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A Study of the Structure of Evolutionary Theory

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Abstract

The scientific status of evolutionary theory has always been one of the focus issues of philosophy of science, and also the primary issue of philosophy of biology. At present, there are two main types of discussion about the structure of evolutionary theory. One is the traditional hypothesis-deductive approach, and the other is the semantic approach relative to the syntactic approach. This paper will discuss three representative schemes, the first one is Williams, the second one is Ruse, and the third is the semantic view. Through the investigation and analysis of these three schemes which make up the two approaches, this paper will point out that both of these approaches have obvious advantages in explaining the structure of evolution, but it will be pointed out in this paper that neither of them can fully explain the structure of evolutionary theory, and a comprehensive approach should be proposed. That is, it can be defended by a semantic view of the theoretical model, and in each concrete sub-theory, deductive construction is carried out.

Keywords

Evolutionary Theory, Modern Synthesis Evolutionary Theory, Syntactic View, Semantic View, Hypothesis-Deductive, Axiomatization

1. Introduction

As the science of studying the phenomena of life and its occurrence and development, biology, especially evolutionary theory contains a number of philosophical issues such as the essence of life, the level of selection, the concept of "species" and the statistical characteristics of biological laws, etc. As the same natural sciences, the main reason why does biology have far more controversies than physics is mainly because biology cannot describe its research objects as clearly and accurately as other scientific disciplines or there is no one unified research object. For example, the subjects studied in fields such as embryology, paleontology, and evolutionary biology are different, which makes it difficult to locate the relationships between them. Therefore, some biological philosophers think if the evolution theory has a logical structure like physics, many of the current controversies in it could be more adequately understood and satisfactorily resolved (Thompson, 1989). Because among these subdisciplines, evolutionary biology occupies a central position. This is just what the studies of the structure of evolutionary theory mainly concern about: does evolution theory have a structure like the theory of physics? Accompanying other issues are as follows: what is a typical physics theory? Does evolution can give deterministic laws? This dissertation is concerned with the structure of evolutionary theory which is one of central issues in the philosophy of biology.

All of these questions are inevitable when we think in the context of current scientific knowledge. With the revolutionary development of biology in the 20th century, especially the great success of molecular biology, many biological phenomena have been explained at the molecular level, which has led many biologists and philosophers to believe that the difference between biology and physics is temporary, and finally, all phenomena of biology can be fully explained by the laws of physics and chemistry, then biology will eventually become a branch of physics (Watson, 1965; Crick, 1966; Rosenberg, 1985). Those who hold this view point are called "provincialism", meanwhile, the opposite standpoint is called "autonomy" (Rosenberg, 1985: pp. 13-35). The two sides had a heated argument about the relationship between biology and physics. Provincialists generally believed that the differences now shown in physics and biology were only of degree rather substantive, such as influenced by experiments or local development strategies of disciplines. However, autonomists insisted that there was an irreconcilable differences do exist between physics and biology. It seems both sides to make sense. On the one hand, biological science shows more and more physical and chemical properties, the nature of life increasingly reveals the rules of movement at the level of cells and even biological macromolecules; on the other hand, the objects of biology are naturally different from those of physics.

Moreover, Rosenberg reminded us that we also needed to distinguish the difference between "reasons" offered in favor of the separation or the assimilation of the two disciplines by these biologists and philosophers and "motives" to impel them to take sides[1] (Rosenberg, 1985: p. 18). As a result, there is an increasing body of philosophical literature on biology and the study of the structure of evolution has become an object of concern for more and more philosophers of science and biologists.

