

**Patterns in Prehistory:
Humankind's First
Three Million Years,
Fifth Edition**

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The Origins of Culture

*What a book a Devil's Chaplain might write on
the clumsy, wasteful, blundering low & horribly
cruel works of nature!*

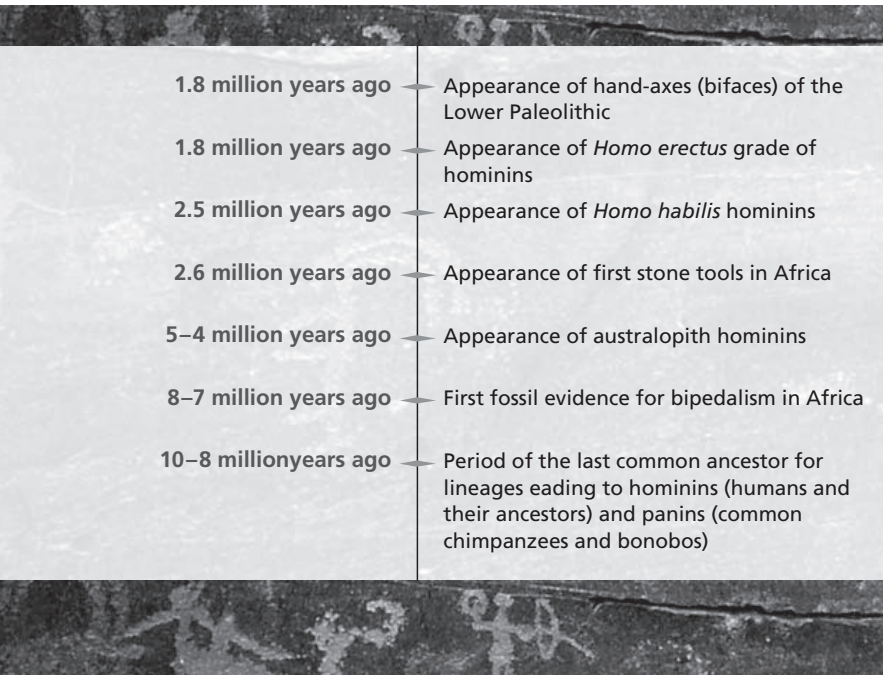
Charles Darwin

Darwin, somewhat ambivalently, concluded that a close study of nature and evolution argued powerfully for the nonexistence, or noninvolvement in human affairs, of a supreme deity. Darwin's analysis convinced him that the origins of the human species, like that of all other species, are to be found in blind and "cruel" competition at all levels—that is, in countless millennia of nature "red in tooth and claw" (a phrase coined by Alfred Lord Tennyson). Darwin was acutely aware of the impact of his ideas on revealed religions, and even today the reverberations of the conflict between evolutionary theory and some religious doctrines echo in some cultures, including the United States.¹

In this chapter we consider our origins in the competitive world of Pleistocene Africa—how our genus, *Homo*, evolved out of more ancient primates in a complex mosaic of environments. In contemporary paleoanthropology one of the most interesting recent developments is the growing consensus that many of the hominins who lived before about 300,000 years ago were not the direct ancestors of us, *Homo sapiens*, genetically. Yet there are still many unresolved issues in these debates and analyses, and it is entirely possible that our current understanding of our pre-*Homo sapiens* past will be radically altered as new evidence is discovered.

THE PROBLEM OF CULTURAL ORIGINS

In the film *2001: A Space Odyssey* our chimpanzee-like African ancestors of some millions of years ago wake one morning to find themselves at the foot of a huge, black, perfectly smooth, monolith. Jabbering in fright and wonder, they contemplate its meaning. In a later scene, a descendant of these creatures, but still an ape-like primate, "discovers" tools—and murder—by using an animal leg bone to smash the skull of another ape. He throws the bone skyward in bloody triumph, where, spinning, it is transformed into a rotating twenty-first-century space station—carrying a man on his way to examine another—or perhaps the same—monolith, which has been found in an excavation on the moon.



1.8 million years ago	Appearance of hand-axes (bifaces) of the Lower Paleolithic
1.8 million years ago	Appearance of <i>Homo erectus</i> grade of hominins
2.5 million years ago	Appearance of <i>Homo habilis</i> hominins
2.6 million years ago	Appearance of first stone tools in Africa
5–4 million years ago	Appearance of australopith hominins
8–7 million years ago	First fossil evidence for bipedalism in Africa
10–8 million years ago	Period of the last common ancestor for lineages leading to hominins (humans and their ancestors) and panins (common chimpanzees and bonobos)

Stanley Kubrick's powerful film of this classic Arthur Clarke story effectively uses the monolith as a symbol, perhaps of human evolution and enlightenment or of some cosmic intelligence. It leaves the viewer to muse on the nature of the possible driving force of human evolution: natural processes, God, extraterrestrial beings, or something else.

Anthropological analyses of the beginnings of tool-use and the nature and significance of our past and future have, perhaps, much less mythic power than *2001*, but the fundamental questions addressed are similar: What factors transformed us from just one kind of genera of African ape into space travelers, and what, if anything, does this transformation "mean"?

Long ago a Greek philosopher suggested we are the progeny of spores blown here millions of years ago through the illimitable reaches of space, and, perhaps, the answers to our questions of origins are, thus, truly, in the stars. Even today some scientists, impressed by the relatively short time between the formation of the earth and the complexity of contemporary human civilizations, consider it possible that life on earth derives ultimately from the accidental intersection of the earth's orbit with a cloud of complex chemicals brewed in some ancient stellar explosion.

Alternatively, people in every age have found great comfort in their sure and certain knowledge that we and the world are the result of Divine Creation and that there is Someone in Charge.

Whatever the value of such speculations, the major premise of anthropology is that one should begin any inquiry into our origins, history, and destiny with a consideration of real-world factors of climate, genetics, culture, and so on. The anthropological assumption is that with the careful sifting and analysis of the shattered fragments of our ancestors, their tools, and other material evidence, we can "know," in a scientific sense, at least something about our nature and our past. Indeed, in their search for human origins, anthropologists have concentrated on such embarrassingly ordinary subjects as chimpanzee sexual behavior and the cuisine of African hunter-gatherers.

THE NATURE OF CULTURE

Intelligence . . . is the faculty of making artificial objects, especially tools to make tools.

Henri Bergson²

If we take Bergson's definition literally, we might conclude that the earliest evidence for human "intelligence" dates to some time before 2.6 million years ago, in Ethiopia, where stone tools have been found under volcanic ash layers dated to that time.³ But what are we trying to explain when we speak of the origins of culture? Anthropologists restrict the term "cultural" to human beings (although chimpanzees are sometimes called "proto-cultural"); thus the origins of culture are essentially the origins of those human qualities that make us a unique animal.⁴ But it is more difficult than it might seem to reduce humanity to this or that constellation of attributes, to capture the essence of being human. In most religions, for example, a human fetus, whether six seconds or six months after conception, is human in the only way that really matters, being imbued with an immortal soul. But what observable, *measurable* qualities can we use to distinguish ourselves from other life-forms?

Most who address this question turn instinctively, as it were, to attributes of the human mind, and particularly to the unique qualities of human thought. Descartes's famous phrase *Cogito, ergo sum* ("I think, therefore I am") is a classic expression of this idea.

A traditional view is that humans are unique in their ability to manipulate symbols and that the evolution of this ability underlies all human achievements. Anyone who has seriously studied chimpanzees at play can feel a sense of kinship with these primates; the term *proto-cultural* seems hardly an exaggeration. But in analyzing the origins of culture, it is how we are *different* from other primates that is important, and in large part this difference resides in our mentality—our creativity, intuition, logic, aesthetics—all the powers of the human mind. Anthropologist Leslie White argued,⁵ for example, that although chimpanzees are clever animals who can use tools and even can be taught to use plastic counters, computers, and sign languages to express emotions and desires, they are fundamentally different from us in two ways: First, they can never use symbols at an abstract level that would give them any understanding of concepts like "holy water" or the casting of a vote; second, even the smartest of nonhuman animals seem to pass relatively little new, learned knowledge from generation to generation in such a way that there is an observable long-term net increase.

For White these differences amounted to a qualitative difference between ourselves and all other animals, but one can also view them as quantitative. We simply do not know what a chimpanzee sees or what he or she "thinks," and White's distinction may be less sharp than it appears. Nonetheless, chimpanzees can smear canvasses with paint in an excellent imitation of "modern art," but they seem utterly untalented at more representational painting; and it seems highly unlikely that even chimpanzees can *respond* in great depth to aesthetics—can savor, for example, the vibrancy of a Van Gogh landscape or the sublime delicacy of a Ming porcelain jar. Their ability to pass new learned knowledge from generation to generation is a more complex problem. Japanese monkeys, for example, have been reported to have learned how to wash sand from handfuls of grain (Figure 3.1) and then instruct younger members of the group how to do this, but there is evidence that even such simple food-related behavior is partially genetically determined.⁶ And even if it were not, such behavior is at a sufficiently low scale that it remains true that "the most characteristic part of being human is the ability to profit from the accumulated and transmitted experience of other human beings."⁷

Tooby and Devore have expressed this sense of the distinctiveness of human intelligence and behavior as a set of two kinds of primate characteristics, and have listed those



FIGURE 3.1 Japanese macaque washing sweet potatoes.

that are unique to humans and those that we share with other primates but to a much different degree.

Fifteen features on this list basically relate to a generalized sense of “intelligence” in combination with some emotional capacities, but the unfortunate reality is that, although we know that we modern humans are different from other primates, we must presume that our earlier ancestors were increasingly similar to other primates as one goes back in time, and we must also recognize that we will never know directly the symbolic capacities of our earliest ancestors: We must

relate “intelligence” to material things that we can find and measure, and for the first several million years of the human clade, this means looking mainly at changes in the size and shape of hominin skulls and bodies, and, after about 2.6 million years ago, at stone tools and the remains of other objects on which our ancestors imposed their intellects. These indirect reflections of evolving symbolic abilities constitute “culture” for the anthropologist in an analytical sense.

One might question why a “moral” sense is not listed as a defining attribute of human mentality, as that characteristic has been the focus of theological definitions of humanity. In rural Southern colloquial American English, if one wants to disparage a person’s knowledge of something, a common phrase is that “he knows about as much about it as a pig knows about Sunday.” Even Mark Twain, no sentimentalist, said, “Man is the only animal that blushes—or needs to.” But many scientists⁸ have considered human moral systems to be learned, not innate, and to have evolved as extensions of the same symbolizing abilities that allow us to categorize “friend” and “foe.”⁹

The paradox that we have only one tool with which to try to understand the origins of the human mind, namely, the human mind, is a bit of cosmic whimsy appreciated by philosophers of all ages. There is an embedded circularity to this form of the analysis that has led some to kick stones, wondering if they are really “there.” Someone observed that “a fish would be the last creature to discover water,”¹⁰ and we may be in similar circumstances—unable to see the reality in which we live because we can see no other reality. Readers interested in such topics and with much time to indulge their interest are referred to volumes 2–9 of Father Frederick Copleston’s rewarding *History of Philosophy*.

What some researchers assume, however, is that our ancestors of about 8–10 million years ago were not much different from the chimpanzees one can see in any zoo today,¹¹ and, yet, today *we* are very different from all other apes. This knowledge of our deep antiquity

and the nature of our physical and cultural evolution—and the search for an explanation for them—is relatively recent.

Early Studies of Human Origins

As discussed in chapter 1, the impact of the discovery of human antiquity was profound.¹² Many scholars lost their comforting faith in a recently created and human-centered world and were forced to peer instead into an abyss of millions of years, one that saw our slow emergence from rodents, reptiles, worms, and, ultimately, the same lifeless chemicals that appear to make up the rest of the universe.

By the end of the nineteenth century both Darwin's ideas (see chapter 1) about the biological evolution of the human species and the discovery of stone tools in association with the bones of extinct animals in extremely ancient geological strata had convinced many scholars of the great antiquity of humans. Nevertheless, as long as no bones were found that were recognized as those of a human ancestor intermediate between ourselves and other primates in physical form, it was still possible to cling to the idea that humans were an exception: that we were an extremely old species, older than had previously been suspected, but that we had not evolved as other species had.

Those who had studied Darwin and Lyell closely, however, knew it was just a matter of time before the first fossil “missing link” was found—or recognized in the bones that had already been found. The French scholar (and full-time customs inspector) Boucher de Perthes, grown old and tired of waiting, offered a 200-franc reward to the discoverer of the first “antediluvian” (meaning “before the flood”) human in France. His enterprising workers were soon “finding” any number of such remains—all of which they had themselves put there, of course, in hopes of collecting the money.

Boucher de Perthes did not know that pre-modern hominins had already been discovered some years before but simply had not been recognized. A fragmentary Neandertal child's skull was found near Liège, Belgium, in 1829–1830, and in 1848 work at a quarry on Gibraltar revealed a skull whose receding chin, heavy brow ridges, and thick bones we now recognize as that of a Neandertal. Neither the Belgium or Gibraltar finds excited much interest at the time. In 1856, however, a skullcap and some limb bones were found in a cave in the Neander Valley near Dusseldorf, Germany (Figure 3.2). Although these remains were dismissed by the great German anatomist Rudolf Virchow as those of a deformed human, Johann Karl Fuhlrott, their discoverer, argued from the beginning that the remains were of an early form of human. But Virchow's opinion, and those of others who variously labeled it an ancient Celt, a victim of rickets, an idiot, or a Cossack, conspired to deny these bones their proper significance for many years. One French savant even suggested that the huge brow ridges of the Neandertal came about because



FIGURE 3.2 The remains of Neandertals were recovered from the Neander Valley, near Dusseldorf, Germany, in 1857. This evidence that ancient people were different from modern humankind was part of the assault by evolutionary ideas and evidence on traditional ideas about our place in the universe.

his deformed arm caused him such pain that he continually furrowed his brow, and the expression became ossified.

In 1886 two partial skeletons similar to the Neandertal specimen were recovered in a cave in Spy, Belgium, in direct association with stone tools and the bones of rhinoceroses, mammoths, and other animal species known to have been long extinct. Although Virchow also refused to accept these as ancient men, the tide of opinion had turned and scientists everywhere were soon looking eagerly for additional specimens of early hominins.

One of these was a young Dutch physician, Eugene Dubois, who spent years wandering the wilds of Sumatra without finding much of interest; only when he arranged a transfer to Java did he make his great discovery. In 1890 he unearthed a fragment of a lower jaw, and over the next few years he recovered a skullcap and a femur (thigh bone).¹³

For the next 30 years, controversy raged over Dubois's find, with some authorities again claiming it to be a deformed freak or a giant chimpanzee, while others recognized it as an early form of our genus and a direct ancestor of modern humans. Dubois's fossil had an approximate brain volume of 1,040 cm³, about a third less than modern people but far more than any living primate. Scholars of the time recognized that if this animal were in fact a human ancestor, it was an ancestor considerably different from ourselves and from "Neandertal man" (whose cranial capacity was slightly larger than that of most modern humans).

In 1906 the German anatomist Gustav Schwalbe proposed three successive stages of hominin evolution: pithecanthropine (as represented by Dubois's fossils), Neandertal, and modern. It was apparent, however, that if this were the correct succession of hominin forms, there would have been many intermediate types not yet found.

The recognition of an earlier stage of hominin evolution did not come until the 1920s, when Raymond Dart discovered a nearly complete skull of a strange-looking child. It was encased in stone quarried from a mine at Taung, some 300 kilometers from Johannesburg, South Africa. The skull's shape, small volume, and primitive teeth convinced Dart he had found one of humankind's earliest, most primitive ancestors, which he labeled *Australopithecus africanus* ("Southern ape of Africa"). While Dart's conclusions were being challenged by some of the most influential scientists in Europe, another important find was made, this time in northeastern China, near Beijing, at a mining installation called Zhoukoudian (formerly rendered in English as "Choukoutien") (Figure 3.3). For centuries, fossilized bones from the area had been ground into powder and used, hopefully, as aphrodisiacs, and many specimens of great scientific significance have probably long since been consumed in the form of impotent aphrodisiacs and medical potions.¹⁴

A somewhat more scientific interest in these fossils was stimulated in 1921 when a single human-looking tooth from Zhoukoudian was given to the English anatomist Henry Black. He recognized it as belonging to an ancient form of hominin, and as a consequence, excavations at Zhoukoudian were begun. Altogether, the remains of about 40 individuals were found, including many skull fragments, and it was obvious that these individuals were similar in brain size, facial structure, and other characteristics to the hominin found by Dubois on Java. This supported Schwalbe's proposed pithecanthropine stage, and fossils of this type were accorded the name *Sinanthropus* or *Homo erectus* ("erect man").

