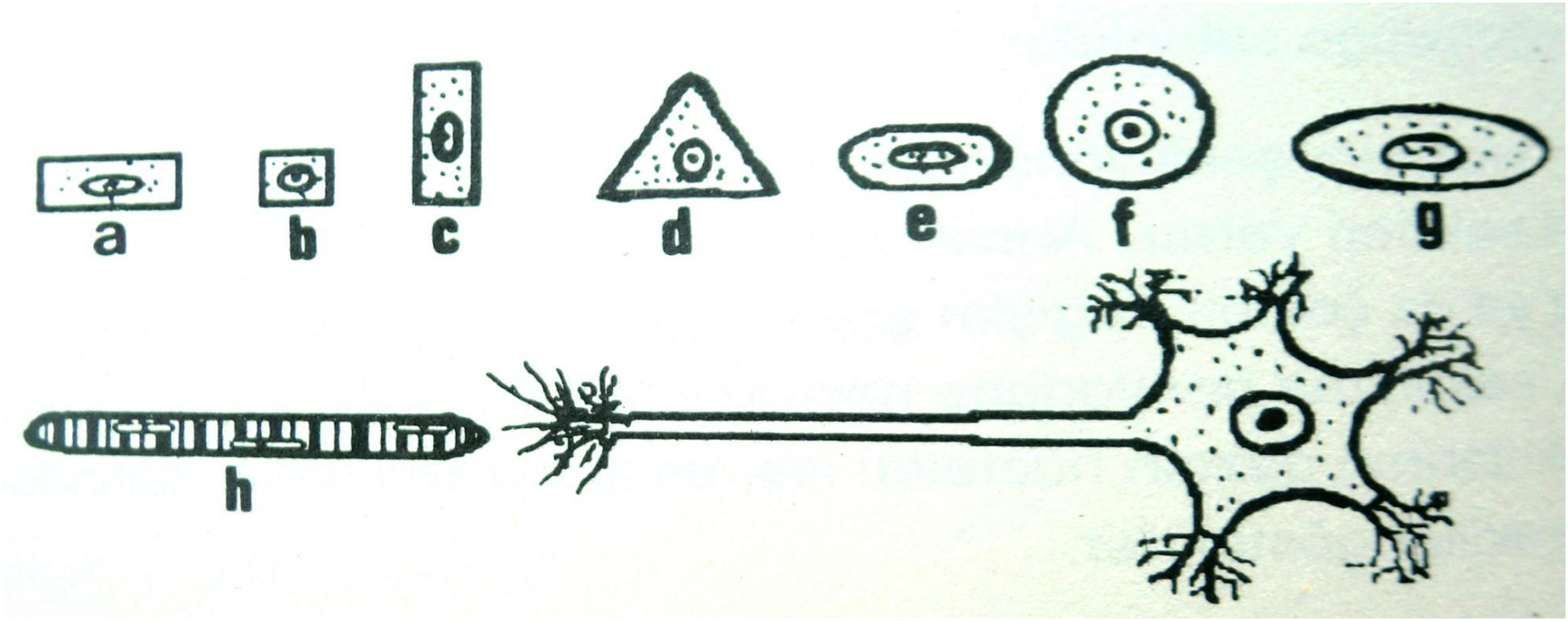
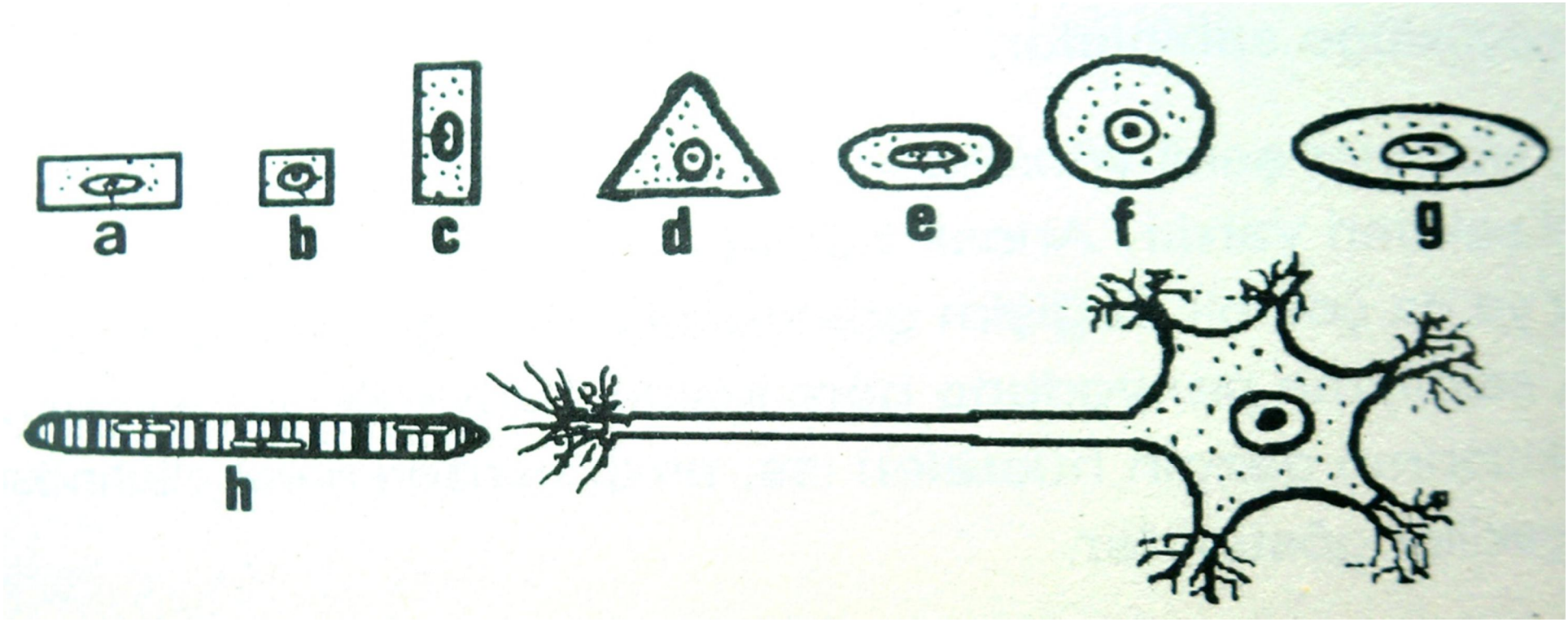
The Cell

