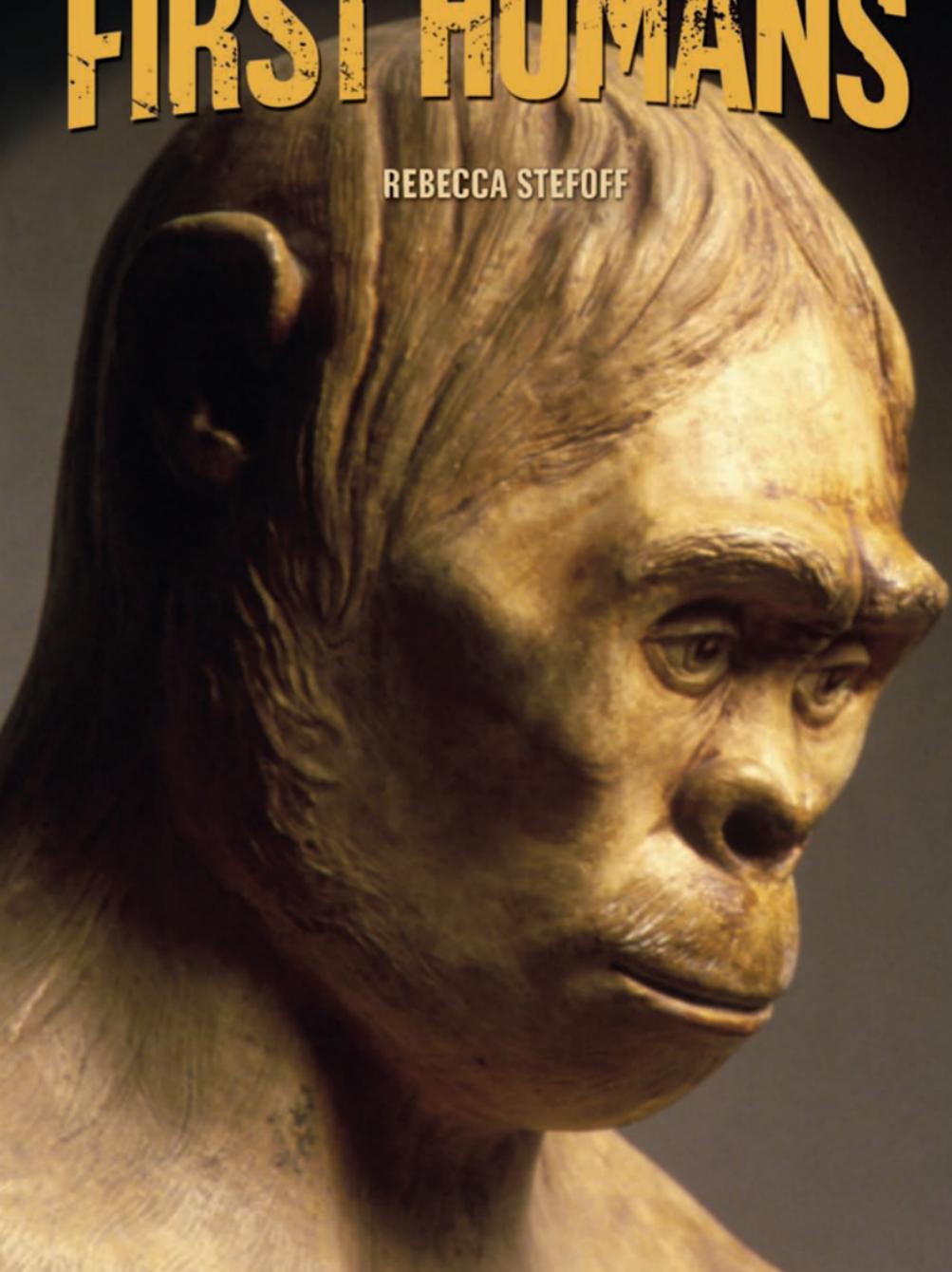


HUMANS: AN EVOLUTIONARY HISTORY

FIRST HUMANS

REBECCA STEFOFF



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REBECCA STEFFO



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Front cover: Dutch anatomist Eugene Dubois made this model of Java Man, whose fossils he discovered in 1891.
Half-title page: Uncovering one of the famous fossilized footprints of a hominin at Laetoli, Tanzania, 1978
Title page: Richard Leakey and two of his fossil finds
Back cover: Molds made from the skulls of rare fossils show a variety of hominin species.

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In Search of Human Origins

Dogs and bones just seem to go together. Canines gnawing bones, or burying them, are the subject of countless pictures and cartoons. Dogs are also linked to the discovery of a famous fossil bone—although they did not dig up the ancient relic, or even chew on it.

Mary Leakey went walking with her dalmatians on July 17, 1959. The place was Olduvai Gorge, a dry, narrow canyon in the East African nation of Tanzania, which was called Tanganyika at that time. Since the 1930s Leakey and her husband, Louis Leakey, had spent much of their time in a tent camp at Olduvai, digging into the past. They had unearthed many fossils, remains of ancient animal and plant life that had turned to stone over long periods of time. Among the vanished creatures that had once roamed that part of Africa were *deinotheres*, elephantlike beasts with tusks that grew downward from their lower jaws.

But the Leakeys had found more than fossils in Olduvai Gorge. They had also found pebbles from which flakes had been knocked off, creating sharp edges. These edges did not form by chance. They were deliberately crafted so that the pebbles could be used as cutters or choppers.

The crude stone tools came from deep in Olduvai Gorge, in layers of earth that dated from about 2 million years ago. They were the oldest known tools that had ever been found. The Leakeys dreamed of finding the 2-million-year-old human ancestors that had been intelligent enough to create and use tools. Such a discovery would be a landmark in paleoanthropology, the study of early humans. Yet although the husband-and-wife team had searched Olduvai Gorge for several decades, looking for fossils of the toolmakers, they had had no luck.



Mary Leakey's dalmatians keep her company as she searches for fossils in Olduvai Gorge.

“I’ve Got Him!”

Years of hard work under the African sun had taken a toll on Louis Leakey, who had fallen ill with several tropical diseases. On that day in 1959, he was ill and did not feel like leaving his tent, so Mary Leakey decided to go to the gorge on her own, with her beloved black-and-white dogs for company.

As she walked along, she noticed something small and smooth sticking out of the ground. At forty-six years of age, Mary Leakey was an experienced fossil hunter. For more than two decades, she had taken part in many expeditions at Olduvai and elsewhere. So when she saw a bit of brownish material half buried in the earth she knew at once that she was looking at fossilized bone.

Mary Leakey bent down and brushed away some of the loose earth. The bone, she saw, was part of a broken skull, with two teeth still attached to the upper jaw. She knew from the teeth that this was not just any old skull. She had seen similar teeth before, in a handful of

fossil remains from South Africa and Asia—fossils of early members of the human family, with humanlike and apelike features mixed together. The Leakeys and other scientists used the term “hominid” to refer to these ancient species that seemed to belong on the evolutionary line leading to humans. (Some experts still use the term that way today, although “hominin” is replacing it.) It was the hope of finding similar fossils that had drawn the Leakeys back to Olduvai Gorge year after year—and Mary had just found one.

Like any good archaeologist or fossil hunter, Mary left the bone exactly where she had found it so that its location could be precisely plotted on a map of the site. She stacked a few stones into a small cairn, or rock pile, to mark the spot, then loaded her dogs into the Leakeys’ battered Land Rover and raced back to camp as fast as she could drive over the rutted road that led up out of the gorge.

“I’ve got him! I’ve got him! I’ve got him!” she cried as she rushed toward Louis’s tent. Roused by the shouting, Louis leaped out of bed and ran from the tent. At first he feared that Mary was hurt. When he realized what she was saying, he asked, “Got what?”

“Him, the man. Our man. The one we’ve been looking for,” Mary answered. “Come quick. I’ve found his teeth!”¹

Louis’s sickness, he later wrote, “departed magically.” He and Mary piled back into the Land Rover. In an article for *National Geographic* magazine Louis described what happened next:

We bounced down the gorge trail in the car, then covered the last half mile at a run. Mary led me to a cairn, and we knelt to examine her treasure. The teeth projected from a rock face. To us these shining bits of fossilized matter represented the end of a 28-year search. For there, in Tanganyika’s remote Olduvai Gorge, lay the remains of the earliest man ever found. We almost cried with joy. After all our hoping and hardship and sacrifice, we had reached our goal.²

Nutcracker Man

Removing Mary Leakey's find from the rock and earth that encased it was not a simple matter. The Leakeys had to chip carefully at the hard matter around the fossil, freeing their precious discovery a little at a time. Then, hoping to find more of the ancient skeleton, they and their assistants slowly and carefully excavated a large area around the original find, sifting the dirt through fine screens that would catch even the smallest shards of bone. In the end, they found more teeth and several hundred fragments of the skull, but no other skeletal remains. The skull probably separated from the body long, long ago, before the bones began to harden into fossils.

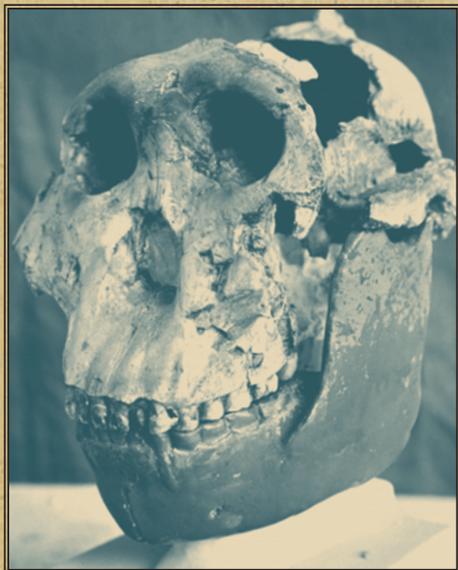
Finding the skull fragments was just the first step. Next came the job of fitting them together like pieces of an ancient jigsaw puzzle. Mary tackled this delicate task. Unfortunately, many pieces were missing from the jigsaw puzzle, and the fragments that the Leakeys found did not add up to a complete skull. Enough remained, however, to show most of the skull's anatomy, or physical structure. After two painstaking months, Mary Leakey's reconstruction of the skull was complete. The result was not what the Leakeys had expected.

Louis Leakey had long believed that the pebble tools in Olduvai Gorge were made by a very early species in the genus *Homo*, the same scientific category that includes the modern human species. The skull, though, clearly did not belong to *Homo*. Although it was humanlike in many ways, its overall appearance was not human. The most striking feature of the skull was a crest or ridge of bone that ran across the top of the head from front to back. The bone of the skull was unusually thick, and the jaws were huge. The molars—the flat teeth at the back of the jaws that are used for chewing and grinding—were another remarkable feature. They were enormous, far larger than those of any humanlike fossil that had yet been found.

Similar skulls had been discovered before, in South Africa, but Louis Leakey decided that the skull Mary had found in Olduvai Gorge

represented a new, unknown hominin. He gave it the scientific name *Zinjanthropus boisei*. The first part of the name meant “East African man,” while the second part honored a man named Charles Boise, who had given financial aid to the Leakeys’ expeditions.

Z. boisei quickly became famous in scientific circles. The fossil’s fame reached beyond the scientific world when Louis wrote his article about



Big jaws and teeth earned Mary Leakey’s find the nickname Nutcracker Man.

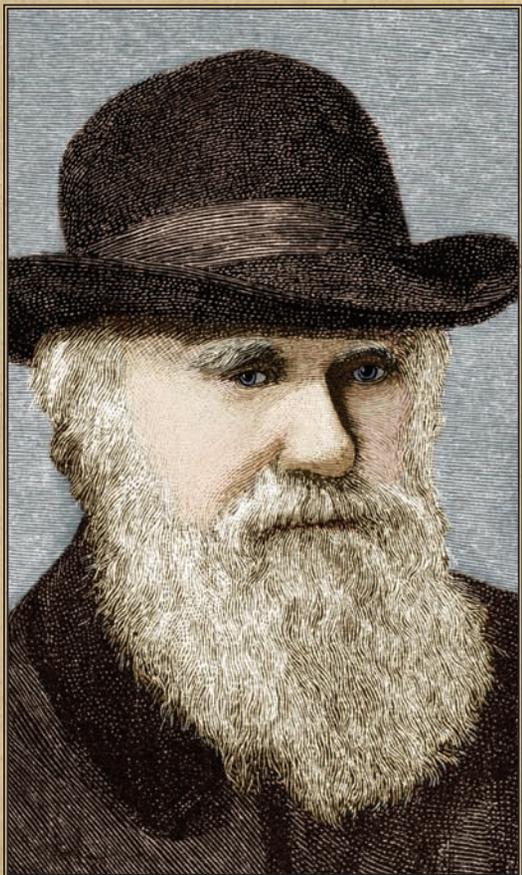
the discovery for *National Geographic*. The skull also acquired a number of nicknames. Some people called it Zinj. The Leakeys took to calling it Dear Boy. But the most common nickname, inspired by the enormous size of the fossil’s jaws and teeth, was Nutcracker Man—a reference to the wooden figures with big teeth that are used to crack nuts.

Mary Leakey’s discovery raised a number of challenging questions for paleoanthropology.

Had Nutcracker Man made the stone tools the Leakeys had found in Olduvai Gorge? How did Nutcracker Man relate to the fossils of other early humanlike beings that people had already found elsewhere in the world? Above all, was this giant-jawed creature a human ancestor? Debates about these questions were part of humankind’s search for information about its own beginnings. In time, that search would lead to an understanding of Nutcracker Man’s place in human evolution.

Darwin’s Big Idea

To understand the story of human evolution, we must know something about evolution in general. Evolution is the pattern of biological



British naturalist Charles Darwin dramatically changed our understanding of the forces that shape living things.

change over time as new species appear and old ones die out. The basic unit of evolution is not the individual organism, or living thing. Instead, evolution occurs at the level of species, or types of living thing.

Biologists admit that *species* is a somewhat slippery term to define, and they have taken a variety of approaches to the definition. For many years, one of the most widespread definitions said that a species is a group of plants or animals that are reproductively isolated from other organisms.

Reproductive isolation does not mean that the plants or animals are stranded on a desert island, lonely and unable to find mates. It means that under natural conditions the plants or animals within the species reproduce with each other but not with organisms outside the species. One problem with this definition is that it does not apply to organisms such as bacteria that can reproduce on their own, without partners.

In recent years, as researchers have decoded the genomes, or genetic signatures, of an ever-growing number of organisms, many scientists have added a genetic element to their definitions of *species*. They now call a species a group of organisms that share the same genome and, if they reproduce sexually, do so only with other organ-

isms in the group. A species may be distributed over a wide or even a worldwide range, like modern humans, or it may occupy a range as small as a single tree, like some rain-forest insects.

Since ancient times people have grouped plants and animals into species, but they thought that species were permanent and unchanging. Life on Earth, in other words, had always been the same. By the nineteenth century, however, new scientific insights were challenging that view. Geology had shown that Earth is far older than people once believed; we now know that the age of our planet is measured in billions, not thousands, of years. Naturalists, people who studied the natural world, had examined fossils of dinosaurs and other creatures that no longer existed, and they had realized that many kinds of life had become extinct. And if species could disappear into extinction, some naturalists asked, could they also appear? Had new species come on the scene during the long history of life?

The answer to that question came from a British naturalist named Charles Darwin. Although a number of naturalists were exploring the question of species at around the same time, Darwin was the first to publish his ideas on the subject, after pondering and testing them for more than twenty years. In 1859 Darwin published *On the Origin of Species*, a book that he called “one long argument” in support of his central claim.³ That claim was that species change over time, and that new species develop from existing ones. At first Darwin did not use the word *evolution* to refer to this ongoing pattern. He called it “descent with modification.” The term *evolution* appeared in the fifth edition of *Origin* in 1869, however, and ever since then it has been linked to Darwin.

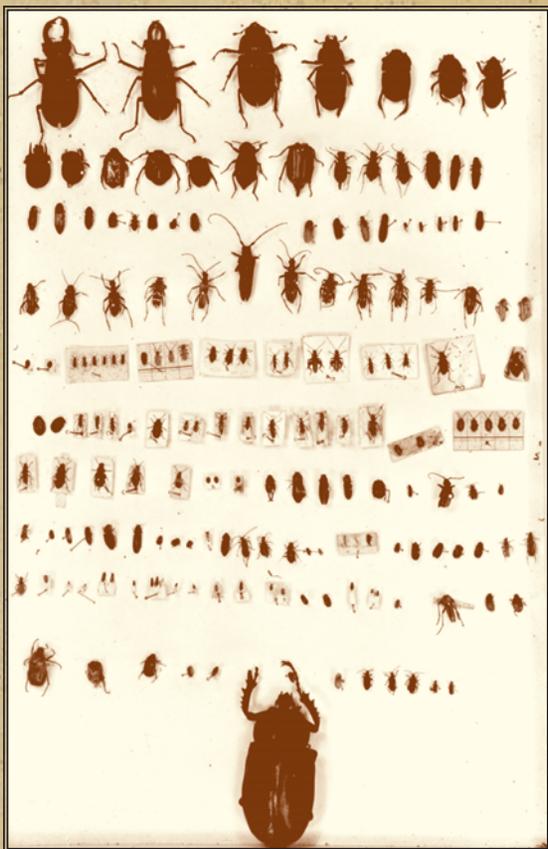
New species evolved, Darwin explained, through a process that he called natural selection. He pointed out that humans have created many breeds, or varieties, of domesticated animals and plants through artificial selection, by choosing plants or animals that have desirable qualities and breeding them with each other. Artificial selection has enabled

people to mold dogs, for example, into varieties that range from huge, hairy sheepdogs to tiny, bald Chihuahuas. Something similar occurs in the natural world, Darwin argued. Over long periods of time, natural selection creates not just new varieties within species but distinct new species.

It works like this: Organisms pass on their characteristics to their offspring, but the characteristics inherited by the offspring include random, natural changes known as variations. If the variations help an

organism's offspring—or, at least, do not harm them—then the offspring will survive to reproduce, passing on their characteristics, including the new features, to their own offspring. In time, as individuals possessing the new features reproduce with each other, those features will be reinforced as they spread through the population. At some point the organisms that evolved with the new features will be different enough from the original organisms to be considered a new species.

Natural selection explained how evolution could take place. In the struggle to survive, Darwin claimed, some organisms inherited favorable variations that gave them advantages in their particular environ-



Part of Darwin's insect collection. His ideas grew out of close study of the natural world.

ments or ways of life. Those organisms could then outcompete other organisms that belonged to the same species but lacked the favorable new variations. A bird with a slightly longer beak, for example, would be able to pluck insects from deeper cracks in logs and tree trunks than the other birds could manage. This would give the longer-beaked bird an edge in survival.

Yet Darwin could not explain the mechanism of heredity—exactly how parents transmitted characteristics to their children, and how variations occurred in those characteristics. Not until the science of genetics developed in the twentieth century, bringing important discoveries about the roles of genes and DNA, did scientists grasp the mechanisms of genetic inheritance and genetic variation.

Work in Progress

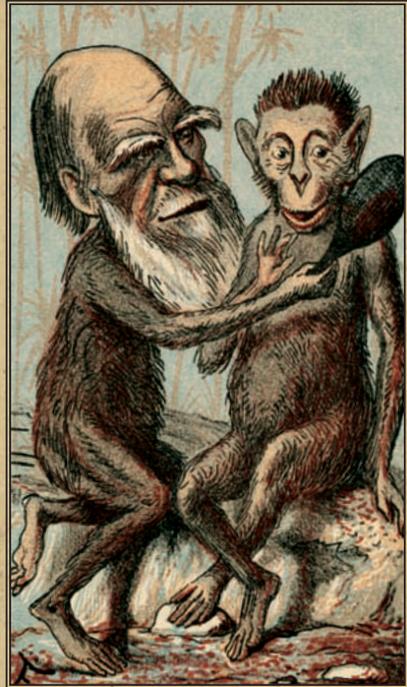
Near the end of *On the Origin of Species*, Darwin wrote that when the world came to accept his findings there would be “a considerable revolution in natural history.”⁴ An understanding of evolution, he said, would not only enrich the sciences but would give people a whole new view of life—all forms of life. “Light,” Darwin predicted, “will be thrown on the origin of man and his history.”⁵

On the Origin of Species is not a short book (although it is a lot shorter than Darwin initially meant it to be). Yet that single sentence near the end of the book is Darwin’s only mention of human origins. Darwin was well aware that many people would be disturbed by the idea that plant and animal species changed and evolved naturally, rather than receiving their complete and final forms through divine creation. But even some of those who could accept the evolution of plants and animals might reject the idea that human beings, too, were part of this natural process. Placing humans in the natural order would seem to go against religious traditions.

