



INTRODUCTION TO MEDICAL MICROBIOLOGY

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Most important concepts

Topics of the lecture

1) Fields of microbiology

Medical

Industrial

Agricultural

Food

Molecular

Sanitary

Environmental

4) Prions

- abnormally folded proteins that cause neurological diseases (TSEs), such as:
1) BSE 2) CJD
- Forms when (PrP^c) converts into (PrP^{sc})
- Transmitted mainly by ingestion, sometimes by iatrogenic route

2) Types of cell

Prokaryotes:
small/ simple/
ribosome 70S

Eukaryotes:
large/complex
ribosome 80S

5) (endo/exo)genous

6) Portal of entry

Respiratory

Alimentary

Genital tract

Skin

Congenital

Others

3) organisms that can cause disease

A) Viruses:
diameter < 0.3 microns
cause intracellular infection
Depend on cell for replication

C) Fungi: Two varieties
1st) Yeasts :unicellular /(2-20) microns.
2nd) Molds: large multicellular organisms

B) Bacteria:
diameter < 1 microns
may cause intracellular or extracellular infection
Replicate by binary fission

D) Parasites: Two classes
1st) Protozoa: unicellular
2nd) metazoa (helminths): Multicellular

7) Useful micro-organisms

Normal flora

recycling vital elements

Sewage treatment

Fermentation

Food industry

biotechnology

MPCA

8) Short history

9) Common terms

Incubation period

Incidence

Period of communicability

prevalence

Case fatality rate

Mortality rate

Epidemic

Endemic

Pandemic

