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The Great Leap Forward

JARED DIAMOND

World population figures around 1 A.D. have been estimated at about 200 million people. One million years prior to 1 A.D., population figures of early humankind of *Homo sapiens* or *Homo erectus* have been estimated at about 125,000. In order for us to understand and appreciate the very long path of this development and growth of humankind, it is helpful to discuss early hominoid history and its development, expansion, and explosion along with a discussion of the relationship of tools, concepts, and technology to that expansion. "The Great Leap Forward" gives some perspectives on the early struggles of humankind and exponential growth toward modern creativity, expansion, and technology.

One can hardly blame nineteenth-century creationists for insisting that humans were separately created by God. After all, between us and other animal species lies the seemingly unbridgeable gulf of language, art, religion, writing, and complex machines. Small wonder, then, that to many people Darwin's theory of our evolution from apes appeared absurd.

Since Darwin's time, of course, fossilized bones of hundreds of creatures intermediate between apes and modern humans have been discovered. It is no longer possible for a reasonable person to deny that what once seemed absurd actually happened—somehow. Yet the discoveries of many missing links have only made the problem more fascinating without fully solving it. When and how did we acquire our uniquely human characteristics?

We know that our lineage arose in Africa, diverging from that of chimpanzees and gorillas, sometime between 6 and 10 million years ago. For most of the time since then we have been little more than glorified baboons. As recently as 35,000 years ago western Europe was still occupied by Neanderthals, primitive beings for whom art and progress scarcely existed. Then there was an abrupt change. Anatomically modern people appeared in Europe and, suddenly, so did sculpture, musical instruments, lamps, trade, and innovation. Within a few thousand years the Neanderthals were gone.

Insofar as there was any single moment when we could be said to have become human, it was at the time of this Great Leap Forward 35,000 years ago. Only a few more dozen millennia—a trivial fraction of our 6- to 10-million year history—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 us from all other animals—monuments such as the *Mona Lisa* and the Ninth Symphony, the Eiffel Tower and Sputnik, Dachau's ovens and the bombing of Dresden.

What happened at that magic moment in evolution? 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, and if so, how did they behave toward each other? We still share 98 percent of our genes with chimps; which genes among the other 2 percent had such enormous consequences?

Understanding the Great Leap Forward isn't easy; neither is writing about it. The immediate evidence comes from technical details of preserved bones and stone tools. Archeologists' reports are full of such terms as "transverse occipital torus," "receding zygomatic arches," and "Chatelperronian

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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. Much of the evidence is missing, and archeologists often disagree over the meaning of the evidence that has survived.

I'll emphasize those inferences rather than the technical details, and I'll speculate about the answers to those questions I just listed above. But you can form your own opinions, and they may differ from mine. This is a puzzle whose solution is still unknown.

To set the stage quickly, recall that life originated on Earth several billion years ago, the dinosaurs became extinct around 65 million years ago, and, as I mentioned, our ancestors diverged from the ancestors of chimps and gorillas between 6 and 10 million years ago. They then remained confined to Africa for millions of years.

Initially, our ancestors would have been classified as merely another species of ape, but a sequence of three changes launched them in the direction of modern humans. The first of these changes occurred by around 4 million years ago: the structure of fossilized limb bones shows that our ancestors, in contrast to gorillas and chimps, were habitually walking upright. The upright posture freed our forelimbs to do other things, among which toolmaking would eventually prove to be the most important.

The second change occurred around 3 million years ago, when our lineage split in two. As background, remember that members of two animal species living in the same area must fill different ecological roles and do not normally interbreed. 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. However, wolves are larger, they usually hunt big mammals like deer and moose, and they often live in sizable packs, whereas coyotes are smaller, mainly hunt small mammals like rabbits and mice, and normally live in pairs or small groups.

Now, all modern humans unquestionably belong to the same species. Ecological differences among us are entirely a product of childhood education: it is not the case that some of us are born big and habitually hunt deer while others are born small, gather berries, and don't marry the deer hunters. And every human population living today has interbred with every other human population with which it has had extensive contact.

