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# *Research on the Status Quo and Technology Evaluation of Innovation and Development of Chinese Biotechnology Companies*

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***Abstract:*** The biotechnology industry is currently a sunrise industry closely related to human health and life safety. Through the relevant analysis of Chinese biotechnology enterprise innovation, it is found that, for enterprise innovation, there is still little research on technology selection and evaluation. Technological innovation is the most critical and the main driving force for the development of biotechnology enterprises, and the level of technological innovation determines the development level and potential of enterprises. Based on the relevant characteristics of biotechnology, this paper studies issues such as technology evaluation, technology selection, and enterprise innovation in biotechnology. As a result, the relevant characteristics of modern biotechnology are systematically researched and summarized in this paper, laying a foundation for further in-depth research on modern biotechnology management. At the same time, the evaluation and selection model of relevant modern biotechnology is also established, which has strong guiding significance for coping with the high uncertainty of modern biotechnology.

***Keywords:*** biotechnology, biotechnology evaluation, biotechnology options, technology innovation

## 1. Introduction

Biotechnology enterprises refer to enterprises that mainly use biotechnology for product development and production, and key products include biological drugs, vaccines, and diagnostic reagents. Biotechnology companies are closely related to human health and life safety, and the biotechnology industry is known as an eternal sunrise industry. In recent years, with the rapid development of biological sciences, especially high-tech technologies such as gene sequencing, the product line and service area of the biotechnology industry have continued to expand, and biological products and services for healthy people have emerged, such as paternity testing, disease prediction, and personality testing. Sequencing services such as intelligence prediction are benefiting from the progress of bioscience and technology. The biotechnology industry has a high degree of innovation. At present, the literature on the innovation of biotechnology enterprises in China is insufficient and mainly focuses on innovation strategy, innovation alliance, and training of innovative talents. This paper studies the relevant characteristics of biotechnology and establishes the evaluation and selection

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model of relevant modern biotechnology, thus guiding biotech companies to deal with the high uncertainty of modern biotechnology and helping them make good development strategies.

## 2. Literature Review

Based on the status quo of technological innovation in China's pharmaceutical enterprises, Wu Xiaobo et al. analyzed the strategic network of enterprise technological innovation and proposed that pharmaceutical enterprises should establish their own strategic network, use an appropriate form to strengthen the close cooperation with all members of the network according to their own conditions, and make full use of network resources for technological innovation, so as to promote the improvement of enterprise technological innovation capabilities [1]. Luo Yafei and Jiao Yucan used the C2R model in the DEA method to conduct a longitudinal analysis of the technological innovation efficiency of China's pharmaceutical industry. The research results show that low resource utilization, insufficient patent output, and small enterprise scale are the main reasons for the ineffectiveness of DEA in China's pharmaceutical industry [2]. Li Tianzhu et al. revealed the characteristics of "relay innovation" of biopharmaceutical innovation from the industrial level by summarizing a large number of real cases. He summarized the connotation and characteristics of expert companies and core companies, studied the functional division of these two types of companies in biopharmaceuticals, analyzed the way and timing of the relay cooperation between the two types of companies, and, finally, concluded the sustainable innovation mechanism of the biopharmaceutical industry [3]. Li Hua et al. proposed that there is a need to cultivate compound talents who understand not only pharmaceutical preparations, production technology, and quality control knowledge, but also pharmaceutical engineering technology [4]. Liu Fengchao and Ma Rongkang used Gould and Fernandez's middleman classification method to analyze the role of the middleman and its influencing factors in the organizational innovation network in China's pharmaceutical technology field based on patent cooperation data, and they discussed the transition path of the middleman's role and the evolution of the organizational innovation network model. The results show that the middlemen in the organizational innovation network are mainly coordinators, gatekeepers, and agents, and there are fewer consultants and liaisons; there are great differences in the role of middlemen in organizations of different natures and different regions [5]. In general, the reports on biotechnology enterprise innovation research are mainly positioned in the aspects of enterprise strategy, inter-enterprise cooperation and learning (innovation diffusion), innovation alliance, innovative talents, etc. The research methods are mainly based on theoretical analysis and case studies.

