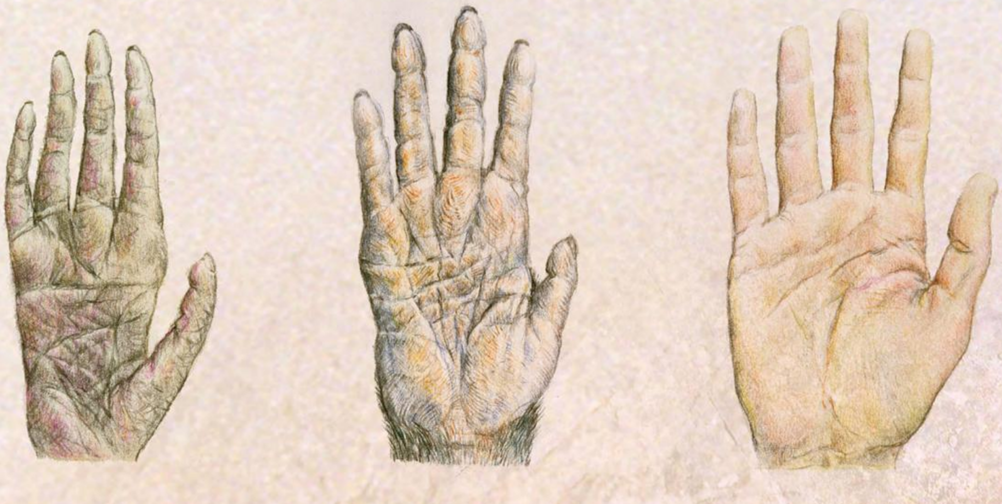
Masters of the Planet

THE SEARCH FOR OUR HUMAN ORIGINS



IAN TATTERSALL

CURATOR OF THE SPITZER HALL OF HUMAN ORIGINS,
AMERICAN MUSEUM OF NATURAL HISTORY

MASTERS OF THE PLANET

For information, address St. Martin's Press, 175 Fifth Avenue,
New York, N.Y. 10010.

First published in 2012 by Palgrave Macmillan in the United States—a division of St. Martin's Press LLC.

ISBN 978-0-230-10875-2

Library of Congress Cataloging-in-Publication Data
Tattersall, Ian.
Masters of the planet : the search for our human origins / Ian Tattersall.
p. cm.
Includes bibliographical references and index.
ISBN 978-0-230-10875-2 (hardback)
1. Human beings—Origin. 2. Human evolution. 3. Evolutionary psychology. I. Title.
GN281.T364 2012
599.93'8—dc23

2011034415

A catalogue record of the book is available from the British Library.

Design by Letra Libre, Inc.

10 9 8 7 6 5 4 3 2 1

Printed in the United States of America.

CONTENTS

PROLOGUE

Stare at the face of a chimpanzee. Look deep into its eyes. Your reactions will almost certainly be powerful, complex, and murky. Perhaps on balance you'll want to recoil, as the Victorians tended to, perceiving in the apes a bestial savagery that served as an unwelcome reminder of humanity's feared and (usually) repressed dark side. In our own day, though, you'll much more likely see in the chimpanzee something more positive: not a failure to achieve human status, but an inchoate glimpse of the deep biological foundations on which our modern civilization and creativity are ultimately based. Still, whatever your exact reaction may be, it will certainly come from perceiving a lot of yourself in those eyes—and the side of the human coin you will see reflected will depend entirely on you, not on the chimpanzee.

This ambiguity makes it very frustrating that the chimpanzee can't articulate his state of mind to us, or answer our questions about it. But then, for all of his physical differences, if he *could* talk he would be one of us. Nothing else he could do would place him more emphatically in the human camp, for it has been recognized since ancient times that language defines us as nothing else does. Indeed, the Scottish jurist James Burnett, Lord Monboddo, anticipated evolutionary thought as early as the 1770s when he suggested that the acquisition of language was the key feature that had levered humankind away from the "lower" animals: an intuitively attractive notion that has been revisited by numerous thinkers since. During the quarter millennium that has elapsed since Monboddo wrote, a vast trove of information bearing on this issue has accumulated, in numerous areas of science that range from linguistics through genomics to neurobiology. Most importantly, we have learned a great deal about the diversity and behaviors of our precursors on this Earth: certainly enough to allow us to begin speculating with some confidence about how, when, and in what context humankind acquired its extraordinary habits of mind and communication.

