The Prime Movers in Hominid Encephalization

One of the common misconceptions concerning the evolutionary process is that it implies progress. People with such a mistaken view of evolution may believe that fish are evolving into amphibians, reptiles are evolving into mammals, and apes will inevitably achieve human status some day. The belief that traits evolve in order to achieve a future goal is referred to as the *teleological error*. When someone argues that birds evolved feathered wings in order to fly or that humans evolved complex brains in order to use tools they are committing the teleological error. The teleological error is a logical fallacy because it implies that future events cause past events.

To understand how birds evolved bodies capable of flight, it is necessary to examine the process as a series of events unconnected to any future outcomes. Feathers were originally modified scales that provided an improved insulating capacity for warm-blooded animals. The low density of these modified scales and certain incidental aerodynamic properties they possessed made them useful in facilitating gliding behavior. Outstretched forelimbs covered with feathers were more advantageous to gliding than those covered with scales. Flight powered by feathered wings developed in birds as a result of natural selection on gliding behavior.

The teleological error is even more likely to be committed when the origins of human capacities are examined. Claiming that our ancestors began walking upright in order that they could use tools is typical example of this error. In fact, the tendency to make the teleological error can be said to be a natural by-product of the evolved mental capacities of the human animal. The human mind has been designed by natural selection to be adept in goal directed behavior. Our minds are so well designed for achieving intended outcomes that we naturally attribute goals and intentions where none exist. Our purposeful manipulation of mental constructs enables us to size up an enormous number of possible solutions to any problem without the time, effort, and risk that would be entailed by actually going through the alternate solutions. This capacity has given humankind an immense advantage over other forms of life. We use it for everything, from rearranging our living room furniture to planning strategy during wartime. The problem, as William James pointed out, is that we are so immersed in this mental process that it colors our perception of reality or in many instances prevents our perception of reality. It is this perceptual blindness that makes it impossible for many people to accept the fact that something as complex as the human brain and as subtle and eloquent as the human mind could be cobbled together by eons of natural selection without plan or purpose. In this chapter we will discuss how this process occurred and describe the end product of this process, namely the modular brain and the modular mind.

Machiavellian Intelligence

Encephalization refers to the amount of brain mass relative to body size. Those species classified as primates are among the most highly encephalized animals on our planet (see Figure 3-1). The relatively large and complex brains of primates can be explained by a number of factors. All living primates are either currently arboreal or descended from arboreal ancestors. Elliot-Smith (1912) proposed the "arboreal theory" to account for the emergence of the primate brain. He argued that the adaptation of terrestrial animals to an arboreal lifestyle necessitated the development of stereoscopic vision and highly manipulative hands. These in turn required a larger and more complex brain. Cartmill (1974) observed that there are many arboreal animals such as tree squirrels that do not have stereoscopic vision or dexterity. Cartmill hypothesized those primate visual and motor adaptations evolved to facilitate insect predation. He pointed out that forward facing eyes and dexterous forelimbs are also found in cats. The primate brain (as both Elliot-Smith and Cartmill argued) must be relatively large and complex to process stereoscopic vision and coordinate fine manual dexterity. The dexterity, visual capabilities, and brain development of members of the order Primates (e.g., monkeys, apes and humans) generally exceed those of members of the order Carnivora (e.g., cats, canines, and bears). This suggests that neither Cartmill's hypothesis nor the one proposed by Elliot-Smith is entirely adequate for explaining the complexity of the primate brain. Unquestionably both the arboreal lifestyle and the predatory habits of the earliest primates were factors. However, even the combination of these two factors will not suffice to account for the highly developed brains found in monkeys and apes. To understand what the selective forces acting on brain development were, we need to look at the most prominent feature characterizing modern primates. This feature is their extreme sociality.

