Peter H. Van Ness, ed., *Spirituality and the Secular Quest* (New York: Crossroad Publishing Co., 1996), pp. 387-413. Volume 22 of *World Spirituality: An Encyclopedia History of the Religious Quest.*

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Scientific Inquiry

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SURVEYING EVOLUTIONARY NATURAL HISTORY, Loren Eiseley, a paleontologist and anthropologist, concluded: "I would say that if 'dead' matter has reared up this curious landscape of fiddling crickets, song sparrows, and wondering men, it must be plain even to the most devoted materialist that the matter of which he speaks contains amazing, if not dreadful, powers, and may not impossibly be… but one mask of many worn by the Great Face behind."[1] The "secular" is the present epoch, this age (sometimes rather puzzlingly contrasted with the "sacred" as though anything sacred must be of some other, supernatural realm, not of this present world). Science is our most recent and sophisticated discipline for studying this secular, empirical world. Some claim that science chases out the holy, but this is proving to be a superficial impression.

Science studies the phenomena, the metaphysicians say; and scientists may agree. What of the noumena, the ultimates that underlie the phenomena, that the metaphysicians, theologians included, desire to make known? To that science has no access, and even the metaphysicians have become increasingly wary about ultimate claims, increasingly sensitive to how all our knowledge is relative to our earthbound circumstances in space and time, theory-laden and culture-bound. Absolutes are out of vogue. Meanwhile, though, what if the phenomena prove increasingly phenomenal? What if the secular world proves to be pretty spectacular stuff? What if we lose our confidence in the supernatural, only to find it replaced by increasing confidence that nature is super, superb, mysteriously animated, and inspirited? We might say that nature has actualized its potential. The molecular self-assembling that issues in evolutionary natural history is a sort of self-actualizing. Is it, though, a complete explanation of these phenomena to find that they are natural, until we have asked whether nature is its own self-sufficient explanation? If not, we may find ourselves asking again, as did Eiseley, whether the phenomena of natural history are a response to the brooding winds of the Spirit moving over the face of these earthen waters. The phenomena could be revealing the noumena.

The secular world, this present, empirical scene, may not be miraculous, but what if it is marvelous? What if it is full of events that make us wonder? Then we have two phenomena to be explained: first, the nature that is full of wonder and, second, the wondering persons, these spirits that have resulted from, and now behold, this wonder-full nature. The forces that animate such nature are the subject of scientific study; the persons who do this are scientists, but they have themselves on their hands as animated spirits. They puzzle over what they find, wondering who they are as they find where they are, and this becomes a quest of the spirit, forced by the character of the secular world they engage. They may, or may not, set the classical religions aside; cither way the secular quest makes its own demands on spirituality, demands for spirituality. We will wonder about that at levels that are astronomical, microphysical, biomolecular, evolutionary, and ecological.

Astronomical Spirituality

Even a secular science is driven toward cosmology; one wonders about the origins of the cosmos. Through most of our human intellectual history, these questions could only be speculative, metaphysical, but in our century that has changed. Physics has made dramatic discoveries at astronomical and submicroscopic ranges, remote from ordinary, native-range experience, and these are relevant to solving some cosmological questions. The universe (this universe at least) originated twenty billion years ago in a "big bang" and has since been expanding. From the primal burst of energy, elementary particles formed, and afterward hydrogen assembled, the simplest element, which serves as fuel for the stars. Later, in the stellar furnaces the heavier atoms were forged. Some stars subsequently exploded (supernovae). The heavier elements were collected to form, in our case, the solar system and planet Earth.

In the last twenty years physics has discovered that startling interrelationships are required for these creative processes to work. Recent theory interrelates the two levels; astronomical phenomena such as the formation of galaxies, stars, and planets depend critically on the microphysical phenomena. In turn, the midrange scales, where the known complexity mostly lies (in ecosystems or human brains), depend on the interacting microscopic and astronomical ranges. Physics cannot do experiments revising the universe, but it can do thought experiments to see whether another one would be more congenial. Such *if-then* experiments conclude that the universe is mysteriously right for producing life and mind.

If the scale of the universe were much reduced, there would not have been enough time for the various elements to form. If the expansion rate of the universe had been a little faster or slower, then the universe would already have recollapsed or the galaxies and stars would not have formed. No mechanism for life has ever been conceived that does not require elements produced by thermonuclear combustion. The stars are the furnaces in which all but the very lightest elements are forged, exploding as super-novae and dispersing this matter, subsequently regathercd to form planets and persons. Humans arc composed of fossil star dust! In this historical perspective, astronomical nature is the precondition of the rational self, of the spiritual self.

No universe can provide several billion years of stellar cooking time unless it is several billion light-years across. If we cut the size of the universe from 10^{22} to 10^{11} stars, then that much smaller but still galaxy-sized universe might first seem roomy enough, but it would run through its entire cycle of expansion and recontraction in about one year! If the matter of the universe were not so relatively homogeneous as it is, then large portions of the universe would be so dense that they would already have undergone gravitational collapse; other portions would be so thin that they could not give birth to galaxies and stars. On the other hand, if the matter of the universe were entirely homogeneous, then the chunks of matter that make development possible could not assemble.[2]

If the universe were not expanding, then it would be too hot to support life. If the expansion rate of the universe had been a little faster or slower, then connections would have shifted so that the universe would already have recollapsed or so that galaxies and stars could not have formed. The extent and age of the universe are not obviously an outlandish extravagance. Indeed, this may be the most economical universe in which life and mind, and embodied spirit, can exist — so far as we can cast that question into a testable form in physics. That makes understanding matter a spiritual quest.

