

W. Mark Richardson and Wesley J. Wildman, eds., *Religion and Science: History, Method, Dialogue* (New York: Routledge 1996), pages 21-82. ©1996. Reproduced by permission of Taylor and Francis Group, LLC, a division of Informa.pic.

SCIENCE, RELIGION, AND THE FUTURE

Without the gift of prophecy, looking into the future is hazardous. The sun will rise tomorrow because it rose yesterday and the day before. Induction is reasonably reliable if one is predicting simple systems. But induction is notoriously problematic, both for logical and empirical reasons, especially if one is dealing with complex systems. If one predicts on the basis of past and present, one will be right much, even most of the time, but wrong at the times of critical innovation, the most important times of all, when the future is unlike the past.

HOLMES ROLSTON, III

The future develops what is already seeded into the present. An acorn, planted, reliably yields an oak. But the oak may be struck by lightning, depending on the luck of the weather, or cut, depending on national forest policy. The present century has taught us how historical contingency mixes with dependability and rationality. The one thing certain is that there will be surprises, the more so in more complicated systems. It is easier to predict eclipses a century hence than to predict tomorrow's headlines. To a considerable extent, therefore, the future is open.

We have been living through a century of change in our ideas about how determinacy and contingency, design and chance, order and chaos fit together to make up the world. These changes shape religion in its account of both science and nature. It now looks as though that reshaping will continue. There are no laws, plus initial conditions, by which we can predict the new millennium; but there are stories that will be told. Science deals with causes; religion deals with meanings; we can be sure that both causes and meanings will be ingredients perennially interwoven in the fabric of history. And, dramatically, we write the next chapters of the story.

Anticipating the future relations between science and theology, we can only extrapolate and wonder. In this century, we human beings have come to know who we are and where we are in ways unprecedented in all past millennia. We know the size, age, and extent of our universe; we know the deep evolutionary history of our planet, and ourselves as part of this story. These facts of science have required integration into our classical religious worldviews; and this blending of theory and principle in science and religion will continue. In this century, we human beings have gained, through science

and technology, more power than ever before to affect, for better or worse, our own well-being, that of the human and natural worlds, and even planetary history. The fate of the Earth, the fate of all who dwell thereon, depends, in the next century, on the responsible use of that power. Everything depends on how we join science, ethics, and religion in practice.

I. WHERE ARE WE? SCIENCE AND RELIGION IN THEORY AND PRINCIPLE

Ian Barbour has summarized four ways of relating science and religion: conflict, independence, dialogue, and integration.¹ It is difficult to conceive of two subject areas whose relations would not lie somewhere within these broad categories. Barbour finds examples of all four present and past; and, one assumes, there will be examples of all four for the indefinite future. Perhaps their frequency ratios will shift, less conflict and more integration, or vice versa. Perhaps the shifting frequency ratios will vary with the discipline. At present, for instance, there is more dialogue and integration in physics, ample conflict and considerable independence between biology and religion. Whether that trend will continue depends partly on discoveries as yet unknown in physics, astronomy, and molecular and evolutionary biology.

Astrophysics and nuclear physics are describing a universe "fine-tuned" for life, although physics has also found a universe with indeterminacy at its most fundamental levels. Meanwhile evolutionary and molecular biology seem to be discovering that the history of life is a random walk with much struggle and chance, although they have also found that, on this seemingly random walk, over millennia, order is built up a negentropic slope, attaining in Earth's natural history the most complex and highly ordered phenomena known in the universe, such as ecosystems, organisms, and—most of all—the human mind.

Cosmology: The Origin of the Universe

Theology has as its principal focus persons in their relationships to God and neighbor, and we will below be amply concerned about science and technology as they in practice help or hinder such relations. Such practice requires a worldview giving persons a sense of who and where they are, an orientation to undergird their sense of what they ought to do. In the monotheistic West, God created the world; that is the first article of the Christian creed, preceding the second article, about Christ and redemption, and the third, about life in the community of the Spirit. In the second half of our century, a remarkable dialogue between theology and astrophysics about this creation has become possible.

The possibility of a natural theology, frowned upon earlier in the century by most theologians, has even been taken up by some physicists. Many, perhaps even most, today think that physics, especially cosmology, is compatible with some kind of monotheism. Victor Weisskopf is explicit:

The origin of the universe can be talked about not only in scientific terms, but also in poetic and spiritual language, an approach that is complementary to the scientific one. Indeed, the Judeo-Christian tradition describes the beginning of the world in a way that is surprisingly similar to the scientific model.²

A big surprise in recent decades has been the anthropic principle in cosmology. 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, the simplest element, which serves as fuel for the stars, where all the heavier atoms were forged. The heavier elements were collected to form, in our case, the solar system and planet Earth. Recent physics interrelates two levels; astronomical phenomena such as the formation of galaxies, stars, and planets depend critically on microphysical phenomena, such as the charges on particles and their energy transformations. In turn, the mid-range scales, where the known complexity mostly lies (in ecosystems or human brains), depend on the interacting microscopic and astronomical ranges.

It now seems that the universe has been "fine-tuned" from the start for the subsequent construction of stars, planets, life, and mind. A plausible interpretation is divine design. Theologians and philosophers have often been wary of design arguments, remembering William Paley, his fine-tuned watch, and the many telling criticisms of such arguments. Nevertheless the physical world is resembling a fine-tuned watch again, and now many quantitative calculations support the argument. 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 that many of them can hardly vary at all, and still have the universe develop life and mind. 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.

