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The Reality of Purpose and the Reform of Naturalism

Abstract

Whitehead and others have decried the „bifurcation of nature", that is, the split between the world depicted by science, which lacks such phenomena as purpose, meaning, and value, and the world of human experience, which is largely constituted by those same phenomena. In order to guide our thinking about how this split might possibly be overcome, I propose three guiding principles, which I hope will be widely accepted: (1) The reality of the human world; (2) The cognitive excellence of empirical science; and (3) The unification of knowledge. All three of these principles are eminently reasonable, and yet they appear to form an inconsistent triad. Naturalism, as the metaphysical worldview extrapolated from empirical science, is distinguished from empirical science as such. I propose that the only way to reconcile the three guiding principles is to reform naturalism in such a way as to recognize the objective reality of biological purpose. Such a reform in the foundations of biology might then provide us with a foundation for reconstructing our view of the human world. The argument in support of this proposed reform proceeds in two stages. First, as *pars destruens*, I show that naturalism as usually construed is anyway untenable, because the two chief theories by means of which biological purpose is supposed to be reduced to mechanism – the theory of natural selection and the theory of cybernetic control – fail as reductive schemas because each theory tacitly presupposes purpose at a crucial point in its explanatory structure. Second, as *pars construens*, I discuss the possibility of using some concepts borrowed from nonlinear dynamics and condensed-matter physics as a way of directly representing biological purpose as a real, emergent phenomenon. Finally, I end with a brief reflection on the implications of the doctrine of ontological emergence for the principle of the unification of knowledge.

Zusammenfassung

Whitehead und andere Autoren haben die „Verzweigung der Natur", d. h. die Kluft zwischen der von den Naturwissenschaften beschriebenen Welt, die keine Phänomene der Art von Zielen, Bedeutung und Wert enthält, und der Welt der menschlichen Erfahrung, die weitgehend von eben diesen Phänomenen

konstituiert ist, beklagt. Um unsere Überlegungen darüber, wie diese Kluft eventuell überwunden werden kann, zu leiten, schlage ich drei Leitprinzipien vor, von denen ich hoffe, daß sie weitgehend akzeptiert werden: (1) die Realität der menschlichen Welt; (2) die kognitive Exzellenz der empirischen Wissenschaft; und (3) die Vereinheitlichung der Erkenntnis. Alle drei Prinzipien scheinen in hohem Masse vernünftig, und dennoch scheinen sie eine inkonsistente Triade zu bilden. Der Naturalismus als die metaphysische Weltauffassung, die aus der empirischen Wissenschaft extrapoliert wird, sollte von der empirischen Wissenschaft als solcher unterschieden werden. Ich schlage vor, daß die einzige Art und Weise, die drei Leitprinzipien zu versöhnen, in einer Reform des Naturalismus besteht derart, daß die objektive Realität biologischer Zielsetzung anerkannt wird. Eine solche Reform in den Grundlagen der Biologie kann dann eine Grundlage bilden für eine Rekonstruktion unserer Auffassung der menschlichen Welt. Das Argument für die vorgeschlagene Reform geht nach zwei Stufen vor. Zuerst, als *pars destruens*, zeige ich, daß der Naturalismus in seiner üblichen Fassung sowieso unannehmbar ist, weil die zwei hauptsächlichen Theorien, durch welche biologische Zielsetzung angeblich auf einen Mechanismus reduziert werden kann – die Theorie der natürlichen Selektion und die Theorie der kybernetischen Kontrolle – keineswegs als reduktive Schemata taugen, weil jede Theorie stillschweigend Zielsetzung an einer entscheidenden Stelle ihre erklärenden Struktur voraussetzt. Zweitens, als *pars construens*, diskutiere ich die Möglichkeit, bestimmte Begriffe aus der nichtlinearen Dynamik und aus der Festkörperphysik einzusetzen, um biologische Zielsetzung als ein reales, emergentes Phänomen direkt zu repräsentieren. Ich schließe den Aufsatz mit einer kurzen Reflektion über die Konsequenzen der Lehre der ontologischen Emergenz für das Prinzip der Vereinheitlichung der Erkenntnis ab.

