Prokaryotic Cell

The term "**prokaryote**" is derived from the Greek word "*pro*", (meaning: before) and "*karyon*" (meaning: kernel). It translates to "***before nuclei.***"

A prokaryotic cell is a primitive type of cell that is characterized by the absence of a nucleus. Furthermore, prokaryotes do not possess membrane-bound cellular organelles. Prokaryotes are exclusively unicellular.

Structurally, prokaryotes have a capsule enveloping their entire body, and it functions as a protective coat. This is crucial for preventing the process of phagocytosis (where the bacteria gets engulfed by other eukaryotic cells, such as macrophages) The pilus is a hair-like appendage found on the external surface of most prokaryotes and it helps the organism to attach itself to various environments. The pilus essentially resists being flushed, hence, it is also called attachment pili. It is commonly observed in bacteria.

Right below the protective coating lies the cell wall, which provides strength and rigidity to the cell. Further down lies the cytoplasm that helps in cellular growth, and this is contained within the plasma membrane, which separates the interior contents of the cell from the outside environment. Within the cytoplasm, ribosomes exist and it plays an important role in protein synthesis. It is also one of the smallest components within the cell.

Some prokaryotic cells contain special structures called mesosomes which assist in **cellular respiration**. Most prokaryotes also contain plasmids, which contain small, circular pieces of DNA. To help with locomotion, flagella are present, though, pilus can also serve as an aid for locomotion. Common examples of Prokaryotic organisms are bacteria and archaea. Also, all members of Kingdom Monera are prokaryotes.

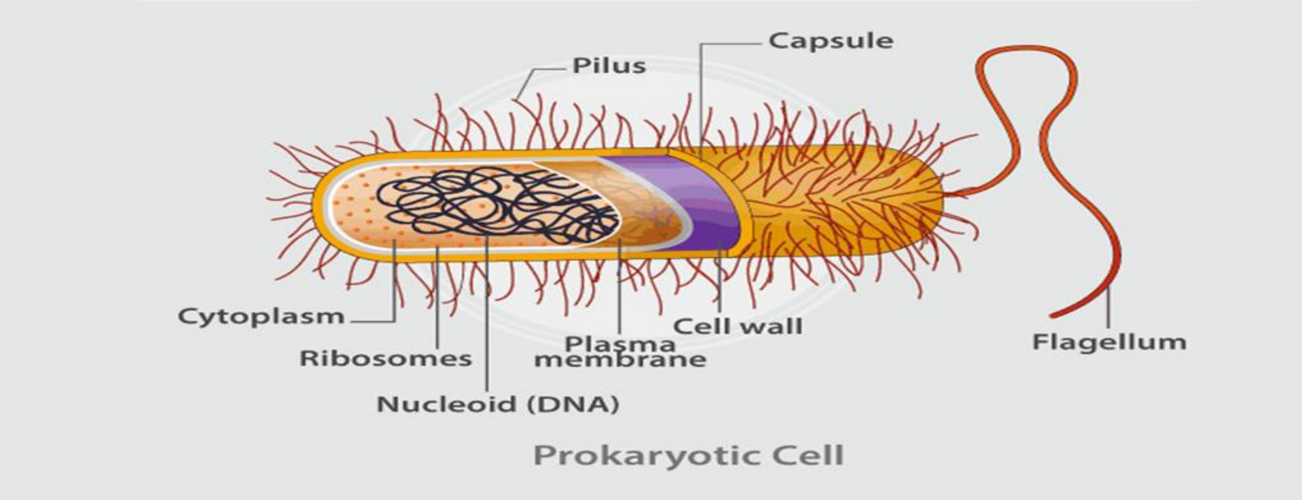

Figure 1: prokaryotic cell.

Eukaryotic Cell

The term "**Eukaryotes**" is derived from the Greek word "*eu*", (meaning: good) and "*karyon*" (meaning: kernel), therefore, translating to "***good or true nuclei***." Eukaryotes are more complex and much larger than prokaryotes. They include almost all the major kingdoms except kingdom monera.

