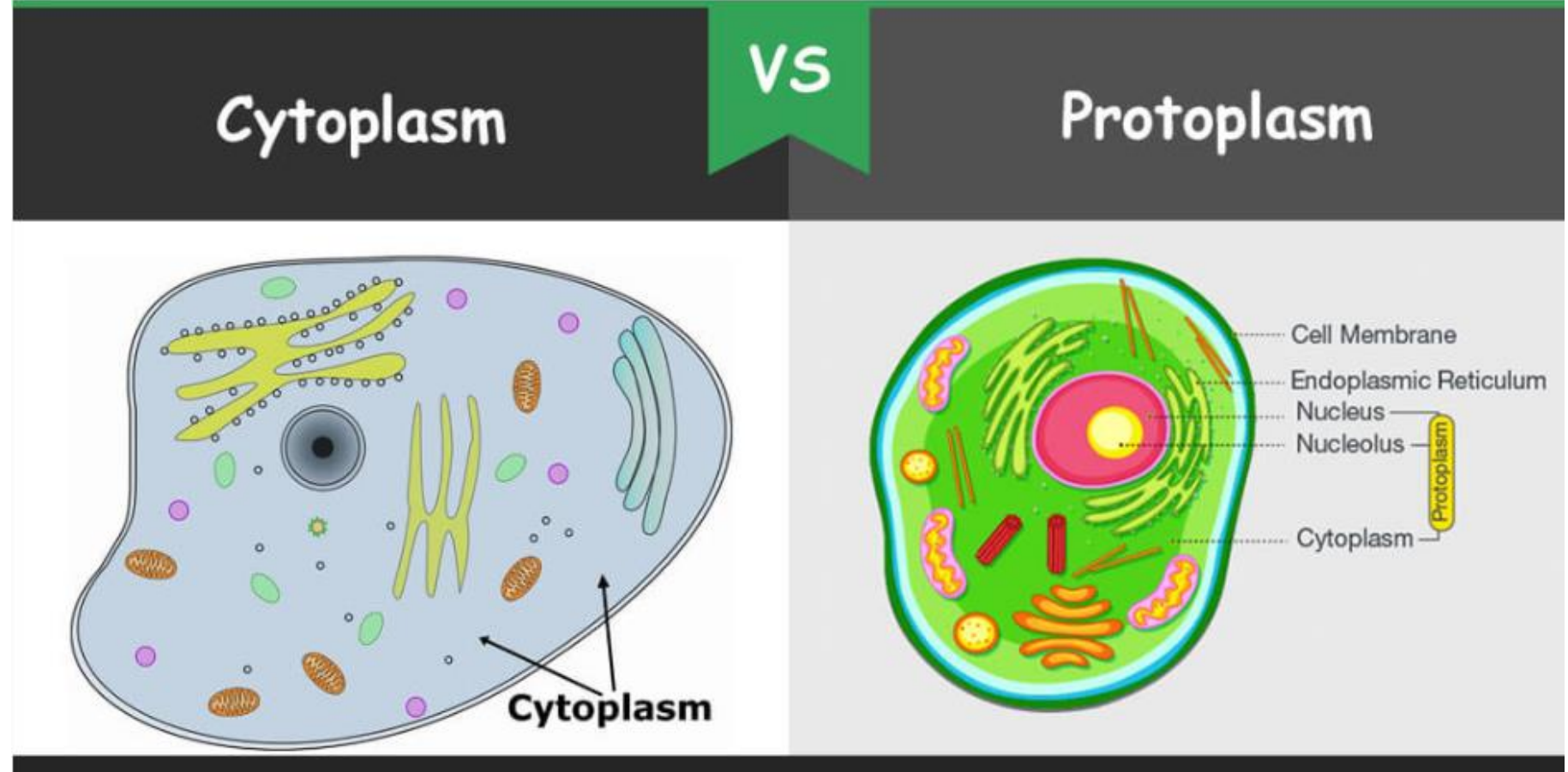


UNIT III PROTOPLASM

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- **PROTOPLASM**

- . All cells are made of protoplasm. Protoplasm was defined as the physical basis of life by Huxley as it does all the activities of living beings. In 1835, Dujardin studied the contents of the cell in certain Protozoa and he described the matrix of cells as a homogeneous mass and called it sarcode
- This matrix of cell was given the name of protoplasm by J.E. Purkinje in 1840. H. Von Mohl, in 1846, stated the protoplasm as a clear, homogeneous appearing (in the light microscope), gelatinous substance.
- According to Huxley the protoplasm is the physical basis of life. Inside the cell wall of living cell the living substance is known as protoplasm. The protoplasm is a thick fluid or jellylike substance.
- These two forms are not much differentiable from each other and may easily be transformed from one form to another. When found fluid state it seems to be more active. Generally it is greyish or somewhat yellowish in colour.

