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# Research on Characteristics, Development Trend and Funding Countermeasures of Biology

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## Abstract

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## Keywords

biology; life science; characteristic; funding



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# Research on Characteristics, Development Trend and Funding Countermeasures of Biology

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Biology has been booming since the second half of the 20th century, when it is closely associated with human health and social and economic development and demonstrates increasing importance. On the 125th anniversary of *Science*, 125 important basic issues challenging the global scientific community were published, of which 54% (68) involved life science. Seventeen of the "Ten Major Breakthroughs in Science" in 2019–2021 selected by *Science* are associated with biology. Biological research has become a core and hot field of competition in global scientific and technological innovation. Developed countries have taken biological research as a strategic measure to improve their core competitiveness and safeguard national security. For example, the United States released in 2012, *National Bioeconomy Blueprint*, a programmatic document providing a forward-looking layout, and accelerated investment in biology to cope with major challenges in healthcare, manufacturing, energy, agriculture, environment and other aspects. In 2020–2021, it promulgated other documents such as *Endless Frontier Act*, *Securing American Leadership in Science and Technology Act*, and *NSF for the Future Act*, further proposing to increase investment in basic research in biological science and other fields. Other countries, such as the UK, France, and Japan, also issued strategic plans to promote the development of life science, biotechnology, industrial economy, and biosecurity.

China has recognized the strategic significance of basic research in biology. In 2018, *Several Opinions of the State Council on Comprehensively Strengthening Basic Research* required to improve the systematic layout of basic research by strengthening basic research on frontiers and forward-looking deployment of major scientific issues in quantum science, brain science, synthetic biology, space science, deep sea science and other fields. However, problems such as lack of sustainable and stable support, insufficient funding for top talents and teams, and lack of major original achievements still exist in biological research in China. Therefore, we need to analyze and solve the existing problems and improve relevant mechanisms, so as to give better play to the role of biological research in supporting national strategic needs and economic and social development.

## 1 Characteristics of biology

Biology is a science studying the structure, function, behavior, development, origin, and evolution of living systems at all levels, as well as the relationship between living things and their surroundings. Integrated with the achievements in other disciplines such as mathematics, physics, chemistry, informatics and materialogy, biology has gradually developed into an accurate and quantitative basic science that goes deeper from individual, group to molecular levels and becomes one of the main means for human beings to explore

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natural laws and life phenomena. By studying life phenomena and laws of life activities, biological research directly promotes the progress of agriculture, medicine, environment, and other aspects associated with human health, living conditions, and environmental quality, playing an essential role in supporting social and economic development and safeguarding national security.

(1) The development of biology reflects the common driving effect of demand and free exploration. Progress in biology is driven by not only the curiosity of scientists and engineers but also the national and social demands. Since World War II, biology has developed rapidly under the impetus of major demand and free exploration, driven by national security, food security, and biosecurity. The achievements of basic biological research have been quickly applied to biological and technical industries such as drug development, animal and plant breeding, and environmental protection. Studies on AIDS, cancers, and vaccines, discovery of artemisinin, and breeding of hybrid rice reflect the national and social needs for life health, food and so on. Scientists, for example, driven by the need to fight against and prevent AIDS and their strong thirst for knowledge, began to study the genetic structure and function of human immunodeficiency virus (HIV), mechanism of interaction with host, and related drugs and vaccines, thus promoting the development and innovation of basic scientific issues and key technologies in a targeted way [1]. Moreover, the research achievements directly benefit human beings.

(2) The theoretical system and technical structure of biology are being perfected. Life science, different from basic sciences such as mathematics, physics and chemistry, is in an era of rapid development when all schools of thoughts contend, and no widely accepted theoretical system has been formed. On the one hand, the depth and breadth of biological research are expanding and the frontiers are changing. For example, the target and mechanism of metformin have been intensively studied in more than 60 years. On the other hand, the fusion of biology with other disciplines and the application of new tools and technologies have given birth to a number of new branches of disciplines, such as bioinformatics and synthetic biology. Theoretical systems and technical structures of these new branches are still under development and need to be promoted by teams with strong research capacity and scientific background.

