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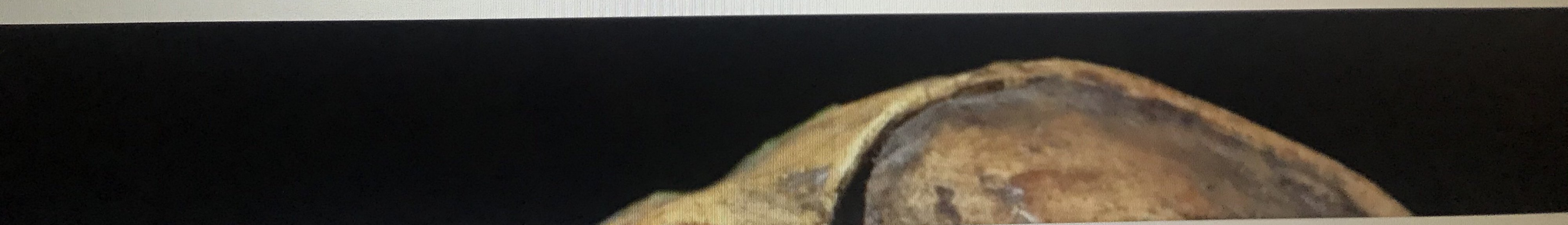
Primate Origins and Evolution

THE FIRST 50 MILLION YEARS



Also known as the "dawn ape," this fossil primate was an early ancestral catarrhine. *Aegyptopithecus* lived approximately 32–29 mya, before the divergence of hominoids (apes) and Old World monkeys. Like many catarrhines, this primate was likely an arboreal quadruped that regularly consumed leaves and fruit.

BIG QUESTIONS

1. **Why become a primate?**
2. **What were the first primates?**
3. **What were the first higher primates?**
4. **What evolutionary developments link past primate species and living ones?**

Remember Georges Cuvier, the Frenchman (introduced in chapter 2) who recognized that fossils are the remains of now-extinct animals and of plants? I bring him up again because of his central role in the study of primate evolution. The field would not have been the same had he not lived in the late eighteenth and early nineteenth centuries, when the scientific method, as we know it, began to take shape. As a child, Cuvier read scientific works of the eighteenth-century biology luminaries Linnaeus and the Comte de Buffon (Georges-Louis Leclerc), and their lived in the late eighteenth and early nineteenth centuries, when the scientific method, as we know it, began to take shape. As a child, Cuvier read scientific works of the eighteenth-century biology luminaries Linnaeus and the Comte de Buffon (Georges-Louis Leclerc), and their works sparked in him a lifelong interest in natural history. He went on to attend college at the University of Stuttgart in Germany, and like many other bright college graduates at the time, he was recruited as a private tutor for a wealthy family, in his case in Normandy, France. While living with his host family, as luck would have it, he met France's leading naturalist and anatomist, Étienne Geoffroy Saint-Hilaire (1772–1844). Professor Geoffroy must have been impressed with young Cuvier because he hired Cuvier as his assistant in comparative anatomy at the new National Museum of Natural History in Paris. Cuvier became interested in the mammal fossils around Paris, and his encyclopedic knowledge of anatomy enabled him to recognize similarities between animals represented by fossils and living animals.

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Among the hundreds of fossil bones and fossil teeth that he studied was a tiny skull, which he found in a gypsum quarry at nearby Montmartre. Dating to the Eocene, this specimen was unlike any skull Cuvier had ever seen. Was the animal it had come from living or extinct? When he published his description of

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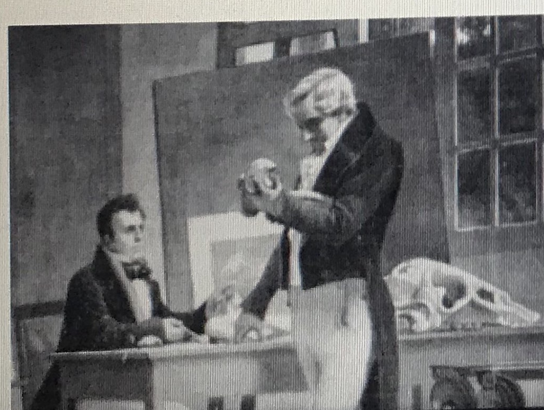
living or extinct? When he published his description of the fossil in 1822, he did not recognize the animal he called *Adapis parisiensis* as a primate (**Figure 9.1**).

