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Organization and Evolution: A 21st Century Baldwinian Synthesis

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ABSTRACT

The "mechanism" of evolution is traditionally viewed as blind, passive selection operating in a non-living, physical environment. There are increasingly compelling reasons to challenge this view. Many modifications to the "neo-Darwinian synthesis" have been proposed to include partly directive processes that are most apparent in, while not limited to, the human case. Although little emphasized during the Century since their writing, the evolution and development theories of James Mark Baldwin argued the case for directed evolution effectively, as an entirely non-Lamarkian result of the action of psyche. It is proposed here that this "Baldwin effect" should be seen as a fundamental process, rather than a superficial "effect." When combined with an interpretation of Robert Rosen's theory of "modeling relations" as a similarly fundamental process, these views combine to form a surprisingly general view of nature itself -- a view that sharply contrasts with the idea of a "physical" reality from which life "emerged." Instead, this view presents nature as resulting from a living reality, defined throughout by self-modeling. That view is consistent with knowledge, from the strange behavior of the quantum world to the otherwise inexplicable origin of the universe and "anthropic principle." That living reality can be described scientifically in terms of a natural relationship between structure and function. In this view, evolution is capable of self-direction, and its pathways are inseparable from a natural process of meaningful definition. This explanation of nature avoids the problems of *de novo* emergence on the one hand, and "intelligent design" on the other, by incorporating intelligence as a natural phenomena originating within systems, as a result of their necessary functional entailments.

Keywords: Evolution, life, ontology, mind-in-nature, Baldwin.

Charles Darwin (1859) indisputably provided the most influential ideas guiding 19th and 20th century thought about life. His theory of evolution, which provided the mechanism for "descent with modification" by "natural selection," dramatically changed scientific and cultural thinking about our place in nature. It also posed serious problems for religious beliefs, fueling a classic public debate lasting to this day. Less well known is the work of James Mark Baldwin (1861-1934), who proposed a causal role of psyche in otherwise passive Darwinian evolution, producing or sustaining behaviors (throughout development and living) on which natural selection operates. The "Baldwin effect" (Baldwin, 1896a) became known mostly in information science as the effect of learning, but is generally unappreciated as a fundamental issue. It could perhaps be called the logical ancestor of now emerging cultural evolution paradigms,[1] but even that is an honor that may belie its greater value.

Baldwin (1896a; 1902; 1909/1910) argued that his modification would have the effect "*of setting a determinate direction in the generation which these creatures represent.*" He also thought that it should apply generally, to all living creatures *"that have any ability to imitate"* or *"make adjustments on their own,"* with the result that evolutionary pathways are biased creatively. He saw the means for this as entirely non-Lamarckian, writing: "This completely disposes of the Lamarckian factor" (Baldwin, 1902, p100).[2] Recent developments in systems theory seem to lend his view considerable support. The implications for understanding the past, present, and future of life are much too fundamental to attribute to a mere "effect." It may in fact be that Baldwinian evolution is the more general theory, within which Darwinian mechanism is a special case, giving evolution a generally creative rather than passive characteristic. We might thus begin discussing "*Baldwinian evolution,"* or in modern terms, *"autevolution"* (Kineman, 1997; Kineman and Kineman, 1999). This presents a completely different perspective on reality, as originating from living relationship rather than mechanism. Such a view has long been sought-after in various theories of "super-organism" and Gaia; but these prior ideas suffered from conventional thinking that was too limited in scope (Kineman, 1991). A new understanding of Baldwin in the context of recent revelations in systems theory, provides a more solid foundation for deep questions about the reality of life, and surprisingly, all of nature. It also provides a rational escape from the classic and highly polarized debate between current evolution theory and creation beliefs.

At issue is whether mankind is to be considered a spiritual creation or a natural one. If it is the former, then surely we owe our origins to a purposeful (and thus meaningful) force in the universe. If it is the latter, then we must look to scientific descriptions for a common ancestry. But that is precisely the problem. To establish a means for describing nature, science developed its image from essentially material concepts that were independent of purpose and meaning. This was thought necessary to establish a basis for testable knowledge. And thus the battle lines were drawn over whether knowable reality comes with or without essential meaning.

The Dark Glass

"Physicalism," which also dominated 19th and 20th Century scientific development, consisted mostly of machine-like analogies (mechanisms) for all natural phenomena of interest. Darwin's theory, while keenly perceptive of biological novelty, was nevertheless, essentially of this type (even though Darwin himself took pains not to rule out more creative influences on evolution, particularly in the case of Homo sapiens). Physicalism reduces explanations to behaviors of definable elements of sensible nature, thus comprising "mechanisms." This, of course, was immensely convenient and productive in many fields of science, most fundamentally in physics. Being based on measurable elements, theories of this style could take advantage of the precision and predictive power of quantitative mathematics. Indeed, success was so intoxicating that many physicists adopted the claim (first attributed to Pythagoras) that "God is a mathematician" (Dirac, 1963). But it was far less successful in the life, psychological, and social sciences, creating a methodological dilemma. Certainly the beauty and mystery of creation as revealed in mathematics, was and remains an awe inspiring discovery, but is it a fully adequate representation of nature?