Meanwhile, the development of evolutionary biology has been provided rich theoretical resources for the study of the structure of evolutionary theory as it is mostly based on the theory of modern synthesis. Since the publication of the *Origin of Species* by Charles Darwin in 1859, the theory of biological evolution has been formally established although the speculation and thought about evolution occurred prior and then it has become the main mechanism to explain the

[1]Usually, there are two brief motives for autonomism: one is professional, the other is ideological.

process of species generation and biological evolution. It was the first time to provide a regular explanation for the overall occurrence and development of the biological community, so that Darwin's theory of evolution connected the various branches of biology with a common theoretical basis. However, evolution theory centered on the natural selection is based on a wealth of biological facts that mostly come from the observations of naturalists so that it cannot link the macro-evolutionary phenomena to micro-genetic mechanisms. This problem was solved until the 1930s-1940s when the modern synthesis appeared. Modern synthesis, also known as neo-Darwinism, was created by a group of geneticists, such as R. A. Fisher, J. B. S. Haldane, Sewall Wright, Ernst Mayr (1982) and Theodosius Dobzhansky, etc. They integrated Darwin's theory of evolution with the content of Genetics and Paleontology to illustrate the process of adaptive evolution from the microevolution of Mendelian genetic variation to the macroevolution of natural selection of species. From then, evolutionary biology has complete experimental methods and quantitative models and has been starting to be closer to a precision science like physics in some ways, which promotes the process of the research on the evolutionary theorizing. Even the founders of modern synthesis have mostly discussed the structural issues of its theorizing.

In fact, the structure of evolutionary theory is highly related to the unification of evolutionary biology. Formalization or axiomatization of evolutionary theory which is the main approach for scholars to study the structural problems need assume that evolution theorizing is a unified theoretical system. In other words, if scholars can give axiomatic or formal solutions to evolutionary theory, then the unity of it is also well resolved. It can be said that it is a consistent pursuit for biologists and philosophers of biology to unify evolutionary biology and then biology. V. B. Smocovitis considered it reflected the worldview of Renaissance (Smocovitis, 1996). Nevertheless, as Thompson said: "we can explore the logical, epistemological, and methodological aspects of biological theorizing" by these researches (Thompson, 1989: p. 1).

However, for this subject, as we enter the second half of the Millennium year, is in various ways ripe for an initial discussion. Not only did evolutionary theory usher in a major theoretical synthesis and leap after a long period of stagnation, the formation of modern integrative Darwinism, also known as modern integrative evolution. The axiomatic or formalized study of evolutionary theory also gained widespread attention in the 1970s and 1980s. The earliest study of this problem was Woodger's axiomatization of genetics in 1937 (Woodger et al., 1937). What followed in the 1970s and 1980s was the emergence of Williams (Williams 1970), Rosenberg (Rosenberg, 1985), Ruse (Ruse, 1973), the Structuralist school (Balzer & Dawe, 1986), and the semantic school (as Lloyd, 1988, Thompson, 1989), etc. Next, this paper will introduce and analyze three well-known schemes for axiomatization or formalization of evolutionary theory to discuss the structure of it for axiomatization or formalization of a theory is the best way to grasp the structure of it. They are axiomatic schemes of Williams, Ruse and the semantic view.

2. Williams' Axiomatization of Evolutionary Theory

The first scheme comes from M. B. Williams. Williams' axiomatic model has been the first complete axiomatic model of biological theory since Woodger attempted to axiomatically deal with Mendelian genetics in 1937, and has been regarded as a classic by the biological philosophy community. It can be said that almost all subsequent discussions of the axiomatization of evolutionary theory cannot avoid the content of this scheme.

To express Darwin's theory of evolution as a deductive system, Williams gave a mathematical model of evolutionary theory of Darwin (Williams, 1970). Firstly, a concept of "biocosm" was created to define the set of reproducing organisms on which natural selection works and with two primitive terms of it: *biological entity* and *is a parent of.* Secondly, she used the two primitive terms to establish two basic axioms in biocosm system. (e.g. no biological entity is a parent of itself). It is worth noting that the axioms are self-evident and the primitive terms are also not defined, but used to define other terms. A biocosm is a set of biological entities connected to each other by the parent relation; the structure of this connection is specified by the two axioms, which are necessary for the statement of the axioms of Darwin's theory of evolution. The mathematical structure of a biocom can be expressed in symbols as the following structure: (B, ⊁), "B" is represent of the set of biological entities, the symbol "⊁" denotes the relation *is a parent of.* At this point, a basic deduction system has been established within which two fundamental principles of this system are used as the two basic axioms from which the remainder of the theory can be deductively derived. This also means that an axiom system of biocosm established. Although the primitive terms are not defined before, this biocosm system actually limits the possible meanings of the two primitive terms with these two axioms, because only the sets of entities that satisfy these two axioms can be called as the sets of biological entities of biocosm axiom system. In the real world, any set of entities (such as organism or gene) satisfying these two axioms is the *interpretation* of biocosm system (Williams, 1970: p. 348).

