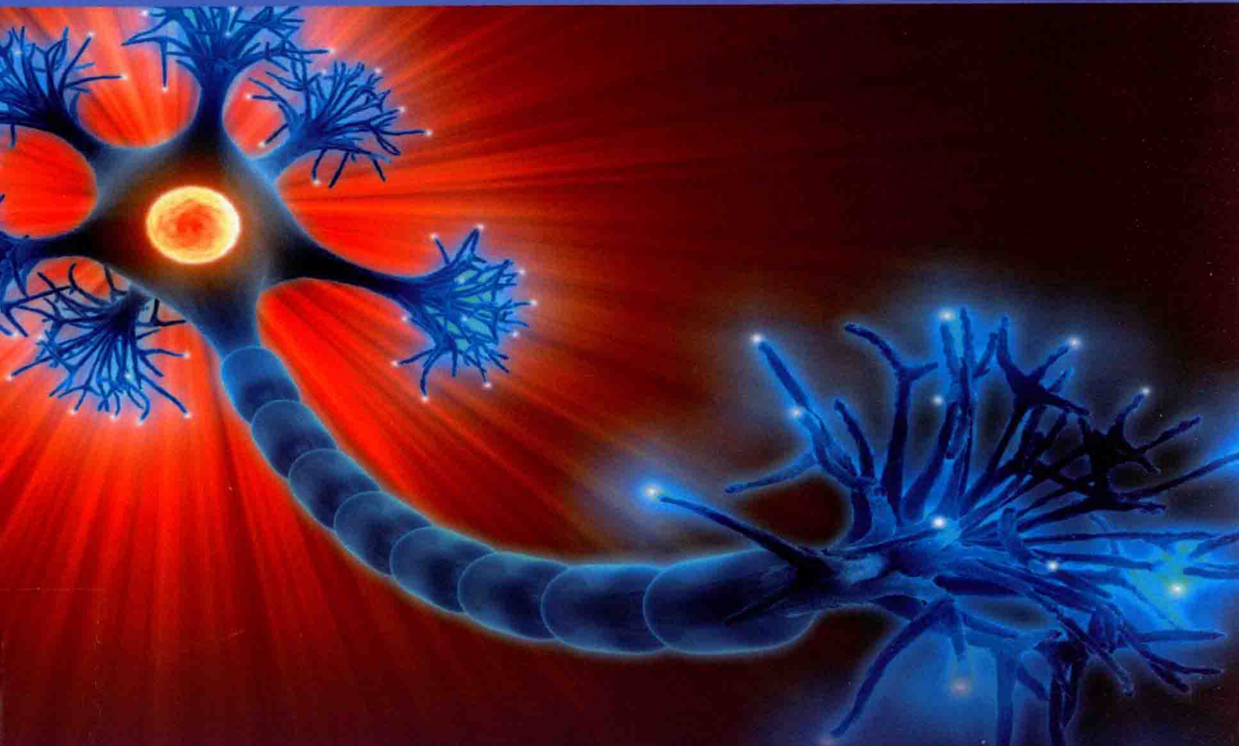
Contemporary Biotechnology and Bioengineering

He Xiaoxian • He Po • Ding Yong



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Preface

Bioengineering technologies are the core of the 21st century high-tech revolution, and the biotechnology industry is a pillar industry in the 21st century. Currently, bioengineering technologies play a strong role in solving the major problems of food, health, environment, resources, population and energy, which human beings now have to be faced with. Biotechnologies are widely used in medicine and health, agriculture, light industry, chemical and energy, and so on, and have promoted modification of the traditional industry technologies and formation of the emerging industries. Bioengineering technologies have permeated almost all disciplines and are closely related with daily life of people, economic and social development. There will be more outstanding talents of various disciplines to participate in research and development in the edge fields which cross with life sciences in the 21st century.

