**Marine Microbiology and Practice** 

## Lecture 1 History and scope of Microbiology

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## Objectives for this lecture:

### • At the end of this lecture, you should be able to:

- Define a microorganism
- Define the spontaneous generation theory and explain how this idea was disproved
- Explain the development and significance of microscopy in discovering microorganisms
- Explain Koch's postulates
- Describe the interaction of plants with microbes giving examples
- Know the names of the main early microbiologists and be able to briefly describe their major contributions including
  - Van Leeuwenhoek; Louis Pasteur; Semmelweiss(山姆维斯); Robert Koch; Beijerinck (拜耶林克); Winogradsky (维诺格拉斯基); Alexander Fleming

Main reference: Prescott's Microbiology. Chapter 1.

## Microbiology

### Definition: The study of <u>microorganisms</u> (microbes)

- defined as organisms too small to be seen by the naked eye (but there are exceptions e.g. multicellular microbes)
- includes bacteria, archaea (古细菌), fungi (molds and yeasts), viruses, algae, and protozoa (原生动物)
- involves understanding:
  - Where are they found?
  - What is their structure?
  - Why do some cause disease while others are beneficial?
  - What is their role in the environment?
  - How can we make use of them?

## Pre-Microbiology era (pre 1660)

- <u>Aristotle</u> (384-322) and other philosophers of Ancient Greece
  - Spontaneous generation: living organisms could develop from nonliving materials.
- Illnesses believed to be caused by
  - Supernatural forces
  - Miasmas (vapours;瘴气)
  - Imbalance of the four humours (blood, phlegm痰, choler胆汁, melancholy愁思)
- Complete inability to control infectious diseases
  - Black death (plague): 25 million died 1347-1352 Europe
  - Smallpox (viral;天花) and cholera (霍 乱bacterial) and numerous other diseases killed millions



"The Doctor Beak of Rome" engraving by Paul Fürst. The beak is a primitive <u>gas mask</u>, stuffed with substances (such as <u>spices</u> and <u>herbs</u>) thought to ward off the plague.

## Pre-Microbiology era (pre 1660)

- Animal husbandry (饲养)
  - Sudden death in animals
- Agriculture
  - Crop failure
- Food production
  - Fermented foods
    - Cheese, yogurt, beer, wine
- Spoilage
  - All fresh foods eaten immediately
  - Short term storage for dried and pickled goods



Farmers and livestock shared living space



Trade in spices drove the economies of the world. Spices were essential for pickling and salting food for storage.

## Development of microscopy

### 1590: Hans and Zacharias Janssen

 mounted two lenses in a tube to produce the first compound microscope (3-10 fold magnification)

#### 1660: <u>Robert Hooke</u> (1635-1703)

- published first drawings of microorganisms,
- 1676: Anton van Leeuwenhoek (1632-1723)
  - amateur microscopist (draper [布商] in Netherlands)
  - first person to observe microorganisms (70 -300 fold magnification)

#### 1883: Carl Zeiss and others

- improved microscopes (such as immersion lenses [油浸物镜] and lenses which reduce chromatic aberration [色差])
- 1931: the first electron microscope (100,000 fold magnification)





### Modern images of microorganisms



Bacteria (orange) invading a human cell (green). (scanning electron micrograph, falsely coloured)



A mixture of microbes from oral cavity.

(fluorescence microscopy with probes labelled a different colour for each microbial species)

http://www.biotechniques.com/news/CLASI-FISHing-for-microbes/biotechniques-315946.html

### Spontaneous generation controversy

#### 1688: Francesco Redi (1626-1697)

 refuted the idea of spontaneous generation by showing that rotting meat carefully kept from flies will not spontaneously produce maggots (蛆)

1748: John Needham

- If flasks of meat broth were boiled long enough (1-2 h), and then closed, microorganisms did not grow
- 1861: Louis Pasteur (1822-1895)
  - proved that microorganisms do not arise by spontaneous generation

#### Concepts

- <u>Sterilization</u>: a method that kills all living organisms (灭菌)
- <u>Aseptic technique:</u> a series of practices to reduce contamination of a sterile site by microbes (无菌技术)

### Pasteur's experiment with Swan-neck



### Proof that microbes cause disease

### 1835: <u>Agostino Bassi de Lodi</u>

 showed that a disease affecting silkworms was caused by a fungus - the first microorganism to be recognized as a contagious (感染性的) agent of animal disease

#### 1847: Ignaz Semmelweiss (1818-1865)

 demonstrated that simply washing hands between delivering babies, significantly reduced the spread of childbed fever(产褥 热)

### 1857: Louis Pasteur

proposed the "germ theory" of disease



## Germ theory of disease

### 1876: Robert Koch (1843-1910)

- cultivated anthrax (炭疽) bacteria outside the body using blood serum at body temperature
- first direct demonstration that bacteria cause disease by injecting mice

#### 1877: Julius Richard Petri

designed a flat circular dish with lid (Petri dish)

1880s: Walter Hesse

- used agar as a solidifying agent
  - melts at 100°C, solid at 37°C

#### Concept

- <u>Pure culture</u>: population of cells that are identical because they arise from a single cell
  - allows isolation of a single microorganism



## Koch's postulates

- Published "Koch's postulates" (1884), the critical test to prove the involvement of a microorganism in a disease
  - 1. The bacteria must be present in every case of the disease.
  - 2. The bacteria must be isolated from the host with the disease and grown in pure culture.
  - 3. The specific disease must be reproduced when a pure culture of the bacteria is inoculated into a healthy susceptible host.
  - 4. The bacteria must be recoverable from the experimentally infected host.
- **BUT**, there are exceptions to every rule
  - e.g. leprosy (麻风) bacillus cannot be isolated in pure culture