Three million years ago, however, there were hominid species as distinct as wolves and coyotes. On one branch of the family tree was a man-ape with a heavily built skull and very big cheek teeth, who probably ate coarse plant food; he has come to be known as *Australopithecus robustus* (the "robust southern ape"). On the other branch was a man-ape with a more lightly built skull and smaller teeth, who most likely had an omnivorous diet; he is known as *Australopithecus africanus* (the "southern ape of Africa"). Our lineage may have experienced such a radical division at least once more, at the time of the Great Leap Forward. But the description of that event will have to wait.

There is considerable disagreement over just what occurred in the next million years, but the argument I find most persuasive is that *A. africanus* evolved into the larger-brained form we call *Homo habilis* ("man the handyman"). Complicating the issue is that fossil bones often attributed to *H. habilis* differ so much in skull size and tooth size that they may actually imply another fork in our lineage yielding two distinct *habilis*-like species: *H. habilis* himself and a mysterious "Third Man." Thus, by 2 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. By around 2.5 million years ago, very crude stone tools appear in large 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. (There is, however, the intriguing possibility that at least some of our robust relatives also made tools, as recent anatomical analyses of hand bones from the Swartkrans cave in South Africa suggest. See "The Gripping Story of Paranthropus," by Pat Shipman, in the April 1989 issue of *Discover Magazine*.)

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 *H. habilis*, who went on to increase in brain size and body size. By around 1.7 million years ago, the differences were sufficient that anthropologists give our lineage the new name *Homo erectus* ("the man who walks upright"—*H. erectus* fossils were discovered before all the earlier ones, so anthropologists didn't realize that *H. erectus* wasn't the first protohuman to walk upright). The robust man-ape disappeared somewhat after 1.2 million years ago, and the Third Man (if he ever existed) must have disappeared by then also.

As for why *H. erectus* survived and *A. robustus* didn't, we can only speculate. A plausible guess is that the robust man-ape could no longer compete: *H. erectus* ate both

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meat and plant food, and his larger brain may have made him more efficient at getting the food on which *A. robustus* depended. It's also possible that *H. erectus* gave his robust brother a direct push into oblivion by killing him for meat.

The shakedown left *H. erectus* as the sole protohuman player on the African stage, a stage to which our closest living relatives (the chimp and gorilla) are still confined. But around 1 million years ago, *H. erectus* began to expand 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 skull roundness. Approximately 500,000 years ago, some of our ancestors looked sufficiently enough like us—and sufficiently different from earlier *H. erectus*—to be classified as our own species, *Homo sapiens* (the "wise man"). However, they still had thicker skulls and brow ridges than we do today.

Was our meteoric ascent to sapiens status half a million years ago the brilliant climax of Earth's history, when art and sophisticated technology finally burst upon our previously dull planet? Not at all. The appearance of *H. sapiens* was a non-event. The Great Leap Forward, as proclaimed by cave paintings, houses, and bows and arrows, still lay hundreds of thousands of years in the future. Stone tools continued to be the crude ones that *H. erectus* had been making for nearly a million years. The extra brain size of those early *H. sapiens* had no dramatic effect on their way of life. That whole long tenure of *H. erectus* and early *H. sapiens* outside Africa was a period of infinitesimally slow cultural change.

So what was life like during the 1.5 million years that spanned the emergence of *H. erectus* and *H. sapiens*? The only surviving tools from this period are stone implements that can, charitably, be described as very crude. Early stone tools do vary in size and shape, and archeologists have used those differences to give the tools different names, such as hand-ax, chopper, and cleaver. But these names conceal the fact that none of these early tools had a sufficiently consistent or distinctive shape to suggest any specific function. 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 tool seems to have been used to cut any of these things, and the categories imposed by archeologists may be little more than arbitrary divisions of a continuum of stone forms.

Negative evidence is also significant. All the early stone tools may have been held directly in the hand; they show no signs of being mounted on other materials for increased leverage, as we mount steel ax blades on wooden handles. There were no bone tools, no ropes to make nets, and no fishhooks.

What food did our early ancestors get with those crude tools, and how did they get it? To address this question, anthropology textbooks usually insert a long chapter entitled something like "Man the Hunter." The point they make is that baboons, chimps, and some other primates prey on small vertebrates only occasionally, but recently surviving Stone Age people (like Bushmen) did a lot of big-game hunting. There's no doubt that our early ancestors also ate some meat. The question is, how much meat? Did big-game hunting skills improve gradually over the past 1.5 million years, or was it only since the Great Leap Forward—a mere 35,000 years ago—that they made a large contribution to our diet?