In order to strengthen and improve students' consciousness of high-tech, train high-quality talents, making college students in higher level consciousness of bioengineering technologies for their future job and the meaning of life, understand the research situation in bioengineering technologies and the development trend of life sciences in the world, the authors of this book extensively collected and borrowed domestic and foreign advantages of similar materials and technological literature in recent years, and finally this book, "Contemporary Biotechnology and Bioengineering", as a teaching textbook for non-bioengineering undergraduates in higher education institutions, was written and now has completed. By reading and learning from this book, most students have a basic understanding of trends and hot spots on life sciences in the 21st century and the knowledge of the major disciplinary development direction of bioengineering technologies and the areas to be covered in the future, so that during their major study students can find the integration point between bioengineering technologies and their own specialty, and become proficient in application of bioengineering technologies to their own specialty, so as to inspire their thoughts to pioneer and innovate, and lay the foundation for their future professional development. We hope that you will find this book a useful revision aid and a stimulus for further study.

This book was translated from Chinese version "Contemporary Biotechnology and Bioengineering" published in 2005 by Science Press, Beijing, China. The contents of the book include 13 chapters, covering not only basic knowledge and basic theories of both contemporary bioengineering technologies, but also their application in various fields and the impact on human society. In the case of constrained class number, teaching content should be concise rather than exhaustive, and should give students the space for studying themselves. For this book, Chapter 1: Introduction; Chapter 2: Science basis for contemporary bioengineering; Chapter 3: Gene and genome; Chapter 4: Gene engineering; Chapter 5: Cells and cell engineering; Chapter 6: Enzyme and enzyme engineering; Chapter 7: Microorganisms and fermentation engineering; Chapter 8: Contemporary bioengineering technologies and agriculture and light chemical industry; Chapter 9: Contemporary bioengineering technologies and biomaterials; Chapter 10: Contemporary bioengineering and biological medicine; Chapter 11: Infection and immunity; Chapter 12: Biodiversity and environmental management; Chapter 13: Safety and social ethics of contemporary bioengineering technologies.

Because of fast development of contemporary bioengineering technologies, and involvement in a wider range of knowledge, and owing to limitation of the author's knowledge level and writing skill, the errors in this book are inevitable, I would like to welcome valuable advice from all readers, and all the compiling staff will be greatly appreciated.

HE Xiaoxian
In Xi'an
June 2013

Acknowledgments

We would like to thank our families, colleagues and friends for their support and help we were writing this book. Thanks are also due to the staff at Science Press, Beijing, China for their encouragement and assistance during this time. Finally, we would like to thank Alpha Science International Ltd. Oxford, U.K. for their support and help English version, "Contemporary Biotechnology and Bioengineering" were successfully published.

We would like to dedicate this book to our parents.

Contents

Chapter 1

Introduction

Life sciences are the key discipline which promotes natural science and makes social progress, and also one of the backbone disciplines in the 21st century. Research subjects of life science relate to activity phenomena and their nature of organisms, as well as to interrelationship between lives and environment. Reviewing the history of development of science, it is easy to see that it mainly concentrated on physics, wherein the theory of relativity proposed by Einstein pulled contemporary physics upward to a glorious peak in the first half of the 20th century, and in the next half of the 20th century, its core tended to life sciences obviously. Among all the Nobel Prize winners from the 1950s to the recent years, we can see that the highest science award has been more and more in the field of life sciences, even some of the so called chemistry awards were won as the object of study and the achieved breakthrough fruit related with life activities.

In the 20th century, life sciences made the most brilliant progress. Protein, sugar and deoxyribonucleic acid (DNA) molecular structures have been clarified in succession. Test-tube baby, transgenic plants and transgenic animals appeared one by one. The human genome project was started up; and the first cloned sheep "Dolly" appeared in the world. All of these rapid progressive events have shown that the 2lst century is the century of life sciences to more and more people. This includes the meaning of two aspects. Firstly, life sciences will become the leading discipline, and provide new solutions and methods for research and development of other disciplines; and secondly, bioengineering industry will become a mainstay industry in the 21st century, and bioengineering agriculture and bioengineering pharmaceutical industry are the two important parts of the bioengineering industry. Bioengineering will finally solve the vital problems influencing human survival, including world's population, grain, environmental pollution, health, energy sources and so on.

