## Chapter 42

## Evolutionary Aside 42.1--Hot-Blooded Dinosaurs

In recent years, the provocative hypothesis that dinosaurs maintained high body temperatures has been debated. The idea was suggested for several reasons, including that we now realize birds, which are endothermic, are a type of dinosaur (see chapter 35). The question is whether endothermy evolved at the origin of birds, or earlier in the evolutionary tree.

Dinosaurs are now commonly portrayed—by Hollywood and in the scientific literature—as active animals with very complicated behaviors. The most active modern vertebrates with the most complex behaviors are mammals and birds (though some reptiles have very sophisticated behavior). As both of these are endothermic, some have hypothesized that dinosaurs must have been endothermic as well.

This hypothesis is difficult to evaluate because physiology obviously does not fossilize. Consequently, scientists must draw inferences from what the fossilized material—primarily bone—tells us about physiology, and from analysis of the phylogenetic context of fossils (see chapter 23). These conclusions are contentious because they are based on inferences drawn from anatomical examination of fossils. By definition this requires interpretation, which may not be agreed upon. Some suggest that the size of some types of cells in bone and the rate at which dinosaurs grew implies endothermy, but this is still contentious.

An argument can be made based on body size alone that at least large dinosaurs maintained high body temperature. The reason is that each cell of an animal's body produces heat, but the amount of heat exchanged with the environment is a function of surface area. Thus, as animals get larger, their surface area relative to volume decreases (remember this argument for cells in chapter 4). At some point, animals are so large that they produce heat at a much higher rate than is lost through their surface area (skin). These animals maintain temperatures higher than their surroundings, even if they have the low rate of metabolism characteristic of reptiles. In the text, we distinguished between ectotherms and endotherms in part on the basis of their metabolic rates—however, at very large sizes, even low metabolic rates produce more heat than the body can dissipate. Many large dinosaurs probably surpassed this size threshold, and so had high body temperatures. In fact for these animals, becoming too hot, rather than too cold, was a more important physiological issue.

However, this explanation only applies to large dinosaurs. What about the smaller ones and the young of the large species? Small endotherms need insulation; otherwise, all the heat they generate will simply radiate into the environment (large mammals, like elephants and hippos, have no hair; they don't need it). Recent fossil finds of theropod dinosaurs (the relatives of *Tyrannosaurus rex* and *Velociraptor*; see figure 23.11) with feathers suggests that these animals were endothermic.  This implies that endothermy may have arisen coincident with the evolution of feathers in the bird/dinosaur lineage.

If endothermy evolved among theropods, the question becomes, what about large members, like *T. rex?*  One possibility, sometimes seen in pictures, is that young *T. rex* were feathered endotherms, then they lost their feathers as they grew large enough to maintain high body temperatures without insulation.

There is a strong argument that many, perhaps most, dinosaurs maintained high body temperatures either because they were insulated with feathers or because they were very large.