THE THIRD CHIMPANZEE

The Evolution and Future OF THE *Human Animal*

JARED DIAMOND

HarperPerennial
A Division of HarperCollins*Publishers*

A hardcover edition of this book was published in 1992 by HarperCollins Publishers.

THE THIRD CHIMPANZEE. Copyright © 1992 by Jared Diamond. All rights reserved. Printed in the United States of America. No part of this book may be used or reproduced in any manner whatsoever without written permission except in the case of brief quotations embodied in critical articles and reviews. For information address HarperCollins Publishers, Inc., 10 East 53rd Street, New York, NY 10022.

HarperCollins books may be purchased for educational, business, or sales promotional use. For information please write: Special Markets Department, HarperCollins Publishers, Inc., 10 East 53rd Street, New York, NY 10022.

First HarperPerennial edition published 1993.

Designed by Ruth Kolbert

The Library of Congress has catalogued the hardcover edition as follows:

Diamond, Jared M.

The third chimpanzee : the evolution and future of the human animal / Jared Diamond. — 1st ed.

p. cm.

Includes bibliographical references and index.

ISBN 0-06-018307-1 (cloth)

1. Human evolution. 2. Social evolution. 3. Man—Influence on nature. I. Title.

GN281.D53 1992

573.2—dc20 91-50455

ISBN 0-06-098403-1 (pbk.)

04 05 RRD(H) 36 37 38 39 40

CHAPTER 2

The Great Leap Forward

FOR MOST OF THE MANY MILLIONS OF YEARS SINCE OUR LINEAGE diverged from that of apes, we remained little more than glorified chimpanzees in how we made our living. As recently as forty thousand years ago, western Europe was still occupied by Neanderthals, primitive beings for whom art and progress scarcely existed. Then there came an abrupt change, as anatomically modern people appeared in Europe, bringing with them art, musical instruments, lamps, trade, and progress. Within a short time, the Neanderthals were gone.

That Great Leap Forward in Europe was probably the result of a similar leap that had occurred over the course of the preceding few tens of thousands of years in the Near East and Africa. Even a few dozen millennia, though, is a trivial fraction (less than 1 percent) of our long history separate from ape history. Insofar as there was any single point in time when we could be said to have become human, it was at the time of that leap. Only a few more dozen millennia were needed for us to domesticate animals, develop agriculture and metallurgy, and invent writing. It was then but a short further step to

those monuments of civilization that distinguish humans from animals across what used to seem an unbridgeable gulf—monuments such as the "Mona Lisa" and *Eroica Symphony,* the Eiffel Tower and Sputnik, Dachau's ovens and the bombing of Dresden.

This chapter will confront the questions posed by our abrupt rise to humanity. What made it possible, and why was it so sudden? What held back the Neanderthals, and what was their fate? Did Neanderthals and modern peoples ever meet? If so, how did they behave toward each other?

Understanding the Great Leap Forward isn't easy, and writing about it isn't easy either. The immediate evidence comes from technical details of preserved bones and stone tools. Archaeologists' reports are full of terms obscure to the rest of us, such as "transverse occipital torus," "receding zygomatic arches," and "Châtelperronian backed knives." What we really want to understand—the way of life and the humanity of our various ancestors—isn't directly preserved but only inferred from those technical details of bones and tools. Much of the evidence is missing, and archaeologists often disagree over the meaning of such evidence as has survived. Since the books and articles listed in Further Readings, pages 373–74, will slake the interest of readers curious to learn more about receding zygomatic arches, I'll emphasize instead the inferences from bones and tools.

TO PLACE HUMAN EVOLUTION in a time perspective, recall that life originated on Earth several billion years ago, and that the dinosaurs became extinct around sixty-five million years ago. It was only between six and ten million years ago that our ancestors finally became distinct from the ancestors of chimps and gorillas. Hence human history constitutes only an insignificant portion of the history of life. Science-fiction films that depict cavemen fleeing from dinosaurs are just that, science fiction.

The shared ancestor of humans, chimps, and gorillas lived in Africa, to which chimps and gorillas are still confined, and to which we remained confined for millions of years. Initially, our own ancestors would have been classified as merely another species of ape, but a sequence of three changes launched us in the direction of modern humans. The first of these changes had occurred by around four

million years ago, when the structure of fossilized limb bones shows that our ancestors were habitually walking upright on the two hind limbs. In contrast, gorillas and chimps walk upright only occasionally, and usually proceed on all fours. The upright posture freed our ancestors' forelimbs to do other things, among which toolmaking proved the most important.

The second change occurred around three million years ago, when our lineage split into at least two distinct species. As background, reflect that members of two animal species living in the same area must fill different ecological roles and do not normally interbreed with each other. For example, coyotes and wolves are obviously closely related and (until wolves were exterminated in most of the United States) lived in many of the same areas of North America. However, wolves are larger, mainly hunt big mammals like deer and moose, and often live in large packs, whereas coyotes are smaller, mainly hunt small mammals like rabbits and mice, and usually live in pairs or small groups. Coyotes usually mate with coyotes, wolves with wolves. In contrast, every human population living today has interbred with every other human population with which it has had extensive contact. Ecological differences among existing humans are entirely a product of childhood education: it's not the case that some of us are born with sharp teeth and equipped to hunt deer, while others are born with grinding teeth, gather berries, and don't marry the deer hunters. Hence all modern humans belong to the same species.

On perhaps two occasions in the past, though, the human lineage split into separate species, as distinct as wolves and coyotes. The most recent such occasion, which I'll describe later, may have been at the time of the Great Leap Forward. The earlier such occasion was around three million years ago, when our lineage split into two: a man-ape with a robust skull and very big cheek teeth, assumed to eat coarse plant food, and often referred to as *Australopithecus robustus* (meaning "the robust southern ape"); and a man-ape with a more lightly built skull and smaller teeth, assumed to have an omnivorous diet, and known as *Australopithecus africanus* ("the southern ape of Africa"). The latter man-ape evolved into a larger-brained form termed *Homo habilis* ("man the handyman"). However, fossil bones that some paleontologists consider to represent male and female *Homo habilis* differ so much from each other