1.1 Life Sciences: the Leading Discipline in the 21st Century

The 20th century is a stage of rapid development of life sciences, especially in the last 20 years of the 20th century, people's attention is more attracted to the speed of development of life sciences. Genetically modified food (GMF) has been laid out on the table of ordinary people; genetic therapy technology has begun to save lives of patients with genetic diseases; and the significant breakthrough in cloning technology has already made it become possible to make copies of animals. The dreams of mankind for several thousand years will come true one by one, with life science century replacing the physics century, and the world will appear more miraculous with development of life sciences. It can be expected in the 21st century from both development and crisis, that life sciences will become the leading discipline of natural sciences.

1.1.1 The Origin and Development of Life Sciences

As a discipline with a long history, Life Sciences was originated in ancient times, formed in the modern times, and developed fast in the contemporary times.

In the ancient times, people came into contact with all kinds of animals and plants in production practice, observed reproduction and death of organisms, and changes of the celestial bodies, and so formed the life view with simple materialism thought that all things were changing. But the people at that time couldn't explain unpredictable life phenomena, which formed the original religious idea that everything had its own soul. About six to seven thousand years ago, Chinese agriculture reached a relatively high level; five to six thousand years ago, original animal husbandry developed; three thousand years ago; people began to breed silkworm indoors; and Chinese people applied vaccine to prevent disease earlier than western people by over 800 years. The Book of Songs, a famous ancient Chinese literary work written in the period of Spring and Autumn and the Warring States, recorded over 260 kinds of animals and 350 kinds of plants. Qi Min Yao Shu, a monograph on agricultural sciences written by Jia Sixie in the Northern Wei Dynasty, systematically summarized the agricultural technical achievements before the 6th century AD. It was an agricultural encyclopedia in ancient China. Meng Xi Bi Tan, written in the Song and Yuan Dynasties, contained a lot of data about anatomy, physiology and Traditional Chinese Medicine (TCM), in addition to much biological knowledge on taxology, morphology and geographical distribution, domestication of animals, and so can be regarded as a milestone in the Chinese science history. Inner Canon of Yellow Emperor, written in the Qin and Han Dynasties, systematically discussed structure and physiology of the human body, and explained about disease-related knowledge. Shen Nong's Herbal Classic, written in the Han Dynasty, recorded 365 kinds of herbal drugs. In the Ming Dynasty the famous scholar Li Shizhen's Compendium of Materia Medica explained about 1892 Chinese medicines. Li's taxological and evolutionary thought made him become a biologist giant prior to Linnaeus and Darwin. All the research achievements before the 16th century mainly stressed on the aspects of medicine (including pharmacy) and agricultural sciences, they had characteristics of empirical property and applicability, adopting the methods including visual description, classification and anatomy to make knowledge on morphological classification and anatomy enrich rapidly.

After the 16th century, with rapid development of the European Renaissance Movement and capitalism, the real experimental natural sciences with a new style emerged in the world, and life sciences also made new progress. In the 17th century, Harvey discovered the blood circulation, and found that the blood vessels formed a closed system through which the blood circulated rapidly around the body and was pumped by the heart. He employed mechanical and chemical quantitative experiments in his research work, which laid a basis for physiology. Robert Hooke, one of the founders of the early scientific revolution, for the first time observed and described cells with a homemade microscope, and opened the door to the microscopic world. Linnaeus established the first scientific biological classification system, so as to establish the order in the kingdom of living things, and laid the basis for systematics as an independent discipline. Wolff proposed the theory of gradual formation of the chicken embryo by studying on development of the chicken embryo with experiments, and established scientific embryology. Overall, from the 16th to the 18th century, the outstanding achievements in the area of life sciences are successive establishments and developments of some branch disciplines of life sciences, such as physiology, taxology, embryology, etc.

