THE ARTS

By Gregory Paul

Becoming a dinosaur artist was easy. When I was a kid, my great-aunt Laurel, an artist-naturalist herself, taught me that tyrannosaurus is pronounced *ty-ran-nosaurus*, not *try-an-o-saurus*, as I was prone to say it. I've been drawing dinosaurs ever since I can remember. Most young children are fascinated by dinosaurs, which isn't surprising. Although fragmentary remains of dinosaurs were first discovered in Europe during the 1830s, the first complete dinosaur skeletons were found during the expansion into the western American territories in the late 1800s. Revealed in this dramatic way to the American public, they became a part of our frontier past. Although most kids, as they reach their teens and adulthood, become disinterested in dinosaurs, these creatures nevertheless populate our political jargon, roam through our comics, and figure in the debate between science and fundamentalists. And if you ever wish to get on the evening news, all you have to do is publish a new theory about what killed them off.

This is a good time to be working on dinosaurs. During the initial dinosaur rush at the turn of the century, dinosaurs were a serious scientific and intellectual proposition, their evolution being a subject of vigorous discussion and debate. At that time some of the best-known restorations of dinosaurs were created by Charles R. Knight. But dinosaurs became victims of their own success, indeed, of their very size. Dinosaurs were so popular with the people that they took on a bit of a circus air, and by the Thirties scientists were shying away from studying them.

Things have picked up since the Sixties, however. The Poles and Mongolians have mounted major dino expeditions into central Asia, crews have reexplored the dinosaur beds of the western United States, and new material has come to light from Argentina. Among the new finds: "sickle-clawed" predatory forms and tiny "rabbit" dinosaurs that challenge the old theories and suggest that dinosaurs were active, agile, birdlike, warm-blooded animals. This brought controversy and more curiosity and in turn spurred more efforts to find dinosaur remains.

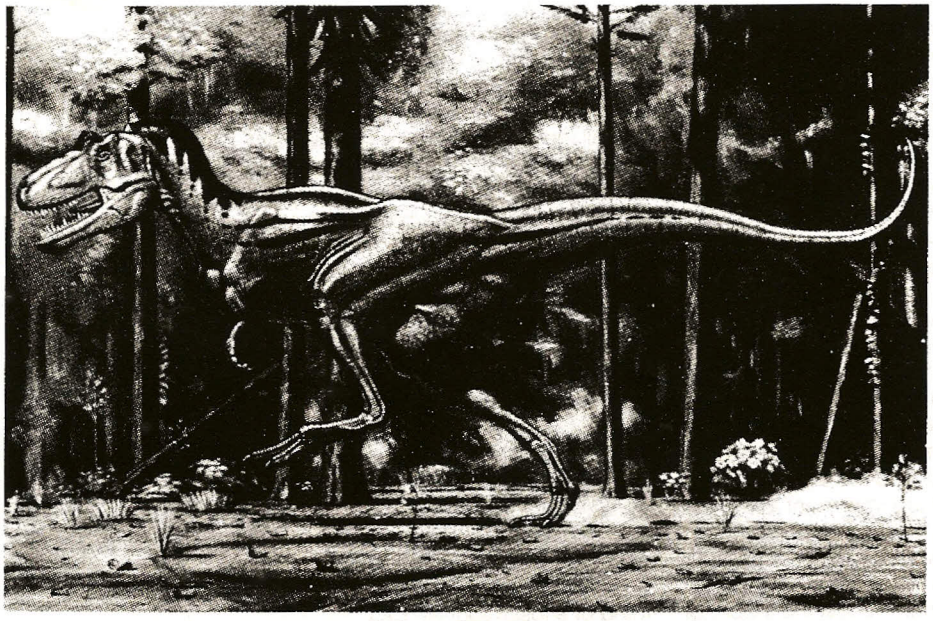
I entered this rejuvenated field in the late Seventies, first as a volunteer at the Smithsonian Institution, then in an informal arrangement with Robert Bakker (an advocate of the theory that dinosaurs were warm-blooded), at Johns Hopkins University. I am not just illustrating dinosaurs. Most dinosaur restorations are the products of limited research or, even worse, are copies of inaccurate originals, so they are not of much help. I've always wanted to know what dinosaurs really looked like, so I have undertaken research on their structure, locomotion, physiology, and so on.

Though one can never know exactly what dinosaurs looked like, my research allows me to present my conception of an alien but very real past world by combining original science and original art in what I hope are accurate and esthetically pleasing illustrations. Because of the lack of attention that dinosaurs received for so long, the field is wide open. Even many of the basic and famous dinosaur genera—allosaurus, camarasaurus, triceratops, stegosaurus, ankylosaurus, brachiosaurus, and others—have never been restored properly. Such newly found dinosaurs as yangchuanosaurus, mamenchisaurus, ouranosaurus, and lagosuchus offer new opportunities for restorations. In fact, whole new faunas, many including babies, herdlike concentrations of remains, and other discoveries, are coming to light.

I will restore a particular dinosaur for a number of reasons: for a commission, for a technical paper, or often just because I want to see how it will come out.

