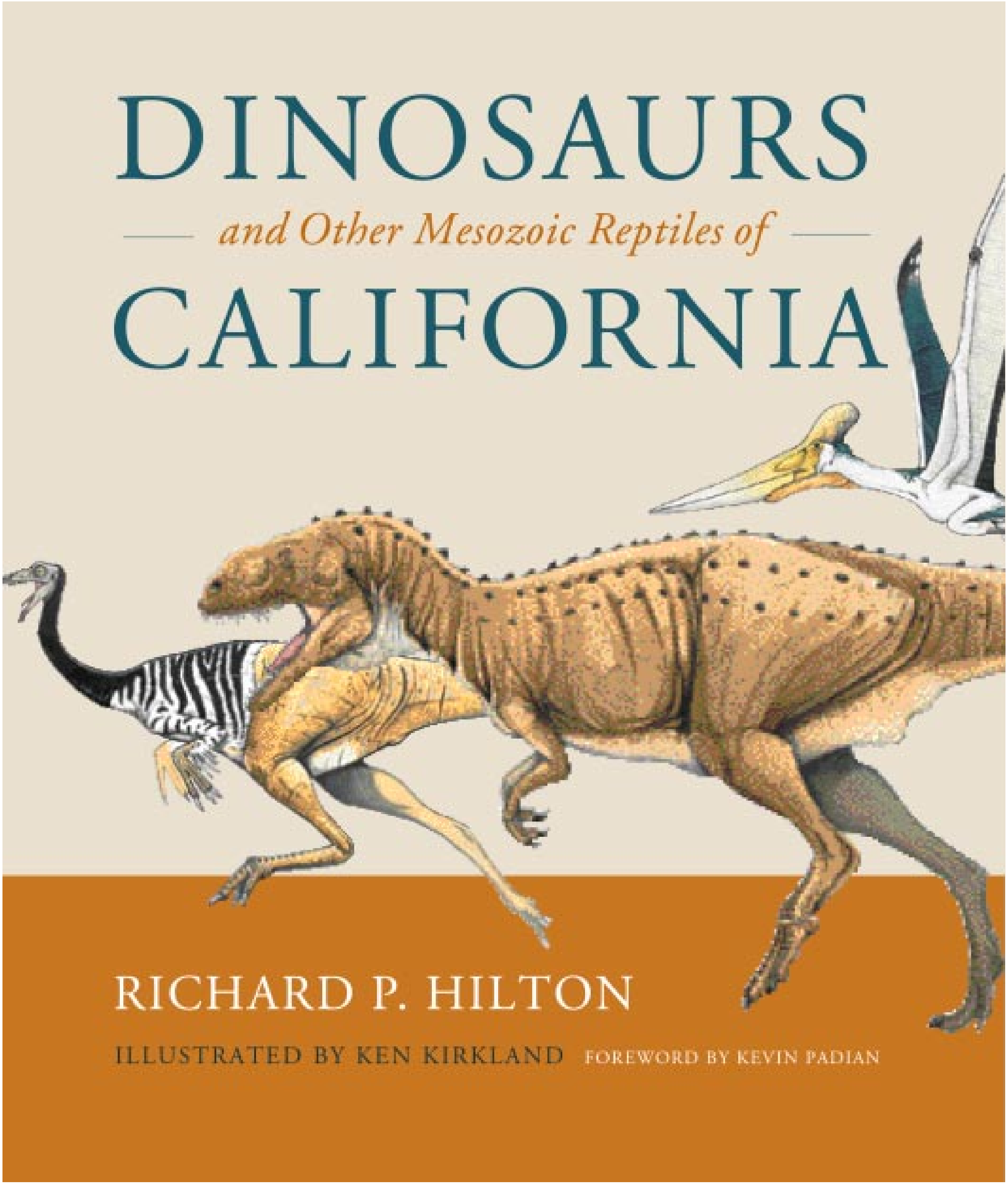
DINOSAURS
and Other Mesozoic Reptiles of
CALIFORNIA
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ILLUSTRATED BY KEN KIRKLAND
FOREWORD BY KEVIN PADIAN

