Evolution, Creation, 
and Biology Teaching

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Recently, creationists, anti-evolutionists, and others have sought to revive arguments that grave doubts should exist as to whether or not all animals and plants, and particularly the human species, are products of the slow, step-by-step, cumulative process of mutation and natural selection that biologists call evolution (Gish 1970, 1973; Levitt 1971; Macbeth 1971; Moore 1972, 1973, 1974; Moore and Slusser 1970; Spears 1972; Wade 1972, 1973; Lucas et al., 1973; Peter 1970). Persons familiar with the data supporting evolution, and others who accept the views of professional biologists without reviewing the evidence themselves, have paid little attention to the creationists' arguments, which are essentially unchanged from those prominent a half century ago (Brown 1922; Dexter 1925; Rice 1925; Barker 1926; Wells 1926; Bush 1926; Linton 1926; Anonymous 1927; 1945). A certain proportion of people who are emotionally involved, probably some on each side, are unlikely to be swayed by arguments or data. Another group, to whom this essay is principally addressed, includes those who for one reason or another remain genuinely in doubt, or unable to satisfy themselves easily and quickly on this issue, and those who seek reviews of the evidence for teaching purposes.

Creationists have concentrated their efforts on secondary and primary school biology courses where they can involve those parents for whom this may become an emotional issue, both because of apparent conflict with religious beliefs and because parents may feel some responsibility to guard their younger children against exposure to certain issues or attitudes. Success is also more likely here than at college levels, because it is easier to enact legislation affecting primary and secondary schools, and to influence classroom materials through the control of school boards. Such efforts have succeeded temporarily in states such as Tennessee, where legislation was passed and later declared unconstitutional, requiring that creation be included in biology textbooks and other classroom materials discussing evolution (Forbes 1972; Dodge 1973).

Bills requiring discussion of creation in high school biology courses mentioning evolution are being submitted yearly to state legislatures. They are modified repeatedly to test what might eventually become acceptable to the legislature in each particular state. Recently, four such bills were presented to the Committee on Education of the Michigan Legislature: Michigan Senate Bills 66, 67; Michigan House Bills 4047, 4339, Jan. and Mar. 1973; one of these passed the House by a vote of 71-25. This is a pernicious move that calls for resistance. If evolutionists were attempting to require that evolution be taught it would be no less pernicious. When a creationist, Darwinist, Marxist, or supporter of any other theory defends his or her views publicly, he or she does everyone a service. But when anyone attempts to establish laws or rules requiring that certain theories be taught or not be taught, he or she invites us to take a step toward totalitarianism. Whether a law is to prevent the teaching of a theory or to require it is immaterial. It does not matter if equal time is being demanded or something called "reasonable" time, because there can be no reasonable time in such a law.
No teacher should be dismayed at efforts to present creation as an alternative to evolution in biology courses; indeed, at this moment creation is the only alternative to evolution. Not only is this worth mentioning, but a comparison of the two alternatives can be an excellent exercise in logic and reason. Our primary goal as educators should be to teach students to think, and such a comparison, particularly because it concerns an issue in which many have special interests or are even emotionally involved, may accomplish that purpose better than most others.

The human background is a central question in the lives of thoughtful individuals who wish to understand themselves and others. Society needs nothing more, perhaps, than a thorough comprehension of human tendencies, motivations, and possibilities. These are, in large part, the issues when one is contemplating the effects of human history upon our behavior. Creation and evolution in some respects imply backgrounds about as different as one can imagine. In the sense that creation is an alternative to evolution for any specific question, a case against creation is a case for evolution and vice versa.

With regard to creationist theories about life, we are in a peculiar position because many people are taught from childhood that there is a Creator, who is to be revered absolutely and unquestioningly. When creation theorists strive to introduce creation into the classroom as an alternative biological theory to evolution they must recognize that they are required to give creation the status of a falsifiable idea—that is, an idea that loses any special exemption from scrutiny, that is accepted as conceivably being false, and that must be continually tested until the question is settled. A science classroom is not the place for an idea that is revered as holy. If efforts to keep creation and Creator in such status, in regard to the history of life on earth, accompany moves to incorporate them into science teaching in public schools, then such efforts would properly be viewed as efforts to introduce religion into the classroom.

The evidence supporting and detailing the facts and theory about evolution can be found in any introductory biology textbook, such as that by William Keeton (1974). The evidence, however, is complex and multifaceted. This is why evolutionary theory will always remain vulnerable to distortion by those who insist upon a quick, simple review. This essay is not intended to provide a description of the range of evidence supporting evolution. On the other hand, the evidence against creationism, as espoused by members of the Creation Research Society and others, involves relatively simple arguments and can be summarized easily. Creationist arguments are few, and they are repeated almost without change or development throughout the creationist literature of this and other decades. Their applicability to biological questions depends wholly upon a number of highly questionable or demonstrably false dichotomies. Creationist arguments can also be shown to involve significant retreats, indicative of untenable hypotheses. By treating creationism as an alternative to evolution, teachers have an excellent opportunity to demonstrate the strength and usefulness of the evolutionary model of life as a framework for biological investigation and understanding.