The 19th century was the century of sciences. Life sciences also made all-round progress, wherein the significant progress was establishment of the cell theory, the evolutionary theory and genetics. Schleiden and Schwann established the cell theory, that the cell is the basic unit of structure and function in all of organisms, which explained consistency of the basic structures of organisms at the cellular level. The 20th century, especially after the 1950s, with widening and deepening of new theories and new methods in modern physics, chemistry, mathematics and computer science, life sciences had great changes and development, from a static, qualitative descriptive discipline to the dynamic, precise and quantitative one, and so experimental biology progressed into a new stage of comprehensive development.

In 1900, Mendel's principles of genetics were discovered once again and proved, which opened a prelude to modern genetics. Morgan put forward the gene theory in 1926, marking formal establishment of modern genetics. Morgan Genetics bridged the gap between embryology and the evolutionary theory, directly promoted the cytology, and laid the foundation for new big integration of biology, facilitated biological research from the cellular level to the molecular level. In the second half of the 20th century, development of biochemistry laid foundation for molecular biology and molecular genetics. In 1941, Beadle and Tatum proposed the doctrine of "one gene one enzyme", which combined gene with protein function. Avery's bacterial transformation experiment in 1944 and the Hirsch phage infection experiment in 1952 proved that DNA was the carrier of genetic information. In 1953 Watson and Crick established the DNA double helix structure model, and laid the foundation of molecular biology, with this as a breakthrough creating a new era to clarify the essence of life activities at the molecular level. Since then, the central dogma in molecular biology was put forward, and so the unified genetic codes in the living kingdom were deciphered, which demonstrated consistent development and relationship in the living kingdom at the molecular level, making life sciences enter a new era of molecular biology.

As a growing point of the contemporary life sciences, molecular biology has infiltrated into various branches of the life sciences, and meanwhile a series of emerging disciplines, such as molecular cell biology, molecular neurobiology, molecular structural biology, molecular taxology, molecular developmental biology, molecular virology, etc., were derived giving organic relation between life activities at various levels to explore laws of life activities in essence from a comprehensive multi-disciplinary viewpoint, so as to open up a new situation of modern life sciences. On the other hand, recombinant DNA succeeded in 1973, and genetic engineering has established since then. After 1980s, contemporary biotechnologies with genetic engineering as a backbone emerged worldwide as a high-tech industry. Conversion of biotechnologies to powerful productivity has shown its broad application prospects. The most ambitious research project "Human Genome Project"(HGP) in modern life sciences began in 1990, it was successfully completed with drawing of the working draft in June 2000, and then its follow-up work went well and was very exciting. In terms of macro-biology, contemporary ecology has developed into a multi-level comprehensive discipline with human research as the main topic, and is playing an increasingly important role in solving the global issues affecting human development.

Life activities are the most advanced, most complex phenomena in nature. So, life sciences have unlimited driving force, and activate more and more scientists such as physicists, chemists, mathematicians and, computer scientists to participate in the life science research, which greatly facilitate development of life sciences in recent decades. For today's life sciences, quantitative analysis under very strict conditions, such as physical, chemical and mathematical methods, can be adopted.

In short, contemporary life sciences in the 20th century have made enormous and remarkable progress. Contemporary life sciences have entered the development stage of great sciences, and are developing rapidly at every depth and every width in a state of leading natural sciences.