# 3

# THE FLYING REPTILES

FLIGHT IS A COMPLICATED FUNCTION that took life literally billions of years to achieve. Insects were the first masters of the sky, evolving wings nearly 400 million years ago. It was not until the Mesozoic that reptiles achieved flight, and it took until the Cenozoic before mammals (bats) took to the air. Although today we have flying fish, flying squirrels, and even flying lizards, these are not true flyers but, rather, sophisticated gliders. Very specialized bones, muscles, and respiratory and circulatory sophistication are required to achieve the incredible coordination and stamina necessary for sustained flight.

Fossils of Mesozoic flying reptiles—the pterosaurs and the birds—are extremely rare, especially from coastal western North America. In order to fly, these creatures had to have exquisitely thin and often hollow bones, which are fragile and thus not likely to be preserved as fossils. Those that did become embedded in rock are again easily broken as they weather out of the substrate, or they may be simply so small that they are easily overlooked.

## PTEROSAURS

Unlike birds that use feathers as flight surfaces, pterosaurs solved the problem of flight by having a long extended finger attached to a broad expanse of skin that trailed back along its body in the rear. Pterosaur fossils have been found primarily in marine sedimentary rocks, perhaps indicating that many pterosaurs were like pelicans and other ocean birds in lifestyle. But remains have also been found in floodplain deposits, and some of those far from shore. This perhaps shows a diversity of living habits or migrations of some species to inland areas during storms or breeding seasons. Bell and Padian (1995) report possible evidence of an Early

