

MOUNTED SKELETON OF *TRICERATOPS PRORSUS*
IN THE SCIENCE MUSEUM

by
Bruce R. Erickson
The Science Museum

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As a result of five consecutive field seasons in the Hell Creek Beds of northeastern Montana, a sizable collection of vertebrate fossils was obtained by the writer.

Among the reptilian remains recovered were two incomplete skeletons of the ornithischian dinosaur *Triceratops prorsus*. These specimens form the basis of the recently mounted skeleton in The Science Museum, St. Paul.

Previously mounted skeletons of *Triceratops* incorporate compositions of bones belonging to numerous individuals as well as to more than one species. The present mount presents a more accurate account in this respect as the materials used represent a single species. Furthermore, this mount is of note because it is considered to represent an immature animal in spite of its proportions which demonstrate an enormity of size that is inconsistent with other interpretations regarding the species.

During the course of development of this skeleton, other noteworthy points were brought out. These will be discussed below.

Triceratops prorsus Marsh

Am. Jour. Sci., Vol. 39, Jan., 1890, p. 82.

The referred material was collected from the Hell Creek formation during the summers of 1960-1964 from exposures in Garfield County, Montana. Two quarries one located in the S. $\frac{1}{2}$ Sec. 3, T. 21 N., R. 37 E., and the other in SE. $\frac{1}{4}$ Sec. 31, T. 21 N., R. 37 E., produced major portions of skeletons: SMVP P60/2/1, comprising a partial skull, vertebral column, pelvis, tail sections, part of the right shoulder girdle, limb elements and numerous rib fragments and phalanges; and SMVP P62/1/1, consisting of a skull, half of jaw, left side of shoulder girdle, partial column, tail vertebrae, partial pelvis, limb and rib sections, respectively.

The first skeleton was discovered by the writer's wife; the second, by the writer.

Substantial portions of these specimens are preserved; hence, there is no discrepancy as to specific agreement. In several instances, substitutions of bones were necessary because of severe fragmentation of the originals. Some of the original bones were completely lacking, in which case plaster reproductions were made.

Of the additional elements used in the development of this mount, there is little question about identification of the species. It is quite possible, in fact, that because of their proximity to quarry sites, these may belong to one or the other above skeletons. However, because it cannot be positively stated, the following catalogue numbers have been assigned to these elements: prementary SMVP P60/5/1, left mandible SMVP P60/8/2, left humerus SMVP P63/11/1, right femur SMVP P60/6/1, and left tibia-fibula SMVP P63/2/1. Size continuity is good as observed in duplications among the various elements, SMVP P62/1/1 being slightly smaller than SMVP P60/2/1.

MOUNTED SKELETON

Development and mounting of this material was accomplished mainly through the efforts of museum preparator Kenneth B. Sander and the writer. Critical preliminary assembly, which involved planning the principal supporting framework and fabrication of same, was greatly assisted by the expert help of Orville L. Gilpin, Chief Preparator of fossils in the Field Museum of Natural History. Valuable assistance was also contributed by C. B. Hanson, R. Erickson, and J. Birch of the part time staff.

As a general guide, the mounted skeletons of *Triceratops* in the American Museum of Natural History and the U.S. National Museum were referred to - the former to a greater extent, especially in regard to pose.

Osteology of the genus is aptly described by Marsh, Hatcher, and Lull (1907) R.S. Lull (1933), and others. Some special points of interest, however, are presented here with a discussion of the new skeleton.

Skull. - The skull of *T. prorsus* is generally distinguished from others of the genus by its prominent supranasal horn which is usually somewhat higher than it is wide, measured through the thickest part of its base. The rostrum of *T. prorsus* extends

only slightly, if at all, anteriorly from the base of the nasal horn before curving downward to form the upper half of the "beak." Along the border of the frill, which is a backward expansion of the parietals and squamosals, are found the so-called epoccipital - small, elongated pieces of bone a few inches in length and so spaced as to give the frill a scalloped appearance at its outer margin. These bones are not peculiar to the species but are characteristic and helpful in determining the relative age of an individual.

Although separated into numerous sections, the skull is fairly well preserved in SMVP P62/1/1. This skull lacks the end of the rostrum, parts of the nasal region behind the nostril, and much of the maxillary region. The premaxillae and some minor portions of the anterior edges of the parietals are also missing.