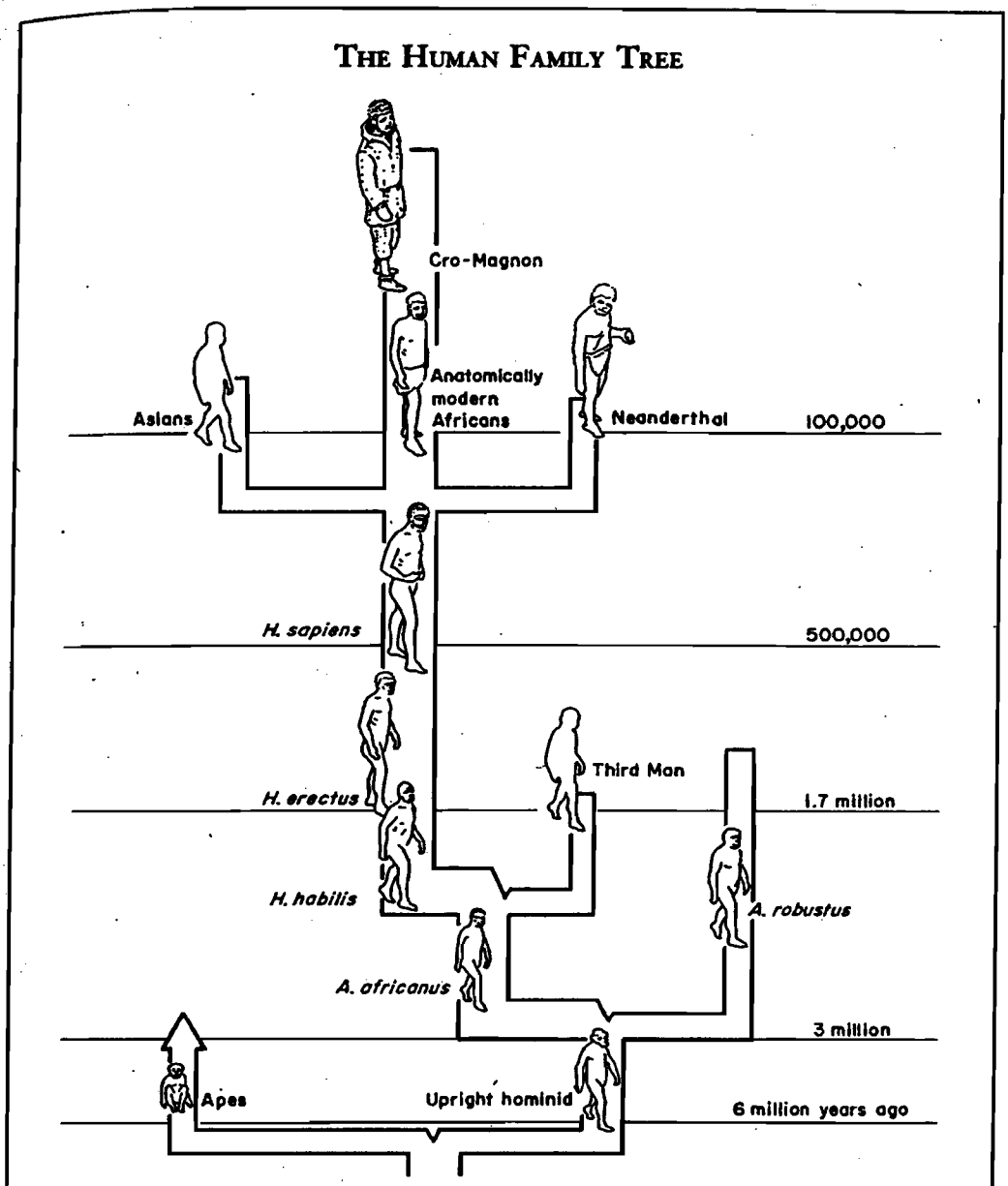

Figure 2. Several branches of our family tree have become extinct, including those belonging to the robust australopithecines, Neanderthals, and possibly a poorly understood "Third Man" and an Asian population contemporary with Neanderthals. Some descendants of *Homo habilis* survived to evolve into modern humans. To recognize by different names the changes in fossils representing this line, they are somewhat arbitrarily divided into *Homo habilis,* then *Homo erectus* beginning around 1.7 million years ago, then *Homo sapiens* beginning around 500,000 years ago. *A.* stands for the genus name of *Australopithecus, H.* for *Homo.*

in skull size and tooth size that they may actually imply another fork in our lineage yielding two distinct *habilis*-like species: *Homo habilis* himself, and a mysterious "Third Man." Thus, by two million years ago there were at least two and possibly three protohuman species.

The third and last of the big changes that began to make our ancestors more human and less apelike was the regular use of stone tools. This is a human hallmark with clear animal precedents: woodpecker finches, Egyptian vultures, and sea otters are among the other animal species that evolved independently to employ tools in capturing or processing food, though none of these species is as heavily dependent on implements as we now are. Common chimpanzees also use tools, occasionally of stone, but not in numbers sufficient to litter the landscape. But by around 2½ million years ago very crude stone tools appear in numbers in areas of East Africa occupied by the protohumans. Since there were two or three protohuman species, who made the tools? Probably the light-skulled species, since both it and the tools persisted and evolved.

With only one human species surviving today but two or three a few million years ago, it's clear that one or two species must have become extinct. Who was our ancestor, which species ended up instead as a discard in the trash heap of evolution, and when did this shakedown occur? The winner was the light-skulled *Homo habilis,* who went on to increase in brain size and body size. By around 1,700,000 years ago the differences were sufficient for anthropologists to give our lineage a new name, *Homo erectus,* meaning "the man that walks upright." (*Homo erectus* fossils were discovered before all the earlier fossils I've been discussing, so anthropologists didn't realize that *Homo erectus* wasn't the first protohuman to walk upright). The robust man-ape disappeared somewhat after 1,200,000 years ago, and the "Third Man" (if he ever existed) must have disappeared by then also. As for why *Homo erectus* survived and the robust man-ape didn't, we can only speculate. A plausible guess is that the robust man-ape could no longer compete, since *Homo erectus* ate both meat and plant food, and since tools and a larger brain made *Homo erectus* more efficient at getting even the plant food on which his robust sibling depended. It's also possible that *Homo erectus* gave his sibling a direct push into oblivion, by killing him for meat.

All the developments that I've been discussing so far were played

out within the continent of Africa. The shakedown there left *Homo erectus* as the sole protohuman on the African stage. It was only around one million years ago that *Homo erectus* finally expanded his horizons. His stone tools and bones show that he reached the Near East, then the Far East (where he is represented by the famous fossils known as Peking Man and Java Man) and Europe. He continued to evolve in our direction by an increase in brain size and in skull roundness. By around 500,000 years ago, some of our ancestors looked sufficiently like us, and different from earlier *Homo erectus,* that they are classified as our own species (*Homo sapiens,* meaning "the wise man"), though they still had thicker skulls and brow ridges than we do today.

