Introduction to Medical Microbiology

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Bachelor degree in Medicine and Surgery - Mutah university

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Course Details

- Course name: General medical microbiology
- Second year (MD program)
- Credit hours: 3 (2 theory, 1 practical)
- Lectures: Sunday and Tuesday for 1 hour
- Lab: Monday, and Wednesday 12:15 -2:15
- Course instructors:
  - Dr. Hala Altarawneh
  - Dr. Sulaiman Bani Abdel-rahman
  - Dr. Mohammad Odaibat
- Exams MID and FINAL

Course Resources

- Lecture and lab notes
- Reference textbook:
    - Greenwood D. *Medical Microbiology: A Guide to Microbial Infections: Pathogenesis, Immunity, Laboratory Diagnosis and Control.* 19th ed. Elsevier, 2012.
    - Carroll KC. *Jawetz, Melnick & Adelberg's Medical Microbiology.* 28th ed. McGraw-Hill, 2019.
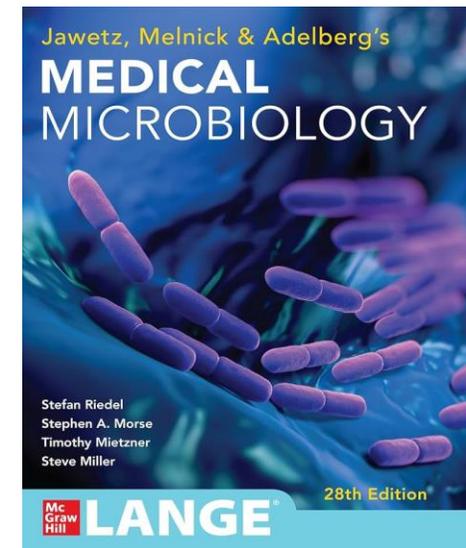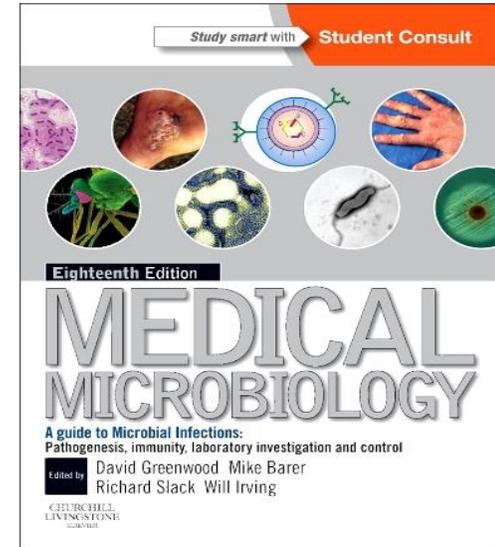
Outline

- Definitions (microbe, microbiology, medical microbiology)
- History of medical microbiology
- Importance of medical microbiology
- Classification of Microorganisms:
  - Bacteria, Viruses, Fungi, Parasites, and Prions
  - Major differences between prokaryotes and eukaryotes

What is a microbe?

Small organisms visible only under **microscope**

What is Medical Microbiology?

- **Microbiology** is the study of microorganisms — tiny living organisms invisible to the naked eye, including bacteria, viruses, fungi, and parasites.

- **Medical microbiology** is a branch of microbiology that focuses on **the study of microorganisms** that **cause diseases in humans** and the ways to **diagnose, treat, and prevent** these infections.

Medical Microbiology: Historical background

Ancient times – ~mid-1800s

- Ancient beliefs often explained disease by:
    - Imbalance of the four humors (blood, phlegm, yellow bile, black bile) — from Hippocrates and Galen.
    - Miasma theory: "bad air" or foul-smelling vapours caused disease.
    - Supernatural causes: punishment from gods, evil spirits, or witchcraft.

