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| **The Transforming Leap, from Four Legs to Two** |
| http://www.pbs.org/wgbh/evolution/images/spacer.gif |
| Those were venturesome steps for some ape-like creatures long ago in Africa. Dropping out of trees, they essayed a novel means of locomotion, for reasons that elude paleoanthropologists. These primates may have sought to reach higher in foraging, see farther over tall grasses, reduce the exposure of their bodies to the searing tropical sun or extend their range beyond the forest to the open savanna. Perhaps they needed to free the hands for carrying food or infants over long distances.  In any case, driven by need or the lure of new opportunity, in their struggle for survival these creatures found some saving advantage in a new way of walking. Instead of scampering about on all fours, as usual, they stood upright and, gradually and no doubt unsteadily at first, began to walk on their hind limbs. Small bipedal steps for apes, and as it would turn out, a giant leap for mankind.  Anthropologists and evolutionary biologists are now agreed that upright posture and two-legged walking - bipedality -- was the crucial and probably first major adaptation associated with the divergence of the human lineage from a common ancestor with the African apes. Once they had thought the development of a large brain or the making and use of stone tools was the pivotal early evolutionary innovation setting human ancestors, the hominids, apart from the apes. But these came much later, long after the transforming influences of bipedality.  Upright walking required profound changes in anatomy, particularly in the limbs and pelvis, and these were passed on to modern humans. It eventually put limits on the size of infants at birth and thus created the need for longer postnatal nurturing, with sweeping cultural consequences. It may have had a bearing on human sexuality and the development of family life.  And it certainly opened the way for later toolmaking, some 2.5 million years ago, and probably set the stage for the eventual enlargement of the hominid brain, not before two million years ago.  "The fundamental distinction between us and our closest relatives is not our language, not our culture, not own technology;" said Richard E. Leakey, a paleontologist and son of Mary Leakey and the late Louis S. B. Leakey; renowned fossil hunters in Kenya. "It is that we stand upright, with our lower limbs for support and locomotion and our upper limbs free from those functions."  If there was any lingering question about the early manifestation of bipedality in human evolutionary history, it has been erased by recent fossil discoveries: a 4.4-million-year-old hominid from Ethiopia, found last year, and a 4.2-million-year-old hominid near Lake Turkana in Kenya, recently reported. The newly identified species were older more primitive and much more ape-like than any hominids known before, but already they were bipedal -- certainly the younger one, probably the other as well.  "This gets close to the hypothesized time of splitting of the ape and human lineages," said Dr. Alan Walker, an anatomist at Pennsylvania State University who specializes in early human studies. He and Dr. Meave Leakey, a paleontologist at the National Museums of Kenya, who is Richard Leakey's wife, discovered the Turkana fossils, to which they have given the new species name *Australopithecus anamensis*.  Dr. Tim D. White, a paleontologist at the University of California at Berkeley, excavated the 4.4-million-year-old hominid, so different from anything seen before that it has been assigned to an entirely new genus as well as species name *Ardipithecus ramidus*. Dr White has yet to assemble and analyze the pelvis and lower limb bones, but he has inferred from other evidence that these creatures probably had an erect posture for walking. They resembled apes more than even anamensis does, showing primitive qualities that might be expected of creatures more than five million years old.  "With ramidus," he said, "we are very very close to the hominid-ape split, surprisingly close."  Molecular biologists, comparing the DNA of modern humans, chimpanzees and gorillas, estimate that the decisive separation of hominids from the ape line occurred seven million to five million years ago. Until now, the earliest and most evocative evidence for hominid bipedality was the footprints embedded in 3.7-million-year-old volcanic ash at Laetoli in Tanzania. They were presumably made by members of the species *Australopithecus afarensis*, until the recent discoveries the earliest known hominid group. The most famous *afarensis* skeleton, of a small female nicknamed Lucy found in 1974 at Hadar in Ethiopia, bore indisputable limb and pelvic evidence of bipedality  The new findings thus pushed back the time for the emergence of bipedalism at least half a million years earlier than previously known, perhaps several hundred thousand years more than that.. They have encouraged scientists in the belief that they will someday fill the fossil gap all the way back to the hominid-ape divide. They have already afforded a glimpse of hominids that were so ape-like in nearly every respect as to accentuate their one human-like trait: upright walking. More than ever, paleontologists say, it is clear that the Rubicon early hominids crossed was not the large brain or toolmaking, but bipedality.  Now the challenge -- one of the ultimate questions in the study of human origins -- is to understand why the earliest hominids stood up. "Bipedalism is a fundamental human characteristic," said Dr. Bernard Wood, a paleontologist at the University of Liverpool in England, "yet virtually nothing is known about its origins."  