Comparisons between the views of creationists and evolutionary biologists are also useful because the most important change that can occur in biology is a dramatic updating of evolutionary theory and teaching. The views of evolution that I see publicized by the creationists of this decade are antique views, with little relevance to what is going on in biology today. They treat the controversy between evolution and creation as if it were static—as if nothing had happened since 1859—when, in fact, evolutionary theory has advanced steadily since Darwin. In contrast, creationist theory has inexorably retreated toward those sets of problems and ideas on which there is yet no significant evidence.

The theory of natural selection is being used today to develop and test predictive hypotheses about sex ratios, sexual dimorphism, sexual competition, sexual selection, parental investment, nepotism, social reciprocity, group-living, altruism, senescence, rates of infant mortality, and other problems to which it was not being applied significantly as recently as a decade ago. Unfortunately, high school biology teachers, who completed their formal training in biology before this new wave of evolutionary ecology and social biology had begun, are being dragged into ancient arguments and diverted from the truly exciting aspects of modern evolutionary biology.

Some General Remarks About Evolution

The massive volume that Charles Darwin published in 1859 resulted from nearly 20 years of field observations, comparisons, experimentation, and logical thought about the nature of living organisms. In it Darwin expounded his theory of evolution by natural selection. In the Galapagos Island region, he had noticed that species, believed at that time to be immutable, were in some cases more similar to one another than in other cases. Sometimes he could not tell if two populations were parts of the same species or parts of two different species. He also noticed that island species, or populations, were more similar if the islands were closer together; and that they were more similar when they occurred in different climatic regions on the same continent than if they occurred in the same climatic regions on different continents. These early observations and comparisons led Darwin to suppose that perhaps species are not immutable after all, but changeable, and that one species may sometimes give rise to two or more species. Eventually he decided that the process of change involved in this speciation, or species multiplication, must result because variants exist within every species; some variants out-reproduce others; and which ones out-reproduce in any given time or place depends upon the
environment. This process of natural selection of variants, which he compared to the artificial selection that man carries out on his domestic animals and plants, would cause populations on different islands to diverge unless they had chances to interbreed; this, in turn, would cause speciation to happen whenever accidental separations lasted long enough.

From this reasonable but startling beginning, Darwin went on to even more astonishing postulates, including the following:

1. All attributes of living organisms might be the result of a cumulative process of natural selection, extending backward through time to the beginnings of life on earth.
2. The major groups of organisms alive today differ from one another because they got separated during speciation processes in the distant past.
3. The entire fossil record is a remnant from the operation of heritable changes, natural selection, and isolation in a succession of past environments. Significantly, he noted that the fossils of a given continent generally resemble the living organisms of that continent rather than the fossils of any other.

From this beginning by Darwin, we derive the three major areas of investigation in evolutionary biology: (1) speciation, or how species multiply; (2) adaptation, or precisely how natural selection works; and (3) phylogeny, or the tracing of the patterns of evolutionary change through time. For the first several decades following Darwin it was phylogeny, and the search for more fossils, that were emphasized in biology. Later, speciation became an enormously popular area of investigation. Today, the study of adaptation, or the predictive and analytical value of natural selection, is paramount.

Darwin's combinings of facts, theories, hypotheses, conjectures, speculations, and guesses made sense in 1859, and they make sense now. Darwin's arguments and his methods have been tested, retested, examined, discussed, and refined by perhaps the greatest army of diligent and skeptical investigators ever to examine any testable hypothesis in the history of man. No evidence is available to deny the evolutionary process that is accepted as the working hypothesis of probably more than 99% of the active investigators in biology today. Thus, biologists pay scant attention to the arguments of the few anti-evolutionists. What they have learned about biology and evolution leaves them convinced that evolution is the framework within which they must operate; they have no uneasiness that what they are doing will be much affected by anything that could be said in brief oral debates or dissections of the arguments of creationists.

Biologists also know that, through their journals and professional meetings, they will root out errors in their findings. On the whole, they subscribe to George Gaylord Simpson's simple definition of science as a self-correcting method of finding out about the universe.

If evolution involved only fruit flies and cabbages, creationists would not attempt to have laws passed saying which theories must or must not be mentioned in classrooms. Anti-evolutionists and creationists are concerned because ultimately the same kinds of questions and tests that evolutionary theory uses to analyze the various other organisms in the world are likely to be applied to efforts to understand ourselves. They recognize the possibility of conflicts between evolutionary theory and their particular religious or belief systems. Such conflicts may often occur when the two systems of explanation are being used to explain or reconstruct human history. No conflict exists, however, between evolution and religion (or any social, political, or economic ideologies) when the latter is concerned with plans or goals for society, or the future of human behavior. Evolution is an explanatory theory about history. Anthropologists, most of whom accept that humans have evolved, ultimately must examine tendencies toward having certain kinds of ideologies as products themselves, directly or indirectly, of the evolutionary process. They began long ago to investigate religion in that fashion. Such investigations have an unnerving aspect. But they also have an intriguing quality. Consider the paradox of an organism possessing some quality of self-awareness, trying to analyze itself, using for the analysis the very attributes that are to be analyzed, when one of the most prominent of those attributes is resistance to any such analysis. That is the most difficult challenge we are likely to extract from this universe for a long, long time.