> „If man is either a part or a product of Nature in any sense, then it must be said that Nature produces values and is compatible with them, Bacon's banishment of final causes from Nature to the contrary notwithstanding."
>
> (Brightman 1958, 281)

The Bifurcation of Nature

The focus of this essay is purpose, considered as a natural phenomenon. I wish to begin, however, by positioning the discussion in the context of the larger problem of „the bifurcation of nature", in Whitehead's (1920) memorable phrase. This is the chasm that seemingly exists between the natural world and the human world, that is, between the world of molecules and atoms and elementary particles revealed to us by the natural sciences and the world of purpose, value, and meaning revealed to us by our own everyday experience. Empirical science, as such, has little to say about the ontology of the human world. However, many scientists and philosophers subscribe to naturalism – that is, the reductionist and materialist metaphysical doctrine extrapolated from empirical science. And naturalism claims that the ontology endorsed by the natural sciences possesses a higher grade of reality, or even is uniquely real, while the ontology of human experience is somehow second-rate, spurious, epiphenomenal, or otherwise illusory. It is naturalism, more than anything else, which has led to the bifurcation of nature.

This is an old topic, but I believe it is worth taking up again because some recent developments in the physical sciences place us in a better position today than ever before to begin making some headway toward bridging the chasm between natural science and the human world. However, in making such a large and contentious claim, I run a great risk of being misunderstood. For this reason, I will begin by enunciating three basic principles that I hope will meet with widespread agreement, and that may serve as guideposts for the rest of the paper.

Three Guiding Principles

Principle 1: The reality of the human world

The human world is the primary datum of our experience; it is the foundation upon which everything else rests. To imagine that our evidence for the reality of molecules or atoms or quarks could ever throw into doubt our direct experience of the reality of purpose and value and meaning is absurd, because science is nothing else than an elaboration of the human faculty of reason. Naturalism, in the strong materialist and reductionist sense, systematically undermines its own foundations. The naturalist who advances propositions as *rationally* warranted becomes entangled in a performative contradiction. Whitehead put this point nicely when he observed that „[s]cientists animated by the purpose of proving that they are purposeless constitute an interesting subject for study“ (Whitehead 1929, 16). On the other hand, the enterprise of empirical science, considered not as a metaphysical *program* but as a knowledge-generating *practice*, has itself grown out of the fertile soil of the human spirit, and as such is deserving of our greatest respect.

Principle 2: The cognitive excellence of empirical science
Some things we come into this world naturally equipped to know. Other things we must find out through dint of unrelenting intellectual effort. Much of the natural world, including a great deal about ourselves, falls into the second category. The natural sciences are highly effective social institutions that we have developed for expanding our knowledge about the way in which the different parts of the world fit together. Therefore, it is reasonable to expect that empirical science will have an important role to play in overcoming the bifurcation of nature that naturalism has created.

Principle 3: The unification of knowledge
One might ask: What is *wrong* with the bifurcation of nature? This question looms especially large at present, when the postmodern movement in Science and Technology Studies teaches us not merely to tolerate, but to celebrate the so-called „disunity of science“ (Galison & Stump 1996), as if the various academic disciplines were so many rival ethnic groups. And, indeed, this counsel might even seem the lesser evil, if the only alternative to it were the unification by leveling that others are urging upon us in which all the other disciplines – the life sciences, the social sciences, even the humanities – are supposed to be replaced by physics (Wilson, 1998). But if universal reductionism – and with it the loss of all that is distinctive of human life – is far too high a price to pay for the unification of knowledge, postmodern pluralism is not without heavy intellectual costs of its own. For, the desire for unification is a basic impulse that deserves our deepest respect. It is arguably at the root of most intellectual understanding, because to come to understand a thing is very often to see how it fits together with the rest of what we already know. Therefore, to abjure the ideal of the unification of knowledge is to renounce the quest for understanding itself.

In short, we ought to take the desirability of the unification of knowledge as a guiding principle, although we must be wary lest it seduce us into the too-easy unity of reductionism. Reductionism as a cure for the bifurcation of nature is worse than the disease. It is a remedy that cures by killing the patient.

It seems that we have here an inconsistent triad. Our constant temptation will be to sacrifice one of the principles in order to save the other two.

For example, if we think hard about the unification principle and the cognitive excellence of natural science, then reductionism will raise its seductive head. If we focus instead on unification and the human world, we may be easily lured into turning our backs on natural science altogether. And if we fix our minds on both the excellence of natural science and the reality of the human world, then we may be tempted by dualism, pluralism, complementarity, „non-overlapping magisteria“, or other such unsatisfying intellectual makeshifts. The question is: How can we respect all three principles at the same time?

