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# EVOLUTION, HUMAN DIVERSITY, AND SOCIETY

*by Bernard D. Davis*

It has been suggested that the growth of all science, like that of human gross anatomy, inevitably will come to a halt because all the important questions will have been answered. But I am sure that such asymptotic leveling of knowledge is far out of sight for biology as a whole, not only because the material is extraordinarily complex (extending to the biological roots of individual and social behavior), but also because it is highly diverse. I shall be concerned particularly with human diversity.

To be sure, earlier studies in biology could observe only the visible features of organisms, and so they focused on the rich diversity of form and of function in the living world. But as biology progressed from the descriptive to the analytical and from the level of whole organisms and organs to that of cells, subcellular organelles, and molecules, an underlying unity emerged and received increasing attention. Indeed, at the molecular level we find that in all cells, from the simplest bacterium to our own brain cells, the genes are composed of DNA, and the working machinery is composed of RNA and pro-

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teins. Moreover, all cells employ very similar sequences of chemical reactions in deriving energy from food and in synthesizing the compounds needed for cell maintenance, function, and growth. Exploration of these universal molecular properties of cells obviously will map the whole territory sooner or later. However, we still will have a virtually endless frontier in the study of biological diversity—whether the origin and the nature of the molecular differences between cell types or the behavioral differences between human beings.

## Public Concern

Paradoxically, at the same time that this flowering of biology has been giving us innumerable valuable applications, both in medicine and in agriculture, we have also seen the rise of widespread public disenchantment with science. There are many reasons.[1] One is a loss of confidence in authority. Another is belated recognition that the technological applications of science have costs as well as benefits. Thus the promise of nuclear energy is built on the threat of nuclear annihilation; our increasing scale of manufacture of useful goods is exhausting many natural resources and accumulating many kinds of pollution; and our most benevolent technological advances, against starvation and disease, have resulted in a population explosion that is rapidly leading to a world crisis. It is all too easy for social critics, taking the benefits for granted, to suggest that we cut down on the advance of science rather than that we learn to control its technological applications more wisely. To be sure, we may not be able to summon up the wisdom and social organization required for that control, but trying to do so still seems preferable to trying to develop social innovations in an atmosphere of scientific stasis.

Against this background, genetics has now become a major focus of anxiety. One area of concern has been genetic engineering, but I shall not take up that set of problems. As I have spelled out elsewhere, on purely technical grounds I do not believe the prospects are imminent or the misuses really feasible or tempting—certainly not enough to justify present public concern.[2] I shall focus instead on another set of problems, which seem to me to have much greater philosophic depth and religious interest: the implications of evolution and genetics for the nature of our species and the relevance of this knowledge for the concepts of equality and social justice.

## Darwinian Evolution

Darwin's theory of evolution by natural selection is a unique product of the scientific method, for it was originally based almost entirely on historical inferences rather than on hypotheses validated by experimental tests. Nevertheless, it is one of the greatest triumphs of that method, and it is clearly the most important generalization in biology. It accounts for both unity and diversity in the living world. Moreover, it provides a realistic picture of man's origin that places him at a unique pinnacle in evolution, replacing earlier speculations that tried to account for his obviously unique qualities in other ways.

The theory of evolution is built on a long time scale. Its dates are now based not only on evidence from geological structures but also on the much more direct evidence from the extent of decay of radioactivity. Hence there is unlikely to be any major correction in the current estimates. To review these briefly: Life on earth began as one-celled organisms about three billion years ago. Only in the last 1/1,000 of the total period of evolution, about three million years ago, did the hominid line, leading to man, branch off from the other apes. Man's rapid cultural evolution, using the written word to accumulate information and using agriculture to accumulate surplus goods, occupied about 1/500,000 of the total—about the last six thousand years. Only in the last 1/20 of that period have we had the scientific method, in which verifiable evidence and testable hypotheses supplement pure reason in our efforts to understand the natural world. And in those three hundred years it is only a bit more than one hundred since Darwin's *The Origin of Species* was published and only thirty since Oswald Avery identified the material substance of the gene. The ethical implications of evolutionary genetics are thus very new, and it is not surprising that we are having trouble elucidating and assimilating them.

