Some Thoughts on the Replacement of 'Divine Intervention' in Irreversible Biological Change

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ABSTRACT

There are few statements made with greater assurance than that evolution has occurred. Regardless, anti-evolution beliefs persist in spite of arguments to the contrary and their methodological inconsistency. One reason for this persistence may be the absence of a theory that makes evolution inevitable. The inadequacy of natural selection to account for evolutionary origins or life itself, is well known, an inadequacy that has been misconstrued as evidence that evolution has not occurred. Recent attempts to invoke the second law of thermodynamics as a cause of evolution through relating evolutionary change to entropic increase suffer from the contentious opinions about what entropy represents and the unavailability of understanding of how it would work to many biologists. Taborsky (1999) has offered a possible cause of evolution through linking energy flow, which follows from the second law of thermodynamics, and matter transformation; energy flows only through agency of the transformation of matter. This idea has been tested using ontogeny as a model for phylogeny. In a comparison of plants that process more, as opposed to less, energy, it was predicted that a feature of development and evolution, emergence, should show greater expression in the former than in the latter. A preliminary test verifies this prediction arguing for further experimentation. These debates focusing on evolution are another example of the conflict between old and new science, a debate that entered biology with Lamarck's rejection of the 18th Century view of the living world as static.

An unflinching determination to take the whole evidence into account is the only method of preservation against the fluctuationing extremes of fashionable opinion (A. N. Whitehead)

In all this, however, the rhetoric of conviction was far ahead of the sober appraisal of the evidence at hand. (S. Jaki, The Relevance of Physics)

1 THE PROBLEM

Irreversible biological change is manifested in ontogeny and phylogeny, two central biological phenomena through which form, the biological world most people perceive, unfolds. Ontogeny encompasses the events an individual undergoes from inception to death; phylogeny the changes within a distinct assemblage of individuals from when they first differentiate to their disappearance, either through extinction or transformation. An event common to both phenomena is emergence, i.e., the appearance of novelty; whether that novelty is expressed as new features or as changed relationships among old features (Maze et al. 2001b).

One looks to theories of change to account for ontogeny and phylogeny, to give us guidance in understanding why and how these biological events occur. Unfortunately, biology has a surfeit of data but a dearth of theories that predict observations that, potentially at least, post-date 18th century natural theology. Most theories of change have been evolutionary and focused on phylogeny, although there have been attempts to merge ontogeny and phylogeny (Løvtrup 1974; Salthe 1993). Evolutionary theories have had a long history in biology starting with Lamarck (1803), although the more usual popular starting point for evolutionary theory is Darwin (1859). In spite of being almost 200 years old, evolutionary theory remains contentious. To biologists, accounts of evolutionary, and as well, developmental, change must be beyond divine intervention that sets aside the laws that control natural phenomena. But a natural account for what biologists call evolutionary change is still doubted. Behe (1996) and Denton (1986) have resurrected the argument from design as applied to the molecular level of life and Johnson (1991) has raised objections from arguments about the nature of evidence. These rejections of evolutionary theory often have a religious basis, usually representing the efforts of some evangelical Christians, and therefore are dismissed by most practicing biologists. But among the evangelical Christians there are biologists (Lamoureux 1999a, 1999b) and physicists (Barbour 1997; Polkinghorne 1996, 2000) who see no conflict between evangelical Christianity and evolutionary theory. They allow for the intellectual freedom required by the acceptance of biological evolutionary theory.

To us there appear to be two issues in these anti-evolutionary views, their validity and the reasons for their persistence. Like most modern biologists, we do not accept their validity, but for reasons not shared perhaps by other biologists. Attempts to refute anti-evolutionary arguments have emphasized the nature of the evidence for evolution and how scientific arguments are constructed. In spite of the fervor that carries these arguments along, they fail in their goal of offering a final defense of evolutionary theory because their approach often is as evangelical as that of the critics of evolutionary theory—only the deity is different. Our dislike of anti-evolution arguments is not based on the evidence for evolution or the nature of scientific arguments, but because their acceptance places unnecessary and unacceptable constraints on intellectual inquiry. That evolution has occurred is a very strong inference based on certain types of similarities among organisms. This type of inference is the same as that used when giving meaning to any other kind of biological similarity; morphological and chemical similarities are valid inferences of family relationship, just as are the chemical and physical similarities often used in forensics to establish guilt or innocence. To establish meaning for one set of similar objects, members of a family or forensic evidence, but to deny it to another set, organisms related back through distant time, is beyond the pale of acceptable intellectual inquiry. It denies a law-based structure to our observations and indeed may even be a form of hypocrisy.