The story of how we became human is a long one, and it is one that is best recounted from its ancient beginnings, well before there was any firm hint of what was to come. So let's return for a moment to that chimpanzee and its relatives. It's hardly surprising that the apes are so unsettlingly like us. They are our closest living relatives in the biosphere, sharing with us an ancestor that lived perhaps as recently as seven million years ago—a mere eye-blink in the history of Life. But in that short time no other animal lineage has changed nearly as much as ours has. This means that even though they, too, have changed, we can reasonably look to chimpanzees and their relatives for clues as to what our common ancestor was like. And if these primates serve as a reliable guide, that ancestor was an extremely complex creature indeed. Chimpanzees bond, quarrel, and reconcile; they deceive; they murder; they make tools; they self-medicate. They live in hugely complicated societies; and in the struggle for status within those societies they form intricate alliances, and indulge in intrigues that some observers have described as nothing less than "politics." If humans had never evolved, apes would almost certainly be today the most cognitively complex animals that had ever existed.

Yet here we are. And the story of how we got here from there, leaving our ape relatives in the dust (or at least in the trees), is perhaps the most intrinsically fascinating and complex story that our narrative-loving species has ever tried to tell. But at the same time it is an elusive one. For while comparing ourselves with apes may help us establish a starting point for our long evolutionary trajectory, it turns out that we modern human beings are not simply an improved version of them. Instead, we are an altogether unprecedented presence on our planet; and explaining the unique has always been a thankless task.

Despite the difficulties inherent in trying to explain ourselves, we have a solid foundation on which to start. The past century and a half has witnessed the accumulation of a remarkable fossil record that, although it will never be complete, already gives us a substantial glimpse of the appearances and astonishing diversity of those ancestral and collateral relatives who preceded us. What's more, these human precursors are unusual in having left behind an archaeological record—butchered bones, stone artifacts, living sites—that speaks eloquently of their daily activities, and of how those activities became more complex as time progressed.

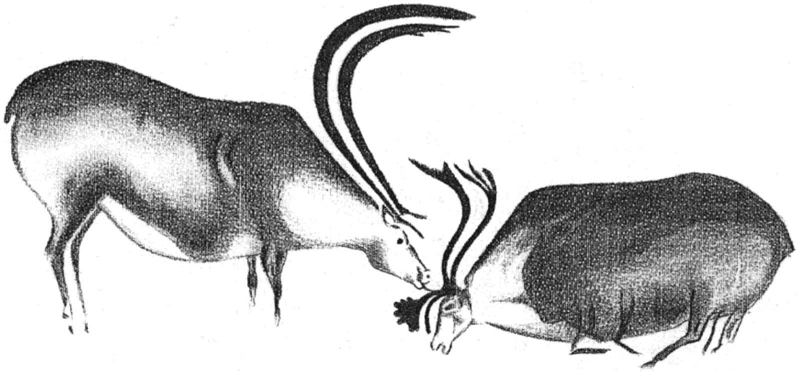
Documenting the huge physical and technological changes that accompanied the long trek from ancient ape to modern human is, at least in principle, a relatively straightforward task. But the secret to the particular kind of success our species enjoys today lies in the very unusual way in which our brains handle information. And mindset is something that is very hard to read from bones or material leavings, at least up to the point at which we have overwhelming evidence for the presence of an intellect equivalent to our own. What is evident, though, is that this final point was reached very late in time—at least compared to the earliest appearance of the human family, although in modern historical terms it was dizzyingly early. Many may find this tardiness rather surprising, because traditionally we have been taught to view the long human story as an extended and gradual struggle from primitiveness toward perfection—in which case, we might anticipate finding early harbingers of our later selves. The reality, however, is otherwise, for it is becoming increasingly clear that the acquisition of the uniquely modern sensibility was instead an abrupt and recent event. Indeed, it was an event that took place *within* the tenure on Earth of humans who looked exactly like us. And the expression of this new sensibility was almost certainly crucially abetted by the invention of what is perhaps the single most remarkable thing about our modern selves: language.

This final communicative and cognitive leap is far from the whole story. The underpinnings of the modern body and mind reach far back into the past, and most of this book is devoted to examining the deep foundations on which the amazing human phenomenon was built. For nothing of what we are today would have been possible in the absence of any aspect of our unique history. And although it is in Africa that we find the earliest stirrings of the modern mind, the vagaries of the record are such that it is only when we contemplate the astonishing cave art of Ice Age Europe that we encounter the first evidence of human beings who not only thought as we do, but who left behind an overwhelmingly powerful body of evidence to prove it.