When Darwin finally published *Origin* in 1859, after incubating the theory for over two decades, he stopped short of discussing the implications for man, though they were clear. Only ten years later did he develop the courage, after watching the intense intellectual controversy that he had precipitated, to spell out this final conclusion in *The Descent of Man.* It was vigorously opposed by the religious establishment on the grounds that the idea of the evolution of man from lower animals by natural selection destroyed the foundations of public morality. In addition, the whole theme of evolution and change was anathema to the social establishment, dedicated to preservation of the status quo.

The polemics of the mid-nineteenth century dwindled after a few decades but by no means with a clear victory for the Darwinians. The scientific evidence was not complete enough to overcome skepticism, and even many biologists remained unconvinced until about the 1930s. For natural selection, which chose traits retrospectively instead of designing them prospectively, could not occur unless heredity possessed two apparently contradictory properties: breeding true and yet producing new variation for selection to act on. But evolution was discovered before the elements of genetics, rather than in the more logical reverse sequence, so Darwin knew absolutely nothing about the mechanism of heredity with its double property of constancy and variation.

In fact, it was only five years after *Origin* that Mendel, abbott of a monastery at Brunn, discovered the existence of fixed, independently segregating units of inheritance, each governing a specific trait. However, since his statistical approach was foreign to biologists of the time the work was buried. It was rediscovered in 1900, and by then some biologists had become receptive to this new mode of analysis, whose value in physics and chemistry had already become evident.

I emphasize this point because the teaching of elementary mathematics in our educational system still does not include a grounding in the fundamental concepts of statistics. Moreover, nonstatistical, qualitative thinking is built into the very structure of our language, so discussions that involve statistical concepts frequently result in failure of true communication. For example, in discussing genetic differences among people, if I say that group A is better endowed than group B in some respect, I would have in mind distribution curves whose mean values differ. I thus take it for granted that this generalization tells us nothing about the standing of any specific members of either group. However, you may think you hear me suggesting that all members of group A are better endowed than any members of group B. This misunderstanding has been the source of enormous confusion, mischief, and polarization.

### The Synthesis of Evolution and Genetics

For several decades the field of genetics remained quite separate from evolution. In the kinds of traits that Mendel and his early successors dealt with a single gene determines a specific trait—say, blue or brown eyes or one or another blood group. Moreover, every gene is present in two copies, which may be identical or may be different; and in sexual reproduction an offspring receives from each parent, more or less randomly, one member of each of that parent's gene pairs. This reassortment, along with the dominance of one form of the gene over an alternative, recessive form, determines the visible trait (phenotype).

Evolutionists, however, are interested primarily in other kinds of traits: those morphological and behavioral traits that vary in a quantitatively continuous manner rather than existing in only two alternative forms. These traits initially do not seem to be inherited according to Mendel's laws, and it took several decades to work out the statistical demonstration that their genes also obey those laws. The difference is that the qualitative traits are polygenic rather than monogenic—that is, a large number of genes contribute to the intensity of a trait, and the variety of their combinations gives rise to an apparently continuous range of values.

Before genetics could be effectively applied to evolution, a second concept had also to be clarified: the interaction of genes and environment. For Mendel's studies—with plants growing in a relatively uniform environment—emphasized the deterministic effect of the genotype (the total set of genes in an individual) on the phenotype (the set of traits observed). But we now know that only a few of the traits that we observe are determined in this way. With most, genes determine the range of potential of an individual, and within that range the interactions with the environment condition the actual phenotype that develops. For example, we know that tall parents tend to have tall children and short parents tend to have short children. However, since the mean height of college students has been increasing over the past seventy-five years, it is also obvious that differences in nutrition (and perhaps in other environmental factors) can affect height. If it seemed socially desirable we could attempt to equalize stature by giving optimal diets to the children from short families and poor diets to the children from tall families. But the success of this form of egalitarianism would still be limited by the ranges of genetic potential of the individuals—and where these ranges did not overlap one could not achieve equality, though one could decrease differences.