In spite of the invective against anti-evolutionary arguments, or the weaknesses we perceive in them, they persist, leading us to wonder if perhaps there may be some reason for that persistence other than religious conviction. One such possible reason for their continuance is that, currently, there is no way that evolutionary change can be argued to be the inevitable result of natural phenomena, such as the movement of energy along energy gradients or the rise and fall of tides. Many biologists view evolution as a fact beyond doubt, but that opinion, in spite of the strength with which it is held, does not make it the inevitable outcome of natural events. A step towards placing evolution, or indeed all irreversible biological change, within a framework of natural inevitability may be the recognition of a clearly defined natural law readily understandable to all biologists. Evolution could then be deduced in the sense that it is the deductive inference based on the application of natural laws to certain contingent conditions, i.e., it follows Hempel's (1966) covering law model where, given the conditions of life plus the relevant natural phenomenon evolution is inevitable.

We are aware that natural selection is often considered to be that law from which evolution can be deduced; Darwin (1859) himself does just that. But natural selection does not, of necessity, lead to change, for example, stabilizing selection leads to stasis. Indeed, natural selection is a variation decreasing force and, as such, is contrary to the appearance of novelty or the emergence of new forms. Actually, natural selection can only act on things already present. Relying on the end point of natural selection, i.e., adaptation, will not offer a plausible account of why there should be anything more elaborate than bacteria since they appear to be well adapted to the environment in which they occur. In addition, philosophers who have looked critically at natural selection (Rosenberg 1985; Himmelfarb 1959; Johnston 1998) have elaborated on its incomplete nature, its inability to offer an explanation, *sensu* Hempel (1966), for evolution. Also, natural selection is not a cause that offers a possible answer to the question, “Why does evolution occur?” Instead it is one proposed mechanism of evolution, an answer to the question, “How does evolution occur?” Finally, natural selection has the property of contingent conditions, not of a natural law.

Over time, there have been attempts to place evolutionary change in the context of a natural law or to present it in such a way that the existence of such a law is, at least, inferred. The first was Lamarck's power of life (Burkhardt 1977); that is, the drive, possessed by all organisms, towards increasing complexity. But Lamarck's theory suffered from an inadequate mechanism where flowing fluids lead to the incorporation of acquired attributes followed by their inheritance. There was also a mystical quality to his power of life that often is offensive to biologists, including Darwin (1859). Some modern attempts to place evolution within the context of natural law have invoked the second law of thermodynamics through relating evolution to an expanded concept of entropy (Brooks and Wiley 1988). The general idea, as we understand it, is that the change in the expression of information that takes place during phylogeny, and ontogeny as well, has entropic properties thereby placing evolutionary theory within the context of post-Newtonian physics, viz., the second law of thermodynamics.

These arguments, placing evolutionary change within the realm of physics via entropy, also invoked the concepts of entropy production and exportation. The expression of information is the result of (or results in) entropy production and exportation, which is inevitable under the second law of thermodynamics as expanded to incorporate open systems (Prigogine 1980).

These arguments relating evolution and entropy remain appealing but, to us as experienced biologists, there remain some problems. First, entropy is a loaded term invoking vastly different reactions, and occasionally invective, from different people. One reason for this is the concept of entropy carries the inference of loss of order, something contrary to the experience of biologists. Second, to us, that still leaves the question of the relevant 'force' unanswered. Yes, entropy may increase but what drives that increase in living things? Third, incorporating terms from physics into biology may be labeled as producing an alternative lexicon but little more. 'Novelty,' a term fairly clearly understood in biology is replaced by 'entropy' but there are no(t) new observations or experiments. The 'dissemination of energy' can be replaced by 'entropy production' but, again, to what empirical or experimental end?

2 A SOLUTION?

Taborsky (1999) has offered a perspective from which one can understand why information may flow, an identification of the elusive force that can account for information transfer. She has argued that energy never exists free, independent of matter. When energy flows from one part of a system to another it is through the agency of matter transformation, where the flow of energy results in matter transformation. For example, when the energy in a cross-membrane hydrogen ion gradient flows it is then captured in the transformation of ADP + P into ATP; when the energy in ATP flows under certain conditions it is captured in the transformation of a carbon compound from a three- to a four-carbon molecule. There are many other examples. This transformed matter is what Taborsky (1999) calls information.

The inference of Taborsky's argument is that information transfer occurs concomitant with the flow of energy along energy gradients. How matter is transformed will be a function of the organism within which it occurs. The force driving information transfer is the flow of energy along energy gradients; the linked flows of energy and information will be directed by the organism within which it is occurring.

