INTRODUCTION TO MICROBIOLOGY

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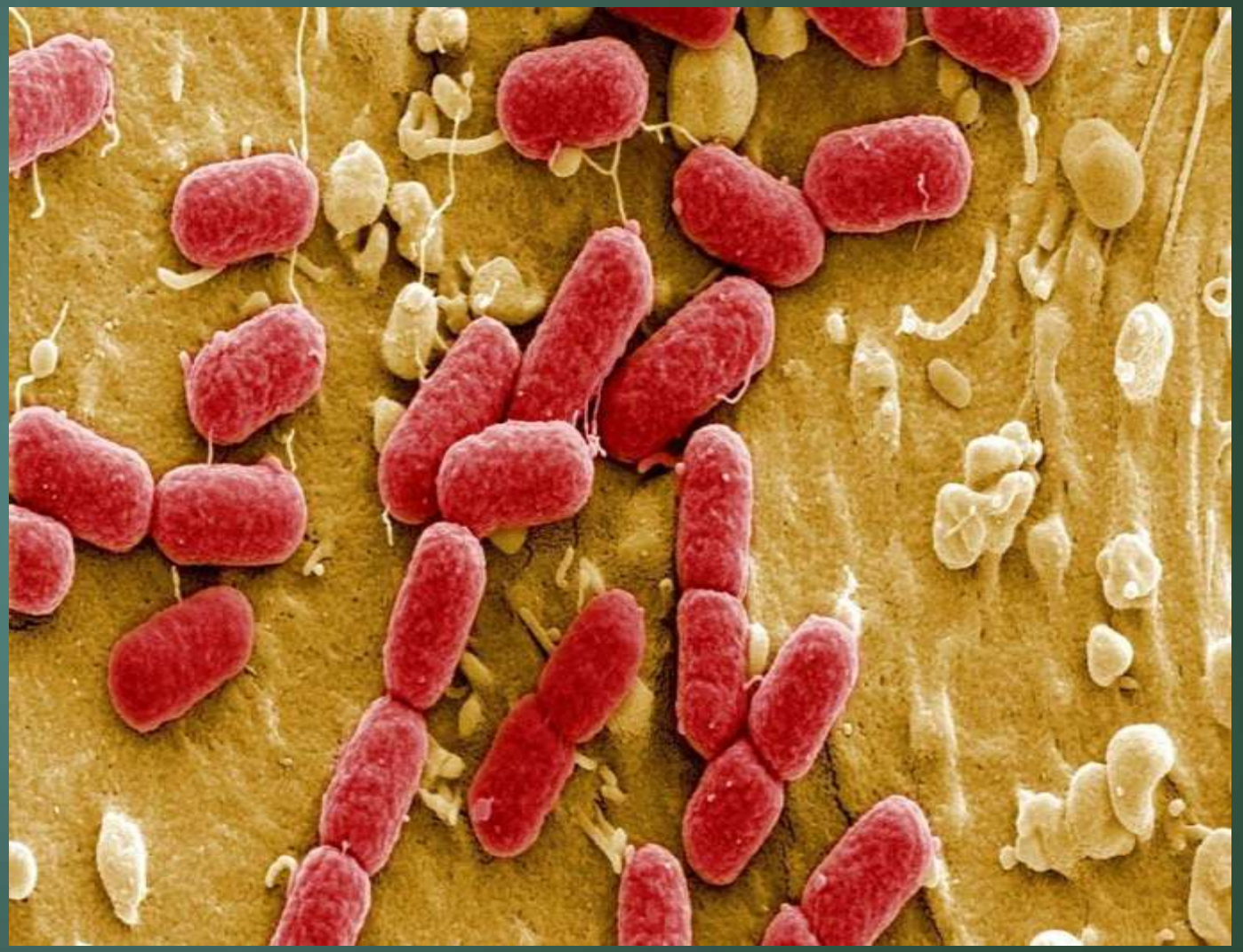
SUMMARY

Introduction
Definition of Terms
Importance of Microbiology
History of Microbiology
Major Categories of Microbes
Types of Microorganisms
Cell Structure
Essentials of Metabolism
Factors Influencing Enzymatic Activity
Host Pathogen Reaction



INTRODUCTION

What is Microbiology?

- It is derived from Greek words:

  Mikros – which means small

  Bios – which means life

  Logos – which means study of

Therefore:

- Microbiology is the study of those living organisms that are not visible to the naked eye and can be seen only under the microscope.
- Includes the study of certain nonliving entities as well as certain living organisms collectively called “microbes”.
- Basically defined as the study of microbes.

