

Chapter 1. The Main Themes of Microbiology

- Scope of Microbiology
- Impacts of Microorganisms
- General Characteristics of Microorganisms
- Historical Foundations of Microbiology
- Taxonomy of Microorganisms

Scope

Microbiology: The study of small organisms (microorganisms)

- Most are too small to be seen with naked eye
- Includes:
 1. **Viruses**
 2. **Bacteria**
 3. **Fungi**
 4. **Protozoa**
 5. **Algae**
 6. **Helminths** (parasitic worms)

Microorganisms Have Large Impacts on Earth

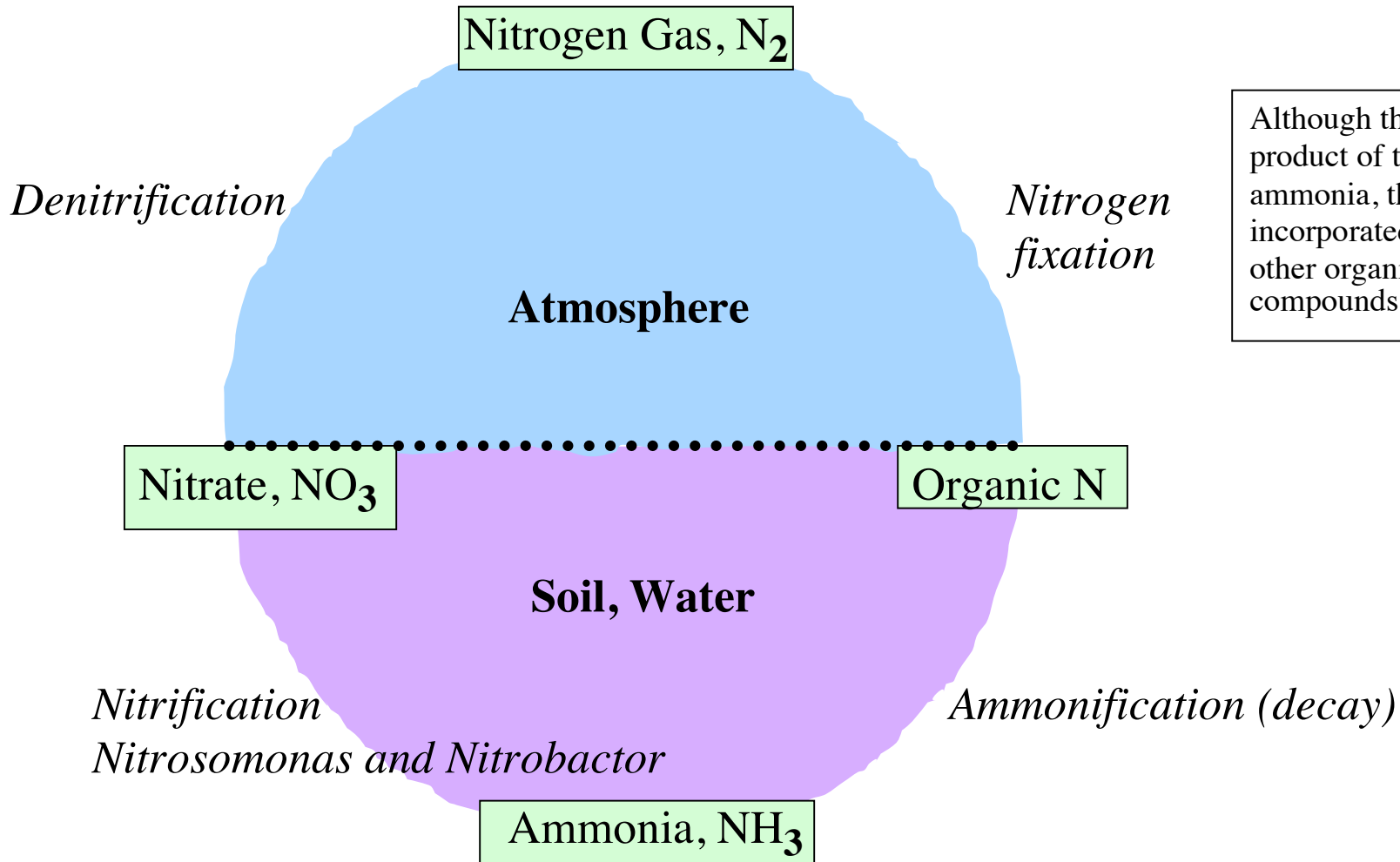
- Bacteria were the **first living organisms** on Earth
 - 1st appeared ~3.5 billion years ago
- Can be found in **large numbers** nearly **everywhere** on earth
 - Soil, oceans, deep underground, extreme environments
 - Closely associated with other organisms