The left side of the skull, anterior to the squamosal-jugal suture, was badly crushed. For purposes of restoration therefore, the left jugal, quadratojugal, and quadrate were replaced by homologous elements from skull SMVP P60/2/1. This complementary substitution was done, instead of plaster restoration of the damaged area, to illustrate a special and interesting pathological condition seemingly due to traumatic causes. The replacement jugal, about at its center, bears what is evidently a premortem puncture wound of a type frequently encountered in ceratopsians (fig. 1.).

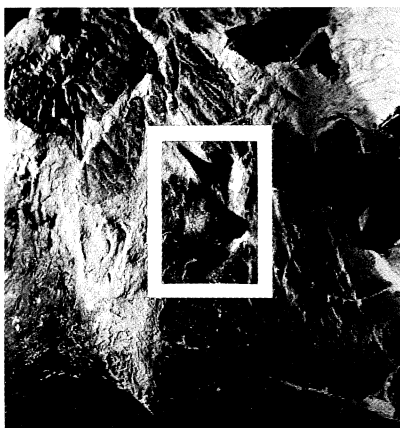


FIGURE 1.

LEFT JUGAL OF *Triceratops prorsus*,
COMPOSITE SKELETON SHOWING PUNCTURE WOUND.

The type skull of *T. prorsus*, YPM 1822, is stated to be that of a fully adult animal, Lull (1903), although of comparatively small size. Evidence for this lies in the absence of a post frontal fontanelle, that opening which communicates with the post frontal sinuses, and a frill which is bordered by well ossified epoccipitals. Theoretically, the post frontal opening closes with maturity - a situation not unlike that in the skulls of mammals. The epoccipitals enlarge to the point of actually overlapping as well as becoming highly coossified.

The referred skull SMVP P62/1/1 is 7 ft. 3 in. in length, measured along the midline from the rostrum to the edge of the frill, and is proportionately larger than the type in other measurements.

The post-frontal fontanelle is only partially closed, the opening being bridged over at its center only. Some epoccipitals are present in places, but the degree of ossification with the frill is slight, again suggesting immaturity. If this evidence is significant and we are dealing with an immature form, then the type of *T. prorsus* must be considered a runt.

Position of the head, as mounted, is believed typical. Its horns are horizontal and directed forward over the face. This brings the "beak" close to the ground. This pose of the head presents the best possible position for defensive and offensive maneuvering. Any shock from impact to the front of the head would thusly be transferred to the occipital condyle, a point of shock absorption.

Lower Jaw. - Each jaw half (dentary) carries a series of some 40 tooth rows forming a cutting edge with the opposed upper teeth. All the teeth have been lost or removed and the dental grooves fitted with plaster reproductions made from the few originals present and others in the collection.

The prementary, together with the rostrum, forms an imposing turtle-like beak. Lull (1933) suggests similar feeding habits in *Chelydra* and *Triceratops*.

In skull SMVP P62/1/1, the prementary was badly crushed; hence for purposes of exhibit, it has been replaced by prementary SMVP P60/5/1 which is virtually undamaged.

Vertebral column. - The vertebral column is known in various stages of completeness from numerous specimens and has been frequently compared to that of *Monoclonius*. Both genera seem to be in close accord structurally and in vertebral formulae.

The present skeleton exhibits a presacral series of 21 cervico-dorsal vertebrae, the first three anterior, consolidated. The 18th presacral is entirely plaster to fill out the desired number. This number is one less than in the New York skeleton, which is an incomplete series.

Curvature of the column was determined by articulating the centra squarely in such a manner as to allow a reasonably good fit between the respective zygapophyses. The curve along the resulting column is somewhat less than in some restorations of ceratopsians which show what is abnormal flexure attributed to opisthotonos.

Considerable displacement of the vertebrae, in situ, especially near the sacral region, accounts for whatever bones may be missing. All ten sacrals are preserved, although much of their dorsal aspect has been lost through erosion, including the first nine dorsal spines. The centra are uncrushed however, and form a smooth natural curve.

The tail extends in an uninterrupted curve vertically downward from the most posterior sacral vertebra. As it approaches ground level, it swings outward to the rear and rests on the ground for about one foot of its length.

Although the entire caudal series was not recovered, the preserved sections are from various regions of the tail and worthy of mention in that they show the overall shape of the tail.

In cross section the tail is shown to be rather circular at its proximal end but having a great measure of lateral compression near its midsection. Distally, the caudal vertebrae lose their neural and haemal arches and the tail is rounded. In the vicinity of the eighth and ninth vertebrae, the lateral processes are longer than often suspected, giving the circular section. The lateral processes gradually diminish in length posteriorly and the tail is narrowed.

