DINOSAUR

NATIONAL MONUMENT

Past and Present

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NATIONAL MONUMENT

PAST *and* PRESENT

by

WM. LEE STOKES

U. S. Geological Survey and University of Utah

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Contents

DINOSAUR NATIONAL MONUMENT is located in Moffat County, Colo., and in Uintah County, Utah, with administrative headquarters near the quarry, 7 miles north of Jensen, Utah, which is on United States Highway No. 40. The monument headquarters may be reached within a day from Denver, Colo., or Rocky Mountain National Park, Colo., via United States Highway No. 40. Salt Lake City, Utah, is only 200 miles distant. Accommodations for monument visitors are available at Vernal, Utah, 21 miles distant.

A small temporary museum exhibiting a number of fossilized bones of dinosaurs and other prehistoric animals as well as numerous maps, paintings, and photographs is open to the public without charge. The dinosaur quarry is a short distance by foot trail from the headquarters.

National Park Service officials have hopes and plans that this world-famous quarry may be protected from weathering and erosion by erecting a roof over it. Such a structure will make it possible to preserve bones now exposed in the quarry face and also house some dinosaur restorations. But above all it will make it possible to present to the public an active, working quarry where men are engaged in uncovering and preserving in place the fossil remains of these great prehistoric creatures.

Communications and requests for additional information should be addressed to the Superintendent, Dinosaur National Monument, Jensen, Utah.

DINOSAUR
NATIONAL MONUMENT
PAST AND PRESENT[1]

Introduction

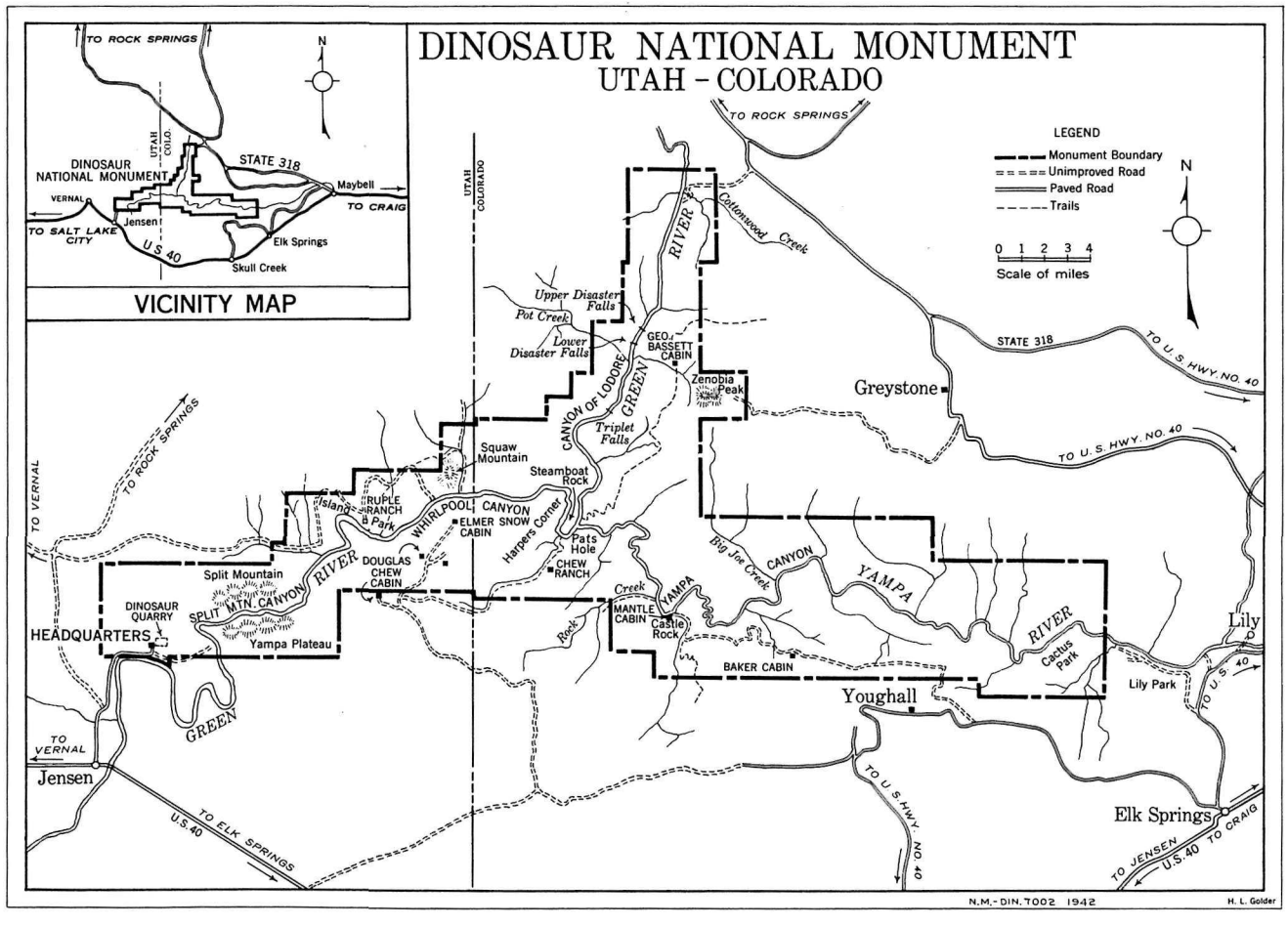
DINOSAURS ARE EXTINCT REPTILES, members of the same group to which belong present-day snakes, lizards, turtles, and crocodiles. They have been extinct for a very long time and are incredibly ancient by all ordinary human standards. No cave man ever saw a dinosaur, in spite of the many cartoons, science-fiction stories, and movies that might suggest otherwise. Dinosaurs had their day of glory and passed from the stage long before man made his entry. We know of their existence only from bones, teeth, tracks, and other indirect clues found preserved in the rocks of the earth's crust. Remains of dinosaurs have been found on all the continents and are especially abundant in some rock layers of western North America. One of the most famous deposits of fossil dinosaurs is that near Vernal and Jensen, Utah, which is now preserved as a national monument.[2] The story of this famous locality and the fossils it has yielded is briefly recounted in the following pages.

