Why is Microbiology Important?

• Diarrhea
• Pneumonia
• Tuberculosis
• Malaria
• Hepatitis B
• Measles
• Tetanus
• AIDS
• Whooping cough
• Amebiasis
• Schistosomaisis

Importance of Microbiology: Infectious Disease Control

Nitrogen Fixation

• Microbes are the main forces that drive the structure and content of the soil, water, and atmosphere
  - produce gases such as CO$_2$, NO, and CH$_4$ that regulate the temperature of the earth
  - the enormous underground community of microbes influence weathering, mineral extraction, and soil formation
  - found in the Earth’s crust, polar ice caps, oceans, and the bodies of plants and animals
  - live in places where other organisms cannot survive
Importance of Microbiology:

**Probiotics**
- *Lactobacillus acidophilus*
- *Lactobacillus casei*
- *Lactobacillus reuteri*
- *Lactobacillus plantarum*
- *Lactobacillus rhamnosus*
- *Bifidobacterium animalis*
- *Bifidobacterium infantis*
- *Bifidobacterium lactis*
- *Bifidobacterium longum*

Importance of Microbiology:

**Food**
- Bread
- Cheese
- Milk Products
- Fermented Vegetables
- Alcoholic Beverages
- Spoilage/Preservatives
- Plant and Animal Disease

Importance of Microbiology:

**Antibiotics**
- Penicillins
- Tetracyclines
- Erythromycin

Importance of Microbiology:

**Molecular Biology**
- Gene cloning
- Genetic engineering
- Metabolism research

**Major Types of Microorganisms**

<table>
<thead>
<tr>
<th>MICROORGANISM</th>
<th>CELL TYPE</th>
<th>CELL WALL</th>
<th>PHOTOSYNTHESIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>bacteria</td>
<td>prokaryotic</td>
<td>yes, almost all</td>
<td>some</td>
</tr>
<tr>
<td>archaea</td>
<td>prokaryotic</td>
<td>some</td>
<td>some</td>
</tr>
<tr>
<td>protozoa</td>
<td>eukaryotic</td>
<td>in some life cycle stages</td>
<td>no</td>
</tr>
<tr>
<td>fungi</td>
<td>eukaryotic</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>algae</td>
<td>eukaryotic</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>viruses</td>
<td>acellular (not composed of cells)</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>prions</td>
<td>acellular (protein only)</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>

**Characteristics of Living Organisms:**
- Made of cells
- Homeostasis
- Reproduce using DNA
- Respond to Environment
- Metabolize (Use Energy from their Environment)
- Evolve
Characteristics of Living Organisms: Cells
• Cells:
  – Basic unit of life
  – Cells enclosed by a water-repellent layer called the plasma membrane

Cell Theory - that all living things are composed of one or more cells

Characteristics of Living Organisms: Homeostasis
• Keeping the balance
• Organisms sense and respond to their environment in order to maintain constant internal conditions through a process called homeostasis

Characteristics of Living Organisms: Reproduce via DNA
• DNA:
  – DNA is genetic material that contains all the instructions for building new organisms
  – Passes information from parent to offspring

Characteristics of Living Organisms: Respond to Environment
• Taking information from internal and external sources to be able to respond accordingly

Characteristics of Living Organisms: Energy from Metabolism
• All organisms need energy to live, they get this energy from their environment.
• Plants are producers:
  – convert energy from the sun into chemical energy
• Consumers use energy from other consumers or directly from producers
  – Ex: cat eats mouse and gets some of the energy that the mouse contained

Characteristics of Living Organisms: Groups Evolving
• Evolution allows an organism to survive and reproduce better than competing organisms
Scientific Method: Development in Microbiology

**THE SCIENTIFIC METHOD**

- **Observations**
- **Hypothesis**
- **Predictions**
- **Test (observations, experiments)**

- **Hypothesis supported**
- **Hypothesis rejected**

**Scientific Method: Observation**

- **Observations:**
  - Fish die off in estuaries
  - Water from fish kill site kills aquarium fish
  - *Pfiesteria piscicada* lives in the water of these living or dead fish

**Scientific Method: Hypothesis**

- A scientific hypothesis is an informed, logical, and plausible explanation about the natural world
- **Must be testable!**

**Hypothesis:** *Pfiesteria piscicada* can kill fish.

**Scientific Method: Prediction**

- Using the hypothesis make a prediction in an “if-then” statement
- Does not have to be an “if-then” statement but it is easier to write this way.

From this hypothesis you predict: If *Pfiesteria piscicada* kills fish then addition of *Pfiesteria piscicada* to an aquarium of fish will increase mortality rates.

**Scientific Method: Test**

- **A controlled experiment:**
  - Comparable in all respects except one or more group(s) are exposed to systemic change and one is not
- **Control group:**
  - No change in independent variable
- **Experimental (or treatment) group:**
  - Independent variable is manipulated by the researcher

**Scientific Method: In Action**

Your hypothesis was supported. Now you have made another observation: that *Pfiesteria piscicada* can kill fish.

Now you can make another hypothesis: *Pfiesteria piscicada* releases a chemical into the water that kills fish.