SYMBOLISM AND THE ART OF THE CAVES

Best exemplified by the famous animal images on the ceilings and walls of caves such as Spain's Altamira and France's Lascaux and Chauvet, the raw power and sophistication of this ancient art is somehow magnified by the knowledge that its painters lived in an unthinkably remote epoch of modern human history. For, despite their brilliance in color and concept, these extraordinary works were the product of hunter-gatherers who lived around the peak of the last Ice Age, between about thirty-five thousand and ten thousand years ago. These were harsh times of cool summers and bitterly long winters, during which trees were often almost entirely banished from a landscape that is thickly wooded today. The antiquity of this art is astonishing; but exposure to it nonetheless makes you fully understand Picasso's alleged remark that the Ice Age painters had left him little to accomplish. Certainly, it's impossible to imagine better evidence that the wonderful and unprecedented human creative spirit was already fully formed at that distant point in modern prehistory.

This realization had not come easily. Intuitively, it was difficult for nineteenth-century scientists to accept that the ancient Ice Age inhabitants of southern France and northern Spain had created an artistic tradition—embracing painting, engraving, sculpture, and bas-reliefs—that, at its best, had equaled or even exceeded in its power anything achieved since. After the first (and among the finest) cave paintings were discovered at Altamira in 1879, immediate admiration rapidly gave way to doubts. How could such refined and accomplished art possibly be the work of hugely ancient people? How could it have been produced by "savages" without fixed abode: mere hunters and gatherers who had roamed the landscape and availed themselves of its bounty, quite the antithesis of civilized nineteenth-century folk who worshiped in magnificent cathedrals, built sturdy houses for shelter, and put the land and what grew on it to work for them? It took repeated discoveries of ancient art, in virgin caves and at untouched archaeological sites, to convince the world that



Monochrome rendering of a now badly faded polychrome wall painting, probably around 14,000 years old, in the cave of Font de Gaume, France. A female reindeer kneels before a male that is leaning forward and delicately licking her forehead. Drawing by Diana Salles after a rendering by H. Breuil.

you could indeed have both a sophisticated mind and a "primitive" lifestyle: to make acceptable the notion that, those many tens of millennia ago, people had existed who did not live in houses and till the fields, but who nonetheless made fabulous art, led mysteriously complex lives, and were just like us in all their cognitive essentials.

Of course those ancient people, and the larger societies whose beliefs and values those images at Lascaux and Altamira embodied, vanished long ago. So, although we have at our disposal miraculously preserved material evidence of the creative spirit of those long-gone humans, we will never know for sure just what those beliefs and values were. Nonetheless, for all their cultural and temporal remoteness, we *can* be secure in the knowledge that those ancient people of Altamira and Lascaux and elsewhere were *us* in all essentials, imbued with the same remarkable human spirit that animates us today.

Significantly, the walls of Lascaux and other caves are not decorated only with animal images, drawn with the deftness, observation, and clever stylization that place their creators among the greatest artists ever. Among and upon those instantly recognizable animal figures, the artists placed geometric motifs—grids, lines of dots, dartlike signs—that clearly had very specific meaning to their creators. Sadly, today we have no way of knowing just what it was the artists had intended to express; but if you consider the clear specificity of the images together with the complex ways in which they are juxtaposed, you rapidly begin to realize that this art was not simply representational. It was *symbolic.* Every image in this cave and others, realistic or geometric, is drenched with meaning that goes far beyond its mere form.

Even though we can't know exactly what the art of Lascaux meant either to its creators or to those for whom it was intended (whether the two were the same, we'll never be certain), what is undeniable is that this art signified something well beyond what we are able to observe directly. And this is, oddly enough, one of the most powerful of the many reasons why so many of us resonate to Ice Age art at the most profound of levels. Because, for all the infinite cultural variety that has marked the long road of human experience, if there is one single thing that above all else unites all human beings today, it is our symbolic capacity: our common ability to organize the world around us into a vocabulary of mental representations that we can recombine in our minds, in an endless variety of new ways. This unique mental facility allows us to create in our heads the alternative worlds that are the very basis of the cultural variety that is so much a hallmark of our species. Other creatures live in the world more or less as Nature presents it to them; and they react to it more or less directly, albeit sometimes with remarkable sophistication. In contrast, we human beings live to a significant degree in the worlds that our brains remake—though brute reality too often intrudes.

Human beings are unusual in many ways, physical as well as cognitive. But our unique mode of processing information is without any question the element that, more than any other, marks us off as *different* from other creatures; and it's certainly what makes us *feel* different. What is more, as I hope this book will convince you, it is entirely without precedent. Not only is the ability for symbolic reasoning lacking among our closest *living* relatives, the great apes; such reasoning was apparently also absent from our closest extinct relatives—and even from the earliest humans who looked exactly like us. At the same time, we modern humans have a huge amount in common intellectually with all of those relatives, vanished and living; and, even more to the point, no matter how much we may vaunt our rationality, we are most certainly not entirely rational beings: a point that should need no belaboring to any observer of our species. One major reason for this is that, through the vagaries of a long and eventful evolutionary history, some of the newest components of our brains—those strange, complex organs in our heads that govern our behavior and experience—communicate with each other via some very ancient structures indeed.

