ISSN 2616-5783 Vol.6, Issue 3: 23-30, DOI: 10.25236/AJHSS.2023.060305

On Popper's Shifting Appraisal of Scientific Status of Darwinian Theory

Han Xiao*

Beijing Normal University, Beijing, 100875, China
**Corresponding author: hxhjdwm@163.com*

Abstract: *The appraisal of scientific status of evolution is a great attempt by Karl Popper to combine Darwinian theory with its falsification theory system. Compared with other natural science theories, Darwinian theory occupies a special and important position in his philosophy of science system. Popper's appraisal of the scientific status of Darwinian theory has experienced a long process from "singular historical statement" to "metaphysical research programme" and to "scientific theory", shifting from denial to approval. The primary reason for this change lies in that Popper has corrected his previous misunderstanding of Darwinism and proved that it is indeed falsifiable. On the one hand, this comes from a flow of new discoveries of biology, on the other hand, it is also the expression of the continuous maturity of his philosophy. However, Popper has never completely gotten rid of the framework of physics to examine Darwinism, so his evaluation of whether evolution theory is science doesn't change completely.*

Keywords: *Popper, Darwinian theory, natural selection, falsification, science*

Darwin's theory of evolution creates a naturalistic explanation for the origin of life, which dispels the role of purpose, design and other factors in evolution, and is opposed to the creationism which claims that God directly created everything in the universe. It pushed the evolution theory on the historical stage of science, and brought a new world to modern science. The biologist Ernst Mayr divides it into five parts: the theory of biological evolution, the theory of common ancestry, the theory of gradualism, the theory of species proliferation and the theory of natural selection. The theory of natural selection which often referred to as "survival of the fittest", as the core of Darwinian theory, has been strongly questioned ever since it was proposed. Thereinto, Popper's evaluation is the most representative and influential, and his evaluation of the scientific status of Darwinian theory also experienced a long process from negation to affirmation.

1. The shifting of Popper's appraisal to whether Darwinian Theory is science

In the book "*Unended Quest*", Popper once reduced Darwinian theory to two assumptions: one is the fact that life evolves continuously; the other is that there are four core in Darwinian theory: heredity, variation, natural selection and variability (evolution).[1] These two assumptions mean: firstly, Popper doesn't doubt the fact that "species come from evolution"; secondly, the "Darwinian theory" here is not the classical theory proposed by Darwin himself, but the "Neo-Darwinism" formed after continuous modification and supplement on this basis, that is, the "Modern Synthetic Theory of Evolution" called by Julian Huxley. Therefore, the theory is actually the "sublation" of Darwin's classical theory of evolution. It preserves and develops what is correct in Darwin's theory, but also abandons the dregs such as acquired inheritance.

By the time Popper began to focus on Darwinian theory, Darwin has passed away for decades, but the theory had grown from a tender seed into a lush tree. As important parts, "heredity" and "variation" are no longer scientific conjectures when they were just put forward. With the gradual development and perfection of the theories of biogenetics and statistical biology, the phenomena of heredity and variation predicted by these theories can be tested by the data obtained from laboratory or field observation. Therefore, the falsifiability of "heredity" and "variation" is not the focus of Popper's questioning, but the natural selection theory is. The changing process of Popper's evaluation of evolution essentially reflects the changing process of his evaluation of natural selection theory (hereinafter referred to as "NS").

ISSN 2616-5783 Vol.6, Issue 3: 23-30, DOI: 10.25236/AJHSS.2023.060305

1.1 Stage 1: It's only a singular historical statement, not a scientific theory

As Popper recounted in his autobiography "*Unended Quest*", he began to pay attention to and discuss evolution in his early reading and learning. The book "*The Poverty of Historicism*" contains Popper's "first brief attempt to deal with some epistemological questions connected with the theory of evolution". But at that time, he primarily questioned the historical character of Darwinism: "The evolution of life on earth, or of human society, is a unique historical process. Such a process, we may assume, proceeds in accordance with all kinds of causal laws … Its description, however, is not a law, but only a singular historical statement."[2] Popper believed that any theory which explained a phenomenon that had occurred only once in history and could not be repeated should not be called a law, because it was not a universal statement and did not have the universality of the laws of nature. So, he called it a singular historical statement. Precisely, historical statements are only an external description of historical events that happened in the past, let alone science.