Change slightly the strengths of any of the four forces that hold the world together (the strong nuclear force, the weak nuclear force, electromagnetism, gravitation — forces ranging over forty orders of magnitude), change critical particle masses and charges, and the stars would burn too quickly or too slowly, or atoms and molecules, including water, carbon, and oxygen, or amino acids (building blocks of life) would not form or remain stable. John D. Barrow and Joseph Silk, astrophysicists, calculate that "small changes in the electric charge of the electron would block any kind of chemistry."[3] A fractional difference, and there would have been nothing. It would be so easy to miss, for the universe to have evolved in ways incompatible with human life, and yet this universe is a delicate, intricate hit. "Somebody had to tune it very precisely," concludes Marek Demianski, a Polish cosmologist.[4]

How the various physical processes are "fine-tuned to such stunning accuracy is surely one of the great mysteries of cosmology," remarks P. C. W. Davies, a physicist. He adds:

> Had this exceedingly delicate tuning of values been even slightly upset, the subsequent structure of the universe would have been totally different.
>
> Extraordinary physical coincidences and apparently accidental cooperation... offer compelling evidence that something is "going on. ..."A hidden principle seems to be at work, organizing the universe in a coherent way,[5]

These results have been summarized as the "anthropic principle" (an unfortunately anthropocentric term), which argues that the universe has been "fine-tuned" from the start and in its fundamental construction for the subsequent construction of stars, planets, life, mind, and spirit. There are both theological/supernatural and nontheological/naturalistic ways of interpreting these discoveries, but either way we have a nature that is remarkable, phenomenal phenomena. One feature of these discussions is their calculations, their equations, their measurements. Cosmology is now as much mathematics as it is metaphysics, and many quantitative calculations support these arguments about the origin of the universe and about its fine-tuned construction.

Astrophysicists and microphysicists have joined to discover that, in the explosion that produced our universe, what seem to be widely varied facts really cannot vary widely; indeed, many of them can hardly vary at all and still have the universe develop life, mind, and our wondering spirits. We find a single blast (the big bang) fine-tuned to produce a world that produces us, when any of a thousand other imaginable blasts would have yielded nothing. Considering the first seconds of the big bang, Bernard Lovell, an astronomer, writes:

> It is an astonishing reflection that at this critical early moment in the history of the universe, all of the hydrogen would have turned into helium if the force of attraction between protons — that is, the nuclei of the hydrogen atoms — had been only a few percent stronger. ... No galaxies, no stars, no life would have emerged. It would have been a universe forever unknowable by living creatures. A remarkable and intimate relationship between man, the fundamental constants of nature and

> the initial moments of space and time seems to be an inescapable condition of our existence.[6]

Lovell's astonishment, as he wonders about this universe in which he finds himself, is fundamentally, inescapably, a spiritual quest.

B. J. Carr and M. J. Rees, cosmologists, conclude:

> Many interrelations between different scales that at first sight seem surprising are straightforward consequences of simple physical arguments. But several aspects of our Universe — some of which seem to be prerequisites for the evolution of any form of life — depend rather delicately on apparent "coincidences" among the physical constants. … The Universe must be as big and diffuse as it is to last long enough to give rise to life.[7]

Fred Hoyle, an astronomer, reports that his atheism was shaken by his own discovery that, in the stars, carbon just manages to form and then just avoids complete conversion into oxygen. If one level had varied half a percent, life would have been impossible:

> Would you not say to yourself, ... "Some supercalculating intellect must have designed the properties of the carbon atom, otherwise the chance of my finding such an atom through the blind forces of nature would be utterly minuscule"? Of course you would. … The carbon atom is a fix.... A common sense interpretation of the facts suggests that a superintellect has monkeyed with the physics. … The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question.[1]

Stephen Hawking, the Einstein of the second half of our century, agrees: "The odds against a universe like ours coming out of something like the Big Bang are enormous. I think there are clearly religious implications."[9]

Mike Corwin, a physicist, concludes:

> This 20-billion-ycar journey seems at first glance tortuous and convoluted, and our very existence appears to be the merest happenstance. On closer examination, however, we will see that quite the opposite is true — intelligent life seems predestined from the very beginning. … Any significant change in the initial conditions would have ruled out the possibility of life evolving later. ... Yet here we are, alive and aware, in a universe with just the right ingredients for our existence.[10]

In this kind of universe, it is proving difficult to be alive and aware with out thinking that the universe is quite wonderful, without engaging it as a wondering spirit. Einstein, who launched so much of this in the first half of the century, had put it this way: "I maintain that cosmic religious feeling is the strongest and noblest incitement to scientific research. … You will hardly find one among the profounder sort of scientific minds without a peculiar religious feeling of his own."[1]

Sometimes we marvel that all these interconnections had to occur for the universe to turn out the way it did. Sometimes we marvel that it could have been otherwise but was not so. Sometimes it is not too clear whether these startling interconnections are necessary or contingent, and we do not know how developing theory will revise the necessities and contingencies of these connections. In the end it hardly matters. So far as these connections are improbable, we seem to need a guiding principle m ongoing superintendence; so far as they are necessary, the guiding principle seems to have been there from the start. We may not know whether to call this a guiding hand, a guiding spirit, or what, but something is going on that challenges our religious sensitivity. We seem to be detecting some astronomical bent toward creativity, even toward spirituality, because here we are, human spirits, alive and well in this universe that was fixed up for spirits. Freeman Dyson, an astronomer, expresses his surprise: "Nature has been kinder to us than we had any right to expect. As we look out into the universe and identify the many accidents of physics and astronomy that have worked together to our benefit, it almost seems as if the universe must in some sense have known that we were coming."[12]

Through it all we marvel how cosmology on the grandest scale and atomic theory on the minutest scale are not irrelevant to what is now taking place in human affairs, with even the further hint that there must be some great Cause adequate to this great effect. The point is not that the whole universe is necessary to produce Earth and *Homo sapiens*. That would be myopic pride; and this is an unfortunate suggestion in the term *anthropic principle*. The issue is richness of potential, not anthropocentrism. There is no need to insist that everything else in the universe has some relevance to our being here. Nature, or God, my have overdone the creation in pure exuberance, and why should the parts irrelevant to us trouble us?

These anthropic necessities and contingencies, by tandem turns on their repetitive upstrokes, integrate into a governing gestalt that detects Something, Someone, some force behind the scenes arranging for the show. The forms that matter and energy take seem strangely suited to their destiny.

Microphysical Spirituality

Already we are finding the microphysics remarkable, for it is coupled with the astrophysics we have just been describing. There is also a deeper dimension to this. We turn next to a mysterious openness, an indeterminacy in this microscopic nature, to nature's energetic possibility. We might almost call this its immateriality. It is difficult to say what makes up a microparticle. In the days of Newtonian physics, everything seemed to be matter in motion in space and time; but now, after Einstein and relativity theory, nature is more energetic process than substantial material. The particles are really microwave clouds that do not have precise position or momentum, before these are demanded by the observer or coagulated by some more comprehensive world events in which they come to participate.