- All living things are made up of cells. Cells are the smallest working unit of all living things.
- Living organisms are made from one cell or many cells. Bacteria are unicellular organisms. All events take place in the cell. Cells appear simple. But they are very complex.

- In the multicellular organisms, cells are in constant cooperation with each other and are constantly exchanging substances and hormones.
- There are some important differences between plant and animal cells.
- Animal cells have a spheric shape. But plant cells are square or rectangular.
- There are chloroplasts in the plant cells, but not in the animal cells.



- The cells are very different in size and shape. The average size is about 15-20 microns.
- Some cells can reach up to 200 microns.
- The cells are very different in size and shape. The average size is about 15-20 microns.



Cells have different shapes according to their location in the body. Cells also have different shapes according to their function. For example; flat, cubic, prismatic, pyramidal, oval, round, shuttle thread and star-shaped.

Cubic cells are found in the urinary system.
Round cells are found in the blood tissue.
Pyramidal cells are found in the kidneys.
Nerve cells have extensions. These extensions are very important for nerve impulses.
Muscle cells are shaped thread, in order to contraction.

- **Protoplasm** is the living content of a cell that is surrounded by a plasma membrane. It is a general term for the cytoplasm. The entire contents of a cell comprising the nucleus and the cytoplasm. It is a semi-fluid, transparent substance which is the living matter of plant and animal cells.

- Substances within the structure of cells are proteins, carbohydrates, lipids, and water. In addition, there are various minerals (Na, K, Ca, P, etc.), enzymes, vitamins and hormones in the cells.
-

- The cells receive nutrients from the external environment. These nutrients are broken down in the cells and are divided into primitive elements. Thus, energy is released. This is called the **catabolic function** of the cells.
- **Anabolism** is the process by which the cell utilizes the energy released by catabolism to synthesize complex molecules. These complex molecules are then utilized to form cellular structures that are formed from small and simple precursors that act as building blocks.

- Catabolism means disintegration, whereas anabolism means reorganization.
- The catabolism implies release of energy, whereas anabolism implies capture of energy.
- Catabolism implies disorganization of matter, whereas anabolism implies a more complex reorganization of matter.
- Two of catabolic and anabolic functions are called METABOLISM.

