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HUMAN EVOLUTION

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A common characteristic of humans is a desire to know their roots. This is evident not only in the tracing of family ancestries, but in the excitement about and attention given to the study of the roots of our entire species — the study of human evolution.

We have, over the past few million years, evolved from an ape-like ancestor to modern *Homo sapiens*. Like evolution in general, the fact of human evolution is as firmly established as anything in science. There are, however, differences among scientists concerning details of this process. In this paper I will give an historical overview and summary of our knowledge of human evolution, and will focus on current disagreements.

The idea that humans have evolved gained major support and acceptance due to Charles Darwin. Although in *The Origin of Species* Darwin avoided humans by discussing the evolution of noncontroversial groups such as barnacles and clams, he did include this sentence near the end of his book: "Light will be thrown on the origin of man and his history." Twelve years later (1871), he met the situation head on by publishing *The Descent of Man*.

There was little direct evidence supporting human evolution when Darwin published the *Origin*. Only one fossil hominid type was known, and its status as an ancestor was controversial. Part of a thick skull and some limb bones had been recovered from a cave in the Neander Valley in Germany. We now know these bones to be from a recent hominid (Neanderthal), but when they were first discovered they were thought to be too brutish to be an evolutionary example. One eminent German anatomist said the bones were from an elderly Dutchman, while another said that they were from a Cossack soldier who had chased Napoleon's army, gotten lost, wandered into the cave and died. A French anatomist said the bones were those of a powerful Celt, resembling a modern Irishman but with limited intelligence. A third German anatomist had the most intriguing explanation. He said that the bones were not primitive at all but were from a contemporary person who had rickets while young, arthritis while old and, in between, had suffered severe blows to the head.

Soon, however, other fossils were found and the physical evidence for human evolution became more abundant. Near Cro-Magnon, France, the first evidence of our most immediate ancestors was found. They

lived about 40-50,000 to 10,000 years ago, and were physically indistinguishable from modern humans. They had an elaborate culture, including detailed paintings on cave walls and beautiful stone and bone tools.

More Neanderthals were found, and it was realized that they actually did represent a fossil group. They are somewhat older than Cro-Magnon (living 40,000 to 200,000 years ago) and, not surprisingly, were somewhat different from them.

The popular image of Neanderthal is of brutish and ape-like creatures. They were anything but. They had a complex culture, made very good tools, were competent hunters, and buried their dead. Their brains were as large as or somewhat larger than ours. That they ritually buried their dead indicates the beginning of supernatural or religious thinking. Neanderthals were bulkier and more heavily muscled than modern humans. Their stockiness is probably due in part to inheritance from their immediate ancestors (*Homo erectus*), who were also stocky. Additionally, since they lived in Europe during an Ice Age, much of Neanderthal morphology may have involved adaptations to severe climatic conditions.

There is recently discovered evidence from the Middle East that over a period of 80,000 years (130,000 to 50,000 years ago) Neanderthal may have gradually evolved into modern humans (Cro-Magnon). In contrast, in other areas, including Europe, gradual changes are not seen and modern humans abruptly replaced Neanderthal 40,000 to 50,000 years ago. One scenario is that an isolated Middle Eastern population of Neanderthal gradually evolved into modern humans who then expanded their range and replaced Neanderthal either by outcompeting or killing them. During this process the two groups may also have interbred. Taxonomically, Neanderthals and modern humans are similar enough to be considered to be the same species (*Homo sapiens*), although exact relationships are still debated by scientists.

In the late 19th century, attention of the fossil hunters began to shift from Europe to tropical regions. Since early Europe had often been cold and covered with ice, it was realized that it would be unlikely for early hominids to be found there. By the 1940s three more hominid species had been identified.

Homo erectus was first found in Java and is also known from Europe, China and Africa. They lived about 2.0 to perhaps 0.1 million years ago (MYA). On the average, they were shorter and smaller-brained than modern humans, but the ranges of the two groups overlap. They are associated with the first known use of controlled fire. *H. erectus* hunted cooperatively, which indicates an advanced ability to communicate, and were able to kill large animals. They evolved into *H. sapiens*.

This still leaves the question of what came before *Homo*. The answer was found in Africa. A new genus, *Australopithecus*, was discovered in the 1920s and two species, *A. africanus* and *A. robustus*, were later identified. They were definitely hominid and not apes, but they had small brains. They walked upright (bipedally).

A. robustus individuals were the larger of the two and had thick jaws, heavily enameled teeth and powerful chewing muscles adapted to browsing and leaf eating. *A. robustus* lived about 1-2 MYA (in part contemporaneously with *H. erectus*) but represent an apparent evolutionary dead end. They may have evolved from *A. africanus*, a smaller more slender hominid that lived earlier (2-3 MYA). In addition to evolving into *A. robustus*, a separate branch of *A. africanus* may have evolved into *Homo*, but this is a point of disagreement among evolutionists.

No more species were found until the 1960s, when Louis Leakey discovered the earliest known species of *Homo*, *Homo habilis*. Specimens are known from about 1.75 to 2 MYA. *H. habilis* was the first stone tool user. They were contemporaneous with *Australopithecus* and evolved into *H. erectus*.

About the time of Louis Leakey's death in 1972, his son, Richard, found in Kenya the best specimen to date of *H. habilis*, an almost complete skull. At first the skull was dated to 2.9 MYA, which would make it 1 million years older than previously found *H. habilis* specimens. Moreover, such dating would make it as old or older than any *Australopithecus* then known, thus meaning that *Australopithecus* could not be ancestral to *Homo*. Instead *Homo habilis* would be our earliest known ancestor. Richard Leakey's discovery put the carefully constructed evolutionary history of humans in disarray.