Definition Terms

Bacteriology – is the study of disease causing bacteria.

Virology – is the study of infectious viruses .

Mycology – is the study of disease causing fungi .

Parasitology – is the study of parasites .

Protozoology – is the study of disease causing protozoans .

Pathogens – microbes that cause diseases.

Nonpathogens – microbes that do not cause disease.

Opportunistic pathogens – microbes that do not usually cause diseases under ordinary conditions but have the potential to cause disease should the opportunity present itself.

Indigenous microbiota – microbes that live on and in the human body.

Importance of the study of Microbiology

- Approximately 10 times as many microbes live in the human body.
- Some opportunistic pathogens inhabit the human bodies.
- Microbes are essential for life.
- Microbes are involved in the decomposition of dead organisms and the waste products of living organisms.
- Some microbes are capable of decomposing industrial wastes (oil spills, for example). Thus we can use microbes – genetically engineered microbes, in some cases to clean up after ourselves.
- Many microbes are involved in elemental cycles such as carbon, nitrogen, oxygen, sulfur and phosphorous cycles.
- Some microbes live in the intestinal tracts of animals, where they aid in the digestion of food and some cases produce substances that are of value to the host animal.
- Many microbes are essential in various food and beverage industries.
- Some bacteria and fungi produce antibiotics used to treat patients.

HISTORY OF MICROBIOLOGY

- Existence of human pathogens have been observed in the bones and internal organs of mummies and early human fossils 4,000 years ago.
- Scientists learned that bacterial diseases such as tuberculosis, leprosy and syphilis, malaria, hepatitis and parasitic worm infections have been around for a long time.
- The first recorded epidemic was in Egypt about 3180 where words pestilence and plague were used without definition.
- The first microbes to be observed where bacteria and protozoa.
- It took 200 years to connect and establish the relationship between microbes and infectious diseases.

Pioneers in the Science of Microbiology were identified

Robert Hooke

- Reported to the world that life's smallest structural units were "little boxes" or "cells".
- He was able to see individual cells.
- His discovery marked the beginning of the cell theory – the theory that all living things are composed of cells.
- His microscope lacked the resolution to enable him to see microbes clearly.

- **Anton Van Leeuwenhoek**
  - the first person to see live bacteria and protozoa
  - he is referred as the "Father of Microbiology", "Father of Bacteriology", "Father of Protozoology.
  - He grounded small metal frames now known as single-lens microscopes.
  - He used his microscopes to examine almost anything.
  - He described "animalcules" which were later identified through his drawings as representations of bacteria and protozoa.

- **Louis Pasteur**
  - French chemist made numerous contributions to microbiology.
  - He discovered what occurs during alcoholic fermentation.
  - Also discovered forms of life that could exist in the absence of oxygen. He introduced the term "aerobes" (organisms that require oxygen) and "anaerobes" (organisms that do not require oxygen).
  - He developed the process of Pasteurization (to kill microbes that were causing wine to spoil).
  - Pasteur showed that microorganisms can be present in nonliving matter – on solids, in liquids, and in the air.
  - He further demonstrated that microbial life can be destroyed by heat and that methods can be devised to block the access of airborne microorganisms to nutrient environments.
  - His discovery formed the basis of **ASEPTIC TECHNIQUE** – a technique that prevent contamination by unwanted microorganisms.

- **Pasteur and Robert Koch**
  - Led to the establishment of Microbiology as a science.
  - The Germ Theory – this idea described the possibility that microorganisms might have similar relationships with plants and animals , specifically that microorganisms might cause disease.

There are 2 major categories of microbes

- Acellular microbes (also called infectious particles)
- Cellular microbes (also called microorganisms)

TYPES OF MICROORGANISMS (MAJOR GROUPS)

1. **Bacteria (singular: bacterium)**

- are relatively simple, single-celled (unicellular) organisms
- bacterial cells are called "prokaryotes"
- it is enclosed in cell walls that are largely composed of a carbohydrate and protein complex called peptidoglycan.
- For nutrition, bacteria use organic chemicals derived from either dead or living organisms.

2. Archaea

- Often found in extreme environments.
- Known to cause diseases in humans
- **Divided into 3 main groups**:
  - Methanogens – waste product from respiration
  - Extreme halophiles – live in extremely salty environments such as the Great Salt Lade and the Dead Sea.
  - Extreme thermophiles – live in hot sulfurous water, such as hot springs.