## 3. The Way of Innovation for the Development of Chinese Biotechnology Companies

For enterprise innovation, there is little research on technology selection and evaluation. Technological innovation is the most critical and the main driving force for the development of biotechnology enterprises, and the level of technological innovation determines the development level and potential of enterprises. The author believes that, based on the relevant characteristics of biotechnology, research on issues such as technology evaluation and technology selection and enterprise innovation in enterprise biotechnology has urgent practical significance for enterprise development, which is specifically reflected in the following aspects:

### 3.1. Effectively Reducing the Uncertainty of Biotechnology Itself

Biotechnology is a typical emerging technology. Therefore, from the perspective of the technology itself, biotechnology has the feature of high uncertainty which is obviously higher than that of general high-tech. This is mainly because biotechnology is a complex technology group, which covers medicine, agriculture, industry, materials, environment, energy, and other fields, intersecting with

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many disciplines. Some small advances in these fields of science and technology may lead to huge changes in biotechnology. For example, the prediction and assessment of the future development track of biotechnology, the degree of satisfaction of the existing market demand, and the discovery and prediction of the potential demand will all directly affect the choice of biotechnology research and development (R&D). Meanwhile, whether a type of biotechnology can be successfully developed during the R&D process and the length of the R&D cycle will greatly affect the development of the technology itself and its later industrialization process. Therefore, in order to develop biotechnology well, it is necessary to effectively evaluate and select its technology and reduce the huge uncertainty of the technology itself.

### 3.2. Significantly Improving the Success Rate of Biotechnology Companies

Attracted by the huge development potential of the biotechnology industry, a large number of biotechnology companies have sprung up all over the world. The total number of biotechnology companies in the United States has reached thousands. In China, hundreds of specialized biotechnology companies have emerged in recent years, and many traditional large enterprises and other high-tech enterprises are competing to transform into biotechnological enterprises. Some biotechnology companies have created amazing business miracles, for example, Genentech started with an initial investment of US$126,000 in 1976 and was finally acquired by Roche in 2008. Its value has exceeded 120 billion U.S. dollars; since its establishment in 1981, Amgen has dominated the global biotechnology pharmaceutical list, and has the ability to compete with traditional large pharmaceutical companies. However, the high uncertainty of biotechnology itself determines that biotechnology companies face huge risks. If they are not properly managed, the development of the company will fail and cause huge losses to investors. In-depth research on the development rules of biotechnology companies and evaluation and selection of their technologies will undoubtedly improve the success rate of companies significantly and help companies win in the fierce competition.

## 4. Influencing Factors of Corporate Biotechnology Selection and Evaluation

The selection and evaluation of corporate biotechnology need to focus on factors such as the technology development track, related technologies and key technologies, progress in basic research, and macro-environment such as society and regulations.

### 4.1. Technology Development Track

Dosi believes that if there is a major breakthrough or progress in a certain technical field, the corresponding technical system will form a technological paradigm. If the technological paradigm dominates the mainstream and direction of innovation in this field for a long time, this paradigm will form a technological track, on which innovation clusters will be generated [6]. Since biotechnology has not yet formed a clear technological development track, when companies make technology choices, they must closely follow the basic domestic and foreign life-science research and technological development trends, gain insight into market development trends, foresee the development direction of industry technology tracks, and combine other environments and conditions of the enterprise (the external environment, strategy, internal resources and capabilities of the enterprise, etc.), thus selecting technologies that may occupy the mainstream in the technology track in the future. By using the initial stage of the technology track, companies can occupy a favorable position and take the lead in future competition.

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### 4.2. Related Technologies and Key Technologies

In terms of the choice of biotechnology, enterprises not only need to consider alternative technologies but also the related upstream and downstream technical support required for the development of alternative technologies, as well as carefully evaluating the development and availability of related technologies. In the initial stage of the enterprise development, there is a need to focus on the development of key technologies with strong versatility, so that it is easy to build a technology development platform, open up a broader development space for the enterprise, and bring flexibility in enterprise R&D and strategic design; if an enterprise cannot develop this kind of technology by itself, it must consider how to obtain the technology, because the development of biotechnology cannot be separated from the support of such key technologies.

### 4.3. Progress in Basic Research

The development of biotechnology shows a remarkable trend of synchronizing theory and application. Today's research results may be tomorrow's new technology. For technology selection, this can be a threat and an opportunity. The threat is that the newer technology may soon replace the technology just selected, which will cause huge losses to the company. For example, before 2001, therapeutic antibodies were mainly produced by mouse antibodies and human-mouse chimeric antibodies. But by 2004, human antibodies have become the mainstream antibody during production. Consequently, basic research results may promote the development of the selected technology and the lack of the related upstream and downstream technologies of the selected technology may be brewing in the laboratory at present, which will provide support for the development of the selected technology. Therefore, enterprises should pay close attention to the progress of relevant basic research when choosing biotechnology.

