In "The Scientific American Book of Dinosaurs"(2000).
Edited by Gregory S. Paul.
St. Martin's Press, New York. pp. 183-189.

Feathered Dinosaurs

by Philip J. Currie

Over the last 30 years, we have seen the development of many new ideas concerning these fantastic animals. Creative thinking by paleontologists in turn has led to many new approaches to studying the past. Like detectives trying to solve crimes of long ago, paleontologists have sifted through the clues and applied increasingly sophisticated technologies in the analysis. Nothing is better for a paleontologist than solving some ancient mystery, especially if you learn that your hunches were correct all along. Few paleontological solutions have been as satisfying as the discovery of feathered dinosaurs.

With the development and spread in the 1970s of the idea that dinosaurs might have been warm-blooded animals that were the direct ancestors of birds, paleontologists and paleoartists started to flirt with feathers on dinosaur reconstructions. After all, they reasoned, if dinosaurs were warm-blooded, then the smaller ones would have needed some kind of insulation to help stabilize their body temperatures. Furthermore, if they were ancestral to birds, it would make sense that the first feathers would have appeared on dinosaurs as a form of insulation. Feathers could not have developed in birds at the moment that they sensed a need to fly. The feathers had to have been on the ancestors first, then adapted into a flight mechanism. Although we normally think of birds as being any animals covered with feathers, their form of powered flight was actually the novelty that set birds apart from all other animals.

Warm-blooded dinosaurs and the dinosaurian origin of birds were two of the most hotly argued controversies at the end of the twentieth century. When first proposed, there were far more people opposed to these hypotheses than there were in support of it. Now things have changed, largely because of some remarkable discoveries made in northeastern China.

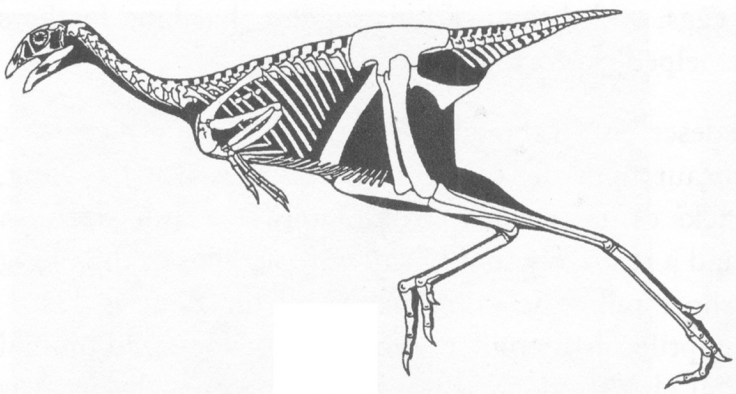
When I left the Gobi Desert of Mongolia in September 1996, I went to Beijing to spend a few days working with my long-time colleague Dong Zhiming on some dinosaurs we had collected in northwestern China. Shortly after arriving, he showed me a Chinese newspaper report of a beautiful little dinosaur skeleton found in Liaoning, a province northeast of the Chinese capital city. The report suggested that the specimen was actually a bird because it was covered with feathers. I expressed interest in seeing the specimen, mostly because small meat-eating dinosaurs are extremely rare discoveries.

Although I was predisposed to the idea of dinosaurs having feathers, the chances of finding a specimen with them preserved are so poor that I discounted the newspaper report completely—probably just dendrites or an ancient fungal growth, I thought.

Dong made arrangements to see the specimen a few days later at the National Geological Museum of China. Surprisingly, when we arrived and met the museum director, Ji Qiang, we found ourselves surrounded by members of the Chinese and Japanese press, who were there to record our reactions! I have no idea if I gave them the reaction they wanted, but I experienced and expressed some of the most amazing feelings of my professional career. The specimen was beautiful, exposed from the tip of the nose to the tip of the tail on a small slab of rock. But that is not what caught my attention: it was the rim of structures that surrounded almost the entire body. They were real and they belonged! I knew instantly that the first "feathered" dinosaur had indeed been discovered.