Eukaryotic cells are cells that possess a true nucleus along with membrane-bound organelles. Eukaryotes can either be unicellular or multicellular.

Structurally, eukaryotes possess a cell wall, which supports and protects the plasma membrane. The cell is surrounded by the plasma membrane and it controls the entry and exit of certain substances.

The nucleus contains DNA, which is responsible for storing all genetic information. The nucleus is surrounded by the nuclear membrane. Within the nucleus exists the nucleolus, and it plays a crucial role in synthesising proteins. Eukaryotic cells also contain mitochondria, which are responsible for the creation of energy, which is then utilized by the cell.

Present in only plant cells, chloroplasts are the subcellular sites of photosynthesis. The endoplasmic reticulum helps in the transportation of materials. Besides these, there are also other **cell organelles** that perform various other functions and these include ribosomes, lysosomes, Golgi bodies, cytoplasm, chromosomes, vacuoles and centrosomes.

Examples of eukaryotes include almost every unicellular organism with a nucleus and all multicellular organisms.

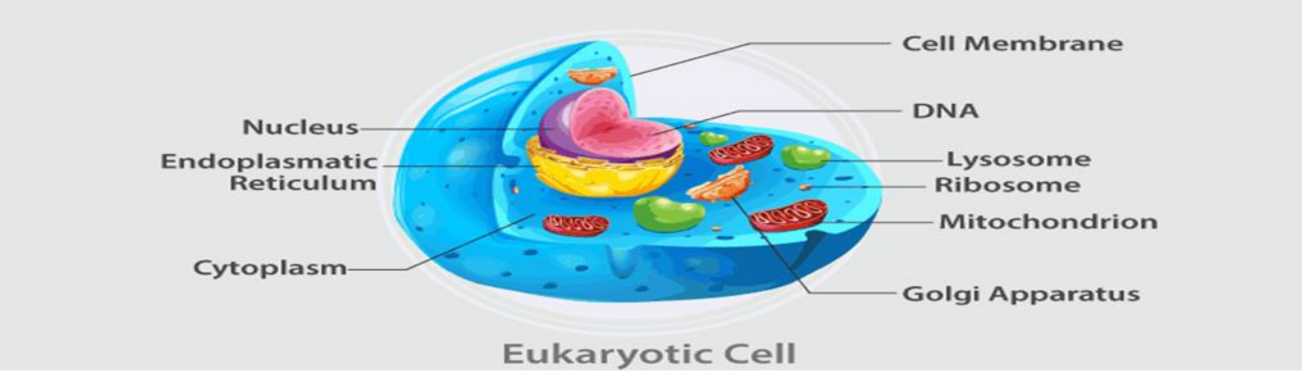

Figure 2: Eukaryotic cell

Difference between Prokaryotic and Eukaryotic Cells

Though these two classes of cells are quite different, they do possess some common characteristics. For instance, both possess cell membranes and ribosomes, but the similarities end there. The complete list of differences between prokaryotic and eukaryotic cells is summarized as follows:

	Prokaryotes	**Eukaryotes**
Type of Cell	Always unicellular	Unicellular and multi-cellular
Cell size	Ranges in size from 0.2 μm – 2.0 μm in diameter	Size ranges from 10 μm – 100 μm in diameter
Cell wall	Usually present; chemically complex in nature	When present, chemically simple in nature
Nucleus	Absent. Instead, they have a nucleoid region in the cell	Present
Ribosomes	Present. Smaller in size and spherical in shape	Present. Comparatively larger in size and linear in shape
DNA arrangement	Circular	Linear
Mitochondria	Absent	Present
Cytoplasm	Present, but cell organelles absent	Present, cell organelles present

Endoplasmic reticulum	Absent	Present
Plasmids	Present	Very rarely found in eukaryotes
Ribosome	Small ribosomes	Large ribosomes
Lysosome	Lysosomes and centrosomes are absent	Lysosomes and centrosomes are present
Cell division	Through binary fission	Through mitosis
Flagella	The flagella are smaller in size	The flagella are larger in size
Reproduction	Asexual	Both asexual and sexual
Example	Bacteria and Archaea	Plant and Animal cell

Introduction to the Chemistry of Life

The elements **carbon, hydrogen, nitrogen, oxygen, sulfur, and phosphorus** are the key building blocks of the chemicals found in living things. They form the **carbohydrates, nucleic acids, proteins, and lipids** (all of which will be defined later in this chapter) that are the fundamental molecular components of all organisms. In this chapter, we will discuss these important building blocks and learn how the unique properties of the atoms of different elements affect their interactions with other atoms to form the molecules of life. These interactions determine what atoms combine and the ultimate shape of the molecules and macromolecules, that shape will determine their function.