Next, Williams further defined the unit of evolution, clan and subclan. "A clan will be defined as a set of containing all of the descendants of some collection of 'founder' organisms" (Williams, 1970: p. 350). *Subclan* refers to a separate part of the main body of the clan, which may subject to a separate nature selection force. After that, she finally could give out five axioms in biocosm system for Darwin's theory of evolution. Such biocosms that satisfy all of the conditions stipulated by all these axioms are called Darwinian biocosms. Conversely, the entities Darwin discussed are biological entities that satisfy a specific biocosm axiom system. She believed that "the axioms of the Darwinian biocosm are, basically, just explicit statements of the ideas underlying Darwin's theory" (Williams, 1970: p. 343), and they would eventually deduce all the basic theorems of

Darwin's theory (Williams, 1970: pp. 373-385). For example:

Informal Theorem D1

The fitness of an organism relative to a subclan to which it belongs is always positive.

Theorem D1

For any b in D (k), 0 < Φ (b, D, k).

Which can be proved directly by axiom D3 and relative definitions,

Informal Axiom D3

For each organism there is a positive real number which describes its fitness in its particular environment.

Axiom D3

For any biological entity b in B, ψ (b) is a positive real number.

From above we can see, the biocosm system is useful for the axiomatization of Darwin's theory of evolution. Although biocosm is an abstract structure it can accurately state Darwin's theory of natural selection after proper explanation. As Williams said: "This axiomatization provides the foundation for a truly predictive (and therefore testable) theory of evolution… but they must first be changed from abstract statements into statements about the real world." (Williams, 1970: p. 370). Through the development of the concept of clan and subclan, the biocosm system from the initial reference to the sets of biological entities and their parental relations can now be regarded as the sets of clan and subclan with the structure determined by the laws stated in the axioms and theorems, also denoted by the notation (B, ⊁). And what's more, the unit of evolution defined by the forces of natural selection is almost an axiomatic system tailored to Darwin's theory of evolution, because this means that natural selection is the fundamental force driving biological evolution which is consistent with Darwin's theory of natural selection.

As an obvious result, Darwin's theory of evolution axiomatized by Williams has a more clear, concise and rigorous expression form and greater predictability. For example, taking theorem D12 as a sample. This theorem reveals similarities between predator-prey theory and heterosis theory that would have been difficult to detect by intuition alone. Since the biocosm system is an abstract theoretical structure, when we translate it into a statement about the real world, we can get three true statements accordingly by using three interpretations in the real world of the primitive terms. According to the theorem D12, when the fitnesses of two non-hybridized subclands are frequency dependent, then the number of individuals of each subcland in the population will reach a balance. When this theorem is applied to the individual level, we can let the two subclands $D_1 + D_2$ be a predator-prey population, where D_1 is the predator, D_2 is the prey. Then we get the fact that they are dependent on each other and they are limited to each other, and there is no interbreeding between them so their numbers be keep in dynamic balance. Then, the fact is proved that the hypothesis of the theorem in this situation is true, that the theorem D12 is a true statement about the real world. The same situation is on the population level, when we use it in the ecosystem. The prediction of theorem D12 is the same as the prediction of the niche theory, they both predicts that in the same ecosystem, there will be a dynamic balance between different species, otherwise new species will appear.

By contrasting interpretations of reality, we can see that Williams' axiomatization can accurately express the contents of Darwinian evolutionary theory. And after being axiomatized, Darwin's theory of evolution is more predictable, that is to say, it has better testable. This is also Williams' reasons for the appropriateness of her axiomatic scheme.

