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A Pluralistic Epistemological Study on Epigenetics

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Abstract

Epigenetics is the mechanism by which biological phenotypes are preserved and transmitted to offspring through pathways such as DNA methylation and chromatin conformational changes, while DNA sequences remain unchanged. In the past two decades, epigenetics has emerged, overturning traditional genetic theories and sparking widespread debate in the scientific and philosophical communities. This article will review the understanding of epigenetics in ontology, the debate between the Darwinian and Lamarckian paradigms sparked by epigenetics, genetic determinism, reductionism in biology, and whether paradigms of theory of evolution need to be supplemented or revised, and respond to these issues from multiple perspectives. In recent decades, research on epigenetics has shown that the environment can promote epigenetic variation, thereby promoting natural selection and evolutionary processes. Epigenetics is stable and can independently influence evolution together with genetics. Therefore, like genetic changes, epigenetics can play an important role in short-term microevolution and contribute to the macroscopic evolutionary process of species formation and improved adaptability. Epigenetics is a very young discipline that requires further exploration. However, in any case, an increasing number of studies are indicating that environmental induced epigenetics can be inherited across generations, and epigenetics is an equally important molecular mechanism as genetics, which needs to be incorporated into a more unified evolutionary theory.

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Keywords

Epigenetics, ontology, darwinian paradigm, lamarckian paradigm, genetic determinism, theory of evolution.

Introduction

Since the rediscovery of Mendel's laws of inheritance, classical genetics has emerged. In the following century, molecular biology and genomics centered around the essence of genes and how genes determine phenotype have emerged. However, the world of life is full of mysteries, and genes do not determine everything. Many phenomena cannot be explained by the genetic theory of gene determining phenotype. There are complex and precise regulatory mechanisms between genotypes and phenotypes in organisms, which is the research scope of epigenetics. If the genomic DNA sequences contain the genetic codes that encode all living things, then epigenetics determines how genetic codes are used to generate different gene expression profiles and phenotypes during individual development and interaction with the environment to better adapt to environmental changes. Since the beginning of the 20th century, both theoretical viewpoints and scientific data have been gradually accumulated in epigenetics, especially since the 1940s when research results have been increasing year by year. In the 21st century, it has become more prosperous, with a large number of academic papers and works emerging. Epigenetics, due to its inherent characteristics and potential ontological, epistemological, and methodological thinking, has attracted particular attention from scientists and philosophers.

Epigenetic Understanding Under Ontology

Laudan pointed out that studying tradition provides a set of guiding principles for the development of specific theories. Part of these guiding principles constitute ontology, which generally defines the types of basic entities that exist in the field or research tradition, and outlines the different ways in which these entities can interact with each other [Laudanum, 1990]. Since 1942, British developmental biologist Conrad Waddington has linked the previously independent fields of developmental biology and genetics, combining the Greek word "epigenesis" (having the meaning of development "theory of epigenesis") with "genetics" to propose the term "epigenetics", which refers to the entire process of development. Now, it has evolved into the current "epigenetics", which can be said to be the beginning of the traditional study of epigenetics. In the second half of the 20th century to the beginning of the 21st century, Ohno, Lyon, Griffith J.S., and others successively discovered epigenetic mechanisms such as X chromosome inactivation, DNA methylation, histone acetylation and methylation, and genomic imprinting. In 1987, Holliday R.'s paper "The Inheritance of Epigenetic Defects" published in "Nature" sparked an explosive use of the concept of "epigenetics" in the 1990s [Ohno, 1959; Griffith, 1969].

