

This particular mammal quarry has proved to be better than any since discovered, it alone having yielded several thousand isolated teeth and jaws of these diminutive mammals. Indeed, it seems almost inexhaustible, for on several occasions on which I have visited it in succeeding and recent years I have always been rewarded by the discovery of a considerable number of the teeth, jaws, and other remains of these animals. Usually these mammal teeth have been abundant in ant hills, built by two or three colonies of ants planted at this locality by me. In excavating their burrows and in collecting material from and beneath the surface these tiny but industrious creatures bring together great numbers of small stones with which to build the small hemispherical hillocks from 1 to 2 feet in diameter in and beneath which they construct their subterranean chambers. Anywhere in this region at a favorable locality among this aggregation of pebbles there will always be found a considerable number of small fossil teeth and jaws, fish scales, small vertebræ, etc. Indeed, not only do I personally, but paleontologists generally, owe a debt of no inconsiderable gratitude to the aid given by the little creatures in making known the wealth of small mammals and other diminutive vertebrates that inhabited this region in Laramie times.

The horizon of the type of *Sterrholophus flabellatus* was perhaps somewhat above that of any of the other members of the Ceratopsidæ yet mentioned from this region, unless it be that of *Triceratops sulcatus*.

The type consisted of a nearly complete but disarticulated skull of a young individual. Perhaps no other skull in all the Ceratopsia material yet discovered affords better evidence as to the form and nature of the different elements. These will, therefore, be described and figured in detail.

The type (No. 1821, Yale Museum) of the present genus and species consists of the skull and a considerable portion of the skeleton of a young individual. The more important of the associated parts were the skull, with lower jaw, femur, ilium, and ischium, portions of the scapulæ, ribs, a few imperfect vertebræ, and a single ungual phalanx.

When discovered the skull lay on its left side in a bed of loose sandy marl. The right or uppermost side of the frill and the right horn core were completely weathered away, while the left squamosal and parietal, together with the left horn core and the entire cranial region and the left maxillary with palatine attached, lay in position and in an excellent state of preservation, save the horn core and a portion of the maxillary, which were extremely rotten and had to be treated with a hardening solution. The right maxillary with palatine, both premaxillaries, nasals, pterygoids, quadrates, and quadratojugals, and in fact the whole anterior portion of the skull, were detached and lay scattered about in the bed of soft sandy marl. Fortunately they were all in a nearly perfect state of preservation. The left jugal was in position, the right was detached. The disarticulated condition in which the different cranial elements were found is proof of the immature age of the animal, and at the same time affords an excellent opportunity for determining the form and relations of the various elements of the skull.

CHARACTERS OF SKULL.

The *squamosals* (Pls. XLIV, XLV, and figs. 6, 10, 11, 15).—These are rather broad and short for one of the larger members of the Ceratopsia. As pointed out by Marsh, both the superior and inferior surfaces of these bones, as well as the parietals, are smooth and entirely destitute of those rugosities and channels present on these elements in other skulls of the Ceratopsia. Marsh has considered this character in the present specimen as alone of generic importance, but to the present writer it appears to be more probably due to the immature age of the individual, while it is quite conceivable that sex may also have had something to do with it. The external border of the squamosal describes the arc of a rather large circle. The parietal border is very thick and concave fore and aft. Behind the buttress for the exoccipital process the squamosal sends forward and upward a broad thin plate for articulation with the postfrontal and jugal, while the lowermost of the three anterior processes shown in fig. 10 overlaps the quadrate and to a small extent the quadratojugal. The antero-inferior border of the squamosal falls far below the quadrate and forms the posterior border of the quadratojugal notch. The antero-inferior angle describes the arc of a rather small circle, and its inferior surface is strongly convex, while the superior is concave. The inferior surface is broadly concave anteriorly.

The *parietals* (figs. 10 and 11).—Only the left parietal and a very small portion of the anterior part of the right is preserved and since no very distinct suture is shown between these elements, notwithstanding the immature age of the specimen, it would appear that the parietals, if ever distinct, must have become completely fused very early in life. On account, however, of the fractured condition of the bone in the region where the suture should appear if actually present, it is not possible to determine definitely whether or not there be a suture. The parietals are proportionally broad behind and narrow in front, but aside from the absence of rugosities and that system of grooves and channels on the surfaces of the bone, already referred to, they do not differ materially from those elements in the genus *Triceratops*.

The *postfrontals* (Pls. XLIV, XLV, XLVI, figs. 6, 10, 11).—The postfrontals are, as usual in the Ceratopsia, the most massive elements in this region of the skull. In Pl. XLIV, prepared under the direction of Professor Marsh, they are figured as extending a little too far backward and as being destitute of a postfrontal (pineal) foramen. A careful examination of the specimen shows this foramen to have been present, the left lateral border of it still being preserved. Posteriorly the postfrontals are in contact with the parietals and squamosals, laterally with the squamosals and jugals, medially they oppose one another, anteriorly they appear on the external surface of the skull as articulating with the frontals and prefrontals, while below they send forward a long wedge-shaped mass which passes beneath the frontals and overlaps the alisphenoids, forming a small portion of the roof of the exit for the olfactory nerve, as shown in fig. 9.

Below, the postfrontals are supported from behind by the supraoccipitals, parietals, and squamosals, and in front by the alisphenoids. Posteriorly they are invaded by a number of large chambers which are more or less completely connected with one another and with the very large cavities at the bases of the horn cores. Some of these chambers connect with the postfrontal (pineal) foramen, and perhaps also with the supratemporal foramina. The postfrontals form the posterior one-half of the orbital borders and give origin to the powerful supraorbital horn cores, which in the present specimen are rather long and slender, nearly circular in cross section distally and ovate proximally where the fore-and-aft diameter is the longer and the posterior surface describes the broader end of the figure.

As it lay embedded in the sandy matrix the left horn core, which was the only one of the two preserved, was incased in a soft, light-colored, decomposed mass of fibrous material about one-quarter of an inch thick, which doubtless represented the disintegrated horny sheath with which in life the horn core was covered.

The *frontals* were small and closely applied to each other. They are somewhat injured and it is not possible to determine with accuracy their true form. They are seen, however, to have overlapped the postfrontals behind and the nasals in front.

The *prefrontals* form the antero-superior borders of the orbits and give support to the supraorbital horn cores from in front. Anteriorly they overlap the nasals, and laterally they are in contact with the frontals on the inner side and with the lachrymals on the outer side.

The *lachrymals* form the anterior borders of the orbits below the prefrontals. They articulate below with the jugals and in front with the nasals and the ascending branches of the maxillaries, forming the posterior borders of the lachrymal foramina.

The *jugal* is a rather large triradiate bone. Above, it forms the inferior border of the orbit and articulates in front with the lachrymal and maxillary and behind with the postfrontal and squamosal. Together with the last-mentioned element it forms the superior, anterior, posterior, and nearly one-half of the inferior borders of the lateral-temporal foramen. Inferiorly the jugal presents a broad, flat, dependent process, which is closely applied to the quadratojugal, entering into the construction of the quadratojugal arch and aiding in furnishing that support to the quadrate necessary for the suspension and articulation of the powerful lower jaw. On its external surface at its lower extremity the jugal bore a small conical epijugal, triangular in cross section. This latter element is free in the present specimen, but in the skulls of older individuals it is firmly coossified with the jugal.

The *quadratojugal arch,* as shown in Pl. XLIV, is formed by the jugal, quadratojugal, quadrate, and a small anterior projection from the squamosal. The element most important in its construction is the quadrate, the inferior and anterior end of which is much expanded transversely to form the articulate surface for the lower jaw. From this the quadrate passes upward and backward as a strong shaft of bone expanding posteriorly into a broad, thick blade which articulates with a strong buttress on the lower side of the squamosal and receives into a deep pocket on its inner side the inferior angle of the pterygoid. Externally the quadrate is overlapped posteriorly throughout about one-half of its length by the squamosal, and anteriorly by the quadratojugal, which sends backward a slender process that passes beneath and is overlapped by the anterior projection from the squamosal. The quadratojugal is an irregularly triangular-shaped bone, thick below and thin above, wedged in between the jugal and quadrate in such manner that only its posterior portion is seen when in position. The form and principal characters of the quadrate and quadratojugal are well shown in figs. 17 and 18.

The nasals.—These are rather massive bones closely applied to one another along the median line, though not coossified. They form the superior and lateral walls of the nasal passage, and are articulated posteriorly with the frontals, prefrontals, and lachrymals. Inferiorly and laterally the nasal articulates with the maxillary and sends forward and downward a long process which meets and overlaps an ascending process from the premaxillary, which latter is wedged in between the maxillary and the nasal. Anteriorly the nasals each send downward a short process. These diverge and receive between them the anterior ascending branches of the premaxillaries. Anteriorly and superiorly the nasals support the single median nasal horn, which is wanting in the present specimen, and which doubtless had its origin in a center of ossification distinct from the nasals, since in a number of instances the nasal horn cores seem to have had only a sutural connection with the nasals. The nasals form the superior border of the external nasal opening, and when seen from the side this border describes a nearly perfect semicircle. The form and characters of the nasals are well shown in fig. 19.

The maxillaries.—The maxillaries in the present species apparently differ from those of some species of *Triceratops* in having the lachrymal foramen placed some distance below the naso-maxillary suture. In front the maxillary articulates with the premaxillary and to a limited extent also with the descending process of the nasal. Posteriorly and externally it articulates with the lachrymal and jugal and internally with the palatine and pterygoid. The alveolar border is continuous throughout nearly the entire length of the inferior border of the bone; on its inner side about 2 inches above the alveolar border there is a series of dental foramina through which passed those blood vessels by which the teeth were nourished during their formation and growth in the dental magazine.[a] The number of these foramina equals that of the

[a] See p. 26.

number of vertical series of teeth in each jaw. The form and characters of the maxillaries are well shown in fig. 22.

The premaxillaries.—The principal characters of the premaxillaries are well shown in fig. 28. They had a widely extended contact with each other and together they formed an imperfect anterior median septum. Anteriorly and superiorly they each send upward a strong pillar, which is inclosed by and gives support to the distal extremity of the nasal, with which it is united by suture only. Below the nasals on the anterior margin of the premaxillaries there is an extended articular surface for contact with the rostral, and this is continued backward on the inferior border of the premaxillary both on its external and internal margin. Posteriorly there is a slender ascending process which is wedged in between the maxillary and nasal and reaches[a] almost to the lachrymal foramen. About midway between the anterior and posterior ascending processes a third median process is given off from the superior margin of the premaxillary. This is directed forward and upward and joins the anterior process just below the nasals and gives additional support to those elements.

The transverse bones.—The transverse bones are reduced to elongated flattened bones located one on the supero-external surface of the lower posterior process of each maxillary as shown at *tr* in fig. 21. They are somewhat thickened on the external median border but are rather thin at either extremity. They have a slight contact with both the pterygoids and palatines, but fulfill none of the functions of the transverse or transpalatine bones as seen in the crocodiles and most modern reptiles. So rudimentary are the transverse bones in the Ceratopsia that they might best be described as vestigial.

The palatines.—These are broad, thin bones, each consisting of two plates, one vertical and longitudinal, running in a plane nearly parallel with the longer axis of the skull, the other vertical and transverse and occupying a plane extending nearly at right angles to the longer axis of the skull. Along their inferior borders the palatines embrace the superior border of the internal portions of the maxillaries. The vertical and longitudinal portions of the palatines are in contact posteriorly with the pterygoids. The vertical and transverse portion has a thickened, free inferior border; laterally it gives support to the lachrymal, the superior process of the maxillary, and apparently also to the prefrontals. At the anterior angle just where the transverse and longitudinal portions of the palatines meet they are produced into long pointed processes which fit nicely into notches on the supero-internal surfaces of the maxillaries, as is well shown in fig. 20. Just above this process the anterior border of the palatine incloses posteriorly an elongated oval foramen which is bounded anteriorly by an ascending process of the maxillary. This foramen passes from the cavity of the mouth to the infratemporal cavity, and may be called the maxillo-palatine foramen. It is situated as shown at *v*, fig. 20, just below the much smaller infraorbital foramen, from which it is separated by a slender process of the maxillary. Above, the palatines approach each other and embrace between them the vomers, the superior extremity of the pterygoids, and the median blade of the alisphenoids. The articulation of these various elements with one another is well shown in figs. 20 and 21.

The pterygoids.—The pterygoids are very irregular in form, as shown in fig. 23. Inferiorly and posteriorly they are broad and thin, with the posterior portion expanded so as to form a broad wing, convex externally and concave internally. The antero-inferior angle of this portion is thick and is lodged in a deep notch on the internal side of the quadrate, while above and posteriorly the broad, thin wing of the pterygoid overlaps on the inner side the thin angular part of the quadrate, as shown in outline in fig. 20. On the superior portion of the concavity on the inner side of this portion of the pterygoid there is a large rugosity for contact with the anterior face of the distal end of the basisphenoid process. Anterior to this broadly expanded portion of the pterygoid and separated from it by a deep rounded notch is the antero-inferior process of the pterygoid which is in contact with the transverse and curves round the posterior extremity of the inferior branch of the maxillary so as to receive a portion of its inner and superior surface into an elongated, rather deep, and rugose cavity. The antero-interior

[a] Here Hatcher's revised typewritten manuscript ends.

margin of each of these two inferior processes of the pterygoids are produced into two broad laminæ, which run obliquely upward across the inner surface of the bone, the free borders curving toward one another and partially arching over a deep canal, broad below but constricted above, which may have functioned as the eustachian canal.

Above the upper limits of these two laminæ the pterygoids are much constricted and the superior process presents a smooth, flattened, external articular surface for contact with the palatines, while on their internal sides they articulate with one another through short grooved articular surfaces, which are partially interrupted near their superior borders by a single large median foramen. The sutural surface for contact with the palatine is projected above that which opposes the pterygoid, and there is a small foramen on the free border between these two surfaces, as shown in fig. 23. The anterior edge of the pterygoid extends forward and forms an elongate plate, crescentic in outline. This articulates with the palatines above and below with the maxillary, as shown in fig. 21. Just above the maxillary a large foramen passes between the pterygoid and palatine. Anteriorly this foramen is bounded by the posterior border of the palatine and posteriorly by the anterior border of the pterygoid. At the extreme top the pterygoids articulate externally with the palatines, and to a slight extent also with the inferior lateral projections from the vomers, while medially they are in contact with one another, save for the interruption due to the median foramen already mentioned, which doubtless served to transmit the sensory nerves to the palate.

The basisphenoid.—The basisphenoid is firmly coossified with the alisphenoids. The basisphenoidal processes are produced somewhat beneath the basioccipital processes and present in front at their extremities rugose surfaces for contact with the pterygoids. Anteriorly and superiorly the basisphenoid is compressed and forms a stout median interorbital septum. The external opening of the middle eustachian canal is situated between and at the base of the basisphenoidal processes, as shown in fig. 23. It is entirely within the basisphenoid instead of being situated between that bone and the basioccipital, as in the crocodile. Two large foramina, situated one on either side of the skull at the bases of the basisphenoidal processes, pierce the basisphenoid and enter the brain case near the base of the olfactory lobe through a deep fossa, which doubtless lodged the pituitary body. Anteriorly the basisphenoidal processes are received into deep pockets on the posterior surfaces of the thin but widely expanded posterior wings of the pterygoids.

The alisphenoids.—The alisphenoids, including also the parasphenoids, with which they are so completely fused, even in young individuals, as to render the latter elements indistinguishable, are extremely irregular in form. They are firmly coossified with one another and with the exoccipitals and the basisphenoid. Together with the latter element they usually form the entire anterior portion of the brain case, save only the extreme anterior portion of the superior border, which in some instances is formed by the anterior projection of the united postfrontals. Supero-posteriorly the alisphenoids articulate with the supraoccipital, and supero-anteriorly with the postfrontals. Just beneath the lateral union of the supraoccipital and postfrontals the alisphenoids are developed into a strong lamina or buttress, which gives greater support to this region. Anteriorly the coossified alisphenoids and basisphenoid are embraced by the vomers and the posterior projections of the palatines, as is well shown in fig. 24, from the type of *Triceratops horridus*, No. 1820 of the Yale Museum collections, though not so apparent in the type of *Sterrholophus flabellatus*, in which these parts are less perfectly preserved. In the type of *Sterrholophus flabellatus* the olfactory nerves, as shown in fig. 9, leave the brain case by a single large median foramen inclosed entirely by the alisphenoids, while in the type of *Triceratops horridus* this foramen is subdivided by a strong but short median partition of bone, as shown in fig. 27. This difference has been shown to be due to age. (See p. 120.)

Note.—No measurements of *Sterrholophus flabellatus* were left by Hatcher, probably because of the disarticulated condition of the skull.—R. S. L.

DICERATOPS Lull.

DICERATOPS HATCHERI Lull.[a]

Original description, Am. Jour. Sci. (4), vol. 20, p. 417.
Gilmore, C. W., Proc. U. S. Nat. Museum, vol. 30, p. 609.

Mr. Hatcher's description is as follows:

Char. generic: Nasal horn core absent. Squamosal bones pierced by large fenestræ,[c] while smaller ones penetrate the parietals. The inferior border of the squamosal lacks a quadrate notch.

Type, No. 2412, U. S. National Museum.

Char. specific: Supraorbital horn cores short, robust, and nearly circular in cross section at base, erect and but slightly curved. Orbits project in front of the horns, the frontal region lying between the horns being concave. Exoccipital processes slender and widely expanded.

The type (No. 2412, U. S. National Museum) consists of a skull without the lower jaw. The posterior portion of the frill is somewhat weathered, but the specimen appears to have suffered comparatively little from crushing.

Locality: The specimen was found in a hard sandstone concretion about 3 miles southwest of the mouth of Lightning Creek, Converse Co., Wyo. [At the place marked +25 on the map, Pl. LI.] When found the concretion in which the skull was embedded had entirely weathered out of the surrounding sandstone and stood at an altitude of 5 or 6 feet above the ground, firmly attached beneath to another concretion. The skull stood on its nose with the frill pointing upward.

The skull: The chief distinctive features of the skull are as follows:

The supraorbital horn cores are comparatively short, robust, and nearly circular in cross section at the base instead of compressed, as in most other species. They rise more directly upward than in other species and are only slightly curved. The orbits also occupy a position more anterior than that seen in other species; the interior borders of the horn cores rise from about the middle of the superior borders of the orbits, so that the orbits project well in front of the horns. The frontal region between the orbits is concave. The exoccipital processes are rather slender and widely expanded.

The nasals terminate anteriorly in a rounded rugosity not developed into anything approaching a nasal horn core and resembling that of the type of *Triceratops obtusus*. The rostral bone is small and firmly coossified with the premaxillaries. The latter are elongate, but not deep. The maxillaries are massive and the lachrymal foramen is elongate and situated below and considerably forward of the orbit. The jugal is broad distally and firmly coossified with the epijugal. The lateral temporal fossa is nearly as deep vertically as longitudinally. The squamosal is elongate, and just posterior to the quadrate groove it is pierced by a large fenestra.[c] The antero-inferior angle is little produced and there is no quadrate notch, the inferior border in this region describing a widely open concavity. The parietals are broad and thin and on either side of the median line, about 235 mm. in front of the posterior border, there is an elongated fenestra,[c] with a longitudinal diameter of 150 mm. and a greatest transverse diameter of 52 mm. This fontanelle is completely inclosed on the right side, but on the left the parietal is injured in this region. In the drawings it has been restored from the right side. The supratemporal fossa is elongate. There is a single median postfrontal fontanelle,[b] as in *Triceratops*, but posteriorly this gives origin to two deep channels, one on either side. These run backward along the surface of the parietal and terminate in two small circular fontanelles, conditions very similar to those which obtain in *Torosaurus*.

Measurements of the type.

	Mm.
Distance from anterior end of rostral to posterior of squamosal	1,990
Distance from anterior end of rostral to anterior of orbits	845
Distance from inferior border of orbit to lower end of jugal	363
Distance from posterior border of nasal opening to extremity of beak	614
Distance from posterior border of orbit to posterior surface of horn core	175
Distance between anterior borders of orbits	340
Circumference of supraorbital horn cores at base	610
Circumference of supraorbital horn cores 200 mm. above orbit	340
Vertical diameter of orbits	165
Antero-posterior diameter of orbits	125

TOROSAURUS Marsh. 1891.

Type species, *T. latus*.

Original description in Am. Jour. Sci., 3d ser., vol. 42, 1891, p. 266.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 43, p. 81; Nature, vol. 48, 1893, p. 438; Am. Jour. Sci., 3d ser., vol. 50, p. 497; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, p. 214.

Dana, J. D., Manual of Geology, 1895, p. 847.

Lambe, L. M., Contr. to Canadian Pal., vol. 3 (quarto), pt. 2, p. 66.

Osborn, H. F., ibid., pp. 9, 14, 15, 20.

Zittel, K. von, Text-book Pal., trans. by C. R. Eastman, vol. 2, p. 245.

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[a] This form was described by Hatcher, but left without a name. *Diceratops* is suggested as a generic name, from the absence of the nasal horn core, while the appropriateness of the specific name is self-evident.—R. S. L.

[b] See footnote on p. 24.—R. S. L.

[c] See footnote on p. 163.—R. S. L.

The present genus appears to be distinct from any of the others that have been proposed for these larger members of the Ceratopsidæ, either from this or other localities. The more important differences are to be found in the parietal and squamosal regions of the skull. In the present genus that portion of the skull posterior to the frontal horn cores is considerably elongated, while the anterior portion is correspondingly abbreviated and more compressed than in *Triceratops*. The most prominent and distinctive characters, however, are to be found in the parietal crest, which is pierced by a pair of large foramina, situated one on either side of the median line, as shown in fig. 12, and designated as the supratemporal fontanelles or parietal foramina. The squamosals are also characteristic, being long and slender, assuming somewhat the form and pattern of a broadsword, instead of short and broad, as in *Triceratops* (see fig. 14; 1, 2, 3). As already remarked, the parietals in the present genus most nearly resemble the same elements in the type of *Monoclonius* (*M. crassus*), and there seems little doubt that the last-mentioned genus was ancestral to *Torosaurus*.[a]

TOROSAURUS LATUS Marsh. 1891.

The type (No. 1830, Yale Museum), from the Laramie of Converse County, Wyo.

Original description in Am. Jour. Sci., 3d ser., vol. 42, September, 1891, p. 266.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 43, p. 81; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, p. 214.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, p. 66.

Osborn, H. F., ibid., p. 14.

LOCALITY.

The type (No. 1830, Yale Museum) was discovered at the locality marked +19, Pl. LI. It lay embedded in an extremely hard bluish calcareous sandstone concretion near the summit of the bluff on the north side of Lightning Creek, about 2 miles above the mouth of that stream, in the bottom and near the extreme head of a small, dry watercourse emptying into Lightning Creek. When discovered the summits of the frontal horn cores and most of the parietal crest had already weathered out and been carried away by the current of water which at times filled the channel of the small watercourse, due either to occasional heavy rains or the melting of the winter's accumulation of snow. Associated with the skull in the same concretion there were, in considerable numbers, plant impressions and small lignitized stems.

ORIGINAL DESCRIPTION.

Professor Marsh's description of the type of the present species was as follows:

Another well-marked species of this group, which may be referred to a new genus, is represented by one skull, and parts of the skeleton, from nearly the same horizon as the specimen above described. One of the most striking features of the present species is seen in the posterior crest, which, instead of being complete, as in the skulls hitherto found, is perforated by a pair of large openings. These are in the parietals, but they have the inner margin of each squamosal for their outer border. They are well behind the supratemporal fossæ, but doubtless were originally connected with them. They may be called the supratemporal fontanelles. The squamosal bones, moreover, are very long and slender, and distally only show near the ends sutures for union with the parietals. Another distinctive character is seen in the main horn cores, which are placed well back of the orbit. The nasal horn core is short, with the apex compressed, and directed forward.

This genus is of much interest, as it represents an earlier and less specialized form than either *Ceratops* or *Triceratops*, both of which have the posterior crest complete. The existing chameleons show the other extreme, where the outline only of the parietal crest has been attained.

Some of the principal dimensions of this skull are as follows:

	Inches.
Length from apex of nasal horn core to extremity of squamosal	80
Distance from same apex to front of orbit	21
Distance from same to front of parietal opening	54
Width between posterior extremities of squamosals	56

This important specimen was discovered by Mr. J. B. Hatcher in the Laramie of Wyoming.

[a] This section of the manuscript is as *originally* written, not having been revised by the author, who later changed his views with regard to the ancestry of the genus (see p. 100).— R. S. L.

DESCRIPTION OF THE TYPE.

The type of the present genus and species consists of a skull (No. 1830, Yale Museum) without the lower jaw. The posterior portion of the parietals, the summits of the supraorbital horn cores, the rostral, premaxillaries, and a considerable portion of the maxillaries are also wanting.

The frill or posterior portion of the skull is greatly expanded, both transversely and antero-posteriorly, and was pierced by two large supratemporal fontanelles. Only the antero-external border of the left one of these fontanelles is preserved in the type, so that it is not possible to determine with certainty either their form or dimensions. Marsh has figured them as elliptical, and his figure is reproduced here as fig. 118.

According to Marsh the squamosals form the postero-external borders of the fontanelles, though I am unable to tell, after an examination of the type, whether or not this is the case. It may be that, as in the following species of this genus, these fontanelles were entirely inclosed by the parietals.

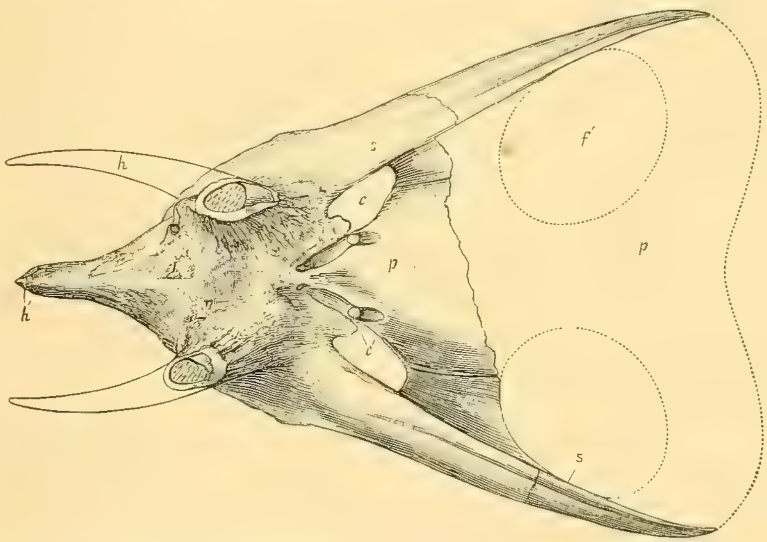

FIG. 118.—Dorsal aspect of skull of type of *Torosaurus latus* Marsh, No. 1830. Yale Museum. One-twentieth natural size. *c*, Supra-temporal fossa; *c'*, anterior temporal foramen; *f'*, parietal fontanelle; *h*, supraorbital horn core; *h'*, nasal horn core; *p*, parietal; *s*, squamosal. After Marsh.

In the present genus the parietals form a considerably greater portion of the frill than in *Triceratops*, and the squamosals are correspondingly smaller, being reduced to long, narrow, blade-like bones on the external margins of the parietals, very narrow behind but broader in front. The skull is extremely broad and massive between the orbits and the anterior extremities of the squamosals, while in front of the orbits the facial region narrows rapidly and appears very short and compressed when compared with the broad and elongate posterior crest or frill. In front the parietals present two large irregular-shaped fossæ, situated one on either side, which are doubtless connected by foramina with the large cavities in the postfrontals at the bases of the horn cores. Just within and near the antero-internal borders of these two large fossæ two foramina pierce the parietals. From the external openings of these two foramina two broad, shallow grooves run forward and upward on the surface of the skull, rapidly converging and terminating in two foramina, separated by a thick partition of bone, which marks the median line of the skull. These two foramina are doubtless homologous with the single median one usually found in this region in skulls pertaining to the genus *Triceratops* and known as the postfrontal foramen or pineal foramen[a] of Marsh. Owing to the age of the individual, the sutures in this region are so much obliterated that it is quite impossible to determine whether these foramina are located in parietals or postfrontals. In the type of the following species, which pertains to a younger but larger individual, they appear to have been located entirely within the parietals. This being the case, it would not be technically proper to call them postfrontal foramina, even though they are homologous with that element in the genus *Triceratops*.

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[a] See footnote on p. 24.—R. S. L.

The squamosals are very long and slender and are united with the parietals only by an open suture. At their anterior extremities the squamosals are firmly coossified with the postfrontals and the jugals. The inferior and anterior angle of the squamosal is not so much produced as in *Triceratops*, and the quadratojugal notch is not so deep. The squamosal is more expanded in front of the groove for the quadrate in the present genus than in *Triceratops*. The transverse diameters of the quadrate at or in front of the groove for the quadrate and just behind the quadratojugal notch are subequal in the present genus.

The frontal region is broad and the supraorbital horn cores are well separated at their bases; they are much compressed, ovate in cross section, with apex of oval directed anteriorly. The horn cores are directed upward, outward, and forward.

The orbits are elliptical in outline, with the longer diameter nearly horizontal and not nearly so vertical as in those species of *Triceratops* which have elliptically shaped orbits. The orbits in the present genus occupy a rather more anterior position than in the genus just mentioned. The sutures are so completely closed in this region that it is impossible to determine the extent to which the various elements enter into the construction of the orbit. The lachrymals, prefrontals, and frontals are so fused with one another and with the postfrontals that their outlines can not be distinguished. A very large round foramen pierces the prefrontal on the right side just within the strong orbital border. There is no corresponding foramen on the left side, and the presence of this foramen of the right side is therefore probably of pathologic origin and of no specific importance.

Beneath the orbits the jugals are much expanded and the external surface of the skull in this region slopes downward and outward and is much less nearly vertical than in the genus *Triceratops*, making the skull appear extremely broad when seen from above. In front of the orbits the facial region contracts very abruptly and appears short and much compressed when seen from above, with a short nasal horn core, broad at the base and sharp above and directed upward and forward. The nasals are completely fused with one another and with the adjoining elements. There is a large lachrymal foramen, situated well in advance of the orbit, but owing to the age of the individual it is impossible to tell whether it is situated entirely within the maxillary, as in *Triceratops* (*Sterrholophus*) *flabellatus*, or between that bone and the nasal, as in *Triceratops prorsus*. The superior surface of the skull in front of the paired supraorbital horns presents a gently concave fore-and-aft surface, while behind these horn cores the postfrontals fall away rather abruptly to meet the parietals and squamosals.

Principal measurements of the type.

	Mm.
Distance from posterior border of orbit to extremity of squamosal	1,640
Distance from anterior border of orbit to front of nasal horn core	440
Expanse of jugals	810
Greatest length of skull (estimated)	2,200
Fore-and-aft diameter of supraorbital horn core at base	266
Transverse diameter of supraorbital horn core at base	153
Transverse diameter of supraorbital horn core 6 inches above base	175
Fore-and-aft diameter of supraorbital horn core 6 inches above base	108
Circumference of supraorbital horn core 6 inches above base	490
Circumference of supraorbital horn core at base	638
Height of nasal horn above inferior border of nasals	148
Transverse diameter of nasals at base of nasal horn core	90
Distance between orbits	432
Antero-posterior diameter of orbit	166
Vertical diameter of orbit	119

TORÓSAURUS GLADIUS Marsh. 1896.

Type (No. 1831, Yale Museum), from the Laramie of Converse County, Wyo.

Original description in Am. Jour. Sci., 3d ser., vol. 42, Sept., 1891, pp. 266–267.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 43, p. 84; Sixteenth Ann. Rept. U. S. Geol. Survey, 1896, pt. 1, p. 215.

Dana, J. D., Manual of Geology, 1895, p. 846.

Lambe, L. M., Contr. Canadian Pal., vol. 3 (quarto), pt. 2, p. 66.

Osborn, H. F., Contr. Canadian Pal., vol. 3 (quarto), p. 15.

The type (No. 1831, Yale Museum) of the present species was found at the locality marked +19 A, Pl. LI. The horizon was considerably lower than that which afforded the type of the preceding species. The fragmentary remains upon which it was based by Professor Marsh were found in a thick bed of shale which forms the gentle northern slope of the low divide between Lightning and Cow creeks, midway between and at a distance of about 1 mile from the mouths of those creeks.

Professor Marsh's description of the species was as follows:

A second species of apparently the same genus is represented by various portions of a skull in good preservation. In this specimen the nasal horn core is short and obtuse, and nearly upright. The main horn cores are elongate, oval in outline, and in position resemble those of the skull above described. The most remarkable features in the present specimen are the squamosal bones, which are greatly elongated and so attenuated as to have the general shape of the blade of a sword, thus suggesting the specific name. These bones, moreover, show but slight evidence at their distal extremity of union with the parietals. As the inner margin is rounded for nearly half the length, this feature will distinguish the present species from all others hitherto described.

The following are some dimensions of portions of this specimen:

	Inches.
Length of horn core from top of orbit to summit	27
Antero-posterior diameter of same horn core at base	8
Transverse diameter of same	5
Length of squamosal behind exoccipital groove	55
Greatest width	15
Width at middle	9

These interesting specimens were also found in the Laramie of Wyoming by Mr. J. B. Hatcher.

The type of the present species consists of a nearly complete parietal, left squamosal, a supraorbital and nasal horn core, an epijugal, the occipital condyle, and other skull fragments of less importance.

The type of the present species represents the extreme development of the form of parietal crest that is peculiar to this genus. The *squamosals*, as shown in fig. 14, are extremely narrow and elongate. The *parietals* are very broad and long and are interrupted by a pair of huge supraorbital fontanelles, well shown in fig. 12. The posterior border of the parietals was emarginate at the median line. The median bar of the parietals was broad, thin, and smooth, especially at the posterior extremity. Its superior surface is nearly flat at the posterior extremity, but becomes more convex anteriorly, where it presents three low, rugose prominences arranged in a longitudinal series. In front of and posterior to the supratemporal fontanelles the parietals expand into broad, thin plates, which form respectively the anterior and posterior borders of the fontanelles. Below, these plates are united by a thin bar of bone, which unfortunately is not complete in the present specimen, but which, when in position, overlapped the superior border of the squamosal and formed the inferior lateral margin of the large fontanelle. There were no epoccipital bones on the posterior border of the parietals such as are present in other genera of the Ceratopsia, but the sharp, thin posterior border of these elements presents on either side of the median line a series of nine elongated prominences alternating with eight shallow emarginations, which give to the periphery of these bones the same peculiar scalloped effect that in *Triceratops* is produced by the epoccipitals.

The narrow and elongate *squamosals* for 25 centimeters at their posterior extremities present a rather thick concave inner lateral border, against and into which fits the posterior external lateral border of the parietal. In advance of this for a distance of nearly a meter the external margin of the parietal overlaps the internal margin of the squamosal. This overlapping and underlapping is carried to the greatest extent in the region opposite the middle of the supratemporal fontanelles, where it amounts to as much as 6 centimeters. Anteriorly the inner borders of the squamosals are much thickened and the inferior surface of each is produced into a long, narrow plate which becomes wider anteriorly. This plate passes beneath the margin of the anterior plate of the parietal and forms a part of the floor of the large supratemporal fossa, while the thickened superior marginal border of the squamosal in this region forms the external lateral boundary of this fossa. The postero-external lateral border of the squamosal is without either sinuosities or epoccipitals, but anteriorly this border is marked by a series of four gentle prominences separated by three elongate and shallow emarginations.

The last of these four prominences forms the antero-inferior angle of the squamosal and marks the posterior border of the quadratojugal notch, which is much shallower than in other genera of Ceratopsia. The groove for the quadrate is far in advance of the position which it occupies in other genera. The more important characters of the squamosal are well shown in fig. 14, 1.

The *supratemporal fossæ* were deep and elongate and the floor of each appears to have been stronger than in *Ceratops* or *Triceratops*. As in the type species of the genus, there was a small foramen on either side of the parietal just within the anterior lateral borders of these fossæ. From these foramina two broad, shallow channels run forward along the superior surface of the parietal. These converge and meet in the median line at the anterior extremity of the parietals, where there seems to have been a single median postfrontal (pineal) foramen instead of two placed one on either side of the median line, as in the preceding species of this genus.

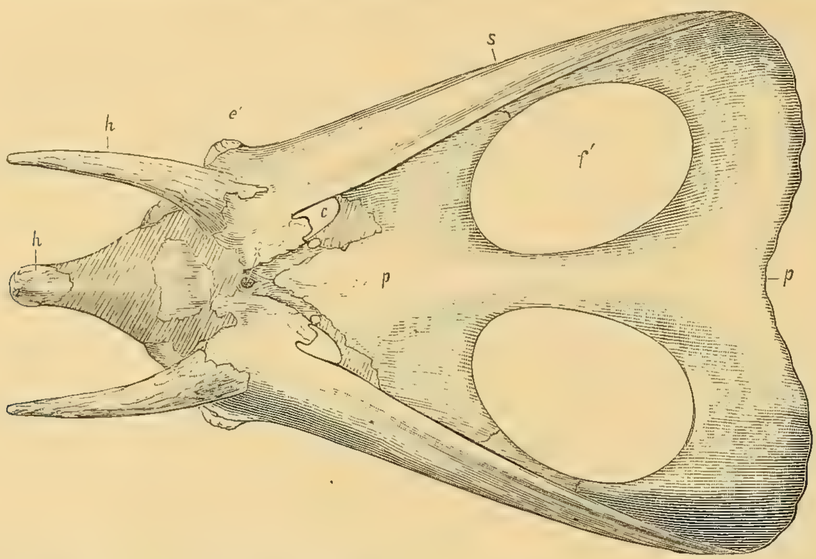

FIG. 119.—Dorsal aspect of skull of type of *Torosaurus gladius* Marsh (No. 1831, Yale Museum). *c*, Supratemporal fossa; *e′*, epijugal bone; *f′*, parietal fontanelle; *h*, supraorbital horn core; *h′*, nasal horn core; *p*, parietal; *s*, squamosal; *x*, postfrontal foramen. One-twentieth natural size. After Marsh.

Owing to the imperfect condition of the specimen in this region, it is not possible to determine with accuracy whether there were one or two of these foramina.

Taken as a whole the entire *frill*, notwithstanding its great size, which considerably exceeds that of any member of the Ceratopsia yet discovered, was remarkably light and frail and could have formed but a very inefficient protection to the cervical region. The surfaces of the bone are throughout smooth and entirely devoid of those grooves, channels, and rugosities so characteristic of the parietals and squamosals in the genus *Triceratops*. In the present specimen the entire frill seems to have been embedded in or covered by soft, muscular tissue instead of bearing a thick and dense dermal or horny sheath, as would appear to have been the case in *Triceratops* and fully adult specimens of *Sterrholophus*.

Only one of the *supraorbital horn cores* is preserved and a portion of the base of this is wanting. It shows these horn cores to have been rather long, slender, and somewhat compressed transversely, with a very rugose surface deeply furrowed with vascular groves, indicating that in life they were covered with formidable horns. They were directed forward, upward, and outward, and, assuming that the facial region was correspondingly as short in the present as in the preceding species considering their length, they must have extended nearly or quite as far forward as the nasal horn.

The *nasal horn core*, which was found detached, is very short and stout, compressed, and has a very sharp-pointed apex. Its surface is extremely rugose and shows a number of deep vascular grooves for the protection of the blood vessels which lay between the bone and the heavy horn with which in life it was insheathed. The surface of this horn core is broadly rounded in front and more contracted behind, so that in cross section it is ovate, with the apex of the oval directed posteriorly. The anterior surface of the horn core seems to have occupied a plane nearly perpendicular to that of the longitudinal axis of the cranium. The bone is comparatively dense without, but the central mass shows a coarse cancellous structure.

A broad, low, disarticulated *epijugal* was found associated with the remains. This differs from the same element in *Triceratops* in being proportionally much broader and in having a concave inferior surface. The external surface of the bone is marked by deep vascular grooves, and it was united with the jugal by a very irregular suture.

The general aspect of this skull as seen from above is well shown in fig. 119, from a restoration of it by Professor Marsh. An examination of this figure will at once show the striking contrast between the enormously elongated posterior region and the abbreviated facial region, which becomes more especially emphasized when compared with similar views of crania pertaining to the genus *Triceratops*.[a]

The detached *occipital condyle* was found with the type. Considering the size of the parietal crest and the total length of the skull, the occipital condyle was small and the sutures between the different elements composing it were not completely closed; when found it had parted along these sutures and lay in three subequal parts. The lower and median of these was formed by the basioccipital, while the exoccipitals formed the upper two-thirds of the condyle, as shown in fig. 7. The size of the condyle shows that, notwithstanding the enormous size of the frill, the skull proper was not unusually large for a member of the Laramie Ceratopsia, being rather under than over the average size.

Principal measurements of the type.

	Mm.
Length of parietals along median line	1,432
Greatest length of parietals	1,568
Greatest length of squamosal	1,400
Greatest breadth of squamosal	430
Estimated length of skull	2,350
Greatest distance between external borders of squamosals measured over curved surface	932
Transverse diameter of supraorbital horn core near base	133
Transverse diameter of supraorbital horn core at middle	82
Fore-and-aft diameter of supraorbital horn core at middle	111
Fore-and-aft diameter of supraorbital horn core near base	191
Fore-and-aft diameter of nasal horn core near base	130
Transverse diameter of nasal horn core near base	81
Circumference of supraorbital horn core near base	510
Circumference of supraorbital horn core at middle	125
Height of epijugal	59
Breadth of epijugal	105
Diameter of occipital condyle	85

NODOSAURUS Marsh. 1889.

Nodosaurus textilis Marsh. 1889

Type No. 1815, Yale Museum.

Original description in Am. Jour. Sci., 3d ser., vol. 38, Aug., 1889, p. 175.

Marsh, O. C., Am. Jour. Sci., 3d ser., vol. 39, May, 1890, pp. 424–425; ibid., vol. 50, Dec., 1895, p. 497; Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, p. 225 (dermal ossicles shown in fig. 5, Pl. LXXV).

Nicholson and Lydekker, Manual Pal., 1889, p. 1164.

Zittel, K. A. von, Handbuch Pal., p. 754.