### 4.4. Macro-environmental Factors

Unlike other high-tech technologies such as IT, biotechnology is deeply influenced by macro-environmental factors such as public opinion, cultural customs, religious beliefs, and laws and regulations. If enterprises cannot take the above factors into consideration when choosing technologies, they will be greatly affected in the future technological development process. It is possible to be constrained by such factors, and sometimes these factors can even become insurmountable obstacles. For example, technologies based on human embryonic stem cells are strictly prohibited in the United States and other countries, while transgenic technology is strongly resisted by the public in the two major markets of the European Union and Japan. At the same time, due to the extremely long development cycle of biotechnology, the above-mentioned macro-environmental factors may change during the process of technological development. Therefore, when making a technology selection, it is necessary to take into account some important factors that may change. It is important to apply appropriate future environmental analysis methods (such as scenario planning) and dynamic and gradual technology selection ideas to deal with possible changes in these factors.

## 5. Principles of Corporate Biotechnology Selection and Evaluation

Enterprise technology selection generally follows the principles of systematicness, dynamics, consideration of economic, social, and ecological benefits, and the combination of advancement and applicability [7]. According to the characteristics of biotechnology, enterprises must also focus on the forward-looking principle and the option principle.

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### 5.1. The Forward-looking Principle

This principle includes two meanings: one is that biotechnology is in the early stages of development, and there is still a broader space for its development in the future. Enterprises must be forward-looking when choosing technologies. They must not only consider the current situation, but also focus on the future. Technology selection falls into a blind situation dominated by short-term profits, which is reflected in the literature [8], "people often make choices based on short-term interests rather than long-term interests" in order to prevent the development of technological capabilities and technological development of enterprises from being locked on the low-level track, so technology foresight at the enterprise level and the industry level is particularly important in the choice of enterprise biotechnology; second, the purpose of technology selection is for the future, and biotechnology has the characteristic of a long development cycle. The evaluation and decision-making of alternative technologies should be based on the development of technologies over a long period of time in the future, which is another manifestation of the forward-looking principle. But at the same time, biotechnology is a discontinuous innovation of technology and market, and its uncertainty is much higher than other technologies. It is difficult to accurately predict the development of technology for a long period of time in the future. Therefore, the application of future environmental analysis tools and strategic planning tools, such as scenario planning and technology roadmap, needs special attention.

### 5.2. The Option Principle

Due to the long development cycle and high uncertainty of biotechnology, decision-making methods such as DCF have actually lost their application space in the selection of biotechnology. When evaluating and making decisions on alternative technologies, the most suitable method is the method of real options. In addition, from a strategic point of view, the development of biotechnology should and must be regarded as the creation of real options which can be used to open up a broader development space for enterprises. For example, as early as 1998, many biotechnology industry giants, such as Amgen, Merck, Eli Lilly, and Monsanto, invested in the Human Genome Project one after another. Although this investment has no short-term benefits, what they are looking at is human genome technology. The huge potential for future development is the actual embodiment of option thinking in the choice of corporate biotechnology.

## 6. A Dynamic Model of Corporate Biotechnology Selection and Evaluation

Based on the aforementioned research, the author proposes a dynamic process model of corporate biotechnology selection as shown in Figure 1, including four interrelated links.

### 6.1. Defining the Scope

Firstly, technology foresight is carried out for the development of biotechnology, the track of technology development is predicted, and the company's current technical capabilities and available resources are evaluated. Combined with the company's strategic goals and development direction, a number of alternative technology fields are delineated.

### 6.2. Researching Alternative Technologies

It is needed to investigate and discover new technologies in the field of alternative technologies. The sources of new technologies generally include internal companies, universities, research institutes, governments, technology transfer agencies, and other technology issuers, as well as technical and trade literature. Next, it is supposed to research and analyze the performance and future development

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potential of the new technology itself, and companies must consider the progress of basic research in related fields and the availability of related upstream and downstream technologies, as well as evaluate and predict the market potential of the new technology, which will eliminate a batch of technologies that obviously have no future, leaving alternative technologies.