These are the difficult problems that every thoughtful biology teacher has to consider in order to discuss organic evolution in the classroom, because evolution leads inexorably to the analysis of human beings. In fact, revolutions in our thinking about human behavior have already begun, chiefly within evolutionary biology; part of the evidence is contained in papers published by Hamilton (1964-1967), Williams (1957-1975), Trivers (1971-1974), Alexander (1971-1977), West-Eberhard (1975), and Wilson (1973-1975). Such revolutions can be productive, so long as they remain in the realm of open scientific debate, and so long as they never lose the quality of self-correction. But biology teachers assume an awesome responsibility when they undertake to discuss the relationship of human history to human behavior in terms of possible and probable causes, including Darwinian or natural selection.

A Statement of Modern Evolutionary Theory

Darwinian theory, as used by evolutionary biologists today, is simple to state, difficult to apply, and astonishing to contemplate. The evolutionary process from which it stems derives from the interaction of five basic phenomena.

1. Inheritance: All living organisms (phenotypes) are products of the interaction of their genetic materials (genotypes) with their developmental (ontogenetic) en-
environments; these genetic materials can be passed from generation to generation unchanged.

2. 

Mutation: The genetic materials do change occasionally, and these changes are in turn heritable.

3. 

Selection: All genetic lines do not reproduce equally, and the causes of this variation may be consistent for long periods.

4. Drift: Genetic materials are sometimes lost through accidents, which are random or nonrepetitive in their effects on populations.

5. Isolation: Not all genetic lines are able, for various intrinsic and extrinsic reasons, to interbreed freely, and thus to continually reamalgamate their differences.

These five phenomena have all been demonstrated repeatedly, and can be demonstrated at will, as can their various interactions. No living things have been demonstrated to lack any of them, or are suspected to lack any of them. Hence, they are the factual basis of evolution.

Of the five main components of the evolutionary process, natural selection, or the differential reproduction of genetic variants, is almost universally accepted as the guiding force. The reasons for this assumption, which are not widely discussed, but which are crucial to the understanding of evolution, are: first, that altering directions of selection apparently always alters directions of change in organisms (although, because of genetic specialization or the absence of appropriate mutants, possibly in some cases only after delay); second, that the causes of mutation and the causes of selection appear to be independent; and, third, that only the causes of selection sometimes (but not always, of course) remain consistently directional for relatively long periods.

Mutations are most often caused by atmospheric radiation. Selection is caused by an updated version of what Darwin termed the “Hostile Forces of Nature”: climate, weather, food shortages, predators, parasites, and diseases. This list implies competition for resources, such as food, or protection from the other hostile forces; accordingly, for all sexual species, we must include as a selective factor competition for mates, and for the best mates.

Because directions of mutation evidently remain random in regard to directions of selection (although not necessarily in any other respect), mutational changes as such are independent of adaptation, or the fine tuning that organisms exhibit in response to their physical and biotic environments. The same is true of genetic drift, for its causes are by definition without cumulative directional effects on the genetic materials. Thus, as evolution proceeds mutations must increasingly tend to become deleterious, and their rates have likely been severely selected downward. Also, directional evolutionary change has to be caused by directional selection. The only apparent exception is the concept of selection suddenly becoming absent in the environment of a complex organism with mutational changes then leading to steady reductions in complexity. Although this effect has sometimes been postulated when some particular selective pressure has evidently disappeared (e.g., reductions in size and complexity of human teeth with the advent of cooked food, or disappearance of eyes in cave animals), such cases are more appropriately explained as changes in directions of selection. In no way do they support an argument that selection itself somehow mysteriously disappeared from the organism’s environment. When one direction or force of selection is removed from the environment of a species, the effect is to cause other previously opposing forces to become more powerful or effective.

These are the reasons, then, for the common tendency to refer to the theory of evolution as the theory of natural selection. They include the assumption that long-term evolutionary changes result from the effects of natural selection across long periods of time (see arguments below on this question). Refinements of evolutionary theory since Darwin have chiefly involved new understanding of adaptiveness from short-term studies of the selective process, and comparative studies of function. The results of these studies lead us to the conclusion that to apply evolutionary theory we must focus our attention on the causes and effects of differential reproduction.

