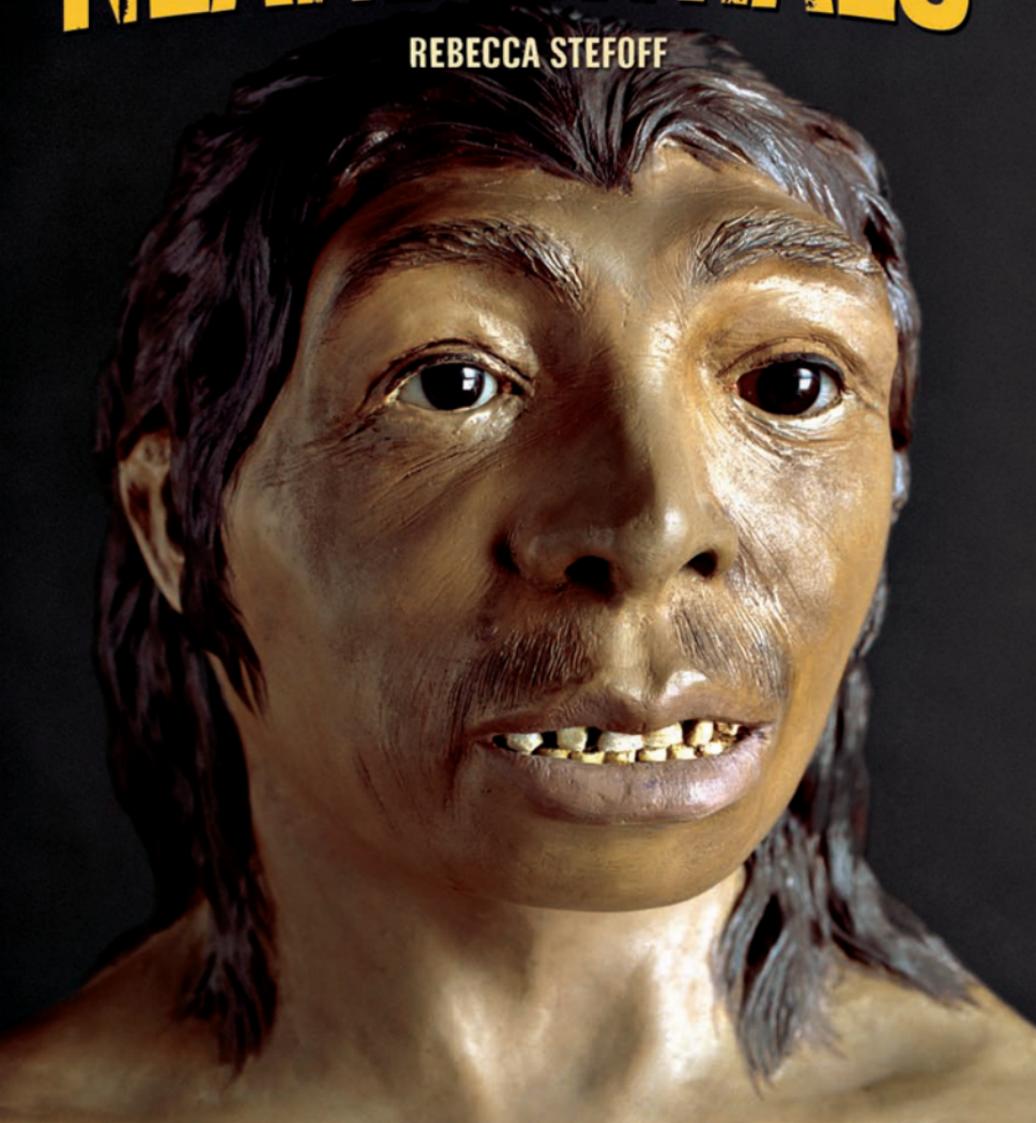


HUMANS: AN EVOLUTIONARY HISTORY

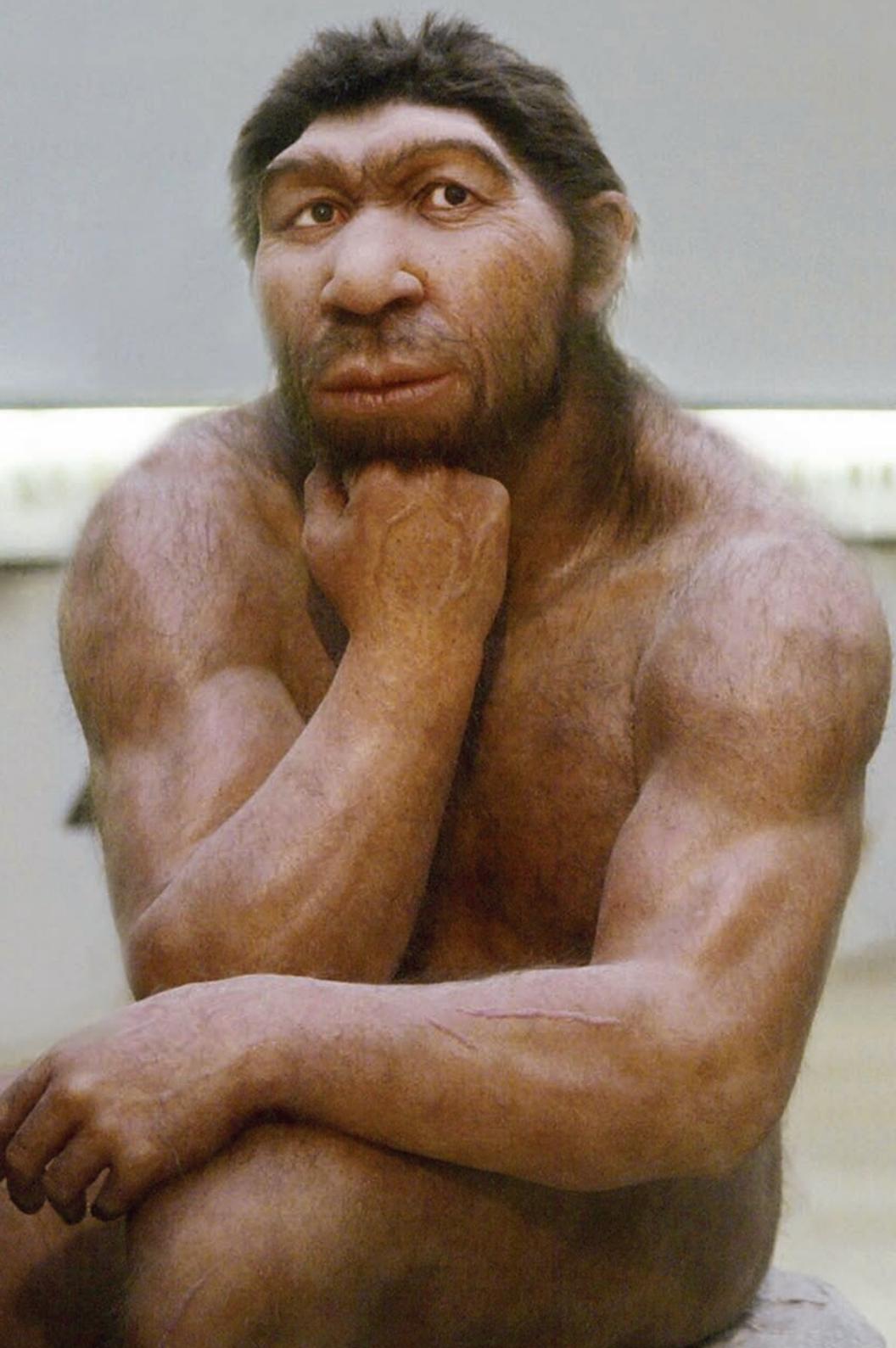
ICE AGE NEANDERTHALS

REBECCA STEFFO



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HUMANS: AN EVOLUTIONARY HISTORY

ICE AGE NEANDERTHALS

REBECCA STEFFO

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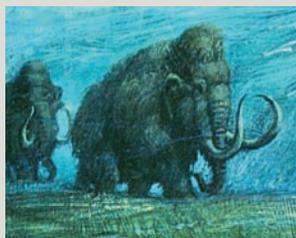
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Title page: *Peering through time—and a camera lens—at our closest extinct relative*
Back cover: *Neanderthals lived in this Gibraltar cave until perhaps 27,000 years ago.*

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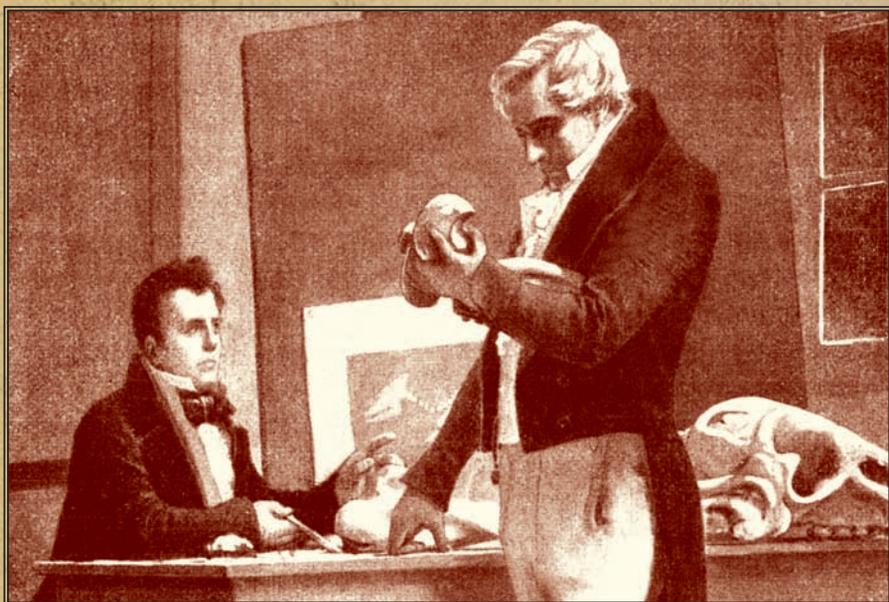
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INTRODUCTION

In Search of Human Origins

“Fossil man does not exist,” declared Georges Cuvier, one of the foremost French scientists of the early nineteenth century.¹ Cuvier’s specialty was anatomy, the study of the physical structure of living things. In the course of his work he had examined the fossils of many creatures that no longer existed, such as extinct species of elephants.

Cuvier knew that fossils had revealed life-forms from the past that were different from those of the present. He explained these differences by saying that a series of huge disasters or catastrophes had wiped out the ancient life-forms, leaving only traces of them as fossils. Humans did not exist until *after* the last catastrophe, according to Cuvier. He also believed that species did not change, which meant that the first humans must have been exactly like modern humans. For these reasons Cuvier was sure that there could be no such thing as a human



Georges Cuvier examines one of the many fossils he collected. None, he was convinced, could be of a human being.

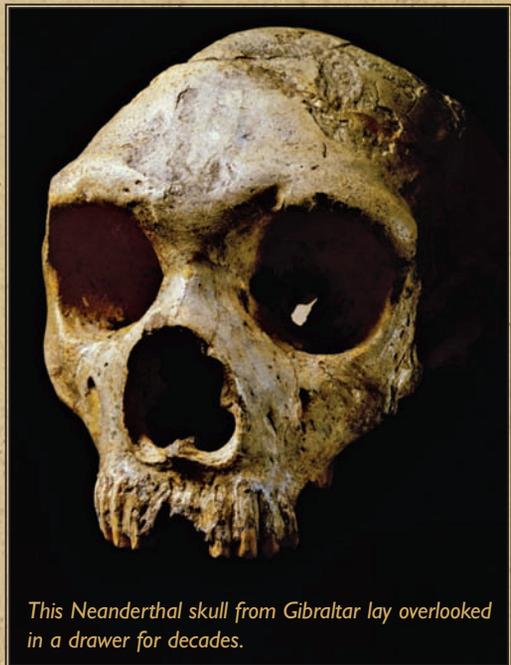
fossil, much less a human fossil that differed from the people of the modern world. Cuvier made his bold assertions in 1812. Many respected scientists at that time shared his opinion.

Less than two decades later, Europeans started finding fossil men—and women and children—from the distant past. These skulls and bones were clearly human, but they were so different from modern people that it took years for scientists to recognize their true nature.

Mysterious Skulls

The first trace of very early human life came to light in 1830, when someone found a fossilized child's skull at Engis, in the western European nation of Belgium. Although the skull looked human, it was not shaped like that of a normal modern child. No one knew what to make of this oddity.

Eighteen years later, the British army built a cannon platform in a quarry in Gibraltar, a rocky peninsula on the southern coast of Spain that has been a British territory since 1713. Workers were using explosives to blast chunks of rock from the quarry wall when they found a fossil skull among the rubble. The skull looked human, except that it was strangely shaped and had large bony ridges above the eye sockets. An army officer presented the skull to the Gibraltar Scientific Society, and a member of the society tucked it into a drawer. No one realized the significance of the Gibraltar skull until after the



This Neanderthal skull from Gibraltar lay overlooked in a drawer for decades.

next discovery of human fossils—a discovery that was destined to cause controversy and to mark the birth of a new science.

Introducing the Neanderthals

Not far from the German city of Düsseldorf, the Düssel River flows through a small valley that was once home to a seventeenth-century musician named Joachim Neander. In his honor the place is called Neanderthal, which is German for “Neander Valley.” During the nineteenth century, local workers quarried limestone from the valley walls. In 1856, while removing stone from the muddy floor of Feldhofer Cave, 60 feet (18 meters) above the valley floor, several workmen came upon the bones of what they thought was a long-dead bear.

The quarrymen tumbled the bones down to the valley floor, where someone noticed that they were not the remains of a bear at all. The bones looked human, yet they were unusually thick and oddly shaped. In all, there were fifteen pieces of a skeleton and a single skullcap,



This skullcap and bones from Germany's Neander Valley became the type specimen, or original scientific example, of a new species: Homo neanderthalensis.

which is the top part of the skull, the section that covers the brain.² The local schoolteacher decided that these strange relics should be sent for examination to an anatomist named Herrmann Schaafhausen.³

Schaafhausen recognized that the remains were human, yet they did not look as though they could be those of a modern person. He thought that the bones might have come from “one of the wild races of northwestern Europe, spoken of by Latin writers.”⁴ The Neander Valley remains, in other words, could have been a relic of primitive tribes that had lived on the fringes of the Roman Empire two thousand years earlier. Roman, or Latin, historians had mentioned these tribes in their writings.

Schaafhausen had looked to the past for an explanation of the Neander Valley fossils, but other experts had different ideas about the thick bones and the skullcap with its heavy ridges of bone above the eyes. One theory was that the remains came from a modern person who had suffered from the disease rickets, which distorts the skeleton. The brow ridges, according to this theory, resulted from years of clenching the forehead in pain. (This idea was way off. Scowling may cause wrinkles, but it cannot reshape bone.) A German anatomist named A. F. Mayer offered another imaginative suggestion: The bones came from a Mongolian soldier who had fought in the Napoleonic Wars of the early nineteenth century. After fleeing the fighting as a deserter, he died in the cave.⁵

Rudolf Virchow, a leading German anatomist, thought that rickets might indeed have caused the unusually thick, curved bones of the Neanderthal skeleton. However, the strange structure of the skull, in his view, was the result of blows to the head, combined with arthritis. Virchow claimed that the Neanderthal remains could not have been those of a primitive tribesman, for only in an advanced, civilized society could someone so severely crippled or deformed have received the help he needed to survive. He concluded that the remains must be those of an unfortunate individual who had lived in recent times.



Rudolf Virchow was among the nineteenth-century scientists who misinterpreted the Neander Valley bones. They did not realize that human species other than our own had once existed.

An Irish geologist named William King published a new view of the Neanderthal fossils in 1864. King declared that the fossils were human—but that they came from a different species of human than the people of the modern world. He called the newly identified species *Homo neanderthalensis*, or Neanderthal Man. (The German word for valley is now spelled *tal* rather than *thal*. The term for early humans first known to us from the Neander Valley may be spelled either *Neanderthal* or *Neandertal*; the correct pronunciation of both is “-tal.”)

King’s claim that Neanderthal Man was an extinct branch of the human family tree was a milestone in science. It was the first time that a scientist had suggested that there had been more than one species of human, and it was the beginning of paleoanthropology, the scientific

study of early humans.⁶ Although King's fellow scientists did not accept his ideas about *H. neanderthalensis* overnight, the bones from the Neander Valley became vital clues in humankind's search for its origins. In time, that search would lead to an understanding of Neanderthal 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 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.

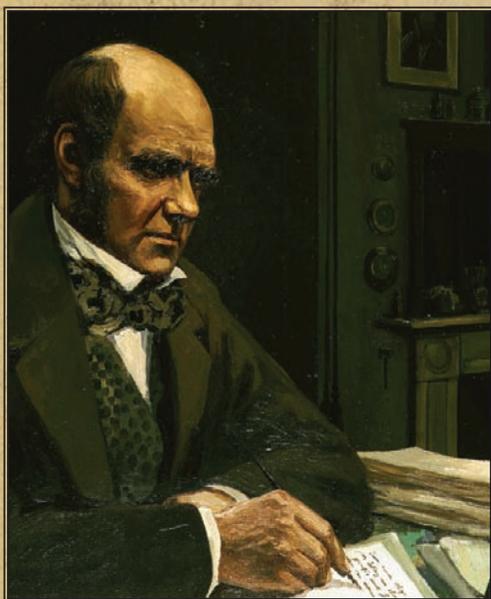
Biologists admit that *species* is a somewhat slippery term to define, and they have taken a variety of approaches to the definition. For many years, one of the most widespread definitions said that a species is a group of plants or animals that are reproductively isolated from other organisms. Reproductive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



Charles Darwin at work in 1858, a year before he published his revolutionary discovery

claim.⁷ 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, or mutations. If the mutations help an organism's offspring to thrive—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



Maize, or corn, shows the results of natural and artificial selection. It evolved from grass, and then humans created many varieties through deliberate breeding.

