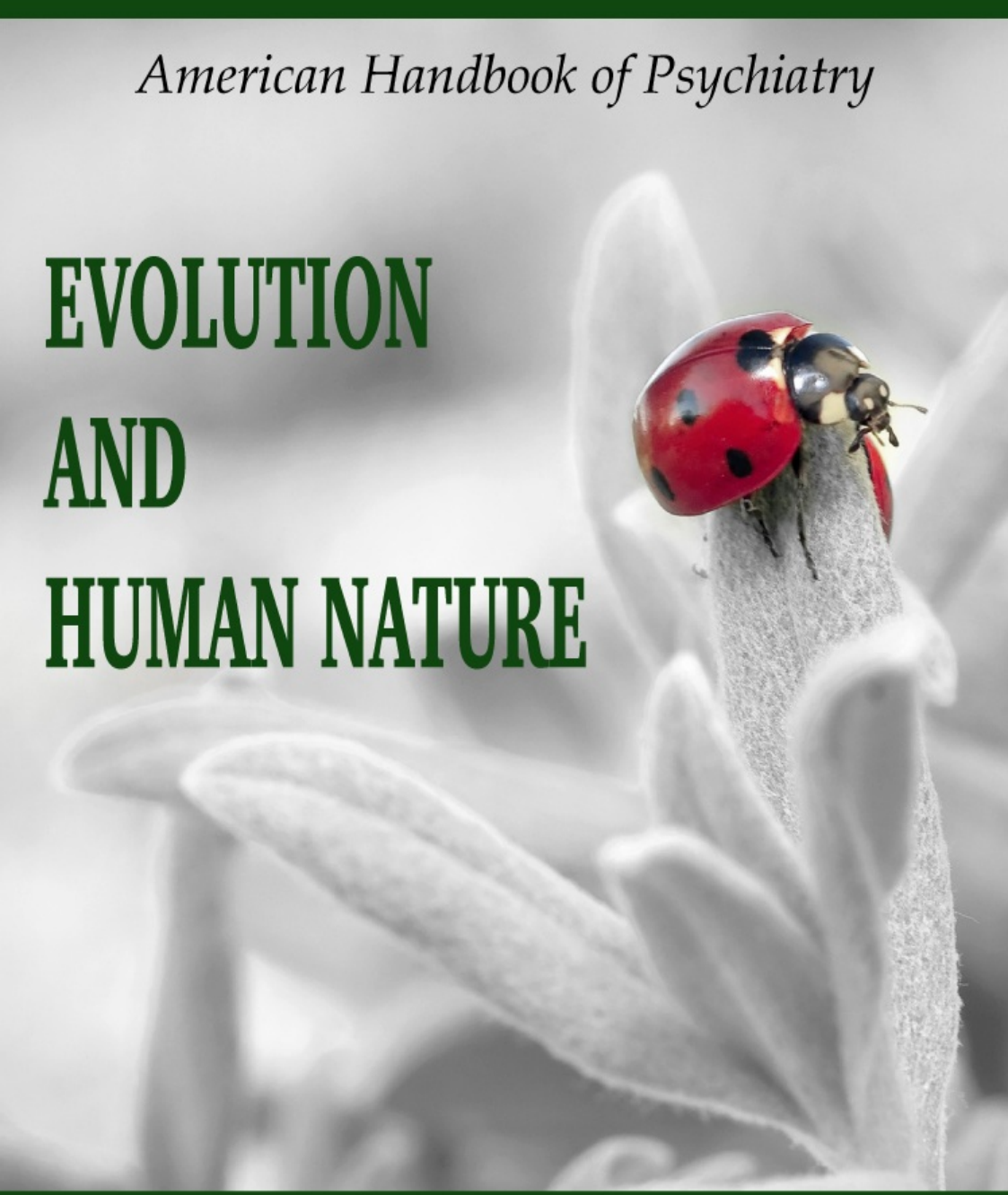
American Handbook of Psychiatry

EVOLUTION AND HUMAN NATURE



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EVOLUTION AND HUMAN NATURE[1]

As Mayr has recently pointed out, acceptance of the concept of evolution through natural selection required the rejection of many previously held ideas. Not only were scientific beliefs about the age of the earth, the nature of geological processes and the causes of biological evolution changed, but since the theory of evolution applied directly to man himself, religion, ethics, and the very foundations of a moral society were challenged. It was not the idea of evolution that was so difficult for people to accept; the idea of steady progress toward perfection, perhaps aided by occasional intervention by a Creator, could be reconciled with traditional European beliefs. Since selection was central to the evolutionary process, however, it was no longer possible to believe in the inevitability of progress or the moral nature of the changing universe.