However, this axiomatic scheme obviously has some limitations. Obviously, Williams' axiomatic model also has boundary conditions that only apply to the principle of natural selection. While, Darwin's theory of evolution is not only a theory of natural selection, but also a theory of gradual evolution and common origin, etc. In addition, it does not include Mendelian genetics that is important to interpretation of evolutionary results. Both of them have aroused dissatisfaction by many scholars (e.g. Thompson, 1989, Sober, 1984). Therefore, this axiomatic scheme can only be regarded as a local axiomatization of Darwin's theory of evolution. It can neither represent the whole axiomatization of Darwin's theory of evolution, nor prove the axiomatization of modern synthetic evolutionary theory. As Ruse commented, "A typical example is Williams, 1970, who succeeds in her axiomatization of evolutionary theory only avoiding all mention of genetics!" (Ruse, 1973: p. 50).

3. Michael Ruse's Scheme for Axiomatization of Evolutionary Theory

As the founder of the philosophy of biology, Ruse's research on the axiomatization of evolutionary theory is also one of the representative ideas of the axiomatization of evolutionary theory, which is a necessary way to study the axiomatization of evolutionary theory. In his book *Philosophy of Biology*, Ruse completely stated his viewpoint on axiomatization of evolutionary theory: evolutionary theory has a unified structure, and the complete axiomatization is possible in principle (Ruse, 1973).

There are two reasons. First, evolutionary disciplines are centered on population genetics. Because, the various evolutionary phenomena studied in these disciplines need to be explained by the heritable mutation mechanism provided by population genetics. For one thing, it is the relationship between evolutionary biology and population genetics. This distinction in name gives the impression that the two are completely different things. In fact, the nature of modern synthesis evolutionary theory and its relation to population genetics can be understood as theories concerning the different scales of evolutionary phenomena. Ruse believes that it is mainly reflected in the problem of "large-scale evolutionary changes" and "small-scale changes" (Ruse, 1973: p. 47). Although evolutionary theory is the study of the large-scale evolutionary changes of biological evolution, modern synthesis evolutionary theory itself emphasizes that organisms are not "mutated" but are the product of a long, relatively slow, gradual process of natural selection acting on continuous, random, heritable variation. And this core theory is what population genetics is all about - the study of the mechanisms of the smallest genetic variation in the large-scale evolutionary process. Therefore, regarding the relationship between modern synthesis evolutionary theory and population genetics, Ruse believes that population genetics is important for the study of large changes which we call as "evolutionary theory", "Population genetics is presupposed by all other evolutionary theory." (Ruse, 1973: p. 48), and modern synthesis evolutionary theory is centered on population genetics and is unified by population genetics. For the other thing, the areas of the study of biological evolution are composed of many different disciplines, including systematics, morphology, embryology, paleontology, and so on. All of these disciplines have their own research topics, but they also need to be supported by the genetic mechanisms of population genetics as their presuppositions and theories. The evolutionary phenomena involved in these disciplines can only be explained by population genetics, which provides the mechanism of microscopic variation. Because according to modern synthesis evolutionary theory, once without of population genetics, the "evolutionary explanation is zero" (Ruse, 1973: p. 56). That's to say evolutionary disciplines such as morphology, embryology, and paleontology will eventually be unified in population genetics. "However, what I suggest is that all the different disciplines are unified in that they presuppose a background knowledge of genetics, particularly population genetics." (Ruse, 1973: p. 48).

Second, according to the results of the above discussion, if modern synthesis evolutionary theory is centered on and unified with population genetics, then the axiomatization of evolutionary theory is in principle possible. The reasons are as follows: population genetics could be axiomatized finally and part of it has been axiomatized, so it is possible for the axiomatization of the entity of evolutionary theory. According to Ruse, the axiomatization of a theory means that other statements can be deduced from some of the premise ones. So, he proved that Hardy-Weinberg law, as one of the most important laws of population genetics, could be derived from Mendel's law of separation to illustrate that population genetics has been partially axiomatic and therefore can be thoroughly axiomatized. The axiomatization of population genetics guarantees the possibility of achieving axiomatization in a population genetics-centered evolution theory (Ruse, 1973: pp. 48-68).