1.2 Stage Two: It's only a metaphysical research programme which cannot be falsified

In the 1960s, Popper gave several more lectures on the scientific status of Darwinism and summarized these views in "*Unended Quest*". In the section "Darwinism as a Metaphysical Research Programme", Darwin explicitly states his assessment of Darwinism theory: "I have come to the conclusion that Darwinism is not a testable scientific theory, but a *metaphysical research programme*—a possible framework for testable scientific theories." In short, Popper denied the scientific status of Darwinian theory as a metaphysical research programme. He came to this conclusion mainly for the following three reasons: the main propositions of Darwinian theory are untestable, tautological and unpredictable. Although these three reasons are based on three different perspectives of analysis, but they are closely linked with each other, nested within each other, and cannot be completely separated:

1.2.1 Untestable

Popper's theories are developed around the concept of "falsification" which is Popper's criterion of demarcation of science. Darwinism "is metaphysical because it is not testable." In addition to its own meaning, the word "metaphysical" of Popper refers to theories that are unfalsifiable. Thus, Popper argued that the reason why Darwinian theory is not science is that it is untestable. In response to this untestable nature, Popper devised an ideal experiment: He imagined that we would find only three types of bacteria on Mars, or only one, or none at all, which would all make sense in NS, because whatever the case might be, we could say that the bacteria that did exist were the ones that were best selected for survival. If Darwinism were testable, we would conclude that the existence of life satisfying genetic and mutational characteristics would be subject to NS and would evolve into different types. But the fact is that we cannot successfully predict the evolution of species through Darwinism, let alone test what the "favorable conditions" of NS are.

1.2.2 Tautology

The most common criticism of NS is the tautology of "survival of the fittest", in which Popper's comment plays an important role. In "*Unended Quest*", Popper explicitly stated that the explanation of NS to "adaptation" would be described "hardly in a scientific way ... in fact, almost tautological." Popper determined that "survival of the fittest" was a tautology, because he thought the terms "adaptation" and "selection" were used in such a way that "if the species were not adapted, it would have been eliminated by natural selection. Similarly, if a species has been eliminated it must have been ill adapted to the conditions." He then explained further in "*Objective Knowledge*". He asserts that there seems to be little difference between the statement "survival is the fittest" and the statement "survival is the survival", because we have no other criterion for fitness than actual survival.[3] It can be seen that according to Popper, the statement "survival of the fittest" is indeed a tautology, because it can't be confirmed by facts, but identically true. In other words, the statement does not contain any empirical content, so it's "not a scientific hypothesis that can be tested, but an unfalsifiable metaphysical assumption".[4]

1.2.3 No predictability

Generally speaking, a scientific theory must be predictable, that is, it can accurately predict possible future situations according to the natural laws contained in the theory. Popper argued, however, that Darwinism "does not really predict the evolution of variety. It therefore cannot really explain it." In addition, by using the example of bacteria exposed to penicillin, he concluded that the Darwinian prediction that penicillin resistant bacteria would eventually emerge was necessarily true, but not

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falsifiable, and that it was simply a "situational logic". In fact, this concept is associated with Popper's "Three Worlds Theory". What he wants to express is that there can be several logically possible worlds, but only exists one empirical world explained. So theoretically speaking, there can be a world with no life but also has evolutionary laws same as that in the empirical world. Obviously, the predictability only works in the empirical world, so only when we restrict the situation in the empirical world can Darwinism works.

In short, Popper believed that Darwinian theory, with NS as its core, was not science, but a metaphysical research programme. However, his understanding of "metaphysics" is different from logical positivism. The latter always holds that metaphysical propositions are meaningless, so should be regarded as a separate existence from science. Although Darwinism is not science, as a "metaphysical research programme", it has many inspirations for the very concrete and practical research via studying the process of biological evolution. As in the case of penicillin, "it allows us to study adaptation to a new environment (such as a penicillin-infested environment) in a rational way: it suggests the existence of a mechanism of adaptation, and it allows us even to study in detail the mechanism at work." Therefore, although Popper here denied the scientific status of Darwinism, he still acknowledged its positive role in science.