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 environments 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

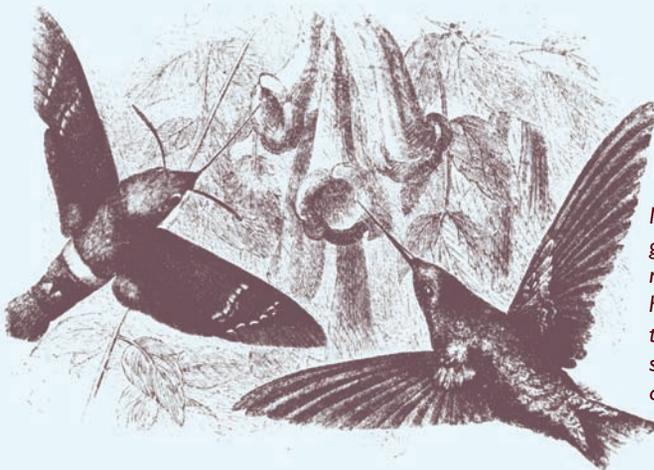
Near the end of *On the Origin of Species*, Darwin wrote that when the world came to accept his findings there would be “a considerable revolution in natural history.”⁸ An understanding of evolution, he said, would not only enrich the sciences but would give people a whole new view of life—all forms of life. “Light,” Darwin predicted, “will be thrown on the origin of man and his history.”⁹

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 connection 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 mech-

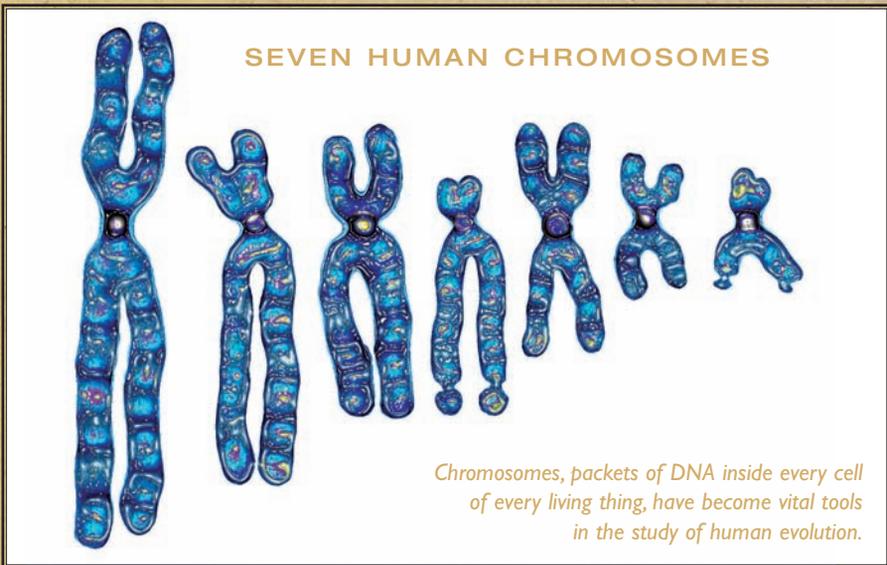


Natural selection has given both the hawk moth (left) and the hummingbird the ability to hover in midair while sucking nectar from deep within flowers.

anisms of evolution and also about the rate at which speciation—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.

“The proper study of mankind is man,” wrote the British poet Alexander Pope in the 1730s.¹⁰ 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.”¹¹ The tools in the toolbox are an array of tech-



niques and skills that fall into three broad categories. One category is genetics, the study of how DNA and genes work. Another is paleoanthropology, which studies 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*, new discoveries about the Neanderthal people have thrown light, just as Darwin predicted, on 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 family tree that flourished in Africa several million years ago. The second book, *First Humans*, focused on other branches of the family tree, including the first true humans, members of the genus *Homo*. This book introduces the Neanderthals and other species that lived in Eurasia during the Ice Age. Lastly, *Modern Humans*, the fourth book in this series, looks at the origins of modern people and how they spread throughout the world. The four books together tell the story of human evolution as it is known today.

Ages of Ice

In the years since Neanderthal remains first came to light, scientists have learned a lot about these human cousins. They have also learned that other kinds of early humans lived in Europe and Asia before the Neanderthals, or alongside them. The Neanderthals and other human species that rose and fell in Eurasia over the past million years or more were forced to adapt to an environment that could be harsh, even brutal. These early people lived in a world shaped by ice. They were citizens of an ice age—one that we still live in today.

Big Freezes

The term *ice age* has several different but related meanings. The best way to understand them is to look at the dramatic climate changes our planet has experienced. For much of Earth's 4.6-billion-year history, the planet was warmer than it is today, and there was no permanent ice anywhere. Earth's temperature occasionally cooled, however, for long intervals that lasted for tens or even hundreds of millions of years. During these cool periods, glaciers and ice sheets formed, sometimes covering vast stretches of the planet. These long cool periods—characterized by ice on Earth's surface and by big temperature differences between the cold poles and the hot equator—are one meaning of the term *ice age*.

There are several explanations for the causes of Earth's ice ages. Scientists believe that these long big freezes are related to plate tectonics, the slow movement of the continents across the surface of the planet. When the continents move toward the poles and away from the equator, they grow cold enough for long-lasting ice to form on them. As ice forms, it lowers the temperature still further because it reflects more sunlight back into

space than bare earth or forest does. Plate tectonics also alters the world's ocean and air currents as it reshapes the world's contours. Such changes can lower global temperatures or raise them, starting or ending an ice age.

Long-term ice ages are also related to changes in Earth's atmosphere. When the atmosphere contains high levels of carbon dioxide (CO₂), Earth holds more of the Sun's heat, which makes global temperatures rise. Scientists know that the level of atmospheric CO₂ has risen and fallen over hundreds of millions of years. Researchers do not yet know, though, whether atmospheric changes caused the ice ages or the ice ages caused atmospheric changes.¹²



Our planet has known many ages when ice covered the land. These mammoths roamed during the last period of widespread ice. We still live in that ice age today—in one of its warmer phases.

Four long ice ages have occurred during the past billion years. The Proterozoic or Cryogenian ice age lasted from about 800 million to 600 million years ago. Ice may have covered much of the planet's surface for long stretches of that time. The Andean-Saharan ice age, between about 460 and 430 million years ago, was shorter and less severe. During the Karoo ice

age, which lasted from about 350 to about 250 million years ago, both the north and south polar regions had immense ice caps.¹³

The most recent long-term ice age, usually called the Cenozoic ice age, began around 52 million years ago. Before that time, Earth was ice-free for millions of years. Tropical conditions reached much farther north and south from the equator than they do today. Polar temperatures were mild, and trees grew in the Arctic and in Antarctica. Alligators, creatures that require warmth to live, flourished on Ellesmere Island in what is now the Canadian Arctic.

All that changed when the planet gradually grew cooler. The big chill started at the poles. About 52 million years ago temperatures at the surface of the polar seas began to fall. Ice caps formed across part of Antarctica. The cooling trend accelerated between 36 and 20 million years ago, and the Antarctic ice caps grew and merged to form a continental ice sheet, a vast mass of ice that covered most of the continent. A warmer period followed, but it was brief in geological terms: just 4 or 5 million years. By about 15 million years ago, Earth was cooling again. Ten million years later, Greenland was covered with ice, and creeping ice sheets from the northern polar region had advanced south into Scandinavia.

Things slowly warmed up again about 5 million years ago. The ice retreated toward the poles, and sea temperatures rose around Antarctica and North America. Warmth-loving plants extended their range into Canada and northern Eurasia. The warmth did not last long, however. Around 3 million years ago, temperatures cooled once more. The Arctic Ocean froze, and the Greenland and Antarctic ice sheets expanded. The huge, slow-moving ice rivers known as glaciers expanded southward from the Arctic region to cover northern North America and Eurasia. Ice caps expanded in southern South America as well. In mountain ranges all over the world, high-altitude glaciers grew larger, creeping down into the valleys.

Even beyond the range of the great ice sheets, conditions changed dramatically. Regions that had been moist and mild, such as central Asia and parts of Africa, became drier and cooler. In eastern and southern Africa,

woodlands gave way to the wide grasslands known as savannas. Forested northern Eurasia shifted toward a tundra environment of short, hardy plants that could survive a climate of brief summers and long, harsh winters.

The warm interlude of 5 million years ago, together with the global chill that followed it, saw the rise and development of a new kind of animal, the hominins. The hominins are an evolutionary line that split away from the African apes and eventually produced humans. The most recent species of hominins form a subgroup, the genus called *Homo*, which includes modern humans, Neanderthals, and the earlier species that gave rise to both. The entire span of genus *Homo* falls within the latest cool climate phase, which has continued from about 3 million years ago to the present day.¹⁴

More Meanings for *Ice Age*

During the long ice ages, climate conditions were not constant and unchanging. The sheets of ice that covered parts of the world's landmasses periodically grew larger, then shrank, then grew larger again, in cycles lasting tens of thousands of years.

The term *ice age* sometimes refers not to the long-term cool periods in Earth's history but to these shorter periods within the long ice ages—the times when the ice sheets expanded to cover large continental areas. When scientists talk about these smaller-scale ice ages, they call them glaciations or glacials. The point during a glacial when the ice covers the largest area is the glacial maximum. The milder periods between glacials, when the ice retreats for a time, are called interglacials.

The shift from glacial to interglacial and back to glacial appears to be triggered by three different kinds of variations in Earth's orbit around the Sun. Each of these variations follows a cycle that takes thousands of years to complete. In one cycle, the shape of Earth's orbit changes slightly, from almost circular to more oval shaped, then back to circular. In the second cycle, the angle of Earth's axis—an imaginary line between the poles—slowly shifts. In the third cycle, Earth's axis wobbles slightly, like a top that

wobbles while it is spinning, which alters the lengths of the seasons. Together, these three cycles determine how much heat from the Sun reaches Earth's surface. Depending on how the cycles interact during an ice age, Earth's climate may be at its coldest (a glacial maximum), its warmest (an interglacial), or moving from one extreme to the other.

Many alternating glacials and interglacials occur within a single long ice age. We are now living in an interglacial, a period of relative warmth. Such warm periods, however, have been rare during the past half million years. For about 90 percent of that time, Earth's temperatures were cooler than they are today.

The last glacial of the current long ice age ended roughly 11,000 years ago. That glacial is sometimes called the Ice Age, with capital letters to set it apart from the long ice ages and from all the other, earlier glacials. The Ice Age was the final phase of a geological period known as the Pleistocene epoch.

The Pleistocene Epoch

In the 4.6-billion-year geological history of our planet, the Pleistocene epoch is very recent. It began about 1.8 million years ago and ended about 10,000 years ago.¹⁵ (The period from 10,000 years ago to the present is known as the Holocene epoch.) Geologists divide the Pleistocene epoch into three ages. The first, called the Early Pleistocene, began 1.8 million years ago and continued until 780,000 years ago. The Middle Pleistocene ran from 780,000 to 130,000 years ago. The period from 130,000 to 10,000 years ago is called the Late Pleistocene.

The entire Pleistocene epoch was a time of frequent, repeated glacial advances. It was also a hugely important time in human evolution. During this period of Earth's history, early species in the genus *Homo* moved out of Africa, where the human evolutionary line originated, to colonize Asia and Europe.

RECENT GEOLOGICAL TIME

MYA=MILLIONS OF YEARS AGO
YA=YEARS AGO

EPOCH	GEOLOGICAL AGE	DATES	STONE AGE
Holocene		Present	
Pleistocene	Late Pleistocene	10,000 YA	Upper Paleolithic 45,000-30,000 YA
	Middle Pleistocene	130,000 YA	Middle Paleolithic 100,000-300,000 YA
	Early Pleistocene	780,000 YA	Lower Paleolithic
Pliocene	Gelasian	1.8 MYA	Paleolithic (Stone Age)
		2.6 MYA	

Glacial Eurasia

The climate and landscape that early humans encountered in Asia and Europe varied considerably, depending upon whether Earth was in an interglacial or a glacial period.

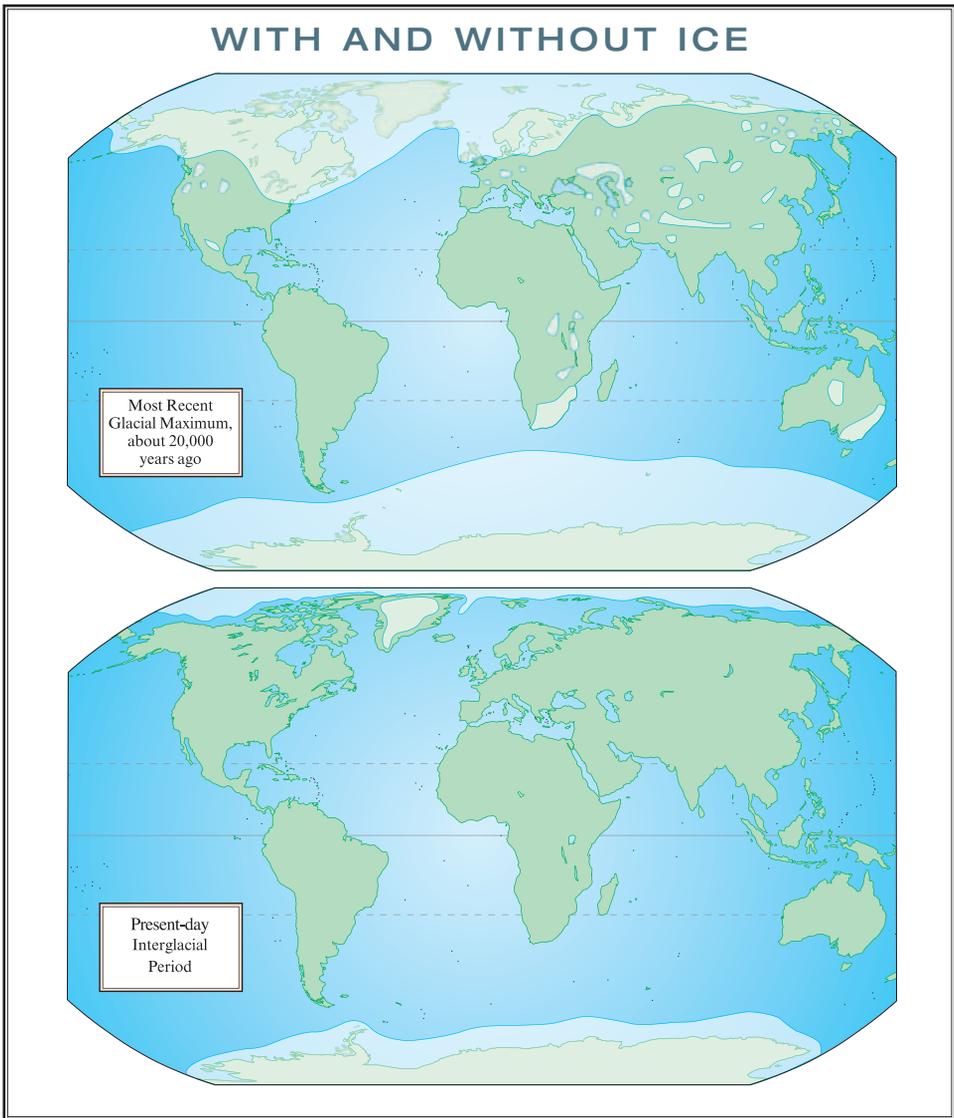
The interglacial periods of the Pleistocene had temperatures similar to those of the present day, or even a bit warmer. During the last interglacial period, between 130,000 and 115,000 years ago, the ice sheets shrank and receded toward the Arctic region. Forests spread far across Eurasia as well as the tropics. Lake, sea, and rainfall levels were high. Animals such as hyenas, elephants, hippopotamuses, and rhinoceroses lived as far north as England—modern excavators have uncovered a well-preserved fossil hippo in London's Trafalgar Square.¹⁶



Paleontologist Simon Parfitt displays a fossil from a hippo that lived in what is now London during a warm era in Earth's past.

After temperatures turned cool around 115,000 years ago, the northern forests shrank and the ice sheets began to grow, reaching out to blanket the land. As more and more of Earth's water became tied up in ice, the sea level fell by as much as 330 feet (100 meters). The falling sea level exposed sections of the continental shelf, the seabed that borders the continents and large islands. This seafloor formed bridges of dry land that linked various

landmasses. At the time of the most recent glacial maximum, around 20,000 years ago, land bridges connected England to France, Sicily to Italy, and Siberia to Alaska.¹⁷ People undoubtedly traveled across land bridges during the Pleistocene glacial maximums.



The heavy sheets of ice that blanketed much of northern Eurasia and North America during the last glacial maximum were 1 mile (1.6 kilometers) thick in some places. As these ice sheets advanced southward, they gouged new valleys into the landscape, pulverized boulders into gravel, and destroyed all plant life. Animals—including humans—either perished or moved south to escape the ice.

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Ice did not cover everything, but the lands bordering the ice grew colder and drier. Only species that were adapted to endure such conditions could survive. The hippos and elephants of the interglacials were not adapted to live in cold environments. They disappeared, giving way to hardier Ice Age species such as woolly mammoths, woolly rhinoceroses, and



reindeer. Yet some species could endure both cold and warm climates, which meant that they were able to live in parts of Eurasia during both glacial and interglacial periods. Wolves, badgers, bears, and rabbits were among these Pleistocene survivors. So were our close relatives, several species of humans that are now extinct.

Woolly mammoths were up to 14 feet (4.25 meters) tall at the “topknot.” Several species of humans shared the Eurasian landscape with these giants of the last Ice Age.



The First Great Migrations

The Neanderthals of Europe were the first species of early humans to be discovered by the modern world, but in the history of human evolution they arrived late on the scene. The hominin line originated millions of years ago in Africa, and the first humans evolved there. At least one early human species spread out of Africa into Asia about 1.8 million years ago, at the beginning of the Pleistocene epoch. By a million years ago humans were living in Europe. These first Europeans, however, were not Neanderthals. The complex history of early humans in Europe started long before the Neanderthals.

Africa and Beyond

Modern humans are “the sole surviving twig,” in the words of paleoanthropologist Ian Tattersall, on one branch of the primate order, which is a category of mammals that also includes apes, monkeys, lemurs, and other small animals.¹⁸ Our branch of the primate family tree is the hominin tribe. Many species of hominins existed in the past—twenty or more of them, in the view of many paleoanthropologists. All of these ancestors and cousins, however, have died out.

Our closest living relatives are the chimpanzees, perched at the end of a different branch on the primate family tree. Like the chimpanzees, the hominins originated within the African apes. Scientists think that the hominin evolutionary line separated from the line leading to chimpanzees 5 million to 7 million years ago. By 4 million years ago Africa was home to hominins called australopiths.

There were several species of australopiths. All of them walked upright on two legs, not on four legs like other primates. The australopiths were not “human” in any other way—they were really bipedal apes—but they mark the beginning of bipedalism, one key trait of later humans. Another key trait had appeared by 2.5 million years ago, when hominins began making and using simple stone tools. Paleoanthropologists do not know, however, exactly which species of early hominins were toolmakers.

