Reviews

The Advancement of Science: Science without Legend, Objectivity without Illusions. By PHILIP KITCHER. Oxford: Oxford Univ. Press, 1993. 421 pages. $18.95.

"Once, in those dear dead days, almost but not quite beyond recall, there was a view of science that commanded widespread popular and academic assent" (p. 3). It regarded science as providing a strictly rational method for the accumulation of truth and saw its history as the unfolding fulfillment of that promise. Philip Kitcher calls this account Legend. In the 1960s the critiques of Paul Feyerabend, Thomas Kuhn, and others struck at the heart of Legend, reducing it to a state of morbidity and in its place encouraging irrationalist evaluations of the scientific endeavor. Kitcher proposes to reswing the pendulum, not back to Legendary claims, but far enough to maintain that science progresses and that it gives us accounts of the physical world containing reliable items of truth.

There are two key elements in his strategy. One is the insistence that "every epistemology needs a psychology" (p. 65). One should think, not about science, but about scientists and remember that "science is not done by logically omniscient lone observers but by biological systems with certain kinds of capacities and limitations" (p. 59). (I would have wanted to go further and say, with Michael Polanyi, that it is done by persons.) This leads to a celebration of variety. Without going to Feyerabend's extreme of asserting that "Anything goes," one should not desire a community of scientists who all think in the same way. Unorthodox lines of inquiry can sometimes prove the right way ahead; too great a deference to authority can be stultifying. Hence nonepistemic goals, such as a desire for the bubble "reputation," can lead scientists into making epistemic gains. "Particular kinds of social arrangements make good epistemic use of the grubbiest motives" (p. 305).

Kitcher's second key strategy is to refuse to be browbeaten into accepting a total "package deal" account of scientific understanding. He uses a detailed analysis of the phlogiston controversy to demonstrate that there are various possible modes of reference ("Theory-laden terms have heterogeneous reference potentials" [p. 103]) and also that Priestley could make important true discoveries while being mistaken about phlogiston. In relation to the latter point, an important idea is that there are "idle" components of past understandings that play no active role in relation to particular true discoveries. Augustin Fresnel's brilliant theoretical prediction and experimental discovery of the bright spot at the center of a spherical shadow was not vitiated by the fact that he believed the waves whose behavior he was discussing to be oscillations in the lumeniferous ether.

This leads to an acceptable and realistic account of piecemeal progress. Bit by bit, our knowledge improves. "The seeming growth of our understanding . . . is,

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I believe, partly captured by the presence in later practices of an increasing number of stable reports of phenomena, with the rate of increase greatly outstripping the rate of revision" (p. 51). Atoms have come to stay! Kitcher defines and discusses a number of kinds of scientific progress: organizational, conceptual, explanatory, and erotetic (the last a favorite word meaning "having the ability to ask fruitful questions").

At least as important as truth for Kitcher is the question of significance. After all, there are a lot of awfully boring facts (I am wearing a red tie today). In accordance with his humble, rather than grandiose, account of scientific progress, this significance often will relate to the answering of specific tractable questions rather than settling issues of great theoretical generality.

These considerations lead Kitcher to what he calls the Compromise Model (pp. 200ff.), which does not deny the presence of irrational elements in scientific activity but allows for the conclusion that eventually cognitive progress emerges from the struggle. He claims that the recognition that our representations of the world depend upon our chosen theoretical stance does not imply that the world itself is theory dependent or that we cannot gain knowledge of it. Common sense should encourage us. "The correspondence theory of truth is often held to involve extravagant metaphysics but, I claim, its roots lie in our everyday practices" (p. 130). Social forces may accelerate or retard scientific progress, but they do not determine its character. "Competitive and cooperative situations, as we have seen, call for refined judgements about the merits of methods or proposals for modifying practice. Thus we can say that a simple view of science as driven by 'external' or 'social' factors would create a vacuum *into which epistemic considerations would have to be introduced to explain how the social factors obtain their purchase on the individual acts*" (pp. 388–89). We cannot do without the nudge of nature.

