

THE SEMANTIC STRUCTURE OF EVOLUTIONARY BIOLOGY AS AN ARGUMENT AGAINST INTELLIGENT DESIGN

by James A. T. Lancaster

Abstract. This paper examines the impact of two formalizations of evolutionary biology on the antiselectionist critiques of the Intelligent Design (ID) movement. It looks first at attempts to apply the *syntactic* framework of the physical sciences to biology in the twentieth century, and to their effect upon the ID movement. It then examines the more heuristic account of biological-theory structure, namely, the *semantic* model. Finally, it concludes by advocating the semantic conception and emphasizing the problems that the semantic model creates for ID's negative and positive theses.

Keywords: Michael Behe; Richard Dawkins; William Dembski; Intelligent Design; Imre Lakatos; Alex Rosenberg; Michael Ruse; semantic structure; syntactic structure; theory of evolution; Paul Thompson; Bas Van Fraassen; Mary Williams

As early as the eighteenth century, one can find critics of the Royal Society contending that its members were more interested in “the collection of diverting and amusing specimens” than with “the sort of programmatic and socially influential enterprise that Bacon had hoped to promote” (Gascoigne 1999, 172). This attitude toward “natural history,” now known to us as “biology,” has been wide reaching from the Enlightenment up to the present day. In fact, as late as the turn of the twentieth century, the Nobel Prize winning physicist Ernest Rutherford (1871–1937) made a public jest at natural historians, remarking that “scientists were divided into two categories—physicists and stamp collectors.” To Thomas Henry Huxley (1825–1895), it was exactly this perception of “scientists” of the organic world that troubled him most. He felt that natural history must be cleansed of its association with clerics and theology, amateurs, and eccentrics, if it was to be brought into the realm of proper “science.” In many ways, attempts such as Huxley’s are representative of a long-standing intellectual trend in the philosophy of biology.

The physical sciences—chemistry, physics, and astronomy, etc.—were, without a doubt, considered the paradigm of formal scientific theorizing

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throughout most of the twentieth century. Their cultural stature was in large part a product of their syntactic, hypothetico-deductive formalizations, which provided them with rigorous mathematical structures to bolster their logical veracity. As a result of such aforementioned criticisms and the cultural stature of physics, biological science in the twentieth century—still relatively young compared to the physical sciences—strove to realize the same syntactic ideal of scientific formalization. The 1930s witnessed the earliest attempt, that of J.H. Woodger, “to establish that biology was a genuine science even though it failed to conform to many of the features of the syntactic conception” (Woodger 1937). In turn, throughout the late 1960s and early 1970s, C.H. Waddington promoted an analogous position (Waddington 1968–1972). Despite the critical view of philosophers who believed “evolutionary biology [to be] so complex that attempts . . . to build syntheses around the framework of rigid, all-inclusive generalizations or laws, [would] continue to be self-defeating,” the endeavor to axiomatize evolutionary biology in a hypothetico-deductive framework persisted (Stebbins 1982, 14).² And, in the 1970s and 1980s philosophers of biology Michael Ruse and Alex Rosenberg argued for two different syntactic formulations of evolutionary biology.³ Thus, the population-genetics account of Ruse and the axiomatization of selection theory promoted by Rosenberg both employed the logical empiricist view of scientific theories. In effect, it was their intent to construct a formal axiomatic system of evolutionary biology, one that could match the logical rigor of the hypothetico-deductive formulation as exemplified in the physical sciences.

DEFINING THE SYNTACTIC MODEL

Let’s take a brief look at the definition of a *syntactic* conception, or “the received view,” of scientific theories.⁴ A scientific theory in the syntactic conception is mathematical; both the language and the deductive structure are formed using mathematical logic. The language is expressed in “well-formed formulas” (wff), which consist of “a set of symbols and a set of rules for the formation of formulas using the symbols,” and are always determined by fiat (Thompson 1989, 26). The other major element is the “deductive apparatus” that either specifies that well-formed formula(s) of the theory function as axioms (postulates) and/or defines the system’s rules of inference. Those wff’s that serve as axioms within the system function as its most general laws, and hence cannot themselves be deduced from further principles. With these components, the hypothetico-deductive system, consisting of language and apparatus, is intended to straightforwardly reflect empirical phenomena. In other words, the axioms and apparatus are meant to *mirror* the phenomenal world in terms of structure and function, and as such are falsifiable through

the production of explanations and predictions. However, in order for theory and phenomena to interrelate, there must also be “interpretation” via *correspondence rules*. Here, “interpretation” simply refers to the fact that “observational data” obtained from the empirical world needs to be “translated” into the mathematical logic and language of a syntactic theory. Thus, correspondence rules, such as the theory of experiment, theory of data, and theory of experimental design, “define the theoretical terms of the theory by reference to observational terms” (Thompson 1989, 43). Put simply, they translate the language in which we observe the empirical world into the theoretical terms of a theory, as exemplified in such terms as “gamete,” “gene,” and “allele.” Thus, through correspondence rules, or “definitions”—themselves a part of the syntactic theory—“the theory as a whole is given empirical meaning” (Thompson 1989, 44). Because such definitions provide the link between theory and phenomena, the theory itself must stipulate how it relates to the world. Consequently, the *syntactic* conception of scientific theories is, in some sense, top-down; that is, it specifies how the world ought to relate to it. When Ruse and Rosenberg endeavored to formalize biology, it was this *syntactic*, or hypothetico-deductive, conception that they aspired to emulate. In this way, they held that biological science could be elevated to the same exhaustive standard of scientific theorizing as the physical sciences.

