THE BRAIN AND CRISES IN HUMAN VALUES

by Hudson Hoagland

Many of our present crises have resulted from the exceedingly rapid advances of science and technologies in a world of archaic social institutions. There is, first and foremost, the crisis produced by nuclear weapons and their means of delivery. This is a new aspect of our environment since 1945. These weapons have arrived in a world of highly contentious ideologies controlled by obsolete concepts of national sovereignty. We are rapidly approaching the time when a nuclear war can render man an extinct species.

There is of course the crisis of the population explosion. This is a result primarily of advances in medical science and public health, which have markedly increased life spans in countries where death rates were very high before the applications of these medical technologies. Birth rates are also high and remain so with ignorance and prejudice blocking birth control. The result is that, in the underdeveloped countries in particular, there has been an enormous upsurge of numbers of people in terms of the resources and economic facilities available, and this is indeed a crisis of major importance.

There is also the crisis of the pollution of our environment by radioactive fallout, by industrial waste in air and rivers, and by the widespread use of insecticides, which last are necessary if the huge populations of the world are to be fed. There is a crisis brought about by automation in industry and by computer technology, which are producing unemployment in the white- and blue-collar classes, but which will in the long run give more leisure to be used, one may hope, constructively.

Then there is a crisis developing of new ways of controlling people. This crisis has arisen through use of the mass media, press, radio, television, etc., for propaganda purposes to control votes, public opinion, and sales. There are also controls of behavior through conditioning techniques, brain surgery, and through chemical agents and drugs.

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In relation to our inherited endowments there is a slowly accumulating crisis, a sort of time bomb, concerned with the deterioration of our irreplaceable genetic material. This genetic material is in the form of the chemical code of DNA molecules located in the nuclei of our sperm and egg cells. All of the material of the DNA in all the germ cells in all of the people in the world if added together would weigh only a small fraction of an ounce. It has taken three billion years to produce this coded material to pass on information to the next generation to tell it how to make a person. We are facilitating the occurrence of mutations, 99 per cent of which are deleterious, of this code by a number of practices. For example, a more serious assault on our genes than that of present levels of radioactive fallout is humane medical practice, which is saving lives of persons with genetic defects that would have been lethal under conditions of natural selection. These people, many of whom are valued citizens, are passing accumulated genetic deficits along to their offspring, and, over generations, deterioration of our genetic code is increasing slowly. There are other ways in which we facilitate this deterioration which H. J. Muller has discussed.[1]

These crises have all come about from advances of science and technology, applied in a framework of social institutions, beliefs, and myths that are unable effectively to cope with them. I believe that there has always been a conflict between the spirit of science and that of orthodox theology. In the ancient world and down through the Middle Ages, shamans and priests were the repositories of special knowledge and learning, and this was essentially a monopoly of these professional groups. It was very much to the personal advantage of the shamans and priests to keep this monopoly of power through knowledge. They, of course, could rationalize (as they undoubtedly did) that the stability of their society was strengthened by holding such monopolies. This, they could argue, was important not only to combat the powers of evil spirits and devils but to hold the morale of the group together against other predatory groups, including rival religious factions. What, after all, was the doctrine of original sin? It was that Adam and Eve ate of the forbidden fruit of the tree of knowledge. Their curiosity got the better of them. They really were the first scientists, you see, who experimented into the unknown despite authoritarian prohibition by God, or rather by the priests who claimed to represent God. And this Old Testament myth has been a continuing source of ecclesiastical power ever since as a formal source of guilt requiring redemption even in infants. Ancient religion and magic are dominated with prohibitory taboos against exploration and new discovery. Breaking taboos can kill men in

primitive societies who believe in them, and breaking taboos can destroy hope of a good life after death. Orthodox taboo against the fruit of the tree of knowledge condemned Galileo, and today condemns for many the effective control of the population explosion by birth control in the name of medieval ideas about the nature of man.

What are other institutions and beliefs that slow adjustments to new scientific advances? Nineteenth-century national sovereignty as a way of life became obsolete in 1945 with the advent of nuclear weapons. Nations simply cannot give security and protection to their nationals by military power in the nuclear age as was done for centuries with conventional weapons. Our present bombing planes are capable of carrying two twenty-megaton bombs, which is at least ten times as much explosive power as was released in World War II in both the Pacific and European theaters by both sides! And this is but a tiny fraction either of our total nuclear armament and means of delivery or of that of the Russians. We have great overkill capacity on both sides, and this is a new dimension in armament which cannot be coped with by traditional concepts of lawless national sovereignty of a type seen in Charles de Gaulle's neolithic attitudes about national glory.