Length of the individual chevrons is a bit conjectural as none were found. However, from comparisons with *Monoclonius* and other ceratopsian material, it is held that those fitted to this skeleton are not far from correct. Figure 4 shows the tail in profile. Figure 2 (A-B) indicates sections at vertebrae eight and nine.

The hypaxial musculature in this region of anterior caudals probably was constricted giving rise to muscles which inserted into the ischium and ilium. The coccygeo-femoralis muscles which inserted into the femur were also present here and contributed to the bulk of the tail.

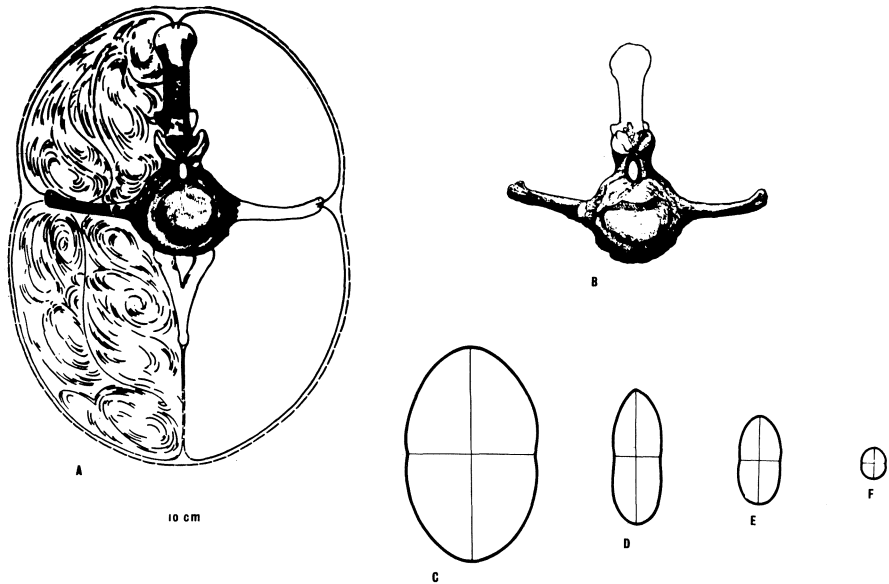


FIGURE 2.

SERIAL SECTION OF TAIL, *Triceratops prorsus*, COMPOSITE SKELETON: A. EIGHTH CAUDAL VERTEBRA, B. NINTH CAUDAL VERTEBRA, C. SIXTEENTH CAUDAL VERTEBRA, D. TWENTY-FOURTH CAUDAL VERTEBRA, E. THIRTY-SECOND CAUDAL VERTEBRA, F. FORTIETH CAUDAL VERTEBRA.

Pelvis. - The tetraradiate pelvis is massively constructed. The wide flat iliac blades, which normally follow the curve of the sacral vertebrae, have been straightened through distortion at the anterior extremities and therefore rise in an unnatural arch to the level of the neural spines.

Osborn (1933) notes that the prepubes were directed forward and outward from the acetabulum and had ligamentous connections with one of the posterior thoracic ribs rather than projecting forward into the abdominal region as was earlier indicated by others. In this corrected position, observed in the New York skeleton, the prepubes angle outward abruptly meeting the thirteenth dorsal rib. The St. Paul skeleton shows a similar relationship which further suggests it equally plausible that the prepubes did not abut the ribs but actually may have extended even beyond the limits of the rib line. In this position, it would seem to allow even more freedom of movement as well as the required support of the abdominal region. The preserved surfaces on the prepubis is not reliable enough to show evidence for a connection with a rib, but a connection here certainly seems logical.

The anterior edge of the prepubis has a harmonious curve with the rib cage. As noted in many specimens, this curve is frequently lost through the susceptibility of the blade-like extremity to be straightened during fossilization. The right pubis is the only plaster bone in the pelvis.

It is not quite clear whether there are ten or eleven vertebrae incorporated into the sacrum of the New York mount - ten are indicated by Osborn (1933); however, in the mount, eleven neural spines can be counted belonging to vertebrae attached to the pelvis. The first of these presumably belongs to a presacral (fourteenth dorsal) vertebra. Unlike the St. Paul skeleton, there is a rib connection between this presacral and the anterior margin of the ilium. No evidence for this attachment is distinguishable in the St. Paul skeleton; therefore, the last dorsal rib was left free as in *Monoclonius*.

Two heavy ischia occupy their normal positions as the hinder members of the pelvis completing the rear of the acetabulum and converging postero-medially beneath the tail.

Ribs. - Most of the dorsal ribs are either missing or severely broken; consequently they have been completed artificially in accord with other specimens. In overall aspect, the rib cage is a bit more "slab-sided" and less expanded than other mounts.