Landscapes of Long Ago

The chain of events that produced the area comprising Dinosaur National Monument began in what is known as the Jurassic period of earth history. This period, according to the best calculations of geologists, occupied an interval of time from 127 to 152 million years ago. At that time most of the geographic features of the North American Continent, as we know it, did not exist. Where the Rocky Mountains now stand, there lay a vast unbroken plain which reached from Mexico to Canada and from central Utah to where the Mississippi River now flows. Lofty

[1] Published by permission of the Director, Geological Survey.

[2] Dinosaur National Monument is located in Utah and Colorado. The Dinosaur Quarry is in the Utah section.


DINOSAUR NATIONAL MONUMENT
UTAH - COLORADO
VICINITY MAP
TO ROCK SPRINGS
N
UTAH
COLO.
DINOSAUR NATIONAL MONUMENT
STATE 318
Maybell
TO CRAIG
VERNAL
Jensen
TO SALT LAKE CITY
U.S. 40
Elk Springs
Skull Creek
LEGEND
Monument Boundary
Unimproved Road
Paved Road
Trails
0 1 2 3 4
Scale of miles
Cottonwood Creek
Upper Disaster Falls
Pot Creek
Lower Disaster Falls
GEO. BASSETT CABIN
Zenobia Peak
CANYON OF LODORE
GREEN RIVER
Triplet Falls
Greystone
STATE 318
TO U.S. HWY. NO. 40
Squaw Mountain
Steamboat Rock
Islands
RUPLE RANCH & Park
WHIRLPOOL CANYON
ELMER SNOW CABIN
Harpers Corner
Pats Hole
CHEW RANCH
DOUGLAS CHEW CABIN
Split Mountain
SPLIT MTN. CANYON
DINOSAUR QUARRY
HEADQUARTERS
Yampa Plateau
TO VERNAL
TO ROCK SPRINGS
Big Joe Creek
YAMPA CANYON
YAMPA RIVER
Rock Creek
MANTLE CABIN
Castle Rock
BAKER CABIN
Youghall
Cactus Park
Lily Park
Lily
TO U.S. 40
TO VERNAL
Jensen
GREEN
TO ELK SPRINGS
U.S. 40
TO U.S. HWY. NO. 40
Elk Springs
TO JENSEN
U.S. 40 TO CRAIG
N.M.-DIN.7002 1942
H. L. Golder

mountains reared their summits in the Great Basin region of Nevada and western Utah, and the Gulf of Mexico extended far northward into the continent. Many of the western mountains were active volcanoes which showered the surrounding lowlands with ashes and dust at frequent intervals. The climate was milder and moister than at present and probably verged on the tropical. Large rivers rising in the western mountains flowed sluggishly across the plains toward the sea, and along these streams vegetation grew in profusion. Animal life was abundant. Although the plants and animals of this ancient landscape were vastly different from those of the present day, the terrain as a whole bore some resemblance to the lower reaches of the Amazon River or the great alluvial plains of India.

The streams that flowed from the western mountains were laden with sediment, most of which they deposited in bars, mudflats, lake bottoms, and river channels long before they reached the ocean. Because the terrain was nearly level and lacked confining valley walls, the rivers were free to meander to and fro across the plains, depositing as they did so a more or less uniform layer of clay, sand, and gravel. This deposit, built up over a long period of time by the combined action of many rivers, is what geologists have named the Morrison formation. This interesting formation can be seen in many places in the mountain ranges and canyon walls of the West and is especially well exposed at Dinosaur National Monument.

On the wide Jurassic plains, the dinosaurs lived and died, and their bones became buried in the shifting river channels. During the course of ages, countless numbers of dinosaurs met death by various means, sometimes singly, but often, mysteriously, in great groups. One instance of mass destruction is recorded in the accumulation of bones found in the Dinosaur Quarry. At or near this locality some unusual catastrophe suddenly overtook a large number of dinosaurs so that they all died at about the same time. The cause of this wholesale destruction is a mystery. It may have been a sudden flood as from a river changing its course; it may have been a shower of volcanic ash which killed the dinosaurs by suffocation; or it may have been a sudden bacterial plague. In any event, dinosaurs large and small, flesh eaters and plant eaters, two-footed and four-footed, succumbed and perished together. Soon after death the huge beasts fell or were washed into a large river and their carcasses were carried downstream until they lodged against a sandbar or shallow bank where the waters could no longer move them. This locality where the bodies or parts of bodies of literally scores of dinosaurs came to rest is now the site of the main Dinosaur Quarry. The mud, sand, and gravel which were carried by the rivers and which ultimately entombed the bodies of the dinosaurs have become the solid stone which makes up the ragged cliffs and colorful slopes of the hills surrounding the quarry site.

Left: SKETCH MAP OF DINOSAUR NATIONAL MONUMENT SHOWING ROADS, TRAILS, AND CHIEF POINTS OF INTEREST.

AIRPLANE VIEW OF THE AREA SURROUNDING AND INCLUDING THE DINOSAUR QUARRY. THIS IS ONLY A SMALL PART OF DINOSAUR NATIONAL MONUMENT. THE ROWS OF RIDGES AND BANDS OF LIGHT- AND DARK-COLORED ROCKS ARE THE ERODED EDGES OF THE VARIOUS GEOLOGIC FORMATIONS THAT DIP SOUTHWARD UNDER THE GREEN RIVER.

Under the Earth One Hundred Million Years

Preservation of the bones of the dinosaurs would have been impossible were it not for their burial under somewhat special conditions. Ordinary bone is a very durable substance, but it can withstand the attacks of the weather for only a comparatively short time. In order for it to be preserved indefinitely it must be petrified, that is, changed into stone. To be petrified a skeleton must be buried almost immediately in water-saturated sediments and then left in an undisturbed state for a long period of time. Petrifaction is a poorly understood process which man has not yet been able to duplicate in the laboratory, but it is known that subterranean mineral-bearing waters are essential for its accomplishment. These slowly percolating waters carry mineral matter into the pores and cavities of the bones, in time converting them into substances usually much harder than the surrounding rock. Flesh and even horn decays too rapidly to be petrified, but wood and bone are commonly preserved in this way. While petrifaction is taking place, the surrounding sediments are usually converted into rock—gravel becomes conglomerate, sand becomes sandstone, and mud becomes shale.