Modern Creationist Arguments

Following is a list of the usual creationist arguments. All of them may be found in the controversies of the nineteenth century and the early twentieth century, as well as in the more recent references cited earlier. These arguments include: (1) Information can be divided into facts and theories. (2) Evidence can be divided into that which is conclusive and that which is only circumstantial. (3) Facts are derived only from conclusive evidence; and (4) Conclusive evidence comes only from direct observations and experiments. (5) Since the essence of science is repeatability, and (6) Repeatability necessarily involves experimentation, which can only be carried out through direct observation, then (7) If a conclusion does not come from directly observable phenomena, it is not scientific because the evidence is only circumstantial. Hence, (8) Comparative study of the present cannot lead to facts about the past; (9) Darwin’s comparative method, by which he “discovered” evolution and speciation, is neither scientific nor conclusive; and (10) We cannot study the past scientifically, especially not the distant past. (11) Questions about life can also be divided into “mechanisms” and “origins,” or “means” and “ends.” (12) General evolution or macro-evolution (ends) cannot be equated with natural selection, special evolution, or micro-evolution (means), for (13) Natural selection deals only with mechanisms, not with origins, and (14) There is no scientific evidence about the origins of kinds of life. (15) Evolution refers to a progression from “amoeba to man” but (16) Selection cannot be demonstrated to cause new organs or new species, rather it is (17) Just a variation on a limited set of themes. (18) Change in living
things can thus be divided into "within-kinds" change and "between-kinds" change. (19) Only "within-kinds" change can be observed directly; and (20) There are no genetic connections between major groups. (21) Mutational changes do not link major groups; nor do chromosomal rearrangements or ploidy. Therefore, (22) Natural selection is different from evolution, and (23) There is no scientific evidence about "between-kinds" change. (24) The fossil record, which might be used to support evolutionists on the gradual nature of evolution, is woefully incomplete; (25) What is missing are all of the links or postulated intermediates between major groups. (26) All known dating methods are notoriously inaccurate; and (27) There is evidence both of a widespread flooding and of overlap of man with trilobites. (28) Evolution also means progressive change, but the only real source of variations upon which selection can act are mutations, and (29) All mutations are deleterious, as is witnessed by the reversion to the "wild state" by all organisms once they are released from artificial selection. Therefore, since (30) All known change in life is degenerate (because all mutations are deleterious), and (31) All known change in non-living matter under natural conditions is also from complex to simple, (32) It is doubtful whether even natural selection can be used to explain anything at all about life. (33) The scientist is like a fisherman who uses a two-inch mesh in his net: he cannot catch fish under two inches in size. (34) Creation is the superior theory because it accords with the gaps in the fossil record and can be used to explain every difficulty that confronts an evolutionary theory.

Permeating these arguments are three principal themes. The first is the idea that there are basic dichotomies in the nature of questions about the history of life, and that although support for a selective mechanism of short-range or minor change may be justified, nothing is thereby suggested about long-range or major change (see arguments 1-23, 33). The second is the argument that the fossil record is essential to evolutionary theory, yet is incomplete in ways that support creation and diminish evolution (24-27). The third is the assertion that all mutations are deleterious and all change by selection therefore degenerate unless it results from created variation as opposed to environmentally induced mutations or novelties (28-32).

Refuting Creationist Dichotomies

Facts and theories are not separated by a magic line. There is no magical or profound difference in what one does with these two concepts. Scientists deal in probabilities. Arbitrarily, scientists have chosen the levels of 95% probability and 99% probability as appropriate confidence levels in statistical analyses of their data. They require that the results obtained in their tests are only 5% or 1% likely to have resulted from chance alone. They call this a positive result, even though something remains unknown about the situation that somehow accounts for that last 5% or 1%. Such a result does not mean that the problem is solved. It simply means that one can proceed to the next step in the investigation with some confidence—95% or 99%, to be "exact."

The creationists' arguments suggest that a fact is something that, once discovered, is kept forever like a coin or a preserved butterfly. Not so. Nothing is irreversibly factual. Any fact may turn out not to be a fact at all; and in scientific investigation the only useful thing one can do with a fact is to use it to build better or more complete explanations. What researchers do with facts is establish the next line of hypotheses. And if their "fact" proves vulnerable, they discard it and start over. It is a fact that 100% certainties are obvious only in useless tautologies such as: Hairless men have no hair. It is a fact that life insurance companies make money by operating on probabilities.

Conclusive evidence and circumstantial evidence are not separated by a magic line. Creationists distinguish between what they call direct or conclusive evidence and circumstantial evidence. So do courts of law. But there is a large difference. Courts admit that no magic line separates the two. Sometimes one cannot tell if the evidence is direct or merely circumstantial. Moreover, courts recognize that facts can derive from circumstantial evidence. People are still sentenced on circumstantial evidence.

We do not know who our relatives are from direct knowledge; we must rely upon what others have told us. Yet, we all consider that we know such things beyond significant doubts. In all likelihood no one ever did an experiment on whether or not the sun would rise the next day, yet we regard it as a fact that the sun rises each day. We do so because we have repeated the observation so many times as to render completely trivial the likelihood that it is accidental or random; but we have not thereby eliminated the possibility that the sun will not rise tomorrow.

There is no fundamental difference between the comparative method and the experimental method in biology. Both experiments and comparative studies attempt to discover statistically significant differences between sets of observations. The distinction is not in the amount of control or the precision of the results, but in the presence or absence of manipulation and in the usual kinds of controls employed. In experimentation, we deal with phenomena that can be manipulated, sometimes to make the comparisons easier or quicker, or more likely to yield unequivocal results. We depend upon comparisons without manipulations when we must—when, for example, we are dealing with long-term phenomena, or with variables whose effects cannot be eliminated and so must somehow be randomized.

