Microbiology

• Specialized area in biology that studies living things too small to be seen by the naked eye
• Microorganisms also called microbes or bugs
• Groups of organism covered:
  – Bacteria, Viruses, Fungi, Protozoa, Algae, and Helminths

Scope of Microbiology

Many Diverse Disciplines:

• Immunology
• Public health microbiology & epidemiology
• Food, dairy and aquatic microbiology
• Agricultural microbiology
• Biotechnology
• Genetic engineering & recombinant DNA technology

Chapter 1

Topics to Cover:

– Scope of Microbiology
– Importance of Microorganisms
  • Human Use of Microbes
– Characteristics of Microorganisms
– History of Microbiology
– Taxonomy

There are six main types of microorganisms: 1.) bacterium, 2.) Fungus, 3.) Algae, 4.) Virus, 5.) Protozoan, 6.) Helminth.

MICROBIAL HABITATS & ROLES:

• Microorganisms are everywhere.
• Microorganisms reside in animals, plants, soil, on the surfaces of furniture, in dust particles, in water - virtually everywhere!
Several reasons to study microbiology - the study (ology) of microorganisms.

Microorganisms are:
- Are part of our environment.
- Important to animal, plant and human health.
- A source of food or important in the production of food.
- Important in the recycling of waste.
- Useful for the production of antibiotics, vitamins, amino acids.
- Are the stuff of genetic engineering - recombinant DNA technology, gene therapy.
- Provide insight into life processes in all life forms.

Microbes are involved in photosynthesis - account for >50% of the earth’s oxygen. Decomposition – nutrient recycling.

Microbes are used to extract copper from ore, synthesize drugs and enzymes, and bioremediate contaminated water.

Infectious Diseases
- Only about 1% of the microorganisms actually cause disease.
  • The remaining 99% may be innocuous or have positive benefits.

Most common infectious causes of death worldwide.
**Cause of death in USA**

<table>
<thead>
<tr>
<th>Table 1.1: Top Causes of Death—All Diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td>1. Heart disease</td>
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<tr>
<td>2. Cancer</td>
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<tr>
<td>3. Stroke</td>
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<tr>
<td>4. Chronic lower-respiratory disease</td>
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<tr>
<td>5. Unintentional injury (accidents)</td>
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<td>6. Diabetes</td>
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<tr>
<td>7. Influenza and pneumonia</td>
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<tr>
<td>8. Alzheimer’s disease</td>
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<tr>
<td>9. Kidney problems</td>
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<td>10. Septicemia (bloodstream infection)</td>
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</table>

*Data adapted from the World Health Report 2002 (World Health Organization).*

**Characteristics of Microorganisms**

- **Cellular Organization:**
  - **Procaryotic** – no nucleus and organelles
  - **Eucaryotic** – nucleus and organelles (mitochondria, etc.)

**There is a difference between the cell structure of a procaryote and eucaryote.**

(a) Cell Types

Microbial cells are of the small, relatively simple procaryotic variety (left) or the larger, more complex eucaryotic type (right). (Not to scale)

**Viruses are neither but are considered particles.**

(b) Virus Types

Viruses are tiny particles, not cells, that consist of genetic material surrounded by a protective covering. Shown here are a human virus (top) and bacterial virus (bottom). (Not to scale)

**Microorganisms vary in size - 1µm to 200 nm.**

**History of Microbiology**

- Microscopy
- Spores and sterilization
- Spontaneous generation
- Aseptic technique
- Germ theory
The history of microbiology is old. It dates to before the bible.
- Egyptian pharaohs protected their pyramids with Aspergillus spores.
- Leprosy was described in the bible.
- The Greeks anticipated microbiology. They could not see microorganisms - only the effect.
- Hippocrates (~400 BC) set forth an enduring set of ethical standards for the practice of medicine. He also associated signs and symptoms to certain illnesses. He observed potential transmission by person to person or by objects.
- Thucydides realized that people who survived the plague were protected and could safely care for plague victims.

Microorganisms were first observed by Antonie van Leeuwenhoek, using a primitive microscope.

- Robert Hooke built the first compound microscope about 1665 and saw cells in a strip of cork.
- Leeuwenhoek - first observed living microorganisms - “animalcules” - using a simple compound microscope. He sampled everywhere and saw protozoa, yeast, fungi and many forms of bacteria. (300X)

Spores and sterilization
- Some microbes in dust and air were resistant to high heat.
- Spores were later identified.
- The term "sterile" was introduced which meant completely eliminating all life forms from objects or materials.

Spontaneous generation
- Early belief that some forms of life could arise from vital forces present in nonliving or decomposing matter (flies from manure, etc)
- Francesco Redi (1600) designed an experiment to refute spontaneous generation. Skepticism reigned.

Cell Types

Fig. 1.9 Leeuwenhoek’s microscope
Maggots developed from "flies".

Results were negated because of "harmful treatment" of air!!

