

## Chapter 1 - The History and Scope of Microbiology

### What is Microbiology?

- ◆ The term “microbiology” is defined as:
  - \* The study of organisms and agents too small to be seen clearly with the unaided eye. Such organisms and agents are termed **microorganisms** (or **microbes**)
  - \* The use of techniques necessary to isolate, grow, and study microbes

### The Discovery of Microbes

- ◆ Before they were visibly observed, microbes were suspected not only to exist, but also to cause disease
  - \* Lucretius, a Roman philosopher
  - \* Fracastoro, a 16th century physician
- ◆ 1590 - Hans Jansen developed the first useful apparatus with compound lenses (telescope? Microscope?)
- ◆ Credit for the first person to observe and describe microbes is given to Antony van Leeuwenhoek
- ◆ However, a recent publication ([H. Gest, ASM News 70:269-274, 2004](#)) clearly shows that Robert Hooke first observed and described microbes
- ◆ Robert Hooke - great scientist/inventor of the 17th century
  - \* Coined the term “cells” to describe the “little boxes” he observed in examining cork slices with a compound microscope
  - \* In 1665, published the book *Micrographia* documenting his various observations
  - \* In 1678, he was asked to confirm van Leeuwenhoek’s observations
- ◆ Leeuwenhoek
  - \* Developed single lens microscopes
  - \* 1673 to 1676 - publishes his discovery of “animalcules”
    - Bacteria
    - Protozoa
    - “Vinegar eels”

## Spontaneous Generation

- ◆ From before the time of Aristotle (384-322 B.C.), people believed that life could arise from non-living matter, i.e., **spontaneous generation**
- ◆ “Evidence” includes:
  - \* Mice from grain
  - \* Beetles from dust
  - \* Worms and frogs from mud
  - \* Maggots from rotting meat
- ◆ In the late 1600s, Francesco Redi challenged this view through a series of experiments involving rotting meat
- ◆ Redi’s experiments, and those by others, refuted the spontaneous generation theory for larger organisms
- ◆ These experiments did not, however, dispel speculation that the theory still held true for microorganisms
- ◆ Proponents cited evidence of microbial growth in boiled extracts of hay or meat
- ◆ For the next 150 years, proponents for and opponents against spontaneous generation provided numerous “proofs”
- ◆ Proponents linked their proof to the a “vital force” that existed in the air and was sensitive to extreme heat
- ◆ By the late 1800s, Pasteur and Tyndall conclusively disproved the theory of spontaneous generation
- ◆ Louis Pasteur
  - \* Father of Microbiology
  - \* Contributions include:
    - Wine fermentation
    - Microbial diseases of grapes and silkworms
    - “Pasteurization”
    - Rabies vaccine
  - \* In 1861, Pasteur provided definitive proof against spontaneous generation using swan-necked flasks
- ◆ Debate Positions:
  - \* Pasteur: Because no living thing is able to reach the broth, there is no growth
  - \* Critics: If accessible and given enough time, the “vital force” will reach the broth
- ◆ Claims by Pasteur’s critics seem to be unfounded since a number of the swan-necked flasks still exist today with no growth yet to be observed in the nutrient broth

## ◆ John Tyndall

- \* English physicist - first scientist to study greenhouse gases and climate change
- \* Demonstrated the existence of heat-resistant bacteria, thereby extending Pasteur's findings

**Role of Microbes in Disease**

- ◆ Despite the discovery of microbes, their role in causing disease was not recognized until the early 1800s
- ◆ Prior to this, it was commonly thought that most diseases were due to supernatural forces, poisonous vapors (miasmas), or an imbalance of the four humors - blood, phlegm, yellow bile, and black bile
- ◆ Support for a **Germ Theory** of disease:
  - \* 1835 - Bassi discovers that a fungus causes a form of silkworm disease
  - \* 1845 - Berkeley proves that the Great Potato Blight of Ireland is due to a fungus
  - \* 1853 - de Bary demonstrates fungal causes for certain cereal crop diseases
  - \* Late 1800s - Pasteur demonstrates a protozoan disease of silkworms
- ◆ Indirect evidence for microbial disease in human comes from Joseph Lister
  - \* Implemented the use of sterile surgical instruments
  - \* Used carbolic acid (phenol) during surgery and on wound dressings
- ◆ Robert Koch - first to directly prove a role for microbes in human disease
  - \* 1876 - used a set of criteria to establish the cause of anthrax
  - \* Criteria first proposed by Koch's mentor, Jacob Henle

