The Atomistic Structure of Relationship:
Robert Rosen's Implicate Order

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Abstract

A careful synthesis of Robert Rosen's theories about relational entities resulted in identifying the implicit entailment between ontology and epistemology. This can be considered an atomistic relationship, emphasizing its foundational status within a relationally analytical framework. This framework constitutes a natural philosophy and underlies material descriptions of reality, including current mechanistic theory. We believe this model represents, in essence, the natural structure of relationship, from which both traditionally objective and traditionally subjective entities arise. The essence of this understanding, however, is to objectify the entire model. The model and some of its possible applications are discussed.

Keywords: Relational, complexity, epistemology, ontology, information.

Introduction

Robert Rosen, commenting on the Mind-Brain problem (Rosen, 1993), provided a very succinct description of his theory of life, which is described in greater detail in his series of books (Rosen, 2000; Rosen, 1991; Rosen, 1985; Rosen, 1978). Throughout his writings there are numerous hints about the profound nature of what he was implicitly proposing–nothing less than a revolution in scientific thought. Today, more than in Rosen's time, such claims have become prevalent, and almost cliché. However, few such claims have definitively presented a more general (and inclusive) view or demonstrated broad practical value. We believe the relational view that Rosen described meets both these criteria. However, for many of his readers, the complete picture has been difficult to grasp, as, indeed, Rosen did not pull his full theory into one cohesive image, as we attempt to do here.

We will not review the underlying theories and assumptions. The reader is encouraged to refer to Rosen's original writings. A general understanding of category theory, the mathematical domain of Rosen's thinking and the diagrams presented here, is also important. The reader is referred to other works on category theory (Louie, 1985). Category theory, which is primarily about "mappings" between natural or formal entities, lends itself well to visual presentations.

In his 1993 paper, Rosen reviews previous attempts to define a constructible world and a corresponding constructible mathematics, which was, in those attempts, assumed to be completely formalizable. *Constructible* and *formalizable* in this sense meant buildable from material, or, in the case of theory, buildable from direct symbols of material according to a unique syntax. That approach was associated with *particulate* or *atomistic* concepts of material and corresponding concepts of energy. While we know today that these concepts dissolve into uncertainties at some level and under certain circumstances at any level, it is now clear that objects do not reduce to objects, and thus syntax cannot be reduced to syntax. No theory of an underlying reality that describes or explains this fact has gained general acceptance, and it is often dismissed as a philosophical matter. But it is actually a flaw in our concept of reality. Theories of the ultimate reality range widely, including theories of multiple universes, hidden dimensions, and mysterious emergences. David Bohm spoke of an "implicate order" tied with self-generation. Mystics throughout the ages have claimed that the material world is an illusion, behind which is a more deeply interconnected and meaningful reality. Can all such ideas be captured in one view? The modern opinion, except for ongoing attempts, has been that they cannot; therefore committing us to an intrinsically dualistic understanding of life and all of its aspects, including perception of the material world as separate from the realm of mind.

Rosen pointed out, however, that the failure of Hilbert's and others' efforts at formalization and constructability, for which failure Russell and Gödel provide a final proof, made the culprit apparent: the natural existence of causal loops, or 'impredicativities.'[1] When these are excluded from formal theory, science is rendered unable to discuss complex properties of nature, particularly any underlying principle of life. Attempting to eliminate such loops, or 'vicious circles,' created a restricted formal domain that could not in itself be complete. Refusing to include impredicative loops in science, i.e., insisting that science must be predictive, ensures its incompleteness, just as it did for mathematics.

Nevertheless, this point was not been generally accepted and the view of science as a strictly predictive endeavor continued. It became clear that no syntactically complete domain of existence could be defined, in either natural or formal worlds, if it contained circular references; in other words, all apparent paradoxes, and corresponding impredicativities, had to be removed from descriptions. That decision resulted in the mechanistic, classical perception of reality, traditionally defined as "objective," with closed-loop causalities considered "subjective" and "beyond the pale of science." Rather than finding a more general theory that could include causal loops, the field restricted science to, and defined it on, mechanisms. To Rosen, this was irrational even if practical at the time, and he deemed other various "solutions," such as eliminating the concept of 'causality' (i.e., expunging natural referents), equally ridiculous. Thus, he objected to the von Neumann approach to complexity, which in Rosen's view only introduced mechanical 'complication' instead, because it preserved this basic subject-object duality, for example in matter-symbol dualism (Pattee, 1995) or by attributing a semantic role to material form (Collier, 1999).

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[1] Impredicative refers to the condition where the internal causalities of a system are not immediately predicated on external causality. This creates the situation of a system-dependent law.

Rosen argued that just such loop causalities, as are represented by impredicativies, are required to explain complexity and life. They directly engage the ‘life-organism’ problem, the ‘mind-brain’ problem, the ‘observership’ problem, and similar dualities in fields, and for those phenomena, where ontology has a direct role in determining the circumstances that will be open to empirical study. We need not run through the many examples of subject-object complementarities in all fields. Suffice it to classify them as ‘chicken-egg’ or closed loop causalities: impredicativities in their mathematical image.

