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A Dinosaur Revival

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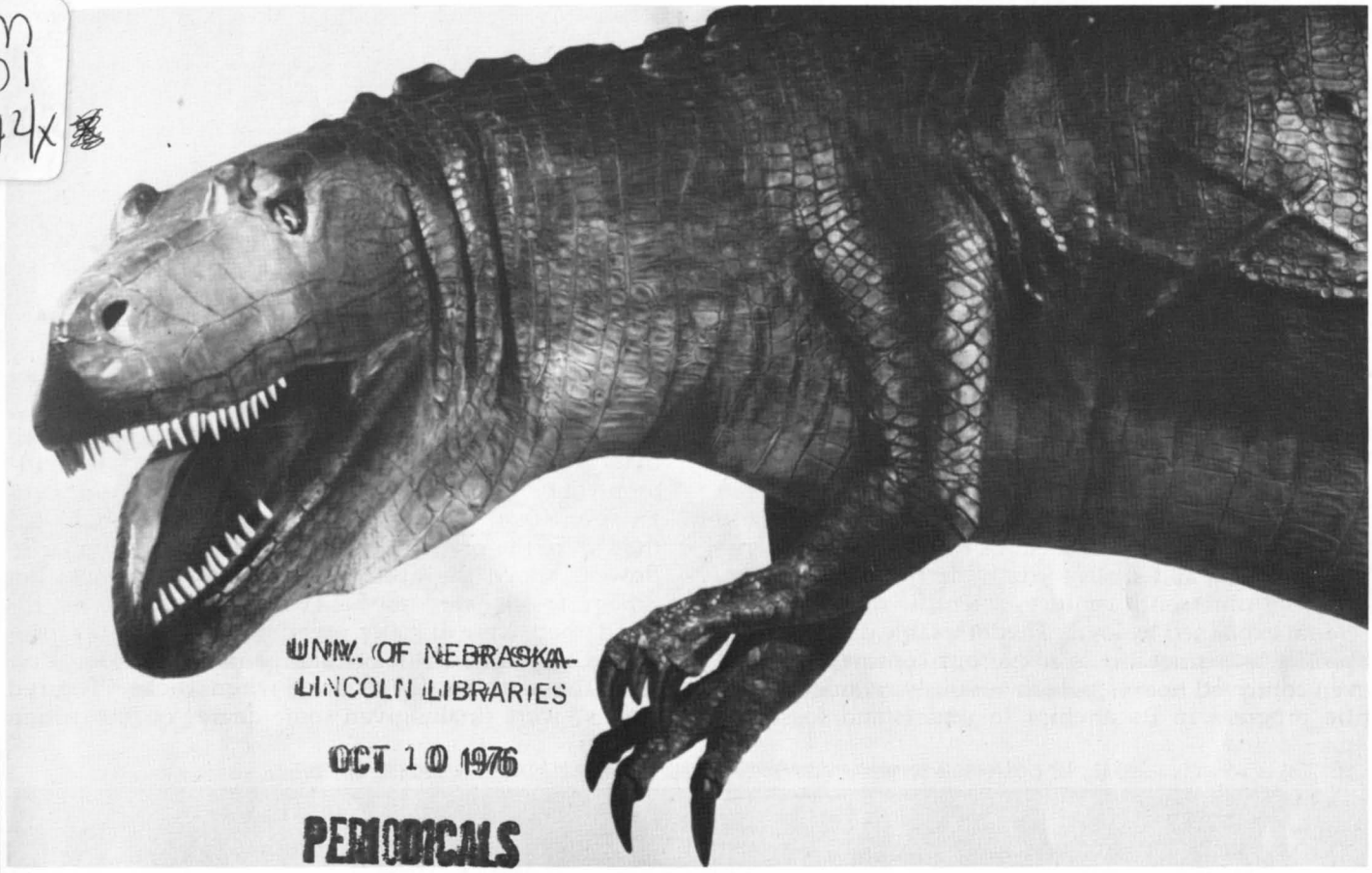


The Museum's new Dinosaur Gallery features a reconstruction of a carnivorous allosaur.

A DINOSAUR REVIVAL

Just about everyone loves dinosaurs! Just ask any museum guard, 4th grader, or grandparent looking for souvenirs at a museum's gift shop. The only natural history exhibits that persistently challenge their popularity, in a child's mind, are the fabled mummies of ancient Egypt. Why does just the mention of the name "dinosaur" activate the imagination of most people? Naturally their size and dominating appearance are significant; however, we would hope people are also intrigued by the very fact that these majestic beasts really existed at all, and for some ill-explained reason seemed to disappear at the height of their reign. How could these impressive animals develop as part of nature's plan? What did they really look like, how did they live, and have they left any descendants among us? These are the types of questions natural history museums should stimulate in visitors, for it is in museums where dinosaurs recapture their three-dimensional form; that imaginations can recreate the Mesozoic world of 150 million years ago. We know that these animals weren't "freaks" in any sense of the word; rather they were a product of nature's changing scene, a biologic potential carried to a natural conclusion through evolutionary processes.

What Are Dinosaurs?

Two orders of extinct reptiles dominated the land areas of the earth for nearly 160 million years. Although paleontologists usually distinguish between the two orders by details of their pelvic and skull anatomy, the popular term "dinosaur" is useful in describing both kinds. The most important feature that all dinosaurs share is their erect posture — a trait which distinguishes them from modern reptiles which *perhaps* was correlated with warm-bloodedness in dinosaurs.

When correctly assembled, as is the Museum's allosaur reconstruction, a dinosaur skeleton has its limbs poised directly under the body in a pose suited to an active mode of life. In contrast, the limbs of modern reptiles, such as turtles, crocodiles, and lizards, splay outward, allowing the belly to rest on the ground when the animal is not moving. Over a hundred years ago when little was known about dinosaur skeletons, restorations were made to resemble giant lizards, complete with sprawling limbs. It is now clear that such conceptions were anatomically impossible and could be made only by forcing the bones into unnatural positions. There is some hint of lizard-like sprawling in the forelimbs of the Museum's *Stegosaurus* skeleton which was mounted many years ago. Were the specimen to be re-

mounted today, we would give it a more elephant like, erect stance. Fashions change in paleontology just as they do in millinery — but more slowly!