Anthropologists routinely reply that we've long been successful big-game hunters, but in fact there is no good evidence of hunting skills until around 100,000 years ago, and it's clear that even then humans were still very ineffective hunters. So it's reasonable to assume that earlier hunters were even more ineffective.

Yet 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. Supposedly, big-game hunting was what induced protohuman males to cooperate with one another, develop language and big brains, join into bands, and share food. Even women were supposedly molded by big-game hunting: they 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.

But studies of modern hunter gatherers, with far more effective weapons than those of early *H. sapiens*, show that most of a family's calories come from plant food gathered by women. Men catch rats and other small game never mentioned in their heroic campfire stories. Occasionally they get 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 around 30,000 years ago.

So I would guess that big-game hunting contributed little 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 rather sophisticated baboons.

To return to our history: *H. sapiens*, you'll recall, took center stage around half a million years ago in Africa, the Near East, the Far East, and Europe. By 100,000 years ago, humans had settled into at least three distinct populations occupying different parts of the Old World. These were the

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last truly primitive people. Let's consider among them those whose anatomy is best known, those who have become a metaphor for brutishness: the Neanderthals.

Where and when did they live? Their name comes from Germany's Neander Valley, where one of the first skeletons was discovered (in German, *thal*—nowadays spelled *tal*—means "valley"). 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. 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 from 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 around 32,000 years ago.

During the time that Neanderthals flourished, Europe and Asia were in the grip of the last ice age. Hence Neanderthals must have been a cold-adapted people—but only within limits. They got no farther north than southern Britain, northern Germany, Kiev, and the Caspian Sea.

Neanderthals' head anatomy was so distinctive that, even if a Neanderthal dressed in a business suit or a designer dress were to walk down the street today, all you *H. sapiens* 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, pulling the whole mid-face 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 nose 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 a chin. Yet despite these startlingly primitive features, Neanderthals' brain size was nearly 10 percent greater than ours! (This does not mean they were smarter than us; they obviously weren't. Perhaps their larger brains simply weren't "wired" as well.) A dentist who examined a Neanderthal's teeth would have been in for a further shock. In adult Neanderthals front teeth were worn down on the outer surface, in a way found in no modern people. Evidently this peculiar wear pattern resulted from their using their teeth as tools, but what exactly did they do? As one possibility, they may have routinely used their teeth like a vise, as my baby sons do when they grip a milk bottle in their teeth and run around with their hands free. Alternatively, Neanderthals may have bitten hides to make leather or wood to make tools.

While a Neanderthal in a business suit or a dress would attract your attention, one in shorts or a bikini would be even more startling. Neanderthals were more heavily muscled, especially in their shoulders and neck, than all but the most avid 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 bone crushing. While their average height was only around 5 feet 4 inches, their weight was at least 20 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, although its reality as well as its interpretation are quite uncertain—the fossil evidence so far simply doesn't allow a definitive answer. But 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 nine months.

Besides their bones, our other main source of information about Neanderthals is their stone tools. Like 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 archeological site in Germany. Despite that (lucky?) success, Neanderthals were probably not very good at big-game hunting; 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. 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 remain are postholes and a few piles of stones.

The list of 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

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cold environment, but that clothing had to be crude since they lacked needles and other evidence of sewing. They evidently had no boats, as no Neanderthal remains are known from Mediterranean islands nor even from North Africa, just eight miles across the Strait 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 modern human population has its characteristic house style, implements, and art. If you were shown chopsticks, a Schlitz beer bottle, and a blowgun and asked to associate one object each with China, Milwaukee, 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 no matter where they come from.

We also take cultural progress with time for granted. It is obvious to us that the wares from a Roman villa, a medieval castle, and a Manhattan apartment circa 1988 should differ. In the 1990s, my sons will look with astonishment at the slide rule I used throughout the 1950s. But Neanderthal tools from 100,000 and 40,000 years ago look essentially the same. In short, Neanderthal tools had no variation in time or space to suggest that most human of characteristics, *innovation*.

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 45. If we lacked writing and if none of us lived past 45, just think how the ability of our society to accumulate and transmit information would suffer.