Thus, by the 1930s at least some of the scientific community recognized four categories of early hominins: australopiths, *Homo erectus*, Neandertals, and modern humans. Since that time the arguments have focused not on *whether* humankind evolved from some sort



FIGURE 3.3 Excavations at Zhoukoudian, China. The rope enclosures on the right mark areas where hominin skulls were found.

of nonhuman ancestor, but on what these various ancestral forms are, how they are related genetically during their evolutionary histories, and what evolutionary mechanisms produced ourselves, *Homo sapiens sapiens*, from pre-human primates. It is somewhat ironic that many scholars today consider the Javanese *Homo erectus*, the Neandertals, and most of the australopiths to have been unrelated or only distantly related to our own ancestors (discussed in chapter 4), but the importance of these early finds is that they demonstrated that we had evolved from nonhuman primates.

We have many sources of evidence about our origins including the study of our primate relatives, the fossil bones of our ancestors, and the early stone tools and other physical traces our forebears left. But before we look at the collected evidence, we must consider the analytical principles we must use to interpret them—specifically, evolutionary theory. The basic premise underlying the study of human origins is that about six to eight million years ago our ancestors were animals something like chimpanzees, and that the forces of evolution changed us into what we are today. But what were these forces?

Evolutionary Theory

The origins of evolutionary theory in the writings of Darwin and others was reviewed in chapter 1, but a more detailed description of evolutionary principles and processes is required here in order to understand how they can be applied to the human past—and to the entire span of biological life on this planet.¹⁵

Evolutionary theory is a complex, often mathematically expressed discipline, and its major elements can only be briefly summarized here.¹⁶

As noted in chapter 1, Charles Darwin made the fundamental observations that still serve as the basic paradigm for evolutionary theory. He noted that many more animals and plants were bred than actually lived to reproduce themselves; further, he noted that there was much variation in the form and physical qualities of individuals in any species. He further inferred that there was some connection between these variations and the differing rates of success of individuals in living and reproducing. Finally, he concluded that “natural selection” was the process in which nature—in the form of different environments—selected some individuals to live and reproduce based on the relative “fitness” of individuals in these environments. Darwin then attempted to show how this general process had worked on innumerable generations to produce the awesome visible biological diversity of the world.

What Darwin did not know, however, was how variations in individuals arose and how they were passed on from generation to generation. The answers to these problems were supplied by geneticists, beginning primarily with Gregor Mendel (1822–1884). Mendel studied the inheritance of color and shape in peas, and in a series of convincing experiments showed that there were predictable patterns to the results of breeding plants of different characteristics.¹⁷ Mendel and later scholars formulated what we now call the *particulate theory of inheritance*, which says that physical characteristics of individual organisms are passed from one generation to the next in the form of discrete particles (informally known as “genes”) and that these particles retain their ability to express themselves even when they do not express themselves in every generation. The *law of segregation* stipulates that these particles are inherited in pairs, one of each from each of the parents.

The elixir of life, in the sense of evolutionary theory, is the substance known as DNA. Within the nucleus of every animal cell are chromosomes, thread-like structures composed of deoxyribonucleic acid, or DNA. DNA in turn is made of four *nucleotides*: guanine, cytosine, adenine, and thymine (Figure 3.4). These nucleotides combine in groups of three to form 20 amino acids, which are the building blocks for all protein formation. The arrangement, or sequence, of these bases determines the physical structure of all living things, from AIDS viruses to elephants (Figure 3.5). Except for the sperm or ova, every human cell, whether it be from the eyeball or toenail, contains the complete genetic code for that individual. If the DNA strand representing the entire code for a particular person were removed from a single cell and straightened, it would be about 6 feet long. The specific sequence of the DNA for any individual reader of this book would be unique and would fill about 125 books the size of the Manhattan telephone directory. DNA contains all the information required to direct the operation of a cell, in combination with another nucleic acid, RNA (ribonucleic acid). DNA has the ability to reproduce itself, and it also offers the potential for the main stuff of evolution, genetic change.

The two main sources of genetic variety are *meiosis* and *mutation*. Animal cells are constantly splitting (*mitosis*) and producing genetically identical copies of themselves, and

thus growth and maintenance are accomplished. But in meiosis, egg and sperm cells are produced that carry only half the genetic code of the parent—in the case of humans, our 23 pairs of chromosomes total 46 total chromosomes in each body cell, but each egg and sperm cell carries only half the total, so each new person receives 23 chromosomes each from his or her father and mother. These genes are shuffled and then recombined in sexual reproduction, and thus the number of genetically unique offspring possible for any human couple is determined by the equation $2^{23} \times 2^{23} = 2^{46}$, or about 70,000,000,000,000.¹⁸ Each of us truly has won a lottery featuring odds against success that dwarf those of the financial kind.

Genetic variability is also produced by *mutations* in chromosomes—errors DNA makes in copying itself. The origins of mutations are not completely known, but some probably arise through the cosmic ray bombardment to which all living organisms are subjected. Early work on DNA involved exposing hapless populations of fruit-flies to radiation, producing monstrous combinations of eye colors, wing size, and other features. And there is reason to believe that industrial pollution, loss of ozone in the atmosphere, and other factors in the modern environment will lead to greater rates of mutation in all living things.

One illustration of the elements of evolutionary theory and its power to explain change in the natural world involves organisms too small to be seen with the naked eye—disease-causing bacteria. We all know of the importance of antibiotic medicines in fighting various diseases, such as *Staphylococcus* and *Streptococcus*. Strains of these bacteria can cause pneumonia or toxic shock, and the development of penicillin to combat them was considered a “miracle.” During World War II, drug companies began mass-producing penicillin as part of the war effort, and by the time of the Korean War the use of this drug proved very effective.

Initially, bacterial infections were successfully killed off when patients were given penicillin. But like all organisms, bacteria also have variations in their genetic composition. Some of these variations are resistant to antibiotics such as penicillin. In evolutionary context, the use of antibiotics selects against those microbes that have no resistance to the

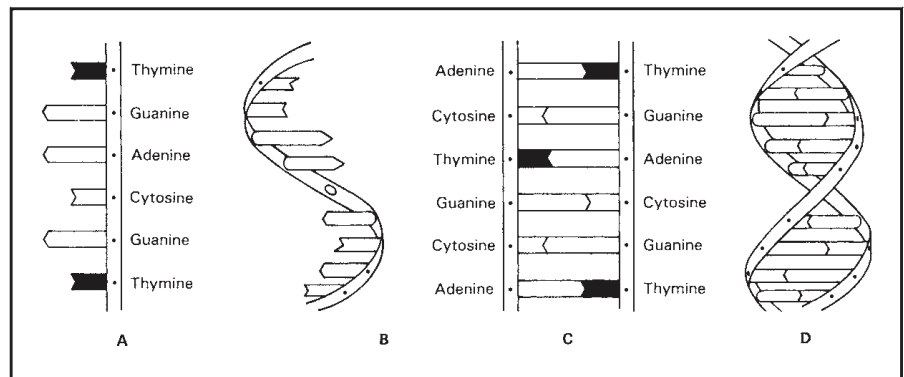


FIGURE 3.4 The genetic code determining the biological characteristics of species lies in the sequence of bases (thymine, guanine, adenine, cytosine) that links two strands of nucleotides to form the double helix that is DNA. (A) Bases in part of one strand of nucleotides. (B) Part of one strand twisted. (C) Complementary bases joined. (D) Two strands joined and twisted.

Human	0							
Rhesus monkey	1	0						
Rabbit	9	8	0					
Duck	11	10	6	0				
Rattlesnake	14	15	18	17	0			
Tuna	21	21	17	17	26	0		
Moth	31	30	26	27	31	32	0	
Yeast	45	45	45	46	47	47	47	0
	Human	Rhesus monkey	Rabbit	Duck	Rattlesnake	Tuna	Moth	Yeast

FIGURE 3.5 Amino acid sequences. Organisms (human, Rhesus monkey, rabbit, duck, rattlesnake, tuna, moth, yeast) differ in the sequence of amino acids in protein cytochrome c, an enzyme used in energy production. The higher the number shown, the greater the difference between any two.

antibiotic, but selects for those variants that have the genetic coding allowing the microbes to fight off the effects of the antibiotic. Somewhat quixotically, our societal practices actually help increase the reproductive success of antibiotic-resistant bacteria. This is what happens, for example, when people indiscriminately use antibiotics to treat viral infections—antibiotics aren't the solution to viruses, but taking antibiotics allows the survival and reproduction of drug-resistant bacteria in our bodies. When we do get a bacterial infection, those drug-resistant bacteria are that much more difficult to treat.

Medical research is thus constantly searching for new types of antibiotics—previous efforts have resulted in the development of tetracycline, erythromycin, and cipro, and many others—to replace those antibiotics that have become less effective. Other drug-resistant diseases most of us have heard about include tuberculosis and gonorrhea.

This example demonstrates all of the major elements of evolutionary theory. It explains biological changes in life-forms over time and space in terms of *natural selection*, at least in the simplistic sense of differential survival over time in organisms on the basis of their genetically determined characteristics. For natural selection to operate there must be *variability*, that is, differences between individuals in their physical form and the specific and unique genetic combinations each individual represents, so that over time there can be selection of characteristics, such as changes in drug resistance, brain size, instinctive migration, and so on.

It is important to recognize that evolution is not goal directed: These bacteria could not intentionally produce drug resistance to solve their problem; evolutionary processes simply and blindly sorted the genetic potential for different degrees of drug resistance on the basis of the advantage in reproduction and survival. The biological history of life on this planet is one of uncountable extinctions of species—which makes it clear that evolution does not “solve” all problems of adaptation.

But the reader should be aware that intense debates continue about the status of Darwinism and what is often called “neo-Darwinism.” In general, biologists do not doubt the essential validity of Darwin's ideas, but they dispute heatedly the mechanisms involved. For example, a major book, *Evolution as Entropy*, by Brooks and Wiley, argues that natural selection is not the most important factor in directional change. Instead, they suggest that existing systems—whether these be organisms, populations, or species—present a configuration that constrains the possible “spaces” or directions in which evolution may take place. These are highly abstract and fundamentally mathematical arguments that are beyond the scope of this book.

APPLICATIONS OF EVOLUTIONARY THEORY TO THE PROBLEM OF HUMAN ORIGINS

Most genetic mutations seem to be “bad,” in the sense that they reduce the chances of the individual carrying them to reproduce successfully. Other mutations are “good,” in that they increase reproductive potential, or “fitness.” But what is good or bad in evolution is measured entirely by reproductive success—and can be good or bad in different environments. For example, sickle-cell anemia—a genetic condition in which red blood cells are misshapen—is a common disease in Africa and the Mediterranean Basin. People who are born with a certain combination of the genes for this condition often die in childhood; but those with another genetic combination appear to have some protection against malaria.

Thus the gene for sickle-cell anemia has persisted because its presence in a population—although it results in the death of some people—helps others to live to reproductive age in zones of the world where malaria has long been a ferocious killer. “Natural selection,” in this sense, is obviously no master or beneficent craftsman.

The spread and perpetuation of genetic mutations through biological populations are accomplished by various mechanisms. The variations in skin color in contemporary peoples, for example, seem to be the result of *migration* into different environments and subsequent adaptation. Dark skin offers a defense against skin cancers and other maladies that direct sunlight on human skin can produce, and so we see dark skin tones not just in Africa, but in the Indian subcontinent and far out into the Pacific Ocean island chains. But in humans the critical nutrient vitamin D is synthesized in the skin through the action of sunlight, and in relatively dark and cloudy climates a dark-skinned person will be at a disadvantage in times of scarcity of dietary sources of vitamin D—in winter months, for example. Early humans from Africa, whom we assume to have been dark-skinned, invaded environments where heavy pigmentation interfered with the synthesis of vitamin D, and eventually natural selection produced the blond, fair-skinned, blue-eyed human physical type typical of northern Europe: We must assume that small variations in skin pigmentation over thousands (replacement model) or millions (multiregional model) of years allowed those with lighter pigmentation to have a slightly greater reproductive “fitness” for living in more temperate environments.

In this way, the world’s “races” were formed, with natural selection acting on mutations in hundreds of genetically determined features. Geographical barriers have been a factor in channeling and constraining these migratory patterns: The Sahara, the Himalayas, and other natural barriers have restricted the matings between people in different areas to the point that modern “races” evolved. Most biological scientists reject the term “race” as imprecise and misleading. Patterns of evolutionary variability in people seem best understood in terms of *clines*, or gradients of variation through time and space that are not easily and discretely compartmentalized. Skin color, for example, varies greatly if one examines people on a cline from Sweden to South Africa, and these variations are only crudely described as “black” and “white.” Also, some of the traits commonly used to identify “race,” such as skin tone, eyelid shape, nose and lip shape, and so on, also show immense—and often independent—variation along gradients through time and space: That is, southern Indians, West Africans, some Pacific Islanders, and others share a relatively dark skin pigmentation but differ greatly in nose and lip shape, hair texture, and so on.¹⁹

Changes in physical form can also result from *sexual selection*: Once individuals choose mates nonrandomly with regard to some characteristics, evolutionary change can result. Gaudy colors and exaggerated features, such as represented by the male peacock, are probably the result of sexual selection, in which females choose mates partly on the basis of elaborateness of the display. Nor are these displays necessarily irrelevant to genetic “fitness,” for they often correlate with superior health and genetic potential of some kinds. Some scientists believe that sexual selection was responsible for such features as the “exaggerated” size (by comparison to other primates) of human penises and female breasts.²⁰

Modern population genetics is a complex mathematical discipline and is largely beyond the scope of this book. And many complex debates continue about the application of evolutionary theory to human evolution.²¹ But for the study of cultural origins and the

other physical changes we will consider here, including plant and animal domestication (chapter 6), the important points to remember are: (1) Genetic variability is constantly arising through various mechanisms; and (2) changing environments, sexual selection, and other factors “select” or act on this variability and differing reproductive success through time and space to produce evolutionary change.

Although modern cultures have erected some barriers to “natural selection” (few people in industrialized countries now die of appendicitis, for example), through our long evolutionary history we have been no less a product of evolutionary forces than any other life-form. Most modern human physical characteristics are the result of complex genetic interactions that involve a subtle, long-term balancing of the costs and benefits of genetic changes. Consider, for example, the average height of human beings. As professional basketball teams and the pygmies of central Africa demonstrate, humans can live perfectly normal lives as individuals 7 feet or 3 feet tall. So why, on the average, are people around the world between 5 and 6 feet tall? And why do they vary sharply in average height by sex and geographical location? Why are we not all about 4 feet tall or 7 feet tall? As it is with almost all human characteristics, the “environment”—nutrition, for example—is a factor in human height. The high-calorie diets of North America, for example, have produced generations of Asian Americans who are significantly taller, on average, than their parents. But height is also partially genetically controlled. And we must assume that we average between 5 and 6 feet and not between 7 and 8 feet or 3 and 4 feet because our average size made sense in complex evolutionary equations. With selective breeding and adequate nutrition, a group of people could probably have been bred to an average height of 7 feet or more, but the costs of maintaining that body mass obviously did not make evolutionary “sense.” The pygmies of the African rain forests appear to have evolved in response to the very low food resources available in a tropical rain forest, where most of the energy is locked in forms of cellulose of no use to humans.

Consider another aspect of the human diet. There is overwhelming evidence that contemporary death rates from cancer and other diseases are directly related to the fact that most of us savage our evolutionary heritage with diets that simply do not meet the needs of the omnivorous hunter-gatherers that natural selection fashioned us to be. Every one of us is the direct descendant of tens of thousands of generations of people who were naturally selected to thrive on the omnivorous diets available to hunter-foragers as they radiated from Africa across the world. In many areas these diets would have been high in fiber and fruit, low on fat and salt—diets that involved eating many different species of animals and plants. Although our ancestors’ diets varied greatly in different times and places, in most cases they would have been very different from the diets of most of us.²²

Since our brief 9,000 years as farmers have had little effect on our basic physiology and metabolism, logic might tell us that we should eat as wide-ranging a diet as our hunting-foraging ancestors did. But, alas, evolutionary equations are complex. One might, for example, vastly increase one’s vitamin C consumption on the grounds that ancient hunter-foragers had high concentrations of this vitamin in their diets, but the factors that improve an individual’s chances of becoming a successful mother or father many times before age 40—an all-important accomplishment in evolutionary terms—may not be the same as those that produce fit and happy 70 and 80 year olds. Until about 10,000 years ago—or just yesterday in evolutionary terms—few people lived past 50. In terms of an individual’s success in passing on his or her genes, what probably mattered most was to have children

and successfully raise them on a diet of some meat, a lot of plant foods, and an exercise regime that modern medical science would consider dangerous.