Most dinosaurs, of course, were large; adults of most species exceeded 15 feet in length. A few species, however, were no bigger than a rooster. The largest known dinosaur, *Brachiosaurus*, weighed 75 to 100 tons; as much as 25 elephants and nearly as much as the blue whale, the largest known animal of all time.

No dinosaurs lived in the sea or could fly. Other Mesozoic reptiles, however, occupied both of these ecological niches. Mesozoic rocks in Nebraska contain the remains of giant seagoing reptiles — mosasaurs and plesiosaurs — as well as the flying reptiles called pterosaurs. Since Nebraska was covered by the sea during most of the Age of Dinosaurs, dinosaur fossils are very rare in the state; only one partial limb bone has been discovered so far.

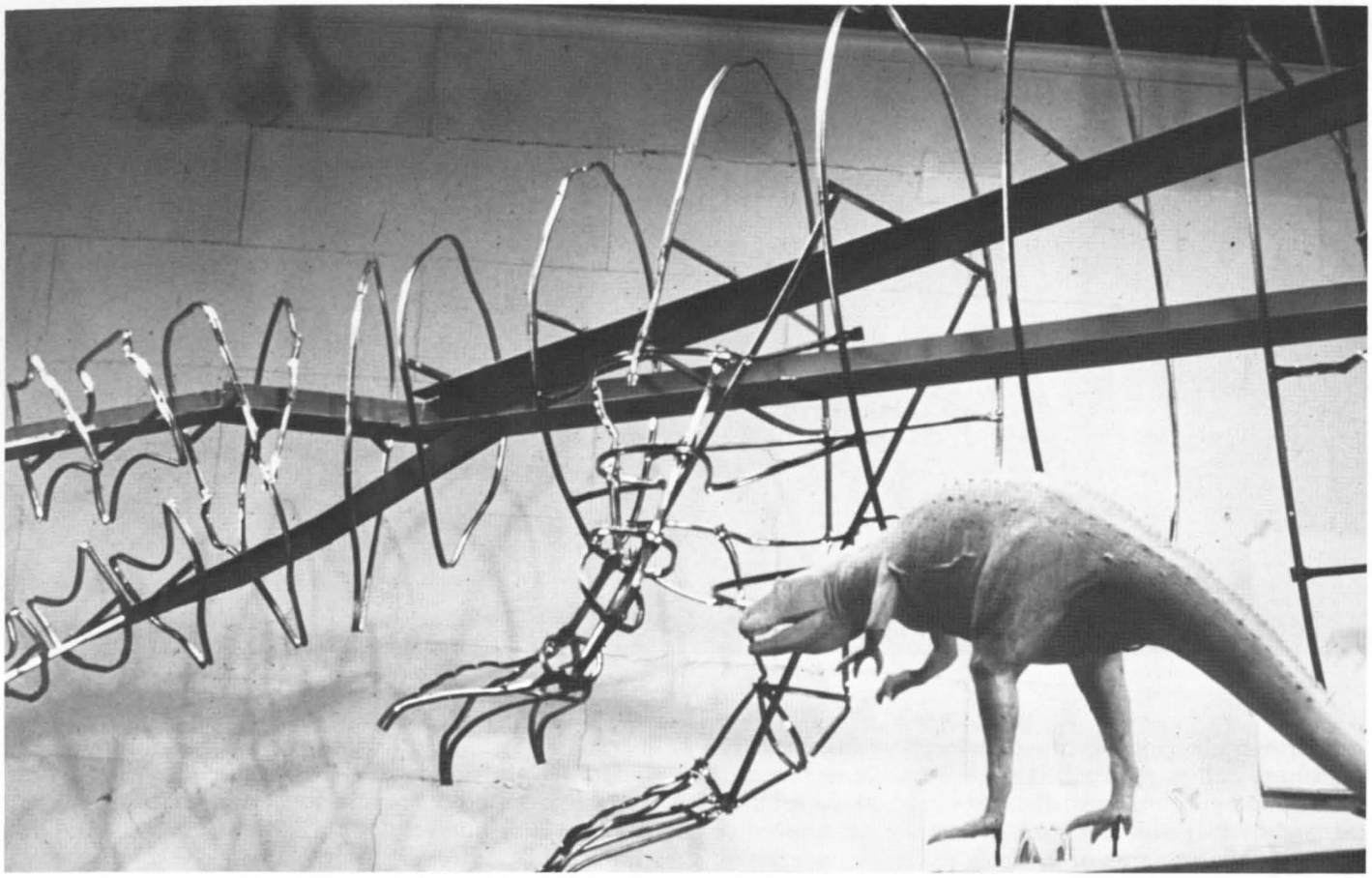
The artist working on a plaster scale model of an allosaur from which the full size reconstruction is built.

The Discovery of Fossils Raised Concerns

The enlightened Greeks of 2500 years ago acknowledged the existence of "fossils," but to our knowledge had few insights concerning their origin. Even during the Renaissance, religious doctrine was predominant in accounting for all oganisms and forced unscientific and often highly illogical conclusions to be drawn concerning the bones and shells "frozen" in the rocks. In fact, until the nineteenth century, scientific discovery was seldom explained by logic. The inevitable differences of opinion that arose led to numerous controversies and even contrived hoaxes, which seriously retarded scientific progress in its attempt to understand fossil organisms. As fossils gradually became accepted as more than accidental shapes, they were attributed to an intermediate position between the Creator's invention of an animal and its actual living state. Others suggested they were the ornaments of the inner earth, similar to flowers above the ground. Whatever the conclusion drawn, fossils were not believed to be prehistoric; instead they were usually accepted as freakishly preserved remnants of historical organisms.