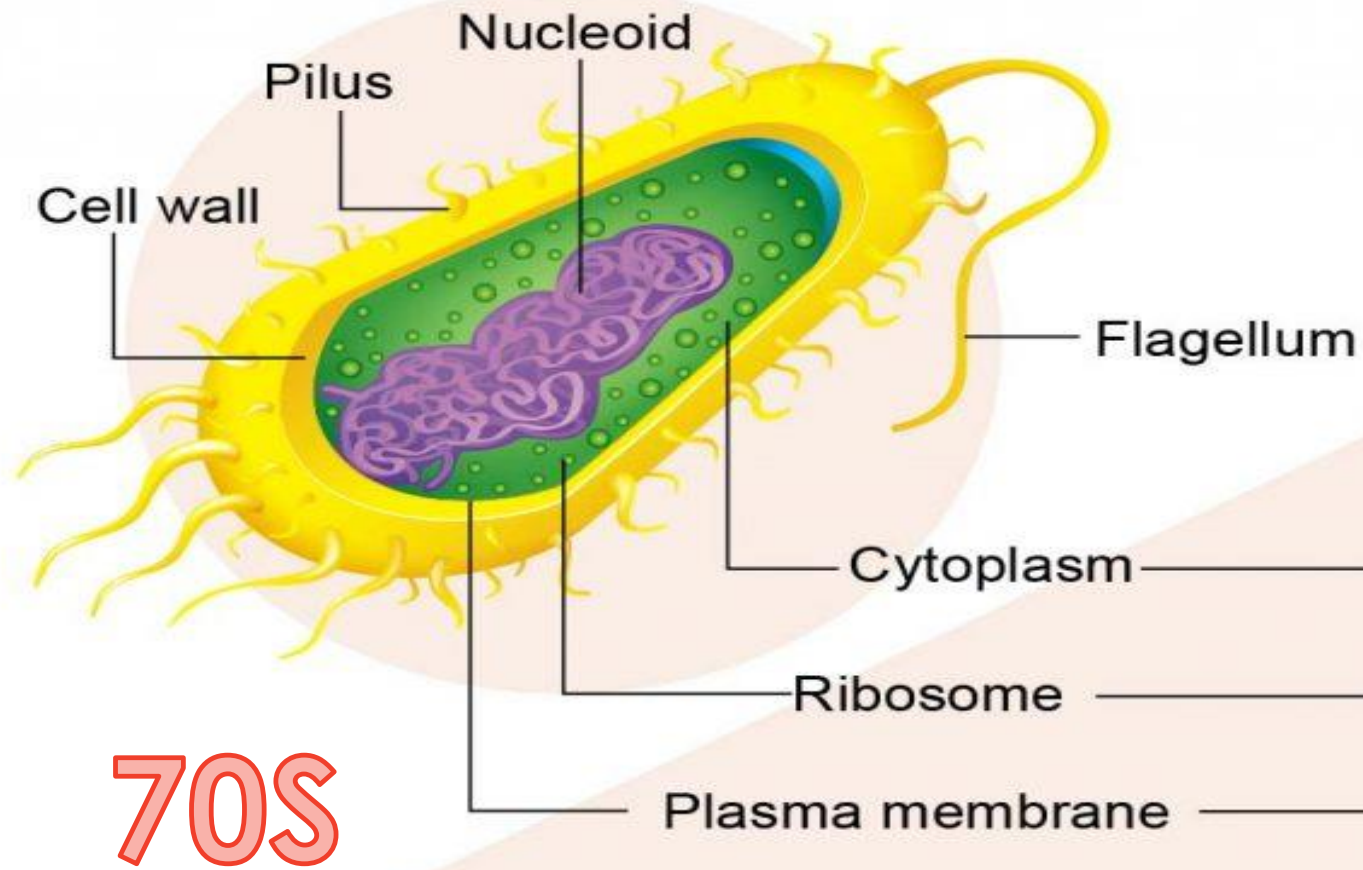
1) Fields of microbiology

- A) Medical Microbiology: is a science of studying micro-organisms that are associated with human disease
This field focuses on **pathogens**, **diseases**, and **body defenses**.
includes : Immunology, Virology, Bacteriology, Mycology (fungi) , and Parasitology
- B) Industrial microbiology: This field focuses on the production of **alcohol**, **enzymes**, **vitamins**, and **antibiotic** by micro-organisms.
- C) Agricultural microbiology: This field is concerned with **Soil fertilization**, **nitrogen**, **carbon**, **sulfur**, and **phosphorous cycles**, as well as **plant disease**.
- D) Food microbiology: This field focuses on micro-organisms that cause **food poisoning**, **toxicity** and **spoilage**.
- E) Sanitary microbiology: is a science based on the detection of risks associated with the production, manufacture and consumption of foods and water. It has been established that environment facts determine the survival, growing and inactivation of the microorganisms.

1) Fields of microbiology

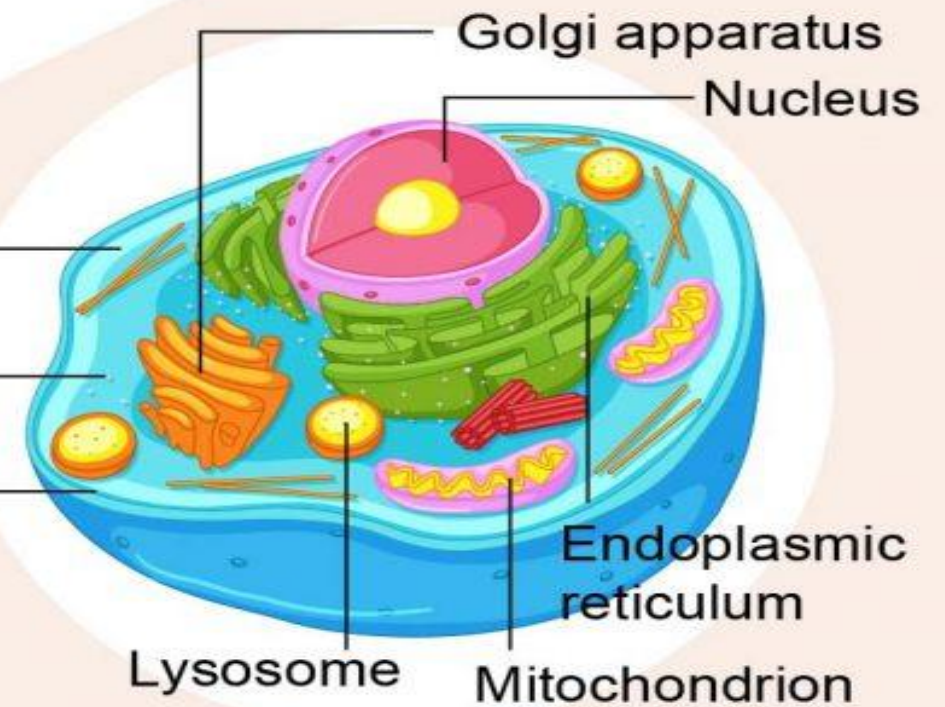
- F) Molecular microbiology: deals with molecular mechanisms and physiological processes of microbes and utilization in production of biotechnology products such as vaccines, and antibodies.
- G) environmental microbiology: is the study of the composition and physiology of microbial communities in the environment.

