

**BACK TO THE STOICS:
Dynamical Monism as the Foundation for a Reformed Naturalism
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ABSTRACT-The metaphysical naturalism underlying most of contemporary scientific and philosophical discourse stands in need of reformation because it leaves out of account one of the most salient features of the world---the normativity that lies at the heart of life itself, and of all higher human forms of value and striving. In the introduction, "Why Naturalism Needs a Reformation," I agree with Alvin Plantinga that mechanistic naturalism is inherently incapable of accounting for normative phenomena; the question is, however, whether naturalism must be identified with philosophical mechanism, or whether a postmechanistic reformation of naturalism may be possible. There are two contemporary philosophical programs which reject mechanistic naturalism and take a realistic stance towards teleological phenomena: intelligent design theory and dynamical monism, a philosophical offshoot of self-organization theory. In the second section, "The Design Inference," I briefly discuss intelligent design theory, agreeing with William Dembski that the mechanistic assumptions underlying mainstream science lead ineluctably to the design inference in the case of organisms. However, I regard Dembski's demonstration as a *reductio* of the premise that organisms are machines. In the third section, "Teleology and Functionalism," I review a number of reasons for rejecting the dominant functionalist philosophy of mind, in particular the doctrine of the "multiple realizability" of functions. In the fourth section, "Elements of a Dynamical Monism," I briefly sketch an alternative view of organisms as natural teleological systems, drawing on recent work in nonlinear dynamics and condensed-matter physics. In the fifth section, "Naturalism and Theism," I consider the question of the epistemic status of metaphysical naturalism. I agree that the metaphysical ground of human reason transcends empiricism and rests in some sense on faith. Nevertheless, I reject the epistemic equivalence between science and religious faith. The reason is that science is essentially an extension of the "animal faith" of common sense, and so is grounded in our universal biological nature in a way that religious faith is not, while religious faith is grounded in particular cultures in a way that science is not. In the last section, "Back to

the Stoics," I draw on the natural philosophy of the Old Stoics to consider what a more universal form of religious faith compatible with a dynamical monist understanding of life and mind might look like.

Why Naturalism Needs a Reformation

Naturalism is the metaphysical doctrine that the world is a closed causal system. If naturalism is true, then science should eventually be able to explain everything about the world without invoking a transcendent causal principle. But is naturalism true? Certainly not in its present form. But does that mean that a supernatural cause is proven? Or might it be possible to save naturalism by reforming it in some way?

I believe it is worth making the attempt to reform naturalism because, if it were true, it would be the most satisfying picture of the world. As Paul Moser and David Yandell have pointed out in a recent article critiquing naturalism, "Explanation in philosophy and science is inherently unifying, subsuming a multiplicity of phenomena under classificatory unity" (Moser & Yandell, 2000; p. 3). Thus, monism---which for present purposes I will take as synonymous with naturalism---is in a sense the natural aim of all science and philosophy. However, the fact that it would be nice if naturalism were true does not make it true. As Moser and Yandell go on to say, "Proponents of monism . . . must attend to the risk of neglecting genuine data and truths resistant to a monistic explanatory scheme. What monism gains by unification of multiplicity in data may be lost by neglect of genuine recalcitrant data. Explanatory unity may be a virtue, but it will be virtuous only if pertinent truths and data are not excluded for the sake of theoretical simplicity" (*idem*).

Now, naturalism in its present form is indeed guilty of just this sort of exclusion of inconvenient facts. The recalcitrant datum it is neglecting---the thing that Alvin Plantinga has aptly called the "Achilles' heel" of naturalism (Plantinga, 1998; p. 356)---is *normativity*. Plantinga writes that "There is no room, within naturalism, for right or wrong, or good or bad. . . . Naturalism also lacks room for the notion of *proper function* for non-artifacts, and hence lacks room for the notion of proper function for our cognitive faculties. It therefore has no room for the notion of knowledge . . ." (*idem*; original emphasis).

This hole at the heart of science where normativity should be is a specter haunting much of our contemporary intellectual life. It is, after all, one of the more obvious facts about the world that biological processes occur for a reason: namely, to achieve some goal or purpose. This teleological organization of living things establishes a norm according to which individual actions may be assigned a value, judged as good or bad, properly functioning or malfunctioning. These are perfectly objective facts about the world, in no way dependent on human observers. If human beings had never existed, countless billions of other living creatures would still have pursued their various goals in exactly the same way. Yet, metaphysical naturalism would have us believe that teleology is some sort of illusion. In other words, all of the life sciences, as well as the social sciences and the humanities, are making constant use of a principle that officially does not exist! This is a deeply pathological situation that cannot go on forever.

If there is any methodological principle that we should be able to agree on, it is surely that we ought to consider all of the evidence. By this criterion, metaphysical Darwinism is an abject failure. It is a failure because it does not give a coherent account of value and purpose, either in the pragmatic form we find in all living things, or in the distinctively human modes of intellectual, ethical, and aesthetic experience---what I like to call the *archangelic* aspect of human nature. For example, the heaven-storming aspiration expressed in the art of a Michelangelo Buonarotti or the paradisiacal bliss evoked by the music of an Arcangelo Corelli, which make their Christian names so fitting. My point is that the aspiration that produced the Sistine ceiling and the feelings evoked by listening to the Opus 6 Concerti Grossi are real. They exist. These emotions and the values they embody constitute an undeniable part of the furniture of the world. And yet they have no place at all in the grand metaphysical scheme of naturalism.

Now, the Darwinian will of course deny this. He will claim that his worldview is quite capable of accounting for these phenomena, and he will point to a slew of recent publications giving Darwinian accounts of everything from moral feeling to the sense of beauty to religion itself. However, all of these supposed explanations are essentially worthless, because Darwinism simply presupposes the normative aspect of all of these things. Natural selection is nothing more than a calculus that tells us what we may expect to happen given certain assumptions about organisms (Shimony, 1993). The most

fundamental of these assumptions is that living things intelligently strive to achieve their goals. All that natural selection says is that the organisms that do this best will flourish---not exactly the earth-shattering insight it is cracked up to be. But most important, it tells us nothing at all about how intelligence or striving or goals are possible in the first place. By taking all of this for granted, natural selection simply begs the question of the origin of normativity (Barham, 2000, 2002; see, also, Davies, 2001).