In this paper I will attempt to show that there *is* a way to respect all three principles, but only on one condition. Naturalism must undergo a *reformation*. It will only be possible to give the barest sketch here of what such a reform movement within naturalistic philosophy might look like. But I hope to be able to indicate enough to justify the claim made at the outset that we are now in a better position than ever before to make some real headway in overcoming the bifurcation of nature.

Biological Purpose

The problem of the bifurcation of nature is above all that of understanding the place of human *consciousness* in the natural world. But I am not going to tackle that terribly difficult subject head on. Rather, I propose an indirect approach via the phenomenon of teleology or purpose. What, exactly, do I mean by „purpose“? I do not have anything obscure or difficult in mind. I just mean the everyday sense of the term, as applied to living things. For example, everyone agrees that the purpose of the heart is to circulate the blood. Equivalently, we may say that the heart beats *in order to* circulate the blood, or that circulating the blood is what the heart *is for*, or what it is *supposed to do*. In general, we often speak of the *goal* of functional actions in living things. Let us call this the *biological* sense of the term.

This sense is to be distinguished from the *intentional* sense, in which my conscious purpose in writing this essay is to express my views on the subject of purpose. Of course, many philosophers are of the opinion that the intentional sense of purpose is the only proper use of the term, and that biological purpose is mere metaphor. I have no knock-down argument to give that would show that this view is wrong. However, it is not the ordinary-language view, which certainly sanctions the ascription of purpose to the parts of organisms. Nor is it a view that can be warranted by biological *practice*. Although biologists may *say* that it is only a matter of convenience, the fact is that biological treatises and textbooks are saturated with teleological, normative, and even intentional terminology of every sort, and it would in fact be impossible to discuss the phenomena of life at all without recourse to such descriptors.[1] It is true that biologists speak more often of „function" than of „purpose", but in biology the word „function" is also used in a clearly teleological and normative sense. Thus, biological purpose is universally recognized, both in everyday life and in life science. And one would think that the universal recognition of something would constitute a pretty strong *prima facie* case for the reality of that thing![2]

So, it seems that purpose is a property that we are compelled to ascribe to living things by the nature of the phenomena themselves. There is little reason to believe that it is an illusion of perspective, an anthropomorphic projection, or anything of that sort, since the phenomena would be the same – the heart of a dog would still circulate its blood in just the same way – even if there were no human beings around to describe the process in words. From this, we may safely conclude that biological purpose is a real or objective feature of the world.

Functional Causation

Why, then, would most biologists and naturalistically inclined philosophers insist that purpose is not an objective fact at all – indeed, that it has been eliminated from our inventory of the real? Because they believe that it has been demonstrated that biological purpose can be „reduced to mechanism". What, exactly, does this mean?

At a minimum, it must mean, in the current context, that any theoretical account of a living process that is being offered as a mechanistic reduction must be one that neither explicitly mentions nor implicitly depends upon any teleological concepts.[3] In order to see better what this requirement comes to, let us look at explicit schemas of teleological, or functional, causation, on the one hand, and mechanical causation, on the other.

Functional Causation Schema:
E is an *end*, i. e., a *preferred state*, of a system.
M, a *means*, causally contributes to E.
M occurs (if it does) *because* it causally contributes to E.
Similarly, for M_1, M_2, and any other functional means that are jointly sufficient for E.
Therefore, E occurs.

There are several things to note about this schema. First, it is impossible to speak of either necessary or sufficient conditions for M's occurrence. That is because, even if M is necessary for E, there may be some other means – call it M_1 – that is also necessary, so we cannot say that M is sufficient. Moreover, it is possible that there may be some M_1 that *is* sufficient, so that M may not even be necessary. For this reason, we can never predict with certitude that M will occur, given the end, E. Furthermore, E itself may fail to occur. The mere fact that E is a preferred state never *guarantees* that E *must* occur. The most we can say is that, given that E is a preferred state of a system, and that M causally contributes to E, M *may* occur.

Another important thing to note is that, *if* M does occur, then it must occur *because* of the fact that it causally contributes to E, in order for the relationship between M and E to count as functional. That is, there must be a causal connection between the fact that M occurs and the fact that E is a preferred state of the system. This proviso excludes the possibility that M's occurrence be accidental and unrelated to E, for in that case, we would not say that M had a purpose or that it was a function or that it was a means to an end. A biological function is something that by its very nature is systematic.