3 A TEST?

It seems to us that one of the criteria in the initial test of an idea is simplicity. The focus of our discussion on irreversible biological change is on evolutionary theory as it offers a naturalistic account for phylogenetic change. But phylogenetic change is complex since it involves the transformation of assemblages of individuals isolated in space and time. As well, the time invoked in phylogenetic change, is time inferred from the interpretation of patterns revealed in data after a certain type of analysis has been performed and which is of sufficient length that it is beyond human experience. A more direct way to evaluate irreversible biological change is to use ontogeny as a model. Ontogeny, the events that refer to irreversible change (development) in an individual is something readily available to investigators. We have all encountered annual or biennial plants that complete their development within one or two growing seasons or frog eggs in a pond that rapidly develop into mature individuals. Even the ontogeny of much longer-lived plants, such as trees, occurs over a time sufficiently short that it is readily comprehended by a human, as was his own development. Thus, a test of Taborsky's (1999) argument about the linked flows of energy and information would be most readily performed within an ontogenetic context.

A testable prediction from Taborsky (1999) is that ontogenetic systems that differ in the flow of energy will show differences related to information: Those with a higher rate of energy flow will show more information expression than those with a lower rate of energy flow. In fact it is just such an interpretation that Maze and Vyse (1993) used in order to offer an account for differences seen in seedlings of *Picea engelmanii* Parry. The plants had been subjected to different treatments that resulted in different rates of energy flow as expressed in growth rate.

4 TESTING THE THESIS

In constructing these predictions designed to test Taborsky's (1999) idea, a first assumption is that within a species more energy will be processed by 'faster' growing, as opposed to 'slower' growing, plants, as energy is converted from sunlight into tissue. More matter will be transformed as a result of the flow of more energy.

In the context of this proposed test, the next question is, how will transformed matter, the information, be expressed and once expressed, how will it be evaluated? It is possible to measure the molecular details of matter transformation, but that is so labor intensive that any sample evaluated would not be large enough to give any statistical confidence in the results. An alternate way to evaluate matter transformation, while indirect, is through measuring growth rates. A faster growing organism will show faster growth rates and enough organisms can be measured to generate a large sample. But the evaluation of growth rates alone can be used only to make inferences about size differences and, as interesting as they may be, size differences are of limited relevance in phylogenetic arguments. The kinds of differences that appear during phylogeny are far more complicated, often being related to shape, than organisms that differ in size.

There is another way to evaluate the transformation of matter that is more appropriate to using ontogeny to model phylogeny. This is to use a feature common to both ontogeny and phylogeny, emergence. A recent series of studies (Maze and Bohm 1997; Maze 1998, 1999; Maze et al. 2000, 2001a, 2001b) has demonstrated that the products of both ontogeny (individuals) and phylogeny (groups of related individuals) show 'emergence' (Our definition of emergence is taken from Polanyi (1958) and is the case when a higher hierarchical level, the whole, has properties not seen at lower levels, the parts. For the protocol of the experiments see the studies cited above). Three of those studies (Maze et al. (2000, 2001a, 2001b) have further demonstrated a relationship between time and the amount of emergence expressed. The longer something has been in existence, whether a group of related organisms (Maze et al. 2001a, 2001b) or developing needles on a Douglas fir (Maze et al. 2000), the more emergence it shows. Thus, on the assumption there is a relationship between rate and time, a certain stage can be reached, either through the passage of a certain amount of time or a faster rate of development over a shorter period of time; the faster growing organisms should show a greater amount of emergence

One test comparing the amount of emergence in faster and lower growing seedlings of Engelman spruce (*Picea engelmanii*) has been performed and the faster growing plants did show a greater amount of emergence (Maze et al. 2002). Further, similarly constructed tests are easy to do. Growth rates in sets of identical plants can readily be manipulated in growth chambers, by the application of fertilizer or modifying the heat environment of a plant. And it is a common phenomenon in conifers that some branches on a single tree will show different growth rates, allowing a comparison of genetically identical needles on such branches.

Should the above predictions linking growth rates and emergence be borne out beyond the initial study in Engelman Spruce then it may be possible to offer an important addition to a search for a naturalistic account for irreversible biological change: the flow of energy through an organized system will be accompanied by a concomitant flow of information, a flow of information from which the distinctive form of that organized system will appear.