By the late nineteenth century, other French paleontologists had realized that Cuvier's fossil was that of an early primate, a finding that has been substantiated time and time again during the twentieth century, making *Adapis* the first primate fossil described by a scientist. Cuvier, the founder of paleontology, had good reasons for not recognizing this animal as a primate. For one thing, *no* fossil record of primates existed then—just about everything discussed in this chapter was found long after Cuvier's time. For another, taxonomists had very little understanding of living primate variation, and they had not yet defined the order much beyond Linnaeus's classification scheme (discussed in chapter 2).



Although Cuvier's assessment was wrong, his meticulous description of the *Adapis* fossil was very important. Stories like this happen often in science: the original discoverer may not recognize the finding for what it is, mostly because there is no context or prior discovery. Nevertheless, the discovery provides later scientists with important evidence. In this case, Cuvier's pioneering detailed description began the long process of documenting primate evolution, a

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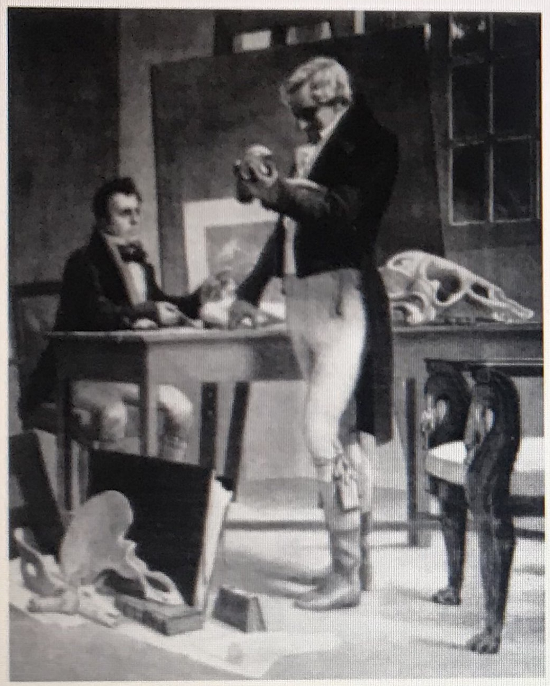

FIGURE 9.1
***Cuvier and* Adapis** In describing the fossil remains of an animal he mistakenly thought was an ungulate or artiodactyl (hoofed mammal), Cuvier (here seated) named the specimen *Adapis*, Latin for "toward sacred bull." Later scholars realized that these remains were the first primate fossil ever recorded by a scientist.

Although Cuvier's assessment was wrong, his meticulous description of the *Adapis* fossil was very important. Stories like this happen often in science: the original discoverer may not recognize the finding for what it is, mostly because there is no context or prior discovery. Nevertheless, the discovery provides later scientists with important evidence. In this case, Cuvier's pioneering detailed description began the long process of documenting primate evolution, a process that continues today. Moreover, Cuvier set the bar high for future paleontologists by demonstrating the value of thorough description. Most important, Cuvier's careful work planted the seeds for asking key questions about primate origins.

In the two centuries since Cuvier, many thousands of fossils of ancient primates have been discovered in Europe, Asia, Africa, North America, and South America (**Figure 9.2**), providing a record—relatively complete for some time periods, frustratingly incomplete for others—of the origins and evolution of the earliest primates and their descendants. In this chapter, we address the big questions by examining the fossil record for evidence of three key developments: the emergence of the first primates, the origins of higher primates (anthropoids), and the origins and evolution of the major anthropoid groups (monkeys, apes, and humans). The time frame for this fossil ever recorded by a scientist.

chapter, we address the big questions by examining the fossil record for evidence of three key developments: the emergence of the first primates, the origins of higher primates (anthropoids), and the origins and evolution of the major anthropoid groups (monkeys, apes, and humans). The time frame for this chapter is expansive—more than 60 million years! We start in the Early Paleocene, somewhere around 66 mya (about 10 million years or so before the emergence of the first true primate), and end in the Late Miocene, around 5.3 mya, the dawn of human evolution. The record indicates that primates were highly successful and, like other mammals, underwent a cycle of adaptive radiations, followed by extinctions, and then new radiations of surviving lineages. These survivors are the primates occupying Earth today, including human beings (**Figure 9.3**).

