ECOLOGY AND ESCHATOLOGY: SCIENCE AND THEOLOGICAL MODELING

by William H. Klink

Abstract. The possibility of in-breakings of God in science is discussed. A realist philosophy of science is used as a framework in which new paradigms are seen as providing ever better approximations to the true underlying structure of nature, which will be revealed in the eschaton. It is argued that ecology—the study of the earth as a whole—cannot be treated as a natural science because there can be no paradigms for understanding the earth as a whole. Instead technology is used as a means for interacting with God through nature.

Keywords: Ecology; eschatology; realism; scientific models; theological models.

INTRODUCTION

I want to talk about ecology and eschatology, two subjects that would seem to be far removed from one another. The connection I propose is through theological modeling, that is, through an enterprise that attempts to make intelligible to a secular society the sense and necessity of talking about God. My starting point will be an analysis of natural science and scientific methodology, and I will introduce a vocabulary that should be of use to other disciplines, in particular religion and theology.

Before beginning, I want to make a disclaimer—I am a physicist interested in theological matters; for that reason, most of my examples and much of my analysis will be drawn from physics as that is the discipline I know best. But it is my hope, particularly at a conference such as this one, that the enterprise of theological modeling

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will be seen as appropriate to all disciplines. As I hope to show, theology as a discipline does not have its own domain as do other disciplines, or put positively, theology is a discipline for which the domains of all disciplines are potentially available for constructing theological models.

My thesis is that there is an eschatological dimension to natural science that offers the possibility of constructing a theological model to show the otherness of God breaking into science. The in-breaking of God into science is seen in the progressive revealing of the underlying structure of nature. There are two modes of this revealing. On the one hand, paradigm shifts, in which a reigning paradigm is replaced by another, are revelations in the world of symbols, often mathematical symbols, created by human beings in their attempt to better understand the underlying structure of nature. On the other hand, thinking of ecology as the study of the earth as a whole, I want to argue that ecology cannot be a natural science among other natural sciences. Nevertheless, the life of the earth as a whole—of which we as human beings are a part—has an underlying structure, which, as with other sciences, will be revealed in the "last days." In the meantime, the goal of ecology, unlike other sciences, cannot be to try to fathom the underlying structure of the earth as a whole, but rather to use nature as the place where a dialogue between God and human beings can occur, where God interacts with human beings through *materia* rather than through symbols.

SCIENTIFIC METHOD

For such remarks to be intelligible, we must remind ourselves of the power and confidence we have in science in our present-day world—in contrast, say, to the Middle Ages when theology was the queen of the sciences. When we have an electrical device such as a radio or a computer that has broken down, we have sufficient confidence in the laws and theories that went into making the device that we do not ascribe the breakdown to an intervention outside of scientific laws. We look for broken wires or burned-out transistors that must be replaced in order for the device to function again. As Ian Hacking has put it, we are all scientific realists when it comes to entities, to manipulating electronic beams or etching materials to make transistors or, at a more mundane level, to repairing our car or fixing a light switch (Hacking 1984, 154).

I want to go further and assume a realist position with regard to scientific theory.[1] To locate an eschatological dimension in science, I want to introduce terms that clarify the notion that scientific theory is an approximation to the true theory of nature, to the underlying structure of nature. By the domain of a scientific discipline I mean that part of nature being investigated by that discipline. Physics investigates solids, gases, plasmas, and liquids, the four states of matter corresponding to earth, air, fire, and water. Biology investigates that part of nature dealing with living organisms; chemistry, big molecules; and geology, matter on the surface of the earth. In all of these disciplines there are laws that give relationships between observable quantities. Such relationships can come from predictions of theories as well as experimental investigations with little theoretical background. One of Kepler's laws says that the distance of a planet from the sun is related to its period, the time it takes for that planet to make a complete revolution around the sun: distance equals the period raised to the two-thirds' power. Kepler discovered this law by carefully analyzing data taken by Tycho Brahe. No explanation was given as to why such a law should hold true or what its significance might be.