### 6.3. Evaluating the Selection

Through the evaluation and selection of alternative technologies, which technologies should be selected for development are determined. The first step is to analyze the future development status of each candidate technology; the second step is to evaluate and select the candidate technology. Real options and the "new performance filter line" proposed in [8] are suitable quantitative methods and selection criteria for evaluating the potential of biotechnological development. Additionally, there is also a need to combine other factors such as the company's strategic goals to conduct a comparative analysis on alternative technologies that meet the selection criteria, thus determining final selection results; the third step is to design and formulate future development strategy for selected technologies.

### 6.4. Putting into Practice

The above three links and the steps within each link are all in a closed-loop relationship, reflecting the dynamic and progressive nature of the corporate biotechnology selection. Besides, the final "putting into practice" link is to put the technology into practice according to the development strategy formulated for the selected technology.

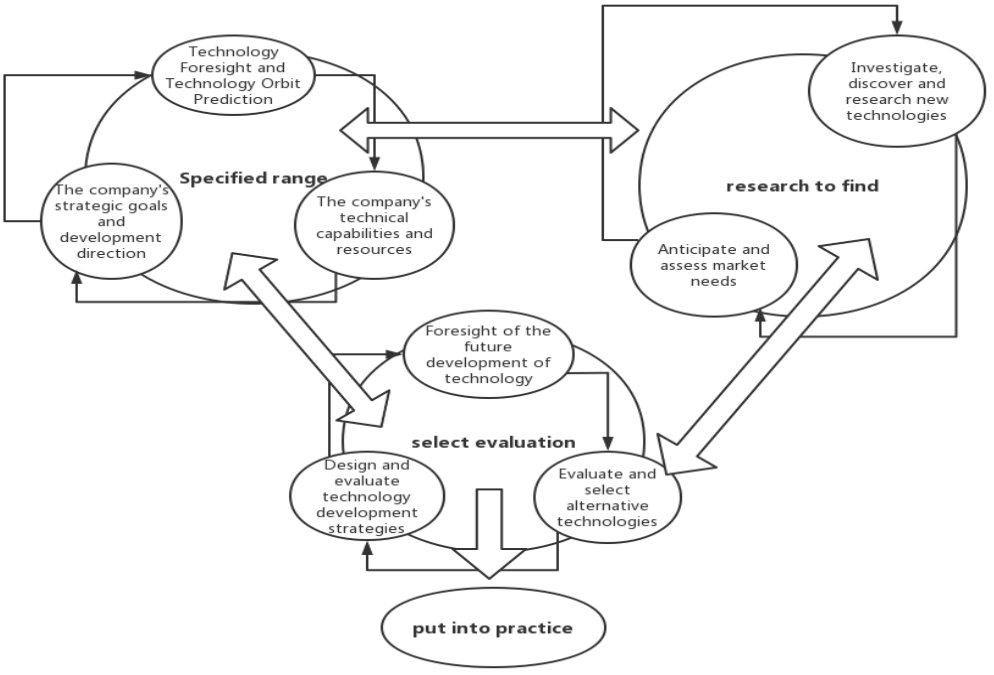


Figure 1: A dynamic model of biotechnology selection and evaluation.

## 7. Conclusion

Since China's biotechnology is in the initial stage of rapid technological and industrial development, and a clear technological development track has not yet been formed, enterprises face greater difficulties in choosing modern biotechnology than ordinary traditional technology and other high

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technology. Generally speaking, when choosing modern biotechnology, enterprises need to focus on the technological development track, related technologies and key technologies, basic research progress, and macro-environmental factors. Moreover, they should adhere to the forward-looking principle and the option principle, and it is a must to follow the dynamic model of delineating the scope, researching alternative technologies, evaluating the selection, and putting them into practice. This paper studies the relevant characteristics of biotechnology, and establishes the evaluation and selection model of relevant modern biotechnology, which has strong guiding significance for dealing with the high uncertainty of modern biotechnology. Good development strategies can thus be formulated for biotech companies. At present, the development of modern biotechnology has given birth to a new industrial structure and enterprise form. Specialized biotechnology research companies and other independent companies that provide external R&D financing are emerging one after another, and they constitute the R&D industry in the modern biotechnology industry. This kind of R&D industry is an important part of the biotechnology industry, which is of great significance to the innovation of the biotechnology industry, and its performance is extremely typical. So, in the future, special research should be conducted on the characteristics, subjects, and operating mechanisms of the modern biotechnology R&D industry.

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