Chapter 1　Microorganisms and Microbiology

Section 1　What is a microbe?

1 Microbe (microorganism) is an organism that is so small that it cannot be seen with naked eyes.

2 Microbial world
Viruse, bacteria, fungi, protozoa and some algae are all included in this category.

3 The size of microbes

Microbes	Approximate range of sizes	Cell type
Viruses	0.01-0.25μm	Acellular
Bacteria	0.1-10μm	Prokaryote
Fungi	2μm->1m	Eukaryote
Protozoa	2-1000μm	Eukaryote
Algae	1μm-several meters	Eukaryote

4 Features of microorganism
A, Small in size and high in surface area – to – volume ratio
B, Ubiquitous.
C, Fast in motabolism and reproduction.
D, Variable, and adaptable.

Section 2　Microbes and our life

In industry：organic acids, enzymes.
In agriculture：biological fertilizers, biological pesticides, plant diseases.
In food：seasonings, products by fermentation, beer, wine, liquor.
In medicine：antibiotics, vaccines and enzyme products.
In scientific research：model organism, material for experiment.

Section3　The history of microbiology

1, Prehistoric Period. 8000BC-1676.
During this period microbes were perceived and used, but not seen. It was a long time in history. Different cultures developed their own experiences to take advantage of beneficial microbes and control hazardous ones. There were products such as beer, wine, dairy products, ect. The most substantial achievements were obtained in China in production of saccharifying moulds and brewing.

The technology of production of saccharifying moulds was invented in China during 8000BC-4500BC. Chinese produced fermented mashed beans and vinegar 2500 years ago during the “warring states period”. In Song Dynasty, they used the older saccharifying mould to reproduce the younger one. They also used sour rice and alum under higher temperature, which was

favorable for its growth, to produce ‘red saccharifying mould’. They found the legumes could increase soil fertility and yield 2000 years ago, therefore the practices of collecting manure, composting and rotation were used to increase beneficial microbes in soil and to raise yield. Autotrophic bacteria were used to produce copper 900 years ago in China.

In medicine, Chinese used saccharifying mould from wheat to cure belly disease. They also had some understanding of infectious and epidemic diseases and took advantage of the techniques of disinfection and sterilization. In addition, in Song Dynasty human pox was inoculated to prevent smallpox. It was 50 years earlier than the invention of small pox vaccine by E.jenner in 1796.

There are 4 features in the technology of producing saccharifying mould. They are long history, unique technology, sufficient experience and various products, which are introduced as follows,

1)Long history. Yeast is the most ancient domestic organism. Though the exact time when alcoholic drink was originated is not confirmed, it is commonly accepted that alcoholic drink was created by the mass during certain period when human being entered the “Agriculture Society”, rather than by a single person. Alcoholic drink was recorded in the ancient literature *Huainanzi* (200BC)and *Jiugao* (300AD, Jin Dynasty). When did Chinese people enter “Agriculture Society”? In 1977, an ancient relics of 8000 years ago was excavated in Zhen County, Hehan. Stone sickle and stone mill were excavated from the tomb, which means that Agriculture Society might start 8000 years ago in China and alcoholic drink might, therefore, start at the same time. Among the excavation of “Longshan Culture”, which was 4000～5000 years ago, potteries for alchohol drink were found, which means brewing technology was quite advanced and Alcoholic drink was commonly consumed then.

2)Unique technology. Alcoholic drinks are divided in four groups. They are wine, beer, saccharifying moulds liqor and distilled liquor. Saccharifying moulds liqor is unique in its techonology during starch of the grains was saccharified by mould and then fermented by yeast. This is an embryo of series fermentation and mixed fermentation today, which takes an important position in the history of fermentation.

3) Sufficient experience. The sufficient experience in saccharifying moulds production and brewing was recorded in *Qimingyaoshu* (600) and *Tiangongkaiwu* (637) in details.

4)Variours products. There were various kinds of Saccharifying moulds and liquors. The Saccharifying moulds included Sanqu, Xiaoqu, Qubing, Caoyaoqu, Hongqu, etc. 39 kinds of liqors were recorded in *Qimingyaoshu*. Exellent strains of rhizopus, aspergillus and yeast were selected. A French called A. Calmette isolated a strain of Mucor, Mucorrouxianus, from Chinese Xiaoqu and used it to establish the famous amylo process.

2, Primary Period, 1676-1861.

In 1676, baceria was observed by Leeuwenhock under a modified microscope. However, till 1861, the knowledge about microbes remained at the level of primitive morphology. There were no

further study on physiology and microbial effects on human. Microbiology was not taken as a independent discipline at that time.