The feature of Kitcher's discussion that gave me greatest unease is his appeal to "eliminative induction" (pp. 244–45). Does entity A possess property P universally? You list all the factors $F_1 \ldots F_n$ that you think might affect the presence of P. If particular A's that individually and severally have factors $F_1 \ldots F_n$ all turn out to have property P, you conclude all A's whatsoever have P. This strategy depends in a most precarious way on our ability to make an adequate list of Fs. It seems to me that induction is both more mysterious than that and also a capacity actually possessed by human persons.

Many interesting issues are raised and discussed in this book. A great deal of it is written in the minutely careful prose of philosophy-speak, which does not make for easy reading by the general reader. Kitcher has a penchant for the kind of schematic discourse of which the preceding paragraph is an elementary specimen. His examples from the history of science center on the work of Lavoisier and Darwin. The discussion is detailed, but the events of 1772–77 and 1859 can be only partially illustrative of the practice of modern science. Nevertheless, the book is one that is well worth the effort of reading and that offers philosophical support for positions congenial to the actual practitioners of science.

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Steps toward Life: A Perspective on Evolution. By MANFRED EIGEN, with RUTHILD WINKLER-OSWATITSCH. Translated by PAUL WOOLLEY. Oxford: Oxford Univ. Press, 1992. 173 pages. $29.95.

In this slim volume, Manfred Eigen, director of the Max Planck Institute for Biophysical Chemistry in Göttingen and winner of the 1967 Nobel Prize in chemistry, sets out his views on the biochemical origins of life. This tightly reasoned and eloquently written book explores the key chemical steps surrounding the transition from nonlife to life, emphasizing the first appearance of information-containing molecules and their reproduction in protocells. By balancing rigorous scientific results with thoughtful speculations, Eigen has written a book that should be read by specialists and nonspecialists alike.

The organization of the book is unusual and works very well. Part 1 (the first fifty pages) is a coherent essay on the origins of life, divided into nine sections. Each section begins with a quote from Thomas Mann's *The Magic Mountain* (London: Penguin Modern Classics, 1928), a novel that was remarkably prescient in its reflections on the emergence of biology from chemistry. Part 2 (the following seventy pages) is a series of fifteen vignettes from molecular biology, each referred to at the appropriate points in part 1 and connected to each other as well. These clearly written summaries of key scientific topics such as nucleic acids, proteins, quasi species, sequence space, and virology are illustrated by beautiful color diagrams. They provide one of the simplest and most accessible introductions to molecular biology that I have seen anywhere. Finally, part 3 contains a brief resume of part 1, a series of footnotes to the text that present a rather complete set of references on the historical development of molecular biology, and a glossary of terms. As a scientist but nonspecialist in molecular biology, I found it most helpful to read part 2 first; this gave me a solid background for reading part 1 straight through. Specialists in the field might start with part 1 and review only certain portions of part 2. Even nonscientists should grapple with the topics discussed in part 2, however. These range from mathematical analysis of nucleic acid sequences to the mode of operation of the HIV virus and present an exhilarating tour through the forefronts of research.

As Eigen points out, "the genes found today cannot have arisen randomly, as it were by the throw of a dice" (p. 11). The goal of his book is to show how basic physical and chemical principles permitted their evolution in the short 4 to 5 billion years since the formation of the earth. Although the actual first steps toward life are lost, perhaps forever, in the distance of the prebiotic soup, observations on how species change and how the genes of one species relate to those of another permit a plausible reconstruction of the earliest forms of life. A central concept in this development is the quasi species, introduced to molecular biology by Eigen's own research. A population of influenza viruses or of *E. coli* bacteria does not evolve toward a single genetic makeup. There is a "consensus" gene sequence that represents the most common nucleic acid at each point along the gene, but typically most or all of the individuals in a species will show random differences (mutations) from that sequence at one or many points. The target of evolution is not a single optimized sequence but sequences distributed broadly or narrowly about the average. Eigen shows that such quasi species are much better

able than hypothetical pure species to explore the available sequence space through evolution, finding an improved consensus sequence (one that is able to reproduce itself more rapidly) or responding to changes in the environment. In this, Eigen's approach moves beyond both the original Darwinian program and the neo-Darwinian idea that there is "an alternation between mutation (= chance) and deterministic selection of the superior mutant (= necessity)" (p. 27). Because the reproductive value of the full quasi species is being tested, much more efficient exploration of sequence space is possible. "Quite at odds with the classical interpretation, the process of evolution is steered in the direction of the optimal value peak, and . . . this steering process is extraordinarily effective. The (quantitative) acceleration of evolution that this brings about is so great that it appears to the biologist as a surprising new *quality*, an apparent ability of selection to 'see ahead,' something that would be viewed by classical Darwinians as the purest heresy!" (p. 125).