The ability of mathematics to provide final explanations of nature was brought into serious and so far irrefutable question (well before Dirac's proclamation), by Kurt Gödel's (1931) "incompleteness" proof. This has been followed by many other demonstrations of mathematical subjectivities (Hersh, 1997). Gödel's proof was an elegant statement of why no formal symbolic system (which mathematics is) can account for all of its own requirements. In other words, there is always something missing from what can be represented in symbolic form.[3] Baldwin (1902), had already said: "*All statements of the nature of a thing get their matter mainly from the processes which they have been known to pass through...however, [they] never exhaust the reality of a thing; since no statements can be the entire truth of the experiences which they state...*" With this finally proven, the troubling result is that only the incorporation of a *mathematician* can complete *mathematics*. A similar problem appeared in quantum mechanical theory, where the definition of precise physical states seems incomplete without "observers."[4] There may be a common reason: *that "syntax" alone (computable structure) cannot account for its own necessary "semantics" (meanings and definitions), and that "semantic closure" (their complete relationship) is required for a system to be whole or natural.*

A SCIENCE OF INCOMPLETENESS

"The Map Is Not The Territory"[5]

Robert Rosen (1985, 1991) introduced a powerful way of employing the principle that all of knowledge consists of necessarily incomplete formal representations of nature (Mikulecky, 1999). He called it the "modeling relation"[6] (Figure 1), which shows the way that a "formal system" of representation (and thus all of science) attempts to mimic "natural systems," by studying and experimenting with its behavior and constructing analogies.

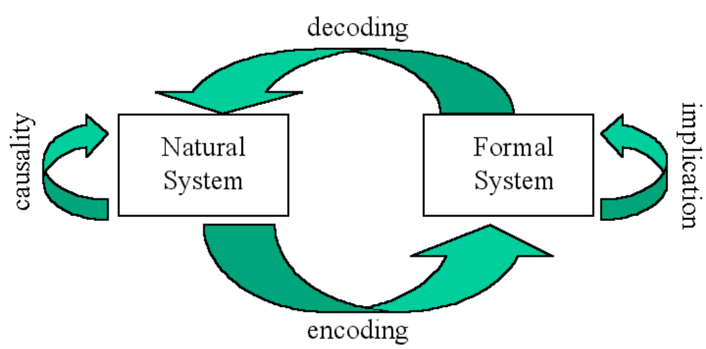

Figure 1: The Modeling Relation (Rosen)

The inability of all such formal systems to provide complete representations of nature implies that:

Postulate (A): *The relationship between a natural system and its formal representation (a Rosen modeling relation) can never fully commute; that is, the two components of that relationship can never behave in exactly the same way.*

The modeling relation was originally developed from an epistemological (study of knowledge) perspective (Dress, 1999). But the analogy between natural systems and models works in both directions. *If semantic closure is required in the description of reality, then something analogous must exist in the natural system.* In other words, nature must already have the ability to close its own semantics, and thus have complete systems that we can then call whole and natural. That critical agency is most likely the same agency that humans are able to provide to close the semantics of modeling. There is little choice but to think of it as *the meaningful act of "modeling" itself*, which must then be assumed to be an ongoing natural process. This act makes a system of representation completable in principle, although not in fact at any specific time. Our human ability to experience and describe nature (including science) could then be said to be an evolved instance of that natural activity.

If the model presented in Figure 1 is to be taken as a natural one representative of a natural act of modeling, it must also be true that:

Postulate (B): *the formal component of a natural system is not simply an artifact of the structure; it must represent causal effects of its own.*

Is Modeling Natural?

We know what "meaning" is only through our own human experience of it, because it cannot otherwise be observed. This makes it difficult to define analytically, or to determine what agency provides it generally. Instead, more specific concepts closely related to meaning, such as "information," are used to meet this need in science. But such analytical terms may ironically loose the original connection with meaning and experience. Alternatively, meaning can be personified as "soul" or "spirit." This is certainly more acceptable in religion, where the statement "God is information" may be no more appealing than calling Him a mathematician. But such theological terms are too vague for scientific purposes. In systems science it is becoming popular to think of this extra quality as the functional or organizational semantics of a natural system.[7]

These aspects of knowing and experiencing clearly do not reside in the manifest (physical) domain that we can describe from sensory inputs. We associate these concepts with domains of mind, consciousness, or perhaps more generally, psyche. Rosen, calls this the "formal" domain, or the domain of formal systems.[8] It is the domain of *representation* as opposed to *manifestation*. So, if we wish to retain some concept of a fundamental "reality," perhaps it is the modeling relationship itself that best represents what is most natural and real.