Although Darwin devoted just one sentence in *On the Origin of Species* to human origins, his readers had no trouble making the con-

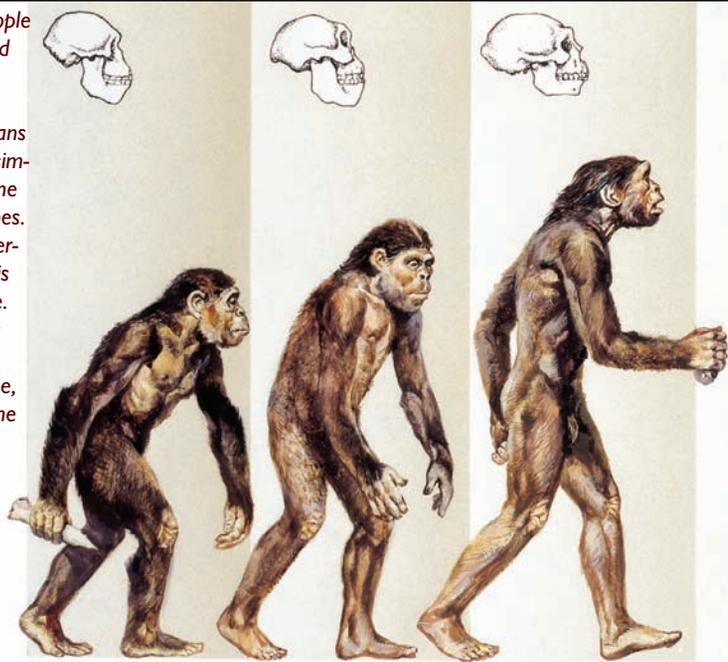
nection between evolution and humankind. Many of them, as he had expected, were outraged. They were disgusted by the suggestion that humans had evolved from animals, and they found the possibility that human origins were natural rather than supernatural to be irreligious. Others, convinced by Darwin's mass of evidence, accepted the reality of evolution in the natural world. Many of these readers recognized that evolution applies to humans just as it applies to other forms of life, and they were able to reconcile the new concept with their religious beliefs. In 1871 Darwin tackled the ticklish subject of people and evolution head-on in a book called *The Descent of Man*. It was one of the early steps in an investigation of human origins that is still going on today.

Although the fact of evolution is now established beyond reasonable scientific doubt, much remains to be learned about how it occurs. As part of the scientific process, experts constantly examine new evidence. This frequently leads them to revise or fine-tune their ideas about the mechanisms of evolution and also about the rate at which speciation, or the emergence of new species, takes place. Evolutionary scientists now know that natural selection is not the only factor that influences the development of new species. Climate change, new mutations, movements of populations, inbreeding, and random chance also play a role in speciation. One lively area of modern evolutionary research, for example, is population genetics, which studies the different ways that genetic variations occur and spread in populations of different sizes, including human populations.



Mockery greeted Darwin's claim that humans are related to apes—but he was right.

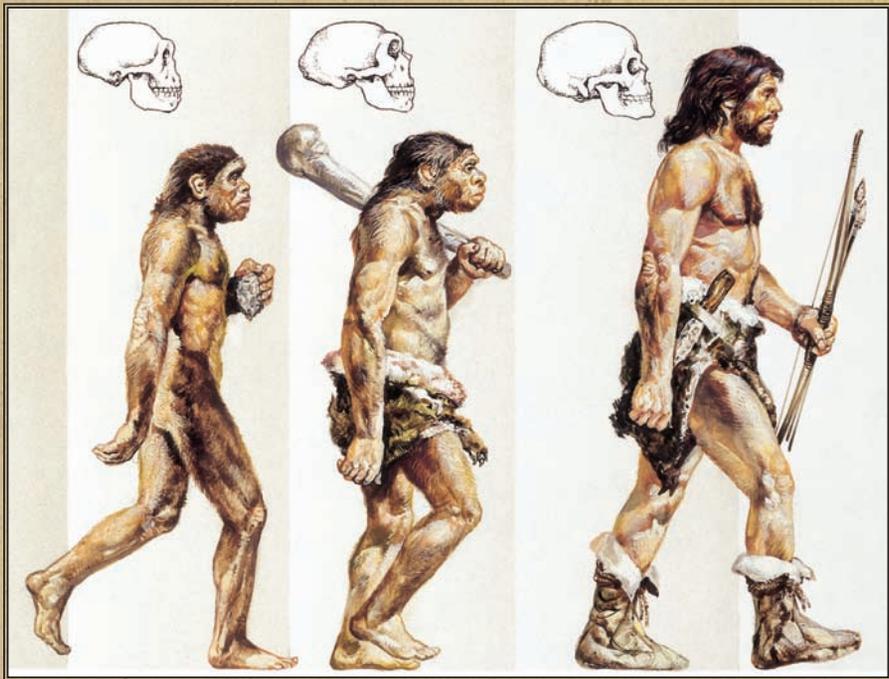
For years, people misunderstood Darwin and believed that modern humans evolved in a simple straight line from early apes. We now understand that this notion is false. Many species branched off our family tree, only to become extinct.



“The proper study of mankind is man,” wrote the British poet Alexander Pope in the 1730s.⁶ People of all times and cultures have speculated about the nature and origins of humankind. In the modern world, science has allowed us to probe deeply into our own nature, yet where we came from and how we came to be what we are today remains a complicated puzzle. More pieces of the puzzle are missing than have been found, but each new discovery adds to the picture, even if the experts are not yet certain where it fits.

For this work in progress, scientists use what has been called “a toolbox for human origins.”⁷ The tools in the toolbox are an array of techniques and skills that fall into three broad categories. One category is genetics, the study of how DNA and genes work. Another is paleoanthropology, the study of ancient human life through physical traces such as fossils and stone tools. The third category is evolutionary science, which looks at the big picture of evolution, with topics such as population genetics and natural selection.

Modern people—*Homo sapiens*, to use the scientific name for our



species—are the only members of the human family that exist today. Yet during the past century and a half scientists have learned that over the span of millions of years, evolution has produced many other species of humans or close human relatives, all of whom are now extinct. In the years since Darwin wrote *On the Origin of Species*, discoveries such as Mary Leakey's Nutcracker Man fossil have thrown light, just as Darwin predicted, on the early stages of human evolution.

The first book in this series, *Origins*, told of the search for the earliest human ancestors and the discovery of the australopiths, a branch of the human family tree that flourished in Africa several million years ago. This book focuses on two other branches of the family tree, including the first true humans, members of the genus *Homo*. The third book introduces the human species that lived in Eurasia during the Ice Age, including the Neanderthals. Finally, the fourth book looks at the beginnings of modern humans and how they spread throughout the world. The four books of the series together tell the story of human evolution as it is known today.

THE ILLUSTRATED LONDON NEWS



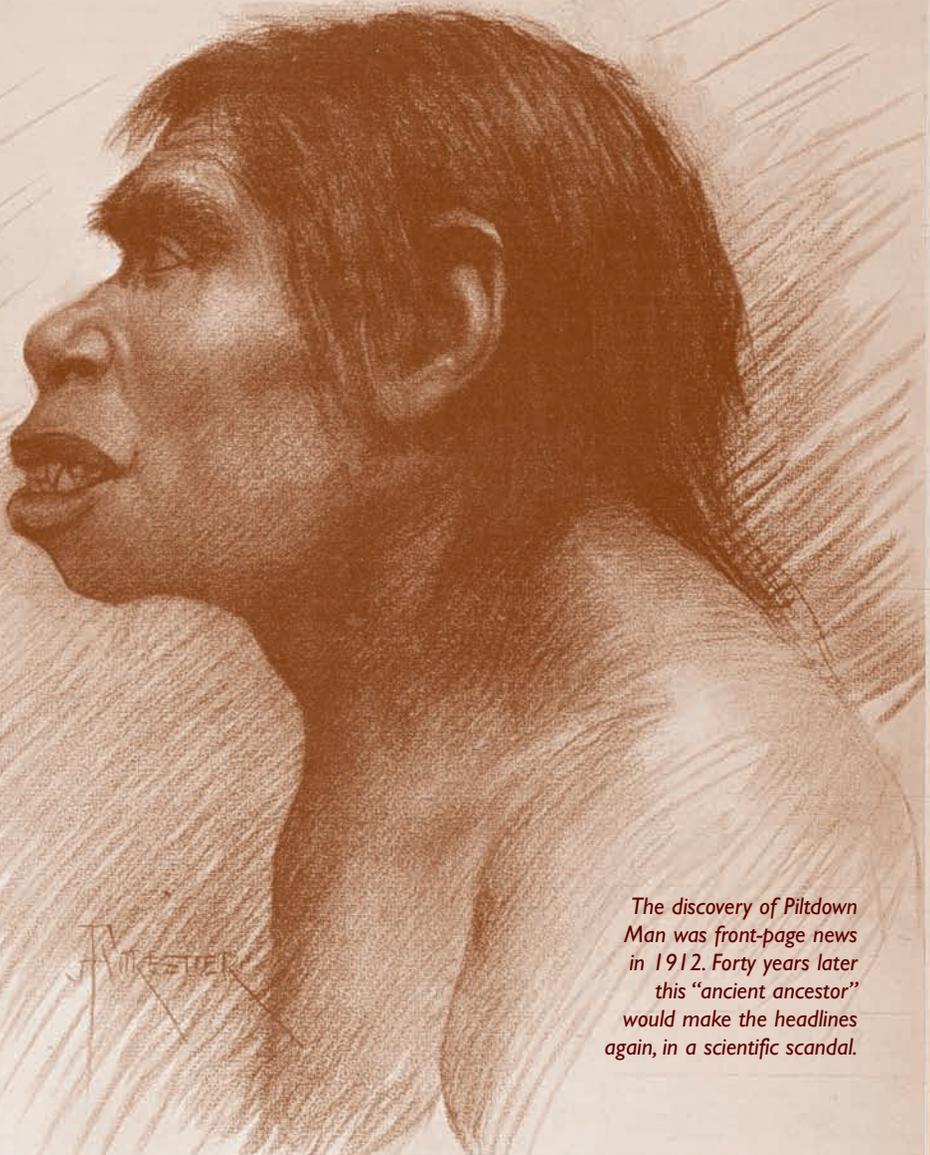
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The discovery of Pittdown Man was front-page news in 1912. Forty years later this "ancient ancestor" would make the headlines again, in a scientific scandal.

ONE 

A Fraud in the Family Tree

Humans, like all living things, evolved into their present form from earlier, ancestral forms that are now extinct. That was the revolutionary insight that Charles Darwin and other scientific thinkers introduced in the mid-nineteenth century. In the late nineteenth century, people started looking for traces of those extinct human ancestors.

Interest in the past was nothing new. Archaeologists had already mapped the tunnels inside the Pyramids of Egypt and unearthed the long-buried capitals of ancient kingdoms in the Near East. The public eagerly devoured news stories of archaeological discoveries such as the stone cities and temples of Angkor in the jungles of Southeast Asia, Great Zimbabwe in the interior of Africa, and Machu Picchu on a South American mountaintop. The last few thousand years of human history were becoming clearer all the time.

The science of paleoanthropology, meanwhile, had been born when researchers turned their attention much further back in time, seeking traces of the earliest humans and the still earlier species that gave rise to them. Slowly at first, a picture of that distant human and prehuman past began to take shape as scientists pored over the first few clues—including the fossils of Piltdown Man, one of the most notorious scientific mysteries of all time.

Confusion over the First Fossil Humans

Before the middle of the twentieth century, people who found fossilized human remains did not know the exact age of these relics. Science had not yet produced the techniques that experts now use to date fossils or

the layers of earth where fossils are found. Placing the remains of early human ancestors in their proper time was a major challenge of early paleoanthropology.

Three years before Darwin published *On the Origin of Species*, for example, workers quarrying limestone in a German cave found pieces of a strange-looking skull and skeleton. We now know that these fossils were the remains of Neanderthal people who lived tens of thousands of years ago. At the time, however, leading scientists declared that the bones came from a deformed or crippled person who had lived in recent times. They failed to interpret the fossils correctly because they did not yet realize that the human species had an ancient, evolutionary origin.

Fossils from Asia were also misunderstood. In 1891, twenty years after Darwin published *The Descent of Man*, a Dutch medical professor and fossil hunter named Eugene Dubois started digging on the Southeast Asian island of Java. Dubois was looking for traces of a “missing link,” a creature partly ape and partly human that would represent a stage of evolution midway between apes and humans. When Dubois found a tooth and part of the skull of an ancient humanlike creature, he called them the remains of “a great man-like ape” and believed that he had fulfilled his quest.⁸

In Dubois’s day, people pictured the missing link as something like a bridge between modern humans and the apes of the modern world, such as chimpanzees and gorillas. Evolutionary scientists now know that the missing link that Dubois sought never really existed. Apes and humans did share a common ancestor millions of years ago, but the two groups have evolved on separate lines ever since then, and humans did not descend from the apes we know today. As you will discover later in this book, Dubois’s Java Man and other ancient hominin fossils from Asia were later recognized as part of the human family. (See *Origins*, the first book in this series, for more about the myth of the “missing link.”)

One other clue to human origins popped up during the early years of paleoanthropology. It was a fossil known as Piltdown Man. First displayed to

the public in England in 1912, Piltdown Man quickly became one of the most famous pieces of bone in the world. Four decades later, it became infamous.

“Dawson’s Dawn Man”

The story of Piltdown Man is a saga of ambition, misplaced patriotism, and scientific trickery. Even the initial discovery of the fossil is shrouded in mystery, because its discoverer and other people who were involved gave accounts that differ in some details.

Charles Dawson, the discoverer of Piltdown Man, was a lawyer in the English county of Sussex. One of his professional duties was managing an estate called Barkham Manor, located in a district called Piltdown. A gravel bed near the estate provided stone for road repairs throughout the area. This gravel bed caught the attention of Dawson, who thought it might contain fossils.

Although Dawson was not a scientist by profession, he was an enthusiastic amateur archaeologist and naturalist. By finding a number of fossils and ancient stone weapons, he had established himself as a well-known scientific figure in Sussex. Along the way, he had gotten to know some famous scientists of the day, including Arthur Smith Woodward, a geologist and paleontologist at the British Museum. Dawson was proud to be an unofficial collector for the museum. He dreamed of scientific fame and yearned to be elected to the Royal Society, Britain’s most prestigious scientific organization.

Sometime around 1908, according to Dawson, workers at the gravel pit told him that they had recently come across an old bone that was round and brown, like a coconut. Unfortunately, they had shattered it with a pickax. A laborer located a piece of the bone for Dawson, who identified it as part of a human skull. Over the next few years he made several trips to the pit, hoping to find more pieces of the broken skull or other fossils like it. In 1911 his patience was rewarded. He spied a larger piece of the same skull sitting on a pile of rain-washed dirt and gravel.

Dawson wrote about his discovery to Woodward, who went to Pilt-down in June 1912 to visit the site with Dawson. Also present was Pierre Teilhard de Chardin, a French priest and paleontologist whom Dawson had met several years earlier while fossil hunting. Later, recalling the day's adventures in a letter to his parents, Teilhard de Chardin wrote, "A man was there to help us dig; armed with picks and sieves, we worked for several hours and finally had success. Dawson discovered a new fragment of the famous skull. . . ."⁹ Piece by piece, the Piltdown skull was taking shape.



Charles Dawson (lower left) lured well-known scientist Arthur Smith Woodward (upper right) to a pit where Dawson claimed to have found part of a mysterious fossil skull.

Excited by this find, Woodward soon returned to Piltdown to help Dawson search the site. It was difficult work. The pieces of fossil bone, stained dark grayish brown from the iron in the soil, looked just like stones. Still, early in the search the two men found more pieces of the skull. "These fragments fitted together perfectly," Woodward recalled.¹⁰ The most spectacular discovery came near the end of June. Years afterward, Woodward remembered the moment:

Mr. Dawson was exploring some untouched remnants of the original gravel at the bottom of the pit, when we both saw the half of a human lower jaw fly out in front of the pick-shaped end of the hammer which he was using.¹¹

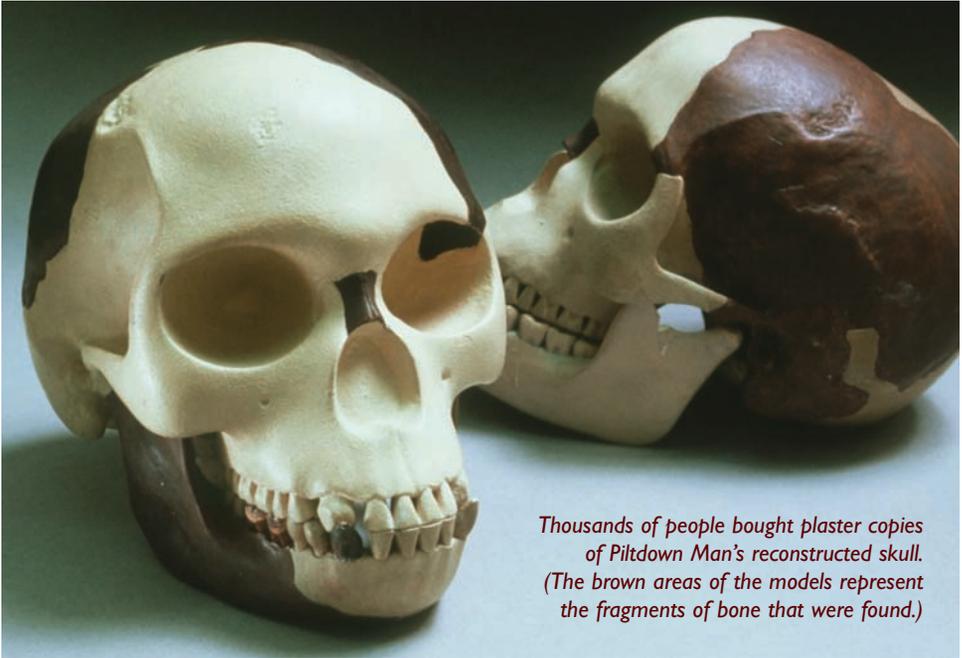
The new find was the right half of a lower jaw, with two molar teeth attached. Woodward had just found another small piece of the skull near the location of the jaw. To find remains of two individuals so close together, Woodward said, would be “startling.”¹² He thought it much more likely that the jaw and skull came from the same individual, but when the two men examined the jaw, they were startled anyway.

The skull pieces looked human. The newly discovered jaw, however, greatly resembled that of an ape—except for the teeth, which looked more humanlike than apelike. The combination of human and ape characteristics was like nothing Woodward had seen before. The Piltdown fossil, it seemed, represented something new and unknown, and possibly older than either the European Neanderthal fossils or Dubois’s Asian fossils. When rumors of the find reached the press, Woodward told a journalist that Piltdown Man “might possibly be found to supply a link between the ape and man.”¹³

After newspapers reported that the “missing link” was missing no longer, interest in the fossil skyrocketed. Woodward and Dawson made the first public presentation of Piltdown Man at a meeting of the Geological Society of London in December 1912. The room was packed.



Dawson and Woodward (both standing at right) look on as expert anatomist Arthur Keith examines the Piltdown skull.



Thousands of people bought plaster copies of Piltdown Man's reconstructed skull. (The brown areas of the models represent the fragments of bone that were found.)

The presentation included a model of Piltdown Man's head that Woodward had fitted together from a total of nine skull fragments and the partial jaw. Based on the reconstruction, Piltdown Man's brain measured about 1,000 cubic centimeters in volume—larger than an ape's brain but smaller than the brains of most modern humans, which range from 1,250 to 1,500 cubic centimeters. Yet the shape of Piltdown's cranium—the part of the skull that contains the brain—was distinctly human. Its jaw, in contrast, was strongly apelike.

In his speech to the Geological Society, Woodward argued that the human evolutionary line must have split into two branches long ago. One branch led to Europe's Neanderthal people, whom Woodward called a "degenerate offshoot" of the human family.¹⁴ The other branch led from Piltdown Man to *Homo sapiens*, or modern humans. Piltdown Man, in other words, was the true ancestor of humankind. Woodward added that the newly discovered ancestor would bear the scientific name *Eoanthropus dawsoni*, which means "Dawson's dawn man."

The Piltdown Problem

Piltdown Man caused a sensation. Plaster casts went on sale; buyers could purchase replicas of the individual fossil pieces as well as of Woodward's reconstruction of the skull and jaw. Scientific journals and popular newspapers published photographs of the reconstruction and artists' ideas of how Piltdown Man might have looked. On December 28, 1912, just ten days after the historic meeting of the Geological Society, *The Illustrated London News* published a drawing of a naked, shaggy Piltdown Man carrying a wooden spear and a stone knife, calling this figure "the most ancient known inhabitant of England."¹⁵



"The first Englishman," as some called Piltdown Man, possessed tools (but not clothes) in this imaginative 1912 drawing.