LE CHOLÉRA
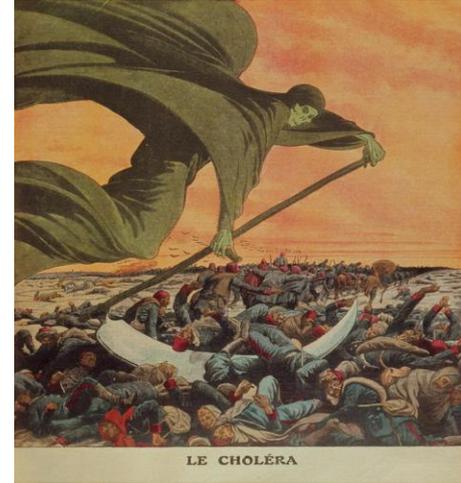
Medical Microbiology: Historical background

Ancient times – ~mid-1800s

- No concept of microorganisms or infectious agents.
  - Some observed contagiousness (plague, smallpox), but no understanding of the mechanism.

- Early public health measures (without understanding cause):
  - Quarantine, isolation, sanitation efforts — sometimes worked, but people didn't know why.

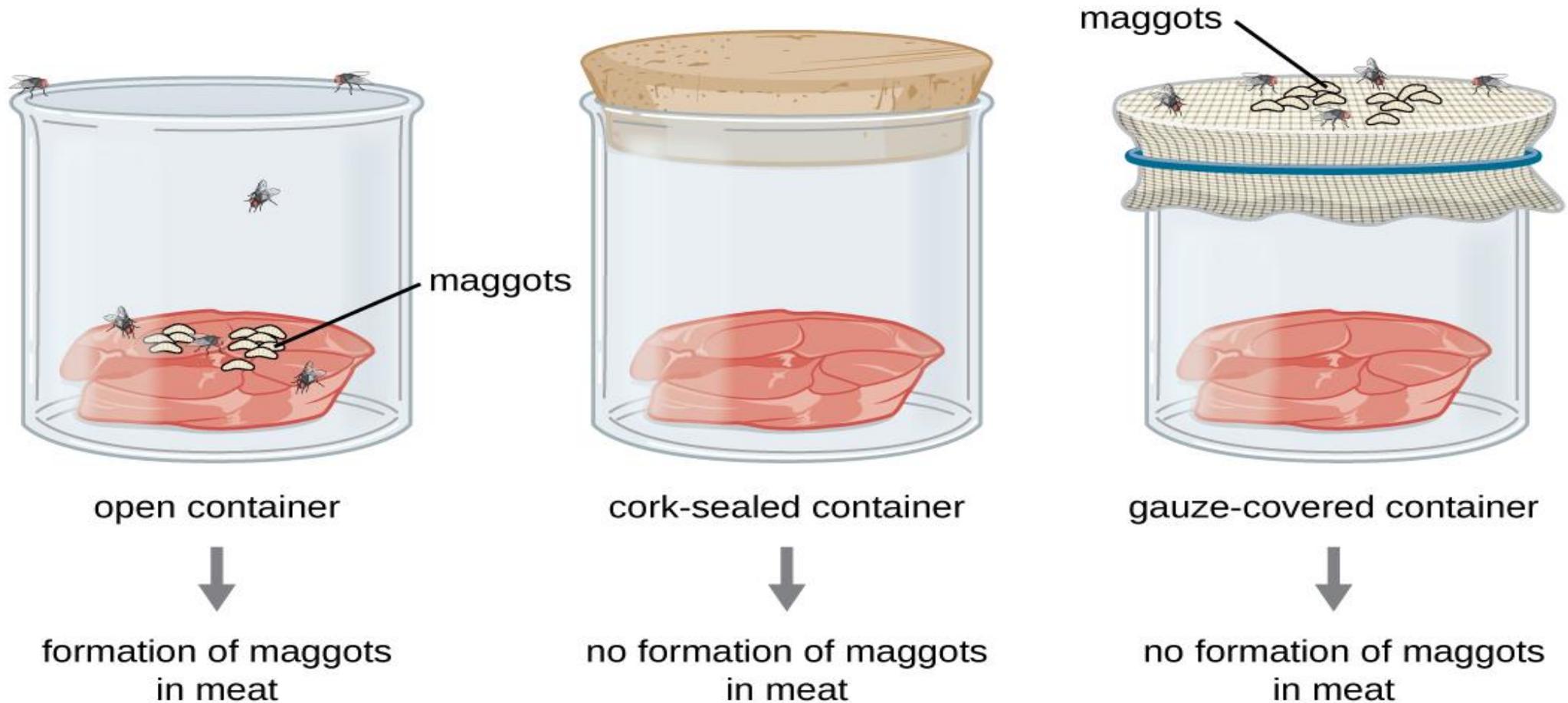# Medical Microbiology: Historical background

