THE EMERGENCE OF VALUES IN GEOLOGIC LIFE DEVELOPMENT

by Kirtley F. Mather

The concept of survival values as an all-important factor in the process of natural selection has long been prominent in the thinking of students of organic evolution. Such values are considered in relation to all kinds of life, prehuman as well as human, plant as well as animal. Like all values, when that term is used in its philosophic sense, survival values are future-oriented. They carry a connotation of an objective, a goal, even a purpose. All living creatures, whether known only from their fossilized remains or by their presence today, seem to share one common purpose: to maintain as long as possible the continuing existence of their kind of life. This is by no means the equivalent of maintaining the existence of the species to which a creature belongs. When the last of the dinosaurs became extinct, near the end of the Mesozoic era about seventy-five million years ago, a kind of life that had been maintained for more than a hundred million years by countless successive saurian species came to an end. When the three-toed horse became extinct, fairly early in the Tertiary period of the Cenozoic era about forty million years ago, the kind of life it represented was continued by its lineal descendants through successive equine species to the one-toed horse of Pleistocene and Recent times.

Organic Survival Values

Extinction of a species does not necessarily mean that its survival values were inadequate. A species is a man-defined segment of what may be a long-continuing sequence of a particular kind of life. Such a sequence of lineally related species and genera is now designated as a taxon. In any consideration of survival values, it is the taxon that must be foremost in mind, although the survival value of a species may be temporarily appraised as involving one step on a long road. Such an appraisal is, however, a tricky business. What may seem good for one species may prove fatal for its descendants a few generations or stages later in the

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taxonomic lineage. Relatively huge bulk may have had great survival value for certain species of saurischian dinosaurs in the Mesozoic era and for the megatheres among the mammals in early Cenozoic time, but both of those taxa were soon—geologically speaking—defunct. The skeletons of many victims of megalomania are strewn in considerable abundance along the path of life.

Survival values have been significantly different for different taxa and for successive species within a taxon at different times. Many of the strains of evolving animals and plants display a cyclical development. The new kind of life arises in some relatively small geologic niche: for example, an embayment of an epicontinental sea at the margin of a continent for a marine invertebrate fauna, or a small land area nearly or quite surrounded by epicontinental seas and with its own particular climatic conditions for a terrestrial vertebrate fauna. In each more or less isolated province the competition for survival leads to the natural selection of the local champions in terms of their survival values. Comparative isolation tends toward many experiments with previously untried organs, structures, or habits, and favors the development of gene pools that give viability to the new species and genera. Then comes one of the far-reaching geographic changes that have occurred so often in earth history. If the marginal embayments are extended to the continental interior by sea transgression, their marine faunas may mingle; if so, the local champions will be pitted against each other in the continental sweepstakes. Survival values that were adequate for continuing existence in each of several different provinces are tested under the new cosmopolitan conditions. Later withdrawal of the seas will return the more successful to marginal provinces similar to those inhabited by their progenitors in the earlier geologic epoch. This cyclical alternation between provincialism and cosmopolitanism seems to have played an important role in geologic life development.[1] I will comment later upon its significance with respect to human values. In a certain sense the cycles are rhythmic, but they are quite irregular in duration. The cycles for land animals are out of phase in relation to those for marine creatures; obviously a time of provincialism for the inhabitants of shallow epicontinental seas is a time of cosmopolitanism for the creatures of the land, and vice versa.

Awareness of the Environment as a Survival Value

The survival values to which I have thus far directed your thoughts pertain to organic structures and forms and to the behavior made possible or necessary by those anatomical features. They are characteristic