Guided by ontology, people constantly explore the nature of epigenetics, and epigenetic research has been continuously developed in various aspects. In 2004, Constantia M et al. proposed that DNA methylation is involved in genomic imprinting, confirming that DNA methylation undergoes significant changes in gamete and early embryonic development [Constancia, 2004]. During this period, chromatin structure and gene expression also became very active research areas. Studies by Cosgrove MS and others have shown that histone modifications, particularly acetylation and methylation, play a crucial role in gene expression [Cosgrove, 2005]. Meanwhile, studies have also shown that RNA plays an increasingly important role in epigenetics, and selective splicing of gene

transcripts can be considered as an epigenetic mechanism [Baulcome, 2005; Sontheimer, 2005; Filipowicz, 2005], as shown in "Table 1". These studies indicate that inheritance not based on DNA sequences exist in various organisms and have been confirmed in microorganisms, plants, invertebrates, and vertebrates.

Table 1 - History of Epigenetics

Time	Events
1940s	Conrad Waddington defined epigenetics as the environment gene interaction that induces developmental phenotypes
1975	Holliday, Pugh, and Riggs discovered DNA methylation
1988	X chromosome inactivation and DNA methylation
1990s	Imprinting genes, allele expression, and DNA methylation
1995	Histone modification and chromatin structure
2000s	Non-coding RNA
2005	Epigenomic atlas
2005	Transgenerational inheritance of epigenetics

At present, biologists define the concept of epigenetics as the genetic phenomenon caused by chromatin changes that do not depend on DNA sequence changes. Various chemical modifications outside of DNA sequence are called epigenetic modifications or epigenetic markers, which are the main carriers of epigenetics. Under the influence of ontology, the epigenome is considered a reversible material entity that regulates gene expression. Epigenetic regulation can affect biological processes such as gene expression, cell differentiation, and development, and plays an important role in maintaining normal development and physiological functions of organisms. It is the basis for guiding and controlling gene expression. If a certain epigenetic regulatory mechanism is disrupted, it may lead to direct cell death, developmental abnormalities, and even serious diseases (such as cancer). The biological mechanisms of epigenetic regulation mainly include DNA methylation, histone modification, and non-coding RNA, etc.

1) DNA methylation is the earliest discovered epigenetic modification, which refers to the biochemical process of adding a methyl group (a chemical group) to a certain base in a DNA sequence. The high methylation of a certain segment of DNA is likely to inhibit the transcription of the corresponding gene (Klose and Bird 2006). Methylation can affect the specific expression of genes at different developmental stages, making it extremely important in body development and cell differentiation. In the process of biological development, some genes are highly methylated in the early stages of development to inhibit expression, while in the late stages of development, they are induced to demethylate and activate expression.

2) Histone modification is also an important surface genetic regulatory mechanism. Histones form chromatin with DNA entangled around them, hence also known as chromatin modification. Different chemical groups can be added to the end of histones to form modifications such as acetylation, methylation, phosphorylation, ubiquitination, etc. These modifications can affect the three-dimensional structure of chromatin, thereby affecting the accessibility of gene transcription, the level and mode of gene expression, DNA replication or repair processes, etc.

3) Non-coding RNA (ncRNA) includes small RNA, long non-coding RNA (lncRNA), small nuclear RNA (snRNA), etc. These RNAs do not encode proteins, but play important roles in gene expression regulation, gene splicing, post-transcriptional processing, and chromosome spatial structure

construction. A portion of non-coding RNA can regulate gene expression, a phenomenon known as RNA interference (RNAi). Research has shown that RNA interference also plays an important role in epigenetic regulation.

The above is not the entirety of the epigenetic regulatory mechanisms, as the transmission of intracellular structures (such as mitochondria, regulatory proteins, etc.) from mother cells to daughter cells also falls within the scope of epigenetics. A major characteristic of the epigenetic regulatory mechanism is holism, which means that different epigenetic factors are connected into a huge epigenetic regulatory network, influencing and coordinating with each other. For example, methylation and histone modification are interdependent, and both are related to chromatin remodeling.