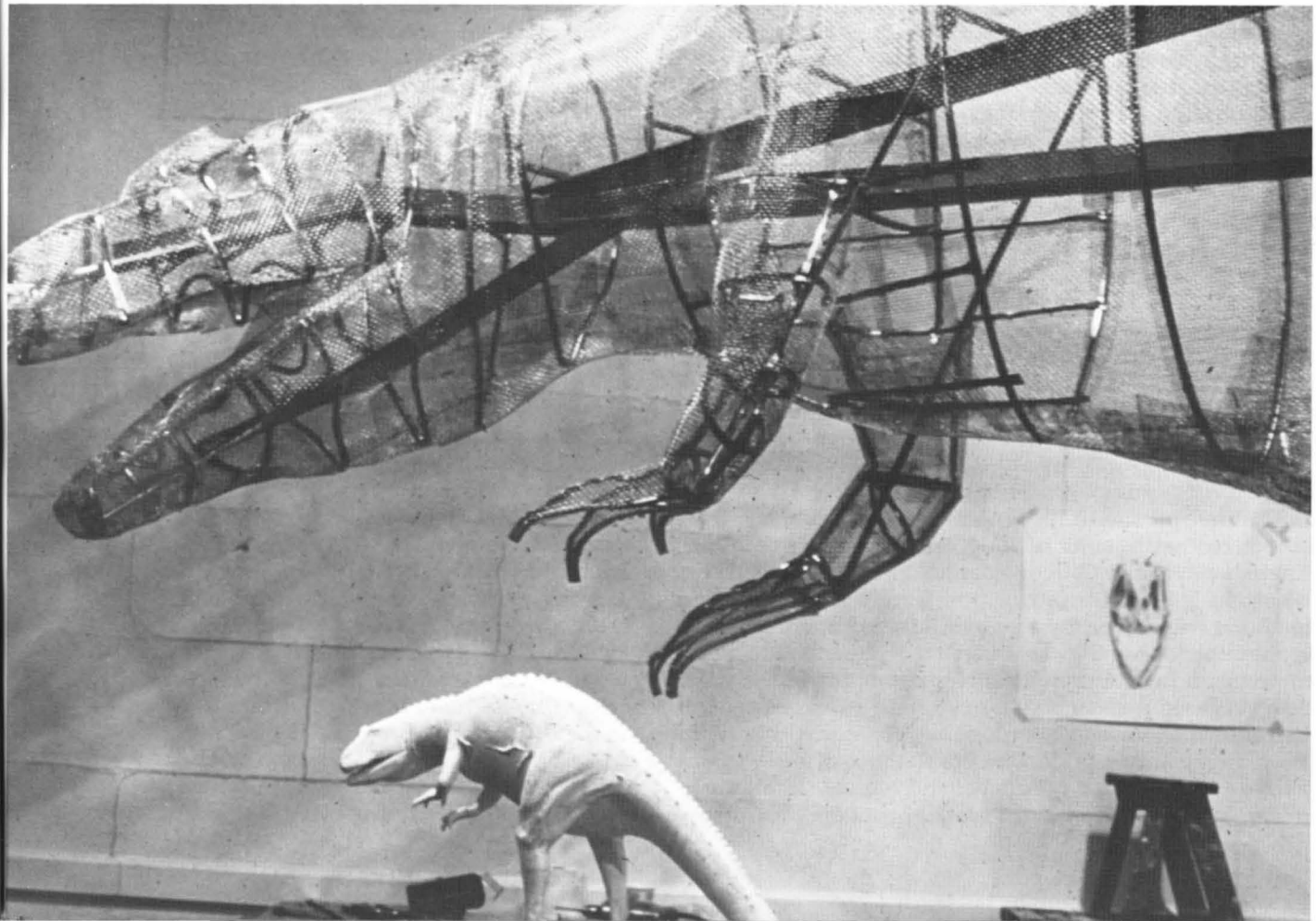
In the eighteenth century when these "figured stones" were finally given some degree of recognition

