

Random Walking

The Game of Science

Science fundamentally, is a game. It is a game with one overriding and defining rule:

Rule No. 1: Let us see how far and to what extent we can explain the behavior of the physical and material universe in terms of purely physical and material causes, without invoking the supernatural.

Operational science takes no position about the existence or nonexistence of the supernatural; it only requires that this factor is not to be invoked in scientific explanations. Calling down special-purpose miracles as explanations constitutes a form of intellectual “cheating.” A chess player is perfectly capable of removing his opponent’s King physically from the board and smashing it in the midst of a tournament. But this would not make him a chess champion, because the rules had not been followed. A runner may be tempted to take a short-cut across the infield of an oval track in order to cross the finish line ahead of his faster colleague. But he refrains from doing so, as this would not constitute “winning” under the rules of the sport.

Similarly, a scientist also can say to himself, “I believe that *Homo sapiens* was placed on this planet by a special act of divine creation, separate and apart from the rest of living creatures.” While this can be a genuinely held private belief, it can never be advanced as a scientific explanation, because once again it violates the rules of the game. If that situation were true, and if *H. sap.* were indeed the result of a special miracle, then in view of Rule No. 1, above, the only proper scientific assessment would be: “Science has no explanation.” The problem with any such statement is that we know from past experience that it probably should have been qualified: “Science has no explanation—yet.” As people who have grown up amid the current scientific revolution know full well, last year’s miracle is this year’s technology.

The vital importance of excluding miracles and divine intervention from the game of science, as is advocated even today by the creationist movement, is that allowing such factors to be invoked as explanations *discourages the search for other and more systematic causes*. Two centuries ago, if Benjamin Franklin and his contemporaries had been content to regard vitreous and resinous forms of static electricity only as expressions of divine humor, we would be unlikely to have the science of electromagnetism today. A century later, a passive belief that God made all of the molecules “after their own kind” would have stunted the infant science of chemistry. And a contemporary who believes devoutly that there are no connections between branches of living organisms is unlikely ever to discover such connections as do exist. *The most insidious evil of supernatural creationism is that it stifles curiosity and therefore blunts the intellect.*

There are those who demand, in a bizarre misapplication of courtroom standards, that the claims of modern science either be proven beyond a shadow of a doubt at this present moment or else be given up entirely. Such people do not understand the structure of science as a game. We do not say, “Science absolutely and categorically denies the existence and intervention of the supernatural.” Instead, as good game play-

ers, we say, “So far, so good. We haven’t needed special miracles yet.” The particular glory of science is that such an attitude has been so successful, over the past four centuries, in explaining so much of the world around us. A good maxim is: *If it ain’t broke, don’t fix it.* The game of rational science has been enormously successful. We change the rules of that game at our peril.

To be sure, many areas exist where we as scientists do not yet know all the answers. But these problem areas change from one generation to another, and that which might have seemed miraculous (to some) a generation ago now is seen to be perfectly explicable by natural causes. In hindsight we would have felt foolish had we written off those areas as the result of miracles fifty years ago; and we would be ill-advised to set ourselves up for ridicule by those who will follow us fifty years from now. It is a reasonable prediction that the attitude of future generations toward twentieth-century “scientific creationism” (an inherent oxymoron according to Rule No. 1, above) will be one of ridicule.

It would augur well, for both science and religion, if creationists and evolutionary biologists would realize jointly that the question of the existence or the nonexistence of a Deity is irrelevant to the study of biological evolution. Both the die-hard atheist and the theistic evolutionist can function as modern biologists with absolute integrity. The people who are entirely beyond the pale intellectually are those who can be characterized as short-Earth creationists and Biblical literalists—those who maintain that it all happened in 6 standard 24-hour days, with the celestial equivalent of a wave of a magic wand. A clear line of demarcation must be drawn between such people and evolutionists of either theistic or nontheistic inclination. Some creationist rhetoricians would like to draw the line between nontheistic and theistic evolutionists and to lump the second group (which probably includes the majority of nonscientists) together with the 6-day, Young-Earth modern “Know-Nothings.” We absolutely must not let them get away with such a tactic.

Science is not a closed body of dogma; it is a continuing process of enquiry. A dry and querulous legalism that tends to inhibit or close off that process is antithetical to science. The cartoonist Sidney Harris once published a cartoon depicting two scientists in consultation before a blackboard filled with equations—obviously some kind of proof in the making. One scientist points to a particular equation and proclaims confidently, “And at this point a miracle occurs!” Real scientists don’t talk that way—not because some of them don’t believe in miracles, sometime, somewhere—but *because invoking miracles and special creation violates the rules of the game of science and inhibits its progress*. People who do not understand that concept can never be real scientists, and should not be allowed to misrepresent science to young people from whom the ranks of the next generation of scientists will be drawn.

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Evolution Under the Fire of Toy Guns

Evolutionary biology has been shot at ever since its inception and yet, intellectually, has never felt the bullets. The reason is that the shots have been blank, despite their noise. In this country, some indefatigable snipers continue the now time-honored tradition of shooting at evolution with toy guns.