Rosen urged that we “*abandon the equation of objectivity with mechanism*” and “*allow an objective status to* [relational] *complexity*”; in other words, “*objectify impredicative loops.*” (Rosen, 1993). He wrote: “In this approach, mechanism does not disappear, it becomes a limiting case of complexity.” Aristotle’s “final cause,” he asserted, “closes impredicative loops.” He defined *final cause* as a description or explanation of something “*in terms of what it entails rather than exclusively in terms of what entails it.*”

This view is clearly foundational. It underlies the mechanistic concept and establishes a more general reality that is relational. It also underlies the framework of space and time and therefore must be considered generative to both. Thus, it provides a strong theoretical foundation for all sciences, including those traditionally disparaged as “soft.”

Rosen wrote: *“Freed from the exigencies of a single constructive or algebraic time frame, mechanistic objections to anticipation no longer apply at all.*” He explained anticipation in terms of “*internal predictive models*” that bring the ontology of causation into a system (e.g., an organism), paralleling Erwin Schrödinger’s idea of what must be responsible for the strange properties of life and the quantum world (Schrödinger, 1943; Rosen, 2000; Chapter 1). Although we will not elaborate on this form of system closure, those discussions being available in other works by the authors, it is important to reiterate that the relational model is self entailed, and thus involves a translation between ontology and phenomenology, neither of which can be explained solely in its own terms.

Rosen concludes his 1993 paper by saying, “*In such a complex world, functional descriptions are perfectly meaningful, and can be quite independent of any mechanistic ones.*” In other papers (Rosen, 1973; Rosen, 1971) he describes the structure-function relation as entirely objective, structure being “*what it is*” and function being “*what it does*” in some context. This parallels the mechanistic way of seeing the world except that it allows functions to be system-dependent and unique. By saying that functional descriptions are meaningful, and final cause and anticipation can be objectified, Rosen was reifying statements of meaning and purpose as contextual relations. We will now see how this is done diagrammatically.

The Relational Atom

We begin with Rosen’s ‘modeling relation’ (**Figure 1**). This was initially presented as an epistemological relationship, that is, a model of the relationship between a natural entity and knowledge of it. However, as discussed above, Rosen’s work gave it the deeper meaning of a complexifing relation that can be seen in nature itself, especially in systems we call living. (Kineman and Kumar, 2007) In other words, nature models itself and is causally entailed in this way, both interactively and contextually (Kineman, 2007). We further note that the mappings in this model, which correspond to a category-theoretic mapping, are informational in nature, existing in the outer context of the diagram itself, and so implicating a holarchy of contexts providing information influences. Accordingly, information (as a process of encoding or decoding) is the "glue" that holds nature together and necessitates its operation.

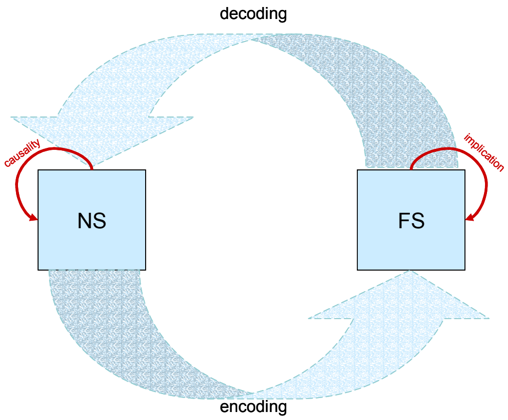

Figure 1: The Modeling Relation

We can see in Rosen's writings that "*encoding*" is associated with measurement, which is also "*abstraction*" of a set of quantities or qualities from a natural system for use in a formal system or model. Again, this can be epistemological or ontological. In either case what is abstracted and applied to the model is clearly within the observable world: It is obtained from our senses, which necessarily present us with abstractions (the classical mechanistic view). Such abstractions constitute what is most often meant by "structure." Furthermore, "*decoding*," both ontologically and epistemologically, clearly indicates an operator that makes changes either in nature or in an analog of nature used to compare and thus test the model. Thus, decoding is congruent with a number of systemic definitions of information, for example, Gregory Bateson's idea of "*a difference that makes a difference*" and in terms of his "*patterns that connect*" (Bateson, 1979).In the relational view we find that decoding is associated with the concept of *function*.

Figure Legend:
NS = "Natural System"
FS = "Formal System"
S = "Structure" (state)
F = "Function"

As seen in **Figure 2**, therefore, structure and function are in a sense "emergent properties" of the modeling relation, representing the empirical world emerging from the ontological. But also apparent is that each of these concepts has roles (entailments) in both the ontological and empirical domains. The straight arrows, labeled 'control,' indicate the directentailment of structure and function in the empirical domain, which corresponds to Aristotle's "*material*" and "*efficient*" causes. These two causalities also form the basis for mechanistic theory (Kineman, 2003), and so generally a mechanistic model can be used at this stage.