Now, having explained what we mean by functional causation, it is not difficult to see what the claim of reduction amounts to. It just means that there must be a way of explaining biological processes by means of a different, *mechanical* causation schema, thus showing that the functional causation schema is superfluous and may be dispensed with without explanatory loss. In order to evaluate this claim, obviously, we need to spell out the mechanical causation schema, as well.

Mechanical Causation Schema:
M causally contributes to E.

M occurs, either by chance, by natural law, or by some combination of the two.
Similarly, for M_1, M_2, and any other mechanical causes that are jointly sufficient for E.
Therefore, E occurs.

If this pattern of explanation really could be applied to biological processes without explanatory loss – *and without tacitly presupposing any distinctive element of the functional causation schema* – it seems as though we could dispense with the notion of purpose, and means and ends, entirely. For, in the mechanical causation schema, there is nothing special about the resultant state E. It is just the joint *effect* of the factors M, M_1, M_2, and so forth, now construed as ordinary mechanical causes. But of course the question remains: *Can* this pattern be applied to biological processes without explanatory loss? And if so, how?

Reduction via the Theory of Natural Selection

There are two bodies of theory that reductionists often claim permit us to make the necessary substitution of the mechanical causation schema for the functional causation schema: the theory of natural selection and the theory of cybernetic control. Therefore, let us look at each of these in turn, to see exactly how it is supposed to effect the reduction of purpose to mechanism.

The theory of natural selection is invoked in many different sorts of explanatory contexts. However, the chief one that is relevant to us here is the claim that it reduces teleology to mechanism by explaining how biological functions can allegedly come about in a completely mechanical way. In this context, organisms are decomposed into a congeries of functional „traits“, which are considered to possess a certain property, „fitness“, which (on the non-circular, „propensity“ interpretation[4]) bestows on the organisms which bear them a tendency to survive and reproduce in a given environment in greater numbers compared to other members of the same population that lack the trait in question. Let us call this the „function-reducing role“ of natural selection.

The most obvious problem with the function-reducing role is that functional traits must already exist before they can be selected. After all, it is the relative functional success of traits that *causes* them to be selected in the first place. In other words, natural selection just *is* the differential reproduction of relatively more successful functional traits. As such, the theory of natural selection says nothing about how a functional trait originally comes into existence. It simply assumes that it does, and then goes on to show why it may be expected to proliferate through a population over time.[5] But it is obvious that no theory that *presupposes* the existence of a thing can possibly *explain* the existence of that thing. So far as natural selection in itself is concerned, the existence of functions is just a brute biological fact.

Why, then, is the belief almost universal that the theory of natural selection *does* explain the existence and teleological character of biological functions? I believe it is mainly because selection is not being considered just in itself, but rather tacitly in conjunction with a further pair of biological claims that form no part of selection theory proper. One of these further claims is that novel functional traits arise in an entirely random fashion. The other is that the organism is nothing but a machine. The function-reducing role of natural selection is entirely dependent upon these two prior assumptions. We will be examining the idea that organisms are machines in a few minutes, so I set that claim aside for now.

With regard to the claim that novel functions are generated at random, what is usually meant by this is that variant *genotypes* are generated by point mutations, sexual recombination, or some other seemingly mechanistic process. Even this much randomness is being called into question today by molecular biology, which is producing considerable evidence that genotype variation is itself under functional control, at least in lower organisms (Caporale 1999; Jablonka & Lamb 1995; Shapiro 2005; Van Speybroeck *et al.* 2002). But set that point aside. The more important point is that it is *phenotype* variation that must be random if natural selection is to play its function-reducing role, and in between genotype variation and phenotype variation comes *phenotype construction*. And phenotype construction is a distinctly *functional* – that is, teleological – process, not a random one.

How are phenotypes constructed from genotypes? In something like the following way. As we all know, the chief function of genes is to code for proteins. Without the necessary proteins, of course, nothing can be done. That is why genes are so important. But the proteins are only the building blocks out of which phenotypes are constructed. *That construc-*

tion itself is controlled by the myriad other interactions among macromolecules that constitute the living cell. This process of construction is highly goal-directed, but also highly flexible. That is to say, the cell reliably builds a particular structure with a given set of material resources, or „gene products“. However, when it encounters a somewhat different set of material resources – say, due to a gene mutation – it will attempt to find a way of constructing an alternate structure that is equally serviceable from a functional point of view. This inherent adaptive capacity of living things is often referred to in the literature as „plasticity“ (West-Eberhard 2003; 2005; see, also, Greenspan 2001; Moss 2003). Since plasticity involves adjusting means to an end, it clearly follows the functional causation schema.