RUSE AND POPULATION GENETICS

In the 1950s, geneticist Theodosius Dobzhansky (1900–1975) argued that “evolution [was] a change in the genetic composition of populations” (1951, 16). And moreover, that the Hardy–Weinberg law (H-W law) was “the foundation of population genetics *and* of modern evolutionary theory” (Dobzhansky 1951, 55; emphasis added). Subsequently, in the 1970s Michael Ruse, recognizing the potential value of population genetics for a formalization of evolutionary biology, picked up on Dobzhansky’s suggestion. Ruse claimed that “evolutionary theory is a *unified* theory with population genetics as its presupposed *core*.” Not only was the hypothetico-deductive model an ideal for evolutionary biology, alleged Ruse, but it could, in fact, be *realized* were population genetics employed as its highest axiom. In this way, evolutionary biology would “share many of the features of the physical sciences,” through which it would attain the highest standard of methodological validation (Ruse 1973, 49–50).

Let’s take a look at Ruse’s initial argument for the role of population genetics in evolutionary biology. In the first, he contends that:

Modern biologists believe that the organic world that we see around us (and of which we are a part) is indeed the product of a slow, gradual, evolutionary process; however, they believe that the process that brings about the largest changes is no more than the long-term cumulative effect of processes that bring about the

smallest heritable changes. But, since population genetics is the science that studies these small changes, we can therefore see its importance for the study of large changes—the study that is called “evolutionary theory.” [Thus,] *Population genetics is presupposed by all other evolutionary studies.* (1973, 47)

As Paul Thompson has pointed out, Ruse’s first argument is extrapolationist in character; that is, “it assumes that the causal mechanisms underlying large-scale evolutionary changes can be extrapolated from the causal mechanisms underlying small-scale change,” for large-scale change is only the cumulative effect of small-scale genetic mutation (1989, 50). From this assumption, it follows that evolutionary phenomena is reducible to the action of genetic behavior in “panmictic” populations (a “panmictic” population is a random mating group of sexual organisms whose number is large enough that it can count as infinitely large for behavioral purposes in measurement) and observable at the molecular level. Thus, evolutionary theory is, at bottom, reducible to the study of the heritability of genes in panmictic populations. And, as it turns out, the mechanism of inheritance that Darwin needed to presuppose for the action of natural selection is the foundation of evolution itself.

Ruse’s second argument is intended to demonstrate that population genetics “fits” the mold of a hypothetico-deductive model of theory formalization. Postulating Mendel’s Law of Segregation in combination with his Law of Independent Assortment allows us to deduce the H-W law, he asserts. Once deduced, the H-W law tells us that, *given a large, panmictic population in which there is no net emigration or immigration and which is in mutational equilibrium, gene ratios will remain constant and, after the first generation, genotype frequencies will remain constant as well.* It can be algebraically formulated $p^2 A_1A_1: 2p(1 - p)A_1A_2: (1 - p)^2A_2A_2$, where A_1A_1 , A_1A_2 , and A_2A_2 represent the allelic heterozygote and homozygotes. Hence, there will be three genotypes (one heterozygote and two homozygotes) and the ratio of A_1 to A_2 will, represented by $p: q$, remain constant in successive generations so long as they are not exposed to any external pressure. Ruse argues that, if the *explanans* contains the axiom(s), in this case the H-W law and statements about particular conditions, that is, selection pressures, then the *explanandum* will, of course, follow logically. In this way, explanations of “population genetics share the same form as do those of the physical sciences”; that is, evolutionary biology will conform to the hypothetico-deductive model as long as it possesses a population-genetics core (Ruse 1973, 62). Because the H-W law is statistical, we have a general axiom that does not appear to be deducible from any further laws, one that will provide biologists with the necessary axiomatic foundation they seek (Ruse 1973, 62).

Given this demonstration of the applicability of the syntactic model to population genetics, Ruse argues that his population-genetics formalization functions as the core of evolutionary theory. The figure below is a rough

approximation of Ruse's conception of the structure of evolutionary biology. In this model, the various subdisciplines of biological science, that is, paleontology, embryology, and systematics, are deducible from the central axiom(s) of population genetics, at least in theory. Ruse admits that, "at best one can say that evolutionists have the hypothetico-deductive model as an ideal in some sense—[though] they are far from having it as a realized actuality" (Ruse 1973, 49).

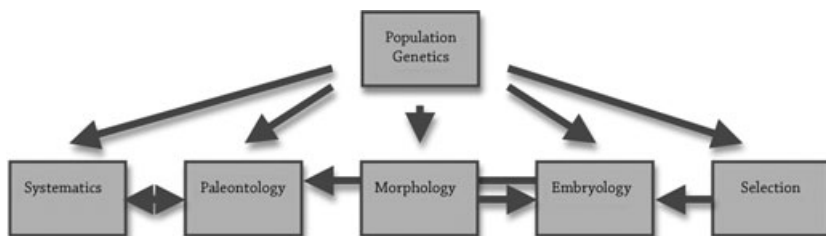


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Nonetheless, he contends that "through the incorporation of population genetics into evolutionary theory there has been an extension of the axiomatic nature of evolutionary theory" (Ruse 1973, 65). If anything, evolutionary theory is one step closer to being formalized in the same syntactic conception as that of the physical sciences.

ROSENBERG, WILLIAMS, AND A MATHEMATICAL SELECTION

The next attempt to formulate evolutionary biology according to the syntactic conception was that of Alex Rosenberg in *The Structure of Biological Science* (1985). For Rosenberg, it was not population genetics, but selection theory that unified evolutionary biology. The *new synthesis* of selection theory can be expressed roughly as follows:

1. The number of organisms of any one type can increase in geometrical proportions. But,
2. The actual number of organisms of any one type remains close to constant over long periods.
3. No two individual members of a type of organism are identical; variation is characteristic, and some of the variation is inherited. Therefore, we may infer that:
4. Because organisms can produce more offspring than their surroundings can support, there must be a struggle among organisms to survive.