Deconstructing reality into modeling relationships (to better understand it) is a theoretical device.[9] It differs from mechanistic analysis only in the fact that it incorporates the formal domain into nature rather than keeping it strictly separate. As described, that introduces a considerable change in our concept of reality. But it is obvious that if we are to explain anything in nature that shares abilities we associate with life, we must consider those abilities as having developed from logical precedents in nature. The key to understanding complex life may thus be in realizing that not just we, but *everything* generates models of nature, and in so doing establishes the capacity for anticipation. Baldwin also realized this principle, writing: "*...no statement can be the entire truth of the experience which they state unless they construe the reality not only as a thing which has had a career, but also as one which is about to have a further career; for the expectation of the future career rests upon the same historical series as the belief in the past career*." It could be said that fundamentally, nature generates models of itself in many simultaneous and interacting ways -- an ability we would normally associate with intelligence or psyche. [10]

Modeling the Modeler

Unfortunately, even the modeling relation cannot completely explain, by itself, how the semantics of a natural system close; an act that an actual living (or complex) modeler[11] can do. The reason is that *a modeling relation is itself still a model, and therefore incomplete.* That circularity is inescapable, being an actual limit to knowledge. Hence:

Corollary (1) to Postulate A: *No system can provide for a complete explanation of its own context (or thus, its origin). Thus there can never be a "largest system" that explains (or contains) all systems. As a result there can never be a complete formal description of reality.*

However, it is possible to use the basic structure of the modeling relation to represent the "modeler" as an unbounded series of modeling relations, each providing the necessary semantics for its sub-systems. This allows one to approximate reality in an analogous way by incorporating the incompleteness problem into all levels of the modeling structure. This has the practical value of allowing one to distinguish proximal causes while not forgetting about more distant ones. It thus assumes that natural systems are embedded in multiple contexts defined by relationships with other systems, the total of which achieves semantic closure. If systems are explained by such multiple contexts, however, they then must include non-local[12] functional relationships, that is, functions that come from relations with other systems. In this way, shared functions may have local effect.

Most of science up to recent times was based on the idea that physical components alone are fundamental and they combine to make larger systems. Science in general accepted such ontologies (theories of origins) of systems in terms of their parts, but not the reverse. If causality is allowed to operate in both directions between larger systems and their components (thus allowing explanation of parts in terms of wholes), nature then appears "participatory" (Wheeler, 1981) and "complex" (Rosen, 1991). It can no longer be thought of as an arrangement of basic "building blocks," from which mysterious properties "emerge."

Such "impredicative"[13] loops cannot be calculated to precisely specify future states. However, the loops themselves may be qualitatively represented (for example in category theory) to show causalities, while other means may be employed to analyze the causal mappings. New methods are needed to relate such mappings to overall system patterns. [14]

Perfect Imperfections

The principle of mutual relationship provides some insight into how nature models itself. To understand how models arise and how they can exist through time, it is necessary to consider mutual causality between systems and their organization in terms of function. We can say without much controversy that only whole, natural systems interact in nature. Thus, a specification of function cannot exist except as part of a real system. The natural relationship in Figure 1 must then be viewed as a relationship between two natural systems, and can thus be applied as a model of natural phenomena, where both sides of the relationship must mimic each other imperfectly.

To accomplish this, a formal system in one relationship must have a secondary relationship with a recording system. This can happen if two systems share a formal system, but then each will be slightly different. For example, if a formal model of an object is to be separately recorded in a memory, say in a book, it will then have to be in a modeling relationship with the physical components of that memory. Due to the relational inequality expressed in Postulate A, it is clear that the formal system differs slightly from the analogous structure of the original system it modeled and from its recording. Hence the record must also be different from the original system, leading to a principle of uncertainty or error in replication. Consequently:

<u>Corollary (2) to Postulate (A):</u>
No natural system can be duplicated, and therefore living systems are naturally unique. There can never be an exact clone.[15]

Gene expression is an example of this imperfect modeling principle. Whereas it was once thought that the genetic code precisely "specifies" structures, that view does not seem to hold up. Instead, it is more likely that the *context* in which a gene is functionally embedded plays a causal role in its ultimate expression. In other words, it is the relationship between a system and its larger system that is functionally conditioning many events, including the specification or development of system components. The same problem appears in otherwise mechanical systems when there are unconstrained mutual causes, as in the n-body problem in kinematics. In that problem, the motions of each part depend directly on the organization of the whole – a causal loop that does not have a precise mathematical solution. One could say that such systems generate new information that is necessary for their own definition and without which their future states cannot be fully specified.

