Accra Technical University

Faculty of Applied Sciences

Department of Science Laboratory Technology

Basic Microbiology (SBT 102)

CHAPTER 1

Introduction to the Microbial World

Academic Year 2025 / 2026

Lecturer

Mr. Abubakari Abdul-Wasid

Meet Your Lecturer

MR. ABUBAKARI ABDUL-WASID

Assistant Lecturer, ATU

DAAD PhD Scholar
University of Hamburg / BNITM, Germany

ACADEMIC BACKGROUND

- ✓ **PhD (in progress)** — Microbiology, Univ. of Hamburg / BNITM (2026 - date
- ✓ **MSc** — Microbiology, University of Chinese Academy of Sciences (2024)
- ✓ **BTech** — SLT (Clinical Biochemistry), Accra Technical University (2018)

RESEARCH INTERESTS

- ✓ Antimicrobial Resistance (AMR) & Genomic Surveillance
- ✓ One Health & Wastewater Epidemiology
- ✓ Metagenomics, GWAS & Phylogeography

CONTACT

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Course Information

COURSE CODE & TITLE

- ✓ **SBT 102**
- ✓ **Basic Microbiology (Theory)**
- ✓ Credit Hours: 2
- ✓ Contact Hours: 30

SCHEDULE & FORMAT

- ✓ **2-hour Lecture**
- ✓ Semester Two
- ✓ Active learning format
- ✓ Lectures
- ✓ Discussions + Q&A + Weekly assignments

LEVEL & PROGRAMME

- ✓ **Level 100**
- ✓ **Science Laboratory Technology**
- ✓ Faculty of Applied Sciences

ACADEMIC YEAR

- ✓ **2025 / 2026**
- ✓ **Chapter 1 of a multi-chapter course**
- ✓ Instructor: Mr. Abubakari Abdul-Wasid

Course Structure & Weekly Rhythm

1. Lectures: Two-hour virtual sessions to introduce core concepts, with real-world microbiology examples.

   ✓Delivered on Zoom. Slides shared after each class.

2. Discussion & Q&A: Every lecture ends with an open-floor discussion.

3. Weekly Assignments: Short weekly tasks including reading responses, concept maps, and case studies to consolidate learning and prepare you for the mid-semester and end-of-semester assessments.

Assessment & My Expectations

ASSESSMENT BREAKDOWN

Attendance & Participation	10%
Weekly Assignments	10%
Mid-Semester Examination	20%
End-of-Semester Examination	**60%**

My Expectations

MY EXPECTATIONS FOR YOU

- ✓ Be Present.
- ✓ Be Prepared. Read the assigned chapter before class. Come with questions.
- ✓ Ask questions
- ✓ Respect the microbes

Table of content

Chapter 1: Introduction to the Microbial World

Learning Outcomes

By the end of this 2-hour lecture, every student should be able to:

- Define microbiology and describe the scope of the microbial world.
- Identify the major groups of microorganisms bacteria, archaea, fungi, protozoa, algae, viruses and helminths.
- Trace the historical development of microbiology from Hooke and Leeuwenhoek to CRISPR.
- **Explain** the germ theory of disease and Koch's postulates.
- **Discuss** the importance of microbiology in medicine, agriculture, industry and environmental science.

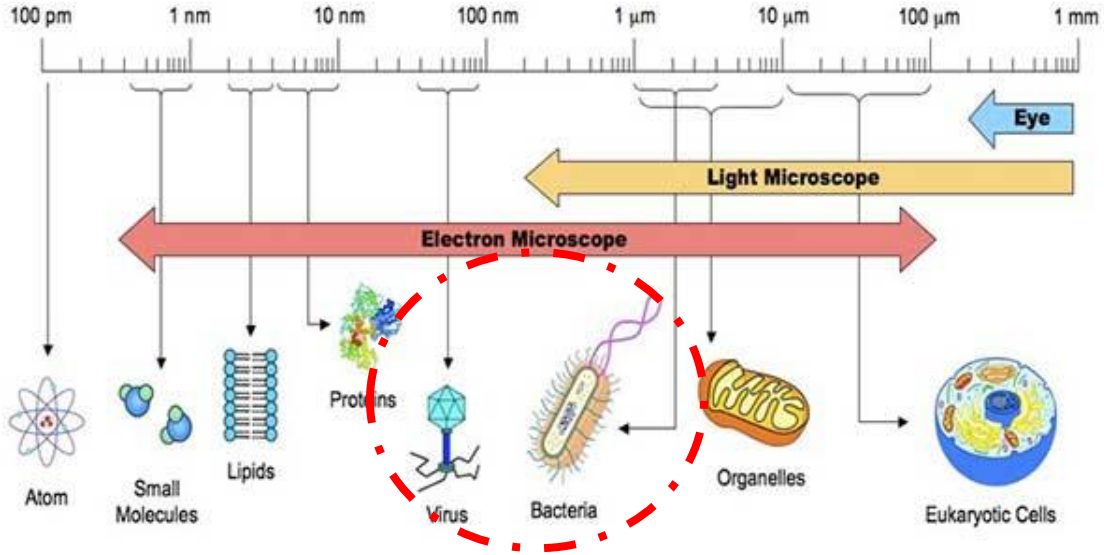
What is Microbiology?

- **Microbiology** is the specialised area of biology that deals with living things ordinarily too small to be seen without magnification.
- Microbiology : the study of small living things. It is a combination of :

✓ micro- : From Greek mikros — small. Too small for the naked eye.

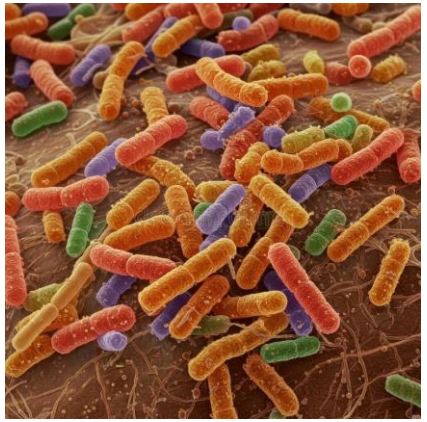
✓ bio-: From Greek bios — life. Living things.

✓ -logy: From Greek logos — the study of a science.



What are Microorganisms?

Microorganisms or microbes are the living things this course is about. They are the ones you cannot see with the naked eye alone.



KEY FEATURES

- Microscopic: typically 0.1 µm to a few hundred µm across.
- Mostly unicellular: one cell does everything a whole organism needs to survive.
- Enormous diversity: bacteria, archaea, fungi, protozoa, algae, viruses, helminths.
- Ubiquitous: found nearly everywhere on Earth.
- Mostly harmless: only a small minority actually cause disease.

Many Names, One Group

You will hear people call microorganisms by many different names. They all point at the same enormous group of living things.

- Animalcules: Historical — the term Leeuwenhoek used in the 1670s.
- Microorganisms: The formal scientific term. Used in textbooks and journals.
- Microbes: The short, everyday name. Very common in research and media.
- Germs: Popular term usually implies "dangerous". Technically imprecise.
- Agents: Medical usage; "infectious agent " of a disease
- Bugs: Informal lab slang ; "the bug that's causing this outbreak."

The Dual Nature of Microbiology

Microbiology has two faces: it is a basic biological science, and it is an applied biological science. You are training in both.

Basic Science

❖ Asking how the microbial world works, without needing to solve a problem right away.

✓Microbial cell structure & physiology

✓Growth, genetics & taxonomy

✓ Microbial evolution

✓ Microbes' interactions with each other and their environment

Applied Science

❖ Using what we know about microbes to solve real-world problems.

- ✓ Medical microbiology & infectious disease
- ✓ Food science, fermentation & safety
- ✓ Agriculture (soil microbes, biofertilisers)
- ✓ Biotechnology, antibiotics, vaccines, biofuels

What Do Microbiologists Actually Study?

- **Cell Structure**: How microbial cells are built.
- **Physiology & Function**: How microbes obtain energy, respire, and carry out chemical reactions
- **Growth & Reproduction:** How populations expand via binary fission, budding, viral replication.
- **Genetics**: Microbial DNA, mutation, gene transfer, and how new traits spread.
- **Taxonomy**: Naming, classifying and identifying microbes.
- **Ecology** How microbes interact with each other, with hosts, and with the environment.

Where do Microbes Live?

Everywhere. That's not an exaggeration.

The Rule of Ubiquity

Microbes are described as "ubiquitous" meaning they are found nearly everywhere.

Wherever there is liquid water and a source of energy, there is life.

From One End Of Earth To The Other

- From frozen Antarctic ice to boiling geothermal vents above 100°C
- From the upper atmosphere to the deepest ocean trenches — 11 km below the surface
- Inside solid rocks, kilometres underground
- Inside every plant, every animal, and every human body

Extremophiles

Some microbes not only survive extreme conditions — they require them. They are called extremophiles.

From One End Of Earth To The Other

- Thermophiles: Love heat. Grow at 45 – 122 °C. E.g. *Thermus aquaticus* — the source of the DNA enzyme used in PCR.
- Psychrophiles: Love cold. Thrive below 15 °C, even in ice. E.g. bacteria beneath Antarctic ice sheets and in glacier meltwater
- Halophiles: Love salt. Live in salt-saturated water. E.g. Halobacterium in the Dead Sea and salt evaporation ponds.
- Acidophiles & Alkaliphiles: Love extreme pH as low as 0 (battery-acid strong) or as high as 12. E.g. microbes in acid mine drainage and alkaline soda lakes.

Microbes Are Also Inside You

Your body is not a sterile machine. You are a walking ecosystem — and the trillions of microbes on and inside you are as much a part of you as your own cells.

Where They Live In You

- Skin: the largest microbial "surface" on your body
- Mouth: hundreds of species between teeth, tongue, cheeks
- Gut: the largest, most diverse microbial community
- Nose, throat & lungs make up the respiratory microbiome
- Urinary & reproductive tracts protective communities

A HUMAN BODY CONTAINS

≈ 40

TRILLION

microbial cells

Roughly the same number as your own human cells.

The Human Microbiome

The **human microbiome** is the community of ~40 trillion microbes that live in and on the human body and the genes they carry.

Three Jobs Your Microbiome Does For You

- Aid Digestion: Gut microbes break down fibres and complex carbohydrates that human enzymes cannot digest releasing energy and short-chain fatty acids.
- Make Vitamins: Bacteria in the gut synthesise Vitamin K (blood clotting) and B-group vitamins that our diet may not fully provide.
- Train the Immune System: Early-life exposure to friendly microbes teaches your immune system to tell friend from foe

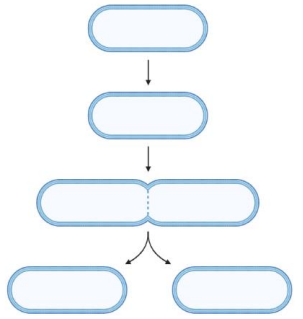
The Major Groups of Microorganisms

Three domains of cellular life, plus the acellular oddities.

The Microbial World at a Glance

Modern biology places every living thing into one of three domains. Viruses and other acellular entities are considered separately — they aren't cells.