After several important mechanisms of surface genetic regulation were revealed, a large number of researchers have devoted themselves to the field of epigenetics (see "Figure 1"), and the important role of epigenetics in development and evolution has been further confirmed. Among numerous studies, there are several representative research achievements that have caused a sensation in the global scientific and philosophical communities. In 2008, a study published in the Proceedings of the National Academy of Sciences showed that the children (F₁ generation) of women who became pregnant after the hunger winter of 1944 in the Netherlands had a higher incidence rate of obesity and heart disease when they grew up. Further research found that their grandchildren (F₂ generation) also had a higher incidence rate of obesity and heart disease, because their IGF2 gene DNA methylation was less, confirmed that living environment conditions can lead to heritable phenotypic changes in humans [Capitanini, 2021]; In 2014, a paper titled "Lamarck Regression" was published in the journal "Nature", proposing that "specific fears can also be inherited across generations." In the experiment, they exposed male mice to a phenylethyl ketone gas with a hawthorn aroma, and each time the odor was released, the mice were electrocuted. After a period of time, the mice developed a fear of this odor, and the offspring (F₁ generation) and grandchildren (F₂ generation) of these male mice developed the same conditioned fear response circuit, were born with a fear of acetophenone [Szyf, 2014]; Two studies in 2023 have shown that the collapse of epigenetic regulatory information can lead to aging in mice, while restoring the integrity of the epigenetic genome can reverse its aging. Researchers say this is evidence of the causal relationship between epigenetics and aging, adding new evidence to the universality of cross representational epigenetics in mammals [Jae-Hyun Yang, 2023; Takahashi, 2023].

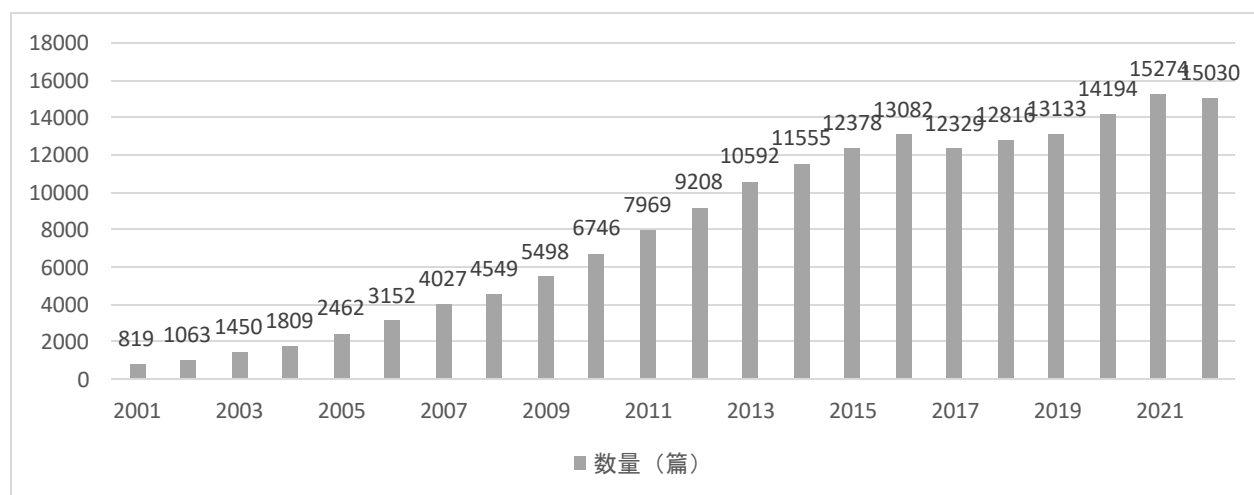


Figure 1 - Number of academic papers related to "epigenetics" published from 2001 to 2022 (data from Aminer platform)

Epigenetics scientists propose that epigenetics is the primary molecular mechanism used by any organism to promote physiological and phenotypic changes. Environmental conditions, such as nutrition, temperature, light, toxins, exposure, stress, or trauma, can trigger epigenetic regulation, promote cell response to the environment, and cause phenotypic variation. The role of early developmental environmental factors can permanently program the molecular functions of cells, thereby affecting the later representative types [Perovic, 2011]. However, some geneticists believe that although epigenetics play a role in cell fate and evolutionary processes, they are far less important than epigenetics believe [Noble, 2015].