Food provides an organism with nutrients—the matter it needs to survive. Many of these critical nutrients come in the form of biological macromolecules, or large molecules necessary for life. These macromolecules are built from different combinations of smaller organic molecules.

The atom is the smallest unit of an element that exists as a stable entity. An element is a substance containing only one type of atom, e.g. iron contains only iron atoms. When a substance contains two or more different types of atom, it is called a compound. For instance, water is a compound containing both hydrogen and oxygen atoms. There are 92 naturally occurring elements, but the wide variety of compounds that make up living tissues are composed almost entirely of only four: carbon, hydrogen, oxygen and nitrogen. Small amounts (about 4% of body weight) of others are present, including sodium, potassium, calcium and phosphorus.

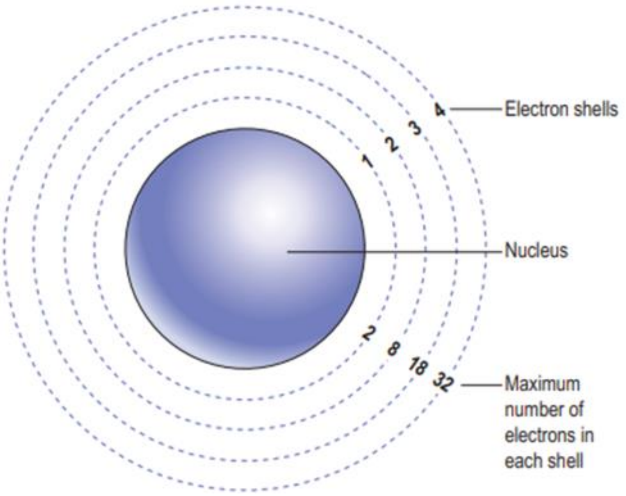

Figure 3: The atom, showing the nucleus and four electron shells.

Atomic structure

Atoms are mainly empty space, with a tiny central nucleus containing protons and neutrons surrounded by clouds of tiny orbiting electrons (Fig. 3). Neutrons carry no electrical charge, but protons are positively charged, and electrons are negatively charged. Because atoms contain equal numbers of protons and electrons, they carry no net charge. These subatomic particles differ also in terms of their mass. Electrons are so small that their mass is negligible, but the bigger neutrons and protons carry one atomic mass unit each.

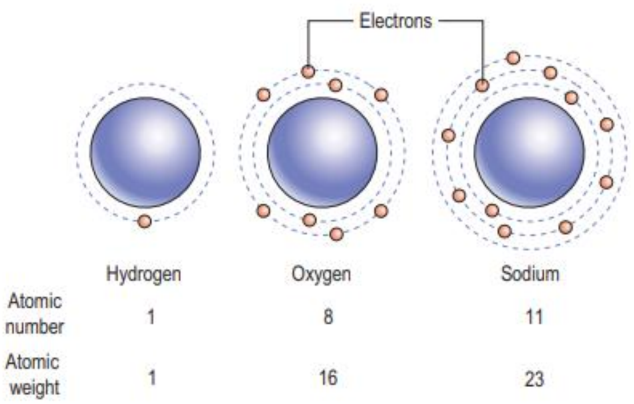

Figure 4: The atomic structures of the elements hydrogen, oxygen and sodium.

Molecules consist of two or more atoms that are chemically combined. The atoms may be of the same element, e.g. a molecule of atmospheric oxygen (O_2) contains two oxygen atoms. Most molecules, however, contain two or more different elements, e.g. a water molecule (H_2O) consists of two hydrogen atoms and an oxygen atom. As mentioned earlier, when two or more elements combine, the resulting molecule is referred to as a compound.