Theologians and scientists alike can find it perfectly intelligible to draw conclusions from a fine-tuned universe, though monotheist conclusions are not the only ones that can be drawn. Indeed, "conclusions" is probably not the word we want here; little is really concluded as we face the next century. Trying to keep more modesty in the insight, we are careful to say only that monotheism is "consistent with" or "complementary to" physical cosmology, but not a hard conclusion commanded by it. Freeman Dyson puts it this way:

I conclude from the existence of these accidents of physics and astronomy that the universe is an unexpectedly hospitable place for living creatures to make their home in. Being a scientist, trained in the habits of thought and language of the twentieth century rather than the eighteenth, I do not claim that the architecture of the universe proves the existence of God. I claim only that the architecture of the universe is consistent with the hypothesis that mind plays an essential role in its functioning.³

The issue seems to be: How friendly is too friendly a relationship between physics and theology? For those with good historical memories, there is a dilemma. The religion that is married to science today is a widow tomorrow, while the religion that is divorced from science today leaves no offspring tomorrow. Within recent memory there were two seriously competing cosmologies: the steady state theory, discarded since the mid-1960s, and the now-favored Big Bang theory. Suppose that the steady state had proved true? Would theology have been the worse? The steady state theory posited the continuous but infrequent *ex nihilo* insertion of subatomic particles throughout the universe, and thus no absolute beginning. That theory too still required the assembly of the light elements, then the stars, galaxies, the heavier elements within the stars, then planets, then people—hardly any less creation for the lack of an initial one. Nothing in Christianity implies the detail of the Big Bang theory; many other cosmologies are compatible with Christian faith in creation. The Big Bang model might prove wrong and the now novel plasma cosmology might replace it.⁴ Then the search for consonance would have to start all over.

Meanwhile it is difficult to envision any cosmology that does not require creation of the complex out of the simple, more out of less, something somehow out of nothing. It is difficult to imagine that all of the remarkable phenomena that work together to make our universe possible will disappear, even though the proportions that we ascribe to contingency and to necessity may change. It is difficult to imagine a universe much less staggering, dramatic, and mysterious, for all its rationality. No doubt there will be surprises in cosmology in the next century, but it would be even more surprising if these were wholly uncongenial to theology.

BIOLOGY: THE NATURAL HISTORY OF LIFE

Creation refers in part to the genesis of life on Earth over the last five billion years. Like physics, biology has developed on two scales: the microscopically small and big-scale history. Molecular biology, discovering DNA, has decoded the "secret of life" (once ascribed to the Spirit of God). Evolutionary history has located the secret of life in natural selection operating over incremental variations across enormous time spans. As with physics, the two levels have been theoretically interrelated. The genetic level supplies variations, does the coding of life, and constructs molecular proteins. Organisms cope at their native-range levels, inhabiting ecosystems. Across deep evolutionary time, species are selected and transformed as they track changing environments.

This process is not fine-tuned. To the contrary, evolutionary history can seem tinkering and makeshift. The genetic variations bubble up without regard to the needs of the organism, and the evolutionary selective forces select for survival without regard to advance. Many evolutionary theorists insist that nothing in natural selection theory guarantees progress.

Here the cause of relating science to religion has been taken up adversely by some

biologists, as with Richard Dawkins and his *Blind Watchmaker*.⁵ Stephen Jay Gould insists, "We are the accidental result of an unplanned process."⁶ Jacques Monod exclaims, "Chance *alone* is at the source of every innovation, of all creation in the biosphere."⁷ Outspokenly monotheist biologists are as rare as those who think physics, is compatible with monotheism are common. Typically, biologists seem to insist that if, from the perspective of science, they find what looks like contingency, then God is eliminated.

But there are also biologists who emphasize the richness in biology: the fecund Earth, the vital creative processes continuing over time, the ascent of life from the simple to the complex, the production of more out of less over long millennia. Biologists can doubt creation, but none can doubt genesis. In fact, the earthly genesis is as impressive as anything in astronomy, because the life genesis requires a coding and a coping, factors wholly novel to anything previously encountered in physics or chemistry. Indeed, we can get from equally eminent scientists (though they are still not outspoken monotheists) a quite opposite reaction: the claim that, life is the destiny of these earthly chemicals.

During the chemical evolution of life, when predecessors of DNA and RNA appear, bearing the possibility of genetic coding and information, they are conserved, writes Melvin Calvin, a biochemist, "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."⁸ The evolution of life, so far from being random, is "a logical consequence"⁹ of natural principles. "This universe breeds life inevitably," concludes George Wald, an evolutionary biochemist.¹⁰

Michael Polanyi, a philosopher of science, finds that "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 see 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.

Also it begins to become clear that the genes, once thought to operate blindly and at random, are a rather sophisticated problem solving device, conserving the successes of the past so as to search the nearby living space for novel innovations, without which life can neither survive nor develop. A kind of genetic engineering has been going on for several billion years, long before the biochemists began recently to undertake, this in their laboratories.¹² Rather surprisingly, computer scientists, at the forefront of cognitive science, have discovered that analogues of genetic problem solving can be effectively used in advanced computing.¹³

Meanwhile, looking backward, we discover a primitive planetary environment in which the formation of living things had a high probability, that is, a pregnant, Earth. And looking forward to the next century, it is difficult to imagine that our evolutionary

natural history will come to seem any less startlingly fecund and prolific. The dialogue between biology and religion will increasingly try to figure out whether in the genesis of these riches we need interference by a supernatural agency or the recognition of a marvelous endowment of matter with a propensity toward life. Do we need something to superintend the possibilities? There will not be much doubt that there has been a marvelous natural history, but there will be dialogue, debate, conflict over whether and how the story needs an Author. My prediction is that the watchmaker-design approach to the Creator, though it may remain appropriate in physics, will not prove the appropriate model for biology, where more autonomy and self-creativity must be combined with the divine will for life, a divine parenting entwined with spontaneous creative process.