During this period, the most distinguished scientist was Leeuwenhock, an amateur scientist. His contribution could be described in 3 aspects. 1) He observed many tiny objects and organisms by a simple microscope and observed the tiny and powerful bacterian for the first time in 1676, removing the obstacle on the road to understand microbial world. 2) In his lifetime, he made 419 microscopes or magnifying lens with the magnification of 50～200, the largest of 266. 3)He published about 400 papers, most of which were published in Enlish Royal Society.

3, Founding Period, 1861-1897.

The features of this period are, 1) A series of essential technologies to study microbes were established, so the obstacles in understanding microbes were removed. 2)A large number of pathogenic microbes were found by effective microbial techniques. 3)Studies of microbiology strided from morphological level to physiological level. 4)The experiments were guided by the rule of getting truth from theory to pracice and from practice to theory. 5) Microbiology began to exist as an independent discipline, though it still existed in form of several applied disciplines.

The representatives of this period were L.Pasteur(French, 1822～1895) and R.Koch (Germany，1843～1910), who could be called the founder of microbiology and the founder of bacteriology respectively.

Pateur's contribution is that he brought up germ theory which confirmed that life came only from life itself. And he believed that it was microbes that caused infectious diseases, fermentation and spoilage. The theories together with series of techniques of pasteurization and sterilization formed the foundation or microbiology. He always drew theories from practice and then applied them to practice. In 1861, Spontanious Generation Theory was toppled by Patuer through his SwanNeck bottle experiment and germ theory was establshed. His studies aimed at solving practical problems such as spoilage of wine/beer(1857), diseases of silkworm(pebrine disease,1865), chicken(cholera,1879), animal(anthracnose, 1881) and human(rabies ,1885). Based on his research, he found that all infectious diseases were caused by a common factor, tiny living organisms, thereby human being's understanding of infectious diseases progressed to a new level. With the guidance of the theory, he solved the practical difficulties effectively. For example, he prevented "disease of weer/beer" by pasteurization, prevented spoilage of food by sterilization, prevented silkworm disease by eliminating diseased ones, prevented chicken cholera, cow/sheep anthrax by inoculation of attenuated trains, and prevented human rabis by inoculation of vaccine.

R.Koch's main contributions were, 1) He established a series of essential microbial techniques, especially the techniques for isolating. He used gelatin solid plate and agar solid plate instead of potato solid medium(1881). After 1881, Koch and his assistants established many techniques in using microscope, including techniques of flagellum staining. 2)He found and isolated such pathogens as anthrax(1877), Mycobecterium Tuberculosis (1882), Streptococcus (1882)and Vibrio Cholerae(1883). 3)He brought up "Kochs postulates".

After Pateur and Koch's work, microbiology developed widthways and a series of subdisciplined appeared, such as bacteriology(Pateur and Koch), surgery sterilzation(J Lister)，immunology(Pateur, von Behring，P. Ehrlich), soil microbiology (M.W，Beijerinck), virology，phytopathology and mycology(De Bary，M. J Berkeley)，Enology (E.C.Hensen，A.Jorgensen) and chemotherapy(P. Ehrlich).

4, Developing Period, 1897-1953.

In 1897, E.Buchner(Germany) produced alchohol by adding extract from yeast cells to glucose solution, which started a new period of microbial biochemistry. From then on, studies on microbial physiology and metabolism made great progress, which is concluded as the following features, 1) Researches were conducted on the level of biochemistry. The role of microbiologists changed from "mirobe hunter" into "vitamin hunter", "enzyme hunter", "antibiotic hunter" and "gene hunter", which reflected the shift of the role of microbiologist from searching out microbes to vitamin, enzyme, antibiotic and gene. 2)Applied microbiology was divided further, more new disciplines appeared. 3) The second rush of searching for useful metablites began. 4)Based on the development of applied microbiology in depth, common microbiology took shape as a comprehensive discipline, which discussed the basic rule of microbes. its representative was M.Doudoroff of Berkeley School, California University. 5) Techniques in the relative disciplines were integrated with microbiology to promote its rapid development.

5, Mature Period, 1953-today.

Microbiology has got into molecular stage since J.D.Watson and H.F.C.Crick published the model of double helical DNA in Nature on April 25th, 1963, which was also a symbol of mature of microbiology. The features of this stage are concluded as follows, 1) Microbiology has become a leading discipline from an isolated applied discipline. 2) In the field of theory, microbiology has stepped into molecular level and microbes have become the subjects of molecular research rapidly. 3) In the field of application, microbiology has become more effective and controlable. Microbes have played an crucial roles in bio-engineering since 1970 with the close integration of genetic engineering, cell engineering and enzyme engineering with fermentation engineering.

From the long run of history, we can find that the role Chinese played in the development of microbiology was not constant. Since 1970, bio-engineering has risen and developed. It is not only the essential contents of the Fourth Industrial Revolution, considering the role microbes played in biotechnology, but also the goal of the Third Rush in the development of microbiology. We are expecting Chinese to make a great achievement in this rush.