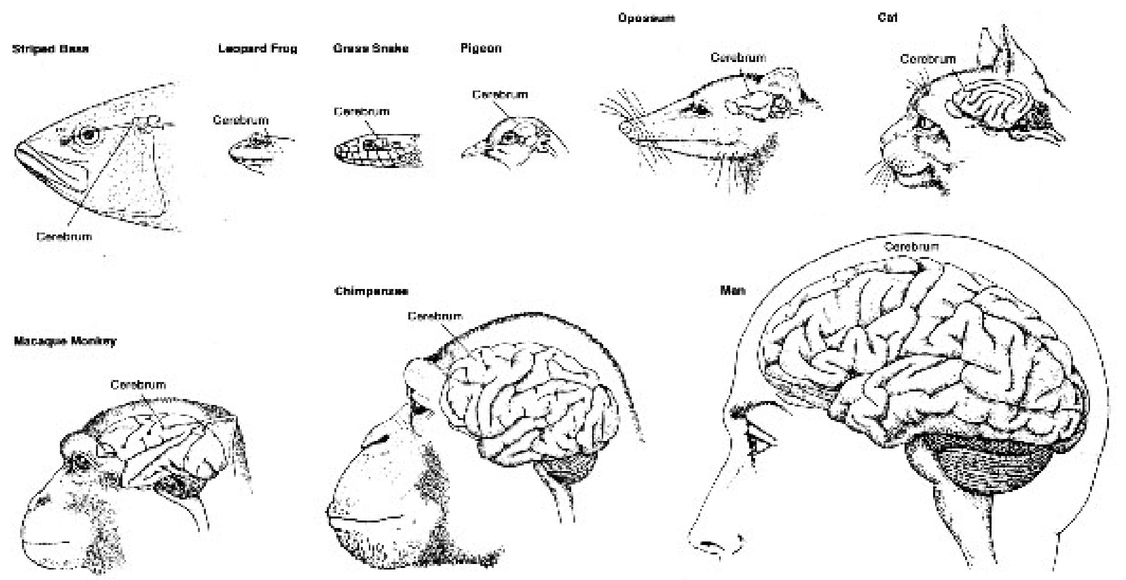

FIGURE 3.1 A comparison of brain development in living vertebrates. Note the leap in size and complexity in the cat and the primates.

The importance of sociality can be illustrated as follows: a certain level of complexity is required to judge the location of a tree branch waving in the wind so that it can be successfully grasped, a somewhat higher level of complexity is required to anticipate the movements of a prey animal and successfully capture it, but a much higher level of complexity is required to anticipate the behavior of a member of your own species in response to your behavior. This last is the challenge facing every social animal.

This social intelligence has been called Machiavellian intelligence after the Italian political philosopher, Niccolo Machiavelli (1469-1527) whose how-to writings on governing have turned his name into a synonym for amorality, cunning and duplicity (Byrne & Whiten, 1988). In his most famous work, *The Prince* (1532), he describes the methods by which a prince can gain and hold political power. In Machiavelli's view, a ruler should be concerned only with rules that lead to political success. Traditional ethical rules are perceived as impediments to the acquisition of power. The following quote from *The Prince* typifies Machiavelli's perspective: "Since love and fear can hardly exist together, if we must choose between them, it is far safer to be feared than loved."

When we observe the behavior of non-human primates, particularly Old World monkeys and apes in a social context, it is clear that Machiavellian concerns *do* play a role in their behavior (Byrne & Whiten, 1988). These animals are highly concerned with their position in the social hierarchy and how to better their hierarchical rank. Complex alliances and coalitions are formed to facilitate upward mobility in certain individuals. Unquestionably the most political of all non-human animals is the common chimpanzee (DeWall, 1982). Male chimpanzees live in a world of political intrigue that would have impressed Machiavelli himself with its guile, treachery, and ruthless focus on acquiring and maintaining power.