3. Fungi (singular: fungus)

- Fungi are eukaryotes, organisms whose cells have a distinct nucleus containing genetic material (DNA).
- It can be unicellular or multicellular
- Most typical fungi is moulds (cottony growths sometimes found in bread)
- They can reproduce sexually or asexually.
- They obtain nourishment by absorbing solutions of organic material from the environment such as soil, seawater, fresh water.

4. Protozoa (singular: protozoan)

- Are unicellular eukaryotes microbes.
- It moves by pseudopods, flagella or cilia.
- Comes in variety of shapes and lives as free entities or as parasites (organisms that derive nutrient from living hosts).

5. Algae (singular: alga)

- Are photosynthetic eukaryotes.
- Abundant in fresh and salt water, in soil, and in association with plants.
- They need light, water and carbon dioxide for food production and growth.
- Because of photosynthesis, algae produce oxygen and carbohydrates that are utilized by other organisms, including animals.
- They play an important role in the balance of nature.

6. Viruses

- They are so small that most can be seen only with an electron microscope.
- They can reproduce as self-sufficient units. In order to reproduce, they need to use the cellular machinery of other organisms.
- They are only considered living when they multiply within host cells that they infect.
- They are not considered living because outside living hosts, they are inert.

7. Multicellular Animal Parasites

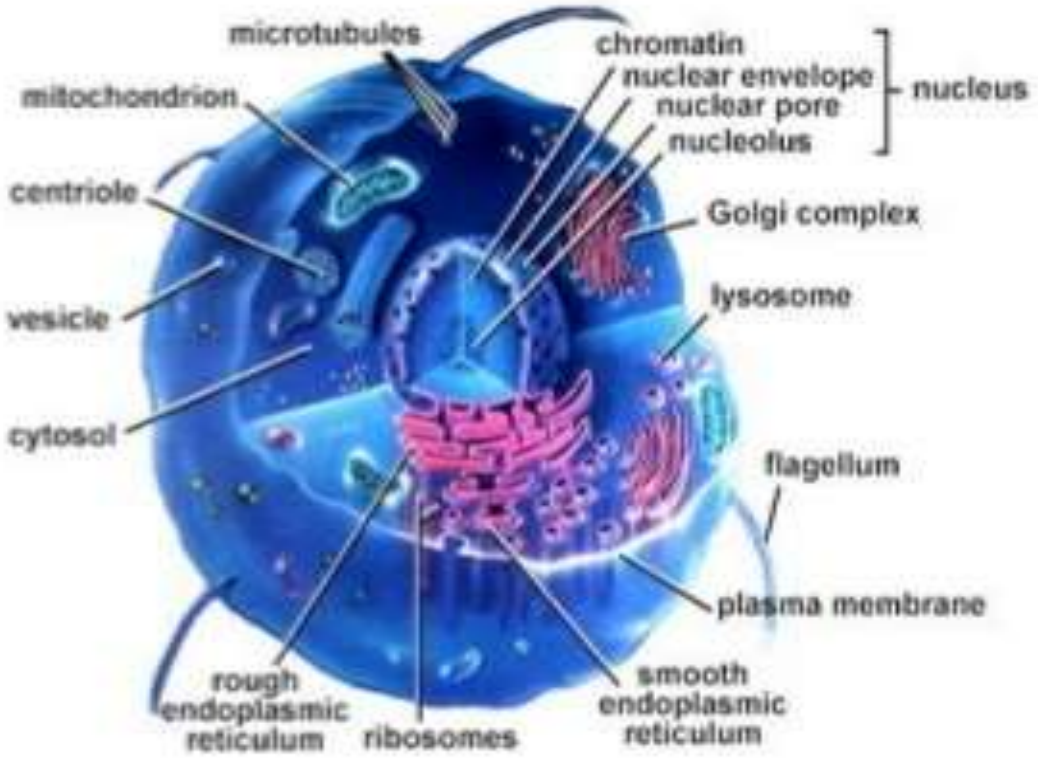
- Not strictly microorganisms, they are of medical importance.
- Animals are eukaryotes.