KNOWING THE COMPLEX

The Complexity of Cats

The modeling relation, when applied as itself a natural system of mutual causalities, may be thought of as a relationship between "actual" and "potential," bearing in mind that each is only relatively distinct within a larger context. For example, a cat is clearly a cat in any observation of it, but nevertheless it is not a fully realized cat outside of the contextual relationships that allow it to breed, eat, and pursue life. The functions of psyche that allow it to be a complete cat involve shared contexts with many other systems; sub-systems, parallel systems, and super-systems. All of these are an essential part of the completeness of the cat. Furthermore, the cat was not manufactured de novo, but evolved over time. It therefore has shared contexts with its own history (ontogeny). All of these shared functions are brought into dim or sharp focus by the formal modeling ability (psyche) that evolved with the organism. At each evolutionary step (as will be shown), that psyche has had Baldwinian interactions with natural selection that have partly determined the path of physical change (phylogeny). The now famous "Schrödinger's Cat"[16] was no exception to such complexity. That much abused theoretical animal demonstrated one fact clearly; that *everything natural depends on its functional context*.

Untangling such an interrelated set of relationships seems an impossible muddle in terms of actual and potential systems, neither of which can be fully known. The modeling relation may provide the appropriate metaphysics for thinking about the problem, but in practical use it must be translated into elements about which there can be direct knowledge. The key is to not lose the important metaphysics in this translation; that is, we want knowable elements that directly relate to both sides of the modeling relation, and mimic that relation.

Structure-Function Complementarity (SFC)

The physical domain can be observed through the senses and expressed in terms of structures (sensory, syntactic knowledge). The formal domain can be understood through subjective processes (psyche), which can be expressed in terms of functions (experiential, semantic knowledge). Yet one must remember that these two ways of knowing are each and together inadequate to fully represent nature due to the limits of knowledge. Therefore, the physically apparent and formally implied domains *both lie outside the domain of "realizations" (natural systems).* They are both models.

Structure and Function, while each incomplete, are nevertheless two primary aspects of nature that we can directly know and thus find most familiar because of our capacity for knowledge. They are also the knowable components of the modeling relation, and thus are the logical candidates for representing it. It follows that they must be presented in an analogous relationship.

An analogous form of the modeling relation (a relationship between modeling relationships) can be identified as a "structure-function complementarity" (SFC) -- relating structures that can be observed and computed, and functions that can only be known by analogy with experience. Complementarity is a term borrowed from quantum physics (Bohr, 1958), which means *two equally causal (i.e., theoretically real) aspects of nature, neither of which can be reduced to the other.* It is a way of understanding that structure and function always exist in an incomplete causal relationship with each other, and thus with error or uncertainty in that relationship.[17] Thus:

Postulate D: *Structure-function complementarity is the practical means by which complex reality can be represented in terms of knowable phenomena.*[18]

For a given system, one is then concerned with the structural aspect of the manifest system and the functional aspect of its model (not forgetting that each of these have hierarchical relationships as well). The functional component of a system is the abstract portion of its formal system model.[19] The structural component is the sensible (tangible) portion of the system of interest, which is roughly its mechanical description.

Figure 2 shows two domains where SFC can mimic natural complexity. At the top of the diagram is shown the epistemological domain where SFC represents classic mind-body

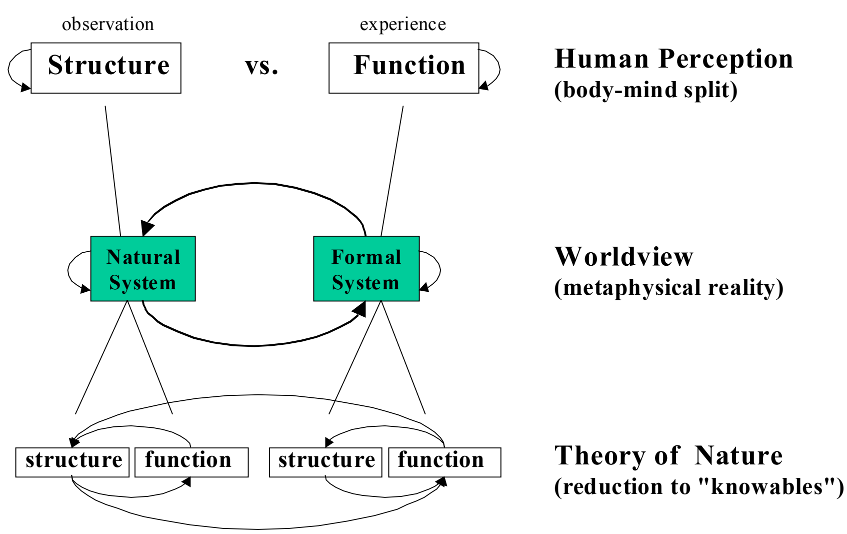

Figure 2: Decomposing Reality

dualism (the knowable elements of reality that we perceive as separate). At the bottom is shown this same dualism, but incorporated into a relational theory structure constituting wholes.