Order and Disorder

The scientific question can be put this way: What is the mixture of order and disorder in the world? The theological question then becomes: Can we detect God in, within, and under the order established, maintained, sustained over against the disorder? When we envision an orderly innovating principle, the randomizing element begins to look different. It does not need to be taken away, at least not all of it, but it can remain as openness and possibility. In both biology and physics, there is a world of infinite possibilities, one in which there is a superposition of possible mutation states over actual ones, but also one where many of the possibilities become briefly actual, real mutants, and then a fractional few stay actual (survive).

In the surviving organism, there is a locally autonomous center of order. The individual 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 genetic information and biochemistries, participates in forming the course of the microevents that constitute its passage through the world. The organism is responsible, in part, for the microevents, and not the other way round. The microscopic indeterminism provides a looseness through which the organism can steer itself by taking advantage of the fluctuations at the microlevels.

But what about the larger system in which these autonomous organisms come to be? What is the origin of this ongoing biological order? The swarms of organisms are edited, so that from many options the well-adapted survive, and this results, at least in the top trophic rungs of the ecological pyramids, in advancing evolutionary creativity. There is an editing on the basis of fitness, which stretches on into advancement. Here we are going to emphasize not the shuffling but the overall sorting. What most needs to be explained is not the disorder, but the negentropic ascent. Biology must posit some constructive forces that give a slope to evolution.

Since life is evidently a highly ordered event, and since presently living organisms in ecosystems on Earth, human beings included, are the most complex things known in the universe, and since there has been the phenomenal evolution of increasing order

over the millennia of natural history, we will have to ask natural selection theory to give what account it can of this composition of order, and press it to do enough explanatory work. We will welcome its causal chains; but, if there is too frequent an appeal to contingency, we will begin to worry that the most striking feature of all, the ascent of life, becomes an anomaly, that is, something which cannot be predicted, derived, or given adequate account of, out of the theoretical model.

It is not that the theoretical model fails altogether to permit and explain what has happened. But it explains only in a weak sense. The story is of chemical evolution, the survival of the fittest, genetic evolution, and so on. But there is not yet enough explanation in the strong sense. We have mostly possibility explanations, seldom necessity explanations, never the assurance that what did happen had to happen. We are given a phenomenal tale of more and more later on out of less and less earlier on. As events move from quarks to protons, from amino acids to protozoans, to trilobites, to dinosaurs, to persons, from spinning electrons to sentient animals, from suffering beasts to sinful persons, the tale gets taller and taller.

It is not just the necessities, nor the contingencies, but the prolife mixing of the two that impresses us. It is not just the atomic or astronomical physics, found universally, but the middle-range earthly system, found rarely, that is so remarkable in its zest for complexity. My prediction is that, in the century to come, science will reveal this order achieved on Earth to be even more remarkable still, and that biological science will continue both to support and to underdetermine it. That will keep an active dialogue between biology and theology about the ultimate source of this creative ordering of our world.

Outspoken biologists may continue to chant, "chance, chance, chance," finding only that across all these millennia. What in fact has resulted is order—increasing in complexity and sophistication, millennia after millennia; and all these incantations of chance do not exorcise the evident order that accumulates. The astounding drive that really needs explanation is what transforms chance into order, as the creatures emerge and exploit the opportunities in their environment, and are themselves transcended by later-coming, more highly ordered, more dazzling forms and dynamic processes. In that sense, though biologists in the next century will likely continue an emphasis on contingency, there will be other biologists who, along with the theologians, continue to insist on "saving the appearances" with theories that not only yield but explain what has evidently appeared in the course of natural history. If such a theory is found in bioscience, it may prove congenial to theology. If it cannot be found there, theologians will find it in their metaphysics, for they will need a metaphysics adequate to occurrent reality. With genius enough, we might some day achieve an integration.

Information, Cognition, and History

Beginning with chemical evolution, where complex living forms are constructed from simple building blocks of amino acids, and continuing onward after a coding evolves in

DNA and RNA to transmit discoveries over generations, we have the steady negentropic climb based on increasing information. Marjorie Grene says:

What makes the DNA do its work is not its chemistry but the order of the bases along the DNA chain. It is this order which is a code to be read out by the developing organism. The laws of physics and chemistry hold, as reductivists rightly insist, universally; they are entirely unaffected by the particular linear sequence that characterizes the triplet code. Any order is possible physico-chemically; therefore physics and chemistry cannot specify which order will in fact succeed in functioning as a code.¹⁴

That order represents something more than physics and chemistry; it is superimposed information. Therein lies the secret of life.

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. The organism as a whole is program-laden, a whole that executes its lifestyle in dependence on this looseness in its parts. On the basis of this information, there is a kind of downward causation which complements an upward causation, and both feed on the openness, if also the order, in the atomic substructures. The genetic coding informs the electronic states of the constituent atoms.

In biology there is a shift from simple systems, like those in physics and chemistry, to complex ones, structured and informed by the information content within them, information that is discovered and accumulates over time. There we shift from a lawlike science to a historically cumulative one in which, in once-upon-a-time, cumulating stages, photosynthesis is discovered. So is the Krebs's cycle, and backbones, and eyes, and hiding, and thinking. Many, perhaps most, biologists doubt whether there are any absolute laws in biology in the physicist's sense: universal laws that can be formalized in equations and applied across the universe. In biology there are only trends, where discoveries are developed and unfolded, until new discoveries launch variant trends. Protein molecules and the genetic codes are earthbound; matter and energy are necessary but, after that, their composition is as historical as it is material and energetic.