Fossils dating from around 2 million years ago or earlier have been identified as belonging to our own subgroup of hominins, the genus *Homo*, or humans. By 1.9 million years ago a new species of early *Homo* had evolved in Africa. Its body size and shape was similar to ours, although its brain was smaller than a modern human brain. The face of this hominin, too, set it apart from modern humans. Bony ridges above the eyes created a bulging forehead, while the lack of a bony projection on the lower jaw meant that there was no chin.



Homo erectus, distinguished from modern humans by its prominent forehead and lack of chin, is believed to be the first human species to migrate out of Africa.

With this species, called *Homo erectus* by some paleoanthropologists and *Homo ergaster* by others, the hominin line crossed several major thresholds. After a few hundred thousand years, *H. erectus* started making stone tools in new, more complex ways. Even before that, however, *H. erectus* became the first human species to spread beyond Africa.

According to the fossil record, almost as soon as *H. erectus* evolved in Africa, some members of the species migrated out of that continent. By at least 1.5 million years ago, perhaps earlier, *H. erectus* was living in Southeast Asia. Later the species became established in China. Fossils show that these hominins continued to live in eastern Asia for hundreds of thousands of years, into the Late Pleistocene. Because of differences between the African and Asian fossils, some scientists identify the African version as *H. ergaster* and the Asian offshoots as *H. erectus*. Other experts regard them all as a single species, *H. erectus*, with local variations.

To say that *H. erectus* migrated out of Africa does not mean that these hominins knew they were leaving one continent for another, or that they planned to colonize other parts of the world. Instead, groups or family bands of these hominins simply expanded into new territory, perhaps in search of food or other resources, or to escape conflict with rival bands. Eventually some of them traveled across the Sinai Peninsula, the narrow strip of land that connects northeastern Africa with southwestern Asia. The range of these hominins kept expanding until *H. erectus* reached the other side of Asia.

Eastern Asia was not the only new region that early humans entered at this time. Hominins also moved north into what is now Georgia, a country in a region called the Caucasus, between the Black Sea and the Caspian Sea south of present-day Russia. In 1991 archaeologists found ancient hominin remains at Dmanisi, Georgia. The Dmanisi bones and skulls show a lot of variety, which means that they may represent more than one species of early human. Dating of the fossils shows that at least one species of early human inhabited the Caucasus region as early as 1.8 million years

ago, at the dawn of the Pleistocene epoch. (*First Humans*, the second book in this series, describes the Dmanisi discovery and scientists' ideas about the fossils found there.)

Into Europe

Geographers regard the mountainous Caucasus region as the dividing line between Asia and Europe. Early humans lived in the Caucasus, on the doorstep of Europe, 1.8 million years ago, but when did they enter Europe itself? And how did they get there?

Three routes could have taken early humans from Africa to Europe, as paleoanthropologists Chris Stringer and Peter Andrews have pointed out.¹⁹ One route leads from the Sinai Peninsula around the eastern coast of the Mediterranean, then north into what is now Turkey or northeast into the Caucasus. Today the Asian portion of Turkey is separated from the European mainland by narrow waterways, but during past glacials a land bridge spanned that gap. Humans could have walked from Turkey into Europe across the land bridge at times of low sea level. They could also have reached Europe from the Caucasus by migrating around the northern coast of the Black Sea.

The other two routes from Africa to Europe would have involved crossing water. One route leads from present-day Morocco, in North Africa, to Gibraltar. The other leads from the North African nation of Tunisia to the island of Sicily, and then on to the Italian mainland. Both of these routes now lie beneath the waters of the Mediterranean Sea. During Pleistocene glacial periods the sea level was considerably lower, but even at glacial maximum, when the seas were lowest, part of each route would have been underwater. Could early humans have traveled from Africa to Europe by water?

Fossil evidence shows that early humans lived in North Africa during the Pleistocene. In 2008 a French-Moroccan paleoanthropological team found a *Homo erectus* jaw at a quarry in Casablanca, Morocco. The same site had already yielded several fossil teeth, as well as stone tools. Experts think that

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the fossils are at least half a million years old.²⁰ Several human jaws found during the 1960s at Tighenif, in the nearby nation of Algeria, may be even older, dating from 700,000 years ago. Perhaps these inhabitants of North Africa crossed the Mediterranean to Gibraltar or Sicily on rafts or logs during Pleistocene glacials, when the water passages were shorter than they are today. If they did so, however, no evidence remains of their watercraft or their voyages.



*This mandible, or jaw, was found in 2008 at a quarry in Casablanca, Morocco. The fossil's discoverers think it belonged to *H. erectus*.*

We do not know how the early humans reached Europe, but scientists are fairly certain that they made the journey more than once. Over hundreds of thousands of years during the Pleistocene epoch, many migrating bands of humans must have entered Europe, possibly by more than one route.

Train Tracks through Time

To determine when humans first arrived in Europe, paleoanthropologists identify the oldest specimens among the fossils of ancient *Homo* that have been found across the continent. (See *Origins*, the first book in this series,

for information about the techniques that scientists use to date fossils and artifacts.) The oldest known signs of human life in Europe come from sites in Italy and Spain, where modern construction projects have revealed ancient remains.

In 1994, during highway construction near the Italian town of Ceprano, south of Rome, a broken skullcap was found in one of the excavations. Experts have estimated its age at about 800,000 years. That same year, ancient hominin remains were discovered at Atapuerca, in Spain.

The Sierra de Atapuerca is a range of limestone hills in northern Spain. The hills are riddled with caves carved out over millions of years by water flowing through the porous rock. Some of the caves open onto the hillsides, and local people have occasionally explored them, returning with fossils such as cave bear teeth. Other caves, however, filled up with sediment long ago, or collapsed. Those caves no longer opened onto the outside world. Their secrets lay buried within the hills until the 1890s, when a railway company began constructing a track through the Sierra de Atapuerca. To keep the track level, the workers cut a trench through the Sierra. In doing so they transected, or cut through, a series of collapsed caves.

In 1910, not long after the railway work was completed, paintings were found on some cave walls at Atapuerca. They were only a few thousand years old, which meant that while they might interest a historian, they had no connection with the very early chapters of human history in Europe. In the 1960s, however, Atapuerca began to reveal a more ancient past, after a member of a Spanish caving club told a museum director that the walls of the Sierra de Atapuerca railway trench contained fossils.²¹

Within a few years, paleontologists—scientists who study early and extinct life-forms—were collecting and analyzing animal fossils from Atapuerca. A paleontology student named Trinidad Torres worked there in 1976. Torres was looking for cave bear fossils, but he found something of greater scientific importance: the fossil jawbone of an ancient hominin. It was the first human fossil found at Atapuerca.



Rock formations beckon beyond the entrance to one of the many caves in the Sierra de Atapuerca.

Torres and paleontologist Emiliano Aguirre dated the Atapuerca jawbone by examining the mixture of plant and animal fossils found with it. The ages of some of those plants and animals were already known from other sites—Torres and Aguirre could assume that the Atapuerca fossils dated from roughly the same time period. This gave them an estimated age of 400,000 years for the jawbone.

Torres's jawbone turned Atapuerca into a leading site for research into early humans in Europe. The next big paleoanthropological find at Atapuerca opened the door into a much more distant human past.

The discovery happened in a sediment-filled cave called Gran Dolina (meaning “big sinkhole”). The railway trench had sliced through this cave, creating a cliff or wall that displays time as a stack of different layers of sediment,

with newer layers on top of older ones. There are eleven layers in all, covering more than a million years. Layer 1, at the bottom, is the oldest. It contains no fossils. Layer 4 dates from about a million years ago and contains the site's oldest fossils of animals, including jaguars, deer, and rhinos. This level has also yielded a few stone tools, but no human fossils.



Scaffolding covers the area of the Atapuerca railway trench known as Gran Dolina. Now devoted to science rather than train transport, the trench is a gateway to the distant past.

Layer 6 of Gran Dolina is of special interest to paleoanthropologists. It contains about twenty-five species of animals, a greater variety than any other layer. It also contains a large number of stone tools. Most important, it has yielded hominin fossils far older than the 1976 jawbone. In 1994 a paleoanthropological team led by José María Bermúdez de Castro removed an early human lower jaw, an upper jaw, and eleven teeth from Layer 6. Thanks to a feature of Earth's magnetic field, we know the age of these fossils with considerable certainty.

Every so often in Earth's history, for reasons that scientists do not yet understand, the planet's magnetic field reverses itself. Because fragments of magnetic rock align themselves with the magnetic field, the reversals can be recorded as rock forms. In rock that forms today, the magnetic fragments

point north, like compass needles. During past periods of magnetic reversal, however, they pointed south.



One of the hominin fossils discovered in Gran Dolina: an 800,000-year-old tooth

By studying the magnetic orientation of rock throughout geological history, scientists have developed a time line of magnetic reversals over millions of years. The most recent reversal took place 780,000 years ago. At Gran Dolina, sediments from Layer 7 of the cave record this reversal. The human fossils that Bermúdez recovered from Layer 6 in 1994 came from just below the reversal, which makes them about 800,000 years old. The ages of the plant and animal fossils found around the human fossils match this date.

Not far from Gran Dolina, the Atapuerca railway trench transects another site called Sima del Elefante (“Cave of the Elephant”). There, in the summer of 2007, Spanish researchers discovered a human tooth. The following year they located part of a lower jawbone. On the same level of the cave they also found thirty-two simple stone tools. Geological tests of the minerals present in that level give an age between 1.1 million and 1.2 million years, which

makes the Sima del Elefante jawbone and tools the oldest human remains yet found in western Europe.²² The search for more evidence of these ancient inhabitants is now under way.

Pioneer Man

Once a fossil is found, scientists must decide whether it belongs to a known species or represents a new species. In the 1990s the discoverers of the Gran Dolina fossils faced that challenge. They estimated that the brain of the 800,000-year-old hominin measured more than 1,000 cubic centimeters in volume, which they felt was too large for *Homo erectus*.²³ Another early human species known from European and African fossils, *Homo heidelbergensis*, had a larger brain than *H. erectus*, but the facial shape of the newly discovered hominin did not seem to match *H. heidelbergensis*. (See the next chapter of this book for more about *H. heidelbergensis*.)

Bermúdez and his colleagues decided that the Gran Dolina discovery was a new species of early human. They named it *Homo antecessor*, from a Latin word meaning “one who goes before” or “pioneer.” Other experts, however, think that the features that appear to set the Gran Dolina fossils apart from *H. heidelbergensis* may be due to age and gender. Some of the most important Gran Dolina remains, such as pieces of jaws, come from juveniles or females, who may have looked somewhat different from adult males. In this view, the Gran Dolina remains could belong to *H. heidelbergensis*.

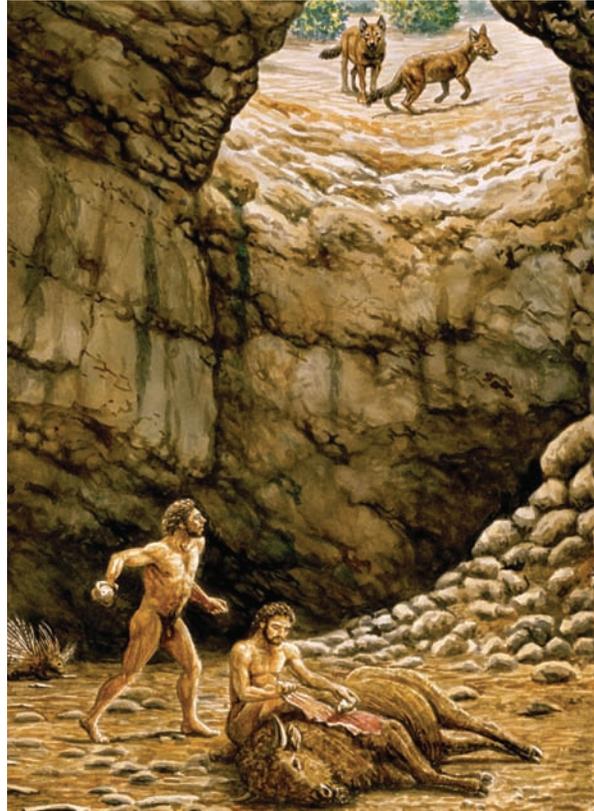
Another possibility is that the Gran Dolina fossils and the fossil jaws from Tighenif in Algeria belong to the same species, and that species is different from both *H. heidelbergensis* and *H. erectus*. If the scientific community eventually accepts this view, the Gran Dolina and Tighenif fossils will be known as *H. mauritanicus*, the name given to the Tighenif remains, because that name was chosen first.

The Gran Dolina fossils are challenging to study because they are just fragments. Finding a complete or nearly complete skeleton is extremely rare in paleoanthropology. At Gran Dolina, excavators have not found even a complete skull. They have recovered about ninety pieces of broken bone or skull from at least six different individuals, including children. One set of fossils, consisting of parts of a skull, jaw, and spine, may come from the same

individual, whom scientists have called Gran Dolina Boy. Experts estimate that he died at around eleven years old.²⁴

The human bones from Gran Dolina were intermingled with animal bones and stone tools. The tools are simple, similar in many ways to the oldest known stone tools made by hominins in Africa 2.5 million years ago. The toolmakers at Gran Dolina left three basic types of artifacts: cutters or choppers, flakes, and hammer stones. A cutter or chopper was a pebble or rounded rock from which one or more flakes had been struck off, creating a sharp edge. The flakes, with bladelike edges, were also used as cutting tools. Hammer stones were pounding tools, used both for striking flakes and for breaking open the bones of animals.

Animal bones from Layer 6 at Gran Dolina tell us that *H. antecessor* was a meat eater. The bones show signs of two types of tool use. The humans used their sharp-edged tools to remove flesh from carcasses, leaving tell-tale cut marks on the bones in the process, and they also smashed bones with hammer stones to get at the soft, nutritious marrow inside. Scientists know that the humans who sheltered in the Gran Dolina cave butchered a variety of animals, including deer and horses. However, they cannot tell whether *H. antecessor* hunted these animals. The humans may have scavenged meat—and possibly skins, to be



Hominins who used the caves at Atapuerca butchered large animals. Whether they hunted them or only scavenged them remains a mystery.

worn for warmth—from the carcasses of animals that died of natural causes or were killed by other predators.

The animal remains at Gran Dolina are not the only bones that show signs of tool use. The human bones also reveal cut marks and evidence of being smashed with hammer stones, just like the animal bones. These signs of butchering are a strong suggestion that *H. antecessor* was a cannibal. Once again, scientists cannot say whether these early humans killed each other for food or merely fed on the bodies of those who had died.

The Spanish paleoanthropologists who discovered the Gran Dolina fossils and have studied them think that *Homo antecessor* evolved from African *Homo ergaster* (or *H. erectus*). In turn, *H. antecessor* evolved into two different lines of descent. One line led to *H. heidelbergensis* and then to the Neanderthals. The other line led to modern humans. If this view of human evolution is correct, *H. antecessor* is the most recent ancestor that we share with our extinct Neanderthal relatives. As you will see later in this book, however, other experts think that *H. heidelbergensis* was the ancestor of both Neanderthals and modern humans.

Species names may change as paleoanthropologists uncover more fossils and learn more about the humans of the Pleistocene epoch. But no matter how many species of humans lived during the Pleistocene, it is clear that there was considerable variety among the populations that spread out from Africa into new parts of the world.

Do the fossils from Dmanisi, Ceprano, Gran Dolina, and the Sima del Elefante mark the beginning of a permanent human presence in the Caucasus and in Europe? Or are they the traces of small populations that made early migrations out of Africa and then died out? Although some paleoanthropologists now think that members of the genus *Homo* may have colonized Europe earlier than previously suspected, they do not yet have enough evidence to settle the question one way or the other. They do know, however, that by half a million years ago one human species was well established in Europe. That species is usually called *Homo heidelbergensis*.



Africa is the birthplace of humankind, but no fossils of ancient humans were found there until this skull, generally agreed to be that of Homo Heidelbergensis, turned up in Zambia in 1921.

THREE

Heidelberg Man

Half a century after limestone workers discovered the first Neanderthal fossils in Germany's Neander Valley, another fossil came to light in a different German quarry. In 1907 a worker found a fossilized lower jawbone, complete with teeth, in a rock and sand pit at Mauer, not far from the city of Heidelberg. A professor at the University of Heidelberg decided that the jawbone was the first evidence of a new species of early human, which he named *Homo heidelbergensis*, or Heidelberg Man.

Other finds soon followed, in Germany and elsewhere. Heidelberg Man, it turned out, was not just a European species. Remains of *H. heidelbergensis* have been found on three continents, with dates that span hundreds of thousands of years. Many paleoanthropologists think that this long-lasting, wide-ranging human species was the ancestor of the Neanderthals. It may have been our ancestor as well.

Tools without Toolmakers

Today Pakefield is a coastal town in southeastern Britain. Seven hundred thousand years ago, a broad river flowed nearby, winding through a flat landscape. At that point in the Pleistocene epoch, the world was in a mild climate phase, with warm summers and short winters. England was warmer than it is today. Hippos and elephants roamed the Pakefield site. So, according to a 2005 discovery, did early humans.

The discovery consisted of thirty-two pieces of flint that appeared to be simple cutting or chopping tools.²⁵ Flint is a hard silica. It was favored by prehistoric makers of stone tools because it often occurs in the form of handy fist-sized, flattened lumps, from which toolmakers can easily split flakes to create sharp edges. According to paleoanthropologist Chris Stringer of the

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Natural History Museum in London, a member of the team that found the flints, rocks can be made to look like tools as a result of natural processes, such as “bashing together in a river bed.”²⁶ The setting in which the Pakefield flints were found, however, was not the bed of a river. The excavators concluded that the flints had not broken naturally but had been fashioned into tools by early humans.

How early? That was the exciting part. Researchers dated the tools to 700,000 years ago. Before Pakefield, the oldest known traces of human presence in Britain were about 500,000 years old. The Pakefield flints meant that humans were active in northern Europe much earlier than previously believed.



Stones sometimes speak. These flint tools from Pakefield said humans were active in Britain thousands of years earlier than scientists had formerly believed.

No human remains were found at Pakefield, but the search is on. Paleoanthropologist Stringer says, “The fact that we know that there were people in Britain at this early date means we can start to look for further evidence of them and perhaps one day be lucky enough to find fossil

remains of these people.”²⁷ So far, however, the flints are the only evidence of human activity in Britain 700,000 years ago. And the flints, unfortunately, don’t tell us anything about the humans who made them and used them.