- **Eukaryotic cells** have a nucleus and cytoplasm. They carry the genetic material in the nucleus.
- In prokaryotic cells, genetic material is dispersed in the cytoplasm. There is no nucleus. For example bacteria, viruses.

The Cell

I. Cytoplasm

A. Cytosol

B. Shaped elements

a. Organelles

. Membranous organelles

. Nonmembranous cytoplasmic organelles

b. Cytoplasmic inclusions

II. Nucleus

CYTOPLASM =

Cytosol + Shaped elements

1- Cytosol

- The cytosol is filled the space of between organelles.
- Depending on the metabolic state of the cell, the cytosol becomes sol or gel.
- If the cytosol gets water, become sol.
- If the cytosol loses water, become a gel.
- 90-95% of the cytosol is water.
- The water ratio is reduced with age in the cytosol.

- A significant portion of the substances, present in the cytosol are protein structure.
- These are glycolytic enzymes, ATP’ase and enzymes which is activated amino acids.
- Also, in the cytosol contains proteins, carbohydrates, lipids, cations, anions, trace elements and oxygen.

- Cytosol does not show inner structure. Because all substances in the cytosol are dissolved.
- If the cells get water from the external environment, cytosol becomes sol.
- If the cell is inactive, gives water to the extracellular environment and the cytosol becomes a gel.
- During tissue preparations, cells loses water. So, the cytosol become gel and cells die.

Proteins in the cytosol

- Cytosolic proteins are globular or thread form.
- These proteins organized and are formed microfilaments or microtubules.
- Microfilaments: It consists of filamentous proteins and globular proteins. Microtubules : contains only globular protein.
- Globular proteins cooperate with lipids to form membranes. That is, membranes are of lipoprotein character. Such membranes are called elementary membranes.
- They are also called UNIT MEMBRANE since they constitute the origin of all membrane organelles.

Unit membran:

Unit membran are seen as three layer using the electron microscope.

The inner and outer layer is seen as a dark (electron-dense) lines. And the middle layer is seen as a clear (electron-lucent) band.

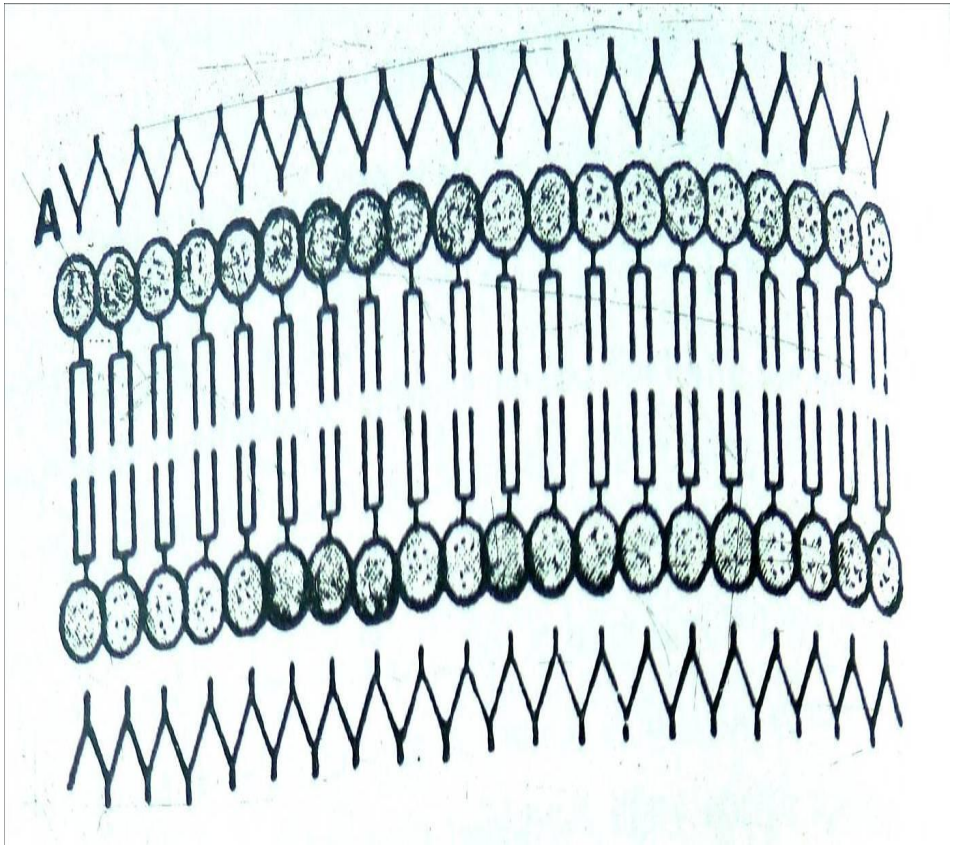
The outer surface of the membrane has the glycocalyx. Glycocalyx contains oligosaccharides, polysaccharides phospholipids, and proteins.