- Bacteria: Prokaryotic single cells, Cell walls with peptidoglycan and Reproduce by binary fission. E.g. *E. coli*, Bacillus, Streptococcus
- Archaea: Prokaryotic single cells, Walls lack peptidoglycan & Unique ether-linked lipids. E.g. methanogens, halophiles, hyperthermophiles
- Eukarya: True nucleus + organelles, Uni- or multicellular. Microbial members: fungi, protozoa, algae, helminths
- Acellular Agents: Not living cells, Need a host to replicate, Studied by microbiology. E.g Viruses, Viroids & Prions

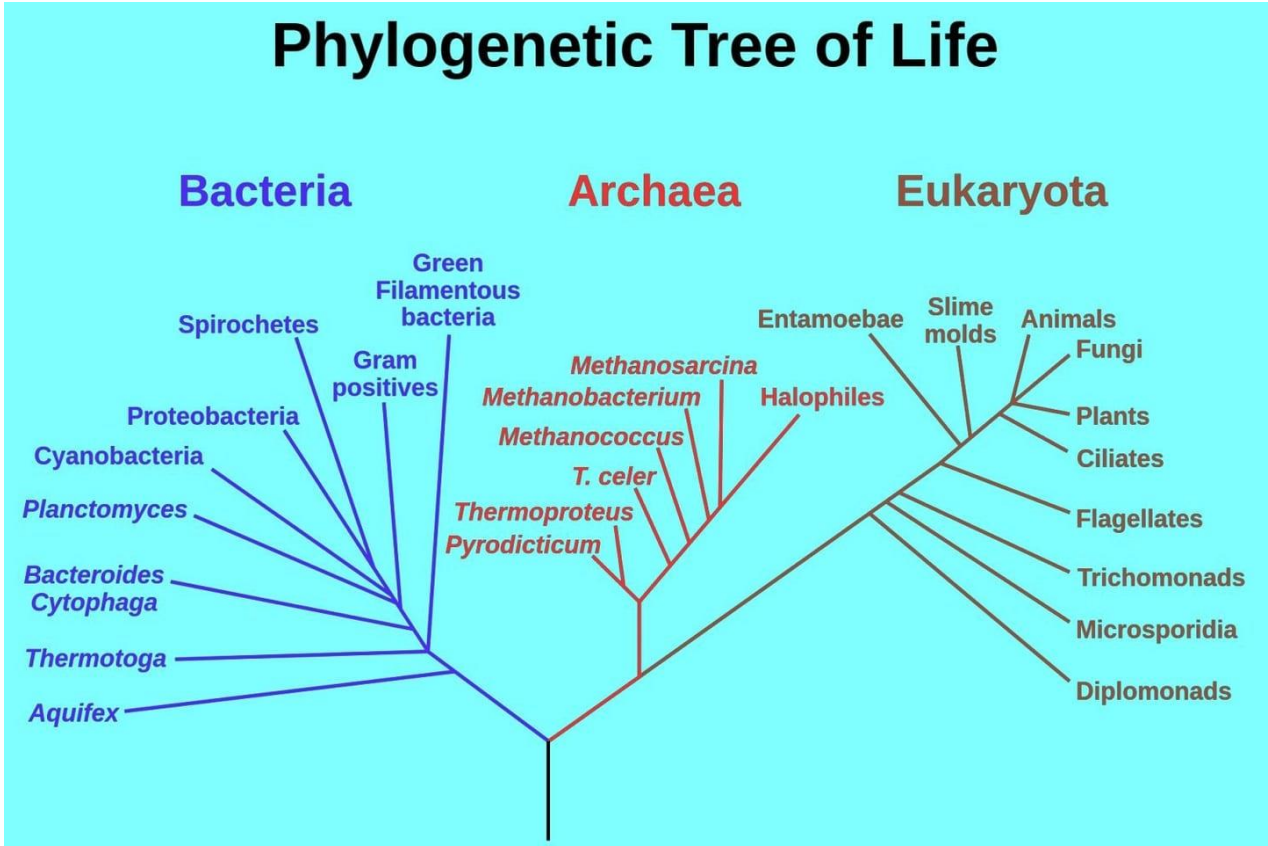


Binary fission

The Phylogenetic Tree of Life

How To Read This Tree

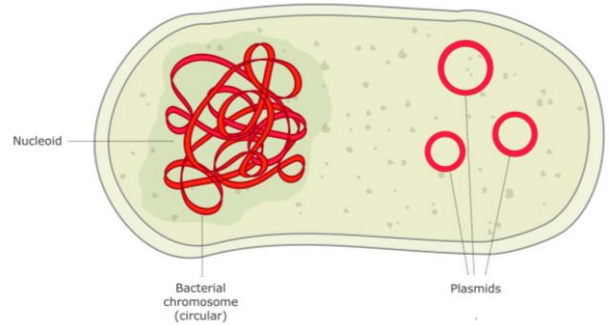
- Every organism is placed on a branch based on shared DNA sequences (especially 16S ribosomal RNA).
- The three domains split from a single ancestor. Notice how much of the tree is microbial — plants and animals are just three thin twigs.
- This system was proposed by Carl Woese in 1977.

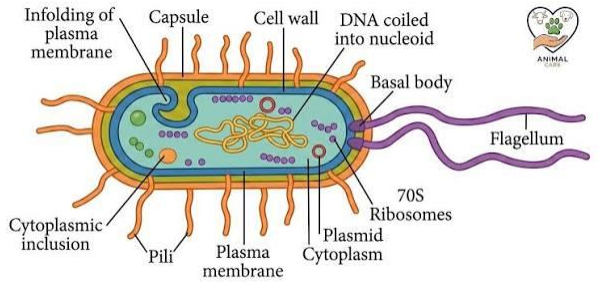


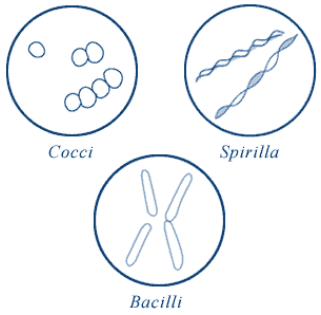
Domain Bacteria

DEFINING FEATURES

- Single-celled prokaryotes: no true nucleus, no membrane-bound organelles
- Cell wall contains peptidoglycan: unique to bacteria
- DNA is a single circular chromosome in the cytoplasm
- Reproduce asexually by binary fission: one cell splits into two identical daughters
- May have flagella (movement), pili (attachment), capsules (protection)
- Three main shapes: cocci (spheres), bacilli (rods), spirilla (spirals)
- Examples: *Escherichia coli,* Staphylococcus aureus, *Bacillus anthracis*, *Mycobacterium tuberculosis*, *Vibrio cholera*, *Salmonella typhi.*



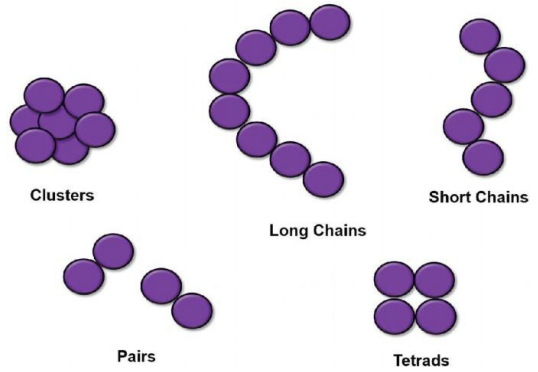




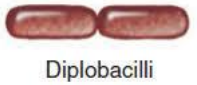
The Three Main Bacterial Shapes

Shape is one of the first things a lab technician looks at under the microscope.

It gives you a quick handle on identity.



- Cocci (singular: coccus): Spherical or oval cells. Arranged in pairs, chains, clusters or grape-like bunches. E.g. Staphylococcus, Streptococcus.
- Bacilli (singular: bacillus): Rod-shaped cells. Straight or curved. Can occur singly or in chains. E.g. *Escherichia coli*, *Bacillus anthracis.*



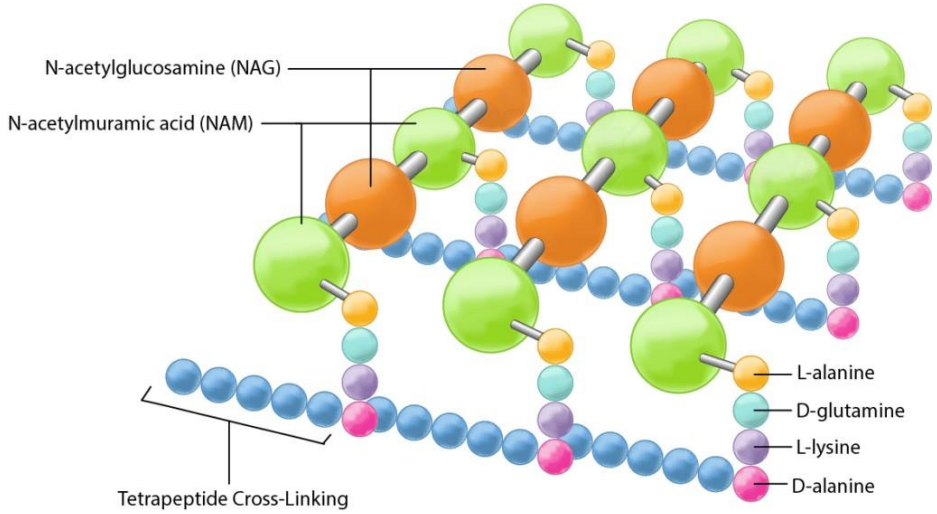
- Spirilla & Spirochetes (helical / spiral shape): Corkscrew-like or wavy cells. Often highly motile. E.g. *Vibrio cholerae*, *Treponema pallidum*

Peptidoglycan

WHY IT MATTERS

Peptidoglycan is a mesh-like polymer that forms the rigid cell wall of bacteria. It gives the cell:

- ❖ Shape : rod, sphere, spiral
- ❖ Rigidity: resists osmotic pressure
- ❖ Protection: physical barrier



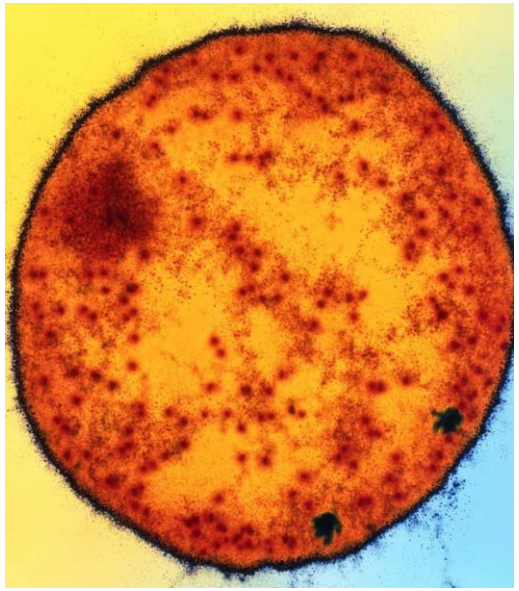
CLINICAL LINK

Penicillin works by **breaking peptidoglycan synthesis**.

Domain Archaea

WHAT MAKES THEM DIFFERENT

- Prokaryotic, like bacteria but a completely separate lineage
- No peptidoglycan. Walls made of pseudomurein, proteins or S-layers
- Unique ether-linked lipids in their membranes
- Genetic machinery (ribosomes, RNA polymerase) looks more like eukaryotes than bacteria
- Often (not always) live in extreme environments
- None are known to cause human disease



DISCOVERED BY

Carl Woese, 1977. He compared ribosomal RNA sequences and realised these "weird bacteria" were actually a third form of life on E arth.