~100 trillion microbial cells per human!
- Affect the **composition of gases** in Earth's atmosphere
 - Generate oxygen (O₂) by photosynthesis
 - Produce greenhouse gases that contribute to global warming

Ex. carbon dioxide and methane

- **Decompose organic matter**, wastes and manmade pollutants
 - Recycles nutrients** needed for life to continue
 - Ex. Carbon, Nitrogen, Phosphorus, Sulfur
 - Detoxifies** harmful pollutants released into environment
- Aid **food digestion** and **synthesize vitamins** in our digestive tract
- Produce **antibiotics** used to treat infectious diseases
 - Ex. penicillin, erythromycin, tetracycline, vancomycin
- Cause **infectious diseases** of humans, animals and plants

Microbial Transformations of Nitrogen in the Nitrogen Cycle



Although the first stable product of the process is ammonia, this is quickly incorporated into protein and other organic nitrogen compounds.

Table 1-2

Figure 1-4

Fields of Study Involving Microbiology

- **Immunology:** Study of the immune system & vaccine production

Ex. Rabies, measles, flu, tetanus, malaria vaccines

- **Public health and Epidemiology:** Study of the occurrence, spread and prevention of infectious diseases

Ex. Epidemics of AIDS, flu and food poisoning outbreaks

- **Medical microbiology:** Study of pathogenic microorganisms and how they cause diseases

Ex. *Clostridium tetani* (tetanus), *Vibrio cholerae* (cholera)

- **Food microbiology:** Food production and preservation

Ex. -Cheese, beer and wine

- **Industrial microbiology:** Manufacture of useful products

Ex. -Enzymes added to laundry detergent to remove stains

-Ethanol for fuel

- **Agricultural microbiology:** Effects of microorganisms on crops and livestock production

Ex. -Bacteria and fungi that increase soil fertility

-Plant and animal diseases

- **Microbial ecology:** Activities of microorganisms in the environment and their roles in nature

Ex. -Breakdown of organic matter and recycling of nutrients

- **Biotechnology:** Application of genetic engineering to produce microorganisms with new or improved properties

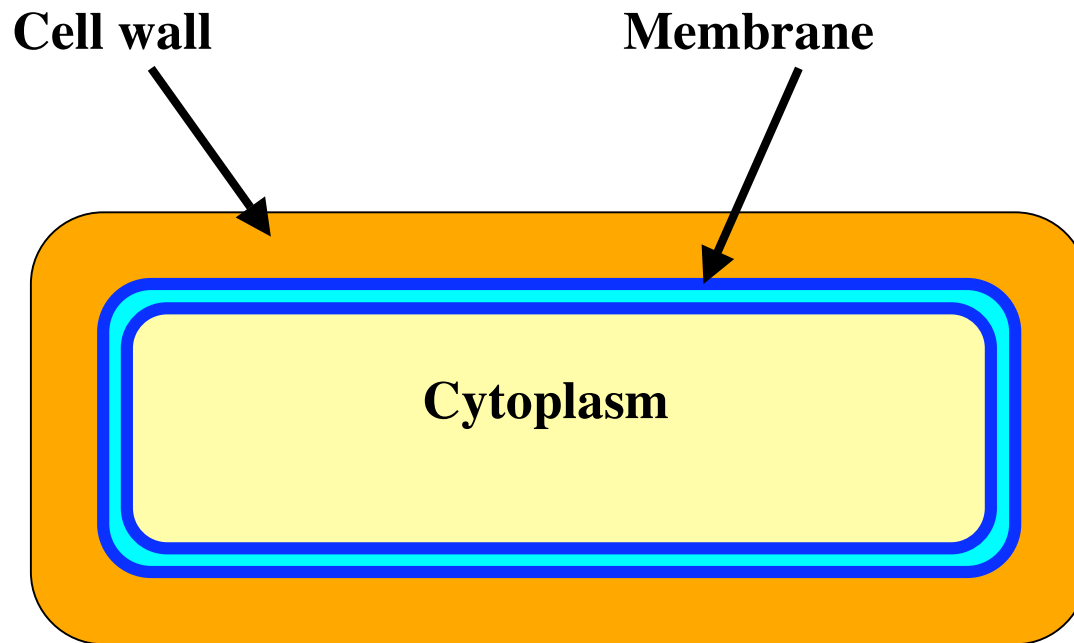
Ex. -Strains of bacteria that produce human insulin

- **Waste treatment and water purification**

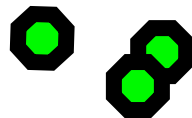
Ex. -Operation of sewage treatment plants and treatment of drinking water to remove disease-causing microorganisms