The missing toolmakers of Pakefield date from about the same time as the fossils from Ceprano and Gran Dolina. They could belong to the species *Homo antecessor*, identified from the Gran Dolina fossils. If, however, the Gran Dolina fossils really represent an early form of *Homo heidelbergensis*, perhaps the Pakefield toolmakers also belonged to that species. Some paleo-anthropologists now use the *H. heidelbergensis* label for all European humans earlier than the Neanderthals, recognizing that classifications will probably change as more fossils are unearthed and the picture of recent human evolution becomes clearer.

H. heidelbergensis in Africa

The fossils that have been identified as *H. heidelbergensis* share certain physical features, including wide noses and large ridges of bone above the eye sockets. Their thick-boned skulls are flatter from top to bottom, and longer from front to back, than those of modern humans, but rounder than those of *H. erectus*. Some *H. heidelbergensis* skulls have a feature called an occipital bun, which is a bulge on the occipital bone, at the very back of the skull. This feature occurred in several species of early humans, especially Neanderthals, but is rare among modern humans. *H. heidelbergensis* lacked a chin, and its teeth were larger than those of modern humans.

On average, the brain of *H. heidelbergensis* was larger than that of *H. erectus*. It was also slightly smaller than the average brains of *H. neanderthalensis* and of *H. sapiens*, or modern humans. Yet the brain of *H. heidelbergensis* fell within the size range of modern humans. *H. sapiens* brains typically measure 1,250 to 1,500 cubic centimeters in volume. When scientists measured ten *H. heidelbergensis* braincases, they came up with volumes ranging from 1,116 to 1,450 cubic centimeters, with a mean volume of 1,274 cubic centimeters.²⁸



Strong and stocky, with a heavy brow ridge, this is how Heidelberg Man may have looked.

No complete skeletons of *H. heidelbergensis* have been found. Scientists must make educated guesses about Heidelberg Man's overall appearance based on scattered individual bones, many of them broken. The bones of *H. heidelbergensis* were more robust—larger and sturdier—than those of modern humans, meaning that Heidelberg Man was stocky and strong. Measurements of an arm bone from Spain suggest that it came from an individual who stood about 5.5 feet (1.7 meters) tall, if Heidelberg Man's body proportions were fairly similar to those of modern humans.²⁹

Although *H. heidelbergensis* was discovered in Europe, similar remains soon cropped up in Africa. In 1921 a miner found a well-preserved fossil skull at the Broken Hill mine in the British colony of Northern Rhodesia, which today is the nation of Zambia. The skull puzzled scientists. Although it had a

very large brow ridge, which they associated with “primitive” hominins such as *H. erectus*, its brain size was close to that of modern people.

The Broken Hill hominin was identified as a new species, *Homo rhodesiensis*. A partial skull of the same species turned up at Saldanha, in South Africa, in 1953, and another partial skull in Ethiopia at Bodo in 1976. Estimated brain size in the three skulls ranges from 1,225 to 1,325 cubic centimeters. Cut marks in the Bodo skull suggest that someone used a stone tool to remove the flesh from the skull.³⁰ Is this a sign of cannibalism, or of some ancient ritual? No one knows.

As far as scientists can tell from the three skulls and the handful of other bones found with them, Rhodesian Man looked a lot like Heidelberg Man. Most paleoanthropologists, in fact, now regard the African fossils and the European ones as belonging to the same species, *Homo heidelbergensis*.³¹

The Life and Times of Heidelberg Man

H. heidelbergensis spanned a broad range of both geography and time. In addition to the German and African finds, *H. heidelbergensis* fossils have been found across Europe (at various locations in England, France, Spain, Italy, Hungary, and Greece) and in western Asia (in Israel). A partial skull from Narmada, India, and a skull from Dali, China, may represent *H. heidelbergensis* in southern and eastern Asia, although some experts think these remains come from *H. erectus*, which is known to have lived in eastern Asia throughout most of the Pleistocene epoch.³²

Experts do not yet know where Heidelberg Man originated. The species could have evolved from an earlier hominin, such as *H. erectus* or *H. antecessor*, in Europe or western Asia. Many experts believe, however, that *H. heidelbergensis* originated in Africa and spread from there to Eurasia, like *H. erectus* before it. One of the oldest *H. heidelbergensis* fossils with a relatively firm date is African: the skull from Bodo, Ethiopia. It was found near a layer of sediment containing volcanic ash that can be dated to 640,000 years ago. That result, together with a study of the plant and animal fossils found in

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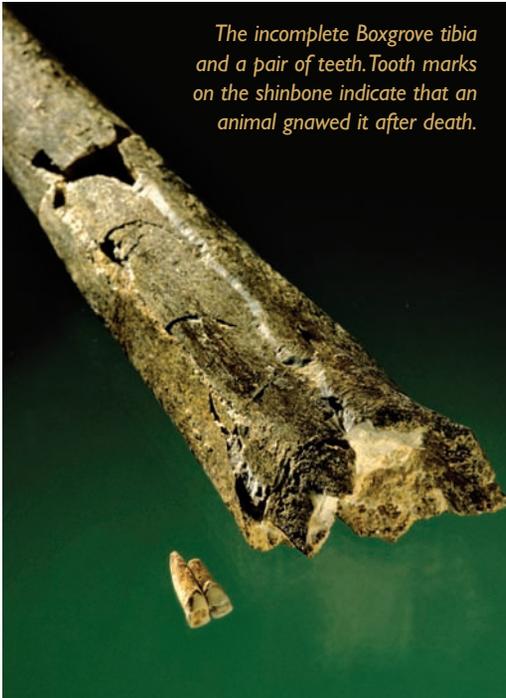
the same layer of sediment, suggests that the skull is about 600,000 years old.³³ At the other end of the time scale, possible *H. heidelbergensis* fossils from a French site called Bau de l'Aubesier are only 195,000 years old.³⁴

Heidelberg Man existed for a long time—well over half a million years, if the Atapuerca remains and the Pakefield toolmakers are included. What was life like for this early human species? A few paleoanthropological sites offer glimpses into how people lived in Pleistocene Europe.

Boxgrove. Quarries and mines have played a large role in paleoanthropology. Many important fossils have been found at these commercial earth-moving operations. One quarry that became a scientific site is Boxgrove, on England's south coast. Paleontologists began excavating fossils of ancient animals from the quarry in 1985. During the following decade researchers found three human fossils at the site: a partial tibia, or shinbone, and two teeth.³⁵ Dated to about 500,000 years ago, these probable relics of *Homo heidelbergensis*

are the oldest human remains yet found in northern Europe.

The Boxgrove tibia, according to paleoanthropologists Chris Stringer and Peter Andrews, is “one of the most massive early human leg bones ever found.” It came from an individual estimated to stand almost 6 feet (1.8 meters) tall and to weigh at least 200 pounds (90 kilograms). “The strength of the bone,” say Stringer and Andrews, “must also reflect the physically demanding life-style that these people had to endure.”³⁶



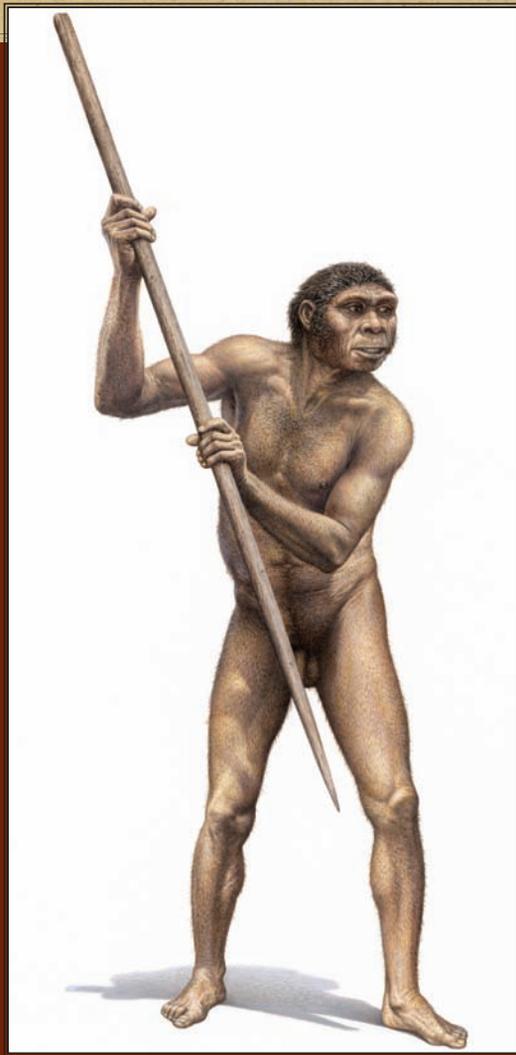
The incomplete Boxgrove tibia and a pair of teeth. Tooth marks on the shinbone indicate that an animal gnawed it after death.

Clues about that way of life lay scattered around the Boxgrove site, where excavators discovered hundreds of stone tools and many animal bones. The tools, made from flints found in the nearby cliffs, are Acheulean hand axes, which replaced the simple pebble tools of the first toolmakers. (The name comes from Saint-Acheul in France, where many examples of the hand ax have been excavated.)

The Acheulean hand ax was a powerful piece of early technology. Humans on several continents made and used these cutting and chopping tools for hundreds of thousands of years. The fist-sized hand axes, usually oval or teardrop shaped, were flattish flints or other stones that could be worked on both sides with hammer stones, giving them longer and sharper edges than the pebble tools. (See *First Humans* for more information about hand axes and their significance.)

Cut marks on the animal bones from Boxgrove show that people used their hand axes to butcher a variety of large mammals, including bison, horses, rhinoceroses, and giant deer. From the way different kinds of marks lie on top of one another, experts have been able to reconstruct the systematic process of butchering. Skinning the carcass was the first step, followed by cutting the body apart, slicing flesh from the bones, and finally breaking the bones open to expose the marrow. Some animal bones from Boxgrove bear the marks of animal teeth as well as cut marks from hand axes. The tooth marks, however, are always on top of the cut marks. This means that the animals gnawed the bones only after the humans had finished with them.³⁷

The Boxgrove people may have waited until a predator such as a lion or saber-toothed cat brought down a prey animal, then advanced as a group to drive away the predator before it could consume the carcass—some Africans get prey this way today.³⁸ The other possibility is that the Boxgrove people actively hunted large prey, working cooperatively to bring down the big animals. If so, they probably used spears. Researchers at Box-



The First Weapons

“I will never forget what I saw next,” wrote Spanish paleoanthropologist Juan Luis Arsuaga. He was describing a visit to a coal mine at Schöningen, Germany, the site of a remarkable discovery in the mid-1990s.⁸⁶ Arsuaga walked through a plastic tunnel into the heart of the mining operation and saw a black bed of peat, an organic material like soft coal.

Above: Sharpened wooden spears show that early Homo made weapons as well as tools.

Atop the peat lay the fossilized pelvis of a horse, dated to about 400,000 years ago, with a wooden spear sticking out of it. That spear was the oldest wooden artifact, or human-made object, ever found.

The horse and spear had been excavated from the peat by archaeologist Hartmut Thieme, who spent years recovering fossils and other artifacts from the mine. He and his colleagues found seven wooden spears and one shorter carved stick at Schöningen.⁸⁷ They think that 400,000 years ago, when the site was the shore of a Pleistocene lake, hunters attacked horses with the spears, then butchered the animals. Horse bones with cut marks also turned up in the mine.

The spears are more than 6 feet (1.8 meters) long, made from the trunks of young Norway spruces. Experts are not sure whether the spears were used as lances for stabbing or as javelins for throwing, but the weapons are heavier at the pointed end, which is a feature of modern javelins. The makers of the Schöningen spears may have used them for both stabbing and throwing.

Stone tools may have been used as weapons, but they were primarily tools. A spear, though, has only one use—as a weapon. The Schöningen spears are the oldest known weapons. They are also, as paleoanthropologist Charles Lockwood has pointed out, a reminder “of what we do not see in the fossil record.”⁸⁸

Our knowledge of early humans is based almost entirely on stone and bone. Everything else decays and disappears. For wooden artifacts to be preserved for hundreds of thousands of years at Schöningen took a rare stroke of luck. Only a few other perishable objects of similar age have survived. *Homo heidelbergensis* and other early human species may have made artifacts of wood, leather, or woven grass long before the 400,000-year mark. Perhaps future finds, as lucky as the Schöningen discovery, will bring us more tools, clothing, and weapons from the distant human past.



A modern illustration, based on fossil evidence, portrays a scene that might have occurred 500,000 years ago at Boxgrove. Three early humans butcher the large carcass of a rhino while one prepares to hurl a stone at two wolflike predators. In the foreground, a toolmaker crafts a stone blade.

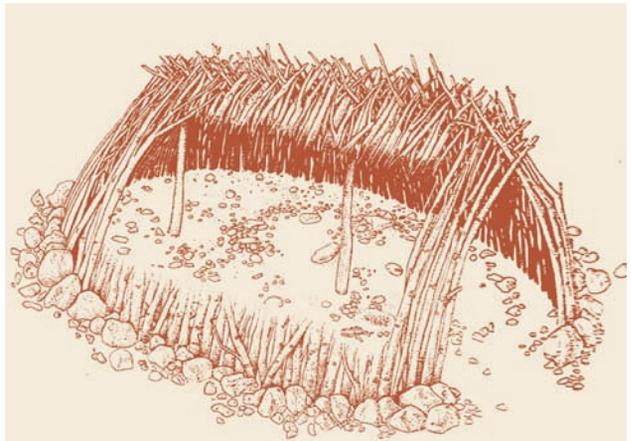
grove found a horse's shoulder blade with a round hole that appears to have been made by the point of a spear, although no trace of the spear has been found.³⁹

A final insight into life at Boxgrove comes from the two teeth found at the site. They are from the front of a lower jaw, and they are covered with pits and scratches. Experts who have studied the tooth surfaces through microscopes believe that the marks were made when the person gripped a piece of skin, meat, or plant material in his or her teeth, held the other

end with one hand, and then used a tool to cut through the material. From the direction of the marks left on the teeth by these slicing motions, we know that the tool was held in the right hand. The Boxgrove teeth came from someone who was, like the majority of people today, right-handed.⁴⁰

Terra Amata. On the coast of the Mediterranean Sea in southern France is an archaeological site called Terra Amata. There, in the 1960s, researchers found flint tools. They also discovered arrangements of stones, holes, and cleared areas in the ground, and evidence of fire. These signs add up to traces of the world's oldest known human-built shelters. Dating from about 400,000 years ago, the shelters were most likely temporary or seasonal camps, perhaps used by groups of hunters. The site does not appear to have been lived in continuously over long periods of time.

A typical shelter was oval shaped and measured up to 25 feet (7.5 meters) in length. The walls were made of poles stuck into the ground, braced with piles of stones at the bases. The poles leaned inward along the sides to meet at the top, forming a roof. Blackened stones and burned bones inside a circular depression in the shelter probably mark the location of a hearth or fire pit. This shows that in addition to building simple shelters, the humans of Terra Amata had mastered control of fire and were using it to cook meat.⁴¹



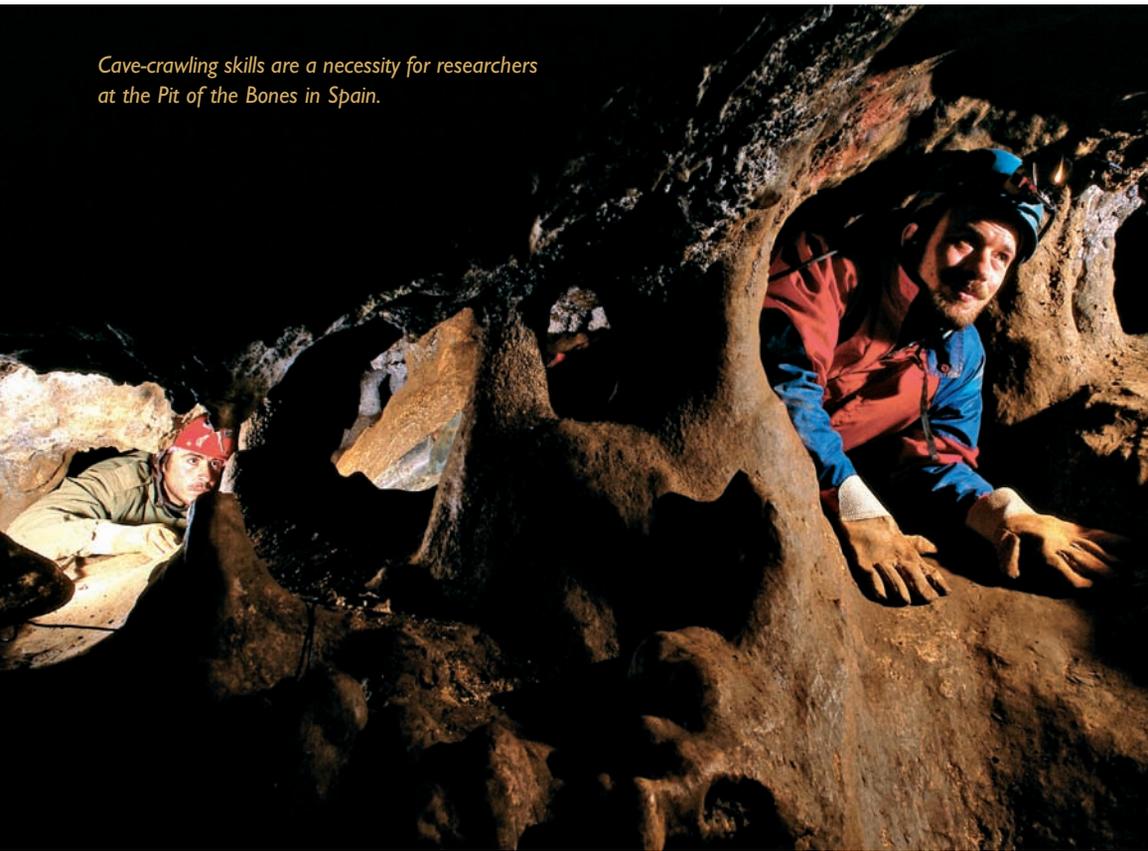
Basing their deductions on holes, burn marks, and piles of rocks, scientists think that the world's first human-built shelter, constructed around 400,000 years ago, looked like this. A portion of one wall has been cut away to show the interior.

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The flint tools found at Terra Amata included choppers, cutters, and scrapers. These could have been used to butcher meat and clean skins from the deer, rabbits, and other animals whose broken bones were also found at Terra Amata. We do not know anything about the language of *H. heidelbergensis*, or even whether *H. heidelbergensis* used language. But the existence of large shelters means that these humans acted together in groups, so they must have communicated with one another to some extent.