1.3 Stage three: It's both metaphysical research programme and science

Only two years later, however, Popper overturned his evaluation of the scientific status of Darwinian theory. In 1977, he came to University of Cambridge and gave a presentation entitled "Natural Selection and the Emergence of the Mind". Popper publicly declared that he had been wrong about the evaluation of Darwinism. Firstly, he maintained that NS served as a research programme because "in many fields it presents detailed questions and tells us how to solve them we can expect to accept."[5] But he changed his opinion on the testability and logical status of NS. Popper described his current view of NS as follows: "It is by no means tautological...Not only is it testable, but it is not, strictly speaking, universally true. As with so many biological theories, there are exceptions, and given the random nature of the variations by which natural selection works, their occurrence is no accident. Therefore, not all phenomena of evolution can be explained only by natural selection theory. However, it is a challenging programme to study in each particular context, showing how much natural selection may have contributed to the evolution of a particular organ or behavioral program.". Till now, Popper abandoned his previous viewpoint that Darwinian theory was not science for its unfalsifiability.

2. An analysis of the shifting in Popper's scientific appraisal of Darwinian Theory

The above reviews the process of Popper's appraisal of Darwinism's scientific status from denial to approval, which lasts for about decades. So, what is on earth contributing to this huge shifting? It should be said that, on the one hand, evolutionary biology was constantly improved with a flow of research achievements; and on the other hand, Popper's research on philosophy of science was constantly mature.

When regarding Darwinism merely a "metaphysical research programme", Popper believed that "survival of the fittest" was the whole meaning of NS, which was the only explanation mechanism for biological evolution. In other words, although there exists heredity and variation, evolution would never happen without the intervention of the force of NS. Later, Popper changed his previous erroneous views on NS and its role in the mechanism of evolution. Firstly, he no longer comprehended "survival of the fittest" only at the semantic level, but began to explore the true meaning of "fittest" and "fitness". Secondly, he no longer believed that NS was the necessary condition for evolution in Darwinism.

In fact, many people, not just Popper, misunderstand NS because of the literal meaning of "survival of the fittest". Mayr once clarified Darwin's original meaning by pointing out that Darwin did not initially use "survival of the fittest" to refer to NS, but later borrowed it from Spencer and used it in the republished book of "*The Origin of Species*", aiming to avoid connecting "selection" with "supernatural beings" (as distinguished from creationism). "This is unfortunate, because it created the problem that the whole natural selection theory was stuck in tautology."[6] Obviously, Popper was one of those who was puzzled. Fortunately, when realized this mistake, he offered "peacock spreading tail" as the counterexample. It goes like this: After a long evolution, the peacock has formed a huge tail that can spread, which is not conducive to its flexibility and even survival from the perspective of self-survival. If the effect of natural selection is to eliminate useless organs and leave useful organs, then the peacock's big tail should have disappeared under the effect of natural selection. The reason why the peacock still retains it and has the

ISSN 2616-5783 Vol.6, Issue 3: 23-30, DOI: 10.25236/AJHSS.2023.060305

behavior of spreading it is based on Darwin's mechanism of "sexual selection" (favored by the opposite sex). Therefore, Popper believed that "adaptation" and "survival" were no longer mutually defined, and that "adaptation" had other criteria besides "survival", such as sexual selection factors.

After clarifying the concept "survival of the fittest", Popper reexamined the role of NS in evolution and found it only a sufficient but not necessary condition for evolution. This conclusion was made possible by attention to the phenomenon of "genetic drift". Popper interpreted as "by isolating a small number of individuals from the dominant population and preventing them from interbreeding with the dominant population, the distribution of genes in the gene pool of the new population will, over time, be different from that of the original population gene pool." In short, “genetic drift” is a phenomenon in which the gene pool is changed by chance in a small population, resulting in a significant change in gene frequency. For example, if a sufficiently small population is geographically isolated and forms two separate populations, the combination of "heredity" and "variation" will result in two populations with different gene distribution. The difference in gene frequency results in reproductive isolation of the two populations and the process of evolution is realized. Obviously, there is no NS involved in this evolutionary process, and this will have happened even if there has been no selection pressure at all. So there are other ways for organisms to evolve besides NS. In fact, Darwin's contemporary Moritz Wagner had already proposed the phenomenon of evolution by “genetic drift”, but at that time, Darwin was still convinced that NS was necessary for evolution.