Another archaic attitude is that dealing with doctrines of racial superiority. Science gives no support to beliefs of superiority and inferiority of genetic differences of a fundamental kind between human racial groups, and yet the spirit of Adolf Hitler still exacerbates relations between the white and colored peoples of the world.

We can observe that the methods of theology operate with glacial slowness. Generations and centuries are required to change value judgments. It is small wonder that the churches have contributed little to solve the crises brought about by the exceedingly rapid growth of scientific information in this century. Over the last thirty years it has been said that scientific information is doubling every ten years. Not only have the churches not been able to meet these crises because of the nature of theology, but religious dogma has sometimes blocked and impeded rational solutions of problems as, for example, prohibitions by some theologians of birth control as a means of controlling runaway populations. What we need are inventions of new institutions, new methods of education, and new ways of thinking about our major problems and value systems. Methods of education that insist upon examination of evidence in the spirit of inquiry can change encrusted prejudices and make fresh approaches to problems in accordance with tested values of psychosocial evolutionary progress.

I personally believe that it is possible to have a science of values.

There are values which men have tested for centuries and have found to work. We also now have techniques through the use of computers to set up trial experiments, in the social sciences as well as in the physical and biological sciences, to test the consequences of various alternative pathways of conduct. Computer techniques can give indication of the consequences of human action—whether in markets, battle tactics, or ethical problems. It thus might be possible to test the consequences of actions based on specific value systems and so form pictures of alternatives in relation to changing variables.

Another approach to the great dilemmas of our time has been proposed by Henry A. Murray in a Phi Beta Kappa lecture at Harvard. Murray said that what we need is "a new book." All of the great civilizations in the past have had a book to inspire them. In the case of the Jews, it was the Torah and the Old Testament, and for Christians the New Testament. These have been our great books. The Koran has been the great book of Islam, and the Iliad the great book of the Greeks, with its ideal of the hero and the meeting ground of their humanism and their religion. The Book of the Dead was the book of the ancient Egyptians. And the writings of Karl Marx and Lenin constitute the book of the Communist world of today. This has inspired their activities and forward drive in what is essentially a new religion. What the West needs is a great book for the application of heart, art, and intellect to adjust the sweep of human evolution to the imagination of people today, and set us going again. This would not mean, of course, rejection of old and tried values. It would mean their reappraisal, and a new Bible based on new concepts of what man is and where he is going. Man is the only animal that can understand and hence direct and control his own evolution, and this is perhaps the most unique thing about him.

Three Kinds of Evolution

We human beings are here today as a result of the same process of evolution by natural selection that has produced all the other myriads of plants and animal forms we see about us. We are the product of three different kinds of evolution. In the first place, there has been inorganic or cosmic evolution. This is evolution from the primordial stuff of the universe, hydrogen, which, over tremendous periods of time and through a variety of nuclear reactions, has evolved the heavy elements, the galaxies, the stars, and their planets over vast ranges of space. Here we measure evolutionary sequences in terms of thousands of millions of years, and this evolutionary process has been going on for at least

six thousand million years and perhaps two or three times as long. We know that the distances are incredible in terms of space. We know that there are a billion trillion stars, and these are located in some hundred billion galaxies of which our Milky Way galaxy is one, and our sun is but one star in this galaxy composed of many millions of stars.

In the process of evolution on earth about three billion years ago, one of the elements, carbon, because of its unusual chemical properties, formed compounds with itself and with hydrogen, nitrogen, and a few other elements that set the carbon compounds on a new path of evolution in the environment then prevailing on the earth. Organic compounds, i.e., the carbon compounds, were formed spontaneously that were able to utilize energy from the environment to reproduce themselves. Organic or biological evolution thus began and has continued to operate by natural selection ever since, eliminating those forms of reproducing chemical systems that were not adapted to the particular time and place in which they arose. Thus a tremendous screening process was under way, and natural selection eliminated countless forms by trial and error which were not adapted to their environments. And so by a very wasteful system of elimination, we now have the tremendous variety of plants and animals which we see about us, including of course ourselves. The reproducing molecules today are the DNA molecules of our germ plasm. These represent, as I said, irreplaceable material that can be permanently damaged by radiation and by other genetic hazards which occur as spontaneous mutations in the structure of this code. This is certainly the most precious material that exists anywhere as far as the human species is concerned.