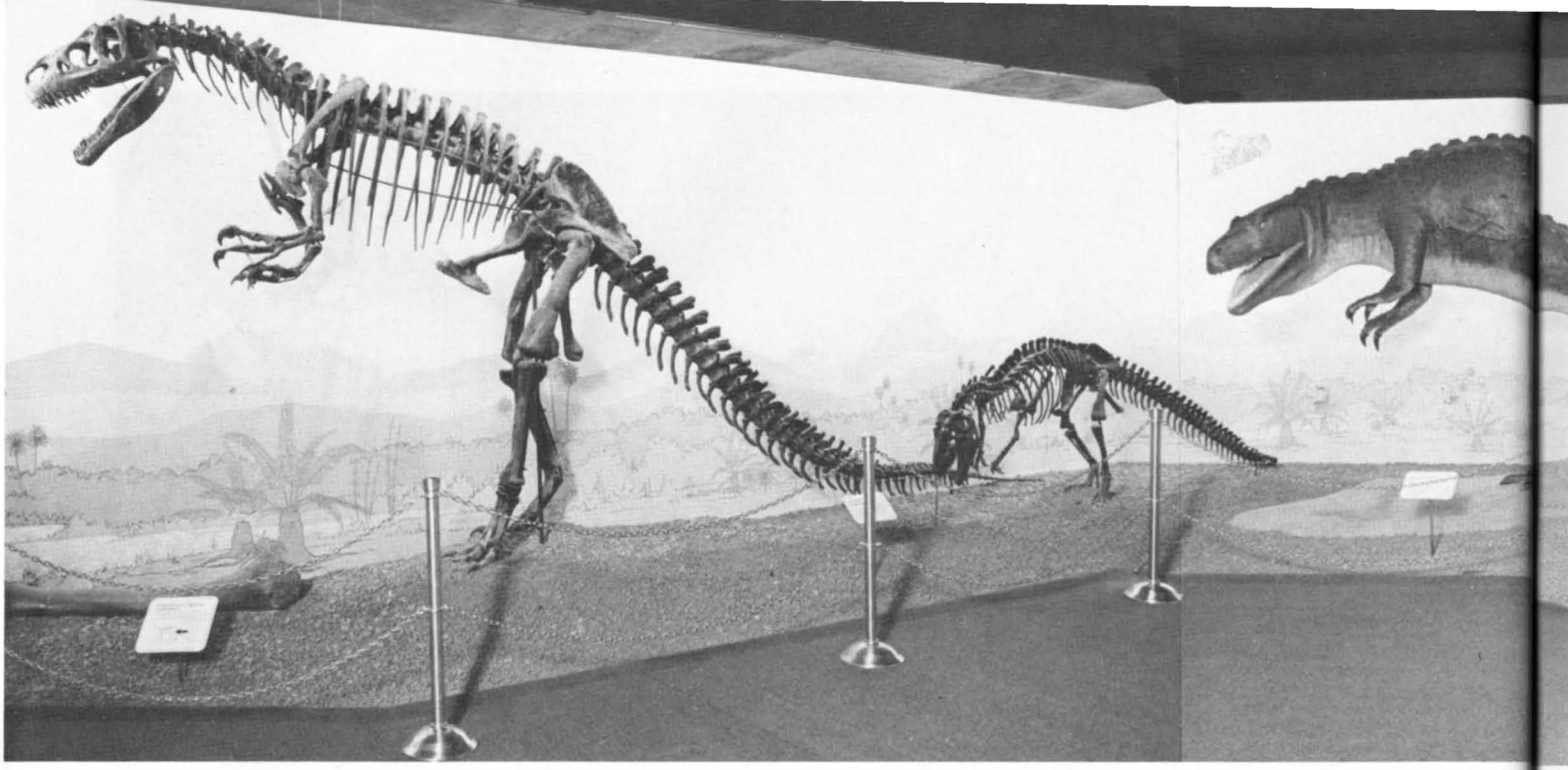
The steel frame is assembled and ready for the contour channels to be attached at one-foot intervals.



Detail of the frame showing contour sections attached to head area, with the scale model in foreground.

The contour sections are covered with hardware cloth which is shaped to approximate the body form of the model prior to the application of the maché skin.





Upon entering the new Gallery one is almost immed Nort

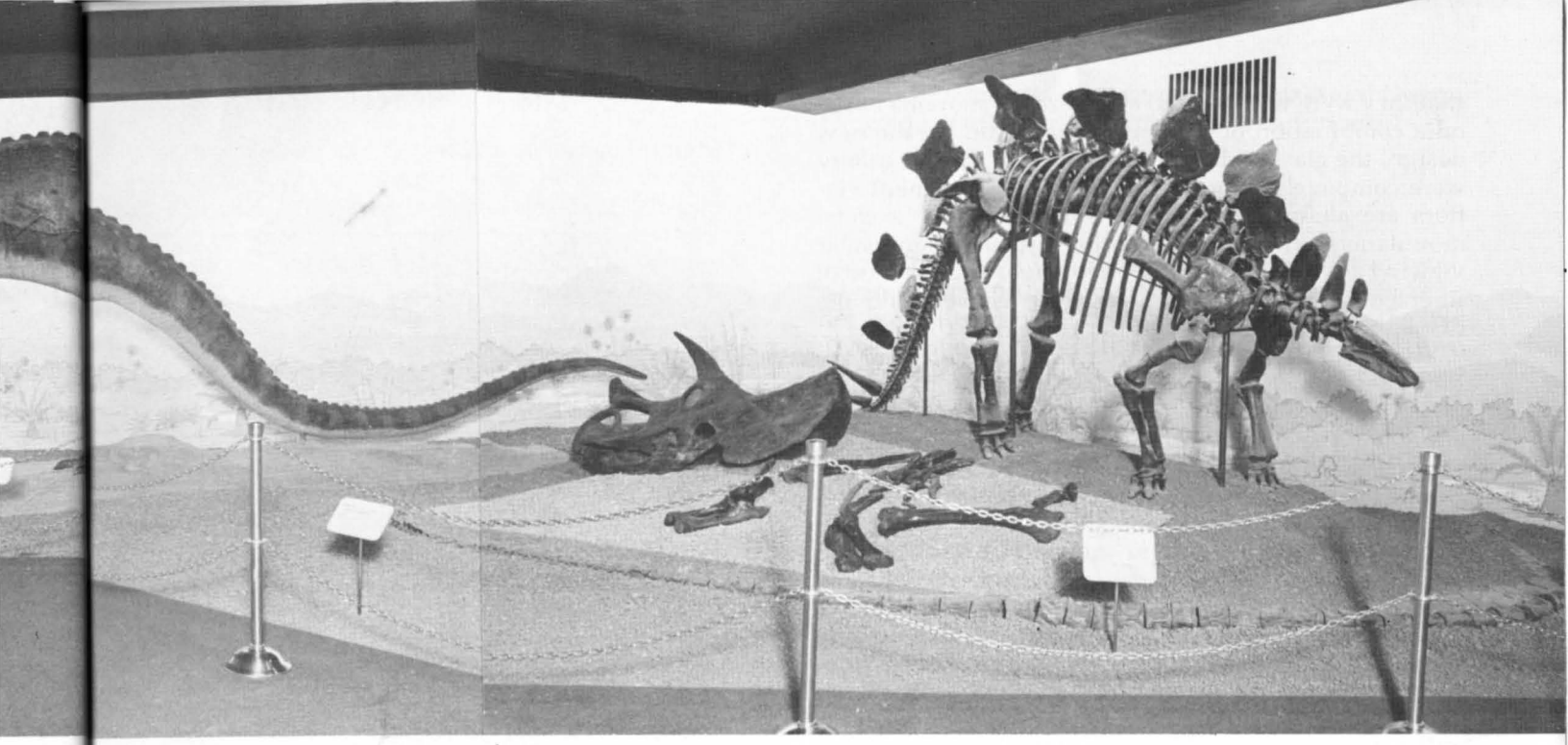
as remnants of extinct pre-Adamite organisms, the Noachian deluge was called upon to account for their demise and entombment. This conclusion held on until the early nineteenth century, when the acceptance of fossils as the remains of a whole realm of once living organisms gradually became obvious to more and more scientists, including the renowned Baron George Cuvier. However, even though Cuvier was one of the most modern thinkers of his time and accepted fossils as the remains of extinct animals, throughout his life he held that extinction was caused by periodic catastrophies rather than natural selection.