Modern molecular genetics has reinforced and explained the mechanisms underlying these principles of classical genetics. We now know that some genes are simply structural, determining the structure of a corresponding protein. When a trait is determined by the nature of that protein (e.g., normal vs. sickle-cell hemoglobin) or by its absence (e.g., absence of a pigment-forming enzyme in albinos), the trait is strictly Mendelian and monogenic in its inheritance. Other traits, however, whose intensity depends on the environment, involve regulatory genes: genes whose protein products interact with appropriate environmental stimuli and also with some other particular gene or genes, thus enabling these stimuli to influence the activity of the responsive genes.

This mechanism was first established with simple bacterial cells, which respond to chemical stimuli in the environment. For example, the colon bacillus (a major inhabitant of our gut) can utilize the sugar lactose as a food, but in its absence the bacterial cells do not make the specific proteins that are necessary for that utilization. When lactose is added it complexes with a specific regulatory protein, and this complex activates the genes that make the proteins required for utilizing lactose. Moreover, mutations in the regulatory genes alter responsiveness to lactose. In humans similar cellular responses to specific chemicals have been observed. Moreover, there is no doubt that other kinds of stimuli, perceived by our sense organs, are ultimately translated (through the mediation of the nervous system) into chemical stimuli that either activate or repress specific genes in appropriate cells. Differences in regulatory responses no doubt are the major molecular basis for individuality.

This knowledge from molecular genetics is certainly relevant for our understanding of intelligence and of other mental traits, but only in general terms. We can be certain that many genes must affect intelligence; they act through the production of proteins that ultimately influence both the wiring diagram of the ten billion cells of a human brain and the functional properties of their connections; various of these genes must differ from one person to another; and the function of the switches (and in early life the formation of these connections) is markedly influenced by learning experiences. But so far we can deal with these genes only in the formal terms of the analysis of polygenic inheritance and not in molecular terms.

## Population Genetics and Race

By the 1930s, even before the molecular mechanisms of gene action were unraveled, the importance of polygenic traits and the ability of genes to determine a range of potential had become clearly recognized. Genetics then fused with evolutionary theory to create the new field of population biology, concerned with the statistical distribution of genes among populations (population genetics) and with the factors that influence these distributions (ecology).

This development has had a consequence of great social significance: It has utterly destroyed the earlier conception of the nature of races, which was long used to justify race discrimination. That conception was derived from the Platonic notion of essences or ideals—the idea that every species, or every kind of object, is characterized by an ideal type which embodies its essential features, while individual members of the class differ from the ideal only adventitiously and in minor ways. This idea was useful in physics and chemistry, where it helped to define classes of entities more sharply; but its application to biological populations, and particularly to races, has been grossly misleading. We now recognize that races can be understood only in statistical, populational terms and not in typological terms. Specifically, races—whether of man or of wheat plants—are subgroups within a species that have been reproductively separated for many generations and hence have accumulated statistical differences in their gene frequencies.

Races can thus be characterized only in terms of their gene frequencies, as inferred from their distribution of traits that are largely or completely determined by genes. A few traits in man, such as skin color or certain features of body or facial shape, have been so highly selected in various geographical regions that the corresponding races do not overlap in their distributions; and it is the high visibility of these traits that generated the unfortunate early typological view of race. However, for mental traits, which are surely the most interesting ones in human beings, it is clear that the various races overlap extensively in their distribution of genetic potentials. Hence the identification of a person with a particular race does not help to characterize his behavioral potentials: Population genetics emphasizes the need to judge an individual as an individual. It is worthwhile to spell out this credit, for, as we shall see below, the early misapplications of genetics to society have made many liberals suspicious of the field.

## Molecular Genetic Evidence for Evolution

Let us return to molecular genetics and to its relation to evolution. Avery discovered in 1944 that the material of the gene was DNA, a giant, long-chain molecule made of four different kinds of units (called nucleotides). In 1953 James Watson and Francis Crick showed that the chain consists of two complementary, intertwined strands (the double helix). That is, the four kinds of units can be divided into two pairs, the members of each pair having complementary shapes and therefore a specific affinity for each other; and in the double-stranded molecule every unit in either strand is paired exclusively with the complementary one in the other strand. Hence the sequence of units in either strand automatically specifies the sequence in the other. Accordingly, the mystery of the replication of a gene in cell division is solved. Its molecular structure is not directly copied (a hypothetical process for which there is no known mechanism), but instead each strand of DNA serves as a template for synthesis of the complementary strand. Thus, by the complementation of each half, the double-stranded DNA as a whole is copied.