To provide an explanation is the function of models. Models are constructs whose structure is known or understood and in which there are elements that can be connected with observable quantities. Models are constructed for cognitive purposes, to enable the modeler to understand why some parts of nature behave the way they do. That models are constructed is important, for it means they are known from the inside. They have been put together by the modeler and can be changed and controlled in a workable fashion. Kepler's laws were explained by the Newtonian model, a mathematical model connecting the observable location (or position) with mass and force in a differential equation, with time as an independent parameter. By introducing the gravitational force into this model, Newton was able to explain the relationship between distance and period that had been discovered by Kepler. Creating models requires scientific imagination and is akin to writing poetry or composing music in its use of hunches, intuition, guesses, prejudices, and play. As such, it is culturally rooted and historically conditioned, located in a specific community that asks questions in a certain way.

What distinguishes model building from speculation is that models must be testable. There must be some means for distinguishing between competing models which purport to explain the phenomena under investigation. By testing models it is possible to distinguish between true and false models and to judge the reliability of a model in its attempt to explain given phenomena. String theory (Schwarz 1985) is a model that attempts to unify the four fundamental forces of nature—the gravitational, electromagnetic, and strong and weak nuclear forces—by viewing the fundamental particles of nature not as points but as curves in four-dimensional space-time. One of the major difficulties with string theory is its inability to make predictions that can be tested. Here Popper's use of the word *falsification* is helpful, in that for a model to be a scientific model, it must make predictions that in principle can be shown to be wrong (Popper 1965). Yet if a model makes predictions that are not borne out by experiments, the model is not thereby discarded. All of the moves discussed by Duhem ([1906] 1974) and subsequently taken up by Kuhn, Lakatos, and other philosophers of science can be made to save the model or at least to modify it so as to bring it in line with known experimental data. But if a model must be continuously modified as a result of new experimental data, there comes a point at which the explanatory power of the model becomes questionable. How and when that happens is a subject of much debate and probably depends to a large extent on whether there are alternative models available.

For example, the Bohr model of the hydrogen atom, in which the hydrogen atom was viewed as a tiny earth-sun system with only certain allowable (quantized) orbits, was initially very successful in its predictions of the energy levels of hydrogen. However, it could not be extended to more complex atoms, such as helium, and after many attempts at modifying it, it was discarded in favor of a wave model developed by Schrödinger in 1926, which became the foundation of quantum theory.

Theories are extended or more fully developed models evolve, and they can be applied, not only to the narrow range of phenomena for which they were first intended, but to a much broader range of phenomena. As I am using the term, there is no difference in kind between models and theories. In some fields, such as mathematics and psychology, models are used as concrete instantiations of more abstract theories, and, consequently, as authors like Ferré have pointed out (Ferré 1969), there are important differences between the two. The way I wish to use the terms, as is common in physics provides no distinction in kind. Thus the wave model of Schrödinger was first successfully applied to the hydrogen atom and then generalized to all atoms and molecules. Today it froms the basis of nonrelativistic quantum theory, an enormously successful theory that forms the basis for almost all of the devices that have so penetrated our society, ranging from transistors and lasers to nuclear reactors and nuclear magnetic resonance.

When a model or theory is successful over a wider and wider domain of nature, a new possibility arises: the theory may become paradigmatic. The theory suggests an overarching conceptual framework for understanding all of that domain of nature. The term *paradigm*, introduced by Kuhn, has been used in a number of different ways; here the sense is as given on page 175 of his book *The Structure of Scientific Revolutions*. Paradigms are suggested by successful theories but then take on a life of their own and provide the framework for extending or modifying theories into entirely new domains. The wave theory of Schrödinger has been enormously successful when applied to systems in which the velocities of particles are much less than the velocity of light. It has led to the basic outline of the quantum paradigm, in which nature is seen as being random and statistical, in contrast to the Newtonian paradigm in which nature is seen as being deterministic. But for systems in which particles travel near the speed of light, the Schrödinger wave theory is inadequate and must be replaced by a relativistic quantum theory, such as quantum electrodynamics. The quantum paradigm is presupposed in the transition to relativistic quantum theory and suggests how relativistic models might be constructed.