(3) The research of life science (especially medicine), compared with general research of science and engineering, has a long cycle. Life science and medicine are experimental disciplines. Influenced by objective factors such as the growth cycle of experimental materials and characteristics of organisms, both disciplines have a long research cycle, which is an objective fact that does not depend on human will. For instance, Mendel, in his eight years of pea crossing experiment, tested more than 20 000 pea plants before bringing forward the law of gene segregation and the law of independent assortment. The research and development of new drugs usually take 15–20 years, during the early stage of which drug discovery must be supported by significant results of basic research. Selection and identification of drug targets, for example, is a process of trial-and-error, and only sustainable and stable support can ensure the smooth progress of research work.

(4) The development of biology is inseparable from the fusion with multidisciplinary knowledge. Physics, chemistry, mathematics, engineering, and informatics provide new theoretical bases, research tools, and technical methods for biological research, thereby promoting the transformation of biological research paradigms. For example, Rudolf Clausius put forward the concept of entropy in thermodynamics, providing a new theoretical perspective for the study of energy flow and stability of living systems. In 1951, Linus Pauling, the founder of quantum chemistry, proposed the theory that α-helix and β-sheet are the basic elements of protein secondary structure, laying a theoretical foundation for the establishment of biochemistry. The invention of advanced instruments such as cryo-electron microscope and atomic force microscope has allowed human beings to observe the conformational changes of proteins and manipulate atoms, and the X-ray diffraction method has helped scientists to unveil the double helix structure of DNA. On the basis of chain termination method, scientists have employed miniaturized technologies such as radioactive labelling, fluorescence labelling, automation and nanotechnology, and microfluids to achieve rapid, automated and personalized DNA sequencing. The development of computer technology and network technology has made it feasible to store and process massive genetic data.

(5) The life ethical issue is present throughout the development of biology. Life ethics is an issue that cannot be neglected in biological development, involving not only the moral behavior and values of an individual but also the moral orientation and value standards of the society. The flourishing of life science and biotechnology revolution has brought great impact on science and technology and the society, and people's roles as a subject (studying) and an object (being studied) have been strengthened synchronously. Advances in genomics, gene editing, assisted reproduction, brain science, and artificial intelligence have, on the one hand, enhanced human's ability to understand and transform nature, and, on the other hand, deeply touched ethics, laws and beliefs, as well as the basic structure and expectation of the relationship between man and man, man and nature, and man and society, thus profoundly affecting the social order.

## 2 Development history and trend of biology

The development of modern biology presents a trend of being both highly differentiated and systematically integrated, being oriented towards both micro cognition and macro exploration, covering both frontier sciences and interdisciplinary sciences, focusing on both disease treatment and health ethics, and emphasizing both the exploitation and the protection and sustainable utilization of biological resources. With the deepening of biological research and the improvement of research ability, the development of biology gradually allows people from understanding life to transforming life, synthesizing life, and even designing life.

Early humans began to understand life in practice by observing, describing and experimenting with themselves and animals and plants around them based on survival needs and religious activities. Before the 18th century, biology in general was in the stage of natural history, when scientists established the biological taxonomy by field collection and specimen collation. Laboring people of ancient China knew plants by tasting, and those of ancient Greece studied the life phenomena. Aristotle, the first man to classify species, classified more than 500 species of animals and plants [2]. *ImportantArts for the People's Walfare* (*Qi Min Yao Shu*) and *Compendium of Materia Medica* (*Ben Cao Gang Mu*) record a large number of animal and plant species. Andreas Vesalius and William Harvey studied human body structure and blood circulation, laying a foundation for learning human body from the anatomical and physiological perspective. In the 18th century, Linnaeus Linnaeus, a Swedish botanist, creatively came up with the binominal nomenclature and established an animal and plant taxonomy system based on natural classification, laying a foundation for systematically understanding life. In the 19th century, cell theory and evolution theory elevated human's understanding of life to the theoretical level and promoted the rapid development of subdisciplines such as genetics, ecology, and biology. Since the 20th century, discovery of DNA double helix structure, creation of genetic engineering and molecular biology, implementation of Human Genome Project (HGP), and emergence of omics have opened the door to life information, marking the beginning of human's understanding of life to the micro scale, quantitative level, and dynamic regulation.