Three Famous Groups of Archaea

GROUP 1

Methanogens: Produce methane gas as a metabolic by-product.

❖ Found in:

- ✓Cow & termite guts
- ✓Swamps & rice paddies
- ✓Sewage treatment plants
- ✓ Deep-sea sediments

❖Major contributors to biogas & global carbon cycling.

❖E.g are; *Methanobrevibacter smithii, Methanosarcina barkeri*

Three Famous Groups of Archaea

GROUP 2

Extreme Halophiles: Require very high salt concentrations to survive — up to 30 % NaCl.

❖ Found in:

- ✓The Dead Sea
- ✓Great Salt Lake, USA
- ✓Solar salt evaporation ponds
- ✓Salted fish and hides

❖Colour salt ponds pink from their bacteriorhodopsin pigment.

❖E.g. *Halobacterium salinarum, Haloferax volcanii*

Three Famous Groups of Archaea

GROUP 3

Hyperthermophiles: Thrive at temperatures above 80°C some grow above 100°C.

❖ Found in:

- ✓Deep-sea hydrothermal vents
- ✓Volcanic hot springs
- ✓Yellowstone geysers

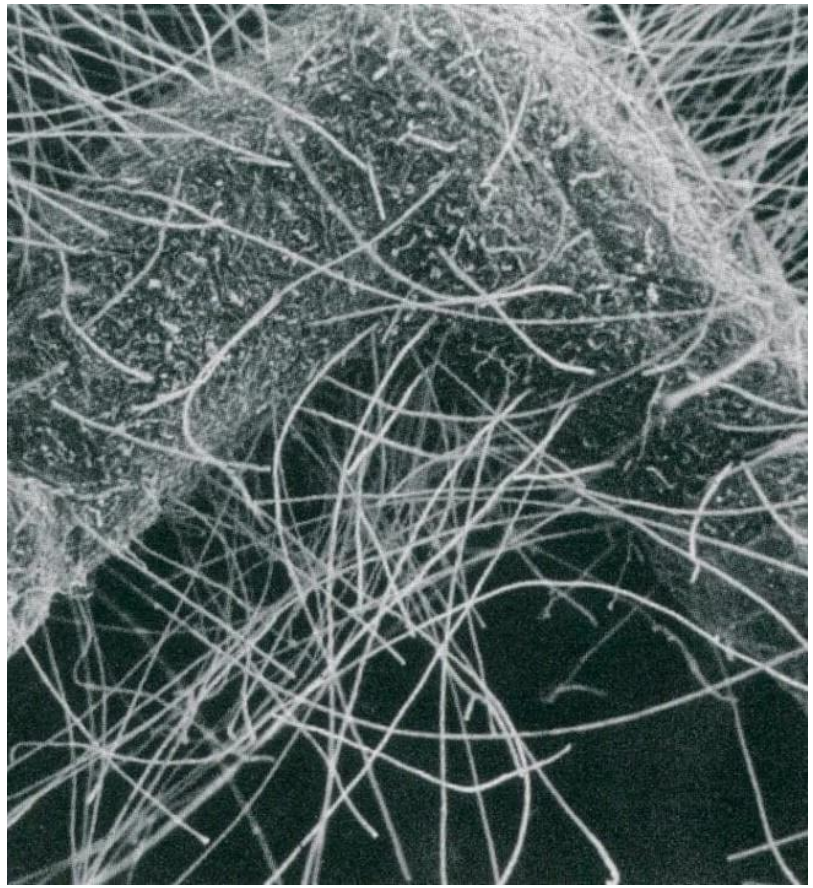
❖Their heat-stable enzymes power modern biotechnology.

❖E.g. *Pyrococcus furiosus, Sulfolobus acidocaldarius*

Eukarya — Kingdom Fungi

Defining Features

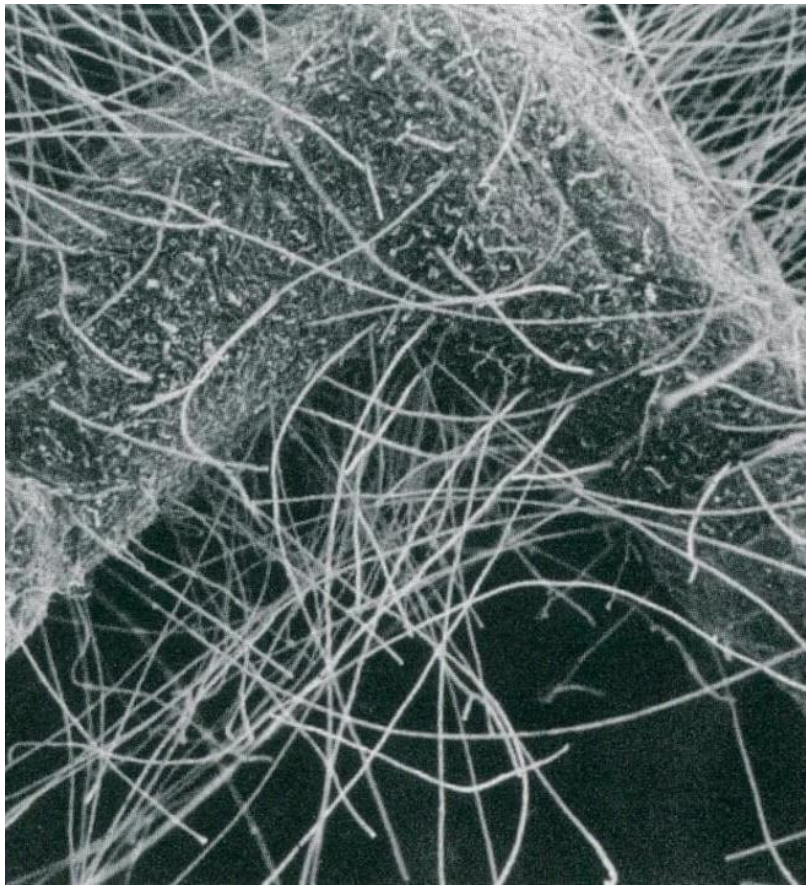
- Eukaryotes have a true nucleus and organelles
- Range from unicellular yeasts to multicellular moulds & mushrooms
- Cell walls made of chitin (not peptidoglycan or cellulose)
- Heterotrophs absorb nutrients from dead or living matter
- Reproduce by spores both sexual and asexual



Eukarya — Kingdom Fungi

Economic Importance

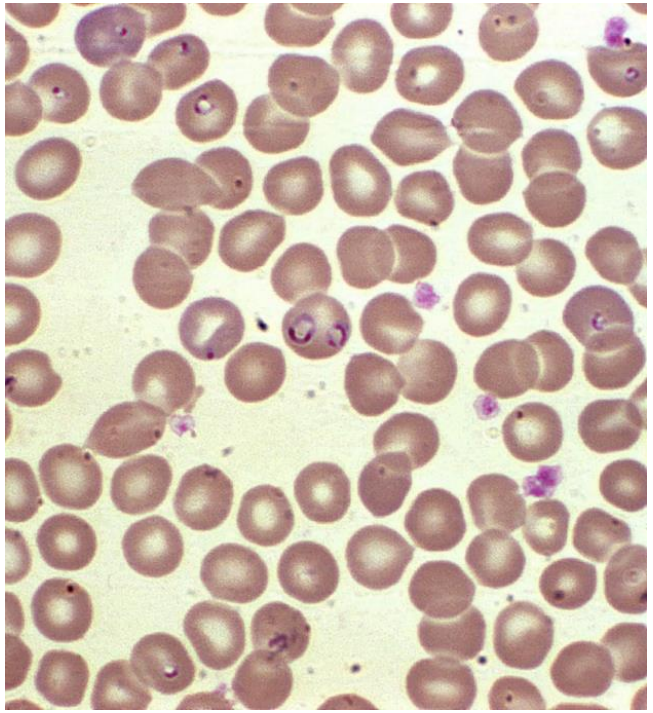
- Decomposers that recycle nutrients in ecosystems
- Yeast (Saccharomyces) — bread, beer, wine
- Source of antibiotics (most famously penicillin)
- Plant pathogens (rusts, smuts) and human infections (athlete's foot, ringworm, thrush)



Eukarya — Protozoa

Defining Features

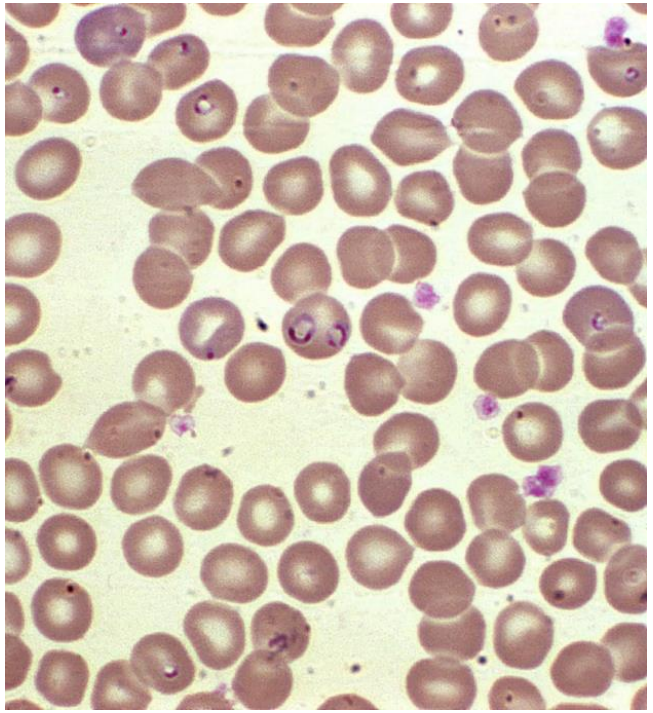
- Unicellular eukaryotes "animal-like" microbes
- No cell wall
- Motile and move using pseudopods, flagella, or cilia
- Ingest food (predators) or absorb it (parasites)
- Live in soil, water, and inside other organisms