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## Environmental microbiology

Culture-based techniques started to be applied to the study of microbes in soil and water

Martinus Beijerinck (1851-1931)

 developed enrichment culture technique, a way to isolate microbes with certain growth preferences

### Concept

 <u>Selective media</u>: microbes can be cultured selectively by providing nutrients required by some but not all microorganisms in a sample

#### Sergei Winogradsky (1856-1953)

 isolated *nitrifying (硝化) bacteria* in soil that use atmospheric nitrogen for growth

#### Concept

<u>Autotrophic growth</u>: using CO<sub>2</sub> as the sole source of carbon



#### Winogradsky column

Different microbes growing in different layers of the column, depending on nutrient levels and oxygen levels, as in a lake or salt-marsh

## Plants and microbes

1845 to 1892

- Potato blight (枯萎) in Ireland (1845-8) due to fungal disease
- Rust and smut (黑穗病) fungi caused disease in cereals

### Martinus Beijerinck

 Nitrogen fixation in root nodules performed by the bacterium, *Rhizobium*

#### Concept

- <u>Symbiosis</u>: The close association of two organisms. Each partner gains from the relationship
- e.g. symbiosis between *Rhizobium* (根瘤菌) and plants such as peas, beans
- published the first evidence of tobacco mosaic virus



Source of blight: the fungus *Phytophthora infestans*(马铃薯 晚疫病菌)



Nitrogen fixing nodules (结节) fix atmospheric nitrogen to ammonia which is used by the host plant for growth.

# How has Microbiology changed the way we live?

### The modern city

- 1860: Separation of drinking water and sewage
- 1866: Introduction of the flushing toilet
- The control of disease
  - Prevention
    - 1798: <u>Edward Jenner</u> performs the first vaccination against smallpox
    - 1867: <u>Joseph Lister</u> introduces aseptic techniques to surgery
  - Treatment
    - 1910: <u>Paul Ehrlich</u> introduces chemotherapy for syphilis (梅毒)
    - 1929: <u>Alexander Fleming</u> discovers first antibiotic, penicillin



Victorian London



Smallpox was eradicated from the world in 1980

# How has Microbiology changed the way we live?

- Prolonged storage of foods
  - 1805: start of mechanical refrigeration
- Industrial scale food production
  - 1900 Dr Ilya (伊利亚) Metchnikoff isolated bacillus from yoghurt
  - 1927 first industrial yoghurt manufacture



Modern Supermarket

### Microbiology today

- Molecular and genomic methods for studying microbes are important recent developments
  - 1941: discovery of DNA as the genetic material
  - 1966: discovery of genetic code
  - 1972: gene cloning
  - 1995: whole genome sequencing
- We are in a time of rapid advancement in knowledge that rivals the golden age of microbiology (Koch, Pasteur etc.)
  - a second golden age?





## Microbiology: A living study



Figure 1-17 Brock Biology of Microorganisms 11/e © 2006 Pearson Prentice Hall, Inc.

### Highlights in the History of Microbiology

- . 1677
- Observed "little animals" (Antony Leeuwenhoek)
- **1796**
- First scientific Small pox vaccination (Edward Jenner)
- **1850**
- Advocated washing hands to stop the spread of disease (Ignaz Semmelweis)
- **1861**
- Disproved spontaneous generation (Louis Pasteur)
- **1862**
- Supported Germ Theory of Disease (Louis Pasteur)
- **1867**
- Practiced antiseptic surgery (Joseph Lister)

### Highlights in the History of Microbiology

- 1876
- First proof of Germ Theory of Disease with B. anthracis discovery (Robert Koch)
- **1881**
- Growth of Bacteria on solid media (Robert Koch)
- **1882**
- Outlined Kochs postulates (Robert Koch)
- **1882**
- Developed acid-fast Stain (Paul Ehrlich)
- **1884**
- Developed Gram Stain (Christian Gram)
- **1885**
- First Rabies vaccination (Louis Pasteur)
- **1887**
- Invented Petri Dish (R.J. Petri)
- **1892**
- Discovered viruses (Dmitri Iosifovich Ivanovski)

### Highlights in the History of Microbiology

### 1899

- Recognized viral dependence on cells for reproduction (Martinus Beijerinck)
- **1900** 
  - Proved mosquitoes carried the yellow fever agent (Walter Reed)
- **1910** 
  - Discovered cure for syphilis 梅毒 (Paul Ehrlich)
- **1928** 
  - Discovered Penicillin (<u>Alexander Fleming</u>)
- **1977** 
  - Developed a method to sequence DNA (W. Gilbert & F. Sanger)
- **1983** 
  - Polymerase Chain Reaction invented (Kary Mullis)
- **1995** 
  - First microbial genomic sequence published (<u>H.</u> <u>influenzae</u>) (TIGR)

## Major fields in microbiology

- Medical microbiology and public health
- Industrial microbiology and biotechnology
- Food and dairy microbiology
- Environmental microbiology/microbial ecology
  - Agricultural microbiology
  - Marine microbiology



### Why study Microbiology?

- Microbes were the first life on Earth
- Microbes created the biosphere that allowed multicellular organisms to evolve
- Multicellular organisms evolved from microbes
- >50% of the biomass on earth is comprised of microbes
- Microbes are everywhere
- Microbes will be on Earth forever

- Our understanding of life has arisen largely from studies of microorganisms (biochemistry and genetics)
- Studies of microorganisms continue to contribute to fundamental knowledge of life processes
- We still know very little about the microorganisms that are present on Earth



## Always trust a microbiologist because they have the best chance of predicting when the world will end.

### 请同学们举几个列子

✓ Health

Agriculture

Food

Environment

✓ Industry





### No yeast, no beer, no bread, no wine.....

### No fly, no maggot.