This discovery founded the field of molecular genetics, whose explosive development soon revealed a great deal about the gene: not only how it is copied at each cell division but also how mutations arise, as rare errors in this copying process that then are perpetuated as an altered DNA; how the incredible stability of the gene and the accuracy of its copying are promoted by several enzymatic repair mechanisms, which correct most errors; how the length of the chain can be expanded to provide the additional genetic material needed for the evolution of higher organisms; how the genetic code specifies the correspondence between the sequence of bases in a gene and the corresponding sequence of amino acids (building blocks) in the cognate protein; how the genes are translated into RNA and protein, the working machinery of the cell; and how the rate of this translation is specifically regulated for each gene, according to the needs of the organism and in response to stimuli from the environment.

Molecular genetics also permits one to formulate and to test a major prediction from evolution: If the progressive accumulation of mutations leads to the evolution of a species into multiple races and eventually into daughter species, the DNA in the diverging lines should accumulate differences. Moreover, the farther apart organisms are on the evolutionary tree the greater should be these differences. This is precisely what is observed. For, when DNA is extracted from cells and purified and its two strands are caused to separate, if they are then placed under the right "annealing" conditions they will zip back together in regions where they are complementary but not where they are not. It thus becomes possible to quantitate the degree of similarity of the total DNA of two species: The two samples, converted to single strands and mixed, will hybridize (pair) with each other to the extent that they have complementary regions of substantial length. Such studies have shown that the DNA of man bears no relation to that of bacteria, has a slight similarity to that of lower vertebrates, and is 99 percent the same as that of the chimpanzee. Similar evidence can be obtained by comparing not total DNA but single, purified homologous proteins from different species (e.g., hemoglobins, or specific cellular enzymes). Their sequences of amino acids reflect the sequences of the corresponding genes, and, as organisms diverge in evolution, the amino acid sequences of their homologous proteins exhibit increasing differences.

These findings confirm a precise and detailed prediction from the modern synthesis of evolution and genetics. They thus provide extremely direct evidence for evolution—far more direct than the stepwise morphological variations and homologies (in different living species, in the fossil record, and in embryological development) that led Darwin to his brilliant synthesis. Hence, though skeptics did not find that early evidence compelling (as I have noted above), today one rationally cannot deny human evolution if he accepts the validity of science as the means of understanding the world of nature—a validity that each of us confirms innumerable times each day in using the fruits of technology. Indeed, I would say that Darwin's theory is now more than a mere theory. It is as firm a law as Newton's laws of motion or the laws of thermodynamics (though its implications are less fully understood).

Nevertheless, it is easy to see why many people have feared, and members of some of our state legislatures apparently still fear, that the replacement of special creation by evolution threatens the foundations of public morality. On the other hand, some of us believe that a deeper exploration of the social implications of our knowledge of evolution may even help to provide a firmer foundation for our moral values. The rest of this paper will consider these two opposing views.

## Misapplications of Genetics and Evolution

There is unfortunately a real historical basis for fear of efforts to relate evolutionary theory to society, for early efforts at such extrapolations not only were unsound but had tragic consequences. The first of these efforts, named "Social Darwinism" (but really the product of Herbert Spencer), focused exclusively on the role of competition in natural selection. The resulting exposition of an alleged natural law was used widely to rationalize the exploitation and cruelties of unrestrained laissez-faire economics. Only many decades later was it recognized that the evolution of social species, ranging from insects to man, has also selected for cooperation. Moreover, kinship selection can now explain the evolution of even an instinct (or a willingness) for altruistic self-sacrifice: The sacrifice of an individual can promote the spread of his genes if it aids the survival, and hence the multiplication, of kin who bear the same genes.[3]

Another premature application of genetic ideas was eugenics. Sir Francis Galton, a cousin of Darwin, advocated such a program, with the aim of improving the stock of our species just as animal breeders had improved the strains of domesticated animals. But he vastly overestimated the role of inheritance, compared with the role of favorable circumstances, in the achievements of the upper-class Britons whom he admired. He also greatly underestimated the cultural value of diversity. It is profitable to try to maximize an obviously valuable trait in domestic animals, such as speed in a race horse or milk production in cows, but in man our goals are not so simple, and there is no self-evident ideal to select for.