It is also well known, however, that paradigm shifts occur, the most famous in physics being the shift from the Newtonian deterministic view of nature to the quantum statistical view of nature. Paradigm shifts occur when the reigning paradigm is no longer able to suggest new models that might explain experimental data at variance with established theories. For example, with blackbody radiation—the radiation emitted from hot glowing objects—no explanation for the distribution of energy with frequency was possible within the Newtonian paradigm. Planck created the first quantum model by suggesting an explanation for blackbody radiation which could not fit into the Newtonian paradigm.

Paradigm shifts occur when it becomes impossible to explain phenomena with the established paradigm. But the new paradigm that emerges must have the important property of encompassing the older paradigm, of explaining all of the successes of the older paradigm in its domain of application as well as explaining phenomena in new domains that cannot be explained by the older paradigm. Thus, Newtonian theory was enormously successful in explaining the motion of middle-sized objects, of objects that we can see and directly manipulate, such as rockets and baseballs. When applied to a new domain, of atoms and molecules, all attempts to provide a deterministic understanding failed, and out of this failure arose quantum theory, which was able to explain the behavior of atoms and molecules in terms of an entirely new conceptual framework. Probabilities are a central feature of the quantum paradigm; all quantum theories such as the Schrödinger wave theory make predictions about the behavior of quantum systems in terms of probabilities. But probabilities with numerical values very close to 1 become virtual certainties, and it has been shown that these certainties agree with predictions of the Newtonian deterministic theory in those domains where Newtonian theory makes correct predictions.

The quantum paradigm has been enormously successful in explaining a wide range of phenomena from nuclei to atoms to molecules to various kinds of solids, liquids, and gases. There are no anomalies that I know of that would seem to threaten the quantum paradigm. There are, of course, still many unresolved problems, ranging from the existence of dark matter in the universe (what kind of matter is it?) to the construction of a relativistic quantum mechanics able to explain in detail the behavior of elementary particles. Moving beyond physics into domains such as biology, all sorts of questions can be raised about the limits of the quantum paradigm: Is it needed to understand life and consciousness, or is it simply irrelevant to the needs of biology? Will a new paradigm emerge in biology which encompasses the quantum paradigm, or will there be two paradigms operating in essentially separate, nonoverlapping domains?

Whatever the answers to these questions may be, most physicists would hesitate to say that the quantum paradigm is true. Rather, they act as though it were true, planning new experiments, examining new consequences of a theory, further probing the validity and consistency of the paradigm, yet knowing that new experiments may reveal behavior seriously at odds with the quantum paradigm. This means that at any point in history a paradigm may be incorporated into a new paradigm, or it may provide the true understanding of nature, but there is no way of deciding between these alternatives. There is thus a series of nested paradigms from the past into the future that constitutes the history, or better, the tradition of a discipline. Paradigms held at any point in history cannot be known to be true or not, but they can be said to give a better approximation to the true underlying structure of nature than previous paradigms, a way of speaking that has been used by some realist philosophers of science (see, for example, Leplin 1984b, 193). Tradition plays an important role in science, for it guarantees the stability of the scientific enterprise against paradigm shifts, in which new theoretical terms may be introduced that have no seeming counterparts in the older paradigm. By insisting that the newer paradigm explain the successes of the older paradigm, terms arising in the new paradigm are connected with those in the older one. For example, trajectories of particles like thrown balls play an important role in the Newtonian paradigm but are not allowed in the quantum paradigm. Yet the notion of a trajectory can be defined as a certain averaging process in quantum theory, which then connects the Newtonian term with a quantum term when it is applicable.

If at any point in history the currently held paradigm gives the best approximation to the actual underlying structure of nature relative to previously held paradigms, does it follow that a progression of nested paradigms will lead (perhaps asymptotically) to the true paradigm, to that paradigm which reveals the actual underlying structure of nature? Not according to such philosophers of science as Richard Boyd, who argues that there are several logical possibilities besides the one mentioned (Boyd 1984, 77). There may be several paradigms that are equally capable of making (true) statements and yet are ontologically inequivalent. Or there may be no asymptotic limit at all, just an infinite progression of nested paradigms, much like peeling an onion, where there is no final core.