The Pit of the Bones. Only three human fossils have been found at Boxgrove. Terra Amata has produced none. At the Spanish site of Atapuerca, however, a cave known as the Sima de los Huesos (“Pit of the Bones”) has yielded thousands of fossils of early humans.

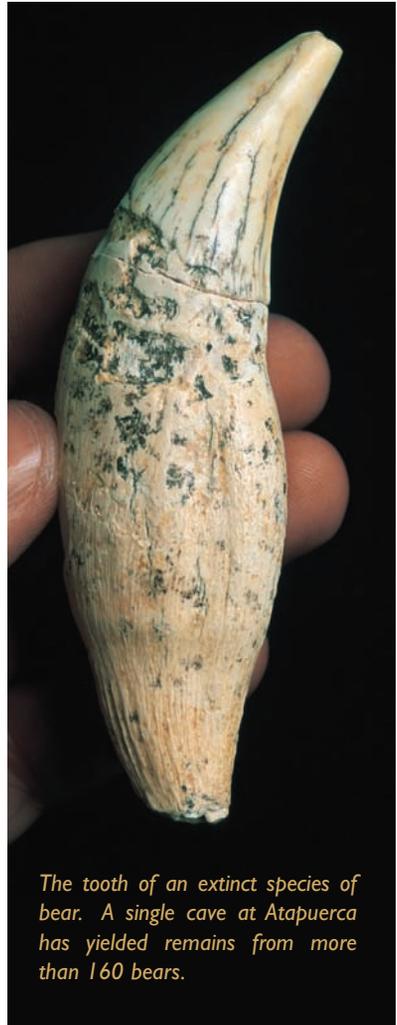
Cave-crawling skills are a necessity for researchers at the Pit of the Bones in Spain.



The last chapter told how the building of a railway through the hills of Atapuerca revealed caves filled with fossils. The Sima is not one of the caves cut through by the railway line. Instead, the Pit of the Bones lies deep within a cave system southeast of the line. Reaching it is no easy task. The route through the cave is so narrow in places that explorers must crawl on their stomachs; at other places they have to lower themselves on ropes. The Sima lies at the muddy bottom of a 43-foot (13-meter) shaft, descended by means of a ladder.

The challenges of getting in and out of the pit did not prevent local men from venturing into the Sima for souvenir cave bear teeth. When Spanish paleontology student Trinidad Torres explored the cave in 1976, he too was looking for bear fossils. The 400,000-year-old human jawbone he found, the first evidence of early humans at Atapuerca, paved the way for a thorough scientific examination of the Pit of the Bones.

The first step was to remove the layers of loose sediment, including many broken bones, that had been stirred up by fossil hunters over the years. Every bag of material taken from the small Sima chamber had to be hauled outside the cave system for study. The arduous task of clearing the disturbed sediments continued until 1992, when workers finally dug down to a level of undisturbed sediments. From that point on, newly uncovered fossils could be studied in their original relationship to each other and to the earth around them.



The tooth of an extinct species of bear. A single cave at Atapuerca has yielded remains from more than 160 bears.

The Sima de los Huesos has yielded more hominin remains than any other site in the world. So far, excavators have removed several thousand bones from at least twenty-eight different individuals.⁴² Using a method



called uranium-series dating, which measures the radioactive decay in certain kinds of stone, scientists have been able to date the limestone deposits around the bones and on top of them. This method gives an estimated age for the fossils of from 350,000 to 530,000 years.⁴³

The large array of Sima remains includes examples of every bone in the human body, but there are no complete or even partial skeletons. Almost all of the finds are individual bones, many of them broken. Only when two pieces fit perfectly together can scientists be sure that they come from the same individual.

Pieced together like a jigsaw puzzle, Skull 5 is a nearly complete cranium from one of the earliest known Europeans.

Despite the difficulty of working with many small fragments, experts have made some reconstructions. One of them, known as Skull 5, is one of the world's most complete hominin skulls, so thoroughly preserved that we know this person died of an infection that started in a

broken tooth.⁴⁴ Other teeth from Sima show the same signs of wear as the Boxgrove teeth, indicating that the Sima people used their teeth to grip material while they scraped or cut it. Like the Boxgrove people, the Sima people were right-handed.

About half of the human remains in the Pit of the Bones are from young people, with ages between ten and eighteen. The animal bones come from carnivores such as wolves, lynxes, hyenas, and bears. There are no grazing animals or small plant eaters.

Scientists do not know why the pit does not hold a more general selection of both human and animal remains. One clue may lie in the only artifact ever found in the Sima, a large Acheulean hand ax made of reddish quartzite, which is a hard stone not often used by early human toolmakers. The researchers who unearthed the hand ax in 1998 think



that the people of Atapuerca *Nicknamed Excalibur after King Arthur's sword, this hand ax may have been used in an ancient ritual at the Pit of the Bones.* may have put this unusual tool in the Pit of the Bones deliberately, perhaps as part of some ritual.⁴⁵ If so, maybe they placed the bodies of some of their dead in the pit as well. Perhaps the human remains found in the pit do not represent a simple

cross section of the human population of the area. Only certain individuals may have been selected to go into the pit for some unknown reason.

From Heidelberg to Neanderthal

Who were the people who left their remains in the Pit of the Bones at Atapuerca? Some paleoanthropologists classify them as *Homo heidelbergensis*, while others think that they were an early form of *Homo neanderthalensis*. The Sima remains have some features, such as a projecting area of the face around the nose and a small depression on the skull, that are typical of Neanderthals. Such features make the Sima fossils “distinctly different from *Homo heidelbergensis*,” in the view of paleoanthropologists Rob DeSalle and Ian Tattersall. They are among the experts who regard the remains from the Pit of the Bones as “early members of the Neanderthal lineage.”⁴⁶

Labeling the Sima remains, however, is less important than recognizing their place in human evolution. The Sima fossils are not the only ones that combine features of both *H. heidelbergensis* and *H. neanderthalensis*—the same Neanderthal traits are present in some other fossils of Heidelberg Man. Rather than thinking of Heidelberg Man and Neanderthal Man as two species with distinct boundaries, we can see them as overlapping populations.

Over time, various populations of *H. heidelbergensis* followed different pathways. Some groups probably died out. This fate may have befallen Heidelberg Man in Asia, where few traces of these early humans have been found. And perhaps the early humans who ventured into northern regions such as England perished when the glaciers advanced. In Africa, however, *H. heidelbergensis* survived and eventually gave rise to the first members of our own species, *Homo sapiens*. (The fourth and final book in this series, *Modern Humans*, offers a detailed look at the origins of *H. sapiens*.) Meanwhile, one or more populations of Heidelberg Man survived in Europe, too. In time, European *H. heidelbergensis* evolved into Neanderthal Man. “In a sense,” writes paleoanthropologist Charles Lockwood, “the last *H. heidelbergensis* in Europe were also the first Neanderthals.”⁴⁷

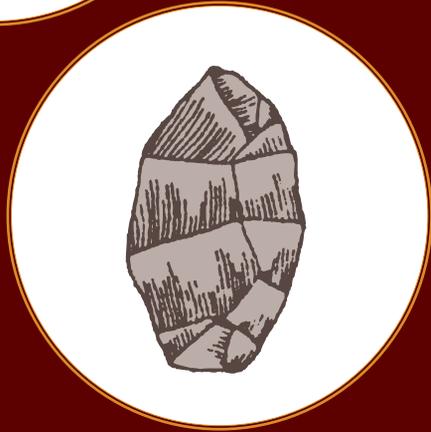
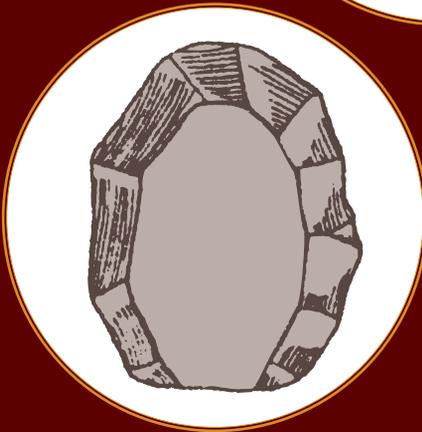
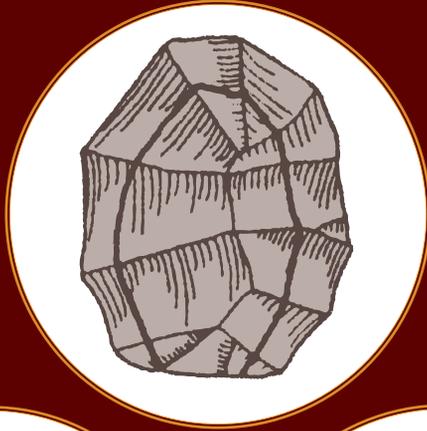
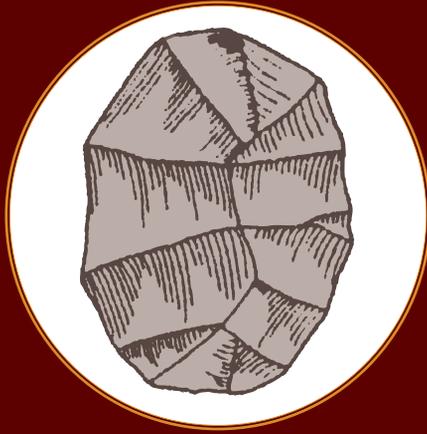
A New Toolmaking Technique

Around 300,000 years ago, during the slow shift from *H. heidelbergensis* to *H. neanderthalensis*, people started making tools in a new way. Archaeologists who specialize in the study of prehistoric toolmaking call this new method Mode 3. (Mode 1 was the manufacture of simple pebble tools. Mode 2 was making Acheulean hand axes by flaking off pieces around the edges of the tool.)

Mode 3 tools first surfaced during subway construction in Levallois, a suburb of Paris, so this toolmaking style is sometimes called the Levallois technique. It is also known as the prepared-core method of toolmaking. After selecting a piece of workable stone, called the core, the toolmaker developed an idea of how he wanted the tool to look. Then he prepared the core by knapping, or striking away, a series of pieces around the edges. Gradually, the desired tool began to take shape on the surface of the core. Then the toolmaker struck a single final blow that allowed the finished tool to break free from the core. The tool would be sharp all the way around the edge.

Scientists do not know where this new method of toolmaking started. It may have been invented many times by different populations of early humans, or invented just once and copied. At first, early humans used the technological innovation to make traditional Acheulean-style hand axes, but later they used it to produce a wide variety of stone artifacts. Tools made with the prepared-core technique have been found in Africa, western Asia, and Europe.

To many paleoanthropologists, one of the most important things about Levallois or Mode 3 toolmaking is not the tools themselves but what they tell us about how the toolmakers' minds worked. "The hallmark of this technique," explains science writer James Shreeve, "is control. Rather than just whittling a lump of flint down to a usable shape, the Levallois knapper preworks the core into a form that will deliver a flake of predetermined shape and thickness."⁴⁸



THE LEVALLOIS TECHNIQUE

In the earlier styles of toolmaking, someone hammered away at a stone until the edge was sharp enough. In the prepared-core method, however, the toolmaker had to make a plan and follow it. Instead of striking directly at the blade edge, the toolmaker worked indirectly, toward a mental image of the desired tool, which would appear only at the final stage of the process. Levallois toolmaking was more abstract, or dependent upon ideas, than earlier techniques. It may represent an early step toward a key feature of the modern mind: abstract thinking. Tools made with this technique have turned up in late *H. heidelbergensis* sites and in many *H. neanderthalensis* sites. As a key piece of early human culture, prepared-core toolmaking bridged the transition between species, from Heidelberg Man to Neanderthal Man.

Opposite: *The Levallois, or prepared-core, technique of toolmaking starts with the selection of a stone called the core (top). The toolmaker visualizes the outline of a tool in the center of the core (second from top), then strikes flakes from the edge to leave the raised shape in the center. A final well-judged blow splits the stone into two pieces: the remaining core (bottom left) and the finished tool (bottom right).*



Neanderthal Man, shown here as he appears in Chicago's Field Museum, looked different from modern people in many ways, but he was recognizably human.

FOUR

A New Kind of Human

For a long time after Neanderthals were discovered in the middle of the nineteenth century, they had what modern paleoanthropologists have called an “image problem.”⁴⁹ Cartoons, illustrations, and eventually television and movies portrayed the Neanderthals in “caveman” stereotypes. These shaggy, stoop-shouldered lummoxes had bent knees and bestial features. They communicated in crude, animal-like grunts and were always bopping women on the head with clubs. Even serious attempts to create scientific portraits of the Neanderthals sometimes exaggerated their primitive appearance.

Today, with scientists learning more about the Neanderthals all the time, a more complex and detailed picture of these large-brained humans has taken shape. The truth about Neanderthals is far more fascinating than any caricature.

Where and When

Neanderthals were first known from European fossils, and the majority of Neanderthal sites are located in Europe. At one time the Neanderthals were thought of as a specifically European species. We now know, however, that the range of these hardy Pleistocene people extended far into Asia.

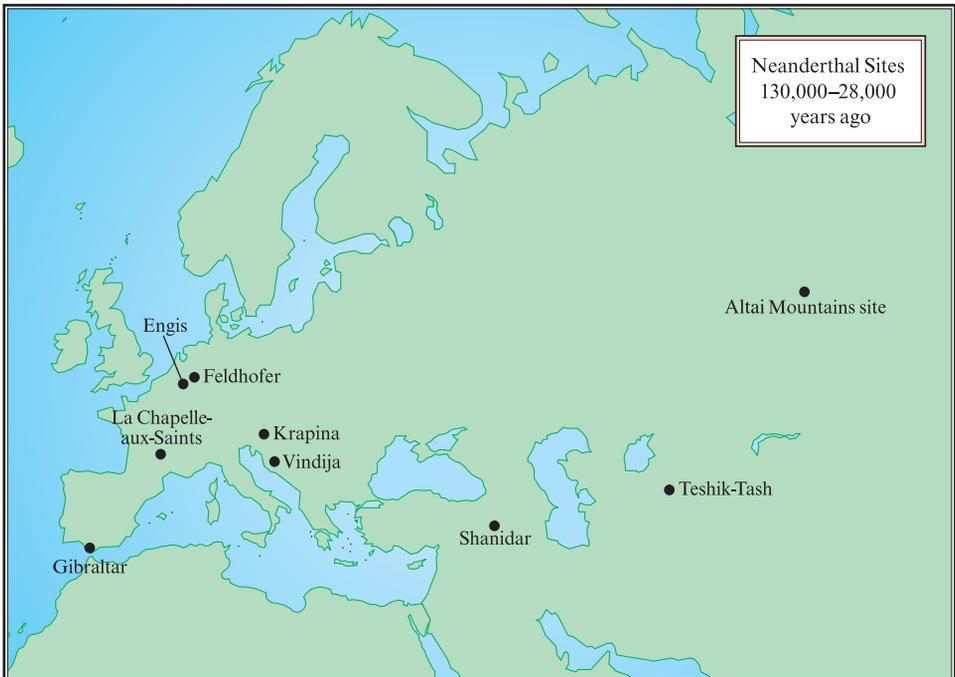
In western Asia, Neanderthal remains have been found in Israel, Syria, Iraq, and the nation of Georgia in the Caucasus region. Farther east, in central Asia, a cave at Teshik-Tash in Uzbekistan held part of the skeleton of a Neanderthal child, discovered in 1938. Although a few stone tools and tiny bone fragments turned up farther east, making some paleoanthropologists think that Neanderthal Man might have migrated deeper into central Asia,

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Teshik-Tash was the easternmost site with solid evidence. Experts regarded it as the limit of the Neanderthals' range.

Then, in 2007, Svante Pääbo, a genetic scientist at the Max Planck Institute for Evolutionary Anthropology in Germany, made a surprising announcement. Pääbo had spent years working with fragments of Neanderthal DNA that were painstakingly recovered from fossil bones. (See chapter 6 for more information about Neanderthal DNA.) Pääbo tested DNA samples from the Teshik-Tash child and also from some bones found in a cave in the Altai Mountains of southern Siberia, about 1,250 miles (2,000 kilometers) east of Teshik-Tash. Both samples were definitely Neanderthal, Pääbo reported. They were very similar to samples from European Neanderthal remains.⁵⁰

By placing Neanderthal Man in the Altai Mountains of Siberia, Pääbo's results extended the known range of *H. neanderthalensis* far to the east. It is



With the discovery of Neanderthal remains in Siberia's Altai Mountains, scientists learned that this hardy species of hominin had ranged much farther east than previously believed.

possible that Neanderthal people did not live continuously in the Altai. They may have moved in and out as Siberia's climate alternated between mild periods, with temperatures like today's, and periods of much colder weather. Researchers think that this advance-and-retreat pattern was probably typical of Neanderthals and other early humans not just in Siberia but all along the edges of their geographic ranges, where conditions were extreme and highly changeable.