The third kind of evolution is psychological evolution and it came about very recently—starting about a million years ago with our hominoid ancestors and accelerating in the last one hundred thousand years with the emergence of *Homo sapiens*. Psychosocial evolution is characteristic of man and man alone. Our apelike ancestors managed to develop crude techniques of weapon and tool making. This gave them an advantage over other animals in spite of the fact that they themselves were peculiarly naked and helpless, unarmed with fighting teeth and claws or horns. They became dominant through the rapid evolution of a remarkable brain. The human cerebral cortex has doubled in size in the last million years, and this has been a result of the advantages that accrued to these animals by natural selection when they applied their brains to solving problems. Success had a feedback action, selecting for survival the most competent individuals with the best brains who could make the best tools and weapons. In the course of time came spoken

and written words as symbols for ideas, and man with this ability to speak, and later to write, could pass on information from father to son at a great rate. In this way a whole new dimension of evolution came about. Agriculture was invented about ten thousand years ago, and city states five thousand years ago. The whole history of invention is the core of this special evolution. In the last three hundred years the accelerated developments through science are a continuation of this amazing psychosocial evolution which is faster than biological evolution by thousands fold.

Of course, the evolution of the physical universe that gives rise to organic life and human culture is obviously creative. But, for the scientist, the explanation of this creativity is sought and found inside rather than outside the universe that he examines.

I would now like to comment on some of the things that we have learned about the nature and control of human behavior, behavior that has evolved with the brain. And I would like to say something later about the evolution of religious behavior and its relation to some other types of behavior such as that of art and science. To do this, I would like first to comment about some fundamental conceptions and misconceptions relevant to scientific approaches to the study of behavior.

Mind, Purpose, and Mechanism

The scientist operates under the tacit assumption that there is order in the universe underlying all phenomena that he can study. Otherwise his work would be pointless. He hopes to find the nature of this order. He also assumes that all forms of order are determined, that is to say, are caused, and his job is to discover these determinants or causes. If he is studying behavior of either animate or inanimate systems, he seeks the mechanisms of the behavior. I know of no scientist today who works outside of a deterministic framework. Thus the student of behavior may be interested in neurological mechanisms and how they effect behavior. On the other hand, the psychiatrist is concerned with psychodynamic mechanisms and may not be interested in the brain at all. He wants to know what events happened in the life of his patient, especially in his childhood, which may have produced a pattern of neurotic behavior. Thus we speak of psychodynamic mechanisms in psychiatry. The social scientist is also interested in mechanisms. He may be interested in the failure of mechanisms to control our balance of payments or effects of tariffs on international exchanges or mechanisms of currency inflation. As a historian one may be interested in the mechanisms that

produced the decline and fall of the Roman Empire. In this broad sense science is primarily concerned with understanding mechanisms.

Considerations of the age-old problem of mind and body, of purpose, and of freedom have undergone modifications over the past century, especially in recent decades, and these considerations are relevant to reflections on human behavior. Julian Huxley has said:

> The only satisfactory approach to the mind-matter problem is the evolutionary one. Let us begin with human beings. We are organizations of—do not let us use the philosophically tendentious word matter, but rather the neutral and philosophically noncommittal term translated from the German *Weltstoff*—the world stuff of which the whole universe is made. We then are organizations of world stuff, but organizations with two aspects—a material aspect when looked at objectively from the outside, and a mental aspect when experienced subjectively from the inside. We are simultaneously and indissolubly both matter and mind.[2]

Huxley considers the possible evolution of mind from simple organisms to man, and its survival value by natural selection. He continues:

> What is the function of mind? Why did it evolve to increasing heights of intensity and importance? What is the biological value of the mental aspect of life in higher animals? It is now certain that natural selection through the differential reproduction of genetical variants is the essential energy of directional change in biological evolution. This being so, mind cannot be a useless epiphenomenon. It would not have evolved unless it had been of biological advantage in the struggle for survival. I would say that the mind-intensifying organization of animals' brains, based on the information received from the sense organs and operating through the machinery of interconnected neurones, is of advantage for the simple reason that it gives a fuller awareness of both outer and inner situations; it therefore provides a better guidance for behaviour in the chaos and complexity of the situations with which animal organisms can be confronted. It endows the organism with better operational efficiency.[3]