THEOLOGICAL MODELING

Eschatology deals with the end of time, with the end of history, when the world in its historically contingent character comes to an end. It comes from the Greek word *eschaton,* which means the last or final things. As such, it arose out of the early Christian belief that the world in its then present state would soon end with a series of world-wide calamities, to be followed by the second coming of Christ, which would usher in a new period of harmony and justice. That the early Christians expected this to occur in their lifetime is well documented, as can be seen, for example, in the writings of Saint Paul (for example, Thes. 4 : 15). But when the second coming of Christ did not occur as expected, it was necessary to revise the meaning and use of the term. There continue to be religious communities that make predictions about when the Second Coming will occur; the Seventh Day Adventists initially predicted it would coincide with the beginning of the First World War and have since continued to modify that prediction. Here I want to use the word *eschatology* not so much as dealing with the end of time, but rather as a way of dealing with meaning. In the eschaton, the meaning of the universe, why nature has the underlying structure that it has, why human beings are what they are, will be revealed. For science, the limit of the progression of nested paradigms, yielding the paradigm that reveals the actual underlying structure of nature, also reveals the meaning of nature. According to Boyd (1984) it does not follow logically that there is an *eschaton* in which the underlying structure of nature is revealed. The assertion as such then becomes a theological assertion; it becomes the starting point for a theological model in which God is seen as the guarantor of truth. God is seen as the guarantor of the worthwhileness of doing science, in that what scientists do is to search for better approximations to the true paradigm, which they believe to exist, yet is never attainable in their historically contingent world. Here I have slipped in the term *theological modeling*. What is theological modeling? Are theological models like scientific models? Can they be tested? And perhaps most important, what is the purpose of theological modeling?

Models are constructed to be able to deal cognitively with phenomena that are puzzling, that are under investigation. Is it then possible to talk about theological models? If so, what is the domain of theology? Initially, one might say that religion constitutes the domain of theological models, for it is clear that many religions talk about God. I want to argue, however, that theology has no material domain and that religion offers one possibility among many others for constructing theological models. Robert Scharlemann, in his essay "Constructing Theological Models," says:

> The recognition that theology does not have a material domain of its own, not even the domain of religion, is one of the consequences—enduring I think—of dialectical theology's critique of religion in the 1920's. Theology may use materials from religion, but it cannot claim religion as its proper domain; for it has no closer kinship with religion than with science, art, and other domains . . . dialectical theology, with its "totally other" God, who was free from and for anything finite, freed theology in principle from religion. Material for theological models may consequently be taken not only from religion, but from any definable domain of human activity and knowledge. The definition and analysis of such domains is not properly theological but metacritical work. (Scharlemann 1973, 65)

Theology then, has no material domain of its own; or put positively, all domains, from science, art, religion, politics, all provide possible material for constructing theological models. To construct theological models means focusing on some structure in a given domain to locate a depth, a transcendence that has not been apparent or stated. Anyone knowledgeable in a given field may see a way of looking at that field so as to bring out a depth or transcendence.

William Pollard, in his book *Chance and Providence,* constructs a theological model by drawing attention to a particular feature of the quantum paradigm. The Schrödinger wave theory is a mathematical theory that predicts the probabilities of outcomes if the preparation of the quantum system is given. Given a beam of electrons boiled off a filament and focused through a magnet, the Schrödinger wave theory predicts that 50 percent of the electrons will be deviated upwards and 50 percent downwards after passing through the magnet. For a given electron, the two possibilities are deviated upwards or deviated downwards, but what actually occurs cannot be ascertained until a measurement is made on that individual electron. That is to say, measurements convert possibilities into actualities, and according to the quantum paradigm, unless the probability is 100 percent, there is no way of knowing before the measurement is made what the outcome will actually be.