The most fundamental notion of all is not matter or motion, space or time, but energetic and evolutionary process, not being but becoming. There are, absolutely, no things, no substances, but only events in a space-time something, not bodies that move in empty space over time, but a scries of moving changes with continuity, forming a relative rather than an absolute identity in an incurably successive world. Matter and motion, space and time, as well as size and shape, color and temperature, wave and particle, light and form — indeed, all the interpenetrating and mutable textures of things in life, mind, culture, history, all this phenomenal animation and spirited inventiveness — arc various dimensions of this process.

The most frequent account, based on general relativity, makes each cloudy wave a kind of wrinkle, bubble, or hill in an omnipresent trans-space-time field, which coagulates relative to each disturbance, to each entity. A particle is not some one substance; it is a concavity that travels in a sort of "plasma" rather as (to use a crude analogy) a dent travels over the surface of a partially deflated basketball. Matter is, so to speak, "freeze-dricd energy." In the Newtonian view, space and time provided a passive and empty container, there independently of any contents, regardless of the matter-in-motion within it. While in Einstein's view some kind of plenum remains, evidenced grossly as space-time, it is not passive but is the generator and carrier of all the particle play. Matter is a crinkle in the matrix, an energetic warp in the great plasma-ether. The phenomena come and go; the particles do their trips and identity flips, taking on the spatiotemporal aspects they yield to observers. Ultimately, there is only a kind of gauzy foam through which quantized pulses run.

There is certainly no ultimacy in the ultrastructures as now known. We have hit no rock bottom in physics and have few signs that we ever will or can, or would know when we had. We have only an ether from which events bubble up from below and take place at levels ranging from the microphysical to the astrophysical. Particles, waves, mattcr-in-motion, stars, planets, persons with their bodies, minds, spirits — all are warps in space-time; all rise up out of a mysterious energy pit. The nature we know has grown soft. Down below, there is something hazy that we can reach with our formulas but hardly imagine. There is a subsurface inaccessibility, plasticity, and mysteriousness that allow us more easily to be spiritual about this now than in the hard world of earlier physics. Each of the old themes of materialism — atomic matter in absolute motion, sensory and pictorial substance, total specifiability, mechanics, predictability, finished logical analysis — has an antithesis in recent physics.

It is hard to know what synthesis to make, but certainly a spiritual synthesis is not precluded. Nature is now less material, less absolutely spatiotemporal, more astounding, more open, an energetic, developmental process. John D. Barrow, a theoretical physicist, says that the principal result of recent physics is that "nature has revealed a deep, hidden flexibility, previously unsuspected."[13] If in one sense this nature is still secular, in another sense it is a suitable arena for the operation of a sacred, creative Spirit. The basic scientific motif in physics Is dynamism in power, and in nature, as viewed as process that moves from particles to persons, there is nothing inimical to a spiritual account.

C. W. Misner, a theoretical physicist, calls space-time an impressively creative kind of ether. "A vacuum so rich... in potentialities cannot properly be called a void; it is really an ether. The entire spacetime fabric. . . from beginning to end" is "a library of unused designs," which arc creatively "enacted into existence."[14] It is not until we leave physics and enter biology that we get an appreciation of what stories can be told with this library of motifs. The astrophysics and the microphysics, profound though they are, pale before the spectacular story of what from them is creatively enacted into existence. On Earth, life appears.

Physics at all its levels differs from biology at all its levels. In biology there is information coded with a know-how for the creation and defense of life. For the first fifteen billion years, there was energetic matter in the stars; for several billion years on Earth matter was churned about. The precursors to life were formed, amino acids, sugars, and the like, but these had no life-code as yet. Then one day, signals appear! Where once there was matter, energy, and where these remain, there is information, symbolically encoded, and life. There is a new state of matter, neither liquid nor gaseous nor solid, but vital. Something begins to catch the constructional upstrokes; there is the informed defense of a life program. That puts adventure, freedom, drama, and surprise into the storied evolutionary course. Matter begins to take on more spirited behavior.

Biomolecular Spirituality

The assembly is of materials, complexity out of simplicity, but there comes with it autonomous life out of dead matter, biofunction out of nonfunctional antecedents, and, with sufficient neural organization, subjectivity out of objectivity. Once there was a world with only matter and energy, but later there appeared within it information centers, and later still, incarnate subjects. Molecules, trillions of them, spin around in complicated ways and generate the unified, centrally focused experience of mind. There is already enough to wonder about when we realize that from a submicro-scopic plasma-ether all the creativity in the world is emitted, bubbling up from below; but there is a complementary picture. We discover a nature that is plastic enough for an organism to work its program on, for a mind to work its will on, a nature phenomenal enough to sponsor the joys and anxieties of incarnate spirits.

Biology is earthbound, unlike physics. There is astrophysics, but no astrobiology — not yet at least. This earthbound biology develops, like physics, on two levels: the macroscopic and the microscopic. The macroscopic is evolutionary history; the microscopic is molecular biology; and, like physics, these two levels are coupled, only now the coupling introduces some radical innovations. For there is a coding level, that of the DNA and the cybernetic secret of life, and a coping level, the native-range world of trees and tigers, of organisms making their way through their niches in the world. A first question about this tandem coding-coping is addressed to the present: How does life operate now both from the "skin in" (questions of metabolism, anatomy, physiology, cell biology, genetics, biochemistry) and from the "skin out" (questions of ecology, ethology, biogeography). A second, and harder, question about this coding-coping is addressed to the past: How did it all originate (questions of the chemical origins of life, of evolutionary natural history, of the increase of diversity and complexity)?

Biochemistry, molecular biology, and biophysics have been remarkably successful in describing how life takes place. The information in the genetic set reenacts itself in the next generation; the DNA makes the protein that makes the DNA. Bioscience, however, is still struggling to discover how these vital processes came into place. We know how eggs come from chickens and chickens from eggs, but not how the chicken-egg-chicken loop originated in the first place. Knowing the secret of life biochemically may still leave the evolution of life a secret, until we know how the life loops get established. Lurking behind these questions is a deeper one, whether the scientific account still leaves room for a spiritual response to the phenomenon of life.

Addressing first the coding-coping phenomenon that today makes life possible, and continuing from microphysics, we now find it remarkable that physics leaves room in nature for those emergent levels of structure and experience that operate despite the quantum indeterminacics and even because of them. Microphysics, though it knows neither coding nor coping, gives space for the higher phenomena. An organism can coagulate affairs this way and not that way, in accord with its cellular and genetic programs. By means of its interaction patterns, the macromolecular system of the living cell influences the behavior of the atomic systems. 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 via its information and biochemistries participates in forming the course of the microevcnts that constitute its passage through the world.