5. In this struggle, the ones whose variations best adapt them to their surroundings, the fittest, survive, whereas the less fit organisms, with less well-adapted variations, do not.
6. *Thus:*
7. Because the variations are heritable, there will be a change in the proportions of the variations from generation to generation: There will be evolution. (Rosenberg 1985, 123)

The problem with this classic conception of selection theory is, of course, that it is far too imprecise to satisfy the scientific rigor demanded by the hypothetico-deductive system. Indeed, as Ruse had previously argued, “no grounds have been given for assuming that a theory involving selection can give but a picture” of evolutionary biology (Ruse 1973, 41). Nevertheless, Rosenberg suggested that what is “striking about the theory of natural selection is not the difficulty identifying the generalizations of the theory, but their extreme obviousness once they are stated” (1985, 123). Indeed, selection theory’s general laws do appear to be exceptionally obvious and elegant. Yet, that does not solve the problem of their imprecision. Hence, Rosenberg argued that “What is required is an axiomatic account of the ideas underlying [such] informal accounts of evolution” (1985, 136).

For such an account, he turned to mathematician and theoretical biologist Mary Williams, who had published just the axiomatization of selection theory that he required in a paper entitled “Deducing the Consequences of Evolution: a Mathematical Model.” Williams had explicitly stated that “The purpose of [her] paper [was] to express Darwin’s theory of evolution as a deductive system in which a few fundamental principles of the theory are used as axioms from which the remainder of the principles of the theory can be deductively derived” (1970, 343). To accomplish this, she employed “primitive” terms in order to formulate axioms from Darwin’s general principles. For instance, the “primitive terms of *biocosm* are *biological entity* (e.g., organism) and is a *parent of...*” (1970, 346). Williams demonstrated that, “by stating [Darwin’s laws] in a sufficiently rigorous form to allow [for] the deductive techniques of mathematics,” it was possible to formulate a functioning hypothetico-deductive system of selection theory (1970, 344). Rosenberg also felt that the “size and the applicability of [William’s] axiomatization [met] this challenge and [met] it clearly” (Rosenberg 1985, 151). Formulated as such, he argued that this “small body of general laws [would] work together to explain a large number of empirical regularities by providing an underlying mechanism common to them all” (1985, 126). Thus, a sufficiently defined selection theory could function as the core of evolutionary theory; it could allow the theorems of its subdisciplines to be deduced from it.

LAKATOS AND THE SYNTACTIC CORE

In order to elucidate the characteristic critical to our investigation of the syntactic formalization of evolutionary biology, let us turn to philosopher of science Imre Lakatos (1922–1974). In 1965, Lakatos responded to Kuhn's *The Structure of Scientific Revolutions* with the proposal of his own conception of a Kuhnian paradigm; what he called a *Scientific Research Program* (SRP) (Lakatos 1978, 110).⁵ The major difference between the conceptions of Lakatos and Kuhn was that, where a SRP “draws a demarcation between internal and external history,” Kuhn emphasized the sociological as well as the rational (Lakatos 1978, 144). In effect, Lakatos's delineation was between two components: a *hard core* and a *protective belt*. For Lakatos, the *hard core* consists of the most general laws (axioms) of a SRP; they do not permit deduction from higher axioms and are, more or less, immutable. The *protective belt*, on the other hand, surrounds the hard core and provides it with a shield of mutable auxiliary theorems, whose function it is to deflect harmful competition. For all intents and purposes, a SRP is the historiographic doppelganger of the hypothetico-deductive formulation of scientific theories. Both specify a set of general laws that function as a core, and both are supported by deducible auxiliary theorems. Where a SRP expresses the historical dimension of scientific theories, a syntactic formulation signifies their logical formalization. With this in mind, we might ask *What does a SRP tell us about attempts to formulate syntactic systems of evolutionary biology?*

A SRP is essentialistic; that is, it attempts to “extirpate conceptual systems from their historical situations” (Richards 1987, 588). Indeed, as Robert J. Richards has noted, “The effort to distill the essential nature of the Darwinian revolution could be sanctioned by the historiographic theory of Imre Lakatos” (1987, 406). His method can, likewise, be used to understand the normative nature of Ruse's and Rosenberg's attempts to formalize evolutionary biology. For the syntactic axiomatization of evolutionary biology demands purposive filtering of biological theorems to demarcate a rationalistic *core*. Here, the philosophies of Ruse and Rosenberg disclose their endeavor to inscribe the nature of evolutionary biology in rationalistic terms; to prove that biological science encapsulates the same veracity as the physical sciences. We have seen Ruse's argument for population genetics; it is intended to prove that explanations in evolutionary biology “share the same form as do those of the physical sciences” (Ruse 1973, 46). Similarly, we have seen Rosenberg argue that Williams's comprehensive axiomatization of selection theory “solves all the traditional questions surrounding the structure, content, and *scientific status* of the theory of natural selection” (Rosenberg 1985, 130; emphasis added). Hence, as the “history of *science* is a history of events which are

selected and interpreted in a normative way,” so the attempts of Ruse and Rosenberg to formalize evolutionary biology are attempts to offer justification of its worthiness to the monolith of *normative* science in the form of hypothetico-deductivism (Lakatos 1978, 121).⁶ They are not alone, though: J.H. Woodger and C.H. Waddington represent another two examples, this time of earlier attempts to formalize biological science. As we have just seen, evolutionary biology has an extensive and problematic history of justifying its scientific status—a problem that has wrought ironic consequences outside the domain of science, strictly speaking.

INTELLIGENT DESIGN

One implication of the problematic status of evolutionary biology’s preclusion to syntactic formalization can be localized in the Intelligent Design (ID) movement. Where the ID movement is concerned, a *methodological naturalism* in science that leads to a widespread *metaphysical naturalism*—the belief that all that exists is material—is the central problem to be reckoned with. In essence, ID has two theses: a negative thesis, known as *antiselectionism*; and a positive thesis, which consists in the belief that there exists an *Intelligent Designer*, a Being not unlike the traditional God of monotheism, who is the real cause of evolution (Kitcher 2007, 18). However, it is primarily “its negative part, its antiselectionism, [that] occupies almost all the movement’s writings,” which roughly consist of a handful of books and a mountain of pamphlets (Kitcher 2007, 83). The convergence on antiselectionism stems from the belief that undermining natural selection will ultimately result in the downfall of metaphysical naturalism. In our case, it is also ID’s antiselectionism that comprises the crucial link back to the formalization of evolutionary biology. Antiselectionism dates back to the nineteenth century, for while the majority of scientists accepted some form of organic evolution, “skepticism about the ability of Darwin’s theory of natural selection to account for the origin of species” had emerged by the 1880s (Numbers [1992] 2006, 52). In essence, antiselectionism consists in the view that natural selection, as the *mechanism* of evolution, is insufficient “to produce the major transitions in the history of life”; that is, ID-ers do not have a problem with evolution per se, but rather with its purported mechanism (Kitcher 2007, 20), for they believe it leads to metaphysical naturalism. In fact, most of them accept that life evolves, but believe that scientists have misjudged the causal power of natural selection to bring about the principal changes in life. As a result, the ID movement has made a number of attempts to substantiate their negative thesis.