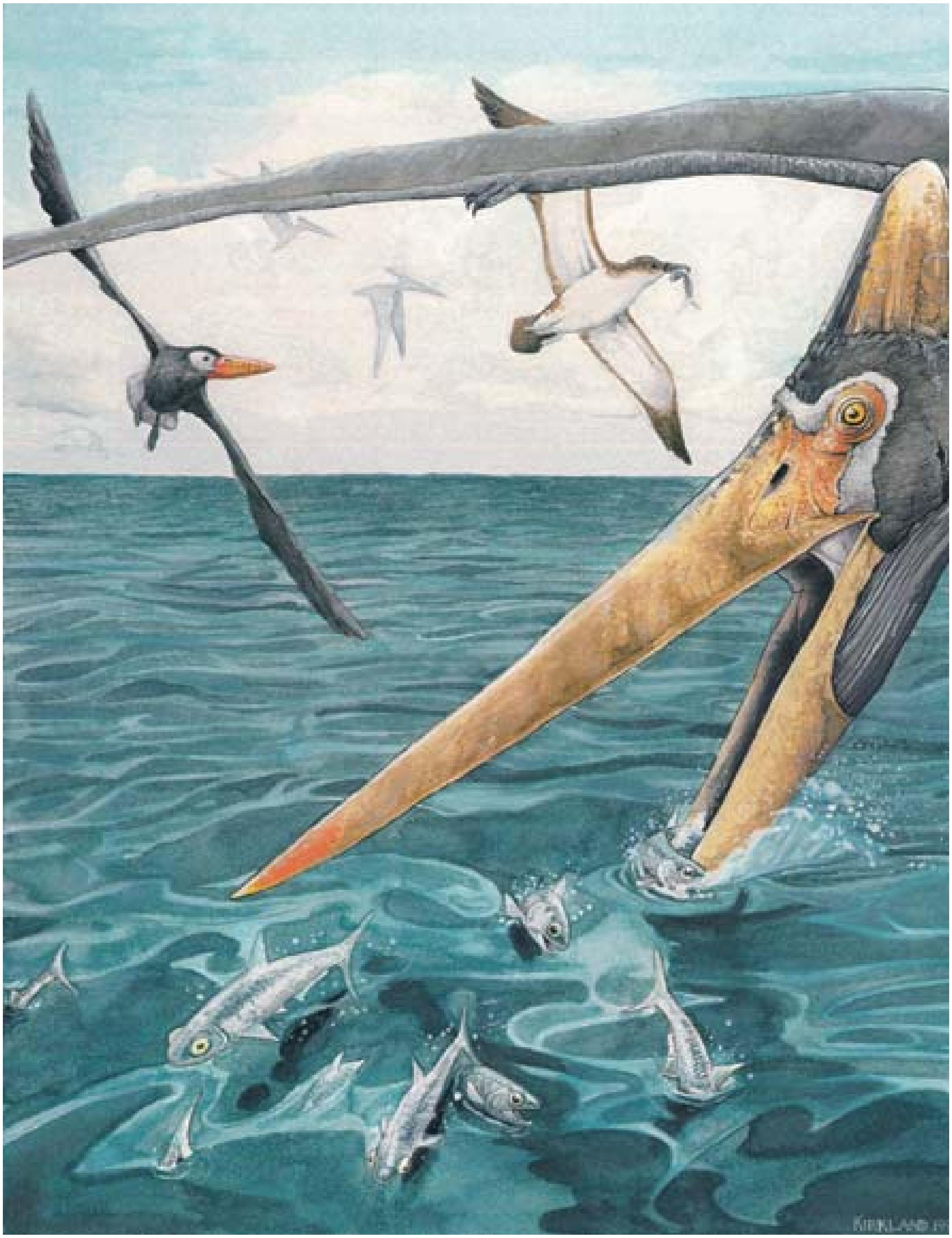


**FIGURE 3.1**

In this Late Cretaceous scene *Pteranodon* (a flying reptile) scoops up fish, while a toothed bird, *Ichthyornis,* and a modern bird fly above.

Cretaceous pterosaur nesting site in a desert far inland from the South American shore, where there may have been less predation pressure.

The remains of three pterosaurs have been found in California, two from Butte County and one from Shasta County. In addition, Downs (1968) reported pterosaur remains from the Late Cretaceous Moreno Formation of the Panoche Hills in the western San Joaquin Valley. (This fossil was reported to have been deposited in the collection of Caltech [now at LACM]; however, no trace of this fossil has been found.) Also, a left humerus and two dorsal vertebrae of a pterosaur were found in marine Late Cretaceous rocks of eastern Oregon (Gilmore 1928). Thought first to be of a *Pteranodon*-like pterosaur, these fragments probably represent a species close to *Quetzalcoatlus* and other azhdarchid pterosaurs (Padian 1984). The presence of Late Cretaceous pterosaur remains in Oregon and northern California suggests these creatures may have been widespread in this region.

The Shasta County pterosaur was found by Patrick Embree in the Budden Canyon Formation of the Great Valley Group (Hilton et al. 1999). This find, a portion of a long bone (SC-VRF8) from a small concretion, is the oldest evidence of a flying vertebrate in the state. Ammonites (fossil mollusks) collected nearby establish an age for the pterosaur as Early Cretaceous, about 115 million years old (Murphy et al. 1969). Unfortunately, the fragment is not very informative as to the type of pterosaur it was from, as it is simply the midsection of a wing or leg bone (Padian, pers. comm., 1998). Fossil plants found in nearby strata indicate the animal may have lived near a warm, moist forest (Axelrod and Embree, pers. comm., 1995), probably in the foothills of the ancestral Klamath Mountains (Dickinson 1976; Nilsen 1986). Whether the pterosaur perished at sea, along a beach, or washed down a river we may never know.

The two Butte County pterosaur bones were found in 1998 by Eric Göhre at separate sites in the marine Late Cretaceous Chico Formation of Butte County. These bones, a fourth metacarpal (SC-VRF5) and an ulna (SC-VRF6), are from the wings of two large pterosaurs, and were verified with the help of Kevin Padian of the UCMP and Wann Langston of the University of Texas, Austin. Both bones were found in turbidites containing mollusk shells, shell fragments, bony fish teeth, and shark teeth, plus well-rounded cobbles of quartz and metamorphic rocks. The cobbles and some of the mollusk remains hint at a nearshore provenance for the material making up the turbidite. The well-rounded cobbles were formed in either a beach or river environment.

