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EVOLUTIONARY HISTORY AND DIVINE PRESENCE

HOLMES ROLSTON, III

Biology has developed at two scales. Molecular biology, discovering genes and DNA, has decoded the "secret of life" (once ascribed to the Spirit of God). Evolutionary history has located the secret in natural selection operating across enormous timespans, with the fittest selected to survive. The two levels are theoretically interrelated. The genetic does the coding of life in DNA and constructs molecular proteins, lipids, assembling them into organisms. Organisms cope at their native-range levels, inhabiting ecosystems. Across deep evolutionary time, species are selected as they track changing environments, transforming one into another.

The process is prolific but not fine-tuned in rather strong contrast to what physicists have been saying with their "anthropic principle." To the contrary, evolutionary history can seem make-shift and blundering at the same time that, within structural constraints and mutations available, it optimizes adapted fit. Natural selection is thought to be blind, both in the genetic variations bubbling up without regard to the needs of the organism, some few of which by chance are beneficial, and also in the evolutionary selective forces that select for survival without regard to advance. Frances Crick complains that biology is not "elegant." As organisms evolve through the interplay of chance and necessity, they become encrusted with solutions by which they cope, but which have no more overarching logic than the layout of the Manhattan subway system.[1] Stephen Jay Gould insists that the panda's thumb is evolutionary tinkering and that orchids are "jury-rigged."[2] Even Darwin, though he could find in some moods a

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[1]Francis Crick, *What Mad Pursuit* (New York: Basic Books, 1988), 6, 137-42.

[2]Stephen Jay Gould, *The Panda's Thumb* (New York: W. W. Norton, 1980), 20-21.

"grandeur in this view of life,"[3] in other moods complained that the process was "clumsy, wasteful, blundering, low, and horribly cruel."[4]

RANDOM NATURAL HISTORY?

Based on the textbook theory of natural selection, evolutionary biologists are quite divided about whether there is any progress in the evolutionary epic. The received theory says only that the better adapted survive, and (despite the use of the word "better") this adaptation leaves entirely open the question whether or not the survivors are better in any sense involving progressive worth. Later-coming grasses are not any better than earlier, now extinct ones; they are just different. Cockroaches and marine shellfish survive over long periods little changed from their ancestors. In other cases, surviving life forms have lost organs—eyes, legs, wings—and become parasites. In climates growing colder or drier, fewer species may live there later.

By one account, species are simply buffeted about by their changing environments. If the environment drifts through tectonic changes, climatic changes, continental drift, and so on, then neither can the life forms that inhabit such an environment have direction. Species just track drift—the species are as aimless as the geomorphic processes. The only form of progress that natural selection can promote is progress in capacity to survive, and that is an independent variable with regard to increasing complexity or increasing diversity. There are local trends (cushion plants in alpine environments; thick leaves in deserts; horns repeatedly evolving), but so far as natural selection theory predicts any long-term or bigscale outcomes, evolutionary history is a random walk.

Stephen Jay Gould is outspoken: "We are the accidental result of an unplanned process … the fragile result of an enormous concatenation of improbabilities, not the predictable product of any definite process."[5] "Natural selection is a theory of *local* adaptation to changing environments. It proposes no perfecting principles, no guarantee of general improvement."[6] Like a rotating kaleidoscope, there is change without development, steady turnover, but it is not really different from the astronomical panorama of the cycling planets and revolving galaxies. The system is without value heading. "Almost every interesting event of life's history falls into the realm of contingency."[7] Michael Ruse insists that "evolution is going nowhere—and rather slowly at that."[8] Although most paleontologists over'the last century have seen progress in evolutionary

[3]Charles Darwin, *The Origin of Species* (Baltimore: Penguin, 1968 [Original: 1859]), 459.

[4]Darwin, in a letter to Joseph Dalton Hooker: quoted in Gavin de Beer, *Reflections of a Darwinian* (London: Thomas Nelson and Sons, 1962), 43.

[5]Stephen Jay Gould, "Extemporaneous Comments on Evolutionary Hope and Realities," in *Darwin's Legacy, Nobel Conference XVIll,* ed. Charles L. Hamrum (San Francisco: Harper and Row, 1983), 95-103; citation on 101-102.

[6]Stephen Jay Gould, *Ever Since Darwin* (New York: W. W. Norton, 1977), 45.

[7]Stephen Jay Gould, *Wonderful Life: The Burgess Shale and the Nature of History* **(New York: W. W. Norton, 1989), 290.**

[8]Michael Ruse, *Taking Darwin Seriously* (Oxford: Basil Blackwell, 1986), 203.

history, this is "pseudo-science,"[9] an overlaying of European ideologies onto the fossil record.

John Maynard Smith says that "there is nothing in neo-Darwinism which enables us to predict a long-term increase in complexity." But he goes on to suspect that this is not because there is no such long-term increase, but because Darwinism is inadequate to explain it. We need "to put an arrow on evolutionary time" but get no help from evolutionary theory.

> It is in some sense true that evolution has led from the simple to the complex: procaryotes precede eucaryotes, single-celled precede many-celled organisms, taxes and kineses precede complex instinctive or learnt acts. I do not think that biology has at present anything very profound to say about this.[10]

INCREASING DIVERSITY AND COMPLEXITY

Evidently, and even if the theory is unenlightening about this, something is learned across evolutionary history: how to make more diverse and complex kinds. This may be true even if neo-Darwinism is incompetent to say much about how this happens. We do not think that there is any progress as the planets spin round the sun; or gases swirl around Jupiter. There is no progress on Earth with the passing of cold and warm fronts; they just come and go. Likewise with the rock cycle, orogenic uplift, erosion, and uplift again. But there is no natural selection there either—nothing is competing, nothing is surviving, nothing has adapted fit, and biology seems different. All those climatological and geomorphological agitations continue in the Pleistocene period more or less like they did in the Precambrian, but the life story is not the same all over again. Where once there were no species, now there are five to ten million. On average and environmental conditions permitting, the numbers of life forms start low and end high.

E. C. Pielou concludes: "Thus worldwide faunal diversification has increased since life first appeared in a somewhat stepwise fashion, through the development and exploitation of adaptations permitting a succession of new modes of life." Life appears in the seas, moves onto the land, then into the skies. Terrestrial communities developed from the Silurian onwards. On the whole, organic evolution has "the result that the present diversity of the world's plants and animals is (or was just before our species appeared) probably greater than it has ever been before."[11] Diversity increases.