Take *Stegosaurus stenops*. A delightfully bizarre being with plates and spines that can put any imaginary alien to shame, it has been known since the 1870s and is the subject of many illustrations. A number of skeletons are also on display, but these are composite mounts made from more than one individual. At the Smithsonian I often walked past one of these skeletons. Virtually complete, it's shown as it was found, lying on its side, partly disarticulated. In all these decades

CONTINUED ON PAGE 170



Tyrannosaurus torsus: *To understand dinosaur anatomy, dissect a chicken as you eat it.*

PAINTING

CONTINUED FROM PAGE 30

no one has restored it and proved once and for all what the stegosaurus looked like. I couldn't resist; so I got out the old monograph that described the specimen. For more data I crawled around the skeleton, measuring it and being careful not to break anything. Soon my desk was piled with sheets of paper bearing various bones drawn to the same scale. These gradually grew into a skeleton.

First came the vertebral column and rib cage. The neck turns out to be longer and more slender than it appears in most illustrations; the neck is carried in a graceful S curve, with the tiny skull flexed sharply upon it. The back is strongly arched, and Bakker's work shows that the tail is carried well clear of the ground—indeed, it forms a graceful upward arch and is very short. The shoulder girdle and hips are attached, and they define a remarkably short trunk.

Most restorations of stegosaurus show the forelimbs sprawling outward like a lizard's. This is wrong. The shoulder joint faces backward and a little inward, not at all outward, as it does in the lizard. The detailed design of the limb bones and joints shows that stegosaurus had elephantlike vertical columns for limbs, good for walking and fast ambling but not for running. *Stegosaurus stenops* is usually portrayed as a rather long and low animal, with a heavy, droopy tail dragging on the ground. On the other hand, a mounted composite specimen of another species of stegosaurus, *S. ungulatus*, shows a tall, erect-gaited, short-bodied, and short-tailed animal. My restoration of the complete *S. stenops* shows that it too is tall of limb and very short in body and tail, a point of scientific importance and very different from the restorations in most books.

I was not, however, able to resolve another long-standing dispute. Most restorations of stegosaurus show two rows of alternating, upright, triangular plates running along the backbone, ending in pairs of spikes near the tip of the tail. This may be correct. But the plates may be paired rather than alternating. The evidence is ambiguous.

The tyrannosaurs and their smaller relatives, the "ostrich-mimic" ornithomimids, have been of particular interest to me. A few years ago a theory was proposed to explain how animals scaled their body design as they became larger. Called elastic similarity, this elegant theory predicts that big animals, like big planes, ships, and trucks, can be fast if they are built properly. Bakker has suggested that some of the big dinosaurs were built for speed, and the ornithomimids and tyrannosaurids are important in this regard because they were very uniform and birdlike in limb design, regardless of their size. *Tyrannosaurus rex* itself was the six-ton equivalent of an ostrich. To test the theory of elastic similarity, I have measured the limbs of ornithomimids and tyrannosaurs in museums in America and Europe. My conclusion: The biggest of the tyrannosaurs and ornithomimids were probably about as fast as horses and ostriches.

The chicken is a very useful animal for understanding dinosaur anatomy. Birds are the direct descendants of such dinosaurs as the velociraptor, and their muscles, especially those of the hind limb, remain very dinosaurlike. To understand dinosaur anatomy, dissect a chicken as you eat it.

A common error is to restore dinosaurs with complex, bulging, mammallike thigh muscles, when in fact birds and dinosaurs share simpler, broader outer thigh muscles running straight from the pelvis to the knee. An even more frequent mistake is to give the predatory dinosaurs and many of the herbivorous dinosaurs rather shapeless, lizardlike shank and foot muscles. Instead, these dinosaurs had a powerful, chickenlike drumstick of calf muscles that narrowed to foot-operating tendons.

But the most consistent error is to give the giant brontosaurs and stegosaurs overly fat, massive limbs to support their weight. Artists do this because they think of elephant limbs as stout and strong; but in fact they are not. Go to the zoo and note that the elephant's thigh is relatively narrower and much less powerful than that of a horse. The elephant's shin is hardly muscled at all.

With skeletal and muscle restoration in hand, I may follow with a sketch or a painting of the dinosaur as it appeared in life. I must confess that it's the end product that I'm after. I do not, therefore, spend hours making and posing models for a sketch or sketching dinosaurs in various poses. It's boring, and I don't need to do it, because I have three-dimensional images of most dinosaurs rattling around in my head. I do spend time imaging dinosaurs, which is a bit like watching a documentary on African wildlife. This is important for developing a feel for how various dinosaurs looked as *real* living creatures, with sunlight falling on their backs and dust kicking up from their feet.

I paint the background first, leaving the dinosaurs as ghost images to be painted in last. This is a terrible technique that would appall the artist who taught me to paint, but I like it. Often, I decide on the dinosaur's skin colors at the last minute. Scientifically, it doesn't matter much what color they are, so long as it looks plausible and works in the painting. Ironically, the question most asked is how I knew what color the dinosaur was. Please do not ask.

One of my aims is to restore the skeleton of every dinosaur that has reasonably complete remains—this is around 120 species. In addition, I hope to do life restorations of all of them. I'll never grow tired of dinosaurs. I hope to be like Friedrich Von Huene, who, from the turn of the century into the late Sixties, published books on dinosaurs. That's a nice thing about paleontology: You can keep on working after you have turned into something of a fossil yourself.

Gregory Paul, a Johns Hopkins paleontologist, is considered one of the finest artists in his field.