Eigen sees virology as a key to understanding evolution. Viruses are simpler than evolved organisms or even than single-cell species and rely on other species to help them reproduce. "[Viruses] stand right at the border between the living and the non-living, and this makes them especially suitable as models for the earlier stages of evolution" (p. 101). Naturally occurring viruses mutate quite rapidly; Eigen gives an example of changes in gene sequences from samples of the influenza virus isolated from 1933 to 1985. Even more important, virus cultures can be incubated in the laboratory and their mutations studied experimentally. Both experiments and computer simulations have revealed the role of the "error rate" in evolution, the rate at which mutations occur during reproduction. When this passes a critical value (the error threshold), information is essentially lost during reproduction, and the genetic composition is randomized; when the error rate is very low, the genetic composition is almost constant. A species such as a virus is most effective at responding to changes in its environment if the error rate is slightly below the threshold. The more complex the species (the larger its genome), the lower the threshold must be to preserve the species. There is thus a trade-off in that more complex, specialized species are less able to respond quickly to changes via mutation.

In his research and in this book, Eigen has emphasized two central concepts: hypercycles and compartments. A hypercycle represents a reaction model in which several components (genes or gene sequences) cooperate though nonlinear feedback loops to promote each other's replication. Each advantage gained by one component contributes to the advantage of the others, and because the effect is quadratic (nonlinear), the selection is sharpened. Each component of the hypercycle can operate at a higher error rate than would be permitted if all the functions were combined in a single gene; this promotes flexibility and allows for rapid change. The second concept, the compartment, is equally important to Eigen's reasoning. A compartment can range from a sharply defined lipid vesicle to an open neighborhood with restricted diffusion away. Enclosure reduces the effects of dilution and allows selection to operate on the level of a set of genes rather than on single genes.

The focus in this book is on the mechanism by which very simple self-reproducing species containing only a few genes (comparable in size to viruses) evolve.

Both the earlier and later stages of evolution are touched on only briefly. In particular, the process by which nucleic acids and proteins formed on the early earth and linked together in the first biopolymers is passed over. The reference to the 1954 Miller-Urey experiments (in which amino acids were formed from simple inorganic starting materials) in this connection is not adequate, because scientists now believe that the composition of the atmosphere was quite different from that employed in those experiments. Christian de Duve has grappled with these early stages in his book *Blueprint for a Cell* (Burlington, N.C.: Neil Patterson, 1991); Eigen here avoids some difficult issues. Likewise, the later stages of biochemical evolution (leading to eucaryote cells and replication via sexual reproduction) are only mentioned, although there is an interesting comment on the relation between sex and death: with the transition from vegetative reproduction (splitting of cells) to sexual reproduction (recombination of genes from two parents), "the ageing and death of the individual became so advantageous for the development of the species that they became an integral part of the evolutionary process" (p. 46).

In the epilogue to the book, Eigen makes a sharp distinction between science and religion, stating that "religious experience is based upon faith and thus possesses the independence that characterizes subjectivity. In this respect, it differs fundamentally from scientific knowledge" (p. 127). Eigen's view is that science and religion are not in conflict but rather are essentially unconnected to one another: in his words, "two incommensurable projections" (p. 127). In spite of this somewhat limited and even naive view of the science-religion dialogue, this book has much to say beyond its clear explication of scientific results, and it connects at many points to questions of central importance to religion. One issue that recurs frequently is the role of chance and necessity: to what extent is the appearance of life on earth a random, historical accident as opposed to being the product of the working out of established physical principles? Here Eigen comes down squarely in favor of the latter hypothesis. Although he recognizes the role of mutation in evolution, such random individual events are part of a greater process that generates complexity in open systems away from equilibrium. In the preface he stresses the opposition of his view to that of Jacques Monod, who in his book *Chance and Necessity* (New York: Knopf, 1971) pictures life as "pure creation from the nothingness of chance, not the revelation of a plan embodied in natural law" (Eigen's words, p. vi). Eigen also writes profoundly about the continuing process of creation and the imperative that it implies for humanity. He concludes part 1 with the words, "Man is still a relative newcomer to the planet Earth, and the creation of humanity has only just begun."