One may point to some of the background behind this behavior in a one-time excursion into philosophy here; and then evoke ways in which the analysis of evolution at the molecular level has once again confirmed, indeed redundantly, that evolution cannot be denied the status of fact.

Science has been very successful in explaining *contemporary* processes in terms of mechanisms that intellectually disqualify the postulate of multiple, *ad hoc* interventions of supernatural forces. According to the most ancient religions, and for a fraction of religious believers down to our day, repeated supernatural interventions are to provide the guidance of observed events; yet this guidance has been shown by science to be exercised by discoverable and measurable interactions that form coherent, reproducible, and predictable patterns. Thus, as a result of scientific research, supernatural interventions turned out to be uncalled for and redundant. They were devoid of specific explanatory power anyway.

How about *past* processes? They can be observed only indirectly, by effects that have come down to us, often in a fragmentary way. They can also be studied by current experiments whose results suggest, or verify, mechanisms that have come into play in the past. There is thus something special about historical facts, and the difference has been the occasion for denying that facts of the past have the same status of likelihood or certitude as facts of the present. Those who wish to believe in recurrent divine interventions in the world of phenomena usually find it too hard nowadays to introduce these interventions into relationships that science has established for the present. They sometimes seek, as a last resort, to smuggle the supernatural into the biological past. Since the arrow of time is made of a succession of "presents," it would seem foolhardy to accept that present phenomena are the only ones that do not require, as an explanatory principle, the intervention of divine fiat and that all other already "accomplished" presents, namely the past ones, did require what our present does not. Reasonable people would not put their fortunes on a losing number.

Coherence is the name of the game when it comes to establishing a scientific theory. Coherence in the organization of observed facts, observed of course in the present, permits one to link present to past and to speak of past facts as well as of present facts. Coherence is not in itself a demonstration of truth, but the more numerous and diverse the observational and experimental elements are that enter into it, and the fewer the irrefutable breaches of it, the better the approximation to truth may be considered to be. The pieces of evidence of various sorts that convergently and coherently point to the reality of evolution are legion. For this reason evolution is more probable than the historical existence of, say, Moses (which is indeed probable) and at least as probable as the historical existence of George Washington.

Many people's intuition tells them that an intelligence is at work in the universe and this is one of the primary bases for the belief in a divinity behind it all. There must indeed be some profound relationship between intelligence, our human intelligence, on the one hand and the world's structures and their interactions on the other. This profound relationship is illustrated by the frequent applicability of pure mathematics to the universe. Science however does not tell us how to understand this relationship. Is the universe an expression of divine intelligence or is what we call intelligence an expression of the universe? If the second is the case, no wonder that evolution appears intelligent. The second view of the correlation is the more probable, because the modes of con-

nection and coherence between phenomena *must* in some way express themselves in intelligence as it appears in sentient beings. If they did not, there could be no understanding of phenomena and no rational dealing with the world. (On the other hand, it is not clear that the notion of an intelligence present before the world's creation makes any sense. Since intelligence as we know it and as we name it is manifest only through the processing of elements that exist outside of itself and without which it is not even conceivable, believing that an intelligence, in some distant past, can have existed without anything else existing at the same time is adding further mystery to a universe that is mysterious enough without this addition.)

So much about the background against which denials of evolution have recurred. What are some of the contributions that the field of molecular evolution is making to confirm evolution, once again, in its status of fact? It is in the nature of the basic study material of this field, namely the informational macromolecules, to offer countless and particularly well defined examples of deduced intermediary evolutionary forms. As is well known, in comparing, say, the amino acid sequences in a given type of contemporary protein as found in different organisms, one can in many cases deduce the likely nature of the amino acid present at a certain position in an ancestral molecule. At the organizationally much more complex level of the organisms, some decisively important features of undiscovered fossils can certainly be inferred by comparing contemporary forms; but a precise deductive reconstruction of evolutionarily intermediate forms is not possible, because of the spotty fossil record and the very large number of theoretical alternative structures. In addition, such alternative structures cannot be tested for functionality, since hypothetical extinct organisms cannot be rebuilt. In the case of proteins, on the other hand, such checks are in principle feasible: a postulated evolutionarily intermediate polypeptide chain could be synthesized, properly folded, and tested for functional properties.

Regarding whole organisms, any outcry about a lack of fossil intermediary evolutionary forms is misdirected, however. Insofar as intermediate forms *can* theoretically be found, a number of them have been and *are* being found progressively. There will be many more in the future (science is exceedingly young!). A prediction that may be considered to be part of evolutionary theory is the following: fossil remains of the true links in the actual lines of descent between different taxa will almost never be found. This is so because of several reasons; among them, the capricious occurrence of the geological conditions for fossilization, the irregularities of sedimentation, and the erosion of strata; as a consequence only a fraction of the diversity of living forms leave informative traces (see Levinton 1988); further, the fact that the most striking diversification of morphological forms occurs at the occasion of adaptive radiations of organisms. Such radiations seem to be brought about recurrently by major natural catastrophes that remove from ecological niches many of the species that occupied them and make room for new invaders. Under these environmental conditions directional morphological changes appear quickly. An accelerated rate of morphological change decreases the total number of individuals of intermediate morphologies that are available for fossilization. An even more radical reduction in number of individuals representing intermediate forms is expected to occur in those events of speciation that are based on the so-called founder effect. Rather few individuals, isolated by various mechanisms from the rest of the population, are inferred in this case to be at the origin of evolutionary change. Their fossil remains can hardly be expected to be found. Thus most fossils found are anticipated to be in a cousin-of n^{th} -degree relationship with the direct ancestors of the organism that one is considering. This does not contradict, it supports the existence of evolutionary filiation. Where cousins are found, filiation has taken place.