PROKARYOTE CELL



70S

80S

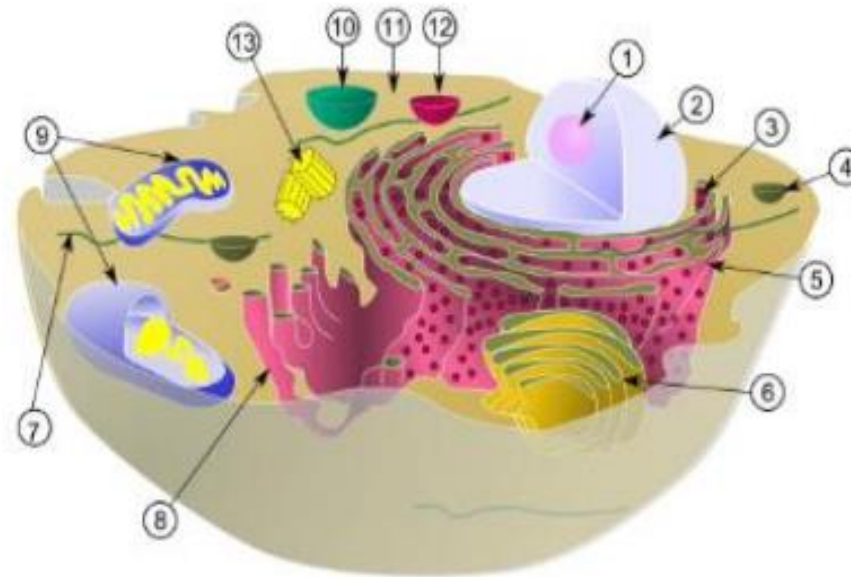


EUKARYOTE CELL

2) Types of cells

Cell structure / Eukaryotes

1. Nucleolus
2. Nucleus
3. Ribosome (80S)
4. Vesicle
5. Rough endoplasmic reticulum
6. Golgi apparatus (or "Golgi body")
7. Cytoskeleton
8. Smooth endoplasmic reticulum
9. Mitochondrion
10. Vacuole
11. Cytosol
12. Lysosome
13. Centriole



2) Types of cells

Characteristic/ type of cell	Eukaryotes	Prokaryotes
Contain nucleus?	Yes	No/ Have nucleoid
What encodes genetic information?	DNA	DNA
Contain RNA?	Yes	Yes
Size of ribosomes?	Large (80S)	Small (70S)
Complex?	Yes	No
Contain organelles in cytoplasm?	Yes	No
Cell membrane?	Yes	yes
Flagella?	Sometimes, but different complexity	
Cell wall?	Sometimes, but different components	
Size?	$\geq 3 \mu\text{m}$	$0.15 - 2.0 \mu\text{m}$
Include?	fungi, protozoa, metazoa and simple algae.	bacteria, blue-green algae

Note: viruses are not cells

3) organisms that can cause disease

- A) Viruses: Small infectious agents that are totally dependent on infected cells for replication. They cause intracellular infection.
- B) Bacteria: Usually measure about one micron or more, can cause intercellular or extracellular infection.
- C) Fungi: subtypes are
 - 1- Yeasts are unicellular organisms measuring (2-20) microns.
 - 2- Molds are large multicellular organisms.

3) organisms that can cause disease

- D) Parasites: these can be of two classes:
 - 1- Protozoa, these are unicellular organisms, they are two subtypes:
 - some are very small (about 3 microns) and can cause intercellular infection.
 - Others are large (80 microns) and cause extracellular infection.
 - 2- Helminthes :multicellular and can reach several meters in lengths.