The type (No. 1815, Yale Museum) of the present genus and species was found, according to Professor Marsh, in the "middle Cretaceous of Wyoming." Marsh's original description was as follows:

Another new member of the Stegosauria, from a lower horizon in the Cretaceous, was discovered several years since in Wyoming and is now in the Yale Museum. The skull is not known, but various portions of the skeleton were secured. One

[a] Marsh's restoration, fig. 119, does not include the portion of the skull in front of the nasal horn; if this were added the disproportion would be less marked.—R. S. L.

characteristic feature in this genus is the dermal armor, which appears to have been more complete than in any of the American forms hitherto found. This armor covered the sides closely and was supported by the ribs, which were especially strengthened to maintain it. In the present specimen portions of it were found in position. It was regularly arranged in a series of rounded knobs in rows, and these protuberances have suggested the generic name.

Near the head the dermal ossifications were quite small, and those preserved are quadrangular in form and arranged in rows. The external surface is peculiarly marked by a texture that appears interwoven like a coarse cloth. This has suggested the specific name, and is well shown in the cut below [fig. 120].

The fore limbs are especially massive and powerful, and are much like those of the Jurassic *Stegosaurus*. There were five well-developed digits in the manus, and their terminal phalanges are more narrow than usual in this group. The ribs are T-shaped in transverse section, and thus especially adapted to support the armor over them. The caudal vertebræ are more elongate than those of *Stegosaurus*, and the middle caudals have a median groove on the lower surface of the centrum.

The animal when alive was about 30 feet in length. The known remains are from the middle Cretaceous of Wyoming.

From the above quotation it is clear that Marsh at that time considered this genus and species as belonging to the Stegosauria. From the title of his paper ("Notice of Gigantic Horned Dinosauria from the Cretaceous") and the context of the text, however, it is also evident that he then included *Nodosaurus* in the Ceratopsidæ, which he at that time considered as a family of the Stegosauria. A few months later, however,[a] he removes this genus from the Ceratopsidæ, making it the type of a new family, the Nodosauridæ. He now includes the families Ceratopsidæ and Nodosauridæ in a single group, the Ceratopsia, which in the introductory paragraph of his article he regards as a suborder, but in the classification of American Cretaceous dinosaurs with which he closes his paper he makes this group of ordinal rank and makes no mention of the Stegosauria. It is clear, therefore, that he at that time regarded the Ceratopsia and Stegosauria as pertaining to distinct orders or suborders, and that he included the Nodosauridæ in the Ceratopsia rather than the Stegosauria. His classification of American Cretaceous dinosaurs as then proposed is as follows:

FIG. 120.—Dermal ossicles of *Nodosaurus textilis* Marsh. Natural size. After Marsh.

The American Cretaceous dinosaurs now known represent several well-marked families, which may be arranged as follows:

Order *Theropoda*. Carnivorous.

(1) The *Dryptosauridæ*, including the large carnivorous forms, of which only imperfect specimens have been found, but sufficient to indicate that they are distinct from the *Megalosauridæ* of the European Jurassic. Limb bones hollow. Fore limbs very small. Feet digitigrade, with prehensile claws.

Order *Ornithopoda*. Herbivorous.

(2) The *Trachodontidæ*, herbivorous forms of large size, with teeth of the *Hadrosaurus* type, in many rows. Cervical vertebræ opisthocœlian. Limb bones hollow. Fore limbs small. Feet digitigrade.

(3) The *Claosauridæ*. Only a single row of teeth in use. Cervical vertebræ opisthocœlian. Limb bones solid. Fore limbs small and feet ungulate.

(4) The *Ornithomimidæ*. Limb bones hollow. Fore limbs very small; hind limbs of avian type. Feet digitigrade and unguiculate.

Order *Ceratopsia*. Herbivorous.

(5) The *Ceratopsidæ*. Highly specialized forms fully defined above.

(6) The *Nodosauridæ*. Heavy dermal armor. Bones solid. Fore limbs large. Feet ungulate.

No Sauropoda are known from the American Cretaceous.

Although in the above classification Marsh treated the Ceratopsia as a distinct order, yet a year later,[b] in the text of a paper accompanying a restoration of the skeleton of *Triceratops*, he remarks:

This group, so far as at present investigated, is very distinct from all other known dinosaurs, and whether it should be regarded as a family, Ceratopsidæ, as first described by the writer, or as a suborder, Ceratopsia, as later defined by him, will depend upon the interpretation and value of the peculiar characters manifested in its typical forms.

[a] Am. Jour. Sci., 3d ser., vol. 39, May, 1890, p. 425.

[b] Am. Jour. Sci., 3d ser., vol. 41, Apr., 1891, p. 340.

This last-mentioned paper was followed in a few months by another[a] accompanying a restoration of *Stegosaurus*, and in this it is clear that Marsh regards the group as deserving the rank of a suborder only, coordinate with the Stegosauria. The two together he then regarded as comprising the order Ornithopoda. Three years later,[b] however, Marsh restricted the term Ornithopoda to its original limits and made the group coordinate with the Stegosauria and Ceratopsia, all three of which he considered as suborders belonging to a single order for which he proposed the very appropriate name Predentata. The following year[c] Professor Marsh presents a revised classification of the Dinosauria, and in this he places the Nodosauridæ and the genus *Nodosaurus* in the Stegosauria rather than the Ceratopsia. This is also the classification followed in his "Dinosaurs of North America,"[d] which may be regarded as the most comprehensive expression of his views on this subject. It would seem, therefore, that Professor Marsh's final decision was in favor of excluding *Nodosaurus* from the Ceratopsia and including it in the Stegosauria.

After a personal examination of the type I am convinced that it is not a member of the Ceratopsia.

[Hatcher's manuscript ends here.]

[a] Am. Jour. Sci., 3d ser., vol. 42, Aug., 1891, pp. 179-181.
[b] Am. Jour. Sci., 3d ser., vol. 48, July, 1894 pp. 89-90.
[c] Am. Jour. Sci., 3d ser., vol. 50, Dec., 1895, pp. 485-498.
[d] Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, p. 243.

PART II

PHYLOGENY, TAXONOMY, DISTRIBUTION, HABITS, AND ENVIRONMENT OF THE CERATOPSIA

BY

RICHARD S. LULL

PHYLOGENY, TAXONOMY, DISTRIBUTION, HABITS, AND ENVIRONMENT OF THE CERATOPSIA.

GENERIC AND SPECIFIC SUMMARY.

GENERAL DISCUSSION OF THE PHYLOGENY.

Of the fourteen genera which have at sundry times and by various authors been referred to the Ceratopsia but seven have survived the process of elimination to which they have been subjected. Of these, three more primitive genera were found in the earlier Judith River beds, and the remaining four, which are much more specialized, were found in the Laramie deposits. That there is a genetic relationship between the earlier forms and their successors is evident, and, as Osborn, Lambe, and Hatcher have suggested, there seem to have been at least two lines of descent, one leading to *Triceratops*, with its entire bony frill, and the other to *Torosaurus*, with persistently open parietal fontanelles.

Professor Osborn's[a] statement is as follows:

> It is not at all improbable that the horned dinosaurs will prove to be diphyletic, one line, with persistent open fossæ, leading from *Monoclonius* to *Torosaurus*, the other leading to *Triceratops* with closed fossæ.

Lambe,[b] in speaking of the parietal of *Ceratops* (*Monoclonius*), says:

> The parietal is about one-third the size of that of *T. gladius*, and would probably represent a proportionately smaller animal, an earlier and more generalized form of the genus, with larger fontanelles than its later Laramie successors.

In Hatcher's unrevised description of the genus *Torosaurus* (p. 150) he says:

> As already remarked, the parietals of the present genus most nearly resemble the same elements in the type of *Monoclonius* (*M. crassus*), and there seems but little doubt that the last-mentioned genus was ancestral to *Torosaurus*.

In the revised portion of his manuscript, however (p. 100), Hatcher reverses this earlier decision in the following statement:

> The affinities of *Monoclonius*, as shown in the type species, *M. crassus* Cope and *M. dawsoni* of Lambe, are apparently with the later genus *Triceratops* of Marsh, while *Ceratops montanus* Marsh, *C. recurvicornis* Cope, *C. canadensis*, and *C. belli* Lambe would seem to be ancestral to *Torosaurus*.

Mr. Lambe's statement is fully in accord with this, while that of Professor Osborn may be reconciled to it if by "*Monoclonius*" he had special reference to *M. canadensis* and *M. belli*, which Hatcher has removed to the genus *Ceratops*. If, on the contrary, Osborn had in mind the type species, *Monoclonius crassus*, his opinion as expressed would be at variance with Hatcher's final idea of these relationships.

The weight of evidence to be reviewed below is certainly in favor of Hatcher's final theory, according to which the genera may be provisionally arranged in two phyla in the following sequence:

Phyla of the Ceratopsia.

Geological horizon.	Triceratops phylum.	Torosaurus phylum.
Denver beds.	Triceratops.	
Laramie of Converse County, Wyo.	Diceratops. Triceratops.	Torosaurus.
Laramie of Black Buttes, Wyo.	Agathaumas.	
Judith River (Belly River).	Centrosaurus. Monoclonius.	Ceratops.

[a] Contr. Canadian Pal., vol. 3 (quarto), pt. 2, p. 31.

[b] Ibid., p. 67.

Of the two most primitive genera *Monoclonius* seems to be the more generalized and represents the earliest known stage in the evolution of the Ceratopsia. Because of the gap between the Judith River beds and those of the Laramie the series is by no means complete, nor are we yet aware of the characteristics of pre-Judith River ancestors. The earliest known Ceratopsia are endowed with the main distinguishing characters, the horns and parietal crest.

With the exception of the genus *Agathaumas*, of which the skeleton only is known, the more important taxonomic characters are found in the cranium, and the genera can readily be differentiated without recourse to the skeletal features; in fact, in four out of the seven genera these are unknown.

REVISION OF GENERA.

Taking the six genera recognized by Hatcher and one erected later by Lambe, which Hatcher would undoubtedly have accepted as valid, the main generic comparisons and contrasts are as follows:

I. THE MONOCLONIUS-TRICERATOPS PHYLUM.

1. *Monoclonius*, the most primitive genus, is comparatively small, and has three horn cores, the nasal being long, powerful, and curved backward. The supraorbitals are diminutive, flattened on the outer surface but very convex on that toward the median line, so that the basal section is almost triangular. The horns are sharp pointed. The orbit is nearly circular and in at least one species has a heavy rugose border. The frill is made up largely of the coalesced parietals, the squamosals being somewhat triangular, plate-like bones, short and proportionately broad. The margin of the crest is crenulated, but the prominences do not seem to have arisen from separate ossifications, as in the succeeding genera of this phylum. The parietals are widely fenestrated—in fact, they do not entirely surround the fenestræ, and the median bar is broad and thin in contrast to the much narrower bar in *Ceratops*. Of the skeletal characters those of greatest taxonomic value are found in the sacrum. The number of coalesced vertebræ in the entire sacrum is ten; of these eight bore sacral ribs, of which four pairs united distally on either side into a longitudinal bar for the support of the ilium. The centra were of medium length, constricted medially, and the sacral ribs arose directly opposite the points of articulation, so that each rib bore equally on two contiguous centra. The ilium is rather long and slender, and the deflected margin posterior to the ischiac peduncle is produced into a somewhat angular prominence. The blade is rounded anteriorly, while posteriorly it is elongate and narrows presumably to a point, though the extremity is not preserved. The blade, when the bone is in position, is horizontal, as in other Ceratopsia. In contrast with the ilium of *Agathaumas* that of *Monoclonius* is smaller and proportionately more slender, and the deflected external margin is more pronounced.

2. *Centrosaurus*.—In *Centrosaurus* the nasal horn is straight, laterally compressed so as to be lenticular in section, and somewhat similar to that of *Monoclonius sphenocerus*. The coalesced parietals entirely surround the large, oval fontanelles and the median bar is very heavy, especially between the peculiar inward-curved processes at its posterior border, but thins perceptibly toward the anterior portion of the frill. On either side the fontanelle is inclosed in a thin extension of bone. In addition to the two curved posterior prominences there are seven others, separated by emarginations, the posterior ones bearing separately ossified epoccipital bones as in *Triceratops*. The squamosals are short, as in *Monoclonius*, being confined to the antero-external angles of the frill.

3. *Agathaumas*.—The genus *Agathaumas*, so far as known from skeletal fragments, is intermediate in character between *Monoclonius* and *Triceratops*. It comes from the lower Laramie, near Black Buttes Station, Wyoming. In *Agathaumas* the main distinctive characters are of necessity derived from the sacrum, the ilia, the dorsal vertebræ, and the ribs. The sacrum has five true sacral vertebræ, probably with one presacral and four caudals, making ten in all, as in *Monoclonius*. In the type specimen, which was not fully mature, there are four pairs of sacral ribs, arising more directly from the articulations than in *Triceratops*, yet, with the exception of the first, not so much so as in *Monoclonius*, being in a condition

transitional between that in each. The four sacral ribs coalesce distally to form the horizontal bar for articulation with the ilia, but in the present instance the bar of each side is not continuous, the ribs being, as Cope expresses it, united in pairs. It is possible that continuity would have come later in life had the creature reached maturity. The centra of the true sacrals decrease in size regularly from first to last, as in *Monoclonius* and *Triceratops*, the first and second being particularly broad and short. They are somewhat more elongate than the dorsal centra, the vertical and transverse axes being more nearly equal. Perhaps the most important distinction is the point of origin of the sacral ribs. There was evidently a pleuro-diapophysial connection with the ilium, as in *Monoclonius* and *Triceratops*, but the diapophyses are not preserved. The dorsal vertebræ exhibit no marked distinction from those of the other genera.

In *Agathaumas* the blade of the ilium is much extended fore and aft, the anterior end being truncated and the hinder extremity narrow and elongate. The external margin is moderately thick throughout its length and much thicker near the extremities and in the deflected region above the ischiac peduncle. The internal margin is thin except in the region of articulation with the sacral diapophyses. A broad, convex ridge of bone extends diagonally across the anterior blade of the ilium to its antero-external angle, inclosing in front a deep depression just external to the acetabulum.

The ilium is actually larger and relatively shorter and broader than that of *Monoclonius*, and the deflection of its external margin is less pronounced. It differs from the ilium of *Triceratops* in being more slender and in having occasional thickenings of the external border, whereas in *Triceratops* the margin is more uniformly thin. The posterior end of the *Agathaumas* ilium is thin, while that of *Triceratops* is thickened.

The ilium of *Agathaumas* is transitional between those of the contrasted genera in general proportions, especially the relative length and breadth.

4. *Diceratops*.—This genus is known from a complete skull and, although unquestionably related to the *Monoclonius-Triceratops* phylum, its serial order is somewhat difficult to conjecture. By the absence of a nasal horn core it resembles *Triceratops obtusus*, though evidently not synonymous therewith. The fenestrated parietals would seem to point to primitive conditions until one notes the presence of similar fenestræ[a] in the squamosals, a character which here appears for the first time. This, together with the fact that the squamosal fenestræ are of unequal size—which may also have been true of those of the parietals, as only the right is preserved—leads one to conjecture whether they may not have been secondarily acquired and together with the vestigial nasal horn, may not be evidences of high specialization from some Triceratops-like ancestor. The main diagnostic characters wherein *Diceratops* differs from *Monoclonius* are the reduced nasal horn, the vastly increased supraorbital horns, the elliptical orbit, the well-developed parietals with their small fontanelles(?), the more elongate fenestrated(?) squamosals, and the separately ossified epoccipital bones.

From *Triceratops*, its nearest ally, it may be distinguished mainly by the much smaller rostral bone; by the absence of the nasal horn, which in all of the species of *Triceratops* except *T. obtusus* is fairly well developed; by the very erect, short, robust supraorbital horn cores, which seem to take their origin much farther back with relation to the orbit; by the concavity of the frontal region between the orbits; and, finally, by the peculiar form of the persistent postfrontal (pineal) fontanelle suggestive of that of the genus *Torosaurus*. The parietals are Triceratops-like except for the small fenestræ on either side of the median line, while the squamosals, aside from the unique fenestræ, differ from those of *Triceratops* in the conformation of the inferior border, which lacks the quadrate notch. Another distinctive feature is in the very erect position of the descending process of the jugal, which is directed slightly forward instead of downward and backward as in *Triceratops*.

[a] The writer is now firmly convinced that all of these apertures through the frill of *Diceratops* are pathologic, having been caused either by wounds or by disease (Am. Jour. Sci., 4th ser., vol. 20, pp. 419–422). Similar perforations occur in the right frontal of the type of *Triceratops serratus* (p. 124) and in the squamosal of that of *T. elatus* (p. 136). Mr. C. W. Gilmore, who prepared the type, is not sure of the parietal perforation, but as no bone adhered to the matrix at that point the opening was allowed to remain.

5. *Triceratops* (including *Sterrholophus*).—In *Triceratops* this phylum reaches its culmination in specialization and size, including some most formidable species.

The supraorbital horns reach their maximum development in *Triceratops*, while the nasal horn is in process of reduction and the broadly expanded frill, though not so large actually or relatively as that of *Torosaurus*, was much more efficient for protection because of its vastly greater strength.

The rostral bone is better developed than in *Diceratops*, being especially heavier in older individuals, and there is generally a sharp cutting edge on its inferior face. The nasal horn, while tending to reduce, is of moderate length in the more generalized species and is directed forward, so that its posterior face rises but little above the level of the upper surface of the nasal bones, in sharp contrast to that of *Monoclonius*. The nasal horn core is generally very rugose. The supraorbital horn cores are slender to robust, ovate in section as contrasted with the triangular cross section of the rudimentary horn cores in *Monoclonius* and the nearly circular section of those of *Diceratops*. In *Triceratops* the horn cores point upward and forward at an angle of 45°, whereas in *Diceratops* they are nearly erect. They range in length from short in *T. brevicornus* to very long in *T. calicornis*. The orbit is generally elliptical in shape with the long axis somewhat diagonal, running from above downward and forward, therein agreeing with *Diceratops* rather than with *Monoclonius*.

The parietals are convex laterally and somewhat concave along the long axis, much expanded posteriorly, but narrowing toward the forward end. They are thick along the more or less elevated and rugose middle line and around their posterior border, but very thin in the center of each side, though there are no traces of fontanelles. It is mainly in this last feature that the parietals differ from those of the other genera. The squamosals are stout and broad, constituting at least half of the area of the frill. The superior surface of the frill, and, in some aged individuals, the margin of the lower side as well, bears vascular impressions, showing it to have been sheathed in a horny covering. These impressions are much more pronounced than in either *Monoclonius* or *Centrosaurus*.

Hatcher has made no final disposition of the genus *Sterrholophus* either in his completed manuscript or in his notes, but one is justified in the assumption that he believed the genus to be synonymous with *Triceratops* on the ground that all of the distinctive features which would serve to separate the genera he considered as juvenile characteristics.

The type consists of disarticulated skull and other skeletal portions of an immature individual and differs from a typical specimen in the entire absence of vascular impressions from the frill. Those on the under surface are seen only in aged individuals, as in the type of *Triceratops prorsus* (Pl. XXXIII), and it may well be that their appearance on the superior surface of the skull is a strictly adult feature.

Another distinction between the skulls of *Triceratops horridus* and *Sterrholophus flabellatus* is shown in figs. 9 and 27, pages 18 and 30. In the former the olfactory foramina are paired, whereas in the latter there is but a single foramen. But, as Hatcher says, "it is probable that the median septum was present as cartilage and was lost in maceration. It is very unlikely that there was in any of these dinosaurs a single olfactory nerve." Another distinction between *Sterrholophus flabellatus* and some species of *Triceratops* is in the position of the lachrymal foramen, which is entirely within the maxillary, not as in other species between the maxillary and nasal. In this feature *Triceratops prorsus* agrees with *Sterrholophus flabellatus*, while in *T. serratus* the other condition obtains, *T. brevicornus* having the foramen between the nasals and maxillary but embraced by an ascending process of the maxillary in its anterior moiety, a condition transitional between that of the other two. This character can thus be considered of specific value only. It would therefore seem wise, in the light of our present knowledge, to consider the newer generic name *Sterrholophus* as a synonym of *Triceratops*.

The main skeletal comparisons between *Triceratops*, *Agathaumas*, and *Monoclonius* which it is possible to make lie in the sacrum and ilia, in which *Triceratops* shows a further advancement over *Agathaumas*. The general structure of the sacrum agrees with that of the latter in having ten vertebræ. Of these four bear sacral ribs, which coalesce to form the longitudinal bar for articulation with the ilium. The first pair of ribs agrees with those of both above-mentioned genera in springing from the point of articulation between vertebræ 2 and 3, bearing equally upon each, while the succeeding sacral ribs arising *behind* the articulation bear very little upon the preceding centrum at all. A reference to figs. 53 and 77 (pp. 52 and 75) and Pls. X and XXV (pp. 218 and 248) will make clear these comparisons and contrasts.

The ilium in *Triceratops* is broad and elongated, much expanded anteriorly and tapering to a somewhat thickened point behind, whereas in *Agathaumas* the posterior extremity is thin. The external border is thin and smooth in contrast to the variably thickened margin in the latter genus. The outline as viewed from above is less regular than in *Agathaumas*, which is due to a greater prominence of the deflected border above the ischiac peduncle. In *Triceratops* the internal margin is greatly thickened, forming the superior border of the acetabulum and strengthening the peduncles. Compare figs. 55, 61, and 82.

II. THE CERATOPS-TOROSAURUS PHYLUM.

Of the second phylum but two genera are as yet known, *Ceratops* and *Torosaurus*, agreeing in the possession of large, persistently open parietal fenestræ and in the general conformation of the squamosal, which, while not so saber-like in *Ceratops* as in *Torosaurus*, exhibits a strong tendency to become so, in sharp distinction with the short, broad, triangular squamosals of *Monoclonius*.

The members of this phylum also agree in the absence of separately ossified epoccipitals, the crenulated effect of the margin of the frill being produced by prominences which do not arise as separate ossifications. An exception to this is found in the type specimen of *Ceratops* (*Monoclonius*) *recurvicornis* Cope, referred to *Ceratops* by Hatcher but possibly representing a new genus, a member of the *Triceratops* phylum.

1. *Ceratops*, a Judith River genus, is known only from portions of the skull, no other skeletal elements having been discovered. Our knowledge of the nasal horn core is imperfect, as it is derived only from the specimen of *Ceratops recurvicornis* mentioned above. In this specimen the horn core is massive, compressed distally, and curves forward instead of backward, as in the contemporary genus *Monoclonius* (see fig. 3). Another isolated horn core, figured in Lambe's memoir (Pl. XVII, fig. 1=Pl. XVIII, fig. 1 of this monograph), was referred by that author with a query to *Monoclonius dawsoni* Lambe. Hatcher claims that it curves forward instead of backward, which would seem to place it in the genus under consideration, though under what species can not be determined.

The supraorbital horn cores show a greater degree of development than in *Monoclonius*, but are apparently still smaller and less massive than the nasal core. They are more nearly circular in cross section, being subtriangular near the base, and are curved forward and upward and, in one species, *C. montanus*, strongly outward (fig. 103).

The orbit is oval, with its long diameter nearly vertical as contrasted with the circular orbit of *Monoclonius* and the more nearly horizontal oval of *Torosaurus*.

The coalesced parietals are reduced to a slender, median bar, subcylindrical in mid-length, and narrow postero-lateral processes, which only partially surround the large elliptical fontanelles.

The squamosals, which overlap the outer portions of the parietals, are triangular and more elongate than in *Monoclonius*, tending toward the form of squamosal found in *Torosaurus*.

2. *Torosaurus*.—The proportions of the *Torosaurus* cranium at once separate it from that of any other genus, especially from its immediate contemporaries, for while in *Triceratops* the frill and facial region are well balanced, in *Torosaurus* the huge crest entirely overshadows the abbreviated anterior portion of the skull.

The nasal horn core in the type species is broad at the base and the sharp apex is directed upward and forward. The supraorbital horn cores are larger, as in all Laramie Ceratopsia, and ovate in basal section, with the broader end of the oval to the rear. The cores are directed upward, outward, and forward. Thus the nasal horn core is relatively smaller while the supraorbitals are larger than in *Ceratops*. The orbits are elliptical, with the long diameter more nearly horizontal than in other genera, and are placed farther forward relative to the position of the horns than in *Triceratops*, while the skull is broad and massive between them, narrowing very rapidly toward the snout. The skull is extremely broad in the region beneath the orbits, as the external surface slopes downward and outward as compared with the more nearly vertical sides of the skulls referable to the genus *Triceratops*. There is a large lachrymal foramen well in advance of the orbit.

The postfrontal fontanelle seems to have been paired, at least in *T. latus*, the type of *T. gladius* being too imperfect to permit one to judge. From this run two shallow grooves directed outward and backward, each ending in a small foramen. There are similar grooves in the type of *Diceratops*, and in the specimen (Nos. 1203 and 1206–1210, U. S. National Museum) referred by Marsh to *Triceratops sulcatus* (Pl. XXXVII, fig. 1) the grooves are present but as the posterior portion of the skull is broken away the terminal foramina can not be seen. In each of these forms, however, the postfrontal foramen is unpaired.

The parietals are broad and long, with large supratemporal fontanelles. The parietal fontanelles are not so large proportionately as in *Ceratops*, and the median bar is broad, thin, and smooth, especially toward its posterior end. The squamosals are very elongate and sword-like, readily derivable from such as are found in *Ceratops*. The quadratojugal notch is much less pronounced than in *Triceratops;* the groove for the quadrate being far in advance of its position in other genera. The posterior margin of the frill is emarginate, but there are no separately ossified epoccipitals as in *Triceratops*.

III. GENERA ELIMINATED OR REMOVED FROM THE CERATOPSIA.

The genera abandoned or removed from the Ceratopsia by Hatcher are named below:

1. *Claorhynchus* Cope, with its one species, *trihedrus*, founded upon a rostral and predentary bone, and now lost sight of, Hatcher supposes, from Cope's description, to pertain to the Trachodontidæ rather than to the Ceratopsia.

2. *Dysganus* Cope, with its four species, *D. encaustis*, *D. haydenianus*, *D. bicarinatus*, and *D. peiganus*, is abandoned on the ground that it was "based on teeth pertaining to two or more genera belonging in part to the Trachodontidæ and in part to the Ceratopsidæ." The type material was very imperfect and the descriptions were inexact and unaccompanied by figures, hence the genus should, in Hatcher's opinion, be considered a nomen nudum.

3. *Manospondylus* Cope, with its single species, *gigas*, is based upon the centrum of a single vertebra (fig. 105). From its general form, its coarsely cancellated internal structure, and the deep fossa of the superior lateral surface it resembles most closely the vertebræ of *Dryptosaurus*, a theropod dinosaur, hence one is justified in removing the genus in question from the Ceratopsia.

4. Another of Cope's genera, *Polyonax*, with the species *mortuarius*, erected upon "fragments of horn cores, vertebræ, etc.," is abandoned because of "the extremely fragmentary and totally inadequate nature of the material upon which the genus and species are based."

5. Finally, Lambe's genus *Stegoceras*, with its single species, *validus*, is based upon two cranial fragments (figs. 99 and 100 and Pl. XXII), which Lambe called "prenasals," but which Hatcher believed are the "superior portion of the occipital, parietal, and frontal segments of the skull" of a reptile which may represent an order new to science. He further adds that "there is no good reason for considering them as horn bearing or the animals to which they belonged as pertaining to the Ceratopsia." Hence Hatcher does not include the genus in that group.

6. *Sterrholophus* Marsh is considered synonymous with *Triceratops*, for the reasons already mentioned.

REVISION OF SPECIES.

I. THE MONOCLONIUS-TRICERATOPS PHYLUM.

MONOCLONIUS.

Of the seven species referred to the genus *Monoclonius* by their several authors, Hatcher retains but three, *M. crassus* Cope, *M. dawsoni* Lambe, and *M. sphenocerus* Cope. He abandons *M. fissus* Cope, because of insufficient type material, while the remaining three, *canadensis* Lambe, *recurvicornis* Cope, and *belli* Lambe, are removed to the genus *Ceratops*.

1. *Monoclonius crassus* Cope (pp. 71–80, figs. 75–88) is the type species and is known from the remains of at least two individuals (type No. 3998, American Museum of Natural History), including the parietals, the frontal and postfrontal bones, a supraorbital horn core, and other portions of the skeleton. Of this material only that pertaining to the skull can be used in specific contrast, for of the remaining species no skeletal parts are known.

The supraorbital horn core (fig. 76) is low, broad below, and pointed above, with a flat outer face and a strongly convex inner surface. The main point of contrast with that of *M. dawsoni* seems to be one of size, as in the latter the horn cores are extremely diminutive, so small, indeed, as to have been overlooked by so careful an observer as Lambe. The orbit is nearly circular, with a thick, rugose border.

The complete parietals (fig. 75) are known only in this species, though fragments of parietals included in the type specimen of *M. dawsoni* show no specific distinctions from those of the species under consideration.

As the parts preserved in *M. crassus* are unknown in *M. sphenocerus* one can not contrast them.

2. *Monoclonius dawsoni* Lambe (pp. 89–93, fig. 92) is known from cranial fragments of specimen No. 1173, Geological Survey, Canada. The second specimen, consisting of parietals and a nasal horn core (No. 971), referred to by Lambe in his original description, has been made the type of a new genus and species, *Centrosaurus apertus* Lambe, in a paper published[a] since Hatcher's death (see p. 93, footnote *b*).

The nasal horn core is large, somewhat compressed, backward curving, and ovate in section, with the broader end in front, differing materially in shape from that of *M. sphenocerus*. The supraorbital horns are described as very diminutive and triangular in section, as in *M. crassus*. About 1 inch of the apex is not preserved.

The parietals are known only from a fragment with four marginal undulations, as in *M. crassus*.

The orbit is large and circular. Both orbit and nasal horn core are very large in proportion to the occipital condyle, maxillaries, and quadrate. Hatcher was "inclined to regard the present species as closely allied to if not identical with *M. crassus* of Cope." Some of the remainder of the material provisionally associated with the type by Lambe, consisting of a sacrum, a scapula and coracoid, a predentary, and a rostral bone, may pertain to other genera and species.

3. *Monoclonius sphenocerus* Cope (pp. 87–88, fig. 91, A, B, C) consists of portions of premaxillary, nasals, and nasal horn of a large though scarcely adult animal. It is distinguished from *M. dawsoni* in the form of the nasal horn, which is much compressed, with the anterior margin acute and the posterior rounded, the reverse of that of the last-mentioned species. In *M. sphenocerus* the horn is straight and directed upward and backward instead of being curved backward, as in *M. dawsoni*. It is, as Hatcher says, the largest and most powerful nasal horn core observed in any of the Ceratopsidæ (fig. 91). Thus *M. sphenocerus* is in sharp contrast with *M. dawsoni*, and probably also with *M. crassus*, though a direct comparison with the latter can not be made. The nasal horn resembles most closely the one associated by Lambe with the parietals which constitute the type of his new genus *Centrosaurus*, and the true affinities of *M. sphenocerus* may prove to lie with that genus.

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[a] Ottawa Naturalist, vol. 18, 1904, pp. 81–84. This paper was issued July 7, four days after Hatcher's death.

CENTROSAURUS.

1. *Centrosaurus apertus* Lambe (p. 93, footnote *b;* fig. 93; Pl. XXIV) is based upon a parietal crest and an associated nasal horn core (No. 971, Canadian Geological Survey), and no specific distinctions need be reviewed.

AGATHAUMAS.

In the genus *Agathaumas* Hatcher retains but one species, *A. sylvestris* Cope, the other, *A. milo* Cope, having been referred later by its author to *Hadrosaurus occidentalis.* Hatcher sums the matter up by adding: "Whether or not this determination was correct the fact remains that *A. milo* is a nomen nudum, and the fragmentary nature of the type precludes adequate description. The species should therefore be discarded."

1. *Agathaumas sylvestris* Cope.—The characteristics of *Agathaumas sylvestris* (pp. 105–111, Pl. XXV) have been discussed under the generic summary.

DICERATOPS.

1. *Diceratops hatcheri* Lull.—This genus contains but one species, *D. hatcheri,* described but left unnamed by Mr. Hatcher, based upon skull No. 2412, U. S. National Museum (p. 149, Pls. XLVII and XLVIII). The specific characters need not be cited in this summary, but one species being thus far known.

TRICERATOPS.

The present writer recognizes ten species under the genus *Triceratops* Marsh, a number which he believes to be in harmony with Hatcher's views, though in the case of *T.* (*Sterrholophus*) *flabellatus* no final statement by Hatcher has been found.

These species are as follows:

1. *T.* (*Ceratops*) *horridus* Marsh.
2. *T. prorsus* Marsh.
3. *T. brevicornus* Hatcher.
4. *T. serratus* Marsh.
5. *T.* (*Bison, Ceratops*) *alticornis* Marsh.
6. *T. sulcatus* Marsh.
7. *T. elatus* Marsh.
8. *T. calicornis* Marsh.
9. *T.* (*Sterrholophus*) *flabellatus* Marsh.
10. *T. obtusus* Marsh.

Thus three species have been brought into the genus, two from *Ceratops* and the only species of *Sterrholophus,* which becomes synonymous with *Triceratops.* One species, *T. galeus* Marsh (p. 132, fig. 111), which was based upon a single horn core that resembles most the same structure in *Torosaurus gladius,* Hatcher decided to abandon on the ground of the fragmentary nature of the specimen.

1. *Triceratops horridus* Marsh (pp. 117–122, figs. 24, 25, 27, 107, Pl. XXVI), the type species, is based upon the imperfect skull of a huge individual, No. 1820, Yale Museum, fully adult and very old.

The rostral bone is very heavy, not so sharp along its inferior border as in some species, downward curved toward the tip, with deep vascular impressions.

The nasal horn core (Pl. XXVI) is very broad at the base, short and blunt in contrast to that of the most nearly allied species, *T. prorsus,* in the type of which the nasal horn is long and directed forward, and *T. brevicornus,* in which it is short and very stout but not highly rugose. This contrast is the more interesting because the types of all three species were aged individuals.

The supraorbital horns in *T. horridus* are exceedingly stout and rugose, long, and directed forward as in *T. prorsus,* in contrast to the extremely short horns of *T. brevicornus.* The great size of *T. horridus* as compared with either *T. prorsus* or *brevicornus* is an important distinction.

2. *Triceratops prorsus* Marsh (pp. 127–132, figs. 35, 37, 40, 41, 49–58, 63–67, 71, 109, 110, Pls. VI–XVII, XXX–XXXVI) is an example of the opposite extreme in size from *T. horridus,* the type skull, No. 1822, Yale Museum, that of an aged individual, being one of the smallest of the Laramie Ceratopsia.

The rostral bone is contrasted with that of *T. horridus* in being somewhat less massive and having a sharp cutting edge, as contrasted with the blunt margin in the other. The inferior margin curves downward toward the point, in agreement with *T. horridus* and *T. brevicornus.*

The nasal horn core is long and is directed forward, the anterior border extending forward and upward at an angle of 30° instead of being perpendicular to the long axis of the skull as in *T. horridus* and *T. brevicornus*. The horn much exceeds that of each of the contrasted species in length, the tip of the horn in the type specimen being just over that of the rostral bone (Pl. XXXIV).

The supraorbital horn cores are slender, and are directed upward, forward, and outward at an angle of 45° for about half their length, then curve gently inward. Here the contrast with the allied species is evident in the stoutness of the horns as compared with their slenderness in *T. prorsus*. The horns of *T. prorsus* are much longer proportionately than those of *T. brevicornus*.

The orbits in the present species are nearly circular as contrasted with the elliptical orbits of *brevicornus*. The form of those of *T. horridus* can not be ascertained, as but a quarter of the margin is preserved, but they would seem to agree more nearly with those of *T. prorsus*.

The lachrymal foramen is entirely within the maxillary bone, as in *T.* (*Sterrholophus*) *flabellatus*, in contrast to its position between the maxillary and nasal as in *T. serratus*, *T. brevicornus* being in a sense transitional between the two types, while the condition which obtained in *T. horridus* can not be determined, as this part of the specimen is lacking.

The frill is deeply arched transversely, ranging through an arc of 27°, with seven lateral and one median epoccipitals, making fifteen in all. The quadratojugal notch is deeper than in any other known species, and the postfrontal (pineal) fontanelle is entirely closed. Posteriorly the frill border was free, for vascular impressions occur on its inferior face for a distance inward of 20 cm. from the margin. This feature, together with the closure of the postfrontal fontanelle, may be a characteristic of old age, but in some old skulls of other species the fontanelle seems to be persistently open.

3. *Triceratops brevicornus* Hatcher (pp. 141-142, Pls. XL–XLII) presents another instance of an aged individual, the type being No. 1834 of Yale Museum.

The rostral bone is proportionately very heavy, with a deeply excavated inferior surface. The nasal horn core is short and very stout, the antero-posterior diameter much longer than the transverse, and the anterior border vertical, as in *T. horridus*.

The supraorbital horn cores are short and stout and, in contrast to the much longer cores of *horridus* and *prorsus*, more nearly circular in section than in any other species.

The orbit is an irregular ellipse, and the lachrymal foramen lies between the nasal and maxillary bones, but is partially embraced by an ascending process of the latter.

The infratemporal arcade is formed from the quadrate, with overlapping processes from the jugal and squamosal, as in *T. serratus*. The frill is elevated somewhat sharply toward the posterior margin, as in *T. prorsus*, and bears nineteen epoccipitals, six pairs of which are borne on the squamosals, as contrasted with fifteen in the last-named species. It is doubtful whether or no this will prove a specific rather than an individual distinction (Hatcher).

4. *Triceratops serratus* Marsh (pp. 122-127, figs. 16, 26, 32, 34, 42, Pls. XXVII–XXIX) is founded upon the skull of an immature individual (No. 1823, Yale Museum), but one in a remarkable state of preservation.

The rostral bone is rather small, lighter and less rugose than in other species; this, however, may be either a juvenile or possibly a sexual character.

The nasal horn core is wanting in the type, having been lost at the suture between it and the nasals. It must, however, have been considerably compressed transversely.

The supraorbital horn cores are slender and much more erect than in most species, somewhat elliptical in section at the base and more nearly circular in their mid-length.

The orbit is large and irregularly elliptical in outline, its long axis running obliquely downward and forward. The position of the orbit is in advance of and superior to that of *T.* (*Sterrholophus*) *flabellatus*.

The lachrymal foramen lies between the nasal and maxillary, as in the last-mentioned species.

The general form of the skull is long and low, the frill, which is twice as broad as long, being but little elevated behind, in contrast to most of the other species except *flabellatus*.

The median ridge of the parietal region is elevated and bears four rugose prominences, wherein *T. serratus* differs from *flabellatus* and *elatus*, but agrees with *prorsus* and *brevicornus*.

The number of epoccipitals is seventeen, five pairs being borne on the squamosals. In this, as in other features, the type specimen agrees with No. 970 of the American Museum, a much larger though still immature skull which the present writer[a] has referred to the same species.

5. *Triceratops* (*Bison, Ceratops*) *alticornis* Marsh (pp. 115–116, fig. 106) is known only from a pair of remarkable supraorbital horn cores (No. 1871E, U. S. National Museum), first referred by Marsh to *Bison* and later to *Ceratops*. Hatcher has removed the species to the present genus for reasons which are at once evident when one contrasts the generic characters of *Ceratops* and *Triceratops*, especially with reference to the relative development of the elements represented by the type.

The supraorbital horn cores are long, with slender-pointed ends, curving forward and outward, then upward.

These horn cores resemble possibly those of *serratus* more than any other species and represent the most highly specialized type within the genus. The frontal region is broad, somewhat convex, and very rugose.

6. *Triceratops sulcatus* Marsh (pp. 133–134, figs. 112, 113, Pl. XXXVII) is based upon some skull and skeletal fragments (No. 4276, U. S. National Museum) of a very large, fully adult animal.

In the original description Marsh describes a deep groove on the posterior surface of the upper half of the supraorbital horn core. Unfortunately but one horn core is now available, and it is incomplete, evidently having been broken off and healed over during the life of the individual. This core does not show the distinctive groove, and Hatcher is inclined to give the presence or absence of the groove but little specific weight.

The horn was ovate in cross section and as preserved shows no distinctive characters. This is also true of the humerus and vertebræ which are preserved.

On the whole there seem to be no characters in the fragmentary material representing the type which afford a basis for a true specific diagnosis. It would be well, therefore, to await the discovery of additional material before deciding as to the validity of this species.

7. *Triceratops elatus* Marsh (pp. 134–138, Pl. XLIII) is based upon a scarcely adult specimen of large size (No. 1201, U. S. National Museum). The rostral bone is of moderate size and is not coossified with the premaxillaries, the upper branch being free.

The nasal horn core is short and stout, its posterior border not being continuous with the upper surface of the nasals as in most species. The apex rises but little above the superior border of the nasals. Another skull (No. 4805, U. S. National Museum) has a horn intermediate between that of the type and that of *T. calicornis*, evidently the nearest ally to the species under discussion.

The supraorbital horn cores are long and massive, curving strongly forward as in *T. calicornis*, much compressed laterally except toward the apex, where they become nearly circular.

The orbit is large, elliptical, with a somewhat oblique axis.

The inferior process of the jugal is directed downward and backward at an angle of 45°, in contrast to other species, wherein it is more nearly vertical.

The frill is much elevated toward its posterior margin and differs from that of other species in the absence of undulations along the margin of the squamosal, this bone being rather sharp edged and regular in outline. Epoccipitals were borne on the parietals and the posterior half of the squamosals only. The number of epoccipitals was fourteen, four pairs on the squamosals and six on the parietals, without the usual median one.

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[a] Bull. Am. Mus. Nat. Hist., vol. 19, pp. 685–695, Pl. LIX.

8. *Triceratops calicornis* Marsh (pp. 138–139, Pls. XXXVIII–XL) is based upon a large but immature skull, jaw, dorsal vertebræ, ribs, pelvis, sacrum, etc. (No. 4928, U. S. National Museum).

The specific affinities would seem to be with the preceding species, *T. elatus,* from the similarity of both nasal and supraorbital horns and of the frills. The main distinctions lie in the proportions of the skull of the present species, as the premaxillaries are here much longer and the rostral bone larger, with a much fuller anterior curve, thus making that portion of the skull in advance of the nasal horn proportionately much more pronounced.

The nasal horn core is low, almost vertical, convex in front and concave behind. *T. calicornis* agrees with *T. elatus* in having the small nasal horn core sharply marked off from the nasals, not apparently continuous with them as in most species.

The descending process of the jugal differs from that of *T. elatus* in being more nearly vertical, as in other species. This may, however, as Hatcher says, be due to difference of pressure in the two types.