Steps toward Life is a thought-provoking and influential book. It is full of felicitous phrases and analogies and metaphors that bring bare scientific concepts to life. One memorable example of the latter is Eigen's analogy between genetic information and a Mozart symphony: "The persistence with which a Mozart symphony reappears in our concert programmes is solely a consequence of its high selection value. In order for this to retain its effect, the work must be played again and again, the public must take notice of it, and it must be continually re-evaluated in competition with other compositions. Stability of genetic information has similar causes" (p. 15). Eigen's book rewards close study; like the

autocatalytic feedback loops that he describes, this book makes one want to begin part 1 again as soon as the epilogue is reached. It is required reading for anyone interested in the biochemical origins of life.

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The Religious Critic in American Culture. By WILLIAM DEAN. Albany: State Univ. of New York Press, 1994. xxiii + 256 pages. $49.50.

William Dean has written an important book. It is important both in its analysis and proposals and also in its timing. There is a real chance it will have a significant effect on the self-understanding of scholars in the field of religion and perhaps in other fields as well.

Dean, like many others, is deeply troubled about the condition of American public life. Having lost its "exceptionalist" myth, it has no master story at all. The religious intellectuals, who should understand this problem, are failing to address it in large part because the ethos of the university separates them from society. The culture of the university encourages scholars to address one another within their disciplines rather than to deal with national needs.

The call to escape narrow disciplinary limits should strike a positive note for readers of this interdisciplinary journal. The book draws on many fields, including the natural sciences. Nevertheless, the call goes beyond overcoming the boundaries between university departments and for entering the public discussion in ways that need the attention of *Zygon* readers too.

The book gives the impression that scholars of religion have as their primary responsibility engaging the religious situation in this country. Dean is not speaking primarily of examining what is going on in churches, synagogues, and other religious institutions. Rather, it is what we used to call civil religion that most interests him.

Dean's concern to overcome the fragmentation of American public life through renewal of a common story is controversial. As Dean knows well, many groups for whom all the past stories have been repressive are now gaining a voice. It is hard to imagine a new common story that would be truly open to the whole multiplicity of voices unless it is the story of how the many are working to live together as one. This could acknowledge that the more appropriate master stories are not those of nations but of deeper traditions and that the task of the nation is to find a way that these master stories can share in shaping a national life that does not have an independent religious quality.

Dean argues that rather than trying to change the university to make it more hospitable to engaged thinking, it is better for those teaching in universities to involved themselves with other third-sector institutions devoted to the common good. They provide a base and context for reflection lacking in the university.

This is the burden of parts 1 and 4, "Abandoning American Culture" and "Reclaiming American Culture." Between these two parts, Dean develops his own religious position under the headings "Recovering Religious Theory" and

"Grounding Religious Theory." Here he argues for a religious naturalism that takes account of the critical teaching of poststructuralism, so influential in the current university, without allowing the resultant relativism to undercut pragmatic involvement in society.

Against poststructuralism Dean calls for the inclusion of nature within the horizon of this religious theory. American civil religion has done this, as have the pragmatic and naturalist traditions to which he appeals. He finds developments at the cutting edge of the sciences that fit well with his understanding of human society.

His major emphasis in these sections is on "convention" as a way of understanding religion. Conventions arise historically and are therefore relative to the societies that produce them. But they are not the projections of individuals. In relation to individuals, and indeed to the whole of a society, they have quite objective power. They are subject to change, and religious intellectuals should lead in changing them. But they cannot be destroyed and created at will. Many of the same points have been made by others in discussing traditions, but Dean's approach is fresh and creative.