Eukarya — Protozoa

Diseases Of Particular Concern In Ghana

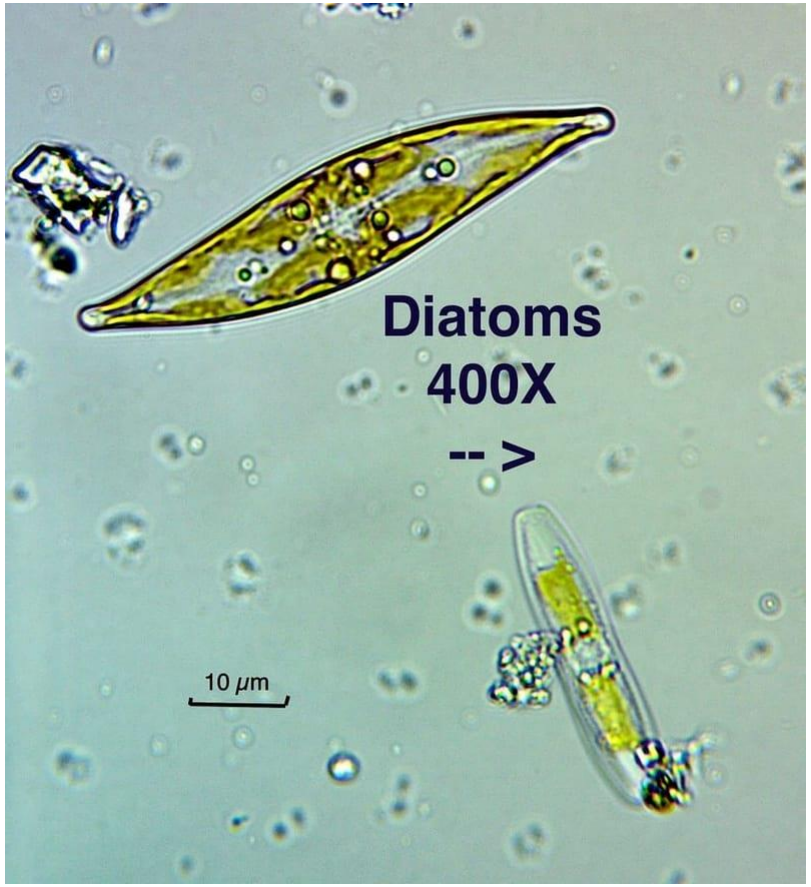
- Malaria: Plasmodium (transmitted by Anopheles mosquitoes)
- Amoebic dysentery: *Entamoeba histolytica*
- Sleeping sickness: *Trypanosoma brucei*
- Giardiasis: *Giardia lamblia*



Eukarya — Algae

Defining Features

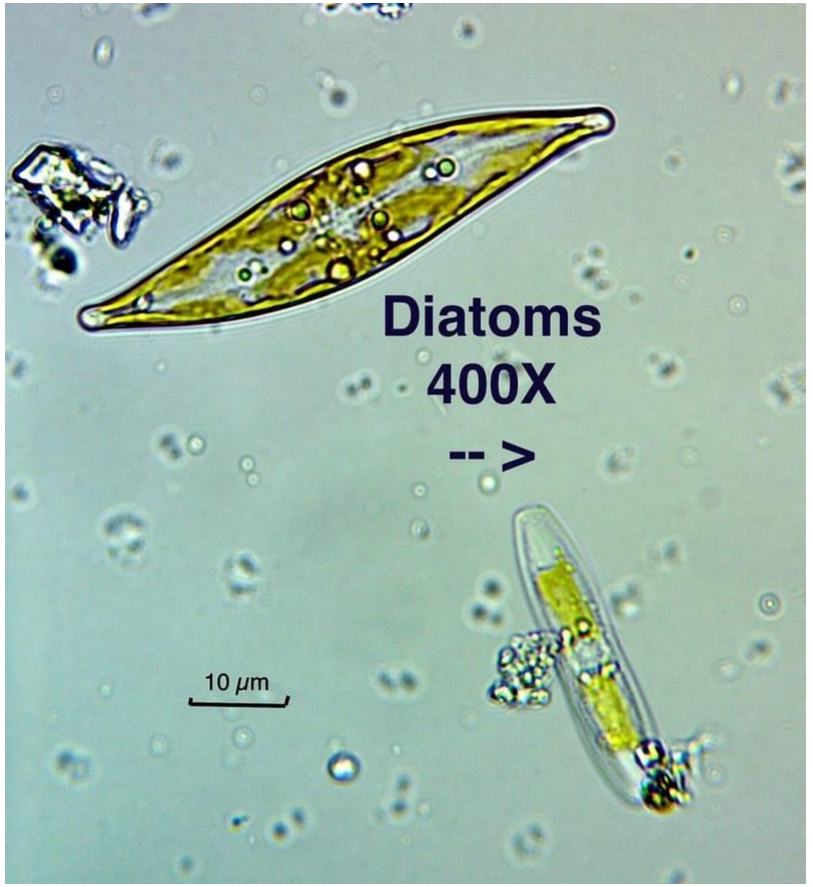
- Photosynthetic eukaryotes produce their own food from sunlight
- Range from unicellular (diatoms) to multicellular seaweeds
- Contain chlorophyll and other pigments
- Cell walls often contain cellulose or silica
- Live mostly in aquatic environments (freshwater & marine)



Eukarya — Algae

WHY THEY MATTER

- Base of the aquatic food web
- Together with cyanobacteria, produce > 70 % of the oxygen on Earth
- Sources of agar, alginates, biofuels, and food supplements
- Can also cause harmful algal blooms ("red tides") that kill fish and contaminate seafood



Eukarya: Helminths (Parasitic Worms)

Helminths are actually visible to the eye animals. So why do microbiologists study them? Because their eggs and larval stages are microscopic, and their diagnosis relies entirely on microscopy.

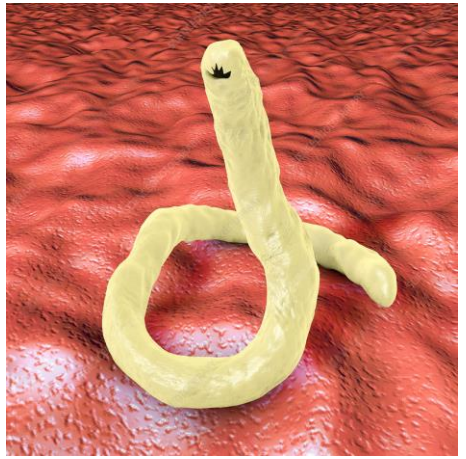
Group 1 — Platyhelminthes: Flatworms

- Flat, ribbon-like body
- Include tapeworms and flukes
- Diseases: schistosomiasis (bilharzia), taeniasis, liver fluke infection
- Transmitted through contaminated water and undercooked meat

Eukarya: Helminths (Parasitic Worms)

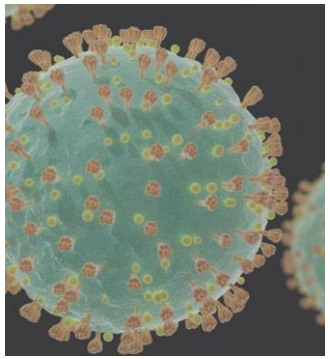
Group 2 — Nematoda: Roundworms

- Cylindrical, unsegmented body
- Include Ascaris, hookworm, Onchocerca (river blindness)
- Diseases: ascariasis, hookworm anaemia, elephantiasis, onchocerciasis
- Major cause of childhood disease in tropical Africa

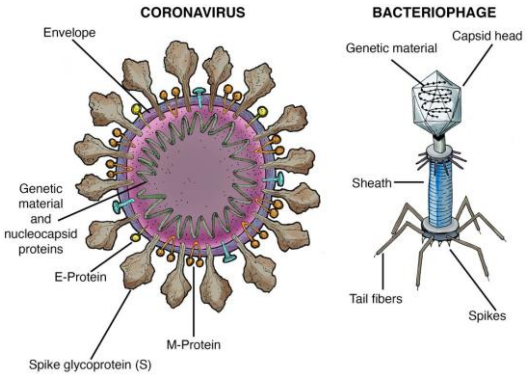


Acellular Agents: Viruses

What Makes A Virus Different



- Not a cell. No cytoplasm, no ribosomes, no metabolism.
- Just a nucleic acid core (DNA or RNA) wrapped in a protein coat (capsid)
- Some also have an outer lipid envelope stolen from a host cell
- Cannot reproduce on their own; obligate intracellular parasites
- Extremely small: 20 – 300 nm, needing an electron microscope to see
- Infect every domain of life; humans, plants, even bacteria (bacteriophages)
- Example: HIV, Influenza, SARS-CoV-2, Hepatitis A/B/C, Measles, Ebola, Rabies, HPV, Polio.



Viroids & Prions

If viruses seem strange, these are stranger. They challenge the very idea of what "an infectious agent" looks like.

TYPE 1:Viroids

Infectious agents that have a short strand of RNA, no protein coat at all.

- Smaller than viruses (~250 – 400 nucleotides)
- Cause serious plant diseases: potato spindle tuber disease, coconut cadang-cadang, avocado sunblotch
- Do not encode any proteins — they hijack the plant's own enzymes
- Discovered by Theodor Diener in 1971

Viroids & Prions

TYPE 2: Prions

Infectious agents made entirely of misfolded protein — no nucleic acid at all.

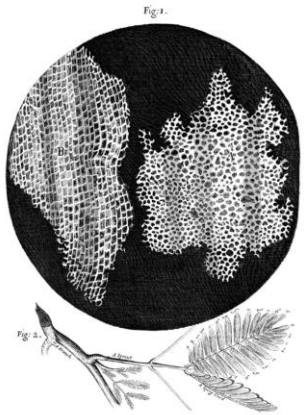
- Convert normal proteins into misfolded copies of themselves
- Cause fatal brain diseases in humans and animals
- Examples: Creutzfeldt-Jakob Disease (CJD), "mad cow disease" (BSE), scrapie in sheep, kuru
- Resistant to heat, radiation and disinfectants that destroy viruses

A Short History of Microbiology

From a merchant's homemade lens to CRISPR in about 350 years.

Robert Hooke: The First to See "Cells"

A Slice of Cork Changes Biology in 1665



- Using a compound microscope of his own design, the English polymath Robert Hooke looked at a thin slice of cork and saw tiny, empty compartments. They reminded him of the small rooms cellae that monks lived in.
- He called them "cells". The word and the beginning of cell biology has been with us ever since.

HIS LEGACY

- Coined the term "cell“: the basic unit of life
- Published Micrographia (1665): the first popular science book
- Set the stage for the cell theory that would emerge two centuries later

Antoni van Leeuwenhoek: Father of Microbiology

A Cloth Merchant Discovers Life Invisible to the Human Eye in Netherlands

1670s – 1723

- Leeuwenhoek was not a scientist by training. He was a linen merchant with a passion for grinding tiny, single-lens microscopes. His best could magnify up to 275×.
- Looking at pond water, rainwater, and scrapings from his own teeth, he was the first person in history to see live bacteria and protozoa.

What He Called Them: Animalcules"

- His term for the tiny "little animals" moving through the water. He sent hundreds of letters describing them to the Royal Society in London.

The Great Debate: Spontaneous Generation

THE OLD IDEA

For over 2,000 years, people believed that living things could arise spontaneously from non-living matter; maggots from meat, mice from grain, and microbes from broth.

Why It Mattered For Microbiology

- When Leeuwenhoek's animalcules kept "appearing" in every jar of nutrient broth, the natural conclusion was: the broth is generating them from nothing.
- If that were true, microbes could not be studied like other living things, every experiment would just breed a new batch of them out of thin air.

Microbiology as a science could not begin until this idea was disproved.

