Water And Cell Membrane Transport, Cell Structure And Function

Question 1: Water and Cell Membrane Transport

Structure of Cell Membrane:

Cell membrane chemical examination revealed that it is primarily made up of lipids and proteins with the tiny amount of carbohydrates. Electron microscope examination of the cell membrane laid down the foundation of the fluid mosaic model.

Fluid Mosaic Model:

S.J. Singer & Garth L. Nicolson in 1972 proposed this model to explain the structure of the cell membrane.

The main component of the cell membrane tends to be phospholipids. Phospholipids are lipid molecules that are made up of two tails and a head. Head contains phosphate groups and tails are made up of fatty acids. Phosphate head tends to be hydrophilic i.e. polar in nature. Whereas, fatty acid tails tends to be hydrophobic i.e. non-polar in nature. In aqueous solution they arrange themselves in a way that the hydrophilic phosphate head of phospholipids adjust themselves on the outer surface. The hydrophilic part of phospholipids forms hydrogen bond with water. It also makes bond with other polar molecules that may present on both sides i.e. external or internal of the cell. While the hydrophobic ends adjust on the inside of the cell; and they will not interact with water. In this way they shape a phospholipid bilayer, which separates the outside fluid from the internal fluid of the cell. The lipid bilayer gives elasticity and flexibility to the membrane.

The second major component of the cell membrane is proteins. Almost half of the cell membrane is composed of proteins. Some proteins are transmembrane proteins and those are implanted in the lipid bilayer. Some proteins act as receptors and they can bind to chemicals or hormones that produce signals. While some proteins act as ion channels which let ions to pass of the cell.

Carbohydrates are the third main constituent of the cell membrane. They are present on the outer external of the cell membrane and are joined with lipids to form glycolipids or proteins to form glycoproteins. By binding with proteins carbohydrates form special sites on the outer side of the cell. In this way they help in cell recognition; i.e. they help the immune system to differentiate between self-tissues or invader tissue. Glycoproteins and glycolipids on the outer side of the cell membrane are together called glycocalyx (sugar coating). The glycocalyx is hydrophilic (water loving) molecule thus it attracts the water to the cell surface.

In animal cells, lipid bilayer also has cholestrol. Cholesterol helps membrane to maintain its integrity and permeability in low or high temperature. It is present in the middle of phospholipid. In this way it helps small molecules to move freely across the membrane.

Function of Cell Membrane:

The main role of the cell membrane is to cover up and guard the cell from surroundings. The cell membrane allows few molecules to pass through it hence it acts as a semi- permeable membrane. In this manner cell membrane keep an eye on the material that comes into or go away the cell and regulate the internal composition of the cell. Cell membrane can also detect chemicals and can identify if foreign chemical is trying to enter the cell. Cell membrane also plays a vital role in cell signalling. Proteins that act as receptors are present on the surface of the cell can attach to signals i.e. chemicals or hormones. After binding the signal transduction pathway is initiated that transmit signals to the specific target. In this way, the cell performs its function and maintains its internal composition.

Transport of molecules:

Cell membrane acts as transporter of molecules via active transport. Example: Nerve cell membranes have carrier proteins in the shape of the sodium-potassium pump. When nerve is in resting mode, sodium potassium pump uses energy and retain the lower concentration of Na+ inside the cell. Simultaneously, it retains the high concentrations of K+ inside the cell. So, the sodium-potassium pump vigorously pushes Na+ to the exterior of the cell and on the outer side of the cell there is the high concentration of Na+ already. At the same time; the pump pushes K+ to in the interior of the cell from the exterior of the cell and in the interior of the cell there is already the higher concentration of K+.

Question 2: Cell Structure and Function

Cell structure comprises of some special structures like the cell wall, cell membrane, cytoplasm, cytoskeleton and cell organelles.

Nucleus:

A double membrane protects the nucleus called nuclear envelope. It consists of tiny pores that play a role like semi-permeable membrane. Nuclear envelope contains a fluid known as nucleoplasm. It contains nucleolus and chromosomes. In nucleolus ribosomal RNA is produced. In nucleolus chromosomes are also present that are able to be seen only during cell division. But when cell is not dividing they are present in the form of thread like structures known as chromatin.

Function:

- Nucleus is an integral component of cell.
- It contains hereditary material of cell i.e. DNA.
- It protects the DNA and separates it from the rest of the cell.
- Ribosomes are also assembled in nucleus.
- It also sends different signal i.e. to divide, to die, to grow to the cell.

Mitochondria:

Mitochondria are bounded by two membranes. They are located in eukaryotic cells. The exterior

membrane of mitochondria tends to be flat while the internal covering forms infolding, called cristae. Cristae create intramembrane space and hence enhance the interior area of the membrane. Mitochondria contain their own ribosomes and mitochondrial DNA.

Function:

- Mitochondria supply energy to the cell and hence they are named as “the powerhouse of cell”.
- Aerobic respiration also takes place in mitochondria.

Chloroplasts:

Chloroplasts also surrounded by two membranes. Their external membrane is also flat but the internal membrane makes sacs called thylakoid. Sacs of thylakoids collectively are called granum. A fluid is present in the inner chloroplast called stroma. Granna float in stroma.