The development of modern genetics showed that the evolutionary process was based on chance mutation, selection, and the fate of genes in populations. The parts of Darwin's theories that were least acceptable to the average person were confirmed by an over-whelming body of experimental science. Now molecular biology has elucidated the nature of the gene and shed light on the way in which life may have originated. The fossil record has also provided some understanding of the nature of life and its history over the last 600 million years, and in the last 1 percent of that time there is now

substantial fossil evidence of our own family, the Hominidae.

The new evidence suggests a solution to many of the traditional problems about the origin of man, some of which will be reviewed in this paper. We believe, however, that the implications of the theory of evolution for the understanding of the biological nature of man are only beginning to become clear. At this point, we think it is more useful to speculate on the implications than to review the facts, although we will try to do both, keeping "fact" separate from speculation. In doing so, we will discover almost at once that such a separation may be more an illusion than a useful explanatory device. In a very fundamental sense, our society and our scholastic traditions are based on a pre-evolutionary view of man and his nature. At the social level, the fact that a custom exists does not prove that it is necessary, efficient, or desirable. At the individual level, the fact that a way of thinking may be logical, traditional and appealing does not mean that it is useful.

The essential point is that man evolved in response to conditions that no longer exist, that the human body and human nature are products of a succession of different ways of life, resulting in a peculiar, specialized kind of creature with great abilities and surprising limitations. In reviewing some of the major stages in our evolution, we will comment on the implications of these ways of life for modern man.

Apes and Men

The classic view of human evolution, as described by Huxley and supported by Darwin, was that mankind was particularly closely related to the African apes (the chimpanzee and the gorilla). In the intervening years most scientists abandoned this position and a wide variety of evolutionary theories were proposed. At present, the human lineage is considered to have originated anywhere from five to fifty million years ago, and the creature from which we evolved is visualized as anything from a tarsier to something very like the contemporary chimpanzee. Recent developments in molecular biology and immunochemistry have resolved these controversies, which could not be settled by traditional anatomical and paleontological methods.

Molecular Clues to Human Evolution

It has now become possible to compare the DNA of different animals and to directly assess the differences in their genetic material. Using this method, man appears to be most closely related to the chimpanzee and gorilla, then to the Old World monkey, the New World monkey, and the prosimian, in that order.

A second method of estimating the similarity between two animals is to compare the number of differences in the sequence of the amino acids in a given protein. While there are no differences between man and chimpanzee

in hemoglobin, for example, there are twelve differences between man and monkey. Similarly, there are no differences between man and chimpanzee in fibrinopeptides and an average of seven differences between man and monkey.

Immunological techniques have also been used to compare man with other primates; although this kind of experiment had been conducted for seventy years, neither anatomists nor paleontologists were convinced by its results. Immunological comparisons have recently been improved by the use of purified proteins and techniques that permit objective quantification. As Table 1-1 indicates, the results are the same as those produced by DNA comparison or by amino acid sequencing: man and chimpanzee appear to be so closely related that the methods are at the limit of their usefulness. The order of relationship among the contemporary primates is: man, chimpanzee, gorilla, orangutan, gibbon, Old World monkey, New World monkey, and various prosimians, including the tarsier.

Table 1-1 Differences between man and chimpanzee and man and monkey as measured by:

	Man-Chimpanzee	*Man-Monkey*
DNA	2.5%	10.1%
Sequence of amino acids in:		
Hemoglobin	0	12

Fibrinopeptides	0	7
Immunology:		
Albumin	7	35
Carbonic anhydrase	4	50

This arrangement of the primates agrees with the classic nineteenth-century consensus and is the same as the pre-evolutionary ordering of these animals. What must be emphasized is that the molecular data can be quantified and counted, and that the conclusions are the same regardless of which method is used or in which laboratory the tests are performed. In this sense, then, these results differ greatly from those obtained by traditional methods, which contain a large subjective element. What many scientists did not anticipate was how closely man appears to be related to the African apes, particularly the chimpanzee. The difference between man and chimpanzee is no greater than the difference between some species of macaques, or between species of *Cercopithecus* monkeys, which have never been regarded as particularly dissimilar. If one examines the tables summarizing the data, the only animals as closely related as man and chimpanzee are such animals as the llama and vicuna, sheep and goat, and kinds of buffalo. Man and chimpanzee are more closely related than dog and fox.