Patriotic pride accounted for some of the enthusiasm. With Piltdown Man, Britain had produced a fossil of early man that outshone the Neanderthal fossils from Europe and Dubois's "manlike ape" from Asia. In the words of Arthur Keith, an expert in anatomy and the head of a museum at Britain's Royal College of Surgeons, the Piltdown fossils were "the most important [find] ever made in England, and of equal, if not greater importance than any other yet made, either at home or abroad."¹⁶

From the start, however, a few experts raised questions about Piltdown Man. Some wondered whether Woodward's reconstruction was correct. To test it, members of the Royal College of Surgeons used a set of the skull fragment replicas to make a skull that was much more modern-looking, with a larger cranium, than Woodward's version.

A French paleontologist named Marcellin Boule and an American biologist named Gerrit Smith Miller were among those who argued that the skull and the jaw did not belong together. They must have come from two different kinds of beings, a human and an ape. Miller made a detailed study, comparing the plaster casts of the Piltdown fossils with many ape and human jaws and skulls, both fossil and modern. He determined in 1915 that "a single individual cannot be supposed to have carried this [Piltdown] jaw and skull."¹⁷

On the other hand, some of the foremost figures in British science threw their support behind Piltdown Man. Two of them were Arthur Keith and another leading British anatomist, Grafton Elliot Smith. Both men had long promoted the "big brain" theory of human evolution, which said that the evolution from apes to human ancestors started with the brain. Piltdown Man fit neatly into this view. To Keith and Smith, Piltdown was an ancestor whose brain had evolved toward "human-ness" while its jaw (and presumably the rest of its body, although none of that was ever found) lagged behind.

The supporters of Piltdown Man eventually disagreed on several points, including the anatomy of the skull and the question of whether Piltdown

Man was really the ancestor of modern humans. They also debated the age of Piltdown Man. Had he lived a million years ago or only several hundred thousand years ago? Still, they were influential scientists, and they continued to insist that the Piltdown skull and jaw came from a single individual.

Questions and doubts about the Piltdown fossils never entirely disappeared, but a trickle of new finds from the Piltdown gravel beds quieted some of the critics. In 1913 Charles Dawson presented several more small fragments of the skull, while Teilhard de Chardin found a tooth from the lower jaw. Paleontologist Woodward had already described how Piltdown Man's missing teeth must have looked. The tooth Teilhard de Chardin found exactly matched Woodward's expectations.

The following year Dawson and Woodward found something new at Piltdown: a slab of fossilized elephant bone 16 inches (40 centimeters) long that appeared to have been deliberately cut or chipped into a tool of some kind, possibly a digging stick. Because the object resembled the bats used in the English sport of cricket, the newspapers jokingly called it a prehistoric cricket bat.

Soon afterward Charles Dawson, the Piltdown discoverer, became ill. He died in 1916. The following year Woodward announced that before his death Dawson had found an *Eoanthropus dawsoni* tooth and fragments of another skull in a field some miles from the original site. Woodward and several other scientists examined these finds, known as Piltdown II, but the precise location where Dawson had found them was unknown. They were the last Piltdown fossils to come to light.

In the decades after Dawson's death, a scientific tug-of-war pulled Piltdown Man's reputation one way and then the other. At first the reputation of *E. dawsoni* rose as a few doubters joined the ranks of the believers. One of them was Henry Fairfield Osborn, a prominent American paleontologist. Osborn had long criticized Woodward's reconstruction of the Piltdown Man skull and jaw. After examining the fossils in person in 1921, however, Osborn was convinced that Woodward had been right all along. Osborn

declared that “the chinless Piltdown jaw, shaped exactly like that of a chimpanzee . . . does belong with the Piltdown skull . . . !”¹⁸

By the 1930s the public took Piltdown Man’s place in evolutionary history for granted—as shown in *Peter Piltdown*, an American comic strip that chronicled the imaginary adventures of prehistoric life, which began appearing in 1935. Three years later Arthur Smith Woodward and Arthur Keith, early supporters of Piltdown Man, dedicated a stone memorial to Dawson’s discovery in the old gravel pit at Barkham Manor. In 1948 Keith wrote the foreword for Woodward’s book *The Earliest Englishman*, the story of Piltdown Man’s discovery and importance.

Yet for many paleoanthropologists, Piltdown Man had become a bigger problem than ever. Between the 1920s and the 1940s dozens of fossils of ancient humans and humanlike beings turned up in Africa, Asia, and Europe. None of these fossils bore any resemblance to Piltdown Man. As scientists sorted the new finds into species, the overall picture of human origins became clearer—except for Piltdown. One anthropologist later recalled writing a paper on human evolution in 1944, saying that he had “simply left Piltdown out. You could make sense of human evolution if you didn’t try to put Piltdown into it.”¹⁹

Down with “Dawn Man”

By the middle of the twentieth century Piltdown Man no longer held an important place in the growing science of human evolution. Most paleoanthropologists, including the experts at the American Museum of Natural History in New York, regarded Piltdown as an accidental mixture of human and ape remains, with no evolutionary meaning.²⁰ The truth, it turned out, was worse.

Kenneth Oakley, a geologist and paleontologist at the British Museum, had long been interested in finding a scientific method for determining the age of fossils. In the 1940s he experimented with a test to measure the amount of fluorine in fossil bone. Fluorine is found in most groundwater

around the world. Bones and teeth buried in the ground absorb fluorine from the groundwater while becoming fossils. The longer a bone is buried, the more fluorine it absorbs.

Because the amount of fluorine in the water varies from place to place, the rate at which bone absorbs fluorine also varies. For this reason the fluorine test cannot tell an investigator exactly how old a fossil is. It can, however, be used to compare fossils taken from the same location. If the fossils contain equal amounts of fluorine, they are the same age. If one contains more fluorine than the rest, it is older.



Kenneth Oakley scrutinizes a fossil in 1953. Oakley's fossil-dating method spelled doom for one of the ancient humans surrounding his desk.

In 1948 Oakley applied the fluorine test to the Piltdown material and other fossils from the same area. The Piltdown skull and jaw proved to be much younger than all of the other fossils—probably less than 100,000 years old. Five years later, at a scientific conference in London, some scientists got their first look at the Piltdown Man remains. One of them was an anthropologist named Joseph Weiner, who was teaching at Oxford University in England.

After the conference, Weiner mused for a long time on the puzzling details of the Piltdown case. Could the skull and jaw really belong to a “man ape” that lived in England less than 100,000 years ago? If not, was it likely that a human skull and an ape jaw would have been found side by side? Neither of these explanations, Weiner felt, was “at all satisfactory.”²¹ The Piltdown teeth were a problem, too. Although both the jaw and the teeth were ape-like, the teeth were worn down in the way human teeth become worn down through use, not in the way ape teeth show wear. Weiner became convinced that only one explanation made sense of all these unlikely features. Piltdown Man was a fake.

Forgery of a fossil was a shocking idea to a scientist, but Weiner was not the first person to think of fraud in connection with Piltdown. As early as 1914 *Natural History* magazine had reported rumors that the bones were a hoax.²² Weiner, however, was the first to act on his suspicions. He examined a cast of the Piltdown jaw and noticed that the jaw had been broken in such a way that the joint and the chin were missing. This had prevented scientists from comparing these important features with those of apes and humans. Weiner also experimented to see whether he could duplicate the Piltdown teeth. He did so easily by filing some chimpanzee teeth to give them fake wear patterns, then staining them with a chemical that gave them the dark brown look of very old fossils. The experiment made Weiner more certain than ever that Piltdown was a deliberate fraud.

Weiner discussed the matter with Wilfrid Le Gros Clark, an anatomist at Oxford, and the two men shared their concerns with Oakley. Although

Oakley had long believed that the skull and jaw were genuine, he took a fresh look at the original fossils, using a powerful microscope to examine the tooth surfaces. As much as it pained Oakley to agree with Weiner and Clark, he saw that Piltdown's teeth had been artificially filed. Next, new and improved fluorine tests revealed that the skull was older than the jaw and the teeth. Finally, when Oakley drilled a small test hole into the skull, he smelled an odor like burning flesh. The odor meant that the bone still contained organic matter that had not yet become mineralized, or fossilized. The skull could be no more than a couple of thousand years old.

Eventually scientists determined that the broken skull was that of a modern human, although the skull was unusually thick. The jaw was that of a small orangutan, an Asian ape. Its teeth had been filed to make them look as though they had been worn down in a human way, and all of the fossils had been stained with a chemical to make them look old. *Eoanthropus dawsoni*, "Dawson's dawn man," never existed. The elephant-bone "tool" was a fake, too.

In November 1953 Weiner, Clark, and Oakley published a report that called the Piltdown fossils "a most elaborate and carefully prepared hoax."²³ The scientific world was startled and embarrassed, but also relieved. Paleanthropologists no longer had to struggle to explain "the most awkward and perplexing element in the fossil record."²⁴

"Fossil Hoax Makes Monkeys Out of Scientists" screamed the newspaper headlines.²⁵ A cartoon in the British comic journal *Punch* showed an ape seated in a dentist's examining chair as the dentist said, "This may hurt, but I'm afraid I'll have to remove the whole jaw."²⁶

The Piltdown affair had serious consequences for the study of human evolution. For many years, while scientists wasted time and energy trying to understand the Piltdown fossils, they neglected or ignored important discoveries of genuine fossils. Piltdown also made scientists look foolish and incompetent. Even in the twenty-first century, long after the hoax was exposed, people who have religious objections to evolution claim that Piltdown Man proves that scientists are bunglers, or that science cannot answer questions



Who Was the Piltdown Hoaxer?

Piltdown Man, cunningly crafted from a human skull and an ape jaw, passed as a “missing link” in human evolution for more than forty years before scientists proved that it was a forgery. Dozens of books have been written about the Piltdown case, yet the central mystery remains: Who made the fake fossil, and why?

Ever since the Piltdown fraud was discovered in 1953, people have speculated about the hoaxer’s identity. Over the years, several dozen candidates have held the spotlight. Some were well-known scientists in the first half of the twentieth century, including such supporters of Pilt-

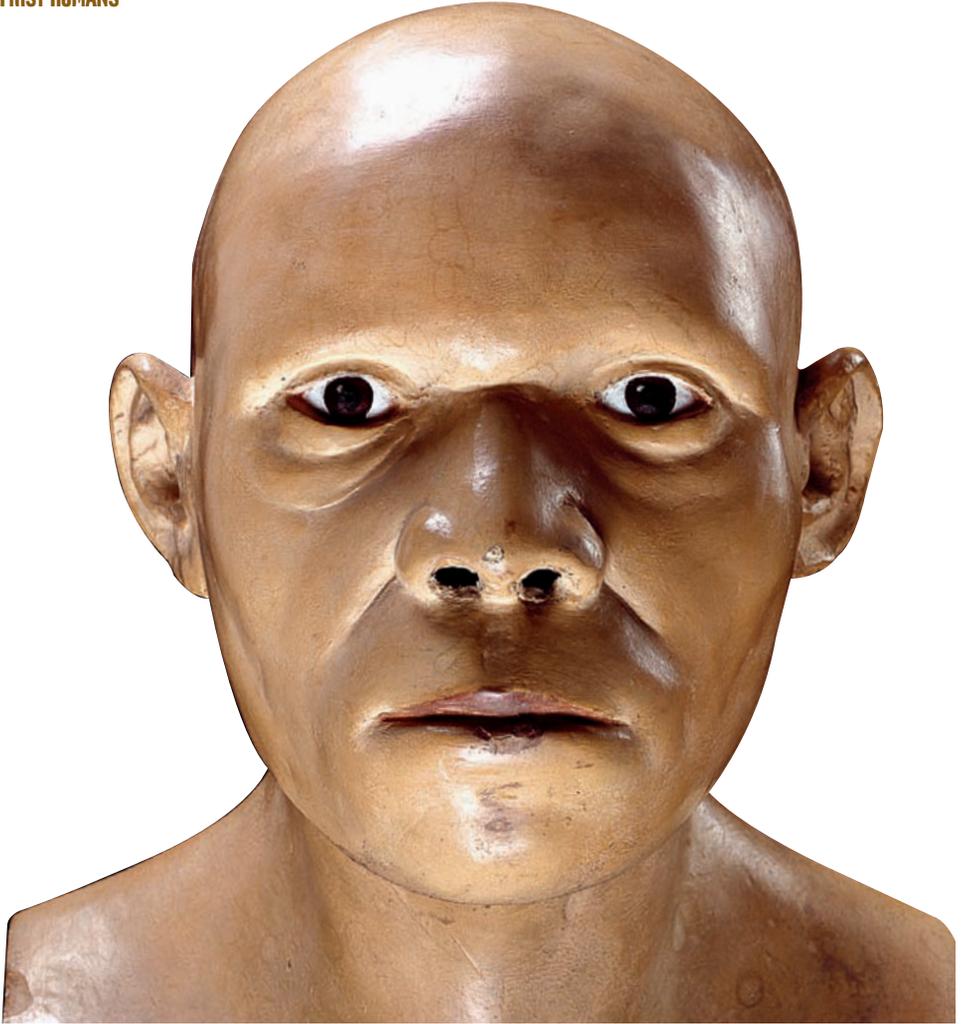
Above: “This may hurt, but I’m afraid I’ll have to remove the whole jaw,” a dentist tells his primate patient in a cartoon about the hoax.

down Man as Teilhard de Chardin, Arthur Smith Woodward, and Grafton Elliot Smith. Martin Hinton, who worked at the British Museum at the time of the Piltdown finds, has also come under suspicion. After his death, teeth and bones that had been carved and stained like the Piltdown forgeries turned up among his possessions. Are these relics signs of Hinton's guilt? Or are they evidence that he had experimented as part of an effort to unmask the culprit? No one knows.

A literary figure has also been accused of being the hoaxer. Arthur Conan Doyle, the creator of the famous fictional detective Sherlock Holmes, lived near Piltdown. Doyle, who believed in communication with the spirit world, is said to have had a grudge against scientists for exposing spirit mediums as frauds. But although Doyle's involvement would make an excellent mystery story, it is unlikely. Doyle lacked the scientific know-how and the materials needed to fake the Piltdown fossils.

In 2003, on the fiftieth anniversary of the discovery of the hoax, British paleoanthropologist Chris Stringer and several colleagues reviewed the case.⁷¹ They concluded that the forger was probably the man who had the most to gain, a figure who many experts agree is the most likely suspect: Charles Dawson, the discoverer of Piltdown Man, who dreamed of scientific fame.

Dawson found nearly all of the Piltdown fossils and was present when the others were found. (Some investigators think that if Dawson was the Piltdown forger, he must have had an accomplice among the scientists.) In recent years, researchers have learned that Dawson was involved in other shady dealings, including forging antiques and plagiarism, which is copying someone else's written work without giving credit. But although the case against Dawson is strong, it is not proof. Unless a signed confession turns up in a dusty trunk in someone's attic, the truth about Piltdown Man may never be known. Speculation about the mystery, however, will surely continue.



This 1950 sculpture gave Piltdown Man an enigmatic gaze. The real enigma is: Who planted the false fossils?

about human origins. In fact, the experts who accepted the Piltdown fossils did make serious mistakes, but those mistakes were eventually set right by other experts who applied critical thinking and scientific methods to the problem. Science is a self-correcting activity. It corrected itself in the case of the Piltdown fraud, although more than forty years had passed.

Why did the fraud succeed? Mainly because the fake fossils from Piltdown fit perfectly into what certain leading British scientists expected. Piltdown appeared to prove the theory that big brains were the first feature to evolve

in human ancestors. Piltdown also appealed to national pride by making England seem like the first home of intelligent, toolmaking human ancestors.

And why did it take so long for the hoax to be exposed? The people who handled the fossils made many simple, preventable mistakes. For example, once a few experts had declared Piltdown genuine, officials at the British Museum failed to test the jaw for the presence of organic material. If they had done so, they would have found that the jaw had not fully fossilized, and they would have known that it was recent, not hundreds of thousands of years old.

The Piltdown affair taught all scientists, not just paleoanthropologists, a painful lesson. They learned that every piece of evidence must be fully and fairly examined, whether it supports cherished ideas or goes directly against them. Fortunately, by the time Piltdown Man was exposed as a hoax, scientists had genuine fossils of human ancestors to study. Since 1924 a stream of discoveries in Africa had been opening new windows into the distant human past.



Nutcracker Man, or Zinj, was a sturdy hominin, with powerful jaws and a ridge above the eyes, that lived in East and South Africa.

“Alongside Man”

Africa would prove to be the birthplace of humankind, Charles Darwin predicted toward the end of the nineteenth century. He was right. As early as 4 million years ago Africa was home to primates that formed part of the evolutionary line leading to humans, even though they had many apelike features.

These creatures were not yet human, but they were on the way to becoming human. Scientists have given some of them the genus name *Paranthropus*, meaning “like man” or “alongside man.” Mary Leakey’s Nutcracker Man, with its enormous teeth and ridged skull, belongs in this genus, which has been called “one of the most remarkable evolutionary experiments in the hominid family.”²⁷

Introducing the Hominin Tribe

In 1924 a South African anatomist named Raymond Dart discovered a fossilized skull that combined a few humanlike features with a lot of apelike ones. Dart named this new species *Australopithecus africanus*, “southern ape of Africa,” but it was not really an ape. It was something new: a being that scientists now call an australopith, or australopithecine.

The australopiths belonged to the hominid family, the scientific category that includes great apes and humans as well as their direct ancestors. Like humans, but unlike apes, the australopiths were bipedal, meaning that they walked upright on two legs. Bipedalism is the reason most experts place the australopiths in a subdivision of the hominid family called the hominin tribe. As hominins, the australopiths are part of the lineage, or evolutionary line, that split away from the apes and eventually led to humans.

Several species of australopiths, dating from about 4 million to about 2.5 million years ago, have come to light in southern and eastern Africa. Most

paleoanthropologists now think that the genus *Homo*, the first true humans, evolved from one of those australopith species. (You can find a detailed account of Dart's discovery in the first book in this series, *Origins*, which tells the story of the australopiths, including Lucy, a 3.2-million-year-old female found in Ethiopia.)

Dart was not the only South African medical man with an interest in early human ancestors. One of Dart's colleagues, a surgeon named Robert Broom, found several australopith fossils in the 1930s and 1940s. Broom made one discovery, though, that did not look like an australopith. In 1938, at a place called Kromdraai in South Africa's Transvaal Province, Broom found the remains of a thick-boned skull that combined some humanlike features with other features that had not been seen before. The skull had broad, heavy cheekbones that would have given it a wide face. Its jaws were huge, and its molars were much more massive than those of any human or australopith. In addition, the Kromdraai fossil had a sagittal crest, a bony ridge running across the top of the skull from front to back. Such crests, which can serve as anchoring points for powerful muscles used in chewing, are seen today in large apes such as gorillas but not in humans.

Broom decided that his find belonged in a separate genus of its own. He created the genus name *Paranthropus* for it, and he gave it the species name *robustus* because it looked robust, or sturdy. Ten years later, Broom found more *Paranthropus* fossils in a South African cave called Swartkrans. He gave these new finds the species name *crassidens* ("thick-toothed"), although experts later grouped them into the *robustus* species with the Kromdraai specimen.

By the middle of the twentieth century, paleoanthropologists were reconsidering Broom's decision to create the genus *Paranthropus*. Most of them now felt that the thick-boned, large-toothed, crested, robust hominins belonged in the genus *Australopithecus* after all. These robust specimens simply represented a distinct species of australopith, one that they called *Australopithecus robustus*. The genus name *Paranthropus* fell out of

use, and scientists started referring to the other members of the genus *Australopithecus* as the gracile, or slender, australopiths to set them apart from the robust species. In this view, all of the known hominin fossils from Africa fell into one genus that included two groups, the gracile australopiths and the robust australopiths.



The bony sagittal crest stands out clearly atop this Paranthropus skull from Swartkrans cave.