General Characteristics of Microorganisms

- **Cellular microorganisms** are composed of a **membrane** that separates the interior from the exterior
 - The interior is filled with **cytoplasm** and other constituents needed for growth and reproduction
 - A **cell wall** is often present on the outside of the membrane

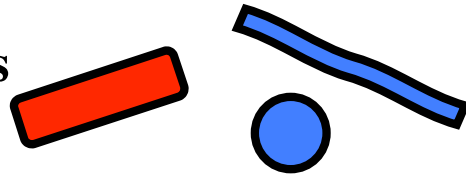


- **Viruses are acellular.** Small particles lacking a cell membrane or cytoplasm



There are 2 basic types of cells

1. Prokaryotic cells



- Smaller and simpler than Eukaryotic cells
- **Lack a nucleus or organelles** in cytoplasm
- Often exist as single cells
- Only **bacteria** are prokaryotes

2. Eukaryotic cells

- Larger and more complex
- Contain a **nucleus & organelles** w/i cytoplasm
- May be **unicellular** (single celled) or **multicellular**
Ex. Yeast, fungi, protozoa, algae, helminths

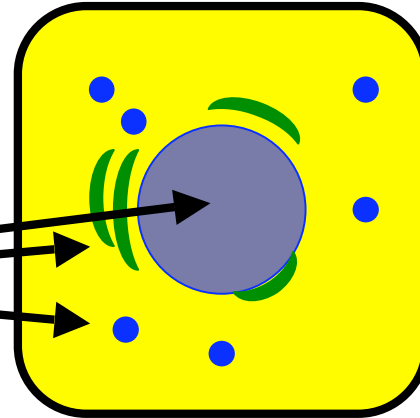


Figure 1-5

Figure 1-6

Sizes of Microorganisms

- The **micrometer**, μm , is the unit of measure often used to describe the size of microorganisms

$$\begin{array}{rcc} 1 \mu\text{m} = 1/1,000,000 \text{ meter} = 0.000001 \text{ m} = 1 \times 10^{-6} \text{ m} \\ \text{(fraction)} \qquad \qquad \qquad \text{(decimal)} \qquad \qquad \text{(scientific} \\ \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \text{notation)} \end{array}$$

- **Typical sizes**

Viruses 0.01 to 0.2 μm

Bacteria 0.2 to 5 μm

Yeast 5 to 10 μm

Algae 10 to 100 μm

Protozoa 50 to 1000 μm

Figure -7

Historical Foundations of Microbiology

- **Biblical times** Protection from contagious diseases by *isolation* of lepers and burial of wastes
- **400 B.C.** **Hippocrates.** Observed that diseases could be *transmitted* from 1 person to another by objects such as clothing
- **1 B.C.** **Romans.** Thought disease could be caused by *invisible animals* that entered body
- **1500's** **Fracastoro.** Contagious disease caused by passage of *unseen germs* from 1 person to another
- **1600's** **Microorganisms discovered.** -Leeuwenhoek made **1st microscope** capable of seeing bacteria
- **1700's** Smallpox *vaccination* introduced by Edward Jenner

- **1800's**
 - Spontaneous generation** disproved
 - Germ theory** of disease proven
 - Introduction of *sterilization* and *antiseptic* procedures in medicine

antiseptic
antibiotic
disinfectant

- **1900s**
 - Microbiology** became a **scientific discipline**
 - Laboratory methods were developed
 - Major disease-causing pathogens discovered
 - Chemotherapy** and **immunology** developed

Spontaneous Generation

- Early belief that **Non-living** objects and substances can **give rise to living** organisms

Ex.

rotting meat → maggots

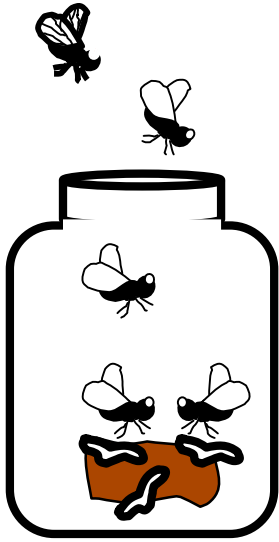
mud → frogs

rags and grain → mice

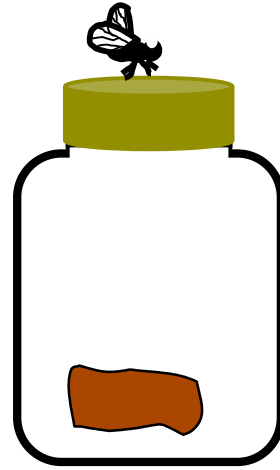
plant & meat broth → microorganisms

- Obscured the relationship between infectious diseases and contamination by the agents of disease (microorganisms)
- Widely believed but **disproved** by Redi, Pasteur and others in the 1800's