The cervicals represented are of interest. Included are what is thought to be the second, third, fourth and part of the fifth - some from either side. Interpretation of the cervical rib sequence is difficult because they show a variety of form and lack of agreement with earlier arrangements.

The first rib was evidently borne by the axis. It is simple, short, and thin. The second was carried on the third and last vertebra of the fused portion of the neck. It is heavier and much wider than the preceding rib and has a prominent ridge pointing forward midway between the capitular and tubercular processes. This ridge presumably served as an attachment area for the levator scapulae. The third rib also has a similar ridge and closely resembles the preceding in form but is somewhat more robust.

Other preserved cervical ribs are distinct from each other in shape and length. These have been arranged according to their respective sizes and lengths which increase rapidly posteriorly (fig. 3).

As the ventral portions of the ribs having attachments with the sternum are cartilaginous, we cannot distinguish a demarcation

between neck and trunk as we do in living reptiles. Brown (1917) uses the change in position of attachment of the capitulum to centrum, to attachment up on the lateral process as the division between the neck and trunk regions of the body. This point may be arbitrarily taken as the separation.

Allowing for the error of incompleteness of the rib series and, as Romer (1956) points out, the transitional condition of the vertebral structure in this region, the present skeleton would have seven to nine cervicals and twelve to fourteen dorsals depending on definition. The seventh rib, which arises on the eighth vertebra, has been connected, in this case, to the sternal by simulated cartilage. This should not necessarily be taken as the first dorsal rib.

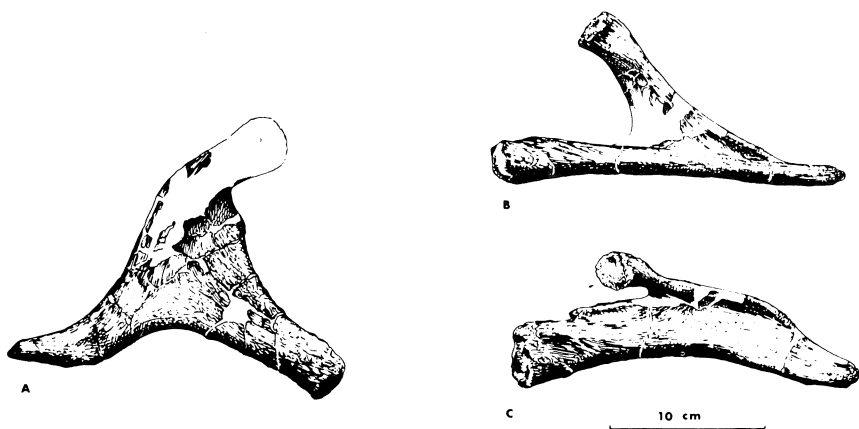


FIGURE 3.

CERVICAL RIBS, *Triceratops prorsus* SMVP P62/1/1: A. FOURTH LEFT RIB, B. AXIS RIB, C. AXIS RIB.

Shoulder girdle. - Elements of this region are strong. The girdle comprises a long flat scapula which angles back along the constricted anterior part of the body. Its tip reaches to the twelfth rib.

A stout coracoid joins the proximal border of the scapula. The glenoid cavity is formed at the rear edge on the junction of the two elements. The left scapulocoracoid has been mounted essentially as it was found, the natural shape seems to be undisturbed.

Sternals were absent but have been reproduced in plaster after *Monoclonius* and a pair of bones ascribed to *Triceratops* by Brown (1906). According to Brown (1917), the sternals of both genera differ only in size.

At the risk of seeming presumptuous, cartilaginous attachments of the dorsal ribs have also been added in plaster mainly for the benefit of support but also to enhance the appearance of the mount (pls. 1 and 2).

Front limbs. - In typical ceratopsian fashion, the humeri extend more or less horizontally outward from the shoulder into such position that the forearm is brought to greatest flexion in a vertical attitude. Osborn (1933) notes the relationship as being the best one allowing for the least restricted movement of the limb. This position, which is reminiscent of large lizards and tortoises, demonstrates a normal walking pose.

Few toe bones remained intact. The feet have been based chiefly on those of *Monoclonius* and the mounted skeleton of *Triceratops elatus* in the American Museum of Natural History. Digital formulae: 2, 3, 4, 5 for the manus and 2, 3, 4, 5, 1 for the pes.

Hind limb. - A most salient feature of the skeleton is the limb disparity between the front and hind legs which is usually interpreted as indicative of bipedal ancestry.