To some extent we face just the random bubbling up of indeterminacies from the microphysics below, but we find also the drawing forth from an indeterminate substrate of just those determinations that serve the organism. The organism has to flow through the quantum states, but the organism selects the quantum states that achieve for it an informed flow-through. The information within the organism enables it to act as a preference sieve through the quantum states, by interaction sometimes causing quantum events, sometimes catching individual chance events that serve its program; and thereby the organism maintains its life course. There is a kind of downward causation that complements an upward causation, and both feed on the openness, if also the order, in the atomic substructures.

Life makes matter count. It loads the dice. Biological events are superintending physical ones. The organism is "telling nature where to go." Biological nature takes advantage of physical nature. Organisms gain and maintain internal order against the disordering tendencies of external nature. They keep winding up, recomposing themselves, while inanimate things run down, erode, and decompose. Life is a local countercurrent to entropy, an energetic fight uphill in a world that typically moves thermodynamically downhill (despite some negentropic eddies, that is, some events moving counter to the statistical increase of disorder with increasing entropy). To make and maintain themselves, organisms pump out disorder.

Thermodynamics need be nowhere violated, because there is a steady "downhill" flow of energy, as energy is irradiated onto Earth from the Sun and, eventually, reradiated into space. But some of this energy comes to pump a long route uphill. This is something like an old-fashioned hydraulic ram, where the main downstream flow is used to pump a domestic water supply a hundred yards uphill through a pipe to a farmhouse — except of course that the ram-pump is deliberately engineered and the "life-pump" spontaneously assembled itself as an open cybernetic system several thousand times more complex and several billion years long. Not only is energy present, not only have the precursor materials assembled, but some force or forces are present that suck order in superseding steps creatively out of disorder. The energy irradiated over matter is order waiting to happen.

Photons of light flow from the Sun; they impact rocks, which are heated and then, when the Sun ceases, cool. That much happens on both Earth and Moon, without any especially interesting results. On Earth, though, some of these photons also impact leaves, and then there is quite a different story. They are captured by antenna molecules in the chloroplasts (a half-million of them per square millimeter of leaf), relayed to a reaction center molecule where, in Photosystem II, the energy of the photons is used to move electrons up to a high-energy perch (at the PS 680 chlorophyll molecule). The electrons then move down a transport chain, cocking an ADP molecule up to its ATP high-energy form, and are passed to the reaction center of Photosystem I. There, with more photons absorbed, the electrons arc moved back up to a second high-energy perch (at the PS 700 molecule). They descend another electron transport chain, this time producing a high-energy NADPH molecule.

The two high-energy molecules (ATP and NADPH) are then used, in the Calvin cycle, to synthesize sugar. This is a complex series of over a dozen reactions that takes carbon dioxide from the atmosphere and shuttles it around in numerous steps to make, first, three-carbon intermediates and then the six-carbon sugar glucose, as well as other products. The sugar can be stored in the plant as starch, as well as sugar. This is the energy that powers essentially all of life in its negentropic climb uphill against thermodynamic breakdown. This is the fuel for natural history

Sometimes used by the plant itself, sometimes eaten and digested by animals, the starch is reconverted to a glucose sugar. The energy is extracted from glucose in two stages: first, glycolysis, the oldest energy extraction process (a ten-step descent), and, second, the Kreb's cycle (an eight-step cycle), a process later evolved and extracting considerably more energy. This time the energy molecules are NADH and FADH2. These are next oxidized in the electron transport chain of oxidative phosphorylation, a complex ten-stage descent through an energy gradient down a series of cytochrome and other molecules yielding more ATP molecules. These ATP molecules are the fuel that powers protein synthesis, metabolism, locomotion, and reproduction. All this has been going on in one form or another for some two and a half billion years, for the cytochrome molecules are at least that old.

In animal metabolism, one of the structures that ATP is used to synthesize, guided by the genetic coding in DNA, is cholesterol. The molecule that results from glycolysis is called acetyl CoA, a two-carbon molecule, and it can, as we indicated, be sent into the Kreb's cycle and energy extracted from it. The same molecule can also be sent into a construction sequence where, in a complex series of steps that move thermodynamically uphill all the way, it is formed into the twenty-seven-carbon cholesterol molecule, which, in turn, is the precursor of many other steroids of vital physiological function, among them the sex hormones testosterone and estrogen, as well as cortisone. Every step demands energy to increase the order and is fueled by using high-energy phosphate molecules. Every step is made possible by complex enzymes — protein molecules coded by the DNA.

The astronomers and the physicists were already impressed by how the universe is well-organized (despite the entropy of its increasing disorganization over time), but now in biology we get organization based on a radical new principle: accumulating information storage localized in organisms, transmitted over the millennia, spreading around the globe, increasing in diversity and complexity Superimposed on the background physical organization of the universe, superimposed on the background increase of entropy, there appears more organization than ever before by many hundreds of orders of magnitude. The secret of it all is these coding molecules — the DNA molecules that "know how" to organize matter in these spectacular ways. The result is the difference between the Earth and the Moon.

We have a naturalistic account of all this molecular biological synthesis in increasing detail. There remains yet much to be known. But what then? After the scientific descriptions are done, is that all there is to be said? Photosynthesis and the anabolism of cholesterol have been explained. Have they been explained away? Moses thought that the burning bush, not consumed, was quite a miracle. We hardly believe any more in that sort of supernatural miracle; science has made such stories incredible. But what has it left instead? A self-organizing photosynthesis driving a life synthesis that has burned for millennia, life as a strange fire that outlasts the sticks that feed it. This is, one might say, rather spirited behavior on the part of dead matter, "spirited" in the animated sense, in the root sense of a "breath" or "wind" that energizes this mysterious, vital metabolism.

This is hardly a phenomenon less marvelous even if we no longer want to say that it is miraculous. Indeed, in the original sense of "miracle" — a wondrous event, without regard to the question whether natural or supernatural — photosynthesis and the life it supports are the secular equivalents of the burning bush. The bush that Moses watched was an individual in a species line that had perpetuated itself for millennia, coping by the coding in its DNA, fueled by the Sun, using cytochrome *c* molecules several billion years old, and surviving without being consumed. To go back to the miracle that Moses saw, a bush that burned briefly without being consumed, would be to return to something several orders of magnitude less spectacular.