Ideas about the nature of purpose and of mechanism have changed from those of the nineteenth century. The principle of negative feedback, whereby energy or information released from part of a system returns to regulate and control further energy or information release by the system, is the basic principle involved in cybernetic mechanisms. Negative feedback blocks and thus controls a process. Positive feedback adds more energy to the process. Typically, an explosion putting the system in chaos is the consequence of positive feedback. Examples of negative feedback mechanisms are engine governors that regulate the speed of the engine automatically, the thermostat that regulates the heating of one's house, the guided missile that bounces its own radar waves back from the target and uses this feedback to regulate its steering and power to make it home on the target. Computers involve a re-

markable complex of feedback processes including the utilization of information storage and its appropriate retrieval, which corresponds in us to memory and recall. Purpose can be defined operationally in terms of mechanisms controlled by negative feedback. Purpose so defined is built into the guided missile and the computer and the thermostat, enabling these mechanisms to accomplish ends of various degrees of complexity. Problem-solving computers can play a good game of chess, translate one language into another, and improve their capacity to discriminate as a result of past experience; that is, computers can learn. Objection may well be raised to calling such mechanisms purposive, since their purpose has been built into them by man. But man himself and his behavior is an emergent product of purely fortuitous mutations, and of evolution by natural selection, acting upon the mutations. Nonpurposive mutation under natural selection has produced purposive human behavior which in turn has produced purposive behavior of the computers.

While feedback devices of control have developed rapidly in engineering in the past twenty years as a product of social evolution, biological evolution by natural selection brought these mechanisms to a high order of perfection some hundreds of millions of years ago, and the engineers have been copying in principle some of these processes. Cybernetic mechanisms are dominantly ones of nerve nets and central nerve ganglia or brains. Regulation, for example, of patterned contraction of muscles for orderly behavior at all levels involves negative feedback systems of control. Thus, the movement of our respiratory muscles enabling us to breathe in and out involves alternate excitation and inhibition playing back and forth in a feedback process from the action of these muscles and central nervous mechanisms. This is true, of course, in the control of posture of the limbs and in the control of muscles of speech, which involve negative feedback mechanisms regulated in this way. Thus the brain, for example, sends impulses to contract muscles. The contraction stimulates sense organs in the muscle that send impulses over sensory fibers back to the central nervous system, informing it of the degree to which the contraction of the muscle has taken place. The central control center then responds by modulating the number of impulses that are sent out by increasing or decreasing them, in this way exerting an orderly control on the contraction. The constancy of control of our internal environment, that is, the properties of our blood and body fluids, is regulated automatically by such mechanisms. Walter Cannon has referred to these as mechanisms of homeostasis. Thus, the control of hormone balance, the control of body temperature in

mammals and birds at a constant level, about 98° F. in man, are examples of homeostasis. These controls are exercised by balanced activity of groups of cells in the central nervous system—brain stem, cerebellum, cerebral cortex, and a whole variety of intricately complicated mechanisms of brain action involving transmission of electrical nerve impulses.

Claude Bernard a hundred years ago said that freedom of an organism from the vicissitudes of its environment is dependent upon this automatic control of its internal environment. Thus we are free from the vicissitudes of external temperature conditions when we regulate our own constant internal temperature; we can go places and do things that cold-blooded animals cannot do. Furthermore, we control the acidity of our blood with great precision automatically. We can then exercise violently, build up acids, and eliminate them quickly in the form of carbon dioxide and lactic acid and in this way regulate the constancy of the acidity of our blood and be free to do various things that one could not do otherwise.

All co-ordinated behavior, conscious and unconscious, uses these cybernetic mechanisms—without them, organized purposive behavior would be impossible. By definition these are purposive mechanisms. The behavior of the organism as a whole in adjusting to its external environment is controlled by information fed back to it in response to its own behavior—words are spoken and acts performed that produce responses from our environment, including our fellows as part of the environment. Acts they perform in response to our own serve further to modify our behavior. Social and economic operations, and political give-and-take, can also be treated from the point of view of this type of mechanism. Feedback to the organism of information from its external environment determines learning and conditioning by way of rewards and punishments, as reinforcing and aversive conditions. Behavioral scientists and neurophysiologists are making advances in understanding the mechanisms involved in behavior at its many levels of manifestation. Throughout all of these studies there runs the tacit hypothesis that individual behavior is dependent upon physiochemical events in the cells, especially those of the brain. There is no reason to abandon this hypothesis despite our present ignorance of what we would like to know about the regulation of behavior including the behavior of thinking. A disembodied psyche is to science a meaningless concept.