It would be hard to imagine the hind legs in any position other than directly under the ilia as supporting pillars with the heads of the femora resting firmly against the bases of the ilia, here then, carrying the greatest share of the animal's weight.

In its present pose, the left rear leg bears the greatest weight and serves as a pivot point while the right rear foot is carried forward into the next step. Movement of the legs would be mostly fore and aft with some radial swing at the knee and some rotation of the ankle.

PRINCIPAL MEASUREMENTS IN METERS

| | |
|--|-------|
| Total length along curvature, rostrum to tip of tail . . . | .7.92 |
| Thorax, maximum width at 18th rib | .1.50 |
| Highest point of back, sacral spine | .2.92 |
| Greatest spread of fore limb. | .2.36 |
| Greatest spread of hind limb. | .1.83 |
| Acetabulum to glenoid fossa, center to center | .2.46 |

Skull

| | |
|---|-------|
| Maximum length, rostrum to edge of frill at midline . . . | .2.21 |
| Rostrum to occipital condyle. | .1.31 |
| Rostrum to front of orbit | .1.08 |
| Front of orbit to edge of frill at midline | .1.17 |
| Frill, maximum width across base. | .1.40 |
| Width across orbits (front) | .40 |

Skull measurements continued

| | |
|---|------|
| Width across base of supranasal horn. | .09 |
| Length of base of supranasal horn | .25 |
| Supranasal horn height. | .27 |
| Height of frill at midline. | 2.35 |
| Jaw, prementary to articular. | .99 |

Vertebral column

| | |
|---|------|
| Atlas to end of tail. | 6.68 |
| Cervical vertebrae (1st - 8th). | .94 |
| Thoracic vertebrae (9th - 21st) | 1.68 |
| Sacral vertebrae. | 1.24 |
| Caudal vertebrae. | 2.77 |

Limbs

| | |
|---|------|
| Humerus, head to distal extremity | .74 |
| Radius, maximum length. | .39 |
| Ulna, maximum length. | .64 |
| Femur, head to distal extremity | 1.14 |
| Tibia, maximum length | .76 |
| Fibula, maximum length. | .74 |
| Length of manus at III | .43 |
| Length of pes at III. | .65 |
| Scapulocoracoid, maximum length. | 1.46 |

Pelvis

| | |
|-------------------------------------|------|
| Ilium, maximum length | 1.65 |
| Maximum width across ilia | 1.50 |
| Ischium, maximum length | 1.19 |
| Prepubis, maximum length. | .65 |

METHOD OF MOUNTING

Mounting of this skeleton makes a significant contribution to The Science Museum's collection of vertebrate fossils as it is the Museum's first complete dinosaur mount.

Both internal and external supports were employed in assembling this mount (fig. 4) to achieve the best support and most attractive exhibit. In many cases, the bones are extremely hard and drilling was not practical.

Each vertebra is pierced by a pair of steel rods which form the main support of the column. This method was used by Gilpin (1959). The rods are fastened in front by a fixed vertical slip joint (fork open upwards to carry the two rods) between the third and fourth free cervicals. Posteriorly, they are secured to the sacral main support by adjustable nuts which allow lengthening or shortening during assembly.

To eliminate drilling, the sacrum was fitted with an external 2" x ½" flat bar below. The rear main upright is welded to this at the point of balance. The entire tail contains a single graduated rod which is fastened at its proximal end by an adjustable union and at its distal extremity by a welded joint.

All limbs and girdles employ external bracing of 1" half-round steel. The skull rests on a single 2" x ¼" wall tube as used for all three main uprights. The post beneath the skull rests on an angle-iron base designed with casters for ease of handling during preparation and assembly. For such a massive skull, some such arrangement is a necessity. This whole unit was eventually secured to the other steel structures.

Ribs, phalanges, and artificial cartilaginous segments contain internal bracing for the most part. All supports are anchored directly or otherwise to an angle-iron frame resting on the floor. The whole assembly is quite sturdy yet flexible enough to withstand any normal vibration.