In short, the testable nature of genetic drift thus led Popper to discover that NS theory was actually falsifiable. NS is not the only dynamics in biological evolution. If we use “a”, “b”, “c”, “d” and “e” to respectively refer to “inheritance”, “variation”, “natural selection”, “evolution” and “genetic drift”, then there will be a universal statement that when conditions “a” and “b” exist, all results “d” are caused by “c”. However, “e” can also lead to “d”, so this theory can be falsified. Therefore, Popper's argument of "genetic drift" is valid, which is similar to the explanatory strategy of "non-adaptive program" adopted by S.J.Gould and R.C.Lewontin et al., that is, Darwin followed the diversified explanatory strategy when explaining species evolution. He restricted the scope of natural selection by separating adaptation from selection and other ways, so as to make adaptive explanations testable.[7]

As for the predictability of Darwinism, in response to an article published in “*New Scientist*” in August 1980, Popper pointed out that historical science also has the characteristics of science. It has "retrodictions", which makes even events that only happened once can be tested. That "retrodictions" are extrapolations of past states from the present. Such retroactive predictions have already been made a lot by evolutionists. For example, scientists have previously predicted the existence of a transitional organism called Archaeopteryx, then the first fossil of which was unearthed in a limestone mine in Germany in 1861 as expected. So, Popper no longer argued that science is predictable simply like this:

Given the initial state of an event A and the natural law that governs it B, we can infer its state C at some point in the future C_1, C_2 ... C_n.

Prediction shouldn’t only be understood as “temporal prediction”, which is a one-way time process from the present to the future, but a two-way concept. It is indeed prediction to infer a certain state of the future from the present through certain scientific laws, but it should also be possible to think backward about such a process, which is also prediction.

To sum up, Popper first proved that "survival of the fittest" is not a tautology through the example of the peacock, and adaptation is not only a criterion of survival, so it is testable. Secondly, Popper proved that NS theory is not the only explanation mechanism for the evolution of life through genetic drift phenomenon, which gave the possibility of falsification of the evolution theory that advocated thorough explanation. Finally, the predictability of evolution is given by changing the predictability from present foresight to logical foresight, which makes evolution become a scientific theory capable of generating new empirical facts. In the final analysis, Popper's standard of dividing science has not changed. The fundamental reason why Darwinian theory was finally judged as science is that Popper was able to prove that it is falsifiable. In summary, Popper mistakenly believed that Darwinian theory was untestable, unfalsifiable, and therefore not science, like astrology, Freudian psychoanalysis, etc., which always provided seemingly satisfactory explanations for events that had already happened. Later, after realizing and correcting his own misconceptions about natural selection, discovering that it was not always true, but falsifiable, he redeclared Darwinian theory as a scientific theory. After all, Popper discovered that Darwinian theory was not a completely correct theory, so recognized it as science.

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3. Reflections on Popper's shifting appraisal of the scientific status of Darwinian Theory

3.1 Popper's shifting appraisal is incomplete actually

What's the effect of Popper's evaluation of evolution, and does it really meet his expectations? The point of this paper is that although Popper tried to prove that evolution was falsifiable in the later stage, from the perspective of his argumentation strategy, he has indeed chosen a "cop out" way to avoid those difficult questions, realizing the falsifiable proof by "stealing" concepts. Therefore, this seemingly successful proof doesn't actually achieve the expected effect:

First of all, **from the perspective of evaluation criteria**, reviewing the whole process of Popper's evaluation of Darwinian theory, we cannot ignore this point: he repeatedly compared it with the laws of physics, such as the law of gravitation, in many works. For example, he argued that "the problems of organisms are not physical: they are neither physical things, nor physical laws, nor physical facts." In fact, his judgment on whether Darwinism is science has always been based on physical science as a "benchmark". More accurately, Popper's criterion of demarcating science is also based on "precise sciences" such as physics. He is willing to call Darwinism a "theory" in the premise that it should conform to the scientific model of physics. To some extent, this inherent thinking is inevitable, because although science is a complex of different specific disciplines, such as physics, chemistry, biology, geology, etc., since physics is where we have explored the most, discovered the most and deepest, and the physical methods are most consistent with Occam's Razor principle of simplicity, So we often apply the standards and methods of physics to other disciplines and even to science as a whole. "The arrogance of the physicists has become proverbial among scientists."[8] For example, Weisskopf once said that "the scientific world view is based upon the great discoveries of the nineteenth century concerning the nature of electricity and heat and the existence of atoms and molecules." Naturally, it is not surprising that Popper found it difficult to completely break away from the framework of the physical sciences when making scientific distinctions.