The biological mechanism of epigenetics is established at the molecular biology level, and the concept of "epigenome" has strengthened the ontology of epigenetics in recent years. The epigenome is a set of chemical modifications of DNA and DNA related proteins in cells, which can characterize how many allele specific active genes and regulatory elements exist in the human genome, as well as the biological functions of these regulatory elements. However, due to the reversibility of epigenetics and the instability of intergenerational inheritance, there are doubts about its ontological commitment. This questioning is temporarily referred to as epigenetic instrumental theory, which believes that epigenetics is not an independent and real entity, but rather a process that occurs in the body under certain conditions over a period of time, especially the phenomenon that causes diseases and physiological abnormalities. Philosophers are also concerned about the scientific development of epigenetics and the issues it raises about the essence of life, biological evolution, ethics, and other related issues.

The Debate Between the "Darwinian Paradigm" and the "Lamarckian Paradigm"

The rise of epigenetics emphasizes the influence of environment on the variation and evolution of biological traits, and some researchers propose that this is a revival of Lamarckism. But many studies have also criticized such views.

The main viewpoints of Lamarckism are: Species undergo changes during the process of evolution; The changes in evolution are slow and difficult to detect; Evolution occurs through adaptation to the environment, usually from simple to complex, although in a few cases it is the opposite; These species are interconnected through a common lineage; The process of evolution begins naturally, meaning that life originates from inanimate matter [Danchin, 2011]. However, under the Darwinian paradigm of the 20th century, Lamarck and Lamarckism were often used as cognitive errors and clumsy theories. For example, the most prominent viewpoint in Lamarck's view is the view of "acquired inheritance", and the example of giraffe neck elongation is always used as a comparison between Lamarckism and Darwin's theory of natural selection [Dias, 2014]. Now it seems that such views need to be re-examined.

Since the 1990s, there has been a significant increase in research on "Lamarckian theory" and "Lamarckism" in foreign countries. Etienne Bucher believed that Lamarck's theory of "inheritance of acquired traits" can now be explained by epigenetic mechanisms [Bucher, 2013]. Jablonka proposed that the scientific findings on epigenetics, as well as the debate about the importance of epigenetics in evolution, indicate that many "marginal" phenomena that were not identified in early research can be classified as epigenetic examples of acquired inheritance [Gissis, 2011]. Francis Dov believed that the latest advances in genetic inheritance, embryology, immunology, and behavioral research to some extent prove that Lamarck's vision 200 years ago was correct [Dov, 2006]. Alessandro Capitanini believed that the characteristics exhibited by organisms are determined by the expression of genetic

information dependent on the genome, epigenome, and microbiome. He pointed out that on the timeline of evolution, according to Darwin's principle, genetic modification takes millions of years to occur and stabilize, but environment and habits can affect the phenotype response of organisms more quickly. According to Lamarck's hypothesis, through epigenetics, people's habits (physiological, psychological, environmental) can determine changes in gene expression and may affect the gene expression of their offspring [Capitanini, 2021]. In recent years, some epigenetic scientists who have achieved important research results also believed that their research results have become evidence of Lamarckism [Yan Wang, 2017].

However, some scholars thought that there is a fundamental difference between intergenerational inheritance in epigenetics and acquired inheritance in Lamarck, and caution should be exercised in this regard. Ilya Gadjev pointed out that when combining "Lamarckism" with advances in gene expression regulation and genetics, there should be a clearer understanding of Lamarckism's ideas and epigenetics, which can contribute to the discussion of "innate" and "acquired" [Gadjev, 2015]. Laurent Loison believed that the discovery of new molecular mechanisms (such as DNA methylation, histone modification, RNA interference, etc.) is evidence to support the authenticity and effectiveness of acquired inheritance, but the true Lamarck concept of acquired inheritance is different from the concept of cross representative epigenetics [Loison, 2018]. Even Francis Dov believed that viewing modern environmental epigenetics as neo-Lamarckism does not truly help [Dov Por, 2006].