I said that Darwinian explanations of the archangelic in human nature are worthless, but in fact they are even worse than that, because they encourage a way of thinking about human nature that is both morally repugnant and politically pernicious. I could elaborate on this theme at length, as I have done elsewhere (Barham 1995), but I do not wish to spend my limited time today discussing the failings of Darwinism---for one thing, I think I would be preaching to the choir! Instead, the question I want to discuss today is whether intelligent design (ID) theory or self-organization theory can do any better.

The Design Inference

I will begin by looking at how ID theory approaches the problem of normativity. No doubt everyone present is already familiar with William Dembski's notion of the design inference (Dembski, 1998), so I will be brief.

The design inference is a semi-formal deductive method that is founded on two fundamental premises. First is the *explanatory filter*. This is the assumption that there are three and only three distinct kinds of causal processes in nature: chance, mechanistic law, and intelligent design. If we can eliminate chance and law as explanations for a given phenomenon, then we can be certain that the cause must have been intelligent design. The second premise is that the formal mathematical apparatus of information theory may be brought to bear on any phenomenon in nature in such a way as to assign it unambiguously to one of the three categories. Now, I agree with Dembski that neither chance nor mechanistic law is a sufficient explanation of the teleological organization that we observe in living things. Nevertheless, I do not accept intelligent design as an explanation, either. The reason is that I question both premises underlying the design inference.

Let's take the second premise first: that information theory is appropriate for analyzing biological phenomena in connection with the explanatory filter. To begin with, for this purpose information theory is unnecessary. To show the vanishingly small probability that even a single protein molecule can have arisen by chance, all we need are ordinary physics and chemistry. The basic problem is that there is no energetically favorable path leading to the immensely long polymers that constitute biomolecules. Therefore, constructing a protein is something highly unnatural from the point of view of physics. Not only do you need nucleic acid templates; you also need enzymes to make the necessary reactions go, the enzymes themselves have to be coupled with exergonic reactions, and you need a ribosome to coordinate everything. In short, to create a protein you need a cell! In my view, the specificity of proteins simply lies in the fact that this whole elaborate song and dance is necessary. All you really need in order to show that a protein could not arise by chance is statistical mechanics. There is no need for information theory.

But not only is information theory unnecessary, I believe it is actually misleading. It misleads us by undermining a realistic attitude towards information. Information in the semantic sense is a perfectly objective phenomenon---all living things use information to interact with their environments. But information theory, despite its name, has nothing to say about objective, semantic information. It tells us nothing at all about how a mere physical process can come to be endowed with a meaning. Rather, information theory simply presupposes a cognitive agent standing somewhere offstage for whom a target pattern is meaningful. Thus, its conception of information is inherently observer-dependent and therefore subjective. What we want to know is how it is possible for a cell to act in ways that are purposive and meaningful, not with respect to an outside observer, but with respect to the cell itself. It is simply not possible to address this problem using information theory.

Furthermore, there are now strong empirical grounds for being suspicious of information theory in this context, as well. ID theory seems to accept the view of mainstream mechanistic science that DNA is the most important locus of causality in the cell, and that it can properly be described as a code. If this received wisdom were true, then it might make sense to reduce biomolecules to their linear monomer sequences and

to regard them as bit strings. But we now know that it is not true, and that cells are capable of regulating their own genomes in a functional, goal-directed manner, in violation of Crick's "central dogma" (Caporale, 1999; Fedoroff, 1999; Shapiro, 1997, 1999; von Sternberg, 1996a, 1996b, 2000).¹ This means that the whole idea that the organism is a machine controlled by the genome in the same way that a program controls a computer is out the window (Gordon, 1999; Gray, 2001; Griffiths & Gray, 2001; Keller, 2000a, 2000b, 2001; Lewontin, 2000; Morange, 2001; Moss, 2001; Nijhout, 2001; Oyama, 2000; Sarkar, 1998; van der Weele, 1999). Furthermore, philosophers are now questioning the idea that DNA constitutes a code at all in the proper sense of the term (Godfrey-Smith, 1999, 2000; Kay, 2000; Sarkar, 1996). In short, the set of assumptions behind ID theory's analysis of biomolecules as bit strings is rapidly being discredited.

Now, what about the first premise underpinning the design inference? You will recall that this was the assumption that chance, mechanistic law, and intelligent design are exhaustive causal categories. How can we know for certain that these three categories exhaust the productive possibilities of nature? It is to this crucial question that I turn next.

Teleology and Functionalism

Now, as I said, there is no question that the teleological organization of living things cannot be reduced to mechanistic interactions. That is because the physical interactions that constitute life, considered individually, cannot possibly explain the way they collectively cohere together collectively and are intricately coordinated in both space and time. But the question is, What are we to make of this fact?

Now, this question is usually discussed in terms of a conceptual dichotomy between dynamical laws and boundary conditions. Numerous authors have emphasized the fundamental importance of this distinction in biology, referring to it by various names. Thus, Polanyi (1969) refers to "boundary conditions," while Monod (1972) speaks of "gratuity," Nagel (1998) of "orthogonality," and Pattee (2001) of "nonholonomic constraints," but each of these terms is merely a different way of pointing to the same phenomenon---namely, the lack of any nomic link in the cell between the behaviors of the parts and the coherent organization of the whole. Certainly, the problem

is a real one. But is the notion of boundary conditions really the best way to pose the problem?