Amidst this unsettled background of controversy came the first intriguing finds in England of extraordinarily large fossil bones and teeth, which seemed to be reptilian in form, but unlike anything known to be living at that time! Earlier in the seventeenth century there were discoveries of apparent dinosaur bones, some of which were recorded in surviving texts. The discoverers, unfortunately, didn't recognize their finds and the specimens have since been lost. Between 1787 and 1818 finds were also recorded from North America in New Jersey, Montana, and the Connecticut River Valley. All of these were misidentified, and at least in one case, were thought to be of human origin!

Dinosaurs Are Something Special

The first person to recognize that these unusual fossils were the remains of long-extinct reptiles was the English physician Gideon Mantell, who published his thesis in 1822. His conclusions were based on a few teeth his wife found by accident. Mantell spent considerable time searching the quarries of the area for more material and came up with many fragments in the next few years. In a second publication in 1825, he named the animal *Iguanodon* after learning, again by accident, how similar the fossil teeth were to those of the *Iguana*, a living tropical lizard. Between 1822 and 1825 Mantell, in trying to identify his find, sought the help of many learned biologists in England and on the Continent — including the renowned Cuvier. Cuvier's initial response was a bit disappointing since, with little hesitation, he concluded the tooth he received was that of a rhinoceros! However, after Mantell's second publication, Cuvier admitted his error and agreed the tooth belonged to an unknown, very large, herbivorous reptile.

Even though these large reptiles were finally accepted as something unique, the actual word "dinosaur" had still not been invented. Mantell continued to collect these fragments, but because of his dedication to these pursuits, he encountered serious financial and personal problems. These concerns forced him to sell his growing collection to the British Museum in 1838. It fell into the hands of a young scientist, Richard Owen, who later became quite renowned in his own right as an anatomist and paleontologist, even being called by some the "English Cuvier." His study of the accumulating fossil reptile material led to his invention of the word "Dinosauria" to describe this group of extinct and peculiar reptiles of great size. Owen's announcement to the British Association for the Advancement of Science in 1841 of his new suborder Dinosauria (which means "terrible lizard") was significant in that it gave these fossil organisms the recognition they deserved and placed them on a solid, scientific foundation. Because of Owen's efforts, this distinct fossil group was given a place in the history of the earth. Dinosaur research progressed slowly during the next 15 years and the new term did not rapidly become a household word. However, when plans were being made in 1854 to move the famous Crystal Palace Exposition from Hyde Park, London, to Sydenham, it was decided to include lifelike reconstructions of dinosaurs in the new location so that people could actually encounter how they might have looked when they dominated the English landscape in Mesozoic time. Owen supervised the reconstructions, but the sculpting was done by Benjamin Waterhouse Hawkins. The final casts were done in concrete. Ever



North American panorama from the Age of Dinosaurs.

though these restorations look quite strange today and indicate considerable speculation based on Owen's predictions, the effort and interest to make these creatures come alive for the public was unprecedented for its time.

Dinosaur research remained sporadic during the next 25 years and did not really blossom until the late 1870s. When it came, the blossoming was more like an explosion, centering world attention on Belgium and the United States where the first spectacular discoveries were made. In 1876 and 1877, large accumulations of dinosaur bones were discovered near Bernissart, Belgium, in a coal mine 1,000 feet below the ground. At about the same time equally impressive discoveries were coming to light at surface exposures near Morrison, Colorado, and Como Bluff, Wyoming. The revelation and excitement caused by the unearthing of tons of dinosaur bones in these two areas resulted in a dinosaur fever that encouraged friendly and not-so-friendly competition. A crash collecting episode followed that set the stage for a swashbuckling, meteoric rise for vertebrate paleontology over the next 40 years. Many additional dinosaur sites were located in Wyoming, Colorado, Utah, and Alberta, Canada, making western North America the mecca of dinosaur discovery during this period. A few of the more famous individuals that participated in this romantic period of exploration included: Joseph Leidy and Edward Cope from the University of Pennsylvania; Othniel Marsh and Richard Lull from Yale University; Samuel Williston from the University of Chicago; Earl Douglass from the Carnegie Museum; Barnum Brown from the American Museum of Natural History; and Charles Sternberg, a contract collector, from Buffalo, Kansas.

By 1917 many of the famous quarries had been thoroughly worked out. Rising costs and saturating the public with news of dinosaur finds brought the dinosaur boom in North America almost to a halt. A final flurry of dinosaur activity developed in the 1920s when Roy Chapman Andrews of the American Museum of Natural History led expeditions into the nearly uncharted heart of Mongolia in search of the site for the origin of mammals, including man. Although no human remains were found and relatively few mammals, rich dinosaur deposits were encountered which made the excursions major successes. Since that time significant dinosaur finds have occasionally come to light, but never with the fanfare that prevailed at the turn of the century. These new finds have come from every continent in the world except Antarctica.