MEMBRANE MODELS

- Sandwich model: In the past, scientists said that cell membranes similar to a sandwich. Namely, the outer surface of the membrane consists of nonmembranous proteins and the middle of the membrane consist of lipid molecules as two layers.

The membrane contains four molecular layers, two of phospholipids and two of proteins. Phospholipids form a double layer.

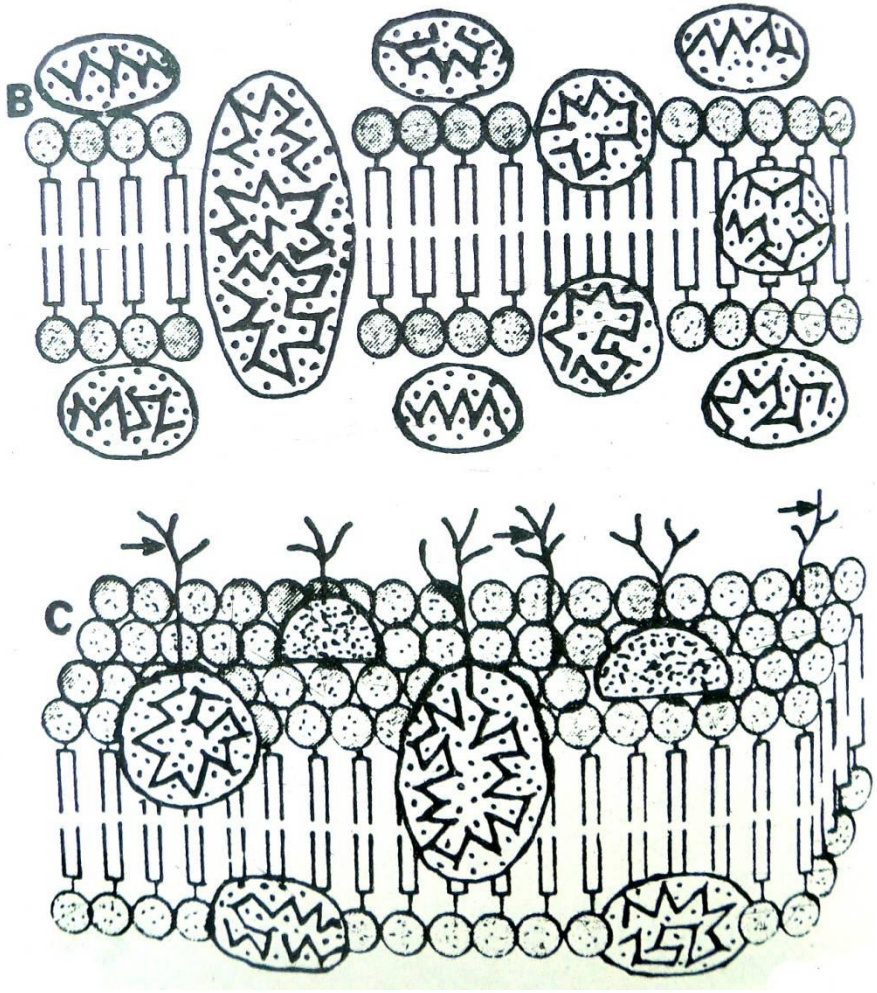
The phospholipids bilayer is covered on either side by a layer of hydrated protein molecules. The hydrophilic polar heads of the phospholipid molecules are directed towards the proteins. The hydrophobic nonpolar tails of the two lipid layers are directed towards the center.