The ideal test of the effectiveness of seat belts in reducing deleterious effects of automobile accidents would be experiments in which groups of identical automobiles driven by groups of drivers identical in weight, height, and
other attributes were caused to have identical crashes. We cannot set up such experiments, but we do not simply give up on making decisions about seat belts. Instead, we search for other methods. Experiments with dummies and animal substitutes are useful. But the most important information probably has come from comparisons of unplanned accidents in which seat belts are (1) used and (2) not used. Such comparisons represent precisely the kinds of studies used by evolutionists to solve problems about long-term processes. By making appropriate comparisons we use the natural experiments, just as Darwin developed the theory of natural selection by comparing variously diverged populations with varying likelihoods of exchanging migrant individuals.

The problem with natural experiments is that they are not designed to answer the particular questions we want to answer. Sometimes, we can answer a question more precisely with specially designed experiments. It is not the precision of the results that represents the difference between the comparative method and the experimental method, however, but the difficulty of discovering how to make the natural experiments answer our question. This involves chiefly the manner in which we control the experiment not its precision. One controls a natural experiment not by eliminating the effects of irrelevant or confusing variables, as in a laboratory experiment, but by randomizing them.

Creationists' distinctions between origins and mechanisms depend upon all the other dichotomies. One must always ask: Origin of what? How does one tell whether he is talking about origins or mechanisms? We can sometimes demonstrate that differences between traits in organisms are due to genetic differences that derive from mutations, and some creationists do not deny this. But they distinguish between origins of major organs, or major traits, and mechanisms. Moore (1958) argues that it is scientific to require the evolutionists to reconstruct each case of speciation. Unless one can tell precisely how and when and where each species formed, he suggests, to talk about speciation as a process is unscientific. Furthermore, since these questions about long-term events like formation of major organs or speciation, cannot be answered, Moore contends that such events must be as easily attributable to creation as to evolution.

Requirements that every case of long-term change be reconstructable in detail from direct observation, however, are approximately as scientific as suggesting that life insurance companies cannot make money unless they know how and when each person insured is going to die; or that we should not fasten our seat belts until the ideal experiment, described earlier, has been carried out. Insurance companies in fact make money by knowing on average when deaths are likely. Evolutionists make progress in understanding the attributes and history of living organisms using the same kinds of information.

Erection of false dichotomies in efforts to employ creation as a theory explaining life has forced creationism to undergo significant retreats. Creationists argue as though evolutionary explanations and creationist explanations are both static, neither advancing and neither retreating. This is not true. With the adoption of an attitude demanding (and admitting) verifiable evidence both for evolution and for creation, creationists were forced to acknowledge existence of the process they came to call "micro-evolution." "Micro-evolution" is synonymous with the evolutionary process evolutionists theorize can be projected in a uniformitarian fashion to explain life in general. This left the creationists defending creation only against "macro-evolution" or long-term change, which they argue cannot be investigated scientifically. Ironically, Darwin, ignorant of both the genetic basis of life and the nature of mutational change, modelled the long-term process of speciation by comparing near and distant island species as early as 1837 (Lack 1961), and may have been led only subsequently to his theory of both short- and long-term change by selection (Darwin 1859) and the slow divergence of populations in different localities with different constellations of selective forces.

Distinguishing macro- and micro-evolution forced creationists to draw the line between these phenomena. Initially, they drew this line between "within-species" and "between-species" changes, contending that these two kinds of changes were not due to the same phenomena because species were products of creation. As biologists' understanding of species developed, however, it became clear that although species ordinarily do not interbreed in nature they can often be caused to do so by altering their environments or forcing them together in the laboratory. In general, the more similar two species are, the more likely it is that they can hybridize, and that the hybrids will be fertile. Thus, no absolute genetic gap exists at the species level. It is also well known that when two different individuals in the same species are mated to produce hybrids, the hybrids are likely to be intermediate in some characteristics, like one parent in some characteristics, and like the other parent in others. The same is true when two species are hybridized.

Moreover, every biologist studying species in any group of organisms finds some populations for which there is no way of deciding whether or not they have achieved full species status, regardless of how that criterion is established. Therefore, every degree of difference, evidently down to the level of individual mutations, exists between diverging populations; and there are numerous cases in which the irreversibility of the divergence of populations is uncertain, depending upon external environmental events such as the permanence of geographic or ecological barriers, which are not entirely predictable.

Contrary to creationist arguments, all of these facts indicate that the differences between species are, like those between individuals within a species, simply accumulations of mutations. Thus, the idea that reproductive barriers between species are the result of anything
alien to the basic evolutionary process as we know it, is unsupportable; evidence for the opposite conclusion is abundant.