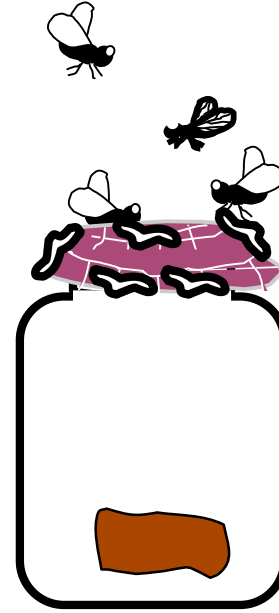
Redi's Experiment



Meat in open jar
Maggots appear



Closed jar
No maggots



Gauze covered jar
Maggots on gauze

Conclusion: Maggots result from fly eggs, not spontaneous generation

Germ Theory of Disease

- **Infectious diseases are caused by living microorganisms** called germs
- Germs can be **transmitted** from one person to another
- A specific disease is caused by a specific microorganism

Ex. *Bacillus anthracis* → Anthrax

Mycobacterium tuberculosis → Tuberculosis

Cell Theory

- The cell is the fundamental unit of life
- All living things are composed of cells
- All cells arise from preexisting cells

Louis Pasteur 1822-1895

- Used swan-necked flasks to disprove spontaneous generation of microorganisms
- Discovered that microorganisms were responsible for the fermentation that produced wine and beer
- Developed vaccines for immunization against anthrax, chicken cholera and rabies
- Developed pasteurization to destroy harmful microorganisms in food and slow spoilage

Figure 1-11

Robert Koch 1843-1910

- Developed methods to isolate and grow microorganisms as **pure cultures**
 - Isolated pathogens responsible for several diseases
 - Anthrax: *Bacillus anthracis*
 - Tuberculosis: *Mycobacterium tuberculosis*
 - Cholera: *Vibrio cholerae*
 - Established **Koch's postulates**: → Proof that a microorganism causes a disease
 1. Same microorganism present in all cases of a disease and absent from healthy animals.
 2. The microorganism must be isolated from a diseased animal and grown as a pure culture.
 3. Inoculation of healthy animal with isolated microorganism must cause the disease.
 4. Same microorganism must be reisolated from the inoculated animal.
- Firmly established the germ theory of disease

Robert Koch 1843-1910
German Physician

Figure 1-12

Other Milestones in Medical Microbiology

1. Introduction of sanitary medical practices

- Ignaz Semmelweis
Hungarian physician
correlated infections with physicians coming directly from autopsy room to maternity ward
Hand washing with chlorinated lime solutions by physicians
- Joseph Lister
Use of antiseptics during surgery: involved disinfection of hands using chemicals (carbolic acid) prior to surgery, use of heat for sterilization

2. Chemotherapy for treating diseases caused by microorganisms

- Paul Erlich
Discovered chemical agents to cure syphilis

3. Antibiotics

- Alexander Fleming
Discovered penicillin

<u>Mortality rate</u> (deaths/100,000)	Year		
	1920	1960	1995
Pneumonia & influenza	207	37	28
Tuberculosis	113	6	<1
Syphilis	16	2	<1
Diphtheria	15	<1	<1
Whooping cough	12	<1	<1
Measles	9	<1	<1
<u>Other (nonmicrobial) causes</u>	925	909	790
Life expectancy (years)	54	70	76

Applications of Microbiology for Disease Prevention & Treatment

- Vaccines, antibiotics and antiseptics
- Sanitary food handling
- Drinking water treatment
- Sewage treatment and disposal

Microbial Taxonomy

- Naming, **classifying** and identifying microorganisms

1. Naming

- Linnaeus introduced **binomial nomenclature**
- Every organism is given a unique two-part name

Genus + species name

Italicized or underlined

Ex. *Escherichia coli*, *Yersinia pestis*, *Bacillus anthracis*

Escherichia coli, Yersinia pestis, Bacillus anthracis

2. Classification

- Organisms with similar characteristics are grouped together

Genus *Bacillus*

Bacillus anthracis, Bacillus subtilis, Bacillus cerus

Levels of Classification (King Phillip Came Over For Grape Soda)

Domain (Archaea, Bacteria, & Eukarya) ---> Kingdom ---> Phylum or Division --->

Class ---> Order ---> Family ---> Genus ---> Species (---> Subspecies or Strains)

3. Identification

- Determination of the name of an organism that has been isolated by observing its characteristics (Shapes, biochemical tests or DNA sequencing)