In order to help us think more carefully about this, I would like to introduce a pair of concrete examples of teleological behavior. First, imagine, if you would, the following scenario. You are sitting at your writing desk. Perhaps you are suffering from writer's block, and, having already sharpened all of your pencils, you suddenly hit on an idea. You have a cup on your desk containing two sizes of paper clips. Your idea is to sort the paper clips by size into two different cups. To achieve this, you spill the paper clips out on your desk, pick them up one by one, look at each one to see what size it is, and place it in the appropriate cup. When you finish, you will have lowered the entropy of your desk by a small amount.

Now, I would like to ask the following question: How are we to understand what just happened from the point of view of natural science? Certainly, the laws of physics are involved---you have to physically move each paper clip where you want it to go. This aspect of the process clearly involves Newton's laws. But, equally clearly, Newton's laws cannot explain which paper clips go into which cup! For this, we must give some account of the principle organizing the motions---namely, your desire to sort the paper clips into uniform groups. It is the value you attach to the physical size of each paper clip that explains which way it goes. There is nothing in the laws of physics that explains this value, and yet it is the very thing that is responsible for the entropy reduction!

Now I would like you to consider a second example. This time, I would like you to imagine a single protein molecule, called the *sodium-potassium pump*, or $Na^+,K^+ATPase$ (Alberts et al., 1994; pp. 513--516). Large numbers of this type of protein span the outer membranes of most cells. Their purpose is to regulate transmembrane electrical and osmotic potentials. What does an individual sodium-potassium pump actually do in order to help achieve this goal? It takes hold of sodium and potassium ions and it sorts them. Namely, it takes sodium ions that are inside the cell and puts them outside, and it takes potassium ions that are outside the cell and puts them inside. It is thought to do this by switching back and forth between two conformational states, alternately opening and closing the transmembrane channel at each end. Without the pump, the electrical gradient across the cell membrane would produce a concentration

of sodium ions inside the cell, which in turn would increase the osmotic gradient across the membrane, causing the cell to swell up with water until it burst.

Now, our molecular biology textbooks tell us that this is all well understood. We know that Na^+, K^+ ATPase is driven energetically by phosphorylation coupled to ATP hydration. As the pump flips back and forth, it bonds with the appropriate ion at each end. And so forth and so on. But to say that this explains the functioning of the pump is exactly like saying that Newton's laws explain the sorting of the paper clips! Ordinary chemistry cannot explain the *organization* of the motions of the ions. How could it, when the whole point of the pump is to move the ions "uphill" against the local potentials in order to maintain a relative low-entropy state inside the cell? This does not mean that natural laws are violated, but it does mean that physics and chemistry as currently conceived cannot explain the very thing that most needs explaining.

Now, I am sure you can see where I am going with these examples. My claim is that your sorting of the paper clips and the sodium-potassium pump's sorting of the ions are analogous. This means that already at the level of the cell we have something closely akin to intelligence. If this claim sounds extravagant to you, take an intermediate example. Say, a squirrel gathering its horde of nuts for the winter. Here, I hope you will agree that there is no essential difference between the way the squirrel sorts the small, round objects in its environment and the way you sorted the paper clips. But this kind of example can be extended as far down the phylogenetic scale as you please (see Albrecht-Buehler, 2000). There is simply no point at which one can draw a line and say, "On that side, dumb machinery; on this side, intelligence." The primary goal of every living thing is to maintain its own existence as an organized system, and the continuous, intelligent sorting of matter is one of the chief means by which it attains this end. If agency is defined as acting by means of one's own powers for the sake of one's own ends, and if reason is defined as utilizing means appropriate to those ends, then it is perfectly reasonable to say that animals are rational agents. But if animals are rational agents, then so are cells.

Now, of course, the mainstream mechanistic materialist will agree with me about there being no boundary line, but he will draw the opposite conclusion. He will say that, like individual cells, animals too are nothing but machines. And when the ID theorist

invokes the concept of boundary conditions, he is essentially agreeing. What both the mechanistic materialist and the ID theorist agree on is that, like manmade machines, the relationship between biological systems and the matter they are made of is entirely contingent, and that the "same" function can be "instantiated" in indefinitely many different material forms. This idea is called *multiple realizability* in the philosophical literature, and it is a basic tenet of the general doctrine known as *functionalism* (Allen et al., 1998; *passim*). Functionalism is basically the idea that all functions, whether natural or artificial, are relational properties between the parts of a system and the whole---that is, the function of something is essentially constituted by the abstract pattern of interactions it is part of, which has nothing to do fundamentally with the matter out of which the system is made. In short, on this view, functions should be understood as arising from organization as such, not from the causal powers of matter.

The germ of this idea may be traced back a long way (Schiller, 1978), but it really caught on after World War II with the invention of the computer and the notions of negative feedback and cybernetic control (Heims, 1991; Kay, 2000). A seminal article by Hilary Putnam in 1967 (Putnam, 1999) brought this idea to the attention of philosophers, whence it has spread far beyond the confines of the academy. It is the idea behind every cyberpunk movie or novel you see or read which assumes that mind is reducible to information. Nowadays, almost everybody assumes it is true. However, I do not believe a word of it.

Functionalism seems to offer a way of unifying all teleological systems, whether natural or artificial---and unification is a good thing. However, it is really nothing more than a logical entailment of the assumption that organisms are machines. We know that multiple realizability is the right way to think about our machines, because it is *we* who decide what arrangement of matter gets to count as a function---with respect to our goals and our interests. But that is no proof that it is the right way to think about natural systems, like organisms---as David Hume pointed out long ago in the *Dialogues Concerning Natural Religion* (Part 7; Hume, 1991; pp. 138--142). Posing the problem of teleology and biological organization in terms of boundary conditions simply assumes that organisms are like manmade machines, and it is from this assumption that the inference of intelligent design inevitably follows. But not only is this assumption

question-begging, it is also just plain unbelievable. If organisms really were machines, then there would be no fundamental difference between brains and computers and no essential difference between organisms and robots. This idea, followed to its logical conclusion, has led artificial life researchers to debate the civil rights of their computer games (Levy, 1992; pp. 340--342) and philosophers to speculate about the mental life of thermostats (Chalmers, 1997; p. 27).