- It is always transparent. Many small granules found in it are food granules. It is a very complex substance and found to be dispersed in the medium of water. It consists of ninety percent of water. The protoplasm found in the cells of the seeds contains less percentage of water, and therefore, it is of thick consistency.
- In such cases the protoplasm is somewhat inactive and becomes active only when sufficient amount of water is absorbed. In addition to water other substances are also found in the protoplasm.
- Among these substances the most important ones are proteins which are found in large quantity. The proteins remain dispersed in the water. The proteins are highly complex chemical compounds. The protein molecules are very large and of very high molecular weight. These complex compounds always contain carbon, hydrogen, oxygen and nitrogen.

- In addition to these elements sulphur and phosphorus are generally found. The proteins of protoplasm always contain sulphur and phosphorus. The protoplasm contains the proteins of various types. The protoplasm also contains some other organic compounds, such as fats and carbohydrates. In addition to these, some inorganic salts also found in it.
- Protoplasm is defined as the organic and inorganic substances that constitute the living the nucleus, cytoplasm, plastids and mitochondria of the cell.
- Protoplasm is the living part of the cell, which comprises of different cellular organelles. It is a jelly-like, colourless, transparent and viscous living substances present within the cell wall. The term protoplasm was proposed in the year 1835 and is known as the primary substance, as it is responsible for various living processes.
- It was believed that cell were containers of protoplasm. However, the concept could not explain the origin of structures formed within the cell, primarily the nucleus.

• **Components and Functions of a Protoplasm**

- The cytoplasm is the initial component of protoplasm, which is found between the cell membrane and the cell nucleus in a eukaryotic cell. In the cell, a cytoplasm plays a vital role in maintaining the cell environment, maintains the shape of cells and also stores substances required by the organelle.
- The nucleus is the second component of the protoplasm, which stores the genetic information of an organism. Ribosomes are also found in the nucleus, which is essential for the production of proteins in the cell. Prokaryotes contain a nucleoid instead of a nucleus where all the genetic information is found.
- Proteins, fats, enzymes, hormones, all make up the protoplasm. These are either dissolved or suspended in the water component of the protoplasm.
- The organic material which consists of proteins and carbohydrates in suspension may be either hydrophilic (water-loving) or hydrophobic (water-hating). The hydrophilic particles occur surrounding the water molecules. The attraction between protein and water is due to electric charges that hold them together.

- **Physical properties of protoplasm**

- The physical properties of protoplasm are principally due to the various chemical inclusions in a gel phase. A gel is a group of suspended particles in a semi-solid condition or jelly-like state. The molecules of a gel are held together by various types of chemical bonds of varying strength.
- The stability of bond depends upon the type of bond and strength of bond. The gel may become more liquid than solid. This process is called solation and the liquid state as sol. Thus, the colloidal protoplasm which is in gel form can change into sol form by solation and the sol can change into gel by gelation. These gel-sol conditions of colloidal system are prime basis for mechanical behaviour of cytoplasm.
- Protoplasm is neither a good nor a bad conductor of electricity. It forms a delimiting membrane on coming in contact with water and solidifies when heated.

- ***Other properties:***

- Besides, the protoplasm also shows the following properties—

- **1. Cohesiveness:**

- The various particles or molecules of protoplasm are adhered with each other by forces, such as Van der Waal's bonds, that hold long chains of molecules together. These Van der Waal's bonds are weak and non-specific forces between non-polar groups of atoms. This property varies with the strength of these forces.

- **2. Contractility:**

- This property is significant in various stomatal operations in plants. The contractility of protoplasm is important for the absorption and removal of water as they generally occur in protoplasm.

- **3. Viscosity:**

- It is the most important property of the protoplasm by which it exhibits three main phenomena, i.e., Brownian movement, amoeboid movement and cytoplasmic streaming or cyclosis.