1.1.2 The Meaning of Life Sciences

"Life Sciences" has meanings at both broad and narrow sense. In a broad sense, "life sciences" are a conventional view and concept. Their definition about systems, methods and, means is uncertain, and internal logic systems in them are not strict. They generally refer to all the scientific activities for research and the phenomena of life. In a narrow sense, "life sciences" are a scientific system with a strict internal logical structure, based on traditional biology, containing two big parts of basic disciplines and applied ones, by means of biotechnologies, after undergoing formation and development of the discipline, and cross and fusion of the discipline and other ones. "Life sciences" mentioned herein are narrowly defined, and their definition is determined from a scientific division point of view, according to the developmental trend of contemporary disciplines and perspectiveness of discipline division in the 21st century. They are different from conventional life sciences in a broad sense.Life sciences relate to studies on substance composition, structures, functions, biodiversity, various life phenomena and laws of life activities of human and other organisms, and relation between the mankind and the nature and between organisms and environment, at the molecular, genetic, cellular, individual, group and ecological levels. Activities of lives are the highest form of motion of matters; and whether structures, functions, metabolism, reproduction, inheritance, development, evolution, or reactions and activities helpful for individuals and races are detailed embodiment of various matter motions in lives. With biology as a basic and backbone discipline, life sciences include various fields of biology, such as microbiology, botany, zoology and, molecular biology which are core disciplines, and at the same time also includes some applied disciplines such as agriculture sciences and engineering and medicine which are based on microbiology, botany, zoology and molecular biology. Life sciences have their own frontier of the development of discipline in various fields and at various levels, and researches in all the fields have their application prospects. The general trend of life sciences is interdisciplinary and comprehensive development by means of mutual infiltration with mathematics, physics, chemistry, astronomy, geology, economy, philosophy and other disciplines, with support from multidisciplinary research fruits such as research on trace elements in the human body.

In recent years, the HGP has made fast progress and great achievements, and such research enters a new era of post-genomic, proteomics, bioinformatics. Research fruits of bioinformatics will expand new areas of life sciences and accelerate the process of their research.

1.1.3 The Relation Between Life Sciences and Contemporary Bioengineering Technologies

1.1.3.1 Relation between life sciences and contemporary bioengineering technologies

Life sciences and technologies relating to substances of lives, may be divided into traditional life science and technology and contemporary life science and technology. The former includes traditional technologies such as brewing, making sauce, breeding, etc., employed by people for thousands of years. And the latter mainly includes genetic engineering, cell engineering, fermentation engineering and enzyme engineering, which currently, has become the frontier field of rapid development.

So, what is bioengineering? Bioengineering, also known as biotechnology, is a multi-disciplinary applied discipline, integrating the latest research fruits in contemporary life sciences (including biochemistry, microbiology, molecular genetics, cellular biology and immunology) with advanced engineering technologies. Bioengineering relates to a wide range of heterogeneous content, and scholars in different parts of the world give it different names. Americans called it"biotechnology and bioengineering"; Europeans "molecular biological engineering"; Frenchmen "génie biologique", i.e.

biological engineering; and the English use the term "biotechnology" to show the technical content of the bioengineering, also to represent the project content, but different from "bioengineering". The word, "Engineering", means the procedure of completing production of goods or providing labour for the society to get benefits, which is characterized as a large-scale, strong complexity and need for coordination between multidisciplinary knowledge and technology; but "technology" refers to use of a specific skill during implementation, and hence the two terms have notable difference. Bioengineering is industrialization of biotechnology. In bio-engineering field, the "technology" process and the "engineering" process cannot separate from each other, but they have their individual independence relatively. The definition of bioengineering accepted widely which was given by International Economic Cooperation and Development (OECD) in 1982, bioengineering refers to those technologies processing raw materials in order to provide products or service for mankind, by utilizing principles of natural sciences and engineering science, and relying on biocatalysts. Biocatalysts mentioned herein can be natural organisms, including microorganisms, animal and plant cells obtained with tissue culture technology, and new types of organisms with specific characters constructed with recombinant DNA technology and cell fusion technology, as well as enzymes or other ingredients produced by these new types of organisms.