Therefore, we can conclude that the explanation mechanism of evolutionary phenomena plays a bridging role in Ruse's axiomatic argumentation of the structure of evolutionary theory. Ruse believes that only population genetics, which studies microevolutionary phenomena, can truly explain macroevolutionary phenomena. Because the phenotype of biological organisms at the macro level must have a corresponding genotype at the micro level, the formation of species is ultimately attributed to the microscopic heritable variation mechanism, and only taking Mendel's law as the starting point for explanation can truly explain how the force of natural selection is passed from one generation to the next. "As far as natural selection is concerned, although admittedly Darwin's natural selection operated at the phenotypes level, it is just a matter of fact that the modern concept of selection operates essentially at the genotypes level." (Ruse, 1973: pp. 55-58). However, the biggest controversy about this assertion is just that population genetics theory is mainly applicable to explain microevolution phenomena. There is not enough evidence to prove that macroevolution can be explained by microevolution.

Furthermore, it can be seen that, unlike Williams' axiomatic scheme, Ruse took the approach of population genetics to construct the axiomatic construction of evolutionary theory. As a result, the two sides have quarreled over who is the core issue of evolutionary theory, Darwin's theory of natural selection or population genetics? The view of taking population genetics as the core of evolution had aroused strong opposition from Rosenberg. "Mendelian genetics does not constitute the core of evolution in any theoretical significant sense." (Rosenberg, 1985: p. 135). Even if population genetics can be the core or foundation of evolutionary disciplines, they are still controversies on the unification of evolutionary theory.

In short, Ruse is a thorough provincialism of biology, but also a firm modern Darwinist. He not only believed that there was no essential difference between biology and physics, but also defended the scientific nature of biology with the theoretical characteristics of physics. At the same time, he believes that only population genetics can be the core of evolutionary biology, and all other evolutionary disciplines including Darwin's theory of evolution need the theoretical support of population genetics. The above discussion is just a narrative simplification. In fact, as one of the founders of biological philosophy who is famous in evolution and scientific demarcation, Ruse's thoughts go far beyond this. Relatively speaking, the research on Ruse's theory has being richer in China, such as the study of his thoughts of biological philosophy and evolutionary epistemology.

4. The Semantic Conception

The semantic conception of theory structure had been applied to biology by John Beatty, Elisabeth Lloyd and Paul Thompson in 1980s. Due to the controversies over traditional approaches to the core issues of evolutionary theory, Beatty, Lloyd and Thompson reflected on the traditional conception of the structure of scientific theories. Thompson called the traditional conception as "syntactic conception". He pointed out that, it was this conception that underlay the accounts of evolutionary theory given by a number of philosophers of biology as Ruse, Hull and Rosenberg and "the fundamental problem with these syntactic accounts is that they assume, and must assume in order for a syntactic account to be possible, that evolutionary theory is a unified theory" (Thompson, 1989: p. 3), which caused the difficulties about the core of evolutionary theory. In this conception, a scientific theory is a set of statements about the real world with a mathematical logic that can be formalized or axiomatized. A problem followed by this view is that two or more theories cannot easily or naturally be employed interactively in order to provide a coherent account of phenomena. Therefore, it failed to adequately capture and exploit the complexity and richness of evolutionary theory and the relationship to other theories, as Thompson said.

In the view of many biologists and philosophers of biology, evolutionary theory is not a unified theory but "a family of interacting" (Beckner, 1959; Thompson, 1989). For example, Thompson thought that while natural selection was an important mechanism of evolutionary change, or Darwinian evolution, it did not have to be elevated to the same level as the whole theory of evolution. In Thompson's view, a proper Darwinian theory of evolution would include, in addition to the mechanisms of natural selection, the mechanisms of heredity and variation, all three of which work together to make evolution happen. "Evolutionary theory is a composite, then, of natural selection, heredity, and variation" (Thompson, 1989: p. 12). Variation, selection, and heredity are indispensable in Darwin's evolution.