The next few months were tumultuous for me. The news spread around the world, slowly at first but with ever-increasing pace. The specimen, as it turned out, had been split down the middle into left and right halves, and the other half had gone to another museum in Nanjing. I went back to China to see this specimen, and I was able to see a second skeleton of a larger individual of the same animal. When it had been found, the discoverer had actually chiseled through many of the "feathers" because he hadn't expected them to be there! The first scientific paper, written in Chinese by Ji Qiang and Ji Shuan named this animal *Sinosauropteryx prima* ("first Chinese dragon feather"). Controversy erupted about whether these really were feathers on *Sinosauropteryx*, which included "scientific" papers written by people who had never even seen the specimens. A third specimen of *Sinosauropteryx* was found, and a delegation of American and German scientists went to see what the fuss was about. By now, controversies on the ancestry of birds and warm-bloodedness in dinosaurs erupted on a scale that surpassed even public and scientific interest in dinosaur extinction!

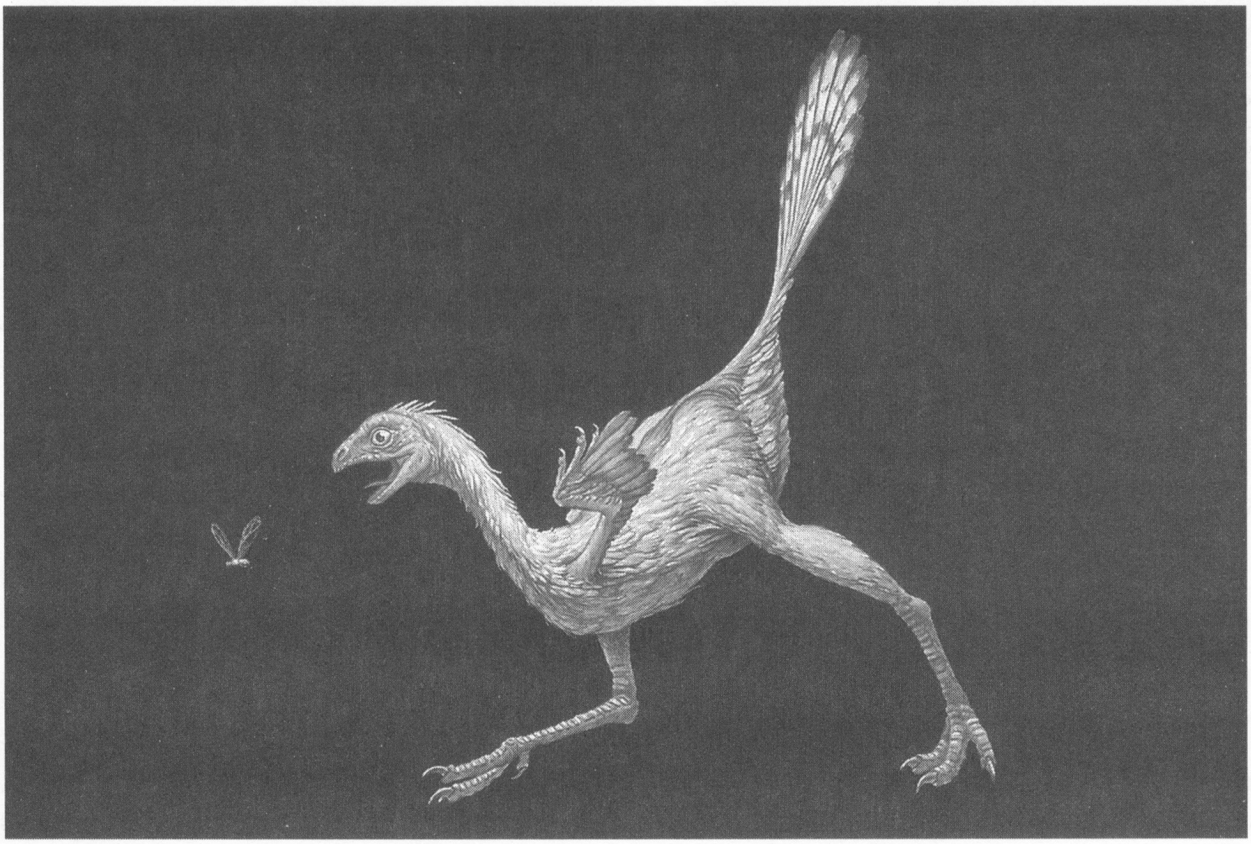
Protarchaeopteryx was described in 1997, again by Ji and Ji. Whereas *Sinosauropteryx* was a cat-sized animal with short arms and an extremely long tail, *Protarchaeopteryx* had long arms and a relatively short tail. In addition to having downy, featherlike structures covering its body like *Sinosauropteryx*, *Protarchaeopteryx* had long quill-like feathers on the end of the tail. This time there could be no doubt concerning the identification as feathers. I went back to China, and this time I went up to the locality in Liaoning that was producing all of these wonderful fossils. In the meantime, two more feathered dinosaurs were discovered. We thought at first these were also *Protarchaeopteryx*, but they were different by having long feathers behind the arms as well. While one of the new fossils was being prepared, we realized that it represented a third species of feathered dinosaur. This one we called *Caudipteryx*, which means "tail