The mid-twentieth century, however, is seeing a dinosaur renaissance in the making. New efforts by another generation of scientists are bearing fruit resulting in some startling conclusions regarding the life, fate, and heritage of these forms which nearly everyone thought had led to evolutionary dead ends. Reflecting this revival in interest, the University of Nebraska State Museum recently opened a new Dinosaur Gallery with the assistance of the Lincoln Family Foundation. An effort was made in the new gallery to reestablish the personal excitement and involvement scientists felt 150 years ago when they were first faced with the reality of these giant reptilian bones, and the implications they imposed concerning the history of life on this planet. This gallery creates an intimacy that blends the past and present, and establishes dinosaurs as real and believable fellow inhabitants of the earth.

We learned that designing an exciting and educational exhibit for specimens as large as dinosaurs is not an easy task from either a financial, spatial, or thematic standpoint. Nearly two years was required to prepare the eventual space for the opening of the Museum's new exhibit. Due to the physical, as well as conceptual dimensions of this exhibit, a new display philosophy for the State Museum began to evolve as planning progressed. A sincere effort was made to involve the visitor with the exhibit subject; to encourage a reaction, whether it be one of quiet awe, a spontaneous eruption of amazement, or of measured learning. We strove to instill in visitors, subconsciously at least, the feeling

that they were witnesses to a Mesozoic panorama based on a combination of fact and imagination. In the new design, the glass and wood barricades of the old gallery were completely removed. With this arrangement visitors are almost immediately surrounded by skeletal mounts as they venture into the carpeted, peninsular viewing area. This openness encourages a convection of interactions to develop between the viewers and the display, which is the key to the success of the gallery.

The invitation to enter the area is extended by the highlight attraction of the gallery, a stunning lifelike restoration of a jurassic allosaur whose gaze is directed straight at the gallery entrance. The restoration was designed and built by Roger Vandiver, a member of our exhibits staff who has done several prehistoric animal restorations for the Museum.

An Allosaur Comes to Life

The prime objective of any reconstruction is to present an extinct animal accurately and to make it believable to the viewer. It should look right to both the casual museum visitor and to the critical eye of the scientist. The pose should be such that it appears to have momentarily stopped; that it will move again in a second. The total configuration of pose, texture, color, and expression should convey a definite character such as all real animals have, but is disappointingly absent in many reconstructions. The experienced museum visitor has undoubtedly been tempted to laugh at one time or another when standing before a poorly executed example. The reconstruction process brings each of these considerations to the fore at various stages.

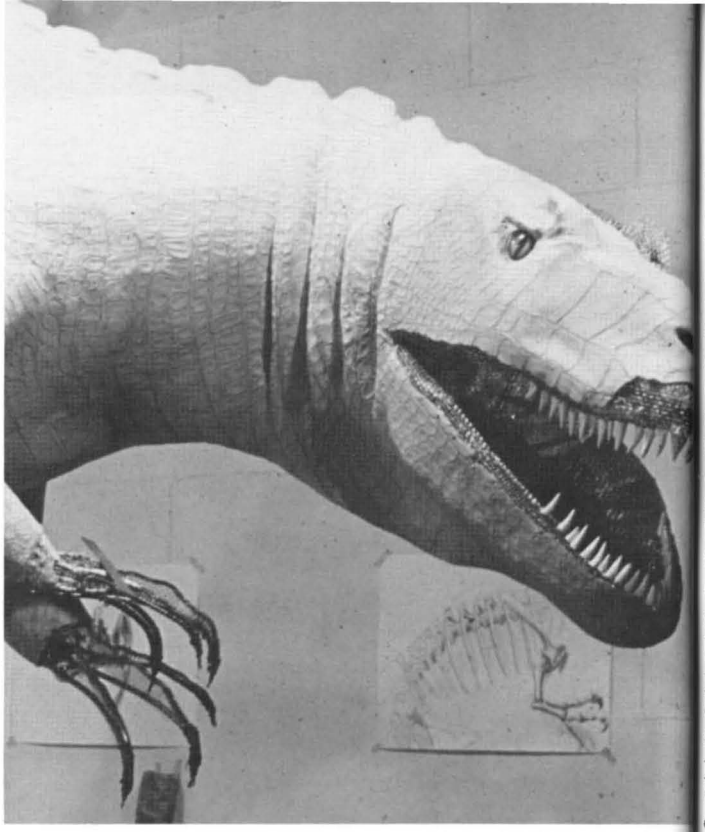
The first step is to build the model. In preparation for the allosaur mount, many drawings were made of the skeletal mount with the dimensions indicated on them. The drawing served to acquaint us with the animal in a more detailed manner than is possible even with very close observation. Scale drawings of the skeleton were made and cut into movable parts to work out the pose. The model was built from the scale drawings and measurements. The model was then reviewed by a panel of vertebrate paleontologists and a zoologist who suggested some minor changes.

The model for the structural frame was built of scale L-beams. From this model the full size structural frame was welded. It had to be made in four sections in order to transport them to the dinosaur gallery and to keep them small enough to handle. These sections all bolted together at the pelvis.

The plaster model served as the basis for the contour sections which were taken at one-inch intervals. These contours were graphed and blown up to full scale for the shaping of the contour channels. The channels were fabricated of 26 gauge galvanized sheet and are U-shaped. This provides structural strength in a malleable material which can be easily shaped to conform to the full-scale contours. These sections were then riveted to the frame at one-foot intervals.

One-quarter inch mesh hardware cloth was then carefully shaped as it was wired on. Final checks of all contours were made at this point.

The actual skin is a maché formula based on asbestos rather than paper. It is composed of equal parts of asbestos shorts and lite-mix, a plaster-pearlite mixture. These were dry mixed. A white glue diluted with water



As the maché is applied and the modeling progresses, the head and fore limbs take on their carnivorous qualities.

was then incorporated to attain a consistency of stiff mush. The maché was troweled on at a thickness of one-half to three-quarters of an inch. The scale pattern was then drawn into the soft surface with a steel modeling tool. All details and texture in each area had to be completed before it hardened. This formula has a bench life of two to three hours, which allowed us to work on about 15 square feet of area each day.