Thanks to the biochemists, molecular biologists, and geneticists, we know how this works. But is this an account that demystifies what is going on? The account we have is, if you like, a naturalistic account, but, as before, this nature is pretty spectacular stuff. Again, we want even more urgently to ask whether, once we have set out this naturalistic account, the explanations are over Yes, there is this spinning round of trillions of molecules, organizing themselves into a code for life, and executing this code in a coping individual. But is there anything that suggests that nature is its own self-sufficient explanation? That question becomes even more intense when we recall how, over time, the matter that first took on life eventually took on spirit, and we ourselves are the proof of that. Again, we who are spirits have ourselves on our hands, bodies and hands, minds and spirits, which emerged out of nature.

Evolutionary Spirituality

Before we can answer whether this self-animating nature is its own explanation, we will have to take a backward look, because the past may hold the secret to understanding the present. That is routinely the case with historical explanations, and biology on Earth is indisputably historical. What can we say scientifically first about the molecular origins of life and subsequently about the natural history by which life has continued over the millennia?

The first stage of the chemical evolution that resulted in life is relatively unproblematic: amino acids were constructed by energy radiated over inorganic materials. These collected in ancient seas into a kind of proto-organic soup. The second stage was much more difficult. Many amino acids must be assembled into long polypeptide chains, with no previous templates or enzymes for their hooking up, with no information to steer the process. One worries that, although some partial sequences might have been produced at random, their spontaneous rate of thermodynamic breakdown would have been vastly higher than their construction rate. The historical pathway from abiological materials to coded, self-replicating DNA megamolecules that, in turn, can code for proteins, is as yet nowhere near being known. Still, we believe that there was such a pathway and hope that someday it may be known reasonably well.

The third stage is to fold these long polypeptide chains into complex functional structures. If — but only if — the sequence is right (from the second stage), they are self-folding. In the presence of the electric pressures of water, the polypeptide chains fold and form their various cross-linkages because they have the sorts of chemistries they have. It is as though shaking the pieces tends to lock a puzzle together. In a fourth stage, coincident with this, other molecules form, which, likewise under the electric pressures of water, organize themselves into hollow microspheres, empty prototypes of cells. These spheres come to envelop the newly emerging proteins, further protecting the about-to-be-life chemistries from their degradation by the outside environment and providing a semipermeable membrane over which can pass the necessary nutrient inputs and waste outputs. Thereby life assumes cellular form.

To have life assemble this way, there must be a sort of push-up, lock-up effect by which inorganic energy input, radiated over matter, can spontaneously synthesize negentropic amino acid subunits. These arc complex but partial protoprotein sequences, which would be degraded by entropy except that by spiraling and folding they make themselves relatively resistant to degradation. They are metastable, locked uphill by a ratchet effect, so to speak, with such folded chains much upgraded over surrounding environmental entropic levels. Once elevated there, they enjoy a thermodynamic niche that conserves them, at least inside a felicitous microspherical environment.

Still, it is a long way up any developmental slope to reach an organism with self-coordinating parts in a metabolic whole. When we remember the enormous complexity of even the simplest of these biological molecules, involving hundreds of amino acids chain-linked in a precisely suitable sequence and then folded dozens of times, and when we recall how many such molecules of differing function but equal complexity must be assembled to gain an organism, it is striking that something favors dramatic structural climbs that would otherwise be utterly improbable. Something makes the improbable probable. Something presses for matter to undertake this animation, this vitality, this spiritedness.

To some it seems that life is an accident waiting to happen, because it is blueprinted into the chemicals, rather as sodium and chlorine are preset to form salt; only much more startlingly so because of the rich implications for life and because of the openness and information transfer also present in the historical life process. Life is not an accident, whatever place dice throwing plays in its appearance and maturation. It is something arranged for in the nature of things. The dice are loaded.

When these enormously complex molecules appear, predecessors of DNA and RNA, they are conserved, writes Melvin Calvin, a biochemist and 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."[15] Peculiar chemistries indeed! With an intrinsic selectivity that filters and forces the process up-slope, toward ever greater molecular complexity and at length to an informational molecule! Such selection combines with these peculiar chemistries forced toward biochemistries, with the result that the evolution of life, so far from being random, is "a logical consequence" of natural principles.[16] We seem almost to be saying that life is the earthen destiny of these chemicals. "This universe breeds life inevitably," concludes George Wald, an evolutionary biochemist, another Nobel laureate.[17]

We should not overdo this "selectivity intrinsic in the structures," for there 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. There is nothing in a [a]thin soup" of disconnected amino acids to predict that they will connect themselves into proteins, nor that they will arrange for DNA molecules in which to code the various discoveries of structures and metabolisms specific to the diverse forms of life. All these events may come naturally, but they are still quite a surprise. Still there is this remarkable story to tell; and, when it happens, though it is no inference, neither does it seem nothing but accident.

So we do posit a primitive planetary environment in which the formation of living things somehow had a high probability, or, in other words, the archaic Earth was a pregnant Earth. Nature here has all these possibilities of animation. Here we may not so much need interference by a supernatural agency, as rather the recognition of a marvelous endowment of matter with a propensity toward life (and, in due course, toward spirit), not in all its lineages but in some of them. Still, we may still need something to superintend the possibilities. Once again, it is not just the necessities, nor the contingencies, but the prolific mixing of the two that impresses us. What is so remarkable is not just the atomic or astronomical physics, found universally, but the middle-range earthen system, found rarely, with its zest for complexity.

Here there is a mixture of inevitability and openness, so that one way or another, given the conditions and constants of physics and chemistry, together with the biased earthen environment, life will somehow both surely and surprisingly appear. After a long study of the possibility of the evolution of biological molecules capable of self-organization, Manfred Eigen, a thermodynamicist and still another Nobel laureate, concludes "that the evolution of life ... must be considered an *inevitable* process despite its indeterminate course."[18] Life is destined to come as part of the narrative story, yet the exact routes it will take are open and subject to historical vicissitudes. So what we really get are possibilities for the story, more than any logical necessity or empirically sufficient conditions for the story to take place.

Not only does life get started, it elaborates. The story goes from zero to five million species in five billion years, passing through over a billion species en route. With the passage of time and trials, there come to pass ever more salient constructions of life, enormous distances traveled upward. Michael Polanyi, a philosopher of science, concludes:

> There is a cumulative trend of changes tending towards higher levels of organization, among which the deepening of sentience and the rise of thought are the most conspicuous. ... From a seed of submicroscopic living particles — and from inanimate beginnings lying beyond these — we sec emerging a race of sentient, responsible and creative beings. The spontaneous rise of such incomparably higher forms of being testifies directly to the operations of an orderly innovating principle.[19]

Responsible, creative beings arising from a creative process, arising to wonder where they are and who they arc — that is matter ending in a spiritual quest.