Pollard takes certain features of the quantum paradigm to uncover a depth which becomes the basis for a theological model. He uses the phrase "God chooses" to mean that which is actualized from the manifold of possibilities allowed by the quantum paradigm. That electron which could have been deviated upwards or downwards goes upwards because God so chooses. More generally, since history is the actualizing out of a manifold of possibilities on a much larger scale—the scale of the earth as a whole—God directs history, bends history to God's will by choosing out of many possibilities that which is actualized.

There are other models that attempt to explain how what is actualized does so out of a manifold of possibilities. Albert Einstein never accepted the quantum paradigm, though he made significant contributions to quantum theory. He always felt that the Newtonian paradigm was the correct one, and his most significant contributions, the special and general theory of relativity, were revisions of Newtonian theory and not theories leading to a non-Newtonian paradigm. He was one of the first to attempt a hidden variables interpretation of the quantum paradigm, wherein the statistical nature of the quantum paradigm was seen as a consequence of a more fundamental level of deterministic behavior. What Einstein used as a guide was Brownian motion—a subject to which he contributed significantly—in which the seemingly random behavior of a particle in colloidal suspension seen under a microscope is caused by countless collisions with tiny particles not seen in the microscope. If it were possible also to see the smaller particles, the seemingly random behavior of the seen particle would be deterministic, caused by the many collisions with the smaller particles; hence, the term *hidden variables.*

This is not the place to discuss the relative merits of these two views of the quantum paradigm. Rather it is to point out that theological models will not be unique in that other explanations of a depth can also be given. Einstein's hidden variables model is itself not a scientific model in the sense that it was constructed in such a way as to agree with all of the quantum predictions and, hence, not to be falsified by any data not also falsifying quantum theory. It is more appropriate to think of it also as a theological model, for it was constructed in such a way as to reflect Einstein's pantheistic view of the world.

This discussion shows that theological models, as with models generally, can be and must be testable to be able to distinguish between true and false, good and bad, and fruitful and unfruitful models. But the testing need not and ought not be akin to the testing of scientific models, in the same way that the testing of historical models need not be the same as the testing of scientific models. One of the ways in which Pollard's model for "God chooses" has been criticized is that it seems to preclude, or at the very least strongly limit, human action. Does God's choosing include choices that human beings make? Is human freedom just an illusion or is there something wrong with Pollard's model? One of the dilemmas that human beings find themselves in today is that we have technical powers at our disposal that seem to be leading us on a collision course with the life of the planet as a whole. Is this use of technical powers a result of human freedom or of God's choosing? If it is of God's choosing, we human beings are absolved of all responsibility for what we are doing to the planet earth.

Since theology does not have a domain of its own, the testing of theological models might seem to depend on some prior conception or metaphor of God. Though it may seem hopeless to find any unity in theological discussion today, David Klemm and others have argued that in the twentieth century, God is most basically figured as the in-breaking of otherness in human existence:

> Much has been said and written about the disunity and fragmentation of theology in our day. But in spite of apparent plurality, a discernible unity and common ground, rarely addressed as such but routinely [evoked] in theological writing, can be articulated. That unity is found in the leading metaphor of God in contemporary theology: God as the breaking-in of "otherness" to human existence.
>
> Individual theological programs may part ways when layers of description are added to this fundamental metaphor. Accounts of otherness vary. So do interpretations of how the breaking-in occurs. Likewise, views of the human existence where this breaking-in takes place are different. But however various the theological schemata may be, they are overwhelmingly governed by this metaphor. (Klemm 1987, 276)

Klemm goes on to point out that the breaking-in of otherness has not always been the dominant motif when talking about God. In the eighteenth century the deist notion of God as a cosmic clockmaker, so influenced by the Newtonian paradigm, was an important motif, whereas in medieval Europe God was seen as Supreme Being.

Further, since the breaking-in of otherness requires interpretation and is not self-evident, the testing of theological models will always have an important hermeneutical component. Testing theological models involves probing the meaning of terms in the model, the odd ways in which a commonly used term may be used to reveal a previously unseen depth, using words or symbols as pointers to the otherness being revealed.[2] Constructing theological models, then, is a way of freeing theology from confessional or metaphysical theology. Any and all domains, any and all material, is potentially available for constructing theological models. As (ideally) with scientific models, theological models can be accepted, modified, rejected, discarded. This means that no theological model is sacred as such; all theological models are expressions of human finitude—expressions of both the necessity and impossibility of talking about God.