- **(a) Brownian movement:**

- It is characterized by the zigzag motion of suspended colloidal particles, occurring due to the bombardment of one particle or molecule by others. This type of movement of particles was first of all observed by Robert Brown in 1827 in the colloidal solution and hence such movements are known as Brownian movements.
- The higher the temperature, more rapid the movement and – thus viscosity of cell is decreased. This means that high viscosity indicates a more gel-like state of protoplasm and low viscosity, a more sol-like condition.

- **(b) Amoeboid movement:**

- The amoeboid movements, as exhibited by Amoeba and other protozoans, and leucocytes, etc., are also the results of viscosity. The continued change and vice versa of sol-gel is responsible for such movements. In this type of movement the cell gives out cytoplasmic projections, the pseudopodia, and the protoplasm enters the pseudopodia due to cyclosis causing forward movement of the cell.

- **(c) Cytoplasmic streaming or cyclosis:**

- It is the intracellular movement of cytoplasm as shown by Paramecium. It usually occurs in the sol-phase of cytoplasm. Its real cause is still not known; but, if there is a decrease in cell metabolism, there is a concomitant decrease in cyclosis. Similarly, increase in metabolic rate also gives rise to an increase in streaming.

- **4. Surface tension:**

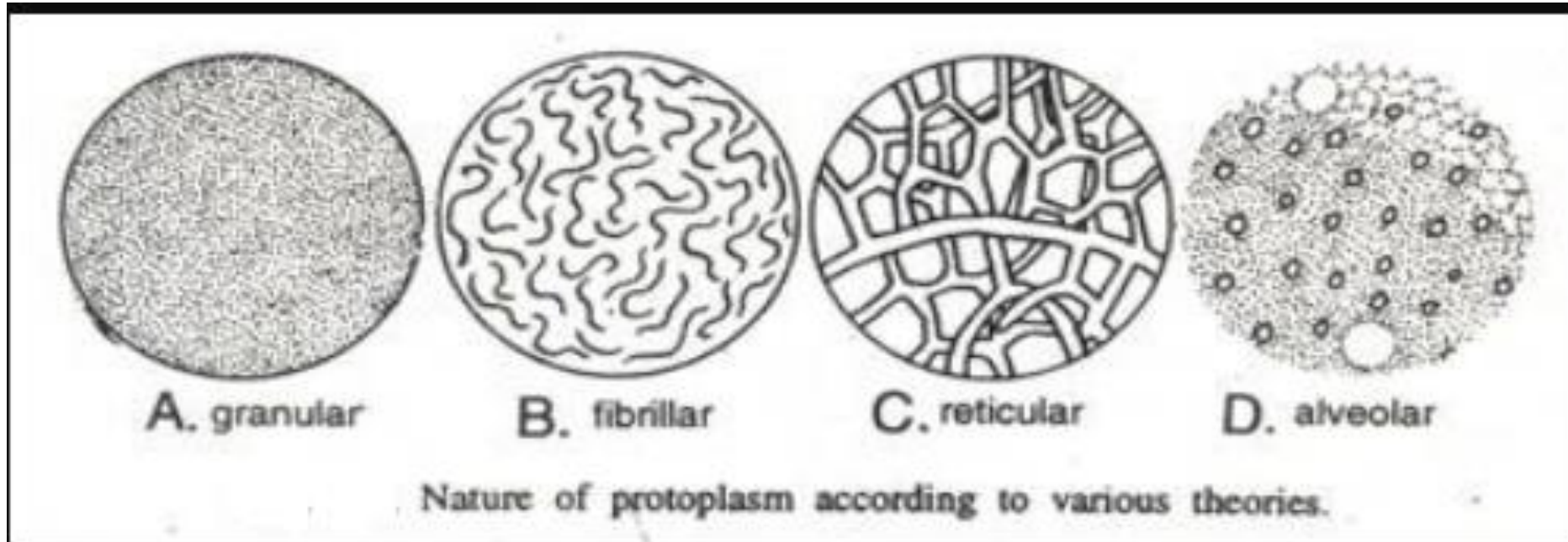
- The protoplasm also shows the property of surface tension. The proteins and lipids of the cytoplasm have less surface tension, hence they are found at the surface forming the membrane. On the other hand the chemical substances (NaCl, etc.) have high surface tension, so they occur in deeper parts of the cell protoplasm.
- Thus physically, protoplasm is a colourless, translucent, viscid, gelatinous and semi-fluid substance, heavier than water and containing molecular suspensions which show various changes as above.