It has been suggested that the small differences between man and the African apes may be due more to evolution slowing down than to any recent

separation. But Barnicot has noted that no reasonable explanation for such slowing down has been given. Fortunately, the immunological information provides a direct check on this hypothesis. Sarich and Wilson compared various primates to carnivores. The distances separating them, measured in immunological units of albumin, are: man 169, gibbon 169, macaque 169, cebus monkey 169. Other experiments give similar results. Thus, there is no evidence of human evolution slowing down. Furthermore, the rate did become slower in a New World monkey (*Aotus*), and it is separated from carnivores by 150 units. If there is a slackening, this method detects it. In prosimians, small forms with short generation times, the distance from carnivores is: *Nycticebus* 143, *Lemur* 150, and *Tupaia* (a tree shrew) 163. Small, short-generation forms have changed less than monkeys, apes, or man. As in anatomy, the rate of evolution is independent of size or generation time. Elephants have evolved more rapidly than rats.

Although the difference between man and other animals may be measured objectively by comparing DNA and amino acid sequences or by investigating various proteins with immunochemical techniques, converting these differences into years is more difficult. Attempts to relate molecular differences to dates when two evolutionary lineages may have separated have been discussed elsewhere, and we will only estimate here that a “molecular clock” will be reasonably well calibrated in the next two or three years.

As far as the origin of man is concerned, the fossil record shows that lines leading to man and chimpanzee cannot have existed separately for less than 5 million years, while the biochemical data appear to rule out any date of over 10 million years. Unfortunately, there are not enough fossils to settle the matter. For example, in 1972 Kurten maintained that the separation of ape and human lineages must have occurred more than 35 million years ago. In 1970 another paleontologist insisted that the separation must have been in the Oligocene, some 25 million years ago, but by 1972 thought that the split might be as little as 10 million years ago. It is disagreements of this order that make it impossible to relate molecular change to the fossil record at this time.

Behavior and Anatomy

Until very recently little information has been available on the behavior of monkeys and apes under natural conditions. Most early descriptions of the behavior of nonhuman primates were based on travelers' tales and reflected the way people expected apes to behave. Over the last fifteen years a large amount of accurate data based on carefully planned field studies has become available. It fully supports the arrangement of the primates that the molecular information suggests.

The behavior of wild chimpanzees reflects a close relationship to man. Chimpanzees are now known to use objects more extensively than any other

mammal except man. They employ a variety of things for a variety of activities. They “fish” termites from their mounds with modified sticks and grasses, sponge rainwater from depressions in branches with crumpled leaves, clean their bodies with leaves, throw rocks and sticks, poke at things with sticks. Chimpanzees stalk, kill, and eat smaller animals, and adult males may cooperate in catching a prey animal. Chimpanzees will also share the meat with others, regardless of individual dominance status, unlike baboons, the only other nonhuman primate known to kill and eat an appreciable number of small animals. Finally, chimpanzees mature much more slowly than monkeys, and consequently the young are dependent upon and remain with their mothers for many years.

Chimpanzee and human anatomy is very similar in the arms and trunk, which accounts for comparable motions at shoulder, elbow, and wrist as well as the similarity of many actions in moving and climbing. On the ground, both chimpanzees and gorillas walk quadrupedally, bending their fingers so that their knuckles touch the ground. This is a specialized kind of locomotion derived from the way in which apes reach and climb about in trees. Both the field studies of behavior and man’s close anatomical similarity to chimpanzees suggest that we developed from a ground-living, knuckle-walking apelike creature and that our ancestors moved about in this way before becoming fully bipedal. The problem of the origin of man has frequently been treated as the problem of how an arboreal ape came down to

the ground, but the field studies clearly show that merely coming down to the ground does not result in bipedal walking.