In general, human physiology appears to have been selected over millions of years to operate on a diet of almost anything, particularly if there is some variety and moderation. Even Irish coffee, that perfect end to a field archaeologist's day, containing four basic food groups—fat, sugar, alcohol, and caffeine—can be tolerated as long as one scavenges widely among the other food groups the rest of the day. Yet Eskimos are reported to eat, during the long winter months, a diet consisting mainly of meat, augmented only with a few scraps of vegetation they find in the stomachs of seals and other animals they kill. And poor Hindu peasants have produced a population explosion on a meatless diet consisting mainly of vegetables, rice, oils, and sugar.

Whatever the diet of our ancestors, we must assume that we are walking, talking genetic packages that reflect what “worked” for hunters and gatherers, plus an unknown amount of “random” genetic change. So although every characteristic of every person cannot be accounted for in terms of its competitive value in passing on one's genes, a lot of what we are must be explained in exactly these terms. Thus, for example, our brain size averages about 1,450 cm³ because that size is a good balance between the advantages of greater intelligence and general cerebration and the high costs of large brains in terms of blood supply and the reduced mobility of the broadened female pelvis, which is needed for successful live birth of the cerebral monstrosities that we are.

There are very real problems with the “adaptationist” views of human evolution—the idea that most or all of what we are is the product of selected accumulated successful mutations. A lot of what we are, in fact, may be the result of random genetic variation, not the direct product of selection for a particular quality or trait. And it is almost impossible to find some trait or behavior that *cannot* be explained as the solution to some kind of imagined evolutionary problem or opportunity.²³ It is also often difficult to identify exactly what the *focus* of selection was for complex physiological or anatomical evolution. Hamilton, for example, suggests that many of the sex differences between men and women and between humans and other apes are the result of long-term selection for high levels of sex hormones—not to exaggerate our sexuality but to give us the stamina we needed as foragers who walked long and often to find food.²⁴

With this simple introduction to evolution, it is easy to see why the Argument from Design—the theory that the universe *had* to have been created by a Divine Being because everything worked together in such harmony—was almost universally rejected by scientists from the late nineteenth century on, and why few professional research biologists and geneticists doubt that humans have evolved from single-cell animals and are genetically related to all other life-forms on this planet. Science has shown that (1) the chemistry of human genetics operates identically to that of other life-forms and (2) the differences between humans and other animals in the “spelling” of their DNA sequence is slight—depending on which aspects of DNA sequences are examined, there is only about a 1 percent difference between a person and a chimp, for example, and only 2 percent between a person and a mouse. In fact, the human DNA sequence contains bits of the same genetic code that produces or once produced mice, plants, ants, dinosaurs, and so forth—a situation that is exactly what one would expect, based on evolutionary theory.

Biological evolution can shape a world of great complexity and, in a sense, beauty. And although it is tempting to see “natural selection” as an active, quasi-intelligent force,

shaping plants and animals for certain purposes and to meet certain requirements, this is a fundamentally flawed perspective. Natural selection does not “know” what will be required at some later date. Natural selection in this sense is simply differential rates of reproduction and survival.

If this is so, what is the key to long-term evolutionary success in a lineage? One important element seems to be the maintenance of genetic variability. A classic example of this is the problem caused by the introduction of rabbits into Australia. Without a natural predator, the rabbits multiplied to the point of becoming a major crop pest. Efforts to control them by introducing a rabbit disease killed millions of them, but because of genetic variability a few individuals were naturally immune. They survived and quickly reestablished a population that was more resistant to this disease.

As the AIDS epidemic demonstrates, Life with a capital L is a constant struggle between life-forms for survival. The AIDS virus’s “strategy” involves rapidly changing forms and a late onset—afflicting many people long after they have already spread the virus to others. But some people will be naturally resistant to the virus, and even if the epidemic sweeps the world, these resistant individuals would be able to reestablish human populations. There is no reason to suspect that the AIDS virus will be the last one to sweep the world; in fact, it seems simply another of a long line of human afflictions, and there are likely much worse ones to come.

A discussion, such as this, of evolutionary theory as applied to us and our ancestors seems to lead inevitably to a consideration of eugenics—attempts to produce individuals with selected genetic characteristics, either through selective mating, abortion, or—now—direct manipulation of a person’s genes.

People are understandably ambivalent about the idea of genetically selected traits. Based on what we know about genetically determined aspects of anatomy and physiology, for example, it seems manifestly evident that not even a lifetime of practice can make one another Mozart, that no amount of education will enable many of us to extend the insights of a Newton. Even something as seemingly effortless as the high-floating left-handed lay-up of the professional basketball player can never be acquired by most of us, even were we to spend a lifetime in practice.

But eugenics, of a sort, is already here. Every year human fetuses are aborted because genetic testing has shown that they would be born afflicted with Down’s syndrome, cystic fibrosis, Huntington’s disease, or some other malady. In China and India, untold numbers of fetuses are aborted because they are female. And there is every indication that these forms of “eugenics” will expand greatly. From a fetus’s genetic structure, scientists can now, or soon will be able to, propose many other conditions an individual might have in later life, such as Alzheimer’s disease, manic depression, breast cancer, some forms of bowel cancer, and obesity. Also, the recent mapping of the entire human genome probably will make it possible to predict occurrences of alcoholism, homosexuality, and many other conditions previously thought to be mainly consequences of choices people made.

Simply put, is such knowledge about genetics good or bad? Every reader of this book can expect to hear increasing debates on this point for the rest of his or her life, for the answer is complex and ultimately a matter of values. One might argue, for example, that our best “strategy” in long-term evolutionary equations is to maintain as much genetic diversity as possible—the antithesis of “eugenics” programs, in effect. For no one can predict what new genetic horrors will arise in AIDS-like viruses or some other disease, and

it may well be that only a few individuals have natural genetic immunity to them. And it may be that some yet-to-be mutated natural resistance to skin cancer, to exposure to asbestos and organic pollutants, or to some newly mutated disease will be the key to our long-term survival as a species.

Evolution is in no sense “over” for us just because we currently are doing rather well.

THE ECOLOGICAL CONTEXT OF CULTURAL ORIGINS

In the bleak mid-winter
Frosty wind made moan,
Earth stood hard as iron,
Water like a stone;
Snow had fallen, snow on snow,
Snow on snow,
In the bleak mid-winter
Long ago.

*Christina Rossetti (1830–1894)*²⁵

One of the central facts of human physical and cultural evolution is that many of the crucial developments of our species occurred in Africa between about 8 million and 10,000 years ago, a period in which world climates fluctuated greatly but were, on average, cooler than today. About 4.2 million years ago, some of our first bipedal (i.e., walking upright) ancestors appeared in Africa. By about 2.5 million years ago massive glaciers had spread over northern lands, such as Europe, and about 1.8 million years ago, when early forms of *Homo* were radiating from Africa, climates began fluctuating, with long periods of intense cold followed by periods that were nearly as warm as climates of today. This period of climatic fluctuation during the past 1.8 million years is known as the *Pleistocene* epoch, or the *Quaternary* period. The correspondence between this period of climatic change and our own development has led scholars for many years to suspect that somehow Pleistocene climatic changes directly shaped human evolution, perhaps by creating difficult and demanding environments that “selected” larger and more intelligent hominins. But the relationship between climatic changes and human changes seems to have been a very complex one.

For the modern individual, sheltered from climate by cities and central heating, the effects of winter are reduced to minor inconveniences, but for our Pleistocene ancestors, the brutal winters of hundreds of thousands of years ago made southern France, Italy, China, and other currently hospitable regions a challenge to hominin resourcefulness and tenacity. Advancing and retreating glaciers and the weather systems that drove them operated in slow but powerful pulses, alternately drawing hominin populations into some areas and evicting them from others, all the while mixing genes, eliciting adaptations, and shaping our cultural and physical evolution. In Africa, too, the great climatic changes of the Pleistocene occasionally changed large areas of formerly habitable land into vast deserts, and then later changed them back to forests and grassland.

Average worldwide temperatures have fluctuated more rapidly in the last 14 million years than ever before, and a world as warm as our own has been a rarity during the last 2.5 million years. There have been, however, occasional interglacials—periods often of

50,000 years or more when temperatures rose almost to present-day levels. Even during the main glacial periods, there were interstadials, short warming phases when the temperature rose but did not reach today's levels. Archaeologists use the term *Holocene* to refer to the last 10,000 years, which likely represents the latest interglacial period.

During the glacial periods themselves, ice sheets spread from the poles and from higher elevations to cover much of the higher latitudes. So much of the seas were locked in ice during the coldest periods that the sea level dropped by as much as 150 m, making dry land of coastal areas that today are many meters below the sea. Land bridges that facilitated the spread of peoples throughout the world formed between North America and Asia, Europe and Britain, and Southeast Asia and what are now offshore islands. Unfortunately, Pleistocene ice sheets have ground many critical archaeological sites to powder, and the rising seas of the post-glacial periods have covered thousands of others.

The great climatic shifts of the Pleistocene seem to have been caused by a combination of factors, including fluctuations in solar radiation, eccentricities in the earth's orbit, mountain-building activity, and changes in the earth's atmosphere.²⁶ But in the next several decades the world may see the invalidation of the cliché, "everyone talks about the weather, but nobody does anything about it." We seem to have been doing something to it since the Industrial Revolution. Various scientists have suggested that we are already seeing the results of the *Greenhouse Effect*—a dramatic warming of average world climates as a result of industrial pollution. Some meteorologists predict that by the mid-twenty-first century, and thus within the life span of some readers of this book, such coastal cities as New York will be partially flooded by rising sea levels.

Between about seven and two million years ago, early hominins lived in the tropics of Africa. We were all Africans, and we were all Africans much later—late, in any event, in our evolutionary story.²⁷ Even with evidence for hominin invasion of Europe and Asia before a million years ago (chapter 4), we must still look to the grasslands and forests of Africa for the environments of our origins.

The history of the hominins appears to represent adaptations to a wide variety of habitats and environments, including *savanna*, bushland, open woodland, and riverine forest, as well as a mosaic of these contexts.²⁸ Savannas are relatively flat, arid expanses with scattered trees and occasional water holes, and their mixed grasses, shrubs, and other plants usually support large herds of grazing animals such as zebras, buffaloes, and gazelles. Woodlands and forests represent somewhat more closed, but wetter environments compared to savannas.

The Evidence of Cultural Origins

We have four basic categories of evidence for analyzing human origins: (1) *paleontology*, the study of ancient forms of animal life, including the ancestors of humankind; (2) *archaeology*, the analysis of the archaeological record—the stones and bones and other evidence of past cultures used by our ancestors; (3) *primatology*, the study of our contemporary nonhuman relatives, the other primates, whose behavior patterns may give us clues to the behavior of our own ancestors and whose genetic composition can be compared through molecular biology with our own to address questions of our common descent; and (4) *ethnology*, particularly the study of contemporary or recent hunting-and-gathering peoples, whom we assume to be living in environments and patterns similar to

those of our Paleolithic ancestors (although any contemporary human societies must be regarded as fundamentally different from those of our earliest ancestors).

Anthropologists use these four kinds of evidence to produce “models of cultural origins”—sets of related hypotheses about the factors that combined to change our ancestors from unremarkable primates to human beings.

PALEONTOLOGICAL EVIDENCE OF HUMAN ORIGINS

*A brain weight of nine hundred grams is
adequate as an optimum for human behavior.
Anything more is employed in the commission
of misdeeds.*

Earnest Hooten

One of the most difficult things for the people of the nineteenth century to accept was the idea that as a species we are the progeny of nonhuman primates. It is perhaps fortunate that they did not know then that an even earlier ancestor seems to have been a small, pink-nosed, libidinous, insect-eating animal whose modern form, the shrew, is on a pound-for-pound basis among the most ferociously effective predators known.

Taken as an overall sequence, is there any trend in the evolution of animal life on this planet that would help us understand the appearance of culture and our own physical type? One possible answer is suggested by the comparison of the ratio of brain size to body size in successive animal forms during the many millions of years before the first culture-bearing animals appeared. The anatomist Harry Jerison has devised an encephalization index by dividing the total brain volume of each animal by the two-thirds power of its body size. This simple index thus represents a scaled ratio of brain volume to overall size. Jerison's results give us an answer of sorts to our questions. The increase in average human brain size—from approximately 500 to approximately 1,450 cm³ in only a few million years—has been extraordinarily rapid, but, overall, we seem to be a continuation of a process that began at least 600 million years ago, a process involving, in some animal forms, long-term natural selection for increased brain-to-body ratios and, presumably, mental capacity.

But we represent something more than just another species in this long-term evolutionary process, for we are truly monstrosities in terms of brain size. Jerison lists the “encephalization quotients” (which take account of the relationship and brain size across invertebrates) for a variety of primate individuals, including ourselves (Table 3.1), and it is clear that we are a radical departure from our nearest primate relatives.

Why should there be this long-term evolution of larger brain-body ratios? We assume that it must be because of the reproductive advantages conferred by this development. But

Table 3.1 Encephalization Quotients, or Brain-to-Body Ratios

Gorilla (male)	1.53	(172.4 kg body weight, 570 g brain weight)
Gorilla (female)	1.76	(90.7 kg body weight, 426 g brain weight)
Chimp (male)	2.48	(56.7 kg body weight, 440 g brain weight)
Chimp (female)	2.17	(44.0 kg body weight, 325 g brain weight)
Human (male)	7.79	(55.5 kg body weight, 1,361 g brain weight)
Human (female)	7.39	(51.5 kg body weight, 1,228 g brain weight)

with regard to human brain size, Jerison stresses that the important point to remember is that very advanced behavior can be governed by very small amounts of brain tissue. The behavioral adaptations of the lower vertebrates are as remarkable as those of mammals in many ways. Encephalization in mammals, in primates, and in the human species is not easy to explain as a correlate of the refinement of behavior. Information-processing of a kind that could be done only by very large amounts of neural tissue must have been evolving in the mammals. But the exact nature of that processing is difficult to demonstrate. Moreover, “rewiring” of brain tissue through evolutionary processes may result in behavioral changes without an increase in total size of brain.

In many fictional treatments of the future, people are portrayed with enormous heads and correspondingly impoverished physiques. Is this likely, given Jerison’s data? Among the grimmer medical implements that was found in many delivery rooms in the last century was a device for crushing the head of the fetus if it was too large to deliver without killing the mother—a situation that, in the absence of medical intervention, may occur as frequently as a few times out of every 100 live births, according to some ethnographic accounts. Even experienced obstetricians²⁹ dreaded performing this procedure—now no longer necessary if the surgical skills to perform a Cesarean section are available. Mismatched fetal head size and maternal pelvic dimensions are expressions of the trend Jerison has identified, but human brain size, in fact, seems to have stabilized at about 1,450 cm³ over the last 100,000 years. Yet 100,000 years is insignificant in the span of animal life on our planet, and encephalization ratios may well continue to increase—or decrease—during the next millions of years. The cliché “time will tell” still has some cogency in evolutionary studies. We too, no doubt, are in a sense “missing links” in the ancient evolutionary experiment that is the history of animal life on this planet.

One question we must address is: Why are people so much smarter than they apparently need to be just to survive and reproduce? As discussed in the next section, we have conclusive evidence that our ancestors, who had brains two-thirds of our size, successfully made stone tools and other implements, competed with a formidable array of other animals, and managed to colonize an area from Java to Spain. In the world of a half million years ago, or even 100,000 years ago, one needed a brain only a few hundred cm³ bigger than that of a chimp to do very well indeed. Why then did we evolve the capacities for quantum mechanics, Arabic verb forms, Puccini arias, and the poetry of Ezra Pound?

Once again it must be stressed that when we ask such questions we must look almost exclusively at our lives as hunter-gatherers, that is, before 10,000 years ago. The agriculture and urbanization that appeared in the past 10,000 years is far too short a span to have produced significant differences in our genetically based mentalities, compared to our Pleistocene forebears.

Early Primates and the Australopiths

I don’t know, but we call him “Bob”

Sam Ervin, former U.S. Senator (when asked what the name of his horse was)³⁰

To return to the paleontological evidence, bits and pieces of various animals have been placed into our family tree as far back as 20 million years ago (Figure 3.6), but there are huge gaps and many questions as to what particular primates are on our ancestral line.

