ARKAN
ACADEMY

# MICROBIOLOGY 1

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Study smarter, not harder!

# Scope and History of Microbiology

- ## Terms
  - **Microbiology** is the study of *microbes* (microorganisms)
    - ✓ They are so small (in the scale of microns) that they require a microscope for study.
  - **Microorganisms** are present almost *everywhere* in air, water (oceans, springs, drinking water), soil, animal & human body (GIT, respiratory tract, and skin), and even in the deep hot interior of Earth (temperatures reaching 110°C), as well as in the Antarctic.

- ## Why Study Microbiology? – Importance of Microorganisms
  - Disease mediators: Microorganisms play a crucial role in *disease* transmission.
  - Production of antibiotics and vaccines: Many antibiotics and vaccines are *derived* from microorganisms.
  - Genetic engineering: Microorganisms are used for producing *interferon*, *growth hormone*, *insulin*, etc.
  - Food industry: Microbes are used in *food production*, like pickles, yogurt, etc.
  - Fermentation: Microorganisms help in making *dough* and *alcohol*.
  - Nitrogen fixation for plants: Certain microbes contribute to nitrogen fixation, which is *essential* for plant growth.
  - Food Chain: Microorganisms can be the first element in the food chain by *capturing* energy and *storing* it in molecules that other organisms use as food.
  - Digestive system: Some microorganisms live in the digestive system of grazing animals and assist in digestion.
  - Decomposition: Certain microorganisms *decompose dead* organisms and waste material.
  - Research: Microorganisms are *studied* in ecology, biochemistry, genetics, and other fields.

- ## Scope of Microbiology – Types of Microorganisms
  1. *Bacteria*
     - ✓ *Prokaryotic cells*
     - ✓ Majority are *single*-celled, with spherical, rod, or spiral shapes; a few are filamentous.
     - ✓ Most bacteria *absorb* nutrients from their environment, though some can ***synthesize*** their own through processes like photosynthesis.
     - ✓ *Widely* distributed in the environment, including decaying matter.
     - ✓ Some cause diseases (*pathogenic* bacteria).
  2. *Algae*
     - ✓ Some algae are single-celled microscopic organisms, while others are large and complex, *multicellular organisms*.
     - ✓ Algae *capture* energy from light and serve as a food source for other organisms.
  3. *Fungi*
     - ✓ *Yeasts* are unicellular, while *molds* may be unicellular or multicellular (e.g., mushrooms).
     - ✓ Fungi *absorb* ready-made nutrients.
     - ✓ *Found* in water, soil, and decomposing organic matter.
     - ✓ Some fungi cause *diseases*; others *produce* antibiotics.

4. *Viruses*
   - ✓ *Acellular* entities composed of nucleic acids (DNA or RNA) and proteins.
   - ✓ *Very small* size; not seen by light microscope.
   - ✓ When viruses are extracellular they are non-viable, but *once* they *enter* a living cell they start to *replicate*.
   - ✓ Many viruses invade human cells and cause *diseases*.
5. *Viroids*
   - ✓ *Very small*, *acellular* infectious agents
   - ✓ Composed solely of nucleic acids *without protein* coatings.
   - ✓ Cause *plant diseases*.
6. *Prions*
   - ✓ Proteins *without nucleic acids*.
   - ✓ Cause diseases such as mad cow disease (Bovine Spongiform Encephalopathy - *BSE*) and Creutzfeldt-Jakob Disease (*CJD*) in humans.
7. *Protozoa*
   - ✓ *Single*-*celled* microscopic organisms, although some amoebas can be seen with the naked eye.
   - ✓ *Possess* at least one nucleus and numerous intracellular structures.
   - ✓ Protozoa *obtain* food by engulfing or ingesting other microorganisms.
   - ✓ *Found* in soil, water, and animals.
8. *Helminths* (Worms)
   - ✓ *Larger organisms* but with microscopic stages in their life cycle.
9. *Arthropods* (Insects)
   - ✓ Studied in microbiology because they can transmit microorganisms and cause diseases (*biological vectors*).
   - ✓ *For example*, the Tsetse fly transmits Trypanosoma, causing sleeping sickness.

- **Scope of Microbiology – Fields of Microbiology**
  - ➢ Field (Pronunciation)
    - ✓ Microbial taxonomy*: Classification* of microorganisms
  - ➢ Health-Related Fields
    - ✓ Immunology*:* How host organisms *defend* themselves against microbial infection
    - ✓ Epidemiology*: Frequency* and *distribution* of diseases
    - ✓ Etiology*: Causes* of disease
    - ✓ Infection control*:* How to *control* the spread of nosocomial (nos-o-ko'me-al), or hospital-acquired, infections
    - ✓ Chemotherapy*:* The development and use of chemical substances to *treat diseases*
  - ➢ Fields According to Applications of Knowledge
    - ✓ Food and beverage technology*:* How to *protect* humans from disease organisms in fresh and pre-served foods
    - ✓ Environmental microbiology*:* How to *maintain* safe drinking water, dispose of wastes, and control environmental pollution