So does complexity. The nonprogressive picture omits the genetic capacity to acquire, store, and transmit new information. All organisms start simple and some of them end up complex. Additionally to merely tracking drifting environments, the life process is drifting through an information search and locking onto discoveries. It is cybernetic or

[9]Michael Ruse, *Monad to Man: The Concept of Progress in Evolutionary Biology* (Cambridge: Harvard University Press, 1996), 526.

[10]John Maynard Smith, *On Evolution* (Edinburgh: University of Edinburgh Press, 1972), 89,98.

[11]E. C. Pielou, *Ecological Diversity* (New York: John Wiley and Sons, 1975), 149-50.

hereditary as geomorphic processes are not; there is no cumulation of information in the hydrologic, climatological, and orogenic cycles, but there is in the birth, life, death, and genetic cycles. Motoo Kimura estimates that the higher organisms have accumulated genetic information from the Cambrian to the present at an average rate of 0.29 bits per generation.[12] That is why biology is historical in ways impossible in physics or geophysics.

A diverse environment is heterogeneous, and species are favored that are multi-adaptable and not just well adapted to one homogeneous environment. Such adaptability requires complexity, capacities to search out better environments and migrate to them, and, once there, capacities to invade successfully, to prey on or resist predation by, or to find and share resources with, the different kinds of organisms that can live in both wet and dry, cold and hot, grassland and forested environments. Complexity helps in coping with the challenges and opportunities offered by diversity. Complexity helps in tracking changing environments. So diversity and complexity are not always independent variables.

Reptiles can cope in a broader spectrum of humidity conditions than can amphibians, mammals in a broader spectrum of temperature than can reptiles. Once there was no smelling, swimming, hiding, defending a territory, gambling, making mistakes, or outsmarting a competitor. Once there were no eggs hatching, no mothers nursing young. Once there was no instinct, no conditioned learning. Once there was no pleasure, no pain. But all these phenomena appear, gradually, but eventually without precedent if one looks farther along their developmental lines,

R. H. Whittaker finds, despite "island" and other local saturations and equilibria, that on continental scales and for most groups "increase of species diversity … is a self-augmenting evolutionary process without any evident limit." There is a natural tendency toward increased "species packing."[13] This is also called "bootstrapping in ecosystems," feed-forward loops that generate new niches that reinforce each other and open up new opportunities for species specialization.[14]

J. W. Valentine, after a long survey of evolutionary history, concludes for marine environments that both complexity and diversity increase through time. First, with regard to diversity: "A major Phanerozoic trend among the invertebrate biota of the world's shelf and epicontinental seas has been towards more and more numerous units at all levels of the ecological hierarchy.... The biosphere has become a splitter's paradise."[15] Complexity also increases:

> A sort of rnoving picture of the biological world with its selective processes that favor increasing fitness and that lead to "biological improvement" is

[12]Motoo Kimura, "Natural Selection as the Process of Accumulating Genetic Information in Adaptive Evolution," *Genetical Research* 2 (1961) 127-40.

[13]R. H. Whittaker, "Evolution and Measurement of Species Diversity," *Taxon* 21 (1972) 213-51; citation on 214.

[14]D. A. Perry *et al.*, "Bootstrapping in Ecosystems," *BioScience* 39 (1989) 230-37.

[15]James W. Valentine, "Patterns of Taxonomic and Ecological Structure of the Shelf Benthos During Phanerozoic Time," *Palaeontology* 12 (1969) 684-709; citation on 706.

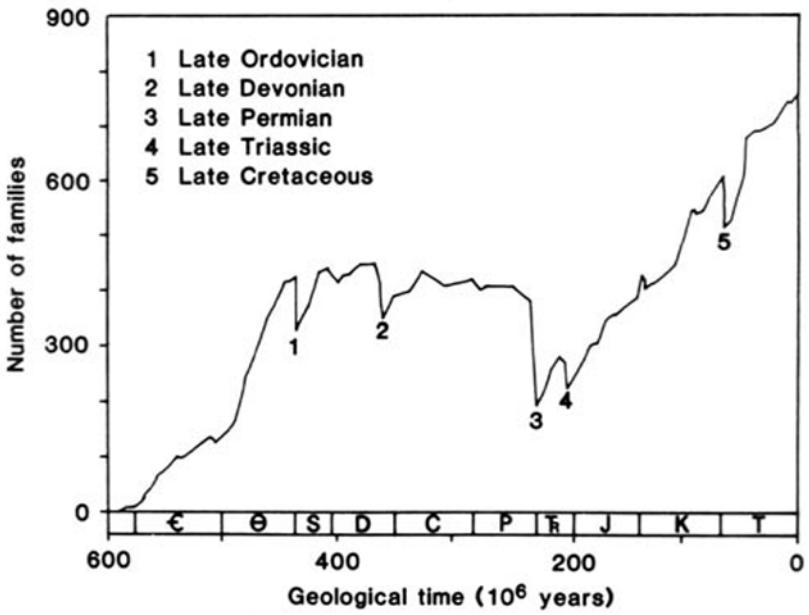

Fig. 1. Standing diversity through time for families of marine vertebrates and invertebrates, with catastrophic extinctions. Reprinted with permission from David M. Raup and J. John Sepkoski, Jr., "Mass Extinctions in the Marine Fossil Record," *Science* 215 (1982), 1502, fig. 2. Copyright 1982 American Association for the Advancement of Science.

> projected upon an environmental background that itself fluctuates.... The resulting ecological images expand and contract, but, when measured at some standardized configuration, have a gradually rising average complexity and exhibit a gradually expanding ecospace.[16]

David Raup and John Sepkoski graph a rise, again with climbs and drops, especially at times of catastrophic extinctions, from zero to perhaps 750 families (Fig. 1).[17] During the relatively flat part of the marine curve, one should notice, life moves onto the land and greatly diversifies there, from the Silurian Period onward. That requires also considerable evolution of complexity, since the terrestrial environment is more demanding. Plants develop steadily on the land masses, graphed by Karl Niklas (Fig. 2). For animals, it is in the vertebrates, most of all, that advance is difficult to deny (Fig.3).[18]

Norman D. Newell graphed the numbers of all families, terrestrial and marine, vertebrate and invertebrate, increasing through evolutionary time (Fig. 4).[19] Interestingly, Sean Nee and Robert M. May have found that

[16]James W. Valentine, *Evolutionary Paleoecology of the Marine Biosphere* (Englewood Cliffs: Prentice-Hall, 1973), 471.

[17]David M. Raup and J. John Sepkoski, Jr., "Mass Extinctions in the Marine Fossil Record," *Science* 215 (1982) 1501-1503.