of the biology of the species or taxon with which the scientist is concerned. Let me take time for just one example. The brachiopods are shallow-water, marine, bivalved invertebrates, quite distinct from the clams and oysters which might also be included in that designation. Their fossils are especially abundant in sedimentary rocks throughout the Paleozoic era, six hundred million to two hundred twenty-five million years ago, but they constitute only a minor fraction of the marine faunas living today. The great majority of the brachiopod fossils found in strata formed in the first twenty or thirty million years of that era (Early Cambrian time) are indicative of inarticulate brachiopods—creatures whose two valves were held together only by the interior muscles, without articulation along a hinge line of projections from one valve into sockets in the other. Even held tightly shut by muscle contraction, the valves could be easily twisted apart by the tentacles of contemporary cephalopods, the most powerful creatures of the Cambrian seas. And the cephalopods presumably enjoyed "brachiopods on the half shell' as an item on their menu, even as we prize "blue points on the half shell" today. There were, however, a small minority of articulate brachiopods in some of the Early Cambrian marine embayments. They were beginning to develop interlocking hinges, some of them of considerable length, such that the shell could not be twisted apart without breaking the shell. The survival value of such an apparatus is obvious; by the end of the Cambrian period (about 100 million years in length) the great majority of brachiopods were articulates. It is but one example of the many episodes in geologic life development during which a small minority possessing superior survival values has become the majority among the creatures of its kind. Any paleontologist can cite scores, if not hundreds, of such events.

The example drawn from brachiopod history pertains to the value of defense mechanisms. There are also many examples of the survival value of organic structures that are useful in aggressive tactics, especially those involving the desire for food. In many of the phylogenetic lineages now known within the more complexly organized branches of the animal kingdom, increased mobility has had obvious survival value, whether the creatures swim freely in water, crawl or creep on the floors of sea or lake, or perambulate on the surface of the land. This involves the ability of the nervous system to coordinate the movements of the various segments of the body of segmented animals and of the paired appendages characteristic of so many orders of animal life. More significant for our present inquiry is the survival value of an increased aware-

ness of what is going on in their environment that is displayed by successive species in many an evolving taxon.

All unicellular protozoa and many of the more lowly multicelled animals are aware only of conditions and things in immediate contact with their cell walls. Cilia and, even better, antennae extend the awareness of creatures possessing such structures to distances of an inch or more from their bodies. Organs of sight, whether merely light-sensitive epidermal cells or single-lensed or compound eyes, had obvious survival value by extending awareness to greater distances. The same is true for organs capable of detecting and identifying sounds or odors. The nature and degree of awareness displayed by any creature that lived in the past or is alive today is probably the best measure of progress as distinguished from mere change. That basis for appraisal is not necessarily equivalent to the measure of an extinct animal's resemblance to man or any other living animal. It simply asks the mathematical question: In how many different ways and to what measurable extent is an animal aware of its surroundings? The answer is found by investigating its anatomy and observing its behavior. This is the least anthropomorphic appraisal of evolutionary achievement we can apply to the various kinds of life we know.

Spirit of Adventure as a Survival Value

Survival values accruing from anatomical structures may be designated as biological values. In addition there are spiritual values that can be recognized by the natural scientist. One such value is the spirit of adventure that appears to have been influential in the evolution of certain taxa among animals that have achieved a considerable degree of awareness of their surroundings. To accept the spirit of adventure as a reality is to acknowledge that mere continuity of existence is not the only objective of some forms of life. A description of certain events that happened during the Mesozoic era, two hundred twenty-five to seventy million years ago, will clarify and sharpen what I have in mind.

The Mesozoic era is often called "The Age of Reptiles." During almost all of that time interval the dinosaurs were the dominant kinds of terrestrial animals. Some were herbivorous, others carnivorous; they gained temporary security for themselves in every habitat afforded by the surface of the land. Even while the saurians were becoming masters of the land, they also deployed into the sea and into the air. In the latter habitat there were two distinct groups of taxa: one, the earlier, included the flying reptiles or pterosaurs that became extinct at the close of the era; the other became the birds that have continued to the

present day. We know fairly well how the terrestrial reptiles evolved into flying reptiles and birds, but the question "why?" can be answered only by speculation. There is no evidence that the land was so overcrowded that some of its inhabitants, ever striving for continuing existence, were forced as a last resort to venture into the radically different and previously untried way of life. Rather, it seems more plausible that there was some kind of internal urge to launch out into the unknown, to try a new experiment—a spirit of adventure. The venture proved eventually to have survival value: about a hundred million years of continuing existence for pterosaurs and at least seventy million years longer than that for birds.