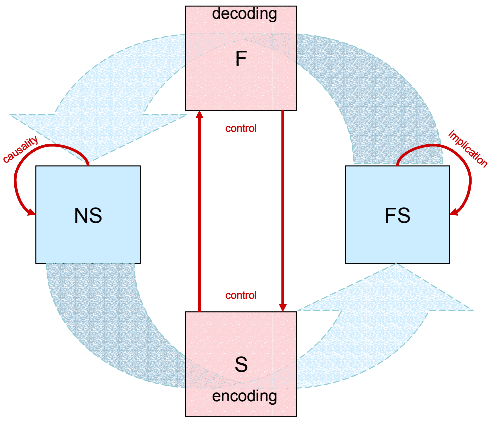

Figure 2: Emergent Epistemology of Structure (S) and Function (F)

As in the analogy with a mathematical function, natural functions that we infer are defined as operators on our structural abstractions, constraining (or defining) state dynamics and explaining change in observable conditions. The function is the operation and may be represented either as a description of what it does or as a set of dynamic equations. In return, functions are constrained by state variables, which collectively describe the conditions under which the expression of a given function varies. This bi-directional entailment involves constraints in both directions. It is similar to Corning's description of "control information," (Corning, 2001). Accordingly, states are constrained by functions and functions are constrained by states. As developed elsewhere (Kineman, 2007), control information can be represented as a combination of the functional dynamics (or description of them) and environmental constraints, which can be defined using the Hutchinsonian n-dimensional niche concept. (Hutchinson, 1953) Fundamentally, a niche is a description of constraint of a functional object along dimensions of a contextual domain. The classic example is a species niche, which is the viability function for that species constrained by the environment.[2] Furthermore, we can assemble niche descriptions at any level, for example to represent all functions or clusters of functions comprising organisms, ecosystem services, or socially emergent phenomena.

Such 'control' information refers to how functions (laws) alter structures and how structures limit the expression of functions. In the simplest case, this interaction may indeed be described mechanistically in terms of what a given function does to a given set of states. Even this relationship, however, can involve causal loops, as functions alter the very structures that constrain them. This sort of relationship has been described as "*niche construction*" (Odling-Smee, Laland, and Feldman, 2003). To properly express this relationship will require iterative solutions like those currently expressible in cellular automata or agent-based modeling (Langton, 1995). Uncertainty need not be invoked, other than to account for error or lack of knowledge (for example, if someone wanted to simulate random movements, not having a model for them). These entailments correspond to what Bánáthy (1995) described as "*state-referential information*". But being fundamentally mechanistic, this kind of entailment is subject to Rosen's admonition of incompleteness discussed earlier. While such direct entailment can indeed incorporate feedbacks between causes and effects (e.g., an organism's effect on its own niche constraints), it is not as deeply complex as the second type of relation discussed below. At this level we have expressed a duality similar to what von Neumann and his followers proposed, albeit in a significantly different way that will allow us to add back their non-dual relations.[3] **Figure 2** shows the direct, and dualistic, relation of structure and function, which emerges from the non-dual ontology of the modeling relation. This is the 'simple' case where specific, well-defined function-structure combinations are related as empirical units. They are at this point subject to general laws, even if these must be iterated, because we are not yet considering why the function exists or where it came

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[2] In theory, since we are objectifying both structure and function in this analysis, each may be said to have a niche in the domain of the other, if that domain can be described as a dimensional space. However, the 'inverse' niche--describing the suitability of a structure in a function space—is not well explored except in certain mathematical analogies..

[3] The way the duality is expressed is important here. Pattee (1995) expresses it as a matter-symbol duality. That form of expression is a reduction of structure and function, which Rosen argues cannot be re-unified.

from, only “*what it does*.” The description of many such relationships could become quite ‘complicated,’ but not yet fully complex.[4] We have so far described only a direct relation between extant structures and functions.

To recapture the deeper ontological complexity, we must represent the non-dual properties of the origin of functions and structures–their co-defining aspect and appearance as attractive or selective potentials of the system. We thus join a very fundamental debate in the philosophy of science: is the mechanistic relation presented above all we can know and describe of the system, and thus all it contains? If so, as many claim, we need not involve the ontological world at all. But in living systems it is precisely the invasion of ontology into epistemology that produces their characteristic behavior. Clearly, evolution defines just that condition. It is equally clear in quantum phenomena, which has turned physicists into philosophers of ontologies; in biological and ecological phenomena that express self-organization; in phenomena associated with consciousness, which certainly beg original phenomena; and by extension into social or political phenomena. Of these, ecology has found it essential to express ideas in terms of unique system-dependent and self-organizing functions that involve ontological relationships with the organism and its behavior. In discourse that is at least comfortable, if still uncertain, ecology now demands a better theory for structure-function relationship (Hochstrasser and Yao, 2003) as well as a more complete delineation of the fundamental link between ecology and evolution. Neither task has yet been accomplished.