5 PROBLEMS

The specific tests performed may create some problems since drastically altering growth rates may produce botanical monstrosities. That problem can be solved through relying on botanical experience, a feeling for the organism (Keller 1983), and by keeping manipulations within a biologically reasonable range. If these ideas, and those of Taborsky (1999), stand up to scrutiny, what has been offered is a naturalistic explanation for one type of irreversible biological change, ontogeny. A most serious problem is linking ontogenetic to phylogenetic change; that is a daunting task. This task is made even more difficult since a studied examination of the relation of ontogeny and phylogeny immediately encounters the twentieth century position of developmental investigators that development appears to be a goal-directed process. This may be carried even to the point of 'double assurance', i.e., more than a single method of achieving a developmental end point being displayed on occasion; this is also inferred in Waddington's (1975) canalization thesis. But any consideration of goal-directed phenomena in phylogeny is held, by some, to be, at the least, irresponsible.

Even so, should a connection between ontogeny and phylogeny be established so that a naturalistic account for evolution be demonstrated, will anti-evolution arguments abate? We would like to think so but our optimism is guarded. Theistic science, from which supernatural accounts for the world originate, is a tremendously complex set of ideas (Griffin 2000; Polkinghorne 1996, 2000). It is possible that this complexity, in spite of Griffin's (2000) optimism, will delay the universal acceptance of naturalistic accounts for irreversible biological change.

6 HISTORICAL PERSPECTIVE

In the fourth century B. C., the worldview described by Aristotle—a biologist-philosopher—was accepted by the Greeks over that of Democritus—a physicist philosopher (Jaki 1975). The holistic position of the systematist-embryologist, Aristotle, with regard to organisms, was preferred to that of the reductionist philosopher, Democritus. This Aristotlean world view remained in place more or less until the confrontation between ancient science (Aristotle-Ptolemy) and new science (Copernicus-Galileo), mediated by the Church, occurred in the 17th Century. It is interesting to note in this regard that the pervading reductionist view of much of modern biology, as expressed in the belief in genetic determinism, seems to be incapable of living up to some of its promises (Strohman 2001).

A similar confrontation between the science of the 18^{th} Century, with its concentration on classification (Mayr 1982, Panchen 1992), and the meaning of systematic relationships resulted from the efforts of a single individual, viz., Jean Baptiste Pierre Antoine de Monet Chevalier de Lamarck. During the final decade of that century Lamarck sought to arrange the Invertebrates in the former Royal Museum collections into meaningful groupings, including both living and fossil forms (Himmelfarb 1959), that summarized their relationships. To that end he produced a carefully developed chain of causations (Mayr 1982) which used mechanistic explanations (electricity, flowing fluids) and he deserves credit for being the first to develop a consistent theory of evolutionary change, a legitimate theory of adaptational evolution (Mayr 1982). Thus, early in the 19th Century, Lamarck established stages in his classification with some branching to represent deviations, environmentally induced, thereby modifying his pattern of phylogeny (Packard 1901). The divisions were produced to establish his hierarchical (artificial) classification (Panchen 1992) that was representative of a phylogenetic evolution of organisms (Løvtrup 1974). In this scheme, two theories of the mechanism of evolution are required (Løvtrup 1974): first, creation of novel organisms—an epigenetic phenomenon; and second, their survival—an ecological phenomenon. The epigenetic would be concerned with the mechanisms taking place in developing organisms (see also Waddington, 1975), while the ecological would be concentrating on factors ensuring survival, or failure of survival, of taxa in nature. Lamarck did not succeed in explaining the epigenetic aspect of the mechanism of evolution though he remained convinced that epigenetic processes were an essential aspect of evolution (Løvtrup 1974).

It has been clear, at least since von Baer's day, that the evolution of organisms must really be regarded as the evolution of developmental systems, and that a theory of evolution requires, as a fundamental part of it, some theory of development (Waddington 1975). Indeed, as Waddington noted, one of the major problems for biological theory is the nature of these processes of development, as brought about during evolution, that result in organic structure precisely adapted to the functions it performs.

In summary, Lamarck, for the first time early in the nineteenth century, had presented evolution as following from four laws: (a) there is a force of life that leads to an increase in dimension and volume; (b) the incorporation of traits results from a need imposed by the environment; (c) the development and effectiveness of organs is proportional to use and disuse; and (d) the inheritance of attributes is acquired through time (Cannon 1959). These laws served to associate the scientific challenge of the study of life with an understanding that nature was an historical phenomenon (Jordanova 1984), which could be reflected in one's systematics.

In the recent debates focusing on evolution, human beings are now front and centre thereby raising the stakes a bit. The idea that humans are demonstrably brute beasts, at least in development and physically, is distasteful to some humans. Perhaps the unwillingness of some students of the living world to separate the physical from the spiritual in their explanatory position is the basis for their anti-evolution views. Interestingly, Lamarck was able to accomplish this feat and avoid the charge of materialism in nineteenth century France.

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