Based on this, Dave Speijer and Sophie J. Veig engaged in a tit for tat debate over the use of "Lamarck theory" and "Lamarckism". Speyer called for an end to the "hasty use of 'Lamarckian style'", as the term "Lamarckian style" often contrasts with "Darwinian style". Veig believed that Speyer provided a "problematic" description of the Lamarckian mechanism, and there is no need to adopt a strong realistic attitude towards Lamarckism. In the era of Lamarckism, cell theory has not yet formed, so it is more reasonable for people to maintain an open attitude towards what is the basis of Lamarckian inheritance. He believed that "Lamarckism" should specifically refer to the paradigm of "use/abandonment". Research on the acquisition of spacer fragments in CRISPR arrays and the inheritance of small RNA in *Caenorhabditis elegans* as acquired characteristic inheritance shows that modeling these processes based on the paradigm of "use/abandonment" can increase understanding of these processes. He suggested abandoning strong ontological commitments, and paying attention on how the Lamarck mechanism enhances people's understanding of epigenetic processes [Speijer, 2019; Sophie, 2019; Speijer, 2019b].

The Challenges of Epigenetics to Genetic Determinism

"Dragon born dragon, phoenix born phoenix" has a genetic metaphor, which may indicate that life has an inherent purpose at the beginning of conception that determines the developmental direction of individuals. There was a debate in ancient Greece between preformationism and epigenesis regarding whether development was predetermined. The former believed that there is a predetermined form of life, and development is only a process of "little people" constantly growing. The latter, represented by Aristotle, believed that the form of organisms is gradually realized during development. Aristotle believed that the blood of an individual's mother provide a material basis, while the semen of the father provides a form-giving principle, which determines the essential properties of the organism. Here, the principle of formation replaces the fixed form and sets the internal purpose for living individuals. Therefore, Aristotle also partially believed in the preformationism that development is still predetermined [Lu Qiaoying, 2021].

Modern synthetic evolution has dominated biological science for over half a century, with its core idea being that "genes encode proteins through the genetic program inherited from their parents, forming organisms, and encoding and determining future offspring". The "genetic information" carried by DNA molecules here replaces "form" or "the principle of formation", setting an inherent purpose for individuals and pre-determining the outcome of development. This is the modern version of preformationism, also known as "genetic determinism". The genetic determinism perspective of modern synthetic evolution has penetrated into scientific literature and textbooks, to the extent that many biologists may not have recognized its conceptual essence. Nathaniel Comfort, in his paper published in "Nature", criticized Robert Plomin's "Blueprint" for conveying the message of classic genetic determinism. "Blueprint" is a roadmap for regressing social policy, and its consequences may be as severe as the infamous genetic determinism before it [Comfort, 2018].

Genetic determinism describes genes as the "blueprint", which may erroneously imply that all the information needed to make up an organism exists in DNA, which is clearly not true. Under the paradigm of modern evolutionary synthesis, people have accepted the ideas of DNA and genetic code, which has led to the view of "genetic program", which can easily lead to mechanical reductionism ideas such as "human body is a large carrier of genes" [Dawkins, 1976]. There are two types of errors here, one is that the gene is the active cause, and the other is that the feedback between the environment and the genome, which may form a cyclic causal relationship, is ignored.

Many researchers in the field of epigenetics have proposed that organisms are not entirely determined by their genomes, and genetic determinism is insufficient to explain the complexity of organisms. The most important theory of epigenetics is the interaction between the genome and the environment, which can help people better understand how the environment shapes phenotypes and the phenotypes of offspring, and may even persist into the next generation [Tammen, 2013]. Epigenetics can avoid gene centrism and allow for a more holistic perspective [Burbano, 2006].