Classifying extinct animals is even more contentious than classifying living ones, but in the traditional classification, we are members of the primate order and the anthropoid suborder, which includes humans, apes, and monkeys; the other primate suborder is the prosimians, which includes lemurs, tarsiers, and other similar animals. We are in the superfamily *Hominoidea* and the family *Hominidae*. The *Hominidae* are separated into three subfamilies, the *Ponginae* (including the orangutan), the *Gorillinae* (the gorilla), and the *Homininae* (common chimpanzees, bonobos, and humans and their ancestors).³¹ The *Homininae* separated from the *Ponginae* and *Gorillinae* at some point in the distant past of the Miocene era (c. 25 to 10 million years ago), when primates included at least 16 genera of hominoids, some of which were forest-dwelling, quadrupedal animals who may have been on our genetic line. Within the *Homininae*, there are two tribes, the *Panini* (common chimpanzees and bonobos) and the *Hominini* (humans and their ancestors, including the australopiths). These two tribes separated from a common ancestor probably around 8 million years ago.

This determination of when the human line split from that of other primates results from a combination of the fossil evidence with evidence from molecular biology.³² These age estimates and sequences are based on estimates of rates of change in nuclear genetic materials and are known to vary widely in the animal kingdom (rates of change are much faster in rodents than in humans, for example). But several analytical techniques have produced similar estimates for the human/chimpanzee split. A crucial period in the evolution of culture appears to be between five million years ago, when the first australopiths appeared, and a million years ago, by which time all the world's hominins belonged to a single genus, *Homo*.

Paleoanthropologists recognize various genera and species of early hominins in the period between about 4.2 and 1 million years ago. These include a sometimes bewildering array of australopiths and early *Homo*. The relationship between these species—and which ones are on the line to modern humans—is not always clear-cut. The australopiths include *Ardipithecus ramidus*, *Australopithecus anamensis*, *Australopithecus bahrelghazali*, *Australopithecus afarensis*, *Australopithecus africanus*, *Australopithecus garhi*, *Paranthropus aethiopicus*, *Paranthropus robustus*, and *Paranthropus boisei*. Early *Homo* species during this range of time include *Homo rudolfensis*, *Homo habilis*, *Homo ergaster*, and *Homo erectus*.³³ These species seem to have differed in various anatomical details and the periods in which they existed, and they are probably most correctly displayed as a “bushy tree” in which lineage and descent is not yet precisely known (Figure 3.7).

The factors that identify Australopiths as probable members of the same tribe are: (1) They all were bipedal, walking upright on two legs all or most of the time—although they were perhaps not quite as well-suited anatomically for this means of locomotion as ourselves; (2) they all appear to have brains only slightly larger, if at all, than modern gorillas and chimps; (3) they all lived in Africa; and (4) they all had teeth that looked somewhat like ours and differed from those of gorillas and chimps in various details, such as flattened



FIGURE 3.6 This species of Southeast Asia tree shrew resembles closely the small insectivorous ratlike animals believed to be ancestral to all primates, including ourselves.

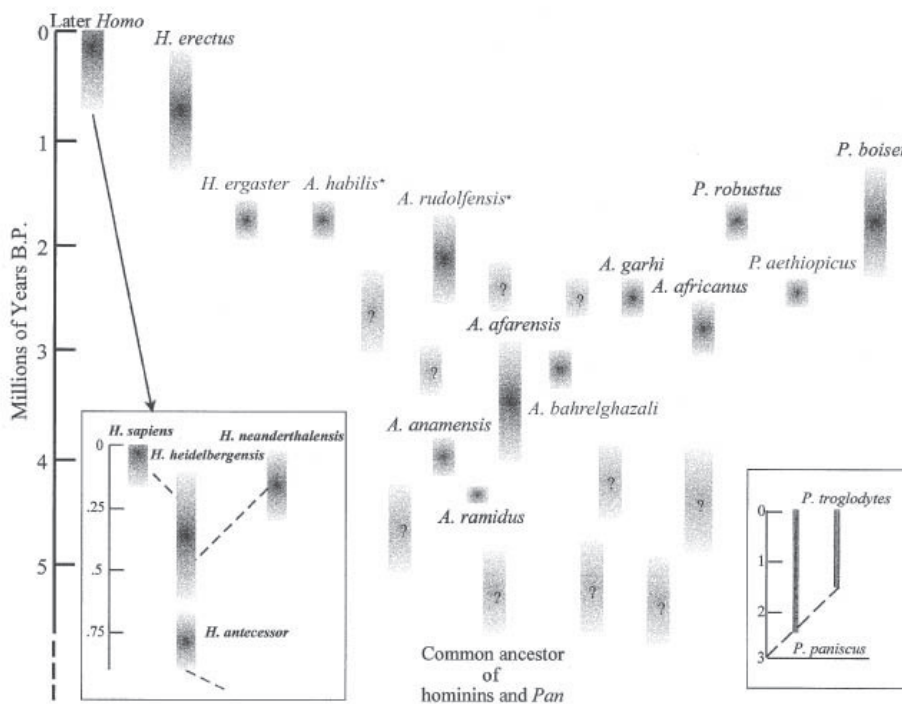


FIGURE 3.7 The “bushy tree” appearance of hominin phylogeny shows the existence of several contemporary hominin species and indicates the difficulty of assigning a particular species to the direct line leading to modern humans.

surface of molars—probably to facilitate grinding of foods. Scholars dispute whether or not any of the australopiths used stone tools. Their remains have been found with such tools but the association is ambiguous.

Early Australopiths Much of the story of cultural origins may have been “over” by 3.8 million years ago. Mary Leakey found human footprints of this age at Laetoli, Kenya, indicating that our ancestors were walking upright by that time, and new fossils such as *Australopithecus anamensis* suggest that bipedalism in the hominins may be at least 4.2 million years old. The tracks of two *Australopithecus afarensis* at Laetoli indicate that they may not have had quite the same

smooth gait as modern humans do, as they seem to have a somewhat rolling walk in which the hips swiveled side to side more than they do when we walk. But they clearly show two bipedal creatures, both between about 1.4 and 1.5 m tall, who apparently walked across this surface at different times.

There is a sort of destiny in bipedalism: The hands are free to manipulate tools, the field of vision gives a slice of time and distance that rewards planning, and the arrangement of the limbs and cranium seems to require only additional brain tissue to “convert” a primate into something human.

But upright posture in the absence of tools—and there is no evidence for stone tool use until about a million years after the Laetoli footprints—means something else. It means that an animal with roughly our body shape (but about two-thirds our size) and with our approximate powers of vision, smell, locomotion, and so on, could compete in a world teeming with awesome predators. Without speed, claws, significant teeth, night vision, or protective coloration, these primates of 3.8 million years ago and earlier flourished. Walking across the same surface as the *Australopithecus afarensis* at Laetoli were tigers, rhinoceroses, elephants, and other animals that competed with the australopiths on these African plains, and one wonders how such an unprepossessing animal could survive in this environment. Perhaps they already possessed embryonic forms of the critical elements of cultural behavior: intelligence, protective human family relationships, and tool-use capabilities that were slightly better than that of the chimpanzees (who use sticks and unmodified stones).

If we had only the tracks at Laetoli as evidence of early australopiths, we would know little about this crucial stage in human evolution, but recent finds have produced the skeletal remains of a growing sample of these individuals—and possibly some of their ancestors. The earliest australopiths are a likely candidate as one of the founding species of the human line; they are represented by fossils that date to between 4.5 and 3 million years ago from several areas of north-central and east Africa.

In the Hadar region of Ethiopia we find the most substantial early remains, including “Lucy” (named after a Beatles song), a female 25- to 35-year-old hominin. About 3.18 million years ago, Lucy strode upright through the river valleys of Ethiopia, as part of a group of primates who were around 1.2 to 1.5 meters tall, but who varied greatly in size and morphological characteristics. No tools of any kind have been found associated with Lucy and her kin, and without tools, we cannot really know much about Lucy and her group—the “First Family,” to use the name Donald Johanson, one of her discoverers, gave them. By counting the number of different bones, we know that there were at least 13 people in Lucy’s group, 4 of them children. A few bits of geological evidence and the absence of other animal bones near the hominins raise the possibility that the First Family was trapped in a ravine by a flash flood, but we’ll never really know.

But if “Lucy” and her group were bipedal, how far back in time does bipedalism go? Several recent finds have begun to illuminate this great transformation in the human past. Between 1990 and 1994, parts of 53 other early hominins were found in the Hadar region, including a particularly well-preserved skull that seems to confirm some of the interpretations of Lucy but raises other questions.³⁴ The age of the skull, about one million years before Lucy, was determined by its location between two layers of volcanic rock. Because the rock contains potassium, the rate at which potassium radioactively decays could be used to date each layer accurately (see chapter 2). The skull of this individual has an ape-like jutting jaw, small braincase, and thick protruding ridges above the eyes—a skull, in other words, that was much more ape-like than human-like.

Tim White has identified some of the earliest Ethiopian fossils as a new genus, *Ardipithecus ramidus*, on the premise that they are different from other early australopiths. This Middle Awash fossil suggests that this small-brained, upright-walking, pre-human species with an ape-like body existed until at least to Lucy’s time without significant anatomical change. Whatever the evolutionary forces were that converted australopiths into us, at least as far as mentality is concerned, they appear either to have been slow processes or not in force at this time. Despite their human-like posture, the brain-to-body ratios of Lucy and her friends were such that it is highly probable they could have led full mental and spiritual lives in any municipal zoo: Lucy’s brain was probably only slightly larger than a softball, and there is no evidence that she or her colleagues used tools or were cultural in significant ways. But the fact that these australopiths had brains insignificantly larger than apes is not conclusive evidence on this point. The human brain probably evolved both through getting bigger and by internal “rewiring,” and we know little about how the latter might have come about.

Another recent discovery of fossils in Kenya supports the idea that by 4.2 million years ago, our ancestors already walked upright, on two legs. In August 1995, anthropologist Meave Leakey³⁵ reported the discovery in northwestern Kenya’s Lake Turkana area of fossil hominin jaws, teeth, a piece of skull including the ear region, and a lower leg bone, all of which date to between 3.9 and 4.2 million years ago. The hominin species from which the

fossils came has been named *Australopithecus anamensis*. Leakey said primitive features distinguishing the species from other known early human ancestors were in the crania and dentition and included almost parallel mandibular tooth rows set close together, large canines with long strong roots, wide flaring molar teeth, and a small elliptical external opening of the ear.

But she notes that in “contrast, the leg and arm bones have relatively modern morphology and the shape of the former indicates that at this early date, human ancestors were walking bipedally.” Leakey said the newly found fossils had features consistent with their being a cross between “Lucy” and the earliest Hadar fossils that have been identified by Tim White as *Ardipithecus ramidus*.

Still another recent find provides cogent evidence about early human bipedalism. Few things are more pedestrian, literally or figuratively, than the human foot, but the archaeological record contains only one reasonably well-preserved set of four articulated hominin foot bones for the critical period when people were becoming (or already were) bipedal. These bones, from South Africa’s Sterkfontein Cave, may date to 3.5 million years ago,³⁶ and they have set off another debate about the origins of human bipedalism (Figure 3.8). They appear to be those of an australopith, and they suggest that these hominins may have retained tree-climbing abilities far beyond what later humans had. One of the preserved bones is the beginning of the big toe, and it suggests that this individual had both ape-like and human-like locomotion abilities. There is no question that the basic anatomy is that of an upright-

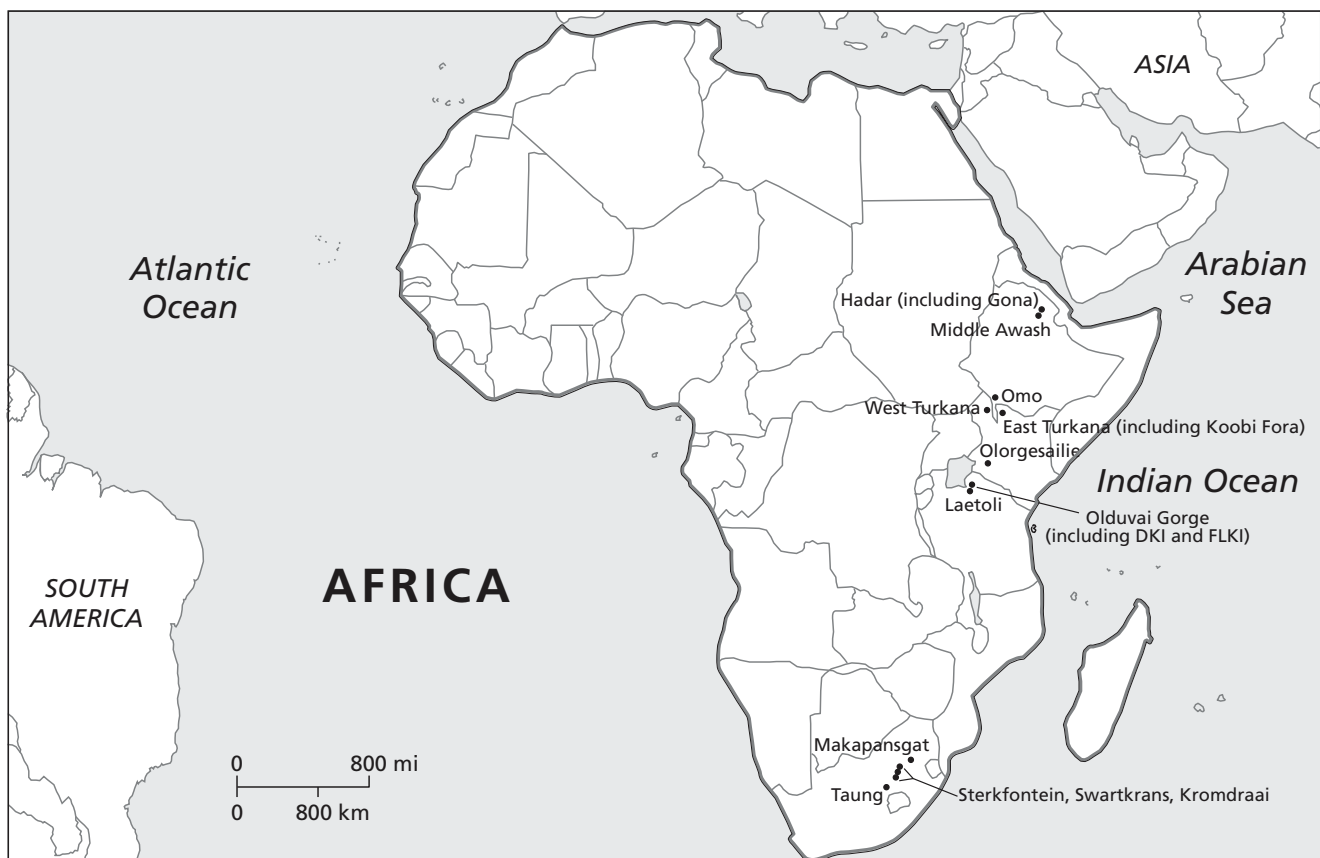


FIGURE 3.8 The distribution of some early hominin sites in Africa.

walking individual, but the big toe diverged sharply to the side, in the manner of apes, providing a highly flexible, opposable-toed foot that would allow the hominin to climb trees.

In summary of these recent finds, human bipedalism probably extends back to 4.2 million years ago and some unknown time earlier than that, but we still have only vague ideas about why this transformation occurred. In any case, the most important point about these australopiths is that they were *bipedal*, and whether or not bipedalism is the stimulus for all later evolution of “culture,” our ancestors appeared soon after bipedalism, and there is reason to assume that this was not an accidental correlation.

The Appearance of *Homo*

Monkeys are superior to men in this: when a monkey looks into a mirror, he sees a monkey.

Malcolm de Chazal

As in the case of most biological classifications, cutting the continuum of hominins into several groups and naming them differently, as in the case of *Australopithecus* and *Homo*, necessarily involves some degree of arbitrariness. Unless we have been badly misled by the data, what we call the first *Homo* arose out of the mix of australopith species and subspecies, and thus these different genera names are mainly collective descriptions of gradually accumulating anatomical differences.

That *Homo* did succeed the australopiths now seems clear. Major disputes remain about the relationship of the australopiths and early *Homo*, but the evidence generally supports the notion that, whatever the genetic relationship between the australopiths and early *Homo*, early *Homo* (1) appeared after about 2.5 million years ago—long after Lucy and her colleagues; (2) had a brain somewhat larger than the australopiths (i.e., c. 600 c³ or larger); (3) made stone tools—or at least some groups of them did; and (4) was the first hominin to leave Africa. Early *Homo* is usually assigned to *Homo habilis*, *Homo rudolfensis*, *Homo ergaster* or *Homo erectus*.