By now, it should be obvious that the function-reducing claim for natural selection is blatantly circular, since the theory of natural selection tacitly assumes the plasticity of the organism that is responsible for phenotype construction. The only way that natural selection could succeed in its function-reducing role would be if the property of plasticity itself could be reduced to mechanism. And, indeed, that is just what reductionists are claiming when they say that organisms are „machines“. So, it is now time to examine this claim more carefully. More specifically, we must now investigate the other chief theory by means of which biological purpose is alleged to have been reduced – namely, the concept of cybernetic control.

Reduction via Cybernetic Control

The idea is the following. First, we note that certain homeostatic systems in animals – for example, the water and electrolyte balance in the blood, body heat in homoiotherms, etc. – can be usefully modeled in terms of cybernetic or negative feedback control. Next, we draw an analogy between such organic homeostatic systems and manmade devices like thermostat-controlled home heating systems, for example. Finally, this analogy between organisms and machines is claimed to provide us with a general model for reducing biological purpose. However, there is a fallacy lurking within this analogy, due to the fact that the concept of cybernetic control incorporates the notion of a preferred state of the system in question, which is a characteristic of the functional causation schema.

Consider what happens when I set the thermostat on my home heating system to, say, 20 °C. I am picking out a particular temperature that is to be the preferred state of the overall system. And more importantly, the various parts of the thermostat and the furnace have already been engineered in such a way that the mechanical causes within the system will result in an air temperature corresponding to whatever set point I choose. These facts should already give us pause. Nevertheless, it might at first seem true that, considered just in itself, a cybernetic control mechanism is entirely describable in terms of the mechanical causation schema alone. And if that were true, then it might indeed look as though the reduction were successful.

The trouble is that, described in those terms, there is nothing *normative* about the set point of the system – nothing that constitutes 20 °C *as* a preferred state. This means that, considered in purely mechanistic causal terms, there is no way to distinguish a functioning heating system from a non-functioning one. If some part breaks, and the set point comes to correspond to a real air temperature of 10° instead of 20°, there is no way to identify this new causal pattern as a failure from within the causal structure of the system itself. Only by stepping *outside* the mechanical causation schema and privileging a particular arrangement of that system over others can the new pattern be identified *as* a malfunction. In other words, it is a malfunction *for me*, because it is *I* who decide what states of the system are to count *as* the preferred state. But there is nothing about the system itself that permits such a determination to be made. This means that a cybernetic control system is a very poor model of a living thing.

After all, my home heating system does not care what the air temperature in my house is, because it is not the sort of thing that cares about anything. But organisms *do* care about things. Above all, they care whether they live or die. To many, this simple observation will sound naïve and anthropomorphic. However, I am convinced that it is nothing of the sort, and that, on the contrary, trying to understand the sense in which *living things are not indifferent to their own continued existence as organized beings* is the most important foundational problem in biology. Stuart Kauffman has expressed the same idea as „autonomous agency", which he defines as a system's „acting on its own behalf" (Kauffman 2004, 655; see, also, Kauffman & Clayton 2006). Until we find a way of understanding this crucial respect in which living things differ from inanimate objects, I do not think that we will make much progress in overcoming the bifurcation of nature.

This way of posing the problem allows us to see better what a successful naturalistic account of purpose would have to do. Rather than attempting the hopeless task of *transforming* the functional causation schema into a mechanical causation schema without explanatory loss, what a successful naturalistic account of biological purpose must do is give a *direct representation* of the functional causation schema. This means, above all, finding some way of modeling the notion of a preferred state using the internal causal resources of the system alone, without recourse to any externally determined normative criterion. It also means showing the causal dependence of the means upon the end – or, as we often say, of the parts upon the whole. It is above all this *holistic* aspect of biological function that any successful model of biological purpose must capture.

Functional Causation as a Field Property

So far, we have been critiquing the mainstream view that biological purpose has already been successfully reduced to mechanistic causation. Now, the time has arrived to look at some new ways of modeling biological purpose directly. These ideas are all tentative, but I hope that some of them will have at least enough plausibility to suggest that the idea of seeking a direct physical representation of purpose is not hopelessly quixotic. If successful, such an approach would constitute a major revision of our usual way of thinking about naturalism.