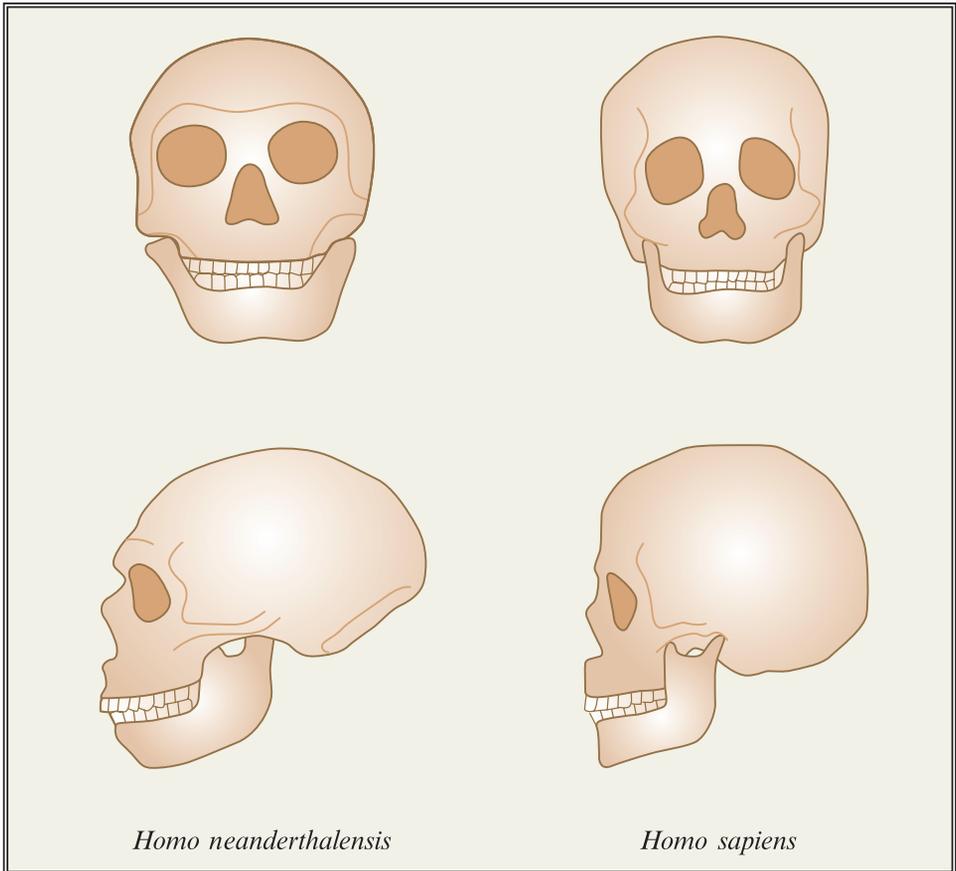
The European fossil record shows that *Homo heidelbergensis* and *Homo neanderthalensis* coexisted for a time. Paleoanthropologists think that *Homo neanderthalensis* evolved from *Homo heidelbergensis* over several hundred thousand years, with many intermediate steps, which makes it hard for them to say precisely where one species ends and the other begins. Fully Neanderthal people, however, had developed by 200,000 to 175,000 years ago.⁵¹

Neanderthals existed for 150,000 years or so. They became extinct much more quickly than they evolved. Over the course of little more than 20,000 years, they disappeared from their former range across Eurasia.⁵² The last known Neanderthal remains in the Middle East date from 50,000 years ago. Neanderthals last lived in France around 32,000 years ago. The date usually given for Neanderthal extinction is 30,000 years ago. In recent years, however, scientists have tested the age of bones and ashes from Neanderthal sites at Zafarrya Cave in Spain, Gorham's Cave in Gibraltar, and Vindija Cave in Croatia. The results suggest that Neanderthals may have survived in these outlying corners of their former range until 28,000 or even 27,000 years ago.⁵³

Physical Features

Since the days of early finds such as the Engis skull and the Neander Valley fossils, the remains of more than five hundred individual Neanderthals have come to light. In addition to isolated teeth, jawbones, and fragments of skulls and bones, there are about twenty partial skeletons.⁵⁴ This wealth of material has given paleoanthropologists a thorough knowledge of Neanderthal bone structure.

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Front and side views of the skulls of a Neanderthal and a modern human. The side views show a marked difference between the braincases. The foreheads and chins of the two species differ as well.

The first Neanderthal remains seen by people of the modern world were skulls. These relics made a powerful impression on everyone who saw them, and for good reason. Neanderthal skulls are human, but different.

Not only did Neanderthals have distinct, arched ridges of bone above each eye, but the centers of their faces jutted forward farther than those of modern humans do. Their noses were quite wide, and they lacked projecting chins. Their heads were flatter on top than ours, and stuck out farther in back, but their brains were as large as our own. Measurements of twenty-four Neanderthal skulls revealed brain sizes ranging from 1,200 to 1,740 cubic centimeters in volume. The mean volume of these brains was 1,420 cc,

well within the modern human range, while the largest Neanderthal brain was larger than nearly all modern brains.⁵⁵

Neanderthal teeth were smaller than those of *Homo erectus*, but still larger than modern human teeth. The front teeth were especially robust, solid and large in proportion to the rest, but these teeth show signs of much hard wear. Even the front teeth of children bear the telltale marks of being used as tools. Neanderthal people appear to have gripped materials in their teeth while they cut or scraped them; they also apparently clenched their jaws and pulled things—possibly bones, skins, or tough plants—outward through their teeth.

Paleoanthropologists know from examining Neanderthal skeletons that these early humans were built differently from *H. sapiens*. Neanderthals were slightly shorter than modern humans, with an average height for males of 66.5 inches (169 centimeters) and for females of 63 inches (160 cm).⁵⁶ Neanderthals were also stockier and sturdier than modern humans. Their broad rib cages widened outward from top to bottom, creating a deep, tapering chest, and they had broad, robust pelvic bones. These wide rib cages and pelvises would have made the Neanderthals thick through the torso. Scientists estimate that if they could compare a Neanderthal with a modern person of the same height, the Neanderthal would weigh 30 percent more.⁵⁷

Muscles make marks on the bones to which they are attached. The muscle marks on Neanderthal bones show that these people were more muscular, and undoubtedly stronger, than modern humans. Their arm and leg bones were thicker and heavier than ours, especially the leg bones. Compared with modern body proportions, Neanderthals' forearms and lower legs were short in relation to their upper arms and thighs. They had stubby, thick fingers but would have been able to use their hands with as much skill and dexterity as modern humans.

Like members of any species, including modern humans, Neanderthal people showed anatomical variations across both geography and time. The Neanderthals of western Asia were taller and less stocky than European

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Neanderthals.⁵⁸ Skulls from at least one late Neanderthal site, Vindija in Croatia, lack the occipital buns that were standard on earlier populations, and some experts have argued that lower jawbones from a few late Neanderthals also show the beginning of a small chin.⁵⁹

Paleoanthropologists have used the term *classic Neanderthal* for specimens from western Europe that display the full set of distinctive, recognizable features associated with the earliest known Neanderthal fossils. Some of these features were inherited from ancestral hominins. Brow ridges, for example, were prominent in *Homo erectus* and *Homo heidelbergensis*, although they were shaped differently in the two species. Other features, such as the proportions of Neanderthals' arms and legs, may have evolved as adaptations to the environment.

A Cold, Cold World

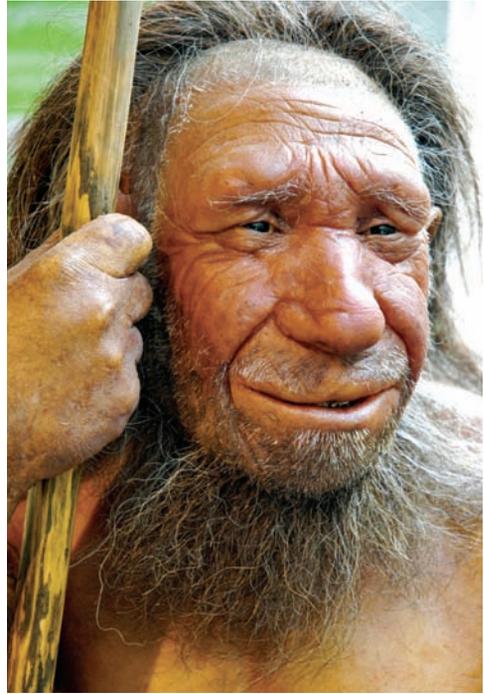
Stocky bodies and short, thick limbs are excellent adaptations to cold. Modern ethnic groups that have lived in cold climates for a long time, such as the North American Inuit and the peoples of far northern Eurasia, are likely to be more heavily built, with shorter limbs, than people from hot climates, such as the Masai of Africa or the people of tropical Indonesia. This is because body shape is directly related to the body's ability to stay warm or cool.

Thin, long-limbed people have a high ratio of skin surface to body mass. With a lot of surface area through which heat can leave the body, they are less likely to suffer from overheating. Theirs is an ideal body shape for keeping cool in warm climates. Stocky, short-limbed people have a lower ratio of skin surface to body mass. They retain body heat because the surface area for heat loss is reduced relative to their overall mass. Their body type is well suited to keeping warm in cold climates.

Many paleoanthropologists think that the classic Neanderthal physique evolved as a response to cold conditions in Europe during the Pleistocene glacial periods. Some have even suggested that the big, wide Neanderthal noses were adaptations to the cold. Large nostrils may have increased peo-

ple's ability to warm the icy air before drawing it into their lungs.⁶⁰

Even though ice never covered the southern part of the Neanderthals' European range, early humans there would have known temperatures that were, on average, colder than those of the present day. In the northern part of their range, as well as in mountainous areas such as the Alps, Neanderthals would have lived quite close to the ice, retreating each time the ice sheets grew larger. Perhaps they evolved to endure the chill of glacial Europe before expanding into milder regions such as Syria and Israel.



Did Neanderthals evolve big noses to help them breathe cold Ice Age air?

Life for the Neanderthals was not just cold—it was short and often brutal. Many Neanderthals perished at an early age. Few lived past the age of forty-five.⁶¹ Scientists who examine Neanderthal bones notice a high number of injuries recorded in these fossils. Broken bones, dislocated joints, and degenerative bone and joint diseases such as arthritis were common.

One survey of Neanderthal Man reports that “evidence of injury or disease in some form or another is found in almost all reasonably complete adult Neanderthals.”⁶² Even the Neander Valley skeleton for which the species is named has a damaged elbow joint, while skeletons from Shanidar Cave in Iraq present “a whole catalogue of injuries and degenerative disease in the heads, arms, ribs, legs, and feet.”⁶³ But although fractured bones and twisted joints paint a grim picture of Neanderthal existence, these signs of hardship also offer hints about how the Neanderthals lived, and how they treated one another.



Frankenstein's Neanderthal

The fictional Dr. Frankenstein stitched together parts from many human corpses to build a manlike creature, which he then brought to life. Anthropologist Gary Sawyer of the American Museum of Natural History did the same thing for a Neanderthal skeleton—minus the part about bringing it to life.

Above: Neanderthals would have been good wrestlers. Gary Sawyer's composite Neanderthal skeleton (left) is noticeably more rugged than the H. sapiens skeleton next to it. According to Sawyer, if you shook hands with this Neanderthal, "he would turn your hand to pulp."

Because no complete Neanderthal skeleton has ever been found, Sawyer and his colleague Blaine Maley of Washington University decided to build one. They started with La Ferrassie 1, the skeleton of a Neanderthal man. Discovered in France in 1909, La Ferrassie 1 is approximately 70,000 years old and lacks a rib cage, a pelvis, and a few other parts. Kebara 2, a 60,000-year-old skeleton found in Israel in 1983, happens to have a well-preserved rib cage and pelvis. Most important, Kebara 2 is very close in size to La Ferrassie 1, so the two sets of bones fit together. Sawyer and Maley filled in the remaining gaps with fossils from other Neanderthals and, when necessary, with modern human bones. The result was the world's first full-body Neanderthal skeleton.⁸⁹ Said Sawyer, "It's almost like making my own fossil discovery."⁹⁰

The assembled Neanderthal man—made from plaster casts of the fossils, not from the actual remains—is 5 feet, 4 inches (1.6 meters) tall. He has a thick torso, wide hips, and a brain 20 percent larger than that of an average modern human.⁹¹ Marks on his bones show that he was heavily muscled and strong. His right forearm was especially muscular, evidence that he was right-handed, with a powerful grip.⁹² "If you shook hands with [a Neanderthal]," Sawyer said, "he would turn your hand to pulp."

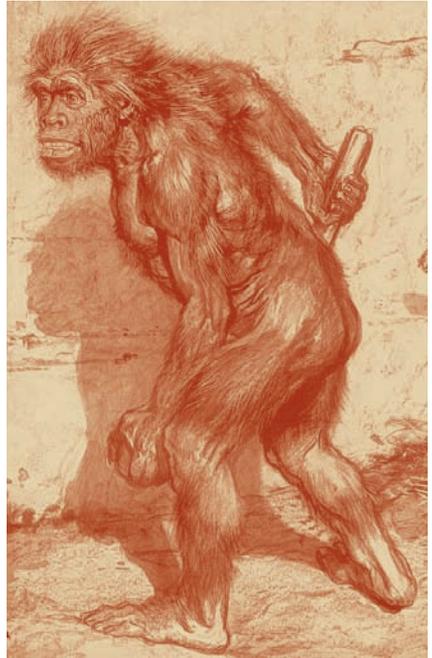
When the reconstruction was complete, Sawyer was surprised by how different the Neanderthal's rib cage and "short, squat" body shape were from those of modern humans. "There is no way, I believe, that modern humans could have evolved from a species like Neanderthal," Sawyer concluded. The pelvises and torsos of the two species are simply too dissimilar. Sawyer shares the view that Neanderthals are our cousins, not our ancestors. They are, as he puts it, "one of those strange little offshoots" of evolution.

Neanderthal Life

Fossils cannot answer all of our questions about the Neanderthals. Bones, stones, and ashes do not reveal whether these early Eurasians sang and danced, or what they believed, or how they viewed each other and the world around them. Physical evidence from Neanderthal sites, however, can give us some insights into their behavior—or at least raise questions for us to ponder. From objects such as skulls, tools, and flower pollen have come theories and debates about many aspects of Neanderthal life, including social bonds, cannibalism, spirituality, and art.

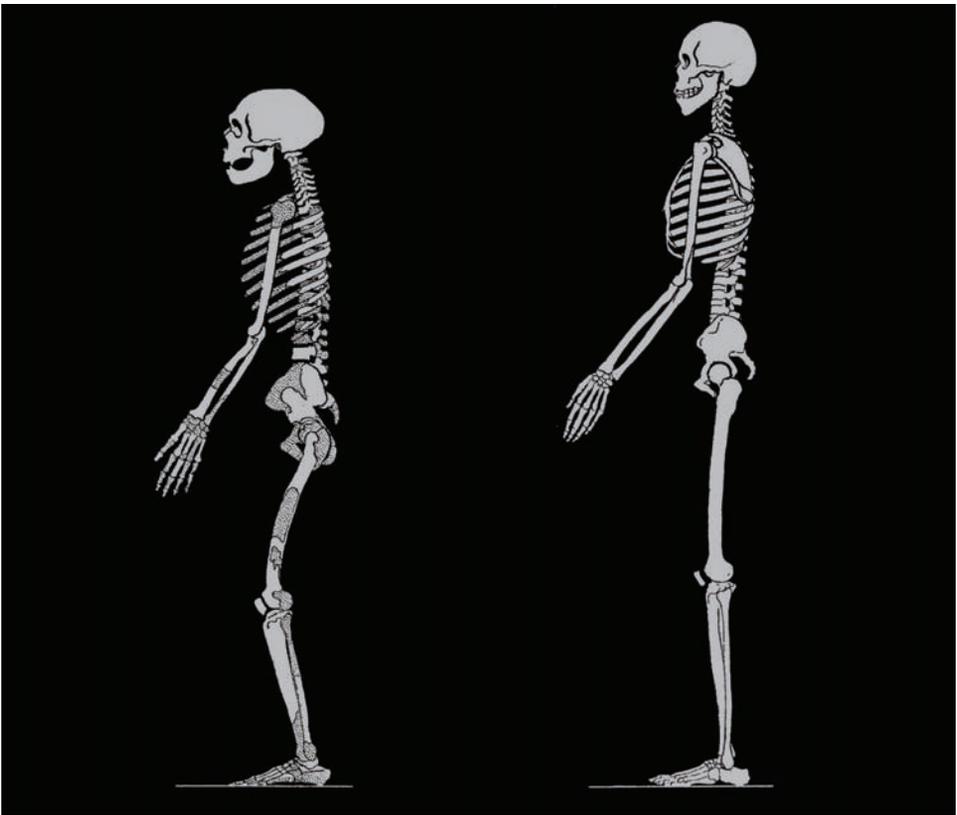
A Tale of Two Skeletons

One of the most significant fossils in the history of Neanderthal studies is the Old Man of La Chapelle. In 1908 French monks discovered this Neanderthal skeleton in a cave at La Chapelle-aux-Saints. They sent the remains to Marcellin Boule, a French scientist who soon published a description of *Homo neanderthalensis* based on the skeleton. Boule's interpretation of Neanderthal anatomy emphasized the crude, primitive, and even apelike characteristics he saw in the remains. He portrayed Neanderthals as bent kneed and slumped, and this view of their posture was echoed in images of Neanderthals for years.



Marcellin Boule worked with the artist to create this first reconstruction of Neanderthal Man—a brutish, apelike figure. The picture appeared in *The Illustrated London News* in 1909.

In 1955 French paleontologist Camille Arambourg re-analyzed the skeleton from La Chapelle. His findings corrected errors that Boule had made, and soon scientists realized that Neanderthals had the same upright posture as modern humans. What interests modern experts about the Old Man, though, is this particular Neanderthal's pathology—his injuries and diseases. These included degenerative bone and joint disease in the skull, jaw, spine, hip, and feet; a fractured rib; the loss of many teeth; and severe infections in the jaw. In the words of researchers Christopher Stringer and Clive Gamble: "All this and not yet 40!"⁶⁴



The skeleton on the left is that of the Old Man of La Chapelle while the one on the right is of a modern human. Judging from the stooped appearance of the Old Man, Boule incorrectly deduced that Neanderthal Man was a primitive, apelike creature. In the 1950s, new studies revealed that Neanderthals had the same upright posture as modern humans. This particular individual's appearance was a result of a combination of factors: severe arthritis, old age, and multiple injuries.

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The Old Man's skeletal remains show that he lived in a seriously weakened state, perhaps crippled, for years before his death. Some researchers think that he could not have hunted or gathered food for himself, and that he must have been cared for by other Neanderthals "long after his arthritis-racked body ceased to be able to find its own sustenance."⁶⁵ Back in the nineteenth century, Rudolf Virchow had declared that the Neander Valley skeleton could not have come from a primitive culture, because only civilized people would help the ill and crippled. The Old Man of La Chapelle turns Virchow's argument in the opposite direction. If Neanderthals took care of this individual, they must have felt compassion and a degree of family or social responsibility.

More evidence that at least some Neanderthals cared for their disabled people comes from northern Iraq, where the Greater Zab River flows through valleys in the Zagros Mountains. High on a sloping wall of the Shanidar Valley is a wide opening that leads into a large cave. In 1951 an American archaeologist named Ralph Solecki surveyed the area. He explored the cave, which was occupied each winter by several families of the local Kurdish people and their livestock.