[18]Karl J. Niklas, "Large-Scale Changes in Animal and Plant Terrestrial Communities" in D. M. Raup and D. Jablonski, eds., *Patterns and Processes in the History of Life* (New York: Springer-Verlag, 1986), 383-405. Karl J. Niklas, *The Evolutionary Biology of Plants* (Chicago: University of Chicago Press, 1997).

[19]Norman D. Newell, "Crises in the History of Life," *Scientific American* 208/2 (1963) 76-92.

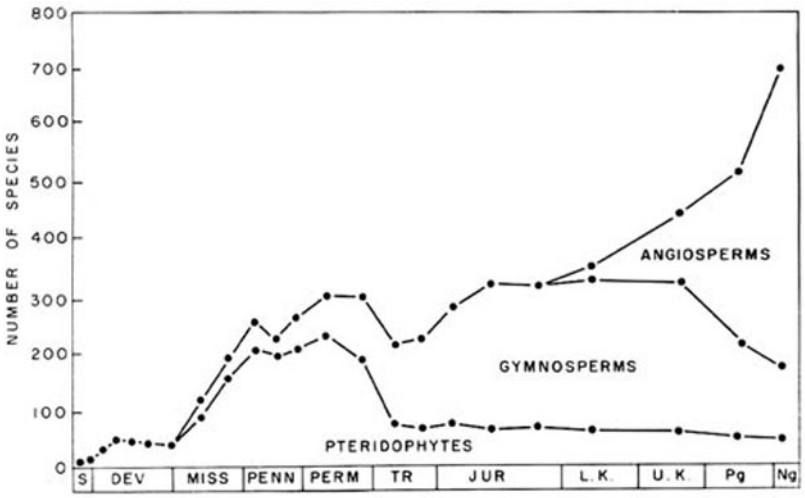

Fig. 2. Species diversity changes in vascular plants (Niklas). Used with permission of Springer-Verlag.

catastrophic extinctions little suppress these trends. Even in the most extreme cases, "approximately 80 percent of the tree of life can survive even when approximately 95 percent of species are lost." Mass extinction cuts off more the twigs of the tree of life (the species), so to speak, than the

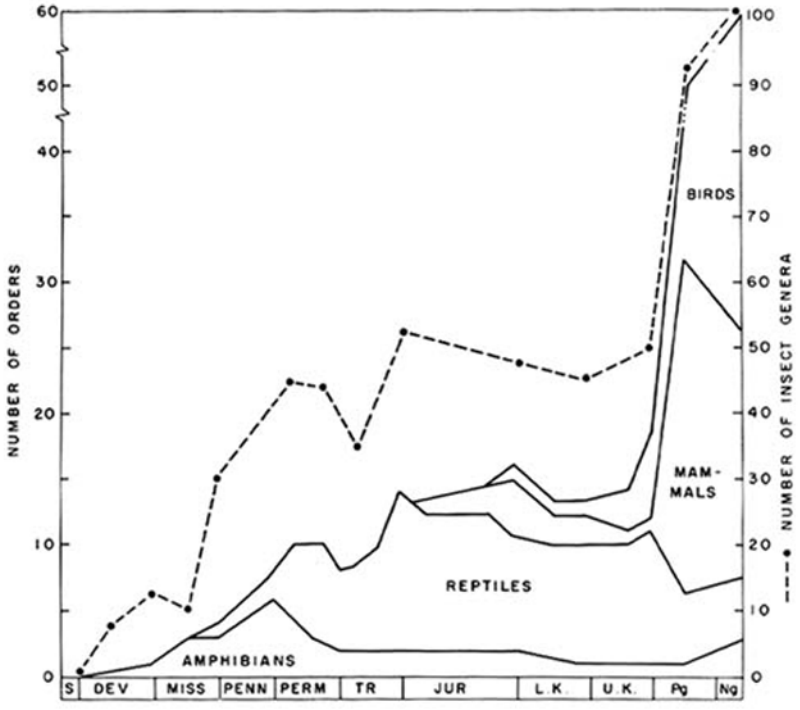

Fig. 3. Changes in the composition of vertebrate orders and numbers of insect genera (Niklas). Used with permission of Springer-Verlag.

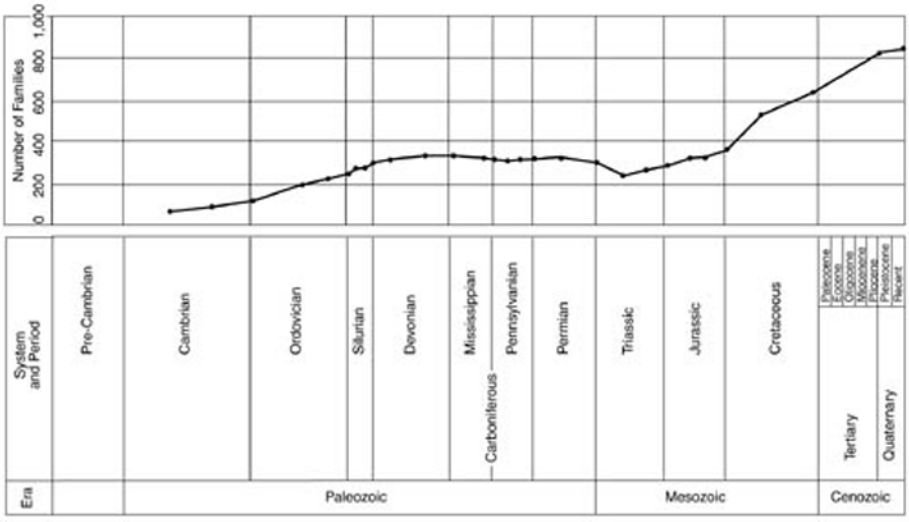

Fig. 4. Number of major families of fossil animals increasing through time (Newell). Used with permission.

main branches (the families, orders, classes), which persist in species that do survive. "Much of the tree of life may survive even vigorous pruning" (Fig. 5).[20]

A graph of increasing complexity is more difficult to produce. There is unlikely to be any single parameter measuring it that always increases over the course of natural history. Nor does complexity always coincide with advancement, because complexity is sometimes a disadvantage. The over-specialized frequently go extinct. Nevertheless, increases in neural networks with control centers (brains surpassing mere genetic and enzymatic control), increases in capacities for sentience (ears, eyes, noses, antennae), increases in capacities for locomotion (muscles, fins, legs, wings), increases in capacities for manipulation (arms, hands, opposable thumbs), increases in capacities for acquired learning (feedback loops, synapses, memory banks), and increases in capacities for communication and language acquisition—all these take increased complexity. Nothing seems more evident over the long ranges than that complexity has increased: In the Precambrian there were microbes; in the Cambrian Period, trilobites were the highest life form; the Pleistocene Period produced persons.