The earliest stone tools known are only between two and three million years old, and we might suspect that they are important markers of the transition to *Homo*. Primates of all kinds, including Lucy, no doubt, use sticks and unmodified stones for a variety of purposes, but making a stone tool requires that a recognition that sharp-edged pieces can be detached from an unworked lump of stone. Evidence suggests that the manufacture of stone tools was a rather late part of the whole transition to humanity, since bipedalism and even increasing brain size were well underway by the time the first stone tools apparently were made. Toth has suggested that “tool use in apes was not directly selected for in evolution but rather was a by-product of a general increase in problem-solving abilities through time.”³⁷ But once humans could make stone tools, that ability became an important factor in the rate at which we evolved and spread throughout the world. The importance of tools to our ancestors can perhaps best be appreciated if one imagines oneself standing about 4 feet tall on the Serengeti Plain of two million years ago, trying to resolve into its component nutritious parts a small antelope one has just killed or scavenged from a temporarily napping lion. Already harried by vultures and other scavengers, one tries to rip into the body with one’s teeth and nails. Even with Lucy’s relatively stout dentition, it would have been difficult. The most nutritious parts—the liver, brain, and other internal organs—are protected by thick layers of skin, flesh, and bone that resist the puny tearing motions to which our ancestors would have been limited. But just a chip off one of the

quartz pebbles abundantly scattered over this area would instantly have opened up life-saving rations for several individuals.

The first hominin to make and use stone tools was probably one of the australopith species (simple stone tools made by hitting one lava chunk with another have been found in Ethiopia under layers of volcanic ash that date to 2.5 million years ago³⁸) or early *Homo*, but the species of the first tool-makers remains a matter of doubt and dispute. Some of these disputes could be resolved if we had many full skeletons of the earliest *Homo*, but we may never have adequate samples of this hominin. Most anthropologists have used the category *Homo habilis* to refer to the species from which *Homo ergaster* and thereby ourselves have descended, and the KNM-ER 1470 skull, dated to about 1.88 million years ago, is perhaps the best example of this category. *Homo habilis* is generally thought to have had a cranial capacity of about 600–650 cm³, halfway between some of the smaller australopiths and *Homo ergaster/Homo erectus*, but its taxonomic position will likely change on the basis of future finds.³⁹ A skull and some limb bones of *Homo habilis* recently discovered at Olduvai (a specimen known as OH 62) have been dated to about 1.8 million years ago, and raise some interesting questions about *Homo habilis* in general. First, this apparently female adult was only about 1 m tall (3 feet, 4 inches). Thus, she was up to a foot shorter than “Lucy,” an australopith who lived about 1.3 million years before her, and whose height appears to have been somewhere between 3.5 and 4 feet. We might expect that human height had been increasing gradually but continuously, as we know that the general trend in hominins was certainly toward greater height. But OH 62 suggests this trend may not have been constant. Here, too, possible sample biases intrude. OH 62 may simply have been an exceptionally short person. But OH 62’s skeletal anatomy looks very much like Lucy’s, and in general she suggests that the australopiths and early *Homo* were only slightly different until after 1.8 million years ago.

In 1984 a group headed by Richard Leakey found a *Homo ergaster/Homo erectus* (known as KNM-WT 15000) near Lake Turkana,⁴⁰ Kenya, that seems well-dated to about 1.6 million years ago and is virtually complete. Such a modern and “brainy” hominin at this time is somewhat surprising, given the other known fossils (this find is discussed in more detail in chapter 4).

These many arguments about human lineage will doubtless continue for many more years, and all that really seems clear at this point is that from 3 to 1.5 million years ago, bipedal primates of about 1.25 to 1.75 m in height roamed the grasslands and forests, and that at least some of these animals made tools.

ARCHAEOLOGICAL EVIDENCE OF THE ORIGINS OF CULTURE

We can begin to look at the *archeological record* to determine how our ancestors actually lived and changed over time. As always, the problem here is one of poor evidence. Perhaps the only way in which we will understand the details of our origins would be if we found several Pompeii-like sites where volcanic eruptions had trapped early humans some two to three million years ago, toward evening, say, around a water hole on the East African savanna. Such a catastrophe might have killed thousands of animals, including some hominins. Without wishing any disaster to even these, our most distant hominin ancestors, such a volcanic event would be most scientifically useful if it happened just after these hominins had scavenged or hunted their food, butchered it with stone tools, and then dispersed into

social groups to sleep off the meal. At present, however, our direct archaeological evidence about the initial period of the evolution of culture is extremely meager; we have only a few small sites, almost all of which are in southern and eastern Africa.

About five million years ago, a large lake covered about 130 km² of what today is the Serengeti Plain, in central East Africa. Countless generations of animals, including, no doubt, our hominin ancestors, lived near this lake, and today their fossilized bones are thickly distributed through the black clay of the ancient shoreline and lake bed. About a half million years before the appearance of culture-bearing animals in this part of the world, the lake and the adjacent areas were the scene of dramatic geological activity. Volcanoes near the lake had been erupting for millions of years, and in a particularly violent episode about a million and a half years ago, a volcano to the south of the lake covered it with a layer of ash and molten rock some 5 m thick. Similar eruptions occurred in succeeding millennia, and today we can measure the intensity of each volcanic episode by gauging the thickness of each superimposed ash level. Sometime during and after these volcanic eruptions, the climate of the area began a cycle of alternating dry and wet periods. These millions of years of volcanic activity and climatic change eventually covered the original lake and adjacent lands with a 100-m-thick deposit of sand, ash, and lake sediments, the surface of which is the present Serengeti Plain. Ancient floods cut down through this plain at several points, creating Olduvai Gorge and revealing in its cliffs and floor many concentrations of stone tools and animal bones. These sites represent by far our best archaeological record of human activities at the time of the emergence of the genus *Homo*.⁴¹

One such concentration, Site DK I, has been radiometrically dated to about 1.75 million years ago, making it one of the oldest in Olduvai Gorge. The site is composed of a layer several meters thick of bones, worked and unworked stone, and other debris. Because of the complex stratigraphy, it is difficult to separate this accumulation into different levels with any assurance that the divisions represent discrete hominin occupations.

The most prominent archaeological feature at DK I is a semicircle of stones (Figure 3.9) lying within a concentration of stone tools and animal bones. Measuring approximately 3 m in diameter and made of chunks of vesicular basalt, this feature was originally interpreted by some as a foundation for a windbreak or some other temporary structure, but the evidence is inconclusive. The tools found here are similar to the other materials from Beds I and II at Olduvai: hundreds of crudely flaked stones, some of them showing evidence of use, others simply by-products of the manufacturing process. Although it is tempting to see Site DK I as a “home-base” for hominins, the evidence suggests that natural processes played a major role in site formation.⁴²

Another Olduvai site, FLK I, is particularly important because several hominin bone fragments were found in its various levels, including the remains of an early hominin that Louis Leakey named *Zinjanthropus*, which most now assign to *Paranthropus boisei* and presumed by many anthropologists not to be a maker of stone tools. This “*Zinjanthropus* floor” covers an area of more than 1,036 m² and contains several thousand pieces of worked stone and about 3,500 identifiable mammal bones. Many stone artifacts and pieces of shattered bone are concentrated in a “working area” some 5 m in diameter, and a relatively clear arc-shaped area in the midst of all this debris suggests to some the remains of a temporary shelter. But just as with Site DK I, the FLK I site is likely the result of cultural and natural processes rather than a pristine living surface.

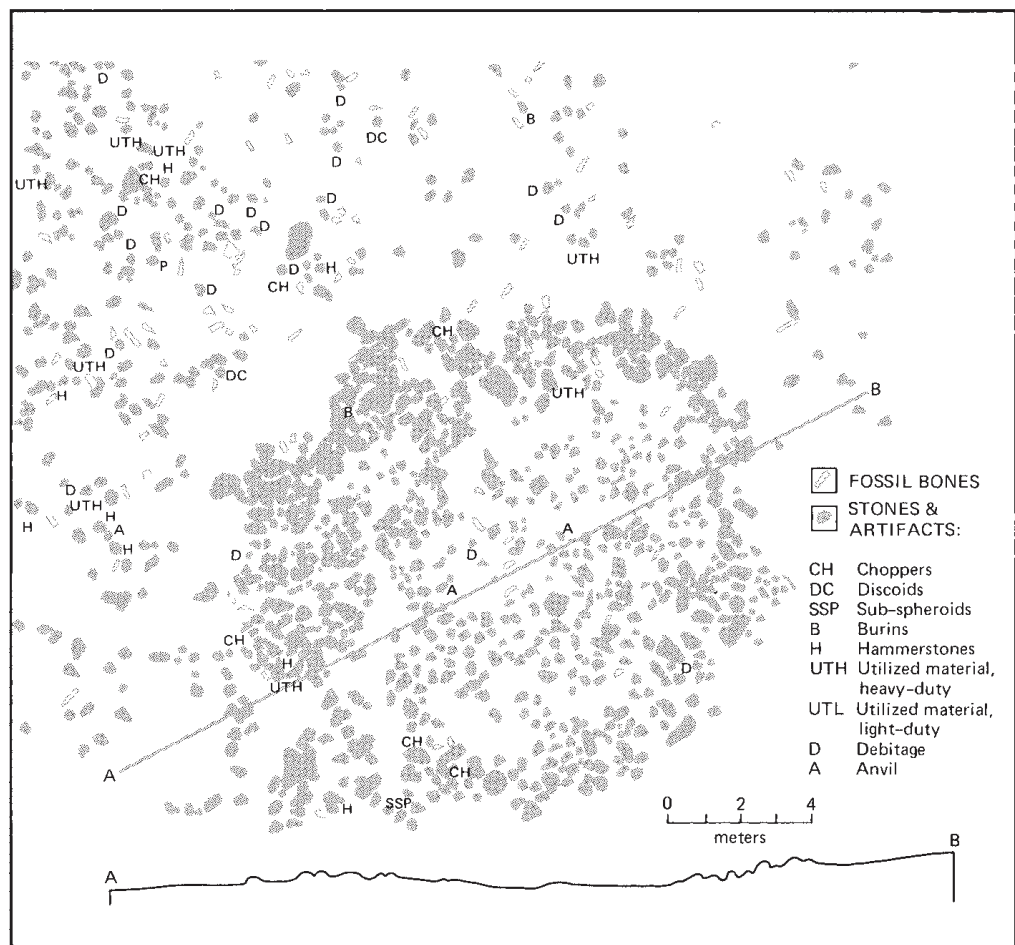


FIGURE 3.9 Site DK I. Plan of the stone circle and the remains on the occupation surface. Stones, including artifacts, are shown in gray. Fossil bones are shown in outline. A consideration of taphonomic processes makes the interpretation of this as a home base or a windbreak unlikely.

A few other sites in Africa have been shown to have stone tools that date to about 2 million years ago, including Koobi Fora, where crude stone tools appear to be at least 2.3 million years old.

These early stone tools from Olduvai, Koobi Fora, and a few other sites provide some indications about the nature of our ancestors. Studies of the Olduvai tools by Nicholas Toth indicate that already by 1.7 million years ago our ancestors at Olduvai had developed a preference for right-handedness.⁴³ Based on the marks left that indicate how they held the stone cores when they hit them to produce stone flakes, the Olduvai hominins seem to have the same proportions of right-handers—90 percent—as do modern populations. Toth also suggests that archaeologists may have been fundamentally wrong about the Olduvai tools in assuming that the big “core-tools” were the object of the tool-making: He studied wear patterns on the putative “hand-axes” from Olduvai and concluded that they rarely show any wear indicative of use—rather, it was the *flakes* that were the point of the tool-making, and the “hand-axes” and the core-tools were in many cases the by-products of tool manufacture.

The question of what these tools were used for is a central element in debates about the nature of our early evolution.

COMPARATIVE PRIMATOLOGY AND THE ORIGINS OF CULTURE

Many researchers view human evolution as a long corridor, where chimpanzees enter at one end and modern hunter-gatherers exit at the other.

J. Tooby and I. Devore⁴⁴

To use primate studies to investigate our origins, we must define clearly the ways in which we are different from them. Tooby and DeVore list six major areas in which we differ fundamentally from other contemporary primates: (1) bipedalism; (2) situation-appropriate, intensive male parental investment and an increase in female parental investment; (3) an unparalleled degree of hunting and meat consumption; (4) a change in life-history correlates: an extension of life span, an increase in the period of investment in offspring, a marked increase in the altriciality (i.e., the length of time the young remain in the direct care and physically with the parents) of human young; (5) an expansion of ecozones occupied, from tropical woodland and forest into savanna areas, but eventually including every other terrestrial ecozone; (6) concealed ovulation with continuous sexual receptivity.

Given that chimpanzees and ourselves share a common ancestor, perhaps as recently as six to eight million years ago, how did these differences arise?

While some scholars think studying contemporary primates will tell us little about our origins, others see in them prototypical behavior for everything that is human. McGrew,⁴⁵ for example, notes that culture in other species is studied by disciplines other than anthropology, such as psychology and zoology. These lend different views to how we define culture and how we recognize culture in nonhuman primates.

A major problem in applying primatological studies to the question of human origins, aside from the fact that poachers are killing off the last remaining wild groups of these animals, is that observing them is not a purely scientific procedure. Observers see aggression, dominance, and so on, partly as a projection of their own personalities, and thus models of cultural origins based on primate studies are inherently suspect.

To begin with the basic physical changes, to make a human out of a chimpanzee-like ancestor, the legs had to be lengthened greatly in relation to body size, the hip and knee joints had to be repositioned to allow bipedalism, and the spine had to develop an S-shaped curvature to cushion the brain against the shocks of bipedal locomotion. The face, jaw, and teeth had to be changed from the straight-row, prominent canines-and-incisors configuration of early primates to the curved human dental arch with reduced canines and incisors, and adapted to grinding rather than puncturing (Figure 3.10). In the long course of our evolution from apes, we lost most of our body hair, our sexual organs and behavior changed greatly, and our brains were greatly expanded and probably “rewired.”

Consider first the simple matter of body size. A survey of numerous primate species indicates that a pronounced size difference between the sexes is relatively uncommon,⁴⁶ and thus “marked morphological and behavioral dimorphism is not a primitive characteristic of primates but has evolved in certain genera in relation to particular patterns of living.”⁴⁷ One clue as to what patterns of living these might have been can be seen in the size

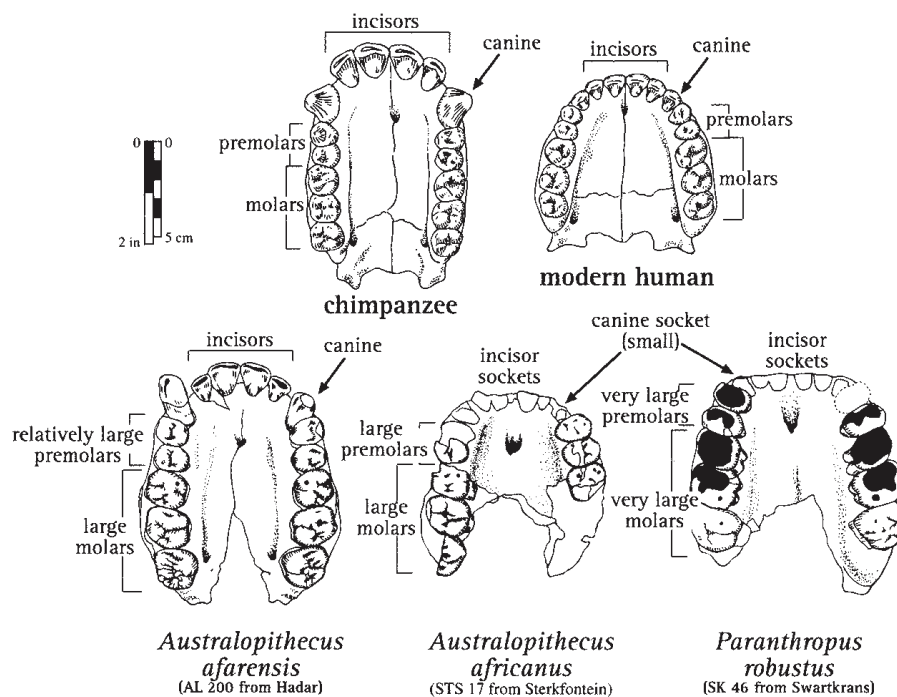


FIGURE 3.10 Teeth preserve best of all body parts. Note the difference between chimpanzees and hominins in the shape of the dental arcade. Other distinctive features include the presence or absence of a canine diastema and the size of the molars.

differences of the sexes in living nonhuman primates. Male and female gibbons, who spend most of their lives in trees, are almost identical in size; among chimpanzees, who spend some of their time on the ground, males are usually larger than females; and among gorillas, who are almost completely terrestrial, males average almost twice the size of females. Why should the physical size of the sexes show this association with terrain?