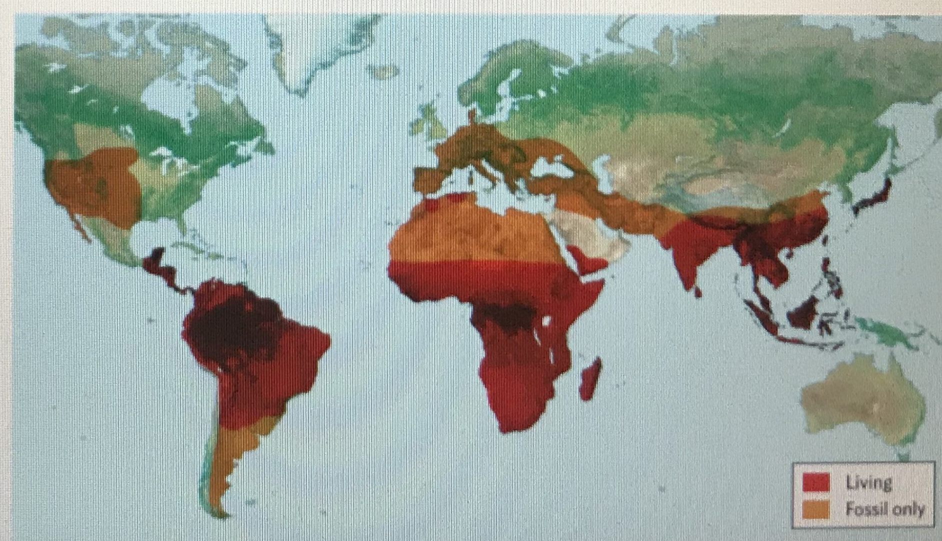

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FIGURE 9.2

Living and Extinct Primates As this map indicates, fossils of extinct primate species have been found on every continent except Australia and Antarctica. Climate changes over millions of years probably explain why primates were once distributed more extensively throughout the world than are modern, living primates.