Characteristics	Viruses	Bacteria	Fungi	Protozoa and Helminthes
Cells	No	Yes	Yes	Yes
Approximate diameter (μm)	0.02-0.2	0.5-2	3-10	15-25
Nucleic acid	Either DNA or RNA	Both DNA and RNA	Both DNA and RNA	Both DNA and RNA
Type of nucleus	Non	Prokaryotic	Eukaryotic	Eukaryotic
Ribosome	absent	70S	80S	80S
Mitochondria	Absent	Absent	Present	Present
Nature of outer surface	Protein capsid and lipoprotein envelope	Rigid wall containing peptidoglycan	Rigid wall containing chitin	Flexible membrane
Motility	None	Some	None	Most
Method of replication	Not binary fission	Binary fission	Budding or mitosis	Mitosis

4) Prions

- The term "prion" is derived from proteinaceous infectious particle
- Prions: small infectious particle that are disease-causing form of a protein because of abnormal folding
- Pathogenesis:
α- Helical protein (PrP^c) $\xrightarrow{\beta\text{- sheet (PrP}^{sc}\text{)}}$ β- sheet (PrP^{sc}) (Prion)
(PrP^c): Found normally on the surface of cells in the central nervous system, but it is also located in other bodily tissues.
- Causes group of diseases known as transmissible spongiform encephalopathies (TSEs) that result in progressive neurodegenerative conditions, there are 2 famous examples:
 1. Bovine spongiform encephalopathy (BSE or mad cow disease) seen in cattle
 2. Creutzfeldt-Jakob disease (CJD) seen in humans

4) Prions

- Transmitted mainly by ingestion.
 - ✓ Sometimes by iatrogenic route (relating to illness caused by medical examination or treatment) e.g. blood transfusion, reuse of needles or IV sets, also drugs may cause side effects which can lead to iatrogenic disease.

5) Endogenous and exogenous

- ✓ **Endogenous infection:**

- ✓ When normal patient flora change to pathogenic bacteria because of change of normal habitat, damage of skin and inappropriate antibiotic use.

- ✓ **Exogenous cross-infection:**

- ✓ Mainly through hands of healthcare workers, visitors, patients.

6) Portal of entry

Microorganisms that cause disease are said to be pathogenic.

- Respiratory: via inhalation.
- Alimentary (GIT): by ingestion.
- Genital tract: sexual contact.
- Skin: abrasions, bites...
- Others: Conjunctiva, blood transfusion, injections and organ transplants.
- Congenital infections (vertical transmission) .

7) Useful micro-organisms

- The majority of Microbes Benefit human, animals and plants.
- a) Normal Body Flora: various bacteria and fungi that are permanent residents of certain body sites without causing disease
 - Characteristics:
 - 1- differ in both number and kind from one to another site, and a single type can normally exist in more than one site at the same time
 - 2- Found usually in certain body parts such as certain body sites especially the skin, colon, oropharynx and vagina.
 - 3- internal organs usually are sterile such as CNS, blood, lower bronchi, alveoli, liver, spleen, kidney and bladder are free of all ,even if occasional transient organisms can occur.

7) Useful micro-organisms

NASOPHARYNX

- Streptococci
- Haemophilus
- Neisseria
- Mixed anaerobes
- Candida
- Actinomyces

SKIN

- Staphylococci
- Streptococci
- Corynebacteria
- Propionibacteria
- Yeasts

UPPER BOWEL

- Enterobacteriaceae
- Enterococci
- Candida

LOWER BOWEL

- Bacteroides
- Bifidobacteria
- Clostridium + E.coli
- Peptostreptococci

VAGINA

- Lactobacilli
- Streptococci
- Corynebacteria
- Candida
- Actinomyces
- Mycoplasma hominis

7) Useful micro-organisms

Summary of the members of normal flora and their anatomic location

Colon:- Bacteroides species, Clostridium species, Enterococcus faecalis ,Escherichia coli ,coliforms,lactobacillus species ,Pseudomonas aeruginosa ,Bacteroides fragilis, Escherichia coli
Throat:- Viridans streptococci
Vagina:- Bacteroides species ,Candida albicans ,Corynebacterium species(diphtheroids), Escherichia coli, coliforms, Gardnerella vaginalis, lactobacillus species, Staphylococcus epidermidis, group B streptococci
Nasopharynx:- Corynebacterium species(diphtheroids),Haemophilus species, Neisseria species ,Viridans streptococci
Mouth:- Candida albicans, lactobacillus species, Neisseria species, Viridans streptococci
Skin:-