Discovery of Microorganisms (~1670s–1700s)

- Antonie van Leeuwenhoek (1674–1683): First to observe and describe bacteria and protozoa, using handcrafted microscopes.

- However, he **didn't connect them to disease**.

Medical Microbiology: Historical background- Disproving spontaneous generation

- Old belief: life arises spontaneously from non-living matter. Common examples believed at the time: Maggots appear from rotting meat.

- Challenged by experiments: Francesco Redi (1668): Maggots come from flies, not meat.

- Disproving spontaneous generation paved the way for the germ theory of disease.

Medical Microbiology: Historical background- Disproving spontaneous generation

maggots

open container

→

formation of maggots in meat

cork-sealed container

→

no formation of maggots in meat

maggots

gauze-covered container

→

no formation of maggots in meat

Medical Microbiology: Historical background

Germ Theory of Disease

- Definition: the idea that specific microorganisms are the cause of specific infectious diseases.

- Key breakthroughs: Robert Koch: proved microbes cause disease (e.g., TB, anthrax); developed Koch's postulates.

- Main principles of germ theory:
  - Microorganisms are living agents of disease.
  - Diseases are not caused by "bad air" or mystical forces.
  - Transmission can be controlled (hygiene, sterilization, vaccination).

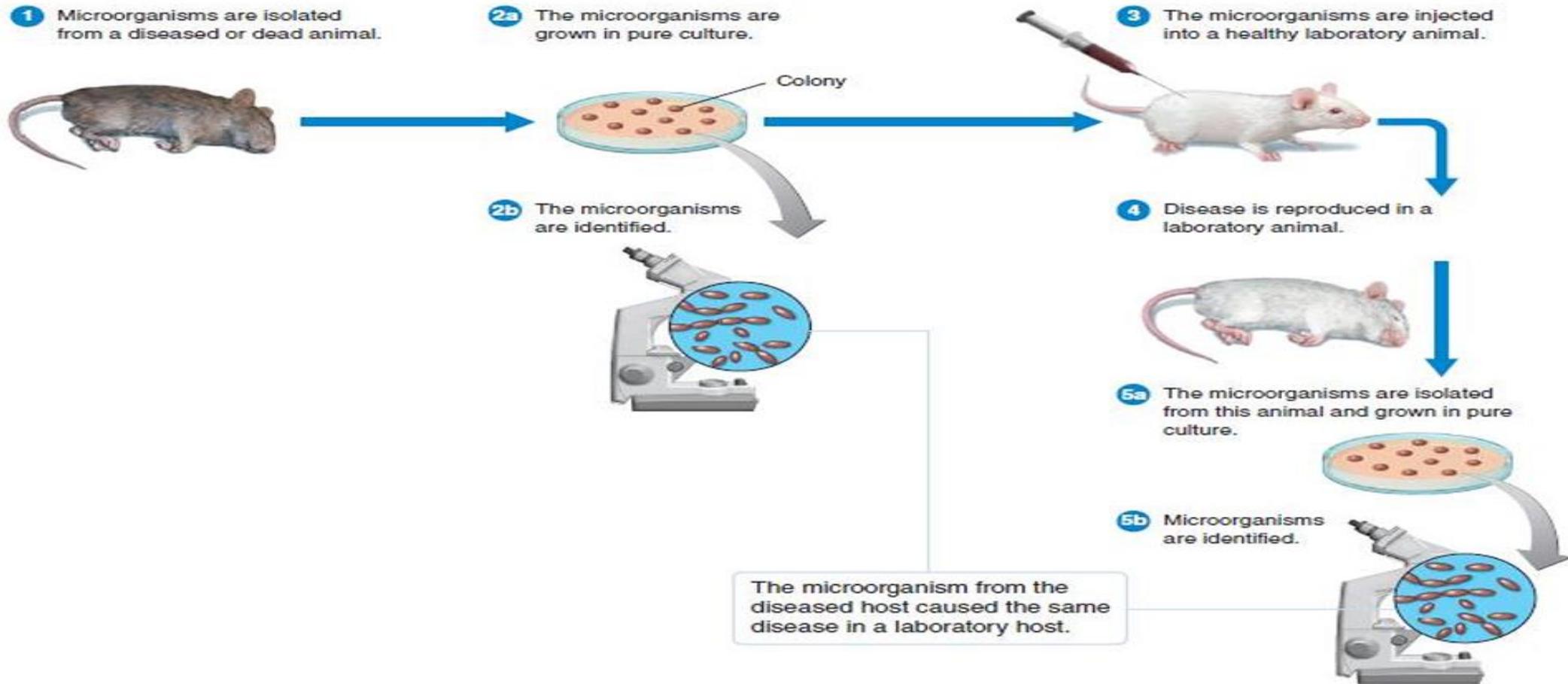# Medical Microbiology: Historical background-Germ Theory of Disease