The largest of Göhre's pterosaur bones is the seventeen-inch fourth metacarpal. It is missing most of both articulating ends, and so would have been at least an inch or two longer. Complete, this metacarpal scales out to an animal with an approximate wingspan of at least fifteen to eighteen feet. Possible candidates include *Quetzalcoatlus* or *Pteranodon,* both found

**FIGURE 3.2**
Fourth metacarpal (left) and ulna (right) of two large pterosaurs found in Butte County by Eric Göhre. Photos by the author.

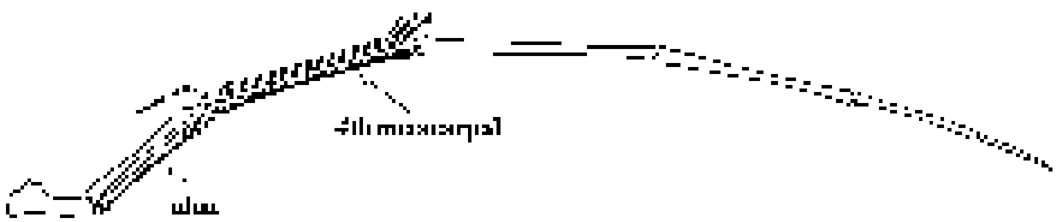
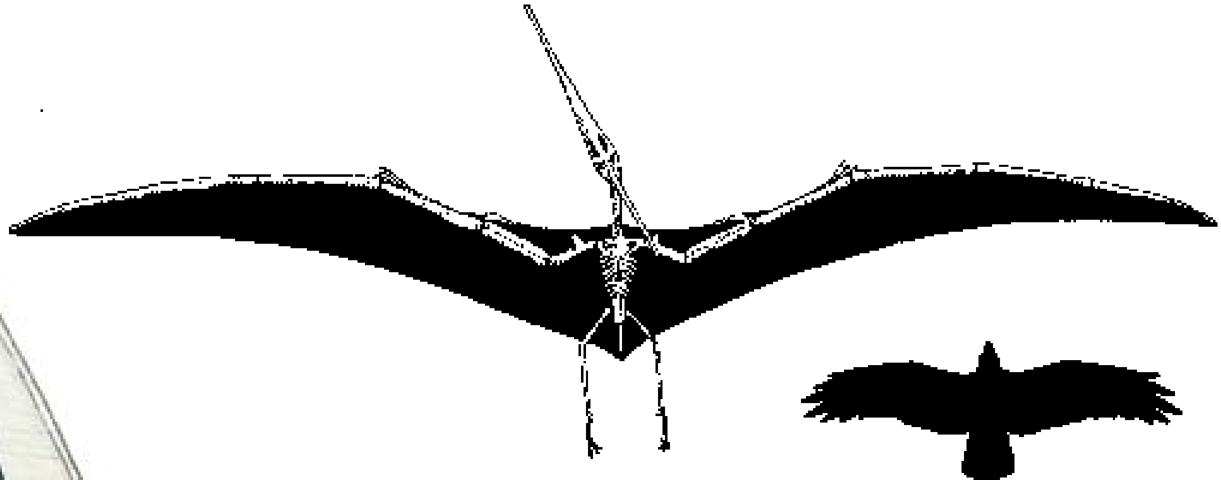


**FIGURE 3.3**
Position of fourth metacarpal and ulna in a pterosaur's wing.

in rocks of Late Cretaceous age in North America and both reaching sizes consistent with the length of this bone (Wellnhofer 1991). Comparison of this bone with the collection at the J. J. Pickle Research Campus at the University of Texas (with the help of Wann Langston Jr.) seems to preclude *Quetzalcoatlus,* as a slight bend in the metacarpal indicative of *Quetzalcoatlus* was absent; *Pteranodon* thus seems the more likely identity. *Pteranodon* was a toothless, crested pterosaur, the largest species of which, *P. sternbergi,* had a wingspan exceeding