A THEOLOGICAL MODEL ARISING OUT OF ECOLOGY AND TECHNOLOGY

To conclude, using this background, I want to present the outlines of a theological model that I think addresses some of the problems in Pollard's model. Instead of a theological model that draws on a specific scientific paradigm, and therefore is open to a "God of the gaps" criticism, what is needed is one that makes use of general structural features of scientific paradigms, as well as notions of technology and the transforming of nature and the study of the earth as a whole—namely, ecology.

The description I have given of scientific methodology arose in physics, I would argue, particularly in the transition from the Newtonian to quantum paradigm. But the general structural features, making use of such terms as domain, models, and paradigms, should be more generally valid, not only in the natural sciences, but also in the human sciences, of which theology is a part. The general structural features I have sketched can themselves be viewed as a metacritical model, that is to say, a general methodological model that can and ought to be tested against other metacritical models.

In any event, I will assume it is possible to apply terms like models and paradigms in biology, and in particular in ecology. I want to argue that if ecology is defined to be the study of the earth as a whole, then ecology cannot be a natural science in the sense that the testing of ecological models cannot be carried out and hence cannot lead to ecological paradigms. The reason is that there is only one earth, not an ensemble of earths, so that the testing of ecological models, as it is normally understood in the natural sciences, is impossible.

In physics there are beams of electrons, ensembles of atoms or molecules that allow for the testing of models; in a more practical vein, there are ensembles of automobiles or airplanes of the same type, so that their performance record in an average sense can be ascertained. Similarly the behavior of biological systems can be modeled and tested in an ensemble sense, as can ensembles of sufficiently similar ecosystems. But what about the earth as a whole? Is it possible to construct models of the earth as a whole? In a recently published article in the *New York Times* (30 May 1993, section 6), E.O. Wilson imagines an ecosystem that is about to be destroyed through technical development. Before the development begins many ecologists sample the plant and animal life, record the temperature, humidity, soil composition, and other relevant factors, all in an effort to record and preserve the life of that ecosystem before it is destroyed. But Wilson concludes that this is an impossible task, for it is not just the present or near present state of the ecosystem that matters, it is also important to know of the conditions in the past that allowed the ecosystem to evolve into what it is. If there were many similar ecosystems, perhaps it would be possible to construct and test ecological models that were able to grasp the structure of that living, evolving ecosystem. For the earth as a whole this is impossible, precisely because there is only one earth, and models for the life of the earth as a whole could only be tested on ensembles of earths. Even computer models and computer simulations, however complex and sophisticated they might be, however well they were able to simulate and even predict certain features of the life of the earth, such as wind or ocean current patterns or the average temperature of the earth—as in the greenhouse effect—could not generate ecological paradigms.

When we take technology into account, matters become even worse. One might argue that although there is no ensemble of earths available, evolution on our earth has proceeded slowly enough so that over periods of time short compared with evolutionary changes, it is possible to replace ensemble averages with time averages of one system. Such a possibility is called the ergodic hypothesis and has played a significant role in a branch of physics called statistical mechanics. It might also have played a significant role in ecology in ages past, when great technical powers, capable of dramatically changing ecosystems over short periods of time, were not available.

But a central issue that must be confronted in our present age is the increasing technical powers at our disposal and the ability and willingness to use these technical powers for dramatically altering ecosystems and, hence, the life of the earth as a whole. I want to date a significant change in our technical powers over nature at about