Then, in 1959, Mary Leakey found the Nutcracker Man skull in Olduvai Gorge. Later that year, at a scientific conference, the Leakeys unveiled the skull before an audience of paleoanthropologists. “It stole the show,” wrote Donald Johanson, the discoverer of the australopith known as Lucy. “Those who were present can still recall the shiver of astonishment that ran through them when Louis proudly displayed the skull.”²⁸

But while paleoanthropologists marveled at Nutcracker Man, most of them disagreed with Louis Leakey’s decision to create a new genus, *Zinjanthropus*, for it. They believed that Nutcracker Man was simply a new species

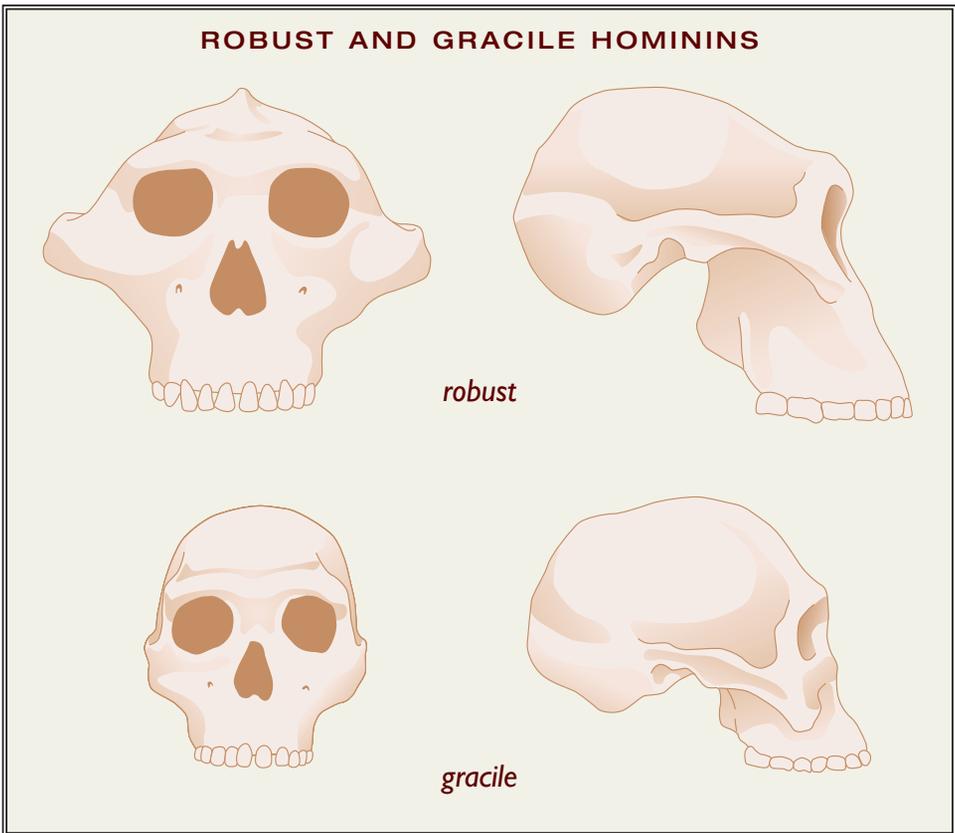
of robust australopith, an East African variety that was even more robust than the robust australopiths of South Africa. In the end, this view won out. Nutcracker Man was reclassified as *Australopithecus boisei*, a new species of robust australopith—although most people still called the Leakeys' fossil by the nickname Zinj.

The Return of *Paranthropus*

During the second half of the twentieth century, researchers digging in southern and eastern Africa recovered more fossils of both gracile and robust australopiths. Paleoanthropologists began taking another look at the two groups of fossils. By the beginning of the twenty-first century, some experts had decided that the differences between the robusts and the graciles went beyond the level of species. Reversing the earlier decision to group graciles and robusts together in a single genus, they revived Robert Broom's old category *Paranthropus* for the robust hominins.

Today experts are about evenly divided on the question. Some of them place robust hominins in the genus *Paranthropus*, while others continue to regard them as members of the genus *Australopithecus*.²⁹ Either way, scientists think that the robust hominins originated in the australopith family. As they evolved distinctive features, they split away to form an evolutionary line of their own. Paleoanthropologists now recognize several species of robust hominins.

***P. robustus* or *A. robustus*.** The first known *Paranthropus* fossils were those of *P. robustus* from South Africa. Remains of this robust hominin have been found at three sites in northeastern South Africa. Most of these remains are fossil teeth or skulls, but there are also a few postcranial remains—a scientific term for body parts below the head. Postcranial remains are a source of valuable information about a species' overall size, appearance, and characteristics. In the case of *P. robustus*, these remains are pieces of arm, leg, and pelvic bones.

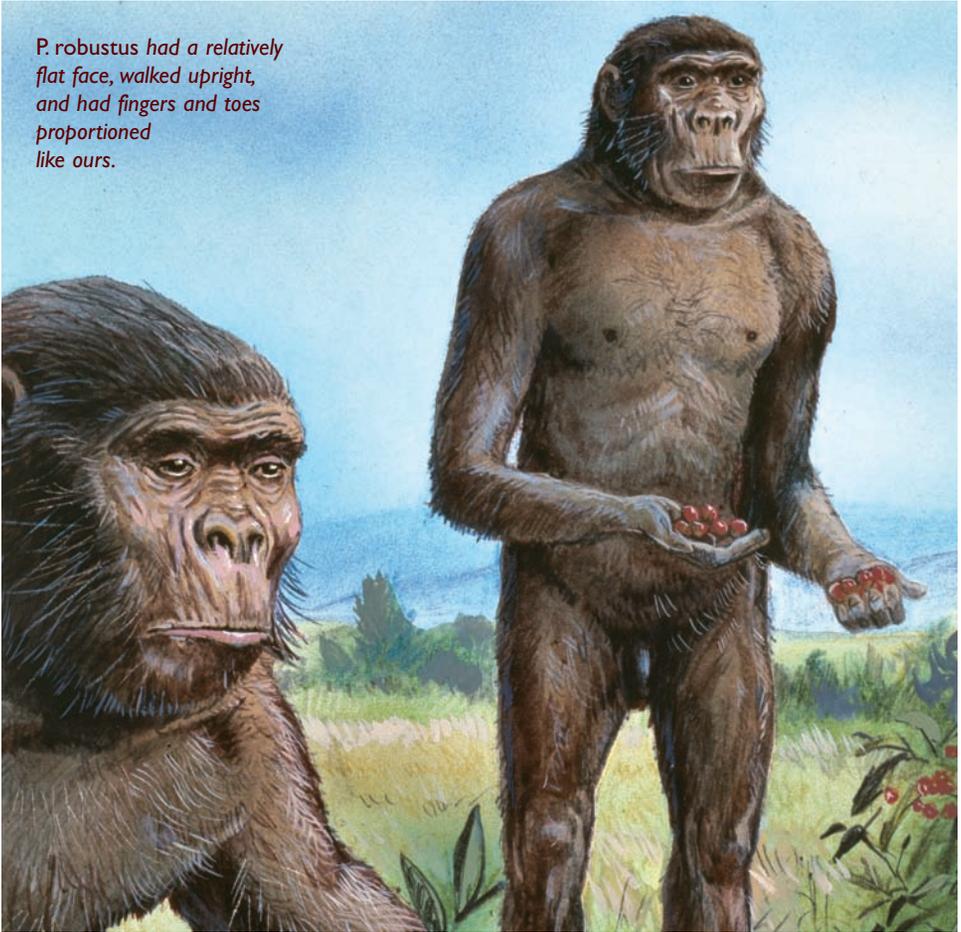


Front and side views of skulls reveal differences between robust hominins and gracile hominins. The robusts were larger overall, with wide cheekbones, big eye sockets, and long faces. The sagittal crest, visible on the robust skull, is never seen on graciles.

The few *P. robustus* fossils that have been found are “strikingly human-like,” in the view of some experts.³⁰ These robust hominins were a little taller than other australopiths but smaller than average modern humans. They reached a maximum height of about 4.5 feet (1.4 meters), but many fossil specimens are a bit shorter than that.

Like the gracile australopiths, the robust hominins were bipeds. They probably walked upright when on the ground but spent a lot of time in trees. Their fingers and toes were proportioned much like those of modern humans. Their jaws did not project forward into snouts or muzzles, as those of modern apes do; instead, their faces were relatively flat, like those of humans.

P. robustus had a relatively flat face, walked upright, and had fingers and toes proportioned like ours.



From the size of *P. robustus*'s jaws and molars, and also from the evidence of strong chewing muscles that were attached to its cheekbones and sagittal crests, scientists think that these hominins were adapted to a diet that included hard foods such as seeds, roots, tubers, and even bark in addition to fruit. Some of these foods are low in nutrition, so the hominins would have had to eat large amounts of them. The robust hominins also probably ate insects and small animals, especially when fruit was unavailable, as apes do today. In turn, the robust hominins were preyed on by the large carnivores that shared their environment. The skull of one young *robustus*, for example, bears holes that exactly match the bite mark of a leopard.

Robustus brains had a volume of about 500 cubic centimeters, significantly smaller than the brains of modern humans but larger than the gracile australopiths’ brains, which measured about 400 cc.³¹ Brain size, however, does not always relate directly to intelligence. For example, modern gorillas’ brains measure about 500 cc and modern chimpanzees’ brains average 400 cc, but this does not mean that gorillas are more intelligent than chimpanzees. Gorillas are simply bigger overall than chimps, so their brains are bigger, too. In the same way, *P. robustus* may have had a slightly larger brain than the gracile australopiths because its overall size was slightly larger.

Scientists have not been able to determine the absolute age of the *P. robustus* fossils. The best estimate, based on the animal fossils found in the same locations, is that *P. robustus* existed between about 2 million and 1.3 million years ago.³²

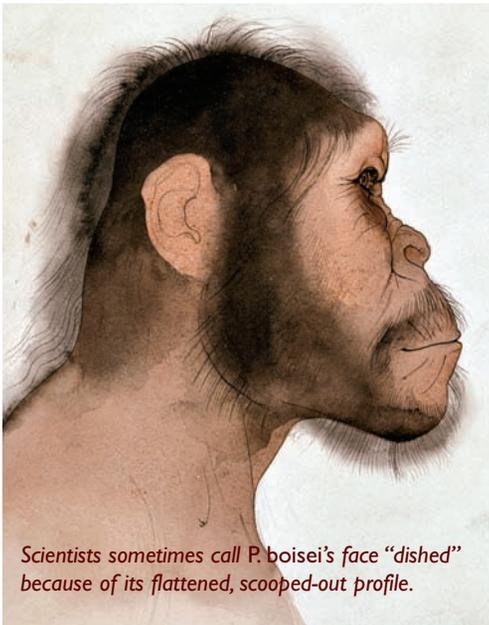
***P. boisei* or *A. boisei*.** Mary Leakey’s spectacular find at Olduvai Gorge in Tanzania introduced a new type of robust hominin, one that some paleoanthropologists describe as hyper-robust, or extra robust, because of its extremely large jaws, molars, and sagittal crest. *Paranthropus boisei*, as Nutcracker Man’s species is called, lived in East Africa between 2.3 million and 1.4 million years ago. Fossils of this species have been found in Ethiopia, Kenya, and Malawi as well as in Tanzania.

As the nickname Nutcracker Man suggests, *P. boisei* was equipped with teeth, jaws, and chewing muscles that would have allowed it to crush and consume hard foods such as nuts and seeds. For a long time, paleoanthropologists assumed that those foods made up *P. boisei*’s diet. To test that notion, researchers in an American study funded by the National Science Foundation used powerful microscopes to examine the marks left on *P. boisei*’s teeth by the foods these hominins ate. The scientists then compared those marks to the signs of wear on the teeth of modern apes and monkeys. To their surprise, the wear marks on *P. boisei*’s teeth closely matched those of modern fruit-eating primates that eat mostly soft foods.³³



The skull found by Mary Leakey (above), an upper jaw from Olduvai Gorge (bottom left), and a lower jaw from Peninj, Tanzania (lower right) are among the scarce remains of the “hyper-robust” hominin Paranthropus boisei.

Paleoanthropologists now believe that *P. boisei*, like a modern gorilla, favored soft fruit over tougher foods such as leaves or seeds. Yet *P. boisei*, again like the gorilla, ate the tougher foods when it could not get fruit. Geological evidence from the fossil sites suggests that these hominins lived in habitats such as lakeshores and open woodlands, where fruit would not have been available year-round as it was in the denser tropical rain forests. The tooth study suggests that although the robust hominins evolved physical features that gave them an impressive chewing capability when they needed it for survival, they did not rely on those features all the time.



The size of the *P. boisei* fossil skulls varies widely, and only the larger skulls have sagittal crests. Sex is a likely explanation for this difference. Many species of plants and animals display sexual dimorphism, which means that there are noticeable differences in morphology, or physical appearance, between male and female individuals. The peacock's brilliant tail feathers are an example of sexual dimorphism—female birds of the same species, called peahens, have no such adornments.

Body size is a common form of sexual dimorphism. Female spiders, for instance, are often considerably larger than males of the same species.

Among gorillas, males are typically much bigger than females—sometimes twice their size. Paleoanthropologists think that the same may have been true of the early hominins. If so, the larger *P. boisei* skulls are those of males. (Size difference between the sexes is much less in modern humans and chimpanzees than in gorillas. Males of these species are, on average, about 15 percent larger than females.³⁴)



A man of the Karo people sits above Ethiopia's Omo River. The world's oldest-known tools were found near here.

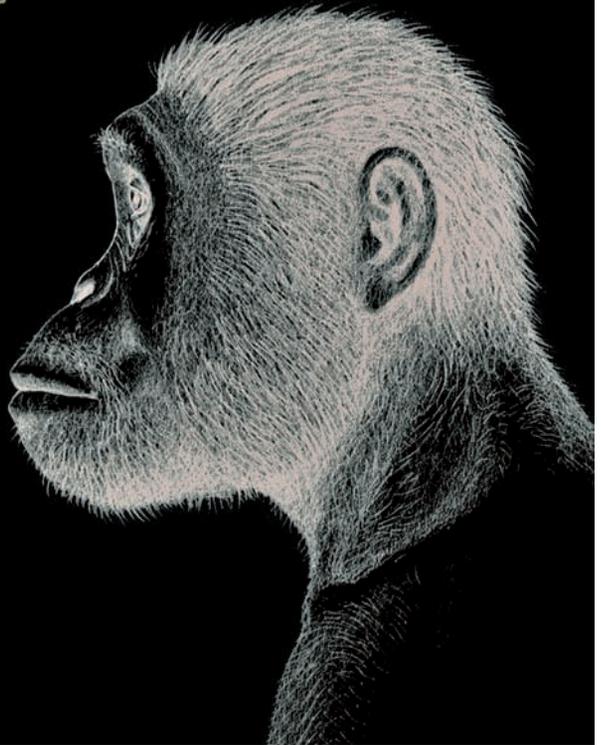
***P. aethiopicus* or *A. aethiopicus*.** In 1967 a French paleoanthropological team found a broken, battered fossil jawbone at a dig site along the Omo River in southern Ethiopia, just north of Lake Turkana. The scientists identified the jawbone as belonging to a new type of hominin, naming the species *aethiopicus* in honor of the country. Nearly twenty years later a team that included Richard Leakey, son of Louis and Mary, was digging on the lake's western shore in Kenya. In 1985 this team made a sensational find: a hominin fossil that has become known as the Black Skull. The skull is generally identified as *P. aethiopicus*, although it is not certain that the skull and the Omo jawbone belong to the same species.

The Black Skull was found between two layers of volcanic ash that can be accurately dated to between 2.3 million years ago and 2.8 million years ago. Scientists think that the skull itself dates from 2.5 million years ago, making it older than the other known species of robust hominins. The skull is not really black, but it is much darker than most fossils of similar age. High levels of the mineral manganese in the soil colored the skull a deep slate gray.

Teams digging in various parts of East Africa have found pieces of fossil jaws, teeth, and arm and foot bones that may belong to *P. aethiopicus*, but the



*In the striking fossil known as the Black Skull, the jaw sticks farther forward, and the tall sagittal crest sits farther back, than in *P. boisei*. The drawing at right gives us an idea of how *P. aethiopicus* looked.*



identification of these bones is uncertain. The Black Skull itself is the most complete *P. aethiopicus* fossil yet found, but, like the majority of hominin fossils, it is incomplete. The lower jaw is missing entirely. The wide, heavy cheekbones and the sagittal crest, however, have been preserved. The lower part of *P. aethiopicus*'s face projects forward, giving this species more of a muzzle than the other two species of robust hominin. *P. aethiopicus*'s braincase is a little smaller than those of *P. robustus* and *P. boisei*.

Life and Death of the Robust Hominins

Scientists have various theories about the evolutionary relationships among the robust hominins. One theory is that *P. aethiopicus*, the earliest known species of robust hominin, evolved new features that moved it away from the main line of australopith evolution. Later the other two species of robust hominins evolved from *P. aethiopicus*. Another theory is that several strains of robust hominins evolved from australopith ancestors independently in different parts of Africa. They developed similar features—such as large molars and jaws—because they adapted to similar conditions. A third possibility is that more than three species of robust hominins existed, but scientists have not yet found fossils of the other species.

Future fossil finds may clarify the history of the *Paranthropus* group, which anthropologist Charles Lockwood has called “one of the most fascinating branches of the human family tree, largely because they reveal to us a radically different way of being hominin.”³⁵ The robust hominins, say Lockwood and other scientists, were “not directly on the human line but well within the hominin group.”³⁶ They are among humankind's extinct cousins.

Our *Paranthropus* cousins disappeared from the fossil record more than a million years ago. What happened to them? Like countless species since the beginning of life, they may have become extinct because of changes in the climate or the environment, or because other creatures, such as monkeys, outcompeted them for food resources. But there is another possibility. *Paranthropus* was not the only hominin in Africa several million years ago.

The robust hominins shared the continent with the first known members of the human genus, *Homo*. Remains of robust hominins and early humans have been found in some of the same African fossil beds. In the words of paleoanthropologists Chris Stringer and Peter Andrews, "The two forms clearly overlapped . . . and then the robusts became extinct."³⁷ Some scientists have suggested that early humans, regarding the robust hominins as prey, hunted them into extinction.

No evidence exists for or against the idea that early humans wiped out their closest relatives. Scientists are still learning about the early human species that flourished after the robusts vanished from the scene. Mary Leakey's Nutcracker Man skull had launched a new era in the study of robust hominins. A few years later, another Leakey find from Olduvai Gorge started a debate about the origins of true humans.

THREE

Olduvai and Beyond

Tucked into a corner of northern Tanzania is a time machine called Olduvai Gorge. It is a dry river canyon that lets scientists travel through the past 2 million years of geological and paleontological history. From Olduvai Gorge and other sites in East Africa have come stone tools and fossil bones that are the oldest traces of the genus *Homo*. These extinct hominins, our close relatives, used tools, migrated out of Africa, and eventually gave rise to our own species. Scientific efforts to uncover the history of early *Homo* started with a controversial discovery at Olduvai.

The Making of Olduvai Gorge

Two million years ago a broad, salty lake spread across what is now northern Tanzania. East of the lake rose Ngorongoro, a massive volcano. Smaller volcanoes dotted the landscape all around. West of the lake stretched a sweep of open woodland, where spreading belts of grassland were gradually replacing stands of trees. Today that vast grassland is called the Serengeti Plain.

The ancient lake changed many times over the years, growing and shrinking in response to changes in rainfall and climate. Eventually it dried up. All this time, lava and ash from volcanic eruptions coated the area. Sand and dust blew in on the wind, adding to the layers of sediment. Small streams flowed over the land and deposited still more sand, along with the bones of creatures that had died in or near the water.

Around a half million years ago, movements of Earth's crust shifted the

course of a nearby river, sending it flowing across the land that had once been the ancient lakeshore. In time the river carved a gorge about 30 miles (50 kilometers) long and up to 330 feet (100 meters) deep. A smaller stream flowed into the river from the south, carving a side gorge of its own. Both waterways later disappeared, leaving a Y-shaped canyon consisting of the main gorge and the side gorge. The gorge walls were like thick slices of layer cake, made up of many bands of sediment that had been deposited by the lake, the wind, the river, and the volcanoes.

The top of the gorge represents the present day. As scientists descend into the gorge, they travel back through time. By the time they reach bedrock on the bottom of the gorge, they are standing on the ancient lakeshore. The layers of rock that rise around them, and the fossils in the rock, tell the story of the region's climate, geology, and life for the past 2 million years.



Seen from above, Olduvai Gorge stretches like a scar across the plains of northern Tanzania. Many important discoveries about human origins have emerged from this canyon.

Man the Toolmaker

Science discovered Olduvai Gorge in the early twentieth century. By 1913 several German fossil hunters had recovered hundreds of fossils, including the remains of extinct animals such as a three-toed horse, from the gorge. One of the Germans, a geologist named Hans Reck, received a visit in Berlin in 1929 from Louis Leakey, a young archaeologist and anthropologist who had been born in Kenya and educated in England.