As the understanding of life deepens, human beings began to modify life. Ancestors modify animal and plant traits by domestication, which, in essence, are genetic changes in species. From early unconscious and conscious breeding and hybridization to precise modification by genetic engineering, the application of transgenic technology, molecular markers, molecular designing, and gene editing has enriched the ways and improved the efficiency of animal and plant transformation. This directly enriches the varieties of food, produces a series of excellent traits such as disease resistance and high yield, and changes the relationship between man and nature. Moreover, domesticated species have, to some extent, also domesticated humans, that is, the transformation of life has deeply affected the development of human history and civilization [3]. In the late 1970s, the revealing of the mechanism of major diseases, as well as the emergence of cell engineering and gene engineering technologies, sped up the process of life transformation, and recombinant DNA technology realized human's dream of editing genes [4]. In 1991, the United States succeeded in introducing the recombinant adenosine deaminase gene (*ADA*) into a patient with congenital immunodeficiency, conducted gene editing and directed modification for heterogeneous creatures, and provided transplants for human ①, which marked the possibility of life (gene) transformation to cure refractory diseases.

The proposal of central dogma, deciphering of genetic codes, and progress in protein structure analysis methods have made it possible to synthesize life components and life. Since the 1960s, scientists have tried the synthesis of biomacromolecules such as nucleic acids and proteins and have gained a series of achievements. In 1965, Chinese scientists took the lead in synthesizing crystallized bovine insulin. In 1977, Sakakura et al. pioneered the synthesis of the gene for the growth hormone release inhibitory factor (GRIF). Thereafter, the genes of insulin, interferon and other proteins were successfully synthesized and expressed. In 2010, scientists synthesized a mycoplasma genome composed of about one million base pairs and transplanted it into another type of mycoplasma cells to obtain JCVI-syn1.0, a synthetic cell with normal growth and division functions [5]. Great progress has been achieved in the research on reproduction of stem cells and organs and embryonic development. Israeli scientists, for the first time, cultured a normally developing mouse embryo by establishing an artificial machine uterus in 2021 [6]. Meanwhile, such achievements have aroused the public concern and discussion on whether humans with the ability to synthesize life begin to play the role as "creator".

With the advances in synthetic biology, artificial intelligence, computational biology, bioinformatics, and bioengineering, scientists begin trying to design life to break the boundary between natural and non-natural worlds and push humans into the era of digital life [7]. By designing and writing DNA sequences in a computer, humans can design biological elements and systems nonexistent in the nature, redesign the existing natural biosystems, and simulate complex biosystems. In 2016, scientists redesigned the bases and synthesized JCVI-syn3.0, a mycoplasma cell with 531 000 base pairs, which is capable of replicating DNA and producing protein and membrane [8]. Afterwards, scientists successively synthesized non-natural nucleotides and amino acids [9] and created the first man-made single-chromosome eukaryote [10]. We can say that the design and synthesis of life

① University of Maryland School of Medicine Faculty Scientists and Clinicians perform historic first successful transplant of porcine heart into adult human with end-stage heart disease. (2022-01-10)[2022-01-31]. https://www.medschool.umaryland.edu/news/2022/University-ofMaryland-School-of-Medicine-Faculty-Scientists-and-Clinicians-Perform-Historic-First-Successful-Transplant-of-Porcine-Heart-into-AdultHuman-with-End-Stage-Heart-Disease.html.