Because of the peculiar construction resulting from their complex history, our brains are far from directly comparable to a feat of human engineering. Indeed, they are probably not comparable at all. For engineers always strive, even where they are consciously or unconsciously constrained, for *optimal* solutions to the problems they are facing. In contrast, during the long and untidy process that gave rise to the modern human brain, what was already there was always vastly more influential on the historical outcome—what actually *did* happen—than any potential for future efficiencies could be. And thank goodness for that. After all, if our brains had been designed like machines, if they had been optimized for any particular task, they would *be* machines, with all of the predictability and tedious soullessness that this would imply. For all their flaws, it is the very messiness and adventitiousness of our brains that makes them—and us—the intellectually fertile, creative, emotional, and interesting entities that they and we are.

This perspective conflicts with the view of evolution that most of us were taught in school—where, if it was mentioned at all, this most fundamental of biological phenomena was usually presented as a matter of slow, inexorable refinement, constantly tending toward achieving the perfect. So, before we embark on the human story, it seems reasonable to take a few moments to look more closely at the remarkable process that operated to produce us—because, extraordinary as we may justifiably think ourselves, we are actually the result of a perfectly ordinary biological history.

THE VAGARIES OF EVOLUTION

Let's start right at the beginning, with the overarching pattern in which Nature is organized, because this is the clearest tip-off we have to the mechanisms lying behind our appearance on the planet. There is a clear order in the living world. The way in which the diversity of animals and plants around us is structured is not haphazard in the least. Instead, it shows an across-the-board pattern of groups within groups. Among the mammals, for example, human beings are most similar to apes; the apes and humans together are most similar to the monkeys of the Old and New Worlds; and apes, humans, and monkeys all resemble lemurs more closely in their anatomies than they do anything else. Jointly, these primates form a distinctive cluster within Mammalia, the order that groups together all the warm-blooded, furry animals that suckle their young. All mammals in turn belong to a bigger group known as Vertebrata (the backboned animals—fish, amphibians, reptiles, and birds, as well as mammals), and so on.

Every other organism is similarly nested into the living world; and graphically, this pattern of resemblance is best expressed in the form of a repeatedly branching tree. Ultimately, every one of all the many millions of living organisms can be embraced within one single gigantic Tree of Life. In this greatest of all trees, biologists group the tiniest branch tips (species, e.g., *Homo sapiens*) into genera (e.g., the genus *Homo*), which are in turn grouped into families (Hominidae), which are grouped into orders (Primates), and so on. As you move up the tree, each successive level departs farther in its configuration from the common ancestral form at the bottom, and from equivalent neighboring branches. And although it is possible to study this self-evident Tree of Life in purely structural terms, the most interesting thing is to know what caused it.

The only testable (and thoroughly tested) scientific explanation of this pattern of resemblance is common ancestry. The similarities that clue us in to the shape of the tree are inherited from a series of shared ancestral forms, whose descendants have diverged from them in various respects. Similar forms share a recent common ancestor, while more disparate ones shared an ancestor much more remotely in time—allowing differences to accumulate over a longer period. No matter how dissimilar they may now appear to the eye, all life forms are ultimately linked at the genomic level to a single common ancestor that lived more than 3.5 billion years ago.

The nineteenth-century naturalists Charles Darwin and Alfred Russel Wallace were the first to come up with a convincing mechanism by which divergence from a common ancestor could occur. Darwin called this instrument of change "natural selection." Once pointed out, this natural process seemed so self-evident that Darwin's famous contemporary Thomas Henry Huxley publicly berated himself for his own failure to think of it. In a nutshell, natural selection is simply the preferential survival and reproduction of individuals that are better "adapted" to their environments than their fellows, in features inherited from their parents. And it is pretty much a mathematical consequence of the fact that, in all species, each generation produces more offspring than survive to reproduce. The idea here is that, over enough time, those with more advantageous inherited characteristics will have greater reproductive success, and therefore will nudge the population in the direction of better adaptation. In this way, members of the lineage will change in average appearance and ultimately evolve into a new species.