***Caudipteryx*, as reconstructed by Gregory Paul is extraordinarily bird-like.**

feather." Related to the Mongolian *Oviraptor*, *Caudipteryx* was a turkey-sized animal with long legs that suggest it was a good runner. The feathers behind its arms look like a rudimentary wing, but they and the arms themselves are much too short to have provided any lift. It is more likely that they, and the long feathers on the end of the tail, were used for display.

Dinosaurs were highly visual animals that evolved a fantastic array of ornamentation (crests, frills, horns, spikes, etc.) to attract mates, warn potential rivals, and otherwise enhance their interactive behavior. Once dinosaurs had acquired feathers for insulation, what could be more natural than to adapt them into display structures: they are lightweight, strong, colorful, and can be shed and replaced. Of course, display may not have been the only function for these longer, stiffened feathers. Specimens of the related *Ovi-*



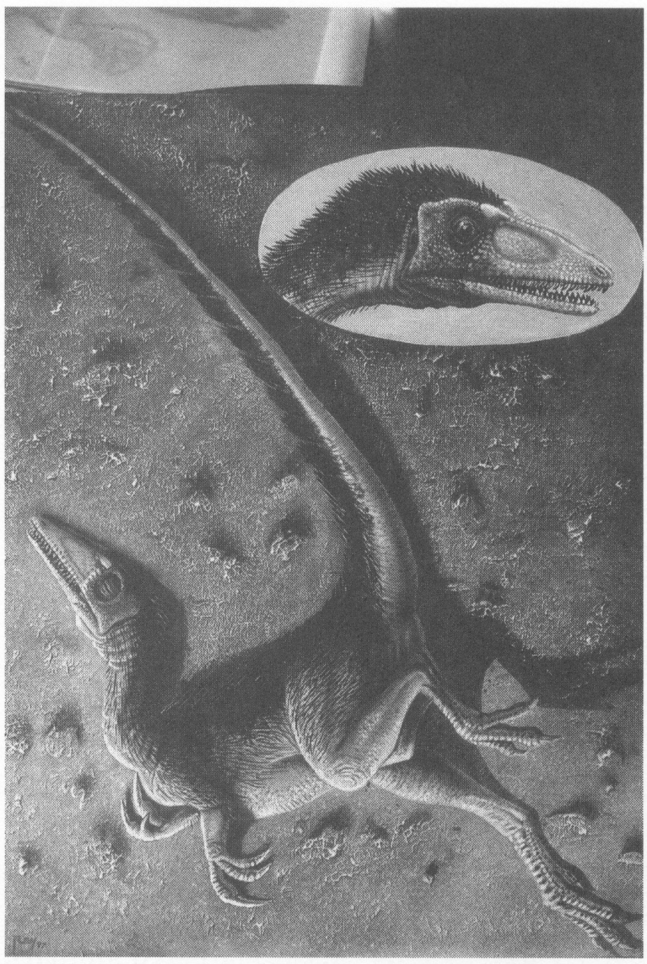
***Caudipteryx*, as restored to life by artist Joe Tucciarone with its feathery outer covering.**