A probable factor in the evolution of both sexual dimorphisms and the overall increase in size of *Homo sapiens sapiens* of both sexes was the need for defense against predators. Our ancestors apparently evolved in environments where competition and predation

by large cats and other carnivores would have been significant, and thus it is not at all surprising that part of our evolution in these environments would have been in the direction of greater physical size. A human with a rifle, or even a crude spear, would have some reasonable defenses, but until tool-use reached this point there would no doubt have been strong direct selection for increasing physical size. Our earliest tool-using ancestors were only about 3 or 4 feet tall, weighing perhaps 60 or 70 pounds—not really a formidable competitor, given the other animals in its range. Today, on the African savannas, baboon populations are able to survive, despite occasional predation by leopards and lions, partly because they have retained impressive canine and incisor teeth and great physical strength. By 10 million years ago, however, our ancestors had probably lost these dental defenses. Another factor may have been females' preference for mating with larger individuals—who may have had greater ability to provide food and protection and to produce offspring with these same qualities.

But drawing conclusions about a primate's physical characteristics and, especially, social behavior on the basis of the characteristics of its physical environment is plagued with ambiguities and difficulties. In some animal species, sexual dimorphisms seem to be linked to differences in feeding strategies of males and females. While this may have been of some importance to our early primate ancestors, the kinds of food eaten by males and females probably overlapped considerably soon after tool-use began.⁴⁸ Nonetheless, early hominin males and females would probably have been under increasingly different selective pressures as soon as males began specializing in hunting and females in gathering—specializations that may have appeared only comparatively late and sporadically.

Another aspect of sexual dimorphism among humans is particularly intriguing when seen in comparison with nonhuman primates: namely, the secondary sexual characteristics that differentiate human males and females. Among human females, breasts are significantly larger than among males—in fact, the size, shape, and other differences distinguishing male and female breasts are much more pronounced than in any other mammal species, and only in humans do breasts first enlarge at puberty rather than at the first pregnancy.⁴⁹ Selection for increased breast size appears to have involved a complex set of factors, including the erotic role; Rose Frisch has even suggested that the disproportionate size of the human female breast may have evolved because of its role “as a cooling fin to get rid of body heat.”⁵⁰ Breast size cannot be explained simply in terms of milk production, since size seems to have almost no relationship to effective functioning in human beings. Similarly, the human penis is far larger, relatively and absolutely, than that of any other primate, including the gorilla. In addition, human females have softer skin and higher voices than males and have lost more of their body hair—although compared to the other species of primates, males also have remarkably little body hair.

Many explanations have been offered for the origins of these characteristics. A primary difference, for example, between humans and other primates, and one that many people link directly to human origins, is that human females do not exhibit estrus; that is, women’s receptivity to sexual intercourse does not seem to increase to any large extent with the rise in estrogen levels that precedes ovulation. How can we account for this? One suggestion is that

in all probability the evolutionary development of hair reduction, increased skin sensitivity and tactile changes involving skin tension were [sic] all associated with increasing the tactile sensations of coital body contact, especially in the frontal presentation. Likewise the breasts of young women taken together with other features (limb contour, complexion, and the like) seem to represent the main visual sexual releasers for the male. While the latter features may have been due to straight-forward intersexual selection by ancient males the former features have probably been selected in both sexes for their effect in improving sexual rewards, in inducing sexual love, and in maintaining pair bonds. The same is also likely to be true for the presence of orgasm in women and the absence of the more typical mammalian estrus.⁵¹

Our loss of the body hair that our primate relatives retained is a more radical development than it might seem. Naked skins may increase sexual sensitivity, and hair loss even seems to have helped, paradoxically, in water conservation; but naked skins increase the risks of skin cancers and other diseases, and they also open the body to vermin in a way that no chimpanzee must live with.

Other basic differences between ourselves and other primates, and possible reasons for them, are evident if we compare baboons and chimpanzees. Baboons inhabit a diversity of environments, but our most reliable and complete information comes from savanna-adapted populations in central and east Africa. Within the baboon troop, the eldest males have almost unimpeded access to food and sex, and they protect their privileges with aggressive behavior. Younger males are allowed access to females only on the sufferance of more dominant males, although they are constantly testing this dominance by attempting to strike up meaningful relationships with concupiscent females. Often this will incite a dominant male to charge and make threatening gestures. Similarly, when desirable but limited food is available, such as fruit or a clutch of eggs, the dominant males and females

take what they want first. A mother and child may share food, but there is no systematic food sharing between adult members of the group.

When baboon troops move across savanna or open environments, they typically position members according to age and sex. Adolescent males are on the periphery, dominant adult males are in the front-center, adult females are behind the adult males, and dependent young are stationed near the adult females. This is of course an excellent defensive formation, offering the best protection to the young and females, on whom the perpetuation of the group depends. There are many more adolescent males than necessary for reproduction, so although they would endure the most losses to predators, the stability of the group would not suffer much. Significantly, when the baboon troop moves into more forested areas, the positioning becomes much more fluid and dispersed, indicating, not too surprisingly, that terrain is an important determinant of behavior for baboons, and that savanna environments seem to put a premium on group cohesiveness and dominance hierarchies—although forest-dwelling chimpanzees, counterintuitively, perhaps, seem to exhibit *more* group hunting, tool-use, and forms of cooperation than savanna-dwelling chimpanzees.⁵²

Some baboon groups seem to construct dominance hierarchies on the basis of length of residence in the troop, and in general baboons seem somewhat more variable and adaptable in dominance hierarchies and aggression than previously thought.

Thus, in trying to explain how culture-bearing individuals developed from our primate ancestors, we must look for factors or conditions that would work against these dominance hierarchies and promote the distinctive human family structure, with its food sharing, division of labor, and pair bonding.

The relevance of baboons to our own ancestry may be somewhat limited because we are much more closely related to chimpanzees. Chimpanzees also inhabit diverse environments, and generalizations about their behavior are as dangerous as in the case of baboons. The most studied chimpanzees are those of the Tanzanian forests, especially those of the Gombe Stream area.⁵³ In Gombe, many of these chimpanzee groups have been regularly fed by the people observing them, and since most groups are cut off by modern development from their complete range and interactions with more distant groups, we cannot expect these primates to be perfect reflections of chimpanzee behavior in the true natural state. But it is striking that the chimpanzees of this area behave very differently from the savanna-dwelling baboons. Access to food and sex is much less rigidly controlled, and the entire dominance hierarchy seems to be less in evidence. In one instance where a female was sexually receptive for a record 21 days, the males of the chimpanzee group, young and old alike, stood in line for her favors with only minor apparent bickering.⁵⁴ This is not always typical behavior, and the adolescents were effectively barred from mating with some females in many cases, but compared to baboons, chimpanzees are absolute libertines in sexual matters. Strictly speaking, chimpanzees do not have true estrus cycles, but they do have periods of greater and lesser sexual receptivity.

Similarly, there is also a diminution of territoriality. Chimpanzees run for kilometers along trails through the forests, often alone or with one or two others, and individuals frequently leave one small group to go live with another. So relaxed are chimpanzees, in fact, about sex and territoriality that they have aroused envious feelings in some human observers. "Chimpanzees, it seems, successfully achieve what *Homo sapiens* radicals only dream of: peaceful, non-competitive, non-coercive, non-possessive, egalitarian, jealousy-free, promiscuous, non-tyrannical communes."⁵⁵

This may be a somewhat idealized picture. Chimpanzees have elaborate threat rituals and do menace each other according to a well-developed hierarchy. In addition, chimpanzees are the only animals besides ourselves who regularly use objects as weapons—usually wooden clubs or thrown rocks and debris.⁵⁶ They fight over food and females, and sometimes over rank, and they are the only other primates known to practice cannibalism, having been observed on several occasions eating young chimps alive.⁵⁷

Tanner notes that wild chimpanzees place nuts on flat roots or stones and then break them open by hitting them with sticks or rocks, suggesting that “a fairly intelligent ancestral ape could have taken the step from such opportunistic tool use during foraging, to tool-making and more regular use of tools in plant gathering.”⁵⁸ She also notes that female chimpanzees use tools more often than males in nut-cracking. Moreover, they generally use tools in more complex ways than males, and they teach their daughters to use tools and even supply them with tools.⁵⁹

In reviewing hunting and meat-eating by chimpanzees, Boesch and Boesch-Achermann⁶⁰ note that the frequency of hunting in wild chimpanzees is quite variable, sometimes being dependent on group size and the number of adult males. There is also no clear evidence that meat-sharing for sexual favors is more common when females are in estrus. In addition, there seems to be a rudimentary sexual division of labor among chimpanzees, with male chimpanzees more adept at hunting and female chimpanzees spending more time nut-cracking or collecting termites and other invertebrates—a prelude, perhaps, to the sharp division of labor in human hunting and gathering groups.

ETHNOLOGY AND THE STUDY OF EARLY HOMININ ECONOMIES

With the evidence from Gona, Olorgesailie, Olduvai Gorge, and the few other sites of this time period (c. 2.6–1.0 million years ago), we must account for, among other developments: (1) the evolution of stone tool-use, (2) the approximate doubling of human brain size, (3) increased stature and changes in facial architecture and other physical features, and (4) the migrations of hominins throughout the warmer regions of the Old World.

Great controversies have erupted over the explanation of these changes, particularly about the *economic* basis of these transitions. What is at issue here is the very basis of almost all human evolution, since we must assume that we are mainly the physical products of the roughly two million years of natural selection on all the generations that connect us to the hominins of Africa. Arguments on these issues have centered on whether or not early *Homo* did no, some, or a lot of hunting, and how much like modern peoples they were in their social relationships.⁶¹ It is not surprising, perhaps, that in trying to understand what those selective forces and environments were, anthropologists have depended heavily on ethnographic studies of people who until recently lived as hunter-foragers in the savannas of southern and eastern Africa, particularly the Kalahari Bushmen. Some feel, however, that the *behavior* of these modern-day hunter-gatherers may have almost nothing to tell us about our hominin ancestors. Edwin Wilmsen,⁶² for example, suggests that almost everything we know about these people is contaminated by Western misperceptions. But the Kalahari hunter-gatherers and others at least illustrate some of the possibilities open to our ancestors in this kind of environment.

Studies of African savanna ecology suggest that *scavenging* could have been a significant part of early hominin repertoires. African savannas would seem to reward animals who are

opportunists and generalists when it comes to food: An early hominin might well have adopted the principle of “eat it if it moves, or has reasonably recently moved.” Schaller and Lowther spent a few days during the dry season on the Serengeti Plain and found a lot of edible meat in the form of a dead buffalo (which did not appear to have been killed by a predator), some lion kills, and a few incapacitated animals that could have been killed.⁶³ Blumenshine and his colleagues found that scavenging would have been possible and even rewarding, presuming that our ancestors went for the brains and marrow of lion kills and other casualties.⁶⁴ Small animals, such as juvenile Thompson’s gazelles, persisted as carcasses for only about a day before some scavenger totally consumed them, but larger animals, such as adult buffalo, remained as significant food sources for about four days, after which even if they were not eaten by lions, hyenas, vultures, and so on, they were putrid to the point that their “market value” had plummeted.

Even without scavenging, our ancestors may have developed a way to subcontract some of the effort and risk of hunting to lions in a way that is right in line with our later history as one of the most selfish, exploitative, rapacious members of the animal family. O’Connell and his colleagues have shown that the Hadza, hunter-gatherers who live in northern Tanzania, sometimes scavenge simply by scaring lions away from kills by making a lot of noise.⁶⁵

The Kalahari hunter-gatherers keep their population densities low and thinly distributed. The low level of productivity of their hot, arid environment, as manipulated by their simple technology (bows, arrows, digging sticks, and so forth), requires that they spend most of the year in groups of 25 people or less, often on the move from one camp to another. Most of their diet is made up of vegetable products, tortoises, and other small game, but occasionally giraffes and other large animals are killed, usually through cooperative hunting by several males. Although females provide the bulk of the group’s food by gathering and processing plants and eggs, nestlings, turtles, and other small animals, men do all the hunting of large animals among most known remaining hunting-gathering societies, including the Bushmen and Australian Aborigines.

Kalahari Bushmen also illustrate the value of division of labor. We all know that it is better, in complicated tasks, to work as an integrated group doing different things than for everyone to do every task, whether the task involves getting a football downfield or building a supercomputer. The Kalahari split tasks into those that men do, those that women do, and those that everyone does, children included.

Hunter-gatherer economic life is also dominated by the principle of reciprocity: Food and other resources are exchanged among kinsmen, balancing out the periodic shortages that may afflict any member or nuclear family in the band.

Like most hunting and gathering societies, the Bushmen are at least somewhat territorial. They move often but always within a relatively restricted region, usually 25–30 kilometers in all directions from a central water hole or home base. Clearly, some degree of territoriality is an advantage if resources are not uniformly distributed; it is efficient to know where reliable sources of flint, vegetables, game animals, and water are within one’s territory, and the group forced out of its territory is faced with unpredictable supplies and, perhaps, the hostility of the group on whose territory it is trespassing. Thus, any models or reconstructions we make regarding our early hominin ancestors should incorporate the assumption that they were probably at least loosely territorial.

Hunter-gatherer population densities are directly determined by resource availability and are maintained by methods of population control that seem harsh to us. The aboriginal population density of most of Australia (or at least these populations as they existed until recent decades), for example, can be predicted with a high degree of accuracy simply from the amount of average rainfall in the various areas. This balance between population and resources is maintained mainly by marriage rules and female infanticide. Birdsell reports that 15 to 30 percent of all babies are killed, usually by the grandmother, who places her hand over the infant's mouth and nose as it is born so that it never draws its first breath.⁶⁶ She acts out a group's unstated decision that keeps a mother from carrying more than one infant while she works.

Studies of !Kung infant breast-feeding may reveal the powerful controls on fertility rates that are available to a group simply through natural mechanisms. !Kung women breast-feed their babies as often as 60 times every 24 hours, including during the night when the mother is asleep, and there is some evidence that this frequency is necessary to produce and maintain the hormonal levels that suppress ovulation; a study of women in Scotland shows that they usually nurse their babies only six times in 24 hours and that this has less effect in suppressing ovulation.⁶⁷

In her study of hunters and gatherers in New Guinea, Patricia Townsend observed that although women produce over 90 percent of one group's food, this society is strongly patriarchal.⁶⁸ Townsend found that the women in this group usually marry soon after puberty and have about six children. Malaria and other diseases kill off about 43 percent of the children early in life, but girls die from diseases at a much greater rate than boys, probably from malign neglect. If thought necessary, unwanted girls are killed by strangulation with a vine soon after birth.

Most hunter-gatherers keep their numbers at a level far below what could be supported in any average year, and it is the older people who remember the worst winters and the longest droughts that must be accommodated by the group's sizes. Someone said that when an old person dies it is like a library burning down, and this is true also among hunter-gatherers.

In summary, the Kalahari Bushmen and other contemporary hunter-gatherers may offer some general guidelines for interpreting the archaeological remains of our ancestors in these areas of Africa—even though we know that in mentality and many other ways they are profoundly different from early *Homo*.

MODELS OF CULTURAL ORIGINS

*The distance is nothing; it is only the first step
that is difficult.*

Marquise de Deffand (remarking on the legend that St. Denis walked two leagues carrying his head in his hands)

Having compared nonhuman primates to ourselves, let us look at several attempts to formulate general explanations for the first stages of the evolution of culture. Many people have considered this problem, and it is a subject fraught with political implications, for it

involves the basic nature of humanity and the forces that produce cultural change. No explanation for cultural origins is complete or conclusive, but many have points of interest.

A great difficulty in explaining the factors that produced humans out of a chimpanzee-like animal is that to do so one must try to reconstruct the patterns of natural selection that existed millions of years ago in ecosystems that no longer exist.

Some years ago, Owen Lovejoy argued that bipedalism as an evolutionary product is essentially a matter of sex and the economics of foraging.⁶⁹ As he notes, in some ways bipedalism seems an unlikely development; it is a slow method of movement, and an animal expends great amounts of energy just holding itself up. Also, because we evolved as a quadrupedal and semi-erect animal, bipedalism is in a sense an unnatural form of locomotion. Our spines evolved to serve as a cantilevered bridge-like structure, and even though this structure was successfully modified into a bipedal erect form, we are heirs to many problems, including slipped disks and other back problems, bunions, hernias, poor blood circulation in our legs and feet, and a shortened birth canal that means difficult births for many mothers. If bipedalism is so bad, why should it appear? Lovejoy argues that all apes are potentially semi-erect animals by virtue of natural selection for “handedness”—the constant use of the hand to forage for food. And if one’s evolutionary niche does not reward great bursts of speed over the short run, bipedalism is quite effective for long periods of methodical hunting and gathering.