Biofunction runs right down to the molecular level, and life is coded to the genes. So it can seem that life has been reduced to molecules in their coded motion. But what determines the codings on these genes? They have been selected for—not at the microscopic level but at the level of organisms in ecosystems. The needs, the environmental niche of the organism determines what genotype is selected and maintained. So the shape of the activity, the molecular conformations, the information at the molecular level are thrown back up to the macroscopic level. The coding at the molecular level is for copies at the ecosystemic level. And the coping is carried on over the millennia,

developing historically. The information stored in the molecular shapes and codings is a story about what is going on in the whole organism at the middle-range level—something like a book with its small print that contains a story of the big world. Molecular and organismic biology tracks big-scale evolutionary biology.

The ecosystem determines the biochemistry as much as the other way round. The shape that the microscopic molecules take is controlled "from above," as information discovered about how to make a way through the macroscopic, terrestrial-range world is stored in the molecules. Sometimes it is hard to say which level is prior and which is subordinate; perhaps it is better to say that we find storied achievements at multiple levels. There is connectedness between the levels through and through. Everywhere there is the interplay of order and disorder, with historically discovered information vital for sustaining and increasing order.

Late in this story, and rather surprisingly, human beings arrive. One can first think that their enlarging brains are to be expected, since intelligence conveys obvious survival advantage. But then again, that is not so obvious, since all the other five million or so presently existing species survive well enough without advanced intelligence, as did all the other five billion or so species that have come and gone over the millennia. In only one of these myriads of species does a transmissible culture develop; and in this one it develops explosively, with radical innovations. There is only one line that leads to persons, but in that line at least the steady growth of cranial capacity makes it difficult to think that intelligence is not being selected for. "No organ in the history of life has grown faster."¹⁵ With this growth, natural selection passed over into something else. Nature transcended itself in culture, with radical new chapters in the ongoing story of the evolution of information, cognition, and history. The world moved into a future quite unlike its past.

Information in wild nature travels intergenerationally on genes;¹⁶ information in culture travels neurally, as persons are educated into transmissible cultures. In nature, the coping skills are coded on chromosomes. In culture, the skills are coded in craftsman's traditions, religious rituals, or technology manuals. Information acquired during an organism's lifetime is not transmitted genetically; the essence of culture is acquired information transmitted to the next generation. Information transfer in culture can be several orders of magnitude faster than and can overleap genetic lines. A human being develops typically in some one of ten thousand cultures, and each heritage is historically conditioned, perpetuated by language, conventionally established, using symbols with locally effective meanings.

The novelty is not simply that human beings are more versatile in their spontaneous natural environments. Deliberately rebuilt environments replace spontaneous wild ones. Animals are adapted to their niches; human beings adapt their ecosystems to their needs. The determinants of animal and plant behavior, much less the determinants of climate or nutrient recycling, are never anthropological, political, economic, technological, scientific, philosophical, ethical, or religious. Natural selection pressures

are relaxed in culture; in all but the most primitive cultures human beings teach each other how to make clothes, thresh wheat, make fires, bake bread. Human beings help each other out compassionately with medicine, charily, affirmative action, or Head Start programs. Human beings hold elections and plan their affairs; they teach their religion to their children. They worry about justice and love.

Two of the notable cultural achievements are science and religion, and both are products of this historical development, which, though it requires the prior achievements in biology, breaks through to radically new levels. Both science and religion not only seek to explain the historically developing worlds they study; each is itself caught up in this history, each needs to explain itself and the other as part of the cognitive story on Earth.

Agency: God's Action in the World

Where is God in such a story? The character of answer here has been shifting; and in the coming decades, I predict, this will further shift in the direction of detecting God within the cybernetic processes. God forms by informing the world, bringing order out of disorder.

In earlier years, one would have cast this as the problem of the natural and the supernatural. As scientific understanding has deepened, the signs of God's active agency in nature have become equivocal. Science gives causal explanations where none was available before, and these have become increasingly detailed with advancing scientific information. God acts—so it once was claimed—in the causal gaps. But the gaps have become fewer and smaller, with progressively less place for God to intervene. God also acts, we are reminded, using natural causes; but if the causal network is unbroken, there is no place for the local agency of God. There is no place for a supernatural God, intervening in nature. So, over the years, monotheism has been steadily pushed toward deism, with a God who, once upon a time, started up the causal nexus, since unbroken.

At the same time, scientific causal explanations, impressive though they are, have not proved to be all that complete, especially in the complex biological world, to say nothing of the even more complex cultural world. Complete causal chains are traced a few steps rearward, but after that they become sketchy, loose, statistical, probabilistic. They involve genes, where, on the one hand, patterns are conserved over millennia, and, on the other, novelties appear in every generation. Present-day cytochrome c molecules, pervasively present in fauna and flora, follow (we believe) in causal chains going back billions of years to early ancestors. Yet myriads of differences have steadily arisen in the billions of other functional and structural biological molecules, which have mutated dramatically over the epochs of natural history. Mutated DNA codes for variant proteins, which are selected for their novel coping capacities, resulted in trilobites, dinosaurs, and human beings.

Many, most, or—by some accounts—even all of the interesting events here are contingent, put down to such explanations (or nonexplanations) as "genetic drift" or

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"random mutations." Disorder everywhere punctuates the order, contingency permeates the certainty. With this discovery, the theological problem has become an opposite one, not too much but too little causation, since the events that matter are said to be fortuitous. Scientific explanation underdetermines events. Are these gaps returning? Is there yet a place for God in the story?

The events that do take place, in addition to their contingent, element, at once are marvelously impressive and yet also have a certain provisional and even makeshift quality. They are both wonderful and wandering. Also, they continue to have the elements of struggle and of suffering, the "nature red in tooth and claw" that has troubled theology since Darwin and before. Yet again, as always, there is the counterpoint: nature is also a prolific scene of genesis of life, a system of life support, into which the species are selected as fit adaptations.