In summary, recent molecular and immuno-chemical studies show that man is particularly closely related to the African apes. Field studies of behavior support this view. These show that many behaviors considered uniquely human are found among chimpanzees. This is in accord with our knowledge of ape and human anatomy. Using the few fossils available, we cannot determine the precise course taken by evolution. What evidence we have suggests that most of the higher primates at Miocene levels were apes (Pongidae). However, most of the apes became extinct in post-Miocene times. The monkeys became the common, successful arboreal primates, even producing several kinds of terrestrial monkeys that have proven to be far more successful than the knuckle-walking apes. Man is descended from one kind of ground-living ape, but men were not as numerous as monkeys until long after the advent of agriculture permitted human populations to expand. If the fossil record of the primates is examined, we find no evidence of any general evolutionary trend toward man, nor, until very recently, any great human success.

The Human Way of Life

Australopithecus

The first creatures in the fossil record that can definitely be identified as human (in the broadest sense) belonged to the genus *Australopithecus.* They lived in East and South Africa between one million and something over four million years ago. The fossils suggest that at least two species of australopithecine existed: two jaw fragments found in Java, which may belong to the genus, indicate that they may have been much more widely distributed than can be proven from the fossil material now on hand. Although fragments of several hundred specimens have been found, the pieces are mostly teeth and jaws. Thus, reasonable disagreement exists over body size, proportions, and habits. The best guess is that these australopithecines were bipedal, hunted, and used stone tools. Since the deposits in which they were found show that they were living in dry savanna, the case for their human affinities is strong. A hand found at Olduvai Gorge, Tanzania has many attributes of a knuckle-walking hand, while a humerus from East Rudolf, Kenya and an ulna from the Omo Valley, Ethiopia show that at least some australopithecines had very massive arms. Stone tools of considerable variety in size and form are found at many fossil sites. In some sites, *Australopithecus* has been found with the bones of the animals he appears to have hunted; in others, both *Australopithecus* and numerous other animals seem to have been the victims of carnivores.

One of the problems in attempting to reconstruct the australopithecines and their way of life has been the prevailing tendency to take each kind of

new fossil man as it is discovered and make it appear as primitive as possible. Neanderthal man was first reconstructed in a very apelike manner, although many proportions of the European Neanderthals are ultra-human, such as their large articular surfaces, short forearms and legs. Java man was depicted as halfway between man and ape, and Pekin man was regarded as too primitive to have made stone tools, although tools were found alongside his bones.

Australopithecus was a victim of the same bias. At first it was even denied that the ilium and the skull could belong to the same skeleton because the pelvis was so human and the skull had such a small cranial capacity. It is true, judging from the few well-preserved skulls found, that the brains of these bipeds were no larger than those of contemporary apes. Holloway's careful reassessment of their cranial capacities shows that australopithecine brains were even smaller than had originally been estimated. In any case, the fact that the brain was small made many scientists at first unwilling to think *Australopithecus* could be human, then unwilling to accept the notion that they could have made stone tools. In our opinion, the discovery of a nearly complete foot by Louis Leakey at Olduvai (see) and of skulls, tools, and limb bones by Richard Leakey in the East Rudolf areas should have settled the matter.

David Pilbeam has provided a comprehensive review of these

discoveries in which the human affinities of *Australopithecus* are evident.

Given the apelike size of the australopithecine brain, it is not surprising that the stone tools found with these creatures are both simple and easy to make. Furthermore, these tools do not increase in complexity over the two-million-year period in which they are found. Since both chimpanzees and contemporary hunter-gatherer peoples use wooden tools, not likely to be preserved in the fossil record over a long time, the lack of apparent progress in tool using may be misleading. Nevertheless, the small brains, roughly half the size of the brain of the beings that succeeded *Australopithecus,* and the simple, unchanging tools all suggest much less effective kinds of behavior than those of subsequent forms of man. If the separation of the human and ape lineages took place more than 6 million years ago, then by far the greater part of human evolution has been dominated by small-brained forms.

Early evolutionary theory held that the brain was the key element in human evolution, and that particularly intelligent apes saw the possibilities of life on the ground. The fossil record shows, however, that the large human brain first appears in the last phases of human evolution, a product of uniquely human evolutionary events. In short, for millions of years before large brains evolved man was a small-brained, tool-using biped who hunted.