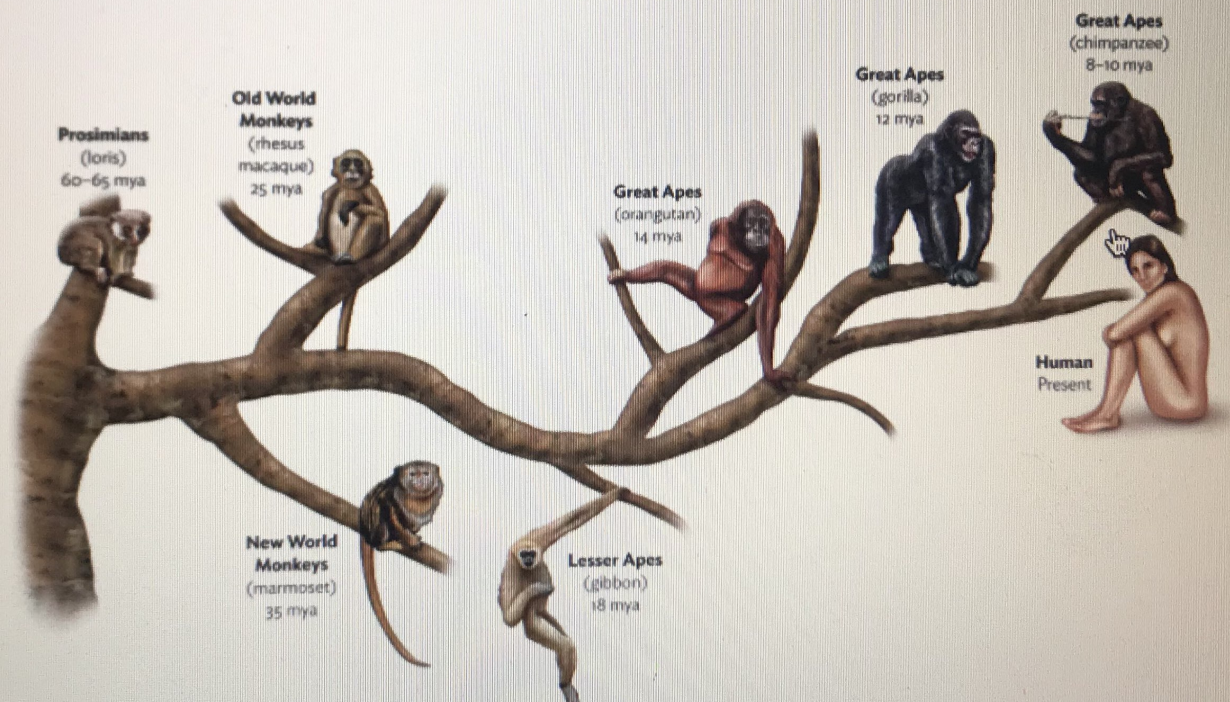
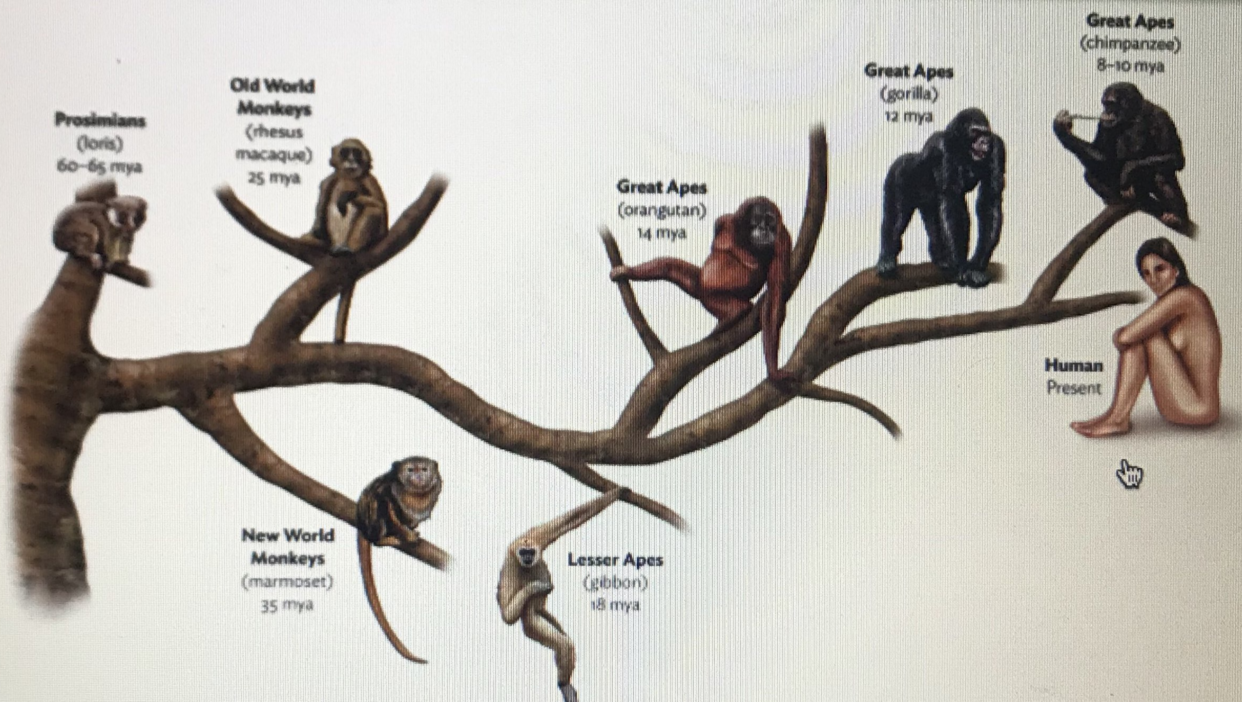


FIGURE 9.3

Primate Family Tree The variety of primates today is the result of millions of years of primate evolution. The different lineages represented by great apes, lesser apes, Old World monkeys, New World monkeys, and prosimians reflect divergences in primate evolution. For example, New World monkeys split off around 35 mya, and Old World monkeys diverged approximately 25 mya. The lineage leading to modern



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9.1 Why Did Primates Emerge?