ID’s foremost advocate of antiselectionism has been Michael Behe, former professor of molecular biochemistry at Lehigh University in the

United States. In 1996, Behe published a book entitled *Darwin's Black Box*, in which he claimed to have made a breakthrough, the result of which was "so unambiguous and so significant that it must be ranked as one of the greatest achievements in the history of science. [A] discovery [which] rivals those of Newton and Einstein, Lavoisier and Schrödinger, Pasteur and Darwin" (Behe 1996, 232–33). Behe dubbed his miraculous discovery *irreducible complexity*.⁷ He tells us, that

By *irreducibly complex* [he] means a single system composed of several well-matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning. An irreducibly complex system cannot be produced directly (i.e., by continuously improving the initial function, which continues to work by the same mechanism) by slight, successive modifications of a precursor system, because any precursor to an irreducibly complex system that is missing a part is by definition nonfunctional. (1996, 39)

His examples of irreducibly complex biological systems include the bacterial flagellum and the blood-clotting cascade. In effect, Behe argues that the molecular structure of these systems cannot be reduced without them suffering a complete functional breakdown; that is, if but one molecular component were to be removed, the system could no longer function. Behe's favored analogy is that of a mousetrap.

Darwin had written in the *Origin* that "If it could be demonstrated that any complex organ existed, which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down. But I can find no such case" ([1859] 1985, 219). Behe argues that irreducible complexity is just such a case; that there is no conceivable means by which the functional complexity of either the bacterial flagellum or the blood-clotting cascade could have been formed by "numerous, successive, slight modifications." Essentially, this is because "natural selection can only choose systems that are already working, [such that,] if a biological system cannot be produced gradually, it would have to arise as an integrated unit, in one fell swoop, for natural selection to have anything to act on" (Behe 1996, 39). Therefore, the mechanism of natural selection is insufficient to explain evolution. What is needed, believes Behe, is a principle of *design*, one which can account for these irreducibly complex biological mechanisms; one that can guarantee that all their components are placed simultaneously. For, in "discrete physical systems—if there is not a gradual route to their production—design is evident when a number of separate, interacting components are ordered in such a way as to accomplish a function beyond the individual components" (Behe 1996, 194). Thus, an investigation of life at the molecular level reveals the "loud, clear, piercing cry of *design*" (Behe 1996, 232).

Another argument for antiselectionism, this time employed by mathematician William Dembski, has drawn on so-called "no free lunch"

mathematical theorems. According to Dembski, “these theorems cast doubt on the power of the Darwinian mechanism to account for all of biological complexity” (2002, 221). The basic line of reasoning is simple; it says, “You cannot get more out of a system than you put into it. Garbage in, garbage out” (Ruse 2005, 254). As it pertains to evolutionary biology, the argument is meant to demonstrate that natural selection cannot take, say, *Ostreococcus*, and transform it into *Homo Sapiens*. It is a variation on the ancient argument that the maker of any given object *must be at least as complex* as the object it makes, or else the maker has made something it does not have the potential to make, which is, of course, impossible. Thus, in the words of Dembski, “we are no longer entitled to think that the Darwinian mechanism can offer biological complexity as a *free lunch*” (2002, 221; emphasis added). Without *Intelligence*, biological complexity is impossible to achieve.

The conclusion drawn by ID-ers such as Behe and Dembski is that “causation by natural selection is, to all intents and purposes, impossible” (Kitcher 2007, 81). They are willing to concede that “natural selection [can] explain rather small changes,” but they are determined to prove that there are “profound difficulties in thinking that it explains much more than trivial changes” (Ruse 2005, 256). The transition from fish to humans is simply out of the question.

CRITIQUE OF ID METHODOLOGY

In 1986, Richard Dawkins published a popularization of Neo-Darwinism in his *The Blind Watchmaker*, presenting an extremely rationalistic rendering of the theory of evolution in which natural selection was elevated to the central role. In Dawkins’s depiction, natural selection became the *core* of a blind, materialistic process of organic evolution. Thus, *The Blind Watchmaker* depicted and popularized a simplified syntactic model of evolution, one that earlier philosophers of biology had attempted to render logically feasible. This popular, rationalist rendering of evolutionary theory demarcated ID’s method of criticism. In effect, ID has directed its attack at natural selection *as if* natural selection were the *core* of evolutionary biology. As a result, their intention has been to dismantle evolutionary biology by striking at its perceived core, thereby removing its metaphysical naturalism, and then to “fill up the gap” with their positive thesis, an Intelligent Designer. Should natural selection be proven insufficient to account for evolution, then *all* of (naturalistic) evolutionary biology will demand a reformulation (it is not hard to imagine what an ID restructuring of evolutionary biology would look like!). Indeed, ID’s methodology abundantly discloses the fact that they perceive evolutionary biology as conforming to a syntactic, hypothetico-deductive formalization,

with selection theory functioning as its core. It is a peculiar consequence of the endeavor to formulate a syntactic axiomatization of evolutionary biology that antiselectionists such as Behe and Dembski believe that simply undermining selection theory can result in the triumph of their Designer. This is the result of a lingering and widespread perception of evolutionary biology as compliant with the formulation of scientific theories that arose during an earlier epoch of anti-Darwinism. The attempts of Ruse and Rosenberg, but more than anything else the popularization of an axiomatic, Neo-Darwinism by Richard Dawkins, to prove that evolutionary biology encapsulates the same logical structure as the physical sciences, has helped to establish the nature of ID's negative thesis. Indeed, it is a little ironic that antiselectionists have criticized evolutionary biology in precisely the same logical formulation that its advocates have argued will secure its scientific status.