Cooperation as a Survival Value

Probably the most important of the spiritual values pertain to the spirit of cooperation and mutual aid. This cannot emerge until individuals in a species become organized to form societies. A colony of coral polyps is not a social organization, even though its members live in constant proximity to each other. There is no allocation of specific duties or responsibilities to particular individuals; none spring to the assistance of others whose welfare is endangered or whose lives are threatened; no communication is possible between individuals separated from each other by any appreciable distance. This last-mentioned item means that the minimum requirement for even the most primitive social organism is a nervous system capable of giving its possessor a considerable degree of awareness of its surroundings. It is highly probable that the first animals to attain that capacity were trilobites. They constitute an extinct class of arthropods, the invertebrate phylum which includes among its many members the modern crustaceans and insects. They had segmented bodies, paired appendages, compound eyes, antennae, and a well-organized nervous system that must have made them the most intelligent denizens of the Cambrian seas. Their fossils are abundant in the Early Paleozoic rocks, reach a climax of diversity near the middle of that era, and disappear completely from the record by its close. Whether or not any of the trilobites developed social organizations will probably never be known. They apparently had the potentialities for doing so, and we are free to speculate that the spirit of cooperation may have emerged in them a half-billion years ago.

Be that as it may, we know definitely that this point has considerable antiquity—some fifty million years or so. Although certain kinds of insects appear in the record of Late Paleozoic life, the social insects—ants and termites and some bees and wasps—did not arise until much

later. Their record begins early in the Tertiary period (seventy million to two million years ago) and continues throughout that period and on to the present day. It is with the ants that social life has attained its highest expression among insects, and judging by their world-wide distribution that formicine ants display the most efficient social organization for that kind of life. There are fossil ants, preserved in amber and dating back to the Oligocene epoch (forty million to twenty-five million years ago), that are scarcely distinguishable from *Formica fusca,* a widely distributed species in Europe and North America today. This is an extraordinary longevity for any complexly structured species. The evidence suggests that the social insects, having climbed to their high state of evolutionary development more than twenty-five million years ago, have continued to exist on a dead level ever since. Even so, it is mute but conclusive testimony to the survival value of the spirit of cooperation.

Although the ants and termites display the ultimate development of social behavior among insects, the wasps illustrate best the evolution of that way of life. The majority of their species are solitary in habit, others are incipiently social, and still others live in highly organized societies. There can be no doubt that social behavior began among insects with parental care of offspring. (Evidently human societies began the same way.) As it evolved, individualism was increasingly submerged for the welfare of the collectivized group. A rigid caste system was established, different for termites from that for ants, but equally inflexible for all. Interestingly enough, social habits have arisen among insects no less than twenty-four times in as many different groups of solitary insects. Some of these have developed only the rudiments of social behavior, but all tend in the same direction. The caste system involves from three to five castes: the queens whose only function is egg-laying; the drones, males performing no function other than reproduction; workers, females whose sex organs are usually undeveloped and who are responsible for the manifold tasks of housekeeping and maintaining the food supply for all in the nest or hive; and warriors, also usually underdeveloped females, who defend the nest and occasionally sally forth to enslave workers from other nests or capture larvae to be reared in slavery. In some insect societies there is no separate warrior caste, and that function is performed on occasion by the workers. In others there are two castes of workers, each performing special duties. These may run a wide gamut from excavating subterranean rooms and corridors, patroling the surrounding area to scavenge everything that might serve as food and tending the herds of domesticated aphid "cows," to

farming beds of fungus or gathering nectar from flowering plants. This sounds like an exciting variety of occupations that might stimulate resourceful individual behavior. But not so; the inescapable regimentation of this instinctively established way of life has reduced the members of all insect societies to mediocrity of appearence and behavior. Brilliant individualism has vanished. The thrilling slogan of the Three Musketeers has been curtailed to "one for all," with no suggestion of "all for one" except perchance with reference to the queens.