But despite all these subhuman qualities, there are three respects in which we can relate to Neanderthals' humanity. They were the first people to leave conclusive evidence of fire's regular, everyday use: nearly all well-preserved Neanderthal caves have small areas of ash and charcoal indicating a simple fireplace. Neanderthals were also the first people who regularly buried their dead, though whether this implies 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 folks to stay alive to the point of such incapacitation. After my 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 Ice Age—human, and yet not really human.

Did Neanderthals belong to the same species as we do? That depends on whether we 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 a pulpy 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. Are they the same species as us?" Naturally, there's only one way to find out, but who among the intrepid explorers— male explorers, of course—can bring himself to make the test? At this point one of the bone-chewing cavewomen is described as beautiful and sexy in a primitively erotic way, so that 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 35,000 years ago, around the time of the Great Leap Forward. But you'll have to be patient just a little while longer.

Remember, 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 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 almost modern in their skull anatomy. Does this mean that, 100,000 years ago in Africa, we have at last arrived at the Great Leap Forward?

Surprisingly, the answer is still no. The stone tools of these modern-looking Africans were very similar to those of the non–modern-looking Neanderthals, so we refer to them as Middle Stone Age Africans. They still lacked standardized bone tools, bows and arrows, art, and cultural variation. Despite their mostly modern bodies, these Africans were still missing something needed to endow them with modern behavior.

Some South African caves occupied around 100,000 years ago provide us with the first point in human evolution for which we have detailed information about what people were eating. Among the bones found in the caves are many of seals and penguins, as well as shellfish such as limpets; Middle Stone Age Africans are 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 birds, undoubtedly because people still lacked fishhooks and nets.

The mammal bones from the caves include those of quite a few medium-size species, predominant among which are those of the eland, an antelope species. Eland bones in

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the caves represent animals of all ages, as if people had somehow managed to capture a whole herd and kill every individual. The secret to the hunters' success is most likely that eland are rather tame and easy to drive in herds. Probably the hunters occasionally managed to drive a whole herd over a cliff: that would explain 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 mostly of very young or very old individuals, while pigs, elephants, and rhinos are virtually unrepresented.

So Middle Stone Age Africans can be considered big-game hunters, but just barely. They either avoided dangerous species entirely or confined themselves to weak old animals or babies. Those choices reflect prudence: their weapons were still spears for thrusting rather than bows and arrows, and—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. As with earlier peoples and modern Stone Age hunters, I suspect that plants and small game made up most of the diet of these not-so-great hunters. They were definitely more effective than baboons, but not up to the skill of modern Bushmen and Pygmies.

Thus, the scene that the human world presented from around 130,000 years ago to sometime before 50,000 years ago was this: Northern Europe, Siberia, Australia, and the whole New World were still empty of people. In the rest of Europe and western Asia lived the Neanderthals; in Africa, people increasingly like us in anatomy; and in eastern Asia, people unlike either the Neanderthals or Africans but known from only a few bones. All three populations were 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 change—at last!—is clearest in France and Spain, in the late Ice Age around 35,000 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. Were one of those gentlemen or ladies to stroll down the Champs Elysées in modern attire, he or she would not stand out from the Parisian crowds in any way. Cro-Magnons' tools are as dramatic as their skeletons; they are far more diverse in form and obvious in function than any in the earlier archeological record. They suggest that modern anatomy had at last been joined by modern innovative behavior.

Many of the tools continue to be of stone, but they are now made from thin blades struck off a larger stone, thereby yielding roughly ten times more cutting edge from a given quantity of raw stone. Standardized bone and antler tools appear for the first time. So do unequivocal compound tools of several parts tied or glued together, such as spear points set in shafts or ax heads hafted to handles. Tools fall into many distinct categories whose function is often obvious, such as needles, awls, and mortars and pestles. Rope, used in nets or snares, accounts for the frequent bones of foxes, weasels, and rabbits at Cro-Magnon sites. Rope, fishhooks, and net sinkers explain the bones of fish and flying birds at contemporary South African sites.

Sophisticated weapons for killing dangerous animals at a distance now appear also—weapons such as barbed harpoons, darts, spear-throwers, and bows and arrows. South African caves 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. Several types of evidence testify to the effectiveness of late Ice Age people as big-game hunters. Bagging some of these animals must have required communal hunting methods based on detailed knowledge of each species' behavior. And Cro-Magnon sites are much more numerous than those of earlier Neanderthals or Middle Stone Age Africans, implying more success at obtaining food. Moreover, 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. Likely victims include Europe's woolly rhino and giant deer, southern Africa's giant buffalo and giant Cape horse, and—once improved technology allowed humans to occupy new environments—the mammoths of North America and Australia's giant kangaroos.