The discovery that information is a critical determinant of history has thrown the causal/contingency debate into a new light, and this promises to redefine the mode of God's agency in the world. The world is composed of matter and energy, with the two united in relativity theory—so physics and chemistry have insisted. But the earthly world, biology now insists, is composed by information that superintends the uses of matter and energy. That vital information is carried on the genes. What makes the critical difference is not the matter, not the energy, necessary though these are; what makes the critical difference is the information breakthrough.

Afterwards, as before, there are no causal gaps from the viewpoint of physicist or chemist, but there is something more: novel information that makes possible the achievement of increasing order, maintained out of the disorder. The same energy budget can be put to very different historical uses, depending on the information in the system. Motoo Kimura estimates that the evolution of higher organisms has accumulated genetic information from the Cambrian to the present at an average rate of 0.29 bits per generation.¹⁷ Thus there is spun the negentropic story of life. If in natural history we define "progress as increase in the ability to gather and process information about the environment,"¹⁸ then, again and again, evolution produces phenomena that rise above the former levels with breakthroughs in achievement and power. The secret of that information, from the perspective of biology, is the genetic process.

Is that all that there is to be said? Yes, by biologists, perhaps; but no, say the theologians who detect God in, with, and under this dramatic informing of the life story. Loren Eiseley straddles the two fields: "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'."¹⁹ "Nature is one vast miracle transcending the reality of night and nothingness."²⁰

Ernst Mayr, one of the most knowledgeable biologists of our century, and no particular friend of orthodox religion, 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."²¹ We sense something sublime, something that takes us to the limits of our understanding and mysteriously beyond. Science studies the phenomena; but the phenomena prove increasingly phenomenal. The secular world proves to be spectacular stuff. Perhaps we have lost our confidence in the supernatural, only to find it replaced by increasing confidence that nature is super, superb, mysteriously animated, and enspirited.

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. But neither is it 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 whether the phenomena of natural history are a response to the brooding winds of the Spirit moving over the face of these earthly waters. The phenomena could be revealing the noumena.

The miraculous is not the punctuation of natural order with supernatural intent, God sneaking into the causal gaps. The miraculous is the more-out-of-less that the coupling of natural order with disorder generates, with nature wonderfully, surprisingly, regularly breaking through to new formations because there is new information emergent in the life codings. These achievements are, if you like, fully natural—they are not unnatural; they do not violate nature. But they also are new achievements of discovery and power. Something higher is reached, and in that sense there is something "super" to the precedents, something superimposed, supervening on what went before; there is more where once there was less, something "super" to the previously natural.

There is creativity, genesis, about which these biologists find it difficult not to be religious, whether they are monotheists or not; and monotheists can detect here the divine superintendence without violating the natural processes. There is autonomy in the natural processes; the creatures are what they are in their own self-actualizing, yet surprisingly, too, there is an informing of them that lifts them to new emergents of performance. Sometimes, when we find what looks like contingency, God is not so much eliminated as called for, and especially so if the cumulative contingencies, coupled with the marvelous endowments and possibilities of matter, issue in a superb story. If we define a miracle as a wondrous event without sufficient natural causes, as 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.

Without denying that the secret of life lies in the DNA, theists may also say that the secret of life lies in the breath of YHWH animating and informing the dust, conserving life in the midst of its perpetual perishing, and lifting it to self-transcendence. This cannot be "fine-tuned" without violating the creaturely autonomy, but must be finely

detected in the vitalities that, over the millennia, spin such a story on this home planet. 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 trilobites), 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 statistical regression line (a progression line!) drawn from procaryotes to trilobites. There are no human beings 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, sinners, and saints—and the drama may prove enough to justify it.

Where is God in the story? God is the historian, the author who informs the action, slipping information into the world, making the improbable probable, converting contingency into destiny. Along these lines, the dialogue between biology and theology faces a promising future. No doubt there will be surprises in biology in the next century, but it would be even more surprising if these discounted the critical role that information plays in both molecular and evolutionary biology, and also surprising if this increasingly cognitive account of biology were wholly uncongenial to theology.

When those in the nineteenth century tried to relate physics and theology, they sometimes failed because the theology was inadequate. The present conflict is also, in part, because classical theology is inadequate. But the nineteenth century reconcilers had more than a theological problem; in the twentieth century we, learned that the physics then was not ready either. Perhaps today the biology is not ready. Is there any unity in historical biology, any "arrow of evolutionary time"? John Maynard Smith, one of the most eminent theoretical biologists, frankly says, "I do not think that biology has at present anything very profound to say about this."²² The full story in natural history remains to be told. When it is, I predict that it will be more congenial with theology, provided that theology, too, is sufficiently resilient. We do not expect biology [B] to imply God [G]: If B, then G. Nor God to imply biology: If G, then B. But we hardly have an unequivocally plausible account yet of their consonance.

Such an account of God's agency, made for the biological sciences, is readily consistent with an account made for the human culture, where again God is the one who informs the history, though now, as we have noted, the transfer of information is no longer merely genetic, because critical determinants are ideological. The drama shifts to forming and reforming human intelligence, with its dramatic possibilities for good and evil in the building of cultures, more or less humane, more or less godly. This intelligence has to be coupled with goodwill. God appears now, not so much as manipulator of the causal processes, as inspiration for meaningful human existence. In the subjectivity of existential presence, in *Existenz*, the coding is not so much in the genes as in religious codes, in the scriptures and creeds that have been so pivotal in our transmissible culture. Now too the information breakthroughs, the revelations, are moral,

appropriately for this moral species, *Homo sapiens*, whose members are called to live together wisely—as their specific epithet claims. This takes us from theory to practice.