Figure 3 shows how the underlying complexity can be brought into the structure-function relationship in a rigorous manner. The *“impredicativity”* in nature that is expressed by a modeling relation (shown in the background of the diagram), can be added epistemologically as a mutually defining complementarity relation (the large curved arrows) between structure and function. That relation represents the potential mutual selection or attraction of structures and functions. This is a second kind of entailment that captures Aristotle’s ‘formal’ and ‘final’ causes, which Rosen claimed are both legitimate and necessary for understanding complexity. We thus re-introduce the natural complexity into the epistemological model in a way analogous to how we believe it is entailed in nature.

The causal loop between structure and function in **Figure 3** (curved arrows), necessarily passes through imputed natural and formal systems. This presumed reality provides the underlying selective or attractive means for relating new structures and new functions, whereby functions can be fulfilled by different structures, and structures can perform different functions. This recaptures the ontological basis for self-definition and self-generation.

Whereas the control relationship is temporal, being defined by measurements, this second kind of

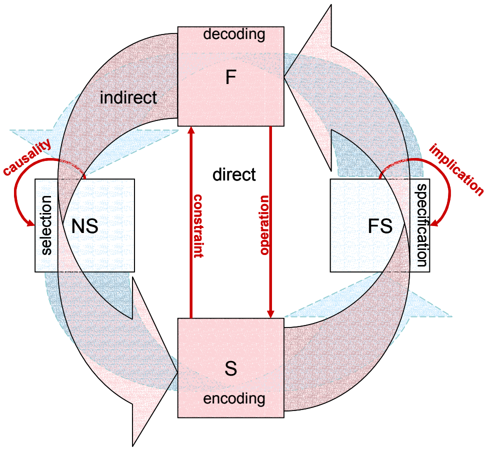

Figure 3: Ontology and Epistemology

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[4] Rosen’s term indicating that the entailment is still computable and thus not yet fully complex.

relationship is not temporal, being reflective of the ontology. In other words, the multiple possible meanings of some material form in various contexts, or the multiple possible ways in which a function can be actualized, exist as potentials, and are thus not yet ordered by space and time. Possessing internalized causes that are not immediately predicated on external events is the essence of "impredicativity," and what confers complexity. Mutual definition, attraction, and selection of structures and functions is uncertain, being influenced by multiple simultaneous criteria, but nevertheless open to probabilistic and perhaps other forms of reason, such as analogy. We label the attraction or selection of structure by function as "actualization"[5], and the attraction or selection of function by structure as "attribution."

Rosen labeled the causal path from ontology to epistemology "*the realization problem*." This can be stated as: How does an abstraction of nature, i.e., models built on the empirical ideas of structure, become part of nature itself, expressing themselves as function? This question is appropriately considered by either nature or science. For example, we can ask how models are entrained into organisms as causal agents producing or explaining anticipatory behavior. Or we can ask how scientific models are applied to natural resource management and ecosystems to effect changes. Both pose the problem of realizing, or as we prefer to say, 'actualizing,' a model in the natural system.

Rosen states that realization of a model must be through induction into a pre-existing natural system (Rosen, 1991), thus opposing the von Neumann school of artificial life by arguing that real life can only be created through existing instances of complex systems (thus excluding a computational environment which is too "*impoverished*").[6] This holds true in **Figure 3** because the relationships shown, including that between ontology and epistemology, are always preserved—they are relationally 'atomistic'—and any instance of a natural complex system or life must therefore have a natural predecessor containing all of these relations. Being general, these relations exist even prior to space and time, and may figure importantly in the origin of both (Kineman and Kineman, 2000).

This can be perceived intuitively. For example, in ecology, it makes sense that a function, (say, decomposition) as a specification of state-based behavior, requires a natural system to express itself. The function can be expressed by various structures, thus subject to adaptive pressure (either phenotypically or genetically in developmental and evolutionary steps). This can be seen as an induction of functional meaning into structural change. This explains, for example, how both primates and pandas, in S. J. Gould's famous example, can exhibit prehensile adaptation to a contextually induced function (i.e., convergent evolution). We can think of this tendency as a system 'attractor,' or a functional 'force' that selects and reinforces any structure that can fulfill it. As a further example, having suitable bear habitat does not mean one has bears, but over time bears

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[5] This is quite similar to Rosen's "realization" except that he used that term more generally. We prefer the term 'actualization' because it does not suggest which side of the duality is to be considered more real.