Secondly, **from the perspective of explanatory strategy**, perhaps aware of the imperfection of this way of demarcating science, Popper restated NS and claimed that the success of Darwinism could be explained by "situational logic". However, "situational logic" only refers to objective selectivity in a particular background, so Darwinism can only provide causal explanation in principle after all, but cannot provide real causal explanation in practice. For answering the question "how is it possible", only a priori model is enough, but for the question "how it actually happens", the empirical law is essential. So, as evolutionary biologist J.M.Smith has said, "Darwinian theory is not falsifiable in Popper's conception of reality ... What a scientific theory needs to do is making a statement about the real world, not just a situational analysis."[9] Although Popper later admitted that Darwinism contains empirical statements, he did not explain that it contains empirical rules. He still hasn't solved the problem that Darwinism as a historical science is different from physical science. As long as Darwinism equals to historical statements, which means that the hypothetical situation must be typical, not the only one, then the so-called law of evolution is only an external description of the past historical events, which only represents a possible explanation of the occurrence of things. That is, "when given that situation, the things we want to explain are likely to happen, rather than a natural law of necessity. In this way, Popper's shifting appraisal of Darwinism's scientific status is still not successful, and even self-contradictory. That's the reason why Popper regards evolution as science on the one hand, but doesn't give up regarding it as a metaphysical research programme on the other hand. This combination of both shows that Popper's is still unclear and fuzzy about this problem.

Thirdly, **from the perspective of the shifting purpose**, Popper believed there was a strong similarity between evolution and his theory of the growth of scientific knowledge. That's the point which push him to change his attitude actively in order to guard and prove the latter theory. To be specific, if Popper still insisted that Darwinian theory was unfalsifiable, then it would be difficult to guarantee the validity of the similar theory of scientific knowledge growth. Therefore, Popper has repeatedly tried to put forward views on the frontier issues of evolutionary biology. For example, in "*Objective Knowledge*", he proposed a mechanism called "genetic dualism" to explain the adaptive evolution of organisms' structure and behavior within the framework of NS.[10] As a result, to Popper, Darwinian theory is not simply a "third party" outside his ideology, but a "clue" that could be applied to his knowledge epistemology. Just as Shu Wei-guang said, Popper's intention was not only to use evolution theory to explain his theory of knowledge, but also to develop evolution theory through the study of evolutionary epistemology.

Finally, **from the perspective of the explanatory process**, although Popper has tried to prove the falsifiability of Darwinian theory through examples like "sexual selection" and "genetic drift", the

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validity of these two examples has been greatly discounted today. First of all, through the example of peacock spreading its tail, Popper found reproductive factors should be applied as the criteria to judge biological adaptation, but in fact, sexual selection has already been proved to be included in NS, and the adaptiveness is judged by the reproduction of offspring in practice. So this example doesn't work when proving "survival of the fittest" is not a tautology. Secondly, Elliott Sober thinks that Popper did not give any examples to explain the phenomenon of genetic drift, so this explanation is just his inference. It can't be proved unless Popper can give real cases. However, even if Popper could do that, the problem can't be solved completely. In fact, in his later proof that evolution is science, Popper actually changed the concept. The proposition he criticized in the early stage was PNS, which he changed into PNSR in the later stage:

- *(PNS) If traits T_1 and T_2 are found in a population, T_1 is fitter than T_2, the two traits are heritable, and no other evolutionary causes impinge on the population, then T_1 will increase in frequency.*
- *(PNSR) All traits in all organisms evolved because of natural selection.*[11]

Apparently, Popper only proved PNSR was falsifiable in the late, but chose not to say anything about PNS. Since both PNS and PNSR are included in the evolution theory, if PNSR is falsifiable, PNS∨PNSR is falsifiable as well. As a result, the whole evolution theory has been proved to be falsifiable in the end, but the effectiveness has already deviated from Popper's aim in advance. As a result, even if the final conclusion is substantial, on the whole the proof is not successful.

Therefore, Popper's shifting in scientific appraisal of Darwinian theory is not complete. Although Popper's will to change is very strong, it's a pity that the actual effect is far from reaching his goal.