At Dinosaur National Monument, the death and burial of the dinosaurs was a very minor episode in the geologic story. The deposition of mud and sand did not cease until the skeletons were buried thousands of feet beneath the surface. In rock layers that overlie the dinosaur-bearing beds, geologists find evidence that the area was invaded by an extensive sea soon after Morrison time. Great thicknesses of muddy sediments accumulated and countless marine creatures died and their shells became fossils as the sediments were converted to stone. At length, however, the sea withdrew, additional river and lake sediments were laid down above the marine beds, and at long last the land began to attain its present aspect. Tremendous forces within the earth soon began to deform the layers of rock into gigantic wrinkles and folds, which became the various mountain ranges of the Rocky Mountain system. Among the large upfolds created at this time was the Uinta Range, on the flanks of which Dinosaur National Monument is located. Had it not been for this mountain-building episode, the dinosaur skeletons would have remained to this day buried deep within the earth.

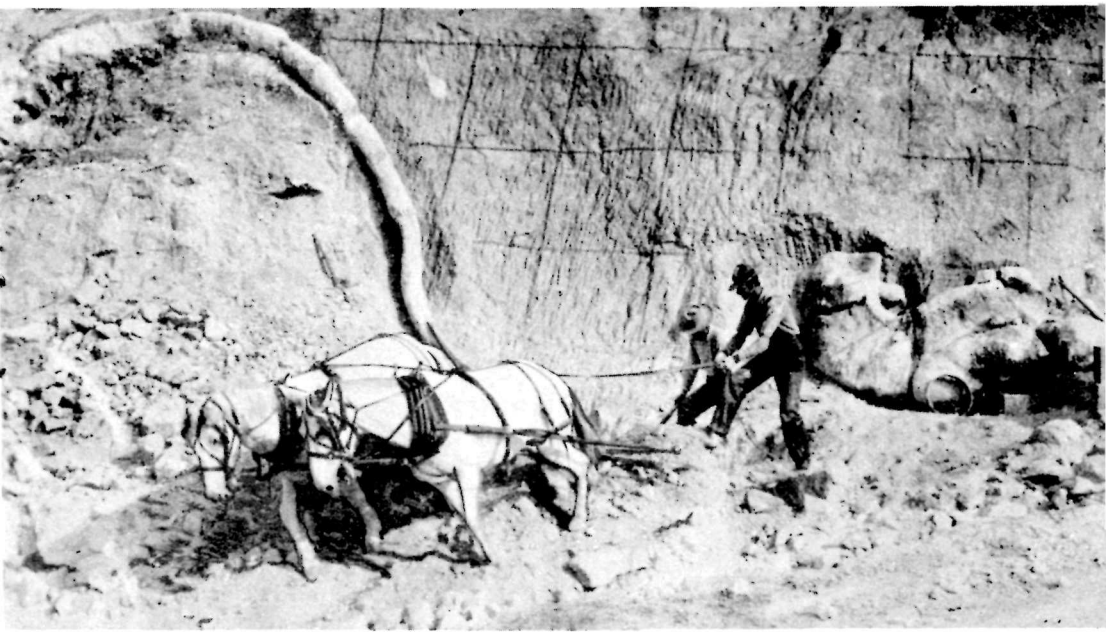
As soon as the mountains were elevated above the general level of the surrounding areas, erosion began to wear them down. New and vigorous rivers ate gradually into the rocks and removed them, layer by layer, until at length the relatively small lens of coarse-grained rock which had once been a river bar on the Morrison plain was uncovered, and the petrified bones of the dinosaurs that had been buried there ages before again came to light.

Many deposits of fossil bone have been removed by erosion and reduced to dust and worthless fragments, but the deposit at Dinosaur National Monument reached the light of day practically intact and at a time when man, a relatively latecomer on earth, was at hand to study its contents and interpret their meaning.

Earl Douglass Finds the Skeletons

The original discoverer of fossil bones in what is now Dinosaur National Monument will probably remain unknown; in such matters, the person who perceives the scientific value of the find and publishes the facts for all the world to know usually gets credit for the discovery. Possibly, ancient Indian hunters knew of the deposit, for there is ample evidence of prehistoric camp sites not far from the quarry. Local cowboys and sheep herders may have observed the huge remains, but if so, they failed to make their finds known to persons capable of evaluating them. As a matter of record, however, O. A. Peterson discovered fossil bones in the vicinity as early as 1892, and Earl Douglass, working for the Carnegie Museum of Pittsburgh, discovered the main deposit on August 19, 1909. Douglass realized the value of the find and under his direction the deposit was developed and worked on a large scale from the time of discovery until about 1922. During this period, the Carnegie Museum removed probably a score of dinosaurs. The work was difficult, slow, and expensive, and it is fortunate for science that Andrew Carnegie was willing to apply part of his immense fortune to such a seemingly impractical project as recovering and restoring fossil dinosaurs.

VIEW OF THE MORRISON FORMATION. THE RAGGED LEDGE OF ROCK ON THE RIGHT IS THE ONE CONTAINING THE DINOSAUR SKELETONS; IT IS THE SOLIDIFIED SAND AND GRAVEL OF AN ANCIENT RIVER BED. THE TEAM OF HORSES IN THE CENTER OF THE VIEW IS DRAGGING CRATES OF FOSSILS FROM THE QUARRY, WHICH IS ON THE SKYLINE.



USING A TEAM AND SCRAPER TO UNCOVER THE BONES. THE LONG WHITE OBJECT IS THE TAIL OF A DINOSAUR ENCASED IN PLASTER OF PARIS. BEHIND THE MEN ARE SEVERAL OTHER LARGE BONES TREATED IN THE SAME MANNER. THE LINES DRAWN ON THE QUARRY FACE ARE PART OF A GRID SYSTEM WHEREBY EACH BONE WAS ACCURATELY LOCATED.

On October 4, 1915, while the Carnegie Museum was operating the quarry, an area of 80 acres was set aside by proclamation of President Woodrow Wilson as the Dinosaur National Monument. After the withdrawal of the Carnegie Museum workers from the site, the United States National Museum operated the quarry for a short time and obtained much additional material. Still later, in 1923 and 1924, the University of Utah continued the exploration and excavation and recovered complete and partial skeletons of several more dinosaurs.