The frill is only in part preserved, but the squamosals are almost entire. They agree with those of *T. elatus* in lacking marginal undulations and apparently bore but three or four epoccipitals on the posterior portion, which are not ankylosed. The squamosals are longer and narrower, a fact which aids in giving to the entire skull a greater proportionate length than that of *T. elatus.* The lachrymal foramen is between the nasal and maxillary in both species, thus agreeing with *serratus* and *flabellatus.* Hatcher expresses the opinion that *T. elatus* and *T. calicornis* may prove synonymous.

9. *Triceratops* (= *Sterrholophus*) *flabellatus* Marsh (pp. 143–148, figs. 6, 8–11, 15, 17–23, 28, 31, 33, 36, 38, 39, 43, 44, 60–62, Pls. XLIV–XLVI) is known from the nearly complete though disarticulated skull of a very young individual (No. 1821, Yale Museum). This species Marsh made the type of a new genus, *Sterrholophus,* because of the character of the frill, but, as shown above (p. 164), the peculiar absence of vascular impressions from the latter may be considered an adolescent character, which may also be said of each presumably generic feature exhibited by the skull.

The nasals are massive, but not yet coossified, nor was the nasal horn core ankylosed, so that this important feature is lacking.

The supraorbital horn cores are rather long, laterally compressed near the base but more nearly circular in section toward the summit. They are inclined forward and outward at a less angle than in other species.

The orbit is elliptical and the lachrymal foramen lies entirely within the maxillary bone as in *T. prorsus.*

The long axis of the frill exhibits less of an upward curve than in other species except *T. serratus.*

The squamosals are rather short and broad, as in *T. serratus,* though the entire frill viewed from above is proportionately much narrower because it is more highly arched.

T. flabellatus bore upon its frill the maximum number of epoccipitals known, nineteen, of which six pairs are attached to the squamosals, the remaining seven upon the coalesced parietals.

10. *Triceratops obtusus* Marsh (pp. 140–141, figs. 116, 117) is known from portions of a skull (No. 4720, U. S. National Museum) representing a large, adult animal.

The nasals are very broad and the nasal horn core is reduced to a broad, rounded, rugose prominence marked with a number of deep vascular grooves.

The dentary is described as exceptionally deep and massive, and the teeth are unusually large. The extreme forward extension of the mandibular fossa seen here is exceptional among Ceratopsia.

RELATIONSHIP OF SPECIES.

If one were to group the species of *Triceratops* according to affinities the result would be expressed something as follows:

Group 1.	Group 2.
T. horridus.	*T. elatus.*
T. prorsus.	*T. calicornis.*
T. brevicornus.	

T. serratus and *T. flabellatus* would each stand alone, although in some features they suggest each other.

Of the species *alticornis, sulcatus,* and *obtusus* the skulls are too fragmentary for a fair comparison. *T. obtusus,* because of its greatly reduced nasal horn, and *alticornis,* from the development of the long, slender supraorbitals, seem to be the most specialized.

II. THE CERATOPS-TOROSAURUS PHYLUM.

CERATOPS.

Of the four species mentioned under this genus in the alphabetical list on pages 11–12, two, *C.* (*Bison*) *alticornis* and *C. horridus,* have been removed to the genus *Triceratops,* with which their affinities clearly lie, and one, *C.* (*Hadrosaurus*) *paucidens* (pp. 103–104), is of questionable validity, for, as Hatcher says:

> It is not at all unlikely that the type of the present species [a maxillary and premaxillary] pertained to one of the several species of Ceratopsidæ already described as from the Judith River beds. Since, however, the teeth, the maxillaries, and the premaxillaries of all these are imperfectly known, it is at present impossible to determine to which of them this specimen should be referred.

Thus there remains of the original four but one, the type species *C. montanus,* to which Hatcher has added three which he removed from the genus *Monoclonius.*

The list of species as revised by Hatcher is as follows:

1. *Ceratops montanus* Marsh. Type.
2. *Ceratops canadensis* Lambe.
3. *Ceratops recurvicornis*[a] Cope.
4. *Ceratops belli* Lambe.

1. *Ceratops montanus* Marsh (pp. 100–102, figs. 103 and 104), the type species, is based upon an occipital condyle and a pair of supraorbital horn cores, No. 2411, National Museum.

The supraorbital horn cores were of moderate length, subtriangular in section at the base, but nearly circular in the upper half. They are not compressed, but curve strongly outward and slightly forward. The frill is unfortunately unknown in the type species.

2. *Ceratops* (*Monoclonius*) *canadensis* Lambe (pp. 93–96, figs. 96, 97, Pls. XVIII, XIX, XXIII) is known from portions of a skull and an anterior dorsal (No. 1254 a, b, c, d, e of the Canadian Geological Survey). Hatcher removed this species from the genus *Monoclonius* because of the similarity of the supraorbital horn core with that of the type species of the present genus. He does not, however, give us his final decision as to whether it is to be considered specifically distinct from *C. montanus* or not, as that point was left for the present discussion, which Hatcher unfortunately did not live to undertake.

The only distinction must lie in the character of the supraorbital horn cores, which, although Hatcher considers them "essentially the same," seem to differ in that the base is subtriangular in section in *C. montanus* and circular in *C. canadensis.* Another distinction lies in the curvature of the horn. In *canadensis* the horns curve well forward, then upward, but in *montanus* they are more nearly straight and, if Hatcher's arrangement expressed in fig. 103 is correct, flare outward strongly in a most peculiar manner.

The nasal horn core was lost before fossilization, as the creature was young, so that its characters can not be determined.

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[a] The present writer questions the reference of *recurvicornis* to this series for the reasons given on page 173.

The squamosal is somewhat triangular, flat, and moderately thin, the outer edge rounded and wavy in outline. One can not contrast it with those of the other species, for with them the element is unknown. (Pl. XXIII.)

All that is preserved of the parietals is a slender bar, triangular in section, which formed the external boundary of the parietal fontanelle. This outer bar is very similar to that of *Torosaurus gladius*.

Hatcher says with reference to this species:

I have little hesitancy in asserting that the squamosal and frontal horn cores of the present species were associated with a parietal of the same general type as that described by Lambe and referred to *Monoclonius belli*, and I am of the opinion that the two may be specifically identical, although from the material at hand it is impossible to determine this point with certainty.

3. *Ceratops* (*Monoclonius*) *belli* Lambe (pp. 96–97, fig. 98, Pl. XXI) is founded upon a pair of parietal bones (No. 491, Canadian Geol. Survey).

The species was described as *Monoclonius* by Lambe, but was removed to the present genus by Hatcher, for, as he says:

After a careful study of the type of the present species, together with that of *M. canadensis* Lambe, one can not avoid being convinced as to their generic identity with *Ceratops montanus* Marsh, while at the same time the great dissimilarity shown in the parietals and squamosals of these species when compared with the same elements in *Monoclonius dawsoni* Lambe affords evidence additional to that already pointed out as obtaining in the frontal horn cores, in favor of the generic distinction of the three former species from that of the last-mentioned species.

The character of these parietals has already been sufficiently discussed, especially since a specific comparison can not be made, as the elements are unknown elsewhere in the genus except for the outer parietal bar of the type of *canadensis*.

The material now available affords scant ground for specific distinctions between *C. montanus*, *C. canadensis*, and *C. belli*, and future discoveries may show that these are synonymous.

INCERTÆ SEDIS.

4. *Ceratops* (*Monoclonius*) *recurvicornis* Cope (pp. 81–87, fig. 90) is based upon fragments of the skull of a young individual (No. 3999, American Museum of Natural History).

Nasal horn core massive, curving strongly forward, heavier than the supraorbitals and much more compressed distally. The nasal bones narrow rapidly anteriorly, so as to appear wedge shaped when viewed from above.

The supraorbital horn cores are short, stout, abruptly pointed, and compressed at the subtriangular apex. The horns are straight, almost erect, in sharp contrast with those of other *Ceratops* species, and are relatively much smaller, though they show a decided advance over those of *Monoclonius*. There seems to have been a lesser horn core just in front of the supraorbital horn, subtriangular in cross section and directed forward. This feature is unknown elsewhere.

The squamosal is stout and of considerable size, with no vascular grooves, evidently a juvenile character, and the edge bears prominences which in turn bear epoccipitals separated by sutures from the squamosal bone.

This species has been removed by Hatcher from the genus *Monoclonius* mainly because of the supraorbital horn cores, which resemble those of *Ceratops montanus* much more than those of *Monoclonius crassus*. The squamosal is so different from that of the type species *M. crassus* that, when taken into consideration with the structural differences found in other portions of the skull, especially the horn cores, Hatcher does not hesitate to refer it to the genus *Ceratops*.

The presence of separately ossified epoccipital bones in this species, which do not seem to occur elsewhere either in the genus or phylum, together with the size, which is decidedly greater than that of most of its contemporaries, added to the differences between the supraorbital horn cores and those of other members of the genus *Ceratops*, leads the present writer to doubt the correctness of Hatcher's conclusions in the matter. It should doubtless be removed from *Monoclonius*, but it seems rather to represent a new genus in the *Triceratops* phylum. In the light of our present knowledge, however, this matter can not be settled.

TOROSAURUS.

1. *Torosaurus latus* Marsh (pp. 150-152, fig. 118) is based upon a specimen (No. 1830, Yale Museum) consisting of an incomplete skull of an aged individual.

Nasal horn core broad at base, sharp above, directed upward and forward. Supraorbital horn cores much compressed, ovate, with apex forward. Horn cores directed upward and outward and forward.

Supratemporal fossæ relatively larger than in *T. gladius.*

Skull broad and massive between the orbits. Parietal fontanelles not entirely within the parietals, in contrast to those of *T. gladius.* Hatcher says that he can not verify this feature in *latus.*

The postfrontal fontanelle paired, as opposed to single median one in *T. gladius.*

2. *Torosaurus gladius* Marsh (pp. 152-155, figs. 7, 12, 14, and 119) is based upon a type specimen (No. 1831, Yale Museum) consisting of detached portions of a skull.

Nasal horn core very short, stout, compressed, with a sharp apex. It is very rugose, the section being an oval with the rounded portion in front.

The supraorbital horn cores are rather long, slender, somewhat compressed laterally, and very rugose. They were directed forward and outward.

The postfrontal fontanelle seems to have been single, as opposed to the paired ones in *T. latus,* but the broken condition of the skull in this region leaves this point somewhat in doubt.

The supratemporal fossæ are proportionately smaller than in *T. latus,* and the fontanelles are entirely surrounded by the parietal bones.

Hatcher says: "The type of the present species represents the extreme development of the form of parietal crest that is peculiar to this genus," though *T. gladius* is geologically the older of the two species.

GEOLOGY AND PHYSIOGRAPHY OF THE VARIOUS CERATOPSIA LOCALITIES.[a]

The remains of Ceratopsia, though referred by various authors to each of several horizons, are referable either to the Judith River of Montana and its equivalent, the Belly River of Canada, or to the Laramie of Wyoming and Montana and the Denver and Arapahoe formations of Colorado.

The principal geographical localities, as well as one or two minor places from which Ceratopsia remains have been reported, are shown on the accompanying map (Pl. L).

The vertical range of the Ceratopsia is limited to the upper half of the upper Cretaceous.

JUDITH RIVER LOCALITIES OF MONTANA.

CORRELATION.

The conclusions reached by Messrs. T. W. Stanton and J. B. Hatcher[b] concerning the stratigraphic position of the Judith River beds and their correlation with the Belly River formation are of prime importance in considering the phylogeny of the Ceratopsia. These general conclusions, based upon a careful resurvey of the upper Cretaceous formations in Montana and the adjacent parts of Canada having special bearing upon the problems in hand, are as follows:

1. The Judith River beds are distinctly older than the Laramie, being separated from the latter by at least several hundred feet of marine shales, identical in their faunal and lithologic features with the Pierre, to which we have given the local name of Bearpaw shales, from the Bearpaw Mountains, about which they are well exposed.

2. The Belly River beds of Canada are identical with the Judith River beds of Montana. The name Judith River beds having priority should be the accepted name for this formation, and the terms Belly River and Fish Creek beds should be dropped.

3. The marine sandstones and shales immediately underlying the Judith River beds do not represent either the Benton, as some Canadian geologists have supposed, or the Fox Hills and upper Pierre, as most geologists of the United States who

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[a] Based upon the writings of Hatcher, Stanton, Lambe, Eldridge, Cross, and upon the writer's own explorations.

[b] Geology and paleontology of the Judith River beds: Bull. U. S. Geol. Survey No. 257, p. 66, 1905.

have examined them have believed, but they constitute a distinct horizon within the Montana group, which we have called the Claggett formation, from old Fort Claggett, at the mouth of the Judith River, near which they are well developed.

4. The Eagle formation, from its stratigraphic position and faunal relations, marks the base of the Montana group in this region.

5. The Bearpaw shales, the Judith River beds, the Claggett, and the Eagle formations all belong to the Montana group, and together probably form the equivalent of the Pierre, as that term is generally understood, though the possibility is recognized that in the typical area the Pierre may have more restricted limits.

The following correlations are shown:[a]

Sections in South Dakota, Montana, and Assiniboia.

	South Dakota section.	Central and northern Montana section.	Southern Assiniboia section.
	Laramie.	Laramie?	Laramie?
Montana group.	Fox Hills.	Fox Hills?	Fox Hills?
	Pierre.	Bearpaw. Judith River. Claggett. Eagle.	Bearpaw. Belly River (Judith River). Claggett. (?)
Colorado group.	Niobrara. Benton.	 Benton.	 (?)
	Dakota.	Dakota?	(?)

The Montana and Colorado groups are generally recognized as larger subdivisions of the strata lying between the Dakota and the Laramie. The South Dakota and Nebraska section is the Meek and Hayden section with the Laramie added, while the other two columns represent the sections studied by us [Stanton and Hatcher]. The queries in the lower part of the columns indicate formations not seen by us, and the queries in the upper part of the columns indicate our doubts as to the correlation of any particular horizon in these sections with the Fox Hills and as to the limits of the Laramie and its relationship with overlying formations that have been described in this region.

DOG CREEK.

The first Judith River locality mentioned by Stanton and Hatcher is at Dog Creek, a small stream emptying into the Missouri from the south, about 2 miles below the mouth of Judith River. This creek rises in the Moccasin Mountains and flows for 25 or 30 miles northward, first in a narrow and shallow valley, through grass-covered table-lands, and for the last 12 or 15 miles through a deep, rugged canyon, with wild, deeply dissected badlands on either side.

The walls of the upper valley are composed of Judith River sandstones and shales; those of the deeper lower canyon are mainly the light ash-colored sandstones and darker shales and clays of the Judith River beds above and "the darker buff-colored sandstones and dark sandy or black clay shales of the underlying Claggett formation" below.

For 5 to 8 miles from the mouth of Dog Creek the beds in the bluffs of the stream are undisturbed, and in this stretch the Claggett underlies 300 or 400 feet of Judith River formation.

A little farther up Dog Creek, in undisturbed areas, the Claggett formation disappears beneath the bed of the stream, and the bluffs of the canyon are formed entirely of the Judith River beds, which have a maximum thickness here of perhaps 500 feet and are composed below of alternating layers of light, ash-colored sandstones and darker shales, abounding in numerous fresh-water Mollusca.[b]

[a] Loc. cit., p. 63.

[b] Stanton and Hatcher, op. cit., pp. 37–38.

Among the ceratopsian remains mentioned are those of *Ceratops* and *Monoclonius*, and it was here, or in this vicinity, that type material referred to *Ceratops paucidens* Marsh was found, the exact locality being—

on the western slope, very near the summit, of a rounded badland hill about 20 rods east of the spring situated about one-quarter of a mile east of the freight road running from Judith to Maiden, Mont., * * * about 12 miles from Judith post-office, on the Missouri River. [See this monograph, p. 103.]

The type of *Ceratops* (*Monoclonius*) *recurvicornis* Cope was found in a bluff on the north side of Missouri River nearly opposite the mouth of Dog Creek, in Montana. According to Cope the geological horizon was near the base of the Judith River beds as these are represented in this locality.

BIRCH CREEK.

Birch Creek rises in the Bearpaw Mountains and flows southward, emptying into the Missouri River nearly opposite the mouth of Dog Creek. The walls of the canyon of Birch Creek are composed of Judith River and underlying formations, while the hills on either side of the

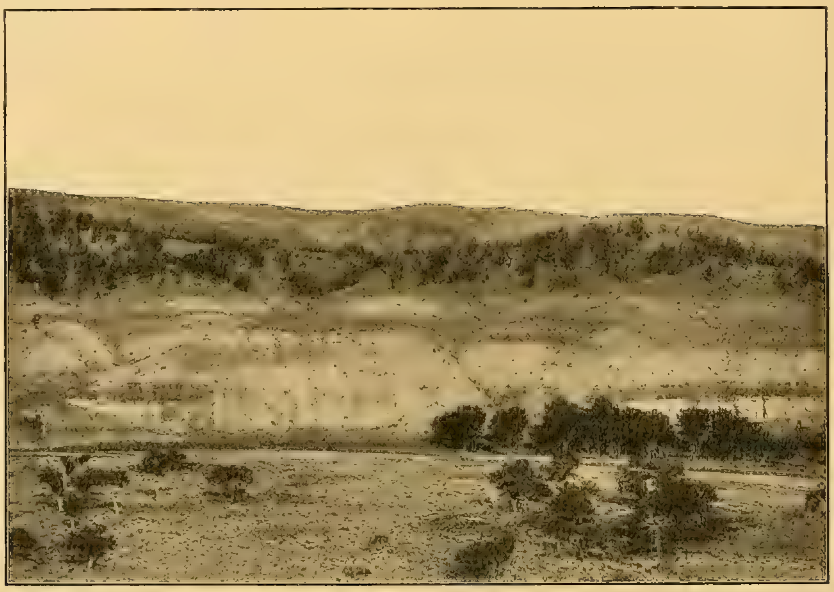

Fig. 121.—Undisturbed Judith River beds, with overlying Bearpaw shales, on Cow Creek, Montana. After Stanton and Hatcher. The contact is below the pine trees on ridge in middle distance.

canyon are formed of the Bearpaw shales. It was from the sandstones near the base of the Judith River beds near the mouth of Birch Creek that Professor Cope, in 1876, secured the type of *Monoclonius crassus*.

The type of *Monoclonius sphenocerus* Cope was found by Charles H. Sternberg on the Missouri River near Cow Island, Montana; level not recorded.

COW CREEK.

Cow Creek, which yielded the type of *Ceratops montanus* Marsh, flows south from the Bearpaw Mountains, emptying into the Missouri about 30 miles below Judith post-office.

Cow Creek flows in a deep, rugged canyon from a place a short distance below the point where it leaves the Bearpaw Mountains to its confluence with the Missouri. * * * The bluffs on both sides of Cow Creek for several miles above its mouth are made up largely of rocks belonging to the Claggett formation, overlain by the lighter colored materials of the Judith River beds.

These exposures are similar to those of the same formations on Dog and Birch creeks, and frequent faulting exposes here and there the underlying Eagle sandstones and Benton shales.

About 10 miles above the mouth of Cow Creek, at the point where the old Fort Benton and Cow Island freight road leaves the creek and turns westward toward the Bearpaw Mountains, there is a conspicuous fault in the Judith River beds. Immediately south of the fault * * * a prominent ridge composed of sediments belonging to the Judith River beds projects into the valley of the creek. The type of *Ceratops montanus* [pp. 100-102] was obtained near the summit of this ridge.

Accompanying *Ceratops montanus* were *Trachodon mirabilis*, crocodiles, fishes, turtles, and a number of fresh-water invertebrates.

JUDITH RIVER (BELLY RIVER) LOCALITIES IN CANADA.

It is to the explorations and consequent publications by Mr. L. M. Lambe, vertebrate paleontologist to the Geological Survey of Canada, that we are indebted for a considerable enriching of our knowledge concerning the earlier Ceratopsia.

FIG. 122.—View of the west side of the valley of Red Deer River, Alberta, showing the lower Belly River beds. After Lambe.

Stanton and Hatcher, in speaking of the Belly River exposures, say:

The exposures examined by us in Canada are all in the southeastern portion of the large, continuous area of Belly River beds mapped by Dawson, McConnell, and Tyrrell. They include both the top and bottom of the formation, as well as good exposures of the overlying and underlying beds, and hence give a fair idea of the formation as described by Dawson. The principal localities that have yielded the Belly River vertebrate fossils described by Lambe are on Red Deer River some distance north of the most northern point visited by us, but we have no doubt that they are on the same horizons which we studied.

The genera and species of Ceratopsia described by Lambe were collected from the Judith River (Belly River) beds in the Red Deer River district of Alberta, in the summers of 1897, 1898, and 1901. Mr. Lambe says of these explorations:[a]

In 1897 the writer descended the Red Deer River, starting from the village of Red Deer (in Alberta), and made collections from the Edmonton subdivision of the Laramie, between Red Deer village and Willow Creek, and from the Belly River series between Bull Pound Creek and Dead Lodge Canyon.

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[a] Contr. Canadian Pal., vol. 3 (quarto), pt. 2, p. 25.

He says, further:

In this year, however, it was found that the best results were obtained in the Belly River series in the vicinity of Berry Creek. Accordingly this locality was revisited in 1898 and again in 1901 and collections made from the Belly River series only, in an extensive area of "badlands" on either side of Red Deer River between Berry Creek and Dead Lodge Canyon.

This locality is in Alberta, just west of the border between that Province and Assiniboia. In speaking of the Belly River series Dr. G. M. Dawson[a] says:

In the region of the Bow and Belly rivers the Pierre is underlaid by an extensive fresh and brackish water series, consisting of sandy argillites and sandstones; the upper portion is characteristically pale in tint, the lower generally darker and yellowish or brownish. This has been called the Belly River series and appears to correspond precisely to that occupying a similar stratigraphical position on the Peace River and there designated the Dunvegan series. These indicate the existence of a prolonged interval in the western Cretaceous area, in which the sea was more or less excluded from the region and its place occupied for long periods by lagoons or fresh-water lakes.

FIG. 123.—View in the valley of Red Deer River, Alberta, upper (primitive mammal) Belly River beds, on east side of the stream south of Berry Creek. After Lambe.

Mr. Lambe, in a letter to the writer dated May 30, 1905, writes:

All my specimens are from near the mouth of Berry Creek, on the Red Deer River, and the rocks there exposed, I was of the opinion, belonged to the upper or "pale" portion (of Doctor Dawson). * * * On either side of the Red Deer River below the mouth of Berry Creek there is an area of "badlands" about 6 to 8 miles, roughly, in diameter. * * * I camped on the river bank on both sides and obtained all the types in this area.

In this upper half of the series there is a great similarity in the beds all through, but for convenience of reference in my field notes I refer to further subdivisions which I have named *lower, middle*, and *upper* (primitive mammal) beds. The upper photograph in my memoir,[b] facing page 25 [fig. 122], shows a characteristic view of the lower beds. The other, the lower photograph [fig. 123], is taken from the level of the upper or primitive mammal beds which at this locality [Red Deer River, at and below mouth of Berry Creek] apparently reach the prairie level, which is seen in the photograph as the distant horizontal line. It is from this upper level that I obtained the type of *Ptilodus primævus*.

[a] Descriptive sketch of the physical geography and geology of the Dominion of Canada, by A. R. C. Selwyn and G. M. Dawson, Montreal, 1884, p. 40.

[b] Contr. Canadian Pal., vol. 3 (quarto), pt. 2.

The specimens representing the species of Ceratopsia may be placed with regard to their horizons as follows:

Cat. No. 971, *Centrosaurus apertus*	Lower beds.
Cat. No. 1254, *Monoclonius canadensis*	Lower beds.
Cat. No. 1173, *Monoclonius dawsoni*	Middle beds.
(These beds should possibly be included with the upper beds.)	
Cat. No. 491, *Monoclonius belli*	Upper beds.
Cat. Nos. 515, 1423, etc., *Stegoceras validus*	Upper beds.

The types, as regards their geographical position, are as follows:

971 (*Centrosaurus apertus*). West side of Red Deer River, July 26, 1901. Not far from it were remains of *Trionyx foveatus*, Leidy.

1254a, etc. (*Monoclonius canadensis*). East side of Red Deer River, August 2, 3, and 20, 1901. At same level and near remains of *Trachodon*.

1173 (*Monoclonius dawsoni*). East side Red Deer River, August 15, 1901.

491 (*Monoclonius belli*). East side Red Deer River, below the mouth of Berry Creek, August 13, 1898. Not far distant and at the same level were found remains of *Trachodon*, *Cimoliasaurus*, and turtles.

515 (*Stegoceras validus*). East side Red Deer River, below the mouth of Berry Creek, August 15, 1898; 1423, east side, August 24, 1901. At about the same level as *M. belli*, *Ornithomimus altus*, *Adocus variolosus*, *Baëna antiqua*, *Trionyx foveatus*, etc., *Ptilodus primævus*, *Myledaphus bipartites*, *Lepidotus occidentalis*, *Diphyodus longirostris*, etc.

There seem to be no very distinct lithological differences on which to base these subdivisions of the Red Deer River rocks, but the lowermost beds seen in the area below the mouth of Berry Creek include some yellowish sandstones, which may be the uppermost beds of Doctor Dawson's lower yellow portion.

LOCALITIES FOR LARAMIE CERATOPSIA.

The main localities for Laramie Ceratopsia are three in number—one near Black Buttes station on the Union Pacific Railroad, in southwestern Wyoming; a second, by far the most notable, in the northeastern part of Converse County, Wyo., in the area shown on the map (Pl. LI), and a third in the canyon of Hell Creek, Montana, a tributary of the Missouri, about 135 miles northwest of Miles City.

THE BLACK BUTTES, WYOMING, LOCALITY.

The Black Buttes locality is interesting historically as having produced one of the first specimens of ceratopsians, the type specimen of *Agathaumas sylvestris* Cope. It lies in Sweetwater County, in southwestern Wyoming, not far from Black Buttes station on the Union Pacific Railroad.

Stanton and Knowlton[a] describe this locality as follows:

> The most prominent feature of the section at Black Buttes is the massive bed of sandstone, somewhat over 100 feet thick at the base of the exposure, forming steep hills and cliffs northeast of the railroad opposite the station and passing beneath the surface by its dip of 9° or 10° near the coal mine. * * * The original specimen of *Agathaumas sylvestris* was found about 20 feet above it.

The bones were found, according to Cope, in a bed of sandstone that lies just above the lower stratum of the Bitter Creek series of coals and is overlain by two other coal seams. This bed of sandstone "crops out high on the bluffs" a half mile east of the station.

From the molluscan fauna it is judged that the beds below and above the dinosaur bed consisted mainly of deposits from brackish water, with alternations of fresh-water deposits and of coal seams, probably implying coastal swamps with abundant vegetation in which frequent slight changes of level occurred, bringing in brackish waters during periods of subsidence and fresh waters during periods of elevation. This would produce physical conditions in keeping with our conception of the environment of the Ceratopsia. (See p. 194.)

THE CONVERSE COUNTY, WYO., LOCALITY.

The history of the discovery by Mr. Hatcher of this, the most important Ceratopsia locality, has already been stated (pp. 7–9), and a description of the location and character of the deposits is given in an earlier paper by Hatcher (Am. Jour. Sci., 3d ser., vol. 45, Feb., 1893, pp. 135–144), from which I shall quote at length. The beds were reached by Hatcher by going north from the town of Lusk, Wyo., on the Fremont, Elkhorn and Missouri Valley Railroad; now they

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[a] Bull. Geol. Soc. America, vol. 8, p. 143. (See also pp. 105–106.)

are more readily accessible from Edgemont, S. Dak., on the Burlington and Missouri division of the Chicago, Burlington and Quincy. The Ceratops beds first appear about 25 miles north of Lusk—

occupying the summit and northern slope of a yellow sandstone ridge extending in a westerly direction from Buck Creek to Lance Creek and crossing the latter stream near the mouth of Little Lightning Creek, a small tributary from the west. A short distance west of Lance Creek the Ceratops beds pass under other beds composed of very similar material and presumably of Cretaceous age. From Buck Creek the eastern border of the Ceratops beds has been traced in an almost continuous exposure extending northeastward to the Cheyenne River and crossing this stream a short distance below the mouth of Lance Creek. From this point it takes a more northerly direction and, skirting the western slope of the Black Hills, it has been traced to the north line of Converse County and on into Weston County. * * * The Ceratops beds were originally confined to the western slope of the Black Hills and of the less elevated series connecting the latter with the Rawhide Range. * * * In no instance have the Ceratops beds been observed east of the Black Hills or their less elevated continuation to the southwest.

The Ceratops beds proper—that is, those beds containing remains of the Ceratopsidæ—are known to have a surface exposure in that portion of Converse County embraced within their eastern and southern border, as defined above, and a line extending from that point on the latter where it passes under the overlying beds a short distance west of Lance Creek, nearly due north to Weston County, i. e., the country drained by lower Lance, Lightning, Cow, Doegie, and Buck creeks, and that portion of the Cheyenne River and its tributaries between the mouth of Lance Creek and the north line of Converse County.

Most of these creeks are shown on Pl. LI, which was originally drawn by Hatcher to accompany the paper just cited, but was not published until later.[a]

The Ceratops beds are made up of alternating sandstones, shales, and lignites, with occasional local deposits of limestones and marls. The different strata of the series are not always continuous, a stratum of sandstone giving place to one of shales and vice versa. This is especially true of the upper two-thirds of the beds. The lack of continuity has rendered it well nigh impossible to establish any definite horizons in the upper members of the series. All the deposits of the Ceratops beds of this region bear evidence of having been laid down in fresh waters. Among the invertebrate fossils found in them, only fresh-water forms are known. * * *

The sandstones largely predominate in the lower members of the beds. They are always fine grained, massive to well stratified, and nearly white to yellowish brown in color. They are occasionally compact and hard, but for the most part quite soft and friable. * * * Almost everywhere in the sandstones are numerous concretions of varying size and shape. Some are almost perfect spheres and vary from the size of a marble to 18 to 20 feet in diameter. Others are from a few inches to several feet in transverse diameter and sometimes several hundred feet in length, a cross section forming a nearly perfect circle. Others still are very irregular in form. These concretions usually show no concentric structure, and while they sometimes inclose foreign objects, as a *Triceratops* skull or a single bone as a nucleus, they are for the most part simply centers of solidification and not true concretions. This is frequently shown by the cross bedding in them, so often seen in the sandstones themselves. * * *

The lignites occur in thin seams, never more than a few inches thick, of only limited extent, and with many impurities. At no place in the Ceratops beds of this region have workable coal beds been found.

The exact localities of the type specimens from the Converse County beds are as follows:

Triceratops horridus at the point marked +1, Pl. LI, on the south side of a canyon entering Buck Creek from the west and about 5 feet from the bottom of the canyon, contained in a concretion formerly embedded in a light-yellow, soft, heavily bedded sandstone.

Stratigraphically *T. horridus* came "from midway between the Fox Hills and Fort Union" of Converse County. Hatcher estimates the stratigraphical range from the locality of the type of *Ceratops montanus* to that of the present species as 3,500 feet, allowing 2,000 feet for the Bearpaw shales and true Fox Hills sandstones and 1,500 for the Laramie below the skull level. (See p. 119.)

The type of *Triceratops* (*Sterrholophus*) *flabellatus* was found at the point marked +2 in Pl. LI, where "it lay in a bed of arenaceous shale, at the summit and the extreme western point of a high and rocky ridge about half a mile in length, running westward from the main divide between Buck Creek and Lance Creek."

Stratigraphically it lay above the position of any other type, with the possible exceptions of *T. sulcatus* and *T. brevicornus*.

Triceratops prorsus, type, lay at the locality marked +3 in Pl. LI. It was situated on Dry Creek, which empties into Lance Creek from the west, about 3 miles above the mouth. It lay on the north side, about 100 yards above the location of the type of *T. serratus*, in a hard

[a] Am. Naturalist, Feb., 1896, vol. 33, Pl. III.

concretion of calcareous sandstone which had weathered out of a thick stratum of soft and almost white sandstone. It was at a slightly lower level than *T. serratus*. The skeleton[a] referred to *T. prorsus* probably comes from nearly the same horizon as the type.

The type of *Triceratops serratus* lay about 20 feet above the bottom of the same side of the draw at the point marked +4, Pl. LI. This skull was in the usual calcareous concretion at the base of a stratum of sandstone. The horizon was slightly above that of *T. prorsus* and considerably above the type of *T. horridus*.

Triceratops sulcatus, type, was discovered at the point marked +5, on the divide between Dry Creek and Lance Creek. Its horizon was a little above that of *T. serratus*, but below the level of *T. flabellatus*.

The locality of the type of *Triceratops obtusus* is at +9, Pl. LI, about 1 mile east of Lance Creek, near the southern border of the Ceratops beds. The horizon "would be about the middle of the Laramie, as those deposits are represented in this region." This would seem to bring the species below the level of *Triceratops horridus*, which is about the middle of the upper half, and hence make it the lowermost species thus far recorded.

Triceratops elatus, type, was found at the point marked +16 on the map (Pl. LI). It lay in loose arenaceous shale a quarter of a mile east of Lance Creek and opposite the mouth of Lightning Creek. The horizon given is about the middle of the Laramie series, which would bring *T. elatus* and *T. obtusus* at about the same level, though, as Hatcher says, owing to the absence of exposures of overlying or underlying deposits in this immediate vicinity it is difficult to determine exact horizons with even moderate precision, and this difficulty is augmented by the frequency with which the sandstones and shales of these deposits replace one another both vertically and laterally, making it extremely difficult to trace any given stratum for any considerable distance. Stanton says the position of *T. elatus* "would not be more than 300 to 400 feet below the highest Ceratopsia remains of this area."

Triceratops brevicornus, type, was discovered embedded in a hard sandstone concretion in the divide between Lance and Lightning creeks, 3 miles above the mouth and 1½ miles south of Lightning Creek, indicated by +22, in Pl. LI. Stratigraphically it lay near the summit of the Laramie deposits, hence is possibly the highest of the known species. Stanton thinks that "its position can not be very much higher than *T. prorsus*, *serratus*, and *sulcatus*."

Triceratops calicornis, the remaining Converse County species, was found at +29, Pl. LI, about a mile east of the abandoned U–L ranch, which is at the junction of Dry and Lance Creeks. It was embedded in a stratum of rather hard sandstone. Hatcher gives us no clue as to the horizon of this specimen. Stanton says, "It is apparently from about the same horizon as *T. sulcatus*."

Of the genus *Diceratops*, with its single species *hatcheri*, the type specimen was found in a hard sandstone concretion about 3 miles southeast of the mouth of Lightning Creek, at the point marked +25, Pl. LI. No statement as to the stratigraphical position is given. From its locality it can not be far from the level of *T. flabellatus*.

Of the two species of the genus *Torosaurus*, one (*T. latus*) was found in an extremely hard bluish-colored calcareous concretion near the top of the bluff on the north side and about 2 miles above the mouth of Lightning Creek. It lay in the bottom and near the extreme head of a small, dry watercourse at the point marked +19, Pl. LI. From its geographical position Stanton believes *T. latus* to be the highest Ceratopsia specimen from this region.

The type of *Torosaurus gladius* came from a horizon considerably lower (200 feet) than that of the preceding species and lay in a thick bed of shale on the northern slope of the divide between Cow and Lightning creeks at +19A, Pl. LI. Hatcher does not give the stratigraphical position of the two *Torosaurus* species with relation to those of the genus *Triceratops*.

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[a] The mounted skeleton, No. 4842, U. S. National Museum.

THE HELL CREEK, MONTANA, LOCALITY.

This locality[a] lies in the northern part of Dawson County, Mont., along the canyon of Hell Creek, a tributary flowing northward into the Missouri River about 30 miles above the mouth of the Milk River and 150 miles east of the Judith River localities. The country has an altitude up to 3,000 feet above sea level and consists of grassy table-lands with occasional flat-topped buttes and, in places along the stream courses, wild dissected badlands.

There seems to be no continuous bone-bearing layer, but occasional localities where specimens, mainly fragmentary, may be found, some in joint clay, some in unconsolidated sandstone, and again in concretions so typical of the Laramie formation.

The American Museum party of 1902 found the remains of thirteen or more skulls, presumably of *Triceratops*, but all had weathered out and disintegrated but one, which was intact except for the nasal horn core, the nasals, and the distal portions of the supraorbital horn cores, which had weathered away. This specimen (see p. 185, fig. 26) was found on the extreme point of the divide separating Hell Creek from a tributary which entered it from the west about 15 miles from the Missouri River. It was about 35 feet from the bed of the canyon and lay in its natural position. The precise horizon was not ascertained.

Few of the Ceratopsia found in this region were in concretions, although the party unearthed portions of the skeleton of an enormous theropod dinosaur (*Tyranosaurus rex* Osborn), which was contained in several bluish calcareous concretions of extremely hard, homogeneous texture. The skull, No. 970 of the American Museum, is doubtless referable to *Triceratops serratus* Marsh.

In addition, the party secured portions of the skeleton of another specimen at a point about a mile south of the place where the first was found and an equal distance away from Hell Creek Canyon. This was also *Triceratops*, but the species has not been determined. It was embedded in joint clay, at the base of a large table butte, the upper portion of which had been baked to a terra cotta from the accidental burning out of the lignite seams.

Two splendid skulls, one probably referable to *Triceratops brevicornus*, were found near Hell Creek, in 1904, by Mr. W. H. Utterback, of the Carnegie Museum in Pittsburg. The *T. brevicornus* skull lay in soft sand and was in perfect condition.[b]

DENVER LOCALITIES.[c]

Ceratopsia remains have been found in the vicinity of Denver, Colo., in beds known as the Arapahoe and Denver, considered to be of post-Laramie age.

The Arapahoe, the older of the two formations, occupies the site of an ancient lake of considerable extent.

> Along the northern and northwestern edges the formation now appears only as a thin horizontal sheet, or in scattered outliers upon the uneven surface of the underlying Laramie. Along the western outcrop, where the strata are highly inclined and confined between underlying and overlying terranes, the formation is 600 to 800 feet thick. * * * The total thickness of the Arapahoe as originally laid down is undeterminable.
>
> The Arapahoe is divisible into two well-marked series of beds; a lower, of sandstones and conglomerates, 50 to 200 feet thick, and an upper, of clay, 400 to 600 feet thick.[d]

The lower member is composed of débris derived from the underlying Carboniferous, the Triassic, the Jurassic, and from the lower divisions of the Cretaceous, up to and including the Laramie. The shales of the overlying member of the Arapahoe are light gray and arenaceous and contain a few ironstones similar to those of the Laramie.

The vertebrate remains "occur in the conglomerate along the foothills and in the basal sandstones and overlying clays beneath the prairies." The few specimens from the conglomerate are worn, while the abundant remains in the clays are finely preserved.

> The Arapahoe formation is distinguished from the Laramie by the sandy nature of its clays, by the comparative paucity of its ironstones, by the generally brighter colors, and by the vertebrate remains. From the overlying Denver the Arapahoe is readily distinguished by the eruptive nature of the material composing the former.[e]

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[a] Lull, R. S., Bull. Am. Mus. Nat. Hist., vol. 19, Art. XXX, Dec., 1903. See also this monograph, p. 185.
[b] Ann. Rept. Carnegie Museum for 1905, p. 24, figure facing p. 64.
[c] Emmons, Cross, and Eldridge, Geology of the Denver Basin: Mon. U. S. Geol. Survey, vol. 27, pp. 150–254.
[d] Eldridge, op. cit., pp. 151–152.
[e] Eldridge, op. cit., p. 154.

Within the area of the Denver Basin the Arapahoe formation rests unconformably upon the Laramie, although along its upturned western edge the break is recognized only through change in sedimentation.

The Denver formation, which lies unconformably upon the Arapahoe, is very different from the latter in the composition of its rocks, though textually they are similar. The materials of which the Denver beds are composed may be classed as the débris of Archean, of sedimentary, and of eruptive rocks. The Archean débris, which is confined to the upper portion of the series, consists of bowlders, pebbles, and sands, and is similar to that of the underlying Arapahoe. The material undoubtedly came from the Archean lands lying to the west.

The sedimentary débris, which is mingled with the Archean in the upper portions of the formation, consists of small sandstone and limestone pebbles derived from the upturned edges of the Mesozoic strata. There are also conglomerate bowlders from the Dakota Cretaceous, while on the plains there is some quartz and feldspar, originally from the Archean but derived immediately from the soft Arapahoe beds.

The eruptive débris is the most characteristic feature of the Denver formation, especially in the lower half, though it ranges to the summit of the beds. These eruptive materials are almost entirely andesitic and imply a period of violent eruptions before the beginning of Denver time.

The total thickness of the Denver is estimated at 1,449 feet.

Fragmentary remains, which doubtless represent several species of Ceratopsia, have been found in the vicinity of Denver; from the Arapahoe is one identified as *Ceratops montanus*, that is "the remains of the same reptile or one nearly allied to it." This identification seems hardly possible, as *Ceratops montanus* is a Judith River type and is vastly older than the Arapahoe. The fragmentary nature of the fossil precludes accurate determination. The type of *Triceratops galeus* is also from the Arapahoe, but Mr. Hatcher has rejected the species on the ground of inadequate material.

From the Denver two species are reported, one referred by Marsh provisionally to *Triceratops horridus*, which may be correct; the other, the type of *Triceratops alticornis*, by far the most notable ceratopsian from this locality. This specimen was found by Mr. Cannon in the rocks of the largest of the tributaries, which rises on the eastern slope of Green Mountain and enters the Platte River near the Larimer Street Bridge, Denver. The exact locality was about 1 mile from the mouth of the smaller stream.

RELATIONSHIP OF THE BLACK BUTTES, CONVERSE COUNTY, AND DENVER BEDS.

Stanton and Knowlton[a] thus summarize our knowledge concerning the relative age of the "Ceratops beds:"

Until a few years ago it was the custom to include in the Laramie all of the beds between the Fox Hills and Wasatch formations. In the Denver region the detailed studies of Cross and Eldridge . . . have resulted in the recognition of the Arapahoe (Willow Creek) and Denver beds separated from the Laramie and from each other by unconformities and distinguished by marked lithologic features. A revision of the fossil floras of that region has also shown that the Denver beds contain a flora composed of species a large proportion of which are not found in the underlying Laramie. . . .