Readers unfamiliar with details of our evolution might be forgiven for assuming that the appearance of *Homo sapiens* constituted the Great Leap Forward. Was our meteoric ascent to *sapiens* status half-a-million years ago the brilliant climax of Earth history, when art and sophisticated technology finally burst upon our previously dull planet? Not at all: the appearance of *Homo sapiens* was a nonevent. Cave paintings, houses, and bows and arrows still lay hundreds of thousands of years off in the future. Stone tools continued to be the crude ones that *Homo erectus* had been making for nearly a million years. The extra brain size of those early *Homo sapiens* had no dramatic effect on our way of life. That whole long tenure of *Homo erectus* and early *Homo sapiens* outside Africa was a period of infinitesimally slow cultural change. In fact, the sole candidate for a major advance was possibly the control of fire, for which caves occupied by Peking Man provide one of the earliest indications in the form of ash, charcoal, and burnt bones. Even that advance—if those cave fires really were man-lit rather than caused by lightning—would belong to *Homo erectus,* not *Homo sapiens.*

The emergence of *Homo sapiens* illustrates the paradox discussed in the previous chapter: that our rise to humanity was not directly proportional to the changes in our genes. Early *Homo sapiens* had progressed much further in anatomy than in cultural attainments along the road up from chimpanzeehood. Some crucial ingredients still had to be added before the Third Chimpanzee could conceive of painting the Sistine Chapel.

* * *

How did our ancestors make their living during the 1½ million years that spanned the emergence of *Homo erectus* and *Homo sapiens*?

The only surviving tools from this period are stone tools that can charitably be described as very crude, in comparison with the beautiful polished stone tools made until recently by Polynesians, American Indians, and other modern Stone Age peoples. Early stone tools vary in size and shape, and archaeologists have used those differences to give the tools different names, such as "hand axe," "chopper," and "cleaver." These names conceal the fact that none of those early tools had a sufficiently consistent or distinctive shape to suggest any specific function, as do the obvious needles and spear points left by the much later Cro-Magnons. Wear marks on the tools show that they were variously used to cut meat, bone, hides, wood, and nonwoody parts of plants. But any size or shape of tool seems to have been used to cut any of those things, and the tool names applied by archaeologists may be little more than arbitrary divisions of a continuum of stone forms.

Negative evidence is also significant here. Many advances in tools that appear after the Great Leap Forward were unknown to *Homo erectus* and early *Homo sapiens*. There were no bone tools, no ropes to make nets, and no fishhooks. All the early stone tools may have been held directly in the hand; they show no signs of having been mounted on other materials for increased leverage, as we mount steel axe blades on wooden handles.

What food did our early ancestors get with those crude tools, and how did they get it? At this point, anthropology books usually insert a long chapter entitled something like "Man the Hunter." The point here is that baboons, chimps, and some other primates occasionally prey on small vertebrates, but recently surviving Stone Age people (like Bushmen) did a lot of big-game hunting. So did Cro-Magnons, according to abundant archaeological evidence. There's no doubt that our early ancestors also ate some meat, as shown by marks of their stone tools on animal bones and by wear marks on their stone tools caused by cutting meat. The real question is: how *much* big-game hunting did our early ancestors do? Did big-game hunting skills improve gradually over the past 1½ million years, or was it only after the Great Leap Forward that they made a large contribution to our diet?

Anthropologists routinely reply that we have been successful big-game hunters for a long time. The supposed evidence comes mainly

from three archaeological sites occupied around 500,000 years ago: a cave at Zhoukoudian near Beijing, containing bones and tools of *Homo erectus* ("Peking Man") and bones of many animals; and two noncave (open-air) sites at Torralba and Ambrona in Spain, with stone tools plus bones of elephants and other large animals. It's usually assumed that the people who left the tools killed the animals, brought their carcasses to the site, and ate them there. But all three sites also have bones and fecal remains of hyenas, which could equally well have been the hunters. The bones of the Spanish sites in particular look as if they came from a collection of scavenged, water-washed, trampled carcasses such as one can find around African waterholes today, rather than from human hunters' camps.

Thus, while early humans ate some meat, we don't know how much meat they ate, or whether they got the meat by hunting or scavenging. It's not until much later, around 100,000 years ago, that we have good evidence about human hunting skills, and it's clear that humans then were still very *ineffective* big-game hunters. Hence human hunters of 500,000 years ago and earlier must have been even more ineffective.

The mystique of Man the Hunter is now so rooted in us that it's hard to abandon our belief in its long-standing importance. Today, shooting a big animal is regarded as an ultimate expression of macho masculinity. Trapped in this mystique, male anthropologists like to stress the key role of big-game hunting in human evolution. Supposedly, big-game hunting was what induced protohuman males to cooperate with each other, develop language and big brains, join into bands, and share food. Even women were supposedly molded by men's big-game hunting: women suppressed the external signs of monthly ovulation that are so conspicuous in chimps, so as not to drive men into a frenzy of sexual competition and thereby spoil men's cooperation at hunting.

As an example of the purple prose spawned by this men's locker-room mentality, consider the following account of human evolution by Robert Ardrey in his book *African Genesis:* "In some scrawny troop of beleaguered not-yet-men on some scrawny forgotten plain a radian particle from an unknown source fractured a never-to-be-forgotten gene, and a primate carnivore was born. For better or for worse, for tragedy or for triumph, for ultimate glory or ultimate damnation, intelligence made alliance with the way of the killer, and

Cain with his sticks and his stones and his quickly running feet emerged on the high savannah." What pure fantasy!

Western male writers and anthropologists aren't the only men with an exaggerated view of hunting. In New Guinea I've lived with real hunters, men who recently emerged from the Stone Age. Conversations at campfires go on for hours over each species of game animal, its habits, and how best to hunt it. To listen to my New Guinea friends, you would think that they eat fresh kangaroo for dinner every night and do little each day except hunt. In fact, when pressed for details, most New Guinea hunters admit that they have bagged only a few kangaroos in their whole lives.

I still recall my first morning in the New Guinea highlands, when I set out with a group of a dozen men armed with bows and arrows. As we passed a fallen tree, there was suddenly much excited shouting, men surrounded the tree, some spanned their bows, and others pressed forward into the brush pile. Convinced that an enraged boar or kangaroo was about to come out fighting, I looked for a tree that I could climb to a perch of safety. Then I heard triumphant shrieks, and out of the brush pile came two mighty hunters holding aloft their prey: two baby wrens, not quite able to fly, weighing about one-third of an ounce each, and promptly plucked, roasted, and eaten. The rest of that day's catch consisted of a few frogs and many mushrooms.