In view of this evidence, supporters of a theory of creation have retreated in two ways. First, they have centered their defense farther up the taxonomic hierarchy, sometimes referring to the genus rather than the species when speaking of the probable products of creation. Second, they have tended to become vague about the exact level at which micro- and macro-evolution become distinct from one another, often speaking of “within-kinds” and “between-kinds” change without defining kinds. In still other instances, they suggest that what was created, or what evolutionary theory cannot explain, are “major groups.”

The species concept, with all its difficulties, has the real correlate of reproductive isolation under natural conditions, sometimes difficult to apply, but directly observable whenever the species involved breed at the same times and places. Genera, on the contrary, are simply groups of species placed together because of overall similarity, with generic limits a matter of opinion and convenience in classification. In fact, hybrids between species belonging to different genera are common (Gray 1954; 1958), and hybrids have even been obtained between species of fish belonging to different families (Hubbs and Dreyer 1960). Major groups are even less definite, and fewer in number. A creationist theory restricted to “major groups” is much less important than one presumed to account for lower-level groups, and too indefinite to be meaningful.

Sometimes, alterations of our views about presumed long-term trends in evolution, such as orthogenetic and “progressive” trends, the idea that ontogeny recapitulates phylogeny, or the particular phylogenetic constructions proposed for certain groups (e.g., horses, see Macbeth 1971) have been regarded as casting doubt on evolutionary theory in general. Such arguments lack foundation because it is highly unlikely that anything as complex and poorly documented as the long-term history of life could be reconstructed without many errors and false starts; and the revisions proposed do not suggest causes other than natural selection. Moreover, every time supposed special features of long-term evolution like orthogenesis, progress, and recapitulation are diminished in importance or eliminated, the argument is strengthened that macro-evolution is nothing but micro-evolution over longer time spans.

When a theory must constantly retreat, this is evidence in favor of its alternatives. In this case, it is not only clear that there is no definite line between natural selection and evolution, but that creation must be applied at some entirely different level in this universe than that of explaining existing traits and kinds of living organisms if it is to remain a viable idea.

Evolution and the Fossil Record

The fossil record is not really necessary to defend an evolutionary explanation of life. Nevertheless, it is extraordinarily supportive of evolution. In terms of whether or not long-term evolution by natural selection has occurred, there simply are no significant problems, just as there are no real missing links between man and proto-man. The important point is not exact dates, exact sequences, or directionality of changes. The dates themselves, or changes in dating, are not challenges to evolutionary theory, though they are often so headlined in the newspapers. The important points are two. First, dates, sequences, and directional changes, as known, generally accord with one another. Estimates of relative ages based on location in the ground roughly match the estimates of relative age based on the nature of the fossil. When isotope dating methods became possible the relative ages determined by those methods for the most part matched what had already been learned. Yet the chances of the above three complex kinds of data matching by accident, in the fashion required to support evolutionary theory, are infinitesimal.

The second important point about paleontological evidence is that due to the incompleteness of the data and the imperfection of the methods of measurement available at any given time, it is entirely predictable that slight mismatches of fossil data will occur. Moreover, increases in numbers or prominence of such cases should occur sometimes when new data or methods are acquired. Such inconsistencies do not support evolution; neither do they negate it. They always must be considered in light of the overall consistency of paleontological evidence and the apparent incompleteness of data on the particular problem involved. Most important is what happens to such cases after they have been identified. Do they tend to disappear as more knowledge is gained? Such trends cannot fail to support evolution. In the face of such trends even the persistence of a “hard core” of inconsistent cases fails to detract from evolutionary theory. Moreover, to support a creationist theory an opposite trend would be required: a growing number of cases inconsistent with evolution that fall into a definite pattern supporting a creationist explanation. Such a pattern already exists to support evolution, based upon thousands of separate cases. Hundreds of new paleontological discoveries are made each year by hundreds of paleontologists competing with one another to discover what really happened during the history of life on earth. The number of problems solved by these discoveries far exceeds the number raised.

Gaps exist in the fossil record for the following reasons:

1. Not all species are preserved.
2. The more time that has elapsed, the more chance there is for loss.
3. Earlier animals tended to be softer and small, hence less likely fossilized.
4. Evolution is sometimes more rapid, giving less opportunity for fossilizing some of its stages.
Gaps exist between major groups because:

1. We define groups as those between which gaps still exist.

2. Intermediates between major groups, as one would expect, tend to be more ancient than those between groups lower in the taxonomic hierarchy and accordingly more recent; hence they are less likely available as fossils.

We reconstruct the past just as we predict the future. Our information is incomplete in each case, and we can gain new evidence in each case to test a model or a prediction. Complaints are made about reconstructions based on sequences developed from data fragments from different places. Perhaps it would be optimal to be able to reconstruct a complete sequence from one beginning, but we really have no reason to expect animals to have been fossilized in perfect arrangements for such a purpose. To argue that the past cannot be reconstructed is even less reasonable than to argue that the future cannot be predicted.