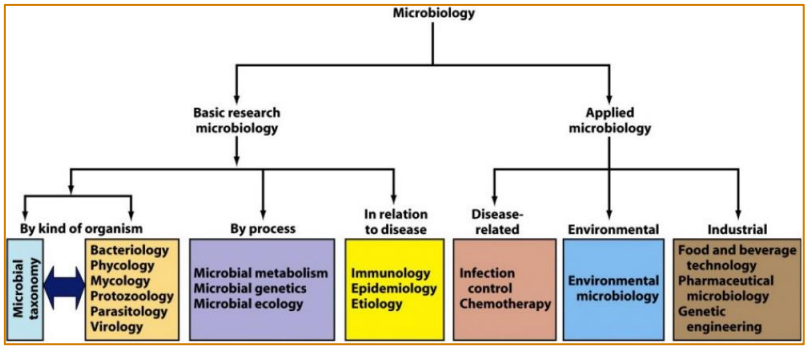
- ✓ Industrial microbiology*:* How to *apply knowledge* of microorganisms to the manufacture of fermented foods and other products of microorganisms
- ✓ Pharmaceutical microbiology*:* How to *manufacture* antibiotics, vaccines, and other health products
- ✓ Genetic engineering*:* How to *use microorganisms* to synthesize products useful to humans

➢ Field according to organism studied:

- ✓ Bacteriology*:* bacteria
- ✓ Phycology*:* algae
- ✓ Mycology: fungi
- ✓ Protozoology*:* protozoa
- ✓ Parasitology*:* parasite
- ✓ Virology*:* viruses

➢ Fields according to processes or functions studied

- ✓ Microbial metabolism*: chemical reactions* that occur in microbes
- ✓ Microbial genetics*:* transmission and action of *genetic information* in microorganism
- ✓ Microbial ecology*: relationships* of microbes with each other and with the environment




- **History of Microbiology**

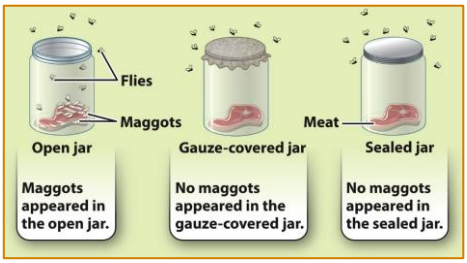
1. Robert Hooke (1664)
   - ✓ Built a compound microscope and used it to observe thin slices of cork.
   - ✓ Coined the term "cell" to describe the small, orderly arrangement of boxes he saw, which reminded him of the cells (small, bare rooms) of monks
2. Anton van Leeuwenhoek (1684)
   - ✓ First to make and use lenses to observe living microorganisms.
   - ✓ His lenses were of excellent quality and magnified up to 300X.
   - ✓ Discovered "animalcules" in various samples.
3. Schleiden and Schwann
   - ✓ Formulated the **cell theory**, which states that cells are the fundamental units of life and carry out all basic life functions.
4. The Germ Theory of Disease

   A. The Hypothesis of Spontaneous Generation
   - ✓ It sets that the *combination* of water , fire , air and soil can create or convert a non-living thing to a living organism

- ✓ E.g. rodents arose from mist grains, beetles from dust, worms & frogs from mud, maggots from rotting meat.

B. Francesco Redi

- ✓ *Conducted* an experiment with meat and open/closed jars, showing that maggots only appeared on uncovered meat (when flies laid eggs).

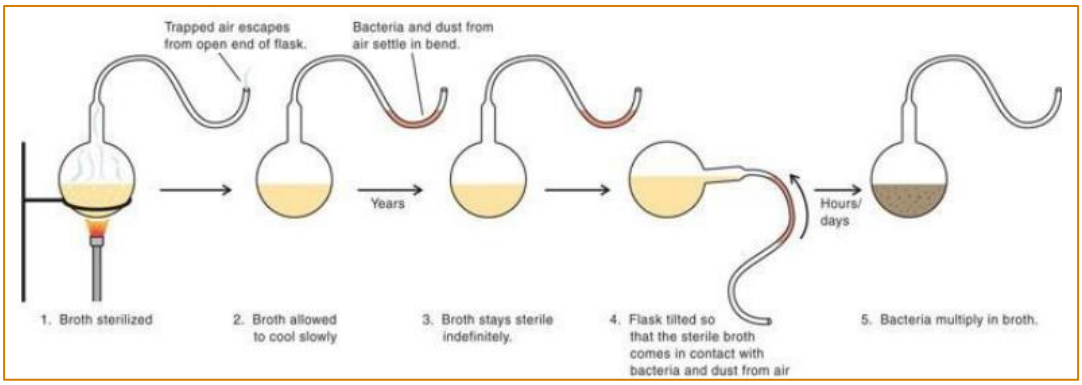



C. Lazzaro Spallanzani

- ✓ Boiled broth, sealed it, and showed no microbial growth, challenging spontaneous generation, though critics argued that the *absence of oxygen inhibited growth.*

5. Louis Pasteur (1822)

- ✓ Ended the *spontaneous generation* debate with the famous swan-neck flask experiment, which showed that microbes in the air could not reach the broth.
  - This experiment allowed air to contact the broth
  - Microbes present in the dust were not able to navigate the tortuous bends in the neck of the flask