Studies of most modern hunter-gatherers with far more effective weapons than early *Homo sapiens* show that most of a family's calories comes from plant food gathered by women. Men catch rabbits and other small game never mentioned in the heroic campfire stories. Occasionally the men do bag a large animal, which does indeed contribute significantly to protein intake. But it's only in the Arctic, where little plant food is available, that big-game hunting becomes the dominant food source. And humans didn't reach the Arctic until within the last few dozen millennia.

I would guess that big-game hunting contributed only modestly to our food intake until *after* we had evolved fully modern anatomy and behavior. I doubt the usual view that hunting was the driving force behind our uniquely human brain and societies. For most of our history we were not mighty hunters but skilled chimps, using stone tools to acquire and prepare plant food and small animals. Occasionally, men did bag a large animal, and then retold the story of that rare event incessantly.

* * *

IN THE PERIOD just before the Great Leap Forward, at least three distinct human populations occupied different parts of the Old World. These were the last truly primitive humans, supplanted by fully modern people at the time of the Great Leap. Let's consider those among the last primitives whose anatomy is best known and who have become a metaphor for brutish subhumans: the Neanderthals.

Where and when did they live? Their geographic range extended from western Europe, through southern European Russia and the Near East, to Uzbekistan in Central Asia near the border of Afghanistan. (The name "Neanderthal" comes from Germany's Neander Valley [valley = *Thal*, or *Tal*, in German], where one of the first skeletons was discovered). As to the time of their origin, that's a matter of definition, since some old skulls have characteristics anticipating later full-blown Neanderthals. The earliest "full-blown" examples date to around 130,000 years ago, and most specimens postdate 74,000 years ago. While their start is thus arbitrary, their end is abrupt: the last Neanderthals died somewhat after 40,000 years ago.

During the time that Neanderthals flourished, Europe and Asia were in the grip of the last Ice Age. Neanderthals must have been a cold-adapted people—but only within limits. They got no further north than southern Britain, northern Germany, Kiev, and the Caspian Sea. The first penetration of Siberia and the Arctic was left to later, fully modern humans.

Neanderthals' head anatomy was so distinctive that, even if a Neanderthal dressed in a business suit or designer dress were to walk down the streets of New York or London today, everybody else (all the homines sapientes) on the street would be staring in shock. Imagine converting a modern face to soft clay, gripping the middle of the face from the bridge of the nose to the jaws in a vise, pulling the whole midface forward, and letting it harden again. You'll then have some idea of a Neanderthal's appearance. Their eyebrows rested on prominently bulging bony ridges, and their noses and jaws and teeth protruded far forward. Their eyes lay in deep sockets, sunk behind the protruding nose and brow ridges. Their foreheads were low and sloping, unlike our high vertical modern foreheads, and their lower jaws sloped back without chins. Despite these startlingly primitive

features, Neanderthals' brain size was nearly 10 percent *greater* than ours!

A dentist who examined a Neanderthal's teeth would have been in for a further shock. In adult Neanderthals the incisors (front teeth) were worn down on the outer-facing surface, in a way found in no modern people. Evidently, this peculiar wear pattern somehow resulted from a use of their teeth as tools, but what exactly was that function? As one possibility, they may have routinely used their teeth as vises to grip objects, like my baby sons, who gripped their milk bottles in their teeth and ran around with their hands free. Alternatively, Neanderthals may have bitten hides with their teeth to make leather, or bitten wood to make wooden tools.

While a Neanderthal in a business suit or dress would attract attention today, one in shorts or a bikini would draw gasps. Neanderthals were more heavily muscled, especially in their shoulders and neck, than all but the most avid modern bodybuilders. Their limb bones, which took the force of those big muscles' contracting, had to be considerably thicker than ours to withstand the stress. Their arms and legs would have looked stubby to us, because the lower leg and forearm were relatively shorter than ours. Even their hands were much more powerful than ours; a Neanderthal's handshake would have been literally bone-crushing. While their average height was only around five feet four inches, their weight would have been at least twenty pounds more than that of a modern person of that height, and this excess was mostly in the form of lean muscle.

One other possible anatomical difference is intriguing, though its reality as well as its interpretation are quite uncertain. A Neanderthal woman's birth canal may have been wider than a modern woman's, permitting her baby to grow inside her to a bigger size before birth. If so, a Neanderthal pregnancy might have lasted one year, instead of our nine months.

Besides their bones, our other main source of information about Neanderthals is their stone tools. As I described for earlier human tools, Neanderthal tools may have been simple hand-held stones not mounted on separate parts such as handles. The tools don't fall into distinct types with unique functions. There were no standardized bone tools, no bows and arrows. Some of the stone tools were undoubtedly used to make wooden tools, which rarely survive. One notable exception is a wooden thrusting spear eight feet long, found

in the ribs of a long-extinct species of elephant at an archaeological site in Germany. Despite that (lucky?) success, Neanderthals were probably not very good at big-game hunting, because Neanderthal population densities (to judge from the number of their sites) were much lower than those of later Cro-Magnons, and because even anatomically more modern people living in Africa at the same time as the Neanderthals were undistinguished as hunters.

If you say "Neanderthal" to friends and ask for their first association, you'll probably get back the answer "caveman." While most excavated Neanderthal remains do come from caves, that's surely an artifact of preservation, since open-air sites would be eroded much more quickly. Among my hundreds of campsites in New Guinea, one was in a cave, and that's the only site where future archaeologists are likely to find my pile of discarded tin cans intact. The archaeologists will also be deceived into considering me a caveman. Neanderthals must have constructed some type of shelter against the cold climate in which they lived, but those shelters must have been crude. All that remains is a few piles of stones and some postholes, compared to the elaborate remains of houses built by the later Cro-Magnons.

The list of other quintessentially modern human things that Neanderthals lacked is a long one. They left no unequivocal art objects. They must have worn some clothing in their cold environment, but it had to be crude, as they lacked needles and other evidence of sewing. They evidently lacked boats, as no Neanderthal remains are known from Mediterranean islands or even from North Africa, just eight miles across the Straits of Gibraltar from Neanderthal-populated Spain. There was no long-distance overland trade: Neanderthal tools are made of stones available within a few miles of the site.

Today we take cultural differences among people inhabiting different areas for granted. Every human population alive today has its characteristic house style, implements, and art. If you were shown chopsticks, a Guinness beer bottle, and a blowgun and asked to associate one object each with China, Ireland, and Borneo, you'd have no trouble giving the right answers. No such cultural variation is apparent for Neanderthals, whose tools look much the same whether they come from France or Russia.