Ernst Mayr, though he realizes that many life forms do not progress and that "higher" is a troublesome word in biology, still asks:

> And yet, who can deny that overall there is an advance from the procaryotes that dominated the living world more than three billion years ago to the eucaryotes with their well organized nucleus and chromosomes as well as cytoplasmic organelles; from the single-celled eucaryotes to metaphytes and metazoans with a strict division of labor among their highly specialized organ systems; within the metazoans from ectotherms that are at the mercy of

[20]Sean Nee and Robert M. May, "Extinction and the Loss of Evolutionary History," *Science* 278 (1997) 692-94, Norman Myers, "Mass Extinction and Evolution," *Science* 278 (1997) 597-98.

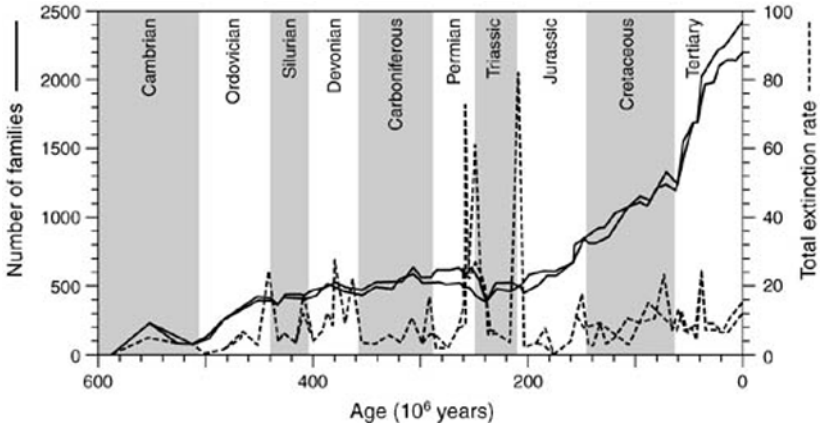

Fig. 5. Proliferation of numbers of families on Earth, continuing through major extinctions. Double lines graph maximum and minimum estimates. Reprinted with permission from Norman Myers, "Mass Extinction and Evolution," *Science* 278 (1997), 598. Copyright 1997 American Association for the Advancement of Science.

> climate to the warm-blooded endotherms, and within the endotherms from types with a small brain and low social organization to those with a very large central nervous system, highly developed parental care, and the capacity to transmit information from generation to generation?[21]

Is all this accidental to evolution? It would be a rather anomalous result if there had appeared novel kinds steadily over many millennia but only by drifting into them. The natural history suggests a creative genesis of life transmitted across a long-continuing turnover of kinds, shared across a long history of struggling toward more diverse and more complex forms of life. Trends, which are a *sine qua non* of historical interpretation, are never directly observable and may be difficult to detect in a limited span of time or range of observation. They show up statistically, but even statistics deal poorly with cognitively developing trends where there is information buildup with trial and error learning making critical discoveries, such as photosynthesis, neurons, or endoskeletons.

The lower forms remain too; there must be trophic pyramids, food chains. There cannot be higher forms all by themselves. They must be superimposed on lower forms, embedded in communities. So there can seem only change, not progress, if one looks at the monocots and dicots, the crustaceans and flatworms. There is no cause to disrespect these forms in the understories of life. But if we are to have the whole story of what is going on, we must look at the uppermost forms. These do seem to get built up over time.

True, much in evolutionary history can seem contingent if one considers only the fortunes of this or that lineage, which is typically the main focus of analysis. The history begins to look different, however, when one considers

[21]Ernst Mayr, *Toward a New Philosophy of Biology* (Cambridge: Harvard University Press, 1988), 251-52.

the evolution of skills, irrespective of what lineage they happen to be in. Assuming more or less the same earthbound environments, if evolutionary history were to occur all over again, things would be different. Still, there would again be plants and animals, photosynthesis or something like it, primary producers and secondary consumers, predators and prey, parasites and hosts, autotrophs and heterotrophs, ecosystemic communities, cells, membranes, reproducing, coding and coping, natural selection, sight, mobility with fins, limbs, wings, smell, hearing, convergence, and parallelism. Life would evolve in the sea, spread to the land, and then to the air.

Play the tape of history again. If played just once more, the differences would strike us first. Leigh Van Valen continues:

> Play the tape a few more times, though. We see similar melodic elements appearing in each, and the overall structure may be quite similar.... When we take a broader view, the role of contingency diminishes. Look at the tape as a whole. It resembles in some ways a symphony, although its orchestration is internal and caused largely by the interactions of many melodic strands.[22]

ACTUAL AND POSSIBLE NATURAL HISTORY

Earth is the planet with genetic natural history. There are no genes on the moon, nor Jupiter nor Mars, Even if there is life elsewhere, we do not expect to find trilobites, or dinosaurs, or tigers, or Neanderthals. We do not expect elsewhere these historically derived genes and their earthy products. They are more particular than universal, more story than law. Once upon a time on Earth, there was no biology, only geophysics and geochemistry, and these materials organized themselves into organisms. So the creativity is already latent in the precursor materials. But the story becomes memorable—able to employ a memory—only with genes (or comparable predecessor molecules). With genes, the story becomes cumulative and transmissible. If there is life elsewhere, one can expect levels of coding and coping, mutating and mating, and perhaps there too the best adapted survive. Wherever there is life, it will have to be defended somehow. But no biologist will predict ribosomes and Golgi apparatus in the Andromeda Galaxy, nor acetylcholine molecules and their transmembrane receptor channels.

Viewing this history, what can we say about how the possible becomes actual over evolutionary time? Here, one must increasingly pass from bioscience to metaphysics. There are eminent biologists—though they tend to be molecular biologists rather than paleontologists—who find this storied natural history to be inevitable, at least in outline, and therefore predictable. Christian de Duve, a Nobel laureate, concludes:

> Life was bound to arise under the prevailing conditions, and it will arise similarly wherever and whenever the same conditions obtain. There is hardly any room for 'lucky accidents' in the gradual, multistep process whereby life

[22]Leigh M. Van Valen, "How Far Does Contingency Rule?" *Evolutionary Theory* 10 (1991)47-52.