People have to know that the life sciences and bioengineering have a clear difference. Life sciences refer to acquirement of biological knowledge, but bioengineering is application of biological knowledge. In most cases, bioengineering processes conduct at a low temperature, low consumption, and generally employ cheap raw materials as substrate.

In fact, bioengineering technologies are organic combination between life sciences and engineering technologies. Now, biotechnology has become closely related to a multi-disciplinary comprehensive interdisciplinary subject, which has close association with microbiology, biochemistry and chemical engineering. It is comprehensive technology based on the life sciences, and utilizing features and functions of organisms to design and construct new substances or new strains with expected performances, and combine with engineering principle to manufacture products or provide service.

Contemporary biotechnology provides various conveniences for human life, mainly including: ①more accurate diagnosis, prevention or cure of infectious diseases and genetic disorders; ②increasing crop yields effectively, get plants with many excellent characters, including resistance to insects, antifungal, antivirus, and adversity resistance; ③developing microbes which can produce chemical drugs, biological polymers, amino acids, enzymes and all kinds of food additives; ④creating livestock and other animals with more desirable characters; ⑤simplifying procedures for removing pollutants and wastes from environment.

At present, life sciences and technology have already gone into common people's houses, and have become an important methods for enhancing whole people's quality of daily life. For example, in some states of America the state-scale DNA databases have been already set up, and are used for cracking criminal cases and identifying criminals. DNA databases can be used for systematic examination of fetus chromosomes in order to determine whether a fetus carries a defective gene, and to improve population quality (although this practice still has dispute). Genetically modified plants and transgenic animals step by step "go" on the table of people, providing for people nutritional food with a more reasonable diet and of higher-quality. Genetic engineering drugs such as insulin, interferon and interleukin have been volume-produced, and put on the market. Polymerase chain reaction technology (PCR) and Southern hybridization method are also gradually widely used diagnosis of disease in molecular. In short, contemporary biotechnology has begun to penetrate into people's life in various ways.

1.1.3.2 Relation of bioengineering and other disciplines

Contemporary bioengineering is a comprehensive interdisciplinary subject relating to biology and engineering, and has a feature of knowledge-intensive, covering the widest range of disciplines in natural sciences. Now that the discipline needs to utilize principles of life activities, the knowledge about organism structure, function, metabolic activity and growth rhythm must be grasped. It is based on all the sub-disciplines of life sciences, such as cell biology, microbiology, physiology, biochemistry and molecular genetics, and combines with some other frontier basic disciplines beside biology, such as chemistry, physics, chemical engineering, mathematics, microelectronics, computer technology and informatics, to form a multi-disciplinary mutual infiltration of comprehensive discipline, wherein major theoretical and technological breakthroughs are fundamental. In addition, in all the areas of biotechnology, a lot of modern sophisticated instruments such as electron microscopy, High Performance Liquid Chromatography (HPLC), DNA synthesizer, biological mass spectrometry, DNA sequence analyzer, capillary electrophoresis instrument, are applied. These instruments are fully automated devices, and are all controlled by computer.

In recent years, cell engineering, tissue engineering and animal cloning have become an indispensable part of biotechnology, and represent the most promising trend in future. In fact there are no obvious gaps between biotechnology and pharmaceutical industry and pharmacy, and they have very close association. Agricultural biotechnology includes variety improvement, molecular breeding, bioreactor, etc.; environmental and marine biotechnology includes ecological restoration, biodiversity conservation, sustainable utilization of biological resources; the biological information service system has already been an important part of biotechnology. The importance of pharmaceutical products which are an eternal need for human, pharmaceutical industry has been never declined, and their development needs new ideas, new approaches. For traditional drug screening process, at first multi-index animal tests should be carried out, then human trials are needed, which has some defects, such as long process, less combination and low efficiency. In the new century, mankind has begun to understand the behaviour of genetic development at the molecular level, and knowledge about the laws of life activities has undergone a qualitative leap. Gene isolation, gene amplification, gene recombination and somatic cell cloning technologies have all turned into reality; structures and functions of some important proteins have been proved; the partial mechanism about signalling between the intracellular and the extracellular membrane and transmission of nerve impulses, and the photosynthesis mechanism about microbial and plant have been understood somewhat; and for the first time, the genetic recombination attempts for some purposes have been carried out, and based on this the strategy of cloning has been put forward. At present, sheep, cows and mice were successfully cloned by mankind. Using the cloning technology, the nucleus of human skin cells is transplanted into unfertilized eggs of the cattle, to cultivate a kind of universal cells and embryonic stem cells, which can develop into all kinds of cells in the human body. This technology has opened a new area for human organ transplantation.