MEMBRANE MODELS

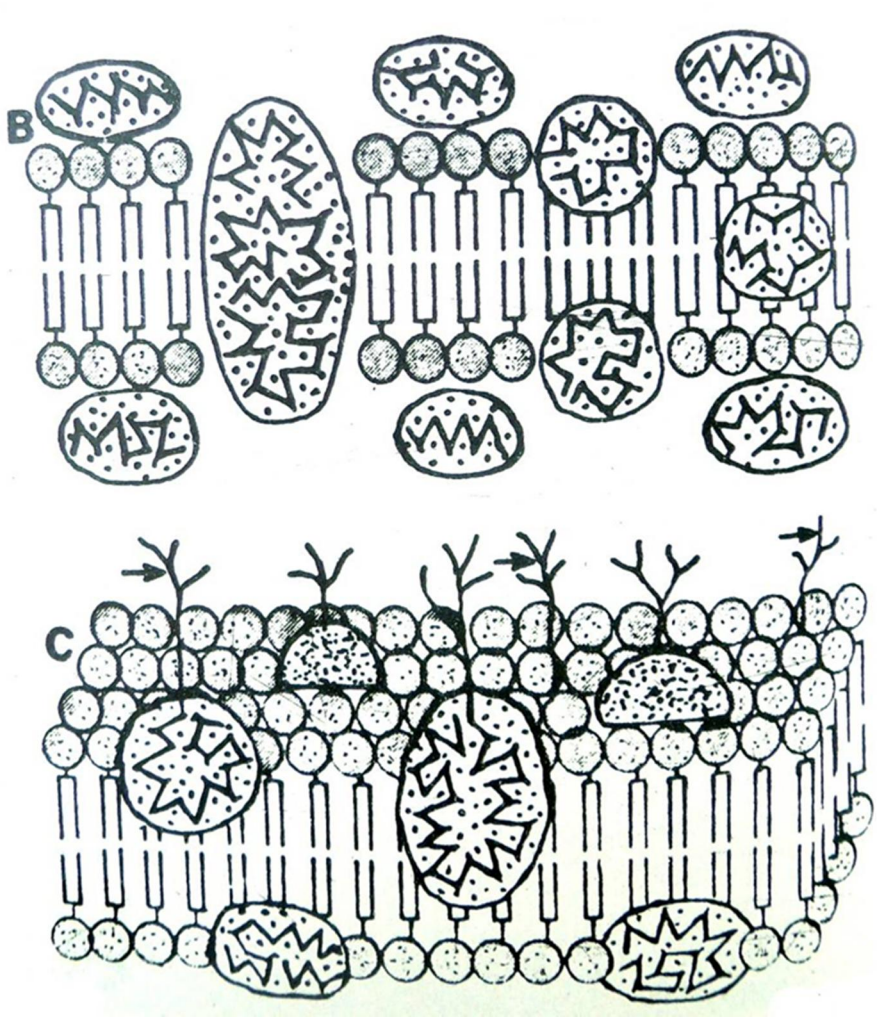
The Fluid mosaic model:

- Membranes consist of lipid molecules two layers and globular protein molecules float on the lipid molecules.
- Globular protein molecules are placed intermittently on the lipid membranes.



The fluid-mosaic model describes the plasma membrane of animal cells. The plasma membrane that surrounds these cells has two layers (a *bilayer*) of *phospholipids* (fats with phosphorous attached). Each phospholipid molecule has a head that is attracted to water (*hydrophilic: hydro* = water; *philic* = loving) and a tail that repels water (*hydrophobic: hydro* = water; *phobic* = fearing). Both layers of the plasma membrane have the hydrophilic heads pointing toward the outside; the hydrophobic tails form the inside of the bilayer.

Because cells reside in a watery solution (extracellular fluid), and they contain a watery solution inside of them (cytoplasm), the plasma membrane forms a circle around each cell so that the water-loving heads are in contact with the fluid, and the water-fearing tails are protected on the inside.



- The great majority of membrane lipids contain different types phospholipids. However, a small amount of cholesterol in the near-surface find. Some membranes also contain glycolipids.
- The cell membrane lipids have an important permeability barrier. Only water, gases, and oil-soluble substances can pass through the membrane lipids.
- Protein molecules are located between the lipid molecules (integral proteins).
- Some of the protein molecules extend from one side to the other side of the membrane. They can even protrusion outward (transmembrane proteins).
- The rest of the protein molecules are seated on the outer surface of the lipid layer (peripheral proteins).
- Although the majority of the membranes are formed by lipids, specific functions are executed by proteins.