When Solecki dug a small test pit in the floor of the cave, he found evidence that people had been living there since prehistoric times. In the years that followed, Solecki and a team from New York's Columbia Univer-



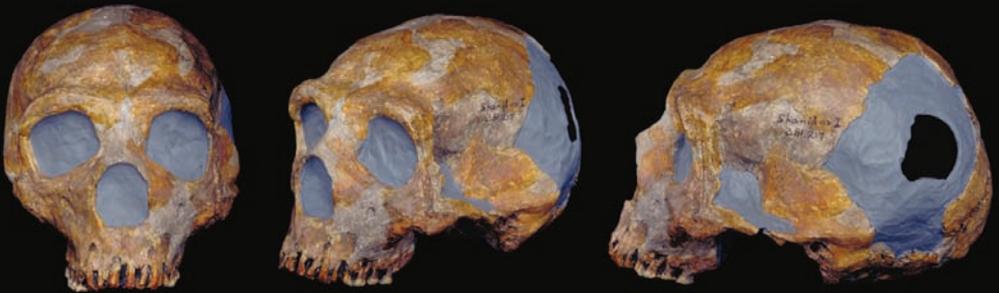
Long home to modern Kurds and their goats, Shanidar Cave, under the leadership of Ralph Solecki, became a portal to the past.

sity, together with Iraqi scientists and Kurdish workers, excavated Shanidar Cave. In the upper levels of sediments they found hearths, tools, and the buried bodies of people who, although they lived thousands of years ago, were modern humans. Then, in 1953, they unearthed the first Neanderthal remains ever found in Iraq—pieces of an infant’s skeleton.

Shanidar Cave turned out to contain nine Neanderthal skeletons that are estimated to be 40,000 to 70,000 years old. One of these skeletons, known as Shanidar I, can be seen as evidence that Neanderthals had a nurturing side.

Erik Trinkaus, the author of a detailed description of the Neanderthal remains from Shanidar, has called Shanidar I “one of the most severely traumatized” hominins known from the Pleistocene epoch.⁶⁶ Other authors summarized this skeleton’s condition in *In Search of the Neanderthals*:

Shanidar I . . . may have suffered head injuries and extensive crushing of the right side of his body—possibly in a cave rock fall—followed by infections and partial paralysis. He was probably blinded in his left eye, and would have been considerably disabled, yet he must have lived with these injuries for several years. . . . This unfortunate individual thus supports the argument that the Neanderthals sometimes took care of their sick.⁶⁷



Three views of Shanidar I’s skull. The side views may offer intriguing insights into Neanderthal social customs. They show a flattening and steepness at the back of the skull, an indication that this individual’s head may have been deliberately deformed in infancy—a practice known to occur among some modern peoples.

The Old Man of La Chapelle and the Shanidar remains reveal that the Neanderthals were capable of compassion and care for the disabled. An even older fossil shows that these qualities have been part of human nature since at least the dawn of the Neanderthal era. That fossil is a jaw discovered in southeastern France in 2000. It dates from about 175,000 years ago, when *Homo neanderthalensis* was evolving from *Homo heidelbergensis*.

The jaw, which combines Heidelberg and Neanderthal features, came from an adult who suffered from severe gum disease and was without teeth for a long time before death. He or she would have needed food that had been cut into small pieces and cooked, or possibly prechewed by someone else, to soften it. Trinkaus thinks that other members of the social group prepared soft food for the toothless one. “This is the oldest example,” he points out, “of someone surviving for some period of time without an effective set of choppers.”⁶⁸

Hunting and Diet

Hunting probably led to many of the broken bones, cracked skulls, and other injuries that are plainly visible on Neanderthal skeletons after tens of thousands of years. Although Neanderthals undoubtedly ate wild plant foods such as fruits, seeds, nuts, and tubers when they were available, several kinds of evidence show that they ate a lot of meat.

Scientists who have studied Neanderthal teeth have found wear marks typical of people who eat significant amounts of meat. Another test analyzes chemical forms called isotopes, which enter the body in food and are absorbed into bone tissue. The isotopes in bones can reveal information about diet, and the isotope content of Neanderthal remains supports the idea that these people were meat eaters. Finally, there are the butchered and broken remains of the animals eaten by Neanderthals.

Animal remains at Neanderthal sites show that these humans ate a wide variety of species. They consumed small creatures such as rabbits, porcupines, and beavers; medium-sized grazing animals such as wild sheep, deer,

horses, and reindeer; and even megafauna, the largest animals of the Pleistocene, such as hippopotamuses in the Middle East and mammoths and woolly rhinoceroses in Europe.

Neanderthals seem to have been both scavengers and hunters, depending upon circumstances. The fact that they carried animal heads back to caves and broke them open, for example, suggests that they scavenged the heads from carcasses during the winter, when food is scarce but even starving animals retain some fat in their heads to nourish their brains. On the other hand, piles of 180,000-year-old mammoth and rhino bones beneath a cliff on an island in the English Channel may be the remains of organized hunting drives, in which Neanderthals—perhaps waving burning branches—drove the animals toward the cliff, where they plunged to their deaths.

The Neanderthals did not have bows and arrows or other weapons that could kill from a great distance. Because they hunted with spears, they had to be fairly close to their prey. Going after a rabbit or a nesting bird poses little danger, but hunting larger animals, as Neanderthals often did, meant risking injury from flying hooves or raking claws.



Neanderthals hunt a fallow deer, a species still found in Britain and other parts of Europe.

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One possible food source has been the subject of endless debates about the Neanderthals. Did they eat human flesh? This idea was first raised by Dragutin Gorjanovic-Kramberger of Croatia. After Gorjanovic-Kramberger discovered a human tooth in a cave called Krapina in 1899, he excavated hundreds of Neanderthal remains from the cave. In 1906 he published a description of his finds, which included bones that were broken and marked in such a way as to suggest they had been butchered for meat and marrow.⁶⁹



Stone tools made these cut marks on a skull from Krapina—one of many signs that Neanderthals practiced cannibalism, at least occasionally.

Broken or cut-marked Neanderthal remains from other sites in France, Spain, and elsewhere have been interpreted as additional evidence that the Neanderthals butchered and ate their dead. Neanderthal bones from Moula-Guercy in southeastern France, for example, have breaks and

cut marks that are identical to those on deer bones from the same site, suggesting that both people and deer were butchered.⁷⁰ Some researchers, though, argue that these signs do not prove that Neanderthals were cannibals. Neanderthals may have cut the flesh from the bones of the dead for ritual reasons, or in order to bury the bones. Other experts have argued that the evidence is unclear, and that the bones could have been broken or marked by natural causes.

Neanderthals probably engaged in cannibalism at times, just as modern humans have done, but we cannot know whether they acted out of ordinary hunger, or starvation, or a belief system that drove them to absorb their loved ones or their enemies. Perhaps there is no simple answer. Modern humans, after all, have a broad range of motives and behavior. The same may well have been true of Neanderthals.

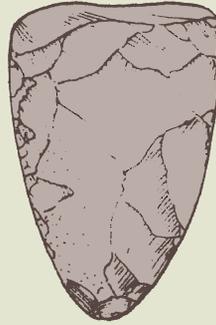
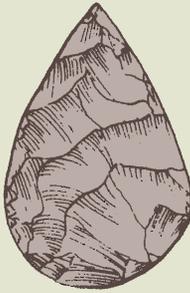
Tools and Technology

Neanderthals were skilled at making tools with the Levallois technique, striking flakes from a prepared flint core, sometimes obtaining more than one tool from the same core. Their tools show more variety than the earlier Acheulean hand axes. Researchers group the Neanderthals' tools into categories such as points, scrapers, and knives or blades, based on the shapes of the tools and on guesses about how they were used. Points, for example, could have been tied to sticks with lengths of tendon and used as spears, while scrapers would have been ideal for cleaning animal skins and furs.

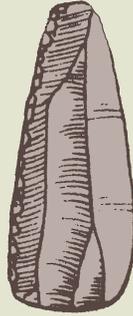
One of the first sites to yield Neanderthal tools was a French cave called Le Moustier. For this reason archaeologists refer to these tools as the Mousterian industry. They are associated with a period of the Stone Age called the Middle Paleolithic, which lasted from about 300,000 to 30,000 years ago in Europe. Across this time span, and across the geographic range of the Neanderthals, the Mousterian industry showed some variety, but the basic technology did not change much.

In southern France and northern Spain, the Mousterian industry gave

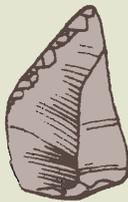
MOUSTERIAN STONE TOOLS



HAND AXES



FLAKE KNIFE



SCRAPERS



POINTS

Typical Neanderthal tool designs. The categories reflect archaeologists' best guesses about how the tools were used.

way around 35,000 years ago to a more sophisticated industry called Châtelperronian. Artifacts from this industry have been found at some late Neanderthal sites. They include tools with toothed or notched edges and a type of flint knife that was sharp on only one side.

Microscopic nicks and chips on some Mousterian and Châtelperronian stone tools appear to have been made by woodworking. Neanderthal hunters probably used the blades to trim and shape lengths of wood into spears. We know that the Neanderthals used these weapons because the remains of wooden spears have turned up at some excavation sites.

Neanderthals may also have cut or trimmed wood for burning. Modern research has shown that in the coldest places where Neanderthals are known to have lived, body fat alone would not have been enough to keep them warm.⁷¹ Neanderthals survived in harsh conditions by using cultural



Neanderthals made more use of fire than any species before them. We do not know whether they relied on burning branches from natural wildfires or knew how to kindle new blazes.

and technological resources—knowledge and tools, in other words. The evidence of cave hearths and burned bones shows that they used fire, but they would have needed clothing as well. They probably made animal skins and furs into clothing and blankets, although no trace of these objects has been found. Nor has anyone uncovered evidence that the Neanderthals built artificial shelters. Throughout their range, however, they made use of the natural shelters offered by caves and rock overhangs.

Social Behavior

Neanderthals were “very sparsely distributed” across their range, according to paleoanthropologists Rob DeSalle and Ian Tattersall.⁷² They appear to have lived in small groups or bands. They were probably nomadic, at least to some degree, moving from place to place to take advantage of changing food resources. We know nothing, however, about family life or social organization within these groups, or about how groups of Neanderthals interacted when they met one another.

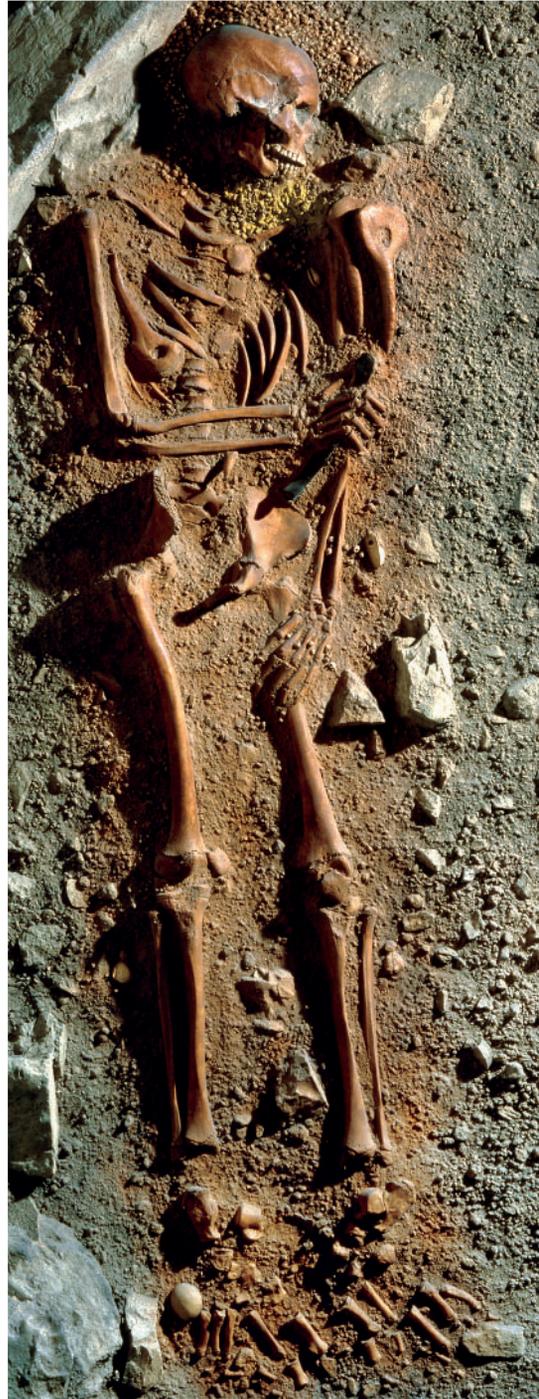
Language is another mystery. Studies of Neanderthal skeletons suggest that the throats and ears of these early humans were not too different from our own. Many researchers now think that Neanderthals could utter and hear many of the sounds used in modern languages.⁷³ Anthropologist Robert McCarthy of Florida Atlantic University has even used computer modeling of a Neanderthal vocal tract to create a recording of how a Neanderthal might have sounded.⁷⁴ Knowing that Neanderthals could produce sounds, however, does not tell us anything about how they communicated.

A lot of scientific speculation about Neanderthal behavior has been sparked by the subject of burials. The main reason scientists now have even a handful of reasonably complete Neanderthal skeletons is that these bodies were buried in caves, where they were protected from scavengers and erosion. Despite claims that such burials could have been natural, or accidental, most researchers now agree that some Neanderthal dead were deliberately buried. Still under debate, however, is the question of what

those burials meant, and whether they involved rituals.

A burial site at Le Moustier contained a mineral called hematite, crushed into reddish powder. At Teshik-Tash in Uzbekistan, goat horns were found around the body of a Neanderthal child. To some researchers, these and similar finds at other burial sites are funerary offerings, objects placed in or near a grave as part of a ritual or ceremony. Ritual burials are signs of a belief system, or at least signs that people intended to honor the dead. They are a form of symbolic behavior, which means giving physical objects a level of meaning that is more than physical.

One Neanderthal skeleton shows how difficult it is to interpret Neanderthal behavior from physical evidence. The skeleton is Shanidar 4, recovered from Shanidar Cave in Iraq in 1960. Shanidar 4 is the partial skeleton, broken into many fragments, of a large adult Neanderthal, probably a man who was between thirty and forty-five years old when he died.⁷⁵ A French archaeol-



Neanderthals sometimes buried their dead, as with this young male in northern Italy. Paleoanthropologists owe the good condition of many skeletons to this practice.

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ogist named Arlette Leroi-Gourhan analyzed sediment from around the body and found traces of pollen from plants. She identified the plants as hollyhocks and other flowers that have been used as medicines in traditional cultures. Leroi-Gourhan believed that the selection of plants was deliberate. Shanidar 4, in her opinion, had received a burial that included the ritual use of flowers—and not just any flowers, but ones that the Neanderthals may have associated with medical or spiritual powers.

A book by Ralph Solecki, the discoverer of the Shanidar site, spread the idea that Shanidar 4 had been buried on a pile of flowers, or that flowers had been placed upon his corpse. The title of Solecki's 1971 book, *Shanidar: The First Flower People*, seemed to link the Iraq Neanderthals to the “flower power” hippie culture of the late 1960s and early 1970s. Solecki suggested that Shanidar 4 may have received a ritual burial because of his special status. “One may speculate,” wrote Solecki, “that the [individual] was not only



Neanderthals may have placed goat horns around a child's grave at Teshik-Tash. Whether such burials really had ritual or spiritual significance, however, is unknown.

a very important man, a leader, but may have been a kind of medicine man or shaman in his group.”⁷⁶

The all-important words *one may speculate* highlight both the possibilities and the limitations of archaeology and paleoanthropology. Evidence such as the flower pollen can open up exciting new ways of thinking about a subject, or directions for further research. Yet there is a danger that speculative ideas will become fixed in people’s minds without firm factual support. In the case of Shanidar 4, the image of Neanderthals burying their dead with flowers has become part of many people’s ideas about these early humans, even though many paleoanthropologists are not convinced that Shanidar 4 was deliberately buried with flowers.

What about the pollen? The Zagros Mountains are home to *jirds*, burrowing rodents similar to gerbils and pack rats that fill their burrows and nests with pollen-bearing vegetation. These animals lived in the Shanidar region in Neanderthal times and may have carried pollen into the cave. Or the pollen could have blown into the cave. Or, as Leroi-Gourhan and Solecki claimed, Shanidar 4’s companions may have placed flowers around their dead comrade in a gesture that reflects a symbolic or spiritual dimension of their lives. We will never know for certain—which is why words like *possibly* and *might have* pepper the pages of most paleoanthropological writing.

No clear proof exists that Neanderthals performed ritual burial. Each of the supposed funerary objects can be explained as a natural occurrence.⁷⁷ Even without funerary offerings, however, simple burials themselves suggest that Neanderthals had at least the beginnings of symbolic thought. They may have come to see the bodies of their dead not simply as part of the natural world but as something deserving of special treatment.

Among modern humans, art is an unmistakable sign of symbolic thinking. Did the Neanderthals create art? Many magnificent prehistoric paintings adorn the walls of European caves, but all of these are related to *Homo sapiens*, not to *Homo neanderthalensis*. A different kind of art, however, has been linked to Neanderthals at the Grotte du Renne, a French cave first excavated in 1949.

Researchers at the Grotte du Renne have found Neanderthal remains and tools made in the Châtelperronian style, which appeared late in the Neanderthals' time span. At the same site, the researchers found animal teeth and bones with holes carved into them, as though they were used as beads.⁷⁸ Jewelry and personal ornaments have been found at a number of sites associated with Cro-Magnon people, as the first *H. sapiens* in Europe have been called. Yet at the Grotte du Renne the human remains are those of Neanderthals,



*The Lion Man of Stadel, a carved figure with a man's body and a lion's head, is 32,000 years old. Most experts think it is the work of early *Homo sapiens*, but some believe it may be a Neanderthal creation.*

not modern humans. To paleontologist Juan Luis Arsuaga, the conclusion is clear: "The Neanderthals at Grotte du Renne wore necklaces."⁷⁹

No art or personal ornament has been found with Neanderthal remains from the early or middle millennia of the Neanderthals' time span. And although ornaments have been found with Neanderthal remains at a few late sites such as the Grotte du Renne, each of these locations also has evidence that *H. sapiens* had arrived in the region and were making and wearing ornaments by the time Neanderthals began doing so. Many paleoanthropologists think that rather than inventing a new tradition of personal ornamentation, Neanderthals took the idea from the Cro-Magnon people who were moving into their territory. We cannot know whether the Neanderthals who made beads were acting on artistic ideas of their own or imitating their *Homo sapiens* neighbors, but we do know that for many years the two species of humans lived in the same places. This overlap between the late Neanderthals and modern humans was part of the final chapter of the Neanderthal story.

The Last of the Neanderthals

Many hominin species share the family tree with us, but the Neanderthals hold a special fascination. They are closest to us in appearance, in behavior, and in time. Their species and ours occupied some of the same parts of the world for thousands of years before they vanished. What happened to them?

Ever since the discovery of the Neander Valley fossils, people have wondered about the fate of the Neanderthals, and whether these extinct humans were our ancestors. Researchers are still investigating these questions, gaining new insights from genetics as well as from paleoanthropological fieldwork.