Kevin N Laland published a paper in "Nature" titled "Does the Theory of Evolution Need to be Reconsidered?" [Laland, 2014]. Based on research on developmental bias, phenotypic plasticity, niche construction, and epigenetics, he emphasized the role of development and environment in biological evolution, pointing out that the evolutionary theory of gene centrism is no longer applicable. Some scholars in the fields of humanities and social sciences believed that theories in epigenetics may replace reductionism and genetic determinism, enabling people to have a clearer understanding of the important role of social life and environment. Kasia Tolwinskia thought that the genome obtains its biological "meaning" through a process of interaction, which may redefine genes and rethink the causal relationship between genes and the environment. Social science discourse on epigenetics is expected to change people's overall view of life phenomena, replacing the reductionist paradigm with a paradigm that integrates environment and genetics [Tolwinskia, 2013]. Some scholars believed that the "revolution" of epigenetics has crossed many disciplines and will deviate from genetic determinism [Waggoner, 2015].

E. Dickins disagreed with the above viewpoint, arguing that the focus on epigenetics leads to confusion between proximate and ultimate causal relationships, which in turn masks key issues related to the organization and regulation of life throughout the entire lifecycle [Dickins, 2012].

Rethinking of Reductionism in Biology

Ingo Brigandt and Alan Love proposed three reductionism theories in biology: (1) Ontological reduction means that every specific biological system (such as an organism) is simply composed of molecules and their interactions; (2) Methodology reduction refers to the most fruitful study of

biological systems at the lowest possible level, and biological experimental research aims to discover molecular and biochemical reasons; (3) Epistemological reduction, which refers to the higher-level knowledge about a certain scientific field, can usually be reduced to another set of more fundamental knowledge [Love, 2012].

Alexander Rosenberg's proposal of "cash reductionism" has had a wide impact in the field of biological philosophy [Rosenberg, 2008], distinguishing between "how possible" and "why necessary" biological explanations. Rosenberg pointed out that according to the reductionism, classical genetics provides a historical description of natural selection regarding how a biological phenomenon occurs (such as why certain butterflies have eye shaped spots on their wings), but this description is not detailed. It is like an outline or a promise, and once molecular genetics completes this description, this promise is fulfilled. The process of fulfilling this promise is the process of restoring classical genetics to molecular genetics [Rosenberg, 2007]. One of the most powerful criticisms of reductionism within the scope of biological philosophy comes from the biological philosopher Philip Kitcher, to which Rosenberg strongly responds [Rosenberg, 2008]. However, the cash reductionism cannot end the debate between reductionism and anti-reductionism in biological philosophy. Slobodan Perovic believes that even from detailed biological explanations at the molecular level, it is impossible to infer reductionism hypotheses because the mutual causality between molecules is crucial for these explanations. The extension of basic physical parameters to the biological context makes the concepts of basic elements and causal levels assumed by reductionists elusive [Slobodan, 2014].

In recent years, the surge in epigenetic research, especially the emergence of a large number of research results on epigenetic mediated transgenerational inheritance, seems to have added evidence to both reductionists and anti-reductionists [Noble, 2015; Danchin, 2011; Dias, 2014; Gluckman, 2007; Klironomos, 2013; Nelson, Nadeau, 2010; Nelson, Spiezio, Nadeau, 2010; Nelson et al., 2012; Rechavi, 2011; Beurton, 2008; Gissis, 2011; Noble, 2011a, 2011b; Pigliucci, 2010].