That was the theory, anyway, though it has subsequently been noticed that natural selection may well act mostly to trim off both extremes of the available variation, keeping the population more or less stable. Another complication is that, when we think of adaptation, we usually have in mind one single anatomical feature, or behavioral property, of the animal in question: the structure of its foot or pelvis, say, or its "intelligence." Thinking of just one feature in isolation, it is easy to envision how that structure might have been improved over time by natural selection. Yet we now know that all organisms are astonishingly complex genetic entities, in which a remarkably small number of structural genes (exactly how many we humans have isn't known for sure, though most current bets are in the 23,000 range) govern the development of an enormous number of bodily tissues and processes. In the end, natural selection can only vote up or down on the entire individual, which is a real mash-up of genes and of the characteristics they promote. It cannot single out specific features to favor or disfavor.

This, though, blurs the "fitness" picture. It is, for example, of little value to be the smartest member of your species if, in an environment crawling with predators, you are also the slowest—or even just the most unfortunate. What's more, in an indifferent world your reproductive success may not in the end have much to do with how magnificently you are adapted to any one thing. Whether or not that predator gets you, or whether or not you get the girl, may simply be a function of blind luck and circumstance. The upshot of complications such as these is that evolutionary histories, certainly as we see them reflected in the fossil record, are not produced by the reproductive fates of individuals alone. Indeed, in a world of constantly changing environments, and of ceaseless competition among different kinds of organisms for ecological space, it is more often the fates of entire populations and species that determine the larger evolutionary patterns we observe when we look back at the fossil record.

And there are yet other reasons for not expecting that evolution should produce tidy perfection. As I've already suggested, change can only build on what is there already, because there is no way that evolution can conjure up *de novo* solutions to whatever environmental or social problems may present themselves. As a result, we are all built on modified versions of a template ultimately furnished us by an ancient ancestor. History severely limits what you can potentially become not simply because you must necessarily be a version of what went before, but because genomes, dedicated as they are to the propagation of mind-bogglingly complex systems, turn out to be hugely resistant to change. In fact, they provide the ultimate example of "if it ain't broke, don't fix it." After all, fiddling around with anything as intricate as a genome is asking for trouble: most random changes to a functioning system this complicated simply won't succeed. The fact that changes in the genetic code carry huge risks explains the inherent conservatism of genomes. It also explains why some organisms that look hugely different to the eye have amazingly similar genes: I've heard it said that we share over 40 percent of our genes with a banana, while a gene that is highly active in determining human skin color is also responsible for regulating the dark stripes on the side of a zebrafish.

It may seem amazing that the same genes or gene families can influence structure across a spectrum of organisms that look as vastly different as, say, a human being and a fruit fly. But it makes sense when you consider not only that all organisms share an ultimate common ancestry, but also that the form of any creature is not solely a reflection of the structure of its individual genes. Instead, adult anatomy is the endpoint of a developmental process that is heavily influenced not just by the underlying genes themselves, but also by the sequence in which the genes are switched on and off; by exactly when this switching happens; and by how strongly the genes themselves are expressed while they are active. This multilayered process (genes, timing, activity) explains the apparent paradox of extreme genomic conservatism together with huge anatomical variety among organisms. And, at the same time, it limits future possibilities. For while changes in the genetic code occur at an astonishingly high rate as a result of simple copying errors (mutations) when cells multiply, few such changes survive in the gene pool. Some mutated genes may linger simply because they don't get in the way (and they may, indeed, turn out to be useful in the distant future, though that won't count for much at the time); but not many will produce a viable result, let alone an adaptively advantageous one. For all these reasons, radical makeovers of the basic structures of heredity are simply not in the cards.

THE ROLE OF CHANCE

Another big reason for not expecting that evolution should be a process of fine tuning is that not all evolutionary changes are the work of natural selection. Chance—technically known as "genetic drift"—is also a huge factor. As a result of those constant mutations, isolated or semi-isolated local populations of creatures belonging to the same species will always tend to diverge from each other purely as a result of what is known as "sampling error"—even in the absence of significant selective forces for change. This is especially true if those populations are small, because the smaller your sample size, the greater your chances of such error. Just think of flipping coins instead of mutations. If you flip a coin only twice, there is a good chance it will come up heads both times; if you flip it ten or a hundred or a thousand times, it is progressively less likely it will always show heads. Tiny populations are equivalent to just a few flips.

Of course, it's also true that not all mutations are equal. Some will have little or no effect on the adult organism; but a few may have a radical influence on developmental processes, and thus upon the creature's final structure. Also important are differences in the degree to which a gene's effects are expressed, or how active its products are in determining the final physical outcome. For all these reasons we should not expect significant evolutionary change in physical form to happen always, or even usually, in tiny and incremental steps. As we will see, sometimes a very small change in the genome itself can have extensive and ramifying developmental results, producing an anatomical or behavioral gap between highly distinct alternative adult states.