Robert Koch's Anthrax Experiment

- Observed *Bacillus anthracis* in blood of anthrax-infected animals.

- Cultured bacteria outside the animal (pure culture).

- Injected cultured bacteria into healthy animals → disease reproduced.

- Re-isolated Bacillus anthracis from experimentally infected animals.

Medical Microbiology: Historical background- Germ Theory of Disease

Robert Koch's Anthrax Experiment

1. Microorganisms are isolated from a diseased or dead animal.

2a. The microorganisms are grown in pure culture.

Colony

2b. The microorganisms are identified.

3. The microorganisms are injected into a healthy laboratory animal.

4. Disease is reproduced in a laboratory animal.

5a. The microorganisms are isolated from this animal and grown in pure culture.

5b. Microorganisms are identified.

The microorganism from the diseased host caused the same disease in a laboratory host.

Medical Microbiology: Importance and scope in medicine

- Infectious Diseases: A Leading Cause of Death Worldwide
- Number of COVID-19 deaths reported to WHO (cumulative total) about **7.1 million.**

- In 2019:
  - Common bacterial infections were the **second-leading cause of death**
  - 33 bacterial pathogens caused **13.7 million deaths**

- In 2021:
  - lower respiratory infections **~2.5 million** deaths

Medical Microbiology: Importance and scope in medicine

Medical microbiology studies microorganisms that **cause human disease**

- Enables accurate diagnosis and targeted treatment of infections
- Guides antibiotic selection and management of antimicrobial resistance
- Supports infection control and hospital hygiene practices
- Vaccine development and outbreak response
- Monitoring antimicrobial resistance developments