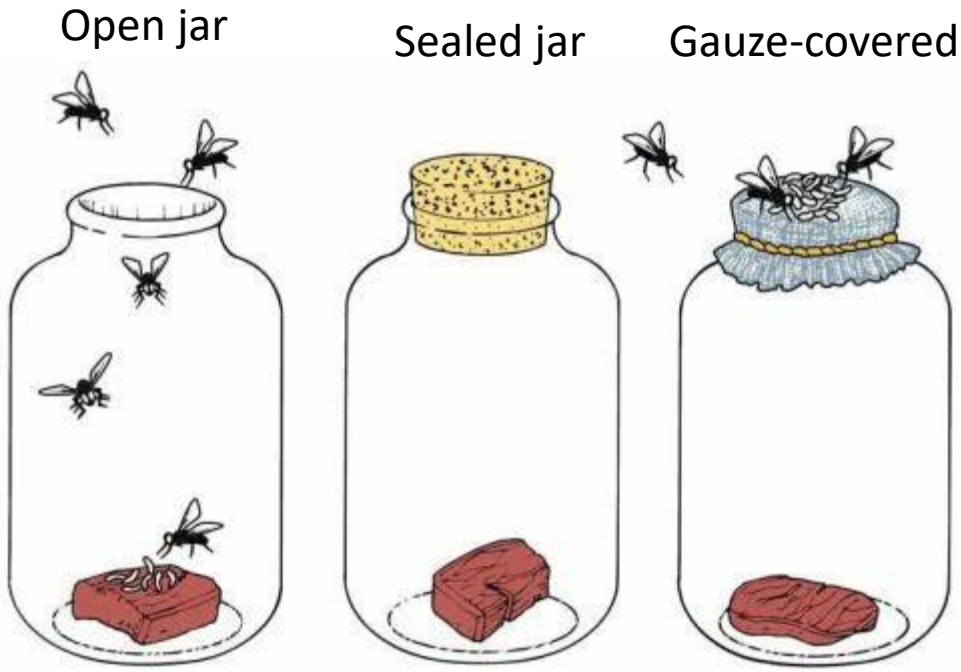
The Great Debate: Spontaneous Generation

THE NEW IDEA — BIOGENESIS

Living things come only from other living things. Establishing this took a series of clever experiments over 200 years from Redi to Pasteur.

Francesco Redi's Jar Experiment (1668)

Italian physician Francesco Redi set out to disprove the idea that maggots arise spontaneously from rotting meat. He designed a beautifully simple experiment, the first known controlled biological experiment.



Meat exposed to air. Flies can land.	No air, no flies.	Meat exposed to air. Flies can land.
MAGGOTS appear	**NO maggots**	**NO maggots**

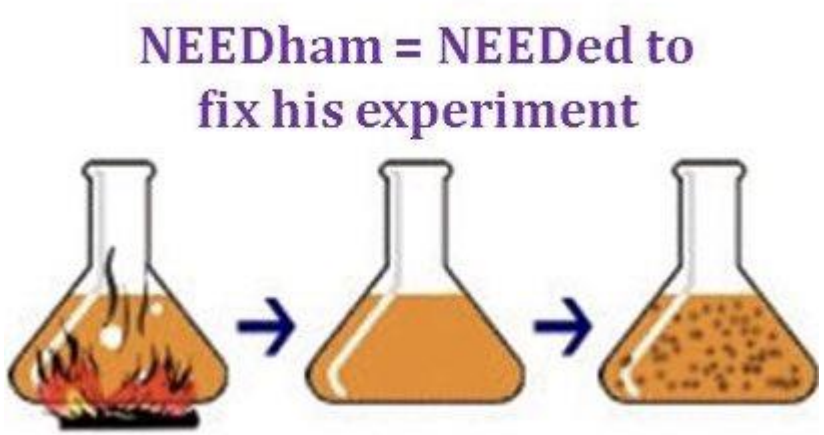
Conclusion: Maggots do NOT come from meat. They come from eggs laid by flies. Life comes from life.

John Needham: 1745 in ENGLAND

Redi settled the maggots question but what about the microbes Leeuwenhoek saw in broth? Two rival scientists tried to answer.

- Experiment: Boiled nutrient broth, poured into a flask, sealed with cork, and waited.
- Result: Broth turned cloudy, full of microbes.
- His conclusion: Boiling should have killed everything. So microbes must have arisen spontaneously from the broth itself. Score one for spontaneous generation!

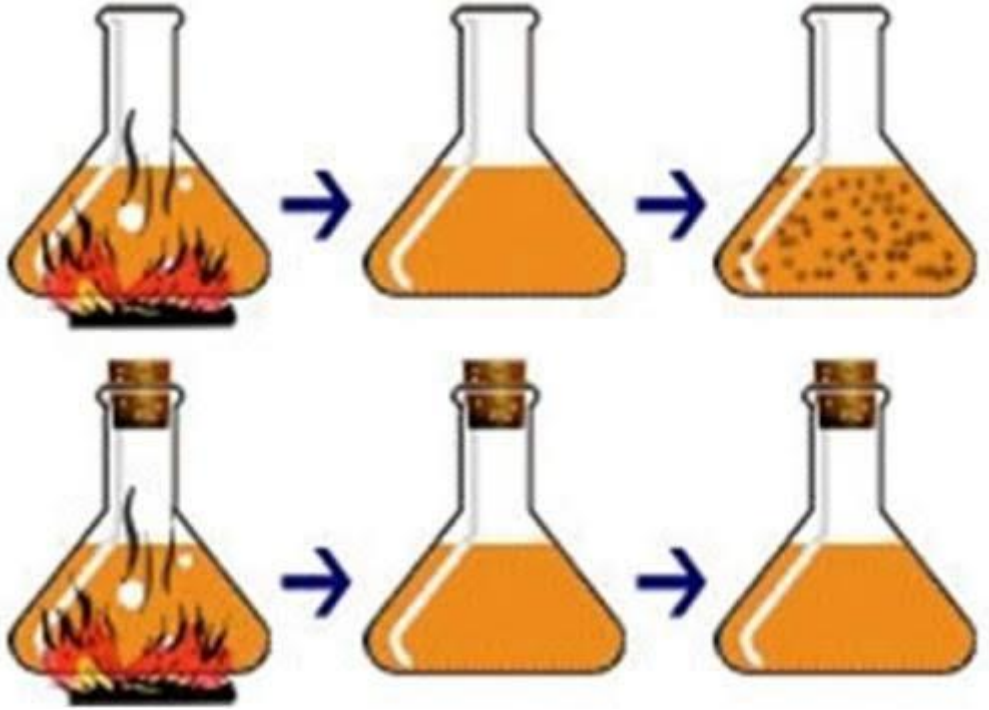
"Spontaneous generation IS real"



Lazzaro Spallanzani: 1765 in ITALY

"Not so fast: Needham didn't boil long enough".

- Experiment: Boiled broth in flasks that were hermetically sealed (fused shut) for over an hour.
- Result: Broth remained clear indefinitely.
- His conclusion: Needham's broth was contaminated after boiling. Sealed properly, no microbes appear. Score for biogenesis!



Louis Pasteur: The Man Who Settled It

A Chemist Who Changed Medicine, Food and Farming

Trained as a chemist, Pasteur was called in by the French wine industry to find out why some bottles were going sour. He answered that question and, in doing so, invented modern microbiology.

Louis Pasteur (1822 – 1895), France.

HIS FOUR BIG WINS

1.Ended the spontaneous generation debate with his swan-neck flasks (1861)

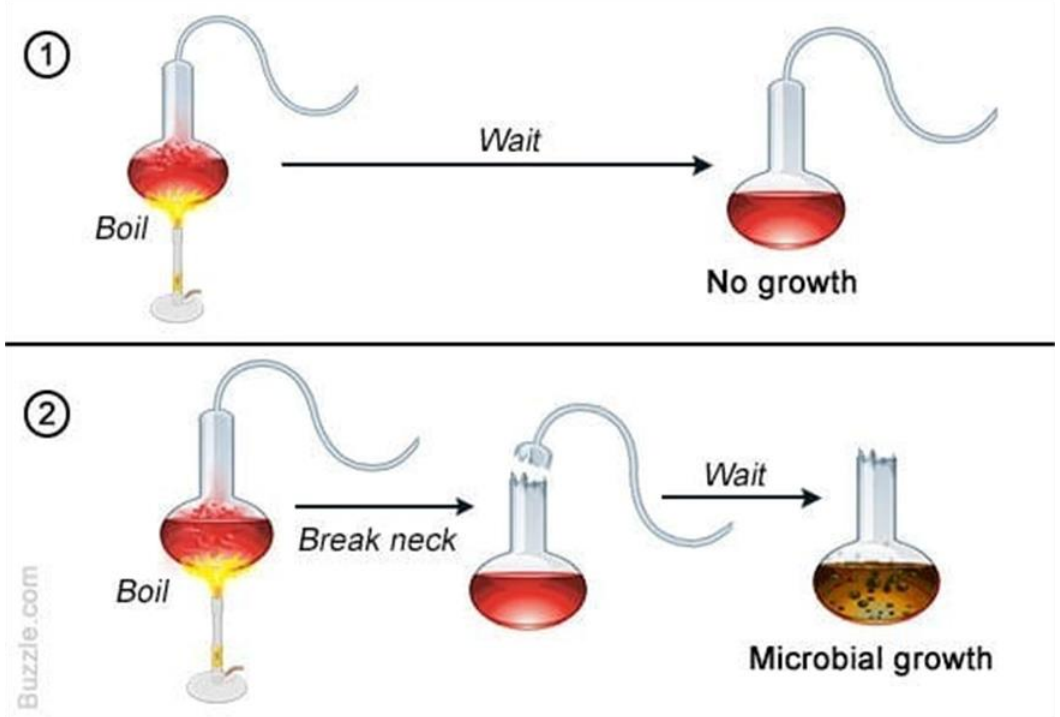
2. Established biogenesis; life from life

3. Invented pasteurisation; gentle heat to kill spoilage microbes without ruining food

4. Developed vaccines against rabies, anthrax and chicken cholera

Pasteur's Swan-Neck Flask Experiment (1861)

- Pasteur used flasks with a long S-shaped ("swan") neck.
- Air could flow in freely but microbes and dust got trapped in the bend and never reached the broth.
- Broth stayed sterile for months even years despite exposure to air
- The moment he broke off the neck, microbes contaminated the broth within hours



VERDICT

Spontaneous generation is DEAD. Life comes from life.

CONTRIBUTION 1: Pasteurisation

Pasteurisation: A gentle heating process typically 63°C for 30 min or 72°C for 15s that kills most spoilage microbes and pathogens without destroying flavour or nutrients.

❖ Still Used Today For:

- ✓Milk — the most famous application
- ✓Wine and beer — the original 1864 use
- ✓Fruit juices, honey, canned foods

CONTRIBUTION 2: The First Vaccines

The First Vaccines: Pasteur discovered that weakened (attenuated) microbes could be used to train the immune system to fight the real disease — the modern principle of vaccination.