None of this is an optimally efficient way to produce adaptation. But, as the luxuriant branching of the Great Tree of Life amply demonstrates, given enough time it *works*. And it works not only as a general explanation of how life diversified over billions of years, but also as an aid to understanding how the deep cognitive gulf separating humans and all other living organisms was so improbably bridged.

This brings us back to the central subject of this book: the story of how human beings came to be the extraordinary creatures they are—as physical entities, of course, but also as an unprecedented cognitive phenomenon. It was a long and eventful (albeit rapid by evolutionary standards) journey from humanity's humble beginnings as a vulnerable prey species, out in the expanding woodlands of ancient Africa, to the position we now occupy of top predator on Earth. But the major outlines of this dramatic story are now becoming clear. And they fit comfortingly well with our emerging views of the multilevel mechanisms underlying evolutionary change. For it's worth repeating that, remarkable as we may think we are, we are actually the product of a routine biological process.

MAJOR EVENTS IN HUMAN EVOLUTION

Event	*Thousand Years Ago*
Origin of Life	3,500,000
Origin of Primates	60,000
Group containing humans and apes begins to diversify	23,000
Earliest hominids (bipeds) appear in Africa	7–6,000
First *Australopithecus*	4,200
Earliest possible use of sharp stone for cutting	3,400
Beginning of glacial cycle	2,600
Distinct expansion of grassland fauna in Africa	2,600
Earliest documented manufacture of stone tools	2,600–2,500
Claimed "early *Homo*" fossils appear	2,500–2,000
First *Homo* of modern body proportions in Africa	1,900–1,600
Hominids first leave Africa (Dmanisi)	1,800
First stone tools made to deliberate shape	1,760
Homo erectus appears in Asia	1,700–1,600
First *Homo* fossils in Europe	1,400–1,200
Earliest evidence of domesticated fire in hearths	790
Homo antecessor appears in Europe	780

First Old World–wide hominid, *Homo heidelbergensis*	600
First evidence of Neanderthal lineage in Europe	> 530
Earliest blade tools in Africa	500
Earliest wooden spears, hafted tools	400
First evidence of constructed shelters	400–350
Earliest prepared-core tools	300–200
Origin of anatomically recognizable *Homo sapiens* in Africa	~200
First possible beadwork	~100
Earliest engravings, heat-treatment of silcrete	~75
Exodus of cognitively symbolic *Homo sapiens* from Africa	70–60
First modern humans in Australia	60
First modern humans in Europe, flowering of art and symbols	40–30
Extinction of Neanderthals, *Homo erectus*	~30
Homo floresiensis extinct	14
Last Ice Age ends	12
Plant cultivation and animal domestication begin	11

ONE

ANCIENT ORIGINS

Among the most important influences not only on how ancient creatures evolved, but on their preservation as fossils, has been the geography and topography of the Earth itself. This has been as true for our group as for any other, so it's worth giving a bit of background here. During the Age of Mammals that followed the demise of the dinosaurs some 65 million years ago, much of the African continent was a flattish highland plateau. This slab of the Earth's crust lay over the roiling molten rocks of the Earth's interior like a great thick blanket, trapping the heat below. Heat must rise, and eventually ascending hot rock began to swell the rigid surface above.

Thus began the formation of the great African Rift, the "spine of Africa," that formed as a series of more or less independent but ultimately conjoined areas of uplift known as "domes." These blistered and split apart the continent's surface along a line that started in Syria, proceeded down the Red Sea, then south from Ethiopia through East Africa to Mozambique. The Rift's major feature, the Great East African Rift Valley, formed as a complex chain of sheer-sided depressions when the swelling below cracked the inflexible rock at the surface. As the continent continued to rise with the injection of more hot rock from below, erosion by water and wind began to deposit sediments in the valley floors—sediments that contain an amazingly rich assortment of fossils. As a category, fossils technically include any direct evidence of past life, but the overwhelming majority of them consist of the bones and teeth of dead animals that were luckily—for paleontologists—covered and protected by marine or lake or river sediments before they could be obliterated by scavengers and the elements. And, as fate would have it, the sedimentary rocks of the Rift Valley include the most remarkable fossil record we have, from anywhere in the world, of the long history of mankind and its early relatives.