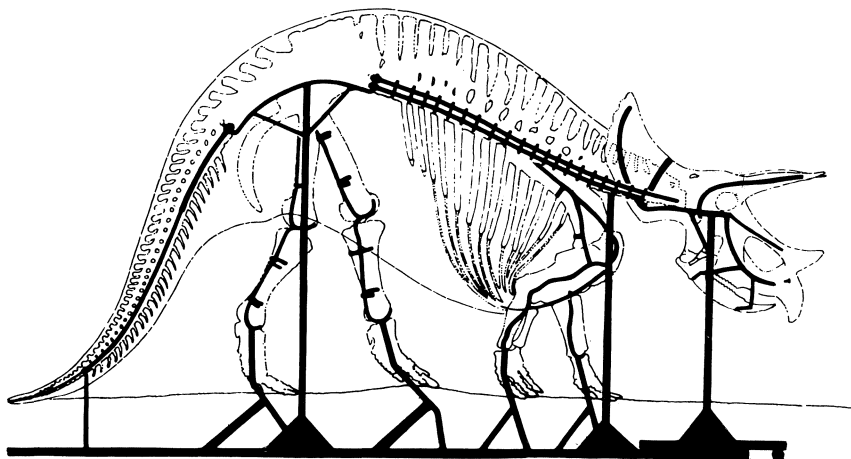


FIGURE 4.
DETAILS OF IRON SUPPORTING STRUCTURE.

NOTES ON RELATIONSHIPS

Abundant remains of dinosaurs in the Hell Creek Beds show *T. prorsus* to be predominant. This species, in fact, seems to be the only member of the genus present in some 200 specimens observed during the course of several seasons in the field. It is likewise obvious that aged members of the population attained enormous size, probably maximum for the genus.

The present skeleton represents a fairly large animal appreciably larger than what is often judged to be average size. Recognizing some discrepancies in size of the specimens comprising this mount, the composite skeleton nevertheless intimates an animal average in size and thereby assumed to be of breeding age, but perhaps not fully matured.

Size range in the species is easily demonstrated by a series of supranasal horn cores in the collection. These show a considerable degree of variation in themselves, but enough post nasal material was associated to give a good idea of the sizes of the total skulls. Several of these skulls would exceed eight feet in length if restored. Larger horn cores are common surface finds and are clues to the relative abundance of larger animals. Only two juveniles may be counted among the remains of some 200 individuals observed. These are an ulna SMVP P64/9/1 and a partial rostrum SMVP P61/2/1.

The gigantic nature of the species is also indicated by an articulated scapulocoracoid, which is substantially larger than the mounted shoulder, in the Eastend Museum, Eastend, Saskatchewan. In absence of contradictory morphological evidence, this specimen is regarded as being *T. prorsus*. The specimen was collected from the Frenchman formation some years ago.

T. Maximus was established by Brown (1933) on the basis of two cervical ribs and a series of eight vertebrae, AMNH 5040, from the Hell Creek Beds of Montana. Structural distinctions between this species and *T. prorsus* escape detection. In light of this and the above evidence, it appears that *T. prorsus* and *T. maximus* must be considered synonymous.

ACKNOWLEDGEMENTS

The writer is indebted to many people for their assistance in collecting and developing the material for this skeleton. I am especially grateful to Kenneth B. Sander for the many hours he spent helping to develop the skeleton and for his text figures. Charles J. Johnston, also of The Science Museum staff, spent several seasons in the field working on this project and has furnished photographs and a very fine model of *Triceratops prorsus* (pl. 3). Special thanks are due to Orville L. Gilpin of the Field Museum of Natural History for his efforts during the early stages of mounting.

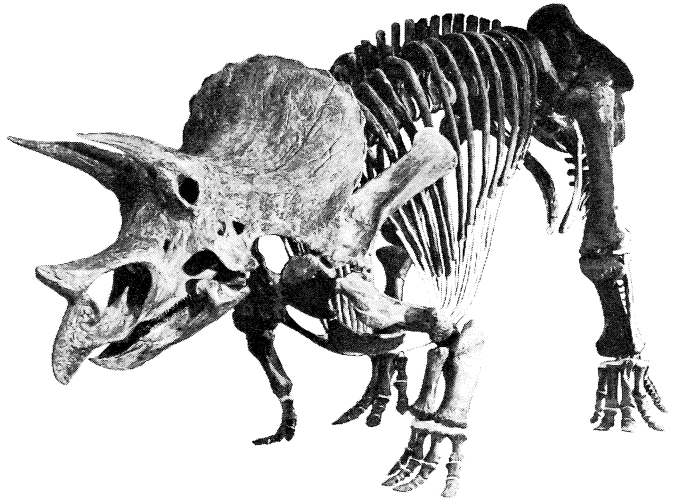
Numerous individuals participated in quarrying operations at various times and to various degrees. At the risk of inadvertently overlooking someone, these include: Wallace H. Hogenson,

James Nelson, Philip Fitzpatrick, Todd Otis, Eugene W. Hall, Delwin R. Olsen, Robert Van Cleave, Robert E. Sloan, Jerry Webers, Charles Boggs, Rodger Merrick, Jeffery Birch, Fred Logman, Steven Garrett, Robert Spading, Paul Lukens, Peter Jensen, Gordon Hadden, and Mark Thiesen.