Societal organization, with its concomitant spirit of cooperation, is commonly displayed among vertebrate animals other than the more primitive members of this phylum. They all have a spinal cord, and most have some sort of brain and nervous system as well as sense organs of greater or lesser efficiency. This permits a considerable degree of awareness of the various factors in their environments and makes them able to communicate with each other, at least in feeble ways. Among the vertebrate societies, some are loosely organized, others firmly structured. They range from a school of fish, a flight of birds, a flock of doves, to a herd of deer, a pack of wolves, a pride of lions, a troop of baboons, to a tribe or nation of men. Organization of a group of individuals may be either for procuring food, for defense against predators, for attack upon other animals, or for construction of shelters. Coyotes, for example, customarily hunt in packs, and beavers join together to build their dams. In several mammalian taxa it is apparent that survival has depended primarily on the effectiveness of coordinated activities made possible by societal organization. Students of evolutionary processes have long recognized the value of the spirit of cooperation and the mutual aid it engenders.

Creation of Man

But our conference is about *human* values. Where is man's place in the pattern of geologic life development? The scientist can now answer that question with great confidence. Man is certainly a part of the animal kingdom, a creature of the earth. He belongs in a taxon, a phylogenetic lineage, the historical development of which can be traced far backward in time. His morphologic and physiologic evolution has been in accordance with the same laws or principles as those to which all other animals are subject, and it will continue so to be.

The hominoid taxon branched away from the pithecine taxa (anthropoid apes) near the end of the Miocene epoch, some ten million years ago. Its earlier members included the various species of the genus *Australopithecus* who lived in southern and eastern Africa during the

Pliocene epoch (the last epoch in the Tertiary period which came to a close between one and two million years ago). The name *Australopithecus* means "Southern Ape," but the genus is a part of the hominoid taxon, not the pithecine taxa. Its members stood and walked erect, they were primitive hominoids with facial features of a somewhat simian cast, and their brain capacity was intermediate between that of modern man and that of anthropoid apes such as chimpanzees and gorillas. The break between them and the contemporary ancestors of modern apes is marked by their adjustment to a new way of life on broad savannas, tropical or subtropical grasslands with only scattered trees and shrubs, whereas the members of the pithecine taxa clung to the old ways of arboreal or semiarboreal life in forests and jungles. In their new way of life, their social organization was even more essential to their survival than it was for their simian relatives in the much safer arboreal environment. Naked, unarmed, and alone, any member of the hominoid taxon is a rather helpless creature, no match for a carnivorous feline, scarcely able to secure adequate food for himself. The australopithecines must have organized themselves in small, tightly knit troops at least as well structured as are the troops of chimpanzees, investigated by modern students of animal behavior. Presumably they used clubs and stones for attack and defense, but no flaked-stone tools or weapons or other artifacts are known in association with their fossil bones.

Representatives of genus Homo first appear in the known geologic record either near the close of the Tertiary period or very early in the Pleistocene epoch ("The Great Ice Age") of the Quaternary period which continues to the present day. Paleontologists and anthropologists have recently revised the nomenclature of prehistoric hominids, discarding many of the names previously used for isolated fragmentary fossils and reflecting the modern consensus concerning the affinities of well-known fossil creatures to each other and to modern man. Thus, *Pithecanthropus erectus* (the famous "Ape-Man of Java," named by Du Bois in 1892) and several other creatures known or believed to have had closely similar characteristics are now known as *Homo erectus,* an extinct species in the genus to which modern man belongs rather than a species in an extinct genus, closely related to, but separate from the one that includes us. Similarly, *Sinanthropus pekinensis* (the "Man of China," found in 1929 near Peking) is now known as *H. pekinensis,* with the same implication of closer affinities to the other species in the genus than had earlier been inferred. Much the same changes in presumed relationship have overtaken the older nomenclature for extinct species earlier referred to genus *Homo.* The segments of the hominoid

taxon for which the names *H. heidelbergensis* and *H. neanderthalensis* were formerly used are now demoted to the rank of extinct varieties within the existing species: *H. sapiens var. heidelbergensis* and *H. sapiens var. neanderthalensis.* Modern man becomes *H. sapiens var. sapiens,* compounding our self-aggrandizement by doubling the number of times we label ourselves as wise.