raptor have been found on nests of eggs, and their positions suggest that long feathers on the backs of the arms might have helped protect and warm the eggs.

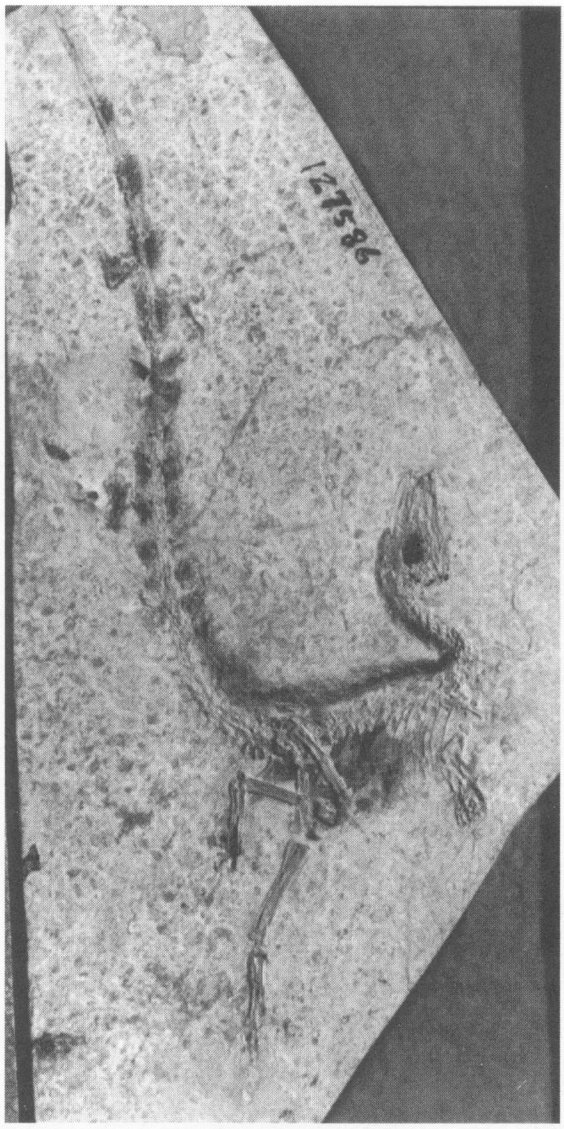
Two more feathered dinosaurs were described in the final year of the twentieth century. *Beipiaosaurus* is a much larger dinosaur than the other feathered forms. It has long, stiff, featherlike structures on the backs of its arms. Approximately the same size as a large man, *Beipiaosaurus* probably had a relatively small head with leaflike teeth, a long neck, long arms, and a relatively short tail. The other feathered dinosaur is *Sinornithosaurus millenii* ("Chinese bird-reptile of the millennium"). This dog-sized animal had sharp serrated teeth and raptorial claws, which is not surprising considering it is closely related to *Velociraptor*, an animal that has become famous for its ferocity thanks to the movie *Jurassic Park*.