❖ HIS VACCINES:

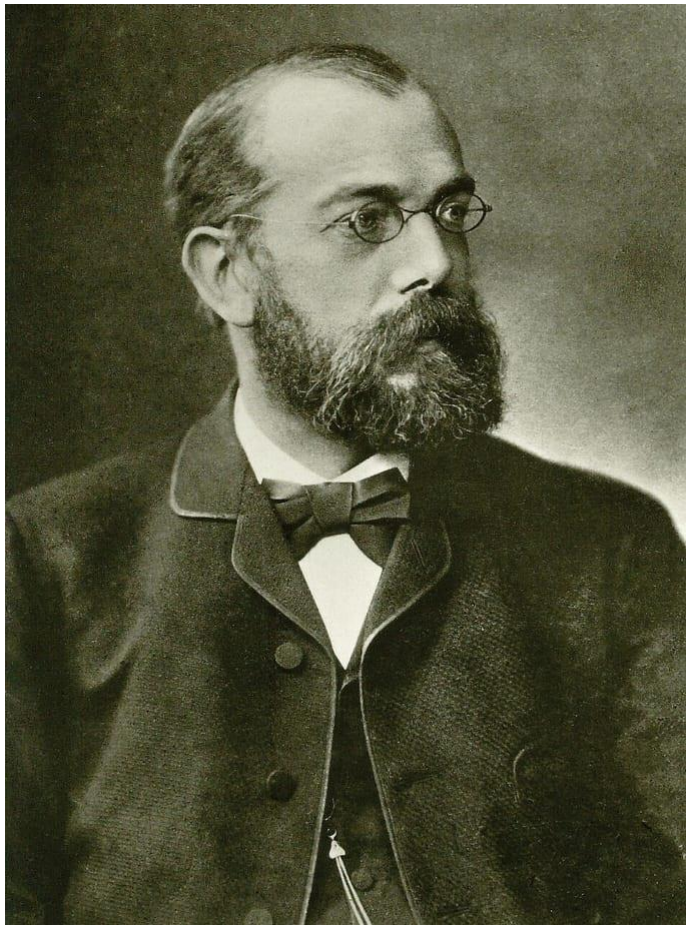
- ✓Chicken cholera in 1879
- ✓Anthrax in livestock in 1881
- ✓Rabies in humans in 1885 (first patient: a boy named Joseph Meister)

❖The word "vaccine" itself comes from Pasteur, honouring Edward Jenner's earlier work with cowpox (vacca = cow).

Robert Koch: Proving the Germ Theory

A Country Doctor Nails Down "Which Microbe Causes What Disease in Germany from 1843 – 1910.

- Pasteur suggested microbes could cause disease. Koch proved it: one disease, one pathogen at a time and gave the world a rigorous method to do so.



Robert Koch: Proving the Germ Theory

❖ MAJOR DISCOVERIES

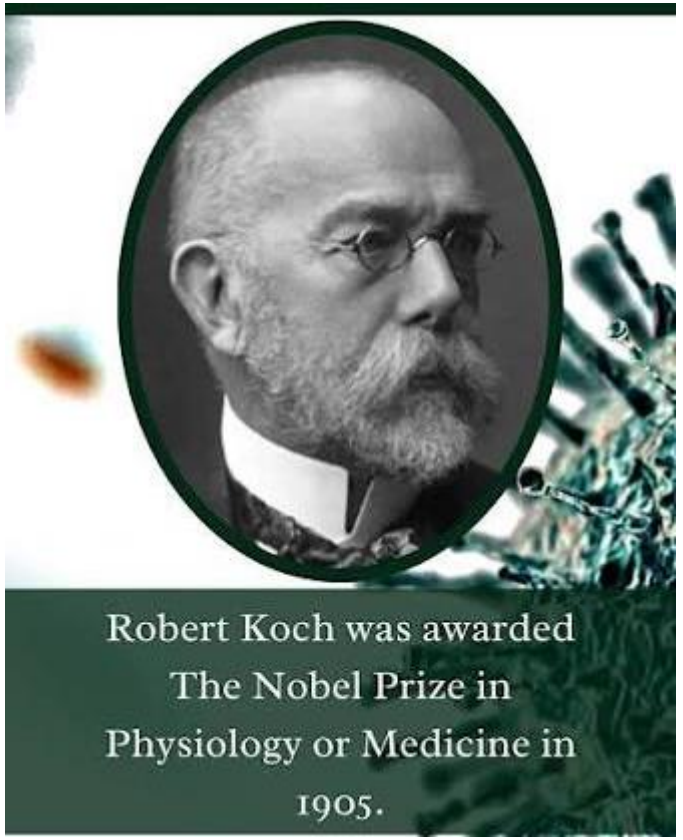
✓Proved *Bacillus anthracis* causes anthrax (1876) — first bacterium linked to a disease

✓Discovered *Mycobacterium tuberculosis*, the cause of TB (1882)

✓ Discovered *Vibrio cholerae*, the cause of cholera (1883)

✓Introduced solid agar culture media and the Petri dish (with Julius Petri & Fanny Hesse)

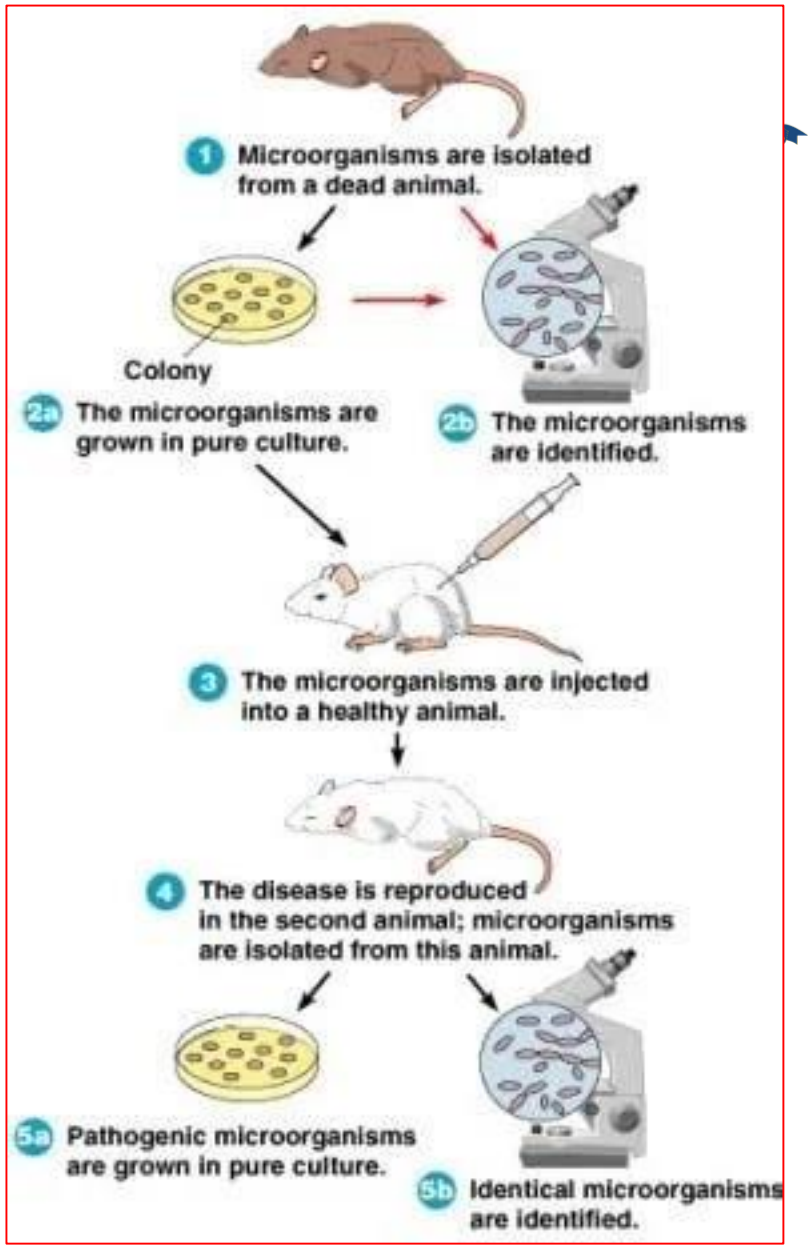
✓Awarded the 1905 Nobel Prize in Physiology or Medicine



Koch's Four Postulates

Four rules to establish that a specific microbe causes a specific disease. Still used with modern updates today.

1) The microbe must be present in every diseased organism and absent in healthy ones.
2) The microbe must be isolated from the diseased host and grown in pure culture in the lab.
3) Introduced into a healthy host, the cultured microbe must cause the same disease.
4) The same microbe must then be recovered from that newly diseased host identical to the original.



Cleaning Hospitals: Semmelweis, Lister & Nightingale

Three pioneers who realised that cleanliness saves lives decades before germ theory was accepted.

Ignaz Semmelweis in Hungry in 1847: The father of hand hygiene

- Observed that women in a doctors' maternity ward died of "childbed fever" at 5× the rate of a midwives' ward.
- Introduced chlorinated lime handwashing for doctors — deaths dropped by 90%.
- His colleagues ridiculed him. He died in an asylum before germ theory vindicated him.

Cleaning Hospitals: Semmelweis, Lister & Nightingale

Three pioneers who realised that cleanliness saves lives decades before germ theory was accepted.

Joseph Lister in Scotland in 1867: "The father of antiseptic surgery"

- Reading Pasteur's work, Lister reasoned that microbes could infect surgical wounds.
- He introduced phenol (carbolic acid) to sterilise wounds, instruments and surgical rooms.
- Post-operative infection rates collapsed. The mouthwash "Listerine" is named after him.

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Florence Nightingale in Crimea in 1854: "The founder of modern nursing"

- In a British military hospital in Turkey, she used statistics to show that sanitation, ventilation and clean bedding lowered soldier mortality.
- A pioneer of infection control long before it had that name.

Cohn & Tyndall — Discovering Endospores

Two contemporaries of Pasteur explained why some broth samples still grew microbes even after prolonged boiling.

Ferdinand Cohn in Germany in 1876: Founder of Modern bacteriology

- Discovered that some bacteria (especially Bacillus) produce endospores, a dormant, thick-walled survival capsules.
- Endospores can survive:
  - ✓Boiling water (100 °C) for hours
  - ✓Extreme dehydration & UV radiation
  - ✓Many disinfectants

This is why we need autoclaving (121°C, high pressure) in the lab, not just boiling.

Cohn & Tyndall — Discovering Endospores

Two contemporaries of Pasteur explained why some broth samples still grew microbes even after prolonged boiling.

John Tyndall in England in 1877 The Tyndalization method

- Showed that microbes are carried by dust in the air, and that some are heat-resistant.
- Invented Tyndallization: repeated cycles of heating and cooling that first kill vegetative cells, then let surviving spores germinate so they can be killed on the next round.
- A cornerstone of early sterilisation science.

Paul Ehrlich: The First Targeted Drug

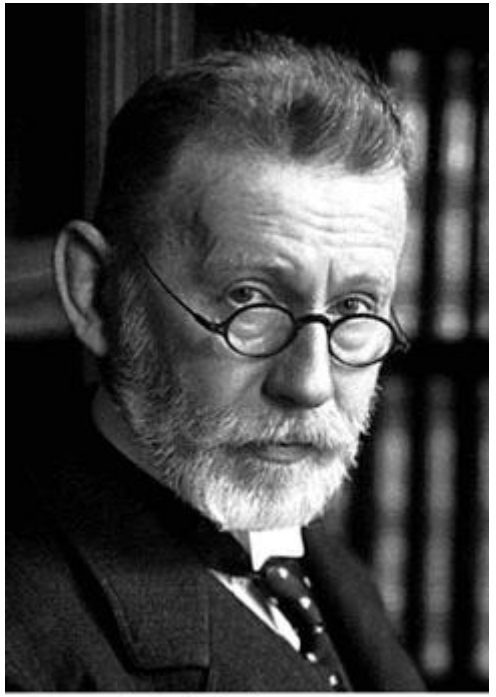
Chemotherapy Begins, the Search for the "Magic Bullet.

- Ehrlich had a radical idea: instead of scrubbing the whole body with antiseptics, could we design a chemical that kills the microbe but leaves the human cell untouched? He called it a "magic bullet".
- After screening over 600 arsenic-based compounds, his team found compound #606 and later named it Salvarsan which effectively treated syphilis (caused by *Treponema pallidum*).