Compounds that contain the elements carbon and hydrogen are classified as organic, and all others as inorganic. Living tissues are based on organic compounds, but the body requires inorganic compounds too.

Covalent and ionic bonds. The vast array of chemical processes on which life is based is completely dependent upon the way atoms come together, bind and break apart. For example, the simple water molecule is a crucial foundation of all life on Earth. If water was a less stable compound, and the atoms came apart easily, human biology could never have evolved. On the other hand, the body is dependent upon the breaking down of various molecules (e.g. sugars, fats) to release energy for cellular activities. When atoms are joined together, they form a chemical bond that is generally one of two types: covalent or ionic. Covalent bonds are formed when atoms share their electrons with each other. Most molecules are held together with this type of bond; it forms a strong and stable link between its constituent atoms. A water molecule is built using covalent bonds.

Hydrogen has one electron in its outer shell, but the optimum number for this shell is two. Oxygen has six electrons in its outer shell, but the optimum number for this shell is eight. Therefore, if one oxygen atom and two hydrogen atoms combine, each hydrogen atom will share its electron with the oxygen atom, giving the oxygen atom a total of eight outer electrons, making it stable. The oxygen atom shares one of its electrons with each of the two hydrogen atoms, so that each hydrogen atom has two electrons in its outer shell, and they too are stable.

Ionic bonds are weaker than covalent bonds and are formed when electrons are transferred from one atom to another. For example, when sodium (Na) combines with chlorine (Cl) to form sodium chloride (NaCl) there is a transfer of the only electron in the outer shell of the sodium atom to the outer shell of the chlorine atom.

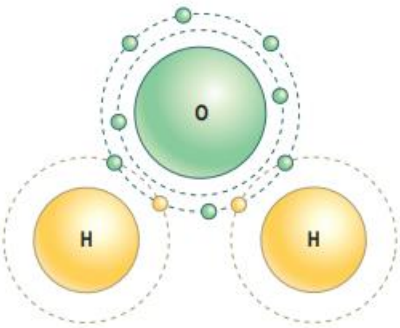

Figure 5: A water molecule, showing the covalent bonds between hydrogen (yellow) and oxygen (green).

Acids, alkalis and pH

The concentration of hydrogen ions ([Hþ]) in a solution is a measure of the acidity of the solution. Control of hydrogen ion levels in body fluids is an important factor in maintaining a stable internal environment. An acid substance releases hydrogen ions when in solution. On the other hand, a basic (alkaline) substance accepts hydrogen ions, often with the release of hydroxyl (OH) ions. A salt releases other anions and cations when dissolved; sodium chloride is therefore a salt because in solution it releases sodium and chloride ions.

The pH (potential of hydrogen) scale

The standard scale for measurement of hydrogen ion concentration in solution is the pH scale. The scale measures from 0 to 14, with 7, the midpoint, as neutral; this is the pH of water. Water is a neutral molecule, neither acid nor alkaline, because when the molecule breaks up into its constituent ions, it releases one Hþ and one OH, which balance one another. Most body fluids are close to neutral, because strong acids and bases are damaging to living tissues, and body fluids contain buffers, themselves weak acids and bases, to keep their pH within narrow ranges. A pH reading below 7 indicates an acid solution, while readings above 7 indicate alkalinity (Fig.6). A change of one whole number on the pH scale indicates a 10-fold change in [Hþ].

Therefore, a solution of pH 5 contains ten times as many hydrogen ions as a solution of pH 6. Not all acids ionise completely when dissolved in water. The hydrogen ion concentration is, therefore, a measure of the amount of dissociated acid (ionised acid) rather than of the total amount of acid present. Strong acids dissociate more freely than weak acids, e.g. hydrochloric acid dissociates freely into Hþ and Cl, while carbonic acid dissociates much less freely into Hþ and HCO3 . Likewise, not all bases dissociate completely. Strong bases dissociate more fully, i.e. release more OH than weaker ones.