The Genus Homo

The larger, more robust australopithecine species probably became extinct, while the smaller, gracile forms evolved into *Homo erectus,* the next stage in human evolution. These forms are known from skeletons found in Java and Pekin, and from more fragmentary remains found in Africa and Europe. Their brains were twice as large as an australopithecine brain, and their long, low skull with its large brow ridges was primitive but definitely human. *Homo erectus* teeth were also human, although often large, and their thigh bone is not exactly like that of modern man, but it is incontestably human in shape. These men hunted large animals and learned how to make fire. The distribution of *Homo erectus* stretched from eastern Asia across to western Europe and down to southern Africa, but in spite of the humanity of these creatures, the fossil record shows that cultural evolution proceeded very slowly.

A million years ago, more or less, complex stone tools appear over most of the Old World, in India, Africa, and Europe. In contrast to the tools found with *Australopithecus,* these tools (Acheulian and related forms) are very hard for a modern human to make. One can learn to make the earliest forms of tools in an afternoon, but an Acheulian bifacial flaked tool can only be made after months of practice. Some are so symmetrical and skillfully flaked that they are esthetically pleasing to modern eyes, and they may, in fact, be regarded as the first direct evidence of art. One of the evolutionary origins of artistic form might be the functional success of skillful manufacturing.

Nonetheless, these tools, which may be attributed to *Homo erectus,* continued with little change in form for hundreds of thousands of years.

Up until some forty thousand years ago these ancient forms of man persisted over much of the Old World. Then, in a relatively brief period of time, *Homo sapiens,* men anatomically like ourselves, appeared and history changed pace dramatically. Evidences of change are everywhere in the archeological record, in shelters, graves, and art. Boats exist, fishing goes on, and shellfish are eaten: water is no longer a barrier to man. Bow and arrow, spear throwers, and many other new tools and weapons are found. Man reaches Australia, conquers the Arctic, and peoples the New World. There is indirect evidence of language, complex social systems, and religion; in short, for human behavior as we know it today.

In summary, there appear to have been three major stages in the evolution of man: a very long early one, in which stone-tool-using bipeds evolve from the knuckle-walking apes; a million-year period, dominated by *Homo erectus,* in which human skills evolve; and, finally, a last stage, a moment in the whole process, in which *Homo sapiens* appears and the world as we know it begins to take form.

Interpretation

We have pointed out that increased intelligence did not cause the lines

leading to man and ape to separate and that the large brain appears late in the fossil record, the result of adaptations to the final phases of human evolution. In this way, man resembles horses and many other mammals. The brain tends to follow in mammalian evolution, and this appears to be the case with man. Since the brain was evolving in a feedback relation with other aspects of human evolution, its structure now reflects this history. For example, the areas of the human brain concerned with manual skills and language are very large compared to those of other primates. In both language and manual skills, control is limited to one side of the cortex. This lateralization is unique to man. Evolution has built structures in the brain that make it easy for man to learn both tool-using and speech. The structure of the brain does not precisely define the functions it makes possible, but it makes classes of learning extremely easy.

The relation of the brain to evolution may be stated in yet another way: since the complex structures of the brain have evolved, they must have important functions whether we know what they are or not. The great evolutionary increase in size of the frontal lobes and the corpus callosum should have made it obvious that these structures had important functions, even before these functions were known. Similarly, the thalamus and other basal ganglia are three times larger in man than in ape, showing that evolutionary expansion is not limited to the newer parts of the brain. The cerebellum has also increased about the same amount, showing that the

whole brain has evolved as a balanced, working system.

Learning of Skills

A comparison with some of the contemporary primates shows that humans have developed a unique ability to learn skills. It is well known that monkeys learn to be social, and the importance of early learning has been shown in many experiments. Chimpanzees mature about twice as slowly as monkeys and man about twice as slowly as chimpanzees. This long period of maturation is necessary to accommodate the peculiarities of human learning. Skills can only be mastered through years of repetition, and the individual is motivated to repeat behaviors by social situations. For example, we may assume that throwing has been extremely important in human evolution. While chimpanzees may throw rocks or sticks, they do not make piles of rocks and practice throwing them, or play games that encourage throwing; nor do appreciative chimpanzee audiences gather to applaud a successful throw. On the other hand, if human adults use spears or bows, they practice these skills in games they play as children before they use them in dangerous situations. The mastery of skills is unique to man. Such behaviors are dependent upon hand-brain coordination, the structure of the brain, and social facilitation. In turn, social facilitation is important in man's unique ability to practice skills and man thus uses his biology far more effectively than any other mammal.