Australia was first reached by humans around 50,000 years ago, which implies the existence of watercraft capable of crossing the 60 miles from eastern Indonesia. The occupation of northern Russia and Siberia by at least 20,000 years ago depended on many advances: tailored clothing, as evidenced by 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 in turn led to the occupation of North America and South America approximately 11,000 years ago.

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

The evident aesthetic sense reflected in late Ice Age trade relates to the achievements for which we most admire the Cro-Magnons: their art. Best known 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 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 40, some Cro-Magnons survived to 60. Those additional 20 years probably played a big role in Cro-Magnon success. Accustomed as we are to getting our information from the printed page or television, we find it hard to appreciate how important even just one or two old people are in preliterate society. When I visited Rennell Island in the Solomons in 1976, for example, 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 around 1905, destroying gardens and reducing his people to a state of desperation. One such person can spell the difference between death and survival for the whole society.

I've described the Great Leap Forward as if all those advances in tools and art appeared simultaneously 35,000 years ago. In fact, different innovations appeared at different times: spear-throwers appeared before harpoons, beads and pendants appeared before cave paintings. I've also described the Great Leap Forward as if it were the same everywhere, but it wasn'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 the Great Leap Forward: namely, the capacity for innovation itself. To us, innovation is utterly natural. To Neanderthals, it was evidently unthinkable.

Despite our instant sympathy with Cro-Magnon art, their tools and hunter-gatherer life 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 women off to their cave. But we can form a more accurate impression of Cro-Magnons if we imagine what future archeologists will conclude after excavating a New Guinea village site from as recently as the 1950s. The archeologists will find a few simple types of stone axes. Nearly all other material possessions were made of wood and will have perished. Nothing will remain of the multistory houses, 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" (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 35,000 years in a time machine, I expect that we would find Cro-Magnons to be equally modern people, capable of learning to fly a plane. They made stone and bone tools only because that's all they had the opportunity to learn how to make.

It used to be argued that Neanderthals evolved into Cro-Magnons within Europe. That possibility now seems increasingly unlikely. The last Neanderthal skeletons from 35,000 to 32,000 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 such people invaded Europe rather than evolved there.

What happened when invading Cro-Magnons met the resident Neanderthals? We can be certain only of the result: within a few thousand years no more Neanderthals. The conclusion seems to me inescapable that Cro-Magnon arrival somehow caused Neanderthal extinction. Yet many anthropologists recoil at this suggestion of genocide and invoke environmental changes instead—most notably, the severe Ice Age climate. In fact, Neanderthals thrived during the Ice Age and suddenly disappeared 42,000 years after its start and 20,000 years 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

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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 adopted European technology (horses and guns) and resisted for some time; and many of those remaining were pushed onto lands the invaders did not want, or else intermarried with them. 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 suspect that Cro-Magnon diseases, murders, and displacements did in the Neanderthals. 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, humans are now threatening to exterminate gorillas in central Africa rather than vice versa. People with huge muscles require lots of food, and they thereby gain no advantage if less muscular people can use tools to do the same work.

Some Neanderthals may have learned Cro-Magnon ways and resisted for a while. This is the only sense I can make of a puzzling culture called the Chatelperronian, 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. Chatelperronian 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 Chatelperronian culture was debated by archeologists until a skeleton unearthed with Chatelperronian 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. And if Neanderthal women were geared for a 12-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 any living people 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 90,000 to 60,000 years ago. The slowness of the transition in the Near East, compared with its speed in western Europe, suggests that the anatomically modern people living around the Near East before 60,000 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 100,000 years ago, but initially making the same tools as Neanderthals and having no advantage over them. By perhaps 60,000 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 into Europe, quickly supplanting the Neanderthals. Presumably, they 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 existed side-by-side until a shakedown left only one. It now appears that a similar shakedown occurred within the last 60,000 years and that all of us today are descended from the winner of that shakedown. What was the Magic Twist that helped our ancestor to win?