Richard Lerner believes that modern synthetic evolution has reversed causal relationships in biology, leading to the failure of reductionism. Although modern synthetic evolution theory, as a geocentric theory of evolution, reductionism approach is effective, it endows "genes" with privileges in causal relationships. In a network of multiple interacting factors, "genes" cannot have privileges. In the context of epigenetic research, the genetic reductionism model under the modern paradigm of comprehensive evolution has led to unreasonable claims about genetic causal relationships [Lerner, 2017]. Paul Davies proposed that epigenomic regulation is an emerging self-organizing complex phenomenon that exists in complex system theories such as nonlinear bifurcations, linkage feedback loops, distributed networks, and top-down causal relationships. The heritable environmental imprints challenge the central law of biology, which assumes that genes control life. Genes are not "autonomous" and cannot be turned on or off on their own. The role of genes is more in the feedback of organisms to environmental stimuli [Davies, 2012]. Epigenetic studies have shown that causal relationships are mutual, acting in both passive and active ways. Passive causal relationships are DNA sequences that act as inert templates, while active causal relationships are the functional networks of interactions that determine how the genome is activated [Noble, 2015]. Modern synthetic evolution requires new theoretical supplements of biological causal relationships. Epigenetics suggests the existence of another evolutionary pointing system that complements Darwin's theory, presenting an ordered response to the environment rather than just random changes like genetic drift [Noble, 2006, 2008, 2013]. This multi mechanism evolutionary theory is closer to some of Darwin's viewpoints rather than "neo-Darwinism", and the combination of epigenetics and classical genetics can provide more complete and effective causal explanations for biology.

However, there are also many researchers who believe that when epigenetics does not completely break away from the tendency of reductionism in conceptualizing developmental relationships, that is, genes and environment play different roles, the field needs to pursue a more rigorous framework for the entire developmental process, which integrates the molecular, organic, and environmental levels of biological tissues, including all the importance of emergence, background, and hierarchical relationships in the developmental explanations [Lickliter, 2017]. Margaret Lock believed that external variables in the body can bring about heritable changes in gene expression or cell phenotype [Lock, 2013], and these epigenetic findings are likely to trigger a new round of somatic reductionism, as research is mainly limited to the molecular level. She also believed that a new biological reductionism is emerging [Lock, 2015]. The work of many scholars can serve as an example of reductionism, such as Mohd Hafiz Rothi's use of intergenerational metabolic methylation labeling technology to determine that methylation can be transmitted from parents to children due to hunger. The author claims that this method shifts the focus of epigenetic research from correlation to causality [Rothi, 2023]. Jun Otsuka et al. used causal graph theory to analyze the essential interaction between Ernst Mayr's "proximate cause" and "ultimate cause" causal relationships, providing a reductionist approach for evaluating or discovering epigenetic or unknown evolutionary phenomena [Otsuka, 2015].

Conclusion

Epigenetics has developed rapidly and research results are advancing rapidly. Currently and in the future, it will be a hot field of scientific research. Scientists will provide more data or causal explanations for the role of epigenetics in the fate and evolution process of cells. Classic genetic and evolutionary theories may be supplemented, expanded, or subverted, which will inevitably update people's understanding of life phenomena and even the world.

The debate between reductionism and holism is long-lasting, and the research results of epigenetics will provide a new perspective for reductionism or holism. At present, it is important to clarify the relationship between reductionism and holism in terms of methodology and epistemology, while fully considering the complex manifestation and significance of causal relationships. Methodology and reductionism hold that the most effective investigation strategy is to break down the system into its constituent parts. If people want to truly understand how these systems work, they need a comprehensive approach. They need to accept the important analytical value of methodological reductionism and reject it in epistemology. For example, the core viewpoint of modern comprehensive theory of evolution is the theory of gene centrality, which has led to the theories of gene determinism, genetic essentialism, and genetic reductionism. Based on epigenetic mechanisms, these issues can be reasonably addressed.

The development of epigenetic science and philosophy can better respond to the question of whether the "Darwinian evolutionary paradigm" is facing challenges. There are three schools of views on whether the "Darwinian evolutionary paradigm" is facing changes: Most scholars believe that the existing evolutionary paradigm needs to be supplemented and expanded by incorporating important theories of epigenetics in biological phenotype, genetics, and evolution, forming an extensional extended evolutionary synthesis (EES); Conservative scholars believe that existing evolutionary paradigms do not face challenges, and that existing theories can also explain new epigenetic phenomena; Radical scholars believe that the "Darwinian evolutionary paradigm" will be replaced to form a more unified theory of evolution. The importance of theory of evolution is beyond doubt. It is not only a scientific or philosophical issue, but also related to people's understanding of life phenomena

and the world. Therefore, research in this area will inevitably be an important research topic in the field of scientific philosophy for a long time to come.