We know *what* primates are. For example, they are agile and adept at grasping, the claws of their ancestors have been replaced by nails, and they have a high degree of visual acuity, a reduced sense of smell, and a big brain (**Figure 9.4**). *Why* they became what they are is far less clear. In the early 1900s, the British anatomists Sir Grafton Elliot Smith and Frederic Wood Jones proposed their arboreal hypothesis to explain primate origins. Smith and Jones hypothesized that primates' defining characteristics were adaptations to life in the trees: grasping hands and grasping feet were crucial for holding on to tree branches, advanced vision including greater depth perception was important for judging distance in the movement from place to place in the trees, smell was no longer as important for finding food, and greater intelligence was

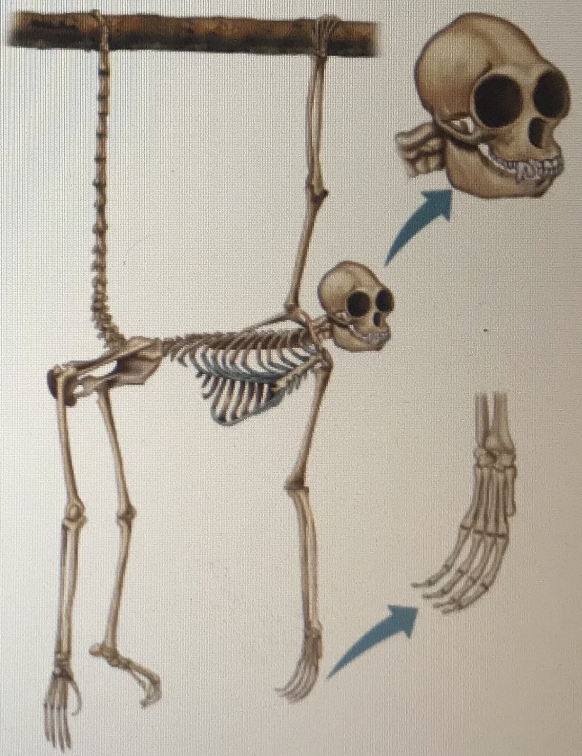

FIGURE 9.4
Primate Characteristics Primates differ from other mammals thanks to a unique combination of traits, such as forward-facing eyes, a

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finding food, and greater intelligence was important for understanding three-dimensional space in the trees. The movement from life on the ground to life in the trees, Smith and Jones surmised, put into motion a series of selective pressures that resulted in the ancestral primate.

The arboreal hypothesis continues to profoundly influence the way anthropologists think about primate origins and evolution. But in the early 1970s, the American biological anthropologist Matt Cartmill challenged the arboreal hypothesis. He pointed out that lots of mammals are arboreal (squirrels, for example), but except for primates none have evolved the entire set of characteristics that define the order Primates. (These characteristics include generalized structure, arboreal adaptation, and care of young; see chapters 6 and 7.) To account for primate origins, Cartmill proposed his visual predation hypothesis. He hypothesized that the first primate specialized in preying on insects and other small creatures, hunting them in tree branches or in forest undergrowth. Cartmill argued that the shift to life in the trees was not the most important factor in explaining primate origins. Rather, the catching of small prey—using both a highly specialized visual apparatus and the fine motor skills of grasping digits—set primate evolution in motion.

Although the visual predation hypothesis elegantly explains the visual adaptations, intelligence, and grasping abilities of primates, it

of traits, such as forward-facing eyes, a postorbital bar or fully enclosed eye orbit, a large cranial vault, a reduced snout, and a versatile dentition. In the postcranial skeleton, primates usually have divergent big toes and divergent thumbs, grasping hands and grasping feet, and nails instead of claws on their fingers and their toes.

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leaves an important question unanswered: *What role do the primate characteristics play in the acquisition and consumption of fruit, which many primates eat?* The American biological anthropologist Robert Sussman has hypothesized that the visual acuity, grasping hands, and grasping feet of primates were mostly adaptations for eating fruit and other foods made available with the radiation of modern groups of flowering plants called *angiosperms.* In other words, the original primate adaptation was about getting fruit and not about preying on insects. Sussman reasoned that because there was little light in the forest, early primates required visual adaptations for seeing small objects. Moreover, their grasping toes helped the animals cling to tree branches while they picked and ate fruit, rather than having to go back to more secure and larger branches, as squirrels do when they eat nuts. Sussman's **angiosperm radiation hypothesis** is grounded in the acquisition of a new food source available in the early Cenozoic: fruit. Fruit was available well before the Cenozoic, but adaptations to long-existing resources can take a considerable amount of time and involve numerous factors in influencing natural selection.

In reality, elements of all three hypotheses may have provided the evolutionary opportunities that resulted in primate origins. Indeed, primates' most special feature is their adaptive versatility, especially in an arboreal setting. Primates have evolved strategies and anatomical features that enhance their ability to adapt to new and novel circumstances. That evolution constitutes primates' story of origin.

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