These conclusions would appear to be a *reductio ad absurdum* of functionalism. But how do we know that computer games and thermostats are not alive? I think the reason that most people would reject this idea out of hand is that it violates one of our deepest intuitions about the way the world works: namely, that the properties and behaviors of things derive from the causal powers of the matter of which they are made. Therefore, I believe that functionalism is a dead-end track in the history of philosophy, just like substance dualism before it. Indeed, as historian of science Dennis Des Chene has pointed out, this "indifference to concrete realizations is what remains in the philosophy of mind from traditional dualism" (Des Chene, 2000; p. 5). The question is, Are we going to continue trying to understand the rational agency of life in terms of the dualistic machine metaphor? Or are we going to try to understand how it is possible for matter itself to be instilled with an objective, internal teleological principle? Realism about functions, and ultimately common sense, require the latter. Of course, that still leaves open the questions, How can there *be* such a thing as natural teleology? and If functionalism is wrong, what are we going to put in its place?

Elements of a Dynamical Monism

I would like to say here that ID theorists have been right to criticize those self-organization theorists who claim that nonequilibrium thermodynamics *per se* explains life (Meyer, 2001). Hurricanes and candle flames are a far cry from being alive. To be sure, it is an interesting fact that nonequilibrium thermodynamic flows can lead to coherent cycling or oscillation, because that is clearly a necessary condition for life. But equally clearly it is far from a sufficient one. So, what else is needed?

Here, I think that F. Eugene Yates, one of our foremost theoretical biologists, has made a helpful distinction. The kinds of mechanistic laws that govern the local and

individual reactions within organisms have traditionally been the object of study of what Yates calls *tactical* biophysics and -chemistry (Yates, 2001). In order to understand biological organization, however, we must develop a *strategic* physical biology that will investigate global and collective behaviors at the level of the organism as a coherent, integrated whole (*idem*). I would like now to discuss a few ideas that I believe may help to move us in the direction of such a strategic biology. For convenience, I will sometimes refer collectively to these ideas, and the metaphysical picture that may be inferred from them, as *dynamical monism*.

First, it is clear that realism about teleology, combined with the rejection of functionalism and the acceptance of the idea that matter matters, commits us to some form of emergence. Now, one might suppose that emergence is anathema to contemporary physics, with its traditional reductionist rhetoric. However, that is not really true---at least not outside of elementary particle theory. Condensed-matter physicists, for example, tend to look much more favorably on emergence. The great success of the effective field theory program, based on the mathematical formalism known as the renormalization group, is increasingly being interpreted by such scientists to mean that reality itself is intrinsically layered into a hierarchy of emergent levels, each with its own characteristic laws that are irreducible to those of other levels (Cao, 1998; Dresden, 1998; Laughlin & Pines, 2000; Schweber, 1997). Meanwhile, some philosophers of science have begun to explore the implications of this emergentist picture coming out of physics for their own problems (Auyang, 1998, 2000; Batterman, 1998, 2000a; Rueger, 2000). Thus, Robert Batterman points out that the very fact that the world is scientifically intelligible at all presupposes the dynamical stability of processes at different emergent levels (Batterman, 2000b, 2000c). *Dynamical stability* refers to the global robustness of processes that are relatively insensitive to perturbations at shorter space and faster time scales. It is the fact that so many real processes *are* dynamically stable that makes it possible for us to ignore the so-called "negligible terms" in our equations and still come up with decent predictions. Such asymptotic methods are the heart and soul of science, but it is hard to understand how they could work if nature really were rigidly deterministic and all causes at higher levels could be reduced in principle to

those at the lowest level. In short, the old reductionist picture is now being strongly challenged from within mainstream science.

The second element in the dynamical monist picture relates back to the boundary condition problem. From the point of view of physics, as Howard Pattee notes (Pattee, 2001), when we call a particular arrangement of matter in any system a "boundary condition" on the system, what we mean is that the arrangement is not a minimum energy configuration. Such a system with a ground state consisting of a large number of nearly isoenergetic substates is said in technical parlance to be *degenerate*. Now, ID theorists believe that energy degeneracy in this sense is evidence of an outside causal agency, at least in the case of very complex structures like biomolecules. But a globular protein is a system with just such a degenerate ground state, and we now have what seems like a pretty good internal explanation for it. When a typical protein folds into its three-dimensional, functional shape, it is unable to settle into a single minimum-energy conformation. That is because the polymer is so huge and so flexible that its myriad noncovalent bonds constantly interfere with each other---a phenomenon that has been termed *frustration* (Bryngelson et al., 1995; Frauenfelder, 1997; Frauenfelder & Wolynes, 1994; Frauenfelder et al., 1999; Wolynes & Luthey-Schulten, 1997). Biophysicists like to describe proteins as "kicking and screaming" as they jump back and forth incessantly between their isoenergetic substates. Now, it is not known exactly how energy degeneracy at the protein's microscale is related to coordinated functional action at its macroscale. Nevertheless, this unremitting writhing does endow proteins with a malleability that would appear to be a necessary, if not sufficient, condition for the self-organization of long-range, coherent motion. At any rate, what is certain is that the energy degeneracy of the three-dimensional structure of proteins is not engineered from the outside; rather, it arises naturally out of the intrinsic causal powers of the polymers themselves.

Finally, I want to mention a third phenomenon that I believe to be of crucial importance for understanding life: namely, the split in biomolecules between high-energy, or covalent, and low-energy, or noncovalent, interactions. Noncovalent interactions include those involving hydrogen, van der Waals, ionic, and others types of

low-energy bonds. This dichotomy is important, both because it makes frustration possible, and also because it appears crucial to the logic of functional action.