In the case of Behe, the problem of irreducible complexity renders the *mechanism* of natural selection impotent to account for life's changes, therefore removing the *core* of a naturalistic theory of evolution. With Dembski, the target is again a *core* natural selection that is unable to produce adaptations to be acted upon. Both consider their target to be the *crux* of a pervasive naturalism. Indeed, ID-ers remain under the impression that antiselectionist tactics are *en route* to the fall of metaphysical naturalism, when, for many biologists and philosophers, formalization in evolutionary biology has long since left the realm of a naive positivism. What ID-ers do not seem to recognize is that natural selection is neither the sole, *causal mechanism* nor the axiomatic *core* of evolutionary biology. To understand the full consequences of ID's misapprehension, we need to look briefly at the nature of the syntactic model's inadequacy for evolutionary biology, and then examine the implications that derive from an alternative model of theoretical formalization.

CRITIQUE OF THE SYNTACTIC MODEL

I have chosen to allocate less space to an explication of the inadequacy of syntactic formalizations of evolutionary biology in order to be unencumbered in the transition to the semantic model. For a full examination of the insufficiency of the syntactic conception, please refer to Paul Thompson's 1989 and 2007 publications in the bibliography. In short, however, the general criticism "is that the ways in which theories relate to the world are complex and inadequately represented by the correspondence rules of the syntactic conception" (Thompson 1989, 40). More specifically, it has been shown that Ruse's axiomatization of population genetics is unsound in at least two ways: foremost, as "the Hardy-Weinberg law depicts a static situation," one which only exists

theoretically, it fails to have any real bearing on *evolutionary* biology; second, the laws of Mendelian genetics are themselves “in need of explanation in accordance with the theory of evolution” (Volpe 1967, 38; Rosenberg 1985, 131). As a result, it is obvious that population genetics cannot serve as the core of a syntactic formalization of evolutionary biology. In addition, Rosenberg’s axiomatization of selection theory proves inadequate in accordance with the common criticism of the syntactic conception; that is, it fails to reflect the true functional complexity of the natural world.

DEFINING THE SEMANTIC MODEL

The alternative conception of biological formalization, the *semantic* model, originated in its most simplistic form in the writings of philosopher of biology Morton Beckner in the 1950s. Beckner’s view was that “evolution[ary] theory consists of a family of related models,” with each model providing “evidential support for [its] neighbors” (1959, 159–60). In essence, Beckner’s conception consisted in the view that the various models of the theory—say, paleontology, biogeography, embryology, Mendelian genetics, and selection—contribute to an “overlapping” formalization, and thus a confirmation of the scientific status of evolutionary biology. It is a conception that Beckner considered to be “less ‘linear’ than, e.g., physical theory, and more ‘reticulate’” (1959). The figure below provides a rough estimation of Beckner’s conception of biological science.

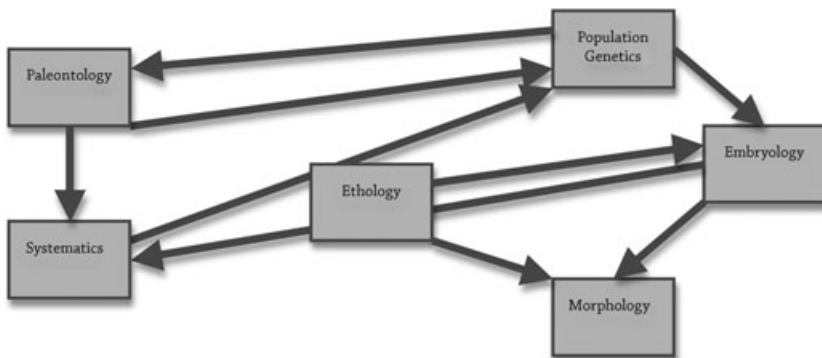


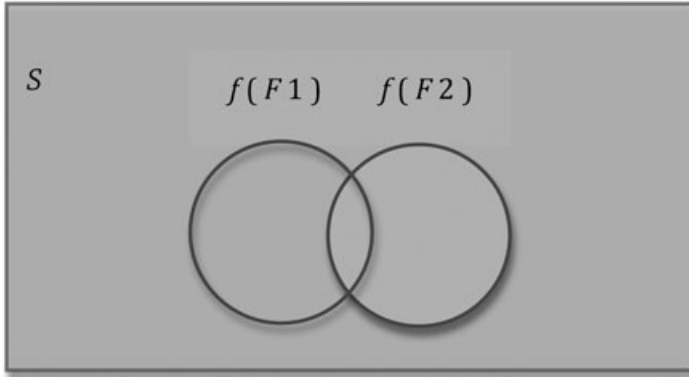
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Beckner argued that this type of formulation was necessary due to the natural differences between physical and biological subject matter; that

is, evolutionary biology simply was not the right subject to be formalized in a syntactic conception. Likewise, Thomas Goudge advocated a similar position to that of Beckner: in *The Ascent of Life* (1961), he argued that the hypothetico-deductive model was altogether the wrong sort of theory formalization for evolutionary biology.