And the cycle continues...
The Nature of Science: Scientific Theory

- A scientific theory is a body of knowledge that has stood the test of time
- A hypothesis becomes a scientific theory:
  - After it has been repeatedly confirmed through diverse methods of testing
  - When it is accepted by experts as the best explanation of the truth about the phenomenon
- A scientific fact is a direct and repeatable observation about the natural world

Just a theory?

- When we use the word "theory" in everyday life, we usually mean an idea or a guess, but the word has a much different meaning in science...
- Some theories in Biology:
  - Cell Theory
  - Theory of Natural Selection
  - Germ Theory

The Microbiology of History

- Microbes have drastically shaped our history and evolution
- Ex: Civil War- 140,414 Union soldiers died of battle-field wounds and 224,097 died of microbial diseases.
- Fall of the Roman empire was hastened by plagues

The Microbiology of History: The Black Plague

- In 1346 the Tartars from Central Asia attacked a trading colony controlled by the Genoese
- During the fight bubonic plague broke out in the Tartars
- They through the bodies of the walls of the city and the fleas on the bodies jumped off and infected the residence, example of primitive biological warfare

The Microbiology of History: The Black Plague

- Italians brought the plague to Europe while the Tartars and Mongols brought it North to Russia and Asia, creating a pandemic
- Approximately 25% of the population died
- Destabilized economies and society
The Microbiology of History: The Black Plague

- Feudalism was a way of England in the 1300s
- Before plague there was a huge supply of cheap workers
- During/after the plague there wasn’t so workers could demand higher wages
- Within 150 years feudalism was over

The Microbiology of History: The New World

- Before Columbus small pox, measles, influenza, and malaria where absent
- When Cortez came to Mexico, he had with him a silent weapon more potent than his Spanish army, infectious disease.
- Native peoples had zero resistance to these diseases
- By 1595, over 18 million Native South Americas had died of smallpox, mumps, measles and other European diseases.

The Microbiology of History: The New World

- Why did Europeans not get infected with South American disease?
- They did not have domesticated animals in the same way Europeans did.
- These diseases likely jumped from domesticated animals some time in the 8000 years we have been working with them.

The Microbiology of History: 19th Century

- Napoleon: 500,000 men marched to Russia, 20,000 returned. Most died of hunger or Typhus.
- The Irish Potato Famine: Ireland was very dependent on potatoes for food. In 1846 potatoes were hit with Phytophthora infestans. Huge famine and approximately 1 million died.
- During the worst of the famine emigration reached approximately 250,000 in one year.

The History of Microbiology

- The study of microbes originated “300 years ago
- Prior to microbiology, many believed people that got sick were being punished for their transgressions
- Before 1900, one of every two (50%) of children died before reaching 10

History of Microbiology

Antonie van Leeuwenhoek was a linen merchant who needed to analyze his cloth fibers and became curious about other specimens like rain water and tooth plaque. To his surprise he found “moving animalcules”!

1676- the first to observe microbes (up to 300X)
History of Microbiology

1796- Edward Jenner demonstrates that inoculation with cowpox material provides humans with immunity to smallpox (origin of vaccines)

Louis Pasteur:
• 1857-Fermentation is caused by microbes
• 1861-Completes S-shaped flask experiments that disprove spontaneous generation
• 1862-Introduces pasteurization to prevent spoilage
• 1881-Develops anthrax vaccine for animals

History of Microbiology: Spontaneous Generation

Spontaneous Generation or Abiogenesis: Early belief that some forms of life could arise from vital forces present in nonliving or decomposing matter. Biogenesis: All living things arise from other living things.
• Two of the most popular experiments to prove biogenesis:
  – Francisco Redi—meat and maggots
  – Louis Pasteur—S-shaped flask

History of Microbiology

In 1859, Pasteur devises the S-shaped flask to disprove the theory of spontaneous generation. Microbes are everywhere (air) and will grow in broth unless killed by boiling and prevented from entering broth

History of Microbiology

• 1688 Francesco Redi- published experiments to disprove spontaneous generation

History of Microbiology

• 1847-1850- Ignaz Semmelweis was the first to test whether disinfecting hands can prevent disease
• 1867-Joseph Lister tested the effectiveness of disinfecting medical equipment using aseptic techniques
History of Microbiology

Robert Koch:
• Studied anthrax and hypothesized that it may be caused by bacteria
• 1876- Proved that microbes cause disease (cause & effect link) by developing Koch’s postulates
• Germ theory of disease uses these postulates
• Invented agar plates

GERM THEORY-diseases are caused by germs and not because you have sinned or done something wrong.

Koch’s Postulates

1. The suspected pathogen must be found in every case of the disease.
2. The suspected pathogen must be isolated in pure culture.
3. Inoculation of a sample of the culture into a healthy, susceptible animal must produce the same disease.
4. The suspected pathogen must be recovered from the inoculated animal.

History of Microbiology

• 1928-1940s- Alexander Fleming accidentally discovers penicillin
• 1910- Paul Ehrlich introduces first chemotherapeutic for syphilis (searched for "magic bullets")