Moore (1974) says that a major prediction of creation theory is that there will be gaps between distinct kinds of forms of living animals and plants, with different degrees of variability within kinds of animals and plants. But does such a theory predict what kinds of gaps will occur? Evolutionary theory predicts correctly that there should be more fossils of bony and shelled animals and more gaps in soft-bodied forms, more fossils of recent forms and fewer of more ancient forms, and erratic gaps because of irregular spacing and varying severity of environmental catastrophes and changing rates of evolution in different circumstances.

If as time passes, no one finds an exception to meet Darwin's challenge of universality, the theory of evolution by natural selection is further confirmed. As additional fossil discoveries continue to increase the number of attributes of organisms for which extinct intermediate forms are known—such as kinds of legs and wings, sizes and kinds of skulls—it becomes increasingly probable that the structures of organs for which no intermediates between extant forms are known were also once represented by intermediates. As the proportion of living forms unrepresented by extinct forms is steadily reduced by fossil finds, as has happened continuously since Darwin's theory was first published, the theory of gradual evolutionary change is increasingly supported. Whenever a specific gap used by creationists as evidence of creation is filled, the power of creation as an explanatory theory is further diminished.

Erroneous Aspects of Creationist Descriptions of Natural Selection

Change by natural selection is not degenerative. Creationists argue that all "constructive" genetic variation was created, that all mutations are deleterious, and that all change by selection acting on mutants must be degenerative. These arguments are paradoxical for several reasons, including:

1. Selection can be shown to act upon any existing variations as well as upon demonstrably novel mutations, simply by altering the environment.

2. Some new mutations can be shown to be identical to alleles already existing (mutations are evidently recurrent).

3. What is deleterious in one environment can be shown to be advantageous in another.

Thus, a line cannot be drawn between existing variation that might have been created and that introduced by recurrent mutations, and whether a variant is advantageous or not depends entirely upon its environment and not upon whether it is a part of what appears to be the existing "natural" variation within a species or a known recent mutant.

Change by natural selection is not progressive, except in the sense of improving adaptiveness. There is no implication of progress from simple to complex, from amoeba to man, nor is there any sense of better or worse, except in relation to adaptiveness to the immediate environment. Accordingly, changes from complex to simple in modern organisms are not evidence against evolution but cases of evolution. When organisms that have been selected by man are released from that selection they are being returned to the environment where their original attributes were acquired, and through natural selection their original traits, or similar traits, once again become prominent.

Natural selection and not creationism leads to testable theories about the evolution of many aspects of life. What does it mean if such phenomena as sex ratios, amounts of sexual dimorphism, and correlation between breeding systems and parental behavior can be explained by the same theory in animals as different as primates, ungulates, and pinnipeds (Alexander, et al. in press.) It means that the theory has general applicability. It also means that we have probably found out about something that has been happening gradually in each of these groups for a long time, beginning long before anyone was watching them. The only theory that has successfully made such predictions is natural selection. This indicates that natural selection can be extended into the past beyond our power to observe its action directly. Continuous ranges of variation in characters involved in phenomena like sexual dimorphism can demonstrate that sexual dimorphism evolves very slowly. So from the study of adaptation as well as the study of speciation we can successfully link short- and long-term evolutionary changes and prove that the two are not different.

Darwin (1859) specified the means for falsifying the idea that observable small changes lead to large changes which take so long that they are not directly observable: "If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory
would absolutely break down.”

Hybridization experiments showing that big differences between species are due to differences in large numbers of separately heritable genes, as well as the general relationship of genes to the development of the phenotype, indicate that Darwin’s next statement, “But I can find no such case,” would represent the conclusion to which modern biologists would also be drawn. Similarly, the alteration of complex organs by matings of individuals in which the organs differ slightly is a clear support for the idea that such organs have evolved through accumulations of small changes.

**Evolutionary theory invokes only demonstrable mechanisms.** A fundamental difference between evolution and creationism is that creationism involves processes and mechanisms that cannot be demonstrated, and that no one has ever observed; evolutionary theory predicts on the basis of processes and mechanisms that everyone can observe and verify today. Evolutionists do not argue or require that no unobserved or unobservable, unverified or unverifiable processes and mechanisms can possibly occur. They simply build their models on the basis of the observable and verifiable, and continue to test those models. As long as predictability keeps on increasing, they keep on refining and adjusting their models and testing the new versions. No creationist has suggested an alternative testing procedure.

**Natural selection is not an untestable hypothesis.** A common objection to the theory of natural selection is that it is a tautology: In survival of the fittest, the fittest survive. Why do they survive? Because they are the fittest. The circularity of these statements has led people to say that natural selection explains nothing because it explains everything. Some of the same people also say that Darwin did not provide a means of falsifying his hypothesis—that he did not tell us about anything that could not be true if natural selection occurs.

We can dismiss the latter contention and introduce a compelling and provocative aspect of evolutionary theory by considering a bold challenge issued by Darwin (1859); it was: If it could be proved that any part of the structure of any one species had been formed for the exclusive good of another species, it would annihilate my theory, for such could not have been produced through natural selection.