The Denver and Arapahoe beds have yielded representatives of a remarkable reptilian fauna consisting largely of horned dinosaurs of the family Ceratopsidæ. The presence of this family in the Ceratops beds of Converse County and probably at Black Buttes has suggested the very reasonable query whether the beds containing them at these places also are not younger than the true Laramie. The facts we have presented relative to the stratigraphy and paleontology of the Black Buttes dinosaur horizon seem to us convincing that it is in the Laramie and near the base of that formation. It is less than 200 feet above the marine Cretaceous, and there is no evidence of a break nor of any abrupt lithologic change. The character of the flora and of the invertebrate fauna also, so far as the species have a distribution in recognized horizons elsewhere, favors its reference to the Laramie. If the dinosaur bed of Black Buttes is not Laramie, then the Laramie is either absent or is represented only by about 100 feet of sandstone. The overlying beds up to and including strata with a Fort Union flora seem to form a continuous series that is indivisible either structurally or lithologically, and we can see no reason for placing the top of the Laramie lower than the base of the lowest bed with a Fort Union flora.

Closely similar conditions are seen in Converse County, the principal difference being a greater development of the beds. The sandstones at the base, overlying the Fox Hills, are a few hundred feet thick, and the variable more argillaceous, higher

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[a] Bull. Geol. Soc. Am., vol. 8, p. 155.

beds, with a fresh-water fauna in large part identical with that at Black Buttes and a flora that also indicates the same horizon, have a much greater thickness. Here again there seems to be no break in a series that has Fort Union plants in its upper member. The abundant occurrence of such a species as *Campeloma multilineata* throughout all but the lowest portion of the series argues strongly for continuous sedimentation.

The difficulty of recognizing unconformities in beds so little disturbed and the possibility that there may be such undiscovered breaks in these two areas is freely admitted, though it does not seem to us probable. From the facts now available it seems most probable that in Converse County and in the Bitter Creek Valley the time representatives of the Denver and Arapahoe beds are undifferentiated portions of a continuous series and can not be separated from the Laramie. The Fort Union beds are apparently distinguishable by means of their flora, and these mark the upper limit of the Laramie in the areas in question.

The *Triceratops* skulls from Hell Creek represent species whose position stratigraphically is about the middle of the Converse County series of specimens, which is evidence in favor of considering the former deposits as contemporaneous with the latter.

Geological sequence of the Ceratopsia.

Formation.	Locality.	Species.
Denver	Near Denver, Colo	Triceratops alticornis.
		? Triceratops horridus.
Arapahoe	Near Denver, Colo	Triceratops alticornis.
		Triceratops galeus.[a]
		? Ceratops montanus.[b]
Laramie	Lance Creek beds, Converse County, Wyo.	Torosaurus latus.
		Torosaurus gladius.
		Diceratops hatcheri.
		Triceratops elatus.
		Triceratops flabellatus.
		Triceratops brevicornus.[c]
		Triceratops sulcatus and calicornis.
		Triceratops serratus.[c]
		Triceratops prorsus.
		Triceratops horridus.
		? Triceratops obtusus.
	Near Black Buttes Station, Wyoming.	Agathaumas sylvestris.
Fox Hills		No Ceratopsia.
Bearpaw		No Ceratopsia.
Judith River beds	Near Judith, Mont	Ceratops montanus.
		Ceratops paucidens.
		Monoclonius crassus.
		Ceratops recurvicornis.
		Monoclonius sphenocerus.[d]
	Red Deer River, Alberta[e]	Centrosaurus apertus.[f]
		Ceratops canadensis.[f]
		Monoclonius dawsoni.[g]
		Ceratops belli.[h]

[a] Species rejected by Hatcher because of the fragmentary condition of the type.
[b] This form is placed among the Arapahoe Ceratopsia by Whitman Cross on page 230 of the monograph on the Geology of the Denver Basin (Mon. U. S. Geol. Survey, vol. 27). It must be a case of mistaken identity (see p. 183 of this monograph).
[c] Also Hell Creek, Montana.
[d] Horizon not recorded.
[e] Belly River beds. The Montana and Alberta species were contemporaneous.
[f] From upper beds.
[g] From middle beds.
[h] From lower beds.

Although the formations above the Fox Hills have been placed in regular sequence in the above table, it may be that the Ceratopsia-bearing strata in Converse County include the equivalents of those near Denver.

COLLECTING CERATOPSIAN MATERIAL.

In the chapter of the present memoir devoted to the history of discovery reference is made to the various expeditions which have searched for these interesting forms. While not the pioneer ceratopsian collector, Hatcher brought to light by far the major part of all of the known material pertaining to this group. His work was mainly among the larger genera of the Laramie, especially in the Converse County locality, and his experience was such that he could have written a most interesting and instructive chapter upon the difficulties and dangers incident to the collection of such huge fossils.

In one specimen collected in Converse County by Hatcher the concretion containing the skull weighed 6,850 pounds when received at the Yale Museum. This is by far the largest specimen of *Triceratops* yet found, having an estimated length of 8 feet from the tip of the rostral bone to the hinder margin of the frill. In the same concretion were many other bones and a large fragment of vegetable origin, further evidence in favor of Hatcher's conception of the habitat of the Ceratopsia.

The present author's experience in the field in search of Ceratopsia, though limited to a single eventful season, was of such a nature as to present a full measure of experience from the variety of conditions met with. This expedition will be taken as an illustration of field methods and the problems to be solved.

During the summer of 1902 Mr. Barnum Brown, of the American Museum of Natural History, accompanied by the author, was sent into the northern part of Montana to explore a new locality for Laramie dinosaurs. The locality was made known to Professor Osborn through Mr. William Hornaday, director of the zoological gardens in Bronx Park, New York, who, in company with Mr. L. A. Huffman, a photographer, of Miles City, Mont., had taken a trip up into the Hell Creek region the season before. While there these gentlemen found a ceratopsian horn core, which showed that there were prospects of finding these fossils in this locality.

The great majority of the Laramie Ceratopsia found by Hatcher were incased in hard sandstone concretions, which, while vastly increasing the weight of the specimen and the difficulty both of collecting and of subsequent preparation for exhibition and study, generally insured its preservation from destruction by the action of the elements. As many of Hatcher's finest specimens had already weathered out of the bank in which they had been embedded, the importance of this fact can readily be imagined.

Our party found no fewer than thirteen skulls, but all of these except one had entirely disintegrated, and the portion of this one that protruded on the surface of the ground was destroyed. This specimen was in unconsolidated sandstone; another was in joint clay; while a third fossil, not a ceratopsian, was inclosed in concretions and gave us a very perfect idea of such collecting. As each of these three matrices presented its special problems for solution, they will be described in some detail.

At quarry No. 1, that opposite the camp, a specimen of a huge carnivorous dinosaur (*Tyranosaurus rex* Osborn) was found embedded in a number of separate concretions. The largest of these was but partially buried, and from the exposed end a broken portion of a huge tibia protruded. By searching down the hill most of the fragments which had been broken away were recovered and afterwards restored to their original position. The excavation of the concretion itself was easily accomplished, but it was far too heavy for shipment, and the work of reducing it to a more moderate bulk was arduous enough, as the rock was hard and the facilities for sharpening and retempering dulled and broken tools were very crude. The block, which contained a tibia and the coossified pubes, weighed 1,700 pounds when all of the matrix possible was removed, and the task of loading it upon the wagon presented a serious engineering problem. A road was cut along the face of the butte to the little valley which divided it from the neighboring hill, to which place the wagon could be brought. The block, carefully swathed in strips of burlap dipped in liquid plaster to protect the protruding bone, was placed upon an improvised stone boat and hauled along the road by means of the block and tackle and one of the heavy horses.

When the load reached the wagon the latter was run into two parallel trenches, so as to bring the wagon bed on a level with the ground, when the specimen was hauled into the wagon with comparative ease. The other concretions were all smaller than the first, most of them containing a single vertebra or one or more small bones, but the deeper lying ones were extremely hard, being composed of a perfectly homogeneous bluish sandstone, and had to be removed bodily to New York, where better tools were available, before their final reduction could be accomplished and the contained bones freed from their matrix.

Our first *Triceratops* specimen (quarry No. 2), consisting of vertebræ, ribs, the sacrum, the lower jaws, and a few limb bones, lay in a peculiar joint clay of a bluish color, though occasionally stained a rusty brown along the joints. The bones were poorly preserved, presenting in this respect a marked contrast with the admirable condition of those of the carnivore, as the joints in the clay ran through the bones as well, which therefore required the most delicate manipulation. The process consisted in the removal of the overlying material, first with a heavy pick and spade, a process technically known as "stripping," then with a light prospector's pick, and finally with a harness awl and whisk broom. The exposed bone surface was then treated with a solution of gum arabic to harden it and then covered, first with tissue paper and finally with strips of burlap dipped into flour paste. The bones were then excavated still farther, the exposed surface being covered as before, and finally were lifted from their age-long bed and the lower side treated in the same manner. While the smaller bones were now ready for packing, the larger ones had to be provided with a plaster of Paris jacket, sometimes with splints of wood for further support, just as a surgeon prepares a broken limb. The bones were then packed in hay in heavy boxes ready for shipment.

Quarry No. 3 contained the great skull of *Triceratops serratus*, No. 970, before referred to and figured in this monograph (fig. 26, p. 29). This was found, together with some limb and foot bones, about 1 mile down Hell Creek from the camp, and presented a third aspect of Laramie collecting.

The specimen in this instance was in unconsolidated sandstone, the skull lying in normal position, with the supraorbital horn cores protruding on the surface and sustaining an abundant growth of vegetation, which aided largely in the disruption of the bone.

The nasals, with their horn core, were eroded away, and the small rostral bone lay displaced on the right side of the snout, while one complete dentary, with perfect dentition, and other portions of both jaws lay beneath the skull, as though still attached by ligaments when the specimen came to its last resting place. As is usual with Ceratopsian skulls, the upper teeth had almost entirely disappeared, which leads one to believe that the huge head must have had great powers of flotation, owing to the cavities in which the expansive gases incident to decay could develop, and was as a consequence probably the last portion of the creature's frame to become buried in the sand.

Our specimen was in fine condition where it was completely buried, though extremely fragile, and the process of excavation was carried out with the utmost caution, the exposed portions being covered at once with plaster bandages to guard against possible injury.

As the broad expanse of frill, measuring in this instance 5 feet in width by nearly 3 feet in length, would not bear its own weight, it was supported from beneath by vertical props as fast as the earth was removed. It was decided to retain the matrix under the palatal portion of the skull for safety's sake, so it was necessary to spray this repeatedly with gum arabic solution, which hardened it, so that it was self-sustaining. The under side of the frill was then plastered, and by occasional tunneling the matrix was bound fast to the skull by means of the burlap strips. Next a complete trestlework was built of scantling underneath the entire structure, and the whole was bound fast with the plastered strips, so that the resultant fabric was extremely solid. The box, which was built beneath and around the specimen without disturbing it in the least, was of the smallest possible dimensions, yet measured 7 feet in length by 5½ feet in breadth, and about 4 feet in depth, and weighed, with its contents, 3,100 pounds.

The skull location was on the extreme point of a divide between Hell Creek and one of its tributaries, with a precipitous descent on either side, so that here again it became necessary to construct a roadway along the edge of the canyon wall to the broader part of the divide above, to which the wagon could be driven. The tackle and horse were used, as before, boards being this time laid along the roadway, with small logs for rollers. Even with a large, wide-gage wagon it was necessary to remove the wagon box, as it could not possibly contain the specimen. Three trunks of trees were laid on the fully extended wagon frame, which was backed up to a convenient bank, on which the hinder end of the logs rested. It was then found that the skull box was too wide to pass between the rear wheels, so they were undermined, and thus lowered beneath the level of the logs. The box was then slid into position with little difficulty, the hind axle was raised with a lifting jack, and earth was thrown beneath the wheels until they again bore the load. The protruding tree trunks were then sawed off, the specimen box was lashed fast to the wagon, and the task of loading was thus completed. The skull was hauled out to Miles City, a distance of 135 miles, whence it was shipped directly to New York.

PROBABLE APPEARANCE, HABITS, AND ENVIRONMENT OF THE CERATOPSIA, AND THE CAUSES THAT LED TO THEIR EXTINCTION.

EVOLUTIONARY SUMMARY.

The earliest known Ceratopsia are from the Judith River beds, and the race continues upward until the close of the Cretaceous period, during which time it underwent a striking evolution, largely one of size and armament.

Of the ancestors of the Judith River forms we have no record, probably because, as Matthew believes (see p. 194), they were dry-land types, notwithstanding the swamp-living habits of their successors.

The Judith River ceratopsians already exhibit the characteristic horns and frill, but the relative proportions of nasal and supraorbital horn cores are the reverse of those of the Laramie types. The nasal horn was the first to develop. It varied somewhat in form, being straight and compressed in *Monoclonius sphenocerus* and curved strongly backward in *M. dawsoni*. In the other Judith River genus, *Ceratops*, it seems to have curved forward instead of backward, and the supraorbital horn cores, which were rudimentary in *Monoclonius*, are much more advanced in development, though the nasal horn was in all probability still the larger. The frill in the Judith River types is by no means so well developed as in the Laramie forms, and in *Monoclonius* and *Centrosaurus* consisted largely of the coalesced parietals, the squamosals taking but little part in its formation, but in *Ceratops*, though the crest still consists mainly of the widely fenestrated parietals, the squamosals become a more prominent factor, tending toward the form of the latter bone found in *Torosaurus*.

There is evidence that the teeth of the Judith River forms were somewhat more primitive than those of the later Ceratopsia in that the peculiar method of replacement was not fully assumed in the earlier types.

The stratigraphical range from the Judith River beds to those containing the earliest Laramie type, disregarding for the moment *Agathaumas*, is 3,500 feet according to Hatcher's estimate (p. 119). This implies a great lapse of time, during which the most striking evolutionary changes occurred, so that *Triceratops horridus*, the earliest recorded Laramie species, exhibits a marked advance in cranial features over its Judith River predecessors. Here the supraorbital horn cores are vastly larger, while the nasal horn is much reduced, tending to disappear almost entirely in *T. obtusus* or *Diceratops*. Correlated with this change of offensive armor is an increased development of the defensive frill, which in *Triceratops* is no longer fenestrated, though in *Torosaurus* it still retains large paired fontanelles in the parietal portion of the crest.

The advance in the structure of the Laramie types seems, therefore, to lie in (1) *the larger size of the individuals*, (2) *the preponderance of the supraorbital horns over the nasal*, (3) *the more perfectly developed parietal crest, and* (4) *the perfection of the type of dentition peculiar to the group.*

Agathaumas, from the lower Laramie, is known only from certain portions of the skeleton and seems to be transitional between *Monoclonius* and *Triceratops*, while *Triceratops alticornis*, from the Denver beds and therefore the most recent of all, exhibits a type of supraorbital horn core which may readily be considered the final stage in the evolution of these weapons.

In the table of stratigraphical sequence (p. 184) the relative positions of the various type specimens are given, except where the level is unrecorded. The phylogenetic series corresponds approximately with the stratigraphic sequence, although of the two *Torosaurus* species Hatcher distinctly states that *gladius* "represents the extreme development of that type of parietal peculiar to this genus," thereby implying that *T. gladius*, which is geologically the older, is the more specialized of the two.

PROBABLE APPEARANCE OF THE CERATOPSIA.

THE JUDITH RIVER TYPES.

Our knowledge of the general form of the earlier Ceratopsia is still very vague, for with the exception of *Monoclonius crassus*, among Judith River types, most of the remains are of incomplete skulls only.

But two attempts have been made to restore Judith River forms, consisting of a statuette and a painting, both by Charles R. Knight. The restorations, which differ somewhat from each other, have been called *Agathaumas sphenocerus*, the supposition being that *Monoclonius* and *Agathaumas* were synonymous genera, the latter term having priority. The restoration is really that of *Monoclonius sphenocerus* Cope.

The statuette, the property of the American Museum of Natural History, is figured as Pl. I, fig. 1, in the Catalogue of casts, models, photographs and restorations of fossil vertebrates, by Professor Osborn,[a] 1898. The painting, also in the American Museum, was reproduced in the Century Magazine[b] for November, 1897.

The conception of the tall, straight nasal horn and the much smaller supraorbital horns is undoubtedly correct, though in *Monoclonius sphenocerus* the compressed nasal horn slants somewhat backward, while in other species of the genus it *curves* to the rear. The writer questions whether the hinder margin of the frill was quite so prominent as it is represented in the model and painting, for in the earlier types the whole crest is much less strongly developed than in the later forms, and although the edge is crenulated yet there is little reason to suppose that the marginal armature was as well developed as it appears to be in the restoration. The general bodily proportions are based upon "a reconstruction of a possibly identical and prior restoration of *Triceratops prorsus* (Marsh)" (Ballou). It is now known that Marsh was in error in making the presacral series of vertebræ too numerous in his restoration of *Triceratops* (fig. 125), hence the probabilities are that here again the back is unduly elongated, though of this we have no positive knowledge.

The Judith River Ceratopsia were smaller than their Laramie successors, and of lighter and less muscular build, and from the development of cranial armature differed in their offensive and defensive tactics.

It is difficult to conjecture in what way *Ceratops* would differ in external appearance from its contemporary *Monoclonius* except in the much greater development of the supraorbital horns. The nasal horn core is unknown except in one species, *Ceratops* (*Monoclonius*) *recurvicornis* Cope, in which it curves strongly forward, in contrast to that of *Monoclonius*. As this species differs from the others that Hatcher refers to *Ceratops* in an important anatomical feature—namely, in the presence of separately ossified epoccipital bones—the present writer is loth to consider it as typical of the genus, if, indeed, it belongs with *Ceratops* at all.

There are no data concerning the bodily proportions or contour of *Ceratops*.

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[a] See also Science, vol. 7, p. 842, fig. 1.

[b] Ballou, W. H., Strange Creatures of the Past, p. 18.

THE LARAMIE TYPES.

Marsh has given us the first skeletal restoration of *Triceratops* in the Sixteenth Annual Report of the United States Geological Survey (Pl. LXXI), reproduced here as fig. 125.

This restoration is very accurate except for the number of presacral vertebræ, which has been overestimated. As Hatcher has shown, in *Triceratops brevicornus* at least (p. 46, fig. 48), the number of presacrals is not more than twenty-two, while in Marsh's figure there are twenty-one *without* the cervicals, which probably number at least eight more. Another feature about which doubt may be expressed is the correctness of the restoration of the feet, for while odd foot bones have been brought to light, no complete manus or pes of this interesting animal has yet been found.

Knight has essayed at least three restorations of *Triceratops*, the first two, a statuette and a drawing, being based largely, if not wholly, upon that of Marsh. The statuette was made for the American Museum, and a view of it is shown as fig. 26 in F. A. Lucas's Animals of the Past (McClure, Philips & Co., New York, 1901), while the drawing was also published by Lucas.[a]

The restoration of *Triceratops* which forms the frontispiece of the present volume was made under Hatcher's personal supervision, and is one of the most successful of Knight's artistic reconstructions. The general proportions are markedly different from those of the preceding conceptions of the animal, notably in the shortening of the back and in placing the highest point in the arch of the vertebral column over the sacrum rather than farther forward. The proportion of head to trunk is also greater, the skull being almost one-third of the entire length of the animal, including the tail. The length of the tail is conjectural, as a complete caudal series is unknown and it is possible that it may have been reduced somewhat, as it no longer subserved the function of a counterpoise, as in bipedal dinosaurs.

The skeleton of *Triceratops prorsus* which has recently been mounted at the National Museum is that upon which Marsh based his restoration, and a comparison of the results is of great interest. The skeleton was mounted by Mr. C. W. Gilmore, of the Museum staff, and his description of the specimen is here given:[b]

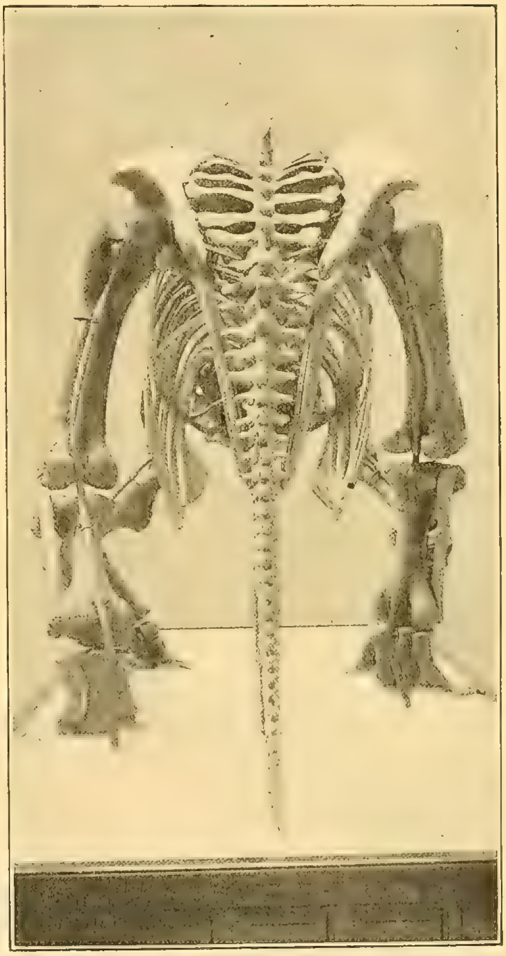

FIG. 124.—Restoration of *Triceratops*. Rear view of the mounted skeleton in the U. S. National Museum. (See also Pl. XLIX.)

The skeleton of *Triceratops prorsus*, recently placed on exhibition in the court devoted to vertebrate paleontology, is the first one of this extinct genus to be mounted. As all of the specimens [of Triceratops] referred to above were more or less fragmentary, the most complete one (No. 4842[c]) [Sk. C, 2082 and 2084[d]] was used as a basis for the present restoration. The missing parts [including the skull (No. 2100)] were substituted from other individuals of about the same size and belonging to the same species. Where suitable bones were not available, as was the case in a few instances, these parts were restored in plaster, colored to somewhat resemble the bones, but having the shade differ sufficiently to be easily recognized. Thus we have been able to present a fairly accurate representation of the skeletal structure of this peculiar reptile. Every bone used in

[a] Ann. Rept. Smithsonian Institution for 1901, p. 644, Pl. I.

[b] Gilmore, C. W., A mounted skeleton of Triceratops: Proc. U. S. Nat. Mus., vol. 29, 1905, pp. 433–435. Some words in brackets have been since added by Mr. Gilmore.

[c] Catalogue number of the U. S. National Museum.

[d] Marsh's original numbers.

the skeleton bears its catalogue number, and all plaster bones are marked with a red +. There is thus preserved a definite record of all the associated material comprising the composite skeleton. * * *

The skeleton as mounted is standing on a base of artificial matrix intended to represent the color and texture of the Laramie sandstone in which the remains of these animals are found.

From the tip of the beak to the end of the tail the skeleton as restored is 19 feet 8 inches in length. The skull, which is 6 feet long, equals nearly one-third of this length [a remarkable proportion]. At the highest point (the top of the sacrum) the back is 8 feet 2 inches above the base. The mounted skeleton presents several features which would otherwise be lost to the observer if seen in the disarticulated condition. The short body cavity, the deep thorax, the massive limbs, and the turtle-like flexure of the anterior extremities are characters appreciated only in the mounted skeleton. The position of the forelimbs in the present mount appears rather remarkable for an animal of such robust proportions, but a study of the articulating surfaces of the several parts precludes an upright mammalian type of limb, [such] as was represented by Marsh in the original restoration. * * * The [tail and] forefeet are perhaps the most conjectural parts of the whole restoration. [The tail is restored almost wholly from Marsh's drawing of this animal.] Mr. Hatcher, after a careful study of all the forefoot material [of this group] known, was unable to arrive at a satisfactory conclusion as to the arrangement or the number of bones comprising the manus. In constructing these parts we have largely followed Marsh's drawing, assisted somewhat by forefoot material kindly loaned by Dr. H. F. Osborn, of the American Museum of Natural History, New York City. [It seems probable that a similar condition prevailed in this animal to that found in the other better known dinosaurs, so instead of introducing a full complement of carpal and tarsal bones, as was done in the first restoration, only two elements were modeled to represent the carpus, while the astragalus alone comprises the tarsus.]

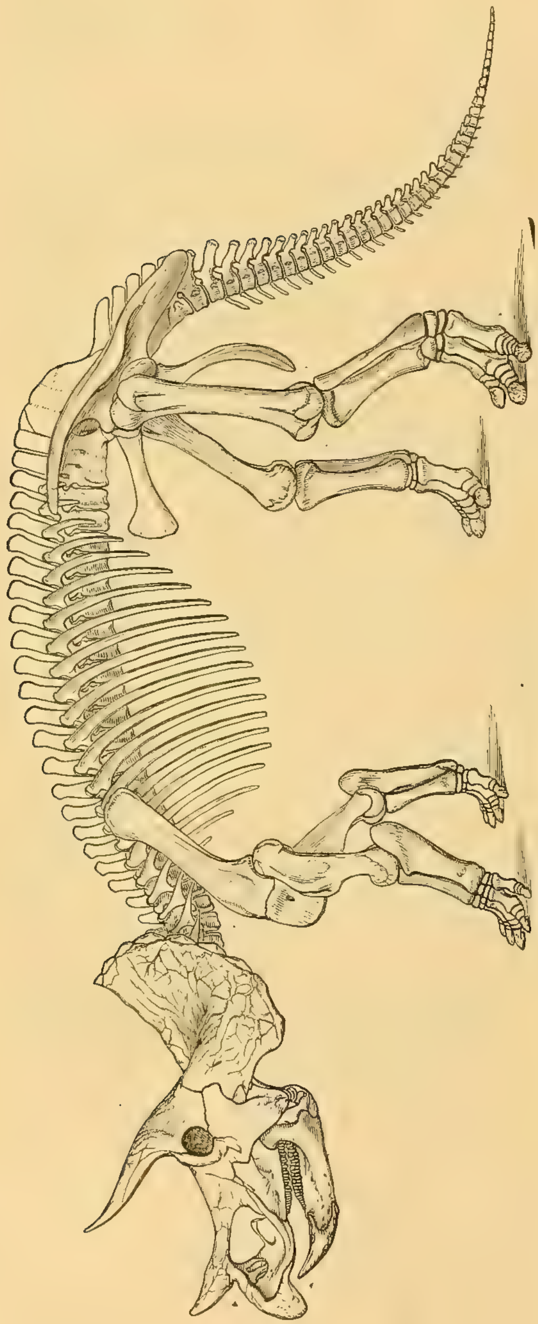

FIG. 125.—Restoration of *Triceratops prorsus*. After Marsh.

The nasal horn [core] of the skull used in the present skeleton appears to be missing, and on account of the unsatisfactory evidence as to whether the horn is wholly or only partly gone, it was decided not to attempt a restoration at this time. This will account for the absence [or rather the apparent lack of development] of one of the important features upon which the name of the animal is based, *Triceratops* meaning three-horn face, in allusion to the presence of the two large horns above the eyes and a third smaller horn on the nose.

It may be of interest to mention here that Professor Marsh used this skeleton (No. 4842), supplemented by other remains now preserved in the collections of the Yale University Museum, for the basis of his restoration of *Triceratops prorsus*, published as Pl. LXXI in the Dinosaurs of North America [fig. 125].[a] Pls. LXIV–LXVIII in the same work were also largely reproductions of parts of this same individual

A comparison of the above-mentioned restoration by Marsh [fig. 125] with the mounted skeleton [Pl. XLIX of this work] shows several differences in points of structure, due chiefly to the better understanding of these extinct forms. The most striking dissimilarity is in the shortening of the trunk by a reduction of the number of presacral vertebræ. Marsh's error was due to an overestimate of the length of this region, a mistake also made in his restoration of *Brontosaurus* (=*Apatosaurus*), as has been shown by Riggs.[b] Mr. Hatcher determined from a well-preserved vertebral column in the Yale University Museum the number of presacrals as twenty-one,[c] this being six less than was ascribed to the animal by Professor Marsh.

[a] Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, p. 386.
[b] Science, new ser., vol. 17, March 6, 1903, pp. 393–394.
[c] Doctor Lull now recognizes twenty-two presacrals (see p. 47).

[In mounting this skeleton an attempt was made to embody all of the discoveries and changes resulting from Mr. Hatcher's thorough study of the Ceratopsia, which he freely communicated in advance of publication. It must be understood, however, that there are still many undetermined points in the anatomy of this group, and the present writer, who mounted the skeleton with the able assistance of Mr. Norman Boss], alone must be held responsible for any anatomical inaccuracies that may be detected in the reconstruction.

One of the most notable features in this skeleton is the great breadth of the pelvis and hind quarters. This impresses one most when the skeleton is viewed from the rear, and is a strong point of contrast between the Ceratopsia and other Dinosauria. (See fig. 124.) This is in the main due to the position of the expanded blades of the ilia, which are horizontal rather than vertical, as in other dinosaurs. The body is so broad that the creature is much better proportioned than one would be led to expect from viewing the skull alone.

Measurements of the mounted skeleton.

	Meters.
Length, following the curve of the vertebral centra (about)	7.25
Skull:	
Length, entire	1.88
Length from condyle to tip of restored rostral	1.10
Length from posterior margin of frill to nasal horn	1.46
Breadth of frill	1.31
Breadth of orbits	.42
Distance between tips of supraorbital horns	.83
Length of right supraorbital horn core from upper edge of the orbit	.70
Girth of horn core just above the orbit	.66
Vertebral column:	
Length of four coalesced cervical vertebræ	.415
Length of entire cervical series	.88
Length of dorso-lumbar series	1.725
Length of sacrum	1.10
Length of restored caudal series	2.41
Breadth of thorax	1.15
Depth of thorax (to lower end of ribs only)	1.525
Length of longest rib (measured along the curve) from tubercle to end	1.45
Length of capitulum to tuberculum	.24
Breadth of sacrum	.64
Breadth of entire pelvis	1.24
Right fore limb:	
Length of scapula and coracoid	1.35
Length of coracoid only	.38
Breadth of coracoid	.39
Breadth of blade of scapula at upper end	.26
Greatest breadth of scapula	.36
Length of humerus	.71
Breadth of proximal end	.40
Breadth of distal end	.36
Girth of shaft	.43
Length of ulna	.65
Breadth of proximal end	.38
Breadth of distal end	.19
Girth of shaft	.36
Length of radius	.41
Breadth of proximal end	.18
Breadth of distal end	.14
Girth of shaft	.205
(NOTE.—As the manus is entirely restored no measurements were taken.)	
Right hind limb and pelvis:	
Length of ilium	1.50
Greatest depth (to ischiac peduncle)	.32
Breadth of blade	.32
Length of pubis	.85
Breadth at anterior end	.28

Right hind limb and pelvis—Continued.	Meters.
Length of ischium (measured on outer curve)	1.50
Breadth of proximal end	.40
Length of femur	1.15
Breadth of proximal end	.42
Breadth of distal end	.43
Girth of shaft	.485
Length of tibia and astragalus	.72
Breadth of proximal end of tibia	.395
Breadth of distal end of tibia	.39
Fibula (restored)	
Length of metatarsal II	.29
Length of metatarsal III	.355
Length of digit III	.325
Length of ungual phalanx IV	.11
Breadth of ungual phalanx IV	.12
Measurements depending on posture:	
Height to summit of back	2.47
Breadth of shoulders at glenoid fossæ	1.25
Breadth of elbows	2.16
Breadth across outer digits	1.70
Breadth across heads of femora	1.50
Breadth across knees	1.93
Breadth across outer digits	2.04

This skeleton has been admirably prepared and mounted by Mr. Gilmore. Two points, however, are open to question, as is clearly recognized by Mr. Gilmore—the position of the skull and that of the ischia.

In the skull here mounted, as well as in the skulls of the type of *Diceratops hatcheri*, of *Triceratops calicornis*, and of other species of *Triceratops*, the condyle, which is supported on a neck, is strongly deflected downward in such a way as to cause the head to be carried low in front if the line of the condyle is continuous with that of the cervicals, which it evidently should be. The hemispherical articulating surface of the condyle is of such extent that the head might have been raised to a somewhat higher position than that given it in the mount or, on the other hand, depressed until the beak reached the ground, but the average position would be with the muzzle about 20 inches (0.51 m.) lower than in the mounted position. In the ischia the articulating extremities are of such a character that their exact method of union with the ilia and pubes is highly conjectural, and further evidence from other specimens may necessitate a radical departure from their position in the present mount.

It seems probable that four is the correct number of digits in the manus rather than five as in the mounted specimen.

The cranial armature at once shows a sharp contrast in development and in mode of use with that of the ancestral *Monoclonius*, for in *Triceratops* the frill was complete and heavy and undoubtedly flared upward and outward to a greater extent than in the former genus, affording not only leverage for muscular attachment, but, as a helmet-like structure, serving to protect the neck region from the horns of the adversary. In *Triceratops*, too, the temporal horns are large and are strongly curved forward, with a corresponding reduction of the forward-directed nasal horn. The restoration (Pl. I, frontispiece) expresses well the appearance of the lowered head, in which all three horns are brought to bear against the enemy at the moment of impact. In *Monoclonius* the offensive stroke must have been an upward thrust in which the erect or backward-curved nasal horn would prove a most efficient weapon, while *Triceratops* would charge with lowered head, seeking either to impale his enemy or to bear the latter down by the impetus of his great weight.

The expansion of the frill and the development of great protecting ridges around the orbit would be such as to best protect the most vital points, the neck and the eyes, from such a mode of attack.

Triceratops was extremely deficient mentally, and was probably of comparatively peaceable disposition except, perhaps, at the breeding season. Then the combats between rival males which probably took place must have been prompted and carried out by blind, unreasoning instinct solely. This would make such weapons and defensive armor very efficient, for the Ceratopsia were evidently not intelligent enough to use weapons requiring skill in their manipulation.

The question of other skin protection can not yet be settled, for while certain dermal scutes and ossicles have been found which may have been borne by *Triceratops*, we have no knowledge of their position or arrangement. It is unreasonable to suppose that the skin was naked, for such condition is found only among exclusively aquatic reptiles, such as the ichthyosaurs.

The limbs were doubtless somewhat elephantine except that the ulna, with its huge olecranon process, gives evidence of having been flexed to a greater degree, as shown in the restoration.

Of the feet we have but little trustworthy knowledge. The hoof-like claws are clearly indicated by the form of the ungual phalanges and, if Hatcher's very reasonable conception of the creature's habitat be correct, one would expect a somewhat spreading foot, which would bear the animal up in soft ground.

Of *Triceratops* only have we any idea of general form and proportions, its contemporaries *Diceratops* and *Torosaurus* being known only from the skull.

Diceratops, it will be remembered, had no nasal horn, and the supraorbitals were erect instead of forward projecting as in *Triceratops*. Its mode of fighting must have differed somewhat from that of the latter, probably in lowering the head much more. The peculiar fenestræ in the squamosals are unequal in size, and the one in the right parietal, near the margin of the frill (the corresponding portion of the left having been destroyed), may have been due to wounds caused by the penetration of an adversary's horn. In the Yale Museum there is a scapula of *Diclonius* with a clean-cut perforation, the edges of which have healed so as to give the appearance of a normal foramen. It is absent in the other scapula of the same animal, and Professor Marsh used to say that it was made by the horn of a *Triceratops*. This is certainly very suggestive of the *Diceratops* fenestræ. The left squamosal of the type of *Triceratops elatus* also shows a perforation near the parietal suture, which is of pathologic character. (See Pl. XLIII, p. 284.)

In *Torosaurus* the cranium was of proportions so different, with its immense though weak frill and its wedge-shaped facial region, that the aspect of the head must have differed greatly from that of *Triceratops*. The upper surface of the frill does not bear the deep vascular impressions of the last-mentioned genus nor are there marginal ossicles, indicating that instead of being somewhat free with a dense horny or tegmentary covering, the crest was more or less buried in the flesh of the neck. It was evidently used to obtain leverage for the head and not like the neck guard of a helmet, to protect the cervical region. The presence of the large vacuities is further evidence in favor of this belief. The two known species of *Torosaurus* are huge creatures, larger than the average *Triceratops* though of less proportions than the giant specimen of the latter genus alluded to on page 185. The supraorbital horns of *Torosaurus* were well developed, though the nasal horn was proportionately reduced and acutely pointed.

PROBABLE HABITS.

The feeding habits of the Ceratopsia are manifest from the tooth structure and from the character of the vegetation preserved with ceratopsian remains. The forward part of the mouth was edentulous and was sheathed on both the upper and the lower jaw, with a cutting beak like that of a turtle. Within the mouth were the magazines of teeth, each series presenting a vertical though slightly twisted wearing surface toward that of the opposing series, the worn surface of the lower teeth facing outward, that of the upper row inward. There is no possibility of a lateral grinding movement, as in herbivorous mammals; the lower jaw must have been moved entirely in a vertical plane. The beak probably served for cropping the more succulent leaves and shoots of low trees or shrubs, while the teeth were used to chop the food into short pieces before it was swallowed. As such pieces would naturally fall outside of the teeth of the lower jaw, the food must have been retained within the mouth by the muscular walls of the cheeks. Unless the teeth also subserved the function of food getting as well as of mastication, which is questionable, it is doubtful whether the gape of the mouth had a greater backward extent than the anterior end of the tooth series. This would bring the corner of the mouth decidedly in advance of the position indicated by Knight in Pl. I. (Compare fig. 5.)

PROBABLE ENVIRONMENT.

T. W. Stanton in a note[a] says:

It is difficult to reconstruct the physiographic conditions which prevailed in the Middle West during later Mesozoic time, but it should be remembered that in that region there was then a great shallow continental or mediterranean sea, and that there were large areas so near sea level that very slight movements would bring them beneath the sea or partly or wholly drain them, so that it is probable that shallow-water and nonmarine conditions were often extended over large areas very rapidly.

It would seem as though some such elevation, occurring at the close of the Claggett, gave rise to conditions under which the fresh-water Judith River deposits could be formed and that the Judith River period was succeeded in turn by a subsidence which caused an encroachment of the sea upon the land, giving rise to the Bearpaw shales. Next a second diastrophic movement caused a recession of the salt waters and inaugurated the conditions which characterized the Laramie.

Hatcher[b] thought that the period of elevation which brought about the close of the marine Cretaceous was followed, during the Laramie, by a period of subsidence not sufficient to cause a return to marine conditions, but such as to allow continual shallow-water deposition, as is evidenced by the great number of lignite seams in the Ceratops beds and by the absence of continuity of strata and the frequent cross-bedding which prevailed. Hatcher says:

The Ceratops beds are thought to afford evidence in themselves of having been deposited not in a great open lake, but in a vast swamp, with occasional stretches of open waters, the whole presenting an appearance similar to that which now exists in the interior of the Everglades of Florida. This condition would account for the frequent changes from one material to another in the same horizon. . . . In some places in the beds these changes are quite frequent, strata of sandstones and shales replacing one another in great confusion. It would also explain the cross-bedding so often seen in the sandstones of this region, in localities remote from the present border of the beds, and hence far removed from the shore of the ancient lake or swamp. This cross-bedding could hardly occur in offshore deposits of a great fresh-water lake of any considerable depth.

The conditions that prevailed over this region during the period in which the Ceratops beds were deposited were probably those of a great swamp with numerous small, open bodies of water connected by a network of watercourses constantly changing their channels. The intervening spaces were but slightly elevated above the water level or at times submerged. The entire region where the waters were not too deep was covered by an abundant vegetation, and inhabited by the huge dinosaurs (*Triceratops*, *Torosaurus*, *Claosaurus*, etc.), as well as by the smaller crocodiles and turtles and the diminutive mammals, all of whose remains are now found embedded in the deposits.

The frontispiece admirably depicts such a scene as Hatcher has described.

Dr. W. D. Matthew,[c] in a recent paper, speaks of three modes of life available during the Mesozoic for land vertebrates, "the amphibious-aquatic, the arboreal, and the aerial, the terrestrial being subordinate because the upland flora was largely undeveloped or inedible as compared with its present condition." The three provinces Matthew believed were peopled by reptiles, mammals, and birds respectively. With reference to the dinosaurs in particular Matthew's views are expressed in a letter to the writer, dated June 6, 1905, as follows:

I believe that they (the dinosaurs) were a—in fact the—land group of reptiles, but that nearly all we know of them is a number of aberrant amphibious or aquatic specialized branches; that the great arid subglacial period of the Perm-Trias gave them their initial trend on lines parallel to the evolution of the Mammalia during the Tertiary-Quaternary; that in the late Jura and the late Cretaceous a reaction to moist, torrid climate caused a great expansion and specialization of amphibious swamp-living forms, adapted to the marshy jungles then prevalent.

These are the dinosaurs we know. Of the dry-land forms we know very little. A few Triassic types, possibly some of the Jurassic ones, like *Ornitholestes* and *Hallopus* and *Laosaurus*, and the jungle-living carnivorous types departed less than the others from the primitive dry-land type. The Sauropoda I regard as exclusively water-living—the larger forms at least.[d]

[a] Proc. Am. Philos. Soc., vol. 43, p. 364, 1904.

[b] Am. Jour. Sci., 3d ser., vol. 45, 1893, p. 142.

[c] Am. Naturalist, vol. 38, Nov.-Dec., 1904, p. 816.

[d] Herein Matthew and Hatcher disagreed, as the latter considered the Sauropoda also as "terrestrial reptiles with amphibious habits, passing much, perhaps most, of their time in shallow water, where they were able to wade about in search of food." The evidence is strongly in favor of Matthew's belief.—R. S. L.

The stegosaurs, claosaurs, and ceratopsians may have been more or less land haunting, but not upland, and they all impress me as amphibious adaptations *from* a type highly specialized for land locomotion.

In the later Cretaceous the terrestrial province was greatly expanded by the development of the upland flora which provided for a corresponding spread of terrestrial types. These were derived mainly from the previously arboreal mammals, the birds maintaining their aerial habitat, while of the reptiles, the lizards and snakes only were able to adapt themselves to these new conditions. At the time of the expansion of the upland realm there was great dwindling of the amphibious-aquatic province, due to the orogenic movements occurring at the close of the Mesozoic, which drained the Cretaceous sea and its adjacent swamps and river deltas and caused the Reptilia to undergo a corresponding diminution.

PROBABLE CAUSES OF EXTINCTION.

Several theories have been advanced as to the probable causes of extinction of the Ceratopsia, some authors maintaining that the horned herbivorous types were in part destroyed by the large carnivorous dinosaurs. There is always, however, a balance in nature, an offsetting of Carnivora or parasitic forms against their plant-feeding contemporaries and, though the latter may have been held in check by the former, it is extremely improbable that strictly contemporaneous forms which have evolved in the same environment could ever exterminate one another. It seems that animals of another race, or hordes of creatures which emigrated from another region, would be more likely to exterminate their predecessors. The mammals fulfill the requirements of a new foe, and the development of the frill in the Ceratopsia has been considered as meeting the necessity for a better protection of the neck blood vessels from the weasel-like attack of small but bloodthirsty quadrupeds. Another notion advanced by Morris and amplified by Cope was that the Cretaceous mammals sought out the eggs of the dinosaurs and destroyed them—Cope even going so far as to suggest the Multituberculata, with their long, sharp anterior teeth, as the probable offenders.