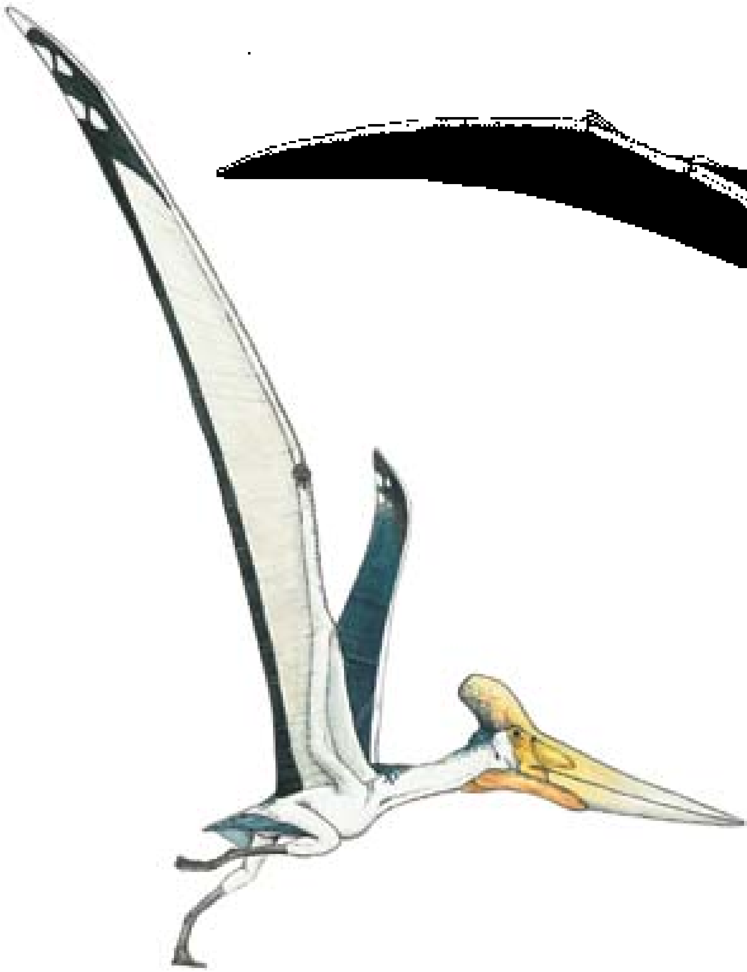


FIGURE 3.4 (ABOVE)
Comparison of *Pteranodon,* shown here with an eighteen-foot wingspan, to the size of a modern golden eagle.

FIGURE 3.5 (LEFT)
The giant pterosaur *Pteranodon* was a toothless, crested flying reptile. Modified from skeletal illustration in Eaton 1910.

thirty feet. The skull alone of *P. ingens* was nearly six feet long; it had relatively small eye sockets and a short neck, but its long wings enabled it to soar far from the shoreline in a probable search for fish (Wellnhofer 1991).

The second bone, the ulna, may be from a smaller animal than the metacarpal, or it may be from a juvenile of the same species as the larger animal. According to Langston, the ulna would scale up to an animal with about a six-foot wingspan.

It is interesting that both of these bones, though extremely fragile, managed to survive. The metacarpal and ulna of pterosaurs, like all their long bones, are hollow and extremely thin; flowing in the turbidity currents, they must have behaved like giant soda straws tumbling in the sediment-filled water. They survived being completely crushed only because sediment was able to flow into the broken ends, filling the open tubes. Many pterosaur bones from North America have been found crushed by the weight of the overlying sediment (Gilmore 1928).

Fossil ferns, redwoods, and leafy flowering trees found by Göhre in the Chico Formation in Butte County indicate that the area where these animals lived was just offshore from a lushly forested ancestral Sierra Nevada.