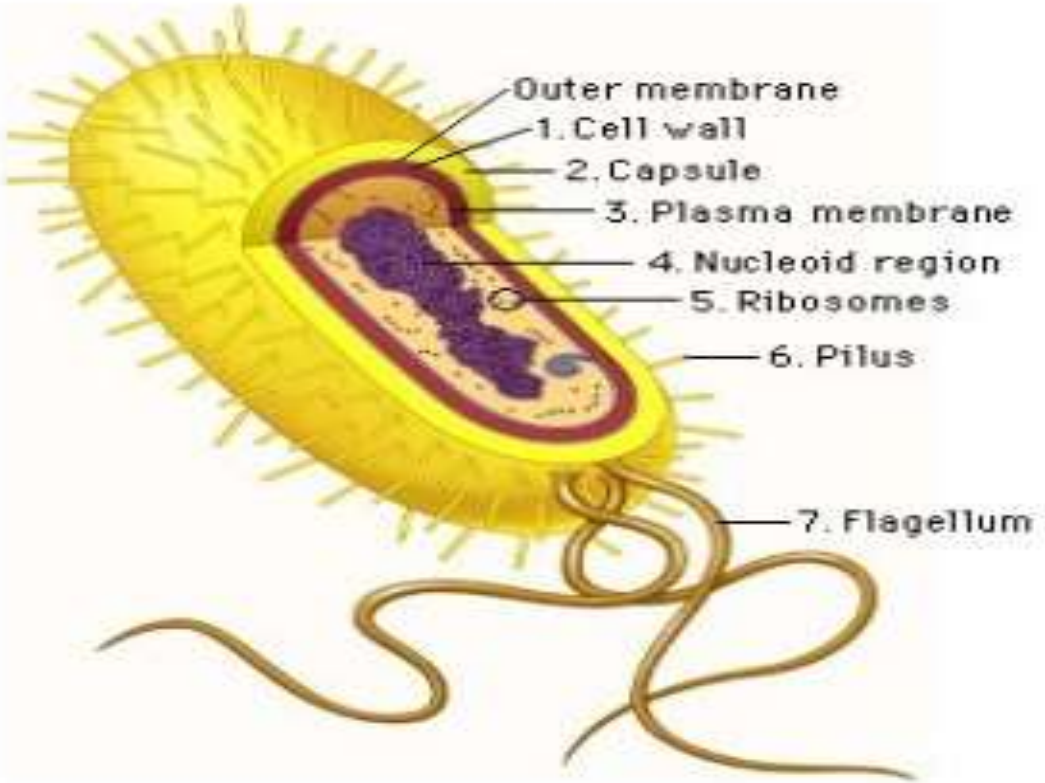
CELL STRUCTURE

What is a Cell?

- is the fundamental unit of any living organism.
- It exhibits characteristics of life.
- It obtains food (nutrients) from the environment to produce energy for metabolism and other activities.
- A cell can grow and reproduce because of its metabolism (refers to all of the chemical reactions that occur within a cell).
- Because of metabolism, cells grow and reproduce.
- It responds to stimuli in its environment (like light, heat, cold, and presence of chemicals).
- Less complex cells are called **Prokaryotic** cells which includes bacteria, archaea and cyanobacteria.
- More complex cells, containing true nucleus and many membranes are called **Eukaryotic** cells. This includes algae, protozoa and fungi.

Eukaryotic and Prokaryotic Cells





Structure	Function and Characteristics	
	Eukaryotic	Prokaryotic
Cell Membrane	• Cells are enclosed and intact by the cell membrane (also referred as plasma, cytoplasmic or cellular membrane). • It is composed of large molecules of proteins and phospholiipds (certain type of fat). • It is like a "skin" around the cell, separating the contents of the cell from the outside world. • It regulates the passage of nutrients, waste products and secretions into and out of the cell. • It has the property of selective permeability, which only allows certain substances to pass through them. • It is similar in structure and function to other membranes found in eukaryotic cells.	• Similar in structure and function to eukaryotic cell. • Many enzymes are attached to the cell membrane where various metabolic reactions takes place.

Structure	Function and Characteristics	
	Eukaryotic	**Prokaryotic**
Nucleus	Eukaryotic cells possess a true nucleus.. The nucleus controls the functions of the entire cell; it is the "command center" of the cell. It has 3 components: - **Nucleoplasm** (a type of protoplasm), - **chromosomes** (embedded or suspended in the nucleoplasm) Consists of DNA molecules and proteins – genes are located along the DNA molecules - **nuclear membrane** (the membrane that serves as a "skin" around the nucleus which contains holes where large molecules can enter and exit the nucleus.	Prokaryotic cells do not possess a true nucleus.