In the 1980s, Paul Thompson, John Beatty, and Elisabeth Lloyd (Lloyd 1994) refined and extended the semantic conception of evolutionary biology. In effect, the basic idea behind their model was the same as Beckner's; that "evolutionary theory is a composite of a number of interacting sub-theories" (Thompson 2007, 503). Nonetheless, their formulation was much more rigorously defined. Let's now take a look at their conception. Like the syntactic formulation of scientific theories, a semantic formalization requires axioms and a deductive apparatus. However, semantic theories are "formalized in terms of models (semantic structures) and, hence, an adequate formal approach to the structure of scientific theories consists in the direct specification of models" (Thompson 2007, 493). In other words, unlike the syntactic conception, which must specify, and thus express its relation to the empirical world in first-order predicate logic, a semantic formalization of scientific theories does not directly interpret empirical data, because it is not a formal system. In the semantic conception, "a theory is just the specification of a kind of system—more a definition than an empirical claim" (Beatty 1981, 410). As a result, where the syntactic model must encompass a precise restatement of natural phenomena in its symbolic language and deductive frame, in a semantic model "the behavior of a particular phenomenal system is claimed to be *isomorphic* to the physical system specified by the theory"; that is, the semantic theory "does not specify either the domain of its application or the methodology involved in establishing an isomorphism" (Thompson 1989, 81–82; emphasis added). Conversely, the task of establishing such an isomorphism between theory and phenomena is left to *correspondence rules*, which express their own systems, and are formulated in close relation to the empirical world. While the resulting process of establishing this relationship will be more complex, this "separation of the theory and the methods of its application" allows for a greater amount of flexibility in both modular formulation and interaction in the theory (Thompson 2007, 496).

The semantic conception is thus composed of a "class of models," something that has been further refined by philosophers of science Bas Van Fraassen and Frederick Suppe (Suppe 1989) in terms of "phase space" or "state space" (topological) structures. A Venn diagram, such as the figure given below, provides a simplistic means to understand the interaction of models in either phase space or state space.



A Venn diagram which depicts the interaction of models.

Just as Venn diagrams entail the selection of a set S and function f that allocates a fraction of S to each predicate F , the interaction between models can, likewise, be specified to a very great degree of complexity. And because theories are abstract in nature (owing to their isomorphic relationship to the empirical world), the semantic conception facilitates a much greater level of interaction amongst the class of models. For example, where $F1$ is *selection* and $F2$ *population genetics*, the increased, functional diversity and interdependence of both models can be represented more adequately and holistically through such a depiction. As Paul Thompson has explained:

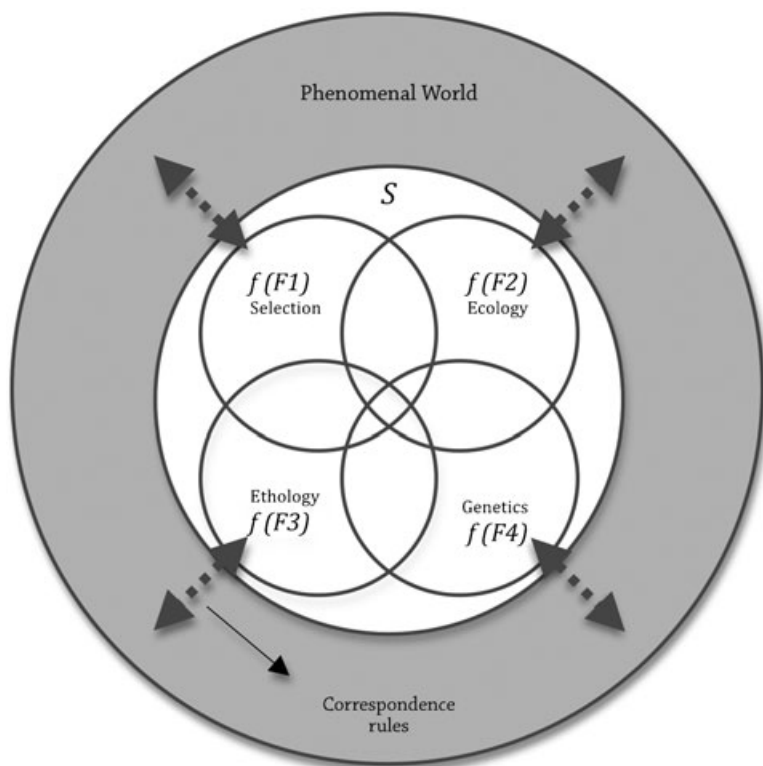
In the semantic conception, two theories can interact on at least two levels. First, there can be inputs to a physical system that result from its interaction with another system such that the state of the system is altered. The laws of interaction will specify, by means of a “next state” function, the possible outcomes that result from these inputs. That is, a “next state” function maps $S \times I$ where S is a nonempty set of states and I is a nonempty set of inputs. In this way, one system will directly affect the behavior of another system. . . A second level of interaction can, and almost always does, occur when a theory is applied to phenomena. (1989, 95–96)

As a result, the semantic conception allows models with different explanatory functions to interact across a plethora of levels. What this ultimately results in, is a much more complex and heuristic conception of scientific theories than what a syntactic formalization can offer. For, it “provide[s] us with a *family* of models, to be used for the representation of empirical phenomena,” which is in stark contrast to the rigid, formal deductive system offered by the syntactic approach (Van Fraassen 1972, 310).

It is clear that the semantic conception of scientific theories will more adequately reflect the nature of the subject studied, which, in our case, is

evolutionary biology. This is because the semantic conception of scientific theories offers “a framework within which a formalization of ‘evolutionary theory’ understood as a family of interacting theories can be given” (Thompson 1989, 97). Instead of being disproportionately related to a hypothetico-deductive *core*, the various subtheories of evolutionary biology are able to interact in a natural and complex way, reflecting the interrelation of life’s true functional diversity. Moreover, in further extrapolating from Ruse and Rosenberg’s syntactic accounts, it is clear that evolutionary biology consists of *both* population genetics and selection theory: it is “a composite of both and more” (Thompson 1989, 67).

An extremely simplified topological rendering of a semantic theory of evolutionary biology is represented below.



Semantic Conception of Evolutionary Biology

The set S represents evolutionary theory (a class of models), while the functions f (i.e., selection, ecology, embryology, genetics) assign a part of S to each predicate F . This represents their various states of interaction; they are also capable of being further compounded, though. The two-directional

arrows symbolize the isomorphism between theory and phenomenal world, as established by functionally distinct correspondence rules. Thus, while the semantic conception of evolutionary biology is still a mathematical formalization, unlike the syntactic formulation, it is not disadvantaged by a formal deductive system that must privilege a *core*; one that must ultimately misrepresent the nature of its subject matter. As Thompson has said, “All theories are equally required for an adequate explanation to be given” (1989, 99).