I would like to start with an interesting suggestion made in 1953 by the British philosopher Richard Bevan Braithwaite. He proposed (1953, 328–336) an analysis of the notion of function that he hoped would succeed in capturing the unique holistic character of functional causation. Braithwaite's suggestion was that the property of plasticity be thought of as a *field property* of the system. This idea has the immediate advantage of allowing us to represent the notion of a preferred state as a global property of a system as a whole. It also allows us to understand plasticity, by showing how the relationship between means and end might vary as a function both of the global end state and of local external conditions that may either facilitate or frustrate the attainment of the end state by various paths. Finally, this idea provides for the kind of causal dependence of the means upon the end that is an irreducible aspect of functional causation.

Unfortunately, the usefulness of Braithwaite's suggestion was severely limited by the fact that the plasticity-as-field-property idea was to be implemented by embedding the system within an *external* field. This was in keeping with the fashion for behaviorist thinking in the life sciences at the time. Only the *behavior* of the system mattered; the internal dynamics could be ignored. However, as philosopher Lowell Nissen (1997, 5–11) has pointed out, this idea fails because it cannot distinguish between the behavior of a biological function and that of an ordinary inorganic physical system. For example, consider spring freshets flowing down a slope within a watershed basin, ultimately forming a river. The behavior of the freshets may be thought of as „plastic", because their actual paths may vary as a function of varying topographical conditions of the slope, and yet they will always arrive at the same global end state. Since even water flowing downhill would satisfy Braithwaite's field-theoretic analysis, the model is obviously inadequate. But the question is: What is the lesson that we ought to take away from Braithwaite's failure? Is it that field-theoretic thinking in the modeling of purpose is a blind alley? Or is it not, rather, that the field idea ought to be transferred from the outside to the *inside* of the functional system?

The idea of an internal field model of biological purpose might initially seem like a complete non-starter, because we are accustomed to thinking of the interior of the living cell as an immensely complicated, somewhat chaotic realm, in which the myriad macromolecules and organelles are suspended in solution, and for which thermal diffusion is the primary motive force. However, this picture of the cell is now known to be mistaken.

The fact is that the cytoplasm is not a bag of molecules in solution, but rather a dense matrix of structured fibers and vicinal water capable of rapid, ordered phase transitions from gel to sol phases and back again (Ho et al. 1996; Hochachka 1999; Luby-Phelps 2000; McNiven 2003; Pollack 2001; Pollack & Reitz 2001; Pollack et al. 2006). Furthermore, where diffusion does operate as a principal motive force, it is only within the context of gradients that have to be actively maintained by work. Diffusion is for the most part a destructive force within the cell, and by far the greatest part of cellular activity is actively directed by forces, including vectorial convection currents, selectively maintained electrical, osmotic, and other gradients, and coordinated gel-sol phase transitions (Wheatley 2003). All of these various physical forces must be construed as part of the cell's overall repertoire of functional control.

Furthermore, if the cytoplasm really is analogous to a gel (Pollack 2001), a liquid crystal (Ho et al. 1996), or some other semi-„solid state“ substance (McNiven 2003), then the theoretical apparatus developed over the past 50 years for the understanding of „condensed matter“ (that is, solid, liquid, and intermediate phases) ought to be applicable to it, in some form or other. And, indeed, over the past decade or so, a number of theoreticians have begun to develop field-theoretic models of limited aspects of the internal functioning of the cell. Two specific approaches are particularly noteworthy.

First, there are models at a phenomenological level that employ the idea of idealized networks of loosely coupled, harmonic oscillators (Freeman 2001, 2003; Ho 1997; Mikulecky 1995, 1996; Tuszynski & Kurzinski 2003; Yates 1994). The fundamental idea here is that biological functions may be identified with highly nonlinear oscillators, such that the limit cycle behavior of the individual oscillators can be coordinated with one another through a sequence of triggers that release the oscillatory behavior only in the presence of the functionally appropriate external conditions. For example, such a model might be applied to the conformational changes that enzymes undergo in the presence of their functionally appropriate substrates, where the initial low-energy bonding between enzyme and substrate at the active site functions as a trigger for the conformational change of the enzyme as a whole. A successful cycle is then completed by the release of the substrate and the return of the enzyme to its original conformational state, which is equivalent to resetting the oscillator to its initial state. On this kind of model, the *dynamical stability* of the oscillator is the global field property corresponding to the preferred state in the functional causation schema. (For more details, see Barham 1996, 2000, 2002, 2004; Yates 1994.)