Although Dean's emphasis is on the constructed character of conventions, he recognizes that they develop in the interaction of a community with its past and with its environment. Thus there is an objective element in conventions other than their social power. The givenness of the past and the environment constrain them, although the past and the environment certainly do not determine their exact form.

God is part of the convention of American civil religion. Hence, Dean believes that religious intellectuals should deal seriously with God as an objective factor in the American situation. Here he takes a position between those who affirm God as transcendent of human thought and language and those who construct a religious language that leaves God out or systematically denies God. Both groups will need to take his challenge seriously.

Although Dean's formulation strongly emphasizes the historicist dimension of the "God" conventions, his formulations are open to some features of the whole of reality to which the convention refers. He speaks, for example, of a "tropism toward complexity" (p. 149). He certainly is correct that this feature of the whole is interpreted and reinterpreted historically in ways that justify a strong emphasis on historicism and relativism. On the other hand, he is wrong when he so strongly opposes the effort to correct and modify reflection about God through further analysis of this tropism. That approach he rejects as metaphysical, and he has nothing positive to say about metaphysics. He seems to assume, wrongly, that such metaphysical speculation is necessarily in antithesis to historicism.

Although Dean appeals to the traditions of American civil religion to support his conventionalist doctrine of God, he appeals against them in his passionate insistence that God is morally ambiguous. His argument here is not always clear, but it seems to be primarily that if God is not morally ambiguous, God must be separate from history, which *is* morally ambiguous through and through. Since for Dean attention to anything outside history (nature being included in history) detracts from the role of the religious intellectual, that intellectual should abjure any such doctrine.

That in fact the belief that God is transcendent as well as immanent has usually functioned in this way is not, and cannot be, shown. One suspects that Dean's animus toward metaphysics is more responsible for his position here than the pragmatic arguments he offers. He devotes little attention to the pragmatic dangers involved in worshiping and modeling human life upon a morally ambiguous God. There also is some question as to whether, for those who hold to some transcendence of God over history, the term *moral* has clear application to God at all.

The organization of the book leaves the impression that to serve the role of being a religious critic in American culture one should agree in some detail with Dean's theories about religion and about God. This is unfortunate. Parts 1 and 4 can be fully convincing to those who disagree in one way or another with the highly controversial positions taken in parts 2 and 3. These are eminently worthy of consideration and debate among religious intellectuals but not as a precondition of functioning as religious critics.

On the other hand, the provocative character of these chapters may increase attention to the book. If so, their placement within it may serve the wider end of challenging academic scholars to deal with the crucial issues of their time. Not all of these issues can be subsumed under religious criticism in American culture. But perhaps if we begin there, we will deal with the other issues as well.

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Biology, Ethics, and the Origins of Life. Edited by HOLMES ROLSTON, III. Boston: Jones and Bartlett, 1995. vi + 248 pages. $27.50 (paper).

> Two critical points are of intense biological and philosophical interest in the natural history of life on Earth. The first is the origin of life; the second the origin of human life. With the first, biology began; with the second, ethics. [p. 2] . . . The origin of life and the origin of human life are events widely separated in time, perhaps two billion years apart and disparate in degree. One assembled the simplest kind of life, replicating molecules; the other, the most complex; the one an event in spontaneous nature, the other launching culture; the one an objective event, the other producing self-conscious subjects. But relate the two we must. . . . These are vital articulations, hinge points in the history of life. . . . At both these events . . . biology touches metaphysics. [p. 3]

So writes Holmes Rolston in the introduction to this exceptionally stimulating collection of essays based on a symposium on Biology, Ethics, and the Origins of Life that he organized in 1991 at Colorado State University, where he is the University Distinguished Professor of Philosophy.

The titles of the eight invited contributions are quite revealing:

1. "The Origin of Life and the Value of Life," by Thomas R. Cech

2. "Facing Nature," by Dorion Sagan and Lynn Margulis
3. "Mass Extinctions and Human Responsibility," by Niles Eldredge
4. "Evolutionary Ethics: A Defense," by Michael Ruse
5. "The Difference of Being Human: Ethical Behavior as an Evolutionary Byproduct," by Francisco J. Ayala
6. "When Natural Selection and Culture Conflict," by Elliott Sober
7. "Biology and Theology on Human Nature, Ethics, and Genetics," by Langdon Gilkey
8. "Darwinism and Postmodern Theism," by Charles Birch

Even more suggestive are the summarizing titles used by Holmes Rolston in an epilogue where he discusses critically the arguments of each presenter. In the following outline of the substance of this symposium I shall use these chapter headings together with direct quotations where possible from each of the authors.