[6] The distinction between complex and living may seem obscure, but according to Rosen it has precisely to do with how this realization is accomplished, for example if the result is self-sustaining through metabolism and repair functions ("M-R Systems"). Other than this, the basic principle involved in life and complexity, that of the modeling relation, may be the same.

may be attracted to migrate to the habitat, or over a longer time something functionally equivalent to a bear may evolve. We can thus model functional replacement

Epistemology Begets Ontology

Having thus described how epistemological entities emerge from the ontological (modeling) relation, we will now consider the reverse: How do empirical realities affect or implicate the ontological, or do they?

Rosen's writings present a necessary relation in both directions. Our observations of nature and its complex behavior, through the abstractions of structure and operations of function, impute the existence of an underlying order described by the modeling relation, and accordingly Rosen's "*internal predictive models.*" His theory emerged from a study of biology where such conclusions seemed inescapable. Implicit natural models, however, are not observable sub-components of a system; they are imputed intrinsic characteristics of the whole system. This does not make them less real or less important than a detectable sub-system, or identifiable part.

While functions are inferred empirical elements, intrinsic 'models' are imputed realities, which more positivistic scientists would claim cannot be known and therefore should not be discussed. We, in keeping with Rosen and many others, take exception to such a narrow definition of science. Since unifying ontologies have become important in physics and cosmology, there is no reason to ignore them in biology. The connection between ontology and epistemology is the key to representing the semantics of a system, and therefore to escape the problem of incompleteness. This view suggests an epistemology of qualified realism–we must make some explicit assumptions about the underlying reality, because every theory will make such assumptions whether those assumptions are made explicit or not. The hidden assumptions of mechanistic theory are an obvious case-in-point.

We should also point out that the degree to which functional components are compartmentalized in an organism is decided by the path of evolution of the organism and its organs, and is a separate matter from the existence of functions systemically. Scientific parsimony requires that we speak of functions aside from any identifiable embodiments, for it is essential in any case to represent their effect. They are the "programs" presumed to exist in life strategies and all living adaptations to environment, most if not all acting in anticipation of the future.

Finally, we can see that the entire diagram in **Figure 3** comprises our concept of nature, objectifying causal loops as Rosen proposed. Thus, we can imagine it to be a novel reduction to a relational entity—the modeling relation—that remains whole at any level of analysis. This is a new kind of *atomistic relationship* based on holistic relational decomposition, in sharp contrast to the now discredited particulate atomism, which Rosen identified as an irreversible "*fractionation.*" Indeed, the entire diagram, because it shows the ontological concept of nature, can be imagined inside the "NS" box, in **Figure 3**. Similarly, we can imagine a larger system using this diagram to illustrate an even larger formal system, thus expressing the holarchical entailment of nature–an explicit illustration of the idea that "everything is connected to everything else." It is understood, of course, that, given the selective nature of proximal relations, more distant relations may be suppressed partially or wholly. The "butterfly" effect, for example, may indeed propagate through a complex web of relations, but it may also be selected out or overridden at any level.

The entailments described provide a common framework that can apply across all disciplines. It should not be taken as a purely instrumental application, because the theoretical commonality across all manifestations of complexity is clearly articulated in this theory. The theory presumes a natural entrainment of impredicative causal loops within a system. In other words, in addition to the general laws of the physical/mechanical perception of nature, there must be system-dependent and thus system-generated laws as well.[7]

Implications for Information Theory

"I think the definition of information has to include some sort of semantic relation. Information is inherently relational-- it is only information if there are referents attached and it is the referent that makes it "information". This is why raw data, divorced from all referents, is not information." Judith Rosen

While Shannon information theory is essentially that of mechanical transmission phenomena, the relational concept of information is non-mechanical (Kineman, 2007). The meta-model presented here, which posits that communication takes place between systems through encoding and decoding relations, thus revises and modernizes information and communication theory. Indeed, the holarchical nature of the relations shown in **Figure 3** implies that the natural entailments we call "causality" are explainable, in a relational analysis, by contextual information relations: structure (encoding), function (decoding), and control. In other words, these types of information are responsible for nature's "hard wiring" —how nature "knows" what to do.

A similar three-part holistic framework of information was proposed by Bánáthy (1995, 1999). His basic idea was that the decomposition of generic information into more fundamental types—"*referential*", "*non-referential*" and "*state-referential*" information—leads to more useful ways of characterizing informational processes. The distinction between non-referential and referential information was first introduced by Csányi and Kampis (Csányi, 1989). Kampis provides a crisp definition: "*At any point in time information has two fragments: the one available in passive, knowledge-like form,*

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[7] Arguably general system laws—those that are presumed to define the physical world—may also be seen as system generated in the same relational entailment, but applied to the general system. Looking from the inside of any system, except for further sub-systems, its laws should appear general.

representing the past and the present of the system (nonreferential information), the other part pointing forward in time, materially coded but phenomenally implicit, having a dynamic, causal character and being responsible for the future (referential information)" (Kampis and Rössler, 1990). More succinctly, non-referential information entails the epistemological aspects of systems, and referential information entails the ontological aspects. **Figure 4** maps these concepts onto the previous diagram. The referential information type covers both attribution and actualization (NS and FS), and the non-referential type covers decoding and encoding (F and S).