 

is predicated on the understanding of life and is a deeper exploration for the origin of life.

Biological research now mainly focuses on the understanding and transformation of life and has attained fruitful results in the understanding of the life process and the transformation of life components, as manifested by revealing of the transfer of genetic information, the conversion of solar energy to bioenergy, the coexistence of biodiversity and unity, and the mysteries of biological consciousness and neurocognition. With theoretical breakthroughs and technology integration, biology will enter the stage of life synthesis and design, and the application of new achievements such as artificial simulation of biomacromolecules and plant production of vaccines will be conducive to improving the health, environment, and energy. Therefore, life can be designed and synthesized by re-understanding and transforming of life. Biology connects human beings with the nature, society, and scientific research, eventually enhancing human ability.

## 3 International practice and experience in funding for biological research

Biotechnology has become a focus of international competition and increased emphasis has been placed on the funding for biological research. Specifically, the funding has the three following characteristics.

### 3.1 Specialized biological research institutions have been established to provide targeted strong support

After World War II, western countries began to put emphasis on the improvement of people's health, and fighting diseases and prolonging the life became the priority of developed countries such as the United States, for which they started to increase support for biological and medical research. In addition to stable support for basic biological research in universities, specialized biological research institutions were also established and provided with sustainable and stable funding support.

The National Institutes of Health (NIH), the largest and most influential biomedical research institution in the world, has 27 institutes/centers dedicated to the research on human physiological activities and diseases such as cancers, diabetes, arthritis, and rare diseases, and 24 of them are directly funded by the United States Congress. Each year, the investment of the United States Congress to the NIH accounts for about 60% of total research investment of the United States government. Such investment makes the NIH, as the largest biomedical funding agency in the world, fund research projects in universities and research institutions in the United States, including the research work of its subordinate institutes/centers and overseas research projects. For example, the National Cancer Institute (NCI) of the NIH has received stable funding from the federal government since 1960 for cancer research. Meanwhile, it has established public projects to fund cancer research in universities and other organizations, so as to promote the implementation of the national cancer research program of the United States. For half a century, the federal government of the United States has provided sustainable funding for the NCI, and organized researchers from the NCI, worldwide research-oriented universities, research institutions and hospitals to participate in cancer research. The cancer research network built by the NCI not only strengthens the basic cancer research but also promotes the rapid application of basic research results into clinical practice. A series of major achievements have also been attained in the basic research, prevention, diagnosis, and treatment of cancer thanks to the sustainable and stable funding, the most prominent of which is that the morbidity and mortality of cancer have been declined continuously since the 1990s (at an average annual reduction rate of 0.7 percent point).

Through the World Premier International Research Center Initiative (WPI), the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has established WPI centers to provide stable support for high-level teams in the selected universities and national research institutions for a decade. Eight of the 13 WPI centers are related to biology and dedicated to the research of integrated cell-material sciences, immunology frontiers, sleep medicine, origins of Earth and life, transformative biomolecules, human biology frontiers, neurointelligence, and nano life science [①]. They have achieved a number of findingss in the microcosmic cognition of life, macroecology, and frontier technologies.

### 3.2 Institutions such as enterprises, non-profit organizations and charitable foundations have actively participated in the funding for basic biological research

Governments of American and European countries have funded biological research by major scientific and technological projects oriented toward national or global cooperation and formed a diversified investment mechanism. In recent years, the federal government of the United States has launched large-scale national science programs, such as BRAIN Initiative, Precision Medicine Initiative, and Cancer Moonshot, for the treatment of critical diseases. The European Commission, aiming at health, food security, and other key issues, has funded for the research on cancer, agriculture, biological frontier technology and other aspects in the

①World Premier International Research Center Initiative. [2022-02-02]. https://www.jsps.go.jp/english/ e-toplevel/data/19_pamphlet/wpi_v17_forWEB.pdf.