We also take cultural progress with time for granted. The wares

from a Roman villa, medieval castle, and 1990 New York apartment differ obviously. In the year 2000 my sons will look with astonishment at the slide rule I used for calculations throughout the 1950s: "Daddy, are you *really* that old?" But Neanderthal tools from 100,000 and 40,000 years ago look essentially the same. In short, Neanderthal tools had no variation in either time or space to suggest that most human of characteristics, *innovation*. As one archaeologist put it, Neanderthals had "beautiful tools stupidly made." Despite Neanderthals' big brains, something was still missing.

Grandparenting, and what we consider old age, must also have been rare among Neanderthals. Their skeletons make clear that adults might live to their thirties or early forties, but not beyond forty-five. If we lacked writing *and* if none of us lived past forty-five, just think how the ability of our society to accumulate and transmit information would suffer.

I've had to mention all these subhuman qualities of Neanderthals, but there are three respects in which we can relate to their humanity. First, virtually all well-preserved Neanderthal caves have small areas of ash and charcoal indicating simple fireplaces. Hence, although Peking Man may have already used fire hundreds of thousands of years earlier, Neanderthals were the first people to leave undisputed evidence of fire's regular use. Neanderthals may also have been the first people who regularly buried their dead, but that's disputed, and whether it would imply religion is a matter of pure speculation. Finally, they regularly took care of their sick and aged. Most skeletons of older Neanderthals show signs of severe impairment, such as withered arms, healed but incapacitating broken bones, tooth loss, and severe osteoarthritis. Only care by young Neanderthals could have enabled such older Neanderthals to stay alive to the point of such incapacitation. After my long litany of what Neanderthals lacked, we've finally found something that lets us feel a spark of kindred spirit in these strange creatures of the last Ice Age—nearly human in form, and yet not really human in spirit.

Did Neanderthals belong to the same species as we do? That depends on whether we could and would have mated and reared a child with a Neanderthal man or woman, given the opportunity. Science-fiction novels love to imagine the scenario. You remember the blurb on many a back cover: "A team of explorers stumbles on a steep-walled valley in the center of deepest Africa, a valley that time

forgot. In this valley they find a tribe of incredibly primitive people, living in ways that our Stone Age ancestors discarded thousands of years ago. Do they belong to the same species as we do? There's only one way to find out, but who among the intrepid explorers can bring himself [male explorers, of course] to make the test?" At this point one of the bone-chewing cavewomen suddenly is described as beautiful and sexy in a primitively erotic way, so that modern novel readers will find the brave explorer's dilemma believable: does he or doesn't he have sex with her?

Believe it or not, something like that experiment actually took place. It happened repeatedly around forty thousand years ago, at the time of the Great Leap Forward.

I MENTIONED that the Neanderthals of Europe and western Asia were just one of at least three human populations occupying different parts of the Old World around 100,000 years ago. A few fossils from eastern Asia suffice to show that people there differed from Neanderthals as well as from us moderns, but too few bones have been found to describe these Asians in more detail. The best-characterized contemporaries of the Neanderthals are those from Africa, some of whom were virtually modern in their skull anatomy. Does this mean that, 100,000 years ago in Africa, we have at last arrived at the watershed of human cultural development?

Surprisingly, the answer is still "no." The stone tools of these modern-looking Africans were very similar to those of the decidedly unmodern-looking Neanderthals, hence we refer to them as "Middle Stone Age Africans." They still lacked standardized bone tools, bows and arrows, nets, fishhooks, art, and cultural variation in tools from place to place. Despite their mostly modern bodies, these Africans were still missing something needed to endow them with full humanity. Once again, we face the paradox that mostly modern bones, and presumably mostly modern genes, aren't enough by themselves to produce modern behavior.

Some South African caves occupied around 100,000 years ago provide us with the first time point in human evolution when we have detailed information about what people actually were eating. Our confidence stems from the fact that the African caves are full of stone tools, animal bones with cut marks from stone tools, and human

bones, but few or no bones of carnivores like hyenas. Thus, it's clear that people, not hyenas, brought the bones to the caves. Among the bones are many of seals and penguins, as well as shellfish such as limpets. That makes Middle Stone Age Africans the first people for whom there is even a hint that they exploited the seashore. However, the caves contain very few remains of fish or flying seabirds, undoubtedly because people still lacked the fishhooks and nets needed to catch fish and birds.

The mammal bones from the caves include those of quite a few medium-sized species, among which those of an antelope called eland predominate by far. Eland bones in the caves represent eland of all ages, as if people had somehow managed to capture a whole herd and kill every individual. At first, the relative abundance of eland among hunters' prey is surprising, since the caves' environment 100,000 years ago was much as it is today and since eland is now one of the least common large animals in the area. The secret to the hunters' success with eland probably lay in the fact that eland are rather tame, not dangerous, and easy to drive in herds. This suggests that hunters occasionally managed to drive a whole herd over a cliff, explaining why the distribution of eland ages among the cave kills is like that in a living herd. In contrast, more dangerous prey, such as Cape buffalo, pigs, elephants, and rhinos, yield a very different picture. Buffalo bones in the caves are mainly of very young or very old individuals, while pigs, elephants, and rhinos are virtually unrepresented.

Hence Middle Stone Age Africans can be considered big-game hunters, but only barely. They either avoided dangerous species entirely or confined themselves to weak old animals or babies. Those choices reflect sound prudence on the hunters' part, since their weapons were still spears for thrusting rather than bows and arrows. Along with drinking a strychnine cocktail, poking an adult rhino or Cape buffalo with a spear ranks as one of the most effective means of suicide that I know. Nor could the hunters have succeeded often at driving eland herds over cliffs, since elands weren't exterminated but continued to coexist with hunters. As with earlier peoples and modern Stone Age hunters, I suspect that plants and small game made up most of the diets of these not-so-great Middle Stone Age hunters. They were definitely more effective than chimpanzees, but not up to the skill of modern Bushmen and Pygmies.

The scene that the human world presented from around 100,000 to

somewhat before fifty thousand years ago was this. Northern Europe, Siberia, Australia, oceanic islands, and the whole New World were still empty of people. In Europe and western Asia lived the Neanderthals; in Africa, people increasingly like us moderns in their anatomy; and in eastern Asia, people unlike either the Neanderthals or Africans but known from only a few bones. All three of these populations were, at least initially, still primitive in their tools, behavior, and limited innovativeness. The stage was set for the Great Leap Forward. Which among these three contemporary populations would take that leap?

THE EVIDENCE for an abrupt rise is clearest in France and Spain, in the Late Ice Age around forty thousand years ago. Where there had previously been Neanderthals, anatomically fully modern people (often known as Cro-Magnons, from the French site where their bones were first identified) now appear. Had one of those gentlemen or ladies strolled down the Champs Élysées in modern attire, he or she would not have stood out from the Parisian crowds in any way. As significant to archaeologists as the Cro-Magnons' skeletons are their tools, which are far more diverse in form and obvious in function than any in the earlier archaeological record. The tools suggest that modern anatomy had at last been joined by modern innovative behavior.