Chronologic overlap of australopithecines and members of genus *Homo* was definitely established by Leakey in the early 1960s when he found in Kenya the fossils of a hominid to which he gave the name *H. habilis* (the "handy man") because of the association with crudely fashioned artifacts. Depending on one of the radioactive timekeepers, he dated those fossils as 1.75 million years old, but that date is not unanimously accepted. Even so, *H. habilis* is probably the earliest known representative of the genus.

When asked how old man is, I cannot answer until I know what the questioner means by man: the variety of *H. sapiens* to which we belong? the species as a whole, including its extinct varieties? the genus, including its extinct species? or the hominid family, including its extinct genera? My own predilection is to use "man" for all varieties of *H. sapiens,* "mankind" for all members of genus *Homo,* and "subhuman hominids" for earlier genera and species of the hominoid taxon (although in other contexts I may refer to all existing human beings as "mankind").

Cultural Evolution and Human Values

Using that terminology, the record of the emergence of man, and of human values, may be briefly summarized. Subhuman hominids lived in Africa for several million years, prior to about one million years ago. There they were in direct and critical competition with the ancestors of anthropoid apes, "old-world monkeys," and predatory felines. It was a down-to-earth struggle for existence. Those that survived were doubtless the best "killers"; they were also the ones best able to engage in collective and coordinated activities as they perfected their social organization in packs and clans. Appearing about two million years ago, or a little less than that, in eastern and northern Africa, mankind spread to South Africa and to the Eurasian continent. There the earliest records are found in Java; they are correlated with the first interglacial stage of the Pleistocene epoch and date back nearly a million years. (The Great Ice Age comprises four glacial and three interglacial stages.) The mankind fossils found near Peking, China, are correlated with the second interglacial stage and are therefore a half-million years or so

before the present. By that time Heidelberg man was living in what is now Germany. It was, however, the Neanderthalers who left the most extensive record of early man. They lived throughout the third interglacial stage and into the fourth glacial stage, an interval of at least one hundred fifty thousand years, during which time they spread along the shores of the Mediterranean Sea and across the Eurasian continent from the Atlantic to the Pacific Oceans. Their cultural development is shown in the progressive improvement of their stone tools and weapons, the artifacts they fashioned from the bones of slain animals, and the fact that some of them buried their dead. Modern man (*H. sapiens var. sapiens*) first appears in the record shortly before the close of the third interglacial stage, fifty or sixty thousand years ago. The best-known type, Cro-Magnon man, entered Europe between 42,000 B.C. and 28,000 B.C., displacing or absorbing its earlier hominid populations.

All these various types of mankind and of man continued the competition with other animals that have been noted as competitors of their australopithecine ancestors. They were hunters and gatherers of food; not until ten or twelve thousand years ago, notably in Asia Minor, did any of the food gatherers become food producers to any significant extent. There must also have been considerable competition between various bands and clans as each "staked out" its own territory to be defended against any and all intruders. Continuing improvement in the fashioning of tools and weapons had its obvious survival value. So also, and perhaps even more importantly, did improvement in the fine art of cooperation. Undoubtedly the acquisition of techniques for using fire was also of paramount value in the continuing struggle for existence. All these called for greater intellectual ability. Gradually the hominid type of brain became larger and more capable. To the ancient function of remembering experiences and observations, with the ability to retrieve needed items from its storehouse, were added the functions of thinking rationally and eventually abstractly, of designing patterns for things and for societal structures, and of becoming vividly aware not only of the physical and biological factors in the environment but of spiritual realities as well. The drawings and paintings in the caves of Lascaux in France and Altamira in Spain, dating from twenty to thirty thousand years ago, as well as the carved figurines found in anthropologists' digs, cannot be overlooked by anyone concerned with the natural history of human values.