> originated.… I view this universe [as]... made in such a way as to generate life and mind, bound to give birth to thinking beings.[23]

'This universe breeds life inevitably," states George Wald, also a Nobel laureate.[24] Life is an accident waiting to happen because it is blueprinted into the chemicals, rather like sodium and chlorine are preset to form salt. When the predecessors of DNA and RNA appear, they are conserved, writes Melvin Calvin, still another Nobel laureate, "not by accident but because of the peculiar chemistries of the various bases and amino acids.... There is a kind of selectivity intrinsic in the structures." The evolution of life, so far from being random, is "a logical consequence" of natural chemistries.[25] After a long study of the possibility of the evolution of biological molecules capable of self-organization, Manfred Eigen, again a Nobel laureate, concludes "that the evolution of life ... must be considered an *inevitable* process despite its indeterminate course."[26]

Such accounts suggest that the possibilities are always there—but such possibilities are seen only retrospectively. If, though impossible, some scientist had under observation the elementary particles forming after the first three minutes, nothing much in them suggests anything specific about

"On Earth, there really is not anything in rocks that suggests the possibility of Homo sapiens, much less the American Civil War or the World Wide Web, and to say that all these possibilities are lurking there is simply to let possibilities float in from nowhere."

the coding for life that would take place fifteen billion years later on Earth—even though scientists, later, when they do arrive, posit an anthropic principle that finds the materials right for life.

After Earth forms, and the lifeless planet is being irradiated by solar energy, as are other planets as well, quantum physics depicts an open system and nested sets of possibilities; but all the atoms and molecules taking nonliving tracks. Only later, do some atoms and molecules begin to take living tracks, called forth as interaction phenomena when cybernetic organisms appear. If there is some "inside order" to matter that makes it prolife, it is in the whole system and not just in the particles. But this is not

[23]Christian de Duve, *Vital Dust: The Origin and Evolution of Life on Earth* (New York: Basic Books, 1995), xv, xviii.

[24]George Wald, "Fitness in the Universe: Choices and Necessities," in J. Oró *et al*, eds., *Cosmochemical Evolution and the Origins of Life* (Dordrecht, Netherlands: D. Reidel, 1974), 7-27; citation on 9.

[25]Melvin Calvin, "Chemical Evolution," *American Scientist* 63 (1975) 169-77; citations on 176,169.

[26]Manfred Eigen, "Selforganization of Matter and the Evolution of Biological Macromolecules," *Die Naturwissenschaften* 58 (1971) 465-523; citation on 519.

evident in the systemic astronomy, since far the vastest parts of the universe are lifeless. Life is an earthbound probability. Nor, on Earth, are the meteorological or geomorphological systems all that suggestive of inevitable life. Biology seems to open up entirely unprecedented levels of achievement and power.

There really is not much in the physics and chemistry of atoms and molecules, prior to their biological assembling, that suggests that they have any tendencies to order themselves up to life. Even after things have developed as far as the building blocks of life, there is nothing in a "thin hot soup" of disconnected amino acids to predict that they will connect themselves or be selected along upward, negentropic though metastable courses into proteins, nor that they will arrange for DNA molecules in which to code the diverse forms of life.

All these events may come naturally, but they are still quite a surprise. Laws are important in natural systems, whether extraterrestrial or terrestrial. But natural law is not the complete explanatory category for nature, any more than is randomness and chance. In nature, especially on this historical Earth, there is creativity by which more comes out of less. Science does not handle historical explanations very competently, especially where there are emergent novelties; science prefers lawlike explanations. One predicts, and the prediction comes true. If such precision is impossible, science prefers statistical predictions, probabilities. One predicts and, probably, the prediction comes true. Biology, meanwhile, though prediction is often possible, is also full of unpredictable surprises—like calcium endoskeletons in vertebrates after millennia of diatomaceous silica and chitinous arthopod exoskeletons. A main turning point in the history of life fused once-independent organisms as the cell and its mitochondria, which became the powerhouses for life. Another critical symbiosis brought free-living chloroplasts into the plant cell, again producing the energy vital for all life.

A biological account of such natural history will not be by way of implication, whether deductive or inductive. There is no covering law (such as natural selection), plus initial conditions (such as trilobites), from which one can deduce primates, any more than one can assume microbes as a premise and deduce trilobites in conclusion. Nor is there any induction (expecting the future to be like the past) by which one can expect, even probably, trilobites later from procaryotes earlier, or dinosaurs still later by extrapolating along a regression line (a progression line!) drawn from procaryotes to trilobites. There are no humans invisibly present (as an acorn secretly contains an oak) in the primitive eucaryotes ready to unfold in a lawlike or programmatic way.

Making this survey, can we insist that the probabilities must always have been there, or at least the possibilities, since what actually did manage to happen must always have been either probably probable or, minimally, improbably possible all along? Push this to extremes, as one must do, if one claims that all the possibilities are always there, latent in the dust, latent in the quarks. Such a claim becomes pretty much an act of speculative faith,

not in actualities, since one knows that these events took place, but in probabilities or possibilities being omnipresent. Is the claim some kind of induction or deduction or the most plausible case conclusion from present actualities?

On Earth, there really is not anything in rocks that suggests the possibility of *Homo sapiens*, much less the American Civil War or the World Wide Web, and to say that all these possibilities are lurking there is simply to let possibilities float in from nowhere.[27] Unbounded possibilities that are posited *ad hoc* to whatever one finds has in fact taken place—possibilities of any kind and amount desired in one's metaphysical enthusiasm—can hardly be said to be a scientific hypothesis, or even a faith claim with sufficient warrant.

But—the reply comes—since all those things did come in subsequent evolutionary and cultural history, their possibilities must have been there all along. Thomas R. Cech, a molecular biologist and another Nobel laureate, reviews the origin of life as follows:

> If intrinsic to these small organic molecules is their propensity to self-assemble, leading to a series of events that cause life forms to originate, that is perhaps the highest form of creation that one could imagine.… At least from the perspective of a biologist, I have given an account of how possibilities did, in times past, become actual. When this happened, life originated with impressive creativity, and it does not seem to me that possibilities floated in from nowhere; they were already present, intrinsic to the chemical materials.[28]

Why not rather suppose that, on the adaptive landscapes in which organisms struggle to increase their fitness for survival, there are changing possibility spaces coming in through evolutionary history? If a ground squirrel is faced with a prey that digs it put of its holes, it can learn to dig faster or to locate its burrows under rocks. Perhaps it can evolve an unpleasant taste. But it cannot grow wings and fly off to another continent, or build rifles and bullets to shoot its predator. That is not in its possibility space. Evolving into *Homo sapiens* may be in the possibility space of *Homo habilis*, but it is not in the possibility space of trilobites (or whatever the remote ancestor in that epoch).

