FOSSILS, APES, MAN, AND CULTURE

(intelligence, water, menopause)

JAMES A. GAVAN

Department of Anthropology
University of Missouri
Columbia, Missouri 65211

SUMMARY

As causal agents for the separation of the pongid and hominid lines of evolution intelligence, water and the menopause are discussed. The implications of these for the development of human culture and society are investigated.

Early in this century the population implications of the basic Mendelian Laws of Genetics began to be appreciated. During the 1930's research in this field coalesced and finally produced the MODERN SYNTHESIS. With the publication of the 1950 Cold Spring Harbor Symposium on Quantitative Biology, this synthesis was brought to the morphological sciences. As a result these sciences took a more dynamic approach to their problems and now routinely utilize the paradigm of Population Genetics as the organizing principle for research.

Today Physical Anthropologists are utilizing types of data which would have been wholly foreign to our intellectual forefathers. These data are organized in terms of the dynamics of the breeding population as the basic analytical unit.

Almost contemporaneously with this intellectual revolution there have been discovered a number of virtual gold mines with respect to fossil man and his non-human primate relatives. Primate Paleontology has had a tremendous spurt in number of discoveries and in ingenuity of data interpretation. It is therefore with considerable regret, at least on the part of some of us, that to date no one has been able to establish a breeding population of fossils.

Even with this failure, however, students of fossil man have been forced to the realization that understanding human evolution cannot be simply in terms of bumps-on-bones. Instead some synthesis of form, function, and behavior must be attempted even though this can be done only indirectly via the study of contemporary primate diversity and uniqueness. Such a synthesis might be referred to as an educated guess. It is such a guess that I wish to present tonight.

The broad picture of change which leads from an insectivor-like animal some 65 million years ago to modern primates is now fairly well known. Recent paleontological work in east and south Africa has documented pretty well the separation of a hominid from a pongid line of evolution. These broad pictures have left the nagging question: what factors were responsible for the separation of our population from that of the chimpanzee-gorilla? In considering this question I wish to discuss three things: intelligence, water, and the menopause. My thesis is that these three are one.

Consider intelligence. At the intraspecific level of individual differences, this is a qualitative concept without a useful definition. Science has difficulty dealing with qualitative phenomena. At the interspecific level, however, we can reduce an analysis of intelligence to a quantitative phenomenon by considering that in a general sense brain size increases with body size, but even at constant body size there is considerable variation among species with respect to brain size. JERISON (1973) has utilized regression analysis for predicting average species brain size from average body size. By dividing actual average brain size by estimated brain size one arrives at what JERISON calls the "Encephalization quotient" or EQ. If this is less than 1.0 the animal has a small brain; if it is greater than one the brain is larger than would be expected from body size.

If the contemporary, primitive primates, the Prosimians, are considered in this way, their average EQ is about 0.9. Or from a quantitative view of intelligence, they are not a particularly bright lot. Monkeys, on the other hand average about 2.0 on this scale. Their brain is almost twice what would be predicted from their body size. It is interesting that little *Tarsius*, a form morphologically intermediate between prosimians and anthropoids, has an EQ of just over 1.0. The Great Apes average a bit better than monkeys, but not a great deal better.

Man stands out, however, with an EQ in excess of 7.0. This is quite proper especially when we remember that man developed this system of classification. Man does have an especially large brain both absolutely and relative to his body size. If this quantitative measure of qualitative attribute be accepted then the question arises when and under what conditions did man become such an intelligent animal?

JOHANSON and WHITE (1979) present fossil evidence for a separation of the hominid from the pongid line at least three million years ago. In terms of a dollar a year, such a sum makes retirement sound very pleasant. In terms of the extent of geologic time, however, this is but a small drop in the proverbial bucket. Three million is but 0.5% of the known duration of complex life on this earth. It is only 5% of the time Primates have been a separate Order.

We know man is a highly intelligent animal by considering the complex civilization which he has built. However, if we take the origin of agriculture as the early sign of this intelligence, and that seems like a good beginning point, then man has evidence of high intelligence for only 0.3% of human existence. Clearly in terms of ability to develop complex cultures, human intelligence is a very recent thing.