Although the deposit is by no means exhausted, there has been little material recovered for more than 20 years. On July 14, 1938, the original monument was enlarged by proclamation of President Franklin D. Roosevelt to include about 325 square miles of territory in Utah and Colorado. This greatly expanded area contains much of scenic, recreational, and scientific worth besides the dinosaur deposit, but most of the newly added country is not readily accessible. The Dinosaur Quarry is, and will probably remain, the chief attraction of the area, especially if present plans for development are realized. National Park Service officials and scientists are co-

operating in a plan to create an on-the-spot museum where dinosaur skeletons in their original positions in the rock will be on exhibition. Some of the material that may be found in the future will be left more or less in its original position and the bones will be partially freed of matrix so as to stand in relief on the walls of the quarry. Other skeletons may be completely excavated and mounted in lifelike poses at the site.

During the more than two decades that have passed since large-scale excavation ceased at Dinosaur National Monument, most of the material collected by the various museums has been unpacked and studied. The rocky matrix has been cleaned away, broken fragments have been repaired, and each bone has been carefully measured, described, and illustrated. The results of this research have been published in

DURING A LATER STAGE IN THE EXCAVATION, REGULAR MINING METHODS WERE EMPLOYED TO REMOVE THE EARTH AND ROCK. THE DINOSAUR-BEARING BED IS ON THE RIGHT.

a series of large volumes, the contents of most of which are highly technical. The various reptilian forms thus far recognized from the Dinosaur Quarry are as follows:

Dinosaurs:
- *Apatosaurus louisae*
- *Barosaurus* sp.
- *Camarasaurus lentus* (Marsh)
- *Diplodocus longus* (Marsh)
- *Pleurocoelus* sp.
- *Uintasaurus douglassi* Holland
- *Antrodemus (Allosaurus)* sp.
- *Camptosaurus medius* Marsh
- *Dryosaurus altus* Marsh
- *Stegosaurus* sp.

Crocodile:
- *Goniopholis* sp.

Turtle:
- *Glyptops utahensis* Gilmore

Phytosaur:
- *Hoplosuchus kayi* Gilmore

Although these names mean little to any but the scientist, it should be pointed out that there are no other designations by which the creatures of the past may be identified. Each name is a sort of scientific shorthand aimed at telling something of the nature of the creature to which it is applied. Thus, *Uintasaurus douglassi* Holland designates the great fossil reptile (Saurian) found in the Uinta Mountains, studied by Mr. Holland, and given the name *douglassi* in honor of Douglass, who discovered the remains. Although scientific names and classifications are important, the life habits and environment of these creatures of long ago are perhaps more interesting.

The Sauropods

The name sauropod refers to any gigantic, four-footed, long-necked, and long-tailed dinosaur having a four-toed foot. Of the creatures named in the foregoing list, the first six belong to this group. Sauropods are perhaps the most amazing of all the dinosaurs, and their remains have been found in greater variety at Dinosaur National Monument than at any other locality in the world. Although there is some disagreement among paleontologists as to just how many kinds of sauropods there were, it is safe to say that at least six different kinds are represented in the bone deposit at the monument.

A typical sauropod has an extremely long neck and tail and a massive slab-sided body. Those so far discovered range from 15 to 80 feet in length. It is certain that there are others awaiting discovery that are larger and smaller than the ones now known. The limbs are massive and postlike, but the skulls are remarkably small for such otherwise gigantic creatures. They stood 15 feet high at the hips and could raise their snakelike necks and heads at least 10 or 15 feet higher.

Sauropods reached the largest size ever attained by land-living creatures and are exceeded in bulk only by the present-day whales. The skeleton of an average sauropod after it has been freed of rock weighs 6 or 7 tons and the animals themselves,

when alive, must have averaged about 40 tons—roughly 7 or 8 times the weight of a full-grown elephant. Although the limb bones are massive and heavy, the vertebrae are marvels of lightness and efficiency, a typical specimen consisting of struts and braces and thin plates of bone between which are deep hollows and cavities giving a maximum of strength and flexibility with a minimum of weight and bulk.

The sauropod skeleton is a graphic solution of a complicated problem in stress and strain relations. The legs are straight and stoutly constructed to support the great weight, while the rest of the bones are reduced in bulk as far as possible to lessen the strain on the limbs. Many of the principles made evident in the skeleton of the huge sauropods have been put to use by man in the construction of modern bridges and skyscrapers, where strength and lightness are desirable.

The sauropod skull is remarkable for its relative smallness and almost delicate construction. The sutures that bind the bones together are rather weakly developed and the skulls of most of these animals must have fallen apart rather soon after death. For this reason, fossil skulls of dinosaurs are rare and greatly prized. Dinosaur National Monument has yielded a relatively large number but still not enough to match the rest of the bones. Several isolated skulls were found in the rocks, and it has been somewhat puzzling to determine to which of the bodies these were originally attached.

SAMPLE VIEW OF THE DINOSAUR REMAINS AS THEY WERE UNCOVERED IN THE QUARRY. THE LARGE UPPER LEG BONE (FEMUR) IN THE CENTER OF THE PICTURE IS ABOUT 5 FEET LONG.

FOSSILS CRATED AND READY FOR SHIPMENT. THE CARNEGIE MUSEUM ALONE OBTAINED MORE THAN 700,000 POUNDS OF MATERIAL, ALL OF WHICH WAS TRANSPORTED BY TEAM AND WAGON OVER 130 MILES OF PRIMITIVE ROAD TO THE RAILWAY AT PRICE, UTAH.

The teeth vary somewhat in general form but on the whole are rather small and peglike, in some forms having the diameter and shape of a blunt lead pencil. All the teeth are confined to the fore part of the mouth and generally protrude from the jaws at an oblique angle.

The food requirements of such huge creatures must have been enormous. It has been calculated that a sauropod required at least half a ton of herbage each day. The teeth and body structure provide no good clue to the nature of the food, but presumably it consisted mainly of soft, succulent plants that flourished in great quantities in or about the streams where the dinosaurs lived. Getting an adequate quantity of food was the major problem of a sauropod's life and in view of the poorly adapted teeth and feeble brain which had to cope with the problem it is surprising that the great beasts were able to survive. The problem seems a little less puzzling, however, when it is recalled that these are reptiles, and reptiles can go for long periods of time with little or no food. Slow movements, cold blood, and weak brains do not require large amounts of energy.

The whole structure of the sauropods indicates they were best suited for a semi-aquatic or amphibious life. Their great bulk and tremendous weight were not conducive to rapid movement on dry land or over rough terrain. Most authorities believe that they spent much of their lives partly submerged in the rivers and lakes where the buoyancy of the water helped to take some of the weight from their limbs.