Perhaps the most important area of the reconstruction in terms of expressiveness is the head. All aspects require care and precision, but the head is what makes the animal come alive. The focus of expression is in the eye. It must seem to be alert with a gleam in its eye. This was accomplished by producing a three-dimensional eyeball complete with colored iris, transparent pupil, and a clear cornea. It was cast of polyester resin in a hemispherical mold. The iris was a painted insert embedded in the partially filled mold. The eye piece was then incorporated into the maché as it was applied and the surrounding area was modeled to achieve the desired expression. The teeth were cast in plaster with a wire embedded in each and then wired into place in the jaws.

An aspect in restorations which is all too often treated in a cursory manner is the coloration. The surface should convey the vibrancy and light reflective qualities of a living reptile. If the color is too shiny or too matte, or if it lacks depth and richness of tone, it will look "painted on." Acrylic paint was used because of its short drying time and the control it offers over surface sheen and transparency. The first undercoat was sprayed on. Successive undercoats were applied with a sponge, as were the various overlays of transparent color. This gradual buildup of color produced a depth and richness unattainable with fewer layers. The final coat of straight matte medium gave just the right amount of sheen to simulate its reptilian appearance and heritage.

A New Approach to Dinosaur Display

With the Mesozoic of 150 million years ago brought to life in the form of the allosaur reconstruction, the major challenge remaining was in deciding how to display a "living" dinosaur in a meaningful context with the stark reality of scientific fact — the three mounted fossil skeletons we already had of the *Allosaurus* and a *Stegosaurus*. Museums have a very serious responsibility when replicating historic objects. They must be certain of what they present to the public, for people, thankfully, tend to believe what they see and hear in museums. Naturally it is the ability to exhibit three-dimensional proof that provides museums with this advantage, so to abuse that trust is inexcusable. Natural history museums in particular must not fall into this trap of increasing interest by embellishing scientific approximations. Even though Richard Owen's reconstructions of 1854 were quite inaccurate, they were based on the best evidence of the time, which was simply too meager. Today museums cannot and do not allow speculation to dominate the predominance of fact and reason; in fact, they usually bend over backward to play down sensationalism in their exhibits. However, even though museums today are very careful to exhibit only those things that have been well documented, the public still must realize that reconstructions are only approximations based on the evidence available at the time.

It was finally decided that fact and scientific speculation could be shown to its best advantage in the new gallery by making use of the air of mystery that naturally surrounds dinosaurs. This was accomplished by positioning the specimens 3 to 4 feet from the walls, which were stylistically painted as a 120 foot continuous Mesozoic landscape in light earth colors against a light bluish gray, featureless sky. The painting was done by our Exhibit Designer Nathan Mohler. This somewhat mystic effect was enhanced by directing the majority of the room illumination from baffled fixtures onto the wall from a point almost directly above the mounts, leaving them partially silhouetted. To complete the intimate, natural feeling, the ceiling of the room was painted black and the peninsular visitor area carpeted in dark earth colors. A continuation of the dark floor covering was carried into the exhibit area by covering the floor with expanded shale, which has the appearance of ochre-colored gravel. This serves to unify the exhibit and also tends to discourage visitors from walking beyond the carpet margins, since expanded shale is quite uncomfortable under foot.

The success of the display rests with the ability of the visitor to respond to the intimate mood engendered by the room design and its inhabitants. This intimacy stresses the reality of dinosaurs rather than their curiosity value. It takes the most impressive of land animals out of the "center ring" and blends them back into the shadowy marshes of the Mesozoic. In this setting the skeletons and the reconstruction become a part of the total environmental panorama, promoting interaction and providing the viewer with a more realistic context for learning, as well as excitement. Most importantly, the end result benefits the dinosaurs as well — for their role in history is reestablished as natural and believable.

Now that the exhibit has captured your interest, just what have scientists discovered in the past eight years that could startle our imaginations even further?

Were Dinosaurs Warm-blooded?