That structure also implies an unbounded series of *inclusive contextual systems.* A contextual hierarchy may be analyzed separately, or represented as functions of more immediate formal systems (for example, the role of environment as reflected within an organism's self-model and life strategy). Similarly, components of such a hierarchy may be presumed to act as contextual systems for their natural components that can be modeled in the same way. This theory structure allows one to specify functions of interest at any level of analysis, although at the cost of attributing them with non-local aspects. It implies something analogous to a "mind" being partly distributed throughout the hierarchy of contexts, but nevertheless brought into local causality by the system.

Wholeness and Uncertainty

Complementarity suggests a unified domain from which the two aspects of the relationship are derived but which they cannot fully represent (hence leaving uncertainties). Thus,

Postulate E: Complementarity exists i*n a relationship when it attempts to deconstruct (model) an unknowable whole.*

By modeling nature in terms of a complementarity, the presumed unity becomes represented as a hierarchy of inclusive relations. That creates a theoretical decomposition that allows explanations in terms of the constructive elements, but represents properties of "wholeness" in terms of contextual systems. The alternative is to decompose reality into presumed real components that have no greater whole. As argued already, that approach is synonymous with mechanism and its failure at representing natural systems is perhaps the strongest evidence for hidden wholeness. The relation between wholes and parts can be seen, for example, in Maturana and Varela's (1980) concept of autopoiesis (self-generation). They describe it as "*...processes interlaced in the specific form of a network of productions* [i.e., a whole system organization] *of components* [i.e., structural parts] *which, realizing the network that produced them, constitute it as a unity.*"

Albert Einstein reportedly spent the majority of his later life in some disappointment about his own work, because part of it led science to conclude that nature is uncertain, which he did not believe. How unfortunate that he did not realize that the need for uncertainty in formal description is itself the evidence of wholeness in reality. The view presented here is that nature is not random and reality is whole, but they are beyond knowledge (and therefore metaphysical), because knowledge itself is predicated on differences that it must establish. Uncertainty must then appear in the domain of what is knowable.

AUTEVOLUTION

Imperfect representation (systems imperfectly modeling each other) may thus be considered a requirement of all natural systems (of which genetic systems are an elaborate example). This principle expressed in terms of a modeling relation and applied to reproduction, development, and evolution may then take on the role of both driver and passenger in evolution. This provides an explicit natural cause for the steps implied in the Baldwinian concept (also reflected in Figure 3), which are:

1. Functional choice/accommodation by individuals.
2. Behavioral development, psychologically selecting and reinforcing various behaviors.
3. Alteration of environment - selection of selective forces.[20]
4. Phylogenic (Darwinian) selection by the environment.
5. Congenital inheritance of factors thus compatible with their functional origin in step 1.

Baldwin summarized: *"It is often by exercise of novel functions that creatures are kept alive to propagate and thus to produce further variations of structure which may in time make the whole function, with its adequate structures, congenital...the accommodations made in ontogenic development, which 'set' the direction of evolution,* are *novelties of function in whole or part (although they utilize congenital variations of structure)."*

Emergence of Creativity and properties of 'Self'

These arguments lead to the conclusion that nature taken as a whole, and including its semantic component, is fundamentally creative, constantly changing from, and resulting from, current definitions. This process includes self-description, as for example, in an organism's model of itself. New functions in organismic models (existing as a natural part of the organism) would change nature in creative ways by adding new information.

Based on his work on the role of mind in development Baldwin (1930) saw no alternative to giving causal importance to functions of a psyche in both development and evolution of living organisms. He saw intelligence, or psyche, as necessary to complete and apply an instinct, and thus effective in introducing novel directions in evolution. He rejected, however, the choice between mechanical and vitalistic explanations of life and evolution He wrote: *"The feat of adaptation requires on the part of the individual organism something equivalent to what we call consciousness in ourselves. But I do not think...that consciousness is a causa vera, whose modes of action do not have physiological parallel processes in the brain and nerves. The alternatives are not really two only, automism -- a theory of mechanical causation of all movement, with the inference that consciousness is a byproduct of no importance, and this vera causa view which makes consciousness a new force injected into the activities of the brain. There is another way of looking at the question...The moment we ask questions concerning a group of phenomena which include more than these things, that moment we are liable to some new statement of the law of change in the group as a whole. Such a statement is the third alternative in this case; and it is the problem of the metaphysics of experience to* *find the category, or the most general principles of experience as a whole, both objective and subjective."* (Baldwin, 1896c)