Many of the tools continued to be of stone, but they were now made from thin blades struck off larger stones, thereby yielding ten times more cutting edge from a given quantity of raw stone than obtainable previously. Standardized bone and antler tools appeared for the first time. So did unequivocal compound tools of several parts tied or glued together, such as spear points set in shafts or axe heads fitted onto wooden handles. Tools fall into many distinct categories whose function is often obvious, such as needles, awls, mortars and pestles, fishhooks, net sinkers, and rope. The rope (used in nets or snares) accounts for the frequent bones of foxes, weasels, and rabbits at Cro-Magnon sites, while the rope, fishhooks, and net sinkers explain the bones of fish and flying birds at contemporary South African sites.

Sophisticated weapons for safely killing dangerous large animals at a distance now appear—weapons such as barbed harpoons, darts,

spear throwers, and bows and arrows. South African caves occupied by people now yield bones of such vicious prey as adult Cape buffalo and pigs, while European caves are full of bones of bison, elk, reindeer, horse, and ibex. Even today, hunters armed with high-powered telescopic rifles find it hard to bag some of these species, which must have required highly skilled communal hunting methods based on detailed knowledge of each species' behavior.

Several types of evidence testify to the effectiveness of Late Ice Age people as big-game hunters. Their sites are much more numerous than those of earlier Neanderthals or Middle Stone Age Africans, implying more success at obtaining food. Numerous species of big animals that had survived many previous ice ages became extinct toward the end of the last Ice Age, suggesting that they were exterminated by human hunters' new skills. These likely victims, to be discussed in later chapters, include the mammoths of North America, Europe's woolly rhino and giant deer, southern Africa's giant buffalo and giant Cape horse, and Australia's giant kangaroos. Evidently, the most brilliant moment of our rise already contained the seeds of what may yet prove a cause of our fall.

Improved technology now allowed humans to occupy new environments, as well as to multiply in previously occupied areas of Eurasia and Africa. Australia was first reached by humans around fifty thousand years ago, implying watercraft capable of crossing water gaps as wide as sixty miles between eastern Indonesia and Australia. The occupation of northern Russia and Siberia by at least twenty thousand years ago depended on many advances: sewn clothing, whose existence is reflected in eyed needles, cave paintings of parkas, and grave ornaments marking outlines of shirts and trousers; warm furs, indicated by fox and wolf skeletons minus the paws (removed in skinning and found in a separate pile); elaborate houses (marked by postholes, pavements, and walls of mammoth bones), with elaborate fireplaces; and stone lamps to hold animal fat and light the long Arctic nights. The occupation of Siberia and Alaska in turn led to the occupation of North America and South America around eleven thousand years ago.

Whereas Neanderthals obtained their raw materials within a few miles of home, Cro-Magnons and their contemporaries throughout Europe practiced long-distance trade, not only for raw materials of tools but also for "useless" ornaments. Tools of high-quality stone

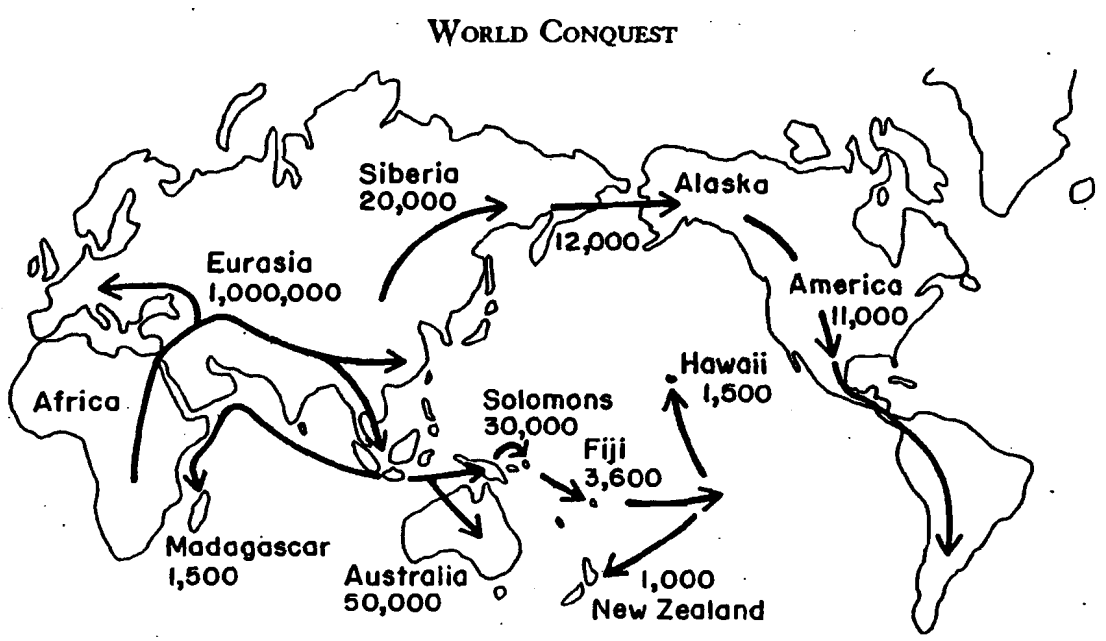

Figure 3. This map illustrates stages in the spread of our ancestors from their African origins to populate the world. Numbers stand for estimated number of years before the present. Further discoveries of older archaeological sites may well show that some regions, such as Siberia or the Solomons, were colonized earlier than the estimated dates shown here.

such as obsidian, jasper, and flint are found hundreds of miles from where those stones were quarried. Baltic amber reached southeast Europe, while Mediterranean shells were carried to inland parts of France, Spain, and the Ukraine. I saw very similar patterns in modern Stone Age New Guinea, where cowry shells prized as decorations were traded up to the highlands from the coast, bird-of-paradise plumes were traded back down to the coast, and obsidian for stone axes was traded out from a few highly valued quarries.

The evident aesthetic sense reflected in Late Ice Age trade in ornaments relates to the achievements for which we most admire the Cro-Magnons: their art. Best known, of course, are the rock paintings from caves like Lascaux, with stunning polychrome depictions of now-extinct animals. But equally impressive are the bas reliefs, necklaces and pendants, fired-clay ceramic sculptures, Venus figurines of women with enormous breasts and buttocks, and musical instruments ranging from flutes to rattles.