7) Useful micro-organisms

Skin:-

candida albicans , Staphylococcus epidermidis , Pseudomonas aeruginosa , Propionibacterium, peptococcus and Corynebacterium species(diphtheroids),

Urethra:-

Less Important Organisms:-

Staphylococcus epidermidis

Corynebacterium(diphtheroids), Various streptococci , Various gram negative rods, e.g. E.coli

Conjunctiva:-

Haemophilus species

Nose:-

Staphylococcus epidermidis, staphylococcus aureus

Dental plaque:-

Streptococcus mutans

Gingival crevices:-

Various anaerobes , e.g. Bacteroids, Fusobacterium, streptococci, Actinomyces

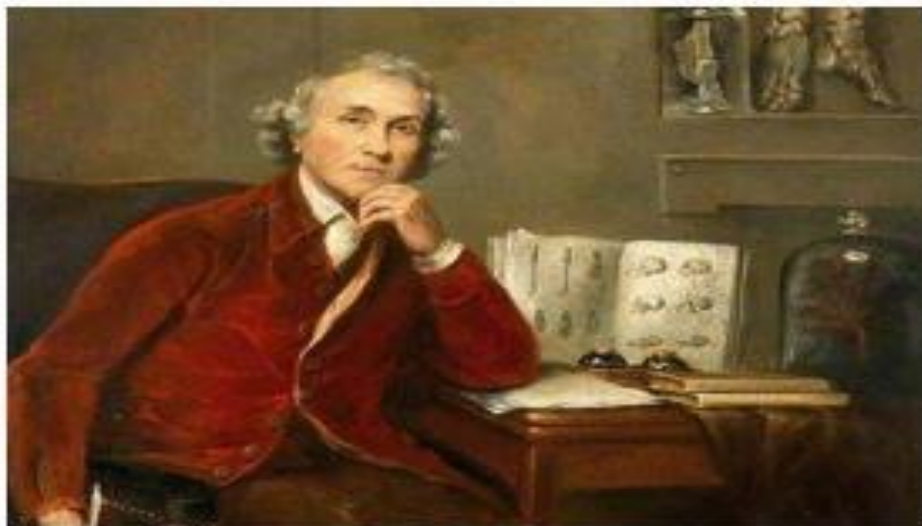
7) Useful micro-organisms

- B) Bacteria participate in recycling vital elements in the environment such as nitrogen, carbon, oxygen, sulfur, phosphorus, etc.
- C) Bacteria is used in sewage treatment, recycling water. (Bioremediation)
- D) Fermentation of some products, in food industry. (for example : using yeast in baking).
- E) Antibiotics production.
- F) Microorganisms are used in insect pest control: (viruses, bacteria and fungi) or their bioactive agents can be used as active substances and therefore are referred as Microbial Pest Control Agents (MPCA)
- G) Bacteria is used now in modern biotechnology such as genetic engineering, insulin, enzymes, vitamins production.

Short History:



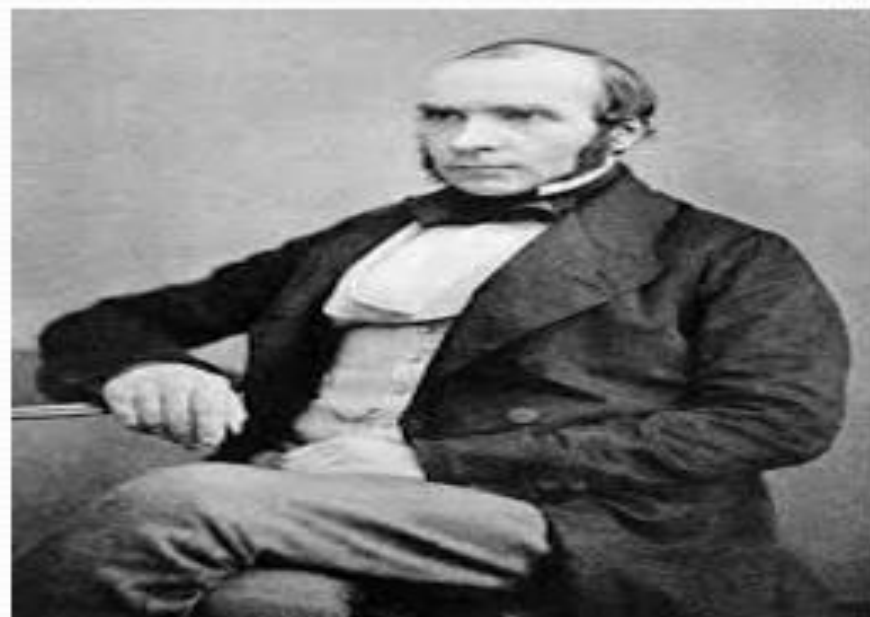
Antony van Leeuwenhoek 17th c: (father of microbiology), Dutch microscopist who was the first to observe live microorganisms in water mud and saliva.