Intending Reality

Baldwin's "third alternative" may be found in "autevolution," which is based on Structure-Function Complementarity and defined as "*evolution of the experiential self, and the role of that self in evolution*." (Kineman, 1997). Such a theory of individual agency constitutes a modern scientific animism[21] that allows us to combine the pure mechanism of neo-Darwinian theory with the apparent vitalism of psychological experience, as Baldwin suggested. SFC means that the properties of the whole are not limited to the aggregate properties of the parts, and it implies that the system will evolve because of the accumulated inequality (error or uncertainty) of self-modeling. Such relational behavior seems most characteristic of living systems and could serve to distinguish living from non-living more fundamentally than present concepts.

Viewed as an action through time, the mutual exchange of system definitions between structural and functional models defines causal loops that are self-generative. A simple example of mutual causalities involved in autevolution, is depicted in Figure 3.

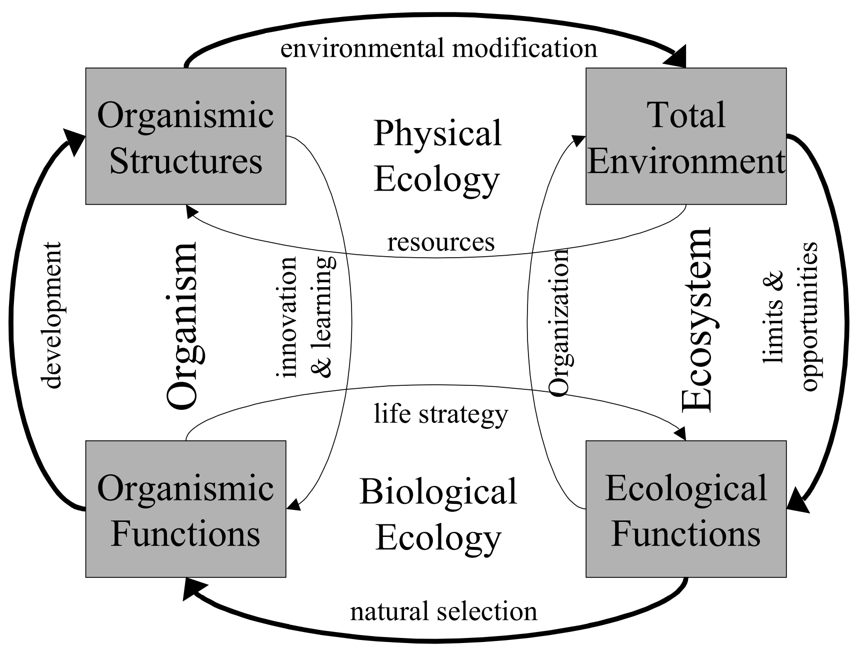

Figure 3: Autevolution Causalities

Futhermore, if organismic functions (the self-model) are causal (postulate B), and contextual (Corollary 1A) then phylogenetic results of evolution can be influenced by *multiple* context dependencies. Hierarchical and parallel systems can be added to this picture, including genetic encodings and decodings within the organism and relations with the environment, other organisms, and so forth.

The ability of an organism to model its own existence and to anticipate the future, along with its ecological ability to modify present selective forces (environments), allows it to pass on models of nature to future generations, employing the environment to record causal elements of that model. For example, a functional choice, with perhaps developmental reinforcement, to engage in aquatic behavior will subject an organism to corresponding selective forces. Those forces, favoring aquatic life, will bias future generations toward corresponding abilities. In this manner, functional choice is reinforced and passed on to future generations, with related effects on structure. Under the influence of such self-modeling, life forms must follow evolutionary pathways that are partly creative, because they are biased by organismic models of self, environment, and future possibilities. This is consistent with Baldwin's (1899, 1902) idea that: *"By securing adjustments and accommodations in special circumstances, the creature is kept alive. By this means those congenital or phylogenetic variations are kept in existence which lend themselves to intelligent, imitative, adaptive, or mechanical modification during the lifetime of the creatures which have them. There arises a more or less widespread series of modifications in each generation's development, in which the congenital and the acquired unite to produce a definite or determinate direction of change."*

Baldwin, being a psychologist, was quite concerned about the relationship between evolution and the mind. He believed, however, that the origination of new functions cannot operate independently of the means to express them. He wrote: *"So we may say that intelligent adaptation does not create* [developmental] *coordinations; it only makes functional use of coordinations which were alternatively present already in the creature's equipment"* (Baldwin, 1896b). He saw psychological abilities as organizing and directing the development of otherwise incomplete or ineffective instincts. What he deemed novel during the organism's lifetime was the organization and application of functions to new situations, which only a "psychogenic" factor can anticipate and provide.