There are now five species of "feathered" dinosaurs from northeastern China. More will be described within coming years because the locality is extremely rich and is being excavated at an unprecedented scale. The five species are all theropods, or meat-eating dinosaurs, but represent five different lineages that are as different from one another as cats, dogs, bears, and weasels are among modern mammalian carnivores. *Sinosauropteryx* is a compsognathid theropod, closely related to the European *Compsognathus*, which was known as the smallest dinosaur for more than a century. *Protarchaeopteryx* is still only known from a single specimen, and it might be the theropod most closely related to what is generally thought of as the earliest bird, *Archaeopteryx*. *Caudipteryx* is an oviraptorosaur, while *Beipiaosaurus* is a therizinosaur. Finally, *Sinornithosaurus* is a dromaeosaurid theropod. The fact that these dinosaurs represent such a diverse assemblage of theropods strongly suggests that many, if not most, of the meat-eating dinosaurs were probably feathered. Consider this for example: *Tyrannosaurus* is on the same branch of the family tree of dinosaurs as all the feathered forms. If the more primitive *Sinosauropteryx* has some form of featherlike structures, and all of its closest relatives had feathers, is it possible that even the mighty *Tyrannosaurus rex* had feathers somewhere on its body at some stage in its life? Perhaps it did, although we can be pretty sure that such a large animal would not have needed them for insulation as an adult. Pebbly skin impressions are preserved for the related tyrannosaurs *Gorgosaurus* and *Daspletosaurus*, and there are no indications of feathers; still, it is not impossible that the newborn chicks might have had some sort of downy insulation, or that the adults used feathers as attractive crests or fans for display.

The presence of feathers on dinosaurs does not prove that birds came from dinosaurs. There is much stronger evidence in the skeleton to suggest that birds and dinosaurs are more closely related to each other than either is to any other type of animal. However, feathers are such complex structures that the discovery of feathered dinosaurs has done far more to convince people that birds are living representatives of the



Artist Luis Rey's restoration of the *Sinosauropteryx* in death, with a vignette of it in life.



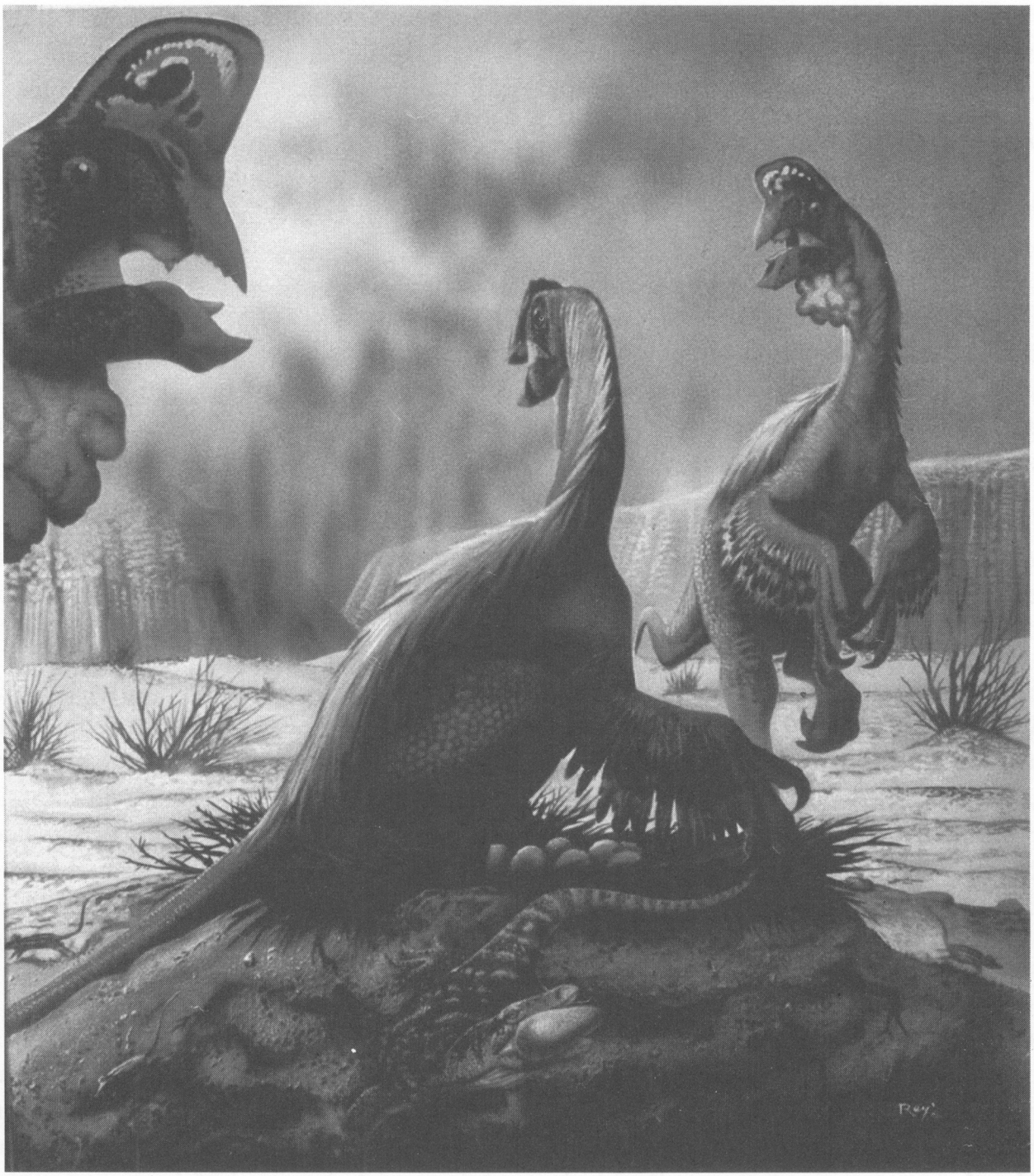
This exquisite *Sinosauropteryx* fossil seems to show the diminutive dinosaur was covered with hair or some kind of proto-feathers.