John Maynard Smith, one of the leading theoretical biologists today, says, "There is nothing in neo-Darwinism which enables us to predict a long-term increase in complexity" He goes on to suspect that this is not because there is no such long-term increase but rather because Darwinism is inadequate to explain it. We need "to put an arrow on evolutionary time" (that is, to give time an asymmetric direction) 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, singled-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."[20] Biology may also be reluctant to say much about the formation of spirits, our human spirits, which also arise in the course of evolutionary history, but nevertheless, here we are, profound among the phenomena, even in our hesitating struggles to understand who and where we are.

Ernst Mayr, a leading evolutionary biologist, though he dislikes any suggestions of teleology and has little sympathy for orthodox religions, is forced to concede that there is evolutionary progress. Many life-forms do not progress: *higher* is a troublesome word in biology. He writes:

> 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 organellcs; from the single-celled eucaryotcs to mctaphytes and mctazoans with a strict division of labor among their highly specialized organ systems; within the metazoans from ectotherms that are at the mercy of 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]

Edward O. Wilson, a Harvard biologist who has devoted his life to the conservation of these diverse forms of life that arise in evolutionary history, concludes:

> Biological diversity embraces a vast number of conditions that range from the simple to the complex, with the simple appearing first in evolution and the more complex later. Many reversals have occurred along the way, but the overall average across the history of life has moved from the simple and few to the more complex and numerous. During the past billion years, animals as a whole evolved upward in body size, feeding and defensive techniques, brain and behavioral complexity, social organization, and precision of environmental control — in each case farther from the nonliving state than their simpler antecedents did. More precisely, the overall averages of these traits and their upper extremes, went up. Progress, then, is a property of the evolution of life as a whole by almost any conceivable intuitive standard, including the acquisition of goals and intentions in the behavior of animals. It makes little sense to judge it irrelevant. … In spite of major and minor temporary setbacks, in spite of the nearly complete turnover of species, genera, and families on repeated occasions, the trend toward biodiversity has been consistently upward.[22]

But here is the rub. Despite the molecular biologists and thermodynamicists, who may judge that life is an accident waiting to happen, when life does happen, it thereafter develops through its narrative stories — so far as evolutionary theory can see — with as much accident as inevitability. For there is really nothing in the theory that says that life must increase in either complexity or diversity. Many forms of life continue, with new species replacing former ones, but without any increase of complexity; some environments grow colder, drier, and simpler; and even the rich environments are subject to many vicissitudes, including periodic catastrophic extinctions. Life develops over the millennia with many misfortunes as well as fortunes.

In fact, the advances are often puzzlingly coupled with the upsets and even the retreats. Often there is a downside before an upside; the upside is life rebounding after setbacks. Upset and rejuvenation are what make really novel speciation possible, by which life can advance. The pattern, at times at least, is that the big changes, including the advances, come after the environmental stresses that result in extinction. Niles Eldredge concludes:

> The particularly compelling aspect of this account is that the factors underlying species extinction — namely, habitat disruption, fragmentation and loss — are the very same as those conventionally cited as causes of speciation. Thus the causes of extinction may also serve as the very wellspring of the evolution of new species.[23]

There is, for instance, a step up of mutation rates under stress. The extinction of dominant species makes room for innovation. Species evolve most rapidly under conditions where environments change most severely.

David M. Raup, the paleontologist who, with Eldredge, has most extensively explored extinctions, also holds that these periodic cutbacks prepare the way for more complex diversity later on. Raup explains:

> Without species extinction, biodiversity would increase until some saturation level was reached, after which speciation would be forced to stop. At saturation, natural selection would continue to operate and improved adaptations would continue to develop. But many of the innovations in evolution, such as new body plans or modes of life, would probably not appear. The result would be a slowing down of evolution and an approach to some sort of steady state condition. According to this view, the principal role of extinction in evolution is to eliminate species and thereby reduce biodiversity so that space — ecological and geographic — is available for innovation.[24]

There is a big shakeup; this is in some sense random; it is, we must say, catastrophic, but the upset is integrated into the creative system. The loss of diversity results in a gain in complexity Catastrophic extinction "has been the essential ingredient in the history of life that we see in the fossil record." The storied character of natural history is increased. Once "we thought that stable planetary environments would be best for evolution of advanced life," but now we think instead that "planets with enough environmental disturbance to cause extinction and thereby promote speciation" are required for such evolution.[25]

From the point of view of the fine-tuned universe that the astrophysicists reveal for us, the picture that we get from evolutionary history leaves us puzzled about the mixture of necessity and contingency through which life has survived over the millennia, developing into the advanced forms. Physics is full of laws, and laws are important in natural systems, but natural law is not the complete explanatory category for natural history, any more than is openness or chance. So what are we to say when the laws of science pass over into the epic of natural history? Sometimes these vicissitudes seem more than we can comprehend. Sometimes they recall the old theological paradox that God writes straight with crooked lines.

One response is to see in nature, beyond any laws, a kind of grace. Grace, some will think, belongs in the theological tradition that posits the appearance of a goodness that one has no cause to expect, a salvation that one has not merited, a favor that one does not deserve. Here too there is surprising goodness, something given that has no justification in law or logic, even if there does seem some destiny filling up the world with these wonders. There is creativity by which this more emerges from less. Science prefers lawlike explanations without surprises. One predicts, and the prediction comes true; but biology is full of unpredictable surprises. Our account of natural history cannot be by way of implication, whether deductive or inductive.

There is no covering law (such as natural selection), plus initial conditions (such as trilobitcs), from which one can deduce primates. Nor is there any induction (expecting the future to be like the past) by which one can expect trilobites later from procaryotes earlier, or dinosaurs still later by extrapolating along a regression line (a progression line!) drawn from procaryotes to trilobitcs. There are no humans invisibly present (as an acorn secretly contains an oak) in the primitive eucaryotes, to unfold in a lawlike way. All we can do is tell the epic story — eucaryotes, trilobites, dinosaurs, primates, persons who are scientists, ethicists, conservation biologists, and saints — and the drama may prove enough to justify it.