In this light Baldwin believed that many problematic issues in evolution become explainable. These include apparently non-random productions of certain evolutionary pathways, punctuated stability observed in evolutionary history, and the unlikelihood of finding a complete series of gradual or sustainable steps toward the evolution of complex organs.

INTELLIGENT LIFE, LIVING BY DESIGN

The Fallacy of "Intelligent Design Theory"

These ideas give us tools to deal with recurring mythologies, including the newest version of scientific creationism, "Intelligent Design Theory" (IDT). IDT maintains that improbabilities found in nature can be accounted for only as the action of a purposeful, universal designer, that is, God (Behe, 1996; 2000). As with the Anthropic Principle[22] (which makes the claim that certain physical constants of the universe are oddly suited for the existence of life), IDT proponents argue that evidence points similarly to organic, biochemical, and molecular improbabilities with regard to evolution. Science has long implied that life in general appears improbable, a fact that cannot be explained in the mechanical view. But all calculations of probability require a determinate, countable basis. Perhaps the unique status of our world is due to how we look at nature and count the alternatives, as if nature is already complete and countable. What if it is not? What if instead it is self-generating? In Baldwin's words: *"The fallacy again is just the assumption that reality is 'finished,' that categories of retrospective reference exhaust the case."*

An intelligent creator theory is certainly one way to look at evolutionary improbability. However, from a scientific perspective it suffers from the same problem discussed at the beginning of this essay -- separation between cause and effect (observer and observed). IDT, while asserting that intelligence is a causal force, attempts to establish it as an external agent, which can then only be described as an unknowable actor. This takes it outside the realm of science. Even from a theological point of view, IDT's philosophical basis -- that of a personified external being (in Man's image?) -- may be seen as superficial. In the deepest spiritual contemplative traditions (Eastern and Western), such externality of the Divine is understood as having a personal psychological origin (an archtypical ego), from which the rest of reality is set apart. It is from that view alone that one's own origin then appears distinct from one's self. Neither the systems perspective, nor contemplative practices support that orientation.

Autevolution explains "intelligent" evolution as the result of self-generating complexity. This finds the necessary semantic closure entirely within natural systems themselves. That makes the matter of nature vs. spirit (or intelligence) approachable by scientific thought, and provides a formal candidate for the "irreducible complexity" claimed by IDT (Behe, 2000). If modeling relations are considered natural in a systems sense (and therefore causal) then knowledge (or intelligence) itself becomes part of the explanation of life and evolution. Baldwin (1896b) wrote: *"In the case of conscious adaptation, we reach a point of view which gives to organic evolution a sort of intelligent direction after all; for all the variations tending in the direction of an instinct, but inadequate to complete its performance, only those will be supplemented and kept alive which the intelligence ratifies and uses for the animal's individual accommodations.*

Reasoning by Analogy

One would naturally wish for a clear test of these ideas in biological evolution. There are several reasons why that is not easily accomplished. Evolution in any form involves the occurrence of unique events. Establishing probabilities requires repeatability or a count of the unrealized possibilities in nature. Therefore, a small bias from functional innovation cannot be easily distinguished from the presumed results of environmental selection, even though it may have a major cumulative effect. Even in more obvious cases of cultural evolution, many scientists still prefer to believe that psychological choices are determined entirely by circumstances, thereby eliminating any role at all for functional novelty. Thus the myth perpetuates that everything can (or should) be explained exclusively from observation, and thus structures. It is only when we look at the broader relational picture from many perspectives that the limitations of that belief become clear.

There are two distinct ways of "knowing" nature. One is sensory, and the other is experiential. As an organism that has evolved the ability to reflect internally we are in a privileged position to gather information, not just about life, but about living. We can reason by analogy to propose and test functional descriptions, just as we do with physical descriptions of structure. For example, the great advances in primate behavior research in the latter half of the last Century resulted from "getting inside" the mind of the animal (which was the vision of Louis B. Leakey).

It is time to realize that as humans we are also examples of life, and just as we can learn about humanity from studying other creatures, we can infer aspects of other creatures by studying ourselves. The validity of that method is given considerable strength by the ability to model self-generative functional relations embedded throughout nature. On that basis, autevolution explains life, not as a series of unlikely accidents, but as the result of a natural tendency toward greater cognition and meaning. In this view such goals are not unique to humans but evolved from a natural drive to comprehend existence. The *necessity of self-knowledge* may thus be more fundamental than the struggle for survival.