3.2 Darwinism really is science

Even so, this does not mean that Darwinism is not science. Actually, no Darwinists have declared that Darwinian Theory is true all the time. As Darwin himself once listed three possible disproofs of his theory: firstly, "If anyone can prove that complex organs of living organisms can be formed without many successive, slight variations, my theory will be absolutely bankrupt"; secondly; "It would be absolutely fatal to my theory if some naturalists believe that many biological structures have been created simply for appreciation or to increase diversity"; thirdly. "It would be detrimental to my theory if anyone could prove that the structure of one species, or parts of it, were formed absolutely for the benefit of another species."[12] In fact, Darwinian theory has been denied, revised and re-affirmed frequently. For example, NS was once considered incompatible with "Blending Inheritance Theory", but later the "Particulate Theory" saved it, which indicates that it is not always true, and is in the possibility of being falsified.

In essence, the difficulty of determining whether Darwinism is science doesn't necessarily lead to its scientific uncertainty, may be a reflection of an inappropriate demarcation of science, especially for biology and other historical sciences. The increasing complexity of scientific discovery forces us to re-examine the characteristics of science. Should physical science still be the paradigm of all sciences? G.G.Simpson even claimed to set physics subordinated to biological science, because the object of physics is only a relatively small number of non-living systems, but more living systems need to be explained by biological principles. Due to the complexity of the hierarchical system of living systems, there are many possibilities for the emergence of each link. Therefore, the interactions among the various systems are extremely numerous and complex, which is difficult to be obtained through simple mathematical calculation. Therefore, it can only be explained through a high-level generality proposition. But the law of biological probability can still explain the reason as well as the law of necessity. In this sense, therefore, we may even say that "all the principles of all science" can be found only in biology. Evolution, then, is still science that "works perfectly well without the expressions that are indisputably called laws."[13] Moreover, Sober suggested that a priori model could be used in biology. He believes that modern evolutionary biology is constantly enriched by mathematical models, which are capable of explanatory and predictive work as empirical rules, so a priori dynamic models can be called laws.

4. Conclusion

All in all, regardless of whether Popper has successfully evaluated the scientific status of Darwinism, he has always been committed to it, even "believed that the influence of Darwin's theory on society was at least as great as that of Newton". He not only expressed his obvious evolutional tendency in public for many times, but also combined Darwinism with his own knowledge epistemology, which is truly evident in "Three Worlds Theory". In fact, what he has discussed indeed set off a huge wave of research in the

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academic circle. On the one hand, many anti-evolutionists use Popper's authority as a sword to refute Darwinism, especially the Intelligent Design (ID) supporters in recent years. For example, in "*Darwin on Trial*", P.E.Johnson criticized evolution by pointing out that the NS theory is tautological. In "*Darwin's Black Box*", M.J.Behe criticized that Darwinism could not explain the "irreducible complexity" of the structure of life. On the other hand, more and more Darwinists are fighting back against the anti-evolutionists, and a group of Darwinists represented by Erst Mayr, Richard Dawkins, Michael Ruth, etc., greatly accelerated studies on evolution theory, constantly revised and improved it. For example, Dawkins wrote a large number of popular science readings, trying to describe the real appearance of evolution to people with simple and interesting words. Ruth defended the scientific status of Darwinism in several trials with ID. S.K. Mills and J.H. Beatty aimed to improve the concept of "fitness" to find its meaning beyond reproductive factors, so as to eliminate the tautology repetition of the proposition "survival of the fittest". P.J.Bowler, a historian of biological thought, has also argued that "natural selection is based on the belief that the fittest do survive longer and reproduce more frequently, but fitness is defined not in terms of survival but as a measure of the organism's ability to cope with its environment by getting food, escaping predators, and so on."[14] In addition, Gould, Sober and others have put forward their own ideas on the subject...In short, synthetic evolutionists have always been trying to rationalize "survival of the fittest". Dobzhansky concludes: "The classics of evolutionism described natural selection as the survival of the fittest. We prefer to describe it as differential perpetuation of genotypes or of genetic systems."[15]

Of course, Popper's subsequent change cannot be divorced with the discovery of "gene drift" phenomenon, modern molecular genetic theory and other theories that have made the evidence available. Besides, other scholars' criticisms are also inevitable, which lead to Popper reexamine his studies effectively. This process undoubtedly reflects Popper's scientific rational spirit, critical spirit and unique personality charm as a great philosopher of science. Just like the title of his book "*Conjectures and Refutations*", Popper explains the rational spirit he advocated by his own actions: insisting on criticizing and testing any theory, rather than believing or defending it.

Acknowledgement

This paper is the periodic achievement of Projects "Research on the Theory Conundrum and Solutions of the Progressive thinking in evolution theory（21BZX004）, supported by the National Social Science Fund of China.

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