I would like to give examples of mechanisms of brain action as they are related to conscious behavior and its control. Consciousness and mind I regard as properties of emergent evolution—emergent in the

course of the development of complex nerve nets. Mind and brain action, then, are two sides of the same coin. To ask which causes the other is a meaningless question. Mental function and brain action are two aspects of reality that we can comprehend together as part of a pattern. Consciousness is best defined as awareness—awareness of one's body and one's environment in time and place. We lose consciousness every day when we go to sleep. Consciousness may also be lost, of course, from a whack on the head, or if one's brain is deprived for three or four minutes of oxygen supplied by the blood. It may be lost if we are deprived of sugar in the blood, and we may go into a diabetic coma, or we may lose consciousness from the effects of chemical agents such as anesthetics. The dependence of consciousness on the nature of nerve action can be readily demonstrated. Thus, one can record electrical brain waves (the electroencephalograph) by pasting electrodes on the scalp or by inserting wires directly to the brain. When one gets drowsy and goes to sleep, there are profound changes in the patterns of electrical pulses from the cerebral cortex. One can tell the depth of sleep; the level of consciousness can be followed as related to the normal sleep pattern of the electrical record and the other aspects of losing consciousness in relation to brain function. We have learned that to be conscious involves an interaction, a feedback interaction, between a region of the brain stem, the cells of the reticular formation, and the cerebral cortex. The reticular formation drives the cortex to keep it awake, and if we cut off the supply of nerve messages going from the reticular formation to the cortex we go to sleep, and if these nerve tracts are permanently cut we permanently sleep in a coma. And so we can demonstrate levels of consciousness in terms of electrical phenomena of brain action and in the relationship of various groups of cells interacting together.

Chemistry and Consciousness

We also know that behavior is intimately related to the chemical state of the brain, and that drugs can affect personalities markedly. There has been an enormous field of development in recent years of a subject called psychopharmacology. This word did not even exist until some fifteen years ago. But psychopharmacology in essence has really been known for a long time. After all, one who drinks too much alcohol has had an experience with psychopharmacology. Alcohol changes the personality, and we are all familiar with personality changes in ourselves and our friends with alcoholic intake.

Advances in psychopharmacology have gone on apace. We now have a variety of tranquilizing drugs that are used for the treatment of dis-

turbed mental patients, such as schizophrenics. Chlorpromazine and its derivatives and *Rauwolfia* alkaloids and a number of other derivatives, when administered to these patients, will have a very marked effect in tranquilizing them and aiding their social adjustments. There is a group of pharmacological agents called the psychic energizers which are finding use in the treatment of the severe psychological depressions of mental patients, and colleagues in our laboratory have been trying to find out how these drugs work. Another interesting group of drugs are those that produce a transient psychotic state resembling in many ways symptoms of schizophrenia. Thus a variety of drugs produce hallucinations and weird experiences of new reality and insight. Some of these drugs are psylocybin, mescaline, and lysergic acid diethylamide (LSD); the latter is exceedingly potent in trace amounts in producing these effects. There are at least fifty other drugs which belong to this class of psychotomimetic drugs.

Some of the drugs have been used for centuries in religious rites by Indians of the Southwest, and they give feelings of religious experience to these people in their ecstatic devotions. Psylocybin, an extract of a mushroom, and mescaline, from the peyote cactus, are drugs with these effects. Effects vary from person to person and even in the same person, depending upon his attitude and his environment when he takes the drug. There is no doubt that under suitable conditions people after taking such drugs experience elevating insights and inspiration that are indistinguishable from spontaneously occurring religious experiences. People having such transcending experiences with psylocybin, mescaline, and LSD refer to these drugs as consciousness-expanding drugs. They believe that such experiences may have enduring significance after the manner of religious insights. Walter H. Clark and Timothy Leary have written: "Psylocybin in connection with the proper setting and preparation accompanied by the fundamental willingness of the subject may release latent religious sensitivities, and so make possible what appears to be either a genuine religious experience or something so similar as to be indistinguishable from it. Like a true religious experience, this may result in a profound change of attitudes and values, but, also like a religious experience, it requires discipline if wholesome results are to be permanent. The essential capacity to reach out toward or to be grasped by the divine resides within the person."[4] They then go on to discuss this in terms of case histories in relation to the studies they have made with prisoner volunteers, and they have convinced themselves that there is an enduring effect of the new insights produced by the use of psylocybin.