The view presented here is a dramatic change from what we have become accustomed to from the physical sciences, but it is entirely within the scope of scientific analysis. It incorporates meaningful relationships into a model of nature by making a new assumption: that structures are in constant relationship with their functional definitions, and each is involved in the origin of the other. Such relationships seem to characterize life. Outside of that creative relationship, where nature appears "finished" and completely describable from observation, we see only mechanisms. Within it, we see the properties of life and a fundamental cause for evolution -- nature in the process of becoming. The basic wholeness, which appears as Structure-Function Complementarity, is in fact the wholeness of a thing and its origin. Clearly that is not the way to look at nature if one is interested only in what is predictable from history. It is the way to see systems that are inventing the future. Nor can one avoid the fact that such creative influences are closely related to mind or psyche, which being a necessary component of the model, is also a necessary assumption about nature. The methods presented here can provide substance to a worldview that begins to bridge the mind-body separation, which is at the root of so many human problems. Certainly the future of humanity depends on understanding these important issues.

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ENDNOTES

[1] Cultural evolution traditionally concerns the evolution of human culture and its causes. It has also been extended to more general principles of guided evolution (Banathy, 2000), and integral culture (Laszlo, 2001).
[2] The inheritance of traits acquired behaviorally during an individual's lifetime was a theory of Jean-Baptiste Lamarck (1744-1829).
[3] Gödel's proof is assumed to apply broadly to any symbolic, rule-based system; hence, any description or model.
[4] This is now known as "the measurement problem." There have been many attempts to explain it, from suggesting nature itself is uncertain to proposing extra dimensions of reality.
[5] This saying is attributed to the founder of "General Semantics," Alfred Korzybski.
[6] Models are often defined as being prescriptive, rather than descriptive. For purposes here, no distinction is made. The terms "model," "representation," or "description" should be taken as synonymously referring to any formal means of representing nature.
[7] "Natural system" in this usage means a complete system with functional (formal) and material (manifest) components in relationship. This also defines what is meant here by "complex." "Formal system" is to be taken to mean a complete natural system that is in a descriptive (encoding) and prescriptive (decoding) relationship with a natural system, which it then, in part, represents.
[8] Because it has been avoided in "hard" science, the domain of the psyche has been mostly associated with human abilities and thus there are no widely accepted general terms for it.
[9] The author finds no way to escape "reduction" of some sort. The issue in developing a "new science" should not be reduction, but rather to what representations of reality one reduces. Mechanistic science reduced reality atomistically, then on finding the limits of that technique, added uncertainty. But it still kept functional representation at arms length – in the mind of the scientist, rather than in nature.
[10] The domain of psyche will be considered, for the purposes of this paper, as synonymous with the "formal domain."
[11] This is analogous, or perhaps identical, to the "observer" in quantum mechanics.
[12] The term "non-local" is used in physics to refer to phenomena that violate space-time constraints, such as a particle appearing in two locations at once (as recently demonstrated with Bose-Einstein matter), or shared properties of two separate particles that are "entangled."
[13] Rosen uses this term. It means mutual causalities that cannot be calculated to yield precise predictions of future states.
[14] Rosen (1991) develops a formal approach within category theory, after Nicolas Rashevsky.
[15] This is the antithesis of the idea (sometimes mistakenly attributed to the Church-Turing thesis, or "Turing Test," which applied less generally) that two systems are identical if there is no descriptive means of distinguishing them.
[16] "Schrödinger's Cat" was a thought problem suggested by Erwin Schrödinger to dramatize "the measurement problem" in quantum physics.
[17] Baldwin (1902, pg. 132), surprisingly, understood and described just this kind of relationship, even producing an effective diagram to represent it.

[18] Knowability consists of both external and internal percepts. The methods of external observation are well-known and correspond with sensory perception that we call objective. The methods of internal observation involve introspection and awareness of personal experiential states that we call subjective. In this picture of reality, neither can be excluded from science because they are the only means available to us for knowing these domains.

[19] This corresponds to the "Platonic" ideal realm of form; but as should be clear from the description, it is not to be thought of in this view as having an independent existence except as we might experience it.

[20] Baldwin did not emphasize this step, but presumed it, citing Headley (Baldwin, 1902; Appendix B) as follows: *"In fact, individuals dictate to their offspring what mode they shall follow, choose the environment that is to act on them, and each generation making a similar choice, development proceeds cumulatively along certain lines; only variations adapted to the chosen environment are selected and in a long series of generations the structures and qualities most in demand are brought to a high pitch of excellence."*

[21] to be distinguished from pre-scientific animistic mythology

[22] According to the Anthropic Principle, we may occupy a preferred place or preferred time in the Universe. We may also occupy a preferred universe. The principle itself does not suggest why.