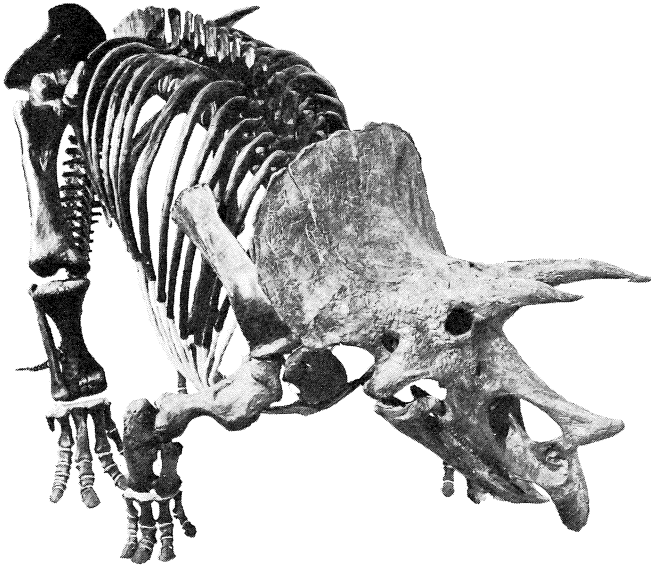
For other aid in this project, sincere thanks are extended to the Louis W. and Maud Hill Family Foundation and to Waldorf Paper Products Company of St. Paul.

BIBLIOGRAPHY

- Brown, B. 1906. New Notes on the Osteology of *Triceratops*. *Bull. Amer. Mus. Nat. Hist.*, XXII, Art. XVII.
- . 1917. A Complete Skeleton of the Horned Dinosaur *Monoclonius*, and Description of a Second Skeleton Showing Skin Impressions. *Bull. Amer. Mus. Nat. Hist.*, XXXVII, Art. X.
- . 1933. A Gigantic Ceratopsian Dinosaur, *Triceratops maximus*, New Species. *Nov. Amer. Mus. Nat. Hist.*, No. 649.
- Gilmore, C. W. 1905. The Mounted Skeleton of *Triceratops prorsus*. *Proc. U.S. Nat. Mus.*, XXIX, No. 1426.
- Gilpin, C. W. 1959. A Free-Standing Mount of *Gorgosaurus*. *Curator*, Vol. II. No. 2.
- Hatcher, J. B., Marsh, O. C., and Lull, R. S. 1907. The Ceratopsia. *Mon. U.S. Geol. Surv.*, XLIX.
- Lull, R. S. 1903. Skull of *Triceratops serratus*. *Bull. Amer. Mus. Nat. Hist.*, XIX, Art. XXX.
- . 1933. A Revision of the Ceratopsia or Horned Dinosaurs. *Mem. Peabody Mus. Nat. Hist.*, III, Part. 3.
- Osborn, H. F. 1933. Mounted Skeleton of *Triceratops elatus*. *Nov. Amer. Mus. Nat. Hist.*, No. 654.
- Romer, A. S. 1956. *Osteology of the Reptiles*. Chicago, Univ. of Chicago Press.
- Russell, L. S. 1935. Musculature and Function in the Ceratopsia. *Bull. Nat. Mus. Can.*, No. 77.



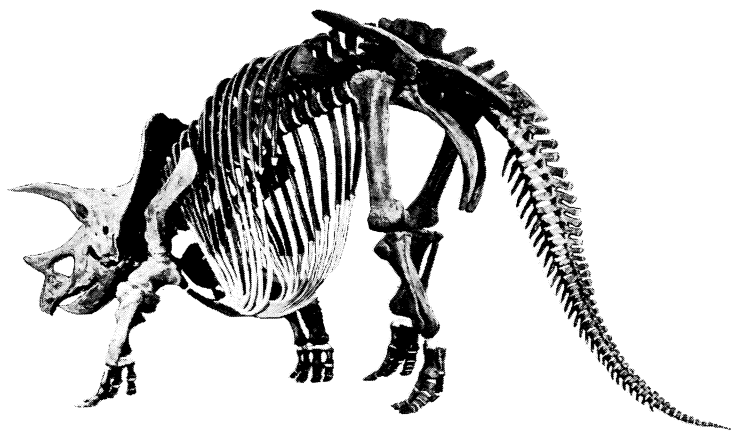
B.



A.