Duties of the integral proteins

1. To carry substances from one side to the other side from membranes **(transport):** Transport proteins have the enzymatic activity, but substances don't undergo conformational changes.
2. Integral proteins bind substances found from the external environment. Thus, cells exhibit behavior towards these substances **(receptor).**
3. Integral proteins have enzyme characters and mediate the **synthesis of lipids.**

1. To carry substances from one side to the other side from membranes **(transport proteins):**

- Transport proteins have enzyme properties. However, unlike other enzymes, they do not alter the substances they are interested in. These carrier proteins in the enzyme properties are also called PERMEASES.
- The cells can protect their inner structure because of the selective membran permeability. So the cell membrane keeps under control the substances constantly.

Exchange of substances on the cell surface

The transport of molecules occurs in various forms.

1- Micromolecules (gases, water, fatty acids, monosaccharides, inorganic ions)

- Passive transport
  - simple diffusion
  - facilitated diffusion
- Active transport

2- Macromolecules (proteins, fats, carbohydrates), and larger substances

- Endocytosis
  - pinocytosis
  - phagocytosis
- Exocytosis

1. Passive transport:

Passive transport is a movement of biochemicals and other atomic or molecular substances across cell membranes without the need of energy input.

•There are two types of passive transport

a) **Simple diffusion**
b) **Facilitated diffusion**

- **A) Simple diffusion**
- Neutral electrically charged material passes by simple diffusion. For example; water, oxygen, nitrogen, carbon dioxide.
- Also, compatible with fatty substances, e.g. fatty acids, alcohol, ether, chloroform can pass with simple diffusion.
- Steroid hormones also pass by simple diffusion.
- In a solution or gas that has an area of high numbers of particles and an area of lower numbers of particles, the particles will diffuse, or move, from the area of higher to the area of lower concentration.

- Simple diffusion does not require energy. Instead, it happens by random motion. Random motion is defined as a movement that occurs by chance because there is no order or regular system by which the movements of the particles shift in a solution or gas.

b) Facilitated diffusion:

•Unlike simple diffusion, specialized transmembrane proteins are used in the transport process. These proteins:

•Channel proteins
•Carrier Proteins

•Electrically charged substances are transported. For example; amino acids, ions, and sugars.

-Channel proteins:

•Channel proteins carry the cations (Na, H, K, Ca).
•Cations pass-through channel proteins.
•Channel protein macromolecules have hydrophobic outer surface and hydrophilic inner surface.

•Thus, the inner face of the channel is in the aqueous medium.
•These channels are closed during rest. When in the channel region collected many ions, with the help of electrical or nerve impulses, these channels are opened.
•The diameter of ion channels is different. They are found in the membranes of muscle and nerve cells.

- Carrier proteins:

- Carrier proteins have Na^+ K^+ adenosine triphosphatase feature.

- Channel proteins have only carried the ions. Carrier proteins together with ions can also carry glucose and amino acids.
- Each of the macromolecules of this integral proteins is formed from several pieces of protein subunits. They have a hydrophobic outer surface and have hydrophilic inner surface. This hydrophilic surface, who are interested in substance, contain specific binding sites.
- Some integral proteins can carry only one type of substance. But the other proteins can carry two substances. In this situation, as the two substances can be transported in the same direction or opposite direction.

- Carrier proteins:

- Glucose and sodium are transported from intercellular space to intracellular space with facilitated diffusion.
- Na^+ ion is linked to the carrier protein. Then positive electric charge increase in this region. And three-dimensional structure of the carrier protein are changed. The molecule loses interest to the substances.
- Glucose and natrium become independent. And then they are taken into the cell.
- Here, substances (Na^+ and glucose) are passes from high concentration medium to low concentration medium. That's why, metabolic energy isn't used.
- Other monosaccharides and amino acids pass from the membrane with the same mechanism.

Active transport

- The use of metabolic energy is required during the active transport.
- To show cell activity, natrium ions are found in higher concentrations outside the cells. But, during the facilitated diffusion, glucose enters in the cell together with sodium. So ion balance is disrupted in the cell. Therefore sodium ions should immediately be taken out of the cell.
- Although sodium ions enter the cell, these ions still are found high concentration outside of the cell. So sodium ions must be transported extracellular medium.

Active transport

- Na^+ ions which is coming from the cytosol binds to the carrier protein(Na^+ K^+ adenosintrifosfatase). Carrier protein is activated and decompose the ATP in the cytosol.

- At that time, metabolic energy is released. With helping the metabolic energy, carrier protein undergoes a change in shape. And Na^+ ions are given to the extracellular medium.

