PHARMACEUTICAL MICROBIOLOGY and IMMUNOLOGY

Assist.Prof.Dr. Müjde ERYILMAZ

OBJECTIVES

- What is microbiology?
- What is pharmaceutical microbiology?
- What is the history of microbiology?
- How do we classify microorganisms?

What is microbiology?

- Microbiology is the branch of biology that deals mainly with the study of microscopic organisms called microbes
- The study of organisms too small to be seen without magnification
- The study of organisms that are too small to be seen with the unaided eye.

- Microorganisms are found at every stage of life.
- They can be found in air, water, soil, sea, within our bodies, animals, plants.

- What are the roles of microorganisms in our lives?

- Do all microorganisms cause disease?

What are the roles of microorganisms in our lives?

- bacteria in the intestinal tract aids food digestion
- mould acts on milk to make cheese
- yeast ferments wine and beer and makes bread
- bacteria can make vitamins for us
- some antibiotics are produced naturally by fungi
- bacteria breaks down garbage

Do all microorganisms cause disease?

Not all microorganisms can cause disease in man.

Microbes are everywhere

PATHOGENS

are microorganisms that cause disease

NON-PATHOGENS

are microorganisms that don't cause disease, they can be beneficial

SAPROPHYTES

are microorganisms that live on dead or decaying organic matters.


First
movie

- What is pharmaceutical microbiology?

The study of microorganisms that are related to the production of antibiotics, enzymes, vitamins, vaccines, and other pharmaceutical products and that cause pharmaceutical contamination and spoil.

- What are the study topics of pharmaceutical microbiology?

- manufacture of antibiotics
- manufacture of steroids
- manufacture of therapeutic enzymes
- manufacture of polysaccharides
- manufacture of products of recombinant DNA technology

- What are the study topics of pharmaceutical microbiology?

- sterilization methods
- sterilization monitoring and validation procedures
- sterility testing
- assesment and calculation of sterility assurance
- aseptic manufacture

- What are the study topics of pharmaceutical microbiology?

- immunology and infectious diseases
- characheristics, selection and testing of antimicrobial preservatives
- characheristics, selection and use of vaccines and antibiotics
- use of biocides in infection and contamination control

- What are the study topics of pharmaceutical microbiology?

- microbiological examination of pharmaceutical products (both sterile and non-sterile products)
- enumeration of microorganisms in the manufacturing environment and in raw materials and manufactured products
- identification and detection of specific microorganisms

- What are the study topics of pharmaceutical microbiology?

- control of antibiotic resistance
- antibiotic susceptibility testing
- antimicrobial efficacy testing
- pyrogen and endotoxin testing

History of Microbiology

- It started with man's quest to know the causes of diseases.

- How people in the past tried to explain the causes of disease?

- How they tried to prevent and to cure them?

History of Microbiology

- Prehistoric people largely explained disease and infection through the spirits they believed in. A bad spirit could enter the body and cause an illness.

History of Microbiology

- In the ancient times, people believed that living organisms could develop from non-living matter, and they named this phenomenon as **spontaneous generation**.
- Aristotle (384 BC–322 BC) believed that simple invertebrates could arise by spontaneous generation.
- The validity of this theory came under challenge in the 17th century.

History of Microbiology

- Francesco Redi (1626-1697) demonstrated that organisms did not arise from non-living materials.
- The spontaneous generation conflict was finally challenged by Redi, who carried out a series of experiments using decayed meat.
- He investigated the ability of meat to produce maggots spontaneously.
- He showed that maggots would not arise from decaying meat, when it is covered.

History of Microbiology

- Antonie van Leeuwenhoek (1632 - 1723) was a Dutch tradesman and scientist
- He invented simple microscope in 1674 and he observed large numbers of organisms including bacteria and protozoa in pond water.
- He called microscopic organisms as ‘animalcules’. It’s the first known description of bacteria.
- He built the best microscopes of his day, achieving magnifications above 200x.

History of Microbiology

- Lazzaro Spallanzani (1729-1799) disproved spontaneous generation theory
- He disputed the theory by showing that boiled broth would not give rise to microscopic forms of life
- He demonstrated that air carried germs to the culture medium.

History of Microbiology

- He did his own experiment by placing broth in two separate bottles, boiling the broth in both bottles, then sealing one bottle and leaving the other open.
- Days later, the unsealed bottle contained living things and the sealed bottle contained no signs of life.

History of Microbiology

- Louis Pasteur (1822-1895)-Father of microbiology
- He was a French chemist and microbiologist
- He disproved the spontaneous generation theory by his experiments
- Pasteur demonstrated that life arises from pre-existing life

History of Microbiology

- He established that living microorganisms are responsible for the chemical changes that occur during **fermentation**

- Pasteur demonstrated that souring of milk is due to the action of microorganisms

History of Microbiology

- He invented **pasteurization.**
- Pasteur suggested that mild heating at 62.8°C for 30 minutes rather than boiling was enough to destroy the undesirable organisms without ruining the taste of the product, the process was called Pasteurization

(**pasteurization:** heat-treatment process that destroys pathogenic microorganisms in certain foods and beverages)

History of Microbiology

- In 1879 Pasteur showed that **chicken cholera** weakened by growing it in the laboratory could protect against infection with more virulent strains.
- Pasteur produced the first vaccines for **rabies** and **anthrax**.
- Pasteur demonstrated diseases of silkworm was due to a protozoan parasite.

History of Microbiology

- **Biogenesis (theory)** states that every living thing came from a pre-existing living thing.