It is not so clear that the creatures in their self-actualizing have or generate all by themselves all these other kinds of selves into which they are transformed. There is enormously more out of less and enormous space for the introduction of novelties that do not seem "up to" the faculties of the organism. One can say, if one likes, that a dinosaur is lurking in the possibility space of a microbe. But that really is not a claim based on anything we know about the biology or ontology of microbes.

Self-creating is more of a holistic, systemic affair; it is what happens to microbes when they are challenged in their habitats and after a very long

[27] Against the caution of Alfred North Whitehead, *Process and Reality: Corrected Edition* (New York: Free Press, 1978), 46.

[28] Thomas R. Cech, "The Origin of Life and the Value of Life," in *Biology, Ethics, and the Origins of Life*, Holmes Rolston, III, ed. (Boston: Jones and Bartlett Publishers, 1995), 15-37; citation on 33.

time. This requires the creation of new possibility spaces. From a God's eye view, perhaps the possibilities are always there, but we humans have no such viewpoint.[29] Looking at a pool of amino acids and seeing dinosaurs or *Homo sapiens* in them is something like looking at a pile of alphabetical letters and seeing *Hamlet.* In fact, *Hamlet* is not lurking around a pile of A-Z's; such a play is not within their possibility space—not until Shakespeare comes around. In Shakespeare plus a pile of letters, *Hamlet* does lurk.

It hardly seems coherent to hold that nonbiological materials are randomly the more and more derandomized across long structural sequences and thus ordered up to life. Something is introducing the order; and, further, something seems to be introducing, layer by layer, new possibilities of order, not just unfolding the latent order already there. Surely the possibility space of serious alternatives does enlarge and shrink. There are times of opportunity, in which taking one direction opens up new possibilities, and taking another shuts them out. Along the way, new design space is brought into the picture, and this is linked with the appearance of new information, to which I turn now.

INFORMED NATURAL HISTORY

If the DNA in the human body were uncoiled and stretched out end to end, that slender thread would reach to the sun and back over a half a dozen times.[30] That conveys some idea of the astronomical amount of information that is soaked through the body. In nature, there were once two metaphysical fundamentals: matter and energy. The physicists reduced these two to one: matter-energy; the biologists shortly afterward discovered that there were still two metaphysical fundamentals: matter-energy and information. Norbert Wiener insists: "Information is information, not matter or energy."[31] George C. Williams is explicit: "Evolutionary biologists have failed to realize that they work with two more or less incommensurable domains: that of information and that of matter.... The gene is a package of information."[32] John Maynard Smith says: "Heredity is about the transmission, not of matter or energy, but of information."[33] The most spectacular thing about planet Earth, says Richard Dawkins, is this "information explosion," even more remarkable than a supernova among the stars.[34] Klaus Dose, after more than thirty years of experimentation on the

[29]"My frame was not hidden from thee, when I was being made in secret, intricately wrought in the depths of the earth. Thy eyes beheld my unformed substance." (Psalm 139: 15-16).

[30]Estimated from data in J. M. Orten and O. W. Neuhaus, *Human Biochemistry,* 10th ed. (St. Louis: C. V. Mosby, 1982), 8,154.

[31]Norbert Wiener, *Cybernetics* (New York: John Wiley, 1948), 155.

[32]Interviewed in John Brockman, *The Third Culture: Beyond the Scientific Revolution* (New York: Simon and Schuster, 1995), 43.

[33]John Maynard Smith, "Life at the Edge of Chaos?" *New York Review of Books* 42/4 (1995)28.

[34]Richard Dawkins, *River out of Eden: A Darwinian View of Life* (New York: Basic Books, 1995), 145.

origins of life, adds that we have only "a better perception of the immensity of the problem rather than its solution. … We do not actually know where the genetic information of all living cells originates."[35]

When sodium and chlorine are brought together under suitable circumstances anywhere in the universe, the result will be salt—sodium chloride. There is no information input needed. When nitrogen, carbon, and hydrogen are brought together under suitable circumstances anywhere in the universe, with energy input, the spontaneous result may be amino acids, but it is not hemoglobin molecules or lemurs—not spontaneously. The know-how, so to speak, to make salt is already in the sodium and chlorine, but the know-how to make hemoglobin molecules and lemurs is not secretly coded in the carbon, hydrogen, and nitrogen. The essential characteristic of a biological molecule, contrasted with a merely physicochemical molecule, is that it contains vital information. All such information once upon a time did not exist, but came into place; this is the locus of creativity.

The central dogma of molecular biology is that random variations are introduced into the replication of this information, that rarely do such variations prove beneficial in the sense that they improve coping with the result that more offspring are produced, and that such variations increase proportionately in the gene pool. The classical view emphasizes that such variations occur at random and without regard to the needs of the organisms. Contemporary genetics is increasingly inclined to interpret this process as a kind of information search using random variations in problem solving and to see the search space as more constrained by the prior achievements of the organism. In a study of whether species as historical lines using various genetic strategies to solve problems can be considered "intelligent," Jonathan Schull concludes:

> Plant and animal species are information-processing entities of such complexity, integration, and adaptive competence that it may be scientifically fruitful to consider them intelligent __ Their adaptive achievements (the brilliant design and exquisite production of biological organisms) are no less impressive, and certainly rival those of the animal and electronic systems to which the term "intelligence" is routinely (and perhaps validly) applied today.[36]

Nevertheless the random element remains prominent. Here is where possibilities lie and where actual novelties are generated out of such possibilities.

John Maynard Smith and Eors Szathmáry have analyzed "the major transitions in evolution" with the resulting complexity, asking "how and why this complexity has increased in the course of evolution. … Our thesis is that the increase has depended on a small number of major transitions in the way in which genetic information is transmitted between

[35]Klaus Dose, "The Origin of Life: More Questions Than Answers," *Interdisciplinary Science Reviews* 13 (1988) 348-56; citation on 348.

[36]Jonathan Schull, "Are Species Intelligent?" *Behavioral and Brain Sciences* 13 (1990) 63-75; citation on 63.

generations." Critical innovations have included the origin of the genetic code itself, the origin of eukaryotes from procaryotes, meiotic sex, multicellular life, animal societies, and language, especially human language. But they find "no reason to regard the unique transitions as the inevitable result of some general law"; to the contrary, these events might not have happened at all.[37]

So what makes the critical difference in evolutionary history is increase in the information possibility space, which is not something inherent in the precursor materials, nor in the evolutionary system, nor something for which biology has an evident explanation, although these events, when they happen, are retrospectively interpretable in biological categories. The biological explanation is modestly incomplete, recognizing the importance of the genesis of new information channels.