THE WAGON TRAIN THAT BROUGHT THE UNIVERSITY OF UTAH DINOSAUR COLLECTION TO SALT LAKE CITY.

At the famous dinosaur deposits of the Tendaguru formation in eastern Africa, numbers of massive sauropod limbs, preserved entire, were found standing upright in the rock, indicating that their owners had perished while standing in the muds (or quicksands) of some ancient lake or seashore.

Sauropods probably were able to wander over the dry land on occasion, but their dependence upon the watery environment for food and bodily support made them entirely unfit for any radically different mode of life. They became, in the words of the paleontologist, "overspecialized." That is a dangerous trend in any animal and a forewarning that if the environment should change drastically, the animal is doomed to extinction.

The intelligence of the sauropods must have been of a very low order, as the brain was exceedingly small. An elephant has about 9 pounds of "gray matter" for 4 tons of body weight, but in the sauropods 1 pound of brain had to serve 40 tons of weight. It should be noted, however, that there were several enlargements of the spinal cord which helped to control the huge body, but these were purely reflex centers. On the whole, the sauropod must have been a very stupid creature who somehow managed to muddle through life without much mental effort.

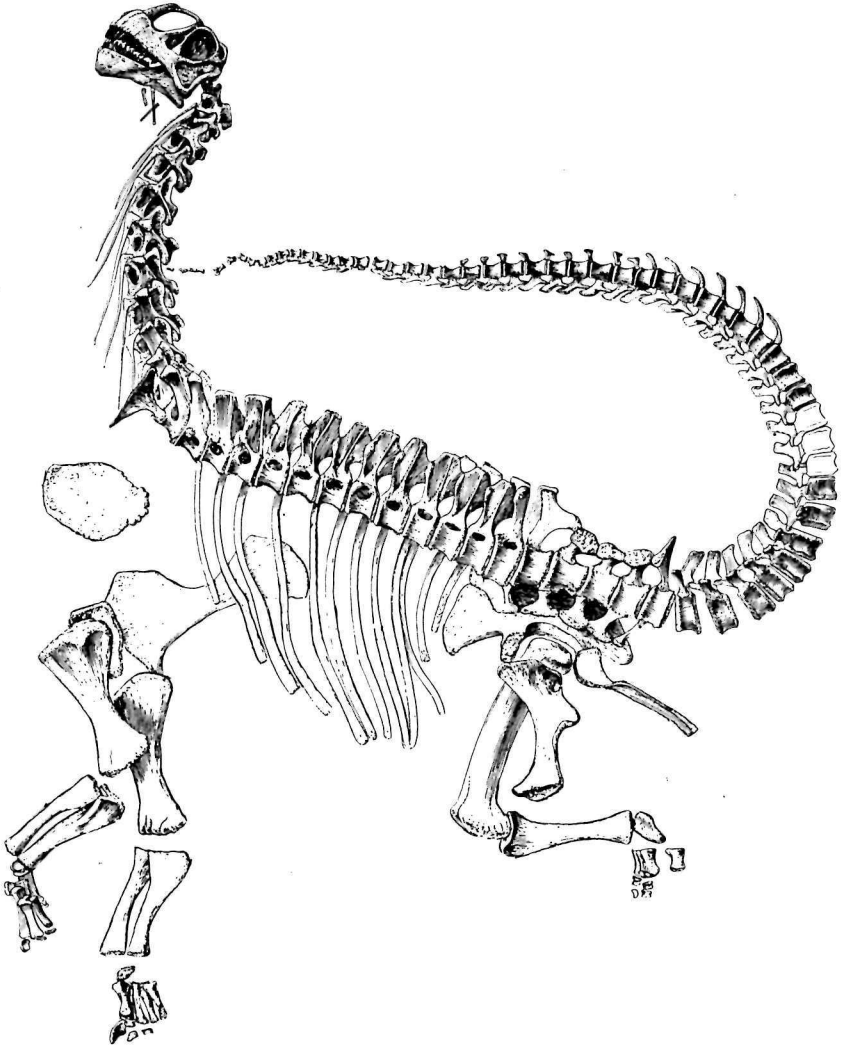
Allosaur

Since the beginning of life upon the earth there has been a continuous struggle between the hunter and the hunted. The eaters of flesh (carnivores) through the ages have pitted their speed and cunning against the strength of the eaters of plants (herbivores). The herbivores would overrun the earth if not kept in check by their

natural carnivorous enemies, and the carnivores are kept to a proper number by the available supply of animal food. In any assemblage of animals, ancient or modern, there are a relatively large number of herbivorous animals and a smaller number of carnivores. In the Jurassic period, therefore, it is not surprising to find a flesh-eating dinosaur fitted by size and structure to prey upon the weaker plant eaters. This creature is called *Allosaurus* (some prefer the name *Antrodemus*) and of him several skeletons have been recovered from Dinosaur National Monument. *Allosaurus* was a biped (two-legged), and his light, well-built skeleton seems to be correlated with

SKELETON OF THE SAUROPOD *Camarasaurus lentus* (MARSH) AS IT WAS DISCOVERED IN THE ROCKS AND AS IT IS MOUNTED FOR PUBLIC EXHIBITION IN THE CARNEGIE MUSEUM IN PITTSBURGH. THIS WAS A RELATIVELY SMALL SAUROPOD MEASURING 17 FEET IN LENGTH AND HAVING A HEIGHT AT THE HIPS OF ABOUT 4 FEET.

(*Courtesy Carnegie Museum.*)



an exceptionally active life. His three-toed feet, tipped as they were with stout claws, resembled those of a gigantic bird. The shorter front limbs were even more remarkable, each finger bearing a curved, needle-sharp talon of truly awesome dimensions; the whole hand was evidently used mainly for grasping and tearing flesh.

The mouth of the *Allosaurus* was literally filled with daggerlike teeth such as few creatures have ever possessed. The individual teeth were serrated like a fine saw blade and when worn out were replaced in such an ingenious manner that the *Allosaurus* had little dental trouble even though he lived to a ripe old age. Each tooth, as its edge began to dull, was pushed out by a fresh sharp tooth from an endless series that came into being in the jaw bones. The process was so ordered that, barring accidents, the *Allosaurus* never lost more than one tooth at a time on each half of the jaw. The two halves of the lower jaw were not solidly fused, and the whole was rather loosely connected with the skull. This was probably an arrangement that permitted the swallowing of large pieces of food. The saw-edged teeth were adapted to tearing but were poorly suited for grinding or chewing. These facts indicate that the *Allosaurus* probably ate rather infrequently and usually in a hurry. Like many present-day reptiles, he probably spent long periods in comparative inaction while his meals were digesting. The *Allosaurus,* as well as other dinosaurs, probably had a powerful gizzard or some other special arrangement for grinding food, as his teeth were poorly adapted to do a thorough chewing job.