Undoubtedly, the ability to manipulate the behavior of conspecifics played some role in the evolution of brain complexity and intelligence but it is not sufficient in and of itself as an explanation. Chimpanzees are highly encephalized animals yet their brain mass is only about one-third that of our own. Moreover, numerous human studies have failed to find any correlation between Machiavellianism (a strategy of social conduct involving the manipulation of others for social gain against the other's self-interest) and IQ scores or real world material success (Wilson, Near & Miller, 1996).

Social intelligence (both Machiavellian and non-Machiavellian) undoubtedly played a role in the general brain evolution of primates. The common ancestor that we shared with chimpanzees about 7 million years ago was a fairly brainy fellow relative to other animals. However, we must look to other factors in addition to social intelligence to explain the trebling in brain size that occurred in our lineage.

The Ice-Ages

A number of researchers have postulated that the *Ice Age* played a significant role in human evolution. Ice ages are periods in the Earth's history characterized by large scale climactic cooling and expansion of glacial ice sheets from the Polar Regions. Ice ages generally persist for periods of about 100,000 years alternating with warm interglacial periods that last about 10,000 years. Ice ages occur in groupings called glacial epochs that last for millions of years. The Earth has had several glacial epochs during its history. The most recent glacial epoch began about 2.5 million years ago is referred to as the *Ice Age* in capital letters. The current interglacial period began about 11,500 years ago and most scientists believe it is only an interlude to be followed shortly (in a few centuries or millennia) by a return to cold conditions as we are still living in the *Ice Age* (see Figure 3-2).

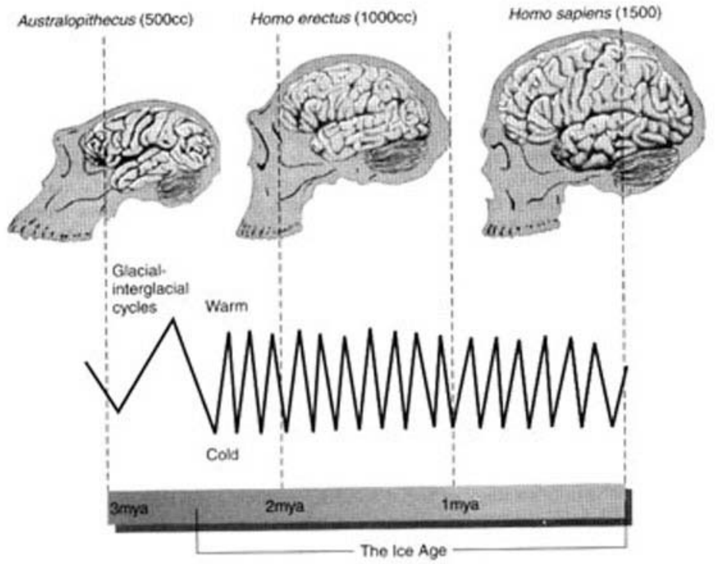

FIGURE 3.2 Hominid encephalization following the onset of the Ice Age 2.5 million years ago.

Vrba (1996) has argued that the onset of the Ice Age corresponds to the emergence of numerous mammalian species, particularly in Africa. Many of the species that appear about 2. 5 million years ago show a pronounced increase in body size. This is consistent with Bergmann's rule, which holds that warm-blooded animals living in cold climates tend to be larger than their counterparts of the same species living in warm climates. The new species also show changes in body proportions which is consistent with Allen's rule which states that animals of a given species show reductions in body extremities when living in colder climates. Both Bergmann's and Allen's rules can be viewed as adaptations to climactic change. Vrba believes that it was the massive climactic changes associated with the Ice Age producing marked aridity in the African continent and a reduction in forested area that triggered the speciation events not only in bovids and antelopes but also in the hominids. During this time the hominid line split into the gracile australophithecines and the robust australophithecines.