Classification of Microorganisms

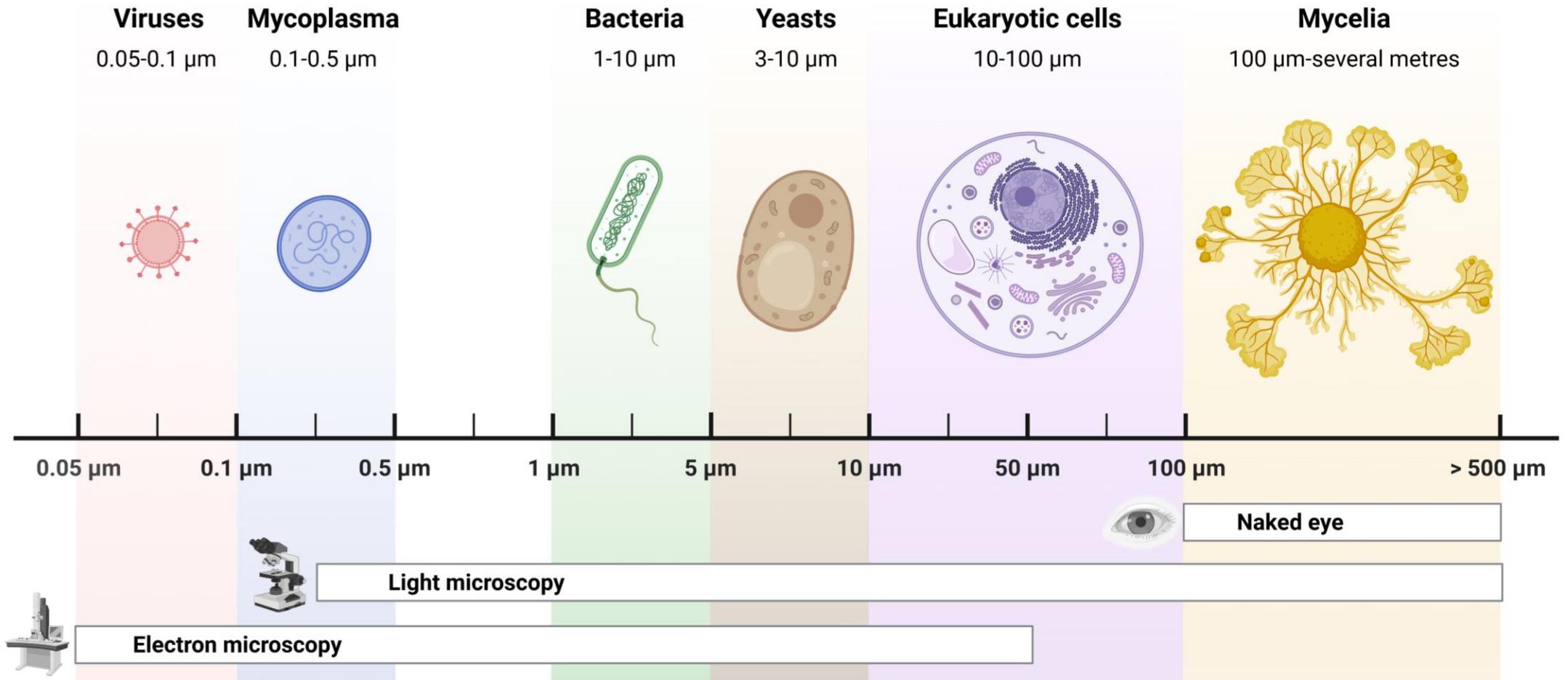| Classification of Microorganisms			
Cellular (living cells)		**Acellular**	
Prokaryotes	**Eukaryotes**	**Viruses**	**Prions**
A single-celled microorganism that lacks a nucleus → Bacteria	any cell or organism that possesses a clearly defined nucleus → Fungi, Parasites	Acellular infectious agents with DNA or RNA in a protein coat; replicate only inside host cells	A misfolded protein that induces misfolding in normal variants of the same protein