Leakey was especially interested in early humans, and he had studied the tools and other artifacts left behind by prehistoric cultures in Africa and Europe. Among the fossils that Reck had brought back from Olduvai, Leakey spotted an ancient stone tool that he recognized at once. It was an Acheulean hand ax.

The Acheulean hand ax was one of the most widely used and long-lasting pieces of technology ever created. Named for Saint-Acheul, a location in France where many examples were found during the nineteenth century, the hand axes were flattish, fist-sized pieces of stone, usually oval or teardrop shaped, that had been made into tools by early humans. Using other rocks called hammer stones, the toolmakers chipped flakes off the ax to create a sharp edge on both sides. Gripped in one hand, the resulting tool could be used to cut or chop. Acheulean hand axes first appeared at least 1.5 million years ago; some researchers now suggest even earlier dates, such as 1.8 million years. The hand axes continued to



An Acheulean hand ax and a hammer stone (upper right).

be made and used for more than a million years before toolmakers replaced them with other types of stone tools.³⁸

At the time Leakey saw Reck's fossil collection, no one knew for sure how old the Acheulean hand axes were. Scientists had not yet developed the tools and techniques they now use to date sediment layers, fossils, and artifacts. (See the first book in this series, *Origins*, for a description of these dating methods.) The experts of the 1920s knew only that the axes were the oldest known tools.

Tools were seen as an important milestone in human evolution. Before Piltdown Man, many experts had thought that big brains were the trait that defined true humans, but they also assumed that two other key human traits—walking upright and making tools—evolved around the same time as big brains, or soon afterward. In this view, increased brainpower triggered the other changes that turned hominins into humans. But after Piltdown, when experts turned their attention to the australopith fossils, they realized that bipedalism had evolved long before brainpower. The australopiths had walked upright, with brains no larger than those of apes, for a long time.

A new picture of human evolution took shape. “Human-ness” did not evolve all at once, as though an apelike hominin walked through a doorway and emerged on the other side as something recognizably human. Instead, different aspects of human-ness evolved separately over long periods of time. The australopith fossils showed the order in which bipedalism and big brains had evolved. What about the third trait, tool use?

Humans are not the only tool users. Otters strike clams against rocks to crack the shells and get at the meat inside. On New Caledonia, an island in the western Pacific, crows grip twigs in their beaks and use them to “fish” for the larvae of insects. Among modern primates, chimpanzees fish for termites with sticks, and orangutans scoop up drinking water with leaves.³⁹ But the making of stone tools for particular purposes seems to be a hallmark of humankind. In the nineteenth century archaeologists coined the term *Stone Age* to refer to a long phase of human technology when tools



Tool use is well documented in some modern primates. This chimpanzee in the West African nation of Gabon is using a leaf as a cup or sponge, to carry water to its mouth.

were made of stone, before people learned to work metal. The Stone Age began with the making of the earliest stone tools, the first durable technology created by humans.

When did toolmaking evolve in the human lineage? Louis Leakey wanted to answer that question. After seeing the Acheulean hand ax in Reck's collection, Leakey was certain that he could find more tools at Olduvai. Two years later, accompanied by Reck, he led his first expedition to the gorge. It was the first of many visits. Over the years Leakey, aided by African fossil hunters, visiting scientists, and his own family, searched the gorge for keys to the distant human past.

Oldowan Tools and the Handy Man

Leakey did find Acheulean hand axes at Olduvai. He also found a completely different group of stone tools that came from deeper in the gorge, which meant that they were older than the hand axes, and older than any other tools ever found. Smaller and simpler than hand axes, these early artifacts have been called Oldowan tools, from a form of *Olduvai*. They are also known as pebble tools because they consist of rounded pebbles, or cobbles, with an edge created by chipping away one or more flakes with a hammer stone. The flake could be used for cutting; the edged pebble made a chopper or a cutting tool. Both have been found near fossil animal bones that bear marks of having been cut with the tools.

Oldowan tools were later found at sites even earlier than the bottom of Olduvai Gorge. The most ancient ones have come from locations along Ethiopia's Gona River that Ethiopian anthropologist Sileshi Semaw calls "the oldest known archaeological sites in the world."⁴⁰ These tools were made between 2.5 million and 2.6 million years ago.



These Oldowan pebble tools from Olduvai Gorge are about 1.8 million years old.

Yet Louis Leakey was the first to find Oldowan tools, and his quest to find the toolmakers led to further discoveries at Olduvai. First came Nutcracker Man in 1959. Then, over the next few years, a series of other hominin fossils turned up in the gorge. In 1964 Leakey and the other scientists on his team identified these partial skulls, jaws, and scattered post-cranial remains as a new species, *Homo habilis*, meaning "handy man" or "skillful man." Leakey was convinced that his new species was the Oldowan toolmaker. In his opinion, it was not only human—the oldest member of



New Views of the Old Stone Age

Humankind has spent most of its existence in the Stone Age. During this long phase of cultural development, the most durable pieces of technology were crafted by hand from stone. The earliest known tools, the Oldowan artifacts from Africa that are 2.5 million or 2.6 million years old, mark the beginning of the Stone Age. The Stone Age ended when people learned to work metal and started making tools and other artifacts out of copper, bronze, and later iron. That shift took place at varying times in different cultures and regions of the world, but it generally occurred between 8,000 and 4,000 years ago.

Above: Parallel lines on a fossil bone from Olduvai Gorge were left by a sharp-edged pebble tool. The tool user remains unknown.

The Paleolithic, from the Greek words for *old* and *stone*, is the earliest—and by far the longest—part of the Stone Age. It stretches across time for several million years, from the first Oldowan tools to the end of the Pleistocene geological epoch about 10,000 years ago.

Scientists have divided the Paleolithic into three periods. Each period in turn is divided into stages based on different industries, or sets of stone tools and types of toolmaking. The three periods of the Paleolithic are the Lower, Middle, and Upper, reflecting the fact that in archaeology and paleoanthropology, the deeper an artifact is found in an excavation, the older it is. The earliest industries, the Oldowan and Acheulean tools made by the ancestors of modern humans, belong to the Lower Paleolithic period, the oldest part of the Old Stone Age.

The division of prehistory into ages of stone, bronze, and iron, and then the division of those ages into periods and industries, was the work of European historians and archaeologists. The system was well established by the late nineteenth century, and it is a useful tool for talking about periods of human existence before the invention of writing and recorded dates. Yet modern archaeologists and anthropologists point out that the three-age system has some weaknesses. The transitions between ages did not happen overnight; people in many parts of the world continued to use stone while also experimenting with metal. And because the three-age system is based on durable stone and metal artifacts, such as tools and weapons, it does not take into account other aspects of human life—such as social organization, use of resources, art, and beliefs—that reveal a lot about human cultures.

Durable artifacts, however, are sometimes all that remain, especially when researchers peer far back into prehistory. The human ancestors who created Oldowan and Acheulean stone tools in the Lower Paleolithic may have made artifacts out of wood, woven grass or leaves, or animal skins, but if they did so, none of their perishable creations has survived the millennia. We know these early humans only by their stone tools.

the genus *Homo* yet found—but also an ancestor of modern humans.

Not everyone agreed with Leakey about *H. habilis*. One problem with the *H. habilis* fossils was that they came from the same levels of the gorge as fossils of *P. boisei*, the robust hominin. Leakey had found certain hand and foot bones that he felt belonged with the jaws, teeth, and skull fragments that he had identified as *H. habilis*, but some scientists thought that those postcranial bones might really belong to *P. boisei*.

Even if all of Leakey's *H. habilis* fossils did belong to the same species, did that species truly belong in the genus *Homo*? Or could it be a new type of australopith or robust hominin? Finally, even if *H. habilis* did belong in *Homo*, was it an ancestor of modern humans, as Leakey believed, or an evolutionary side branch?

Paleoanthropologists still debate those questions. Many think it is unlikely that all the different fossils that various researchers have labeled *H. habilis* really belong to a single species, because these fossils show a wider range of variation—especially in brain size and skull shape—than other hominin species, including modern humans. Most experts, though, now recognize *Homo habilis* as a species, even if they question the identification of certain fossils.

Scientists use the term *holotype* or *type specimen* for a fossil that becomes the basis for defining a species. The *H. habilis* holotype was uncovered in Olduvai Gorge by Leakey and his colleagues. Its official name is OH 7, but the Leakeys called it Jonny's Child because their son Jonathan found it.

OH 7 consists of a lower jaw with teeth, several pieces of a skull, a tooth from an upper jaw, and more than twenty finger, hand, and wrist bones. A nearby fossil foot may belong to the same individual, who was twelve or thirteen years old at the time of death.⁴¹ From these broken remains scientists have learned that *H. habilis* had more humanlike teeth than the australopiths or robust hominins. *H. habilis* was a little shorter and less heavily built than *Paranthropus*, but it had a slightly larger brain.⁴² It was bipedal.



A female Homo habilis, as reconstructed by model-makers at the Science Museum of Barcelona, Spain

THE HANDY MAN'S HAND AND FOOT



The anatomy, or structure, of Homo habilis's hand and foot. The dark areas represent bones that researchers have found. Scientists have relied on anatomical knowledge—and a pinch of guesswork—to create the light areas.



The hands of *H. habilis* are especially interesting to paleoanthropologists, because they show physical features that might have helped with tool-making. *H. habilis*'s hands are a mix of human and apelike characteristics. The fingers are curved like a chimpanzee's, but they end in broad fingertips like a human's. Anatomists who have studied the hand and finger bones think that OH 7 could perform a human movement called a precision grip, which is pressing the fingertips against the thumb with pressure and control. The evolution of the precision grip was an important step toward complex toolmaking. Chimpanzees are stronger than humans, but the precision grip lets humans hold and manipulate objects more delicately yet forcefully than chimpanzees can manage.

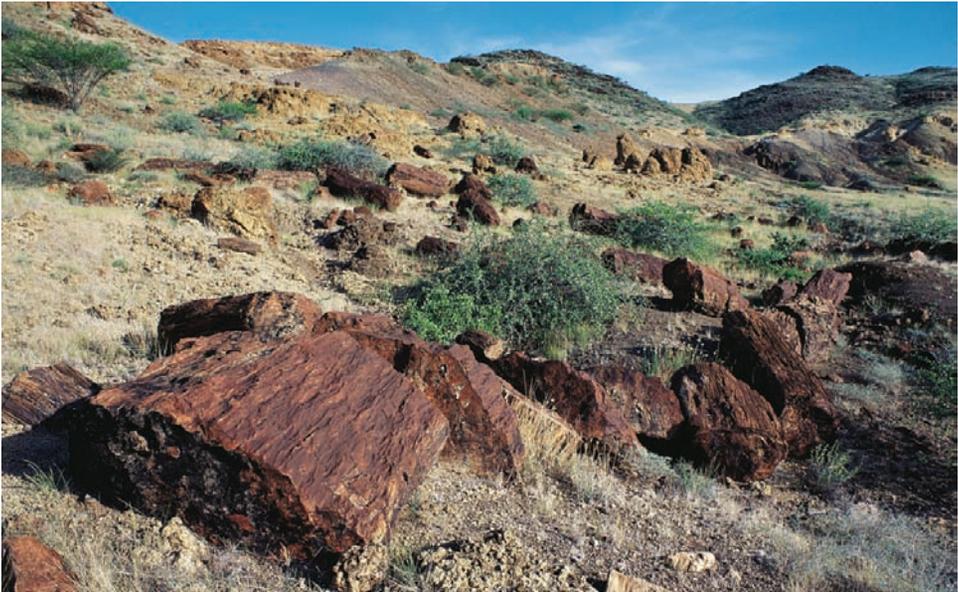
Discoveries at Koobi Fora

The holotype fossils of *H. habilis* came from Olduvai Gorge, but many important specimens of *H. habilis* have come from a different East African site, a place called Koobi Fora. Pioneered by Louis and Mary Leakeys' son Richard, Koobi Fora has produced a stream of fossils from several species of early human.

In 1967 Richard Leakey was twenty-three years old and a junior mem-

ber of a paleoanthropological expedition working along the Omo River in southern Ethiopia. One day he took a helicopter ride to scout for a place where he could work independently. That flight has been called “the most fateful ever taken by a fossil hunter.”⁴³

Leakey flew south from Omo along the eastern shore of Lake Rudolf (now called Lake Turkana) in Kenya. He landed in an area known as East Turkana, a region of rock and soil that has been heavily eroded by wind and water—just the kind of place that attracts fossil hunters. Stepping out of the helicopter, Leakey discovered “a desolate Plio-Pleistocene landscape that was littered with fossils.”⁴⁴



In East Turkana, scientists don't always have to dig to find relics of ancient plants and animals—some fossils lie on the surface.

The East Turkana badlands are made up of layers of sediment from two recent geological stages in Earth's history: the Pliocene epoch, from 5.3 million to 1.8 million years ago, and the Pleistocene epoch, from 1.8 million to about 10,000 years ago. During these epochs the area was home to many animals whose remains became fossilized in the sediments. Some of them, Leakey soon learned, were hominins.

Koobi Fora, a spit of land sticking out into the lake, became Leakey's base of operations in 1968. Today it is part of Kenya's Sibiloi National Park, where scientists excavate and study fossils through the Koobi Fora Research Project. In the early years of Richard Leakey's work there, he organized some of the African expedition members into a highly skilled team of fossil hunters who discovered most of the several hundred hominin fossils that have been found in East Turkana. Kamoya Kimeu, who later became a museum official in charge of hominin sites throughout Kenya, was one of the most successful of these fossil hunters. In 1973 Kimeu made a major contribution to the study of human evolution when he found a 1.9-million-year-old *H. habilis* skull at Koobi Fora.

One year earlier another of the Koobi Fora fossil hunters, Bernard Ngeneo, had found a hominin skull as old as Kimeu's find. But KNM-ER 1470, as Ngeneo's find was labeled, did not look like a typical *H. habilis* skull. It was larger, with a longer, flatter face and bigger teeth. Overall, the skull looked more like modern humans than *H. habilis* did. A reconstruction of the skull by anthropologist Meave Leakey, Richard Leakey's wife, gave a brain size of 752 cubic centimeters, more than half the size of an average modern human brain.

By the mid-1980s some scientists had decided that skull 1470, together with a single jawbone found separately, represented a new species of early *Homo*. This new species received the name *H. rudolfensis* in honor of Lake Rudolf, although by that time the lake's name had changed to Turkana. Some paleoanthropologists, however, felt that the two fossils did not add up to sufficient evidence for a separate species.

New questions about *H. rudolfensis* arose in 2007, when an anthropologist at New York University presented his own reconstruction of skull 1470. Using a moldable cast and computer models of the skull, Timothy Bromage based his version of 1470 on data about how mammals' eyes, ears, and nostrils are arranged in relation to one another. Bromage's model differed significantly from the model that scientists had studied since the

1970s. The face jutted forward in a more apelike way, and the brain measured only 525 cubic centimeters.

Bromage's findings are controversial. Some experts feel that while Bromage might have been right to reshape the face, he made a mistake in reducing 1470's brain size. According to anthropologist Robert Martin of Chicago's Field Museum, "It's probably right that the face should stick far more forward. But to say that because they've changed the angle of the face, the brain size has to get smaller doesn't make any sense."⁴⁵ Only further review by the scientific community will determine whether Bromage's theories about skull 1470 gain acceptance.

Mysteries of Early *Homo*

Some questions about the first members of our genus are difficult to answer in the current state of scientific knowledge. One of those questions is: How old is the genus *Homo*?

The most complete fossils of *H. habilis* and *H. rudolfensis* are a bit less than 2 million years old. Older remains of *Homo* have been found in East Africa, but it is hard to assign them to species because they are just fragments. A piece of skull from Kenya, a jawbone from Malawi, and an upper jaw from Ethiopia date from 2.4 million to 2.3 million years ago, for example, but these fossils are often described simply as "early *Homo*" without being assigned to a particular species.⁴⁶ Most paleoanthropologists think that the first *Homo*



Louis Leakey thought this partial foot came from an adult H. habilis. Others believe it represents an adolescent of the species.



Remains of both *P. boisei* (left) and *H. habilis* (right) were found in Bed I, the oldest level of Olduvai Gorge, which means that the two species lived in the same place at about the same time.

species, usually identified as *H. habilis*, appeared around 2.5 million years ago and lasted for nearly a million years before disappearing from the fossil record.

Another unanswered question is whether different kinds of hominins had anything to do with each other. The robust hominin *Paranthropus boisei* lived in East Africa at the same time as early *Homo*. Fossils of *P. boisei* have been found in Olduvai Gorge, Koobi Fora, and other places that have also yielded fossils of *H. habilis* (or *H. rudolfensis*). This tells us that the two kinds of hominins overlapped—but did they also interact? Did they fight and prey on each other? Or were they so different that they did not compete for food or places to live and rarely took notice of each other?

Tools are another mystery. The Gona River tools from Ethiopia are just a bit older than the earliest known *Homo* fossils. Could they have been made by something other than *Homo*? Oldowan tools have been found in

the same sediment deposits as fossils of *Paranthropus boisei*, the robust hominin with a brain about the size of a chimpanzee's. To complicate matters, during the 1990s researchers in Ethiopia found the 2.5 million-year-old remains of a new species of hominin called *Australopithecus garhi* not far from fossilized animal bones that showed signs of having been cut with stone tools, although the tools were not found. (*Origins*, the first book in this series, has a more detailed account of this discovery.) Did *A. garhi* wield the tools that made those cut marks? No one knows.

P. boisei and *A. garhi* had brains a little larger than those of modern chimpanzees and bonobos. An Indiana University researcher named Nicholas Toth decided to see if a modern ape could learn to make an Oldowan-style tool. Toth showed a bonobo named Kanzi how to use a hammer stone to chip a flake off a pebble, creating a sharp edge that could be used to cut the string around a box of food. Kanzi grasped the point of the experiment, but



A bonobo uses two rocks—one as a hammer and the other as an anvil—to open hard-shelled nuts. No modern ape, however, has been known to shape a stone tool.

he could not make a sharp-edged flake using the hammer stone. Eventually, though, Kanzi found a different way to get the blade he needed to cut the string. He hurled stones on the floor until one of them broke in a way that made a sharp flake.⁴⁷

The experiment proves that modern bonobos have some problem-solving skills and can learn new things by watching others, but it does not tell us whether australopiths or robust hominins could have been toolmakers. The nerves, bones, and muscles in the hominins' hands would not have been identical to those of a modern ape. The hominins' brains—particularly the parts of the brain responsible for planning actions and for controlling hand movements—were probably different as well.

Some paleoanthropologists agree with Louis Leakey, who thought that all of the Oldowan tools were made and used by early *Homo*. If other East African hominins were also tool users, there is no solid evidence of it. Also lacking is clear evidence of exactly how the early toolmakers used their choppers and cutters.

Marks on animal bones show that early hominins used Oldowan tools for two things: cutting meat from carcasses, and smashing bones to expose the nutritious marrow inside them. Scientists do not know, however, whether the hominins hunted and killed the animals, or simply scavenged meat and bones from dead animals that had been killed by predators such as hyenas or leopards. On some bones, the cut marks appear to lie on top of predators' bite marks, meaning that the hominins cut meat from an animal already killed by a predator. This suggests some degree of group cooperation among the scavengers, for it would take more than one puny hominin to drive a large predator away from its kill. Other bones have cut marks but no predators' bite marks, which could mean that hominins killed this prey and then butchered it. Either way, the use of stone tools to cut meat from carcasses gave the early toolmakers a broader diet, richer in animal protein from meat, than hominins had ever eaten before.

H. habilis and *Paranthropus* were not the only hominins in Africa almost 2 million years ago. Another hominin shared their landscape of grasslands, open woodlands, and lakeside wetlands. This hominin was clearly a member of the genus *Homo*. Almost as tall as modern humans, it walked and ran with a more modern gait than any of the other early hominins. Some scientists call this tall hominin *Homo ergaster*, while to others it is *Homo erectus*. It originated in Africa, and then it became the first hominin to migrate beyond that continent. *Homo erectus* became known to science, in fact, through fossils found far from Africa, in the tropical river valleys of Southeast Asia and the hills of northern China.



An early member of the human genus called Peking Man lived in China for about three-quarters of a million years.

FOUR

Ancient Asians

Africa, the source of the oldest known fossils of human ancestors, is now known to be the birthplace of humankind. But for a few decades in the late nineteenth and early twentieth centuries, many scientists thought that Asia was the human birthplace, and some of them searched for fossils to prove it. In Asia they found traces of *Homo erectus*, a branch of the human family tree that flowered long before modern humans, but long after our earliest ancestors. Around 2 million years ago *H. erectus* began spreading from Africa to Asia, where the species continued to evolve. Much of what we know about these human relatives comes from the Asian fossils.