Horizon Europe program. In addition to federal agencies, enterprises, non-profit organizations, and charitable foundations have also actively participated in the funding for large biological science programs. For example, enterprises represented by Google and GSK, as well as the Allen Institute for Brain Science, Kavli Foundation, Simons Foundation and other institutions, in addition to federal governments and institutions such as the NIH, Defense Advanced Research Projects Agency (DARPA), Food and Drug Administration (FDA), and National Science Foundation (NSF), have also invested the BRAIN Initiative. Among them, Google has worked with Allen Institute for Brain Science to develop related data sharing and storage platforms; Kavli Foundation has co-built a neuroscience institute with several universities and funded the neurodata without borders pilot programs ①.

Adhering to the concept that basic research is the source of technology and industrial competitiveness, enterprises and non-profit organizations in developed countries attach importance to the investment in basic research. The proportion of the investment from enterprises in the United States in basic research remains about 20%, and the enterprises in South Korea invest even more than the government, at about 55%. In general, enterprises are mainly involved in the basic research investment of the Pasteur's Quadrant, which, on the one hand, makes up for the deficiencies of government guidance, and, on the other hand, promotes the transformation of pure research to industrial application. For example, Merck & Co., Inc. established the first research laboratory in 1933. The researchers in this laboratory won five Nobel Prizes in 1940–1950. The laboratory began drug research and development at the molecular level by centering on the discovery of drug targets and the dissection of pathological mechanisms of diseases in 1975, ever since, the drug discovery has been sped up, which is of great significance for the treatment of critical diseases. Google has focused on the investment in the interdisciplinary research of computer science, artificial intelligence, bioinformatics, and other disciplines and developed AlphaFold which can accurately predict the three-dimensional (3D) structure of proteins at the atomic level based on amino acid sequences [11]. This not only solves the protein folding problem afflicting scientists for 50 years but also provides a new way for the 3D structure analysis of proteins. *Nature* praised this result as "It will change everything".

### 3.3 Importance has been attached to the layout and funding of biosecurity research

The international biosecurity is in an important transitional period full of turbulence and transformation. Emerging infectious diseases, public health security, biological resource security, alien species invasion, attack of biological weapons, misuse of biotechnology, biological monitoring and early warning, and life ethics have received wide concern.

Developed countries such as the UK, the United States, France, Germany, and Russia have formulated biosecurity strategies and deployed research projects in related fields to prevent major biological threats to national security. The United States, for instance, released such documents as *National Biodefense Strategy*, *National Strategy for Countering Biological Threats*, and *National Strategy for Biosurveillance* after the anthrax mail attack in 2001. Driven by these strategies, the United States launched the National Biomonitoring Program and Project BioShield in 2003 to promote the construction of biological laboratories and the research on infectious pathogens or toxins, serious infectious diseases, biotechnology misuse, and biological antiterrorism. Many departments and agencies in the United States, such as the Department of Defense (DOD), Department of Energy (DOE), Health and Human Services (HHS), the United States Department of Agriculture (USDA), NIH, and the United States Army, have provided support for biological monitoring, research on pathogens, microbiological safety, and new infectious diseases. For example, the NIH has funded the research on new vaccines in response to COVID-19. The United States Army Medical Research Institute of Infectious Diseases (USAMRIID) has provided sustainable funding for the research on bacteria, toxins, and biological weapons threatening the health of the army and the public. In 2021, the DARPA deployed such projects as physiological overmatch and unburdening the warfighters from chemical/biological defense, thereby funding for the treatment of war wound, protection of solders' life safety, and prevention and control of infectious diseases [12].