In order for functional action to be possible, three things are needed in addition to coherent, dynamically stable oscillation. First, there must be a partial thermodynamic decoupling between the functional system and its surround, so that it is not driven along willy-nilly by local energy fluxes. Second, in order to work actively *against* local gradients, the system must have access to an external or internal energy supply it can draw on as needed. Third, a system must know when action is needed. For a functional action to be successful, its timing must be coordinated somehow with those external conditions that will allow the action to go through. That is to say, successful functional action presupposes the ability to perceive or sense when the external circumstances are favorable. What this means is that the system must be able to anticipate or predict that an action, if undertaken now, is likely to pay off. How is such a thing possible? That is where the high-energy/low-energy split comes in.

All cognition makes use of signs, which are essentially low-energy triggers of action. A sign is something physical which in itself is too small to hurt you, but which helps you to tell apart the big things that *can* hurt you from the things that can do you good. I have argued elsewhere (Barham, 1996) that this is the essence of information in the semantic sense---*the meaning of a sign is the prediction of successful functional action.*

At the level of the whole organism, it is easy to see that this is so. For example, gentle collisions of photons on my retinas help me avoid less gentle collisions as I navigate through traffic. But the same principle can be seen to operate in functional action all the way down to the level of enzymes. An enzyme may be thought of as sensing its environment through the noncovalent interactions at its active site. If the active site perceives that a certain molecule is its proper substrate, then it triggers the large-scale conformational change of the enzyme as a whole, which will usually result in covalent bonding or some other relatively high-energy interaction. It is this perception-like sensing at the active site that allows enzymes to *select* the molecules they interact with functionally. When this all works like it is supposed to, dynamical stability is maintained, which constitutes success of the functional action. However, sometimes an

enzyme may make a mistake. In fact, that is how most drugs work---they mimic the natural substrate of an enzyme just enough to fool the protein into committing to a functional interaction with them. When an enzyme makes a blunder of this sort, and the molecule it thought was its substrate turns out to be the wrong one, the functional action cannot go through. Often, the ringer molecule will remain stuck to the hapless enzyme, whose oscillations then cease. This loss of dynamical stability constitutes failure.

Now, this may all sound like an elaborate metaphor, but in fact I mean it more or less literally. I believe that the sort of highly nonlinear, trigger-dependent, dynamically stable oscillations we see in enzymes are the physical basis of proper functions. That is to say, the dynamical stability of such oscillators constitutes the norm defining the success or failure of biological functions, and therefore is the physical foundation of value in nature.¹ It should be noted in passing that this idea resolves one of the greatest puzzles of teleology: the apparent influence of the future upon the present. Teleology is not about backward causation. It is about dynamical stability, about coherent, goal-directed action and low-energy triggers, about anticipation and prediction---in short, about *knowledge*.

These three principles---dynamical stability, energy degeneracy, and low-energy triggers---are only a few of the ideas in the literature that I believe move us in the direction of a strategic biology. The old reductionist habits of mind are being questioned in many other areas, as well (Bock & Goode, 1998; Harold, 2001; Kirschner et al. 2000; Laughlin et al., 2000). One of the most striking of these is neuroscience, where the computer metaphor is fast giving way to dynamical modeling of the large-scale self-organization of nerve cell assemblies (Freeman, 1999, 2001; Juarrero, 1999; Keijzer, 2001; Kelso, 1995; Port & van Gelder, 1995; Shaw & Turvey, 1999; Turvey & Shaw, 1999; van Gelder, 1998, 1999).

To be sure, none of these ideas amounts to a full-fledged theory of natural teleology. Eventually, they must all be tied together somehow into a coherent package. While there is no lack of interesting speculations in the burgeoning theoretical biology literature (Ho, 1993; Hyde et al., 1997; Lumsden et al., 1997; Mikulecky, 1995; Peyrard, 1995; Savageau, 1996; Yates, 1994; for further references, see Barham, 2000), what we probably need most are new experimental methods that will give us the means of

studying biological dynamics *in vivo* without destroying them (Laughlin et al., 2000). At the end of the day, though, I must admit that we are not there yet. In particular, the origin of life remains very much a mystery. Which raises the question, What conclusion should we draw from our present ignorance?

Naturalism and Theism

ID theorists insist that the design inference is not intended to be an argument from ignorance (e.g., Dembski, 1999, p. 223; Meyer, 1998, pp. 138--139). However, one might ask, What is wrong with arguing from ignorance? Certainly, there is a case to be made that the reason why we have failed to explain life naturalistically so far is that life did not have a natural origin. Thus, Plantinga has asked,

Why could a scientist not think as follows? God has created the world, and of course has created everything in it directly or indirectly. After a great deal of study, we can not see how he created some phenomenon P (life, for example) indirectly; thus probably he has created it directly.

(Plantinga, 1996; p. 221)

Now, there is an obvious weakness in this argument: How can we know when "a great deal of study" is enough? After all, every breakthrough in the history of science was once a mystery. But even so, I cannot pretend that my predilection for naturalism is based on some dispassionate assessment of the history of science. If I am honest, I must admit it is closer to something like a faith. But is faith in naturalism really epistemically equivalent to religious faith?

First, let me say that I recognize that the dynamical view of the organism I have sketched for you today commits me to something very like Polanyi's view of human knowledge (Polanyi, 1964). That is to say, only a small part of what we know is knowledge-by-description that can be formulated explicitly. The vast bulk of what we know is tacit knowledge-by-acquaintance, and can be represented explicitly only imperfectly, if at all. But this is as good as saying that there can be no absolute demarcation between science and religion. Both are equally aspects of human experience, and all our experience must be brought to bear whenever any judgment is made. In the end, all there is, is just *making sense*. Things either make sense to us or

they don't. And every single bit of our experience, including the believer's direct perception of God---Calvin's *sensus divinitatis* (Calvin, 1960; vol. I, p. 43)---will inevitably and rightly bear upon this making sense.

However, having said that, it does not follow that no absolute distinction between science and religion means no distinction at all. It is one thing to acknowledge that science and religion both exist within the same tacit dimension of human knowledge; it is something else to claim that they stand there on an absolutely equal footing.