Matthew, however, has given the Mesozoic Mammalia a totally different habitat from that of their dinosaurian contemporaries in the belief recently expressed that the mammals were distinctively arboreal, while we are led to believe that all dinosaurs were either terrestrial or possibly amphibious, the Ceratopsia at least inhabiting the lowlands in a swamp or delta region.

By far the most reasonable cause, and the one which Hatcher himself believed, seems to be that of changing climatic conditions and a contracting and draining of the swamp and delta regions caused by the orographic upheavals which occurred toward the close of the Cretaceous. The Ceratopsidæ and their nearest allies, the Trachodontidæ, both highly specialized plant feeders, were unable to adapt themselves to a profoundly changed environment because of this very specialization, and, as a consequence, perished.

That the Ceratopsia made a gallant struggle for survival seems evident, for they lived through the first series of upheavals at the close of the Laramie and also the second series at the close of the Arapahoe, which were accompanied by great volcanic outbursts in the Colorado region; but the changes accompanying the final upheavals which formed most of the great western mountain chains and closed the Mesozoic era gave the death blow to this remarkable race.

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PLATES.

PLATE II.

PLATE II.

COMPARATIVE VIEWS OF CRESTS.

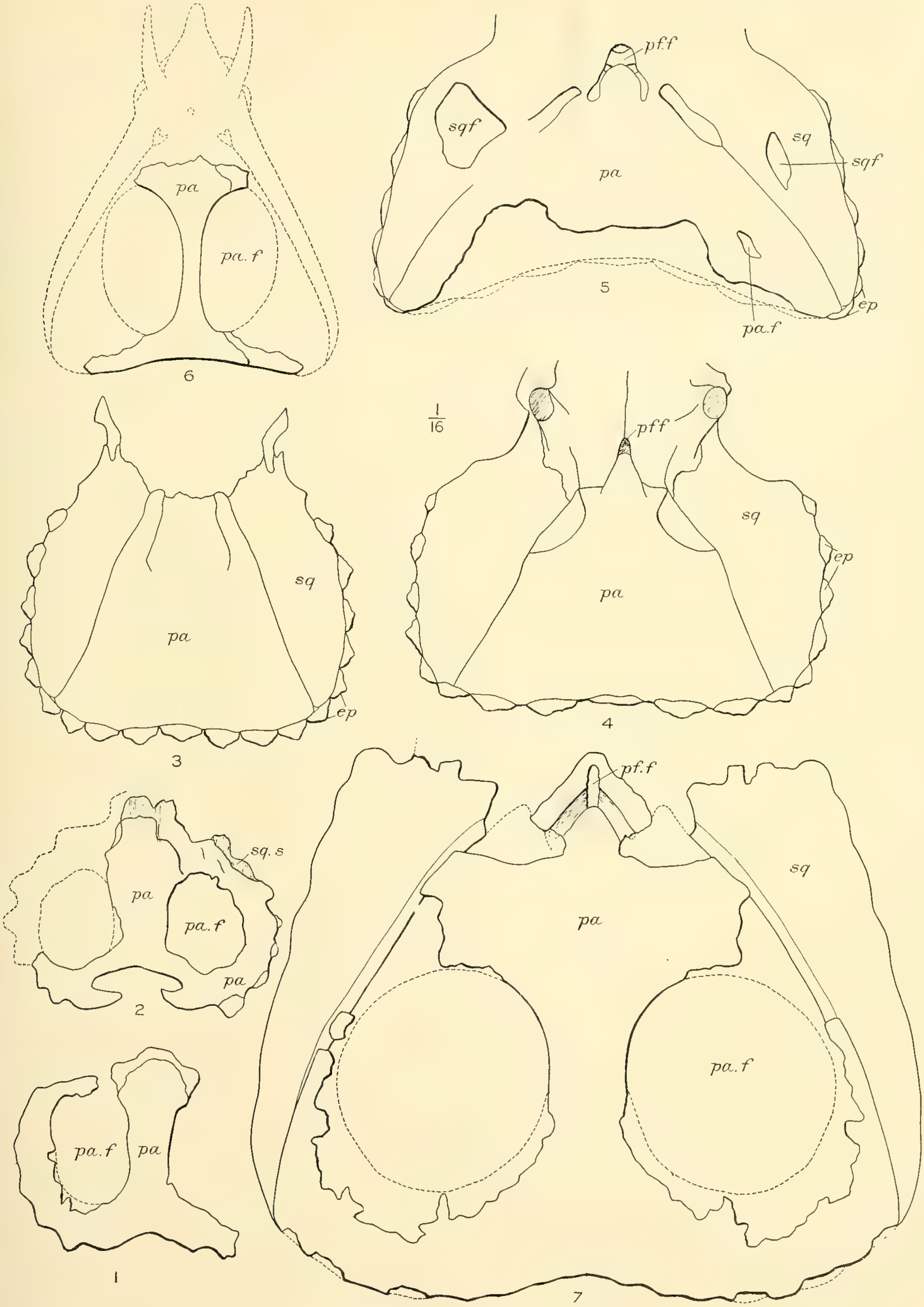
(See p. 19.)

Plate prepared under the direction of Lull.

Fig. 1. Type of *Monoclonius crassus* Cope. No. 3998, American Museum of Natural History.
Fig. 2. Type of *Centrosaurus apertus* Lambe. No. 971, Canadian Geological Survey. After Lambe.
Fig. 3. Type of *Triceratops flabellatus* Marsh. No. 1821, Yale Museum. After Marsh.
Fig. 4. Type of *Triceratops serratus* Marsh. No. 1823, Yale Museum. After Marsh.
Fig. 5. Type of *Diceratops hatcheri* Lull. No. 2412, U. S. National Museum.
Fig. 6. Type of *Ceratops* (*Monoclonius*) *belli* Lambe. No. 491, Canadian Geological Survey. After Lambe.
Fig. 7. Type of *Torosaurus gladius* Marsh. No. 1831, Yale Museum.

ep, epoccipitals.
pa, parietal.
paf, parietal fontanelle.
pff, postfrontal fontanelle.
sq, squamosal.
sqf, squamosal fenestra.
sqs, squamosal suture.

All one-sixteenth natural size.



COMPARATIVE VIEWS OF CRESTS.

PLATE III.

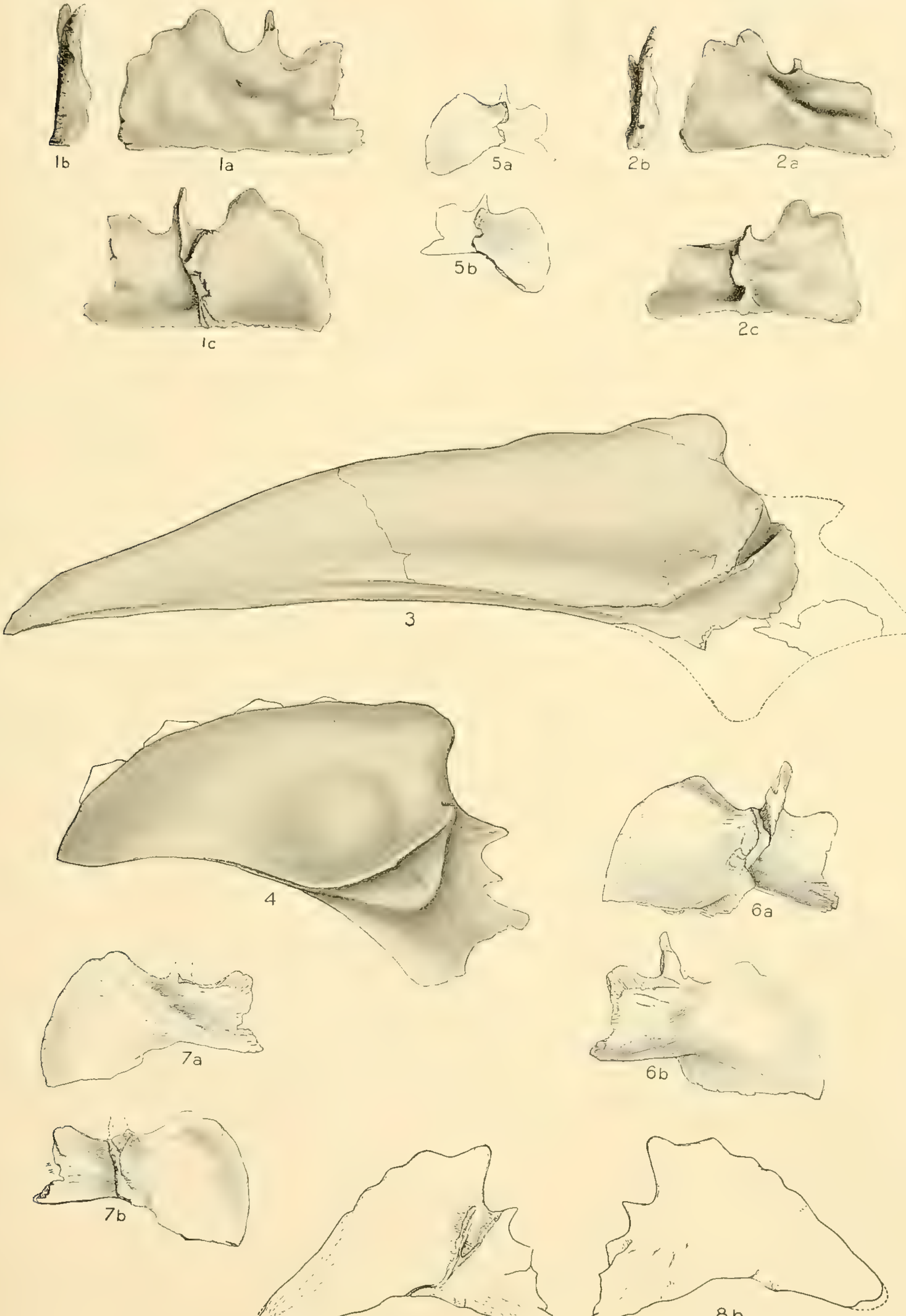
PLATE III.

COMPARATIVE VIEWS OF SQUAMOSAL BONES.

(See p. 20.)

Plate prepared under the direction of Lull.

FIG. 1. *Ceratops montanus?* Marsh. No. 4802, U. S. National Museum. After Marsh.
a, Dorsal aspect; *b*, end view; *c*, ventral aspect.
FIG. 2. *Ceratops* sp. (young). No. 2415, U. S. National Museum. After Marsh.
a, Dorsal aspect; *b*, end view; *c*, ventral aspect.
FIG. 3. *Torosaurus gladius* Marsh. No. 1831, Yale Museum. After Marsh.
Ventral aspect.
FIG. 4. *Triceratops flabellatus* Marsh. No. 1821, Yale Museum. After Marsh.
Ventral aspect.
FIG. 5. *Monoclonius* sp. No. 3394, American Museum of Natural History.
a, Dorsal aspect; *b*, ventral aspect.
FIG. 6. *Monoclonius* sp. No. 3996, American Museum of Natural History.
a, Ventral aspect; *b*, dorsal aspect.
FIG. 7. *Monoclonius* sp. No. 3995, American Museum of Natural History.
a, Dorsal aspect; *b*, ventral aspect.
FIG. 8. *Ceratops canadensis* Lambe. No. 1254, Canadian Geological Survey. After Lambe.
a, Ventral aspect; *b*, dorsal aspect.
All one-twelfth natural size.



COMPARATIVE VIEWS OF SQUAMOSAL BONES.

PLATE IV.

PLATE IV.

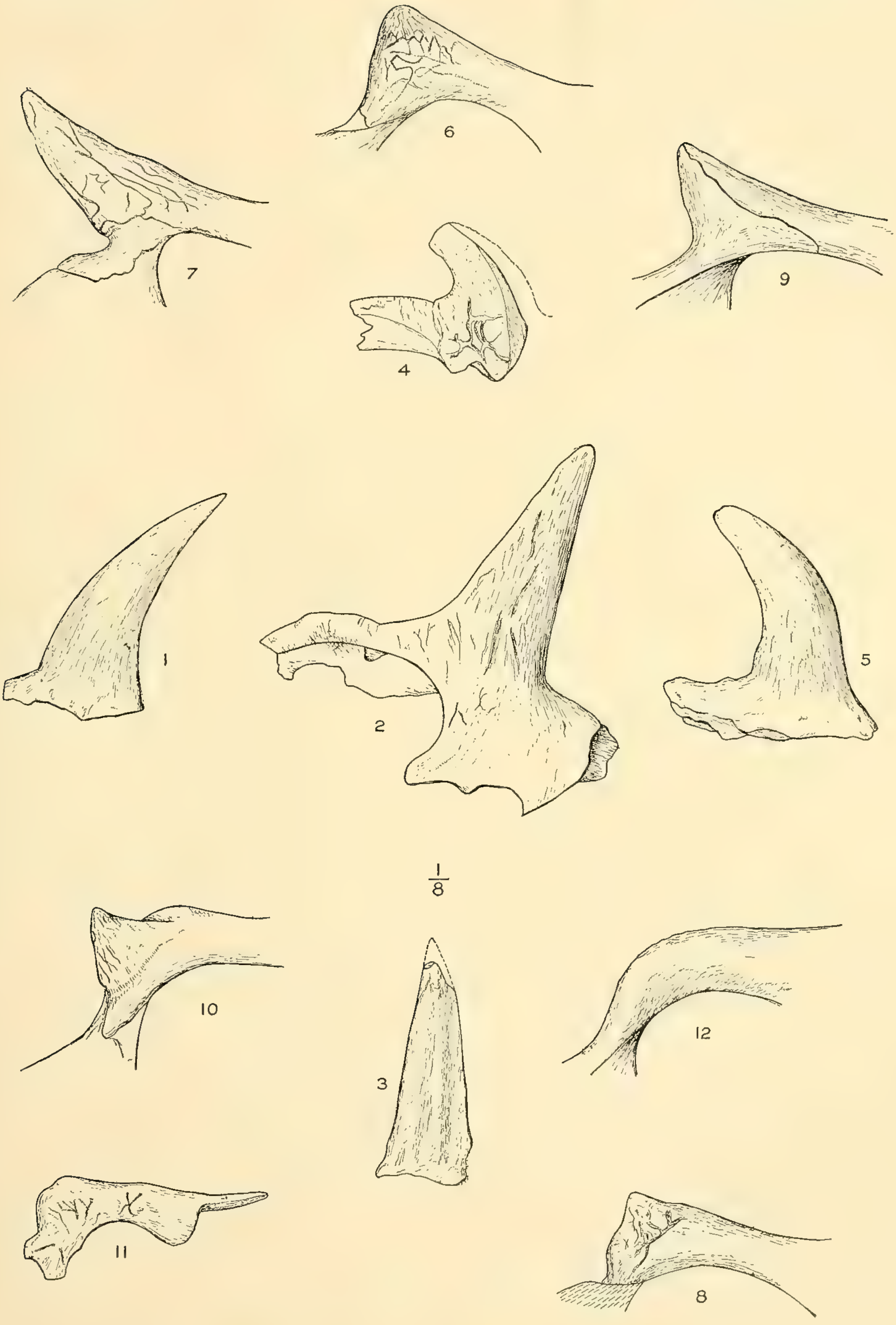
COMPARATIVE VIEWS OF NASAL HORN CORES.

(See p. 32.)

Plate prepared under the direction of Lull.

Fig. 1. Type of *Monoclonius dawsoni* Lambe. No. 1173, Canadian Geological Survey. Modified from Lambe.
Fig. 2. Type of *Monoclonius sphenocerus* Cope. No. 3989, American Museum of Natural History.
Fig. 3. Type of *Centrosaurus apertus* Lambe. No. 971, Canadian Geological Survey. After Lambe.
Fig. 4. Type of *Ceratops* (*Monoclonius*) *recurvicornis* Cope. No. 3999, American Museum of Natural History. After Cope.
Fig. 5. *Ceratops* sp. referred with a query to *Monoclonius dawsoni* Lambe, by Lambe. No. 190, Canadian Geological Survey. Modified from Lambe.
Fig. 6. Type of *Triceratops horridus* Marsh. No. 1820, Yale Museum.
Fig. 7. Type of *Triceratops prorsus* Marsh. No 1822, Yale Museum. After Marsh.
Fig. 8. *Triceratops prorsus?* Marsh. No. 2100, U. S. National Museum.
Fig. 9. Type of *Triceratops brevicornus* Hatcher. No. 1834, Yale Museum.
Fig. 10. Type of *Triceratops calicornis* Marsh. No. 4928, U. S. National Museum.
Fig. 11. Type of *Triceratops obtusus* Marsh. No. 4720, U. S. National Museum.
Fig. 12. Type of *Diceratops hatcheri* Lull. No. 2412, U. S. National Museum.

The figures are all viewed from the left side and are all one-eighth natural size.



COMPARATIVE VIEWS OF NASAL HORN CORES.

PLATE V.

PLATE V.

COMPARATIVE VIEWS OF SUPRAORBITAL HORN CORES.

(See p. 32.)

Plate prepared under the direction of Lull.

FIG. 1. *Monoclonius crassus.* No. 3997, American Museum of Natural History.
FIG. 2. Type of *Ceratops montanus* Marsh. No. 2411, U. S. National Museum, oblique back view.
FIG. 3. Type of *Ceratops* (*Monoclonius*) *canadensis* Lambe. No. 1254, Canadian Geological Survey. Modified from Lambe.
FIG. 4. Type of *Ceratops* (*Monoclonius*) *recurvicornis* Cope. No. 3999, American Museum of Natural History. Modified from Cope.
FIG. 5. Type of *Triceratops prorsus* Marsh. No. 1822, Yale Museum. After Marsh.
FIG. 6. *Triceratops prorsus?* Marsh. No. 2100, U. S. National Museum.
FIG. 7. Type of *Triceratops brevicornus* Hatcher. No. 1834, Yale Museum.
FIG. 8. Type of *Triceratops calicornis* Marsh. No. 4928, U. S. National Museum.
FIG. 9. Type of *Triceratops* (*Sterrholophus*) *flabellatus* Marsh. No. 1821, Yale Museum. After Marsh.
FIG. 10. Type of *Diceratops hatcheri* Lull. No. 2412, U. S. National Museum.

The figures, except fig. 2, are all viewed from the left side and are all one-eighth natural size.

COMPARATIVE VIEWS OF SUPRAORBITAL HORN CORES.

PLATE VI.

PLATE VI.

LOWER JAW OF TRICERATOPS SULCATUS MARSH.

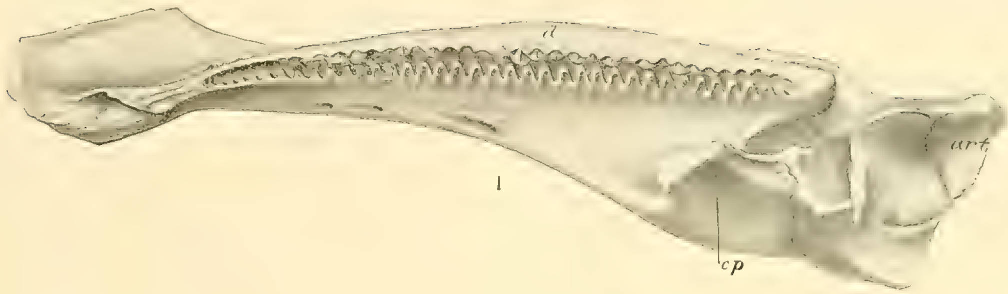
(See p. 39.)

Plate prepared under the direction of Marsh.

Specimen No. 4276, U. S. National Museum.

FIG. 1. Superior view.
FIG. 2. Internal view.
FIG. 3. External view.

ang, Angular; *art*, articular; *cp*, coronoid process; *d*, dentary; *s*, splenial; *sang*, surangular.
One-sixth natural size.



1

$\frac{1}{6}$

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3

LOWER JAW OF TRICERATOPS SULCATUS MARSH.

PLATE VII.

PLATE VII.

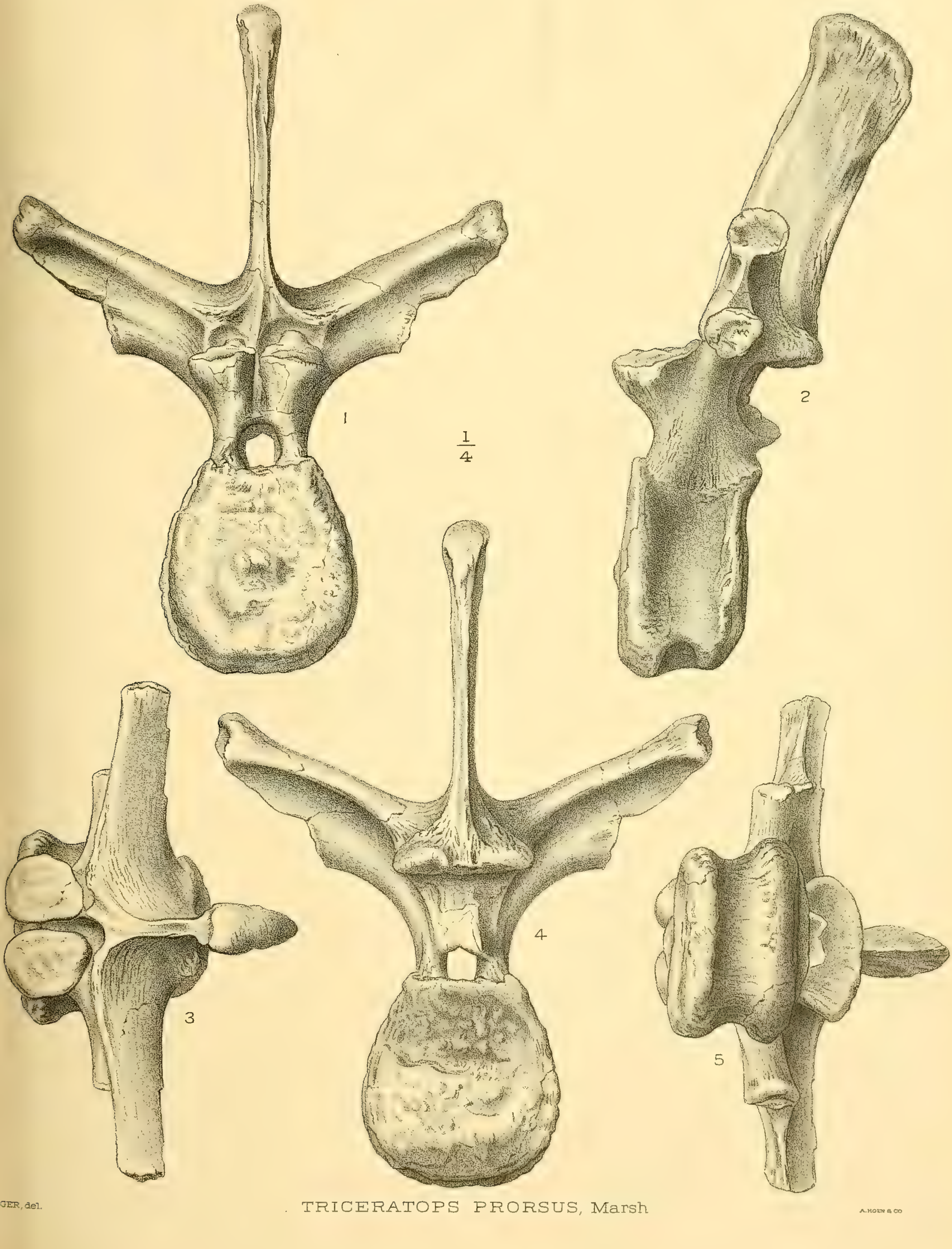
POSTERIOR DORSAL VERTEBRA OF TRICERATOPS PRORSUS MARSH.

(See p. 51.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum.

Fig. 1. Anterior view.
Fig. 2. Left lateral view.
Fig. 3. Superior view.
Fig. 4. Posterior view.
Fig. 5. Inferior view.
One-fourth natural size.



GER, del.

TRICERATOPS PRORSUS, Marsh

A. HOEN & CO.

PLATE VIII.

PLATE VIII.

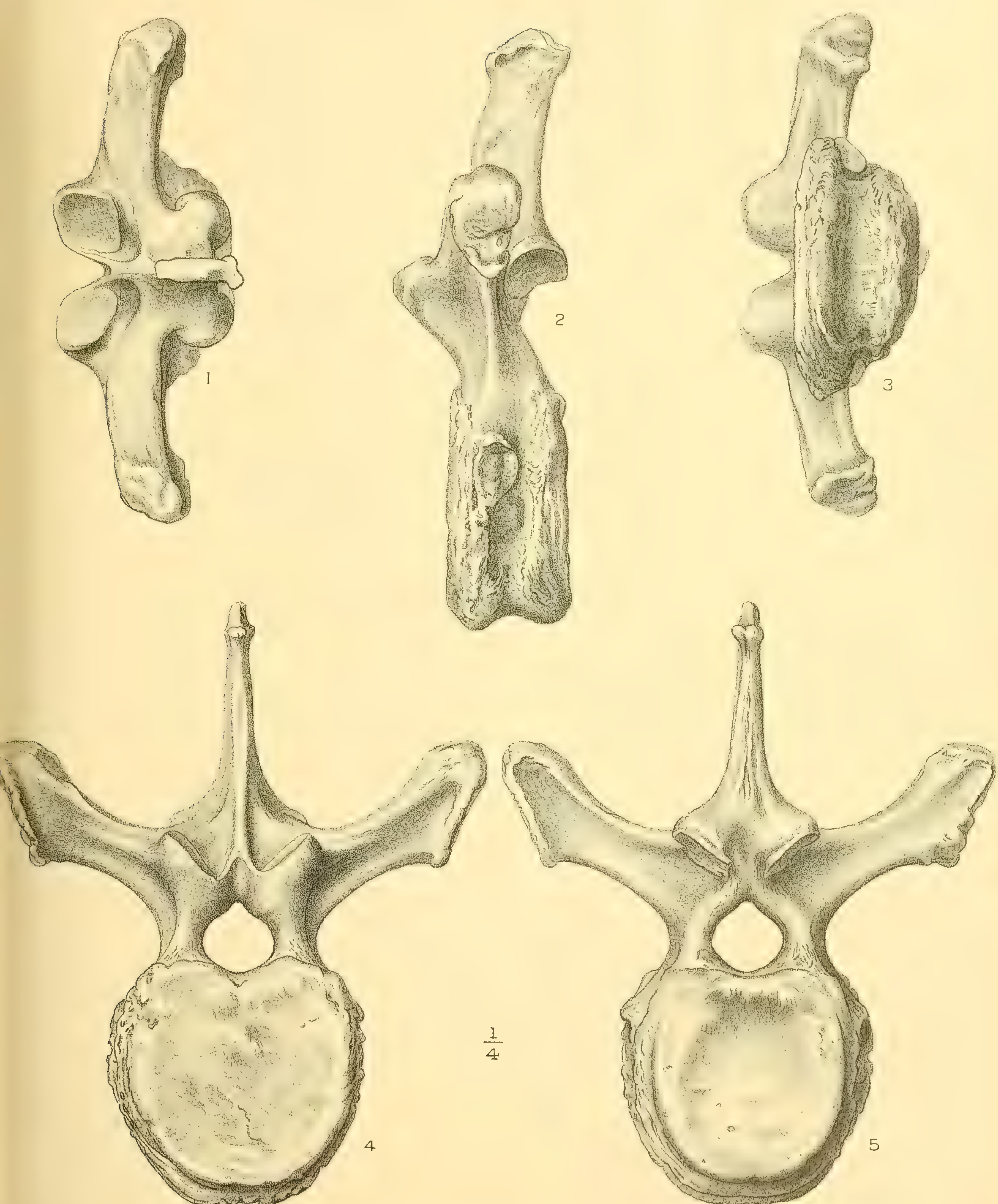
ANTERIOR DORSAL VERTEBRA OF TRICERATOPS PRORSUS MARSH.

(See p. 50.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum.

Fig. 1. Superior view.
Fig. 2. Left lateral view.
Fig. 3. Inferior view.
Fig. 4. Anterior view.
Fig. 5. Posterior view.
One-fourth natural size.



GER, del

TRICERATOPS PRORSUS, Marsh

A HOEN & CO

PLATE IX.

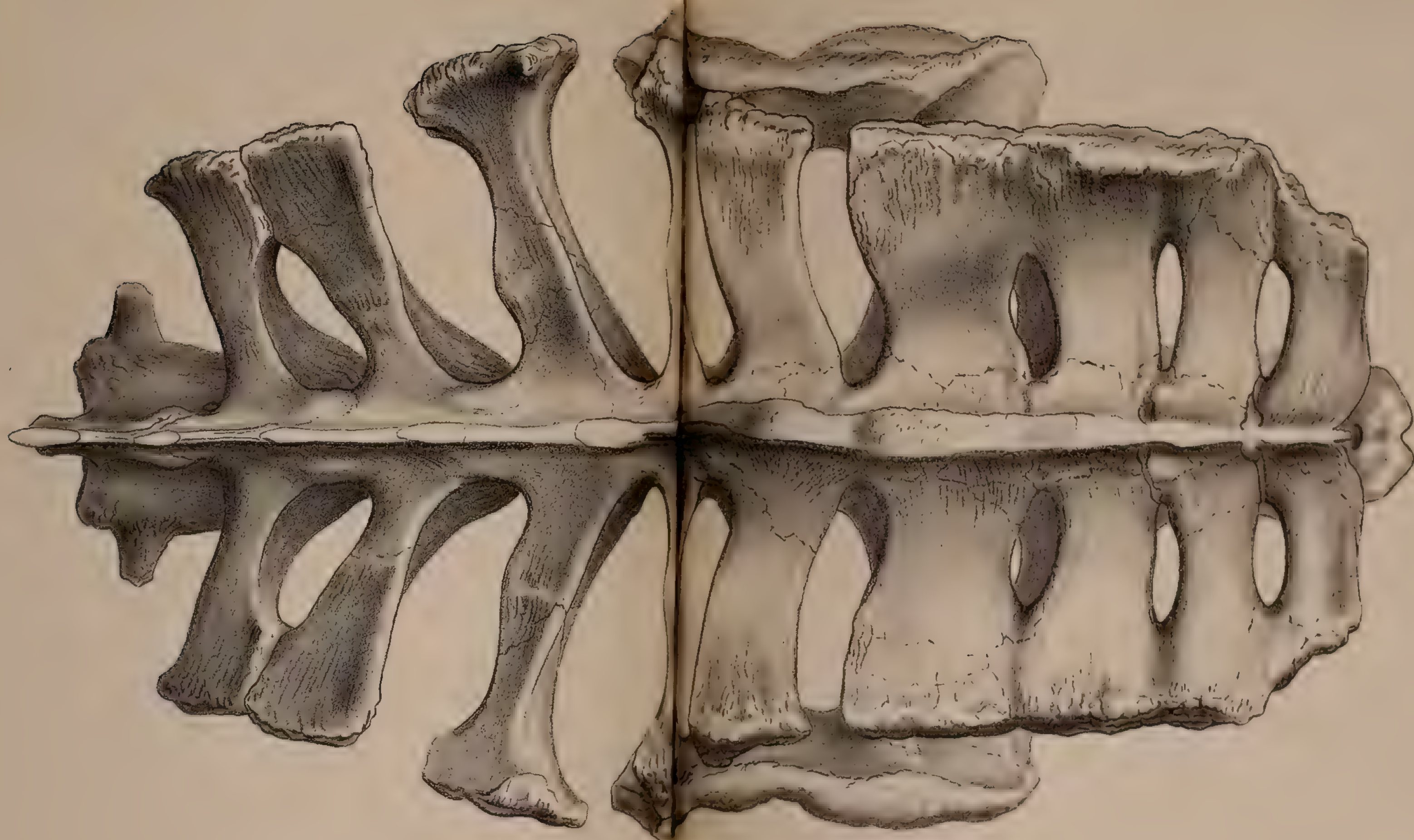
PLATE IX.

SACRUM OF TRICERATOPS PRORSUS MARSH.

(See p. 51.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum. Superior view.
One-fourth natural size.



$\frac{1}{4}$

F BERGER, del

PLATE X.

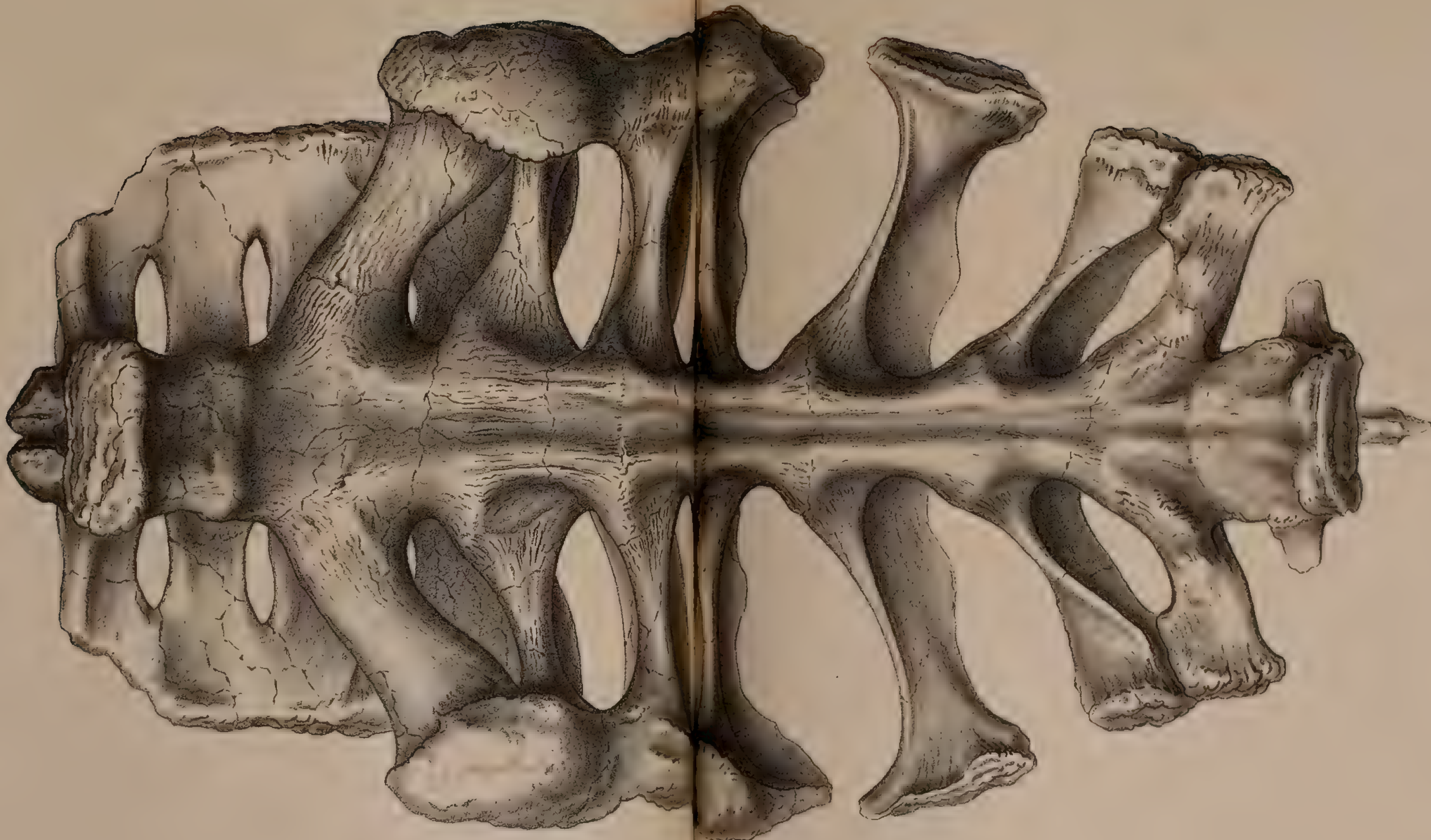
PLATE X.

SACRUM OF TRICERATOPS PRORSUS MARSH.

(See p. 51.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum. Inferior view.
One-fourth natural size.



F. BERJER, del.

TRICERA[illegible] [illegible]RSUS, Marsh

PLATE XI.

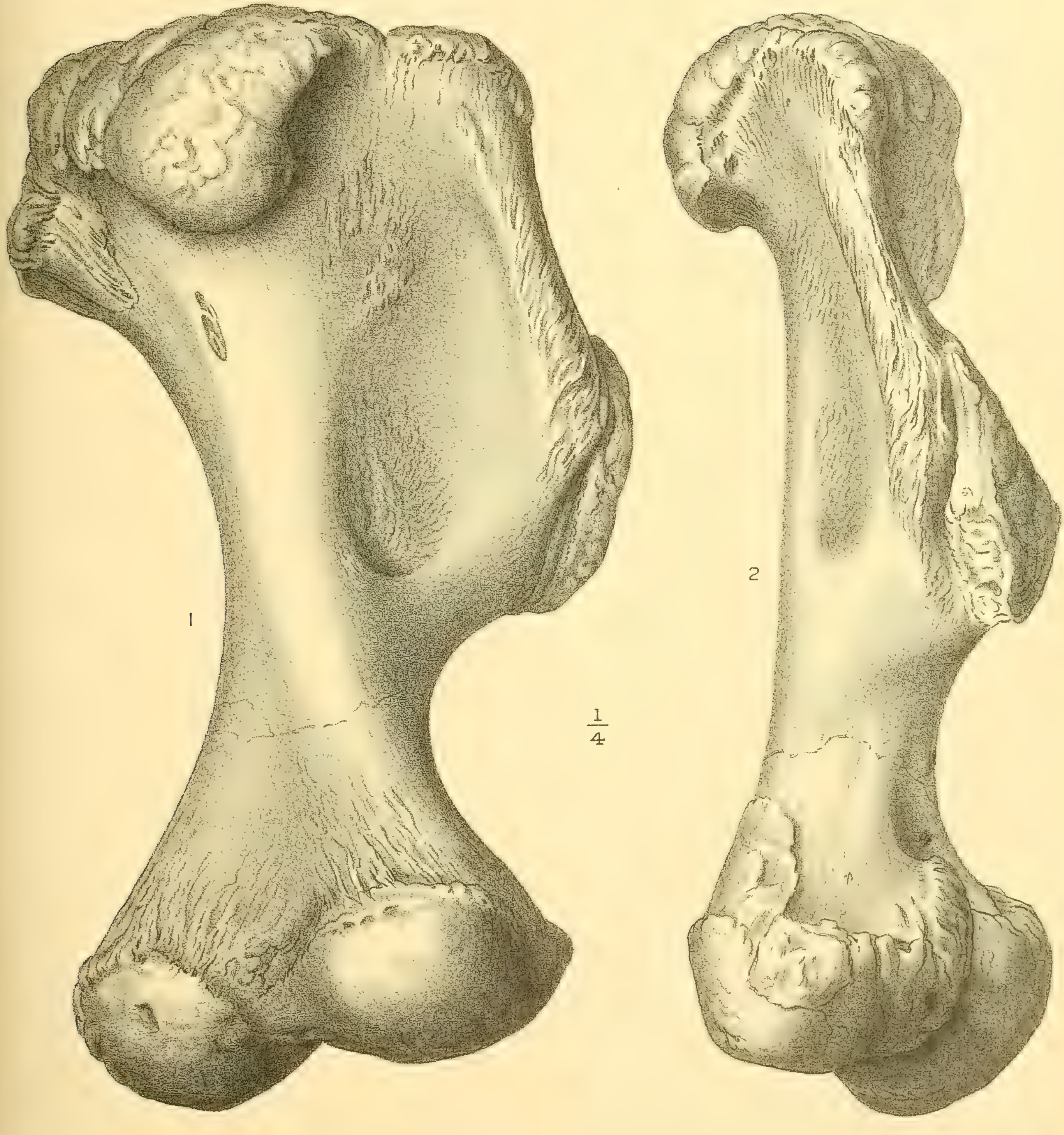
PLATE XI.

RIGHT HUMERUS OF TRICERATOPS PRORSUS MARSH.

(See p. 60.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum.
Fig. 1. Posterior view.
Fig. 2. External view.
One-fourth natural size.



R del

TRICERATOPS PRORSUS, Marsh

A HOEN & CO.

PLATE XII.

PLATE XII.

RIGHT HUMERUS OF TRICERATOPS PRORSUS MARSH.

(See p. 60.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum.

Fig. 1. Anterior view.
Fig. 2. Proximal view.
Fig. 3. Distal view.
Fig. 4. Internal view.
Fig. 5. Section of shaft.

One-fourth natural size.

TRICERATOPS PRORSUS, Marsh

PLATE XIII.

PLATE XIII.

LEFT ULNA OF TRICERATOPS PRORSUS MARSH.

(See p. 60.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum.

Fig. 1. Posterior view.
Fig. 2. Internal view.
Fig. 3. Proximal view.
Fig. 4. Distal view.
Fig. 5. External view.
Fig. 6. Anterior view.
Fig. 7. Section of shaft.
One-fourth natural size.

F. BERGER del.

TRICERATOPS PRORSUS, Marsh

PLATE XIV.

PLATE XIV.

LEFT FEMUR OF TRICERATOPS PRORSUS MARSH.

(See p. 62.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum.

Fig. 1. Anterior view.
Fig. 2. Proximal view.
Fig. 3. Posterior view.
Fig. 4. Distal view.
One-fourth natural size.

TRICERATOPS PRORSUS, Marsh

PLATE XV.

PLATE XV.

LEFT FEMUR OF TRICERATOPS PRORSUS MARSH.

(See p. 62.)

Plate prepared under the direction of Marsh.

Specimen No. 4842, U. S. National Museum.

Fig. 1. External view.

Fig. 2. Internal view.

Fig. 3. Section of shaft.

One-fourth natural size.

TRICERATOPS PRORSUS, Marsh

PLATE XVI.

PLATE XVI.

LEFT TIBIA AND ASTRAGALUS (COOSSIFIED) OF TRICERATOPS PRORSUS MARSH.

(See p. 62.)

Plate prepared under the direction of Marsh.

Specimen No. 2082, Yale University Museum.

FIG. 1. Posterior view.
FIG. 2. Anterior view.
FIG. 3. Internal view.
FIG. 4. External view.
FIG. 5. Proximal view.
FIG. 6. Distal view.
FIG. 7. Section of shaft.
One-eighth natural size.

TIBIA AND ASTRAGALUS OF TRICERATOPS PRORSUS MARSH.