- Meanwhile, K^+ ions are connected to the carrier protein; The carrier proteins change their shape again. And K^+ ions pass the cytosol by active transport.

Active transport

- The fact that these two events, ie Na^+ ions are given out of the cell and K^+ ions are actively transported into the cell is called the in **sodium potassium pump**.
- During pumping, three of sodium ions are removed each time, while two potassium ions are taken in.
- That is why Na^+ ions are present in the intercellular substance in greater amounts, and K^+ ions are present in greater amounts in the cytosol.

Active transport

- As is known, the outer face of the cell membrane has a positive electric charge, inner side of the cell membrane has a negative electric charge. One of the factors that make this difference is that Na^+ ions and K^+ ions are present in different amounts on both sides of the membrane.

Active transport

- Na^+ K^+ pump, located in the membranes of all animal cells.

- Glucose, in most cases, is found in a greater amount out of the cell. That's why glucose must take into the cell by facilitated diffusion.

- However, in the intestinal tract and kidney tubules, the taking of the glucose, occurs by active transport. Because glucose concentration in the cell is greater than the intestinal track.

Duties of the integral proteins

1. To carry substances from one side to the other side from membranes **(transport):**

2. Integral proteins bind substances found in the external environment. Thus, cells exhibit behavior towards these substances (receptor).

- Some integral proteins exceed the cell surface. These proteins are called receptors. Hormones bind to these receptors and these hormones bring about some enzymatic reactions in the cytosol.
- For example; if adrenaline binds to the receptor protein, glycogen is broken down into glucose.
- If Insulin binds to the receptor protein, glucose is used in the cell.

- Another part of the cell surface receptor is stimulated by neurotransmitters (nerve stimulators).
- Such receptors are most commonly found in muscle fibers, in skeletal muscle.
- Channels (receptors) are located where in the portion contacting with the nerve endings of muscle fibers, which are opened by the effect of calcium^{++} ions.
- With the opening of these receptors, acetylcholine (neurotransmitters) flows into the synaptic cleft. Acetylcholine bind to the Na^{+} ion channels (receptors) in the muscle fibers membrane. Then, Na^{+} ions channels are opened. This time, Na^{+} ions enter channels. And cause the occurrence of electrical stimulation of muscle fiber.
- So, here is a chemical stimulus (acetylcholine) cause an electrical impulse.
- In the cell membrane, there are many types of substances binding receptors.

Duties of the integral proteins:

1. To carry substances from one side to the other side of membranes**(transport):**

2. Integral proteins bind substances from the external environment. Thus, cells exhibit behavior towards these substances **(receptor).**

3. Integral proteins have enzyme characters and mediate the synthesis of **lipids.**

- The third part of the integral proteins have the enzyme properties.
- These proteins synthesize lipids from the fatty acids.

Shaped elements

A- Organelles

B- Cytoplasmic inclusions

A- **ORGANELLES**

a- Membranous organelles

b- Nonmembranous cytoplasmic organelles

A- MEMBRANOUS ORGANELLES

1-Cell membran

2-Ergastoplasm: a) free ribosomes

b)endoplasmic reticulum

3-Golgi apparatus

4- Lysosomes

5-Microbodies

6-Mitochondria

A. Organelles are divided into two main groups.

a. Membranous organelles : They are involved in metabolic processes.

b. Nonmembranous cytoplasmic organelles : They are related to the motion events.

Membranous organelles

- Cell membrane
- Ergastoplasm (endoplasmic reticulum and free ribosomes)
- Golgi apparatus
- Lysosomes
- Microbodies
- Mitochondria

Cell membran(plasmalemma)

- The cell membrane is in the unit membrane structure. However, the amount of cholesterol in it is more than other membranes. The cell membrane is also seen as 3-layer in the electron microscope.

There are some important properties of the cell membrane structure. Other biological membranes do not have these properties.

- The outer surface of the cell membrane is covered by **glycocalyx**.
- Glycocalyx is formed carbohydrates.
- Carbohydrates, or sugars, are sometimes found attached to proteins or lipids on the outside of a cell membrane.
- That is, they are only found on the extracellular side of a cell membrane.
- These carbohydrates form the **glycocalyx.**

- Oligosaccharides and polysaccharides are attached to membrane proteins.
- Oligosaccharide bound protein is called **glycoprotein** and polysaccarid bound protein is called **proteoglycan.**
- Both oligosaccharides and polysaccharides linked to integral proteins. But only peripheral proteins bound to oligosaccharides.