## BIRDS

It now seems fairly clear that birds evolved from small meat-eating dinosaurs and are the only close relatives of dinosaurs to have survived the mass extinctions at the end of the Mesozoic. Besides having many skeletal characteristics similar to dinosaurs, birds also have scales on their legs, and a few even have claws on their wings (hoatzin and screamers, for example). Some fossil birds had teeth as well. One Late Cretaceous bird found in Madagascar has a mosaic of characteristics of both birds and theropod dinosaurs (Forster et al. 1998), and the recent find of a bird-sized theropod in Early Cretaceous rocks in the Liaoning region of China proves that some dinosaurs were small enough to have evolved into birds (Xu et al. 2000). In the same deposits an eagle-sized dromaeosaur called *Sinornithosaurus millenii* was found, complete with downy featherlike structures, and although it did not fly (and was possibly secondarily flightless, as are ostriches), it had evolved the prerequisites for powered flight in its shoulder girdle. It is the most birdlike of all of the dinosaurs discovered thus far (Xu, Wang, and Wu 1999). Other dinosaurs (*Caudipteryx* and *Protarchaeopteryx,* for example) found in the same area suggest that featherlike structures may have had a broad distribution on theropod dinosaurs (Xu, Tang, and Wang 1999). A nonavian dromaeosaurid dinosaur from the Early Cretaceous has been found in China that has feathers identical to those found on modern birds, perhaps indicating that feathers evolved on dinosaurs before the emergence of birds (Norell et al. 2002).

The remains of a few Mesozoic birds have been found in Alta and Baja California. These specimens probably represent only a small fraction of the avifauna that existed in California during the Cretaceous.

The first such remains (LACM-33213) in western coastal North America were found in 1971 by H. J. Garbani and J. Loewe in the Late Cretaceous La Bocana Roja Formation of northern Baja California (Morris 1974c; Brodkorb 1976). They consisted of the following bones: from the shoulder, a left scapula and left coracoid; from the wing, the right ulna (a forearm bone); from the legs, a left femur and the distal end of a right femur (upper leg bones), and the right tibiotarsus (lower leg bone) (Brodkorb 1976).

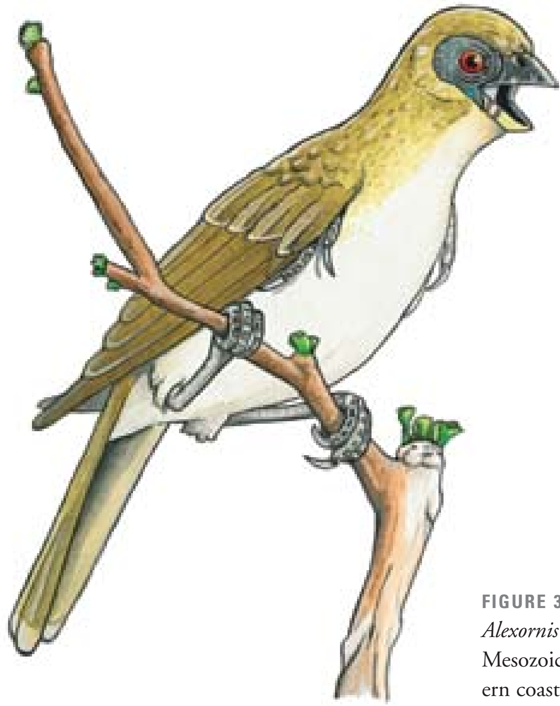


**FIGURE 3.6**
*Alexornis antecedens.* Its bones were the first Mesozoic bird remains to be found in western coastal North America.

Brodkorb (1976) classified these sparrow-sized remains as belonging to a new genus and species of land bird he called *Alexornis antecedens.* Brodkorb named the genus *Alexornis* for his friend Alexander Wetmore; the species name means "going before in rank or time, ancestral," in reference to the supposed ancestry of this bird to the orders Piciformes and Coraciiformes.