A Walking Fortress

The gigantic sauropods apparently depended on sheer bulk to protect themselves from the attacks of the hungry carnivores, but another potent means of defense was developed by the dinosaur known as *Stegosaurus.* He was a veritable walking citadel, protected by plates of bone and armed with huge club-like spikes in such a way that the predaceous *Allosaurus* would have had to be hungry indeed to assault him. Along the neck and back was a double series of great triangular bony plates, standing upright and alternating in position from side to side. These plates were relatively small near the head, but over the hip region they were as much as 2 or 3 feet high. Near the tip of the tail were four heavy spikes of bone, two on each side. In addition, there were numerous small pieces of bone embedded in the skin of the throat region. Just how *Stegosaurus* employed this array of defensive armor we do not know. Perhaps he simply squatted down to earth to protect his more vulnerable stomach and discourage his enemy with vicious swipes of his club-studded tail. *Stegosaurus* was a four-footed creature, but his front legs were very short and clumsily posed so his shoulders were much lower than his hips. This peculiar structure seems to be traceable to the ancestors of *Stegosaurus,* who at one time walked almost exclusively on their two hind legs. Later they reverted to the four-legged posture, but the fore-

limbs had become shortened and so altered that they were awkward and poorly adapted for walking.

Stegosaurus is notable for the possession of a so-called second brain. This was an enlargement of the spinal cord in the hip region. It was many times larger than the true brain in the skull. Although *Stegosaurus* was as large as an elephant, his true brain was smaller than that of a kitten.

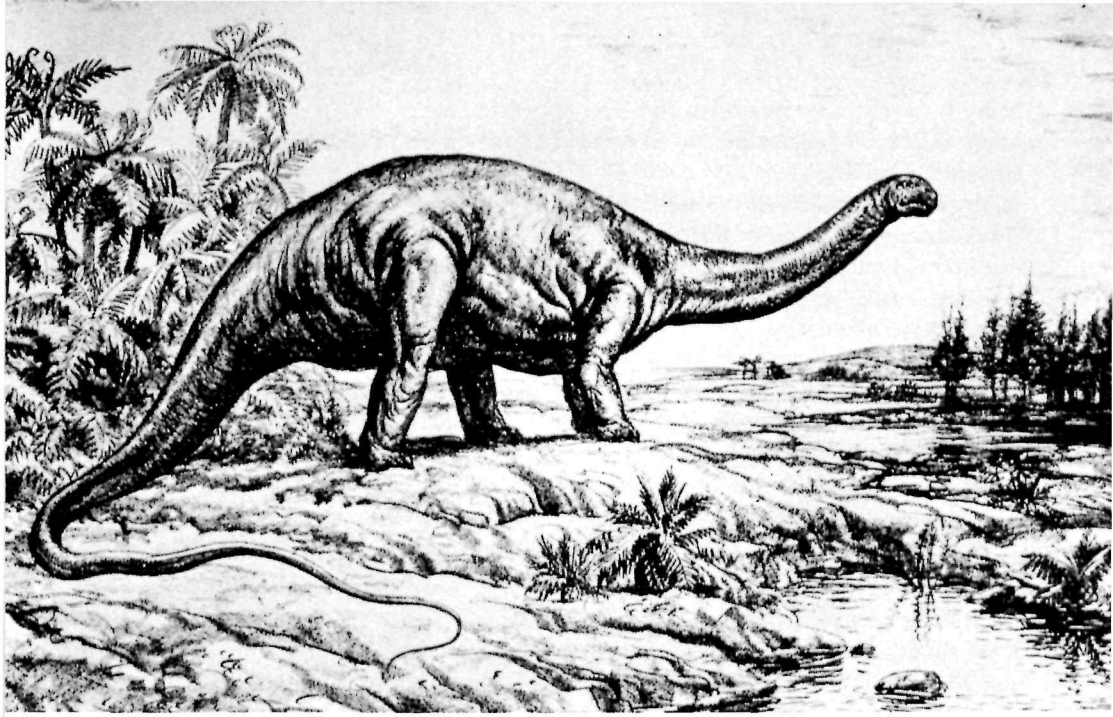
The Smaller Dinosaurs

The story of Dinosaur National Monument is not complete without some mention of the less spectacular, but nonetheless important, dinosaurs. Three relatively small, unassuming plant-eaters—*Camptosaurus, Laosaurus,* and *Dryosaurus*—are known from remains found in the bone deposit. These, however, are small only by comparison with their gigantic contemporaries; in bulk, they compare with domestic cattle of the present day. These smaller types no doubt were the customary prey of the hungry *Allosaurus* because they have no evident means of defense and do not appear to have been built for speed. They probably lived in small herds in the less vegetated regions between the main streams and must have required a type of plant food different from that of the sauropods.

These creatures were all bipeds, but could go on all fours while browsing or traveling slowly about the countryside. *Camptosaurus,* the most common, is the best known of the small plant eaters. His teeth were flat and leaflike, with coarsely serrated edges well adapted for cutting vegetation. There were no teeth in the front of the mouth, either above or below; instead, there was a sort of a horny beak or sheath which probably had a strong cutting edge. This distribution of the teeth contrasts strongly with the sauropod dentition, which, it will be recalled, was mostly confined to the front of the mouth.

Relatives of the Dinosaurs

Although the mighty dinosaurs dominated the Morrison scene, there were a few other forms of reptilian life that were able to maintain a rather modest foothold. Among these were the turtles and crocodiles, the ancestors of, and really very little different from, our present-day forms. These two groups have always played a subordinate, unimportant role in the animal world, but have the compensation of having endured long after their more spectacular contemporaries of the Jurassic period had disappeared. They did not attain large size or have specialized appetites, and were able to weather the adverse conditions that exterminated many other form of life.