Almost all other mammals stand and walk or run on four limbs. Those that stand on two feet have quite different postures and gaits from humans. Kangaroos hop on their two feet. Some monkeys, natural quadrupeds, may occasionally walk bipedally, especially when carrying food. Chimpanzees, the closest relatives to human beings, are capable of brief bipedal walks, but their usual means of getting about on the ground is knuckle-walking -- standing on their hind legs but stooping forward, resting their hands on the knuckles rather than on the palms or fingers, which are adapted for climbing and grasping in the trees. Of the primates, only humans are fully developed bipeds.  As scientists have learned to reconstruct ancient climate from cores drilled in the ice of Greenland and sediments on the sea floor, one of the favorite explanations for the transition to bipedality has centered on drastic environmental changes that swept Africa more than five million years ago. By that time, Dr. Elisabeth S. Vrba, a paleontologist at Yale University, has pointed out, global climate had become significantly cooler and drier. As it did, grasslands in sub-Sahara Africa expanded and rain forests contracted, shrinking the habitat where tree-dwelling primates lived and foraged.  Another factor possibly upsetting the East African environment at the time was the region's unsteady terrain. Dr. Yves Coppens, a paleontologist at the College of France in Paris, contends that a seismic shift, recognized by geophysicists, deepened the Rift Valley which cuts through Ethiopia, Kenya and Tanzania. The sinking of the valley produced an upthrust of mountains, leaving the land west of the valley more humid and arboreal, while the east became more arid and dominated by savanna.  As a result, he hypothesizes, the common ancestors of the hominids and the chimpanzees found themselves divided. Those adapting to the humid west evolved into the chimpanzee family. Those left in the east, Dr. Coppens wrote in 1994 in *Scientific American*, "invented a completely new repertoire in order to adapt to their new life in an open environment."  In any event, according to the hypothesis, at least one type of these primates responded to the environmental crisis by venturing more and more into the open grasslands, looking for food, but retreating to nearby trees to escape predators and sleep at night. To move about more efficiently, perhaps also to keep a lookout above the grasses for distant food or predators, these primates began standing up and walking on two legs. Their success presumably improved their chances of surviving and passing on genes favoring this unusual stance and gait, leading eventually to bipedal hominids.  Critics have pecked away at the hypothesis. Some contended that the mechanics of two-legged locomotion were not energy efficient, compared with those of four-legged creatures like dogs, horses and the big cats. After studying the question, Dr Henry McHenry and Dr. Peter Rodman, paleontologists at the University of California at Davis, established that bipedality was indeed an effective way of covering a large amount of territory in the foraging for dispersed plant goods, especially for hominids. Moreover, hominids were close relatives not of horses or lions, but of primates whose particular form of quadrupedality was adapted mainly to arboreal locomotion and was already modified for a semi-erect posture under some circumstances.  Walking on two legs, in the succinct conclusion of the two scientists, was "an ape's way of living where an ape could not live."  One problem with the environment hypothesis has arisen with the new fossil findings. Both the Leakey-Walker anamensis and the White ramidus bones were found in areas that were once densely wooded, not savanna. And by analyzing carbon residues in ancient soils from the Rift Valley, Dr. John D. Kingston, a Yale anthropologist, recently determined that for the last 15 million years the mix of forest and grasslands was much the same as it is today, which also raises questions about an ecological crisis underlying the change in hominid locomotion.  Proponents of the hypothesis are not backing down. The soil measurements, they contend, may not be precise enough to reflect significant but short-term changes in vegetation. Nor do they think that the wooded setting in which the two sets of fossils were found necessarily represents the environment in which the species both lived and foraged.  In fact, other evidence indicates that for a million years or more early hominids probably had the best of two worlds, combining efficient bipedal locomotion on the open ground with the grasping and climbing abilities of arboreal quadrupeds. They may have foraged on two legs and rested or hid up in the trees. In July, South African paleontologists reported finding "a locomotor missing link" in the hominid fossil record. The foot bones of a species that lived as much as 3.5 million years ago, they said, included a weight-bearing heel used for two-legged walking with a big toe capable of grasping, much like a chimpanzee's.  If the origin of bipedality was related to prospecting the opening grasslands, Dr. Peter E. Wheeler, a physiologist at Liverpool John Moores University in England, suggests that there may have been another contributing factor. The early hominids, he notes, might have found the heat there especially stressful. Most animals living on savanna can let their body temperature rise during the day without wasting scarce water by sweating. They have built-in ways of protecting the brain from overheating. Not so humans, and presumably their distant ancestors. The only way they can protect the brain is by keeping the whole body cool.  Then perhaps the hominids stood up to keep cool. From his studies with a scale model of the Lucy skeleton, Dr. Wheeler found that a quadrupedal posture would have exposed the body to about 60 percent more solar radiation than a bipedal one. Standing tall thus might result in a substantial reduction in water loss. And the upright body could also catch the cooler breeze above the ground.  