World War II and argue, following Hans Jonas (1974), that something new in human history has appeared, the consequences of which we cannot foresee. To make this somewhat more quantitative, let me argue that around World War II human beings had, for the first time in history, powers at their disposal that were comparable to the power of a tornado, or hurricane, or violent thunderstorm. Power is energy divided by time; electrical bills come as kilowatt hours, a unit of power (kilowatts) times time (hours), which then gives energy. The power I am talking of is not only nuclear power, but chemical and mechanical as well. We have all been amazed to see a bit of swampy, "useless" land transformed within weeks into a subdivision, with streets, sewers, and electrical connections. This would not seem so amazing if the transformation took a long time; the energy in either case would be the same. But the power in the former is very large compared with the latter. Such technical power enables us to transform large areas of land from complicated, biologically diverse ecosystems, to much simpler and probably unstable ecosystems. For the first time in the history of human beings, which is very short compared with the history of life on the planet, it is possible to contemplate so altering the life of the earth as to lead to completely unknown consequences. For the first time, as Hans Jonas has so eloquently pointed out, our responsibilities extend not only to other human beings, but to the environment as well; we must now care for the environment. Previous cultures of course altered, polluted, and transformed ecosystems. This is not a new feature in human history; but, as Jonas points out, previously the range and scope of human actions were always sufficiently limited so that concern about the long range consequences of those actions was considered unnecessary. Nature was so overwhelming in size and power that it was pointless to think of being able to compete with, or subdue, nature.

That has changed dramatically in the past fifty years and there is rightfully much debate going on as to what we should be doing. Wilson calls those persons exemptionalists who believe that whatever we do with our technical powers, things will work out all right. Included in such a group of technological optimists would be thinkers like Buckminster Fuller, as well as most developers, capitalists, and economists who view environmental problems in the short run. On the other side, those called environmentalists by Wilson, are persons truly alarmed at what we are doing to the earth. This group would range from the technological pessimists, such as Jacques Ellul and Robert Heilbroner (who predicts that unless we change our ways, we as a species are doomed), to more moderate environmentalists (which is where Wilson locates himself) who feel that some changes in our behavior are starting to take place, thus providing some hope for the future. In his *Times* article, "Are Humans Suicidal?" Wilson cites changes in population growth and the meeting of many heads of state in Rio de Janeiro as instances of positive change.

I want to argue for a third possibility, technology as ambiguity. Even if Wilson is correct, we don't know whether a breaking point has already been reached, whether there are already too many people on this planet, or whether too many ecosystems have already been destroyed, so that the earth cannot recover from its present state. If there were a paradigm for the life of the earth as a whole, it could be used to argue for certain courses of action that would be compelling. But as I have argued, not only is there no such paradigm, there cannot be one, even in the future, even after much more research.

I am, however, assuming that there is an underlying structure for the life of the earth as a whole, that there is a true ecological paradigm that we in principle cannot approximate, as is the case with other domains in natural science. This means that in the eschaton, the life of the earth as a whole, along with all other domains of science, will be revealed in all its unity. In my theological model, there is this promise that the underlying structure of the universe, in its incredible size and diversity, will be revealed.[3] Ecology is a natural science insofar as there is a true paradigm governing the behavior of the life of the earth as a whole, but it is not a natural science insofar as it is impossible to develop better and better approximations to this true paradigm. Unlike other natural sciences, which can pursue the goal of developing better paradigms at their leisure, ecology investigates an earth which is rapidly changing—hence, ecologists cannot have the luxury of waiting to see what happens to the earth.

It is the situation we human beings find ourselves in that I want to exploit for constructing a theological model. Included in this theological model is that God has given us technical powers to carry out changes for good or ill. God has given human beings the technical powers we now have and will continue to develop. Before the eschaton, we human beings must continue to live on this planet, to live with the technical incursions into ecosystems that are so altering the life of the earth in unknowable ways.

But the new powers of technology that we now have need not be used only for subduing or overcoming nature. They can also be used to interact with nature; that is, we can regard our transformations of ecosystems not only as a way of overcoming nature, but as a way of listening to how nature responds to these transformations. In some cases, the response is almost mechanical—the depletion of the ozone layer leads to increases in certain kinds of cancer and to mutations. In other cases the consequences of our technical incursions take longer to discern. Overfertilizing in my state of Iowa has led to polluted water sources. In many instances the response is surprising, such as traces of DDT found in the shells of birds' eggs far away from where the DDT was used. But in all instances there is ongoing evolutionary change as the ecosystem responds to the changes wrought by human beings, changes that in general we cannot predict.