  - In 1668, Francesco Redi proved that no maggots appeared in meat when flies were prevented from laying eggs.
  - In 1765, Lazzaro Spallanzani demonstrated that microorganisms were present in the air, and could be killed by boiling.
  - In 1861, Louis Pasteur performed a series of experiments which demonstrated that organisms such as bacteria and fungi do not spontaneously appear in sterile, nutrient-rich media.

History of Microbiology

- Robert Koch (1843-1910)- Founder of modern bacteriology
- He developed the **agar plate technique** for growing microorganisms. He used it to culture the isolated anthrax.

(Anthrax is an infection caused by the bacterium *Bacillus anthracis)*

History of Microbiology

Koch established criteria for proving the causal relationship between a microorganism and a specific disease. These criteria are known as Koch postulates.

1. the microorganism or pathogen must be present in all cases of the disease
2. the pathogen can be isolated from the diseased host and grown in pure culture
3. the pathogen from the pure culture must cause the disease when inoculated into a healthy, susceptible host
4. the pathogen must be re-isolated from the new host and shown to be the same as the originally inoculated pathogen

History of Microbiology

- He is known for his role in identifying the specific causative agents of **tuberculosis**, **cholera**, and **anthrax**

- Koch began to utilize agar to grow and **isolate pure cultures**

(**Pure culture**: a culture of a single form of microorganism uncontaminated by other organism)

History of Microbiology

Germ Theory:

- Pasteur postulated the germ theory of disease, which states that microorganisms are the causes of infectious disease but his attempts to prove the germ theory were unsuccessful.

- However, Robert Koch provided the proof by cultivating anthrax bacteria apart from any other type of organism. He then injected pure cultures of the bacilli into mice and showed that the bacilli invariably caused anthrax.

History of Microbiology

Germ Theory:

- The germ theory of disease states that many diseases are caused by microorganisms.
- These small organisms, too small to see without magnification, invade humans, animals, and other living hosts.
- Their growth and reproduction within their hosts can cause a disease.

History of Microbiology

- Joseph Lister (1827-1912)- Father of antiseptic surgery
- He was the founder of **antiseptic medicine** and a pioneer in preventive medicine
- Lister successfully introduced carbolic acid (now known as phenol) to sterilise surgical instruments and to clean wounds

History of Microbiology

- Edward Jenner (1749-1823)- Father of vaccination/immunology

- He was the pioneer of smallpox vaccine, the world's first vaccine.

Classification of Microorganisms

- Microorganisms are classified into groups according to their cell types/structures, reproduction and nutrition habits or other characteristics (such as DNA base composition)

Classification of Microorganisms

1. Acellular
    - Prions
    - Viroids
    - Viruses

2. Unicellular

    a) Prokaryotes (200-2000 nm)
    - Bacteria
    - Archaea

Classification of Microorganisms

b) Eukaryotes (>2000 nm)

- Fungi (Yeasts)
- Protozoa

3. Multicellular

- Fungi (Molds)
- Helminths
- Arthropods

Prions

- Prions are infectious particles, smaller than viruses, that contain no nucleic acids (neither DNA nor RNA).

- A prion is an atypical form of a mammalian protein that can interact with a normal protein molecule and cause it to undergo a conformational change so that it, in turn, becomes a prion and ceases its normal function.

Prions

- Prions are the agents responsible for transmissible spongiform encephalopathies, e.g. Creutzfeldt-Jakob disease and bovine spongiform encephalopathy

- They are the simplest and most recently recognized agents of infectious disease, and are important in a pharmaceutical context owing to their extreme resistance to conventional sterilizing agents like steam, gamma radiation and disinfectants

- 134 °C for 18 minutes in a pressurized steam can destroy prions

Viroids

- Viroids are the smallest infectious pathogens known.
- They are solely composed of a short strand of circular**, single-stranded RNA without protein coat**.
- All known viroids are inhabitants of higher plants, in which most cause diseases

Viruses

- Viruses are noncellular entities that consist of a nucleic acid core (DNA or RNA) surrounded by a protein coat.
- Viruses can not reproduce outside a host cell and can not metabolize on their own. They are obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants and animals.
- Ultramicroscopic size, ranging from 20 nm up to 450 nm (diameter). (Bacteria 1000-2000 nm).

Prokaryotes-Eukaryotes

- Prokaryotic cells do not contain a nucleus or any other membrane-bound organelle. Prokaryotes include two groups: bacteria and another group called archaea.

- Eukaryotic cells contain membrane-bound organelles, including a nucleus. Eukaryotes can be single-celled or multi-celled, such as animals, plants, fungi, and insects.


Second
movie

Differences Between Eukaryotic and Prokaryotic Cells

FEATURE	PROKARYOTES	EUKARYOTES
Size	Typically 1-5 µm	10 µm<
DNA	DNA is naked (without histones)	DNA associated with histones
	DNA is circular	DNA is linear
	In the cytoplasm, usually attached to the cell membrane	Within a true nucleus separated from the cytoplasm by a nuclear membrane
Reproduction	Asexual (binary fission)	Asexual (mitosis) or sexual (meiosis)
Ribosomes	70S	80S
Internal Structures	Membrane bound organelles are absent	Membrane bound organelles are present

Naming of Microorganisms

- Linnaeus established the system of scientific nomenclature (naming) of organisms in 1735.
- Latin was the language traditionally used.
- Scientific nomenclature assigns each organism two names (Binomial):
- The genus is the first name and is always capitalized. The specific epithet (species name) follows and is not capitalized.

e.g. *Staphylococcus aureus*