In 1998 Eric Göhre found fossil bones from two species of birds at two sites in the Chico Formation of Butte County, California—the first evidence of Mesozoic birds found in Alta California. These bones, which were identified by Thomas Stidham of UCMP (Hilton et al. 1999), consist of a partial humerus (UCMP-170785) and a nearly complete ulna (UCMP-171185). The humerus is from the toothed, tern-sized bird *Ichthyornis,* which, much like living terns, is thought to have been a fish-eating plunge diver. The bone was found in a turbidite containing mollusk shells and fragments, bony fish teeth, and shark teeth. These materials probably had their origins nearshore and were later washed by turbidity currents into deeper water.

The ulna Göhre found is from a neognath, one of the earliest modern birds ever found, about the size of a modern pigeon. It was found in a small lens composed of shell hash also carried from a nearshore environment by a turbidity current.

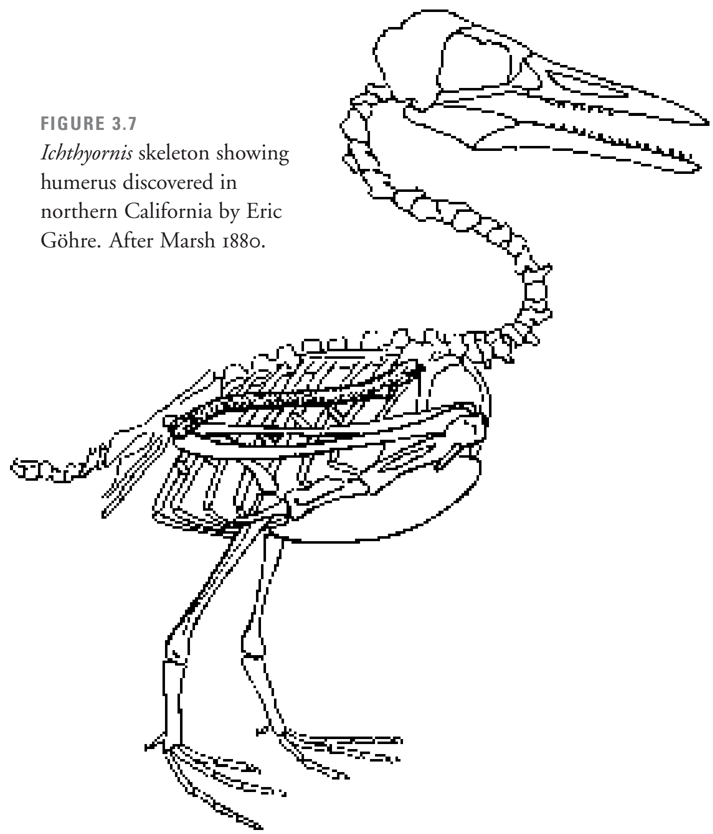
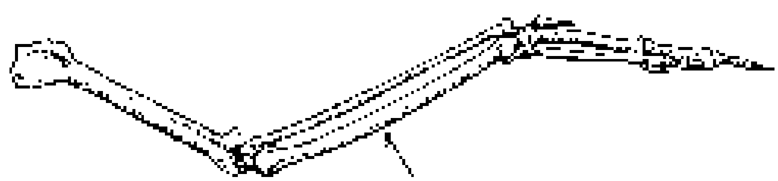