Lovejoy notes that through the later history of the primates, there has been an evolution in the reproductive strategy. The trend has been toward decreasing the number of offspring a female has but increasing the parental investment in each one, so that they have a better chance to survive and in turn reproduce. (Ecologists call this a *k-strategy*, as opposed to the *r-strategy* of an animal like the housefly, which has thousands of offspring, only a few of which survive.)

The heart of Lovejoy’s argument is that bipedalism was selected over quadrupedalism in our ancestors because it was a way to increase reproductive success. It allowed our ancestors to have more offspring while maintaining a high level of parental investment in the form of food provision, protection, and training. This was accomplished by evolving an economic adaptation and social organization that allowed the mother to spend less of her energy getting her own food and more of her time taking care of offspring. Lovejoy argues that one way females could successfully raise several children born within a short time interval would be to induce the male to provide the female with food on a regular basis, to take part in other tasks of raising many children, and to do it all without competing with other males to the point that the group would break up into murderous, insanely jealous individuals. This meant that the dominance hierarchy and competition common in other primate groups had to be suppressed. One way in which this might occur is if individuals began to differ in perceived “attractiveness,” so that qualities of physical appearance and personality played a role in sexual desirability and feelings of “love.” The advantages of suppressed conflict in the human group might also be related to the fact that humans developed concealed ovulation and sexual receptivity.

Many people have criticized Lovejoy’s model. As Kinzey notes, studies of chimpanzees show that it is the females, not the males, who most frequently share food with young chimps.⁷⁰ Another problem is that substantial differences in size between males and females in primates seem to be associated with competition between males in polygamous mating patterns, whereas Lovejoy proposes monogamous patterns for early hominins.

But if one argues, as various scholars have, that the negative aspects of bipedalism are compensated for by the increased intelligence and better tool-making abilities of our ancestors, how was it possible for bipedalism to appear before any significant increase in brain size and—presumably—intelligence took place? Recently, this question of the origins of bipedalism has emphasized several major avenues of research, including biomechanics, energetics, and ecological contexts.

*Biomechanics*⁷¹ is the study of motion and the effects of forces on the body, for example, how bones are shaped in part by the actions of muscles on them. We know, for instance, that modern human babies are born with a femur (upper leg bone) that has a bicondylar⁷² angle of zero degrees (Figure 3.11). As a growing child learns to walk, the femur begins to “knee-in” (develop the bicondylar angle) as a result of how the muscles and ligaments interact (create a mechanical load) on the condyles—by about eight years of age, a child achieves the adult bicondylar angle of 8 to 11 degrees.⁷³ This angle is important because it helps stabilize balance as a human walks. Close examination of the form of fossil hominin bones therefore offers clues as to whether or not they walked bipedally in the same way as modern humans.⁷⁴ While interpretations have varied, some researchers have suggested that the type of bipedalism that australopiths such as “Lucy” had was not exactly the same as ours today. Such studies are important in examining how bipedalism evolved in the hominins.

Some researchers have examined the energetics of bipedality to assess whether this was potentially significant in the origins of this type of walking. Leonard and Robertson,⁷⁵ for example, propose that energy savings are important to reproductive success in early hominins. Their model, which is based on a hypothetical reconstruction of “Lucy” (*Australopithecus afarensis*), suggests that walking bipedally results in an energy savings of 4 percent over short day ranges (distances traveled in the search for food) and 15 percent to 20 percent over large day ranges compared to nonhuman primates (monkeys and apes) that walk quadrupedally (using all four limbs). These energy savings could be used for growth and reproduction,⁷⁶ thus echoing some of Lovejoy’s early ideas about the benefits of bipedalism.

Still other researchers have concentrated on the ecological contexts that may have facilitated the development of bipedalism. These studies often focus on the period of the last common ancestor (LCA) to hominins and chimpanzees, in the period around 8 to 10 million years ago. Common to all of these is the observation that environmental changes resulted in discontinuous habitats. That is, as open terrain in the form of wooded parklands and savanna grasslands developed due to worldwide climatic drying trends, the continuous forested areas in which the LCA lived were broken up by these more open contexts. Food resources would become more scattered as a result.

One explanation for the origins of bipedalism stresses that this context would lead to increased competition for food and aggression both between groups and within groups.⁷⁷



FIGURE 3.11 The epigenetic development of the bicondylar angle in the human femur is shown in this growth sequence from a seven-month fetus (right) to a seven-year-old child (left).



FIGURE 3.12 Bipedal behavior in a bonobo.

The development of bipedal displays, such as are seen in living chimpanzees (Figure 3.12), is a mechanism for peacefully resolving these conflicts, because actual attacks that lead to death or injury tend to occur rarely in these situations. Instead, the threat underlying the bipedal display is enough to prevent an actual attack. Males that have bipedal display behavior might thus be more successful in attracting mates, while females with this behavior might have more access to food resources as well as the ability to protect their young more effectively. Over time, the juveniles in the group add the “play” behavior of bipedal displays, and the wider spread use of this behavior leads to changes in anatomy that facilitate walking bipedally.

Other explanations for the origins of bipedalism in this context emphasize having the hands free to gather as well as carry food,⁷⁸ or the adoption of one type of LCA social organization, the large group.⁷⁹ Having a large group size, of course, is one way to outcompete smaller groups for resources simply by the force of sheer numbers and threat of aggression. The disadvantage of a large group is that it will eat up the resources in a given area at a much faster rate than a small group. This means that a large group will have to cover more distance on a daily basis in the search for food, and bipedalism is a strategy to accomplish this extended travel. The evolutionary line leading to chimpanzees, on the other hand, emphasized small

group size and less daily distance to travel, thus leading to the retention of quadrupedal walking.

It is quite clear that bipedalism is very ancient, and that it originates long before stone tool-use. But, what of other behavioral patterns that might have lead to or accompanied the origins of culture? Food-sharing, for example, would tend to lengthen the period during which a female was sexually responsive, if sex served as an inducement to food-sharing. And this was an important evolutionary change in more ways than one. Human females are fertile for only a relatively unpredictable three days a month, so intercourse at least a few times a week would be necessary for successful fertility rates.

In an analysis of the link between sexual behavior and other aspects of culture, Donald Symons has addressed the problem of human origins on the basis of a sustained comparison of sexuality in men and women.⁸⁰ Symons summarizes the major differences between men and women in this regard as follows. (1) Intrasexual competition generally is much more intense among males than among females, and in preliterate societies competition over women probably is the single most important cause of violence. (2) Men incline to polygyny, whereas women are more malleable in this respect and, depending on the circumstances, may be equally satisfied in polygamous, monogamous, or polyandrous marriages. (3) Almost universally, men experience sexual jealousy of their mates. Women are more flexible in this respect, but in certain circumstances women’s experience of sexual jealousy may be characteristically as intense as men’s. (4) Men are much more likely to be sexually aroused by the sight of women and the female genitals than women are by the sight

of men and the male genitals. (5) For men, physical characteristics, especially those associated with youth, are by far the most important determinants of women's sexual attractiveness. For females, physical characteristics are somewhat less important determinants of men's sexual attractiveness; political and economic prowess are more important, and youth is relatively unimportant. (6) Much more than women, men are predisposed to desire a variety of sex partners for the sake of variety (although one is reminded here of Cornelia Otis Skinner's remark that "Women's virtue is man's greatest invention"). (7) Among all cultures, copulation is considered to be essentially a service or favor that women render to men, and not vice versa, regardless of which sex derives or is thought to derive greater pleasure from sexual intercourse.⁸¹

In the absence of evidence for a genetic basis for these supposed traits, however, and given the fact that patriarchal societies have dominated human history, we cannot tell if any of these traits are biologically based or are, instead, cultural constructions. Opinions on this point vary. Admitting the great plasticity and potential for variability of human sexual behavior, Symons thinks that there is a strong biological, genetic, profoundly evolutionary basis to these apparent behavioral differences between males and females and these cultural aspects of sexuality. And this is what one would expect, given our evolutionary origins. For millions of years the evolutionary advantage has been with men who have had intercourse with as many young women as they could—provided that the resulting progeny could be raised to reproductive age. Lovejoy's model was based on initial monogamous pairings, but ethnographic evidence suggests that human mating patterns have been primarily polygamous for millions of years.

John Tooby and Irven DeVore have suggested that the various models of cultural origins and subsequent human evolution seem most plausible if we assume that our ancestors of several million years ago began to increase the time they spent hunting or scavenging other animals.⁸²

They begin with *male parental investment*. As noted previously, it is highly unusual among primates for males to invest significant energy in providing their offspring with food, yet humans do. Tooby and DeVore note that, whereas it is not economically efficient to carry low-calorie vegetable foods long distances back to one's mate and offspring, meat is a concentrated form of high-calorie nutrition, and thus would be more advantageous to transport. Tooby and DeVore also point out that "male coalitions" may have developed because of the advantages of group hunting. Reciprocity, sharing, and exchange, too, may be linked to hunting. Tooby and DeVore argue that vegetable foods offer few evident rewards to the kinds of exchange, sharing, and reciprocity typical of all human groups. Vegetable foods come in many different forms and sizes, and animals tend to gather them on the basis of energy costs and immediate needs. But meat, "unlike vegetable foods, comes in discrete quantities: an entire animal is either captured or lost. . . . [V]ariability in hunting success, and the fact that meat comes in chunked quantities often in excess of what the capturers can readily consume, provides a ready explanation for food sharing, food exchange and risk sharing through deferred reciprocation among the larger social group."⁸³

Regarding the pronounced sexual division of labor among humans, Tooby and DeVore suggest that extreme differentiation in the kinds of foods males and females gather is not feasible without food exchange between males and females. "If males changed from occasional to intensive hunting, one consequence would be the extreme sexual division of labor found among humans, with females exploiting the more [fixed, vegetable] food

sources.”⁸⁴ Similarly, they see stone tool-use as probably an adjunct to the requirements of animal butchering and hunting.

These forms of small-game hunting and scavenging would have rewarded group cooperation, reduced dominance hierarchies, improved communication systems, and encouraged the development of stone tools for processing meat and vegetable foods.

In general summary of these models, we have seen that bipedalism, human sexuality, social networks, terrain, hunting/scavenging, and various other factors may all be related in complex patterns of interaction, resulting in the kinds of animals represented by “Lucy” and the other Hadar fossils. These hominins need not have been major tool-users to have been “cultural” in fundamental ways.

Analyzing the Evidence

How can we go about integrating all this ethnographic, archaeological, primatological, and paleontological evidence and use it to understand our origins? To begin with, in an evolutionary analysis we must concentrate on those factors that might have allowed some individuals and not others to have survived to pass on their genes, so that over time our brain size increased and all the other dimensions of the human animal were formed. And once we start examining differential reproduction, we must look directly at how food was procured, shared, and consumed.

Initially, researchers vigorously debated whether early hominins hunted or scavenged animals based on observations of marks on animal bones and stone tools.⁸⁵ One might think that the simple conjunction of stone tools amidst piles of animal bones, some of which show obvious cut marks from being hacked at with stone tools, irresistibly would lead one to the conclusion that our ancestors butchered and ate these animals. But one archaeologist’s stone-tool-cutting mark was another archaeologist’s hyena-bite mark, and when it came to the statistics of the extent and significance of different kinds of bone alteration, entirely different interpretations arose.

Since then, numerous studies have examined not only the marks on animal bones, but also the availability of animal carcasses in the landscape.⁸⁶ These suggest that animal carcasses with plenty of remaining meat would have been especially available in the ecological niche along the woodlands margins (Figure 3.13). Unlike the open grasslands, where hyenas and other scavengers would make quick work of most existing carcasses including the bones, the woodland margins are not usually inhabited by these scavengers. Thus carcasses left behind by leopards that carry their prey up into the trees, or by other large cats, are more available in this setting. Additionally, the teeth of the large cats are not efficient at stripping off all the meat, so that early hominins observing the cats could approach the carcasses once the cats left them behind. Stone tools therefore provided “sharp teeth” for hominins to strip meat from bones and clearly offered an advantage in these circumstances. Of course, it is entirely possible that hominins also scavenged bones from these carcasses and cracked them open with hammerstones to obtain the greasy and nutritious marrow.

The stone tools of two million years ago include a diversity of forms, but most sharp-edged pieces are simple flakes. They certainly are adequate for butchering animals, whether hunted or scavenged. The absence of “spear-points” or anything resembling them strongly suggests that these early hominins had no means of killing large animals,

Ecological, zooarchaeological, and behavioral correlates of competition for larger mammal carcasses, as documented in the Serengeti ecosystem of northern Tanzania.

	Low competition	High competition
Ecosystemic variable (N. Tanzania)		
Habitat	Riparian woodlands	Non-riparian <i>or</i> non-wooded
Season and place (Serengeti only)	Dry in north, wet on plains	Wet in north? Dry on plains
Type of competing carnivore	Flesh-eater	Bone-cruncher
Carnivore:ungulate ratio	Low (Serengeti)	High (Ngorongoro)
Stratum	Arboreal	Terrestrial
Time of day	Mid-day	Dawn/dusk
Cause of death	Mass drowning	Predation by bone-crunching carnivore
Zooarchaeological traces		
Skeletal parts	Little differential destruction	Denser bones survive preferentially
Portions	High epiphysis:shaft fragment ratio	Low epiphysis:shaft fragment ratio
Species	Low carnivore:ungulate ratio; dominated by single species as in glut; more small species	High carnivore:ungulate ratio; high species diversity?; more large species
Age (mortality)	High neonate:adult ratio	Low neonate:adult ratio
Fragmentation	Low NISP:MNE or MNI	High NISP:MNE or MNI
Surface marks	Low incidence; single agent	High incidence; multiple agents
Behavioral strategy		
Timing of access	Planned search?; unrestricted access, including early in resource life	Opportunistic search?; access restricted to end of resource life
Processing/consumption	Energy limited?; complete consumption	Time limited?; consumption of highest net yield available
Transport	Process and consume where found	Transport easily removed parts to safe/concealed locale
Defense/pilfering	No strategies needed	Cooperative and/or artificial techniques
Predation risk from competitors	Lower	Higher

FIGURE 3.13 Opportunities for scavenging carcasses in the East African landscape are assessed using experimental and observational data.

although perhaps they could have used wooden spears—or, as noted earlier, they may not have hunted.

Why is it so important to know about the addition of meat to the diet? Here again we are dealing directly with the factors that shaped us physically and to some extent mentally. When anthropologists argue about the economy of early hominins they are arguing about one of the driving forces of human evolution.

COULD EARLY PLEISTOCENE HUMANS SPEAK?

Maybe. Academics are notorious for their maddening penchant for qualifying everything to the point of utter irresolution, but that's the nature of human analysis, and when we ask a question such as this, the correct answer has to be that it depends in part on how one defines "speech." Do chimpanzees, for example, speak? Clearly they communicate vast amounts of information to each other through noises they make, and they may well communicate far more than we think they do. If we take the reasonable position that human abilities to convey meaning through speech can all be placed on a continuum between the abilities of a chimpanzee and Winston Churchill, then we can ask when abilities equal to our own first evolved, and why.

Various scholars⁸⁷ believe that our contemporary fluency of speech appeared only after about 50,000 years ago and in only a limited number of hominin species (perhaps only one); others believe that even the tool-makers of Olduvai Gorge could communicate vocally with much greater fluency than chimpanzees. We'll probably never know much more about this issue than we do now. The areas of the human brain most associated with speech, Broca's and Wernicke's areas, both of which are located on the left side of the brain, were almost certainly not as developed in early hominins, given that their brains were much smaller than ours. But speech is not simply a matter of brain size. Unlike the anatomy of other animals, the human larynx (air passageway in the throat) and the pharynx (food passageway in the throat) converge low in the throat, so that we cannot breathe and swallow at the same time—something most of us occasionally prove by choking on food swallowed "the wrong way." The advantage to this odd configuration is that it provides a relatively large chamber over the vocal cords, permitting sound production of great variety. Some estimates of the extent to which early hominins were evolving this human sound apparatus have been made on the basis of computer models, but we simply do not have adequate samples of the relevant anatomy of early hominins to be sure of their resemblance to us in this regard.