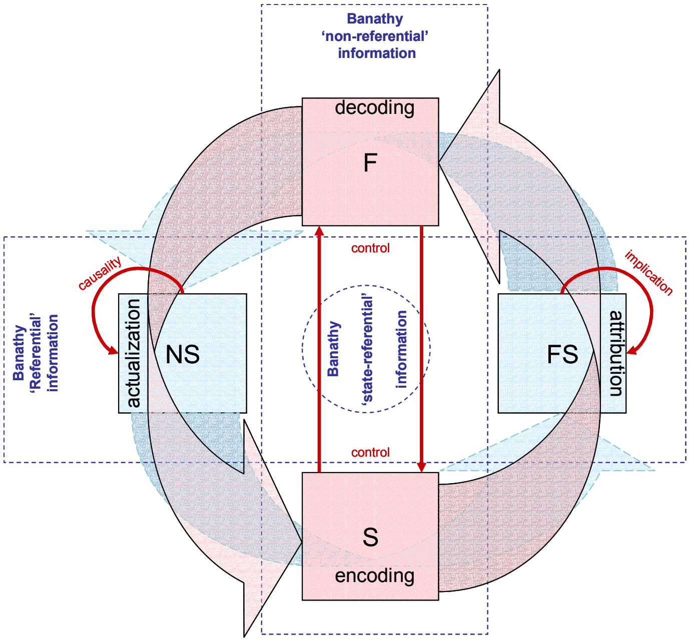

Figure 4: "Referential" and "non-referential" Information

Bánáthy (1999) points to a third information type—state-referential—to account for instances where the other two types are confined to a priori state spaces. This corresponds to the "control" information mentioned above. Making the state-referential distinction avoids the distortions and confusion that arise in applying state-determined descriptions (information as knowledge) to phenomena that are not so determined; or in activating state-determined processes (information as action) in systems that are not, by nature, state-determined. To reiterate: both referential and non-referential informational acts can be constrained to (defined in) a state-determined frame of reference. This is precisely what happens in the scientific/technological enterprise when we delegate tasks to computer-based agents.

The three types of information have a specific entailment relationship to each other: non-referential information cannot fully explain or account for referential informational processes; and state-referential cannot fully explain or account for either non-referential or referential (Bánáthy, 1999). Since the ontology of referential informational processes cannot be fully accounted for within the epistemology of non-referential information the difficulty we face is analogous to what was earlier identified as "the realization problem." Once again, the relationships shown in **Figures 4 (and 3)** allow us to objectify causal loops thus extending our information systems to the domain of complexity and life.

Implications for Ecology

Structure and function are necessary and central concepts in ecology. Ecology as a discipline, however, has had a rough time establishing a theoretical basis. This was so frustrating at one point that Simberloff wrote, not entirely facetiously, that ecologists should give up on theory and only do lab and field work (Simberloff, 1981), a problem easily attributed to a romance with physics and theoretical ecology's attempts to copy it (Platt, 1964). However, a relational foundation is essential in ecology, a field defined on the relationship between an organism and its environment, but the mechanical formulation, as Rosen noted, accomplished the "destruction" of that precise relationship and boundary. Per Schrödinger's insight, a system boundary is essential for establishing internally closed causal loops, and as a result the system-dependencies that are characteristic of biology and ecology.

The structure-function relations discussed here can be applied directly to the design of ecological and biological informatics, to build a system that is itself entailed like nature. In such a system, one stores not just observations as data, but also inferences of functions, including models of them. A possible way to implement the necessary complex relationship in this architecture would be to represent the actualization and attribution entailments shown in **Figure 4** in terms of mutual selections between structures and functions, employing niche models to describe functional potentials and system attractors (Kineman, 2007).

Implications for Physics

The mechanist's criticism of ontological research that is commonly made, to be fair, is not that it is unimportant, but that it is arbitrary with regard to the mechanics, and undecidable. This much is correct, and, if it were true that we have only physical systems to study, this assumption of arbitrariness in the underlying 'reality' would be justified. But it is not true if the complex ontology emerges as we have described. Living systems bring their ontology into the empirical world, making it possible to identify a general ontology that is not mechanistic. Elsewhere the authors describe, as Rosen did, how the mechanistic view emerged from this more general relational view. Put simply, mechanisms correspond to collapsed modeling relations, where implications of a formal system correspond precisely (in theory) with the causalities of the physical world. Furthermore, mechanism requires that this correspondence should be fully computable, without impredicativities, and thus it conforms to the constructible and formalizable science that Hilbert attempted unsuccessfully to establish. Stated equivalently, a machine is a system in which its functions are entirely general (Kineman, 2007). Rosen also defines a machine as a system for which there can be a largest computable model (Rosen, 1991). As we have seen, a machine is also a system which does not contain any closed-loop causalities, or any notion of final cause. All these definitions are equivalent.