Further Understanding of the Brain and Behavior

There are other new ways of dealing with behavior. For example, brain surgery has been able to change personality and modify emotional behavior in animals and man. Thus, lesions made in the pyriform-lobe-hippocampal-amygdaloid complex in the phylogenetically ancient brain can change savage and dangerous animals into fearless and kindly ones. One can take a savage cat or monkey and convert it into a tame friendly one by such surgery. Furthermore, if you later do another operation on its hypothalamus, you can change that same friendly cat back into a savage wildcat again. And you can do this without particularly modifying the animal's intelligence or its other reactive capacities. After such a taming operation, I have put my hand in the mouth of a formerly savage macaque monkey that before the operation would have snapped my hand to pieces. Following such taming operations, monkeys that were aggressive leaders, top monkeys in their social hierarchies, have been observed to drop to the foot of the social pecking order. Eventually chemical agents may be found to act selectively in this same way. It has been reported, for example, that cats exposed to chemical agents that are being tested for chemical warfare purposes are rendered terrified at the sight of mice.

Neurophysiologists have shown that there are specific regions in the hypothalamus and limbic areas which, if stimulated electrically, will produce highly aversive reactions (pain, fear, avoidance, and flight) on the part of animals, whereas adjacent regions will produce profound pleasure if stimulated electrically by small shocks. Much work has been done over the past decade with animals, including pigeons, rats, cats, dogs, monkeys, apes, dolphins, and (when helpful in medicine and surgery) man, in which microelectrodes have been implanted surgically in a reward center of the brain and the animal taught to stimulate its own brain by tapping a key placed before it. When the reward center is thus self-stimulated, an animal may continue to tap the key until it falls exhausted, entranced by the pleasurable world produced by its self-stimulation. A rat or a monkey or a cat or a pigeon will ignore food and sex, and continue hour after hour stimulating his reward center. It has been suggested that the main function of the cerebral cortex is to select from the environment experiences that will maximally activate these reward centers and avoid activation of the aversive mechanisms of the hypothalamus. An electric shock delivered to a monkey in its aversive area, a few millimeters away from the reward area, produces a tremendous fear response and a wild attempt to escape. We are, of

course, unaware of many of our subconscious drives arising in this primitive limbic brain region—aggressions and sex drives which are socially unacceptable. Our neocortex rationalizes these drives and channels them into acceptable activities. Sigmund Freud's views on the role of the unconscious and our rationalization of drives of the id deal with this at the psychological level.

One of the most exciting emergents of recent behavior studies is in the field of mechanisms of learning; how the brain records new information from the environment and stores it in the form of chemical traces in brain cells. As you know, the substance deoxyribonucleic acid (DNA) comprises the genes and carries a code of chemical information that is the basis for the phylogenetic memory of the species. It is the material basis of our evolutionary memory. Now research indicates that ribonucleic acid (RNA) appears to be the substance involved in storing memory traces in our own brains. Thus the learning process involves passage of nerve impulses over extensive patterns of nerve pathways, and with repetition of the experience there appears to be a cumulative synthesis of RNA in the nerve tracts involved. The RNA synthesizes new protein structures within the nerve cells. Evidence has been presented that these new protein structures then delineate the pathways which have been used in the particular learning process. If true, this is a very exciting thing, because it indicates that both personal and phylogenetic memory are determined by the same chemical systems. Recent experiments have been reported of a substance that blocks protein synthesis, which, if injected into the brain, will wash out learned experiences. Furthermore, there are chemical agents which will speed learning. Here we have a possibility of actually facilitating learning by chemical means. This has very dangerous implications too, since the use of such substances in drinking water by a dictator could make his propaganda more effective. But it also has promise for facilitating the rates at which people can learn and their ability to remember.

The point of these various examples is that science is becoming able to manipulate our spiritual lives via consciousness, emotion, mood, learning, and memory. In the hands of a Hitler or Stalin these procedures have awful potentialities to destroy the fabric of society, or they could be of great help to advance society in a society motivated to improve itself by directing its evolution constructively. It is here, I think, that religion and theology have much to contribute by reconsidering the value concepts of our inherited traditions in the light of insights of psychosocial evolution and the direction we want it to go. The theologians must recognize that this new era has been produced by the scien-

tific revolution and that new ways of dealing with value concepts are necessary. I have suggested the predictions of consequences of operations of value systems aided by computers to give some insight in relation to alternative choices of conduct. What is most needed is a revolution in our educational system to make us recognize the biological and psychosocial nature of man which is in sharp contrast to the traditional medieval view of theologians on these matters. Our values, distilled from centuries of human experience, need new expressions consistent with the biological facts.