Paul Ehrlich: The First Targeted Drug

WHY IT MATTERED

- ✓ First truly effective drug against a bacterial disease
- ✓ Launched the field of chemotherapy
- ✓ Introduced the systematic screening approach still used by pharma today
- ✓ Ehrlich also won a 1908 Nobel Prize for immunology work



Paul Ehrlich (1854-1915)

EHRLICH'S BIG IDEA

"We must learn to shoot microbes with magic bullets."

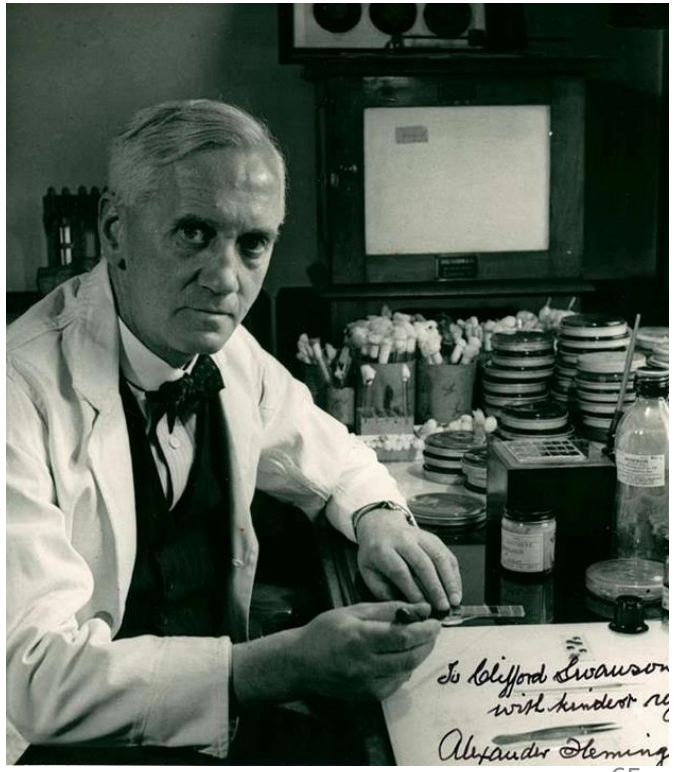
— Every antibiotic and antiviral drug that followed is built on this idea of **selective toxicity**.

Alexander Fleming: The Lucky Petri Dish (1928)

A Contaminated Plate Becomes the Most Important Antibiotic in History.

- Returning from vacation, Fleming noticed that one of his Staphylococcus plates had been contaminated with a blue-green mould and that a clear ring of dead bacteria surrounded the mould.
- The mould was *Penicillium notatum*. It was producing a substance that killed bacteria. Fleming called it penicillin.

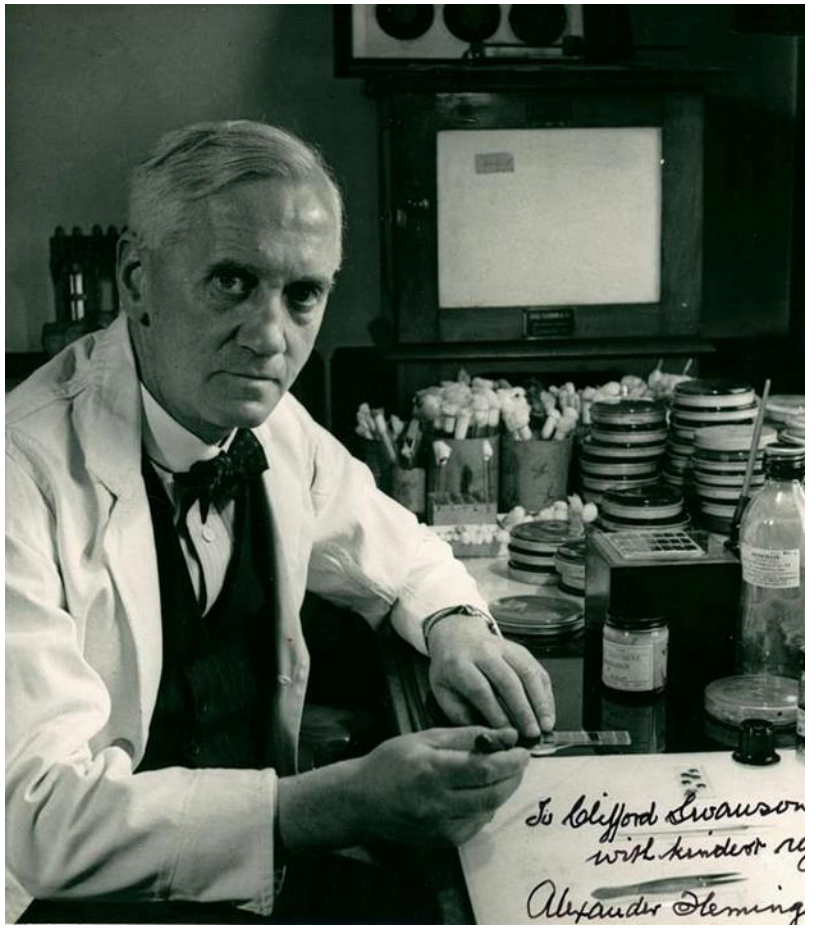
SCOTLAND / UK in 1881 – 1955



Alexander Fleming: The Lucky Petri Dish (1928)

WHY IT MATTERED

- ✓ First natural antibiotic began the antibiotic era
- ✓ Mass-produced from 1941 saved countless lives in WWII
- ✓ Fleming, Florey & Chain shared the 1945 Nobel Prize
- ✓ Its overuse today is why we now face antimicrobial resistance (AMR) a topic I am researching directly



The Modern Era from PCR to CRISPR

The last 50 years: microbiology becomes a molecular science.

50 Years of Molecular Milestones

1970s: The Molecular Toolkit Arrives

Discovery of **restriction enzymes** (Nathans, Smith, Arber in 1978 Nobel); the "molecular scissors" that made recombinant DNA possible. Genetic engineering is born.

1983: PCR Is Invented

Kary Mullis invents the **Polymerase Chain Reaction (PCR)**. Suddenly, tiny amounts of DNA can be amplified a billion-fold enabling diagnostics, forensics, and the entire modern DNA industry. (Nobel Prize, 1993.)

2000s: Small RNAs & the RNA Revolution

Recognition that tiny RNA molecules (**microRNA, siRNA**) regulate gene expression. New drug classes and vaccine platforms follow.

2012: Human Microbiome Project (Phase 1)

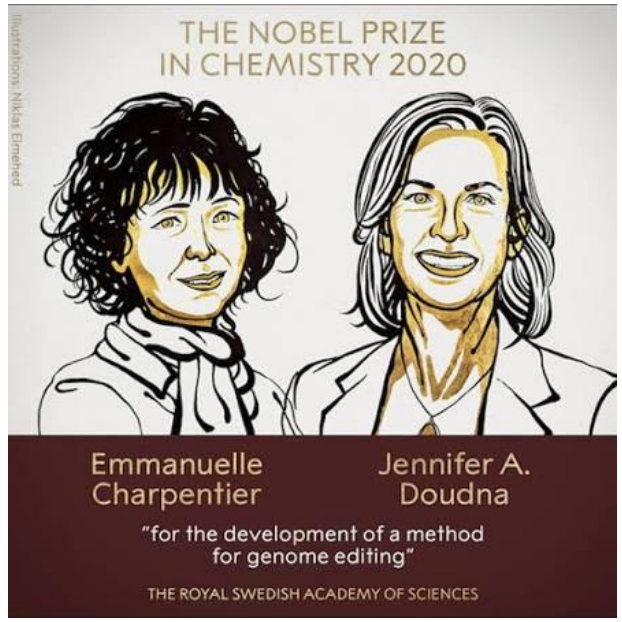
A large international effort catalogues the microbes that inhabit the healthy human body laying the groundwork for microbiome medicine.

2012: CRISPR-Cas9 Gene Editing

Doudna & Charpentier re-engineer a *bacterial immune system* into a precise gene-editing tool. Nobel Prize in Chemistry, 2020.

CRISPR: A Bacterial Weapon Turned Human Tool

CRISPR-Cas9 is a natural bacterial immune system that scientists have hijacked to edit any DNA sequence in almost any organism, with unprecedented precision.

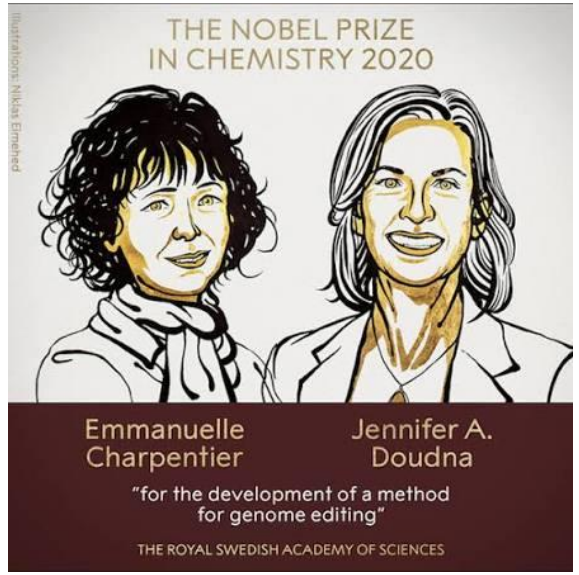


The Biology Behind It

- Bacteria use CRISPR to remember viruses that have attacked them: they keep short DNA scraps from past invaders as "mugshots".
- When the virus attacks again, a scissor-like enzyme called Cas9 uses the mugshot as a guide to find and cut the invader's DNA.
- Scientists realised: we can supply our own guide RNA — and cut whatever DNA sequence we want.

CRISPR: A Bacterial Weapon Turned Human Tool

What It Lets Us Do



- Cure genetic diseases; first CRISPR therapies (e.g. for sickle cell disease) were approved in 2023
- Create disease resistant crops
- Rapidly diagnose infectious diseases e.g. CRISPR-based tests for TB, HIV, COVID-19
- Build "gene drives" to fight malaria mosquitoes
- Study any gene's function replacing years of work with days

Nobel Prize in Chemistry, 2020 to Jennifer Doudna & Emmanuelle Charpentier.