- **Chemical Nature:**
- Protoplasm chemically reacts as a weak alkali. It is soluble in dilute alkalies and acids but solidifies when treated with strong acids or alcohols. It is quite unstable and readily decomposes into H_2O , NH_3 and CO_2 , etc., during chemical analysis.
- By Chemical analysis it has been found that protoplasm essentially consists of 34 elements out of which about 12 elements are supposed to be present universally. (Chemical element is a fundamental substance which can not be broken into two or more simpler substances.). 99% of protoplasm is made of 4 basic elements, i.e., oxygen, carbon, hydrogen and nitrogen Therefore; these are called major constituents of the protoplasm. 8 other elements (trace elements), present in quantities of less than 1% each, are sulphur, phosphorus, potassium, iron, magnesium, calcium, sodium and chloride.
- These elements are usually not present in a free state, but are found as various compounds such as phosphorus is the main component of adenosine triphosphate (ATP), deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- Many other trace elements are required for various physical activity (osmosis and diffusion) and biochemical activity such as impulse conduction, etc.

- **Percentage of water in protoplasm**

- The approximate percentage of water in protoplasm is about 85% to 90%. The water forms the dispersion medium in which other elements lie suspended.
- The water occurs in two forms—free water, and bound water, Ninety five percent of the total cellular water is free water in which various inorganic substances and organic compounds are found dissolved. The remaining five percent of the total cellular water is bound water which is loosely linked with protein molecules by hydrogen bonds or other forces.
- The percentage of water in the protoplasm of an organism depends directly on the age, habitat and metabolic activities. For example, the cells of the embryo have 90 to 95% water which decreases progressively in the cells of adult organism. Aquatic lower animal cells possess more water than the cells of higher terrestrial animals.

- Generally, the dry protoplasm shows the following constituents—
- Protein 45% Carbohydrates 25%
- Lipids 25% Other substances 5%
- These various compounds may be either of organic nature comprising C, H, N, O, or of inorganic nature consisting of salts, gases and some elements in Free State, like S, Fe, P, Cl, etc.



- The various components give the appearance to protoplasm of four different kinds:
- **1. Granular theory:**
- This theory was propounded by Altmann in 1893. According to this theory, protoplasm consists of numerous tiny granules as shown in Amoeba. Henle, Maggi, etc., considered these protoplasmic granules as plastidules. Altmann recognized them as 'elementary organisms', or bioplasts (or cytoplasts).
- **2. Alveolar theory:**
- The alveolar nature of protoplasm was suggested by Butchlli in 1892. According to him, protoplasm consists of many suspended droplets or alveoli or minute bubbles, resembling the foams of emulsion.

- **3. Fibrillar theory:**

- This theory was put forward by Flemming. According to him, protoplasm consist of fibres embedded in the inner mass of matrix. The fibrillae are called mitome or spongioplasm formed of proteins called micelles, and ground substance is termed paramitome or hyaloplasm.

- **4. Reticular theory:**

- This theory was postulated by Klein, Comoy, etc. It suggests that protoplasm consists of a reticulum of fibres in its hyaloplasm.
- The organic material which consists of proteins and carbohydrates in suspension may be either hydrophilic (water-loving) or hydrophobic (water-hating). The hydrophilic particles occur surrounding the water molecules. The attraction between protein and water is due to electric charges that hold them together.

BASIS FOR COMPARISON	CYTOPLASM	PROTOPLASM
Meaning	The semi-solid material, present between the nucleus and the cell membrane. Mainly made up of water and is responsible for the half of the cell's volume.	Protoplasm is called as the living substance of the cell, and it surrounds the cell membrane, the nucleus and the cytoplasm. So we can say protoplasm constitute the cytoplasm as well as the nucleus.
Structural difference	Cytoplasm contains organelles like Golgi body, Endoplasmic reticulum, Mitochondria, Ribosomes, Lysosomes, etc., but not the nucleus.	Protoplasm contains cytoplasm as well as the nucleus; thus we can say that protoplasm = nucleus + cytoplasm.
It contains	Cytoplasm is one of the constituents of the protoplasm, it is jelly like fluid and contains water, metabolic wastes, proteins, food reserves.	Protoplasm is thick, viscous fluid which is translucent and is made up of proteins, lipids, carbohydrates, nucleic acid and inorganic salts. It is the site for various biological and chemical activities.