Some Religious Implications of Biological Knowledge

I now want to say something as a biologist about the nature of religion and its appeal. Let me emphasize that the brain is first and foremost an organ of survival giving biological advantage to its possessor. This is true whether the brain is that of a fish, insect, monkey, or man. The brain is an instrument of survival by natural selection in the same way as are fighting teeth, claws, horns, wings, and speed of locomotion. Man is a curiously helpless animal, lacking a natural armamentarium, slow of foot, and without protective armor. He is an embryo-like creature with a very delayed childhood, but curiously enough he has turned these disadvantages into assets. Man's brain has evolved with remarkable rapidity in the last million years. As I pointed out, his cortex has enormously increased in size. His unique development of speech, and later of writing, and his long dependency on parental care have made it possible for him to receive and pass on information, and he has thus developed at a rate incomparably faster than other animals. His unique psychosocial evolution has had a feedback on his biological evolution further to develop his brain. The role of the brain in discovering truth in science, philosophy, religion, and the arts, which is what we intellectuals try to do with it, is incidental to its role as an organ of survival. The primary concern of the brain is to give its possessor a competitive advantage to enable him to be effective in his environment, to control and dominate it, including of course other animals and his fellows within that environment. A primary use to which our cerebral cortex has been put has been to rationalize drives and desires arising in our old ancient brain—the hypothalamus and the limbic portions of the brain which are primarily concerned with our emotions. These phylogenetically ancient parts of the brain, in contrast to the neocortex, have changed very little in the past fifty million years of evolution.

A primary function of the brain, from worms to man, is to synthesize perceptions from the environment into meaningful configurations to

which the organism can respond effectively. The primary function of the brain is to bring order out of chaos. Without this role of the brain we could not survive. Thus, from cockroaches to man we observe the responses to curiosity in animals exploring their environments. This drive of curiosity is one of the most basic ones among animals. For example, Robert Butler found that monkeys inclosed in a dimly lighted box would press a lever to open and reopen a window for hours on end and for no reward other than a chance to look out. The rate of lever pressing depended on what the monkey saw through the open window. The sight of another monkey or of a moving toy train elicited far more window opening than did an empty room or even a bowl of food in the room when the monkey was hungry. Three-day-old monkeys, barely able to walk, will crawl across the floor of a box to reach a lever which briefly opens the window so they can peer out; some press the lever hundreds of times within a few hours. This high level of curiosity is deeply innate. It was found that monkeys will struggle for days to solve mechanical puzzles and, having learned the solution, will repeat the successful manipulations over and over again with no reward other than that of the apparent satisfaction of doing it. There is good evidence from well-controlled experiments that the drive to explore for its own sake is a primary reason for learning. This is especially marked in young animals and children, quite aside from the seeking of food rewards or escaping from painful situations.

Scientists are people highly motivated to open new windows on the world and to solve puzzles. The satisfaction of genuine discovery is a most rewarding experience. Quite independently of monetary returns or other forms of personal recognition, these satisfactions are deeply rooted biologically and are perhaps the principal basis for the dominant position of the primates—monkeys, apes, and men—among the vertebrate animals. The more highly developed the brain among animals, the more pronounced the animal's curiosity and the more able it is to learn increasingly difficult tasks. Man's great cerebral cortex gives him a top billing among the animals in this hierarchy of achievements. The satisfaction of curiosity has had great survival value through natural selection over millions of years of evolution.

The drive to make sense of the world around us is a very deep one inherited from our subhuman ancestors. Appropriate responses to the environments are, of course, a prerequisite for survival. Those animals with sufficiently well-developed nervous systems, able to perceive themselves in relation to configurations of changing events around them, are

best fitted to find food and shelter and fight or escape from environmental threats or to modify the threats in such a way as to render them innocuous. The ability to form meaningful configurations that encompass large segments of the environment is a property of the more highly developed brains, and a good case can be made for the view that man's concerns with science, philosophy, political ideologies, and theologies are a reflection of a basic property of his nervous system to integrate extensive configurations relating himself to his environment.