Lucky . . . But Wrong

One of the nineteenth-century scholars who believed that Asia would prove to be the source of the human race was a German biologist named Ernst Haeckel. Scientists now know that the closest living relative of human beings is the chimpanzee, an African ape, but Haeckel believed that our closest relative was an ape called the gibbon, which lives in Southeast Asia.

Haeckel concluded that Southeast Asia must also have been the home of the prehuman ancestor of the human race. He even coined a name for this unknown species, although no trace of it had yet been found (modern biologists frown on the practice of naming nonexistent species). Haeckel called this supposed ancestor *Pithecanthropus alalus*, which means “ape-man without speech,” because he regarded language as the distinguishing characteristic of true humans. His ideas greatly influenced Eugene Dubois, the Dutch medical professor who in 1889 went to Southeast Asia to find fossils of the “missing link.”



Evolutionist Ernst Haeckel in the “tropical” setting of a photo studio.

Dubois was not particularly well qualified for the task. As paleoanthropologist Donald Johanson puts it:

What are the odds that a young Dutch anatomy professor who scarcely knew anything about fossils, who had never actually seen a [hominin] fossil, who had never been outside Holland, could go halfway around the world to a place where no fossils had ever been collected, just on a logical hunch, and find something?⁴⁸

The odds in Dubois’s favor were slim. Still, over the objections of his family and the advice of his colleagues, Dubois set off for Indonesia, which at that time was a Dutch colony. He got a job as a military doctor on the island of Sumatra, where he explored caves but

found no promising fossils. Two years later Dubois fell ill with the mosquito-borne disease malaria and was sent on sick leave to the nearby island of Java. There he almost immediately found fossils at a place called Trinil, on the bank of the Solo River.

The sediments at Trinil yielded a stream of fossils, especially after the Dutch colonial government assigned convicts to work for Dubois as diggers. Dubois discovered some extinct species of mammals, but no fossils of primates—the order of mammals that includes monkeys, apes, and humans.

Then, in 1891, Dubois's luck changed. He found a primate molar and a primate skullcap, which is the top surface of the skull. About 50 yards (45.5 meters) from the skullcap, Dubois found a femur, or thighbone. It was a primate thighbone, and its shape showed that it came from a species that walked on two legs, like a human.

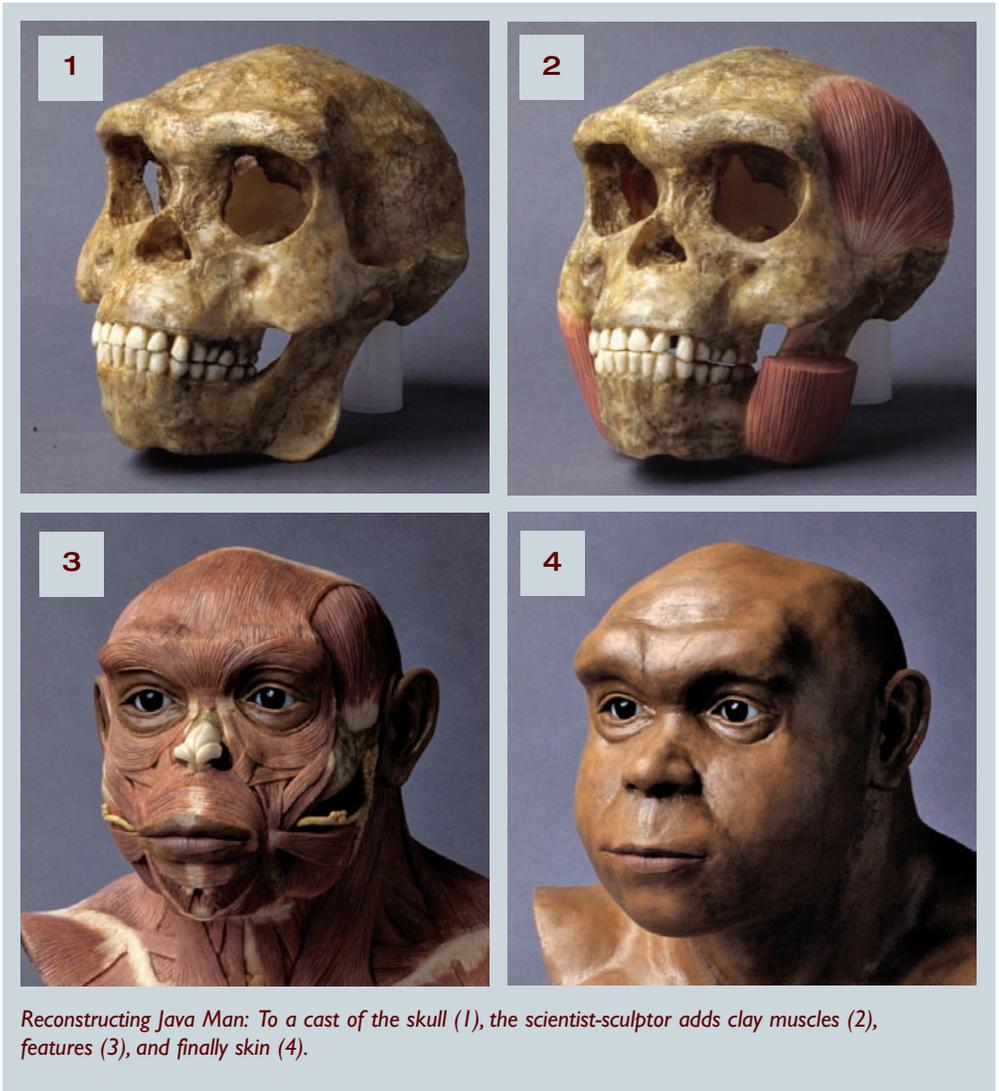
Convinced that he had found the remains of a “manlike ape,” a creature partly ape and partly human, Dubois returned to Europe with his fossils. He named the newly discovered species *Pithecanthropus erectus*, or “erect-walking apeman.” Dubois had been amazingly lucky to find the primate fossils he sought. Unfortunately, he was wrong about their meaning.

Java Man

For years Dubois engaged in bitter controversies with other scientists, trying to convince them that his fossils represented the “missing link.” At first experts doubted Dubois's claim that all of the fossils came from the same individual, or even the same species. Many thought that Dubois had lumped together an ape's skull with the femur of a human being.

Then Arthur Keith, the English anatomist who would later throw his support behind Piltdown Man, analyzed the Java fossils. Keith came to the conclusion that the fossils represented an early form of human, not an apeman. Keith's verdict infuriated the stubborn Dubois, who refused to give up the idea of the “missing link.” According to paleoanthropologists Noel Boaz and Russell Ciochon, authors of a history of early humans in Asia, Dubois “was generally thought to have gone a bit insane in his advanced years.”⁴⁹ He eventually hid the Java fossils under the floorboards of his house and refused to discuss the matter further.

Java Man, as Dubois's find came to be called, had a brain that was smaller than a modern human brain but larger than the brain of any known ape. Java Man also had a heavy brow ridge, a thick growth of bone that would have given its forehead a bulging appearance above the eyes—a feature not seen in modern humans. The fossil molar was humanlike, and the



thighbone suggested that Java Man stood about as tall as the average modern human. Arthur Keith was right to conclude that Java Man was an early form of human, but without more fossil remains, scientists could learn little about *Pithecanthropus erectus*. The fossils that helped clarify the identity of Java Man, however, came not from Java but from a location far to the north, in China.

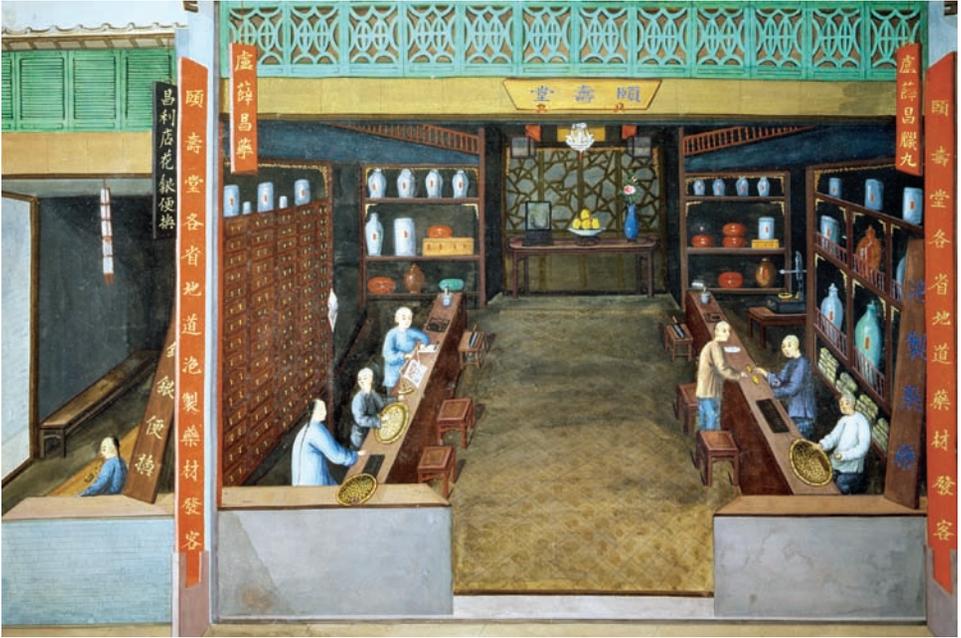
Dragon Bone Hill

Dragons hold a special place in Chinese mythology. They are symbols of royalty, strength, and good fortune. According to Chinese tradition, people could gain the dragon's strength and power by consuming potions made from its bones. The "dragon bones" offered for sale in Chinese medicine shops, however, were really fossils excavated from the countryside, sold to traders and healers, and ground into powder.

At the end of the nineteenth century, Western scientists in China learned that a good way to find fossils was to browse traditional medicine shops for "dragon bones." A German naturalist who visited China in 1899 bought a number of fossils from shops in the major cities. Some of these fossils came from extinct, unknown species of mammals. One tooth appeared to be from a hominin. It was the first trace of a possible human ancestor on the Asian mainland. Unfortunately, no one knew where the tooth had been found.⁵⁰

In 1918 a Swedish geologist named Johann Gunnar Andersson was working in China when he heard about a village where another westerner had seen "dragon bones." The village was Zhoukoudian, nestled in a semi-circle of hills about 31 miles (50 kilometers) southwest of the Chinese capital city Beijing, which westerners called Peking in the early twentieth century. Andersson visited Zhoukoudian, where the local people had quarried limestone from the surrounding hills for many years, and saw that fossils were abundant there. He arranged for a young paleontologist named Otto Zdansky to work at Zhoukoudian beginning in 1921.

Zdansky concentrated on a site that the villagers called Longgushan, which means "Dragon Bone Hill." This limestone cliff overlooking an abandoned quarry had caves full of sediments, and the sediments turned out to be full of animal fossils from the Pliocene and Pleistocene epochs. A few sediment layers also contained small, sharp stone flakes. Zdansky felt that the flakes had been created naturally when small pieces of rock split away from the cave ceiling, but Andersson thought the flakes might be primitive



A nineteenth-century Chinese painting of a traditional medicine shop. Some of the jars probably held ground-up fossils, or “dragon bones.”

tools. He hoped that the excavation would reveal hominin remains. To Zdansky he said, “I have a feeling that there lie here the remains of one of our ancestors and it is only a question of your finding him. Take your time and stick to it until the cave is emptied, if need be.”⁵¹

But Zdansky did not have to stick to it until the cave was emptied. He left China in 1923, taking with him the fossils he had found at Longgushan. Among those fossils were the remains of a new type of Chinese dinosaur, a three-toed horse with a long snout, and other rare specimens of extinct animals. Also, unknown to Andersson, there was a fossil that Zdansky had recognized as a hominin tooth. Nearly sixty years later, Zdansky admitted to a journalist that he had not told Andersson about the tooth because he feared he would have to turn it over to Andersson, and he wanted a chance to publish an article about it first. In addition, an argument between Andersson and Zdansky had apparently led to friction and bad feelings on Zdansky’s part.

In Sweden, the fossils from Dragon Bone Hill were examined by Zdan-

sky's mentor, Swedish paleontologist Carl Wiman of the University of Uppsala. Zdansky and Wiman found a second hominin tooth among them. They identified the two teeth as belonging to an unknown species of genus *Homo*. Finally, in 1926, Wiman sent Andersson a report about all the Dragon Bone Hill fossils. When Andersson read the report, he was excited to see that the hominin fossils he had predicted had actually been found in the cave. The news became public, and the world learned that China had produced unmistakable evidence of early man.

Peking Man

Davidson Black was a Canadian physician and anthropologist who had gone to China in 1919 to teach anatomy at a Western-run college for Chinese medical students in Beijing. Black, who had made a special study of human evolution, examined photographs of the Longgushan teeth and confirmed that they were hominin remains. Together with Wenhao Weng, the director of the Chinese Geological Survey, Black oversaw a new period of digging for fossils at Zhoukoudian that began in 1927.

During the first season at Zhoukoudian, the excavators unearthed another hominin tooth. Black felt that this tooth, together with Zdansky's finds, added up to enough evidence for a new species, which he called *Sinanthropus pekinensis*, or "Chinese man from Peking." However, the more casual name Peking Man became far better known than Black's scientific name.

A young Chinese geologist named Wenzhong Pei made the next major discovery at Zhoukoudian. In 1929, at the very end of the digging season, he found a hominin skullcap embedded in the wall of a deep tunnel that the excavators had dug. Carefully removing the skullcap in two pieces and wrapping them, Pei hid the precious fossil in his luggage, hoping it would escape the notice of the warlords and bandits who infested the region. The skullcap made it safely to Beijing, where Black pronounced it a relic of *Sinanthropus*. Both men received gold medals from the Chinese Geological Survey in honor of this important find.



Wenzhong Pei (far left) and Davidson Black (on right, with pipe) received medals for the discovery and study of a hominin skullcap from Dragon Bone Hill.

Excavation continued at Zhoukoudian throughout the 1930s. At the peak of activity in 1932, the scientists in charge of the site employed more than a hundred workers each day. Pei, chief excavator Lanpo Jia, and their colleagues recovered many impressive fossils, including the complete skeleton of a giant, extinct species of hyena. To the great excitement of paleoanthropologists around the world, they also found more hominin remains: more teeth and skullcaps, a jawbone, and a dozen or so limb bones or partial limb bones. Three skullcaps were found in 1936 alone.⁵²

Davidson Black studied the Zhoukoudian finds until, in 1934, he died of a heart attack at his desk at the medical college in Beijing, with *Sinanthropus* fossils from Dragon Bone Hill all around him. A German anatomist named Franz Weidenreich, forced to flee his homeland because as a Jew he

was persecuted by the powerful Nazi Party, replaced Black at the medical college and also took over as the scientist in charge of the hominin remains. Weidenreich's work in Beijing was cut short, however, by the events of World War II.

Japanese forces invaded China, and although activities at the medical college and the Zhoukoudian excavation continued for a while during the Japanese occupation, conditions became increasingly dangerous. By late 1941 Weidenreich had to leave China for New York. He wanted to take the Peking Man fossils with him, fearing that they would be stolen, damaged, or destroyed if they remained in Beijing, but the director of the school overruled him. Weidenreich took only his detailed notes on the fossils as well as plaster casts he had made of every piece. Fortunately for science, Weidenreich's plaster casts survived the trip to New York's American Museum of Natural History. The original Peking Man fossils disappeared in the turmoil of wartime Beijing and have not been seen since November 1941.

Early Humans in Asia

In 1930, with the flow of hominin remains from Zhoukoudian under way, a young German paleontologist named Ralph von Koenigswald decided to follow in Dubois's footsteps and look for fossils in Java. In the years that followed, von Koenigswald found fossils at several excavation sites in Java. He also learned to locate "dragon bones" in the shops of the Chinese merchants who plied their trade throughout Southeast Asia.

One of von Koenigswald's discoveries was an extinct primate called *Gigantopithecus*, the largest ape that ever lived. What von Koenigswald really wanted, though, was to find more of the "ape-man" species that Dubois had called *Pithecanthropus*, and he did. Between 1934 and 1938 he recovered one hominin jaw and two skulls. Von Koenigswald had read about Weidenreich's work on *Sinanthropus*, or Peking Man, in China. When Weidenreich in turn read about von Koenigswald's finds, he traveled to Java to see them.



The Mystery of the Missing Fossils

Peking Man and Piltdown Man are opposites. Peking Man was a set of real fossils that were lost to science, while Piltdown Man was a set of fake fossils that stood in the way of science for forty years. Yet the two have something in common: they are mysteries. The fate of the original Peking Man bones has spawned almost as many theories as the identity of the Piltdown Man forger.

In November 1941, after Japan had invaded China, two Chinese staff members of the Peking Union Medical College packed the original Peking Man fossils into several wooden crates. Various theories exist about what happened after that. Most are based on statements later made by people who were at the college or at the U.S. Marine Corps barracks in Beijing in November 1941—but none of these statements can be verified.

Many theories about the fossils' fate start by saying that the crates

Above: A Zhoukoudian skull served as the basis for this model of Peking Man's face.

were turned over to the marines for safekeeping or for shipment to the United States (which had not yet entered the war but had stationed troops in China). Depending upon the theory, the fossils were then stolen or lost by the marines who picked them up at the medical college; or seized by the Japanese from a military train or warehouse; or placed aboard a ship that sank after leaving China. If Japanese soldiers did gain possession of the fossils, did they carry their valuable scientific prize back to Japan? Or, thinking the bones were the honored remains of Chinese ancestors, did they simply smash them? Japan's government has long denied any knowledge of the fossils' whereabouts.

Claire Taschdjian, who had worked in Beijing as the secretary to Franz Weidenreich, the last scientist to study the fossils, wound up in New York City after the war. In 1977 she published *The Peking Man Is Missing*, a novel in which she imagined the fossils' fate this way: Stolen from the medical college by a heroin dealer, smuggled into the United States by his widow, Peking Man ends up being tossed into a garbage crusher by a landlady who doesn't know the old bones' value. Taschdjian was not the only one to see dramatic possibilities in the missing bones. The Peking Man fossils have inspired other mystery and adventure novels and television shows, as well as nonfiction books.

Rewards have been offered, searches have been made, old files and letters have been scrutinized, but no trace of the original Peking Man fossils has ever been found. Some people think that they still lie hidden somewhere, perhaps buried in China, with no clue surviving to reveal their location. Noel Boaz and Russell Ciochon, who reviewed the facts and theories in *Dragon Bone Hill: An Ice-Age Saga of Homo erectus* (2004), think that the fossils most likely never left China. Stolen, looted, misplaced, or discarded, they could very well have been "transformed back into dragon bones"—sold and ground into powder for potions, like many fossils before and after them.⁷²

Weidenreich was convinced that von Koenigswald's discoveries belonged to the same species Dubois had found. He declared that a skull found by von Koenigswald in 1938 matched Dubois's skullcap "as one egg does another."⁵³ Weidenreich also noticed that the Java Man fossils were much like the Peking Man fossils. After comparing the two sets of fossils, in 1939 Weidenreich and von Koenigswald published a paper in which they claimed that Java Man and Peking Man either belonged to the same species or were close relatives.

Paleoanthropologists today agree that Java Man and Peking Man are closely related, but they have done away with the genus names *Pithecanthropus* and *Sinanthropus*. Java Man and Peking Man are now known to belong to the genus *Homo*, the human genus. In 1980 the Java hominin fossils were classified as *Homo erectus*. Most paleoanthropologists regard the Chinese hominin fossils as belonging to that species, too.⁵⁴

H. erectus was closer to the size and overall proportions of modern humans than *H. habilis* had been. The *H. erectus* individuals whose remains have been found in Asia would have stood slightly shorter than modern humans, and they would have been larger boned and more muscular. Scientists suspect that these hominins, as well as *H. habilis* and other early human species, may have been hairier than modern humans but less hairy than other primates, such as apes and monkeys. Hominins clearly evolved to be less hairy over time, because modern humans have far less body hair than the other living primates. The rate at which humans lost body hair as they evolved is unknown, however, because skin and hair from extinct species have not been preserved.

The skulls of Asian *H. erectus* tell us that these hominins looked different from modern humans in several ways. Their foreheads were low, compared with ours, sloping back from the large, prominent ridges above the eyes. The teeth of *H. erectus* were similar to modern human teeth, but they were larger. Modern humans have a bony chin beneath the lower jaw, but *H. erectus* lacked this feature, which was also absent from earlier hominin



*By piecing together skull fragments from many individuals found at Zhoukoudian, anatomists created a composite skull of a half-million-year-old female *H. erectus* with a pronounced brow ridge.*

species. The lower part of *H. erectus*'s face sloped back toward the neck without a forward-pointing chin.