A new revolution in agricultural sciences and technology is triggered by bioengineering. Genome work framework map of China's rice and database have been completed. Two-line hybridized rice technology is established. The genetically modified gene engineering strain constructed by using the new *Bacillus thuringiensis* insecticidal gene has a strong insecticidal effect and can substitute for chemical pesticides. Using molecular marker assisted breeding technology produced a series of fine varieties. With transgenic technology, the fluorescent genes are transferred into the silkworm to obtain a fluorescent genetically modified silk successfully, which lays a good foundation for further improvement of silk quality.

Genetic engineered bacteria can efficiently produce high quality L-methionine, and its all quality indices have attained the international standards and the standards of Chinese Pharmacopoeia (2000 edition) according to the tests performed by the state statutory drug test institution. The expression level of α-acetolactate decarboxylase, produced by genetically engineered bacteria, reaches more than 900U/mL in fermented broth, and as high as 4-5 times the world's existing highest expression level. This technology has been now widely used in many breweries. Phytase, which is produced by engineered yeast in China, is a novel animal feed additive, and this technology reaches the international advanced level and is commercialized in Jiangxi province.

In modernization of traditional Chinese medicine, analysis and research on genes and enzymes of plants and their biochemistry and structure-activity are carried out; and effective ingredients of plants are extracted by biotechnologies. Plant cell reactors are used to produce paclitaxel, ginkgo lactone, artemisinin, shikonin, ephedrine, etc.; and animal cell reactors can produce monoclonal antibodies, interferon, growth hormones, growth factors, enzymes, etc. Organ transplantation is also making important progress by utilizing transgenic technology in animals. In addition, gene therapy has extended to treatment of cancer, cardiovascular disease and Acquired Immune Deficiency Syndrome (AIDS) apart from genetic diseases. A batch of gene therapy solutions and genetic engineering drugs have progressed into the clinical trial stage and gene therapy has made great progress. Therapeutic vaccines are beginning development of industrialization, and it is expected to progress into clinical trials soon. Completion of the HGP and discovery of functional genes of a certain disease will make bioengineering technologies play an increasing role in treatment and diagnosis.

Energy and the environment are the major themes of sustainable development. Serious pollution and increasing shortage of fossil fuels require for a new clean alternative energy. Among renewable clean energy classes, hydrogen energy made from biomass has broad prospects. Various alcohols produced with starch as raw material can be replaced novel alternative energy material, such as cellulose. Genetically modified oil crops can produce the important chemical raw materials for alternative energy, such as degeneration fatty acids. Polylactic acid may be used to produce biodegradable plastic and genetically modified crops can be utilized to manufacture PHA (polyhydroxyalkanoates, one kind of biodegradable plastic). All these products may replace petrochemical products and are better than it. In addition, pollutant biodegradation technology based on recombinant microbes will become the backbone of the environmental protection industry. For example, it has been discovered that many microbes have biodegradation action on a variety of contaminants in soil, water and air. The crude oil desulfurization engineered bacteria with high efficiency and specificity, developed by USA Bioenergy Corporation, have far more advantages over traditional desulphurization methods. Through transformation of microorganisms and their degradation action, exciting research fruits have been achieved in both pollution control and resource application of organic agricultural wastes.