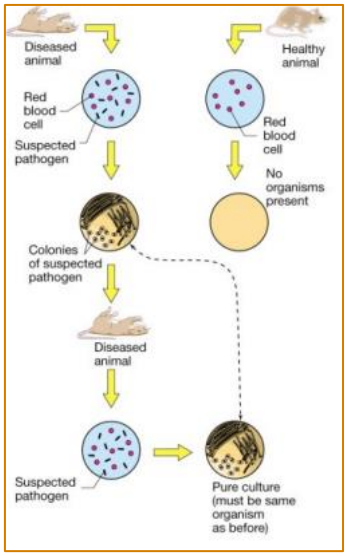

- ✓ Developed *pasteurization*, a method of heating liquids to kill unwanted organisms (heating wine to 56 °C in the absence of oxygen for 30 min).
- ✓ Contributed to the *wine and silk industries*
- ✓ Developed a *rabies vaccine*.
  - Made of dried spinal cord from rabbits infected with rabies - Administered to a 9-year-old boy who had been severely bitten by a rabid, then the *boy survived*

6. Robert Koch

- ✓ Developed methods for growing bacteria in *pure cultures.*
  - First he used gelatin but it melts as some microbes liquefy it, then he took the suggestion of Angelina Hesse to add agar to his bacteriological media
- ✓ Identified bacteria causing diseases like *anthrax* and *tuberculosis* in both dividing and dormant (spore) form
- ✓ He developed *tuberculin* as a vaccine for tuberculosis
  - Although tuberculin *failed* as a vaccine, it is still used in a skin test to diagnose tuberculosis
- ✓ Created **Koch's Postulates**, which are used to link specific microbes to specific diseases.

**Koch's Postulates**:

1) The *causative* microbe should be present in all affected organisms, but not in healthy ones.
2) The microbe must be *isolated* and *grown* in pure culture.
3) The *cultured microbe* should cause the same disease when inoculated into a healthy organism.
4) The microbe should be *re-isolated* and shown to be the *same* as the original pathogen.




7. The Germ Theory of Disease
   - ✓ Stated that *microorganisms* (germs) could invade other organisms and cause disease, a concept that laid the foundation for *modern microbiology*.
8. Virology
   - ✓ Emerged after bacteriology due to size of viruses
   - ✓ Scientists used *porcelain filter* to remove bacteria from water but the filtrate remained infectious due to very small pathogenic agents which were then recognized to be viruses.
9. Ignaz Semmelweis
   - ✓ He found a connection between staff hygiene (cleanliness) and the incidence of puerperal (childbed) fever
   - ✓ He proposed the practice of hand washing with *chlorinated lime* (calcium hypochlorite) solutions to reduce the postpartum mortality rate .But some doctors were offended by his suggestions.
10. Joseph Lister
    - ✓ Introduced the use of carbolic acid (phenol) to sterilize instruments and reduce postoperative infections, considered the father of **aseptic surgery**.
11. Ancient Chinese
    - ✓ Noticed that individuals scarred by smallpox were immune to further infection and used *variolation* (sniffing powdered scabs or introducing infected fluid) to provide immunity.
    - ✓ Variolation was later practiced in Europe but by soaking a thread in the fluid of a smallpox vesicle (blister) and then introducing it through a small incision in the arm

- **Immunology and Chemotherapy**

1. Edward Jenner
   - ✓ Observed that milkmaids who had cowpox didn't get smallpox and inoculated a child with cowpox, proving immunity to smallpox. This led to the development of the **vaccine**.
2. Elie Metchnikoff
   - ✓ Discovered *phagocytes*, cells in the body that ingest microbes, challenging the belief that immunity was due to non-cellular substances in the blood.
   - ✓ He developed several vaccines, some were successful while others failed
3. Paul Ehrlich
   - ✓ Discovered that certain dyes stained microorganisms but not animal cells, leading to the concept of ***selective toxicity***.
   - ✓ This led him to search for the 'magic bullet', a chemical that would *destroy specific* bacteria without damaging surrounding tissues
   - ✓ Developed ***Salvarsan*** to treat syphilis and coined the term ***chemotherapy***.
4. Alexander Fleming
   - ✓ Discovered *penicillin*, a groundbreaking antibiotic, after observing that Penicillium mold prevented bacterial growth.
   - ✓ While the work on penicillin was going on, *sulfa drugs* were also being developed from sulfonamide-containing dyes (i.e. prontosil)
   - ✓ Many antibiotics were then produced *from soil bacteria* e.g. streptomycin, chloramphenicol and chlorotetracycline

- **Modern History of Microbiology – Examples**

1. Genetic Engineering
   - ✓ *Microorganisms* have been genetically engineered to *produce* drugs, hormones, vaccines, and other biologically important compounds.
2. Bacteriophage Therapy
   - ✓ Bacteriophages, *viruses* that attack and *kill* specific bacteria, were developed as a treatment in the 1920s.
   - ✓ Today, there is a trend to *re-examine* such an approach especially with the progressive emergence of antibiotic resistance.

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