The changes in body form that occurred were achieved through slight changes in the growth rate and maturation rates during ontogeny. For example, the gracile australophithecine line shows a trend toward neoteny or paedomorphosis. In this condition juvenile characteristics are retained in the adult animal. Neotony, thus would be achieved through prolongation of the maturation process, or a suppression of that process. In the robust australophithecines, however, a more rapid onset of maturation would account for the increased thickness of the skull and enlargement of the jaws and teeth. Slight modifications in the activity of various genes during the developmental process are typical of evolutionary changes in complex organisms. This process is referred to as *heterochrony*, which is defined as a phyletic change in the onset and/or timing of development such that the development of a trait or traits in an organism is either accelerated or decelerated relative to the same trait or traits in an ancestor.

Once a certain level of complexity is achieved (i.e., multicellular organization) a more fundamental level of change, such as radically different, gene structures is usually disastrous. Thus the avenue most readily open to evolutionary change is in the control of the expression of existing genes, which is accomplished through slight modifications in the regulator genes. To make an ape more human-like, the genes that control maturation of the skull need to be suppressed, preventing the development of a thick, buttressed skull and huge teeth and maintaining a head that is relatively large in proportion to the body (see Figure 3-3). Not only is the head of adult humans characterized by juvenile features, but the adult human mind can be considered child-like in its retention of curiosity and plasticity in dealing with the environment. In summation it can be said that the Ice Age altered the African ecosystem and triggered the emergence of a plethora of new life forms. However, only one taxonomic lineage led to the highly encephalized organisms called humans. We must continue to look for other factors to account for the evolution of the very complex human brain.

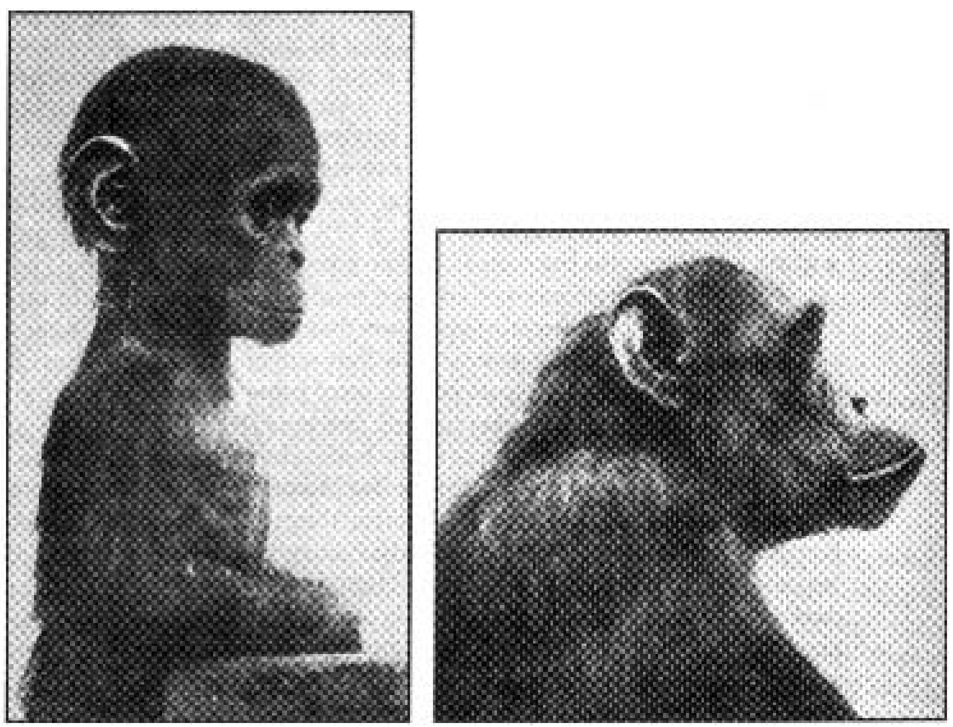

FIGURE 3.3 A comparison of an infant chimpanzee with an adult. The human appearance of the infant ape lends credence to the theory that neoteny or pedamorphosis played a major role in human evolution.