THE CONSEQUENCES OF THE SEMANTIC MODEL FOR ID

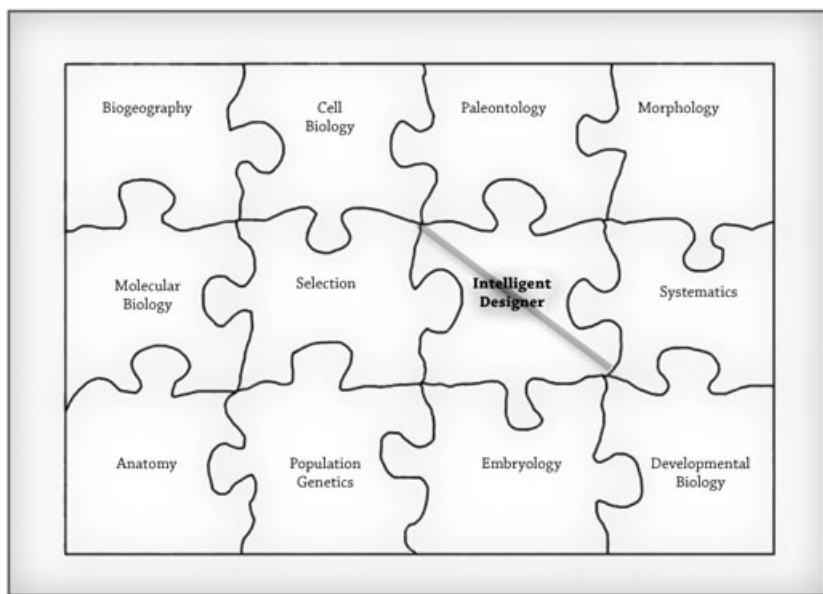
Like the syntactic conception, the semantic structure of evolutionary biology results in definitive consequences for the ID movement. But, unlike the illusion of a “selection *core*” generated by the syntactic model, one that has delineated the nature of ID’s polemical method (antiselectionism), the semantic conception of evolutionary biology rules out both ID’s negative and positive theses. We will turn first to the implications of the semantic formalization for ID’s negative thesis, its antiselectionism.

As I have already explained, attempts to formulate a syntactic formalization of evolutionary biology, either with a selectionist or population-genetics *core*, have given rise to the common illusion that evolutionary biology does, indeed, conform to the hypothetico-deductive model of scientific theories. In turn, this common misapprehension has played a role in determining the nature of ID’s polemical critique of evolutionary biology; that is, their antiselectionism. This has led ID-ers such as Behe and Dembski to believe that a demonstration of the inadequacy of natural selection will result in the collapse of the edifice that is modern evolutionary biology. With a restructuring required, the ID movement will then plaster the gap with their Intelligent Designer. Unfortunately for them, natural selection is not the syntactic core of evolutionary biology. On the contrary, evolutionary biology is more adequately reflected in the semantic conception.

Because the semantic formalization “refers to a complex framework of interacting unified ‘theories’ which as a whole describes the causal mechanisms of evolution,” there is no such “target,” no core of evolutionary biology at which to strike (Thompson 1989, 52). As a result, the semantic conception has no such *Achilles’ heel*, like that of the syntactic formalization. Evolution is not *the mechanism*, as in the syntactic conception, but, as the semantic model implies, it is a mutually reinforcing *part*. Thus, any attempt to dismantle any one model of a class of models must contend against a *methodologically naturalistic* account of biological evolution *in toto*. Thus, the class of models representing evolutionary biology (i.e., selection, population genetics, embryology, etc.) prove, as an *interacting* structure,

to be an exceedingly powerful argument in favor of a methodologically naturalistic, scientific understanding of evolutionary biology. For, just as every other model in evolutionary theory, natural selection is reinforced by the fact that it is an intricate *part* of the fabric of the theory—it is woven into evolutionary biology. And what’s more, the semantic conception demarcates a crucial function for selection theory; not the central position, but an essential and mutually reinforcing state function amongst the theory’s class of models.

Undermining natural selection proves to be a much more complex task for an ID-er faced with a semantic formalization. To illustrate this point, take a look at the figure of the “semantic puzzle” that represents evolutionary biology below. In essence, what the semantic conception tells us, is that “not just any odd puzzle piece will fit.” You cannot simply force your “piece” into the semantic conception of evolutionary biology; there are many crucial determining factors involved in a model’s “fit” into the class. The problem is that, even if ID-ers “jam” their piece in, the puzzle will be left disfigured and broken.



Semantic Puzzle

An *Intelligent Designer* cannot simply replace the functional role of natural selection within the semantic conception of evolutionary biology. For, the class of models specifies the characteristic nature of the missing piece, and it is nothing like a supernatural *Intelligent Designer*. In fact, evolution as established by the semantic conception includes a natural

selection-like mechanism; it has no room for a Designer. Even if another principle were at work, it could be nothing like *Intelligence*. As a thought experiment, let's imagine what this Being would have to be like in order to fit: foremost, this Designer would have created all organisms according to one plan, DNA, and this plan would specify only the initial emergence of life; humans would be one inconsequential branch of His tree of life; He would have to be impartial to the suffering of his creation, for evolution requires birth and reproduction followed by suffering and death; and, He would have to be "natural," not *supernatural*, in order to fit in with the other pieces. This sounds a lot like natural selection. As Philip Kitcher has noted, when it comes time to move past antiselectionism, "the rest is silence:" "Neither in Behe's writings, nor in those of any other ID-er, is there the slightest indication of how Intelligence performs the magic that poor, limited, natural selection cannot" (2007, 104).