## 4 Present situation and problems of biological research funding in China

Since the 21st century, China has made great progress in the biological research, with enlarging talent teams as well as improved research level and international status. In 2017, China (59 066 papers) ranked second in biological SCI papers, second only to the United States (84 459 papers). A number of influential results have been achieved in life science, agriculture, medicine, and ecology. For example, Yuan Longping won the Wolf Prize in Agriculture and Tu Youyou won the Nobel Prize for Physiology or Medicine. Plenty of research achievements and scientists with international influence in biology have emerged in China. However, problems such as few original results, insufficient support for solving national major issues, incomplete layout, unbalanced development, and lack of top talents and teams still exist in biological research.

① BRAIN Initiative. Neurodata without borders pilot programs. (2013-04-25)[2022-02-10]. http://www.braininitiative.org/funding-opportunity/neurodata-without-borders-pilot-programs.

 

(1) Insufficient investment and unbalanced layout. In the early days of the People's Republic of China, the state mainly followed the example of the Soviet Union in establishing the industrialization system and higher education model. In the case of financial constraints, it mainly invested in fields related to national security (e.g., military and industry) and such disciplines as mathematics, physics and chemistry, and less in biology-related fields. This investment system has been adopted for a long time, due to which the proportion of biology, especially life medicine, in the scientific community, remains low, and no or less support is provided for some important fields in life science. For example, the funds for immunology, especially special and major projects, are low, and infrastructure in biology, such as underlying general technology, biological resource base, and medical database, is also underinvested. In contrast, developed countries put a high value on the research of life science. In the United States, there are more than half PhDs in life medicine every year, and the NIH has been established to lead the country's research and funding in life medicine.

(2) Lack of sustainable and stable funding support. Compared with developed countries, China lags behind in the support for basic research of life science and medicine, lacks the overall planning for the free exploration and strategic basic research under the guidance of major national demand, and does not form the sustainable and stable support pattern for biological research, especially life medicine. On the one hand, the biological research projects in China have short periods and are discontinuous, most of which are competitive funding projects, and some researchers tend to follow the project guidelines. On the other hand, the lack of stable and sustainable support for national strategic science and technology in biology is not conducive to the cultivation and stability of core talent teams. The financial funds are scattered, making it hard to form the agglomeration effect and to give full play to the role of national strategic science and technology.

(3) Insufficient funding for top talents and teams. Scientific research is the fruit of human intelligence, while the results cannot be obtained without the culture and support of talents. On the one hand, China's existing funding and evaluation mechanisms are not conductive to forming an academic atmosphere of research, since the dissertation and title-oriented research evaluation system generally makes researchers focus on the existing research hotspot instead of devoting themselves to the research of major scientific issues. On the other hand, the current talent programs impose many restrictions on the personnel system and funding ways, such as age limitations for young talents, the great disparity in fund support, evaluation of professional ranks and other aspects between local talents and returnees, and insufficient incentive for researchers who just start their career.

## 5 Policy suggestions

### 5.1 Optimizing the research funding system at the national level

From the national top-level design on the positioning of research institutions, the funding for research projects should be classified according to basic research, basic application research, and application development research. It is suggested that the state clearly position and divide the research work of the institutes directly under the Chinese Academy of Sciences and ministries and commissions, the research institutions of industry, and universities, so as to avoid repeated support and layout of limited scientific and technological resources and homogeneous competition. The state should set strict budget limits based on the types of research activities, such as the proportion of funds for basic research, basic application research, and technological research and development. Package- or pocket-type projects should be avoided, and the research projects can be classified into basic research, basic application research, and application development research. Targets can be accepted according to the types of projects.

### 5.2 Improving the funding system for biological research in China

The funding system for biological research in China can be improved according to the characteristics and development laws of biological research and the international funding experience.

(1) Improving the layout of biological research field and establishing a funding mechanism driven by demand and free exploration. In biology, new discoveries are constantly emerging, and the development frontiers are changing fast. The fusion of biology with other disciplines is frequent, which fully reflect the characteristic of "multi-point discovery and multi-point breakthrough" of biological research. Therefore, it is suggested that the state deploy key areas of biological research in an overall way rather than in a point-to-point way and include strategic biological scientist consultant teams. Considering the major strategic demand and urgent problems of social and economic development in China, as well as the development frontiers and key scientific issues in biology, the government can summarize research needs, determine priority fields to be supported, and establish a topic selection mechanism combining the "top-down" demand and "bottom-up" free exploration.