Indeed, the drama may evoke a sense of marvelous natural given, the experience of grace. If we define a miracle as a wondrous event without sufficient natural causes, so far as is known, then there remains miracle here, and we hardly yet find that, under bioscience, the secret of life stands explained, certainly not explained away. Man and woman arising via all the intermediate steps (trilobites, dinosaurs, primates) from the maternal Earth is not less impressive, rather more so, than Aphrodite arising from the formless seas.

Loren Eiseley, with whom we began, surveying evolutionary history, exclaims: "Nature is one vast miracle transcending the reality of night and nothingness."[26] Ernst Mayr, troubled by those higher forms arising, finding the creativity in natural history undeniable, says: "Virtually all biologists are religious, in the deeper sense of this word, even though it may be a religion without revelation. ... The unknown and maybe unknowable instills in us a sense of humility and awe."[27] We sense something sublime in the awe-inspiring sense because there is something sublime that takes us to the limits of our understanding, and mysteriously beyond.

Ecological Spirituality

Natural history is the story of what has been taking place over past evolutionary epochs, at levels from the biomolccular incubating, coding, conserving, and elaborating of life to the marine and continental ecosystems that are the womb of life. This natural history brings us, in the end, to the present, to the drama of life continuing around us, a scene on which we humans have, especially in the twentieth century, been having so dramatic an impact. Here we reach, in closing, what we can call an ecological spirituality, rising from the human response to a nature now threatened by our human choices. (This theme is continued in chapter 17, below.) The end of this century, passing into the beginning of twenty-first century, may well be the era of the end of nature.

Science brings us just that possibility. The late-coming, moral species, *Homo sapiens*, has still more lately gained startling powers for the rebuilding and modification, including the degradation, of this home planet. We have been recalling how the two great marvels of our planet are life and mind, both among the rarest things in the universe, so far unknown elsewhere. Life is the product of evolutionary natural history, the toil and achievement of three and a half billion years. For perhaps two hundred thousand years, the human mind has produced cultures superposed on natural systems. Diverse combinations of nature and culture worked well enough over many millennia, but no more. Our recent modern cultures threaten the stability, beauty, and integrity of Earth, and thereby of the cultures superposed on Earth.

Perhaps the four most critical issues that humans currently face are peace, population, development, and environment. Human desires for maximum development drive population increases, escalate exploitation of the environment, and fuel the forces of war. Those who arc not at peace with one another find it difficult to be at peace with nature, and vice versa. Those who exploit persons will typically exploit nature as readily. All this has produced, in the century when science has flourished as never before, a crisis of the human spirit. In other centuries, critics might have complained that humans were alienated from God. In this century, critics complain that humans are alienated from their planet. This secular crisis proves to demand, at depth, a spiritual quest. To the questions about who we are and where we are we must add another question: What ought we to do? Perhaps we can set aside cosmological questions, but we cannot set aside global issues, except at our peril. We humans face an identity crisis in our own home territory, trying to get the human spirit put in its place.

The late twentieth century has been a time of seeing Earth ecosystemically, as a whole, the home planet. Viewing Earthrise from the Moon, the astronaut Edgar Mitchell was entranced:

> Suddenly from behind the rim of the moon, in long, slow-motion moments of immense majesty, there emerges a sparkling blue and white jewel, a light, delicate sky-blue sphere laced with slowly swirling veils of white, rising gradually like a small pearl in a thick sea of black mystery. It takes more than a moment to fully realize this is Earth... home.

Mitchell continued, "My view of our planet was a glimpse of divinity."[28] Mitchell enjoys an overview of the material Earth, a marvelous view of a marvelous place, and believes that he is seeing God.

A first response of both scientists and theologians may be that the astronaut is going to extremes. Earth is not divinity. A frequent fear of creation spirituality is that it slips over into vague pantheism and uncritical naturalism; we begin romantically and naively to worship Nature and not intelligently and diligently to worship God. A frequent complaint by hard-nosed scientists is that we must stick to the facts and not get carried away in mystical interpretation.

Earth is, after all, just earth. Earth is, in a way, a big rock pile like the Moon, only one on which the rocks are watered and illuminated in such a way that they support life. No doubt Earth is valuable, but that is because humans arc able to value it. It is really human life that we value and not the Earth, except as instrumental to life. We do not have responsibilities to rocks, air, ocean, dirt, or Earth; we have responsibilities to people, or living things. We must not confuse duties to the home with duties to the inhabitants. We must get clear about what it is that is deserving of such respect.

Yet is it so amiss to see this home biosphere as the sphere of divinity? Consider all the complexity and diversity, integrity, richness, natural history, and cultural history — the whole storied natural and cultural history of our planet. Say, if you like, that Earth is only a big rock pile, mere matter, but, as Eiseley insisted, when we consider the story these rocks spin, it must indeed be plain to the materialist that matter contains dreadful powers. Really, the story is little short of a series of "miracles," wondrous, fortuitous events, unfolding of potential; and when Earth's most complex product, *Homo sapiens*, becomes intelligent enough to reflect over this cosmic wonderland, everyone is left stuttering about the mixtures of accident and necessity out of which we have evolved. Nobody, though, has much doubt that this is a precious place, a pearl in a sea of black mystery. Earth could be the ultimate object of duty, short of God; and if one cannot get clear about God, there is ample and urgent call to reverence the Earth.

Earth is dirt, all dirt, but here we find revealed what dirt can do when it is self-organizing under suitable conditions with water and solar illumination. That is pretty spectacular dirt. We can, if we insist on being anthropocentric, say that it is all valueless except as our human resource, though quite valuable in that respect; but we will not be valuing Earth objectively until we appreciate this marvelous natural history. This really is a superb planet. Earth is the only planet, so far as we know, that is a home. This is the biosphere, the planet known to have an ecology (etymologically, "the logic of a home").