So what is the difference between science and religion, epistemically speaking? I think the answer is that there is a cognitive asymmetry between them that can be traced to the emergence of man's special nature out of our generic nature as organisms. On the one hand, much of what I believe about the world reposes, not on some logical demonstration, but on my instinctive trust that today will be like yesterday and tomorrow like today. This trust---what Santayana called *animal faith* (Santayana, 1955)---is something we share with all living creatures. Animal faith is no doubt more complex in us, but it is still the bedrock upon which all else is built. On the other hand, upon this foundation there has somehow emerged the uniquely human, archangelic world of thoughts and feelings. This new world was made possible by language, which gave us the ability to detach ourselves from our own particular perspectives, and to experience the viewpoints of others in our imaginations. Once freed from the prison of our own perspective, we were then able to wander in our minds over all of space and time. But even though it is true that we swim in language and culture like fish swim in the sea, it is important to remember that it is a second sea that has emerged out of the first great sea of natural teleology.

Let me use another analogy to illustrate the relationship between the two seas. I spoke above about the role that signs play in functional action even at the molecular level. Now, semioticians distinguish between two fundamental kinds of signs, which they call *icons* and *symbols*. Icons are linked to the state of affairs they predict by some kind of intrinsic causal connection, whereas symbols are not. An example of an icon would be the taste of honey. Honey tastes sweet because sugar is a fuel for us. The taste of honey is a sign or trigger to the rest of the organism that says it is okay to swallow. Sweet means eat. It is a predictor that when the sweet-tasting thing gets to the stomach, it

will be metabolized properly. The sweetness and the metabolizability are directly, physically linked to each other through two different aspects of the structure of the same sugar molecules.

Now, contrast this with symbols. The relationship of a symbol to the state of affairs it predicts is genuinely arbitrary. Think of a traffic signal, for example. In this case, green means go. But, in contrast to the sweetness of honey, there is no intrinsic connection between the green light and its meaning. Rather, in this case the meaning is determined by socially imposed rules. Within the appropriate social context, the green light functions just as reliably as the sweet taste does, but its metaphysical basis is very different.

What does all of this have to do with the relationship between science and religion? Just this. I believe that science, though a product along with religion of the second sea of human culture, remains anchored in the first sea of animal faith in way that religion does not. The knowledge we gain from science is more like the knowledge we have that sweet means eat. Religion, on the other hand, while a universal attribute of human nature, is anchored metaphysically in the second sea in a way that science is not. For this reason, the knowledge that it imparts to us is more like the knowledge that green means go. It is this fundamental asymmetry in the metaphysical ground of the knowledge they afford us, I believe, which explains why there are many religions, but only one science.

Now, the theist might even accept this analysis, but still object that science does not equal naturalism---that naturalism, no matter how reformed, is still more like a religion than it is like science. And I think I would be inclined to agree with him! I am prepared to admit that my reformed naturalism probably functions in my psychic makeup in a religion-like way. I am not shy about saying this, because religion is, after all, one of the great manifestations of the archangelic in man. Of course, the whole point of naturalism is to seek a metaphysical system consistent with science, so perhaps it is best viewed as an amphibious creature, with a foot in each sea.

Back to the Stoics

The phenomenon of religion has many different facets, but to my mind one of its most elevating aspects is the way it gives the individual a sense of communion with one of the great historical cultural traditions. To conclude today, I would like to explore how, as a quasi-religion, reformed naturalism might fulfill this role as well, by coming to see itself, not as something new under the sun, but rather as standing in a venerable intellectual tradition of its own.

What tradition might that be? Unfortunately, most of the names for it have an unpleasant ring to modern ears---animism, pantheism, vitalism, panpsychism, hylozoism. Perhaps organicism and emergentism are the least pejorative of these. I see the tradition as being defined by two basic principles. The first is a form of naturalism that is close to pantheism (see Copleston, 1982; Levine, 1994). According to it, the intelligibility of nature derives from an objective rational order that is immanent within nature itself. This means that nature gave birth to mind, not the other way around. This principle contrasts with theism, which posits a human-like mind prior to nature. The second principle is dynamical monism proper---a sort of vitalist evolutionism or organicist emergentism. It is the idea that matter is active and dynamic, not passive and inert, and contains within itself the resources for the eventual development of life and mind. This idea contrasts with substance dualism, functionalism, and mechanism. Out of the many historical figures who come to mind (see Appendix), I would like to pick out the Old Stoics as being among the closest in spirit to dynamical monism (Hahn, 1977; Lapidge, 1978; Sambursky, 1987; Todd, 1978).³

The ultimate principle in Stoic cosmology is a unified, undifferentiated *something* (*ti*). This something is fundamentally material in nature. The pluralistic world of qualitatively different things comes into being out of this something by a process whereby matter acts upon itself. Here two fundamental principles are distinguished in order to explain how qualitative differentiation occurs: the *that-which-acts* (*to poioun*) and the *that-which-is-acted-upon* (*to paschon*). However, this is a conceptual distinction only. The passive and active principles are merely aspects or capacities of a single substance. The passive principle is also referred to as matter, while the active principle is known variously as *creative fire* (*technikon pyr*), *breath* (*pneuma*), or *god* (*theos*). The active principle is rational and teleological, but since it is just an aspect of matter, it is

also intrinsically dynamical. Both the active, dynamical principle and the passive, inert principle are held to completely interpenetrate each other in a universal continuum. A particular qualitative state of a body is explained through the varying strength of *pneuma* at different locations within the continuum. As Sambursky has put it, ". . .hexis, the physical structure of a body, is nothing else but the superposition of all the mixtures of pneuma corresponding to the various qualities of the body. Each of these mixtures forming the ensemble of the hexis co-exists with the others, and they all together permeate the body as tensional motions, thus making it a dynamic entity" (Sambursky, 1987; p. 46). This is strikingly reminiscent of modern field theory in which particles are viewed as nodes or resonances formed by the superposition of waves. Certainly, it is suggestive of a way of looking at nature that is very different from the one that has dominated Western thinking during the past four hundred years. As one of the ancient doxographers puts it: "The Stoics made god out to be intelligent, a designing fire which methodically proceeds towards creation of the world, . . . and a breath pervading the whole world, which takes on different names owing to the alterations of the matter through which it passes" (Long & Sedley, 1987; pp. 274--175). I think that this vision of a creative fire or divine breath permeating matter and shaping it according to a rational principle immanent within it is not a bad metaphor for the dynamical monist metaphysics of modern self-organization theory.