Oligosaccharides are also attached to the outer side of lipid molecules.

They constitute **glycolipids.**

The formation of glycoprotein starts in the rough endoplasmic reticulum and are completed in the Golgi apparatus. Proteoglycans and glycolipids are only made of in the Golgi.

Oligosaccharides + protein = glycoprotein
Polysaccharides + protein = proteoglycan
Oligosaccharides + lipids = Glycolipid

- Glycocalyx is an analog of the plant cell wall, bacteria, and fungi walls. It's located outside the animal cell membrane.
- Sialic acid, which is a part of the carbohydrates in the glycocalyx, has a negative charge. Therefore, the positively charged materials can easily hold the cell surface.
- Glycocalyx creates a suitable environment for the antigen-antibody complex on the cell surface.
- The glycocalyx is a type of identifier that the body uses to distinguish between its own healthy cells and transplanted tissues, diseased cells, or invading organisms.
- Glycocalyx is cell-adhesion molecules that enable cells to adhere to each other and guide the movement of cells during embryonic development.
- Glycocalyx on the surface of red blood cells determines blood groups.

Glikokaliks

- Covers the cells.
- It has a negative electrical charge.
- It allows the antigen-antibody combining.
- It is an antigen for other living organisms.
- Blood groups are determined by the antigenic properties of glycocalyx.

The purpose of the morphological changes in the cell surface

1. To provide substance exchanging
2. To give movement to the cell
3. To provide the connection between the cells

1. Membranous structures providing the substance exchanging

a. Microvilli: They are formed as a result of the cell membrane evagination. Their length is less than 1 micron. In the light microscope, the microvillus-bearing surfaces of the cells appear as a thin layer of brush. It is called **brush border.**

- Microvillus expand the cell surface 15-30 times. In this way, it is ensured that a large amount of substance is taken by passive or active transport in a short time.
- In some cells (intestinal epithelium, proximal kidney tubule cells) are found in large amounts microvilli on the cell surface.

- There are 20-30 actin filaments in the interior of the microvilli.
- Actin filaments are anchored to the **terminal web** at the apical cell membrane.
- The **terminal web** is a filamentous structure found at the apical surface of epithelial cells. It is composed primarily of **actin filaments.**
- Actin filaments together with myosin molecules are bound to cell membrane.
- Microvilli, the result of the interaction with actin and myosin filaments, makes the swelling and contraction movement.

- The cells, also make substance-exchange in other ways.
- **endocytosis**
- **exocytosis**

- Both of them require metabolic energy.

Endocytosis:

- Pinocytosis
- Phagocytosis

Substances, in either event, take into the cell by binding to receptors on the cell membrane.

- **Pinocytosis:** The molecular or colloidal solution is taken into the cell during the pinocytosis (drinking liquid of the cell).
- Pinocytotic vesicles are coupled with each other and formed endosomes.
- Endosomes and lysosomes combine with each other. After that, endosomes are divided into subunits and given into cytosol.
- Substances took by pinocytosis pass through the capillary endothelial cytoplasm. (transcytosis-cytopempsis: Transportation of a substance into a cell and through the cytoplasm in a vesicle followed by its release to the exterior without utilization by the cell)

- **Phagocytosis:**
- Phagocytosis is a specialised form of endocytosis in which a cell engulfs solid particles from the extracellular space.
- This is mediated by cell surface receptors.
- Cell membrane sends pseudopodium toward the solid substance.
- Pseudopodium capture the solid substance. And cell membrane becomes invagine.
- In this section is broken up the cell membrane, and a vacuole occurs in the cytoplasm (phagosome).

- The cell takes useful substances via pinocytosis.
- Phagocytosis is made by specialized cells (microphage and macrophages).
- Harmful substances taken via phagocytosis, are broken down by lysosomes in the cytoplasm.
- A portion of the disintegrated substances is stored in cells as the lipofuscin pigment. The other part is ejected from the cell via exocytosis.

Exocytosis

- Exocytosis is a removal of substances from the cells as macromolecules, vesicles or granules.
- Macromolecules and granules are found in the cytoplasm surrounded by a membrane.
- These structures reach the cell surface membranes, come into contact with the cell membrane at one point.
- The membranes are ruptured at the contact point and thereby contents are taken out of the cell.
- Meanwhile, membrane vesicles or granules are added to the cell membrane.

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