Chapter 1. Thomas Cech: "Catalysis and Creativity." Thomas Cech holds a joint appointment as Professor of Chemistry and Biochemistry and Professor of Molecular, Cellular, and Developmental Biology at the University of Colorado, Boulder. He was awarded a Nobel Prize in chemistry in 1989 for his discovery that certain RNA molecules are not only sources of information, like all nucleic acids, but also catalysts for specific chemical reactions, the way most proteins are. This has led to the fruitful idea that life on Earth could have come about through the original formation of such molecules in an early RNA world. Cech concludes that "we see life as being the likely, perhaps even the inevitable, consequence of chemistry" (p. 31). Discussing the catalytic reactions that make otherwise improbable events take place he notes that "catalysis is the word I have been using . . . but what is also involved here is what a philosopher or theologian might call creativity" (p. 32). Further, "if intrinsic to these small organic molecules is their propensity to self-assemble, leading to a series of events that cause life forms to originate, that is perhaps the highest form of creation one could imagine" (p. 32).

Chapter 2. Dorion Sagan and Lynn Margulis: "Facing Earth's Symbiosis." Lynn Margulis and Dorion Sagan—mother and son—are prolific co-authors who continually address in different ways the question *What Is Life?*, the title of their most recent collaboration. Lynn Margulis, Distinguished University Professor of Biology at the University of Massachusetts at Amherst, is best known for her research and writings championing two of the most influential departures from mainstream biology in our time, the symbiotic theory of cell evolution and the Gaia hypothesis (with James Lovelock) concerning life as a global phenomenon.

These authors describe life as "a cumulative series of sensuous interactions that include symbiotic adventures in which partnerships conquer. . . . Early evolution of microbial life was marked not only by destructive interactions but by symbiosis—mediated emergence of genetically distinct 'individuals' residing within each other that formed new kinds of more complex 'selves' with unique identities. One 'self' comes to merge with another 'self' and a new 'self' arises. Biological identity is not fixed. . . . This kind of merging to form larger individuals is the way of the world and applies also to humans" (p. 59). They go on to say that "all

organisms dwell in ecosystems. James E. Lovelock has interpreted all living things on Earth, humans included, as a giant geophysiology, a superorganismic system whose energy system is photosynthesis from the sun. Gaia is a planetary self" (p. 60). Therefore, "the borders of ethical responsibility transcend *Homo sapiens* . . . sooner or later we face the Earth."

Chapter 3. Niles Eldredge: "Life Hanging Tough." Niles Eldredge, Curator, Department of Invertebrates, American Museum of Natural History in New York City, and Stephen Jay Gould of Harvard University are the well-known proponents of the theory of "punctuated equilibria," which states that long periods of no change—equilibria—are punctuated by episodes of rapid evolutionary activity, suggesting that evolution is driven far more by environmental forces than by genetic competition. Here, Eldredge recounts "the extremely checkered career that life has had on Earth" (p. 70). The study of numerous mass extinctions through the fossil record shows that "there is a spectrum ranging from worldwide, nearly complete biotic turnover down to minor episodes, local in effect and encompassing more modest percentages of species" (p. 72). He believes "the outline of a general theory of mass extinction is emerging: global climate change (often, though not necessarily, involving global temperature drop) is the usual underlying culprit" (p. 72). Eldredge invites us to ask about the contingent versus the predictable in natural history and to puzzle over how the same factors that cause extinction simultaneously promote the emergence of new species.

Extinctions are never the end of the story. "Earth's biota is tough, able to rebound in both an evolutionary and ecological sense after even the worst of biotic devastations" (p. 68). To overcome our present biodiversity crisis, "we must strive to put a halt to continued habitat destruction, meaning, as the bottom line, that we must curb human population growth" (p. 83). "It is our job to keep going, indeed to thrive. But we can no longer do so at the expense of the rest of the biosphere" (p. 84).