Consistency of the relational view—with mechanism as a special case—its apparent necessity in biology, its parsimony, its general applicability, and ability to guide theory development, all establish it in the philosophy of scientific revolutions. Its applications in physics should be explored as an alternative to other meta-theoretical "realities," many of which are motivated by a desire to retain the mechanical assumptions in higher dimensions. If this suggestion is pursued, Rosen's claim that biology can inform physics, might be realized.

Rosen wrote: *"... there is nothing in the relational strategy that is unphysical, in the sense of 'ideal' physics. The organization of a natural system (and in particular, of a biological organism) is at least as much a part of its material reality as the specific particles that constitute it at a given time, perhaps indeed more so. As such it can be modeled or described, in full accord with Natural Law; the resulting formalisms have at least as much right to be called images of material reality as any reductionistic model based on states and dynamical laws."* (Rosen, 1991)

Implications for Society

During the past few centuries we have achieved a remarkable synthesis of science and technology. We have been less successful in establishing a graceful or even workable relationship between nature, humanity, science, and technology. It is becoming increasingly important for us to ask the fundamental questions that will lead to an understanding of these relationships, particularly in view of the massive scale at which we are applying science and technology to the construction of our physical, social, and cultural reality.

In terms of the triadic information typology being discussed in this paper, scientific and technological construction is captured as state-referential information. In **Figure 4** this corresponds to the circular region in the center of the illustration. Investments in the formalization/mechanization of science and technology extend the state-referential region in the application areas in which such investments are made. This is illustrated in **Figure 5** by the lobes that extend into the NS, FS, F and S regions. For example, massive investment in the formalization of model decoding would tend to metabolize some non-referential information in the F region into state-referential information, stretching the state-referential lobe further into that region. In theory at least, this process can continue, eventually covering the entire region, resulting in fully mechanistic model decoding that would certainly collapse the modeling relation. Clearly, a completely state-referential treatment of any one or more of the remaining three regions would collapse the modeling relation also.

In order to preserve the natural entailment of causal loops we must (learn how to) partition tasks between human beings and computer-based agents in a manner that avoids reduction to completely state-referential implementation. A preliminary sketch of an approach to such task partitioning can be found in the earlier work of Bánáthy (1996); unfortunately, except for ongoing efforts,

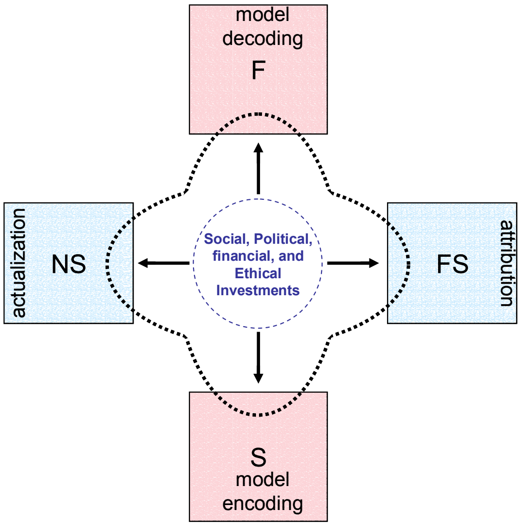

Figure 5: Balancing Human Investment in all Four Areas

developments in this area have been grounded in an unquestioning acceptance of a mechanistic perception of reality. The unintended consequences of a failure to achieve appropriate task partitioning may be devastating, particularly with respect to scientific models applied to management of natural resources and ecosystems. We submit that the conceptual foundation presented in this paper can serve as a basis for the development of task partitioning protocols that entail complexity and life.

It is also the case that if the investments in science and technology are not balanced in all four regions (shown in these diagrams) then we would, in effect, attenuate the causal loops in the region(s) in which investment is lacking, possibly leading to the collapse of the modeling relation. Clearly these considerations have serious implications for public policy particularly since "investment," in this context, has significant social, political, and ethical dimensions, in addition to the traditional financial one. Our social institutions, most notably education, will be affected.

Conclusion

We believe that practical application of this theory will yield different results than any mechanistic approach. It should be clear how our approach will lead to a different architecture than has been implemented so far, although not one wholly unimagined in ecology (Marcot and Vander Heyden, 2001). Developments in this area have likely been impeded by the lack of a solid theoretical underpinning linking ontology and epistemology. We have attempted to provide that missing element. The main difference this makes lies in the holarchical structure of the fully relational view--that it always retains its association with a natural ontology. That it can generally accommodate many disciplines and even relate to valuistic, humanistic, and spiritual dimensions Kineman (2005) gives it an obvious advantage in providing a truly integral view of nature and humanity.

References

Bánáthy, B. A. 1995. The 21st –century Janus: the three faces of information. *Systems Research* 12:319-20

Bánáthy, B. A. 1996. Information-based design of social systems. *Behavioral Science.* 41.: 104-23.