PLATE 1

- A. *Triceratops prorsus* MOUNTED SKELETON, THE SCIENCE MUSEUM.
LEFT OBLIQUE ANTERIOR VIEW.
- B. *Triceratops prorsus* MOUNTED SKELETON, THE SCIENCE MUSEUM.
RIGHT OBLIQUE ANTERIOR VIEW.



B.



A.

PLATE 2

- A. *Triceratops prorsus* MOUNTED SKELETON, THE SCIENCE MUSEUM.
ANTERIOR VIEW.
- B. *Triceratops prorsus* MOUNTED SKELETON, THE SCIENCE MUSEUM.
LEFT OBLIQUE POSTERIOR VIEW.

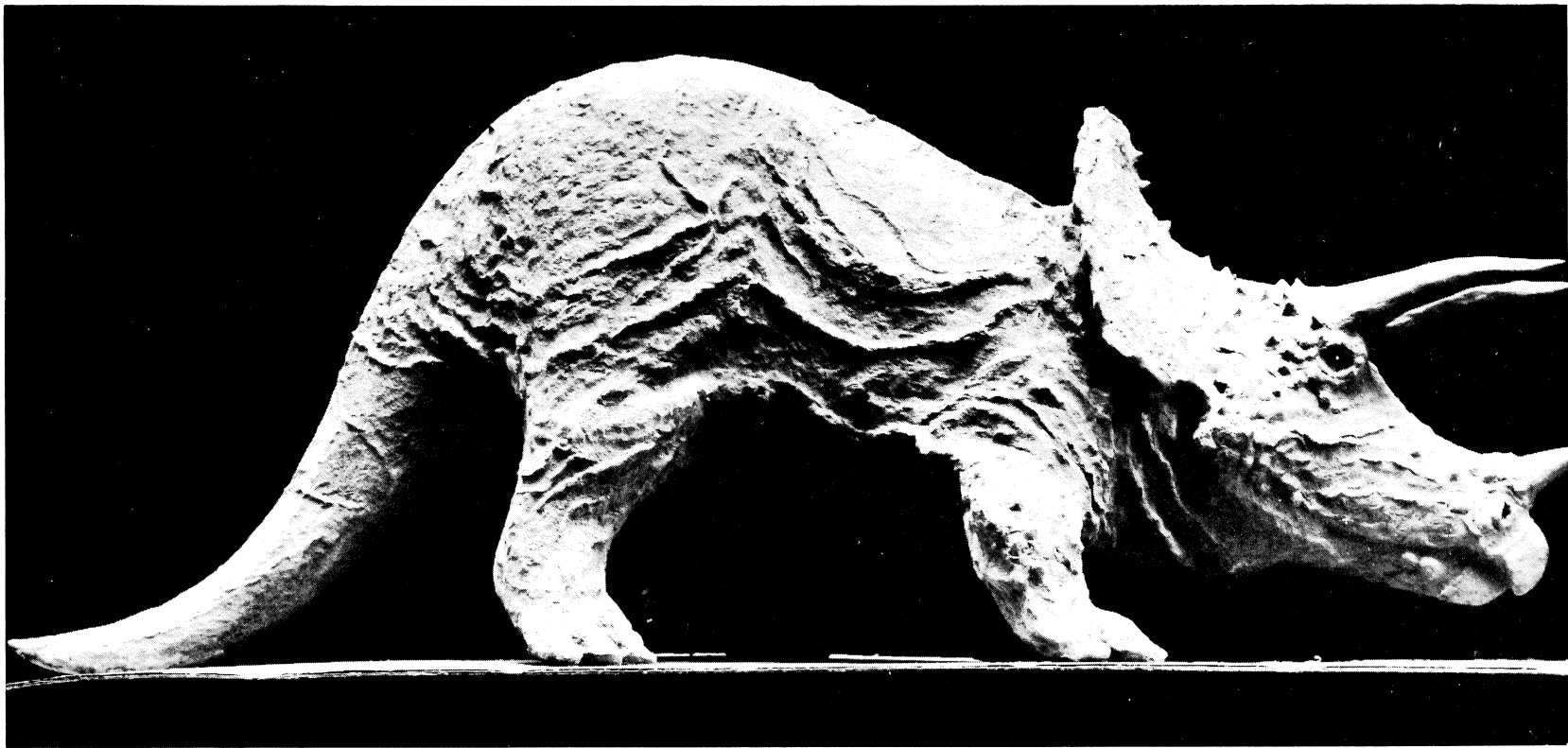


PLATE 3

Triceratops prorsus, FLESH RESTORATION. MODEL BY CHARLES J. JOHNSTON.