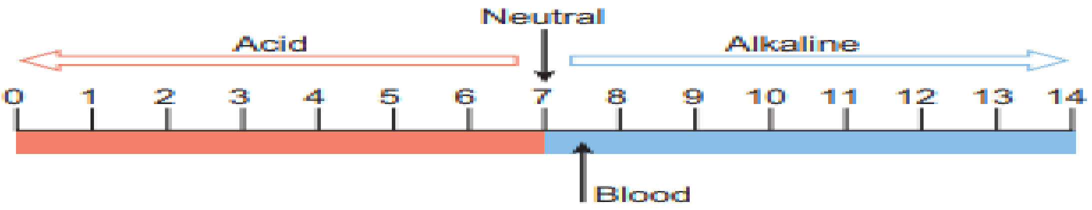

Figure 6: The pH scale

1. Which of the following organelles is absent in prokaryotic cells?

a) Ribosome

b) **Nucleus**

c) Cytoplasm

d) Plasma membrane

e) Cell wall

2. What is the function of the pilus in prokaryotic cells?

a) Protein synthesis

b) **Attachment to surfaces**

c) Locomotion

d) Energy production

e) Nutrient storage

3. Prokaryotic cells are unique because they:

a) **Do not contain membrane-bound organelles**

b) Have a true nucleus

c) Perform photosynthesis

d) Are always multicellular

e) Reproduce sexually

4. Which of the following structures helps prokaryotic cells resist phagocytosis?

a) Ribosome

b) **Capsule**

c) Flagella

d) Mesosome

e) Plasmid

5. Which is the correct size range for prokaryotic cells?

a) 1 µm - 5 µm

b) 0.5 µm - 3 µm

c) **0.2 µm - 2.0 µm**

d) 10 µm - 100 µm

e) 5 µm - 50 µm

6. What type of genetic material is found in prokaryotic cells?

a) **Circular DNA**

b) Linear DNA

c) Chromatin

d) RNA

e) DNA and RNA

7. In prokaryotic cells, the primary site of protein synthesis is:

a) Nucleus

b) Mitochondria

c) **Ribosomes**

d) Golgi apparatus

e) Lysosomes

8. Which of the following is NOT found in a prokaryotic cell?

a) Plasma membrane

b) **Mitochondria**

c) Ribosomes

d) Cytoplasm

e) Cell wall

9. Which of the following is a common example of prokaryotic organisms?

a) **Bacteria**

b) Fungi

c) Animals

d) Plants

e) Protists

10. Prokaryotic cells primarily reproduce through:

a) Mitosis

b) **Binary fission**

c) Meiosis

d) Budding

e) Sexual reproduction

11. Which cell type has lysosomes and centrosomes?

a) Prokaryotic cells

b) **Eukaryotic cells**

c) Both prokaryotic and eukaryotic cells

d) Neither prokaryotic nor eukaryotic cells

e) Only animal cells

12. The protective layer outside the plasma membrane of a prokaryotic cell is:

a) Cytoplasm

b) **Capsule**

c) Endoplasmic reticulum

d) Ribosome

e) Golgi apparatus

13. Which structure is involved in locomotion in prokaryotic cells?

a) **Flagella**

b) Nucleus

c) Endoplasmic reticulum

d) Ribosome

e) Lysosome

14. Which of the following types of cell division do prokaryotes undergo?

a) Mitosis

b) **Binary fission**

c) Meiosis

d) Budding

e) Fragmentation

15. Which type of bond involves sharing electrons between atoms?

a) Ionic bond

b) **Covalent bond**

c) Hydrogen bond

d) Metallic bond

e) Peptide bond

16. The cell wall of prokaryotes is:

a) Absent

b) **Chemically complex**

c) Chemically simple

d) Composed of cellulose

e) Found only in archaea

17. Which structure assists in prokaryotic cell respiration?

a) Ribosome

b) **Mesosome**

c) Cytoplasm

d) Endoplasmic reticulum

e) Mitochondria

18. In eukaryotic cells, the nucleus is surrounded by:

a) Plasma membrane

b) Cytoplasm

c) **Nuclear membrane**

d) Ribosomes

e) Nucleoplasm

19. Prokaryotes are generally:

a) **Unicellular**

b) Multicellular

c) Multicellular and unicellular

d) Colonies

e) Pluricellular

20. What is the main component of the prokaryotic cell wall?

a) Lipids

b) **Peptidoglycan**

c) Proteins

d) Cellulose

e) Glycoproteins

21. Which of the following is a eukaryotic cell feature?