**FIGURE 3.7**
*Ichthyornis* skeleton showing humerus discovered in northern California by Eric Göhre. After Marsh 1880.

**FIGURE 3.8**
Tern-sized, *Ichthyornis* was a toothed plunge-diver. After Marsh 1880.

**FIGURE 3.9**
Position of ulna found by Eric Göhre in wing of modern bird.



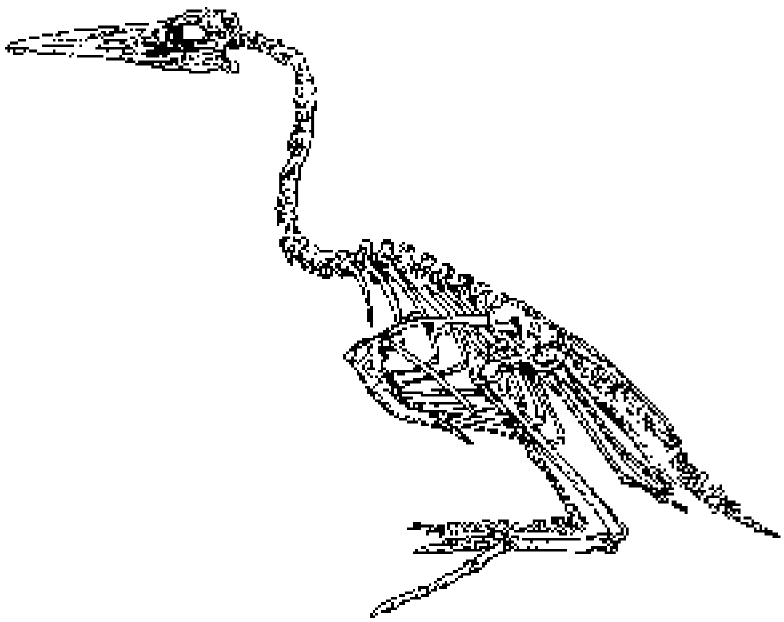
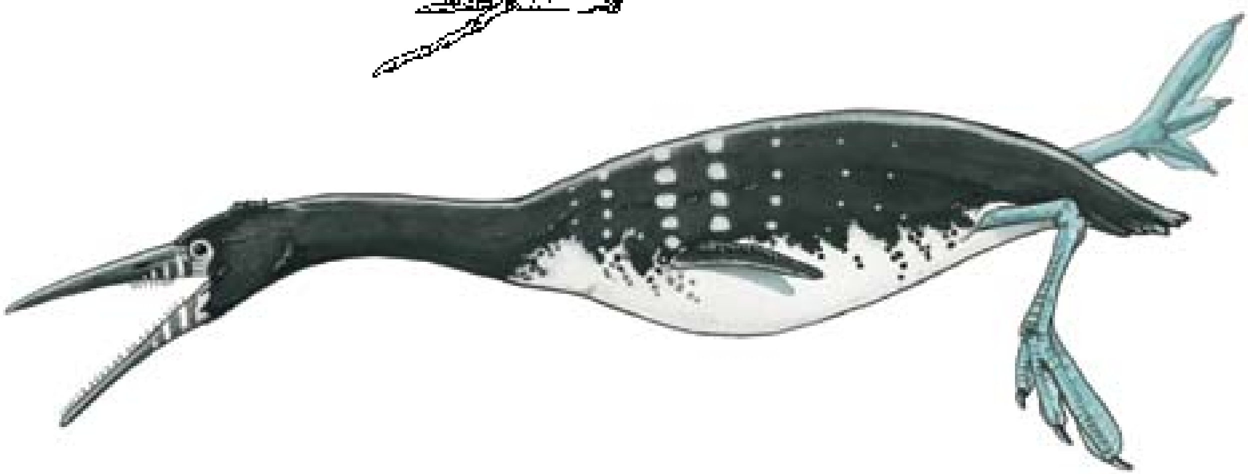


**FIGURE 3.10 (LEFT)**
Skeleton of *Hesperornis.* After Marsh 1880.

**FIGURE 3.11 (BELOW)**
Flightless, *Hesperornis* was a massive, toothed diving bird resembling modern cormorants.



In 2000 Göhre found another bird bone in the same area, an extremely large phalanx (toe bone) (SC-VBHE1). It was examined by Kevin Padian, who identified it as belonging to the genus *Hesperornis,* based on comparison with material illustrated by Marsh (1880). *Hesperornis* was a large, flightless diving bird that is known from Late Cretaceous rocks from the seaway that invaded central North America. The construction of its breastbone and shoulder shows that it evolved from a flying ancestor. Some specimens were over four feet long with strong hind limbs and lobed feet, and they used their teeth to capture swimming prey (Marsh 1880).