However when in geologic time did man become an intelligent animal? In terms of JERISON'S criterion, the fossil record is not particularly adequate. Fossils must be sufficiently complete to permit an estimate of both brain size and body size. During the Eocene, which began about 60 million years ago, there are a number of Prosimian fossils complete enough for such estimates. In these cases JERISON'S EQ averages only about 0.6. By the end of the Oligocene, some 25 million years ago, the human-ape line has separated from the prosimian and monkey lines. The EQ estimate for human-apes is about 0.8. In other words, the Primates are well established by the end of the Oligocene, some 60% of the time Primates have been separated from other mammalian orders, but still show no great increase in brain size.

During the Miocene, 25 to 10 million years ago, the human-ape ancestral line gives an estimate of JERISON'S EQ of 1.6 or a significant increase in brain size.

The human and ape line separated some time in the Pliocene and by three million years ago a hominid line is well established as attested by the great number of fossils found in east and south Africa. PILBEAM and GOULD (1974) have studied these fossils by regressing brain size on a logarithm of body size.

They found one line of comtemporary apes, pigmy chimpanzee, common chimpanzee, orang and gorilla, gave a regression coefficient of 0.3. That is for every unit increase in log body size there is 0.3 of a unit increase in brain size. For the fossil sequence *Australopithecus africanus, A. robustus, A. boisei* the coefficient is also 0.3. This fossil sequence is one which shows a tremendous increase in body size but most investigators feel it is a dead end with no contemporary descendants. Their brain size increase is the same as in those contemporary pongids that differ in body size. When these authors considered the sequence *Australopithecus africanus, Homo habilis, H. erectus, H. sapiens* the coefficient became 1.7 or a drastic increase over our close relatives both living and dead.

This analysis would indicate that man's ancestors began their great increase in relative brain size about three million years ago. It is tempting to explain this sudden increase as being due to the development of culture, but if we consider some recent work with the great apes such an explanation seems unlikely. Jane VAN LAWICK-GOODALL (1964) has summarized her data on chimpanzee ethology and shows that not only do these relatives of ours use tools but also that they make them. Special sticks are prepared for hunting termites, and vegetation is chewed into a form for getting water out of the crotches of trees.

Initially the GARDNERS (see GARDNER and GARDNER, 1971) working with Washo, a chimpanzee, and subsequently others working with gorilla and orang, have been able to teach these animals to communicate via sign language. It is evident that these animals are using symbols and not merely repeating memorized signs. In this sense they have language.

On the assumption that because all modern descendants have these abilities, they must have been present in the common ancestor; we must postulate that our human-ape ancestor of the Pliocene also had such abilities. Then why did our ancestor develop culture whereas these others, equally able primates, retain the old way of life? I believe at least part of the answer lies in the man's rather peculiar water requirements.

In order to appreciate this man-water relation it is necessary to take a quick look at the Africa-Asia world during the Miocene. During the latter part of that epoch, there was a continuous stretch of forest from south Africa to Asia. These forests were occupied by our human-ape ancestor. With the coming of the Pliocene there sets in a period of dessication. The forest breaks up into segments with stretches of savannah in between. As the forest decreases in size there must have come a period of competition among groups of primates and my suspicion is that our ancestors lost the battle and were driven onto the savannahs. At least early hominid sites are found on what was savannah and near what was a permanent source of water.

In the forest our ancestors were always near a ready supply of water. They lived in a hot, humid environment, but one which was not excessively stressful. Once on the savannahs the situation becomes very different. NEWMAN (1970) has explored the implications of this shift. He points out that on the savannahs man is subject to tremendous heat but with low humidity and a constant breeze. Man maintains his body temperature by sweating a lot. In fact man can sweat 1,000 grams of water per square meter of body surface per hour. Very few mammals can exceed 500 grams of water per square meter of body surface per hour. At least the cosmetic industry will be forever grateful for man's virtually unique abilities in this matter.

Tests have shown that if man loses 2% of his body weight through sweat he becomes thirsty; if he loses 10% he is incapacitated, but if he loses 20% he is dead. Yet camels, sheep, and donkeys can lose 30% of their body weight through sweat without ill effects. Man is a very sweaty animal, but he cannot withstand dehydration. He must drink continuously. Just try to put a three-year-old to bed some night when he doesn't want to go. His thirst is unbelievable.

In order to live on the savannahs man must drink continuously. Here again man is unique. The camel can drink 10 liters per minute and can hold a total of 100 liters. The donkey can drink 6.7 liters per minute and hold 20 liters. The guanaco 1.1 liters per minute for a total of 9 liters. The sheep 0.9 liter per minute and hold 9 liters. But man can drink only 0.2 liter per minute and can hold only 2 liters. Try drinking a six-pack real fast, but don't race a camel. Man is a sweaty animal; he cannot withstand dehydration, nor can he hold very much water at any one time. Man moves onto the savannahs, but he retains the water physiology of a forest animal.