Why would people have a better or worse chance of living and reproducing successfully based on their language abilities? Many possible reasons could be suggested. Just the knowledge conveyed from one person to another, or from one group to another about resource availability in distant areas, conflict resolution, technological methods, or any number of other matters could improve the chances of survival and reproduction. If the !Kung Bushmen are any guide in this matter, language would be an extremely important adaptive tool even in this low-tech era—and it would greatly mitigate the crushing boredom of this way of life as well.

SUMMARY AND CONCLUSIONS

We are but "pulvis et umbra," Horace said, "dust and shadow," and certainly this is true for the long line of fossils that connect us to our beginnings. Nor are the factors that have shaped our evolution entirely clear. Climate changes, scavenging, hunting, evolutionary change in the biology of our sexuality and mentality, bipedalism, tool-use—all these and many other factors seem to have been ingredients in the evolutionary experiment that is our past, but the evidence is far too slight to reduce us to some simple product of a few factors.

Even if we fight through all these issues of causation and taxonomy and eventually reach a consensus, we will be left with an equally important and profound question—the nature of the mode and tempo of human physical and cultural evolution. The question is this: Does evolution in such things as human cranial capacity (Figure 3.14), technological efficiency, administrative centralization, urbanization, and so forth, proceed gradually, with approximately the same rate of change, or are there long periods of stability punctuated by periods of rapid change? As Robert McC. Adams phrased it in the context of early states, does the simile of a “ramp” or of a series of “steps” best describe our evolutionary history?⁸⁸

This simple question involves some fairly murky political issues. Some fear that to consider human behavior as largely an adaptation and the result of natural selection means that human behavior is beyond social change, that aggression, racism, and so forth may be genetically inherent. Some people think the Marxian concept of dialectical development means that even in such matters as the physical changes from the australopiths to ourselves, we should look for a developmental pattern showing long periods of stability punctuated by periods in which physical characteristics changed relatively rapidly. Thus, Gould and Eldredge say that “no gradualism has been detected within any hominid taxon.”⁸⁹ But J. E. Cronin and others who have analyzed the measurements on fossil hominins from four million years ago to ourselves found no evidence of “stasis” or “punctuation” and believe that the record of human evolution is best seen as an example of gradual change with some periods of varying rates of evolution.⁹⁰ To have any kind of conclusive test of these competing ideas, we need the remains of hundreds of early hominins, at least some of which fall in the time “gaps” for which we now have no information.

M. Henneberg has taken an interesting and novel approach to the lack of precise dates and the problem of the rate at which human cranial capacities increased. He plotted the estimated dates for a large group of human fossils from the past 3.5 million years against the date for each of these fossils that would be predicted based on the assumption that the

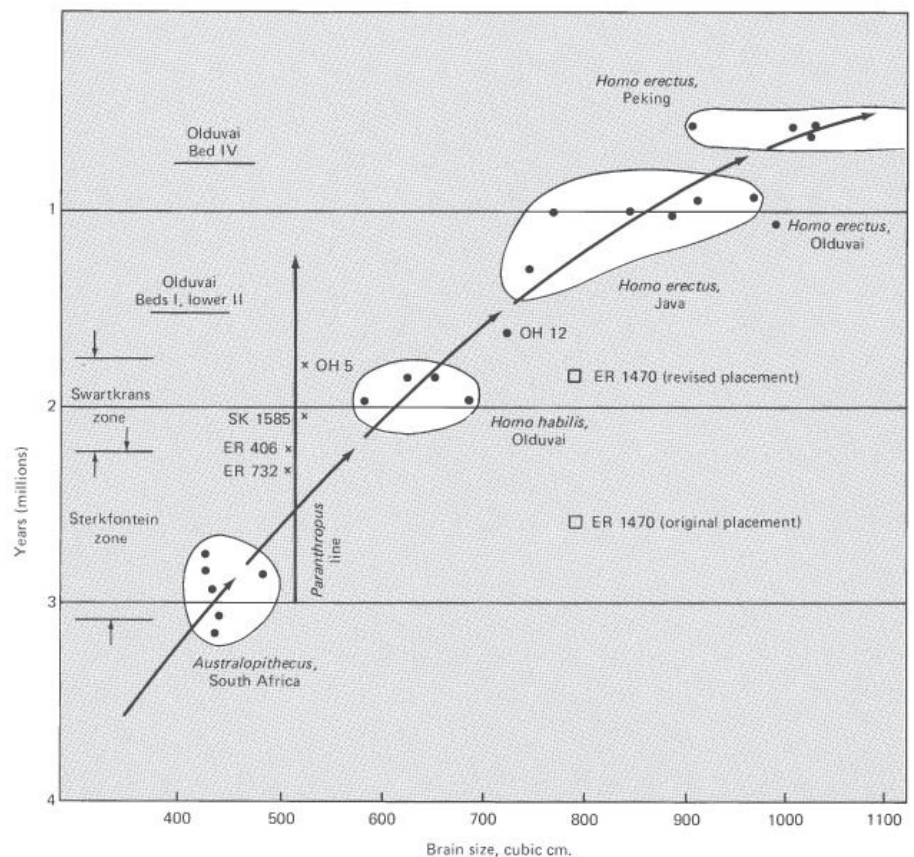


FIGURE 3.14 The increase in cranial capacity over time in our ancestors was enormous and rapid by evolutionary standards, but the rate of increase has slowed in the last 1,000,000 years, and we may have reached the limits allowed by the mechanics of human birth and locomotion.

increase in cranial capacity over time was gradual, at about the same rate—a rate estimated by a standard mathematical technique called regression.⁹¹ The results suggest that the increase over time in human cranial capacities was in fact gradual and at about the same rate—if one assumes that some fossils are incorrectly dated.

As important as all these issues are, they are in a sense all just refinements on a basic advance in human intellectual history: Whatever the tempo of human evolution, we now know its modes, its mechanisms, and its results more clearly than a person of a century and a half ago would ever have thought possible.

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NOTES

1. Recent news stories have discussed Federal and ACLU lawsuits against various school districts to maintain the separation of church and state, as well as state legislature attempts in at least nine states to introduce the teaching of "intelligent design" into school curricula as an alternative to the theory of evolution.
2. Bergson, *L'Evolution Creatrice*.
3. Semaw, "The World's Oldest Stone Artefacts from Gona, Ethiopia: Their Implications for Understanding Stone Technology and Patterns of Human Evolution Between 2.6–1.5 Million Years Ago."

4. Some researchers, for example, McGrew, "Culture in Nonhuman Primates?", argue that differences across primate species may be a matter of degree rather than kind. This would mean that in a broad sense, species such as chimpanzees and humans both have culture, although the specifics of the cultures will differ.
5. White, *The Science of Culture*.
6. Wheatley, "Cultural Behavior and Extractive Foraging in *Macaca fascicularis*." The Japanese macaque "cultural tradition" of washing sweet potatoes, and later wheat, in salt water, appears to have persisted over several generations; see, for example, Watanabe, "Precultural Behavior of Japanese Macaques: Longitudinal Studies of the Koshima Troops."
7. Brace, *The Stages of Human Evolution*, p. 51.
8. See, for example, Alexander, "The Search for a General Theory of Behavior."
9. Alexander, "Evolution and Culture."
10. Various attributed.
11. These types of assumptions, however, must be viewed with some caution because they imply that chimpanzees have not evolved appreciably over the past several million years.
12. Grayson, *The Establishment of Human Antiquity*.
13. Dubois's finds were eventually classified as *Homo erectus*.
14. Von Koenigswald, "Early Man in Java." See also Harrison, "Present Status and Problems for Paleolithic Studies in Borneo and Adjacent Islands," pp. 54–55.
15. Relethford, *The Human Species: An Introduction to Biological Anthropology*, is an up-to-date introduction to evolutionary theory as applied to people.
16. For the introductory student a good and well-illustrated introduction to evolutionary theory in anthropological applications is in Farraro et al., esp. pp. 59–71.
17. There's good reason to believe that Mendel falsified his data because his results are far too "perfect" mathematically and do not show the expected levels of "chance" variation, but this does not detract from his overall contribution. See Thomas, *Refiguring Anthropology*, pp. 288–291.
18. Birdsell, *Human Evolution*.
19. Brace et al., "Clines and Clusters Versus 'Race': A Test in Ancient Egypt and of a Death on the Nile."
20. Crook, "Sexual Selection, Dimorphism, and Social Organization in Primates."
21. See, for example, the exchange between Tattersall and Wolpoff, in *Evolutionary Anthropology*, 3(1), 1994.
22. Several examples of diet books based on presumed hunter-gatherer diets can be found, for example, Audette and Gilchrist's *Neanderthin: Eat Like a Caveman to Achieve a Lean, Strong, Healthy Body*, and Cordain's *The PaleoDiet: Lose Weight and Get Healthy by Eating the Food You Were Designed to Eat*.
23. Lewontin, "Sociobiology as an Adaptationist Program."
24. Hamilton, "Revising Evolutionary Narratives: A Consideration of Alternative Assumptions About Sexual Selection and Competition for Mates."
25. Rossetti was describing the day of Christ's birth here in *A Christmas Carol*, not the Pleistocene.
26. Williams et al., *Quaternary Environments*.
27. Shipman, "We Are All Africans."
28. Wood and Richmond, "Human Evolution: Taxonomy and Paleobiology."
29. I (Wenke) am indebted to Dr. Thomas Morgan for some anecdotes on this point.
30. Attributed.
31. This taxonomy is quite recent and recognizes the close genetic links between chimpanzees and humans. The older terminology used the word "hominid" to mean humans and their ancestors. With the taxonomic revisions, hominid now applies to gorillas, chimpanzees, humans and their ancestors. The correct term for humans and their ancestors is "hominin." See Wood and Richmond, "Human Evolution: Taxonomy and Paleobiology," pp. 20–21.
32. Conroy, *Primate Evolution*.
33. There is some disagreement among scholars regarding the exact placement of several of the hominins. For example, some researchers prefer to classify *Homo rudolfensis* and *Homo habilis* as *Australopithecus rudolfensis* and *Australopithecus habilis*. Other researchers place *Homo ergaster* with *Homo erectus*.
34. Kimbel et al., "The First Skull and Other New Discoveries of *Australopithecus afarensis* at Hadar, Ethiopia."
35. Leakey et al., "New Four-Million-Year-Old Hominid Species from Kanapoi and Allia Bay, Kenya."
36. Clarke and Tobias, "Sterkfontein Member 2 Foot Bones of the Oldest South African Hominid."
37. Toth, "The Oldowan Reconsidered: A Close Look at Early Stone Artifacts."
38. Semaw, "The World's Oldest Stone Artefacts from Gona, Ethiopia: Their Implications for Understanding Stone Technology and Patterns of Human Evolution Between 2.6–1.5 Million Years Ago."
39. See Clark, "Some Thoughts on the Black Skull"; also McBrearty and Brooks, "The Revolution That Wasn't: A New Interpretation of the Origin of Modern Human Behavior"; McHenry and Coffing, "*Australopithecus* to *Homo*: Transformations in Body and Mind"; Wood and Richmond, "Human Evolution: Taxonomy and Paleobiology."
40. Brown, Harris, and Walker, "Early *Homo erectus* Skeleton."

41. Potts, *Early Hominid Activities at Olduvai*. See also Peters and Blumenschine, "Landscape Perspectives on Possible Land Use Patterns for Early Pleistocene Hominids in the Olduvai Basin, Tanzania"; Potts et al., "Paleolandscape Variation and Early Pleistocene Hominid Activities: Members 1 and 7, Olorgesailie Formation, Kenya."
42. Petraglia and Potts, "Water Flow and the Formation of Early Pleistocene Artifact Sites in Olduvai Gorge, Tanzania."
43. Toth, "The Oldowan Reconsidered."
44. Tooby and DeVore, "The Reconstruction of Hominid Behavioral Evolution," pp. 215–217.
45. "Culture in Nonhuman Primates?"
46. Crook, "Sexual Selection, Dimorphism, and Social Organization in Primates," p. 235.
47. Ibid.
48. Pianka, *Evolutionary Ecology*.
49. Anderson, "The Reproductive Role of the Human Breast."
50. Frisch, "Comment on Anderson, P. 'The Reproductive Role of the Human Breast.'"
51. Crook, "Sexual Selection, Dimorphism, and Social Organization in Primates," p. 254.
52. Bosch-Achermann and Boesch, "Hominization in the Rainforest: The Chimpanzee's Piece of the Puzzle."
53. Goodall, *The Chimpanzees of Gombe*. Long-term studies of chimpanzees have also been undertaken in the Mahele Mountains National Park in Tanzania, in Bossou in Guinea, in the Kibale forest of Uganda, and in the Taï National Forest of Côte d'Ivoire; see Boesch and Boesch-Achermann, *The Chimpanzees of the Taï Forest*.
54. Van Lawick-Goodall, "Some Aspects of Aggressive Behavior in a Group of Free-living Chimpanzees."
55. Van den Berghe, "Sex Differentiation and Infant Care: A Rejoinder to Sharlotte Neely Williams," p. 772.
56. Van Lawick-Goodall, "Some Aspects of Aggressive Behavior in a Group of Free-living Chimpanzees."
57. Van Lawick-Goodall, "The Behavior of Free-living Chimpanzees in the Gombe Stream Area"; idem., "Some Aspects of Aggressive Behavior in a Group of Free-living Chimpanzees"; idem., "The Behavior of Chimpanzees in Their Natural Habitat."
58. Tanner, "The Chimpanzee Model Revisited and the Gathering Hypothesis," p. 20.
59. Ibid., citing Boesch and Boesch, "Sex Differences in the Use of Natural Hammers," and Boesch and Boesch, "Possible Causes of Sex Differences in the Use of Natural Hammers by Wild Chimpanzees."
60. *The Chimpanzees of the Taï Forest*, pp. 159–164, 204–205.
61. Binford, "Human Ancestors."
62. Wilmsen, *Land Filled with Flies: A Political Economy of the Kalahari*.
63. Schaller and Lowther, "The Relevance of Carnivore Behavior to the Study of Early Hominids."
64. Blumenschine, "Characteristics of the Early Hominid Scavenging Niche"; Blumenschine et al., "Competition for Carcasses and Early Hominid Behavioral Ecology: A Case Study and Conceptual Framework."
65. O'Connell et al., "Hadza Scavenging: Implications for Plio/Pleistocene Hominid Subsistence."
66. Birdsell, "Ecological Influences on Australian Aboriginal Social Organization."
67. Anderson, "The Reproductive Role of the Human Breast," p. 31.
68. Townsend, "New Guinea Sago Gatherers: A Study of Demography in Relation to Subsistence."
69. Lovejoy, "Hominid Origins: The Role of Bipedalism."
70. Kinzey, *The Evolution of Human Behavior: Primate Models*, p. x.
71. Biomechanics uses physics to examine the action of forces on the body. In addition to statistical analyses, many of these studies use computer modeling and computer-generated simulations.
72. The distal end of the femur (upper leg bone) articulates (meets) the proximal end of the tibia (large lower leg bone). At the distal end of the femur are lateral (toward the outside) and medial (toward the inside) condyles (rounded areas of bone that articulate with hollowed out areas on the proximal end of the tibia). In human bipedalism, the medial condyle grows at a faster rate than the lateral condyle, thus creating the bicondylar angle.
73. Shefelbine et al., "Development of the Femoral Bicondylar Angle in Hominid Bipedalism."
74. For example, see Kramer, "Modelling the Locomotor Energetics of Extinct Hominids"; Ruff and Runestad, "Primate Limb Bone Structural Adaptations"; Thorpe et al., "Dimensions and Moment Arms of the Hind- and Forelimb Muscles of Common Chimpanzees (*Pan Troglodytes*)"; Harcourt-Smith and Aiello, "Fossils, Feet and the Evolution of Human Bipedal Locomotion."
75. Leonard and Robertson, "Rethinking the Energetics of Bipedality," and "Locomotor Economy and the Origin of Bipedality: Reply to Steuden-Numbers."
76. Of course, not all researchers agree with Leonard and Robertson; see Steudel-Numbers, "The Energetic Cost of Locomotion: Humans and Primates Compared to Generalized Endotherms."
77. Jablonski and Chaplin, "Origin of Habitual Terrestrial Bipedalism in the Ancestor of the Hominidae."
78. Richmond et al., "Origin of Bipedalism: The Knuckle-Walking Hypothesis Revisited."
79. Isbell and Young, "The Evolution of Bipedalism in Hominids and Reduced Group Size in Chimpanzees: Alternative Responses to Decreasing Resource Availability."

80. Symons, *The Evolution of Human Sexuality*.
81. Ibid., pp. 27–28.
82. Tooby and DeVore, “The Reconstruction of Hominid Behavioral Evolution.”
83. Ibid., pp. 223–224.
84. Ibid., p. 224.
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