The philosophical, metaphysical, and theological challenge left over after the current scientific accounts is the question: What is the most adequate account of the origin of this genetic information? In the course of evolutionary history, one would be disturbed to find matter or energy spontaneously created, but here is information floating in from nowhere. For the lack of better explanations, the usual turn here is simply to conclude that nature is self-organizing (autopoiesis). An autopoietic process can be just a name, like "soporific" tendencies, used to label the mysterious genesis of more out of less, a seemingly scientific name that is really a sort of mystical chant over a miraculous universe. Perhaps a more plausible explanation is that, complementing the self-organizing, there is a Ground of Information, a.k.a. God.

THE DIVINE PRESENCE

The world existed for ten or fifteen billion years without any biological information present. The divine presence in that epoch will need to be found in the set-up, in the fine-tuned universe. This will be both at the start-up and all along the way—in, with, and under the physics, astrophysics, and chemistry. Even there, it is difficult to get clear on the mixture of necessity and contingency in such a universe. One way or another, God is the Ground of Being. Such divine presence continues during the biological epoch on Earth.

But the creativity to be explained on Earth is especially that which generates the information vital to life. Again, one can appeal to the set-up. The interplay of matter and energy, in our corner of the universe, accumulated into a solar system with one lucky planet. Earth is a kind of providing ground for life, a planet with promise. Located at a felicitous distance from the sun, Earth has liquid water, atmosphere, a suitable mix of elements, compounds, minerals, and an ample supply of energy. Radioactivity deep within the Earth produces enough heat to keep its crust constantly mobile in counteraction with erosional forces, and the interplay of such forces

[37]John Maynard Smith and Eors Szathmáry, *The Major Transitions in Evolution* (New York: W. H. Freeman, 1995), 3.

generates and regenerates landscapes and seas—mountains, canyons, rivers, plains, islands, volcanoes, estuaries, continental shelves. The Earth-system is a kind of cooking pot sufficient to make life probable, even inevitable.

God is somehow behind that set-up. God created Earth as the home (the ecosystem) that could produce all those myriads of kinds. "Let the earth bring forth living creatures according to their kinds" (Gen. 1:24). The system does prove to be pro-life; the story goes from zero to five million species in five billion years, passing through perhaps another five billion species that have come and gone *en route.* If, once, there was a primitive planetary environment in which the formation of living things had a high probability, for such living things to become actual would not so much require interference by a supernatural agency as the recognition of a marvelous endowment of matter with a propensity toward life. Such a natural performance could be congenially seen, at a deeper level, as the divine creativity.

But we still have to give an account of the information appearing "ex nihilo," that is, where no such information was present before. One may need indeed an endowment of matter with a life propensity (helped perhaps by the anthropic principle in astrophysics) and at the same time still need something to superintend the possibilities during evolutionary history. Complementary explanations do not always mean that one is superfluous. Here one can posit God as a countercurrent to entropy, a sort of biogravity that lures life upward. God would not do anything in particular, but be the background, autopoietic force energizing all the particulars. The particulars would be the discoveries of the autonomous individuals. God would be the lift-up (more than the set-up) that provokes the creatures along their paths of cybernetic and storied achievement. God introduces new possibility spaces all along the way. What theologians once termed an established order of creation is rather an order that dynamically creates, an order for creating.

Returning to the metaphor of the alphabet and Shakespeare, the question is whether, in the introduction of these possibilities, one needs an author as well as an alphabet. Perhaps the alphabet-author analogy is flawed. That analogy places all the creativity in the author working with an inert alphabet. One needs rather to posit a self-organizing alphabet, and a maker only to start up such a self-organizing alphabet. Here too, the skeptic will say, there is no need for an author at all. One can have law without lawgivers, history without historians, creativity without creators, and stories without story-tellers. Change the analogy: The elements are more like "seeds" than "letters." The root meaning of "nature" is "generating," and nature has all these possibilities "seeded" into it.

The problem with such a model is that we now know what is in seeds as the secret of their possibilities: information; and there is no such information inside amino acids, much less hydrogen and carbon atoms, much less electrons and protons. The creation of matter, energy, law, history, stories, of all the information that generates nature, to say nothing of culture, needs

an adequate explanation; some sources, source, or Source competent for such creativity. Seeds need a source. In the materializing of the quantum states, in the compositions of prebiotic molecules, in the genetic mutations, there are selective principles at work as well as stabilities and regularities that order the story and perpetuate a swelling wave over the elementary particles.

This portrays a loose teleology, a soft concept of creation, and yet one that permits genuine, though not ultimate, integrity and autonomy in the creatures. What comes to pass wells up from below, congealing out of the quantum states. Perhaps already in physics and chemistry, higher levels can come to superintend the lower, but this becomes still more evident in biology. Microphysics, though it knows neither coding nor coping, gives space for the more informed biological phenomena. An organism can coagulate microscopic affairs this way and not that way, in accord with its cellular and genetic programs. The organism is fine-tuned at the molecular level to nurse its way through the quantum states by electron transport, proton pumping, selective ion permeability, DNA encoding, and the like. The organism constitutes the course of the microevents that result in an informed flowing through the world. The information within the organism

"We must detect God in the improbabilities as well as in the probabilities, for it is in the mixture of the two that the epic of natural history is told."

enables it to act as a preference sieve, by interaction sometimes causing quantum events, sometimes catching individual chance events that serve its program.

But what is true of the individual organism can likewise be believed of the generating evolutionary process overall in which such individuals are caught up. We have in the life adventure an interaction phenomenon, where a pro-life principle is overseeing the affairs of matter. The divine spirit is the giver of life, pervasively present over the millennia.

God could also be in the details. That might be difficult to know, especially if God operated with the resolve to maximize the creaturely autonomy and integrity, to prompt rather than to command. Still, God could be slipping information into the world. That will not be detectable as any gap in or perforation of the natural order; it might be detectable in the resulting genesis or creativity. If the roulette wheels at Las Vegas spin at random most of the time, but once a year God loaded the dice, that would be difficult to know. Chance is an effective mask for the divine action. One might suspect such divine presence if the resulting story, in the lotteries of natural history, produced the epic adventures that have in fact actually managed to happen.