PLATE XVII.

PLATE XVII.

FOOT BONES OF TRICERATOPS.

(See pp. 61, 63–64.)

Plate prepared under the direction of Marsh.

Left metacarpal I, specimen in the U. S. National Museum.
- FIG. 1. Dorsal view.
- FIG. 2. External lateral view.
- FIG. 3. Palmar view.
- FIG. 4. Internal lateral view.
- FIG. 5. Proximal view.
- FIG. 6. Distal view.
- FIG. 7. Section of shaft.

Left metacarpal IV, specimen in the U. S. National Museum.
- FIG. 8. Dorsal view.
- FIG. 9. External lateral view.
- FIG. 10. Palmar view.
- FIG. 11. Internal lateral view.
- FIG. 12. Proximal view.
- FIG. 13. Distal view.
- FIG. 14. Section of shaft.

Metatarsal, specimen in the U. S. National Museum.
- FIG. 15. Anterior view.
- FIG. 16. Lateral view.
- FIG. 17. Posterior view.

Ungual phalanx from the pes, specimen in the U. S. National Museum.
- FIG. 18. Superior view.
- FIG. 19. Lateral view.
- FIG. 20. Inferior view.

All one-fourth natural size.

METACARPALS, METATARSALS, AND TERMINAL PHALANX OF TRICERATOPS PRORSUS AND T. HORRIDUS MARSH.

PLATE XVIII.

PLATE XVIII.

HORN CORES OF CERATOPS.

After the originals by Lambe.

NASAL HORN CORE OF CERATOPS.

(See p. 92.)

Specimen No. 190, Canadian Geological Survey collection.

FIG. 1. Right aspect.

FIG. 2. Sectional outlines at *a* and *b*.

One-half natural size.

RIGHT SUPRAORBITAL HORN CORE OF TYPE OF CERATOPS CANADENSIS LAMBE.

(See p. 94.)

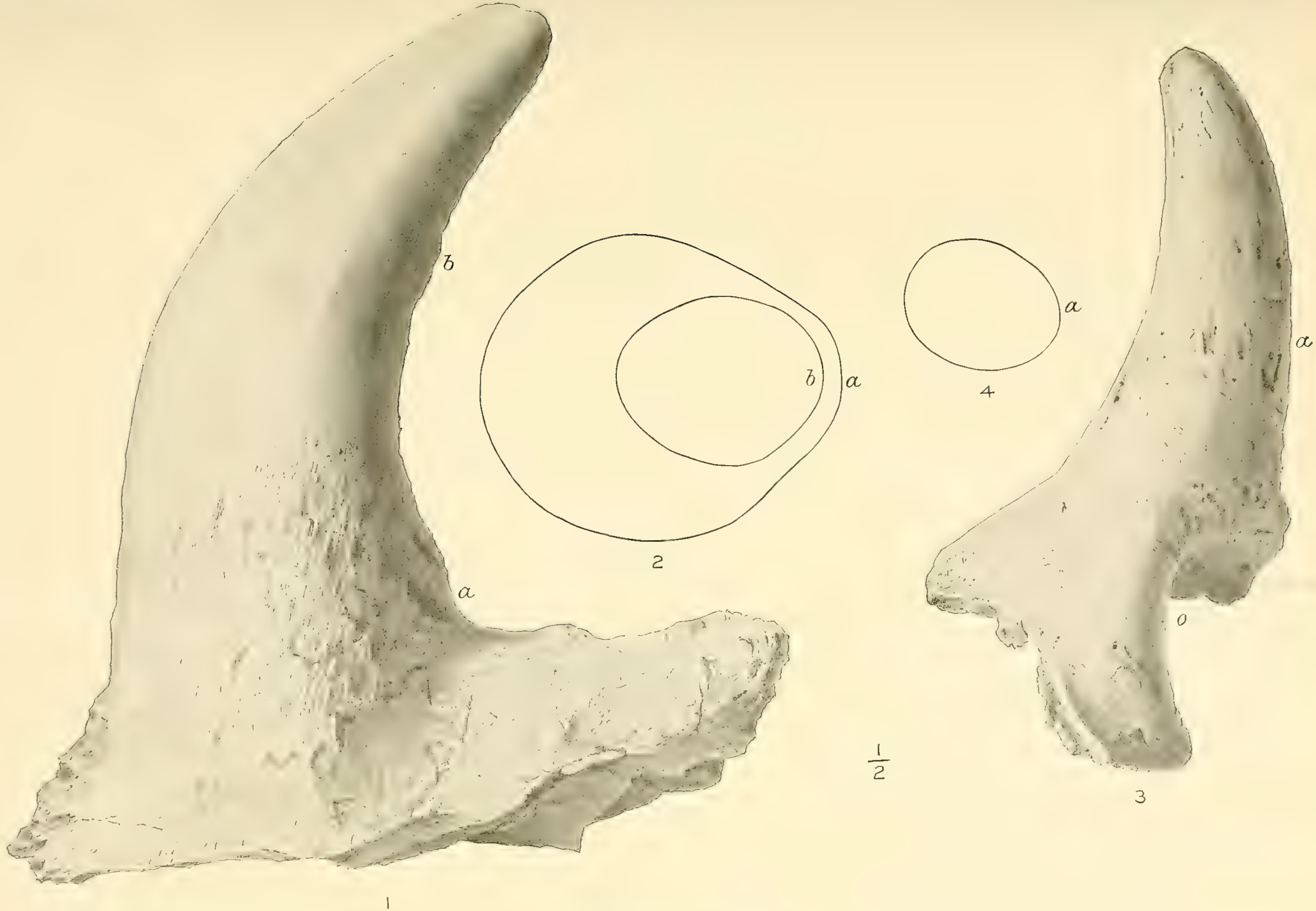
Specimen No. 1254, Canadian Geological Survey collection.

FIG. 3. Oblique rear view.

FIG. 4. Sectional outline at *a*.

o, Orbit.

One-half natural size.



HORN CORES OF CERATOPS.

PLATE XIX.

PLATE XIX.

RAMUS AND TEETH OF CERATOPS CANADENSIS LAMBE.

After the originals by Lambe

RIGHT MANDIBULAR RAMUS.

(See p. 94.)

Specimen No. 284, Canadian Geological Survey collection.

FIG. 1. External view.

FIG. 2. Internal view.

a, Alveolar groove; *b*, symphyseal surface; *c*, mandibular groove; *e*, coronoid process; *f*, dentary-predentary facet.

One-half natural size.

MAXILLARY TOOTH.

(See p. 95.)

(Provisionally associated with *Ceratops canadensis* Lambe.)

FIG. 3. External view.

FIG. 4. Internal view.

Natural size.

MANDIBULAR TOOTH.

(See p. 95.)

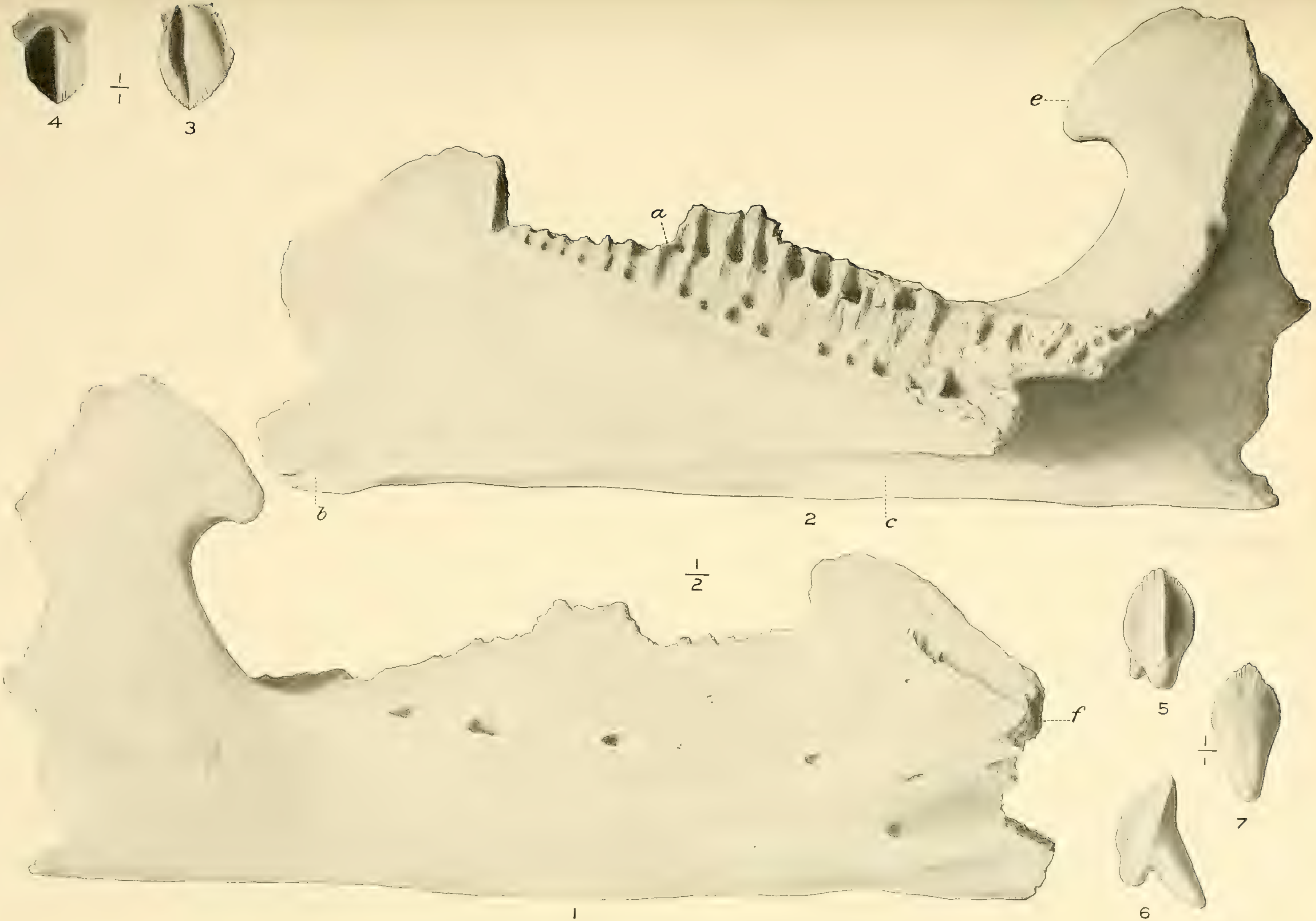
(Provisionally associated with *Ceratops canadensis* Lambe.)

FIG. 5. Internal view.

FIG. 6. Lateral view, showing divided fang.

FIG. 7. External view.

Natural size.



LOWER JAW AND TEETH OF CERATOPS CANADENSIS LAMBE.

PLATE XX.

PLATE XX.

SCAPULA AND CORACOID AND PREDENTARY BONE OF MONOCLONIUS DAWSONI? LAMBE.

LEFT SCAPULA AND CORACOID.

(See p. 90.)

After the original by Lambe.

(Provisionally associated with *Monoclonius dawsoni* Lambe.)

Specimen No. 506, Canadian Geological Survey collection.
FIG. 1. Internal view.
One-fourth natural size.

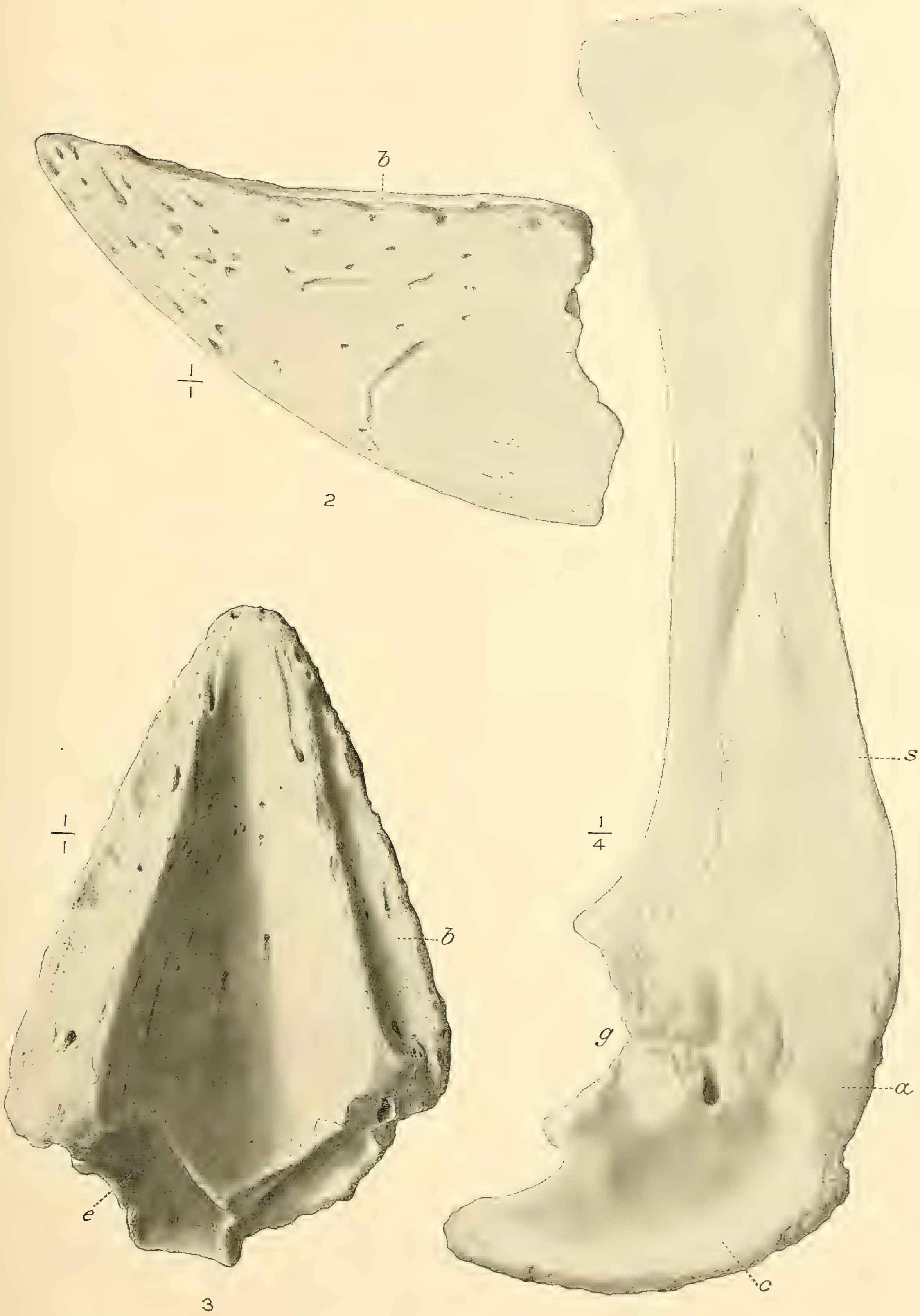
PREDENTARY BONE.

(See p. 91.)

After the originals by Lambe.

(Provisionally associated with *Monoclonius dawsoni*.)

Specimen in the Canadian Geological Survey collection
FIG. 2. Left lateral view.
FIG. 3. Superior view.
Natural size.
a, Suture between scapula and coracoid; *b*, upper border; *c*, coracoid; *e*, groove for dentary; *g*, glenoid fossa; *s*, scapula.



SCAPULA AND CORACOID AND PREDENTARY BONE OF ?MONOCLONIUS DAWSONI LAMBE.

PLATE XXI.

PLATE XXI.

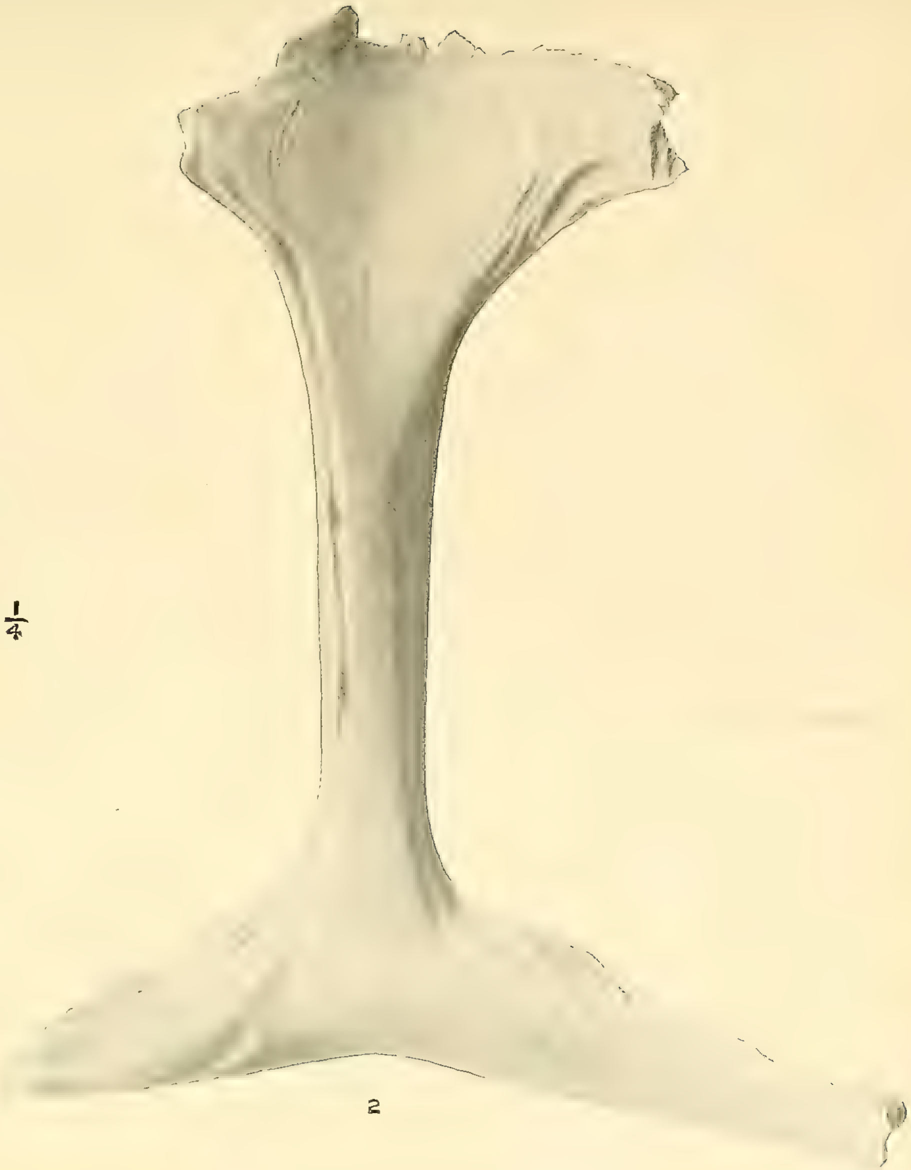
PARIETAL ELEMENT OF CREST OF TYPE OF CERATOPS BELLI LAMBE.

(See p. 96.)

After the originals by Lambe.

Specimen No. 491, Canadian Geological Survey collection.
Fig. 1. Superior view.
Fig. 2. Inferior view.
One-fourth natural size.

1



2

$\frac{1}{4}$

PARIETAL OF CREST OF CERATOPS BELLI LAMBE.

PLATE XXII.

PLATE XXII.

SUPERIOR PORTION OF OCCIPITAL, PARIETAL, AND FRONTAL SEGMENTS OF SKULL, WITH COALESCED DERMAL OSSIFICATIONS, OF STEGOCERAS.

(See p. 97.)

After the originals by Lambe.

Stegoceras validus Lambe. Type specimen, No. 515, Canadian Geological Survey Collection.

Fig. 1. Lateral aspect.

Fig. 2. Inferior view.

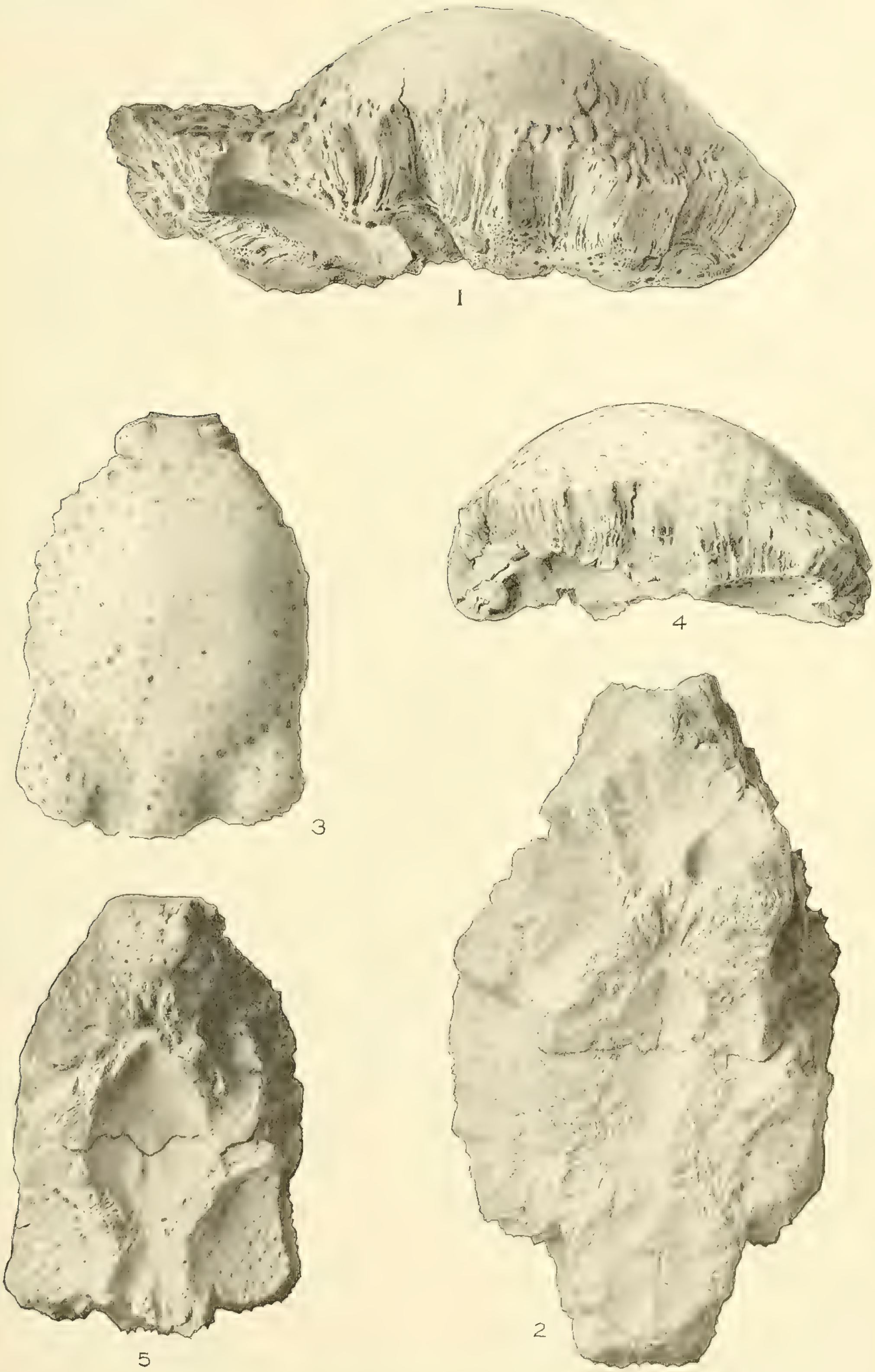
Stegoceras validus Lambe. Specimen No. 1423, Canadian Geological Survey Collection.

Fig. 3. Superior view.

Fig. 4. Lateral view.

Fig. 5. Inferior view.

Natural size.



SUPERIOR PORTION OF OCCIPITAL, PARIETAL, AND FRONTAL SEGMENTS OF SKULL OF STEGOCERAS LAMBE.

PLATE XXIII.

PLATE XXIII.

ELEMENTS OF POSTERIOR CREST OF TYPE OF CERATOPS CANADENSIS LAMBE.

After the original by Lambe.

(See p. 94.)

Specimen No. 1254, Canadian Geological Survey collection.

Fig. 1. Superior view of right squamosal.

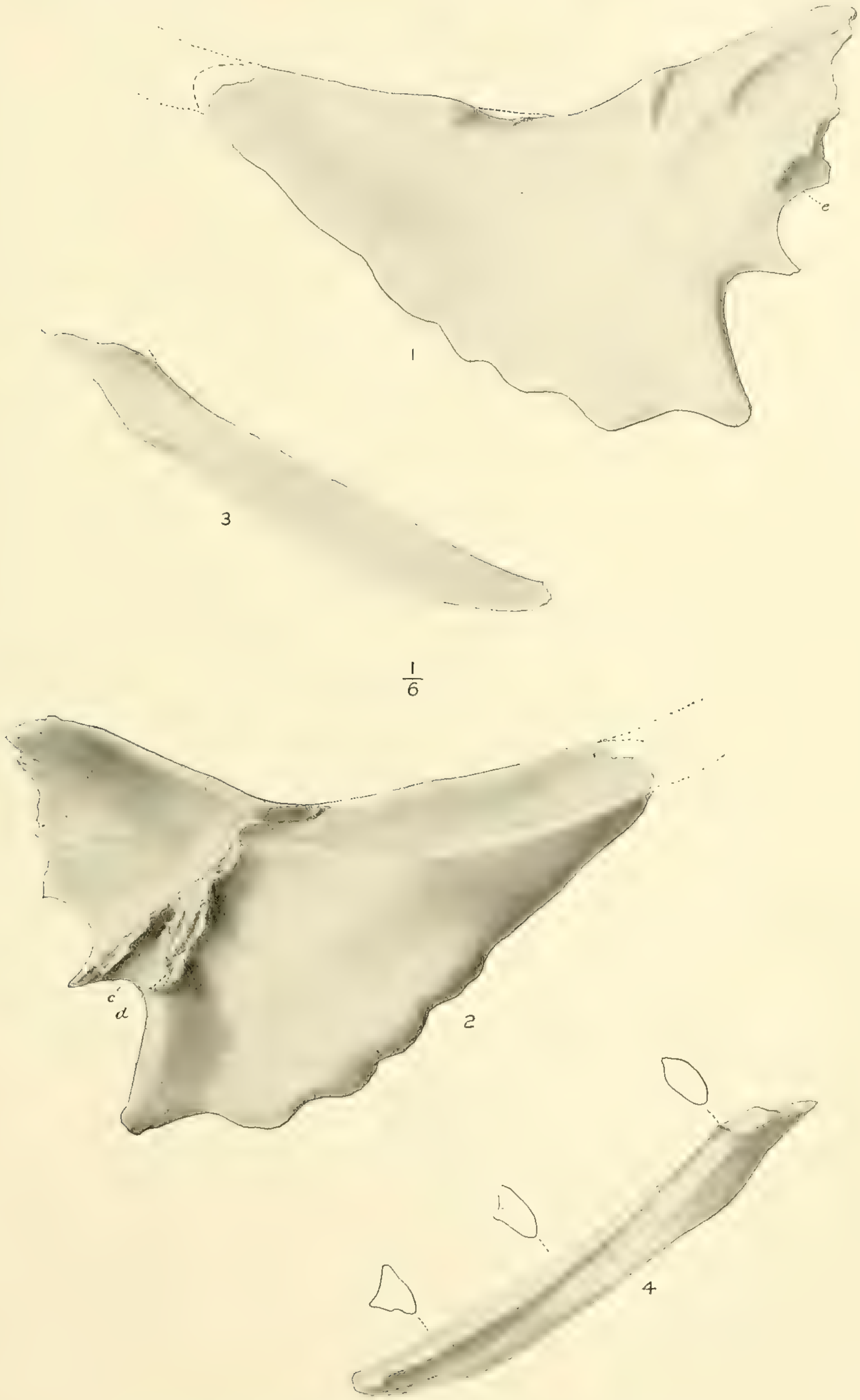
Fig. 2. Inferior view.

Fig. 3. Upper surface of front end of right lateral posterior extension of parietal.

Fig. 4. Lower surface.

c, Pit for process of quadrate; *d*, surface for articulation with exoccipital; *e*, surface for contact with jugal.

One-sixth natural size.



PARTS OF CREST OF CERATOPS CANADENSIS LAMBE.

PLATE XXIV.

PLATE XXIV.

TYPE OF CENTROSAURUS APERTUS LAMBE.

(See p. 93.)

After the original by Lambe.

Specimen No. 971, Canadian Geological Survey collection.

FIG. 1. Dorsal view of parietal crest.
FIG. 2. Right lateral view.
FIG. 3. Lateral view of nasal horn core.
FIG. 4. Section of horn core.
a, Parieto-squamosal suture; *b*, parieto-frontal suture.
One-eighth natural size.

PARIETAL CREST AND NASAL HORN CORE OF CENTROSAURUS APERTUS LAMBE.

PLATE XXV.

PLATE XXV.

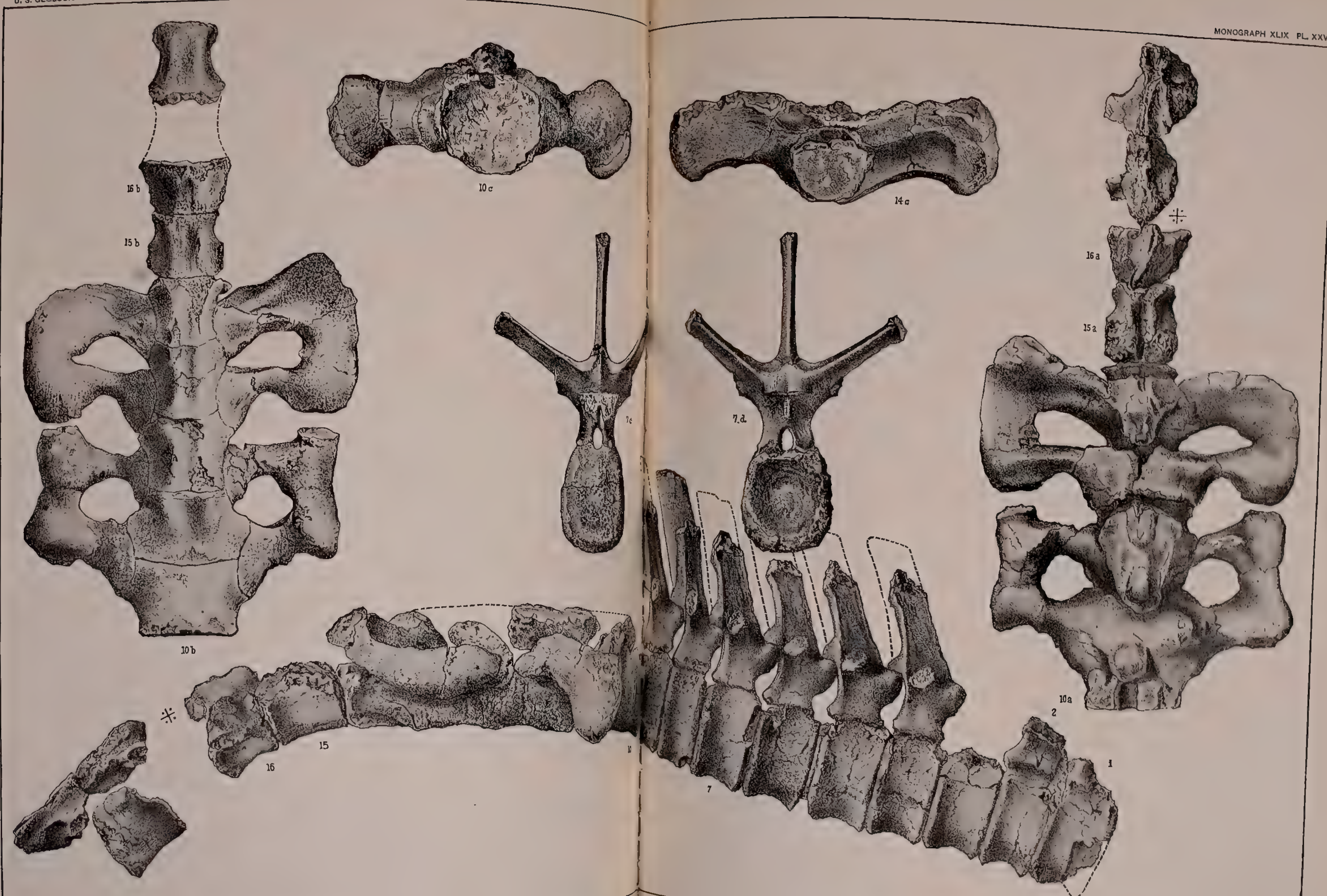
TYPE OF AGATHAUMAS SYLVESTRIS COPE.

(See p. 106.)

After the original by Cope.

Specimen No. 4000, American Museum of Natural History.

Figs. 1–16. Lateral views of presacral and sacral vertebræ.
Fig. 7c. Anterior view of seventh vertebra.
Fig. 7d. Posterior view.
Figs. 10a–16a. Dorsal view of sacrum.
Figs. 10b–16b. Ventral view.
Fig. 10c. Proximal end.
Fig. 14c. Distal end of fifth sacral vertebra.
One-sixth natural size.



VERTEBRA AND SACRUM OF AGATHAUMAS SYLVESTRIS COPE.

PLATE XXVI.

PLATE XXVI.

TYPE OF TRICERATOPS HORRIDUS MARSH.

(See p. 118.)

Plate prepared under the direction of Hatcher.

Specimen No. 1820, Yale University Museum. Left lateral view of anterior portion of the skull.

ju, jugal.
m, maxillary.
nas, nasal.
nh, nasal horn.
no, nasal opening.
o, orbit.
pf, postfrontal.
pm, premaxillary.
q, quadrate.
r, rostral bone.
soh, supraorbital horn.
sq, squamosal.

One-fourth natural size.

SKULL OF T[illegible] MARSH

PLATE XXVII.

PLATE XXVII.

SKULL OF TYPE OF TRICERATOPS SERRATUS MARSH.

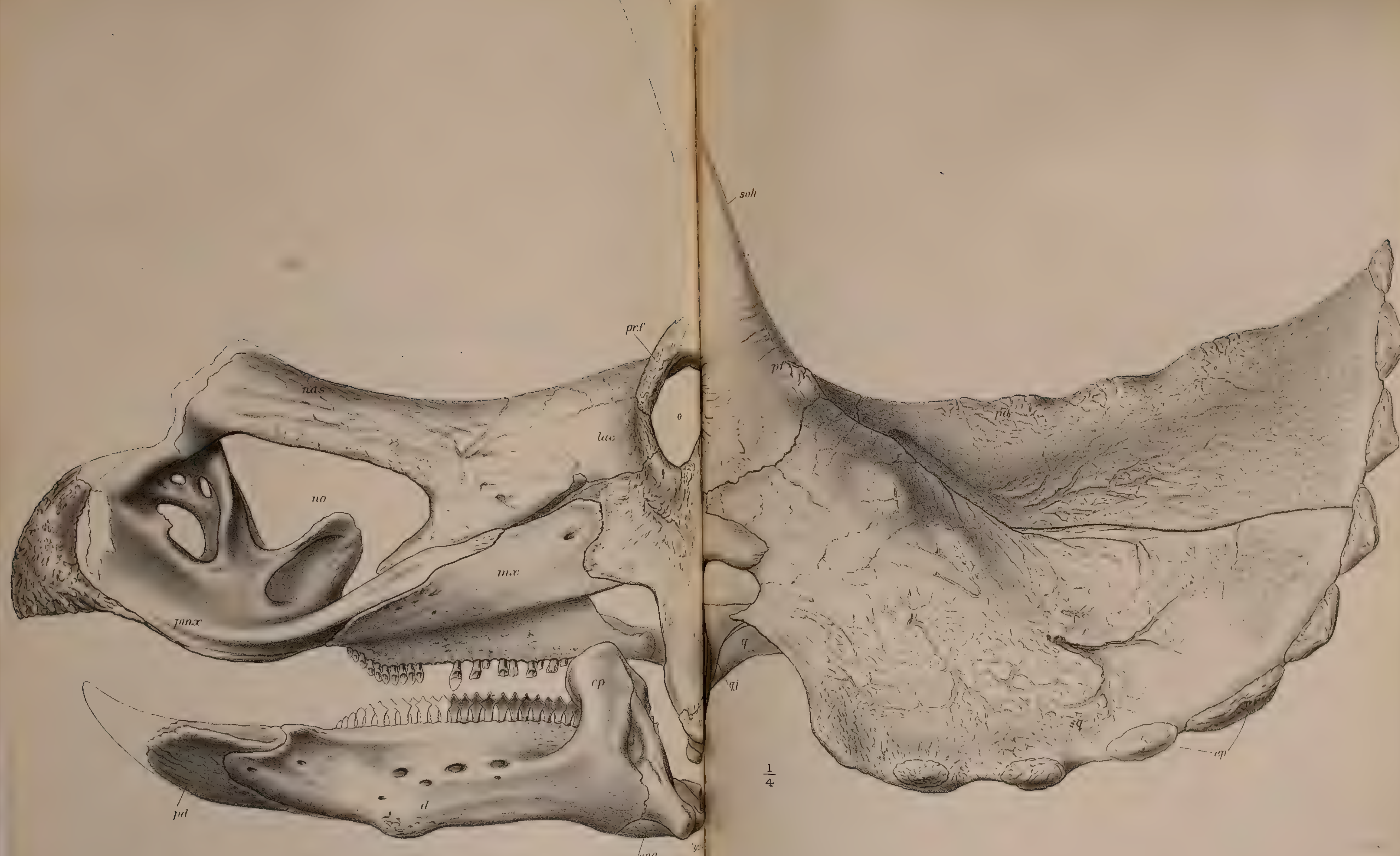
(See p. 122.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1823, Yale University Museum. Left lateral view.

ang, angular.
art, articular.
cp, coronoid process.
d, dentary.
ej, epijugal.
ep, epoccipital.
j, jugal.
lac, lachrymal.
mx, maxillary.
nas, nasal.
no, nasal opening.
o, orbit.
pa, parietal.
pd, predentary.
pf, postfrontal.
prf, prefrontal.
q, quadrate.
qj, quadratojugal.
r, rostral.
sang, surangular.
soh, supraorbital horn core.
sq, squamosal.

One-fourth natural size.



F. BERGER del

TRICERATOP· ·RATUS, Marsh

PLATE XXVIII.

PLATE XXVIII.

SKULL OF TYPE OF TRICERATOPS SERRATUS MARSH.

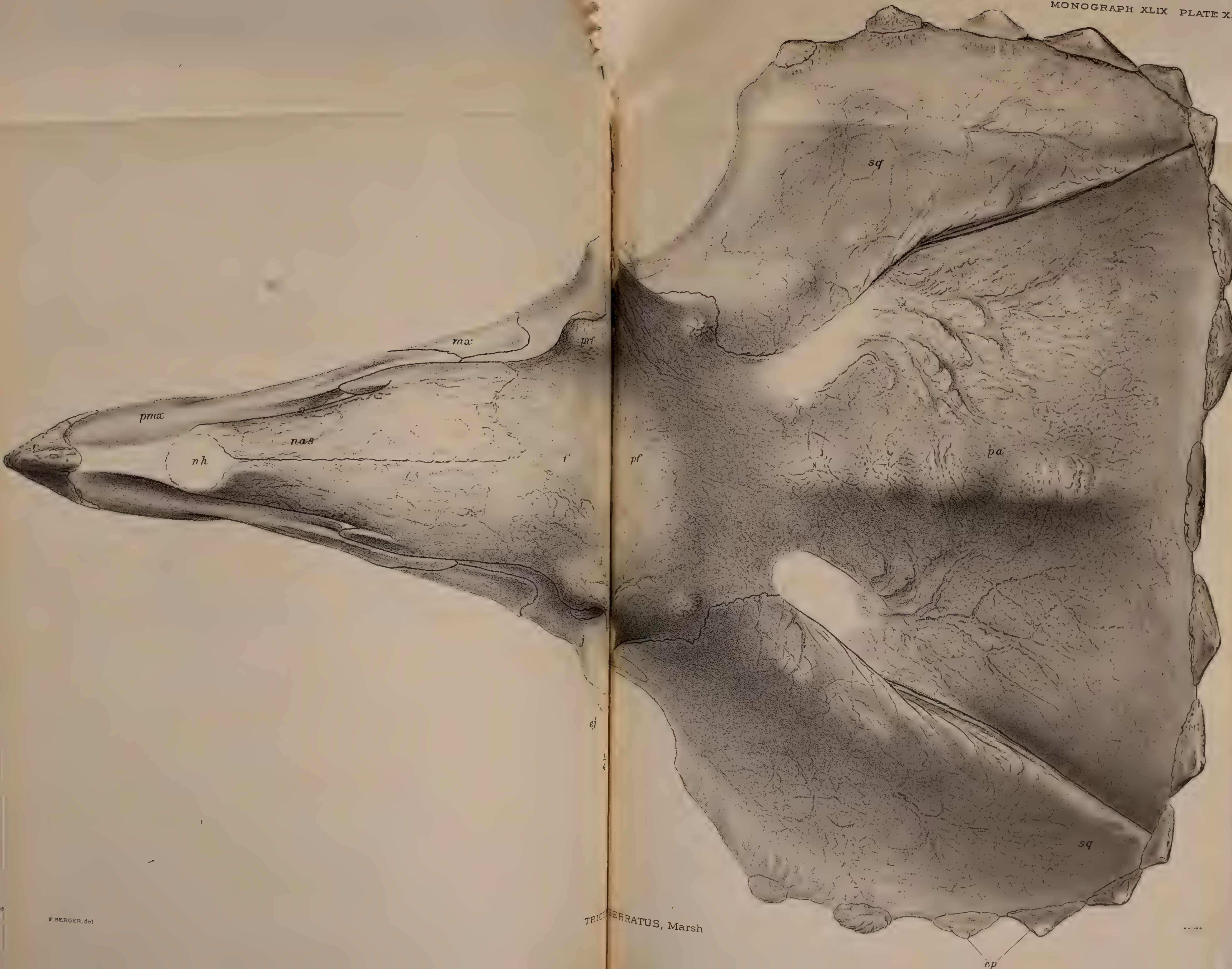
(See p. 122.)

Plate prepared under the direction of Marsh

Type specimen, No. 1823, Yale University Museum. Superior view.

ep, epoccipital.
ej, epijugal.
f, frontal.
j, jugal.
mx, maxillary.
nas, nasal.
nh, surface for articulation of nasal horn core.
pa, parietal.
pf, postfrontal.
prf, prefrontal.
pmx, premaxillary
r, rostral.
sq, squamosal.
soh, supraorbital horn core.