Chapter 4. Michael Ruse: "Ethics as Authentic Illusion." Professor of Philosophy at the University of Guelph, Michael Ruse was the subject of a special Profile issue of *Zygon* (March 1994) honoring his untiring effort to join biology and ethics. "The question is not whether biology—specifically our evolution—is connected with ethics, but how" (p 95), he writes. "Our moral sense is an adaptation helping us in the struggle for existence and reproduction no less than hands and eyes, teeth and feet. It is a cost-effective way of getting us to cooperate. It is in our biological interests to cooperate. Thus, we have evolved innate mental dispositions . . . inclining us to cooperate, in the name of this thing we call morality" (p. 97). "We see that morality has no objective foundation. It is just an illusion fobbed off on us to promote altruism" (p. 93). "Ethics is a collective illusion of the human race fashioned and maintained by natural selection in order to promote individual reproduction" (p. 101). "What excites the evolutionist is the fact that we have feelings of moral obligation laid over our brute biological nature, inclining us to be decent for altruistic reasons" (p. 97).

Chapter 5. Francisco Ayala: "Necessary and Sufficient Byproduct." Professor of Biological Sciences and also Professor of Philosophy at the University of California at Irvine, Francisco Ayala is coeditor, with Michael Ruse, of the jour-

nal *Biology and Philosophy*. Ayala propounds two theses, namely that "the capacity for ethics is a necessary attribute of human nature; and that moral norms are products of cultural evolution, not of biological evolution" (p. 118). "Humans exhibit ethical behavior by nature because their biological nature determines the presence of the three necessary, and jointly sufficient, conditions for ethical behavior: (a) the ability to anticipate the consequences of one's own actions; (b) the ability to make value judgments; and (c) the ability to choose between alternative courses of action. Ethical behavior came about in evolution not because it is adaptive in itself, but as a necessary consequence of man's eminent intellectual abilities, which are an attribute directly provided by natural selection" (p. 118). "Natural selection is not a process moral or immoral in itself or in its outcome, in the same way that gravity is not a morally laden force" (p. 126). "Moral norms are not determined by biological processes but by cultural traditions and principles that are products of human history. That is the difference of being human" (p. 134).

Chapter 6. Elliott Sober: "Free-Floating Monkey Wrenches." Professor of Philosophy at the University of Wisconsin, Madison, Elliott Sober has published widely on evolutionary theory in a social context. He discusses here how the evolution of culture differs from biological evolution. "The human brain can throw a monkey wrench into the idea that adaptationism applies to human behavior with the same force that it applies to behavior in other species. . . . The important thing is that cultural selection can be more powerful than biological selection. The reason for this is not some mysterious metaphysical principle of mind over matter. . . . The reason is humble and down to Earth: *thoughts spread faster than human beings reproduce*" (p. 156).

Positing a selection process such as Richard Dawkins uses in his discussion of memes in *The Selfish Gene* (New York: Oxford, 1976), Sober writes "Genes are discarded as the mode of transmission . . . individuals acquire their ideas because they are exposed to ideas. . . . Some ideas catch on while others become passé" (p. 152). Thus, "biological selection produced the brain, but the brain has set in motion a powerful process that can counteract the pressures of biological selection. . . . Natural selection has given birth to a selection process that has floated free" (p. 158).

Chapter 7. Langdon Gilkey: "Choosing Ourselves: Biology, Biologists, and the Humanum." Professor of Theology, Emeritus, at the University of Chicago Divinity School, Langdon Gilkey (like Francisco Ayala) served as an expert witness in the 1981 Arkansas trial on the teaching of evolution. Here he insists that mental, moral, and spiritual aspects of our humanity must be taken into account together with scientific understanding if we are to fully appreciate the nature of our humanity. "Nature edges into mind; mind edges into nature" (p. 168). "*All* our possibilities are in the end genetic; our physical, psychological, moral, and spiritual similarities, as well as our differences, have their patterns set in our genetic endowments. Thus it is true that our common social customs, manners, laws, morals, mores, and our religious rites, myths, and laws can or could be traced back into the dim recesses of the human past. Our behaviors and beliefs evolve no less than our bones and our biochemistries" (p. 168).