The question poses an archeological puzzle without an accepted answer. You can speculate about the answer as well as I can. To help you, let me review the pieces of the puzzle: Some groups of humans who lived in Africa and the Near East over 60,000 years ago were quite modern in their anatomy, as far as can be judged from their skeletons. But they were not modern in their behavior. They continued to make Neanderthal-like tools and to lack innovation. The Magic Twist that produced the Great Leap Forward doesn't show up in fossil skeletons.

There's another way to restate that puzzle. Remember that we share 98 percent of our genes with chimpanzees. The Africans making Neanderthal-like tools just before the Great Leap Forward had covered almost all of the remaining genetic distance from chimps to us, to judge from their skeletons. Perhaps they shared 99.9 percent of their genes with us. Their brains were as large as ours, and Neanderthals' brains were even slightly larger. The Magic Twist may have been a change in only 0.1 percent of our genes. What tiny change in genes could have had such enormous consequences?

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Like some others who have pondered 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 as symbols not just signs and computer keys but also sounds. Wild vervet monkeys, for example, 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 the words.) Given this capability, why have apes not gone on to develop 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, our vocal tract depends on the precise functioning of many parts. Chimps are thought to be physically incapable of producing several of the commonest vowels. If we too were limited to just a few vowels and consonants, our own vocabulary would be greatly reduced. Thus, the Magic Twist 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 hit on the concepts of word order and case endings and tenses, and to develop vocabulary. But if the Magic Twist did consist of changes in our vocal tract that permitted fine control of sounds, then the capacity for innovation that constitutes the Great Leap Forward 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 an existing spoken language. If Neanderthal language was much simpler than ours or nonexistent, it's not surprising that Cro-Magnons didn't choose to associate with Neanderthals.

I've argued that we were fully modern in anatomy and behavior and language by 35,000 years ago and that a Cro-Magnon could have been taught to fly an 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 2,000 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 Great Leap Forward—developments that included, among many others, the domestication of plants and animals.

Until the Great Leap Forward, human culture developed at a snail's pace for millions of years. That pace was dictated by the slowness of genetic change. After the Great Leap Forward, cultural development no longer depended on genetic change. Despite negligible changes in our anatomy, there has been far more cultural evolution in the past 35,000 years than in the millions of years before. Had a visitor from outer space come to Earth before the Great Leap Forward, humans would not have stood out as unique among the world's species. At most, we might have been mentioned along with beavers, bowerbirds, and army ants as examples of species with curious behavior. Who could have foreseen the Magic Twist that would soon make us the first species, in the history of life on Earth, capable of destroying all life.

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BOX 1 Perspectives

After reading "The Great Leap Forward," one can reflect on these human phenomena. The human body has not changed biologically in the last 50,000 years. The *Homo sapiens* brain has the potential of 10 (to the 11th power) neurons and 10 (to the 14th power) connectors, which are capable of storing the equivalent of 20.5 million volumes of information (Pytlik 1985, 286)! With this brain power, humans have the capability to think abstractly, intuitively, and creatively and to project into the unknown. "Science and technology have fostered this potential dramatically. Ten thousand years ago humans learned to write and so to store information outside their bodies. This landmark moved the human drama from pure biological evolution to a cultural revolution." (Pytlik 1985, 286).

Excerpted from Pytlik, E., Lauda, D., and Johnson, D. (1985). *Technology, Change and Society.* Worcester, Massachusetts: Davis.

QUESTIONS

1. What three changes took place in human development to distinguish humans from apes?
2. What physical characteristics are evident in the development of *Homo erectus*?
3. Approximately when did the Great Leap Forward occur?
4. What misconceptions does the author mention regarding popular beliefs about Neanderthals?
5. What conclusions might be drawn from the fact that tools used 40,000 years ago by Neanderthals differed little from those used by them 100,000 years ago?
6. What human behaviors have been found in the investigation of Neanderthal societies?
7. What are some basic differences between the Neanderthal and the Cro-Magnon of the Great Leap Forward?
8. Speculate why today's society would find a more comfortable link with Cro-Magnon society than with Neanderthal society.
9. Discuss why a possible encounter between Cro-Magnon and Neanderthal societies might have meant an end to Neanderthal life.

DISCUSSION

1. When you read the above paragraph, what are your reflections about the unique development of humankind?
2. After reading "The Great Leap Forward," what are your reflections on the role of technology, language, and writing to humankind's development? Discuss the contributions of language, writing, and information processing to the continued development of humankind.

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