The transition to the savannahs must have required a drastic change in his social organization especially when we consider that lactating females and children have an even higher water requirement than adult males. The adult female water requirement must have been high as they were probably either pregnant or lactating their entire adult lives. In order to live, the group must have developed a division of labor. Males left the group to seek food at a distance, females cared for the young and stayed in the group. Whether man was an active hunter, a scavenger, or merely a seeker of vegetable foods makes no difference.

If this division of labor is to work, a camp must be established and moved when all members are present. Otherwise the males on their return would not know where to make contact with the others. Also, on their return, the males must share the food they have found with those who remained in the camp.

These three things, division of labor, semi-permanent camp, and the sharing of food, are very non-primate concepts. No contemporary primate does any of them as a routine thing. Yet all are present in all human societies today. These are human attributes, a result of a forest animal adapting to life on the savannahs. These changes must have taken place about three million years ago. The next change, the menopause, came later; just when, we do not know, but probably some time between one-half and one million years ago.

So far as we know, a very non-primate characteristic of *Homo sapiens* is the menopause. Woman's life expectancy is greater than their reproductive years. The neo-Darwinian synthesis attributes evolution to reproductive success. What kind of success is it to evolve a group of people who cannot reproduce? What possible selective advantage could there be for having such people in the society?

About five hundred thousand years ago a group of species *Homo erectus* lived in the cave of Chou Kou Tien not far from Peking, China. Of the forty-five individuals represented almost five percent have an estimated age in excess of fifty years. In all cases since then where a number of individuals are represented in the skeletal population, some of them have an estimated age of more than fifty years at the time of death. The average woman today will go through menopause by fifty years. Thus it seems reasonable that for the last half million years we and our ancestors have always had some individuals in the society who were incapable of reproducing.

In preliterate societies today such people form a council of elders, a most respected segment of society. They are looked up to and their council is solicited in times of crises. More importantly, however, they are the repository of the traditional knowledge of the group. They are the libraries of preliterate society. As our ancestors adapted to environments outside the savannahs, as their culture became more complex, knowledge had to be stored in a retrievable manner. People who no longer had to assume immediate responsibility for the younger generation took on this role. The august profession of professor had been born.

At some point in this sequence another change was taking place. *Homo sapiens* develops an adolescent period in his growth cycle. At nine years of age the average child is adult neither sexually nor physically. He cannot play the role of an adult, yet such individuals have 90% of their adult brain size and probably all the neurons they will ever possess. Thus man not only develops a class of teachers he also develops a group of individuals who are capable of being taught and who have the time to be taught because they have not reached the point where they can take a complete adult role.

Losing the battle for the forests to the chimpanzee-gorilla forced man on to the savannahs. In order to live he had to change his social organization and cooperate in ways other than for group defense. This laid the ground work and gave selective advantage to culture. This in turn gave a selective advantage to having teacher and teachable members of the group. None of these things happened to our ape relatives.

Today we have developed a tremendous technology; part of that technology has mechanized the storage of information. Thus teaching has been socialized; the state now pays young people to teach other younger people. That segment of society who at one time played such an essential role is now superfluous. We send them to Florida, let them play shuffle board, and get skin cancer.

LITERATURE CITED

GARDNER, B. T. and R. A. GARDNER 1971 Two-way communication with a chimpanzee. In SCHRIER, A. and F. STOLLNITZ (Eds.) Behavior of Non-human Primates. Volume 4:117-184, Academic Press, NY.

JERISON, H. J. 1973 Evolution of the Brain and Intelligence. Academic Press, NY.

JOHANSON, D. C. and T. D. WHITE 1979 A systematic assessment of early African hominids. Science 203: 321-330.

NEWMAN, R. W. 1970 Why is man such a sweaty and thirsty naked animal: A speculative review. Human Biology 42: 12-27.

PILBEAM, D. AND S. J. GOULD 1974 Size and scaling in human evolution. Science 186: 892-901.

VAN LAWICK-GOODALL, J. 1964 Tool-using and aimed throwing in a community of free-living chimpanzees. Nature 201: 1264-1266.

Dr. Gavan in the discussion group.

At the banquet for the 11th Stadler Genetics Symposium.