It will be said that to look for God in the particulars of information discovery is a mistake. God does not intervene as a causal force in the world; if so, science could detect such a cause. God perennially underlies the causal forces in the world, and God gives meaning to the world, which science is incompetent to detect. Information, however, is not a mere cause, not in any physicochemical sense; but a cause that puts meanings into events.

There once was a causal chain that led to vertebrae in animals, where there were none before, an incremental chain no doubt, but still a chain by which the novelty of the vertebral chord was introduced on Earth. But such a chain is only constructed with the emergence of more and more information; this information, coded in DNA, informs the matter and energy so as to build the vertebral chord. The chord is constructed because it has a value (a significance, here a precursor of meaning) to the organism. It makes possible the species of life that the vertebrate animal defends. Continuing the development of the endoskeleton, it makes possible larger animals with mobility, flexibility, integrated neural control. The causal events are informed by values, which have their significances to the fauna and flora whose vitalities are thereby maintained. When such construction of valuable biodiversity has gone on for millennia, the epic suggests mysterious powers that signal the divine presence.

The contingencies bring in innovations, and now it is not just averages but new possibilities, not there before, which make a critical difference. For a good story, God the Narrator beyond God the Statistician, we need critical control at turning points. It is not merely statistical averages that make history; it is critical surprises, anomalous turns, new beginnings. Narratives do not fit regression curves; regression curves (as every statistician knows) cannot be extrapolated very far through history. Large historical outcomes can turn on thresholds at initiating points. We must detect God in the improbabilities as well as in the probabilities, for it is in the mixture of the two that the epic of natural history is told,

One should posit, says Daniel Dennett, "cranes" not "skyhooks" for the building up of evolutionary history.[38] That contrast of metaphor seems initially persuasive, appealing to causes more natural than supernatural, more immanent than transcendent. When we pinpoint the issue, however (namely, what account to give of this remarkable negentropic, cybernetic self-organizing that characterizes the life story on Earth), the metaphor becomes more pejoratively rhetorical than analytically penetrating. There is the repeated discovery of information how to redirect the downhill flow of energy upward for the construction of ever more advanced forms of life, built on and supported by the lower forms. Up and down are rather local conditions (down or up a few miles); it does not matter much which direction we imagine this help as coming from—east or west, from the right or left, below or from above, high or deep, immanence or transcen-

[38]DanieJ C. Dennett, *Darwin's Dangerous Idea* (New York: Simon and Schuster, 1995), 73-80.

dence, skyhooks or cranes. The Hebrew metaphor was that one needs "wind" as well as "dirt." The current metaphor is that one needs "information" as well as "matter" and "energy."

Stripped of the rhetoric, what the "skyhook" metaphor means, Dennett says, is explanations that are more "mind-like" whereas the "crane" metaphor posits "mindless, motiveless mechanicity." Dennett holds that Darwinian science, extrapolated philosophically, has discovered cranes upon cranes "all the way down" building up and up with "creative genius." "There is simply no denying the breathtaking brilliance of the designs to be found in nature."[39] But if the secret of such creativity is information possibilities opening up and information searched and gained, then the kind of explanation needed can as plausibly be said to be mind-like as mindless mechanicity. One might look to the potential deep in matter, "cranes all the way down." One can just as well look to some destiny toward which such matter is animated and inspired (skyhooks). Even after an infinite regress of cranes, or a regress ending in nothing at all, or in informationless matter-energy, or in a big bang, one might not find that explanations are over. The issue is where the information comes from by which matter and energy become steadily so informed that there is, across evolutionary history, this river of life that flows uphill, this brilliant output from a beginning in mindless chaos, how "out of next to nothing the world we know and love created itself."[40]

Does one then need God to do biology? No, cranes will do. The only forces that biology is competent to detect are natural ones. But when the cranes rise skyward over the millennia, and when biologists are in dispute about whether this is random, or inevitable, or partly both, or worry that they have "nothing profound to say" (Maynard Smith), and yet are left in awe over the genetic creativity that "resembles a symphony" (Van Valen), one may need to philosophize over biology, and the questions may not be over until the God-question has been faced. Since the information is not really there at all, but is more like a possibility floating in from nowhere, the "skyhook" is a rough and ready metaphor, hardly better than cranes—but it does get at the novelty.

Anyone who takes the divine inspiration seriously will have to posit occasions—seasons, contexts, events, episodes, whatever they are called—during which God provides information in the world, breakthroughs, as it were, incremental and cumulative though these can also be—by some inspiration that first animates matter and energy into life, or launches replication and genetic coding, or eucaryotes, or multicellular life, or sexuality, or energizes life with mitochondria and chloroplasts, or glycolysis and the Krebs cycle, or moves life onto land, or invents animal societies, or acquired learning, or endows life with mind, and inspires culture, ethics, religion, science.

[39]Ibid., 76,155,74.

[40]Ibid., 185.

Dennett is also impressed with how remarkably good a job evolution does of "designing" organisms:

> To me the most fascinating property of the process of evolution is its uncanny capacity to mirror *some* properties of the human mind (the intelligent Artificer) while being bereft of others. While it can never be stressed enough that natural selection operates with no foresight and no purpose, we should not lose sight of the fact that the process of natural selection has proven itself to be exquisitely sensitive to rationales, making myriads of discriminating "choices" and "recognizing" and "appreciating" many subtle relationships.[41]

Dennett holds, of course, that monotheists can find no comfort in this. He supposes a vast set of invisible but presumably "stupid" moves to account for an unbroken string of "exquisite" triumphs. He needs an enormous "impossibility space," so to speak, trials that do not become actual, or stay actual, to get what we actually have.

Would it not be better for Dennett to draw, even from his own premises, a more agnostic conclusion—that he does not know whether there is an invisible hand shaping possibility spaces, supporting the information searching, even supplying information here and there, amidst the "uncanny" processes of natural selection? And if one adds not so much the desire of a Creator to conceal such complementing selective activity as to optimize the integrity, autonomy, and self-creativity of the creatures—letting them do their thing, using trial and error, generating and testing, discarding what does not work and keeping what does—with divine coaching on occasion, then a conclusion that there is a divine presence underneath natural history becomes as plausible as that there is not. The question becomes not so much a matter of conclusive proof as of warranted faith. Biologists cannot deny this creativity; indeed, better than anyone else biologists know that Earth has exuberantly brought forth natural kinds over the millennia. The molecular self-assembling is certainly a self-actualizing of living organisms, but it is surely also a response to the brooding winds of the Spirit moving over the face of these earthen waters.

[41]Daniel C. Dennett, *The Intentional Stance* (Cambridge: MIT, 1987), 299.