**Role of Microbes in Disease (cont.)**

- ◆ Criteria known as **Koch's Postulates**:
  1. The microbe must be present in each disease case, but absent from healthy individuals
  2. The suspected microbe must be isolated from the disease case and grown in pure culture
  3. The same disease must result when a healthy host is inoculated with the isolated microbe
  4. The same microbe must be isolated again in pure culture from the diseased host
- ◆ Using these principles, Koch demonstrated the causes of anthrax (1876), tuberculosis (1882), and cholera (1883)
- ◆ Koch published his postulates in 1884
- ◆ Today, "Molecular Koch's Postulates" have been established in light of advances in the molecular biology of pathogenic microbes

### Microbial Disease Control

- ◆ ca. 1122 B.C. - Disease thought to be smallpox is described in China
- ◆ ca. 164 until 189 - Galen describes an epidemic in Italy believed to be the first recorded caused by smallpox
- ◆ ca. 500 - Chinese immunize people against smallpox via the inhalation of dried scabs produced by the disease
- ◆ 1518 - Smallpox, carried to the Caribbean island of Hispanola (Santo Domingo) by the Spanish, devastates the native population, then spreads to Cuba and Puerto Rico
- ◆ 1519 - Part of the Cortez expedition to Mexico infects the Aztec population killing more than 50% of those people
- ◆ 17th century - Smallpox epidemics occur periodically in the American colonies and in Europe
- ◆ 1701 - Children in Constantinople are immunized against smallpox by a procedure latter called variolation (reported in 1715 by Pylarini)
- ◆ 1717/1721 - From her observations of immunization procedures in Turkey, Lady Montagu introduces “ingrafting” to England (venous injections of small material from smallpox lesions)
- ◆ Chinese also develop “**variolation**” (inoculation of a cut on an arm with a thread soaked with pus from a lesion)
- ◆ 1721 - variolation employed in Boston to stem smallpox outbreaks with good success although some die from the disease caused by the inoculation
- ◆ In the French-Indian War (1755-1764), the British used smallpox-infected blankets as a “biological warfare” agent against Native Americans
- ◆ 1764 - Benjamin Jesty, a farmer and cattle breeder in England, uses pus from a cowpox lesion to immunize his family (all survive a smallpox epidemic)
- ◆ 1776 - George Washington orders all his entire army to undergo variolation
- ◆ 1796 - Edward Jenner is first scientist to test the use of cowpox to as an immunization agent against smallpox - a procedure latter termed “**vaccination**”
- ◆ Based upon Jenner’s work and observations of attenuated bacteria made in his laboratory, Pasteur and colleagues developed vaccines for chicken cholera (1880), anthrax (1881), and rabies (1885)
- ◆ Subsequently, the Pasteur Institute was established to develop vaccines

## The Microbial World

- ◆ Two fundamentally different types of cells exist among microbes
  - \* Procaryotic - “before nucleus”
  - \* Eucaryotic - “true nucleus”
- ◆ Procaryotes
  - \* Lack a membrane-bound nucleus and organelles
  - \* Include all bacteria and the archaeobacteria (“ancient bacteria”)
- ◆ Eucaryotes
  - \* Possess a membrane-bound nucleus and organelles
  - \* Includes all algae, fungi, protozoans, and helminths (Higher plants and animals are also eucaryotic, but are not typically a focus of study by microbiologists.)
- ◆ Also studied by microbiologists are viruses - acellular, obligate intracellular parasites
- ◆ In 1969, Whittaker used the cellular basis of procaryotic and eucaryotic life, as well as their modes of nutrition, to divide organisms into **Five Kingdoms**
  - \* Monera (bacteria)
  - \* Protista (mainly protozoans)
  - \* Fungi (molds and yeasts)
  - \* Planta
  - \* Animalia
- ◆ Through advances in cell biology, biochemistry, and genetics, it is clear that living organisms are more complex than once thought and are now divided into **Domains** which themselves are comprised of various kingdoms
  - \* Eubacteria (procaryotic - “true bacteria”)
  - \* Archaea (procaryotic - “ancient bacteria”)
  - \* Eucarya (eucaryotic - “true nucleus”)

## Relevance of Microbiology

- ◆ Steven Jay Gould has stated that we live in the “Age of Bacteria”
- ◆ Microbes influence human society in countless ways
- ◆ One indicator of the importance of microbiology is reflected by the number of Nobel Prize winners - one-third of all awardees are microbiologists or investigators using a microbial model

- ◆ Areas impacted by microbes include:
  - \* Medicine
  - \* Agriculture
  - \* Industry
  - \* Ecology
  - \* Genetics
  - \* Biochemistry
  - \* Molecular Biology
- ◆ Presently, and for the foreseeable future, microbiologists will face many challenges to solve many of society's problems including combating disease, reducing environmental pollution, and maintaining/improving the world's food supply