II. WHAT OUGHT WE TO DO? SCIENCE AND RELIGION IN ETHICS AND PRACTICE

Science, Conscience, and Values

Science increasingly finds itself facing the philosophical truth that, for all our advances in culture, scientific and modern though these may be, the value problems remain as acute as ever. In 1993, George Brown, Jr., Democrat from California, the influential chair in the United States Congress of the Science, Space, and Technology Committee, addressed the annual American Academy of Science and Technology Policy Colloquium:

Global leadership in science and technology has not translated into leadership in infant health, life expectancy, rates of literacy, equality of opportunity, productivity of workers, or efficiency of resource consumption. Neither has it overcome failing education systems, decaying cities, environmental degradation, unaffordable health care, and the largest national debt in history.... Basic human needs—elemental needs—are intrinsically different from other material needs because they can be satisfied. Other needs appear to be insatiable, as the consumption patterns of the United States clearly demonstrate. . . . Once basic human needs are met, satisfaction with our lives cannot be said to depend on the amount of things we acquire, use, and consume. . . . More technology-based economic growth is not necessary to satisfy humanity's elemental needs, nor does more growth quench our thirst for consumption. In terms of the social contract, we justify more growth because it is supposedly the most efficient way to spread economic opportunity and social well-being. I am suggesting that this reasoning is simplistic and often specious.²³

The soaring consumption in a consumer society is a doubtful blessing. Surveys in our modern age—an age that can even proudly proclaim itself to be heading into the postmodern age—do not reveal any increasing happiness or sense of well-being.²⁴ We are putting science in the service of satisfying desires on an ever-accelerating treadmill, without being sufficiently critical of those desires; and, unsurprisingly for the theologians, we find science an uncertain savior. The problem is an information gap again; science tells us how to get what we want, and yet does not provide the information, much less the resolution and goodwill, necessary for high-quality living, for what, in Christianity, has been called the abundant life. Science is a means, but not an end for either conscience or values.

JUSTICE FOR ALL

Not only has a science-based technology failed to solve the deeper problems of developed nations, but a larger problem looms globally. There are about five billion persons

in the world. Approximately one-fifth, those in the developed nations, produce and consume about four-fifths of the material goods that a science-based industry provides; about four-fifths of the world divide the remaining one-fifth of the wealth, and about half of these live in poverty." There are more poor persons today than ever before; there will be yet more in decades ahead. For every person added to the population of the developed nations, twenty individuals are added in the less developed ones. For every dollar of economic growth per person in the one, twenty dollars accrue to each individual in the other. Of the ninety million new people on Earth this year, eighty-five million will appear in the Third World, the countries least able to support them. Meanwhile, the five million new people in the industrial countries will put as much strain on the natural resources and cause as much environmental degradation as the eighty-five million new poor.

There are three problems: overpopulation, overconsumption, and underdistribution. The reasons for these outcomes are complex, but whatever justifications one finds for this maldistribution of wealth, the outcome hardly seems either just or loving. There is a first tendency to say that the problem is that too many of the Earth's peoples are unblessed by the fruits of science and technology; what we need is to teach everyone how to produce up to Western standards. The distribution pattern reflects achievement; what the other nations need to do is to imitate this.

But one soon sees that we simply cannot have five billion persons—projected to be twelve billion persons in the next century—all consuming at the escalating, all-American rates that Congressman Brown finds so insatiable, even if we could distribute the world's produce equitably. Teaching everyone how to be an escalating consumer is absurd. That ought not to be the next chapter in the story we are writing. Worse, that illusory promise only hides how much the existing distribution patterns reflect exploitation, callousness, self-aggrandizement, and greed. The poor regularly come off poorly when they bargain with the rich; and wealth that originates as impressive achievement can further accumulate through exploitation. Much, even most, of the answer has to lie in sharing as well as producing, if there is to be an ethic of either justice or love.

To solve this problem, science is necessary, since providing for human needs in the next century without science and technology is unthinkable, but science is not sufficient without conscience that shapes the uses to which science is put, informing policy. Science and religion must face together the impending disaster of today's trends projected cumulatively into tomorrow: population explosion, dwindling food supply, climate change, soil erosion and drought, deforestation, desertification, declining reserves of fossil fuels and other natural resources, toxic wastes, the growing gap between concentrated wealth and increasing poverty, and the militarism, nationalism, and industrialism that seek to keep the systems of exploitation in place. Few problems or none loom more foreboding on the horizon than these, and I predict that these value problems are likely to become more acute than ever in the coming century.

Religion has been the classical informer of conscience, and still remains a powerful force in moral life. Ethics can be autonomous—independent of religion—but such ethical systems have not yet proved themselves capable of shaping cultural reformations over generations. Here the religious ideologies do persist over changing science. It is much safer to predict that the Golden Rule will be an imperative in ethics a century hence than it is to predict that cosmology will continue to affirm a Big Bang with an inflationary period in the first few nanoseconds. It is also, alas, much safer to predict that the seven deadly sins will still be present a century hence, with human life needing to be redeemed from these sins, than that biologists will be emphasizing the contingency in natural history over against a tendency for increased complexity over evolutionary time. Whether the Golden Rule or covetousness will have done more to shape the future is not safe to predict; that outcome depends, in significant part, on the extent of the dialogue between science and religion.