In other words, throughout human evolution there have been selective pressures for skillful performance. In the case of the hands, these pressures have operated to produce strong, effective holding; for example, the structure and proportions of the thumb itself, its muscles, and the areas of the cortex and cerebellum where manual skills are controlled. In the case of speech, as we shall see later, selection has improved the articulatory apparatus that makes the sound code possible, increased lateralization of control, and enlarged related parts of the brain. To be sure, individual skills must be seen as part of a complex socio-biological matrix which makes populations successful.

The Ability to Learn

The kinds of performance from which the selections have been made in the evolutionary past have become easy to learn. For example, humans may learn to speak with ease and will learn a language under almost any circumstances. However, the fact that something is easy to learn does not mean that it is learned quickly or that the final form is closely determined by the underlying biology. It takes a child years to learn to speak, and he may learn a wide variety of linguistic conventions in the process. Nevertheless, man is the only animal with a biology that makes this kind of learning possible.

Chimpanzees, our closest relatives, cannot be taught to speak. Great efforts have been made to help them, including bringing young apes up with human children, but without success. The sounds nonhuman primates make under natural conditions are designed primarily to convey information about the emotional condition of the animal making the sound. These sounds may be produced by stimulating the limbic system through electrodes implanted in the brain. Neither sounds nor facial expressions are altered by removing large amounts of the cortex. On the other hand, in man speech control becomes lateralized in the cortex during the first few years of life, and lesions 0f the cortex may greatly affect speech.

The communication system of nonhuman primates is multimodal, using sounds, gestures, and postures. Gesture and tone are still important in man, especially for expressing emotion, but most communication is through the use of a sound code. That is, of combinations of a very few short sounds. This code allows an almost infinite number of combined sounds and thus an almost infinite number of meanings, although obviously the meaning assigned to any combination must be arbitrary. No nonhuman primate has anything resembling such a sound code, which helps to explain why these animals cannot be taught to speak.

Many attempts have been made to discover when the human kind of communication system with its sound code evolved. Unfortunately, no one

has been able to demonstrate that the ability to make the necessary short noises and combine them can be functionally related in any way to a piece of bone that we might hope to find in the fossil record. The best guess is that languages as we know them today are some forty thousand years old. But simpler modes of speech must have preceded the whole modern complex.

We have suggested that the necessity for practicing motor skills may have been a factor leading to selection for delayed maturation in man. It is equally likely that language influenced this development, since it takes years to learn a language, and participation in human social systems is not possible without it.

Language is not the only thing that man learns easily, however: because of our evolutionary past we have a biology that allows us to be social, to control rage and other emotions. The degree to which humans are able to control their emotions is remarkable, especially if man is compared with the nonhuman primates. Imagine an auditorium filled with several hundred chimpanzees, many of them in estrus! Control involves cost to the individual, however, for biology and social relationships do not operate on separate levels. Biological individuals learn from other individuals. The ability to learn is both a biological and a social concept, with a dimension in time as well. Learning may be both conscious and unconscious, but it always involves emotion as well as intellect (limbic system and cortex).

The ability to learn may be illustrated by the problem of aggression. If this term is limited to mean only inflicting damage or threatening to inflict damage on another human being, then it is clear that man easily learns to be highly aggressive. Johnson has also given an excellent review of the nature of the biological and social causes of aggression. From the evolutionary point of view, aggressive behavior has been necessary in most human societies for a very long period of time. Livingstone estimates that some 25 percent of adult males were killed in warfare among primitive societies. Killing people from other tribes was regarded as the way to social success and essential behavior for any real man. Until very recently, most fighting took place between individuals, victory often being followed by the torture of captives. The extent of human violence throughout history has been summarized by Freeman.

Hunting and fishing are other examples of human behavior that man easily learns and enjoys. The most minimal success, or even hope of success, is all that is necessary to motivate a wide variety of human activities. Since hunting was important to man for millions of years, a biological base evolved that made learning to hunt easy and the act of killing enjoyable.