Dinosauria than the obscure details of wrist and ankle anatomy have. Still, not everyone is convinced, and some of these people are more vocal than the majority of paleontologists who accept that birds descended from dinosaurs. The detractors' arguments are plagued by lack of a convincing alternative for bird ancestry and by a certain amount of circular reasoning. For example, they have argued long and hard that the structure of the ankle is very different in theropod dinosaurs and birds. Now they claim that *Caudipteryx* is a bird because it has feathers. Yet *Caudipteryx* has the same ankle structure as theropod dinosaurs such as *Velociraptor* and *Tyrannosaurus*. Clearly, one of their two arguments has to be wrong because they are contradictory.

Ultimately, it does not matter whether we classify *Caudipteryx* and the others as dinosaurs or birds. Classifications are human concepts that help us organize nature so we can better understand it. Most scientists agree *Archaeopteryx* is the dividing line

Gregory Paul's skeletal reconstruction of *Oviraptor* shows this dinosaur, too, had many bird-like features.

between dinosaurs and birds. Related animals more derived or advanced than *Archaeopteryx* are birds. But species that are more primitive are not. Using this concept, birds are animals that either fly or, in the case of penguins and ostriches, have direct ancestors that flew. Feathers separate birds from flying insects, flying reptiles, and bats, but they are not what make a bird unique. We could redefine birds as feathered animals, for example. But if we did, we would have to reclassify all feathered dinosaurs as birds. And to do that, we would also have to classify all of their direct descendants as birds. To most people, classifying *Tyrannosaurus rex* as a bird is not as logical as emphasizing flight, rather than feathers, in the definition of what a bird is. The fact that we are having these arguments and that we are having trouble classifying many of the new fossils we are discovering effectively shows how close dinosaurs and birds are to each other. As we draw toward consensus on the ancestry of birds, attention is shifting to equally interesting problems—the evolution of feathers and the origin of flight.



Rey's vision of an *Oviraptor* nesting ground has a distinctly avian feel to it, right down to the feathers and the brooding mother on the clutch of eggs.