Classification of Microorganisms

Relative sizes of viruses, bacteria, yeasts, mammalian cells, and fungal mycelia
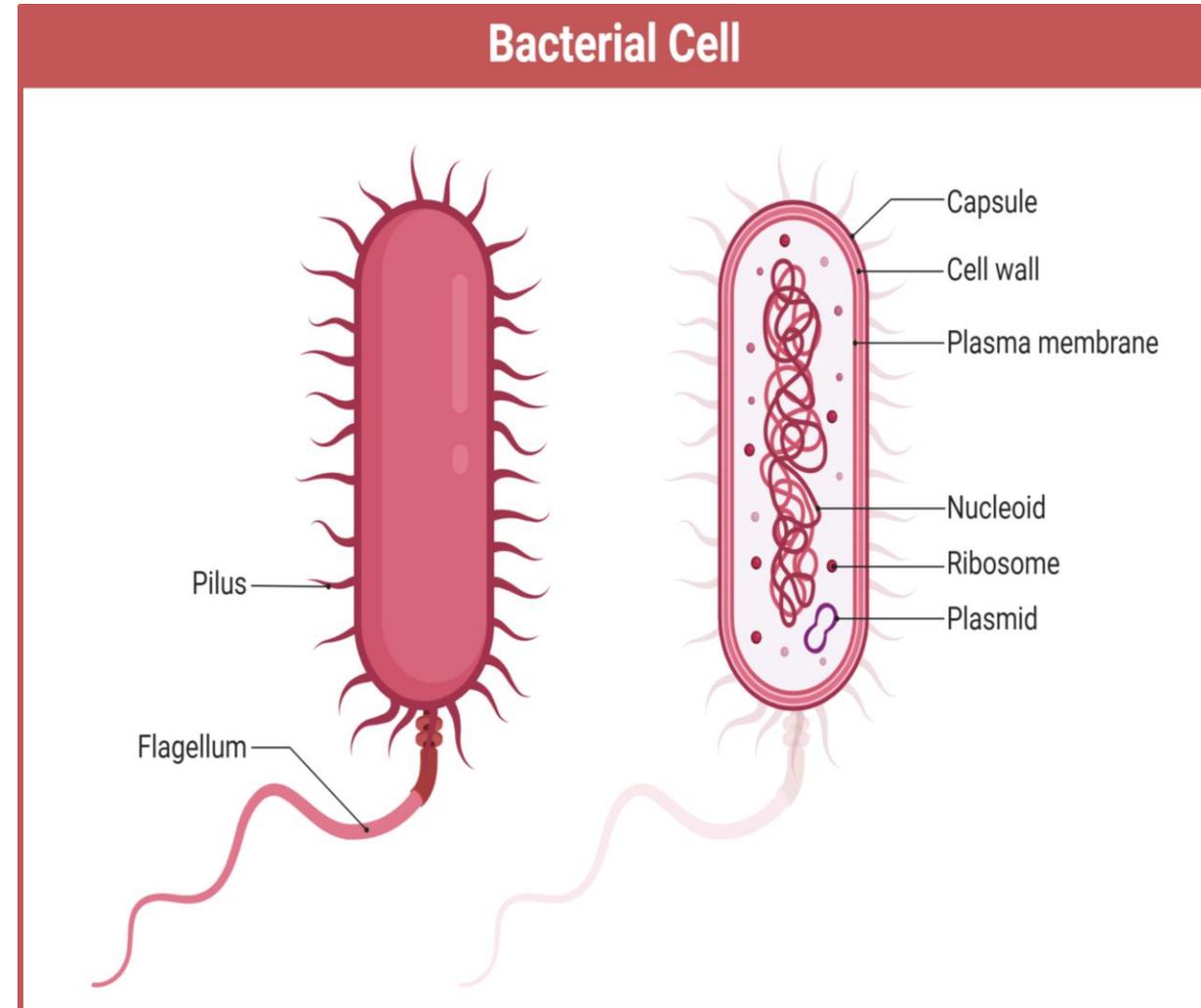

Viruses 0.05-0.1 μm
Mycoplasma 0.1-0.5 μm
Bacteria 1-10 μm
Yeasts 3-10 μm
Eukaryotic cells 10-100 μm
Mycelia 100 μm-several metres

0.05 μm   0.1 μm   0.5 μm   1 μm   5 μm   10 μm   50 μm   100 μm   > 500 μm

Naked eye

Light microscopy

Electron microscopy

Classification of Microorganisms: Prokaryotes

Prokaryotes

Pro = Before

karyon = Nucleus

• Literal meaning:

→ "**before the nucleus**" →
cells **without** a nucleus.

• DNA in nucleoid

Bacterial Cell

- Capsule
- Cell wall
- Plasma membrane
- Nucleoid
- Ribosome
- Plasmid
- Pilus
- Flagellum

Classification of Microorganisms: Prokaryotes

- **Definition: Unicellular** organisms **without a nucleus** or **membrane-bound organelles**

    ✓No nucleus; DNA in nucleoid (usually circular).