(2) Improving the funding layout in biology and increasing the investment in life medicine. Important directions to be funded, such as basic research that is not included in the key research and development program (such as immunity and health, artificial intelligence and biocomputing, generic underlying technology, and biodiversity), and basic research of Science and Technology Innovation 2030-Major Project, can

 

be supported as an independent direction of biological research. Important directions that have been supported with limited funds, such as microbial dark matter and nucleic acid biology, can be provided with more sustainable and stable support in the future. The funds for big biological data scientific research platforms and other infrastructure can be increased. Under the background of the Party Central Committee's new judgment and thinking of being oriented towards people's life health and after comparing with developed countries, it is suggested that China increases the proportion of the investment in life medicine.

(3) Establishing a meritocratic stable supporting system for high-level biological research teams. Biological research has a longer period than the research of other disciplines. For example, the research and development of new drugs generally takes 15–20 years, and thus a stable support mechanism is essential. As life science and medicine are currently in a stage of rapid development, they are highly dependent on high-level talent teams. Globally, excellent research teams and groups can usually make great breakthroughs in succession or in different crossing fields. Therefore, it is suggested that China give full play to the role of national strategic science and technology in biology, and select high-level biological research teams by directional competition and provide sustainable funding for them to engage in the research on strategic issues and key scientific problems related to the medium- and long-term development and form an internationally influential biological research highland. Meanwhile, social funds from enterprises and new research institutions can also be attracted to biological research.

## References


1 Chen Z. Trends in life sciences and strategies for life science development in the CAS. Bulletin of Chinese Academy of Sciences, 2003, 18 (3): 170–175 (in Chinese).

2 Sun X F, Lian Y S. Discuss on three phases of life science development history. Journal of Dialectics of Nature, 2010, 32 (3): 41–44 (in Chinese).

3 Roberts A. Tamed: Ten Species that Changed Our World. Translated by Li W T. Lanzhou: Duzhe Publishing House, 2019: 5–13 (in Chinese).

4 Zhao G P. Synthetic biology: Unsealing the convergence era of life science research. Bulletin of Chinese Academy of Sciences, 2018, 33 (11): 1135–1149 (in Chinese).

5 Gibson D G, Glass J I, Lartigue C, et al. Creation of a bacterial cell controlled by a chemically synthesized genome. Science, 2010, 329: 52–56.

6 Aguilera-Castrejon A, Oldak B, Shani T, et al. Ex utero mouse embryogenesis from pre gastrulation to late organogenesis. Nature, 2021. 593: 119–124.

7 Venter J C. Life at the Speed of Light. Translated by Jia Y M. Hangzhou: Zhejiang People's Publishing House, 2016: 213–220 (in Chinese).

8 Hutchison C A 3rd, Chuang R Y, Noskov V N, et al, Design and synthesis of a minimal bacterial genome. Science, 2016, 351: aad6253.

9 Zhang Y, Ptacin J L, Fischer E C, et al. A semi-synthetic organism that stores and retrieves increased genetic information. Nature, 2017, 551: 644–647.

10 Xie Z X, Li B Z, Mitchell L A, et al. "Perfect" designer chromosome V and behavior of a ring derivative. Science, 2017, 355: eaaf4704.

11 Jumper J, Evans R, Pritzel A, et al. Highly accurate protein structure prediction with AlphaFold. Nature, 2021, 596: 583–589.

12 Zhang Y, Lou T Z, Wang L. Analysis of DARPA biological projects for 2021 fiscal year. Military Medical Sciences, 2020, 44 (9): 641–645 (in Chinese).



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