Unfortunately, both the eugenic movement and Social Darwinism were used to bolster ancient notions of racial superiority and inferiority. These misapplications of genetic ideas contributed to the restrictive immigration laws of 1924 in this country, and they reached their culmination in the Nazi idea of the master race and its right to engage in genocide. But modern population genetics, as I have noted above, has radically revised our concept of race, and in so doing it has thoroughly dispelled the prescientific assumptions and the pseudoscientific rationalizations that perpetuated these primitive social views.

We also now know that neither the 100 percent hereditarian view nor the 100 percent environmentalist view of human behavior can be defended. Both genes and environment contribute to the observed variation in a population, and their relative contribution will vary from one trait to another. Moreover, this proportion, often expressed quantitatively as heritability (the ratio of genetic variance to total variance), will also differ from one population to another, depending on the distribution of its genes and its environments.

Heritability can be measured in experimental animals in two ways: by exposing a variety of genotypes to the same environment or by exposing the same genotypes to a variety of environments. Since we cannot control these variables as completely in man as in experimental animals, the numbers obtained have a much larger margin of error. But there is no doubt that genes and environment both contribute a good deal to such traits as, say, general intelligence. Nevertheless, people interested in advancing our knowledge in this field are sometimes accused of being biological determinists, perpetuating obsolete nineteenth-century dogmas. One might as justifiably identify a modern surgeon with the phlebotomists of past centuries!

## Implications of Evolution for Human Genetic Diversity

Let me further emphasize that, even if no one had ever devised a test for measuring IQ, we could still be confident, on grounds of evolutionary theory, that our species contains wide genetic variance in intelligence.[4] The reason is that natural selection cannot proceed unless it has genetic diversity, within a species, to act on; and when our species is compared with its nearest primate relatives, it is obvious that our main selection pressure has been for an increase in intelligence. Indeed, this change proceeded at an unprecedented rate (on an evolutionary time scale). In the past three million years the brain size of the hominid line increased threefold, starting at about the level of our present nearest primate relatives. Yet this period is so short that our DNA as a whole changed by only 1 percent from that of our relatives, and our biochemical traits changed little; moreover, the change in our physical traits were mostly those subject to the same selection pressures as intelligence because they made it more useful (e.g., opposable thumb for making and using tools, bipedal posture to free the hands, a female pelvis with a larger birth canal to accommodate a larger cranium). It is as though once the trick of abstract thought emerged in evolution it had such selective advantage that it was intensified at a remarkably high rate. Such rapid selection for increased intelligence could not have occurred unless the selection pressure had a large substrate of genetic variation to act on.

We may also note that the uniqueness of man arose from this pressure for rapidly intensifying the valuable, novel traits of the hominid line, which increased its capacity to adapt to novel circumstances and to manipulate the environment. The result was that a single hominid species emerged to populate the whole earth, whereas other families of organisms have numerous species which occupy different ecological niches.

It is clear, then, that evolving mankind must have had a wide range of genes that affected behavioral traits. To be sure, these traits exhibit unusually great plasticity of response to the environment, so their genetic components are difficult to measure. For this reason, reinforced by social convictions, some people believe that in our species cultural evolution now has replaced biological evolution entirely, and cultural adaptability has replaced genetic diversity. But this is a fanciful concept. A dramatic switch from recent, great biological variation to present, virtual homogeneity would contradict all we know about the mechanisms of population variation and the slow pace of evolution. There is every reason to believe, from first principles, that mankind is still evolving.[5] Moreover, since our species still possesses a large, easily demonstrable reservoir of genetic variation for both physical and biochemical traits, and since our behavioral traits have evolved even more rapidly, I would find it impossible to entertain serious doubts that these traits also have such a reservoir.

We see widespread reluctance to accept this concept today, based on fear that it will undermine the struggle for greater equality. Indeed, one of the implications of evolution, as noted above, is that long-separated populations, subject to the pressures of different environments, will accumulate statistical differences in genes that affect behavioral potentials, just as in their other genes. Evolution does not predict the magnitude or even the direction of such differences, but it does say that we cannot predict the numerical outcome if barriers to equality of opportunity are removed.