A second sort of model is more fundamental, from a physical point of view. It employs electric-dipole fields associated with such cellular structures as bilayer membranes, proteins, and ordered vicinal water to explain long-range coordination of motion (Ho 1998; Hyland & Rowlands 2006; Pokorny & Wu 1998; Tuszynski & Kurzinski 2003; Vitiello 2001). According to this sort of model, at least some of the functional organization of cell processes would be explained by analogy with phonons and other sorts of field quanta in condensed-matter physics.

Now, I do not wish to suggest that we currently have empirical grounds for believing that any of these specific ideas are correct. Unfortunately, for the moment such ideas are far too sketchy to be put to effective empirical test. However, with the establishment of the new Institute for Complex Adaptive Matter, and other similar centers for the study of life from a physical perspective, there is reason to believe that this situation may improve in the near future. But even assuming that these ideas or some similar ones do prove fruitful in the long-term, the question will remain: Why are these ideas not just another form of reductionism?

If the mere fact of proposing a physical model of biological purpose were tantamount to reduction, then we would obviously be no better off with the field-theoretic models than we are with selection theory and cybernetics. So, the question is: How is it possible that a physical model of purpose might be conceived of as something other than reductionistic?

A New View of Emergence

First, and most importantly, the field-theoretic models of biological function do not attempt to transform purpose into something it is not – that is, they do not attempt to „reduce" purpose to the mechanistic causation schema. Rather, they postulate a physical theory adequate to the phenomena in that it preserves the holistic character of the functional causation schema. Here, it is the natural phenomenon of purpose that is in the theoretical driver's seat. It is a commitment to respect the evidence of ordinary experience and actual biological practice that is guiding our theory choice, rather than the metaphysical commitment to mechanistic reductionism controlling what we are willing to acknowledge as real.

I think that this reflection ought already to set our minds somewhat at ease. However, there is another consideration that I believe adds further support to the idea that a physical model need not *ipso facto* constitute a reduction. Namely, it is increasingly recognized today even within the physics community itself that reality is essentially layered, in the sense that each of the various levels of structure in the world enjoys a large degree of autonomy and stability. Let us call this the „emergentist" view of the world.

It is important to clearly distinguish what is sometimes referred to as „strong“, or „ontological“,[6] emergence, from the weaker, epistemological form. Clayton (2006, 7) has given a crisp definition: „Strong emergentists maintain that genuinely new causal agents or causal processes come into existence over the course of evolutionary history“. Clearly, it is the strong form of emergence that is required if we are to develop a satisfying alternative to reductionism that will respect the objectivity of biological purpose, and ultimately the reality of the human world. But are there any independent reasons for believing that strong emergence is actually true?

The answer to this question is decidedly Yes, and it is one of the most significant recent developments in the natural sciences. Anti-reductionism is one of those intellectual fashions that are perennially coming in and out of style. But what is different about the current cycle of interest in emergence is that it is not restricted to biology or psychology, but is largely driven by recent developments in the physical sciences themselves. In particular, the condensed-matter physics community, which had been skeptical of high-energy-physics-style reductionism all along, has at last begun to find its voice (Cao 1998; Dresden 1974; Georgi 1989; Laughlin & Pines 2000; Laughlin et al. 2000; Schweber 1997). This seems to me to be of the greatest importance for the problem of the bifurcation of nature, because any emergentist doctrine focused just on life or on mind will always seem *ad hoc*. But if contemporary physics itself is providing us with good reasons for seeing the whole of reality as layered, then it seems much more natural to see life and mind as particular stages within that more general emergentist perspective.

What are the reasons that the condensed-matter physicists give for seeing reality as layered? In a nutshell, one of the chief reasons is the nature of the body of physical theory that has been developed for understanding condensed matter. This is the so-called „effective field theory program“ (Georgi 1989), in which a few leading mathematical concepts, such as symmetry breaking, the renormalization group, and criticality, are applicable across levels, but in which the full articulation of the field theory at any given level requires the input „by hand“ of empirically derived quantities associated with the ontology unique to that level. In other words, while levels are not entirely cut off from each other, and some sense can be made of the emergence of new structures with novel causal powers out of the lower level thanks to the mathematical tools that transcend all the levels, nevertheless it seems to be an essential feature of contemporary physical theory that new laws emerge at each higher level that cannot, even in principle, be derived from the laws at the lower level.