It is possible that aesthetic appreciation had no survival value, but awareness of ethical principles certainly did. With increasing necessity for effectively organized collective activities rather than idiosyncratic

individual behavior, codes of approved and disapproved conduct were developed long before communication by means of pictographs or hieroglyphs had been achieved. Doubtless those codes stemmed from the "law of the jungle" to which our pithecine progenitors—and some of our more recent ancestors as well—were subject. We must not be misled, however, by Kipling's or anyone else's equating of that "law" with the supremacy of "tooth and claw." As Ardrey[2] has expressed it in his vivid prose, that "law" is a combination of "enmity-amity"—enmity toward those outside one's own congregation, amity toward all within it. The history of the hominoid taxon, especially during the last quarter-million years, has been marked by increasingly efficient organization of individuals in societal groups on an amicable basis and by progressive expansion of the territories within which amity is sovereign. Families have banded together into clans, clans have united to form tribes, and tribes have joined together to create nations.

Cultural Evolution Becomes Cosmopolitan—Cooperation and Freedom

For thousands of generations, evolution within the hominoid taxon has been under the influence of provincial conditions, but provincialism has given way to cosmopolitanism during the last few hundred years. This radical modification is the result not of geologic or geographic changes but of human activities. Continuing improvements in means of transportation on sea or land or in the air and in methods of communication have made man the most cosmopolitan of all animals. Many of the values and consequent behavior that were adequate for survival under the old provincialism may be quite inadequate under the new cosmopolitanism.

Thanks to science and technology, we live today in a world of potential abundance and inescapable interdependence. The opportunity to use the rich resources of the bountiful earth for the welfare of all mankind is ours. In grasping that opportunity it will be necessary to engage in carefully planned collective action on a scale and in ways that were scarcely imaginable a century ago. Coordination of the activities of the individuals in a society may be accomplished in either of two ways: (1) by a totalitarian supervision of the behavior of individuals according to rather rigid, detailed, and narrowly defined rules for the overall societal needs, or (2) by a program that allows greater freedom for individuals to respond in their more unique and differing ways to a looser, more abstract, or more generalized definition of the overall societal needs to which individuals are committed by their social training. If we choose

the first way, the future of human cultural evolution will parallel that of the biological evolution of the social insects in the past. It is an experiment already tried and found wanting; social insects have existed on a dead level for at least ten million years. If we choose the second way, we shall be engaged in an experiment in cultural evolution more akin to the biological programs adopted by the vertebrates and mammals, where the evolution of an increasing capacity of the nervous system allows each individual to discover and successfully adopt novel patterns of adaptation in each new generation or even in each new encounter of his individual life experience.

This second experiment in cultural evolution has great appeal in spite of the disappointments and frustrations of these mid-century years. Actually there is much in its favor. As Wheeler[3] pointed out many years ago, insect societies represent final and relatively stable accomplishments which have developed along purely physiological and instinctive lines. This instinctive basis, with consequent absence of education and cultural tradition, constitutes a fundamental difference between them and human societies. The cultural evolution of modern man reaches into everything involved in the organization of human societies and in the endeavor to resolve the paradox of the individual and his social organization in ways that will enhance his unique personality.

Fortunately the tempo of cultural evolution, whether progressive or retrogressive, is much more rapid than that of biological evolution. Knowledge and values, ideas and ideals, acquired or developed in one generation, may be transmitted immediately and directly to the next, whereas changes in anatomy can be transmitted only if they are the result of prior changes in the genes, the "carriers" of inheritable characteristics. Competent geneticists affirm that the "gene pool" of existing populations is adequate to produce human beings who are aware of values in life that are essential to the attainment of a truly human civilization.

The description and selection of the most noble human values are literally of cosmic significance today.

NOTES

1. Kirtley F. Mather, "Geologic Factors in Organic Evolution," *Ohio Journal of Science* 24 (1924): 117–45.

2. Robert Ardrey, *African Genesis* (New York: Atheneum Publishers, 1961).

3. W. M. Wheeler, *The Social Insects, Their Origin and Evolution* (New York: Harcourt, Brace & Co., 1928).