A critic may demur that science has been productive and beneficial enough, spectacularly so, and that it is too much to expect science to redeem humanity from all its failures. Yes, but these failures, rather than faulting science or scientists, do reveal what science is incompetent to do. They reveal science as a human institution. They reveal not so much what science should do, but what religion must do, complementing science. Religion continues to occupy this critical role, along with the other humanities, for science has the same need for evaluation as do all other human activities, including religion. A century hence, we will still be needing God's agency in the world, informing and inspiring the courses of history to make and keep life human.

The same critic may next object that religion is no more competent than science to deal with these immense problems of good and evil. That also may be true, though religion has always claimed whatever successes it has had in the midst of another claim about a perpetual human brokenness. Saints there sometimes are; frequently there are persons struggling to be redeemed from evil, with limited successes; and always there is original sin—order and disorder again, but now at the moral levels. Religion knows that human beings are warped by ambiguity, by the evil that besets their loftiest aspirations toward the good. When human beings emerge out of natural history into culture, we emerge into, and fall into, a process that contains the seeds of its own destruction. We rise to a vision of the good that has evil as its shadow side. We rise to the possibility of being children of God, in love, justice, and freedom, at the same time as we fall into being demonic, in arrogance, in lust, in bondage to sin.

Both scientific rationality and would-be morality, unredeemed from self-love, will prove dysfunctional. This is the value crisis again, taken to a new level. The prophetic genius of Israel is epitomized in the admonition "to do justice, and to love kindness, and to walk humbly with your God."²⁶ That loving of God and neighbor is a basic human commandment, likely to remain the secret of whatever abundant life is attained in the centuries hence. Science in the service of concupiscent human nature is likely to prove tragic, as much in the twenty-first century as in the twentieth.

Caring for Others

There is a rising and revealing critique of science, one that is likely to prove still more forceful in the decades ahead. Science presents itself as detached and objective, capable of describing the world as it is in itself. That first seems plausible; indeed it is somewhat plausible. After all, the claims of physics about the Big Bang and the expanding universe, or those of biology about evolutionary history, are claims about what once took place on Earth, long before human beings arrived. The genetic coding in the DNA and the protein synthesis by which organisms are produced and maintained, the food chains in ecosystems, the adapted fitness of organisms, their capacities for coping as they make a way through the world—all these seem to be descriptive claims. Science seems to have its independent authority warranting these claims.

But look more deeply. Science is the quest for knowledge, and knowledge is power. Even pure science is driven by a desire to understand, and that, *ipso facto*, is a desire to conquer, seldom pure. The fundamental posture of science is one of analysis, the discovery of laws and generalizations, theory with implications, prediction, testability, repeatability. One wants better probes, better techniques, higher-resolution detectors, more computing power. This always invites control; but more than that, this very approach to nature is driven by the desire to control. The underlying premise of all scientific logic is mastery; and with that insight, the claims to detachment, objectivity, and independence take on a different color. Allegedly objective science is inevitably bent, sooner or later, into the service of technology, and such scientific knowledge coupled with technological power is neither detached nor objective. Willy-nilly, such information will be put to use for some better or worse ends. Thus relativity theory is used to make nuclear weapons; the human genome, mapped, invites first medical therapy and later genetic engineering. Such utility is not simply an outcome of science, it underruns its worldview.

The unavoidable question is: What do scientists care about? What do those to whom their science becomes available care about? This is the value question again, now probing the logic of science and worried about its zest for mastery, fearful lest this become a lust for mastery. This sees not only the outcome but the presumption of science in the escalating consumerism of the First World and in the disproportionately distributed wealth between First and Third Worlds, or, as we will increasingly say, between North and South. These are symptoms of a fundamentally misplaced caring. Science is the product of white Western men, lament the feminists, out to dominate nature, and ready enough to colonize elsewhere and harvest whatever resources they can wherever they can, to build machines of industry and of war, to dominate other peoples and races, having long since dominated their own women.²⁷

The scientist, to be sure, when moving from pure to applied science, pretends to care; the benefits of science in the service of human beings are preached incessantly. No doubt such benefits are often realizable; but it is equally certain that science with-

out critical caring for others has produced the present crisis. And caring for others—loving one's neighbor—is the central claim in religious ethics. Science is not religion. Religion cannot suggest the content of any science, but religion can notice the forms into which such content is being poured; it can also defend a content of its own. One can do science without adverting to theology, but one cannot live by science alone. Indeed, science cannot teach us what we most need to know—that about which we should most care. In that sense, science is not independent. There is an information gap, this time not in the causal chains of science, but in the very logic of science itself. More computing power is not likely to give us the information we need here. There are no algorithms for good and evil. All this suggests that the dialogue between science and religion is likely to continue. There will be a humane future only if we can integrate the two.

Saving the Earth

Science and religion have their differences of outlook and interpretation; and we earlier said that dialogue between the two has of late been more problematic in biology than in physics. We hoped for more congenial relations in the future, as biological theory is further developed. But we are already seeing one comprehensive area where, primarily in practice and not without implications for a concept of nature, science and religion are increasingly partners. That is in concern for biological conservation, for the well-being of the biosphere. Though biologists are often uncertain whether life arrived on Earth by divine intention, they are almost unanimous in their respect for life, and seek biological conservation on an endangered planet. That concern for saving the Earth is certain to increase, with considerable promise for dialogue between theology and biology.

Biology is earthbound, so far as we know. This is the only home planet, the only planet with an ecology, on which there has been an evolutionary natural history. And what are we to anticipate for the future of this quite special planet? Earlier, future salvation might have been couched largely as the question of heaven, or as the hope for an *eschaton* launched by divine intervention; and the question might have been whether science permits such heaven and hope. Those questions are still relevant. But the question of salvation has become earthy. Nature and the future of nature, and the future of human cultures in entwined destiny with natural systems—that is increasingly not only a scientific but also a religious assignment. Our escalating human desires, coupled in this century with more power than ever before to transform the Earth, have put nature at risk.