This basic property of the world goes under various names. For example, Laughlin and Pines (2000) refer to it as „protection". Others speak of „stability". The crucial point, though, is simply that the world seems to comprise particular, privileged domains that are autonomous in the sense of being unaffected by the details of the physics at lower levels. It is interesting to reflect upon the fact that if the world did not have this sort of structure, physics would be impossible, because there would be no such thing as „negligible terms" in our equations. Thus, our existence as stable systems and our cognitive capacity to discover the underlying physical reasons for that stability appear to be intimately connected.

Now, there is certainly room for disagreement about the strong emergentist interpretation of the effective field theory program. Most elementary-particle physicists, I think, continue to look with some skepticism upon the anti-reductionist claims of their condensed-matter colleagues. But at a minimum, it is fair to say that emergentism is now gaining a lot more credibility within the physics community itself. And if it is good enough for the physicists, why should it not be good enough for biologists?

Finally, there is a different sort of worry that I must try very briefly to address. Someone following this discussion might reasonably wonder: Why doesn't emergence offend against the unification of knowledge principle?

In reply, I would admit that emergentism does involve a *reinterpretation* of that principle. To some, this may seem like cheating. But I think the real point is that many of us unconsciously *equate* unification with reduction. Obviously, emergence must violate any unification principle interpreted in that way. But if the world really is emergentist in its deepest structure – if novelty and creativity are written into the fabric of being itself – then we must learn to seek the intellectual satisfaction of unification in a slightly different way. I believe there is a kind of cognitive unification that is consonant with an emergentist ontology. Let us call it *integrationism*. To learn to see scientific progress in terms of integration of all levels, rather than as reduction to a single level, is, then, a crucial part of the necessary reform of naturalism.

Conclusion

I have made some negative claims and some positive claims. As to the negative claims, I think it is tolerably clear that the two principal mainstream approaches to reduction – via the theory of natural selection and via the theory of cybernetic control – do not succeed, because they tacitly rely upon aspects of the functional causation schema at various points in their own explanatory structure. As to the positive claims, I think the major objection that might be advanced against the ideas I have discussed too briefly here would be that they remain sheer speculation. With this, I can only agree. I certainly do not wish to be misunderstood as making a stronger claim on their behalf than could be justified by the actual work that has been done to date. All I would claim is that they appear to provide us with some grounds for hoping that the bifurcation of nature might eventually be overcome, without sacrificing any of our three guiding principles.

Notes

1 The claim that the use of teleological (i.e., purposive, in the biological sense) and normative language in biology is a mere *façon de parler,* and that all such expressions could in principle be translated into the language of chemistry and physics, will be addressed below. However, here it is necessary to point out that many investigators (e.g., Mayr 1988), obliged by the nature of things to use teleological language in their work, like to signal their mechanistic *bona fides* by employing the neologism „teleonomic", instead. I reject this usage as an attempt to evade the difficult philosophical questions through verbal sleight of hand.

2 For a fuller defense of biological purpose in the restricted, non-mental sense, see Bedau (1990).

3 How to understand reduction in general is a controversial matter. Several different senses of the concept are commonly distinguished: theory, explanatory, and constitutive (entity) reduction (e.g., Sarkar 1992). However, all that is required for „reduction to mechanism" in the present sense is that a complete account of a given biological phenomenon be provided which neither explicitly mentions nor implicitly depends upon any teleological concept. Whether this amounts to theory reduction, explanatory reduction, or constitutive reduction is a further question that need not concern us here.

4 See Brandon (1978); Mills & Beatty (1979).

5 One sometimes encounters the claim (e.g., Millikan 1989) that functions ought to be *defined* as „selected effects", or, in other words, that a biological trait should only *count* as a function after it has been selected. This claim

is highly counterintuitive. The fact that my heart is supposed to circulate blood seems in itself to have nothing to do with its selection history; rather, it seems to have everything to do with keeping me alive. For many of us, there is a powerful intuition that the heart of my duplicate who popped into existence a moment ago due to a cosmic accident would have precisely the same function as mine – to circulate my duplicate's blood, in order to keep him alive. Due to this intuition, functional causation was well understood in Antiquity, long before the theory of natural selection was articulated. For a fuller discussion of this and related issues, see Walsh (2000, 2006).

6 Sometimes, the term „ontological" emergence is used to refer to a position akin to substance dualism. Here, I use the term merely to distinguish a claim about the world itself from a claim about our ability to know the world. The sort of strong emergence envisioned by the physicists cited in the text obviously has nothing to do with substance dualism. It is merely the claim that a hierarchy of levels, each with its own distinctive entities and causal powers, objectively exists.

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