Unlike Neanderthals, few of whom lived past the age of forty, some Cro-Magnon skeletons indicate survival to sixty. Many Cro-Magnons, but few Neanderthals, lived to enjoy their grandchildren. Those of us accustomed to getting our information from the printed page or television will find it hard to appreciate how important even just one or two old people are in preliterate society. In New Guinea villages it often happens that younger men lead me to the oldest person in the village when I stump them with a question about some uncommon bird or fruit. For example, when I visited Rennell Island in the Solomons in 1976, many islanders told me what wild fruits were good to eat, but only one old man could tell me what other wild fruits could be eaten in an emergency to avoid starvation. He remembered that information from a cyclone that had hit Rennell in his childhood (around 1905), destroying gardens and reducing his people to a state of desperation. One such person in a preliterate society can thus spell the difference between death and survival for the whole society. Hence the fact that some Cro-Magnons survived twenty years longer than any Neanderthal probably played a big role in Cro-Magnon success. Living to an older age required not just improved survival skills but also some biological changes, possibly including the evolution of human female menopause.

I've described the Great Leap Forward as if all those advances in tools and art appeared simultaneously forty thousand years ago. In fact, different innovations appeared at different times. Spear throwers appeared before harpoons or bows and arrows, while beads and pendants appeared before cave paintings. I've also described the changes as if they were the same everywhere, but they weren't. Among Late Ice Age Africans, Ukrainians, and French, only the Africans made beads out of ostrich eggs, only the Ukrainians built houses out of mammoth bones, and only the French painted woolly rhinos on cave walls.

These variations of culture in time and space are totally unlike the unchanging monolithic Neanderthal culture. They constitute the most important innovation that came with our rise to humanity: namely, the capacity for innovation itself. To us today, who can't picture a world in which Nigerians and Latvians in 1991 have virtually the same possessions as each other and as Romans in 50 B.C., innovation is utterly natural. To Neanderthals, it was evidently unthinkable.

Despite our instant sympathy with Cro-Magnon art, their stone tools and hunter-gatherer life-style make it hard for us to view them as other than primitive. Stone tools evoke cartoons of club-waving cavemen uttering grunts as they drag a woman off to their cave. But we can form a more accurate impression of Cro-Magnons if we imagine what future archaeologists will conclude after excavating a New Guinea village site from as recently as the 1950s. The archaeologists will find a few simple types of stone axes. Virtually all other material possessions were made of wood and will have perished. Nothing will remain of the multistory houses, beautifully woven baskets, drums and flutes, outrigger canoes, and world-quality painted sculpture. There will be no trace of the village's complex language, songs, social relationships, and knowledge of the natural world.

New Guinea material culture was until recently "primitive" (i.e., Stone Age) for historical reasons, but New Guineans are fully modern humans. New Guineans whose fathers lived in the Stone Age now pilot airplanes, operate computers, and govern a modern state. If we could carry ourselves back forty thousand years in a time machine, I suspect that we would find Cro-Magnons to be equally modern people, capable of learning to fly a jet plane. They made stone and bone tools only because no other tools had yet been invented; that's all they had the opportunity to learn.

IT USED TO BE ARGUED that Neanderthals evolved into Cro-Magnons within Europe. That possibility now seems increasingly unlikely. The last Neanderthal skeletons from somewhat after forty thousand years ago were still "full-blown" Neanderthals, while the first Cro-Magnons appearing in Europe at the same time were already anatomically fully modern. Since anatomically modern people were already present in Africa and the Near East tens of thousands of years earlier, it seems much more likely that anatomically modern people invaded Europe from that direction than that they evolved within Europe.

What happened when invading Cro-Magnons met the resident Neanderthals? We can be certain only of the end result: within a short time, no more Neanderthals. The conclusion seems to me inescapable that Cro-Magnon arrival somehow caused Neanderthal

extinction. Yet many archaeologists recoil at this conclusion and invoke environmental changes instead. For example, the *Encyclopedia Britannica*'s fifteenth edition concludes its entry for Neanderthals with the sentence "The disappearance of the Neanderthals, although it cannot yet be fixed in time, was probably the result of being creatures of an interglacial period unable to avoid the ravages of another Ice Age." In fact, Neanderthals thrived during the last Ice Age, and suddenly disappeared over thirty thousand years after its start and an equal time before its end.

My guess is that events in Europe at the time of the Great Leap Forward were similar to events that have occurred repeatedly in the modern world, whenever a numerous people with more advanced technology invades the lands of a much less-numerous people with less-advanced technology. For instance, when European colonists invaded North America, most North American Indians proceeded to die of introduced epidemics; most of the survivors were killed outright or driven off their land; some of the survivors adopted European technology (horses and guns) and resisted for some time; and many of the remaining survivors were pushed onto lands that Europeans did not want, or else intermarried with Europeans. The displacement of Aboriginal Australians by European colonists, and of southern African San populations (Bushmen) by invading iron-age Bantu speakers, followed a similar course.

By analogy, I guess that Cro-Magnon diseases, murders, and displacements did in the Neanderthals. If so, then the Cro-Magnon-Neanderthal transition was a harbinger of what was to come, when the victors' descendants began squabbling among themselves. It may at first seem paradoxical that Cro-Magnons prevailed over the far more muscular Neanderthals, but weaponry rather than strength would have been decisive. Similarly, it's not gorillas that are now threatening to exterminate humans in central Africa, but vice versa. People with huge muscles require lots of food, and they thereby gain no advantage if slimmer, smarter people can use tools to do the same work.

Like the Great Plains Indians, some Neanderthals may have learned some Cro-Magnon ways and resisted for a while. This is the only sense I can make of a puzzling culture called the Châtelperronian, which coexisted in western Europe along with a typical Cro-

Magnon culture (the so-called Aurignacian culture) for a short time after Cro-Magnons arrived. Châtelperronian stone tools are a mixture of typical Neanderthal and Cro-Magnon tools, but the bone tools and art typical of Cro-Magnons are usually lacking. The identity of the people who produced Châtelperronian culture was debated by archaeologists until a skeleton unearthed with Châtelperronian artifacts at Saint-Césaire in France proved to be Neanderthal. Perhaps, then, some Neanderthals managed to master some Cro-Magnon tools and hold out longer than their fellows.

What remains unclear is the outcome of the interbreeding experiment posed in science-fiction novels. Did some invading Cro-Magnon men mate with some Neanderthal women? No skeletons that could reasonably be considered Neanderthal-Cro-Magnon hybrids are known. If Neanderthal behavior was as relatively rudimentary, and Neanderthal anatomy as distinctive as I suspect, few Cro-Magnons may have wanted to mate with Neanderthals. Similarly, although humans and chimps continue to coexist today, I'm not aware of any matings. While Cro-Magnons and Neanderthals weren't nearly as different, the differences may still have been a mutual turnoff. And if Neanderthal women were geared for a twelve-month pregnancy, a hybrid fetus might not have survived. My inclination is to take the negative evidence at face value, to accept that hybridization occurred rarely if ever, and to doubt that living people of European descent carry any Neanderthal genes.