In order to defend the scientific status of evolutionary theory, and to better illustrate the properties of the sub-theories of evolution they developed a new conception of theories, called the "semantic conception". According to this conception, evolutionary theory is a family of interacting theories rather than a hypothesis-deductive system. Furthermore, a scientific theory is a model or a class of models of a formal system rather than a statement of a phenomenal system. The relationship of a theory to the empirical (phenomenal) system within its intended scope is one of isomorphism. That means laws do not describe the behavior of phenomena while they are definitions of a formal system, the relevant laws and statements serve only as descriptions and specifications of the ideal system. When the theory is regarded as a model of the objective world isomorphism, Lloyd gives the concept of "confirmation". "Confirming a theory amounts to confirming models—more accurately, confirming the empirical claims made about models, i.e., the claims stating that a natural system (or kind of natural system) is isomorphic in certain respects to the model" (Lloyd, 1988: p. 145). According to this view, a scientific theory becomes only a model of the natural system, and then the scientific explanations and predictions will become the application process of the model, scientific laws are no longer descriptions of the real world, so there is no need to be responsible for universality.

Thompson believed that syntactic view was more suited to the scientific theories which were fairly simple to be given a linguistic formulation, while the advocates of the semantic view discuss complex theories as evolutionary theory. Obviously, this account has many advantages: 1) the laws of evolution are no longer a necessary condition for the scientific legitimacy of evolution. 2) more suitable for the multidisciplinary characteristics of evolutionary theory rather than a unique logical structure between various theories of evolution.

In the semantic conception, the semantics of a theory is provided by defining a class of models instead of by correspondence rules of logical positivism. So, evolutionary theory doesn't have to require a hypothesis-deductive axiomatic system structure, they only need to construct a class of models suitable for the phenomenon. Then, both Thompson and Lloyd followed the state space approach of Bas van Fraassen and Frederick Suppe to construct evolutionary theory. According to the state-space method, the composition of a theoretical or ideal system consists of four main parts, including: defining a state space and state variables, parameters, and a set of laws of coexistence and succession for the system (Lloyd, 1988: pp. 33-41). A state space is a set of state variables. For population genetics, its state space describes the genetic states and changes in the population, so that all possible genetic states of the population can be considered in terms of genotype frequency which is an important part of the theory of population genetics[2]. The state space of population genetics selected by Lloyd and Thompson is the possible physical space state for the genotype frequency of the population and the physical change of genotype frequency that may be caused by isolation and reproduction as state variables (Lloyd, 1988: p. 34; Thompson, 1989: p. 12). Thus, for population genetics, its physical state space is a Cartesian n-space, where "n" is a function of the number of possible allelic pairs in a population, and the state variables that are the "measurable physical magnitudes" to which Thompson refers are the frequencies of each genotype, represented by real numbers from 0 to 1. The subsequent construction of the ideal system will be slightly different. Thompson's specific detail is to establish satisfying functions about measurable physical quantities, while Lloyd further subdivides the semantic view structure of population genetics into parameters and laws such as the Hardy-Weinberg equation and its variants are fundamental laws of coexistence and succession in population genetics theory, parameters refer to values that occur in the laws of succession and coexistence and are the same for all possible states of the defined system as the selection coefficient s in the Hardy-Weinberg system. The last step involves an explanation of the interactions between the models. So far, the semantic view model of population genetics has been established.

The semantic view of evolutionary theory is a major advance in the formalization of evolutionary theory, which differs substantially from the axiomatic approach of the earlier accepted view, and resolves most of the philosophical debates in evolutionary theory area. But it still cannot avoid some inappropriate. The most important one is this conception betrays scientific realism to some extent. If a theory is just a model of the phenomenal world how can we get the truth? In addition, Lloyd acknowledged the empirical contents of the laws when

[2]In this regard, Lewontin (Lewontin, 1974) has claimed that evolutionary theory involves at least two different kinds of state Spaces, they are phenotypic state space and genotype state space. And a proper theory of evolution should include laws that describe the interaction of these two state spaces. Lewontin also raised the problem of establishing mapping relationship between genotype state space and phenotype state space. This paper does not give a thorough introduction to this, but chooses the mapping relationship between Thompson's evolutionary theory as the main basis object.

analyzing the confirmation process of evolution. Once it has empirical significance, the models at this time have the same properties as the sets of propositions. Then there is no substantial difference between the syntactic conception of structure of theories.