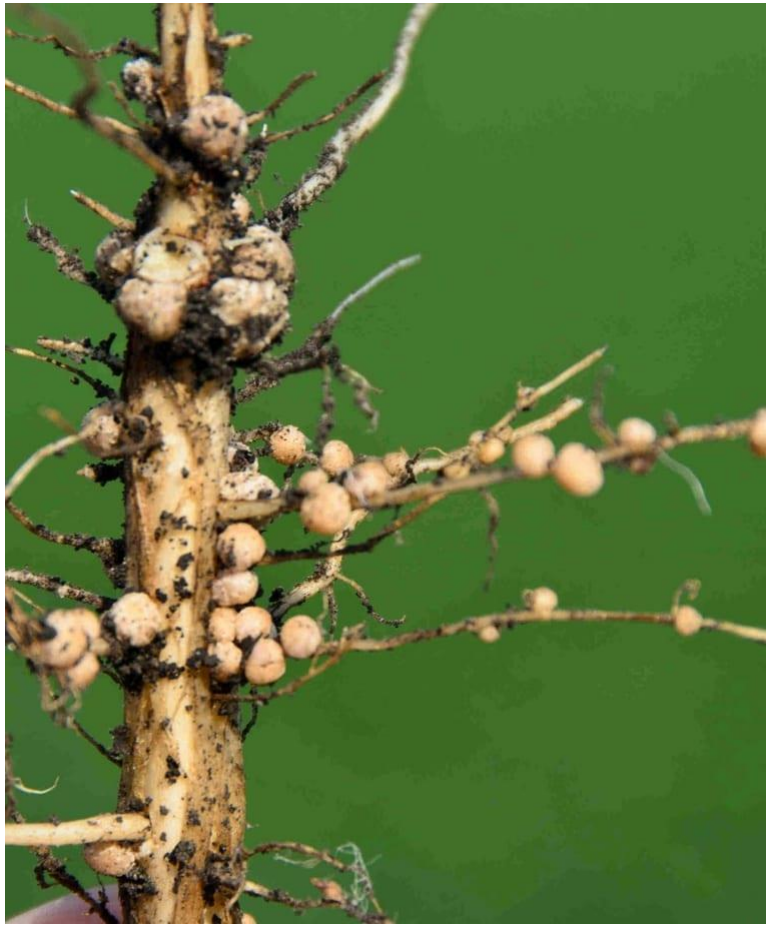
Why Microbiology Matters

In your health, your food, your farms, and your economy.

Microbes Run the Planet: Environmental Roles

THE JOBS MICROBES DO FOR EARTH

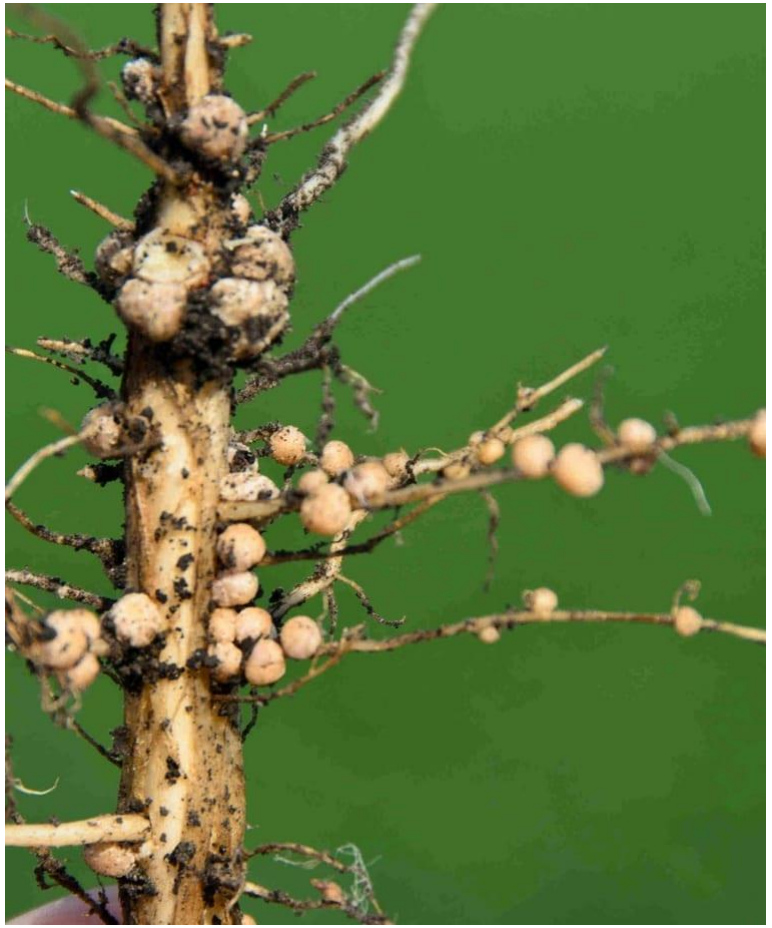
- Oxygen production: algae & cyanobacteria carry out more than 70 % of Earth's photosynthesis
- Decomposition: fungi and bacteria break down dead plants and animals, releasing their nutrients back into the soil
- Nutrient cycling: microbes run the global cycles of carbon, nitrogen, sulfur and phosphorus



Microbes Run the Planet: Environmental Roles

THE JOBS MICROBES DO FOR EARTH

- Nitrogen fixation: bacteria like Rhizobium convert atmospheric N_2 into forms plants can use, maintaining soil fertility for free
- Bioremediation: microbes degrade oil spills, plastics, pesticides and heavy metals
- Sewage treatment: wastewater plants are essentially controlled microbial gardens



Microbes Feed Us: Food & Industry

FOOD PRODUCTION

- Bread: yeast (Saccharomyces cerevisiae) produces CO_2 that raises the dough
- Cheese & yoghurt: lactic acid bacteria ferment milk
- Beer & wine: yeast ferments sugar into alcohol
- Vinegar, soy sauce, kimchi, palm wine, all microbial ferments

Microbes Feed Us: Food & Industry

INDUSTRIAL PRODUCTS FROM MICROBES

- Enzymes: used in detergents, textiles, biofuels
- Vitamins: B_{12}, B_2, and others produced by fermentation
- Antibiotics: penicillin, streptomycin, tetracycline
- Organic acids: citric acid (from Aspergillus) in soft drinks
- Biofuels: ethanol from yeast; biogas from methanogens

Microbes in Medicine

Medicine both fights microbes (pathogens) and uses them (drug factories, diagnostics, vaccines).

- Most antibiotics come from other microbes, moulds and soil bacteria that evolved them as chemical weapons. E.g. Penicillin, streptomycin, tetracycline, erythromycin
- Killed or weakened microbes or just parts of them train the immune system to fight the real disease. E.g. Measles, polio, hepatitis B, tetanus, COVID-19, HPV

Microbes in Medicine

Medicine both fights microbes (pathogens) and uses them (drug factories, diagnostics, vaccines).

- Lab microbiology identifies the “pathogen" causing an infection so it can be treated correctly. Culture, Gram stain, PCR, antibody tests, sequencing
- Tracking outbreaks, monitoring water and food, controlling epidemics all rely on microbiologists. E.g., Cholera surveillance, TB control, AMR monitoring, COVID-19 response

Biotechnology & Genetic Engineering

Modern biotechnology treats microbes as tiny programmable factories. Insert a gene, and bacteria will make the protein you asked for at industrial scale, cheaply, and safely.

HUMAN PROTEINS NOW MADE BY MICROBES

- Human Insulin
- Growth Hormone. E.g. Human growth hormone (hGH), used for treating growth disorders in children
- Recombinant Vaccines. Hepatitis B and HPV vaccines are made by yeast carrying viral genes

Beneficial vs. Harmful Microbes

Most microbes are friends or neutral. A minority are pathogens. Both must be understood.

BENEFICIAL: The Vast Majority

- Gut microbiome: digestion, vitamin production, immune training
- Nitrogen fixation : feeding the world's crops
- Food production: bread, cheese, yoghurt, wine, beer
- Decomposition & nutrient cycling
- Antibiotics & other medicines
- Bioremediation of pollutants

Beneficial vs. Harmful Microbes

Most microbes are friends or neutral. A minority are pathogens. Both must be understood.

HARMFUL (Pathogens): A Serious Minority

- Human infectious diseases: TB, malaria, HIV, cholera, typhoid
- Livestock diseases: anthrax, brucellosis, foot-and-mouth
- Crop diseases: cassava mosaic virus, cocoa swollen shoot
- Food spoilage: moulds, spoilage bacteria
- Food poisoning: Salmonella, E. coli O157, Listeria
- Biofilms on medical implants and water pipes

Branches of Microbiology

Organism-Based: Classified by the type of organism being studied.

- Bacteriology: bacteria
- Virology: viruses
- Mycology: fungi
- Phycology: algae
- Parasitology: protozoa & helminths
- Protozoology: protozoa specifically

Branches of Microbiology

Applied: Classified by the human problem being solved.

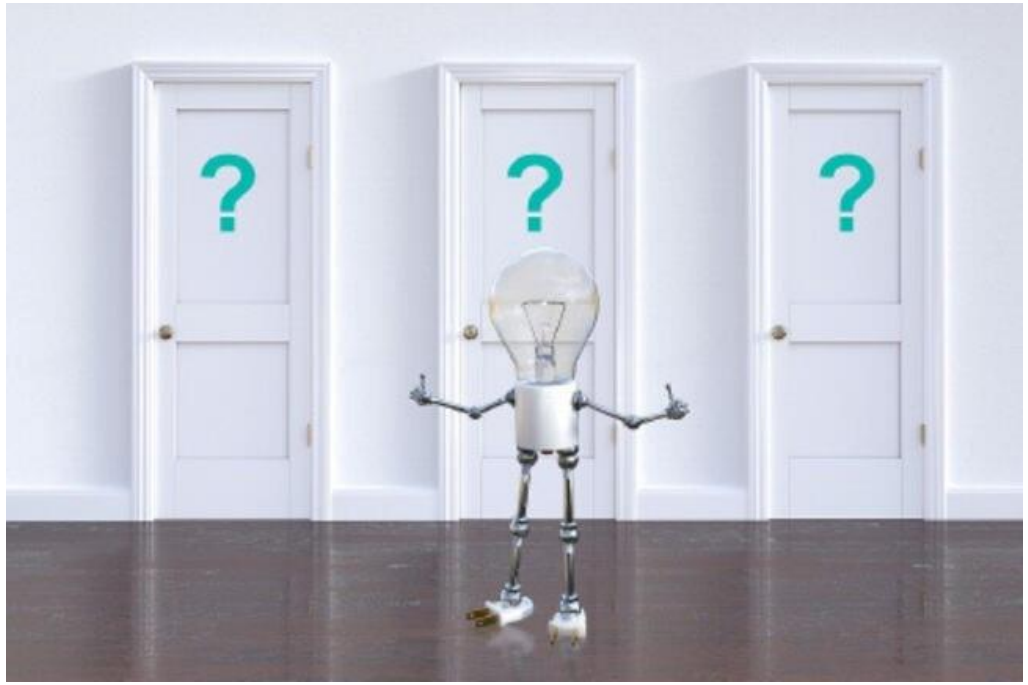
- Medical microbiology
- Public health / Epidemiology
- Agricultural microbiology
- Food & dairy microbiology
- Industrial microbiology
- Pharmaceutical microbiology

Where This Course Can Take You

A grounding in microbiology opens the door to many career paths inside and outside the lab.

- Clinical Lab Scientist: diagnosing infections. Identifying infections, Plasmodium every day.
- Public Health Officer: GHS, WHO, Noguchi. Outbreak investigation, disease surveillance, immunisation programmes.
- Food & Water Quality: FDA-Ghana, GSA, water companies, breweries. Ensuring what we eat and drink is safe.
- Research Scientist: Universities, WACCBIP, KCCR, BNITM, and elsewhere.
- Biotech & Pharma: Vaccine, antibiotic and diagnostic manufacturers. Quality control, regulatory affairs.
- Environmental / Agri: Soil labs, biofertiliser companies, waste treatment plants, cocoa/coffee research institutes.

To see is to know" but with microbes, we had to invent the seeing first.



"There are more microbes on the palm of your hand than there are people on Earth."

— A GOOD REASON TO WASH THEM