John Needham refuted these experiments: because they had merely driven off the oxygen which they considered to be required for growth.

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- John Needham refuted these experiments: because they had merely driven off the oxygen which they considered to be required for growth.

- The French Academy of Science held a competition in 1859 to clarify the situation using scientific experiments.

- Louis Pasteur entered the swan-neck flask experiment.

- A difficulty with all of these experiments is that boiling does not necessarily kill all microorganisms....lucky moment!!!
Medical Microbiology

- John Tyndall conducted similar experiments and identify microbes in dust and air with high heat resistance.

- A lucky observation with these experiments is that boiling does not necessarily kill all microorganisms!!!
- Pasteur developed pasteurization (56°C/30 min) in the absence of oxygen to preserve wine from spoilage.
- Pasteur prepared the first rabies vaccine – made of dried spinal cord from a rabbit infected with rabies virus. Remember that none had any idea of the concept of viruses at that time!!
- In the late 18th century, Jenner noted that milkmaids seldom contracted smallpox. Using this observation he developed the first vaccine - successful immunization against smallpox.

Robert Koch, a contemporary of Pasteur, made a critical contribution to the field of infectious disease with his formulation of Koch's postulates. A corollary of this hypothesis is that one infectious agent causes one disease.
1) The specific causative agent must be found in every case.
2) The infectious agent must be isolated in pure culture.
3) Inoculation of the pure infectious agent into a susceptible animal must result in the same disease.
4) The infectious agent must be recovered from the inoculated animal.

Koch's postulates cannot be applied to all infectious agents - why??
- Some diseases are not caused by microorganisms
- Some microorganisms cannot be cultured
- Some microorganisms can cause different diseases
- Some diseases can be caused by different microorganisms.

Vaccination
- Lady Montagu – variolation to treat against smallpox
- Edward Jenner – protected humans against smallpox using the related virus cowpox
- Louis Pasteur – Developed vaccines against rabies and cholera. He introduced the term attenuated vaccines

Chemotherapy
- Cinchona (quinine) to Europe to treat malaria
- Paul Ehrlich – coined the term chemotheraphy and the concept of magic bullet (selective toxicity)
- Developed compound 606 (Salvarsan) to treat syphilis
- Alexander Fleming – identified lysozyme and penicillin from the mold Penicillium
- Rene Dubos – discovered two antibiotics produced by the soil bacterium Bacillus
Taxonomy

• A system for organizing, classifying & naming living things.
• Primary concerns of taxonomy are classification, nomenclature, and identification.
• Carl Linnaeus introduced taxonomic categories or taxa.

Nomenclature

• Binomial (scientific) nomenclature
• Genus – Bacillus, always capitalized
• species - subtilis, lowercase
• Both italicized or underlined
  – Bacillus subtilis (B. subtilis)

Identification

• The process of discovering and recording the traits (physical, biochemical, genetic) of organisms, thereby, placing them in a taxonomic scheme.

Levels of Classification

• Domain
• Phylum or Division
• Class
• Order
• Family
• Genus
• species
**Robert Whitaker** (1969) - developed after the five-kingdom system of classification.

The five-kingdom system became the standard until molecular biology techniques were used to develop the Domain system.

The Domain system was developed by Dr. Woese. The basis of the Domain system is the rRNA sequence information.

**Domains**

- Developed after the five-kingdom system
- Three domains:
  - Eubacteria - true bacteria, peptidoglycan
  - Archaea – odd bacteria that live in extreme environments, high salt, heat, etc
  - Eukarya - have a nucleus, & organelles

**Subdivisions or Kingdoms**

- Monerans
- Archae and Eubacteria
- Fungi
- Protists
- Plants
- Animals

**Evolution**

- Classification schemes allow for a universal tree of life “phylogenetic tree”.
- Living things change gradually over millions of years
- Changes favoring survival are retained & less beneficial changes are lost.
## Cause of death worldwide

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<table>
<thead>
<tr>
<th>Worldwide</th>
<th>No. of Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heart disease</td>
<td>11.1 million</td>
</tr>
<tr>
<td>2. Cancer</td>
<td>7.1 million</td>
</tr>
<tr>
<td>3. Stroke</td>
<td>5.5 million</td>
</tr>
<tr>
<td>4. Respiratory infections*</td>
<td>3.9 million</td>
</tr>
<tr>
<td>5. Chronic lower-respiratory disease</td>
<td>3.6 million</td>
</tr>
<tr>
<td>6. Accidents</td>
<td>3.5 million</td>
</tr>
<tr>
<td>7. HIV/AIDS</td>
<td>2.9 million</td>
</tr>
<tr>
<td>8. Perinatal conditions</td>
<td>2.5 million</td>
</tr>
<tr>
<td>9. Diarrheal diseases</td>
<td>2.6 million</td>
</tr>
<tr>
<td>10. Tuberculosis</td>
<td>1.6 million</td>
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</tbody>
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