One-fourth natural size.



F. BERGER, del

TRICERATUS SERRATUS, Marsh

PLATE XXIX.

PLATE XXIX.

SKULL OF TYPE OF TRICERATOPS SERRATUS MARSH.

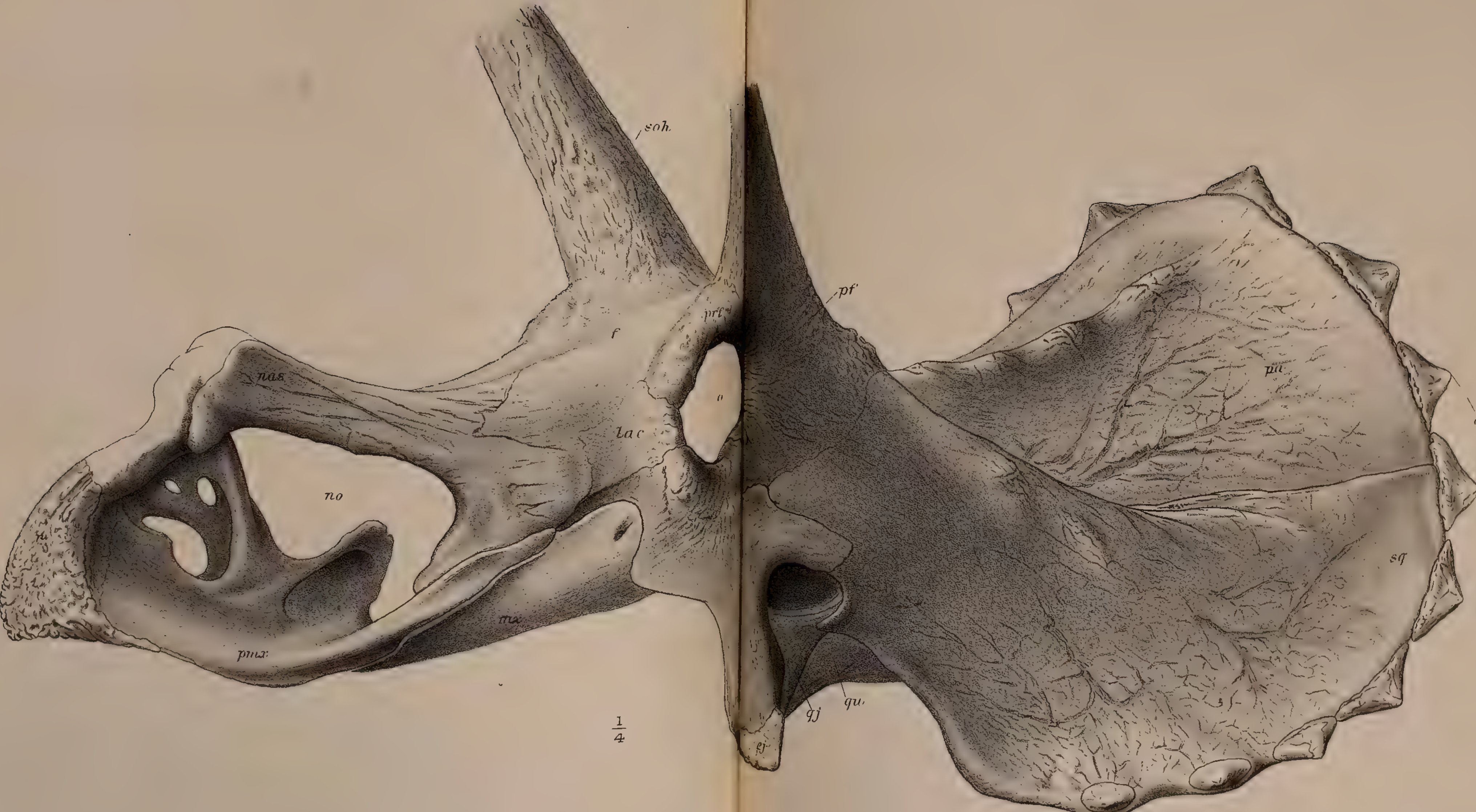
(See p. 122.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1823, Yale University Museum. Oblique front view.

ep, epoccipital.
ej, epijugal.
f, frontal.
ju, jugal.
mx, maxillary.
nas, nasal.
no, nasal opening.
o, orbit.
pa, parietal.
pf, postfrontal.
prf, prefrontal.
pmx, premaxillary.
qj, quadratojugal.
r, rostral.
qu, quadrate.
sq, squamosal.
soh, supraorbital horn core.

One-fourth natural size.



TRICERATOPS SERRATUS Marsh

PLATE XXX.

PLATE XXX.

SKULL OF TRICERATOPS PRORSUS? MARSH.

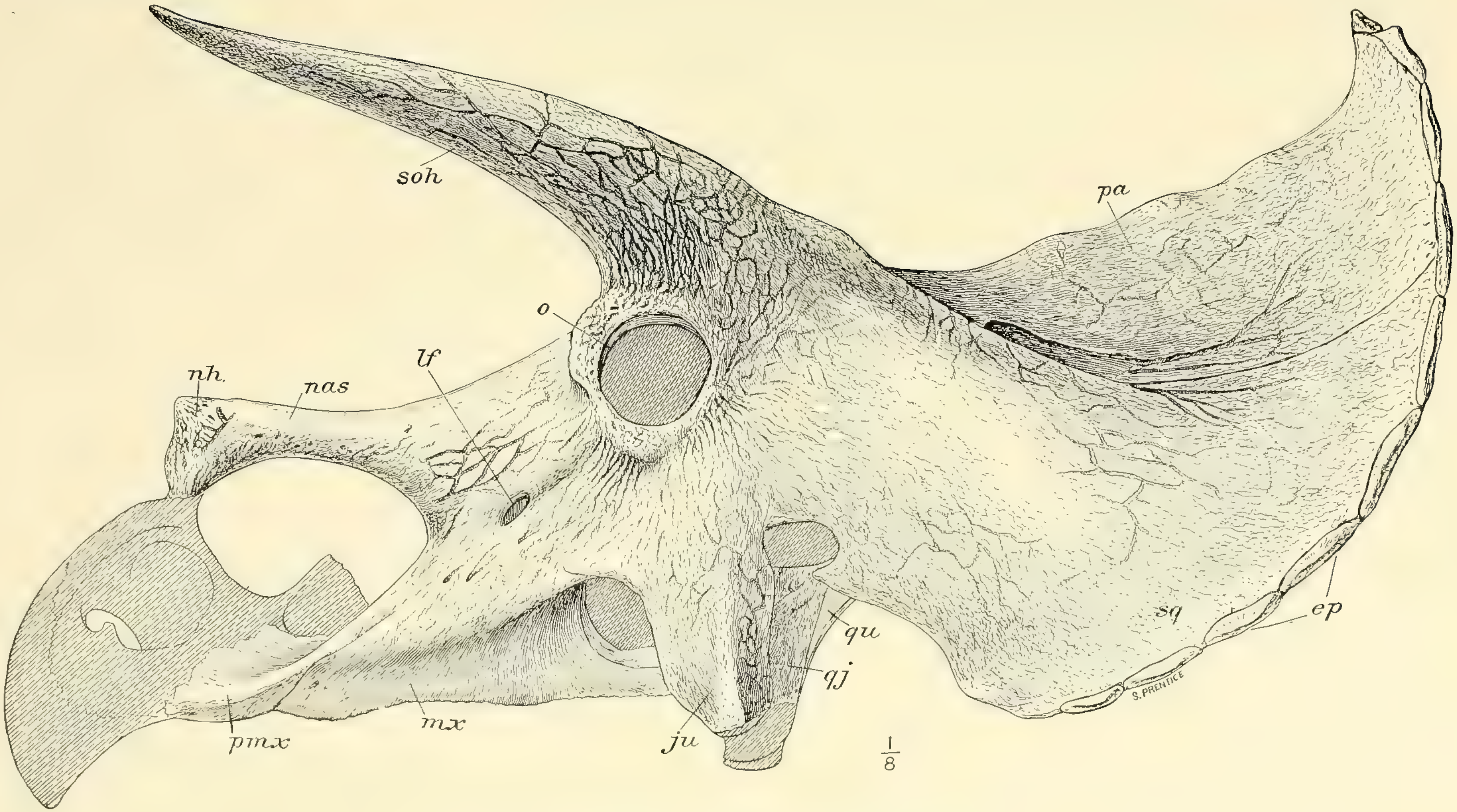
(See pp. 190–191.)

Plate prepared under the direction of Hatcher.

Specimen No. 2100, U. S. National Museum. (Skull of mounted skeleton.) Left lateral view.

ep, epoccipital.
ju, jugal.
lf, lachrymal foramen.
mx, maxillary.
nas, nasal.
nh, nasal horn core.
o, orbit.
pa, parietal.
pmx, premaxillary.
qj, quadratojugal.
qu, quadrate.
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF TRICERATOPS PRORSUS? MARSH, SIDE VIEW.

PLATE XXXI.

PLATE XXXI.

SKULL OF TRICERATOPS PRORSUS ? MARSH.

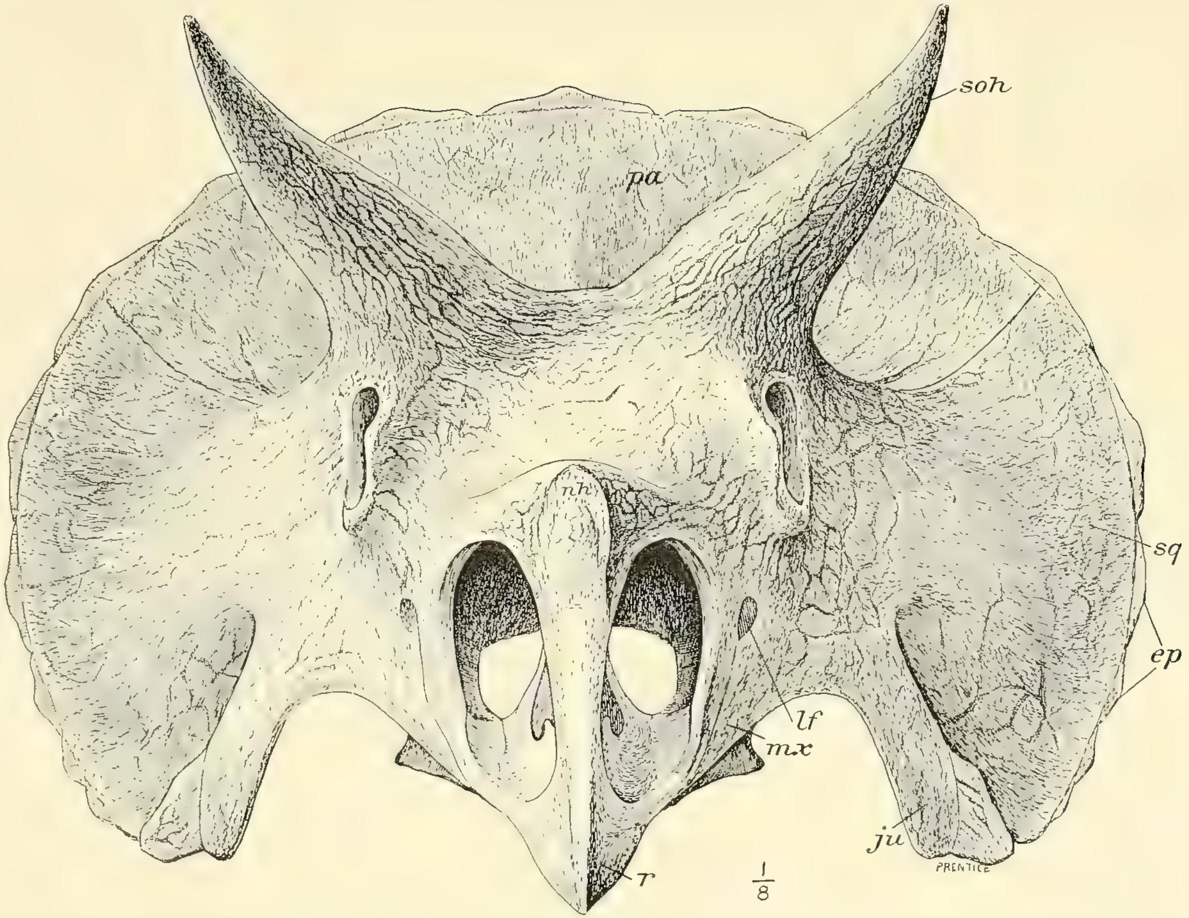
(See pp. 190–191.)

Plate prepared under the direction of Hatcher.

Specimen No. 2100, U. S. National Museum. (Skull of mounted skeleton.) Front view.

ep, epoccipital.
ju, jugal.
lf, lachrymal foramen.
mx, maxillary.
nh, nasal horn core.
pa, parietal.
r, rostral.
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF TRICERATOPS PRORSUS? MARSH, FRONT VIEW.

PLATE XXXII.

PLATE XXXII.

(See p. 127.)

SKULL OF TYPE OF TRICERATOPS PRORSUS MARSH.

Plate prepared under the direction of Marsh.

Type specimen, No. 1822, Yale University Museum. Front view.

ang, angular.
d, dentary.
ep, epoccipital.
ju, jugal.
lf, lachrymal foramen.
mx, maxillary.
nh, nasal horn core.
pa, parietal.
pd, predentary.
pmx, premaxillary.
r, rostral.
sq, squamosal.
soh, supraorbital horn core.
t, mandibular teeth.

One-fourth natural size.

TRICERATOPS PRORSUS Marsh

PLATE XXXIII.

PLATE XXXIII.

SKULL OF TYPE OF TRICERATOPS PRORSUS MARSH.

(See p. 127.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1822, Yale University Museum. Posterior view.

art, articular.
bo, basioccipital.
d, dentary.
ep, epoccipital.
exo, exoccipital.
fm, foramen magnum.
oc, occipital condyle.
pa, parietal.
pd, predentary.
qu, quadrate.
so, supraoccipital.
sq, squamosal.
soh, supraorbital horn core.

One-fourth natural size.

$\frac{1}{4}$

TRICERATOPS PRORSUS, Marsh

PLATE XXXIV.

PLATE XXXIV.

SKULL OF TYPE OF TRICERATOPS PRORSUS MARSH.

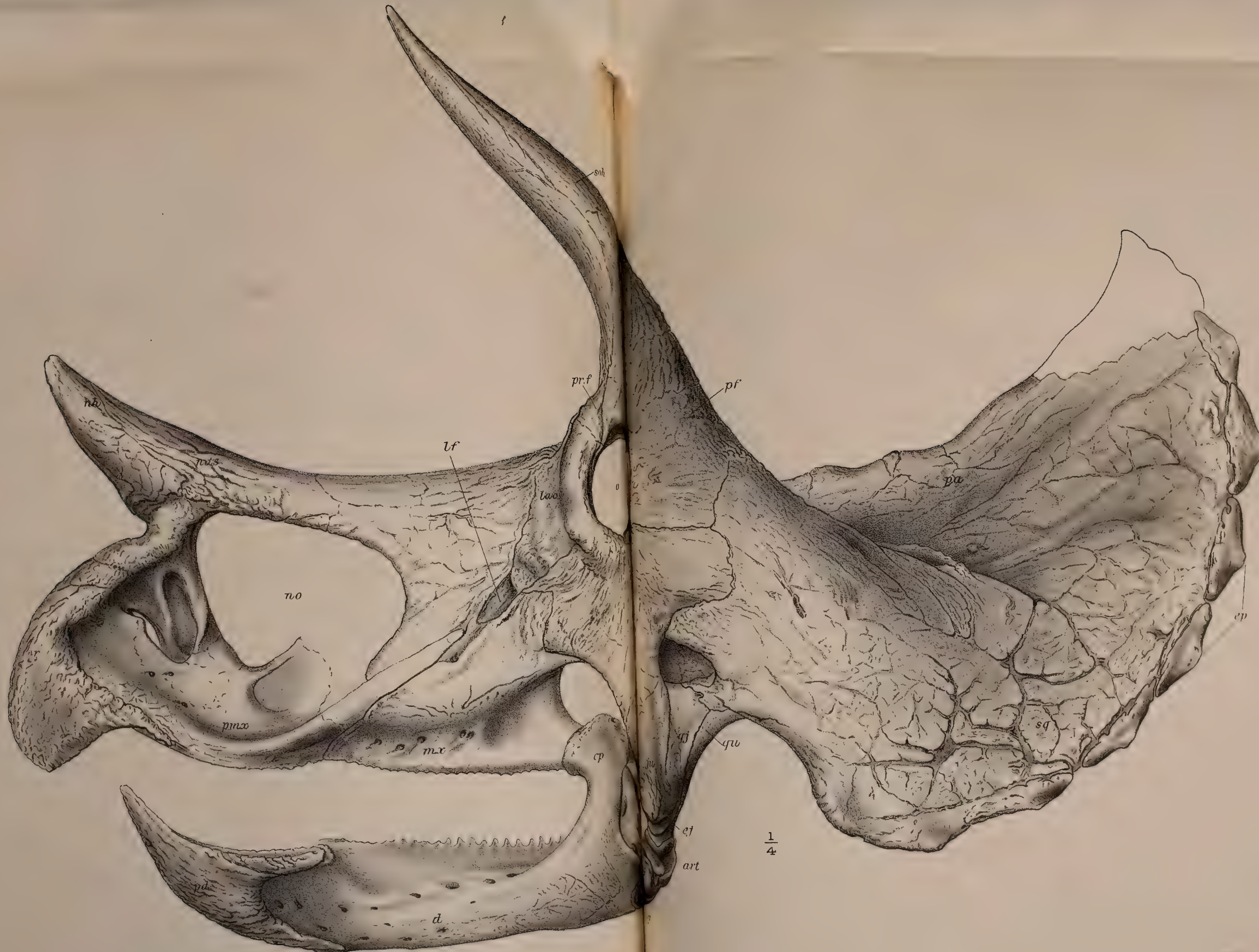
(See p. 127.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1822, Yale University Museum. Left lateral view.

ang, angular.
art, articular.
cp, coronoid process.
d, dentary.
ej, epijugal.
ep, epoccipital.
ju, jugal.
lf, lachrymal foramen.
mx, maxillary.
nas, nasal.
nh, nasal horn core.
no, nasal opening.
o, orbit.
pa, parietal.
pf, postfrontal.
prf, prefrontal.
pmx, premaxillary.
qj, quadratojugal.
qu, quadrate.
r, rostral.
sang, surangular.
sq, squamosal.
soh, supraorbital horn core.

One-fourth natural size.



F BERGER, del.

TRICERATOPS PRORSUS, Marsh

PLATE XXXV.

PLATE XXXV.

SKULL OF TYPE OF TRICERATOPS PRORSUS MARSH.

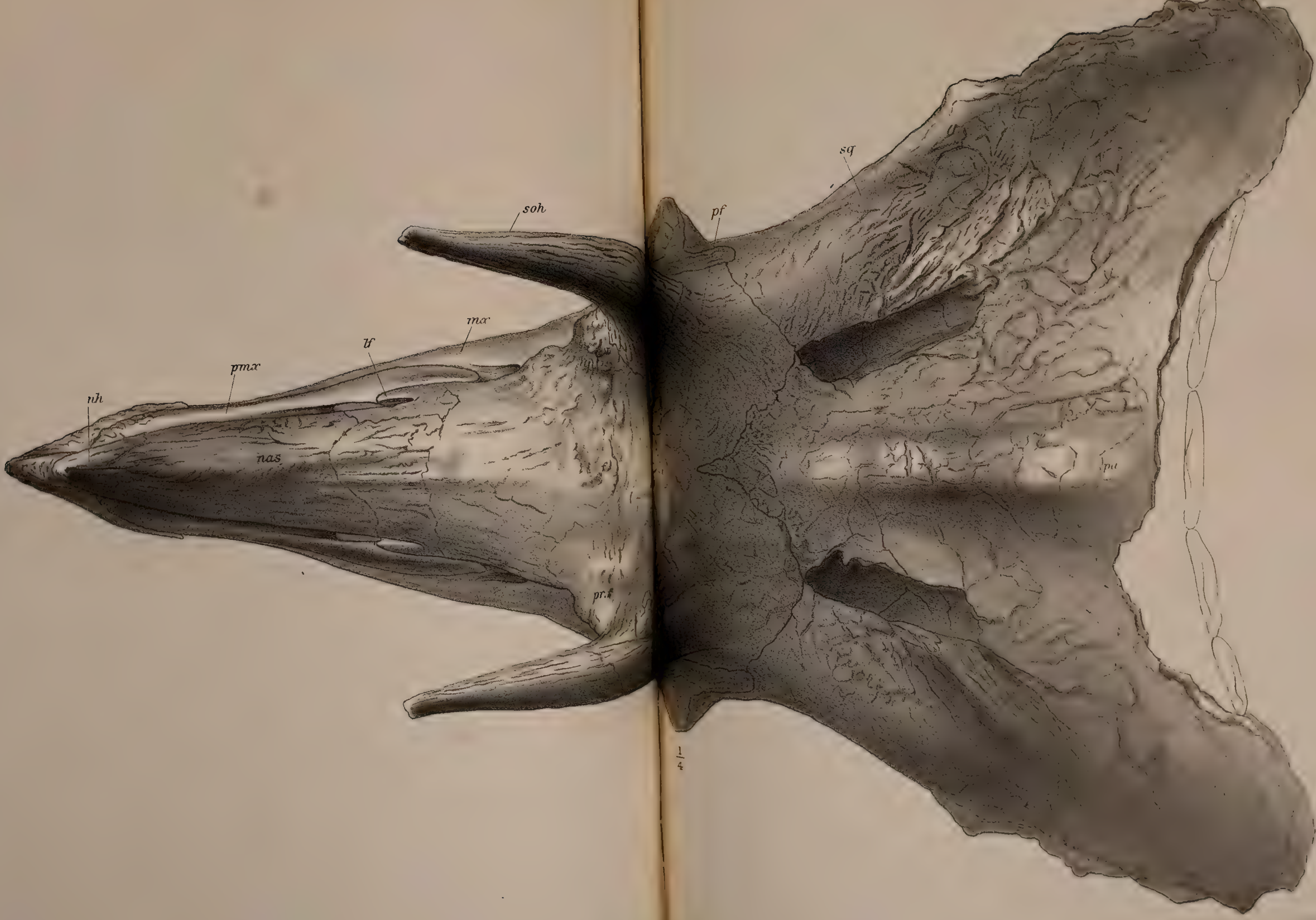
(See p. 127.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1822, Yale University Museum. Superior view.

f, frontal.
lf, lachrymal foramen.
mx, maxillary.
nas, nasal.
nh, nasal horn.
pa, parietal.
pf, postfrontal.
prf, prefrontal.
pmx, premaxillary.
r, rostral.
sq, squamosal.
soh, supraorbital horn core.

One-fourth natural size.



TRICERAT[illegible] Marsh

PLATE XXXVI.

PLATE XXXVI.

SKULL OF TYPE OF TRICERATOPS PRORSUS MARSH.

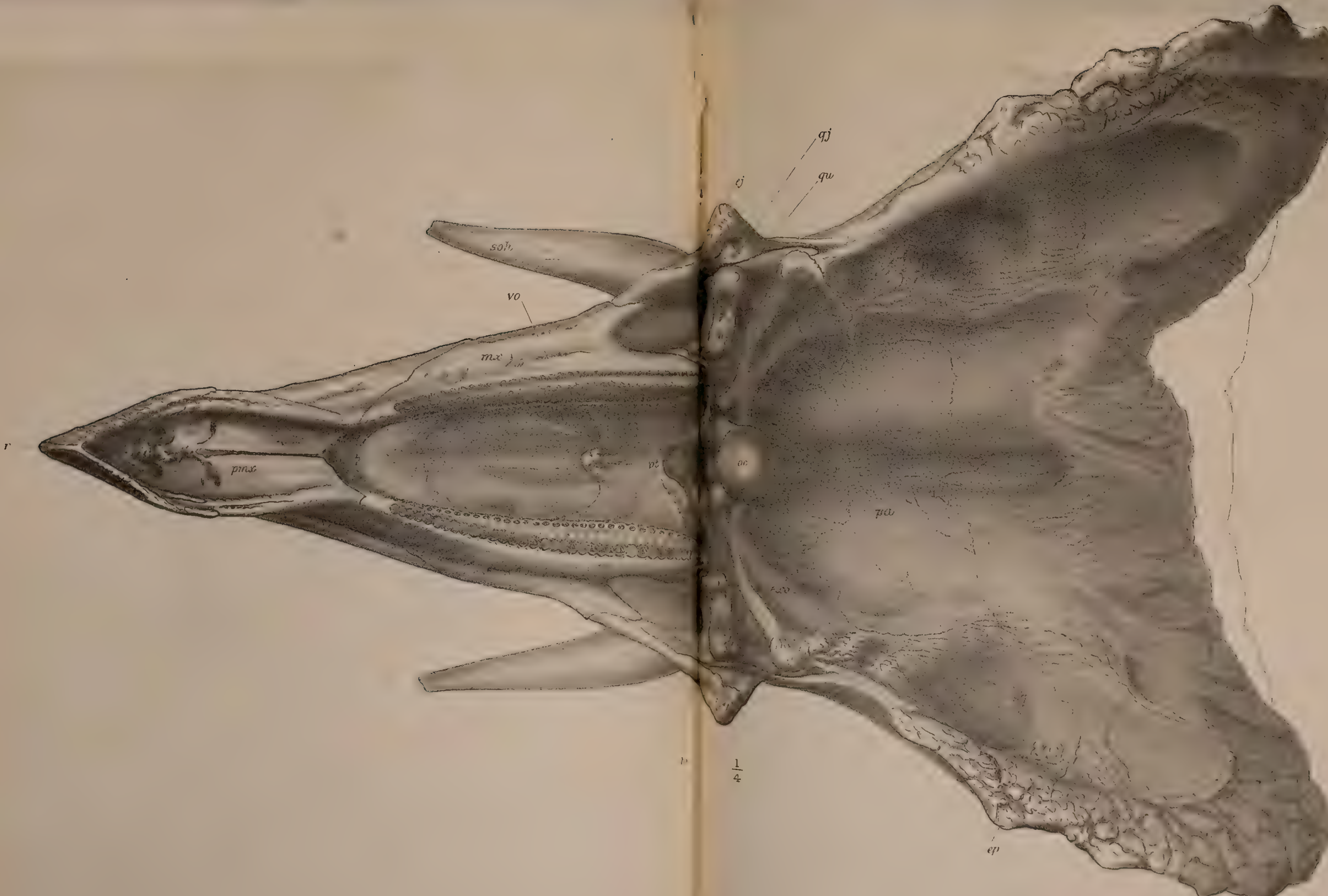
(See p. 127.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1822, Yale University Museum. Inferior view.

bo, basioccipital.
ej, epijugal.
ep, epoccipital.
exo, exoccipital.
ju, jugal.
mx, maxillary.
oc, occipital condyle.
pa, parietal.
pmx, premaxillary.
pt, pterygoids.
qj, quadratojugal.
qu, quadrate.
r, rostral.
soh, supraorbital horn core.
sq, squamosal.
vo, vomer.

One-fourth natural size.



F BERGER, del

TRICERATOPS PRORSUS, Marsh

PLATE XXXVII.

PLATE XXXVII.

SKULL REFERRED BY MARSH TO TRICERATOPS SULCATUS MARSH.

(See p. 134.)

Plate prepared under the direction of Marsh.

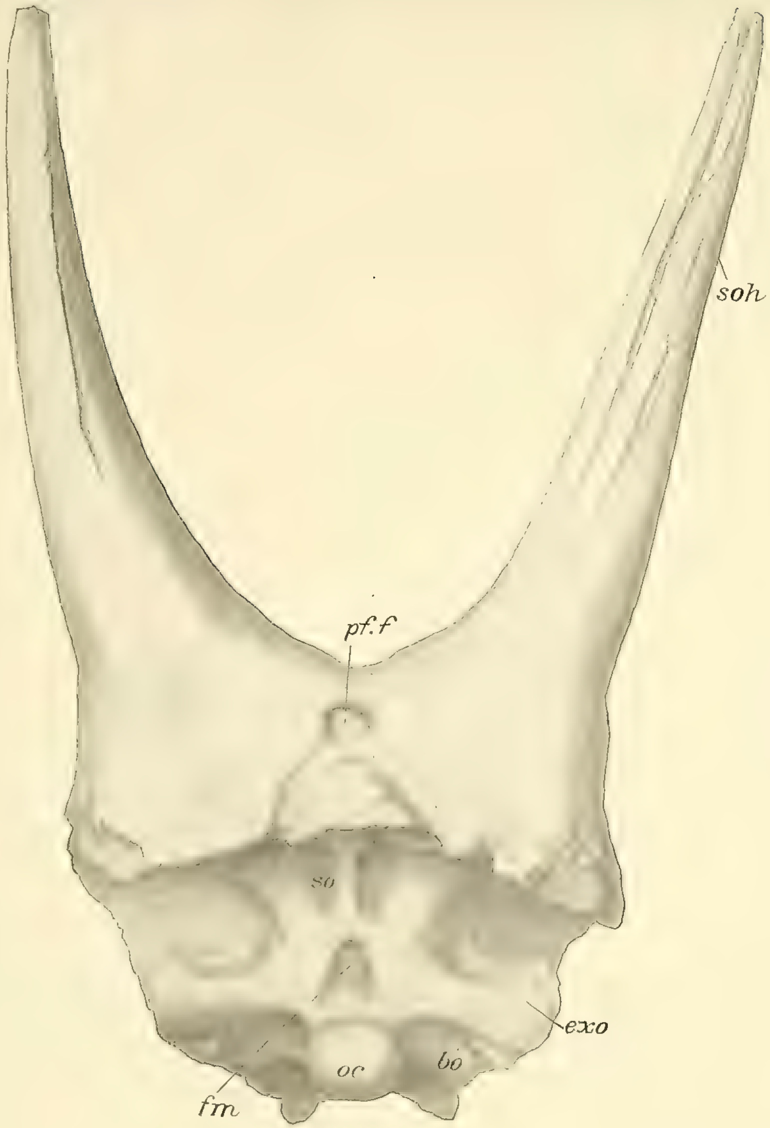
Specimens Nos. 1203, 1206–1210, U. S. National Museum.

FIG. 1. Posterior view with crest broken away, showing occiput.

FIG. 2. Anterior view.

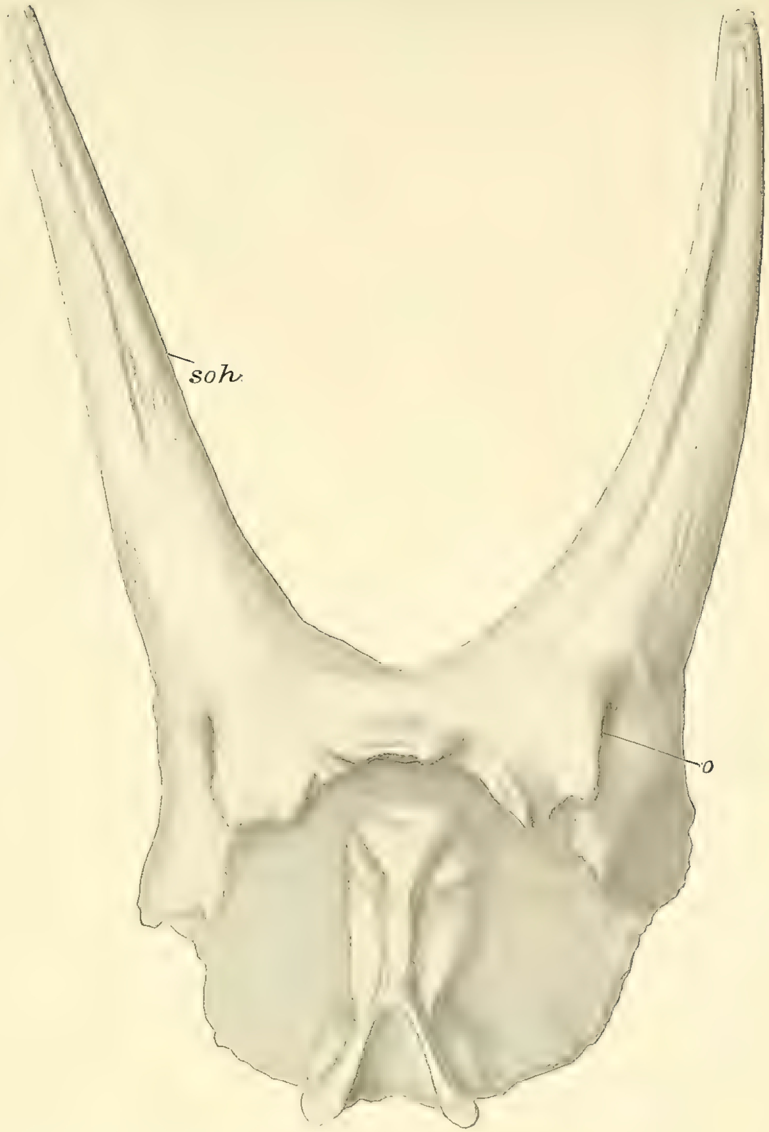
bo, basioccipital.
exo, exoccipital.
fm, foramen magnum.
o, orbit.
oc, occipital condyle.
pff, postfrontal fontanelle.
so, supraoccipital.
soh, supraorbital horn core.

One-eighth natural size.



1

$\frac{1}{8}$



2

SKULL REFERRED TO TRICERATOPS SULCATUS MARSH.

PLATE XXXVIII.

PLATE XXXVIII.

(See p. 138.)

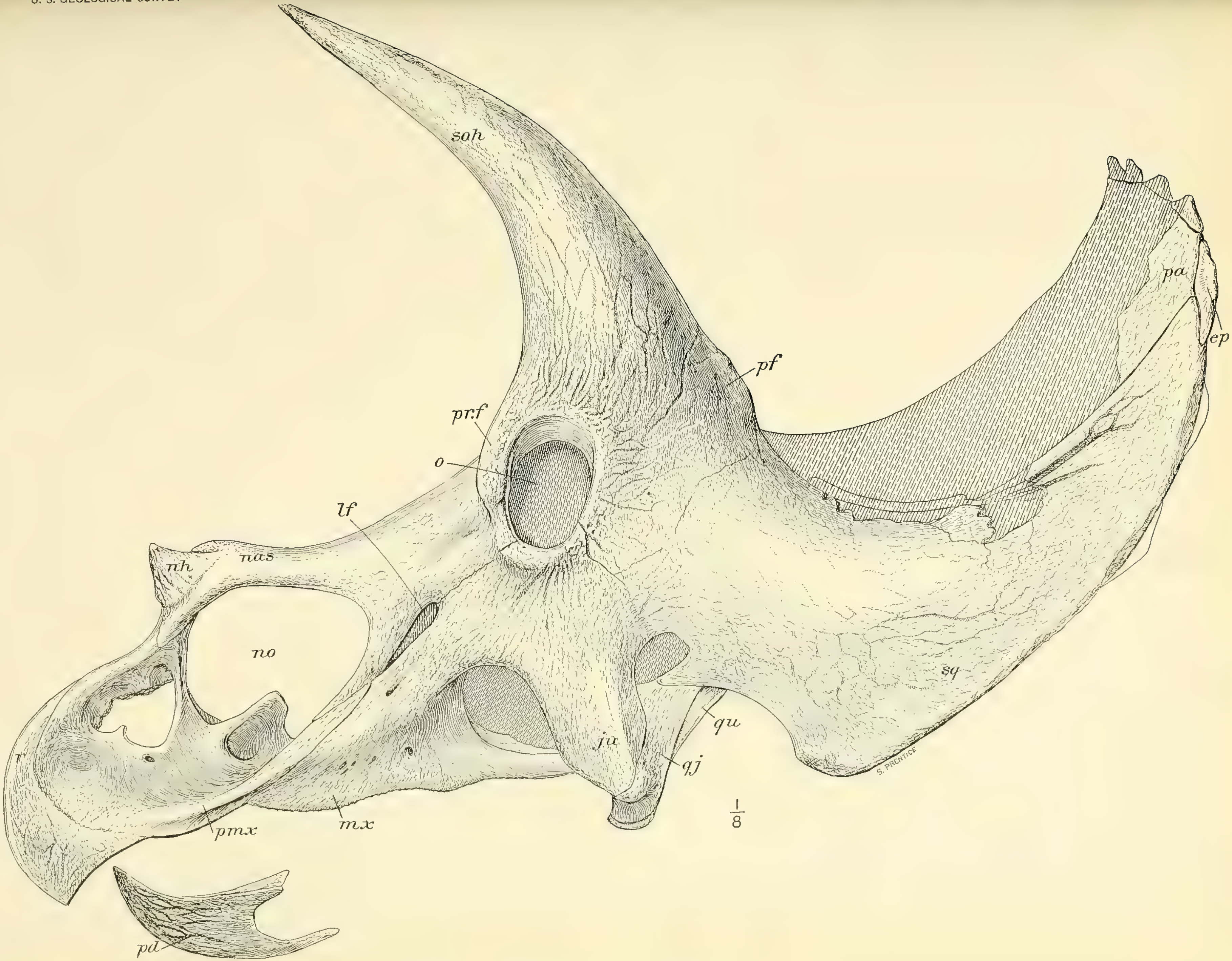
SKULL OF TYPE OF TRICERATOPS CALICORNIS MARSH.

Plate prepared under the direction of Hatcher.

Type specimen, No. 4928, U. S. National Museum. Left lateral view.

ep, epoccipital.
ju, jugal.
lf, lachrymal foramen.
mx, maxillary.
nas, nasal.
nh, nasal horn core.
no, nasal opening.
o, orbit.
pa, parietal.
pd, predentary.
pf, postfrontal.
prf, prefrontal.
qj, quadratojugal.
qu, quadrate.
r, rostral.
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF TRICERATOPS CALICORNIS MARSH, SIDE VIEW.

PLATE XXXIX.

PLATE XXXIX.

SKULL OF TYPE OF TRICERATOPS CALICORNIS MARSH.

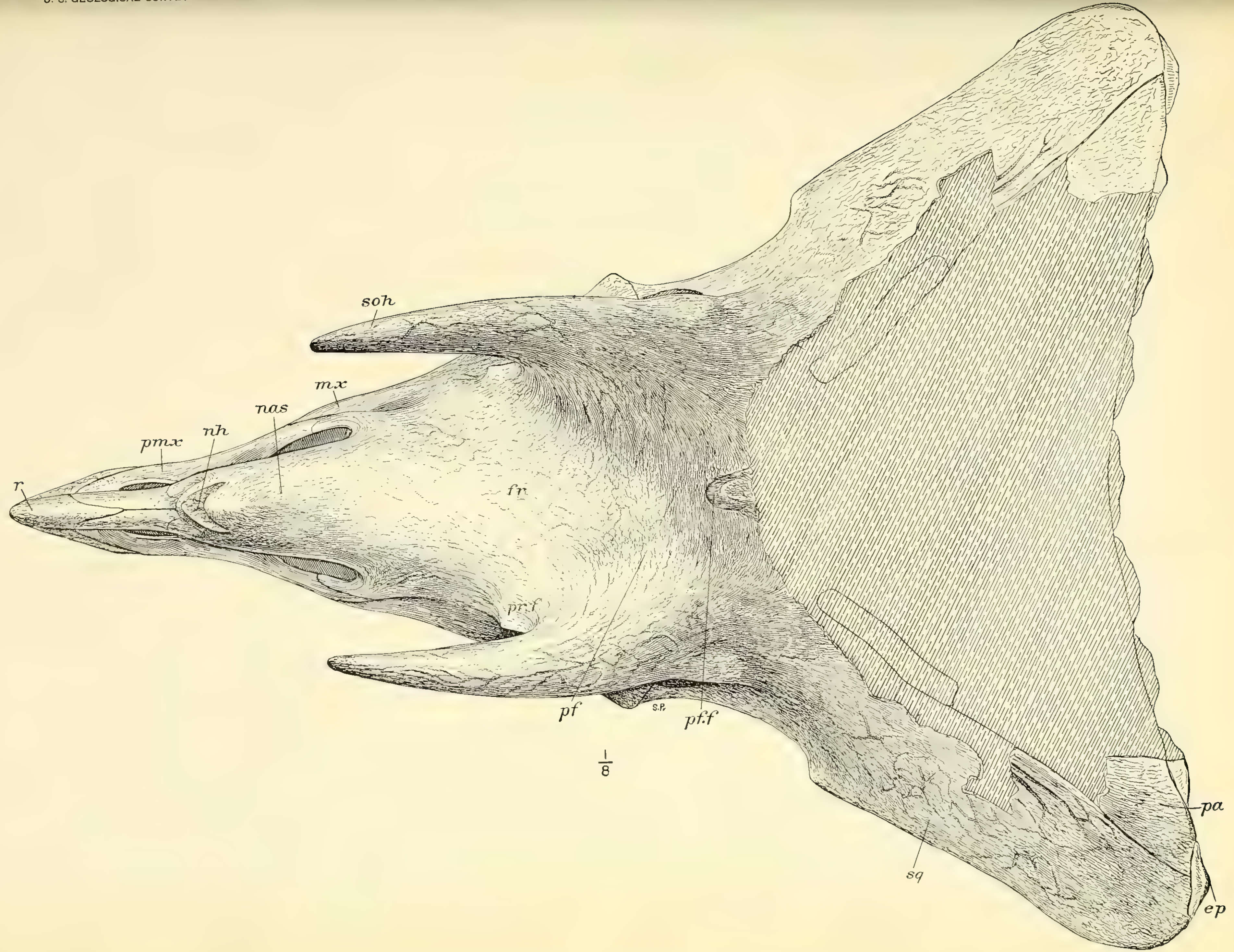
(See p. 138.)

Plate prepared under the direction of Hatcher.

Type specimen, No. 4928, U. S. National Museum. Superior view.

ep, epoccipital.
fr, frontal.
mx, maxillary.
nas, nasal.
nh, nasal horn core.
pa, parietal.
pf, postfrontal.
pff, postfrontal fontanelle.
prf, prefrontal.
pmx, premaxillary.
r, rostral.
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF TRICERATOPS CALICORNIS MARSH, TOP VIEW.

PLATE XL.

PLATE XL.

VERTEBRÆ OF TRICERATOPS.

(See pp. 46, 139, 142.)

Plate prepared under the direction of Hatcher.