Whereas the morphologies of organisms can be remarkably constant or remarkably changeable over evolutionary time, the rate of evolutionary change in any given type of informational macromolecule does not show such extreme variation. The comparison between contemporary informational macromolecules shows that their changes during evolution are progressive and continue to occur even in so-called living fossils, that is, in those organisms that have remained morphologically stable over long periods of time. It would be foolish to assume that each protein variant, or any particular ones among them, have been created separately by an intervention of divine power. The absurdity of such a supposition takes on particular relief when one compares very similar molecules, for instance, similar hemoglobins. There is one single difference among 146 amino acids between a gorilla β -hemoglobin chain and the corresponding human hemoglobin chain. Single amino acid substitutions do arise spontaneously in contemporary hemoglobins and it is entirely possible that the gorilla substitution exists in some human individual. Why should any reasonable person assume that God has made both gorilla and human hemoglobins *de novo*? Between the human and chimpanzee chains there is, on the other hand, no difference at all. Would God make two identical hemoglobins separately and *de novo*? Saying: "Stop! Here we meet with a mystery" would not do when the critic has set in motion and intended to pursue what he claimed to be a rational discourse. No one may stop an argument at the precise moment when it is shown to be on a track of absurdity and still claim to be intellectually responsible.

As to natural selection, to doubt its importance is to doubt the importance of function. The history of natural selection throughout evolution is the history of the birth, conservation, and modification of functions. To negate natural selection does not at first sound as though it were equivalent to negating life—yet it is. Negating function would indeed be negating life, since organisms can be considered as meshworks of functions that insure their development, temporary stability, and reproduction. It happens that function and selection are essentially the two sides of the same coin. A function will be, *has* to be selected—or in most cases it will disappear. A selected structure will be functional—or it won't be selected. Proteins and certain RNAs are, as it were, the elementary units of an organism's functions. They permit us to see in detail how, at the level of their structural foundations, functions are carried out, maintained *despite* structural changes, and modified *thanks* to structural changes. They also have already permitted us in some experimental systems (e.g., Q β RNAs; Davis 1991 and literature quoted therein) to witness how function originates. An important point is that an origination *de novo* of a functional macromolecular structure probably has occurred only very rarely over the last, say, one billion years. Most of the time a macromolecular structure endowed with a new function arises through the modification of a preexisting functional macromolecular structure. The new sits on the shoulders of the old. The shoulders of the old; that is what is required at each step of evolution, not special creation.

As is also well known by all those acquainted with the field, the evolutionary trees deduced from contemporary informational macromolecules largely coincide with those that paleontologists and comparative anatomists, on fossil as well as contemporary evidence, have themselves deduced from their analyses. Thanks to the application of relatively recent sequencing techniques, differences between corresponding contemporary informational macromolecules have been determined and counted. The larger the number of these differences as now ascertained, the further apart on the phylogenetic tree the organisms that contain these molecules had been judged to be by the morphologists. If there was evolution, this is what one would have predicted to find—and it was predicted.

The two types of evolutionary deductions, morphological and molecular, have been obtained entirely independently. Their degree of coincidence is far too great to be attributable to chance. The conclusion is either that the reality of evolution, once again, is strongly supported, this time by the contributions of the field of molecular evolution; or that God has gone to incredible lengths in making us believe that evolution existed when it didn't. If God wanted so badly to fool us scientists, should we oppose His wish to make us believe in evolution?

As has often been pointed out, science does not pronounce itself about first causes and is compatible with many concepts of what God is and stands for. To give an example, evolutionary biologists have been members of the Pontifical Academy in Rome. Peaceful relations with various churches and millions of believers notwithstanding, science as such cannot accommodate God among the explanations of *phenomena* and of their connections. To paraphrase Dickerson, the very project of science would thereby be denied; and in fact, as science progressed, God kept being removed, case after case, from his original position of provider of explanations for phenomena. We need to think only of the origin of the rainbow for which, for so long, God's direct intervention was the explanation. ("I am putting my bow in the clouds. It will be the sign of my covenant with the world." Genesis 9:13–14). Eventually the rainbow was understood in terms of interacting observable and measurable processes that can be fully accounted for without resorting to the postulate that they are driven by any will or intent. There have been many replays of this type of story and the way it ended. Some people refuse to learn from experience.

References

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