John Hunter 18th c: Scottish surgeon he was considered the leading authority on venereal diseases, and believed that Syphilis and Gonorrhea were caused by a single pathogen.



Edward Jenner 18th-19th c: An English physician and scientist who pioneered the concept of vaccines including creating the smallpox vaccine, the world's first vaccine.



John Snow 19th c: An English physician, known for locating source of cholera outbreak in London (thus establishing the disease as water-borne), also he is considered one of the founders of modern epidemiology.



Ignaz Semmelweis 19th c: A Hungarian physician and scientist, known as early pioneer of antiseptic procedures . Described as the "savior of mothers", he discovered that the incidence of Puerperal sepsis can be prevented if the attending nurses apply hygienic measures. Hand washing stops infections



Louis Pasteur 19th c: French biologist, microbiologist , and chemist.

1. Discovered the principle of Fermentation of alcohol by microorganisms.
2. Invent a technique of treating milk and wine to stop bacterial contamination, a process called pasteurization.
3. Created the first Vaccines of *rabies*, *Bacillus anthrax*.



Louis Pasteur and the germ theory.

Louis Pasteur worked in the middle and late 1800s. He performed numerous experiments to discover why wine and dairy products became sour, and he found that bacteria were to blame. Pasteur called attention to the importance of microorganisms in everyday life and stirred scientists to think that if bacteria could make the wine “sick,” then perhaps they could cause human illness.

Pasteur's attempts to prove the germ theory were unsuccessful. However, the German scientist **Robert Koch** provided the proof by cultivating anthrax bacteria apart from any other type of organism.



Robert Koch 19th c:

Developed microbiological media & streak plates for pure culture.

Germ theory (Koch's postulates):

- Microorganism must be present in every case of the disease.
- Organism must be grown in pure culture from the diseased host.
- Inoculation of above into host must give same disease.
- Organism must be recovered from experimentally infected host.



Alexander Fleming – 1928 – A Scottish physician and microbiologist, his best known discovery the world's first broadly effective antibiotic (Penicillin G) from the mould [*Penicillium rubens*](#) in 1928.



Kary Mullis 1986: An American biochemist , invent Polymerase Chain Reaction (PCR) technique.



Zur Hausen : A German virologist, He has done research on cancer of the cervix, where he discovered the role of [*papilloma viruses*](#), This research directly made possible the development of a vaccine HPV.

9) Common terms

- Incubation period: the time between acquisition of the organism & the beginning of symptoms, it varies from hours to days to weeks .
- Period of communicability (infectious period): the time during which the infectious agent may be transferred directly or indirectly from an infected person to another person. even if the infected patient doesn't have any symptom
- Incidence rate: “is a measure of the disease risk” refers to the number of new cases of a disease within a time period
- Prevalence: “is a measure of the disease burden” a statistical concept referring to the number of cases of a disease that are present in a particular population at a given time.

9) Common terms

- Mortality rate: is a measure of the frequency of occurrence of death in a defined population during a specified interval.
- Case fatality rate: “is a measure of the severity of the disease” , is the proportion of deaths from a certain disease compared to the total number of people diagnosed with the disease for a particular period.
- Endemic infection: a disease that exists permanently in a particular region or population. Malaria is a constant worry in parts of Africa.
- Epidemics: is the rapid spread of disease to a large number of people in a given population within a short period of time.
- Pandemic: when an epidemic spreads throughout the world, “has spread across a large region, for example multiple continents or worldwide”