Future development of biotechnology depends on width and height of the technology platform, and now many platforms, including recombinant DNA technology, cell culture and DNA chips, have been established. Through them many fruits are achieved or some technologies are industrialized. Gene therapy, genetic engineering drugs, genetically modified plants, cloned animals and diagnostic reagents all attribute to these technology platforms. Some new platforms have been formed in the 21st century. The first is the gene-level platform, in which all the whole genome sequences from dozens of microorganisms and four model organisms (yeast, *Caenorhabditis elegans*, *Drosophila*, and *Arabidopsis thaliana*) have so far entered the database, and the draft of human genome sequence also has just been completed, which means that hundreds of thousands of genes and proteins encoded by these genes can be used in manipulation of genetic engineering and protein engineering, so as to expand the scope of biotechnology industry very much. The second platform is biological chip, it is the intersection and integration of a variety of high-techs in the molecular biology, chemistry and physics field. Both DNA chip extended and other silicon chips containing all kinds of biological molecules will combine with nanotechnology to make the chips manipulated *in vitro* develop into the components that can perform some function *in vivo*. The third platform is stem cell biology, which is the basis of animal cloning and tissue and organ cloning. The key for the developing technologies is control over differentiation and development of totipotent or pluripotent stem cells. For example, neural stem cells can develop into various types of cells in the nervous system. Improvement of the platform will bring organ transplant in medicine and excellent livestock breeding in agriculture with revolutionary progress. The fourth platform is bioinformatics which has been widely used in genome and proteome research. With discovery of functions of most genes and proteins, bioinformatics will have a new development prospects, i.e., on a computer simulating biochemical metabolic processes in cells, even simulating the course of evolution, which will make biology really go into the new theoretical period. The high technology how to use computers to design new types of organisms will also become a reality. The fifth platform is neuroscience. Nowadays, a big science program about neurobiology is carrying out internationally. Higher nervous activities in the human body, such as feeling, cognition and thinking will eventually be analyzed at the molecular level and cellular level. In the near future, new biotechnologies will appear on this platform. On one hand, they will bring Gospel for human mental illness; and on the other hand, based on this, highly intelligent computers and robots will be developed.

1.1.4 Life Sciences: the Leading Discipline in the 21st Century

Contemporary biotechnology has been paid attention by many people in various fields in the development history of nearly 20 years. 21st century is called the life science century by many experts, and contemporary biotechnology industry can be called the rising sun industry in the 21st century. Due to the rapid development, contemporary biotechnology is applied widely. Also, contemporary biotechnology has advantages over any other technology, i.e. it helps in sustainable development. Faced with a series of serious problems which directly related to the whole human survival, such as population expansion, resource exhaustion, environment pollution and so on, more and more people deeply realized the necessity and urgency of sustainable development of new technologies and new industries. Since biotechnology is based on organisms (animals, plants, cultured microorganisms cells, etc.) to manufacture products, the raw materials are renewable. And at the same time, few pollutants are produced in the production of products, and hence destruction of environment is little. What's more, recombinant microorganisms can even eliminate pollutants in environment. In view of the above characteristics of the biotechnology industry, clean and economical biotechnology will gain inevitably greater development in the 21st century.

At the turn of the century, biotechnology has shown us the grand plan in the new century, from the pharmaceutical revolution to the green revolution, from the new energy to the sustainable ecological environment, which indicates that biotechnology progresses into a rapid and steady development period. Publication of the draft of the recombinant human genome became the headline news in 2001; in December of the same year, the gene sequencing task of the 20th pair of chromosome of human was completed, which marked completion of a new chapter in the bible of human lives.

Hou Yunde, vice dean of Chinese Academy of Engineering, pointed out that information technology and biotechnology in our country were the key technologies relating to economic development and national destination in the new century, and will become an economic growth point for the innovation industries. Biotechnology will solve a series of problems, such as disease