What do we gain by associating modern science with these old ideas? My only purpose in this exercise has been to help give dynamical monism a poetic resonance it would otherwise lack---one that I hope will enhance its value as the foundation for a reformed naturalism. As William James remarked about the writings of the Christian mystics: "There is a verge of the mind which these things haunt; and whispers therefrom mingle with the operations of our understanding, even as the waters of the infinite ocean send their waves to break among the pebbles that lie upon our shores" (James, 1982; p. 421). I merely wish to say that, to my ear at least, the Old Stoics provide a music that mingles well with the operations of the understanding in contemporary self-organization theory.

What would a reformed naturalism that was in harmony with this ancient music look like in detail? I am not sure what its positive characteristics would be, but I am sure

what it would not be. It would be neither a sentimental New Age cult nor a cynical neo-existentialist philosophy. On the one hand, it would decline to view mankind as comfortably ensconced in the cosmic web of Mother Nature. Nature is assuredly our mother, but she hardly resembles the nurturing goddess Gaia; she is much more like one of those marine tortoises who lays her eggs on the beach, then swims out to sea, leaving her young to be devoured by the birds of prey. On the other hand, reformed naturalism would also reject the view of man as an alienated existence without an essence, thrown into an absurd universe upon which he vainly attempts to impose his own arbitrary meanings. Life is not just rolling a boulder up a hill for eternity for no reason and no reward---tell that to the fox that chews off its leg to escape the trap! Life itself is the highest reward for all living creatures. Except, perhaps, for man, who is the only animal not content merely to live. I think there can be little doubt that our exceptional nature gives us a special part to play in the drama of life.

When all is said and done, we must recognize that science and religion both derive from the same source within us. They are both great expressions of the archangelic in man---the thing in us that loves, and longs, and strives---and for this reason, we ought to see them as allies. There is great work for such an alliance to do. For my part, I would like to see a reformed naturalism join hands with traditional religion in the task of rehabilitating teleology, both for its own sake, and in order to defend aspiration and value from their many enemies in the contemporary world.⁴

NOTES

¹ In prokaryotes, transposable elements are rearranged within a single organism, as well as shared among different organisms, in response to functional needs (Caporale, 1999; Fedoroff, 1999; Lombardo et al., 1999; Shapiro, 1997, 1999). Similar phenomena exist in eukaryotes, as well: in addition to transposons, cassettes, and other mobile elements that cause DNA itself to be reorganized both within and across generations (D'Onofrio et al., 1999; Hall et al., 1999; Sinden et al., 1999), there is of course the well-known phenomenon of "editing"---i.e., cutting and pasting of RNA transcripts. It was long thought that introns---the DNA sequences corresponding to the discarded RNA transcripts---were accumulated evolutionary "junk"; now it appears likely that they have a functional role in the regulation of mutation rates of exons (Olivera et al., 1999). What all of this means is that instead of falling back on the intellectually lazy neo-Darwinian concept of "junk DNA," we must now proceed on the assumption that all DNA is functional, and that the chromatin is a reciprocally integrated element in the self-regulation of the cell. Finally, we must not forget the fact that inheritance of many functional capacities is not mediated by the chromosomes at all, but is rather carried out epigenetically---that is, through the soma of the ovum (Jablonka, 2001; Jablonka & Lamb, 1995; von Sternberg, 2000)---and, of course, behaviorally (Avital & Jablonka, 2000; de Waal, 2001).

² I believe that the source of value and the source of subjective feeling or conscious awareness are conceptually distinct problems. However, the question naturally arises as to the place of subjective feeling in the dynamical monist scheme of things. I think that the realist approach to teleology advocated here helps a little with this problem, because it "opens up" nature, so to speak, and makes it easier to see how something like a highly nonlinear, trigger-dependent oscillator can have an "inside" dimension. But in the end I think we must face the fact that knowing and being are distinct categories which happen to coincide within us. Facing inward, our first-person perspective is just what it is to be a knower---it is the *being of knowing*. But facing outward, our third-person relation to the external world is a very different sort of thing---it is the *knowing of being*. It seems to me that to ask to establish a third-person relation (which is what giving an explanation amounts to) with the first-person perspective is a kind of category mistake that confuses

the knower *qua* knower with the knower *qua* being. It is another question altogether whether feeling and value in the dynamical sense outlined here are coterminous in nature (that is, whether there is something that it is like to be an *enzyme*), whether subjective experience is limited to metazoan brains, or whether consciousness begins somewhere in between these two extremes. These are all questions that I believe can be fruitfully studied from the third-person perspective *via* neural correlates (Metzinger, 2000). But, of course, we must not confuse the question of determining whether a given creature has subjective experience with the question of what that experience is like.

³ The Old Stoa consisted primarily of Zeno of Citium (335--263 BC), the founder of the school, and his immediate successors, Cleanthes (331--232 BC) and Chrysippus (c.280--207 BC). There was also a Middle Stoa (Panaetius [c.185--109 BC], Posidonius [c. 135--c.51 BC]), a Roman Late Stoa (Seneca [c.1--65 AD], Epictetus [fl. c.100 AD], Marcus Aurelius [121--180 AD]), and a Renaissance neo-Stoic revival (Justus Lipsius [1547--1606]). For the ancients, see Rist (1969), Sandbach (1994), and Sharples (1996); for neo-Stoicism, see Lagrée (1994) and Saunders (1955); for a conspectus of the entire Stoic tradition, see Spanneut (1973). The physical doctrines discussed in the text are mainly associated with the Old Stoics, while the later writers were mainly preoccupied with ethical problems. The writings of the Old Stoics are lost, and such knowledge of their physical doctrines as we have resides on fragments and reports preserved in later writers (Long & Sedley, 1987; pp.266--343). Due to the fragmentary nature of our knowledge, and perhaps to the obscurity of the original sources, it is difficult to get a clear picture of Stoic cosmology. Perhaps the best brief introduction is Sharples (1996, pp. 43--55). For more detailed studies, see Hahn (1977), Lapidge (1978), Sambursky (1987), and Todd (1978).