In eastern Africa, Rift sediments began to be deposited in the Ethiopian Dome about 29 million years ago, and similar deposits mark the initiation of the Kenya Dome only a few million years later, at about 22 million years. This occurred during the period known to geologists as the Miocene epoch, and it happens to have been an exceptionally interesting time in primate evolution, as the fossil record shows. It was what you might call "the golden age of the apes," and it set the stage for the evolution of the human family, which appeared toward its end.

Today's Great Apes—the chimpanzees, bonobos, gorillas, and orangutans—constitute a mere handful of forest species now restricted to tiny areas of Africa and a couple of southeast Asian islands. But the Miocene was the apes' heyday, and over its 18-million-year extent, scientists have named more than 20 genera of extinct apes from sites scattered all around the Old World, though mostly in East Africa. The earliest of these ancient apes are known as "proconsuloids." They scampered along the tops of large branches in the humid forests of the eastern African early Miocene in search of fruit, some 23 to 16 million years ago. Like today's apes, they already lacked tails; but in many ways they were more monkeylike, with less flexible forelimbs than those their descendants eventually acquired.

Around 16 million years ago, African climates seem to have become drier and more seasonal, changing the character of the forests. True monkeys began to flourish in the new habitat, and the proconsuloids themselves yielded to "hominoid" apes that more closely resembled their modern successors. Most notably, the apes of the later Miocene developed mobile arms that they could freely rotate at the shoulder joint, allowing efficient suspension of the body beneath tree branches and imparting all-around greater agility. These early hominoids also typically had molar teeth with thick enamel that were set in robust jaws, allowing them to tackle a broad range of seasonally available forest foods as they began spreading beyond the Afro-Arabian region into Eurasia.

In both Eurasia and Africa, paleontologists have found the remains of several different hominoid genera that date back between about 13 and 9 million years ago. These probably represent the group that gave rise to the first members of our own "hominid" family (or "hominin" subfamily; for most purposes the distinction is merely notional). Most of the genera concerned are known principally from teeth and bits of jaw and cranium; but one of them, the 13-million-year-old *Pierolapithecus,* is well known from a fairly complete skeleton discovered not long ago in Spain. *Pierolapithecus* was clearly a tree climber, but it also showed a host of bony characteristics that suggest it habitually held its body upright. Such a posture—in the trees, at least—may actually have been typical for many hominoids of the time (as it is for orangutans today). However, the skull and teeth of *Pierolapithecus* are different from those of any of the putative early hominids that we'll read about in a moment.

WILL THE EARLIEST HOMINID PLEASE STAND UP?

The earliest representatives of our own group lived at the end of the Miocene and at the beginning of the following Pliocene epoch, between about six and 4.5 million years ago. And they appear just as the arrival of many new open-country mammal genera in the fossil record signals another major climatic change. Oceanic cooling affected rainfall and temperatures on continents worldwide, giving rise in tropical regions to an exaggerated form of seasonality often known as the "monsoon cycle." In Europe this cooling led to the widespread development of temperate grasslands, while in Africa it inaugurated a trend toward the breakup of forest masses and the formation of woodlands into which grasslands intruded locally. This episode of climatic deterioration furnished the larger ecological stage on which the earliest known hominids made their debut.

Before we look at the varied cast of contenders for the title of "most ancient hominid," perhaps we should pause for a moment to consider just what an early hominid *should* look like. How would we recognize the first hominid, the earliest member of the group to which we belong to the exclusion of the apes, if we had it? The question seems straightforward, but the issue has proven to be contentious, especially since members of related lineages—such as our own and that of the chimpanzees—should logically become more similar to each other, and thus harder to distinguish, as they converge back in time toward their common ancestor. But while the characteristics that define modern groups should even in principle lose definition back in the mists of the past, attempts to recognize very early hominids have paradoxically been dominated by the search for the early occurrence of those features that mark out their descendants today.

When the Dutch physician Eugene Dubois discovered the first truly ancient human fossil in Java in 1891, he called his new find *Pithecanthropus erectus* ("upright ape-man"). His choice of species name emphasized the importance he attached to the erect stature of this hominid (indicated by the structure of its thighbone) in determining its human (or at least close-to-human) status. But soon thereafter the emphasis changed, at least temporarily. Modern people are perhaps most remarkable for their large brains; and in the early years of the twentieth century, brain size expansion replaced uprightness as the key criterion for any fossil seriously considered for inclusion in the hominid family. Indeed, its big human braincase (which was matched with an ape jawbone) was the basis for recognizing the famously fraudulent English Piltdown "fossil" as a human ancestor in 1912. The fraud was only officially uncovered some 40 years later, although many scientists were suspicious of it from the start; and as time passed the Piltdown specimens became increasingly ignored, which had the effect of bringing the big-brain criterion into disfavor. In its place came a behavioral yardstick rather than an anatomical one: manual dexterity and the manufacture of stone tools became the key to human status, as the notion of "Man the Toolmaker" took hold.