Psychologists of the Gestalt school have helped illuminate this property of the nervous system. Studies of learning are of interest here, particularly in relation to the phenomenon of insight which refers to the fact that novel, puzzling situations, at first devoid of meaning, suddenly come together to make sense. This sudden precipitation of significance out of a puzzle has sometimes been called the "aha phenomenon," and the experiencing of "aha, that's it" associated with the clothing of a situation with meaning is emotionally very satisfying, and is the major charm of scientific research and of artistic creation, as well as in the solution of crossword puzzles. The aha phenomenon with its emotional charge can be thought of as a kind of revelation, although not necessarily one corresponding to reality. At an emotional level it seems to me to be of the essence of what is called the religious experience. The basic phenomenon of revelation can also be demonstrated in animals. It is not at all exclusive to the convert, to the prophet, or to a Shakespeare, or to an Einstein. Let me give examples. Wolfgang Köhler put a very hungry chimpanzee in a cage with a banana out of reach behind bars. A stick was also put in the cage. After various attempts to reach the banana by hand or to break out of the cage, the chimpanzee suddenly grasped the situation, picked up the stick, and fished the banana within reach of his hand. It happened all at once: the problem was solved by a flash of insight—by the closure of a meaningful configuration of patterned messages in the brain, the relation of the stick to the banana was perceived. A chimpanzee could do this also if two sticks were put in the cage, neither one of which alone would reach the banana. But if the sticks could be put together, joined fishpole fashion, to make a long one, this would be done suddenly and effectively by the brighter apes, and the banana retrieved. Again Köhler hung a banana from the ceiling of a room, out of reach of the chimp. Several boxes were distributed around the room and, after a time, the ape suddenly solved the problem by piling one box on another, climbing swiftly up before his architectural achievement could collapse, and

grabbing the banana. This sort of problem is approximately the level of difficulty that can be solved by a normal three- or four-year-old child.

In my opinion, the motivations of scientist, painter, poet, musician, theologian, and philosopher all stem from this property of our nervous systems that has enabled us and our animal forebears to survive and that gives satisfaction when we believe we have brought order out of chaos. Whether we have or not brought order is not the point. The emotional satisfaction comes with the belief that we have. The more effectively we think we bring large segments of our environment into meaningful relations, the more satisfied we feel, and I believe this is the basis for religious beliefs which are the products of brains trying to make sense of the universe as a basic survival mechanism in the way that a cockroach's brain makes it systematically explore its cage in order to survive.

Religion is concerned with relating the individual to the whole, the particular to the universal, and this is the primary role of the brain of all animals if its possessor is to survive and propagate its species.

Our highly developed ability to think, to relate past and future events, to make tools, and to speak and write has made us the dominant animal. Unlike other animals—well armed by biological evolution and equipped with instincts to control their lethal fangs, claws, horns, and tusks—our only control of our aggressions in the nuclear age is our ability to think intelligently, to forsee the consequences of our acts, and to control them in terms of our ethical principles.

Man has never really tried to use science in the realm of his value systems. Ethical thinking is hard to change, but history teaches us that it does change. There are a number of human institutions and practices that were supported in the past by the thoughts and ethics of the very best men of their times. These include slavery, infanticide, burning of witches, gladiatorial circuses, and religious sacrifices of living persons. The abolition of these practices was thought to be contrary to human nature. But they have been abolished. War must also be abolished in this nuclear age or it will abolish us.

Significant scientific insights into man's moral responsibility have been presented by the distinguished evolutionary theorist, George Gaylord Simpson:

> The evolutionary process is not moral—the word is simply irrelevant in that connection—but it has finally produced a moral animal. Conspicuous among his [man's] moral attributes is a sense of responsibility. . . . There has been disagreement and indeed confusion through the ages regarding to whom and for what man is responsible. The lower and the higher superstitions have pro-

duced their several answers. In the post-Darwinian world another answer seems fairly clear: man is responsible to himself and for himself. "Himself" here means the whole human species, not only the individual and certainly not just those of a certain color of hair or cast of features.[5]

Because his brain and his culture now let man see in advance what nature—his own and his environment's—will require of him, he is unique among animals in being able and being morally responsible to direct and control his own evolution.

NOTES

1. See, for instance, his article in H. Hoagland and R. W. Burhoe (eds.), *Evolution and Man's Progress* (New York: Columbia University Press, 1962).
2. Julian Huxley, article in *Journal of the Royal College of Surgeons of Edinburgh,* VII (1962), 163.
3. *Ibid.*
4. Timothy Leary and Walter Houston Clark, "Religious Implications of Consciousness Expanding Drugs," *Religious Education,* LVIII (May–June, 1963), 251–61.
5. *This View of Life* (New York: Harcourt, Brace, & World, 1964).