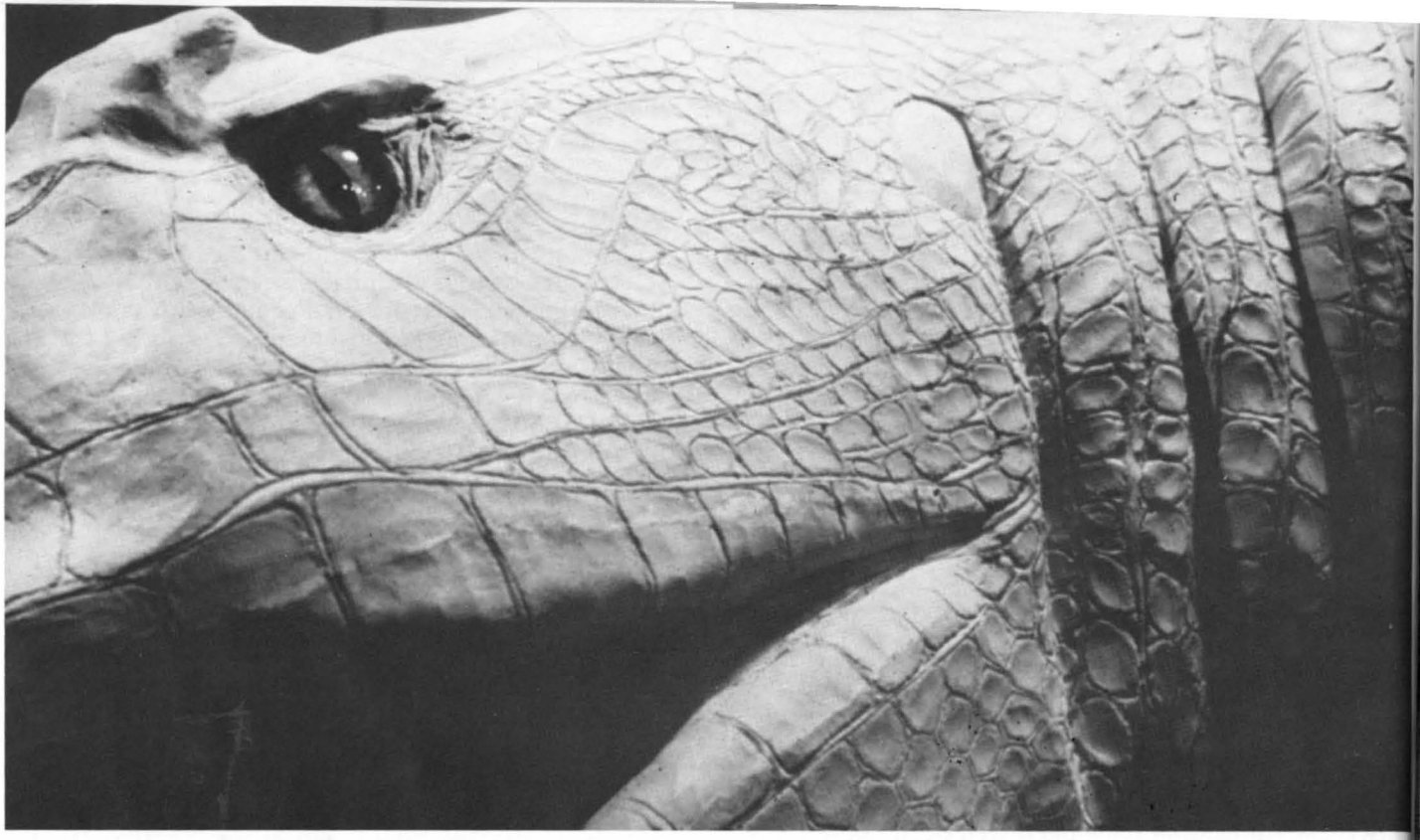
Dinosaurs have traditionally been regarded as typically reptilian in their internal economy. Modern reptiles are ectothermic ("cold-blooded"), so goes the argument, dinosaurs were too. Some paleontologists during the past few years have begun to question previous interpretations, and have concluded that some, if not all dinosaurs were endothermic ("warm-blooded"). Four principal lines of evidence have been used to support this conclusion.

1) *Anatomy*. The erect stance of dinosaurs is more mammal- or bird-like than reptile-like and, by analogy, may indicate that dinosaurs, like birds and mammals, were endothermic. Likewise, the microscopic structure of dinosaur bones contains numerous blood vessel openings, as in mammals, in contrast with the comparatively dense, inert bone characteristic of modern reptiles.

2) *Relationships*. It has long been known that the closest living relatives of dinosaurs are crocodiles and birds. Recent studies show that the dinosaur-bird relationship is very close indeed; the oldest known bird skeletons, in fact, are nearly identical to those of small carnivorous dinosaurs. One specimen of the 150 million year old fossil bird, *Archaeopteryx*, was even classified as a small dinosaur until careful study in the 1970s revealed its true identity. It seems clear that birds are directly descended from small two-legged dinosaurs. It is inferred by some paleontologists that the high metabolic rate present in birds must also have been characteristic of dinosaurs.

3) *Ecology*. Fossil bones of carnivorous dinosaurs are rare compared to those of plant eaters of similar size. These plant eaters were probably the principal food of the carnivores. In like manner, fossil carnivorous mammals are outnumbered by their prey by about 30 to one. The same relationship between predators and prey holds true among modern mammals as well, and it reflects the high activity level of mammals. In contrast, cold-blooded predators are less active and take fewer prey, so the predator/prey ratio tends to be higher among ectotherms. The similarity of predator/prey ratios among Mesozoic dinosaurs and the mammalian communities of more recent times has been interpreted to mean that the activity level of dinosaurs equaled that of mammals.

4) *Behavior*. We cannot directly observe the behavior of extinct animals, but we do have some direct and indirect evidence regarding this aspect of dinosaur biology. Dinosaur tracks, which are extremely abundant in some layers of sedimentary rock, provide a wealth of information about the daily activities and habits of dinosaurs. The evidence seems clear that at least some dinosaurs were social animals which traveled in herds. This contrasts with the generally low level of socialization among living reptiles and is another similarity to birds and mammals. The peculiar crests and other "bizarre" structures found in many dinosaurs, especially herbivorous ones, have been interpreted as playing an important role in the mating be-



A closeup of the head reveals the scale pattern and the critical modeling around the eye.

havior of dinosaurs as much as plumes, crests, pinnae, or elaborate feather displays do in birds.

The case for endothermy in dinosaurs is being hotly debated by paleontologists around the world today. It seems highly probable that some dinosaurs, especially the small, bird-like ones, were warm-blooded. But whether this conclusion can be extended to all dinosaurs remains doubtful. Critics of the "new dinosaur biology" have pointed out that many dinosaurian features appear to be typically reptilian — notably the skin (fossil skin impressions show no evidence of feathers or other insulating substances which might indicate endothermy) and the brain. The brain size of almost all dinosarus is appropriate for a reptile of a particular size, but far smaller than that of an equivalent mammal or bird. The only exceptional, big-brained dinosaurs are the small bird-like forms which we have already guessed to be warm-blooded on other grounds.

All the evidence is not yet in. New discoveries of dinosaurs and new interpretations of old data remain to be made. Perhaps the most crucial question regarding dinosaurs is not how they lived, but why they disappeared rather suddenly some 65 million years ago. The extinction of the dinosaurs appears to have occurred in less than 2 million years — less than one-tenth of one percent of geologic time — and the reasons for the decline and fall of this spectacular reptilian dynasty are still far from clear.

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