But this too had its difficulties. Eventually and inevitably, attention refocused on anatomy, and various potentially diagnostic morphological features of hominids were touted. Teeth, which are coated with the toughest biological material and thus preserve particularly well in the fossil record, received particular attention. One dental characteristic that many noticed among potential early hominid fossils was thick molar enamel—although, as we have seen, this indicator of a tough diet is also found widely among Miocene apes. Another hominid dental feature that has perennially attracted attention is the reduction in size of the canine teeth. This occurs in conjunction with the loss of honing of the large upper canine against the front premolar of the lower jaw with which it occludes. Large-bodied male apes typically have fearsome upper canine teeth with razor-sharp back edges—although in small females these teeth can be dainty. But again, a tendency toward canine reduction is not unique to hominids. It is also found in various Miocene apes, most famously the bizarre late-Miocene *Oreopithecus,* an insular form that additionally showed a distinct tendency toward postural uprightness. What is more, the remarkable *Oreopithecus* was recently reported to have had "precision-grip capability"—something else that was once thought unique to tool-making hominids.

Part of the problem of spotting features that are unique to hominids stems from the nature of evolutionary diversification. As we look farther back into hominid history, every feature indicative of modern hominids is likely to become less distinctive—and more reminiscent of its counterparts in members of related lineages. Given this reality, it is hardly realistic to expect that we'll ever find an anatomical "silver bullet" that will by itself tell us infallibly if an ancient fossil is a hominid or not. Every effort to do this has foundered on one technicality or another. Take, for example, the early-twentieth-century attempt of the English anatomist Sir Arthur Keith to set a "cerebral Rubicon" of 750 cubic centimeters (cc) minimum brain volume for membership in the genus *Homo.* Any smaller than this, Keith said, and you didn't belong to the club. This was certainly a convenient and easily measurable criterion; and, at a time when very few hominid fossils were known, perhaps it was even a workable one. But predictably, as the hominid fossil sample increased, problems arose. Brain size is notably variable within populations (modern human brains range in size from about 1,000 to 2,000 cc, with no indication that people with larger brains are necessarily smarter), so that even in principle this standard might have admitted an ancient hominid to our genus while excluding his or her parents or offspring. Accumulating fossil finds predictably forced later authors to lower Keith's figure several times, until it became obvious that the entire "Rubicon" idea was misguided.

in 2001 in the central-western African country of Chad (well to the west of the Rift Valley). What has so far been published of this form consists of a badly crushed cranium (informally dubbed "Toumaï"—"hope of life" in the local language) and some partial mandibles. These fossils caused a stir when discovered, because nobody had anticipated an ancestral hominid like this. What was particularly strange about Toumaï was that it combined a small (hence rather apelike) braincase with a large, flattish face that was distinctly unlike the more protruding snouts of younger fossil hominids (or apes, for that matter). Two things caused its describers to classify this form as a hominid: first, the teeth. The molars had moderately thick enamel, the canines were reduced, and there was no lower premolar honing mechanism. So far, so good; but as we've seen, both thick enamel and the reduced canine-premolar complex can be matched outside Hominidae. So the key finding was in the base of the crushed cranium, where the foramen magnum, the large hole through which the spinal cord exits the cranium, appeared to be shifted underneath the skull to face largely downward. This is significant in that you would expect to find this setup in an upright biped like us: a skull balanced atop an erect spine. In a quadrupedal chimpanzee, the skull hangs on the front of a horizontal spine, so the foramen magnum has to be at the rear of the skull, facing backward. Unfortunately, though, the skull of *Sahelanthropus* was badly crushed, so the crucial claim about its foramen magnum was inevitably disputed.

In response, researchers took CT-scans of the crushed skull in a medical scanning machine, and produced a computerized virtual reconstruction that eliminated the distortions. Now, no matter how high-tech the procedure is, there's always an element of human judgment involved in making any reconstruction. But the resulting model of the pristine *Sahelanthropus* skull gave its creators substantial grounds for viewing Toumaï as plausibly—if not definitively—the skull of a biped. There are still some skeptics; but although the bipedality question will never be finally settled until key parts of the body skeleton of *Sahelanthropus* are announced, the reconstruction does appear to give this form the benefit of the doubt.

If Toumaï was a hominid—or even if he wasn't—what can we say about his way of life? Fossils found in the same deposits suggest that *Sahelanthropus* lived in an environment that was well watered, with forest

INDEX