a) Circular DNA

b) **Membrane-bound organelles**

c) Plasmids

d) Binary fission

e) Nucleoid region

22. The main function of ribosomes in cells is:

a) Energy production

b) **Protein synthesis**

c) Storage of genetic material

d) Photosynthesis

e) Cell division

23. What type of reproduction is most common in prokaryotes?

a) Sexual

b) Asexual through **binary fission**

c) Mitosis

d) Spore formation

e) Budding

24. Which of the following structures is unique to eukaryotic cells?

a) Ribosomes

b) **Mitochondria**

c) Cell membrane

d) Cytoplasm

e) Flagella

25. In which of the following organelles is DNA found in eukaryotic cells?

a) **Nucleus**

b) Ribosomes

c) Lysosomes

d) Plasma membrane

e) Golgi apparatus

26. In terms of DNA arrangement, prokaryotes have:

a) Linear DNA

b) Chromatin

c) **Circular DNA**

d) RNA-DNA hybrid

e) Double-stranded linear DNA

27. Which component is present in both prokaryotic and eukaryotic cells?

a) Mitochondria

b) Nucleus

c) **Ribosome**

d) Endoplasmic reticulum

e) Lysosomes

28. The energy production in prokaryotic cells happens through:

a) **Mesosomes**

b) Mitochondria

c) Chloroplasts

d) Ribosomes

e) Nucleus

29. Which type of ribosomes are found in prokaryotic cells?

a) Large ribosomes

b) **Small ribosomes**

c) Membrane-bound ribosomes

d) Ribosomes in the nucleus

e) Ribosomes attached to the ER

30. The term “eukaryote” translates to:

a) **True nuclei**

b) Before nuclei

c) Primitive nucleus

d) Large nucleus

e) Functional nucleus

31. Which of the following statements is true for prokaryotes?

a) Prokaryotes have a nucleus

b) **Prokaryotes lack membrane-bound organelles**

c) Prokaryotes undergo mitosis

d) Prokaryotes have linear DNA

e) Prokaryotes reproduce sexually

32. Eukaryotic cells differ from prokaryotic cells because they:

a) **Contain a nucleus**

b) Lack ribosomes

c) Are unicellular

d) Have circular DNA

e) Lack a cell wall

33. Which of the following molecules is held together by covalent bonds?

a) Sodium chloride

b) **Water**

c) Potassium chloride

d) Magnesium oxide

e) Calcium chloride

34. The key difference between prokaryotic and eukaryotic cells is the presence of:

a) Ribosomes

b) **Nucleus**

c) Plasma membrane

d) DNA

e) Cell wall

35. The prokaryotic flagella are:

a) Larger than those in eukaryotes

b) **Smaller than those in eukaryotes**

c) The same size as eukaryotic flagella

d) Non-functional

e) Absent in prokaryotes

36. Which process is responsible for prokaryotic cell division?

a) **Binary fission**

b) Mitosis

c) Meiosis

d) Fragmentation

e) Budding

37. The mass of protons in an atom is measured in:

a) Electron volts

b) Joules

c) **Atomic mass units**

d) Grams

e) Kilograms

38. The pH of water is considered neutral because:

a) Water is an acid

b) Water is a base

c) **Water has equal H+ and OH- ions**

d) Water has more OH- ions than H+ ions

e) Water has more H+ ions than OH- ions

39. Which type of bond is generally weaker than covalent bonds?

a) **Ionic bond**

b) Hydrogen bond

c) Peptide bond

d) Metallic bond

e) Disulfide bond

40. Acids in solution release:

a) **H+ ions**

b) OH- ions

c) Electrons

d) Neutrons

e) Anions