Why Did the Neanderthals Disappear?

Homo neanderthalensis existed for 150,000 years or more in a variety of environments, from the mild Middle East to the harsh conditions of Ice Age Eurasia. So why did this successful species become extinct?

The last glacial maximum was 20,000 years ago. Climate changes connected with its approach may have had something to do with Neanderthal extinction. Alterations in weather patterns might have led to food shortages and the dwindling of a population that was small and scattered even at the best of times. Yet another factor must be considered. Most researchers think that it cannot be coincidence that Neanderthals disappeared after *Homo sapiens*, modern humans, came on the scene. (See the fourth volume in this series, *Modern Humans*, for current scientific thinking about the origins and spread of *H. sapiens*.)

Modern humans had a wider range of tools and appear to have been more inventive than Neanderthals. They may also have had larger or more

elaborate social structures, and more effective planning and communication abilities. These features could have made *Homo sapiens* more efficient at obtaining and sharing food than Neanderthals, or better at fighting. Equipped with tools, weapons, clothing, and fire, the modern humans survived the last glacial maximum in Eurasia, 20,000 years ago. By that time the Neanderthals were gone, although paleoanthropologists do not know if modern humans killed the Neanderthals or drove them into extinction by outcompeting them for resources such as food and shelter.

Many caves have yielded both Neanderthal remains and those of early modern humans. Throughout Europe, evidence from the sediment layers in these caves shows that the modern humans used the caves after Neanderthals. But in the Levant, the lands bordering the eastern Mediterranean Sea, Neanderthals came *after* modern humans. This region saw not one but several transitions between Neanderthals and *H. sapiens*.

Since the 1980s experts have developed a prehistoric time line for the Levant based on the dates of fossils and artifacts from cave sites in Israel. Early modern humans appeared in the region around 130,000 years ago and occupied it until around 80,000 years ago or so. Then, around 75,000 years ago, Neanderthals appeared in the area. Increasing glacial ice and falling temperatures at that time might have caused the Neanderthals to migrate into the coastal zone from mountainous areas inland or farther north, but it is not clear whether the modern humans withdrew first or were chased out.

Between 75,000 and 47,000 years ago, only Neanderthals lived in the caves in Israel. Then modern humans returned, and the Neanderthals disappeared from the Levant.⁸⁰ After that time they survived only in Europe, where the ice sheets were marching toward the last glacial maximum.

Neither in Europe nor in the Levant has anyone found evidence to show how Neanderthals and modern humans interacted, or even *if* they interacted. In *The Complete World of Human Evolution* Chris Stringer and Peter Andrews review the possibilities:

Within an area as large as Europe, and over such a long time span, many different kinds of interactions would have been possible, ranging from warfare, through avoidance, to peaceful coexistence, trade and even interbreeding. Given what we know of human behavior today, any of these could have occurred, and perhaps they all did at certain times and in certain places.⁸¹

Until someone unearths a Neanderthal skull with a Cro-Magnon spear buried in it, or finds a cave with unmistakable evidence that Neanderthals and modern humans shared it at the same time, we can only speculate.

Were the Neanderthals Our Ancestors?

Ever since Neanderthals were recognized as members of the human family, people have wondered whether they were the ancestors of modern humans. The answer to that question has changed over time as scientists have learned more about both species.

In 1906 Dragutin Gorjanovic-Kramberger, the excavator of Krapina Cave in Croatia, identified Neanderthals as the direct ancestors of *Homo sapiens*. Other scientists came to agree with that view, which remained in force for decades. Experts argued, for example, that Neanderthal remains from Krapina and from several sites in Israel share some of the features of modern humans. This seemed to reinforce the theory that Neanderthals evolved into *H. sapiens*.

A rival view arose in the 1970s. Paleoanthropologists Chris Stringer and Jean-Jacques Hublin made separate, highly detailed studies of Neanderthal fossil crania, or skulls. Each of them declared that modern humans could not have evolved from Neanderthals. The differences in morphology, or physical form, were simply too great for one species to have turned into the other. In this view, which has gained considerable support over recent decades, the Neanderthals are cousins on our family tree, but they are not our ancestors.

Tales of Two Species

Scientists are not the only explorers of the lost world of *Homo neanderthalensis*. Storytellers have imagined what life was like for these early humans, so similar to us yet so different, and envisioned how things might have gone when their species met ours.

One of the first novels about Neanderthals was *La Guerre du Feu* (The Fire War). Published in France in 1911 by J. H. Rosny Sr., it is the story of three cavemen who go searching for a source of fire. They encounter people who look and act strange—*Homo sapiens* as seen through Neanderthal eyes. One traveler is adopted into the *H. sapiens* tribe, where he learns the secret of starting fires. He marries an *H. sapiens* woman, who later accompanies him when the three Neanderthals return to their tribe. The book is seldom read today, but it was the basis of the movie *Quest for Fire* (1982).

British writer H. G. Wells, the author of *The Time Machine*, *The War of the Worlds*, and other imaginative works, wrote about the Neanderthals in a short story called “The Grisly Folk” (1921). Wells imagines that meetings between these “grisly folk” and modern humans must surely have ended in bloodshed: “Many and obstinate were the duels and battles these two sorts of men fought for this world in that bleak age of the windy steppes, thirty or forty thousand years ago.”⁹³

In *The Inheritors* (1955), British writer William Golding told a story from the point of view of a couple whose daughter has been kidnapped by a tribe of strangers. The couple are Neanderthals and the strangers are modern humans, who see the Neanderthals as hairy forest demons. In Golding’s tale, modern humans are intruders who will ultimately destroy the Neanderthals.

Twenty-five years after *The Inheritors*, an American writer named Jean Auel published *Clan of the Cave Bear*, the first in a series of books called *Earth’s Children*. The heroine of the tale is Ayla, a young *Homo sapiens*

female. After Ayla's parents die, Neanderthals raise her, but they cannot accept her new ideas and her independent spirit, so she leaves to seek her destiny among other people like herself. Auel based her physical descriptions of Creb and Iza, two Neanderthal characters in *Clan of the Cave Bear*, on skeletons from Shanidar Cave in Iraq.⁹⁴



In 1980, the same year Auel's book appeared, a novel called *Dance of the Tiger*

was published in English. Written by a Finnish paleontologist named Björn Kurtén, this book is the story of Tiger, a man from a violent, aggressive *Homo sapiens* tribe. He marries a Neanderthal woman and joins her more peaceful, woman-ruled society.

Science fiction writers have used imaginary devices to work Neanderthals into their tales. In Isaac Asimov's 1958 short story "The Ugly Little Boy" scientists use a time machine to bring a Neanderthal child to the present. The nurse who is hired to care for him finds him repulsive at first, but she soon admires his intelligence and gentleness. The scientists send the child back to his own time and, in an act of love, the nurse goes with him so that she can continue to protect him.

In 2002 and 2003 Canadian writer Robert J. Sawyer published *Hominids, Humans, and Hybrids*. The three novels make up The Neanderthal Parallax, a trilogy about a parallel world in which *Homo neanderthalensis* rather than *Homo sapiens* become the sole surviving human species. The novels describe what happens when scientific researchers create a portal between the Neanderthals' world and our own. Sawyer's Neanderthals have technology similar to ours—or superior to it—but their government, family life, and religion are unlike anything known in our world. As in many stories about Neanderthals, the power of The Neanderthal Parallax lies in its vision of a profoundly different way of being human.

Above: A scene from the 1985 movie *Clan of the Cave Bear*, in which Neanderthals raise a *Homo sapiens* girl

Both *Homo neanderthalensis* and *Homo sapiens* evolved from an earlier hominin, probably *Homo heidelbergensis*. The Neanderthals became extinct, but *H. sapiens* went on to populate the world.

Genetic researchers routinely use DNA analysis to answer questions about the relationships among modern species, populations, or individuals. Starting in the 1990s, some researchers have turned to DNA to clarify the relationship between Neanderthals and modern humans.⁸²

DNA is the molecular basis for information transfer from one generation to the next. It makes up the code that defines what an organism is and how it will develop and function. As DNA passes from one generation to the next, it not only recopies the genetic heritage over and over again but also accumulates mutations. By analyzing the amount of variation in DNA from different species or populations, scientists can measure how closely or distantly those species or populations are related. Neanderthal DNA, therefore, could say a lot about the relationship between us and the Neanderthals. But while it is easy to get hold of modern DNA for testing, where can scientists get the DNA of Neanderthals, who have been extinct for tens of thousands of years?

In the mid-1980s the Extinct DNA Study Group at the University of California in Berkeley pioneered techniques for obtaining bits of DNA from the preserved bodies or skins of lost species such as the quagga, a relative of zebras that went extinct in 1883. One of the international scientists who studied the methods of the Berkeley group was genetics expert Svante Pääbo, who had already succeeded in getting DNA from a 2,400-year-old Egyptian mummy.

Pääbo's goal was to explore the DNA of all kinds of extinct species, be they plants or animals. In the 1990s he turned his attention to the question of relationships between humans and extinct hominins. No fragments of mummified Neanderthal skin or flesh existed, only bones in various states of fossilization. Was it possible to obtain DNA from such sources? Pääbo was determined to try. He went to the original source—the Neander Val-

ley bones found in 1856. It took him two years to convince the museum officials in charge of the remains to let him have a chunk of Neanderthal Man's arm bone.⁸³

Two teams of scientists, one in Germany and one in Pennsylvania, performed tests on the bone, taking great care to avoid contaminating the ancient DNA with modern genetic material such as skin flakes or airborne pollutants. They drilled into the bone to create a fine powder, then dissolved the powder in a chemical solution to isolate any surviving fragments of DNA. This method produced strands of DNA that could be analyzed.



Hoping to recover Neanderthal DNA, a technician draws a sample from a precious scientific relic. Protective clothing and gear guard against contamination by modern human cells.

The researchers focused on assembling fragments of mitochondrial DNA, or mtDNA, from the sample. Mitochondrial DNA is a special length of DNA found only in the mitochondria, which are structures outside the nucleus of each cell that generate energy within the cell. Because mitochon-



A single mitochondrion (pink) photographed through a scanning electron microscope. This tiny body within a cell records the genetic legacy passed from mothers to offspring in both Neanderthals and our own species.

drial DNA is transmitted by mothers to their children, but never transmitted by fathers, it records evolutionary descent through females.

Pääbo and his colleagues compared the mtDNA from Neanderthal Man to samples from a thousand or so modern humans. Neanderthals turned out to be equally distant from all groups of people in the modern world—a result that disproves the idea that Neanderthals contributed to the ancestry of today's Europeans. The mtDNA test also suggested that the genetic separation between the ancestors of Neanderthals and the ancestors of modern humans began 500,000 years ago. This result supports the theory that Neanderthals and humans evolved separately from a half-million-year-old common ancestor, such as *H. heidelbergensis*.

The first mtDNA results for Neanderthals were published in 1997. Since that time scientists have analyzed mtDNA from more Neanderthal remains, as well as from Cro-Magnons and other early *H. sapiens*. Their results support the conclusion that Neanderthals did not contribute to the genetic makeup of modern humans.

In 2006 Pääbo and American geneticist Edward Rubin announced a

breakthrough in Neanderthal DNA studies. They had succeeded in retrieving and analyzing some sequences of nuclear DNA from a 38,000-year-old thighbone found in Croatia's Vindija Cave.

Nuclear DNA is contained in the nucleus of every living cell. It is the organism's blueprint, its complete genetic code. Although nuclear DNA is far longer and more complex than mtDNA, the two teams hope to decode the complete Neanderthal genome and publish it on the Internet, a feat that has already been accomplished for modern humans and many other species. Early results of the nuclear DNA project support the mtDNA tests that placed the genetic split between the Neanderthal and *H. sapiens* lines at roughly 500,000 years ago.⁸⁴

Although DNA evidence is a strong argument against Neanderthals as our ancestors, it does not rule out the possibility that Neanderthals and modern humans interbred, at least occasionally. Such interbreeding may have produced children who were unable to reproduce, as is the case today with the offspring of unions between horses and donkeys, or lions and tigers. Some paleoanthropologists think, however, that Neanderthals and early modern humans would have been so different in physical appearance that they would not have seen each other as possible mates.⁸⁵ All we know at present is that if the two species did interbreed in the shadow of the Pleistocene glaciers, their unions do not seem to have left a Neanderthal "genetic footprint" in our own DNA.

The German limestone quarrymen who flung "bear bones" to the floor of the Neander Valley in 1856 would have been astonished to know that those fossils really came from a different kind of human, a species that once lived in Europe alongside our own. *Homo neanderthalensis* is long extinct, but our curiosity about him is alive and well. Today scientists are delving deep into Neanderthal bones, seeking to unravel the DNA of our closest human relative. As fossil hunters and genetic researchers continue their explorations of the Neanderthal past, we will undoubtedly learn much more about our own origins.

Modern Discoveries about Ice Age Neanderthals

1830 Neanderthal remains found at Engis, Belgium.

1848 Neanderthal remains found at Gibraltar.

1856 Neanderthal remains found in the Neander Valley, Germany.

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

1864 Irish geologist William King names species *Homo neanderthalensis*.

1871 Darwin publishes *The Descent of Man*.



*The Broken Hill skull
discovered in 1921*

1906 After excavating Krapina Cave, Dragutin Gorjanovic-Kramberger of Croatia says that Neanderthals were cannibals and also human ancestors.

1907 Jawbone from Mauer, Germany, named as new species *Homo heidelbergensis*.

1908–1914 Discovery of several Neanderthal sites in France.

1921 Fossil found at Broken Hill mine, Zambia; later identified as *H. heidelbergensis* or *Homo rhodesiensis*.

1929 Neanderthal remains found in Israel.

1938 Neanderthal remains found in Uzbekistan, central Asia.

1949 First excavations at the Grotte du Renne, France.

1950s Excavation of Neanderthal site at Shanidar, Iraq.

1976 First human jawbone found at Atapuerca.

1984–1998 Excavation of early human remains at Atapuerca.

1994 *Homo antecessor* remains found in Gran Dolina cave, Atapuerca; first wooden spear found at Schöningen, Germany.

1997 Svante Pääbo recovers first Neanderthal DNA from original Neander Valley fossil.

2000 Fossil jaw found in France suggests toothless early Neanderthal adult received care from others 175,000 years ago.

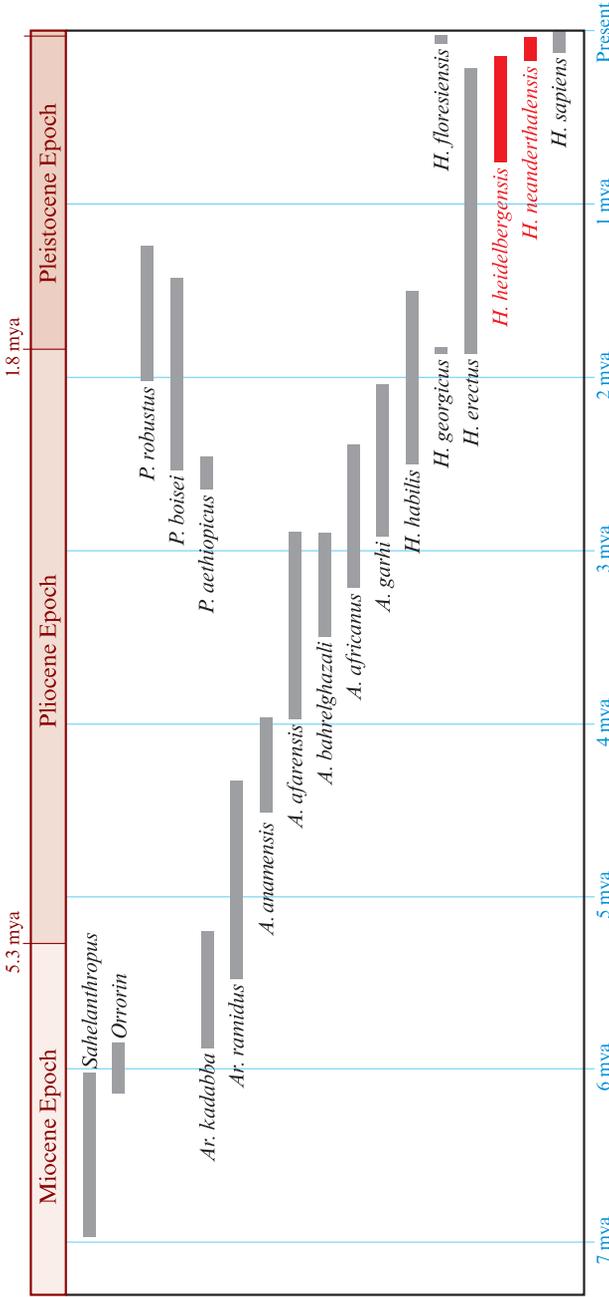


2005 Stone tools dated to 700,000 years ago found at Pakefield, England.

Recovering Neanderthal DNA was a scientific landmark.

2007 DNA tests on fossil bones place Neanderthals in the Altai Mountains of Siberia; human jawbone more than 1.1 million years old found at Atapuerca, Spain.

Time Line of Human Evolution



mya = millions of years ago
 = discussed in this volume

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

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.

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).

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.

paleontology The study of ancient life, mainly through fossils.

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

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

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Web Sites

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

<http://www.amnh.org/exhibitions/atapuerca/granhumans/index.php>

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. The site's "Atapuerca" page offers details about early human fossils from Spain.

<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>

<http://anthropology.si.edu/HumanOrigins/ha/neand.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. The site's Neanderthal page features photos of some of the most important fossil finds.

<http://www.atapuerca.com/>

Searchable in both Spanish and English, the Web page for Spain's Atapuerca archaeological and paleoanthropological site offers an overview of discoveries and a time line of human evolution.

<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.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, *Human Beginnings*, which includes a section called "Neanderthal."

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

The companion site to the PBS *Nova* documentary "Neanderthals on Trial" features interactive videos and coverage of recent research on Neanderthal DNA.

http://www.museum.state.il.us/exhibits/ice_ages/

The Illinois State Museum maintains this site about the causes and effects of the ice ages that have occurred throughout Earth's history, including the glaciations of the Pleistocene epoch, when early humans colonized Eurasia.

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

The companion site to the PBS *Nova* documentary "Cracking the Ice Age" covers recent scientific discoveries about the causes of ice ages and their effects on life on Earth.

<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/wwwcavemen/

Walking with Cavemen, a companion site to a 2003 BBC television series, includes information about human ancestors as well as an interactive “Caveman Challenge.”

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