This is a painful message for liberals, and I wish those of us who are deeply concerned with social justice did not have to face it. But if we wish to pursue the goal of equality on a realistic basis we must recognize the fundamental difference between social equality, which we can legislate, and biological equality or inequality, which is beyond our control. If we insist on assuming a nonexistent biological equality between people we will pay a large price in the long run. Thus if we set unattainable goals in education we will demoralize our teachers by blaming them for every failure, and we will thrash about from one program to another because none reaches the assigned goals. We will ensure chronic social unrest by promoting a profound fallacy: Unequal achievements not only may be due to unequal opportunities (as has been all too true too often) but are proof of unequal opportunities (which is false). We will promote guilt and friction among parents by making them consider their faulty guidance responsible for all behavioral problems in their children. And we will jeopardize the struggle for racial justice by basing it on fragile, conceivably disprovable assumptions about matters of empirical fact (the distribution of potentials) rather than on moral and political convictions. On the other hand, the better we can identify differences in various potentials, and in patterns and rates of learning, the better we will be able to provide true equality of educational opportunity—that is, the opportunity to have everyone's education equally designed for maximal fulfillment of his potentials.

If equality of opportunity, combined with the existence of genetic heterogeneity, produces a result that does not satisfy society's strong pressure for greater equality of outcome, biological considerations suggest that we examine more closely what we mean by equality of outcome. At present we seem to be aiming at leaving the reward system more or less untouched but satisfying the social pressures by setting up quotas for distributing the more highly paid or prestigious jobs among various, identifiable groups. This solution seems unstable to a biologist. However, as a biologist, I have no objection to an economic rather than a vocational egalitarianism—one that would aim at matching responsibilities with abilities but would then increase equality in the reward system.

It is ironic that recognition of genetic diversity as an implication of evolution finds intense opposition from the Left today, just as the implications of evolution with respect to our origins aroused opposition from the Right a century ago. Yet a pluralistic society should be able to recognize our biological diversity as a great cultural asset. Indeed, just as our rapid biological evolution required a wide range of variation for natural selection to act on, so our rapid cultural evolution depends on the capacity of the population to generate, and then to select in its social practices, from a variety of behavioral responses to new challenges; and that variety in response obviously has been enormously increased by our variety of genetically conditioned potentials, drives, and preferences. Indeed, if nature had selected for behavioral genetic homogeneity in our species, or if we should set up a successful eugenic program with this ultimate egalitarian goal, then, even if the most admirable traits were selected for, it is clear that we would have a much duller culture. We would also decrease the adaptability of our species to unforeseeable changes in the environment—a property of the utmost importance for our survival.

I would further suggest that the polemics over the heritability of IQ not only have blinded us to the advantages of diversity but have seriously distorted our perspective. The very intensity of the opposition fortifies the tendency to treat IQ measurements as an index of human worth rather than as a useful index of likely performance in certain types of education. Instead of fervently denying the existence of genetic variation in intellectual potentials, or the practical value of tests as guides for educational placement, it would be much more constructive to emphasize the real but limited social significance of differences in intelligence, the value of many other traits, and the cultural value of diversity.

## Evolution and Ethics

I would now like to discuss some aspects of the interaction of science, and particularly of evolution, with the problems of morals. In the nineteenth century the interaction led to a war between science and theology, based on fear that public morality would suffer if we abandoned the transcendental, metaphysical conceptions that had long provided its foundation for a majority of people in the Western world. From my point of view as a scientist, established religion was wrong in the position it adopted, for it was led to oppose verifiable truths about the world of nature, and it was bound to lose. But we can now see that the clergy were right in their prediction of troubles ahead. Since an increasing fraction of the population can no longer accept traditional, supernatural explanations for the origin of a moral code, the public moral consensus has been attenuated. This development has no doubt contributed to the weakening of social bonds and to the recurrence of barbarism in enlightened societies.