The theory of evolution has made significant progress in the past century, and modern synthetic evolution theory (Neo-Darwinism) is the current paradigm [Jablonka, 2017; Laland, 2014; Olson-Manning, 2012]. However, modern synthesis is insufficient to explain the complexity of molecular genetics, whole genome DNA sequence mutation analysis, and the phenotypic and rapid evolution observed in genetic variation. For example, phenotypic plasticity is a good example of physiological changes promoting adaptation, but most phenotypic plasticity is not related to genetic DNA sequence changes. Modern synthetic evolution theory centered around gene centrality cannot explain these phenomena well, which has sparked a debate on whether the current evolutionary paradigm needs to be re-evaluated.

Modern synthetic evolution theory holds that genetic variation centered around genes is the driving factor for phenotypic variation, and genetic variation is crucial for evolution, driving biological phenotypic variation and adaptation to the environment. However, genetic mutations typically require an epigenetic regulatory precursor, including DNA methylation or histone modifications. In recent years, the proposal of extended evolutionary synthesis (EES) has supplemented the concept of modern synthesis. EES regards epigenetic processes as an important role and extends the concept of classical genetics. EES accepts the view that epigenetics can also promote phenotypic variation, but lacks details on how the environment directly affects development and biological processes independent of classical genetics.

Environmental stress leads to the selection of new phenotypic traits, resulting in genetic changes, and environmental epigenetics provides relevant molecular mechanisms for this phenomenon. An increasing number of studies on mammalian species also support the role of environmental induced epigenetic transgenerational inheritance in adaptation and evolution. In recent decades, research on epigenetics has shown that the environment can promote epigenetic variation, thereby promoting natural selection and evolutionary processes. Epigenetics is stable and can independently influence evolution together with genetics. Therefore, like genetic changes, epigenetics can play an important role in short-term microevolution and contribute to the macroscopic evolutionary process of species formation and improved adaptability. Epigenetics is a very young discipline that requires further exploration. However, in any case, an increasing number of studies are indicating that environmental induced epigenetics can be inherited across generations, and epigenetics is an equally important molecular mechanism as genetics, which needs to be incorporated into a more unified evolutionary theory.

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Плюралистическое эпистемологическое исследование в области эпигенетики

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Аннотация

Эпигенетика – это механизм, с помощью которого биологические фенотипы сохраняются и передаются потомству посредством таких путей, как метилирование ДНК и конформационные изменения хроматина, в то время как последовательности ДНК остаются неизменными. За последние два десятилетия возникла эпигенетика, опрокинувшая традиционные генетические теории и вызвавшая широкую дискуссию в научных и философских сообществах. В этой статье будет рассмотрено понимание эпигенетики в онтологии, споры между дарвиновской и ламаркистской парадигмами, вызванные эпигенетикой, генетическим детерминизмом и редукционизмом в биологии, а также

необходимость дополнения или пересмотра парадигм теории эволюции, а также ответы на эти вопросы с точки зрения множественные перспективы. Исследования последних десятилетий в области эпигенетики показали, что окружающая среда может способствовать эпигенетической изменчивости, тем самым способствуя естественному отбору и эволюционным процессам. Эпигенетика стабильна и может независимо влиять на эволюцию вместе с генетикой. Следовательно, как и генетические изменения, эпигенетика может играть важную роль в краткосрочной микроэволюции и способствовать макроскопическому эволюционному процессу формирования видов и улучшению адаптивности. Эпигенетика – очень молодая дисциплина, требующая дальнейшего изучения. Однако в любом случае все большее число исследований указывает на то, что эпигенетика, вызванная окружающей средой, может передаваться по наследству из поколения в поколение, а эпигенетика является столь же важным молекулярным механизмом, как и генетика, который необходимо включить в более единую эволюционную теорию.

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Ключевые слова

Эпигенетика, онтология, дарвинистская парадигма, ламаркистская парадигма, генетический детерминизм, теория эволюции.

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