In times past, hunting was socially approved and techniques were practiced in play. Thus, a kind of behavior that was easy to learn was reinforced by the social reality. Since hunting and fishing are no longer essential forms of behavior for most people, selection pressures have altered

and social reinforcement is lacking in most cases. None-the-less, these forms of behavior continue to be easily learned because of our evolutionary past.

In general, men and most nonhuman primates will learn easily in response to a social reward. Experiments have shown that monkeys will respond even if their only reward is the sight of another monkey. Juvenile humans who are apathetic in the classroom, where activities are maintained by discipline, may respond to sports, where the individual is rewarded by activity, support of others, emotional involvement, and in some cases, social position. Human ability to learn can only be maximized if the rewards are in accordance with man's nature and, in addition, involve social situations and emotions over substantial periods of time. Because we resemble non-human primates in these basic ways much can be learned from the behavior of our nearest relatives and little from the behavior of pigeons.

The Primitive World

Man adapts through his social system, his technology, and his intelligence. Recently there have been enormous changes in technology and in the number of people in the world. But, as noted before, most of human evolution took place before the advent of agriculture, when men lived in small groups, on a face-to-face basis. As a result, human biology has evolved as an adaptive mechanism to conditions that have largely ceased to exist. Man

evolved to feel strongly about a few people, short distances, and relatively brief intervals of time; and these are still the dimensions of life that are psychologically important to him. Children readily form deep attachments for a few individuals; they become familiar with small areas: the homesick child has no doubt of the importance of a small, psychologically meaningful world. Although man s perception of time changes with aging, no person can feel strongly about a period of more than a few years. Not only are millions of years of geologic time emotionally meaningless, but saving for one's old age must be enforced by law.

In discussing language, we pointed out that the meanings humans ascribe to combinations of the sound code are arbitrary. In the physical and biological sciences, the meanings of words are specified by the operations being performed; but in daily life and in the social sciences, words may have little or no meaning. The simple relation of word and referent in the primitive world is lost in our huge, complicated modem world, and our educational systems provide no guidance to understanding either languages or their relation to the brain. The reality of the present world is the many, the far, the complex, the impersonal. The human mind did not evolve to operate effectively under these conditions. To a person in a primitive society, the universe is small and the world is flat. Without access to a telescope, the human brain interprets stars as small, nearby objects, while the sun itself appears to travel across the sky. Simple, personal explanations are devised

for complex natural phenomena; otherwise inexplicable events are thought to have been caused either by spirits or by other human beings. Other groups of humans are regarded as barbarians at best, as inhuman at worst.

Before scientific methods were developed, the human brain adapted to the small world of its experience through beliefs that were common to mankind. None of these folk beliefs corresponds to the nature of the world as it is revealed by scientific technology, and this is what is meant by the statement that the brain is an organ of adaptation, not an organ of truth. The apparently necessary beliefs of the primitive world about the nature of time, space, size, and cause, beliefs that were essential parts of human behavior, do not correspond in any way to the nature of the universe as seen by science. The human brain was simply unable to think its ways unaided to a more accurate way of looking at the world, and technology had to be invented to provide the necessary information for the brain to use in adapting.

Techniques developed in the physical and biological sciences have resulted in views that have expanded the limits of the primitive world. The belief in spontaneous generation has been superseded by an understanding of the function of DNA; bacteria have replaced spirits as the causes of some diseases; but in everyday life and in many of the social sciences, primitive ways of thinking still persist.

The study of evolution raises the issue of whether there can be a useful social science that pays no attention to the biology of the human participants in the social system. The doctrine that there are separate levels of understanding—physical, biological, and social—is a barrier to understanding the evolutionary process and, we think, a barrier to understanding human behavior. Future generations will probably regard such academic divisions as economics, political science, sociology, and anthropology as being as antiquated as the concept that the elements of the world are earth, air, fire, and water.

These categories, which seemed sensible in the nineteenth century, stem from the belief that man is a rational animal and that unaided human thought can arrive at some lasting truth. But the brain is a product of evolution. It evolved in response to the selection pressures of the primitive world, and it adjusted to the conditions of that world by adapting. The scientific-technical world is new. There is no more reason to think that the brain can judge the social scene correctly than to believe that astronomy could evolve without a telescope.

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Notes

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