Structure	Function and Characteristics	
	Eukaryotic	**Prokaryotic**
Cytoplasm (a type of protoplasm)	Is a semifluid, gelatinous, nutrient matrix. It is where most of the cell's metabolic reactions occur.	Contains water, enzymes, dissolved oxygen, waste products, essential nutrients, proteins, carbohydrates and lipds. – these are required for metabolic functions.
Endoplasmic Reticulum	Is a highly convoluted system of membranes that are interconnected and arranged to form a transport network of tubules and flattened sacs within the cytoplasm.	NONE

Structure	Function and Characteristics	
	Eukaryotic	**Prokaryotic**
Ribosomes	Are 18 to 22 nm in diameter Are the sites of protein synthesis	For protein synthesis
Golgi Complex	Connects or communicates with the Endoplasmic reticulum	NONE
Lysosomes and Peroxisomes	Small vesicles that contain lysozyme and other digestive enzymes that break down foreign material taken into the cell by phagocytosis (the engulfing of large particles)	NONE

Structure	Function and Characteristics	
	Eukaryotic	**Prokaryotic**
Mitochondria	Are considered as the power plants or energy factories within a cell.	NONE
Plastids	Are membrane bound structures containing various photosynthetic pigments. Photosynthesis is the process by which light energy is used to convert carbon dioxide and water into carbohydrates and oxygen	NONE
Cytoskeleton	Is a system of fibers served to strengthen, support and stiffen the cell, and give the cell its shape.	NONE

Structure	Function and Characteristics	
	Eukaryotic	**Prokaryotic**
Cell wall	Contains external structures that provide rigidity, shape, and protection	Bacterial Cell wall is chemically complex. Different from eukaryotic cell wall Has the same function. Gram positive bacteria – have thicker layer of peptidoglycan
Flagella and CIlia	Flagella – are long thin structures which enables the cells to “swim” through liquid environment Cilia – are organelles of locomotion; but are shorter and thinner which tends to beat with coordinated, rhythmic movement.	Flagellated bacteria – are motile Non flagellated bacteria - usually non motile. Rotates to push the cell Bacteria doesn’t have a cilia.

Structure	Function and Characteristics	
	Eukaryotic	**Prokaryotic**
Glycocalyx	None	Is a gelatinous polysaccharide and/or polypeptide covering. Capsules may protect pathogens from phagocytosis. Capsules enables adherence to surfaces, prevent desiccation, and may provide nutrients.
Cytoplasmic Particles		They are the sites of protein synthesis.

Structure	Function and Characteristics	
	Eukaryotic	Prokaryotic
Pili (Fimbriae)		Hair like structures but not associated with motility. Fimbrae helps cells adhere to surfaces. Pili are involved in twitching motility and DNA transfer.

ESSENTIALS OF METABOLISM

- Metabolism
  - this refers to the sum of all chemical reactions within a living organism.
  - It is viewed as an energy-balancing act.

- 2 reactions:

  - Catabolism
    - Refers to the chemical reactions that result in the breakdown of more complex organic molecules into simpler substances.
    - This reaction usually release energy.
  - Anabolism
    - refers to chemical reactions in which simpler substances are combined to form complex molecules.
    - This reaction usually require energy.
- Enzymes
  - refers to the proteins, produced by living cells, that catalyze chemical reactions by lowering the activation energy.

Factors influencing enzymatic activity

- **Temperature**
  - At high temperatures enzymes undergo denaturation and lose their catalytic properties
  - At low temperature, the reaction rate decreases
- **pH**
  - at optimum pH, enzymatic activity is at maximal.
- **Substance concentration**
  - Enzymatic activity increases as substrate concentration increases until the enzymes are saturated.
- **Inhibitors**
  - Competitive inhibitors compete with normal substrate for the active site of the enzyme.
  - Noncompetitive inhibitors act on other parts of the enzyme and decreases the enzyme's ability to combine with the normal substrate.

HOST PATHOGEN REACTION

- Pathology
  - Is the scientific study of disease.
  - It is concerned with the etiology (cause), pathogenesis (development) and effects of disease.
- Infection
  - Is the invasion and growth of pathogens in the body.
- Host
  - Is an organism that shelters and supports the growth of pathogens.
- Disease
  - Is an abnormal state in which part or all of the body is not properly adjusted or is incapable of performing normal functions.

There are 3 types of symbiosis:

- Commensalism (one organism benefits and the other is unaffected)
- Mutualism (both organisms benefit)
- Parasitism (one organism benefits, and one is harmed).

- Opportunistic Microorganisms do not cause diseases under normal conditions but cause disease under special conditions.
- In some situations, one microorganism makes it possible for another to cause a disease or produce more severe symptoms.