Brain size in *H. erectus* was larger than for any earlier hominin species. Six skulls from Zhoukoudian in China have an average brain size of 1,059 cubic centimeters, while one from Ngandong in Java measures 1,149 cc.⁵⁵

Asian *H. erectus*'s substantial brain rested inside another striking anatomical feature, a thick-walled, heavily boned skull. Although *H. erectus* does not have a vertical sagittal crest like that found on the robust hominins in the African *Paranthropus* genus, it does have heavy bars of bone above the eyes and across the back of the skull, as well as extra thicknesses of bone, called keels, at several places on the skull.

Why did Java Man and Peking Man evolve such heavy armor for their heads? Paleoanthropologists Noel Boaz and Russell Ciochon have theorized that the armored skulls evolved for protection against a specific kind of violence. They believe that dents and cracks visible in *H. erectus* skulls from Longgushan (and in Weidenreich's plaster casts of the lost fossils) are signs of what modern crime specialists describe as blunt cranial trauma, or "head bashing."⁵⁶

H. erectus individuals could have struck one another on the head with wooden clubs, stone tools, or both. According to this theory, which is just one point of view about *H. erectus*, males may have fought over females. Or family groups or small bands may have routinely attacked other groups. Ecological evidence suggests that northern China was a challenging place to live during the time span of *H. erectus* at Longgushan, from about 1 million years ago to about 250,000 years ago or even later.⁵⁷ That time span included three glacial periods, ages when temperatures dropped, food resources dwindled, and *H. erectus* populations might have had to migrate into new areas.

If the stresses of migration, hardship, and competition led to chronic violence, individuals with thicker skulls would have been likelier to survive attacks that involved head bashing. Over the generations, the genes for thick-boned skulls would spread through the *H. erectus* population. Boaz and Ciochon argue that "interpersonal violence was so prevalent in this species for so long . . . that major skull reorganization resulted. . . . [I]t is chilling to contemplate how mindless, methodical, unquestioning, and unmerciful killing of individuals outside of one's own small group would have been."⁵⁸

As with many theories about human evolution and hominin species, further evidence and more study will be needed to determine whether this grim explanation of how Asian *H. erectus* got its thick skull is correct. Another unanswered question concerns cannibalism among *H. erectus*. Some researchers have interpreted broken skulls and bones as signs that humans ate meat from human carcasses, while others have interpreted the same evidence as signs that hyenas preyed on the humans.

Paleoanthropological fieldwork continues in Java and China as scientists search for new sites, more fossils, and more information about early humans. The discoveries made there have opened a window onto *Homo erectus* in Asia. But how did *H. erectus* get to Asia? To answer that question, scientists are fitting together evidence found on three continents. A picture is emerging of how the early members of the genus *Homo* evolved, lived, and spread across half the world.

The Rise of Genus *Homo*

Java Man and Peking Man lived in Asia for hundreds of thousands of years, but the origins of their species lay in Africa. Although many questions remain to be answered about the complicated history of the early *Homo* species, paleoanthropologists have learned a great deal from a series of fossil finds since the 1970s. One of the most spectacular finds was of a boy who lived 1.6 million years ago in East Africa's Rift Valley, the source of many discoveries about human ancestors and evolution.

Turkana Boy

Richard Leakey and his team of fossil hunters began work at Koobi Fora, on the eastern side of Kenya's Lake Turkana, in 1968. Later Leakey's team also worked on the western shore of the lake. There, at a place called Nariokotome, Kamoya Kimeu made an exciting discovery in 1984.

Kimeu's find was the nearly complete skeleton of an adolescent hominin, now called Turkana Boy or Nariokotome Boy because the shape of the pelvis shows that this individual was male. The layer of sediment that held Turkana Boy is sandwiched between two layers of volcanic material that scientists can date to 1.64 million and 1.39 million years old. Based on these dates, experts believe that Turkana Boy lived about 1.6 million years ago.⁵⁹

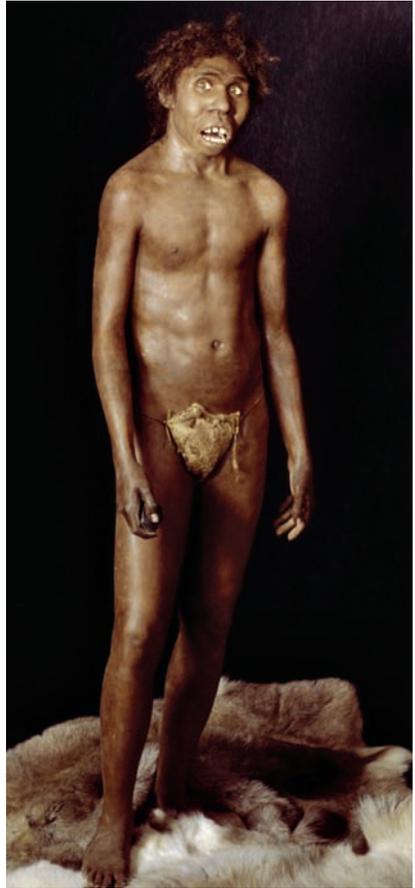
Turkana Boy probably stood a bit more than 5 feet (1.5 meters) tall at the time of his death. If he had reached adulthood, he might have been as tall as 6 feet (1.8 meters)—if, that is, his species grew at a similar rate as modern

humans. His brain measured 900 cubic centimeters in volume but would probably have been a little larger in adulthood. Turkana Boy's age at the time of death depends upon how his remains are interpreted. When Turkana Boy is compared with modern standards of development, such as the rate at which teeth appear and openings in skulls and joints close up, he appears to have been 11 or 12 years old. Yet his teeth, examined in microscopic detail, show growth lines that suggest that he was younger, perhaps 8 or 9. This evidence may mean that Turkana Boy's species matured more quickly than modern humans do.⁶⁰

Turkana Boy was closer to our image of "human" than *H. habilis* had been. He was, writes paleoanthropologist Ian Tattersall of the American Museum of Natural History, "recognizably modern in most of his bodily characteristics."⁶¹

The Somali, Masai, and other modern ethnic groups in East Africa are tall and slender, with long arms and legs. Turkana Boy had the same body shape. This physique has evolved in some groups of people who live in hot, dry climates because it has a higher ratio of skin surface to body mass than shorter, heavier physiques. With a higher ratio of surface area to mass, more heat can leave the body, helping the individual stay cool. (The shorter, stockier *H. erectus* of China would have had a lower ratio of surface area to body mass, which would have kept them warmer in cold times.)

Despite Turkana Boy's modern-seeming body shape, he differed from



Turkana Boy's reconstruction started with the most complete ancient human skeleton ever found.



Unlike modern humans, Turkana Boy had a prominent brow ridge.

present-day humans by having a bony brow ridge. This feature was not as prominent as in Asian *Homo erectus*, however, and Turkana Boy did not have the thick-walled skull seen in his Asian relatives. Turkana Boy's pelvis was narrow, which may have made him a good runner, and so was his rib cage. Unusual features of the spine make some researchers think that Turkana Boy suffered from a disease or deformity such as curvature of the spine, but this is not certain. Scientists do not have enough similar specimens to know what was normal for this type of hominin. Turkana Boy remains a singular marvel, "the most complete ancient human skeleton yet discovered."⁶²

Many Species or One?

Turkana Boy clearly belonged to genus *Homo*. But what species was he? Many paleoanthropologists classify him as *Homo erectus*. Others, however, think that he is different enough from Asian *H. erectus* to be identified as a separate species, which they have called *Homo ergaster* (from the Greek word for "workman"). Various other *Homo* skulls and jawbones from eastern and southern Africa have been included in *H. ergaster*, although some experts think these

specimens are too varied in size and other features to belong to one species.⁶³

In spite of different approaches to classification, paleoanthropologists have generally agreed on the broad outline of how early *Homo* left Africa. By about 2 million years ago, *H. ergaster* (or *erectus*) had appeared in Africa, probably evolved from *H. habilis*. Almost immediately some members of the new species spread beyond Africa. Environmental researchers have learned that climate changes around the beginning of the Pleistocene epoch brought a period of wet conditions to the hot, dry Sahara Desert of northern Africa. Lakes and vegetation made the area newly appealing to many animals. Hominins probably spread northward from their traditional habitats at this time. Eventually some of them crossed the Sinai Peninsula, which links the northeastern corner of Africa to western Asia.

These early humans did not realize, of course, that they had entered a new continent. They were simply expanding into new territory to find food and also, perhaps, to avoid competition with other groups of hominins. The journey across Asia probably took many lifetimes, during which the hominins moved about with no particular destination in mind. Once they had reached Southeast Asia they spread to Java and possibly other places that are now islands. During glacial periods, when so much of the world's water was tied up in northern glaciers that the sea level was significantly lower than it is now, they could have walked to these locations.

Hominins had reached Java by 1.5 million years ago, perhaps earlier.⁶⁴ Separated from the ancestral form of *H. ergaster* (or *erectus*), the Asian hominins evolved new features such as thick skull bones and heavy brow ridges. The question remains open: Was *H. erectus* a single, widespread species that just happened to have a lot of regional variation, or did early *Homo* evolve into a number of separate regional species? A third possibility is that *H. erectus* consisted of small, scattered populations that were similar enough to interbreed when they encountered one another but different enough to be considered separate subspecies (such as *H. erectus javanensis* and *H. erectus pekinensis* for Java Man and Peking Man).

Complications

Since the 1990s, several fossil discoveries have contributed new data on the evolution and spread of *Homo erectus*. The first of these discoveries took place in 1991, at an archaeological dig at Dmanisi, which is in the nation of Georgia, between Turkey and Russia on the eastern side of the Black Sea. The Dmanisi site had yielded many animal fossils and some stone tools, but no hominin remains. On the final day of the dig, a German graduate student named Antje Justus removed the fossils of a saber-toothed cat. To her astonishment, she saw that beneath the cat's remains lay a hominin jawbone, complete with teeth.

Volcanic deposits at the site dated the jawbone to about 1.7 million or 1.8 million years ago.

By the end of the 1990s, researchers at Dmanisi had found four skulls (with an average brain size of 650 cubic centimeters) as well as various back, arm, and leg bones.⁶⁵ They had also unearthed more than a thousand Oldowan-style stone tools.⁶⁶

Paleoanthropologists have taken a variety of approaches to classifying the hominin remains from Dmanisi. Some see the Dmanisi individuals as *H. erectus* or as a transitional form between *H. ergaster* and *H. erectus*. Others see a mix of *H. habilis*

and *H. erectus* features; perhaps the Dmanisi hominins represent a transition between those two species. Other experts think that the fossils represent a new species of early human, *Homo georgicus*. Whatever they are called, the Dmanisi remains show that early humans made their way north into Eurasia at the same time they migrated into eastern Asia. Many more fossils of early *Homo* may await discovery, perhaps across a wide range of Eurasia.



An artist's vision of an elderly male *Homo georgicus*, possibly the first hominin in Europe.



The early species of the genus *Homo* described in this book are known from fossils found at key sites in Africa and Eurasia. More evidence of our early human ancestors no doubt lies waiting to be discovered by future paleoanthropologists.

Back in Africa, meanwhile, the Koobi Fora site on Lake Turkana produced yet another surprise. In 2007 paleontologists Meave Leakey of the Koobi Fora Research Project and Frederick Manthi of the National Museums of Kenya published a description of two fossils found in the Turkana area. One was a jawbone identified as *Homo habilis* and dated to about 1.44 million years ago. The other was a skull identified as *Homo erectus* and dated to 1.55 million years ago.

If these identifications and dates are correct—and they have yet to be fully reviewed and accepted by the scientific community—then *H. habilis* survived for longer than scientists had thought, and it lived side by side with *H. erectus* (or *ergaster*) for some time. Paleoanthropologist Chris Stringer has suggested that if *H. habilis* was primarily a scavenger and the larger *H. erectus* an active hunter, the two could have occupied different niches in the same ecosystem.⁶⁷

The discovery of these two fossils has cast some doubt on the long-standing idea that one species had been the ancestor of the other. “Their co-existence makes it unlikely that *Homo erectus* evolved from *Homo habilis*,” said Leakey.⁶⁸ Biologist Fred Spoor of London’s University College pointed out that “the easiest way to interpret these fossils is that there was an ancestral species that gave rise to both of them somewhere between two and three million years ago.”⁶⁹ Now the search is on to find that possible ancestor.

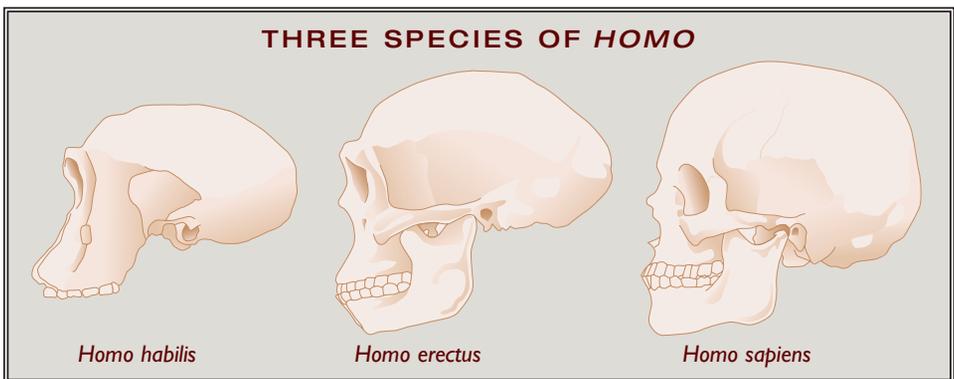
Unsolved Mysteries

Some of the biggest questions about human origins cannot be answered by fossils. When did language appear in the human lineage? What kinds of social and family life did early humans share? Although behavior does not leave traces in the form of fossils, scientists can make some educated guesses about early *Homo*’s behavior from the clues that do remain: bones, stone, and ashes.

As shown by the fossils of Turkana Boy, *Homo ergaster* would probably

have been a good, although not fast, runner. The anatomical features for running might have evolved as this species became a more active hunter, perhaps chasing down larger or faster prey than lizards and rodents. Hunting large game would probably have demanded at least minimal communication. This does not necessarily mean that *H. ergaster* had language in the sense we use it today—chimpanzees and wolves hunt in groups, and they do not speak as we do. But some form of communicating or cooperating in group activities may have been part of life for early *Homo*. Unfortunately, there is no solid evidence to settle this question one way or the other. Individuals or bands of *H. ergaster* and the other early *Homo* species may simply have preyed upon small animals and scavenged from the carcasses of larger ones.

Another anatomical feature that appeared in the *Homo* line after about 2 million years ago was an increase in brain size. As brain size increases, infants must be born at earlier stages of development in order to fit through their mothers' birth canal. A chimpanzee has a smaller brain than a human. It reaches a greater stage of development before birth than a human baby, and it requires a shorter period of care from its mother. With brains larger than those of apes, although still smaller than those of modern humans, early *Homo* babies must have been dependent on their mothers for



Gradual changes took place in human skull anatomy from *Homo habilis* through *H. erectus* and on to *H. sapiens*. Braincases expanded. Faces became flat rather than outward thrusting. By the time our species evolved, brow ridges had vanished and chins had appeared.

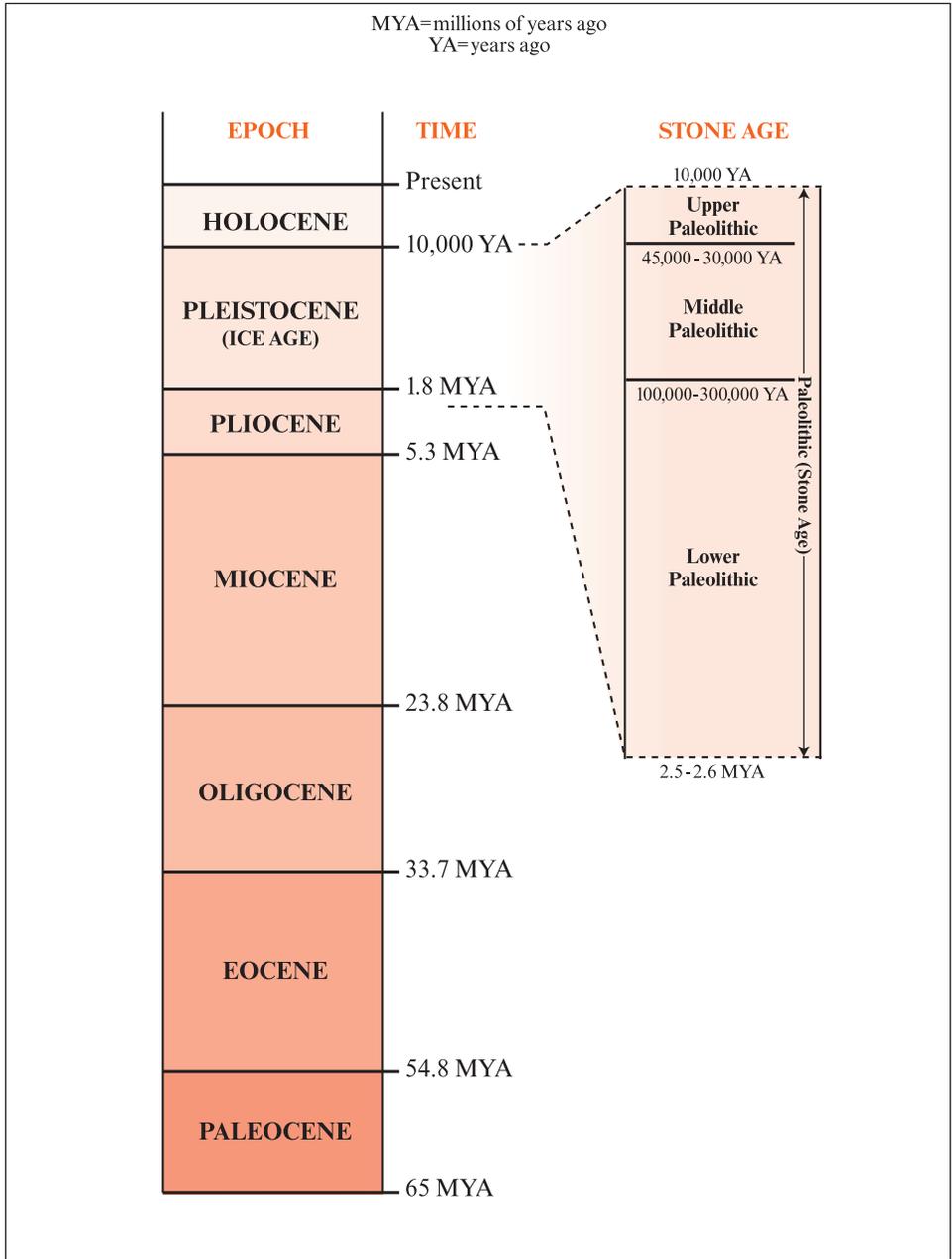
some time. Fathers or other relatives may have provided food to mothers with young children, strengthening social bonds.

Many paleoanthropologists think that along with moving faster and having bigger brains, humans started eating more meat about 2 million years ago. The growing importance of meat in the diet, in fact, could have fueled—or at least developed alongside—the increase in brain size and the ability to run. Although only Oldowan-style tools have been found at Zhoukoudian and Dmanisi, more complex and versatile Acheulean tools are associated with *H. ergaster* or *erectus* remains from other locations. Both types of tools would have given early *Homo* an expanded ability to get nourishment from animal carcasses and bones, to dig for tubers and roots, and to pound tough plant foods to make them easier to eat.

What about fire? Mastery of fire has long been seen as a vital step on the road from primitive to advanced human. Evidence that early *Homo* used fire, however, is slim. Some paleoanthropologists have interpreted burned bones and ash layers from sites at Zhoukoudian in China and Swartkrans in South Africa as signs of fire use by early *Homo*; other scientists, however, have questioned these interpretations. Early *Homo* could well have used accidental fires, started by lightning, to cook food—possibly after tasting meat from the carcasses of animals burned in lightning fires. As far as controlled or domesticated fire is concerned, the oldest unmistakable signs of fire use date from about 790,000 years ago.⁷⁰ If humans domesticated fire before that time, no positive evidence has yet been found.

Hominins did not become human all at once. The physical and behavioral features that set humans apart from earlier hominins evolved slowly over time in the handful of species that scientists call “early *Homo*.” The next phase of the human story would see a flowering of new species that would move out of Africa to colonize Europe and Western Asia during the long period of prehistory known as the Ice Age.