For perhaps two hundred thousand years, the human brain and hand have produced cultures superposed on natural systems—cultures broken and failed enough in the midst of their glories. Meanwhile, diverse combinations of nature and culture have worked well enough for nature to continue over many millennia. But no more. As we face the next century, our modern cultures threaten the stability, beauty, and integrity

of Earth, and thereby of the cultures superposed on Earth. In the same century when we gained the vision of one world, symbolized by photographs of Earth from space, we also came to fear the shadow of none, first as a nuclear threat, now the threat of environmental tragedy, an outcome more probable than ever was the nuclear threat (which itself still looms). As a result of human failings, nature is at more peril today than at any time in the last two and a half billion years. The sun will rise tomorrow, because it rose yesterday and the day before; but nature may no longer be there. Unless in the next millennium, indeed in the next century, we can regulate and control the escalating human devastation of our planet, we may face the end of nature as it has hitherto been known.

Several billion years worth of creative toil, several million species of teeming life, have now been handed over to the care of this late-coming species in which mind has flowered and morals have emerged. Science has revealed to us this glorious natural history; and religion invites us to be stewards of it. That could be a glorious future story. But the sole moral and allegedly wise species has so far been able to do little more than use this science to convert whatever we can into resources for our own self-interested and escalating consumption, and we have done even that with great inequity between persons. There is something perverse about an ethic, practiced sometimes in the name of religion, sometimes in the name of science, and often both, that regards the welfare of only one of Earth's several million species as an object and beneficiary of duty.

Justice and love—those are thought to belong to an interhuman ethics. But when we ask about appropriate caring, the boundaries enlarge to the whole community of life on Earth. Care for human beings we must, and religions have been an inspiration for that appropriate care. But caring only for human beings will increasingly be replaced by caring for human beings as residents in a larger biotic community. Our responsibility to Earth might be thought the most remote of our responsibilities; it seems so grandiose and vague beside our concrete responsibilities to our children or next-door neighbors. But not so: it is the most fundamental, the most comprehensive of our responsibilities. The next five hundred years of science and technology cannot be like the last five hundred years, indeed the next century cannot be like the last. And, though recent and novel on global scales, the future imperative recalls the first commandment: to till the garden earth and keep it.

This is the Earth in which we live and move and have our being, and we owe this Earth system the highest allegiance of which we are capable, under God, in whom also we live and move and have our being. Biologists, again, may not share the monotheism, but they are coming to share the concern for the Earth. When they do, the mentality of dominance in science, about which we have worried, can itself become regenerated, and science put in the service of responsible care for this only home planet. Scientists, as much as anyone else, theologians included, wish for a sustainable harmony between human beings and this very special planet. That bodes well for increasingly congenial relations between biology and theology.

III. WHERE ARE WE GOING? SCIENCE AND RELIGION IN THE FUTURE

My projections, then, are that astrophysical cosmology will remain reasonably congenial with theology and that, on Earth, the dialogue between religion and biology will grow more subtle, with an increasing understanding of the relationship between order and disorder and of the historical character of the evolutionary genesis, with information transmission and breakthrough a critical determinant of that history. The agency of God may be to fine-tune the astrophysics and the microphysics, an aboriginal creative forming, but the agency of God is to superintend by informing an earthbound, autonomous biology, where possibilities become actual in a perennial struggling through to something higher.

The radical differences between nature and culture, if not already evident, will become yet more evident as the speed of cultural innovation increases. In the more recent centuries, and in the most recent decades of this century, information has accumulated and traveled in culture at logarithmically increasing speeds. The pace of the story steps up, and now, as we turn from the long evolutionary and cultural past to face the future, there is a certain feeling that the pace of the action is accelerating, both with excitement and danger. The computer revolution exemplifies this, with its dramatic capacities for extending human computational power, for information storage and processing, for long-distance communication and networking. Discoveries in physics and chemistry let us in on how the world was made. Discoveries in the bio-sciences—mapping, for instance, the human genome, with the further possibilities of genetic engineering—offer us the possibility of remaking the world. We human beings are also agents, powerful agents.

We seem to have reached a turning point in the long, accumulating story of cognition actualizing itself. We are now coming around to oversee the world and to face the prospect of our own self-engineering, to the genesis of a higher-level ordering of the world in the midst of its threatening disorder. Increasingly we are like gods. But we need the wisdom of God, and that programs poorly on computers, and is not found in physics, chemistry, or biology textbooks. There is an information gap about good and evil.

So my projection is also that ethically and axiologically there lie crises ahead, not for the lack of science but for the lack of wisdom, a wisdom that only religion in the broad sense can supply—worldviews that orient us philosophically and that can redeem our human nature from its perennial failings. The need for justice, for love, for caring will remain undiminished, and science will need conscience in the next century more than ever before. What on Earth are we doing? There is no figuring that out without both science and religion; there is no doing it right without integration of the two,

Science seeks to understand the world, and that understanding, we have hoped and feared, is in order to change it. We certainly must recognize the underlying agenda of science in the context of larger social and psychological forces. But pure understanding is one of the glories of being human, and science and religion in integrated

understanding are godly indeed. Here, too much emphasis on the pragmatic utility of science is increasingly likely to obscure the most genuine reason for doing it, which lies in the joy of, and human need for inquiry into the nature of things. At this point science does need religion to keep science humane, not only in the pragmatic sense but in the principled and deeply metaphysical sense of keeping science meaningful. Among the humanities, religion pushes science toward questions of ultimacy, as well as of value, and it can keep science from being blinkered, or, more elegantly put, religion can keep science deep. That is why there now is, and always will be, room after science for religious conviction.

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