The date was not widely accepted. Fossil pig species associated with (and thus the same age as) Richard Leakey's hominid were known from other areas. These pigs lived about 2, not 2.9, MYA. Eventually the Leakey find was redated at 2 MYA, younger than *Australopithecus*. The original rocks which had been dated to 2.9 MYA proved to have been contaminated with older material, yielding a date now considered erroneous.

Perhaps the most spectacular hominid fossils known were found in the 1970s by Donald Johanson and Timothy White. Most fossil hominid finds are fragments of individuals, usually parts of skulls or jaws, although occasionally some limb bones or other postcranial material had been found. The oldest semi-complete skeleton known had been Neanderthal remains. In 1974 Johanson and White, working in the Afar region of Ethiopia, found one of the oldest known hominids, dated to 3.3 MYA. Nicknamed Lucy (after the Beatles song "Lucy in the Sky with

Diamonds," which was playing at the time of the discovery), it is, amazingly, 40% complete. Lucy was about 3½ feet tall and had a tiny brain, somewhat larger than a modern chimpanzee's. She was fully bipedal and walked erect, although her legs were proportionately shorter than those of later hominids. This ended a debate over whether bipedalism or a large brain evolved first; bipedalism must have. Johanson considers Lucy to be an early *Australopithecus* species, *A. afarensis*.

The following year, Johanson made another incredible discovery: at least 13 individuals dated to about the same age as Lucy, possibly a single hominid band including men, women and children. Johanson considers all of these to be *A. afarensis*, while Leakey says that they represent a mixture of species, including *Homo*. Leakey does not accept *A. afarensis* as a valid species but considers the fossils as representatives of already known species. He proposes that all Australopithecines are side branches of the direct line to us, and that his and his father's discovery, *Homo habilis*, is our oldest known ancestor. Johanson considers his discovery, *Australopithecus afarensis*, to be the ancestor of *H. habilis* and, in a separate lineage, to have led to the other Australopithecines. Other phylogenies also exist and exact relationships are hotly debated.

Hominid fossil remains dating to 4 MYA (400,000 years older than any previously known) have recently (1981) been discovered in Ethiopia. They are fragmentary and have not yet been fully analyzed, but the individuals were small-brained and bipedal, and may represent an earlier, more primitive version of, or perhaps an ancestor to, *A. afarensis*.

The study of human evolution is multidisciplinary. Neurologists are examining casts of the insides of fossil skulls to learn about brain evolution. Fossil pollen experts are gaining information about ancient environments. Electron microscopy of fossil teeth is giving evidence of early hominid diets. Artifacts (tools) associated with early hominids are also being studied.

One area which has generated much debate is molecular biology. We are biochemically very similar to our closest living relatives, the chimpanzees and gorillas (our proteins are about 98% the same). This is about as similar as horses and zebras, or grizzly bears and polar bears. Molecular biologists argue that this biochemical similarity means that we and the apes share a very recent common ancestry and that we diverged only about 5 million years ago. Traditional interpretations of the fossil record have indicated that the split occurred much earlier, about 20 to 25 million years ago.

Certain assumptions are used to calculate a date from the molecular data. A critical one is that the proteins being studied evolved at con-

stant, predictable rates. If these proteins actually evolved more slowly than the molecular biologists believe, then close biochemical similarity and a long time since divergence would be compatible. The controversy is by no means settled, but the mounting molecular evidence has caused the conversion of some scientists who had previously believed in the older date for the split. Unfortunately, the fossil record for the period in question (4-6 MYA) is very poor and thus direct evidence is lacking.

A final comment. We as humans are self-centered in our view of life. This is evidenced in the emphasis we place on studying our own species and in the delight we take in the apparent success of it. The average mammalian species in the fossil record lasts between 200,000 and 2 million years. Modern humans have only been around about 50,000 years, since the appearance of Cro-Magnon. If the evolutionary success of a species is evidenced by its longevity, then by this measure *Homo sapiens* has a long and dangerous path to follow before it can be considered successful.

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Man or Mouse?

When testing a new compound (Chlorfenvinphos) for killing ectoparasites on dogs, Vernon Brown of the Shell Toxicology Lab in England found the LD₅₀ differences between species to be enormous. For rats, the LD₅₀ value was 12 mg per kilogram of ordinary feed, for mice 100-200 mg, while dogs proved indestructible at 12,000 mg.

Since veterinarians would be handling the substance it was necessary to know whether man was more like a rat, a mouse, a dog, or none of these. Believing man to be more like a dog than a rat, the intrepid researcher swallowed some of the compound. Unpleasant reactions persuaded him that he had been wrong. Man, or at any rate one man, was in this instance more rat than dog.

It could be said that millions of people unwittingly act like Vernon Brown everyday. Birgitta Werner of the Poison Information Center in Stockholm, Sweden produced LD₅₀ figures on nicotine. For dogs the value is 9.2 mg/kg, for rats 53 mg/kg, for pigeons 75 mg/kg. But for man a lethal dose of nicotine can apparently be as low as 0.9 mg/kg. This huge difference between species is not one that favors the cigarette smoker. Question: Why are taxpayers asked to subsidize the tobacco industry while science, education and food producers are cut from the federal budget?