But while the conflict between science and religion is far from resolved, recent advances in our understanding offer promise of helping by eliminating some grievous misconceptions that have clouded the issues. First, I would emphasize that scientism—the assumption that science can solve any problem—is obsolete. We are only now recovering from this illusion, though centuries ago Hume pointed out that one cannot derive an ought from an is. At the same time, we must recognize that science is not irrelevant to problems that involve values. For in choosing a goal we not only make a value judgment but also estimate the relative feasibility and the consequences of alternative goals. Science can help us make those estimates more realistic and reliable. The scientific method for understanding the world of nature and the concern of religion with goals and values can thus be viewed as complementary guides to action rather than as conflicting approaches trying to take over each other's territory.

A second advance is the increasing sophistication in our understanding of the simultaneous evolutionary selection of competitiveness and cooperativity. Even with disease-producing viruses and bacteria, a strain that rapidly kills off its host is not as successful (i.e., does not multiply as much) as one that can multiply for a long time within a surviving host and thus has more time to infect another host. As I have noted above, sociobiology has now accounted for even the evolution of extreme altruism, leading to self-sacrifice for the common good.

The conflict between cooperative and competitive drives in man is thus not unique but an example of the usual ambivalence of evolution, selecting for balance and compromise between opposing traits. Religious leaders have long recognized this duality as an inherent feature of the human condition, and Freud described it in terms of superego and id, or eros and thanatos. Sociobiology now provides an additional approach to the problem, deeply embedded in reality and aiming at the modest but solid, stepwise advances characteristic of science. And just as the uncertainty principle in physics has helped to illuminate the nature of matter, so a recognition of the biological roots of conflict, and the limitations in our power to eliminate it, may help us to set realistic goals and to identify the factors that we can control profitably.

Finally, I would suggest that we should reevaluate an apparent implication of evolution that has had particularly destructive consequences: the view that eliminating the traditional absolutist framework for ethics necessarily leads us to the alternative of complete moral relativism, in which anything goes. In the light of sociobiology this is a superficial rather than a logical conclusion. For since evolution has built into every kind of organism a deep-seated drive for survival of its species, and since we have evolved as a highly social animal, we must have within us strong, genetically determined instincts for patterns of social behavior that are compatible with that survival. Our evolutionary endowment thus is incompatible with unlimited moral relativism. It requires restraints on our behavior, based not only on self-interest but on an instinctive interest in the welfare of our group and our progeny.

In looking more closely at the idea of our having a genetically limited range of social behavior we may view language as a useful model. We are not born with a particular language, but we are born with the capacity for learning a language; and while our cultural evolution has created many languages, which differ enormously in detail, they all have deep structural features in common. As Noam Chomsky has emphasized, these common features must reflect anatomical structures in the parts of our brain that are concerned with language.[6] A student of evolution would add a thought about origins: Those structures are there, and the language that they use corresponds closely to various aspects of the world around us, only because the structures have evolved in response to the pressure to communicate with one another in increasing detail about the world around us. We could not transform sense perceptions and novel associations of remembered perceptions into a vocabulary of thousands of words unless our genes had built into our brain the required sets of connections, which are there waiting to perform those tasks. Similarly, we are not born with a detailed ethical system, but we are born with the capacity and the need to develop an ethical system, whose details will vary, like those of language, from one culture to another.

Sociobiology thus contradicts the arguments for extreme moral relativism. In so doing it provides a biological base for the insights of the ancient religions and for the traditional and universal aims of education, parental guidance, and psychiatry: to help people balance immediate gratifications with long-term goals, and aggression with love. It does not deny the role of ritual and emotional appeal in reaffirming and strengthening recognition of nonhedonistic moral values. It rather complements religion by substituting a realistic base for one that is no longer plausible for many people. Moreover, by recognizing species survival and not individual survival as the overriding biological goal, sociobiology can help us to define the range of values compatible with this survival. It may thus usefully supplement the traditional approaches in guiding our responses to our truly novel and frightening ethical problems, which are being generated by our alterations of the world around us, by the increased communications among people in all parts of the earth, and by our increasing ratio of population to resources.

Let me close by reemphasizing a value that is especially dear to scientists: the habit of truth.[7] Experience has taught scientists that in their area (in contrast to many other human activities) distortion of the facts does not pay, for nature always has the last word. The same value is also relevant for the problem of achieving a more just society. For while this problem is not primarily a scientific one, the success or failure of our approach will depend on the correctness of its underlying assumptions about the facts of human diversity. And here nature will again have the last word.

NOTES

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