So much for the Great Leap Forward in western Europe. The replacement of Neanderthals by modern people occurred somewhat earlier in eastern Europe, and still earlier in the Near East, where possession of the same area apparently shifted back and forth between Neanderthals and modern people from ninety thousand to sixty thousand years ago. The slowness of the transition in the Near East, compared to its speed in western Europe, suggests that the anatomically modern people living around the Near East before sixty thousand years ago had not yet developed the modern behavior that ultimately let them drive out the Neanderthals.

Thus, we have a tentative picture of anatomically modern people arising in Africa over a hundred thousand years ago, but initially making the same tools as Neanderthals and having no advantage over them. By perhaps sixty thousand years ago, some magic twist of

behavior had been added to the modern anatomy. That twist (of which more in a moment) produced innovative, fully modern people who proceeded to spread westward from the Near East into Europe, quickly supplanting Europe's Neanderthals. Presumably, those modern people also spread east into Asia and Indonesia, supplanting the earlier people there, of whom we know little. Some anthropologists think that skull remains of those earlier Asians and Indonesians show traits recognizable in modern Asians and Aboriginal Australians. If so, the invading moderns may not have exterminated the original Asians without issue, as they did the Neanderthals, but instead interbred with them.

Two million years ago, several protohuman lineages had coexisted side by side until a shakedown left only one. It now appears that a similar shakedown occurred within the last sixty thousand years, and that all of us alive in the world today are descended from the winner of that shakedown. What was the last missing ingredient whose acquisition helped our ancestor to win?

THE IDENTITY of the ingredient that produced the Great Leap Forward poses an archaeological puzzle without an accepted answer. It doesn't show up in fossil skeletons. It may have been a change in only 0.1 percent of our DNA. What tiny change in genes could have had such enormous consequences?

Like some other scientists who have speculated about this question, I can think of only one plausible answer: the anatomical basis for spoken complex language. Chimpanzees, gorillas, and even monkeys are capable of symbolic communication not dependent on spoken words. Both chimpanzees and gorillas have been taught to communicate by means of sign language, and chimpanzees have learned to communicate via the keys of a large computer-controlled console. Individual apes have thus mastered "vocabularies" of hundreds of symbols. While scientists argue over the extent to which such communication resembles human language, there is little doubt that it constitutes a form of symbolic communication. That is, a particular sign or computer key symbolizes a particular something else.

Primates can use not just signs and computer keys, but also sounds, as symbols. For instance, wild vervet monkeys have a natural form of

symbolic communication based on grunts, with slightly different grunts to mean "leopard," "eagle," and "snake." A month-old chimpanzee named Viki, adopted by a psychologist and his wife and reared virtually as their daughter, learned to "say" approximations of four words: "papa," "mama," "cup," and "up." (The chimp breathed rather than spoke those words.) Given this capability for symbolic communication using sounds, why have apes not gone on to develop much more complex natural languages of their own?

The answer seems to involve the structure of the larynx, tongue, and associated muscles that give us fine control over spoken sounds. Like a Swiss watch, all of whose many parts have to be well designed for the watch to keep time at all, our vocal tract depends on the precise functioning of many structures and muscles. Chimps are thought to be physically incapable of producing several of the commonest human vowels. If we too were limited to just a few vowels and consonants, our own vocabulary would be greatly reduced. For example, take this paragraph, convert all vowels other than "a" or "i" to either of those two, convert all consonants other than "d" or "m" or "s" to one of those three, and then see how much of the paragraph you can still understand.

That's why it's plausible that the missing ingredient may have been some modifications of the protohuman vocal tract to give us finer control and permit formation of a much greater variety of sounds. Such fine modifications of muscles need not be detectable in fossil skulls.

It's easy to appreciate how a tiny change in anatomy resulting in capacity for speech would produce a huge change in behavior. With language, it takes only a few seconds to communicate the message, "Turn sharp right at the fourth tree and drive the male antelope toward the reddish boulder, where I'll hide to spear it." Without language, that message could not be communicated at all. Without language, two protohumans could not brainstorm together about how to devise a better tool, or about what a cave painting might mean. Without language, even one protohuman would have had difficulty thinking out for himself or herself how to devise a better tool.

I don't suggest that the Great Leap Forward began as soon as the mutations for altered tongue and larynx anatomy arose. Given the

right anatomy, it must have taken humans thousands of years to perfect the structure of language as we know it—to arrive at the concepts of word order and case endings and tenses, and to develop vocabulary. In Chapter 8 I'll consider some possible stages by which our language might have become perfected. But if the missing ingredient did consist of changes in our vocal tract that permitted fine control of sounds, then the capacity for innovation would follow eventually. It was the spoken word that made us free.

This interpretation seems to me to account for the lack of evidence for Neanderthal-Cro-Magnon hybrids. Speech is of overwhelming importance in the relations between men and women and their children. That's not to deny that mute or deaf people learn to function well in our culture, but they do so by learning to find alternatives for a spoken language that already exists. If Neanderthal language was much simpler than ours or nonexistent, it's not surprising that Cro-Magnons didn't choose to marry Neanderthals.

I'VE ARGUED that we were fully modern in anatomy and behavior and language by forty thousand years ago, and that a Cro-Magnon could have been taught to fly a jet airplane. If so, why did it take so long after the Great Leap Forward for us to invent writing and build the Parthenon? The answer may be similar to the explanation why the Romans, great engineers that they were, didn't build atomic bombs. To reach the point of building an A-bomb required two thousand years of technological advances beyond Roman levels, such as the invention of gunpowder and calculus, the development of atomic theory, and the isolation of uranium. Similarly, writing and the Parthenon depended on tens of thousands of years of cumulative developments after the arrival of Cro-Magnons—developments that included the bow and arrow, pottery, domestication of plants and animals, and many others.

Until the Great Leap Forward, human culture had developed at a snail's pace for millions of years. That pace was dictated by the slow pace of genetic change. After the leap, cultural development no longer depended on genetic change. Despite negligible changes in our anatomy, there has been far more cultural evolution in the past forty thousand years than in the millions of years before. Had a visitor from Outer Space come to the Earth in Neanderthal times, humans

would not have stood out as unique among the world's species. At most, the visitor might have mentioned humans along with beavers, bowerbirds, and army ants as examples of species with curious behavior. Would the visitor have foreseen the change that would soon make us the first species, in the history of life on Earth, capable of destroying all life?