A RESTORATION OF THE GREAT SAUROPOD DINOSAUR *Apatosaurus louisae* (HOLLAND) AS IT APPEARED WHEN ALIVE. THIS DINOSAUR HAD A LENGTH OF ABOUT 75 OR 80 FEET. (*Drawn by Dr. A. Avinoff of the Carnegie Museum.*)

Most of the plant and animal inhabitants of the Age of Dinosaurs were vastly different from those of today, but some were practically identical. Grasses and grains which directly and indirectly support so many kinds of animals in the present world were lacking in the Jurassic period, and flowering plants were just developing. There were, however, evergreen trees and ferns in abundance. Fish of familiar, as well as unfamiliar, types swam in the fresh-water streams, and the lower forms of animal life, such as clams and snails, were little different from those that may be found in similar environments in our own time.

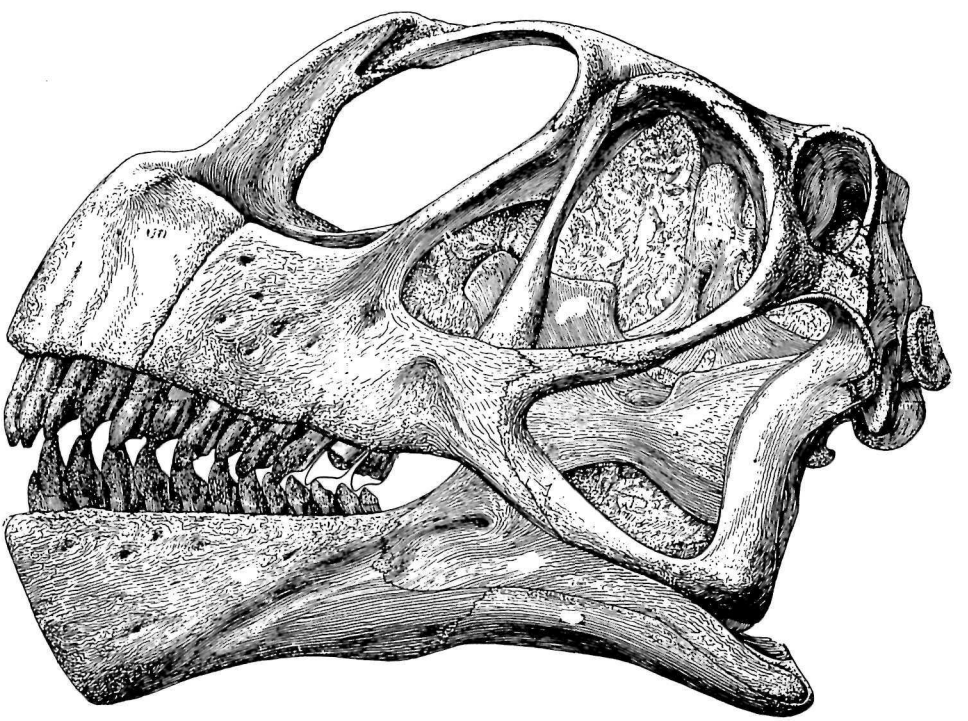
Gastroliths

Among the many interesting rock specimens that are found in the Morrison formation in Dinosaur National Monument and elsewhere are the so-called gastroliths, or "gizzard-stones." These are hard, brightly colored, flinty pebbles of various sizes, which are usually very smooth and even highly polished. Many theories have been advanced to account for these stones and especially to explain their remarkable smoothness and polish. Not the least attractive and credible of the theories is that the stones were swallowed by dinosaurs and were polished in their stomachs or

gizzards where they served the useful purpose of grinding up the food. It is an undisputed fact that dinosaur skeletons have been found with small deposits of smooth stones between the ribs and that many modern animals such as ostriches, seals, and domestic fowl have the habit of swallowing stones to aid digestion. For the most part, however, the remains of Morrison dinosaurs are not intimately associated with the polished stones; in fact, the gastroliths are mostly found in slightly higher beds which some geologists would consider as belonging to an entirely different formation. This, of course, only complicates the problem, for if the dinosaurs did not produce the gastroliths, some other agency must be invoked. There are several alternative ideas. The stones may have been polished by exposure to wind-driven dust for long periods before burial, or they may have been polished by obscure chemical actions within the muds and clays after burial. At any rate, this is a subject which never fails to arouse lively discussions among scientists and laymen alike.

THE SKULL OF *Camarasaurus lentus* (MARSH). THE SKULL IS ABOUT 13 INCHES IN LENGTH. THE NUMEROUS OPENINGS AND RATHER DELICATE CONSTRUCTION EXPLAIN WHY SUCH SKULLS ARE APT TO FALL APART AND ARE SELDOM PRESERVED ENTIRE.

(*Courtesy Carnegie Museum.*)