Darwin thus provided, in 1859, a means by which his theory could be falsified, and he so identified it. (He said, in effect, that his theory, if correct, should explain everything observable but not everything imaginable. Moreover, he did not say that an exception to his view of adaptation would weaken or diminish his theory, rather that it would annihilate his theory. Darwinian theory thus demands a selective background for the traits of all organisms and simultaneously rejects the possibility of certain kinds of altruism as evolved adaptations (but does not thereby exclude them from the behavioral repertoires of modern humans, who need not be bound by their evolutionary history). In other words, Darwinian evolution was, by Darwin himself, placed in a maximally vulnerable position by his clear exposition of what is required of living things if it is to be upheld. Darwin did tell us how to falsify his theory.

Although Darwin spoke only of “structure” we are obviously forced to expand the challenge to include all traits, whether morphological, physiological, or behavioral. Although he spoke only of altruism between species we cannot avoid the fact that all forms of genetic or reproductive altruism within species are also contrary to evolutionary theory, and should exist only as a result of accidents, or sudden environmental changes rendering an organism temporarily “maladapted.” The human environment, however, includes our ability to reflect consciously and plan deliberately; we can thwart the adaptive background of our genes.

One more thing needs to be said about the supposed circularity or tautology of the phrase “survival of the fittest.” If we never could predict differential survival or reproduction, but could only analyze it in retrospect, this criticism would be justified. Of course, this is not so.) We can make countless accurate predictions from variations in the attributes of organisms, such as in an environment including sharp-eyed hawks and a white sand substrate, white mice will out-reproduce black mice. Thus, the concept of natural selection does not require circularity.

**Darwinism is not an ideology.** Darwinian natural selection may provide the core item in analyzing the causal history of the traits of living organisms, even including the general patterns of human behavior and culture. I think there is ample evidence making this an appropriate hypothesis. On the other hand, it does not follow, in any sense whatever, that Darwinism provides a basis for the construction of desirable political, economic, social, moral or ethical systems to be employed now or in the future. Darwinism’s usefulness in these regards remains strictly in the realm of providing information that will assist humans in developing whatever system they may elect to strive for. It has no role in determining the nature of that system.

**Conclusion**

When one is a member of a frustrated minority, it is tempting to seek to force one’s views on others. A society such as ours must constantly guard against such efforts if it is to move towards openness. Some creationists have implied repeatedly that society is already closed because editors will not publish their papers. It is easy to believe that critical referees are wrong and that one is being persecuted, and sometimes both complaints are well-founded. But there are numerous scientific publications, and scientists do not usually seek to get laws passed to protect themselves from criticism.

No laws were ever passed saying that evolution had to be taught in biology courses. The prestige of evolutionary theory has been built by its impact on the thousands of
biologists who have learned its power and usefulness in the study of living things. No laws need to be passed for creationists to do the same thing. Recently creationists have reiterated that all they want is to resolve these issues on purely scientific grounds, but their behavior with regard to the law suggests otherwise. Moore (1974) in asking whether there is need for legislative intervention, implies that such legislation may be the only way to “true academic freedom” unless high school biology teachers start teaching creation.

The greatest threat to society and to our children is not whether students are exposed to wrong ideas—after all, many high school biology students are legally adults with voting privileges, and all high school biology students have already been exposed to many wrong ideas. What is important is whether each has been taught how and given the freedom to test new ideas, evaluate them, and respond appropriately. The question of whether evolution or creation or both are mentioned, supported or taught in any or all of the schools is trivial by comparison. As long as biology teachers conduct their courses in the spirit of free inquiry, open debate, and self-correcting searches for predictive theories and repeatable results, no parent need fear that his or her children are being subjected to anything but the best kind of preparation for life in the technologically complex and socially demanding society in which we live.

References


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(Concluded on p. 107)
FIGURE 2. Students working independently on dissection.

where their abilities can be challenged rather than allowing them to do their traditional best without help.

The academic needs of honors students are obvious: they need to learn as much as they are capable of learning. By allowing honors students complete freedom to pursue their interests without guidance, and in some cases, allowing them to coast, we are guilty of an instructional and intellectual cop-out. Honors students need direction as much as the exceptional children. The multimedia LAP program meets their needs.

Less obvious, but equally important, are the affective needs of such students. Responsibility is a quality usually associated with honors students, but there is always room for improvement. Individual goal-setting on LAPs and projects, and the sharing necessitated by limited materials helps to develop responsibility. Development of a positive self-image is perhaps the greatest need of all students. Increased contact with the instructor and other students allows for the development of rapport and relationships that can lead to an improved self-image. The satisfaction of being responsible for their work, having a definite say in the content of what they study, and being able to define and achieve their own goals in areas of interest they choose, all give the honors student a feeling of achievement and increased confidence.

I believe that the desire for continued learning is instilled by activities such as goal setting, individualized learning, and contractual education. Students involved in these activities will continue to learn even after they leave the school environment.

References


Bioethics Rationale . . . from p. 90


"Who Should Survive?" Kennedy Foundation-Lowengrad and Brotherhood, 999 Asylum Ave., Hartford, Conn. 06105, 25 min.

Slide Tape Presentations


Written Materials


Evolution, Creation . . . from p. 104