But "this is not the whole story. . . . We discover that we are in part self-directing, directed beings. . . . Strangely, we humans must choose, affirm, and use these possibilities of our nature. . . . We 'choose ourselves,' given our genetic inheritance and . . . familial, communal, and cultural inheritances. . . . Morals and science alike spring from the *humanum*, the human world—what theology has classically termed 'the image of God'" (p. 169).

Chapter 8. Charles Birch: "The Lure of God." Professor of Biology, Emeritus, at the University of Sydney, Charles Birch received in 1990 the Templeton Prize for Progress in Religion. Here he emphasizes that "for science and theology alike, a great and positive contribution that Darwinism makes to our thinking about nature is the role of chance. It closes the door on absolute determinism and opens the door to freedom and choice. Indeed, there is even a sense in which the role of chance makes both life and ethics possible" (p. 204). Drawing on the ideas of Alfred North Whitehead and Charles Hartshorne, he remarks that "Hartshorne hit the nail on the head when he said 'There must be something positive limiting chance and something more than mere matter in matter, or Darwinism fails to explain life'" (p. 205).

Birch proposes that "there are two central aspects of postmodern theism: (1) the recognition of creativity of self-determination within the individual entities from protons to the first primitive RNA organisms and to people and (2) the universal persuasive influence in the world, which is called God, to which the individual entities respond" (pp. 206–7). "The possibilities of the universe are realities that constitute a continuous lure to creation (p. 210) . . . the lure of God" (p. 212).

Evolution, of course, and creation are the underlying themes of all the above presentations. We see, with Holmes Rolston, "that getting more out of less requires a mixture of the inevitable and the contingent" (p. 219). "On the one hand we are impressed with the possibilities intrinsic to the chemicals; on the other we are impressed with the contingent narrative of events in which—despite death, extinctions, and catastrophes—there are ever novel achievements of biological vitality and power" (p. 220).

Many of us have become aware of the importance of these ideas through the eloquence of two of the most engaging writers in science today, Richard Dawkins and Stephen Jay Gould. For an update, it happens that on the shelves of our bookstores this season are four exceptionally attractive new volumes dealing with these controversial themes. In *River out of Eden* (New York: Basic Books, 1995) Richard Dawkins discusses the significance for information theory of his gene-centered and essentially reductionist approach to evolutionary explanation, while Niles Eldredge in *Reinventing Darwin* (New York: Wiley, 1995) presents arguments on the other side favoring a more naturalistic view, where discontinuity is as important as continuity in depicting a world composed of discrete entities. In *Darwin's Dangerous Idea: Evolution and the Meanings of Life* (New York: Simon and Schuster, 1995), Daniel Dennett shows how in Darwinism "all the fruits of evolution can be explained by an algorithmic process." He considers, too, the recent merger of evolutionary biology with artificial intelligence. Computer simulations are also considered by David Depew and Bruce Weber in *Darwinism*

Evolving: Systems Dynamics and the Genealogy of Natural Selection (Cambridge: MIT Press, 1995), a magisterial survey, where Stuart Kauffman's ideas on self-organization and selection in evolution (see *The Origins of Order* [New York: Oxford, 1993]) are compared with previous thinking on those fundamental topics. I should add that in my own reading I have found two elegant anthologies by Connie Barlow to be a rich source of key statements, pro and con, on most major issues in biology. They are *From Gaia to Selfish Genes: Selected Writings in the Life Sciences* (Cambridge: MIT Press, 1992) and *Evolution Extended: Biological Debates on the Meaning of Life* (Cambridge: MIT Press, 1994).

I must end now by saying that *Biology, Ethics and the Origins of Life* is the kind of book that will make you want to read all of the above, and more. Holmes Rolston, well known to *Zygon* readers for past articles and reviews, has done a superb job in planning and editing this volume, not only contributing a thoughtful introduction to the symposium as a whole but also supplying separate introductions for each chapter, a final provocative overview by way of an epilogue, and a helpful glossary and index. This slim volume on biology and origins is not to be missed by anyone at all interested in religion and science and life.

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