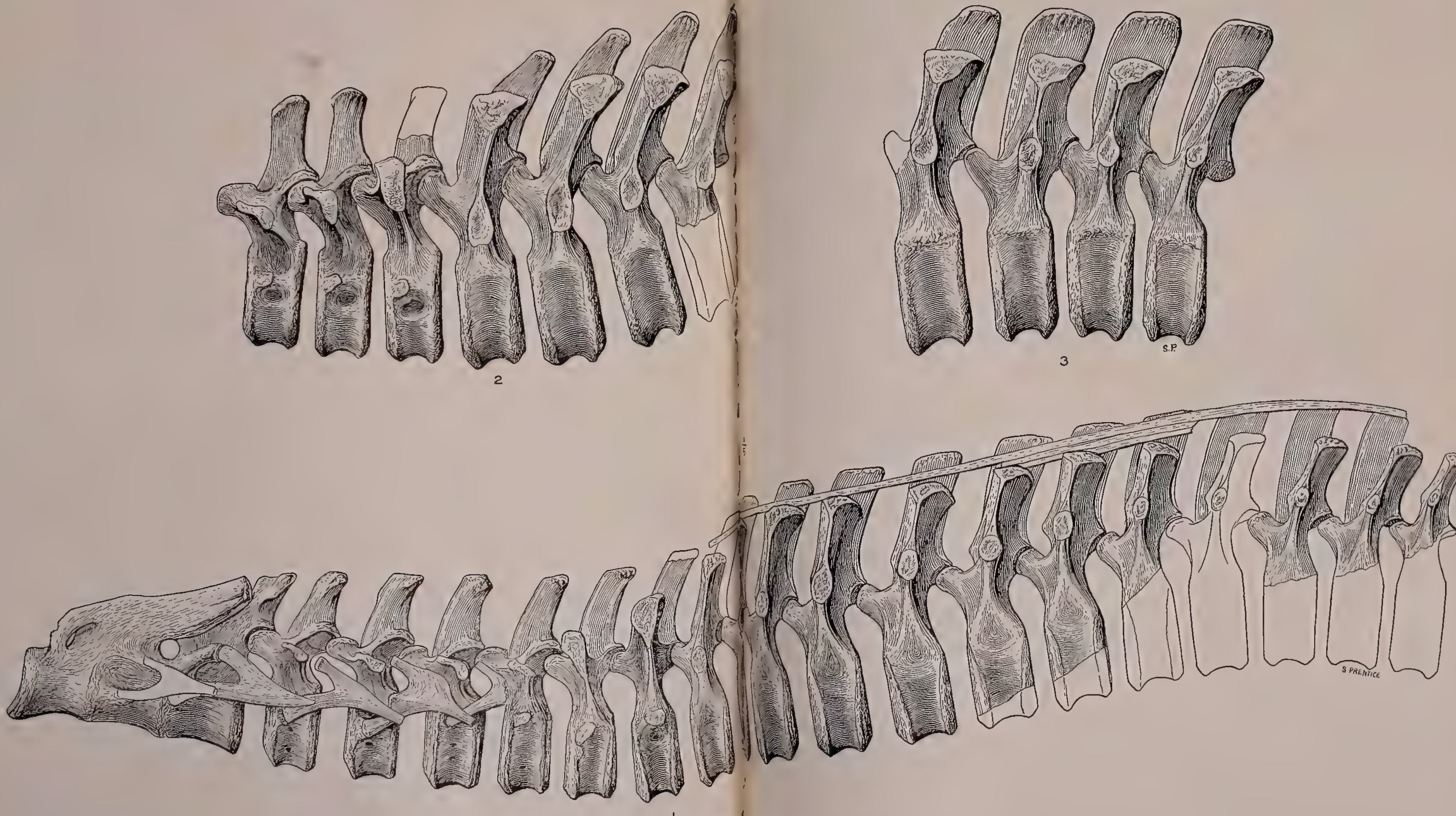
FIG. 1. Presacral vertebræ of *Triceratops brevicornus* Hatcher. Type specimen, No. 1834, Yale University Museum.

FIGS. 2, 3. Vertebræ of *Triceratops calicornis* Marsh. Type specimen, No. 4928, U. S. National Museum.

FIG. 2. Cervical 8 and dorsals 1–6.

FIG. 3. Posterior dorsal vertebræ.

One-sixth natural size.



VERTEBRÆ OF TRICERATOPS BREVICORNUS HATCHER AND T. CALICORNIS MARSH.

PLATE XLI.

PLATE XLI.

SKULL OF TYPE OF TRICERATOPS BREVICORNUS HATCHER.

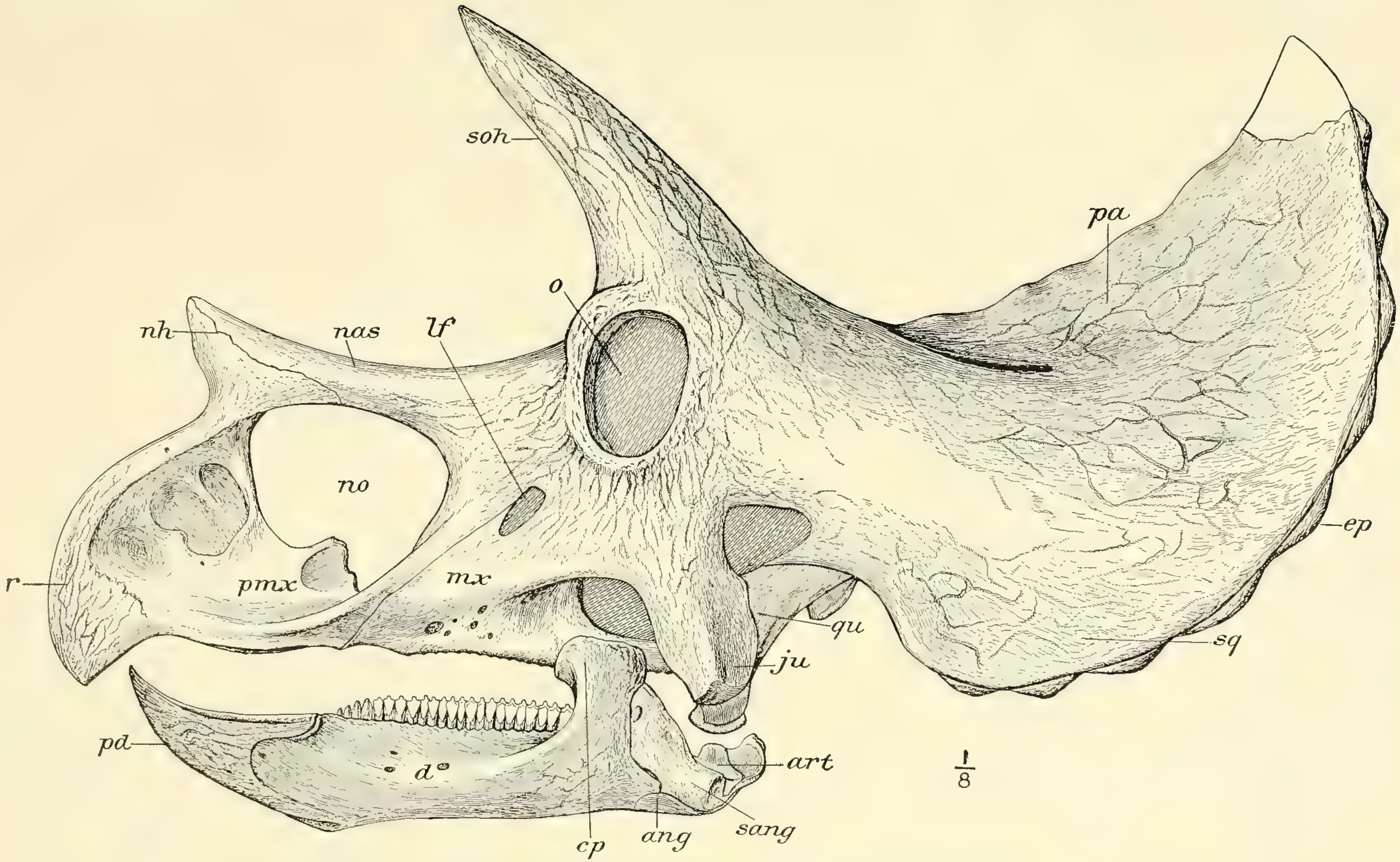
(See p. 141.)

Plate prepared under the direction of Hatcher.

Type specimen, No. 1834, Yale University Museum. Left lateral view.

ang, angular.
art, articular.
cp, coronoid process.
d, dentary.
ep, epoccipital.
ju, jugal.
lf, lachrymal foramen.
mx, maxillary.
nas, nasal.
nh, nasal horn core.
no, nasal opening.
o, orbit.
pa, parietal.
pd, predentary.
pmx, premaxillary.
qu, quadrate.
r, rostral.
sang, surangular.
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF TRICERATOPS BREVICORNUS HATCHER, SIDE VIEW.

PLATE XLII.

PLATE XLII.

SKULL OF TYPE OF TRICERATOPS BREVICORNUS HATCHER.

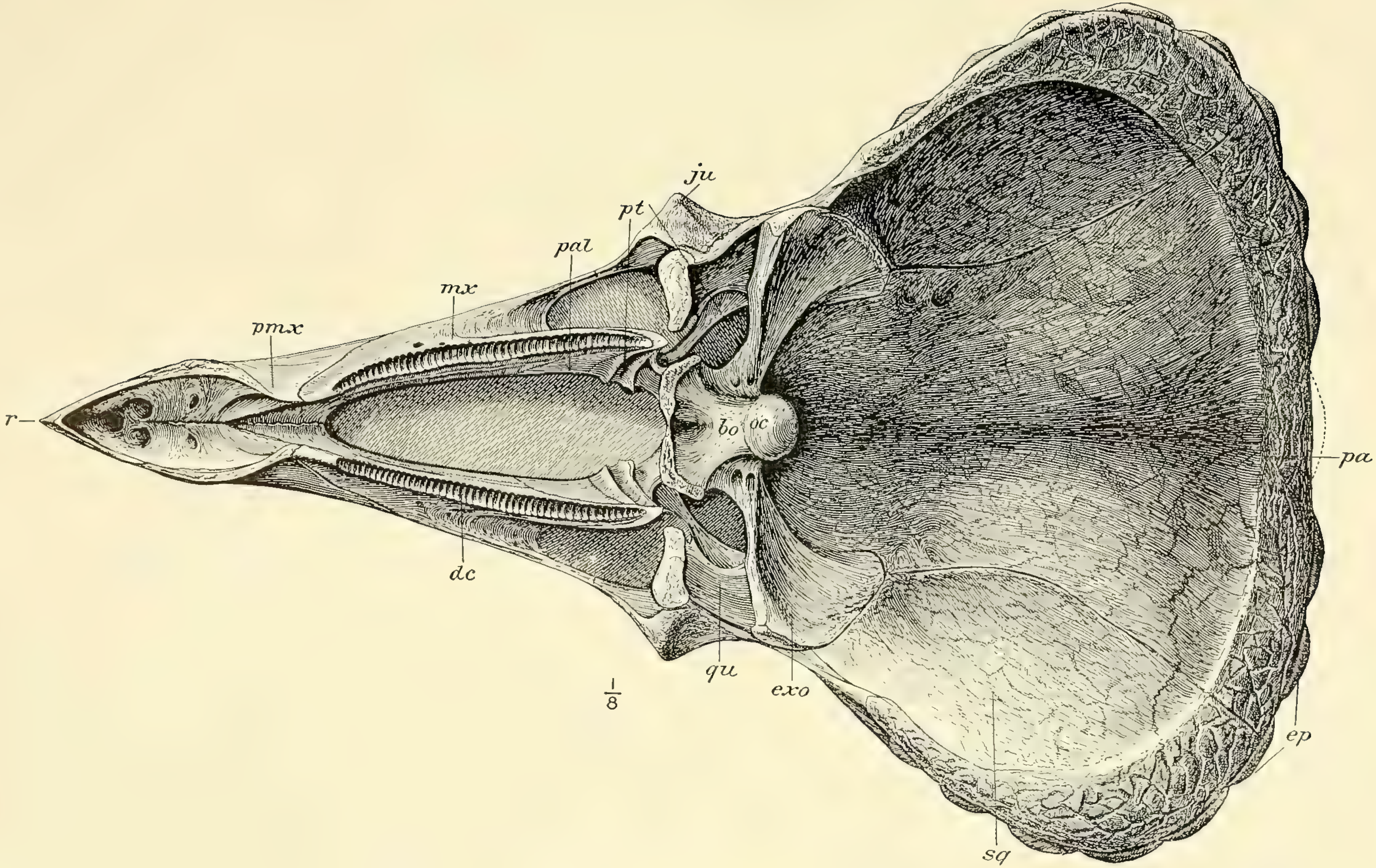
(See p. 141.)

Plate prepared under the direction of Hatcher.

Type specimen, No. 1834, Yale University Museum. Palatal view.

bo, basioccipital.
dc, dental channel.
ep, epoccipital.
exo, exoccipital.
ju, jugal.
mx, maxillary.
oc, occipital condyle.
pa, parietal.
pal, palatine.
pmx, premaxillary.
pt, pterygoid.
qu, quadrate.
r, rostral.
sq, squamosal.

One-eighth natural size.



SKULL OF TRICERATOPS BREVICORNUS HATCHER, PALATAL VIEW.

PLATE XLIII.

283

PLATE XLIII.

SKULL OF TYPE OF TRICERATOPS ELATUS MARSH.

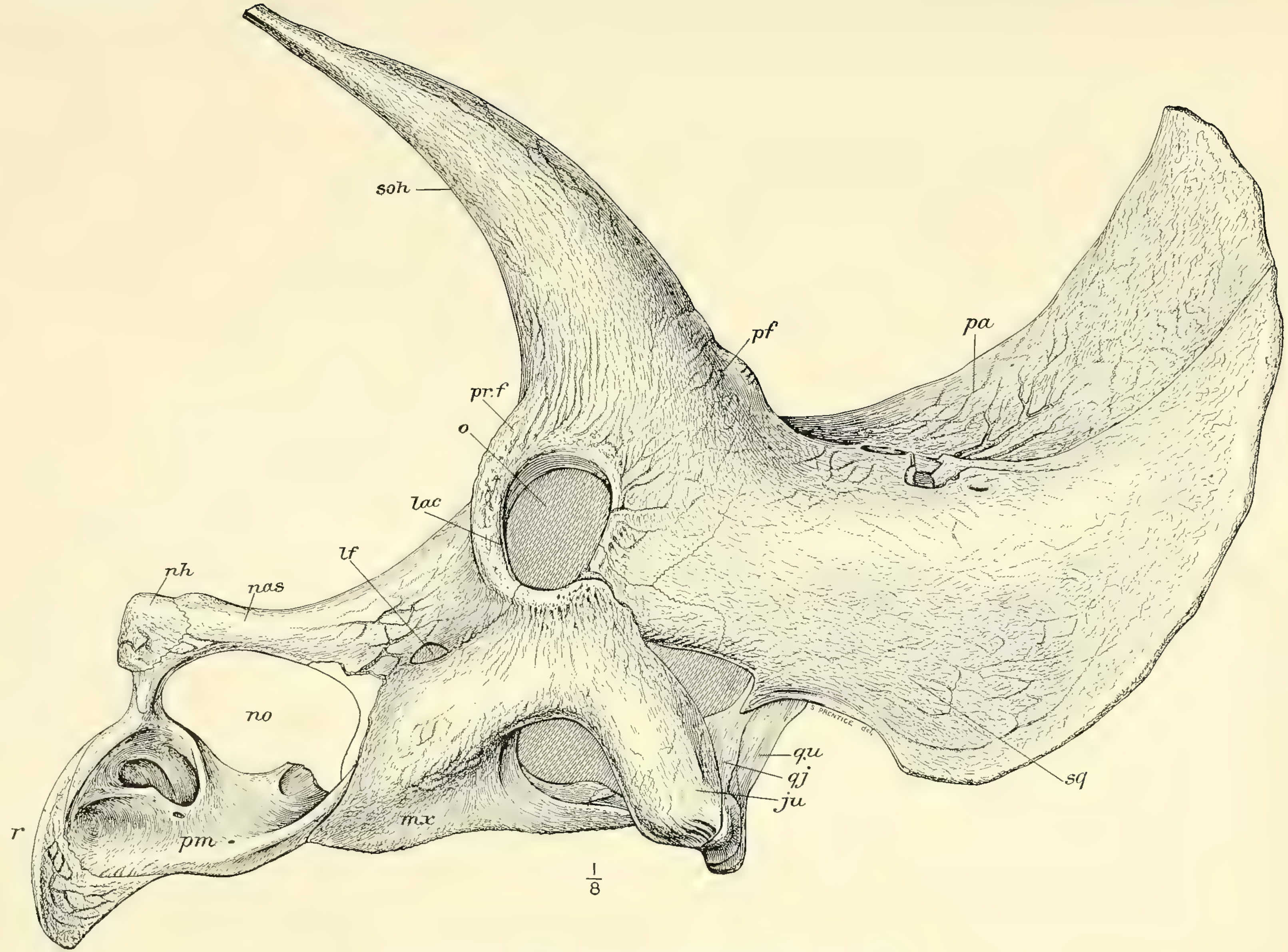
(See p. 135.)

Plate prepared under the direction of Hatcher.

Type specimen, No. 1201, U. S. National Museum. Left lateral view.

ju, jugal.
lac, lachrymal.
lf, lachrymal foramen.
mx, maxillary.
nas, nasal.
nh, nasal horn core.
no, nasal opening.
o, orbit.
pa, parietal.
pf, postfrontal.
pm, premaxillary.
prf, prefrontal.
qj, quadratojugal.
qu, quadrate.
r, rostral.
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF TRICERATOPS ELATUS MARSH, SIDE VIEW.

PLATE XLIV.

PLATE XLIV.

SKULL OF TYPE OF TRICERATOPS FLABELLATUS MARSH.

(See p. 143.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1821, Yale University Museum. Left lateral view.

ang, angular.
cp, coronoid process.
d, dentary.
ep, epoccipital.
ju, jugal.
lac, lachrymal.
lf, lachrymal foramen.
mx, maxillary.
nas, nasal.
nh, nasal horn core.
no, nasal opening.
o, orbit.
pa, parietal.
pd, predentary.
pf, postfrontal.
pmx, premaxillary.
prf, prefrontal.
qj, quadratojugal.
qu, quadrate.
sang, surangular.
sq, squamosal.
soh, supraorbital horn core.

One-fourth natural size.

TRICERATOPS [illegible] Marsh

PLATE XLV.

PLATE XLV.

SKULL OF TYPE OF TRICERATOPS FLABELLATUS MARSH.

(See p. 143.)

Plate prepared under the direction of Marsh.

Type specimen, No. 1821, Yale University Museum. Superior view.

ep, epoccipital.
f, frontal.
ju, jugal.
nas, nasal.
pa, parietal.
pf, postfrontal.
pmx, premaxillary.
prf, prefrontal.
sq, squamosal.
soh, supraorbital horn cores.

One-fourth natural size.

TRICERATOPS [illegible]LATUS, Marsh

PLATE XLVI.

PLATE XLVI.

SKULL OF TYPE OF TRICERATOPS FLABELLATUS MARSH.

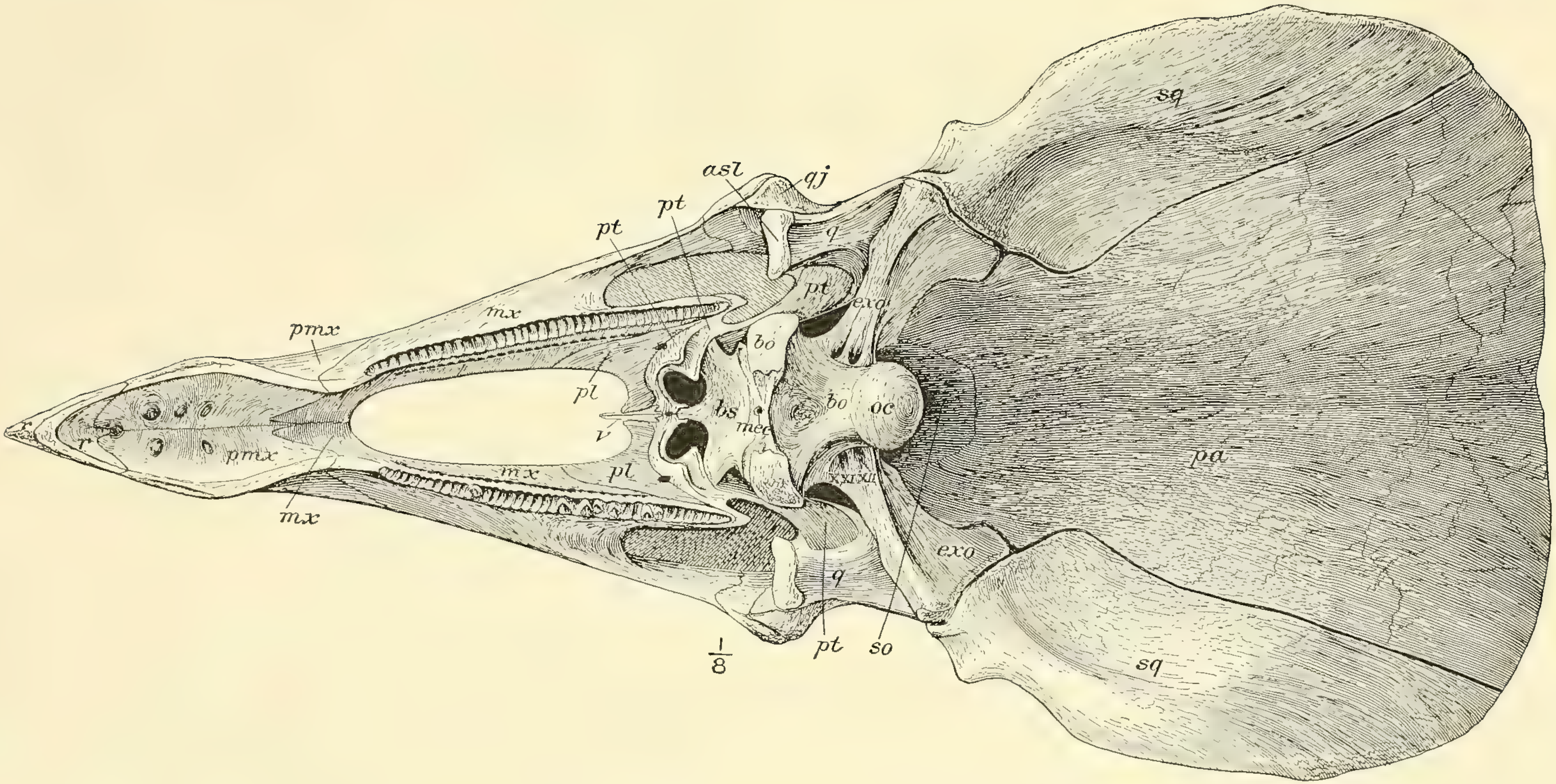
(See p. 143.)

Plate prepared under the direction of Hatcher.

Type specimen, No. 1821, Yale University Museum. Palatal view.

asl, articulating surface for lower jaw.
bo, basioccipital.
bs, basisphenoid.
exo, exoccipital.
mec, median eustachian canal.
mx, maxillary.
oc, occipital condyle.
pa, parietal.
pl, palatine.
pmx, premaxillary.
pt, pterygoid.
q, quadrate.
qj, quadratojugal.
r, rostral bone.
so, supraoccipital.
sq, squamosal.
v, vomer.
X, XI, XII, cranial nerve foramina.

One-eighth natural size.



SKULL OF TRICERATOPS FLABELLATUS MARSH, PALATAL VIEW.

PLATE XLVII.

PLATE XLVII.

SKULL OF TYPE OF DICERATOPS HATCHERI LULL.

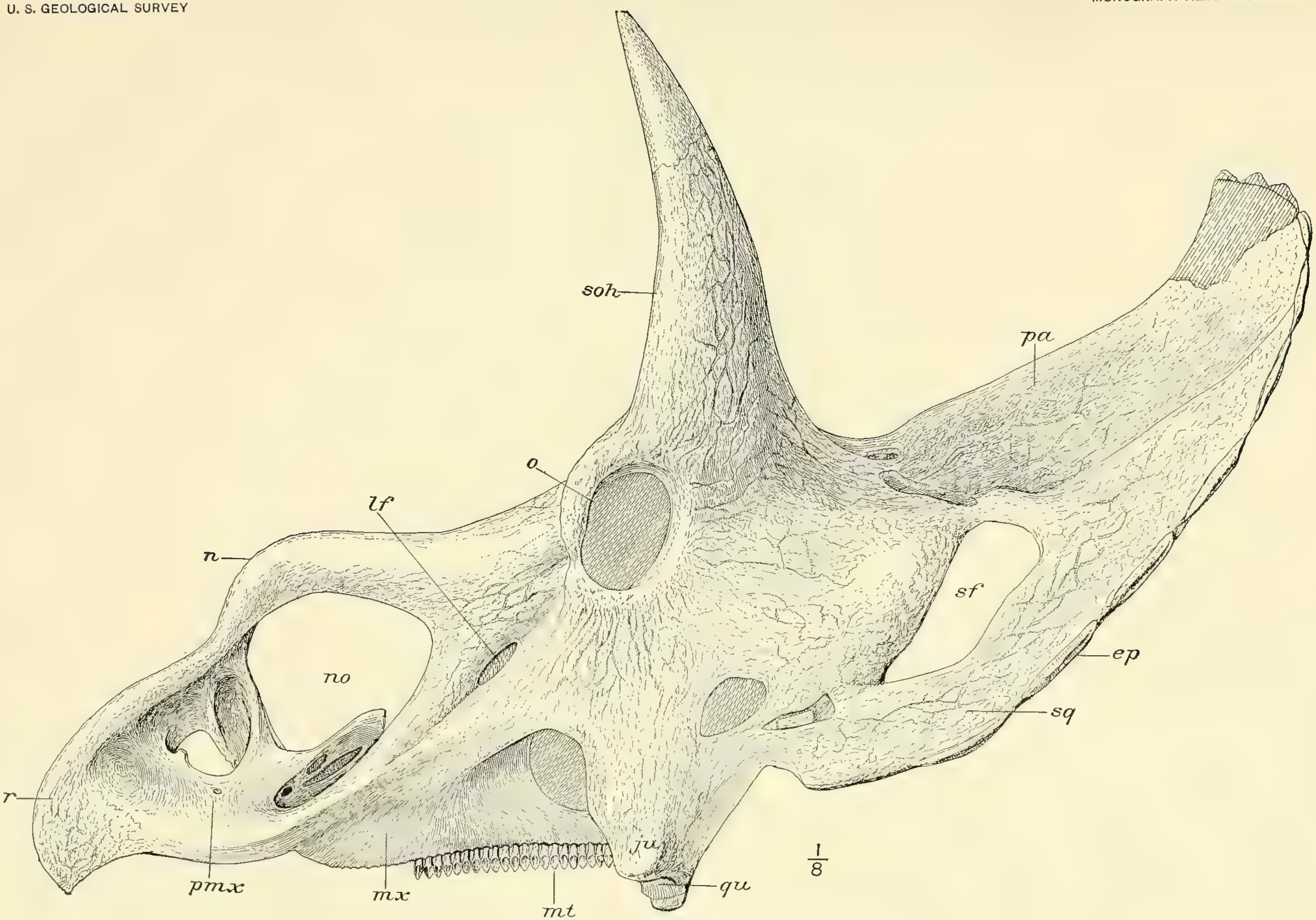
(See p. 149.)

Plate prepared under the direction of Hatcher.

Type specimen, No. 2412, U. S. National Museum. Left lateral view.

ep, epoccipital.
ju, jugal.
lf, lachrymal foramen.
mt, maxillary teeth.
mx, maxillary.
n, nasal.
no, nasal opening.
o, orbit.
pa, parietal.
pmx, premaxillary.
qu, quadrate.
r, rostral.
sf, squamosal fenestra?
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF DICERATOPS HATCHERI LULL, SIDE VIEW.

PLATE XLVIII.

293

PLATE XLVIII.

SKULL OF TYPE OF DICERATOPS HATCHERI LULL.

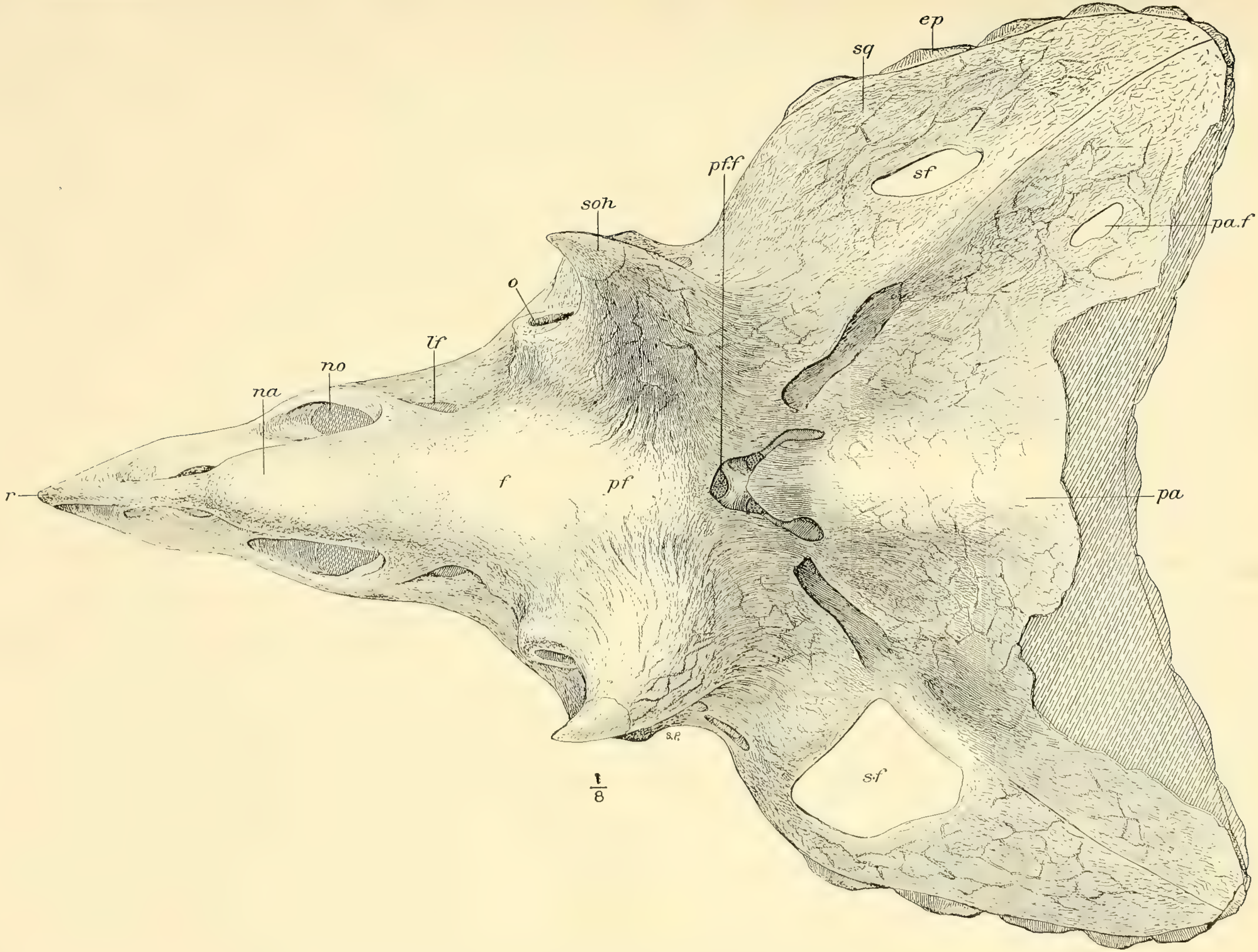
(See p. 149.)

Plate prepared under the direction of Hatcher.

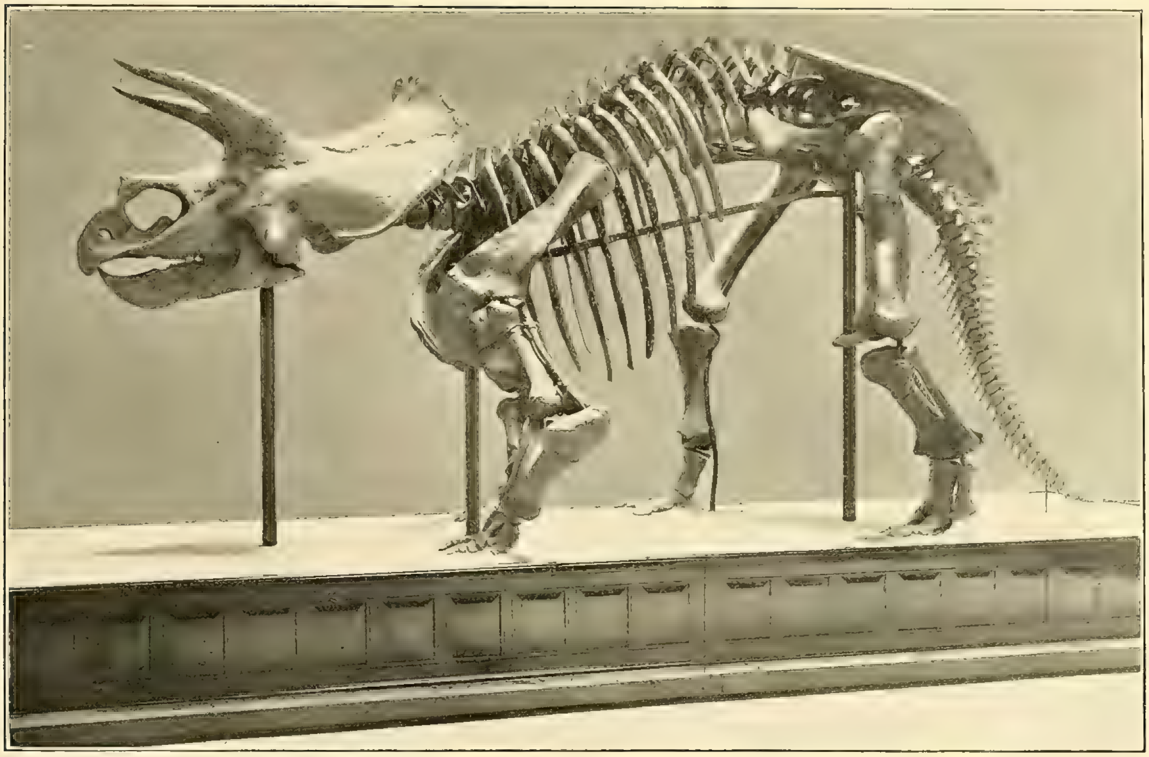
Type specimen, No. 2412, U. S. National Museum. Superior view.

ep, epoccipital.
f, frontal.
lf, lachrymal foramen.
na, nasal.
no, nasal opening.
o, orbit.
pa, parietal.
paf, parietal fenestra?
pf, postfrontal.
pff, postfrontal fontanelle.
r, rostral.
sf, squamosal fenestra?
sq, squamosal.
soh, supraorbital horn core.

One-eighth natural size.



SKULL OF DICERATOPS HATCHERI LULL, TOP VIEW.



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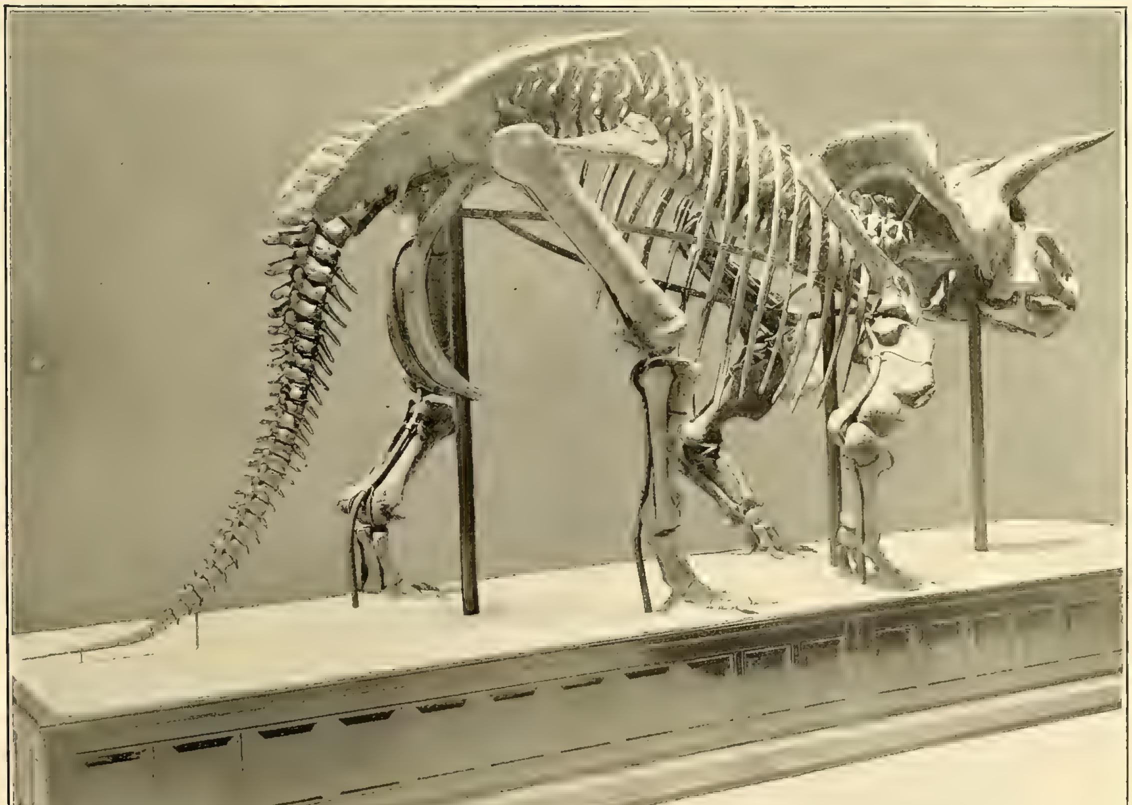


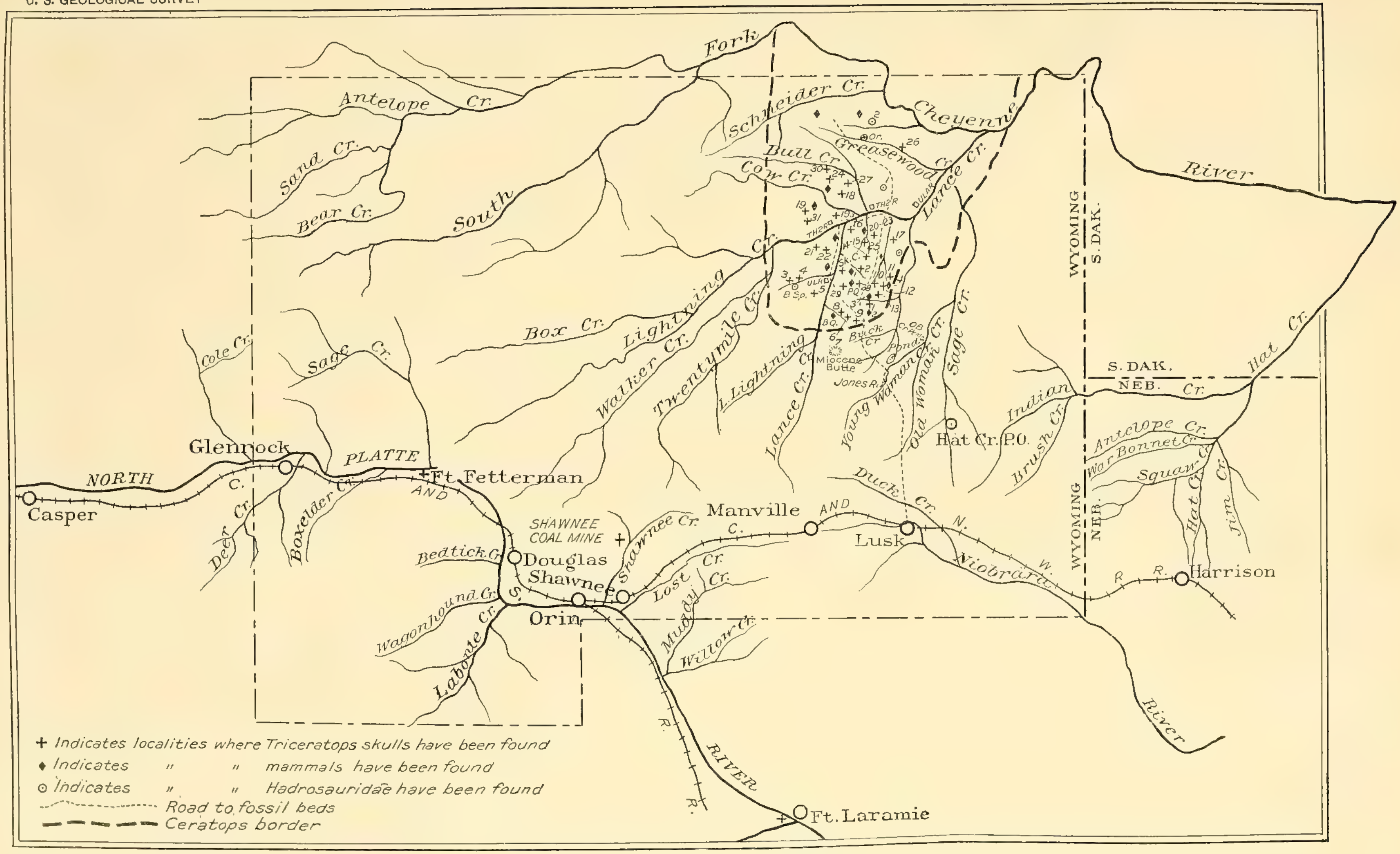
B

RESTORATION OF TRICERATOPS.

Views of mounted skeleton in United States National Museum. *A*, Side view; *B*, oblique rear view.

MAP SHOWING PRINCIPAL CERATOPSIA LOCALITIES.

Compiled by R. S. Lull.



MAP OF CONVERSE COUNTY, WYO.

After J. B. Hatcher.

INDEX.

[Names in *italic* are synonyms; figures in **black-face** type indicate descriptions; figures in *italic* denote illustrations.]

PUBLICATIONS OF UNITED STATES GEOLOGICAL SURVEY.

[Monograph XLIX.]

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of the United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A list of the Monographs follows, and a circular giving complete lists of all the publications can be had on application.

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MARCH, 1907.

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