The astronaut Michael Collins recalled being Earthstruck:

> The more we see of other planets, the better this one looks. When I traveled to the Moon, it wasn't my proximity to that battered rock pile I remember so vividly, but rather what I saw when I looked back at my fragile home — a glistening, inviting beacon, delicate blue and white, a tiny outpost suspended in the black infinity. Earth is to be treasured and nurtured, something precious that *must* endure.[29]

Ernst Mayr's thoughtful biologist not only has a sense of religious humility but also a sense of respect for nature: "And if one is a truly thinking biologist, one has a feeling of responsibility for nature, as reflected by much of the conservation movement."[30]

Edward O. Wilson, a biologist who has been repeatedly, sometimes intensely, critical of the classical religions with their hope for transcendence, is, interestingly, as a secular humanist, the biologist who most demonstrates a virtually religious respect for the life he finds on Earth. He preaches its conservation with evangelical intensity: "What event likely to happen during the next few years will our descendants most regret?" His answer: "The one process now going on that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us."[31] In another place he writes: "Of all the evils of the twentieth century, the loss of genetic diversity ranks as the most serious in the long run."[32]

Why is it an almost unforgivable sin to destroy thousands of other species? Because in so doing we harm other people, but that is not Wilson's deepest reason. He urges forming a human bond with other species, loving not only human diversity but biodiversity throughout the fauna and flora. He wants to stretch the self over to a "nobility… defined as reasoned generosity beyond expedience," to "the ultimate ennobling act."[33] We ought to respect life, to value other forms of life as we do our own. This is in our enlightened self-interest, but for those humans who can move outside their own pragmatic utilities and learn to appreciate the "mysterious and little known organisms" with which we coinhabit this planet, "splendor awaits in minute proportions."[34] Wilson marvels and rejoices at his prolific home planet with its teeming life, exuberantly projected up from the primeval ooze and mud, an emergent vitality expressed in millions of species.

The planet loves life, and so ought we, Wilson urges. In this biophilia, innate within us, "the more the mind is fathomed in its own right, as an organ of survival, the greater will be the reverence for life for purely rational reasons."[35] In this love we are the evolutionary epic become conscious of itself. We arc, Wilson holds, innately inclined to act in our self-interest; this is the law of the survival of the fittest; but, unique among the species, we humans find that our own survival, and flourishing, requires a loving concern for the nature, the biodiversity, with which we have an entwined destiny. "Natural philosophy has brought into clear relief the ... paradox of human existence. … We need the most delicate, knowing stewardship of the living world that can be devised. … The paradox can be resolved by changing its premises into forms more suited to ultimate survival, by which I mean protection of the human spirit."[36]

The sermon continues: "The green prehuman earth is the mystery we were chosen to solve, a guide to the birthplace of our spirit, but it is slipping away. ... If there is danger in the human trajectory, it is not so much in the survival of our own species as in the fulfillment of the ultimate irony of organic evolution: that in the instant of achieving self-understanding through the mind of man, life has doomed its most beautiful creations."[37] We hardly yet understand that evolution and ecology because we take it all for granted:

> The flower in the crannied wall — it *is* a miracle. … Pull out the flower from its crannied retreat, shake the soil from the roots into the cupped hand, magnify it for close examination. … The handful may be only a tiny fragment of one ecosystem, but because of the genetic codes of its residents it holds more order than can be found on the surfaces of all the planets combined. It is a sample of the living force that runs the earth — and will continue to do so with or without us.[31]

That living force runs through the preacher himself, and we can hear Wilson's own spirituality embodied in what he urges:

> Humanity coevolved with the rest of life on this particular planet; other worlds are not in our genes. … Humanity is part of nature, a species that evolved among other species. The more closely we identify ourselves with the rest of life, the more quickly we will be able to discover the sources of human sensibility and acquire the knowledge on which an enduring ethic, a sense of preferred direction, can be Built. … We do not understand ourselves yet and descend further from heaven's air if we forget how much the natural world means to us. Signals abound that the loss of life's diversity endangers not just the body but the spirit.[39]

Perhaps the noumenal world lies beyond our kin, but the world of phenomena, revealed by science and seen at hand, is phenomenal enough to ennoble our spirits.

Biology and religion are not always easy disciplines to join, as illustrated by Wilson's misgivings about any transcendence to be detected as immanent in world history or his efforts to join selfish genes and reverence for life. One place they have increasingly joined in recent years is in admiration for this marvelous planet that we inhabit. That respect sooner or later passes over to a reverence. No other species can be either responsible for or religious toward this planet, but *Homo sapiens* reaches a responsibility that assumes spiritual dimensions: "There can be no purpose more inspiriting."[40] In a planetary, environmental age, spirituality requires combining nature and grace at new levels of insight and intensity. Nature is grace, whatever more grace may also be. The geophysical and biological laws, the evolutionary and ecological history, the creativity within the natural system we inherit, and the values these generate are the ground of our being, not just the ground under our feet.

Life persists because it Is provided for in the ecological Earth system. Earth is a kind of providing ground, where the life epic is lived on in the midst of its perpetual perishing, life arriving and struggling through to something higher. Ultimately, there is a kind of creativity in nature demanding either that we spell nature with a capital *N* or pass beyond nature to nature's God. Biology produces many doubts. Here are two more. I doubt whether one can take biology seriously, the long epic of life on Earth, the prolific fecundity that surrounds us as human spirits on this planet, without a respect for life, and the line between respect for life and reverence for life is one that I doubt that you can always recognize.

When J. B. S. Haldane found himself in conversation with some theologians and was asked whether he had concluded anything about the character of God from his long studies in biology, he replied that God had an inordinate fondness for beetles. God must have loved beetles, since he made so many of them. Species counts, however, are only one indication of diversity, and perhaps the fuller response is that God must have loved life, since God animated such a prolific Earth. Haldane went on to say that the marks of biological nature were its "beauty," "tragedy," and "inexhaustible quccrness."[41]

This beauty approaches the sublime; the tragedy is perpetually redeemed with the renewal of life, and the inexhaustible queerness recomposes as the numinous. If anything at all on Earth is sacred, it must be this enthralling creativity that characterizes our home planet. If anywhere, here is the brooding Spirit of God. So the secular — this present, empirical epoch, this phenomenal world, studied by science — does not eliminate the sacred after all; to the contrary, it urges us on a spiritual quest. If there is any holy ground, any land of promise, this promising Earth is it.

Notes

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4. Marek Demianski, quoted in Dietrick E.Thomsen, "In the Beginning Was Quantum Gravity," *Science News* 124:10 (3 September 1983): 152.
5. P. C. W. Davies, *The Accidental Universe* (New York: Cambridge University Press, 1982), 90, 110.
6. Bernard Lovell, "Whence?" *New York Times Magazine,* 16 November 1975, 88, 95. See also Bernard Lovell, *In the Center of Immensities* (New York: Harper and Row, 1978), 123-26.
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33. Wilson, *Biophilia,* 131.

34. Ibid., 139.

35. Ibid., 140.

36. Ibid.

37. Wilson, *Diversity of Life,* 344.

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40. Ibid., 351.

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