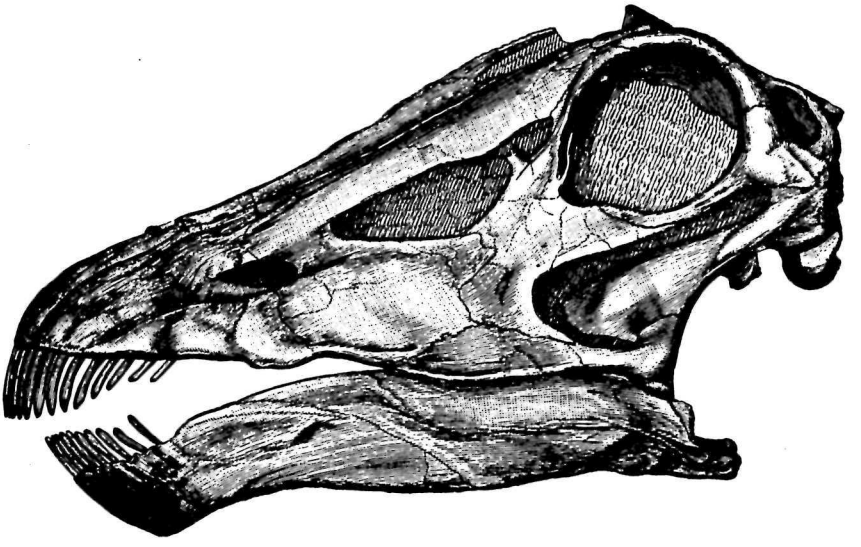
The Problem of Dinosaur Eggs

Most known reptiles lay eggs, and it is supposed that many, if not all, of the dinosaurs did too. The question is often asked why none are found with the dinosaurs in the Morrison formation. We can only speculate on the problem and make use of the facts we know regarding modern reptiles. Crocodiles, turtles, snakes, and lizards are extremely particular about where they deposit their eggs; in fact, the eggs of some reptiles are so cleverly hidden that they have never been found by scientists. Although the nest is usually well chosen, the hatching of the eggs is left largely to outside agencies. Reptiles, unlike birds, do not cover and protect their eggs and are incapable of supplying any heat to facilitate hatching. It is therefore assumed that the dinosaurs had certain areas, probably warm sandy deserts, to which they resorted in the egg-laying season, and that they did not deposit their eggs indiscriminately in the places where they spent most of their lives. This supposition is supported by the finding of remarkable accumulations of dinosaur eggs in the Gobi Desert in Mongolia. Here, paleontologists found that certain sandstones contain the scattered and broken remains of many dinosaur eggs. They also found numbers of perfect eggs—the most valuable ones in existence. This area probably was an ancient breeding ground which was used through a long period of time by several kinds of small dinosaurs. Perhaps some day we shall discover a place where the mighty sauropods laid their eggs. And if the eggs were in proportion to the creatures that laid them, we would expect them to be as large as small kegs. It is unlikely, however, that dinosaur eggs will ever be found among bone deposits such as those at Dinosaur National Monument.

Extinction of the Dinosaurs

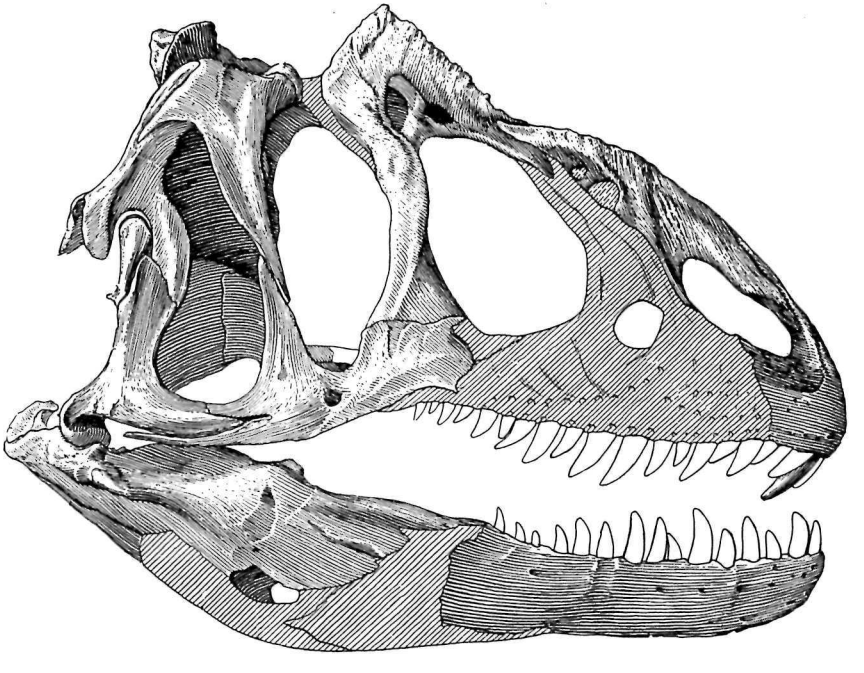
The mass destruction of dinosaurs at the site of Dinosaur National Monument may have made a notable gap in the local dinosaur population, but it was by no means fatal to the race. Dinosaurs carried on successfully for many millions of years after Morrison time. There did, however, come a day when the last dinosaur drew his final breath, leaving the world to new, different, and more intelligent creatures. The possible causes of the complete extinction of such a successful and powerful race is of more than ordinary interest, for in the study of such causes we may expect to learn something of our own possible future.

A favorite explanation of paleontologists for the extinction of the dinosaurs is that they became too specialized. That is, they became so adapted to one mode of life that when conditions changed they were unable to change with them. The giant sauropods could not suddenly take to mountain climbing and the flesh eaters could not adapt to a diet of vegetation. Underlying the whole great problem is the radical



SKULL OF *Diplodocus*, A SLENDER, LESS MASSIVE SAUROPOD. NOTE THE WEAK, PENCIL-LIKE TEETH. THE NOSTRILS OPENED HIGH ON THE SKULL ABOVE THE EYES, PROBABLY SO THE CREATURE COULD FEED UNDER WATER. SKULL ABOUT 2 FEET LONG.

SKULL OF THE CARNIVOROUS DINOSAUR *Allosaurus*. THE CROSS-LINED BONES REPRESENT THOSE THAT WERE MISSING IN THIS PARTICULAR SKULL. SKULL 28 INCHES LONG.



change that took place in the environment of the dinosaurs. This change involved almost the entire earth and consisted of vast upheavals of the lands, changes in the positions of seas and oceans, creation of deserts where once had been swamps and lowlands, and the slow cooling of the climate. To this combination of changes in the physical world the dinosaurs were unable to adapt themselves and so became extinct.

Where the Dinosaurs May Be Seen

Dinosaur skeletons from the deposit at Dinosaur National Monument may be seen in many of the large museums of the United States. By far the finest and most complete assemblage is that at the Carnegie Museum at Pittsburgh. Here may be seen the skeletons of several of the sauropods, of *Allosaurus,* and of the plant-eating *Camptosaurus.* The skeleton of *Diplodocus,* which forms one of the central and most prized exhibits of the United States National Museum, came from this deposit. An *Allosaurus* from the quarry is mounted in the Geological Museum of the University of Utah. A very fine *Diplodocus,* one of those obtained by the Carnegie Museum, has been mounted at the Museum of Natural History in Denver, Colo., and a *Barosaurus,* obtained originally by the University of Utah, is exhibited by the American Museum of Natural History in New York City. In addition to providing the general public with a thrilling look into the past, the skeletons recovered from the monument have provided geologists and paleontologists with unrivaled material for study and research.

SKELETON OF THE HERBIVOROUS DINOSAUR *Camptosaurus medius* (MARSH) AS IT IS PREPARED FOR EXHIBITION AT THE CARNEGIE MUSEUM AT PITTSBURGH. THE SMALL INSET REPRESENTS THE CREATURE AS IT APPEARED WHEN LIVING.

(*Courtesy Carnegie Museum.*)