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**APPENDIX:
Intellectual Lineage of Dynamical Monism**

WESTERN

I. Ancient and Medieval

Presocratics
(7th--5th c. BC)

Furley (1987); Kirk et al. (1983);
Long (1999)

Aristotle (384--322 BC)

Aristotle (1992, 1993); Barnes (1995);
Devereux & Pellegrin (1990);
Freudenthal (1995); Kullmann &
Föllinger (1997); Gill & Lennox (1994);
Gotthelf (1985); Gotthelf & Lennox
(1987); Lerner (1969); Nussbaum &
Rorty (1992); Sorabji (1983)

Stoics
Zeno of Citium (335--263 BC)
Cleanthes (331--232 BC)
Chrysippus (c.280--207 BC)

Hahn (1977); Lapidge (1978);
Long & Sedley (1987);
Sambursky (1987); Todd (1978)

Plotinus (c.204--270 AD)

Gerson (1996); D.J. O'Meara (1993);
Plotinus (1991); Rist (1965)

Johannes Scottus Eriugena
(c.800--c.877 AD)

Cappuyns (1933); Carabine (2000);
John the Scot (1976); Moran (1989,
1990); J.J. O'Meara (1988);
Sheldon-Williams (1967)

Solomon Ibn Gabirol (c.1021--c.1070)
(Avicebron)

Brunner (1965); Sirat (1990; pp. 68--81)

David of Dinant (fl. c. 1210)

Maccagnolo (1988); Théry (1925)

II. Renaissance

General

Cassirer (1963); Charbonnel (1969)

Bernardino Telesio (1509--1588)

van Deusen (1932)

Giordano Bruno (1548--1600)

Bruno (1950, 1975, 1998);
Védérine (1967); F.A. Yates (1991)

Tommaso Campanella (1568--1639)

Bonansea (1969)

III. Early Modern and Enlightenment

General

Duchesneau (1985, 1998);
Giglioni (1999); Jacob (1981);
Pagel (1986); Wright & Potter (2000);
Yolton (1983)

Jan Baptista van Helmont (1579--1644)

Giglioni (2000a); Pagel (1982)

Francis Glisson (1598--1677)

Giglioni (1996); Henry (1987)

John Toland (1670--1722)

Heinemann (1944); Toland (1976)

Denis Diderot (1713--1784)

Diderot (1964, 1966);
Vartanian (1953)

IV. Late Enlightenment and Romantic

Edinburgh School

William Cullen (1710--1790)

Robert Whytt (1714--1766)

Wright (1990)

Montpelier School

Théophile de Bordeu (1722--1776)

Pierre Cabanis (1757--1808)

Xavier Bichat (1771--1802)

Bichat (1994); Haigh (1984);
Staum (1980)

Jean Baptiste Lamarck (1744--1829)

Giglioni (2000b); Lamarck (1984)

Johann Friedrich Blumenbach
(1752--1840)

Lenoir (1989)

Friedrich Wilhelm Joseph Schelling
(1775--1854)

Bowie (1993); Esposito (1977);
Heuser-Kessler (1986);
Schelling (1984, 1986);
Snow (1996)

Naturphilosophen

Lorenz Oken (1779--1851)

Gode-van Aesch (1966)

V. Late 19th and Early 20th Centuries

Gustav Theodor Fechner (1801--1887)	Fechner (1946); James (1977); Marshall (1974); Woodward (1972)
Charles Sanders Peirce (1839--1914)	Corrington (1993); Esposito (1980); Peirce (1992); Raposa (1989); Sheriff (1994)
Eduard von Hartmann (1842--1906)	von Hartmann (1931)
Conwy Lloyd Morgan (1852--1936)	Blitz (1992, pp. 59--109); Lloyd Morgan (1925, 1931); McLaughlin (1992)
Samuel Alexander (1859--1938)	Alexander (1950); McLaughlin (1992)
Henri-Louis Bergson (1859--1941)	Bergson (1975, 1983); Gunter (1993); Kolakowski (1985); Mullarkey (1999a, 1999b)
Alfred North Whitehead (1861--1947)	Cobb (1993); Code (1985); Leclerc (1958); Lucas (1989); Rapp & Wiehl (1990); Schilpp (1951); Whitehead (1968; 1978)
Hans Driesch (1867--1941)	Driesch (1979); Freyhofer (1982)
Charlie Dunbar Broad (1887--1971)	Broad (1925); McLaughlin (1992); Schilpp (1959)

VI. Recent

Charles Hartshorne (1897--2000)	Griffin (1993); Hartshorne (1975, 1991); Hahn (1991)
Hans Jonas (1903--1993)	Jonas (1982, 1996)
Ivor Leclerc (1915--1999)	Bogaard & Treash (1993); Leclerc (1986a, 1986b)
David Ray Griffin (1939-)	Griffin (1998)

VII. General (Western)

Blandino (1969); Bloch (2000);
 Driesch (1914); Nordenskiöld (1928);
 Pichot (1993); Smith (1976);
 Wolfe (2000)

EASTERN**INDIA**

Advaita Vedanta

Shankara (c.788--c.820 AD)
 (Samkara)

Copleston (1982; pp. 68--95);
 Eliot (1973); Radhakrishnan
 (1996; vol. 2, pp. 445--658)

CHINA**General**

Neo-Confucianism

Chu Hsi (1130--1200 AD)
 (Zhu Xi)

Tu (1989)

Chan (1964); Ching (2000);
 Needham (1962; pp. 455--505);
 Peterson (1986)

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