    ✓Ribosomes: 70S (30S + 50S).

    ✓Size: ~0.5–5 µm; divide by binary fission; rapid growth.

    ✓Energy: No mitochondria— electron transport chain (ETC) on cell membrane.

- Prokaryotes are primarily organisms belonging to the domains of life called **Bacteria** and Archaea.
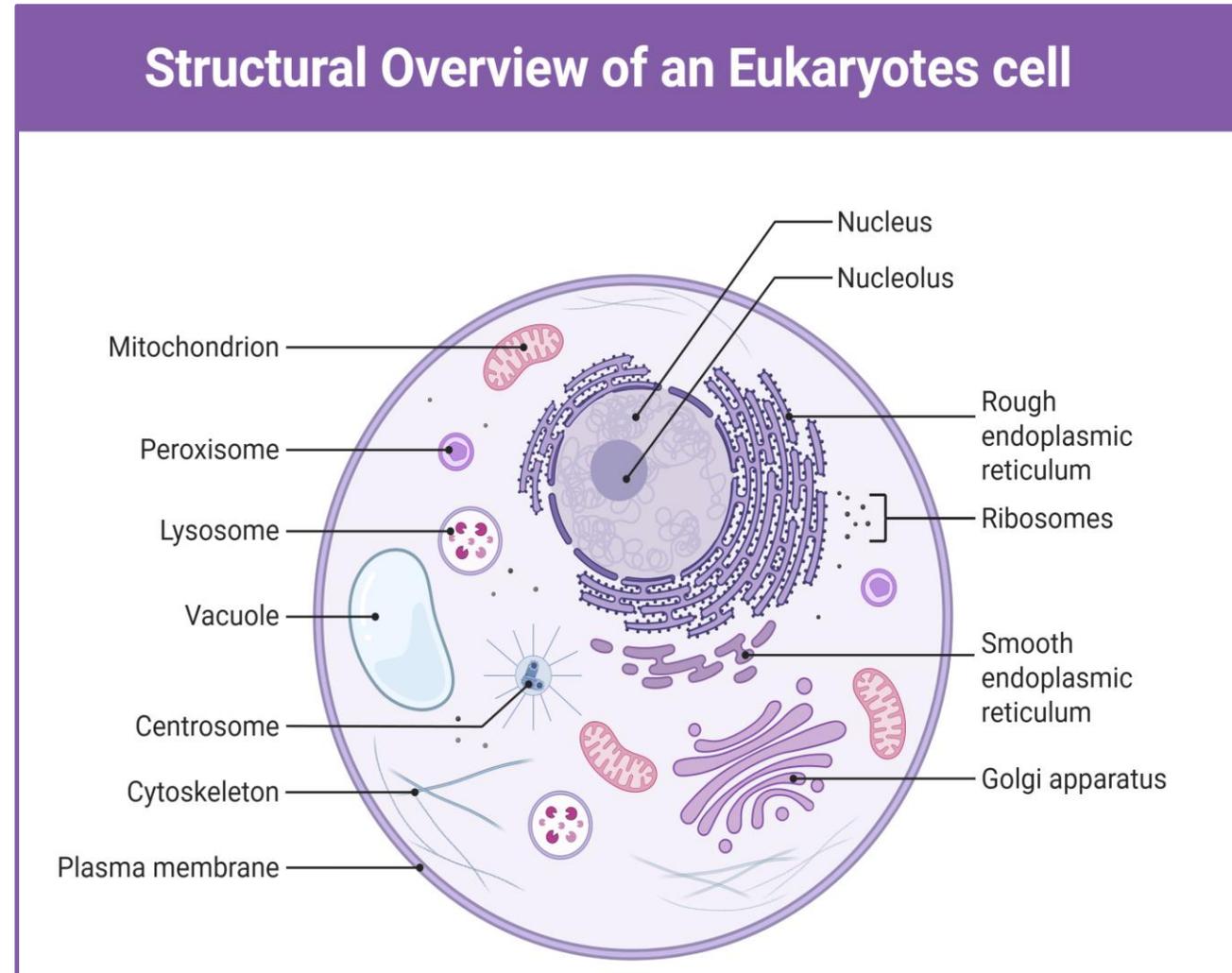
Classification of Microorganisms: Eukaryotes

Eukaryotes

Eu = True

Karyon = Nucleus

- Literal meaning:

→"**true nucleus**" → cells with a nucleus.