There is thus the possibility of a dialogue between human beings and nature, mediated by technology from the side of human beings. Such a dialogue is similar to what Martin Buber (1970) talks about between human beings. There are I-It relations in which no genuine dialogue takes place and in which case the relationship is destructive to both sides. This is the case in our present relationship to nature. Or there can be genuine dialogue, in an I-Thou relationship, a listening and responding, treating the other person as worthy of respect. It is such a relationship that I hope might be possible in our relationship with nature.

For the most part, we are bad listeners. Many of us are city or town folk and don't know how to begin to listen. We may try to learn how to listen by going to Yellowstone Park and glorying in some of nature's marvels. But Yellowstone is now so overcrowded with people and their campers that the act of trying to learn how to listen itself changes the ecosystem. There are, however, persons trained to listen. In the dialogue I have in mind, ecologists are to be seen less as scientists creating models of ecosystems than as superbly trained listeners who have ears to hear and are able to understand the subtle signals nature is relaying to us in response to our transformations of ecosystems. This does not mean that ecologists take on the role of prophets; rather, they relay to communities how nature is responding to technical incursions and how nature might respond to future technical incursions.

In the theological model I have in mind, the otherness of God breaks into science in two ways. On the one hand, paradigm shifts in science are seen as the in-breaking of God in the progressive revealing of new and more encompassing paradigms that better approximate the true underlying structure of nature. New paradigms are new in-breakings of God. Here in-breaking refers to an in-breaking into the symbolic world of scientific models, theories, and paradigms, culminating in the revealing of the true underlying structure of nature. In this case, paradigms play a similar role in science as great works of art play in the humanities.[4] And as with great art, even after a paradigm has been superseded by newer paradigms, it continues to play an important role in the tradition and history of science. Ecology plays a limiting role in this theological model. There are no approximate paradigms for the earth as a whole at any point in history, but instead there is a listening to God through nature. In-breaking then refers to an in-breaking into nature, using nature as a vehicle for interacting with human beings. So, on the other hand, technology is seen as the means by which a dialogue of human beings with God can be carried out. In-breaking then refers to an in-breaking into nature, in response to human beings' use of technology in nature. To not listen, to arrogantly subdue nature, is to cease interacting with God through nature. It is to deny the responsible use of the technical powers given us as a new means for dialogue. Human beings are thereby not absolved of responsibility or denied their freedom but can choose whether to participate in the dialogue or not. The technological pessimists in this sense are correct—not to change our ways, that is to say, not to listen—is to invite destruction.

So the question we ask and cannot answer is: Is the end near at hand or is God preparing a way out? Put this way, we see clearly both the power human beings have through technology and the futility of human beings to control their own destiny. Technology as ambiguity means all we can do is listen as carefully as possible. This means pushing for recycling in the face of economic arguments against it, making much greater efforts at controlling human population, attempting to lessen the gap between rich and poor—many of the things advocated by environmentalists—but with the theological model I have sketched forming the background of our actions, so that in listening we anticipate surprises, new possibilities, unexpected possibilities from God as otherness breaking into the life of this earth and universe.

NOTES

1. Various realist positions are discussed in *Scientific Realism* (Leplin 1984a).
2. The testing of theological models and its relationship to the truth of theological models is more fully developed by Robert Scharlemann in his book, *The Being of God* (1981, Chap. 1) as well as in his essay "Constructing Theological Models'" (Scharlemann 1973, 65). But it is also clear that much more analysis and discussion is needed in order to bring the testing of theological models to a level comparable to the testing of scientific models.
3. The jump from the underlying structure of the earth as a whole to the universe as a whole is not unwarranted. In many ways the structure of the universe is better understood than that of the earth because it seems to be much simpler, a great deal is known, for example, of the birth, life, and death of stars, not only in our galaxy, but in the universe.
4. In his book *Real Presences,* George Steiner argues for the necessity of an *other* which is behind all great works of art (Steiner 1989).

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