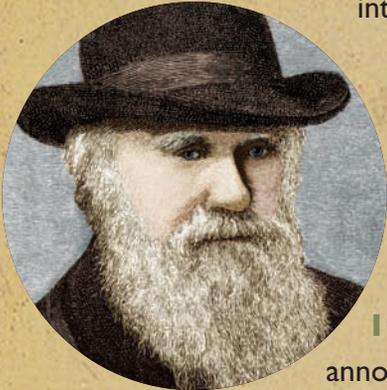
Geological Time Periods



Modern Discoveries about the First Humans

1856 Bones of an ancient Neanderthal found in Germany.

1859 Charles Darwin publishes *On the Origin of Species*, introducing evolution.



1871 Darwin publishes *The Descent of Man*.

1891 Eugene Dubois finds Java Man fossils in Southeast Asia.

1912 Discovery of Piltdown Man in Britain announced.

Charles Darwin

1924 Raymond Dart finds first *Australopithecus* fossils in South Africa.

1926 Fossil teeth from Peking Man, identified as hominin, found in Zhoukoudian, China.

1931 Louis Leakey makes first expedition to Olduvai Gorge.

1938 Robert Broom finds first *Paranthropus* fossils in South Africa.

1939 Java Man and Peking Man identified as same species, later called *Homo erectus*.

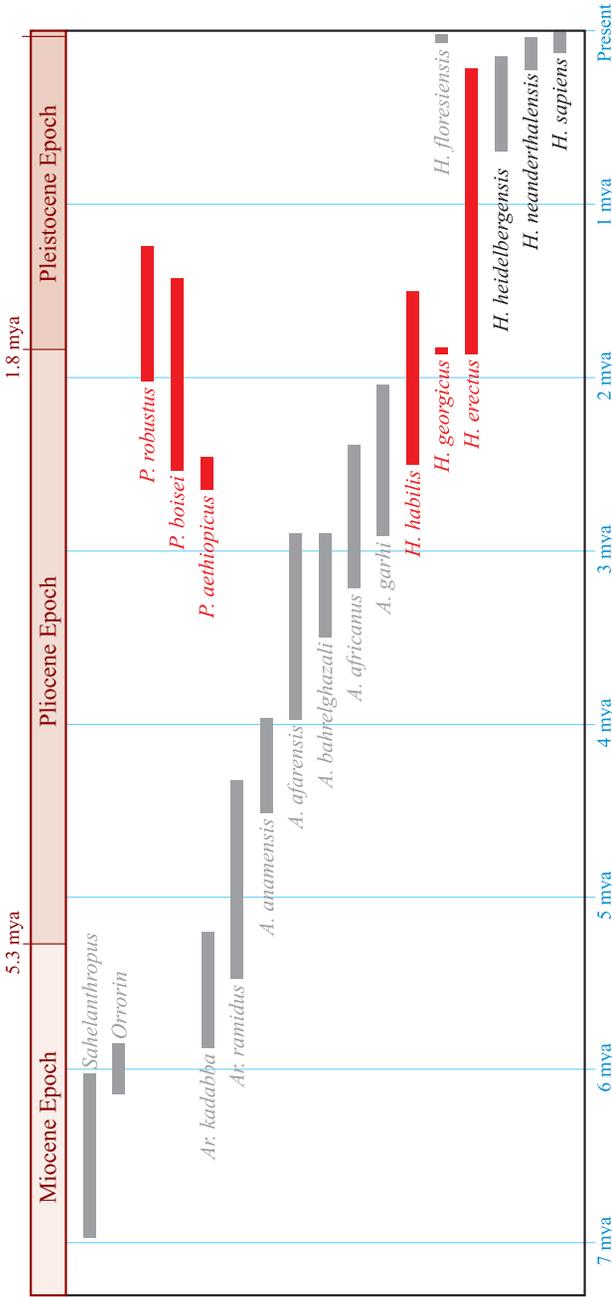
1941 Peking Man fossils disappear in wartime China.

- 1953** Piltdown Man exposed as hoax.
- 1959** Mary Leakey finds *Zinjanthropus boisei* at Olduvai Gorge in Tanzania.
- 1964** Louis Leakey and others announce discovery of *Homo habilis* at Olduvai.
- 1968** Richard Leakey begins excavations at Koobi Fora, Kenya.
- 1972–1973** African fossil hunters find *H. habilis* and skull 1470 (possibly *H. rudolfensis*) at Koobi Fora.
- 1984** Turkana Boy, the most complete skeleton of an early human, found in Kenya; identified as *H. ergaster* or *H. erectus*.
- 1990s** Fossils of *Australopithecus garhi* found in Ethiopia, near signs of tool use.
- 1991** Early *Homo* fossils found at Dmanisi, Georgia.
- 2007** Fossils from Koobi Fora suggest that *H. habilis* and *H. erectus* may have lived in the same area at the same time.



Turkana Boy

Time Line of Human Evolution



Ar. = genus *Ardipithecus* P. = genus *Paranthropus*
 A. = genus *Australopithecus* H. = genus *Homo*

mya = millions of years ago
█ = discussed in this volume

Glossary

- adapt** To change or develop in ways that aid survival in the environment.
- anatomy** The physical structure of an organism.
- australopith** Member of the genus *Australopithecus* or *Paranthropus*, several species of small-brained, bipedal human ancestors known from African fossils; also called australopithecine.
- bipedal** Walking upright on two legs.
- DNA** Deoxyribonucleic acid, the substance that contains the genetic code or blueprint for each individual and is found inside the cells of living things.
- evolution** The pattern of change in life-forms over time, as new species, or types of plants and animals, develop from old ones.
- extinct** No longer existing; died out.
- fossil** Part of a living thing, such as a leaf or a bone, that has turned to stone over time as minerals in groundwater replaced organic materials.
- genetic** Having to do with genes, material made of DNA inside the cells of living organisms. Genes carry information about inherited characteristics from parents to offspring and determine the form of each organism.
- hominid** Member of the family Hominidae, which includes living and extinct orangutans, gorillas, chimpanzees, bonobos, and humans (this term was formerly used for humans and their direct ancestors).
- hominin** Member of the tribe Hominini, which includes living and extinct species in the evolutionary line that split away from apes and eventually produced humans (formerly called hominids).
- Java Man** Name given to fossils first found on the Indonesian island of Java in 1891, now regarded as belonging to the species *Homo erectus*.
- mammal** Warm-blooded animal that gives birth to live young and nurses the young with milk from mammary glands.
- morphology** Physical form.

paleoanthropology The study of ancient human life and human origins, mainly through fossils and other physical remains.

paleontologist A person who studies ancient life, mainly through fossils.

Peking Man Name given to fossils found near Beijing (formerly Peking), China, in the early twentieth century; Peking man is now regarded as part of the species *Homo erectus*.

primate Member of the order of mammals that includes humans, apes, monkeys, lemurs, and other small animals.

sagittal crest Vertical ridge of bone running from front to back across the top of the skull; serves as an attachment point for powerful jaw muscles; seen in the *Paranthropus* genus of hominins.

species Group of organisms that share a genome and are reproductively isolated from other organisms.

Further Information

Books

Anderson, Dale. *How Do We Know the Nature of Human Origins: Great Scientific Questions and the Scientists Who Answered Them*. New York: Rosen Publishing Group, 2004.

Bowman-Kruhm, Mary. *The Leakeys: A Biography*. Westport, CT: Greenwood, 2005.

Fleisher, Paul. *Evolution: Great Ideas of Science*. Minneapolis, MN: Lerner Publishing, 2005.

Gamlin, Linda. *Eyewitness: Evolution*. New York: DK Publishing, 2000.

Gardner, Robert. *Human Evolution*. New York: Franklin Watts, 1999.

Lewin, Roger. *Human Evolution: An Illustrated Introduction*. 5th edition. Hoboken, NJ: Wiley-Blackwell, 2004.

Lockwood, Charles. *The Human Story: Where We Come From & How We Evolved*. New York: Sterling, 2008.

- McKie, Robin. *Ape/Man: Adventures in Human Evolution*. London and New York: BBC Books, 2000.
- Sloan, Christopher. *The Human Story: Our Evolution from Prehistoric Ancestors to Today*. Washington, DC: National Geographic, 2004.
- Steffoff, Rebecca. *The Primate Order*. New York: Marshall Cavendish Benchmark, 2006.
- Van Oosterzee, Penny. *Dragon Bones*. New York: Basic Books, 2000.
- Walker, Denise. *Inheritance and Evolution*. North Mankato, MN: Smart Apple Media, 2006.
- Wood, Bernard. *Human Evolution: A Very Short Introduction*. New York: Oxford University Press, 2006.

Web Sites

<http://www.amnh.org/exhibitions/permanent/humanorigins/>

The companion site to the new Hall of Human Origins in New York City's American Museum of Natural History offers information about human evolution and video interviews with scientists Ian Tattersall and Rob DeSalle, curators of the exhibit.

<http://www.pbs.org/wgbh/evolution/library/07/index.html>

The PBS online *Evolution Library* links to pages on a number of topics, including human evolution. "Evolution of the Mind," for example, is a video interview with Steven Pinker about the evolution of language.

<http://anthropology.si.edu/humanorigins/faq/encarta/encarta.htm>

The Smithsonian Institution's *Human Origins Program* is an online guide to resources that explain dozens of topics in paleoanthropology and human evolution, from primate origins to the cultural and social evolution of modern humans.

<http://evolution.berkeley.edu/evolibrary/home.php>

The University of California at Berkeley's *Understanding Evolution* site provides excellent explanations of many topics in general evolutionary biology and includes an archive of articles about human evolution, geared for general audiences.

<http://www.pbs.org/wgbh/nova/hoax/>

This companion site to the PBS *Nova* program “The Boldest Hoax” offers a good overview of the Piltdown fossil forgery and its significance to the science of paleoanthropology.

<http://www.talkorigins.org/faqs/homs/>

The *TalkOrigins Archive* links to dozens of articles on the topic of human evolution. The site also contains information about the creationist position against evolution.

http://www.bbc.co.uk/sn/prehistoric_life/human/

The Science and Nature Division of the British Broadcasting Corporation (BBC) maintains this site on *Human Beginnings*. A section called “Evolution of Man: Leaving Home” is devoted to the early *Homo* species.

<http://www.leakey.com>

This site, dedicated to the paleoanthropological work of several generations of the Leakey family in East Africa, includes biographies of family members, photos of important fossil finds, and a summary of the family's contributions to understanding human origins.

<http://www.unesco.org/ext/field/beijing/whc/pkm-site.htm>

Zhoukoudian, China, is a source of fossils of *Homo erectus*—or Peking Man—and also a United Nations World Heritage Site. This Web page

provides a summary of past and present paleoanthropology at Zhoukoudian.

<http://topics.nytimes.com/top/news/national/series/dnaage/index.html>

In a series of articles called “The DNA Age,” science writer Amy Harmon describes advances in genetic science and how they are changing our lives as well as helping us learn more about our evolutionary past. Originally published in the *New York Times*, the series won the Pulitzer Prize for Explanatory Journalism in 2008.

<http://www.asu.edu/clas/iho/index.html>

<http://www.becominghuman.org/>

The Institute of Human Origins (IHO) at Arizona State University maintains these two Web sites. *Becoming Human* includes an interactive video documentary, while the main IHO site features links to current news in the world of paleoanthropology.

<http://www.survivingexhibit.org/>

Surviving: The Body of Evidence is the online companion to an exhibit about human origins at the University of Pennsylvania Museum of Archaeology and Anthropology. Among other features, the site has biographies of discoverers such as Charles Darwin and Mary Leakey.

<http://www.archaeologyinfo.com/evolution.htm>

The *Human Ancestry* page of this archaeology-focused site has a virtual “Hall of Skulls,” with photos and descriptions of important hominid and hominin fossil finds.

http://www.bbc.co.uk/sn/prehistoric_life/tv_radio/wwcavemen/

Walking with Cavemen, a companion site to a 2003 BBC television

series, includes information about human ancestors as well as an interactive “Caveman Challenge.”

Selected Bibliography

The author found these works especially helpful when researching this book.

- Aczel, Amir D. *The Jesuit and the Skull: Teilhard de Chardin, Evolution, and the Search for Peking Man*. New York: Riverhead, 2007.
- Ciochon, Russell, and Noel Boaz. *Dragon Bone Hill: An Ice-Age Saga of Homo erectus*. New York: Oxford University Press, 2004.
- DeSalle, Rob, and Ian Tattersall. *Human Origins: What Bones and Genomes Tell Us About Ourselves*. College Station, TX: Texas A&M University Press, 2008.
- Sawyer, G.J., and Viktor Deak, editors. *The Last Human: A Guide to Twenty-Two Species of Extinct Humans*. New Haven, CT: Yale University Press, 2007.
- Spencer, Frank. *Pittdown: A Scientific Forgery*. New York: Oxford University Press, 1990.
- Stringer, Chris, and Peter Andrews. *The Complete World of Human Evolution*. New York: Thames & Hudson, 2005.
- Weiner, Joseph, and Chris Stringer. *The Pittdown Forgery*. 50th anniversary edition. New York: Oxford University Press, 2003.
- Zimmer, Carl. *Smithsonian Intimate Guide to Human Origins*. New York: Madison Press, 2005.

Notes

Introduction

- 1 Louis Leakey, “Search for the World’s Oldest Man,” in Melville Bell Grosvenor et al., editors, *Great Adventures with National Geographic*, Washington, DC: National Geographic Society, 1963, p. 210.
- 2 Leakey.
- 3 Charles Darwin, *The Origin of Species*, New York: Avenel, 1979, reprinted from first edition of 1859, p. 435.

- 4 Darwin, *Origin*, p. 455.
 5 Darwin, *Origin*, p. 458.
 6 Alexander Pope, *Essay on Man*, Epistle II, line 2, 1733–1734.
 7 Rob DeSalle and Ian Tattersall, *Human Origins: What Bones and Genomes Tell Us About Ourselves*, College Station, TX: Texas A&M University Press, 2008, p. 21.

Chapter One

- 8 Quoted in Richard Milner, *The Encyclopedia of Evolution: Humanity's Search for Its Origins*, New York: Henry Holt, 1990, p. 147.
 9 Quoted in Frank Spencer, *Pittdown: A Scientific Forgery*, New York: Oxford University Press, 1990, p. 31.
 10 Quoted in Spencer, p. 33.
 11 Quoted in Spencer, p. 34.
 12 Quoted in Spencer, p. 34.
 13 Quoted in Spencer, p. 49.
 14 Quoted in Spencer, p. 50.
 15 Reproduced in Spencer, pp. 52–53.
 16 Quoted in Spencer, p. 56.
 17 Quoted in Spencer, p. 98.
 18 Quoted in Spencer, p. 107.
 19 Sherwood Washburn in 1984, quoted in Roger Lewin, *Bones of Contention*, 1987, online at http://www.clarku.edu/~PILTDOWN/map_expose/chain_of_fraud.html
 20 Richard Harter, Pittdown Man page, online at <http://www.talkorigins.org/faqs/pittdown.html>
 21 Quoted in Spencer, p. 135.
 22 Richard Harter, Pittdown Man page, online at <http://www.talkorigins.org/faqs/pittdown.html>
 23 Quoted in Spencer, p. 141.
 24 Quoted in Spencer, p. 141.
 25 Milner, p. 363.
 26 Reproduced in Spencer, p. ii.

Chapter Two

- 27 Chris Stringer and Peter Andrews, *The Complete World of Human Evolution*, New York: Thames and Hudson, 2005, p. 129.
 28 Donald Johanson and Maitland Edey, *Lucy: The Beginnings of Humankind*, New York: Warner, 1981, p. 93.
 29 For examples of differing approaches to classifying the robust hominins, see Stringer and Andrews, *The Complete World of Human Evolution*, which defines them as robust australopiths, and G.J. Sawyer and Viktor Deak, *The Last Human: A Guide to Twenty-Two Species of Extinct Humans* (New Haven, CT: Yale University Press, 2007), which places them in the genus *Paranthropus*.

- 30 Sawyer and Deak, p. 108.
- 31 Stringer and Andrews, p. 127.
- 32 Stringer and Andrews, p. 127.
- 33 Jeanna Bryner, "Nutcracker Man strangely preferred fruits," *msnbc.com*, April 30, 2008, online at <http://www.msnbc.msn.com/id/24388112/>
- 34 John Noble Wilford, "Fossils in Kenya Challenge Linear Evolution," *New York Times*, August 9, 2007, online at http://www.nytimes.com/2007/08/09/science/08cndfossil.html?_r=2&oref=slogin&ref=science&pagewanted=print&oref=slogin
- 35 Charles Lockwood, *The Human Story: Where We Come From & How We Evolved*, New York: Sterling, 2008, p. 47.
- 36 Lockwood, p. 47.
- 37 Stringer and Andrews, pp. 128–129.

Chapter Three

- 38 Stringer and Andrews, *The Complete World of Human Evolution*, New York: Thames and Hudson, pp. 208–209.
- 39 Carl Zimmer, *Smithsonian Intimate Guide to Human Origins*, New York: Madison Press, 2005, pp. 62–65.
- 40 Sileshi Semaw CV, online at <http://www.stoneageinstitute.org/PDFs/Semaw-CV.pdf>
- 41 C. David Kreger, "Homo habilis," online at <http://www.archaeologyinfo.com/homohabilis.htm>
- 42 Brain size in four *H. habilis* skulls ranges from 590 to 687 cubic centimeters, according to G.J. Sawyer and Viktor Deak, *The Last Human: A Guide to Twenty-Two Species of Extinct Humans*, New Haven, CT: Yale University Press, 2007, p. 124.
- 43 Donald Johanson and Maitland Edey, *Lucy: The Beginnings of Humankind*, New York: Warner, 1981, p. 113.
- 44 Johanson and Edey, p. 113.
- 45 Stefan Lovgren, "Did Earliest Human Ancestors Have Apelike Faces?" *National Geographic News*, April 5, 2007, online at <http://news.nationalgeographic.com/news/2007/04/070405-human-skull.html>
- 46 Charles Lockwood, *The Human Story: Where We Come From & How We Evolved*, New York: Sterling, 2008, p. 68.
- 47 Zimmer, pp. 69–70.

Chapter Four

- 48 Donald Johanson and Maitland Edey, *Lucy: The Beginnings of Humankind*, New York: Warner, 1981, p. 30.
- 49 Noel Boaz and Russell Ciochon, *Dragon Bone Hill: An Ice-Age Saga of Homo erectus*, New York: Oxford University Press, 2004, p. 1.

- 50 Boaz and Ciochon, pp. 3–4.
- 51 Boaz and Ciochon, p. 9.
- 52 The Peking Man World Heritage Site at Zhoukoudian, online at <http://www.unesco.org/ext/field/beijing/whc/pkm-site.htm>
- 53 Boaz and Ciochon, 2004, p. 61.
- 54 G.J. Sawyer and Viktor Deak, *The Last Human: A Guide to Twenty-Two Species of Extinct Humans*, New Haven, CT: Yale University Press, 2007, pp. 165 and 173.
- 55 Sawyer and Deak, pp. 158 and 168.
- 56 Boaz and Ciochon, p. 81.
- 57 Chris Stringer and Peter Andrews, *The Complete World of Human Evolution*, New York: Thames and Hudson, 2005, p. 138.
- 58 Boaz and Ciochon, p. 171.

Chapter Five

- 59 G.J. Sawyer and Viktor Deak, *The Last Human: A Guide to Twenty-Two Species of Extinct Humans*, New Haven, CT: Yale University Press, 2007, p. 143.
- 60 All data in paragraph from Chris Stringer and Peter Andrews, *The Complete World of Human Evolution*, New York: Thames and Hudson, 2005, p. 139.
- 61 Introduction to Sawyer and Deak, pp. 21–22.
- 62 Stringer and Andrews, p. 139.
- 63 Sawyer and Deak, p. 141.
- 64 Stringer and Andrews, p. 139.
- 65 Sawyer and Deak, p. 151.
- 66 Pat Shipman, “Doubting Dmanisi,” *American Scientist*, November–December 2000, online at <http://www.americanscientist.org/issues/pub/doubting-dmanisi>
- 67 James Urquhart, “Finds test human origins theory,” BBC News, August 8, 2007, online at <http://news.bbc.co.uk/1/hi/sci/tech/6937476.stm>
- 68 Urquhart.
- 69 Urquhart.
- 70 Rob DeSalle and Ian Tattersall, *Human Origins: What Bones and Genomes Tell Us About Ourselves*, College Station, TX: Texas A&M University Press, 2008, p. 125.

Sidebar

- 71 Chris Stringer, “Piltdown 2003,” online at <http://www.talkorigins.org/faqs/homs/piltdown2003.html>
- 72 Noel Boaz and Russell Ciochon, *Dragon Bone Hill: An Ice-Age Saga of Homo erectus*, New York: Oxford University Press, 2004, p. 54.

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