Structural Overview of an Eukaryotes cell

- Nucleus
- Nucleolus
- Mitochondrion
- Peroxisome
- Lysosome
- Vacuole
- Centrosome
- Cytoskeleton
- Plasma membrane
- Rough endoplasmic reticulum
- Ribosomes
- Smooth endoplasmic reticulum
- Golgi apparatus

Classification of Microorganisms: Eukaryotes

- **Definition:** Cells with **a nucleus** and **membrane-bound organelles** (mitochondria, endoplasmic reticulum, Golgi apparatus); 80S cytosolic ribosomes.

- **Core features:**
  - ✓Genome: multiple linear chromosomes; transcription in nucleus, translation in cytoplasm.
  - ✓Ribosomes: 80S
  - ✓Energy: Mitochondria (oxidative phosphorylation)
  - ✓Division: mitosis (± meiosis/sex in many).
  - ✓Size: typically, ≥5–100 μm

Prokaryotes vs Eukaryotes — Quick Compare"

Feature	Prokaryotes	Eukaryotes
Nucleus	— (nucleoid)	✓ (true nucleus)
Chromosomes	Usually **single, circular** ± plasmids	**Multiple, linear**
Ribosomes	**70S**	**80S**
Organelles	—	✓ (mitochondria, ER, Golgi)
Cell wall	**Peptidoglycan** (most)	Fungi: **chitin/β-glucan**; protozoa: lack ture cell wall
Division	**Binary fission**	**Mitosis** (± meiosis)
Size	~0.5–5 μm	≥5–100 μm

* Exceptions: Vibrio (2 chromosomes); Borrelia (linear); Mycoplasma (no wall, has sterols).

Classification of Microorganisms: Prions

- Prions are infectious, **misfolded** forms of a normal human **protein** (PrP)

- It propagates by **templating other** PrP molecules **to misfold**

- **PrP^c ("cellular" PrP):** normal host protein on neurons; α-helix–rich, soluble, protease-sensitive, non-pathogenic.

- **PrP^{sc} ("scrapie"/pathogenic PrP):** misfolded form; β-sheet–rich, aggregates, protease-resistant, infectious.

# Classification of Microorganisms: Prions

- Accumulation of PrP^{sc} in CNS → spongiform change (vacuoles), neuronal loss.

- No inflammation and no immune response (it's a self protein, not foreign) ➔ Result: rapidly progressive, fatal neurodegeneration.

- **Notable examples:**
  - Bovine spongiform encephalopathy (BSE) – "mad cow disease" in cattle
  - Creutzfeldt–Jakob disease (CJD) – in humans

- **Transmission:**
  - Transmitted by ingestion.
  - Sometimes iatrogenic route e.g. blood transfusion, reuse of needles or IV sets

How to Reach Me
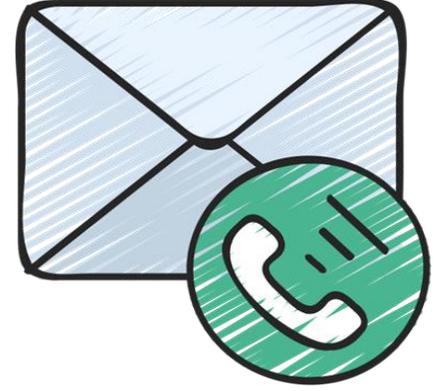
💬 Best way: **Microsoft Teams (chat)**

✉️ Or send me an email: **hala.altarawneh@mutah.edu.jo**

📍 You can find me in my office – **Third Floor**

🕐 I'm available on **Sundays & Wednesdays, 11:00 AM – 1:00 PM**

Just message me first before dropping by ✨