The new posture, Dr. Wheeler also said, might explain the evolution of the human as the naked ape. It obviated the need for complete body hair. Hair not only keeps heat in, it keeps it out. By standing upright, hominids had less need of hair to keep heat out, except on the head and shoulders. The advantages of height might also explain the evolution over time of taller hominids.  Dr. Ian Tattersall, an evolutionary biologist at the American Museum of Natural History in New York City finds the cooling hypothesis "particularly attractive," if not the whole story. Dr. Wood of the University of Liverpool wonders if it really explains the origin of bipedalism, or merely explains why bipedalism was advantageous when hominids routinely foraged in more open habitats.  Dr. Kevin D. Hunt, an anthropologist at Indiana University in Bloomington, has offered another possible explanation. Observing chimpanzees in the field, he saw that their bipedalism was related to feeding. On the ground they stood on their hind legs to reach for fruit in trees. They also stood up on branches to grab food on a higher branch. This suggested that hominids might have adapted to a form of bipedalism long before they came down out of the trees.  Many such ideas are too narrow to account for something as broadly transforming as bipedality, in the opinion of Dr. C. Owen Lovejoy, an anatomist at Kent State University in Ohio who is a specialist in research on the origins of human locomotion. Instead, he has proposed a behavioral explanation with such sweeping implications that if correct, it would amount to a kind of grand unified theory of early hominid evolution.  Any trait that proves to be so advantageous that it is passed on to succeeding generations through natural selection, Dr. Lovejoy points out, almost always has some direct bearing on the rate of reproduction. Sex, that is, may have been the motivating force.  Upright walking, according to his hypothesis, began in the relative safety of the forest floor, not on the more perilous open terrain. Female hominids, restricted by the demands of infant care, spent most of their time gathering fruit and insects over a limited range. Their rather poor nutrition probably accounted for the slow maturation of the young and a low reproduction rate of one child only every four or five years. And as long as the female was nursing, she was unavailable for copulation.  So there could have been an incentive for males to free their hands for carrying food, especially nuts and animal protein found on their wider-ranging foraging. They could have brought the food back and exchanged it for sex, as anthropologists have observed pygmy chimpanzees doing in Africa today. This could be the basis for some kind of long-term bonding, perhaps the forerunner of modem human mating practices. In this way, the female would spend less time in search of food and more time and energy caring for her young. The children's chances of survival would improve, and the females would presumably resume ovulating somewhat earlier, and thus be sexually receptive. And the male that had been bringing home the bacon would be the favored mate.  Accordingly, Dr. Lovejoy contends, "The males of such pairs were most successful if competently bipedal and capable of proficient provisioning." They would be more likely to pass on their genes to later generations, thus establishing bipedality as the hominid locomotion and improving hominid prospects by significantly improving reproduction rates.  Dr. Lovejoy goes further to say that such behavior related to two legged walking may have contributed in the long run to other peculiar human traits. Other primate females display pronounced genital swellings when they are ovulating. The loss of external signs of ovulation in humans, he said, could have been related to the advantages of fidelity. Likewise, human females are the only primates with permanently enlarged breasts, which in other animals would be an announcement that the female was not ovulating.  "Only the male that consistently copulated with a female [with hidden ovulation] would have a high probability of fathering her offspring," he said.  Of the Lovejoy hypothesis, Dr Tattersall said: "It makes a nice story. But I don't think many people are convinced. We know so little about the lifestyles of those early hominids."  In his book, *The Fossil Trail; How We Know What We Think We Know About Human Evolution*, published by Oxford University Press, Dr. Tattersall favors the explanation that upright bipedalism "was intimately tied up with a change in climate and environment, that it somehow represented a response to the shrinking and fragmentation of formerly extensive forests in the part of Africa lying in the rainshadow to the east and south of the great domed-up Rift Valley."  These open spaces were a source of roots, shrubs, grasses and even the carcasses of animals killed by predators, he wrote, "a whole range of food resources for creatures with the wit to exploit them."  But in an interview, he conceded that scientists may never know for sure what made hominids stand up and walk on two feet. "We will always be driven to speculate," he said, "and, hopefully, our speculations will become more informed and insightful."  -John Noble Wilford, September 1995  Copyright © 1995 by the New York Times Co. 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The Transforming Leap, From Two Legs to Four Legs

1. Why would these creatures want to stand on two legs? Provide 2 reasons.
2. What was probably the first major adaptation associated with the divergence of the human lineage from a common ancestor with the African apes? Why?
3. How could have bipedality led to the creation of “family life”, “nurture”?
4. How could have bipedality lead to processes such as tool making? (Hint: what part of the body is now free for use?)
5. How do studies of ancient climate and geology contribute to the study of hominid evolution?