Bánáthy, B. A. 1999. An information typology for the understanding of social systems. *Systems Research* 16: 479-94.

Bateson, G. 1979. *Mind and Nature: A necessary Unity*. Bantam, Toronto.

Collier, J. 1999. Causation is the Transfer of Information. In: *Causation, Natural Laws and Explanation*. Sankey H (ed.). Klewer: Dordrecht.

Corning, P. 2001. Control information: The missing element in Norbert Wiener's cybernetic paradigm? *Kybernetes* 30(9/10):1272-88.

Csányi, V. 1989. *Evolutionary Systems and Society*. Duke University Press, London

Hochstrasser, T, Yao J. 2003. When and how does structure affect function? A discussion of structural constraints on process at different LTER sites. In *LTER All Scientists Meeting (ASM): Embarking on a Decade of Synthesis*. LTER/ASM: Seattle.

Hutchinson, G.E. 1953. The Niche: An Abstractly Inhabited Hyper-Volume. In *The Ecological Theatre and the Evolutionary Play*. Yale University Press: New Haven, p26-78. Also, *Proc. Acad. Nat. Sci.*. 105:1-12.

Kampis, G. and Rössler, O.E. 1990: How Many "Gods" Do We Need? Endophysical Self-Creation of Material Structures and the Exophysical Mastery of Universal Libraries. In: Cybernetics and Systems '90. Trappl, R. (ed.), *World Scientific,* Singapore, pp. 27-34.

Kineman, J.J. 2003. Aristotle, complexity, and ecosystems: A speculative journey. In *Proceedings of the 47th Annual Conference of the International Society for the Systems Sciences.* Allen J, Wilby J (eds.). ISSS: Heraclion.

Kineman, J.J. 2005. Vedic ecology and the new eco-accounting. In *Proceedings of the 49th Annual Conference of the International Society for the Systems Sciences.* Allen J. Wilby J. (eds.). ISSS; Cancun.

Kineman, J.J. 2007. Modeling relations in nature and eco-informatics: A practical application of Rosennean complexity. *Chemistry and Biodiversity*, in press.

Kineman, J.J, Kuma,r, K.A. 2007. Primary natural relationship: Bateson, Rosen, and the Vedas. *Kybernetics*, in Press.

Kineman, J.J, Kineman, J.R. 2000. Life and space-time cosmology. In *Proceedings of the World Congress of the Sys*tems Sciences and 44th *Annual Conference of the International Society for the Systems Sciences.* Eds. J. Allen, J. Wilby. Toronto: ISSS.

Langton, C.G, ed. 1995. *Artificial Life: an Overview*. MIT Press, Boston, MA.

Louie, A.H. 1985. Categorical systems theory. In *Theoretical Biology and Complexity: Three Essays on the Natural Philosophy of Complex Systems*. Rosen R (ed.). Academic Press, Inc: Orlando.

Marcot, B.G, Vander Heyden, M. 2001. Key ecological functions of wildlife species. In *Wildlife-habitat relationships in Oregon and Washington.* Johnson DH, O'Neil TA (eds.). Oregon State University Press: Corvallis. p168-86.

Odling-Smee, F.J., Laland, K.N. Feldman, M.W. 2003. *Niche Construction: The Neglected Process in Evolution*. Princeton University Press: Princeton.

Pattee, H.H. 1995. Evolving self-reference: Matter, Symbols, and Semantic Closure. *CC-AI* 12:9-27.

Platt, J.R. 1964. Strong inference. *Science* 146:347-53.

Rosen, R. 1971. The Polarity between Structure and Function. Dialogue Discussion Paper, Center for the Study of Democratic Institutions Special Collections, Davidson Library. University of California, Santa Barbara.

Rosen, R. 1973. Structural and functional considerations in the modeling of biological organization. Dialogue Discussion Paper, Center for the Study of Democratic Institutions, Box 77, Special Collections, Davidson Library. University of California, Santa Barbara.

Rosen, R. 1978. *Fundamentals of Measurement and Representation of Natural Systems*. North-Holland series in general research systems. North-Holland: New York. 221p

Rosen, R. 1985. *Anticipatory Systems: Philosophical, Mathematical, and Methodological Foundations*. New York: Pergamon Press.

Rosen, R. 1993. Drawing the boundary between subject and object: Comments on the mind-brain problem. *Theoretical Medicine* 14:89-100.

Rosen, R. 1991. *Life Itself: A comprehensive Inquiry into the Nature, Origin, and Fabrication of Life.* Columbia University Press: New York.

Rosen, R. 2000. *Essays on Life Itself.* Complexity in Ecological Systems Series. Columbia University Press: New York.

Schrödinger, E. 1943. *What is Life?* Cambridge University Press: Cambridge.

Simberloff, D. 1981. The sick science of ecology. *Eidema* 1.