5. My Viewpoint

So far, all the structural reorganizations of evolutionary theory have finally achieved the formalization or axiomatization of certain parts of it rather than the entirety. Putting aside the incompleteness of these solutions themselves, a common fundamental problem here is that all these schemes including the semantic conception assumed that evolutionary theory was a unified theoretical system. But, the success of modern synthesis evolution does not mean that a unified theory of evolution has been established and there is s reduction relationship between all composition theories, which are necessary for formalization or axiomatization. In addition to the reasons gave by Beckner (1959), Eldredge and Gould (1972), Sahotra Sarkar made a comprehensive analysis on the concept of "synthesis" in 2004. When we talked about modern synthesis, "1) a synthesis is a unification of originally disparate scientific structures (models, sets of models, theories, or even disciplines), and 2) in the synthesized structure, there is epistemic parity between the structures so unified." (Sarkar, 2004: p. 1217). For example, the synthesis between population genetics and classical genetics can be seen as epistemic parity instead of theoretical reduction. "There was epistemic parity at least between classical and population genetics." (Sarkar, 2004: p. 1219). It can be seen that, according to Sarkar's view, epistemic parity and theoretical reduction are different things, and the extent of theoretical reduction is stronger than epistemic parity. Therefore, he believes that it is not possible to say that modern synthetic evolution has reached a unity of reductive relations in the structure of theories.

Nevertheless, formalization or axiomatization is one important route to understanding science and to making major theoretical advances within science, which has mostly been the consensus of scientific philosophers (e.g. Williams, Thompson and Suppers, they are clearly aware of the significance of their research). The principle of unification of science relays on the foundation of unification of the world. Maybe, the current difficulties in achieving unified evolution are just limitations in existing evolutionary theories. With the development of evolutionary biology, nothing is conclusive.

But is the axiomatic approach really suit to the structure of a complex scientific theory such as the theory of evolution? The emergence of dissipative structure theory and nonlinear theory has provided us with more abundant explanations for understanding the peculiarity of scientific theories. Based on the above discussion, I think, as the "Received View", the criterion of logical positivism for the structure of scientific theory, i.e., the hypothesis-deductive structure, is a very strict criterion. If this criterion can be reached, then it just could be said that the scientific theory is a normative scientific theory rather than judging the legitimacy of science about it. Science is supposed to be pluralistic, like the axiom systems, even in mathematics, Euclid is not the only axiom system, there are also non-Euclidean geometric. So, the structure of scientific theories should also be expanded just as what the semantic conception does to be seen as multi-system cooperation. But at the same time they're all real systems about the empirical world just like different axiomatic spaces. In conclusion, I believe that this integrated strategy will solve the major current structural problems about evolutionary theory to the greatest extent possible.

6. Conclusion

This paper mainly discusses the axiomatization of evolutionary theory, which is the most important analysis of the structure of evolutionary theory. Different types of axiomatic schemes are introduced and analyzed, such as Williams' axiomatization and Ruse's axiomatization, and the formalization of evolutionary theory in semantic conception which breaks through the traditional syntactic conception. Through analysis, it is found that Axiomatizations of Williams and Ruse, are both axiomatic schemes under the traditional logical positivism scientific theory conception, focusing too much on Darwinian evolutionary theory or population genetics as the core of evolutionary biology. In fact, these two schemes do not complete the axiomatization of evolutionary theory. They are only axiomatizations of some of it. According to the semantic view of the scheme, the different sub-theories of evolutionary theory can be viewed as family models of interactions, which is a good explanation for the multidisciplinary nature of evolutionary theory. But, model theory used to be indirect and complex in describing the relationship between scientific laws and the real world, and could not completely exclude empirical contents when analyzing the confirmation process of evolution.

We can draw a conclusion, neither of these two approaches can give an ideal answer to the structural questions about evolutionary theory. Therefore, in the end, I propose a comprehensive solution that adopts the concept of family models of scientific theory in a semantic view, different evolutionary sub-theories are regarded as highly related to each other but not yet in a unified structure; on the other hand, according to the traditional syntactic conception, they are all being as real systems about the empirical world, and the hypothesis-deductive structure is followed in each sub-system. I think it makes sense because we can extrapolate the problem of unity between these systems upwards to the expressiveness of our formal system rather than seeking an axiomatization for all of the theories from a downward unified of the perspective of God.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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