To adequately evaluate the strength of the semantic conception in relation to the ID movement, however, it is important to examine some counter-arguments. Foremost, one could contend that, even within a semantic formalization, it would be sufficient to demonstrate the viability of supernatural agency in only one piece; this would have the effect of negating an all-pervasive metaphysical naturalism across the board. In other words, were one, naturalistic piece of the semantic puzzle undermined, the other pieces would be rendered inconsequent to the success of the ID argument. This is true. Both the syntactic and the semantic conceptions are, broadly speaking, rationalistic constructions; indeed, advocates of the semantic conception have championed its rationality over-and-above the syntactic conception. As a result, the force of the semantic argument against ID needs to be understood as one of *degree*. Within a semantic formalization of evolutionary biology, it is precisely the fact that no one piece is subordinate to any other, that each is mutually reinforcing of the others, which lends it its strength. In attempting to remove methodological naturalism from one piece, the nature of the other pieces must be taken into account, for *together* they specify what can and cannot fit. As a result, it is not *impossible* that an Intelligent Designer could, in fact, be one such piece, but *highly unlikely*. On the other hand, should a syntactic *core* be undermined, the subordinate auxiliary theorems would likewise have to change. However, as we have seen, a syntactic conception does not adequately reflect the complexity of natural phenomena, and hence should be dismissed. The semantic model provides a probabilistic strength to the argument in favor of a naturalistic evolution.

Another, more radical counterargument to the semantic model can be formulated in theological terms: an Intelligent Designer, as Creator of the *entire puzzle*, would not be limited to agency within one piece, e.g., natural selection; surely He could intervene simultaneously throughout the puzzle to maintain its coherence. In other words, would not the ID movement

simply dismiss the necessity of methodological naturalism across the board in order to ultimately overthrow metaphysical naturalism?⁸ The answer to this counterargument is multifaceted. First, it is important to emphasize that ID proponents have mounted their criticisms against a naturalistic evolution in the aforementioned manner; that is, Behe and Dembski have attacked the sufficiency of one element of the puzzle, natural selection; they have not rejected methodological naturalism across the board. This is important, for it tells us something about the ID method, and why it is unlikely to succeed. Unlike Creation Science, ID has not employed theological arguments to undermine natural selection, but biological and mathematical critiques. In other words, Design-ers have attempted to demonstrate—employing mainstream scientific methods—that “science” disproves natural selection, therefore making a space for their Designer through “scientifically legitimate” means. The use of normative, scientific methods to “make room” for their Intelligent Designer is a distinguishing feature of the ID program. In essence, the desire of ID advocates has been to legitimate Christianity within a dominant, scientific culture, through *scientifically acceptable* means.

While ID could claim that their Designer created the whole puzzle—“He can do whatever He wants”—this would leave them with an unspecified, *theistic* evolution; not a *science* that demonstrates God’s necessary role, but a *theology*. As a result, their grievances against naturalism would take the form of a *philosophical* critique, not unlike that forwarded by Alvin Plantinga. Yet, ID attempts to “fit” a Designer into the normative, scientific puzzle speak contrary to this. If the ID movement retains this distinctive approach—that is, the use of normative scientific critiques in an attempt to undermine naturalistic evolution—it will be compelled to confront the *semantic* formalization on its own terms. As a result, the inherent strength of the semantic conception comes to light; when forced to confront a rationalist formalization of evolutionary biology by the nature of their own methods, ID will discover a much greater challenge to their program in the semantic conception. It is not a syntactic theory of evolution, but a *semantic* formalization that needs to be dealt with. It is time for a change in tactics. For, in reality the ID movement *must*—by the nature of their own methods—attempt to dismantle a mutually reinforcing class of theories, which not only includes selection theory, but the naturalism of population genetics, embryology, molecular biology, cell biology, developmental biology, systematics, paleontology, anatomy, biogeography, and morphology.

This paper has attempted to validate two theses; one historical and the other philosophical: foremost, that the critical approach of the ID movement has been dependent upon a *syntactic* conception of biology—a formalization that, ironically, was an attempt to strengthen the veracity of evolution in relation to the physical sciences, but instead became the

crux of criticism. And second, to argue that the semantic conception of evolutionary biology renders a specifically ID attempt to undermine the naturalism of evolution very *improbable*, for it provides a more holistic and formidable account of the naturalism of evolution; indeed, that the semantic conception makes it very clear that replacing a naturalistic mechanism with a Divine Being is unlikely to be justified a position within evolutionary biology, so long as ID proponents attempt to keep their method of criticism within mainstream, scientific culture. As Maynard Smith wrote in his classic *The Theory of Evolution*, “Evolution tends to adapt the nature of animals and plants to their environments. In history, man has adapted his environment to his nature” (1993, 343). This statement is doubly potent, for both the rationalist proponents and religious critics of evolutionary theory have adapted it according to their own desires.

NOTES

1. I would like to acknowledge the assistance of Paul Thompson and the critical feedback provided to me by Tom Aechtner, Willem B. Drees, and Zygon’s reviewers; the finished product is much improved on account of their efforts. Additionally, I would like to thank Michael Ruse for allowing me to reproduce two figures. Finally, I would like to acknowledge the Templeton Foundation and the Venice Summer School for Science and Religion (VSSR), which provided the stimulus for the writing of this paper. Any infelicities that remain are reflective of authorial error.
2. See also Goudge (1961) and Beckner (1959).
3. Alex Rosenberg drew extensively on Williams (1970).
4. The term “received view” was coined in Putnam (1962).
5. International Colloquium in the Philosophy of Science, London, 1965.
6. It should be noted that both Ruse and Rosenberg serve in this paper as classic examples of axiomatization, whose value resides in their historical situation. That is, the positions of both Ruse and Rosenberg have become more complex and intricate in the many years since the publications cited in this paper. Nonetheless, the argument made herein is dependent upon these historically situated attempts to axiomatize evolutionary biology for their historicity.
7. The same problem, though unnamed, was tackled by Darwin in the *Origin*, Chapter VI *Difficulties on Theory*, § *Organs of Extreme Perfection and Complication*.
8. I am indebted to Willem B. Drees for the suggestion of this argument.

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