Function:

- Chloroplasts are organelles where photosynthesis takes place.
- It also contains green pigment; i.e. chlorophyll and all other associated pigments required for photosynthesis.

Lysosomes:

Lysosomes are single membrane bound organelles. Lysosomes structure is like a sphere that is made up of lipid bilayer. Inside lipid bilayer a fluid is present which contains hydrolytic enzymes.

Function:

- They contain digestive enzymes that can play a role in the breakdown of food and other foreign material in the cell.
- Lysosomes fuse with vacuole where enzymes are present.
- They engulf foreign bodies that try to enter in the cell and hence protect the cell from harmful substances.

Endoplasmic Reticulum:

All eukaryotic cells have endoplasmic reticulum. It is a network of interconnected channels. It is a broad system of cisternae that spreads from cell membrane to nuclear envelope. Two forms of endoplasmic reticulum are present. RER is irregular due to the ribosomes attach on it. While SER (smooth endoplasmic reticulum) does not have ribosomes on it hence it is smooth.

Function:

- It helps in the transport of substances from one part to other part of cell.
- They play a role in protein synthesis, synthesis of lipids, glycogen and steroid.
- They play a role in metabolism of lipids and carbohydrates. It also helps in detoxification of harmful chemicals.

Golgi apparatus:

Camillo Golgi discovered cicternae in cell, which are piled up on top of each other. Whole set of cisternae was called golgi apparatus. Golgi apparatus has two faces. One is cis face, other one is trans face. Cis face is present close to the ER. The trans face is present farthest from the nucleus and it secretes golgi vesicles to other part of cells. There are lumens and cisternae are also present on it.

Function:

- Golgi apparatus modifies molecules that come from rough endoplasmic reticulum and pack them into golgi vesicles.
- It also helps in transportation of these vesicles to different parts of the cell.

Ribosomes:

Ribosomes are small granular structure. Ribosomes are made up of nearly equivalent quantity of rRNA & proteins. They are made up of two sub units, one subunit is larger the other one is smaller. Prokaryotes have 70S ribosomes comprising of 50S and 30S subunits. Eukaryotic cells have 80S ribosomes comprising of 60S and 40S subunits.

Function:

- They help in the protein synthesis.
- It helps in production of mRNA that is synthesized in nucleus and then transported to cytoplasm.
- Helps mRNA in translation of proteins.

Microtubules:

Microtubules are structures of cytoskeleton and are hallow cylinders made up of tubulin protein; especially alpha and beta tubulin. Both alpha and beta bind together to form protofilament. Protofilaments arrange themselves in cylindrical form to form microtubules.

Function:

- Helps in cell movement
- Helps in cell division
- Maintain the shape of cells
- Help in movement of organelles

Actin Filaments:

Actin filaments are also the structure of cytoskeleton. They have a diameter of 7nm. These are made up of actin proteins. Microfilaments are thinner and flexible threads that linked together to form various structures. They help cells to change their shapes.

Centrioles:

Centrioles are made up of hallow and cylindrical tubules with a diameter of about 250nm and with a length from 150-500 nm. Nine triplets of microtubules are present in each centriole. In some organisms they are found as simple and single microtubule. But in most of the organisms like animals they are found as complex triplets.

Function:

- Help in cell division by forming spindle fibers.
- Help in formation of cilia and flagella.

Question 3: Biomolecular Structure and Function

Structure of biological molecules:

Cells are mostly made up of compounds that incorporate carbon. Since carbon atoms can structure steady bonds with 4 different atoms, so they can build complicated molecules. These complicated molecules are usually made up of oxygen, nitrogen and hydrogen atoms, as nicely as carbon atoms. These molecules may additionally consist of somewhere from tens to millions of atoms correlated collectively in precise arrays. However, no longer all of the carbon-containing molecules in cells are constructed up from participants of one of 4 exceptional family of small natural molecules i.e. amino acids, fatty acids, sugars, and nucleic acids. Each of this family includes a crew of molecules that look like each other in each shape and function.

The catalytic molecules in cells are called enzymes. By nature enzymes are proteins. Being catalysts they take part in many biological reactions. Enzyme binds to a substrate and bring undergo some changes and convert the substrate into product. Enzymes catalyse a chemical reaction. Reaction rates with enzymes are million time more rapid than the reactions without enzymes. Enzymes usually bind specifically with substrates considering its nature, form and type of reaction. Enzymes can play a role in many industries like food industry, beverage industry and paper industry and as biological detergents.

Proteins are formed when thousands of amino acids join together. The amino acids have amino and carboxyl group. R group may be a carbon atom or hydrogen atom. Two amino acids bind together by removal of water molecules to form peptide bond.

Proteins make 50% of the dry mass of cells. Proteins are necessary in the development of protoplasm. Leather can be made from proteins that are used to formulate bags, shoes, jackets, etc. Proteins used to make bakery items. Plant proteins are used as food.

Nucleic acids are vital for every living organism. They have long chains that are composed of nucleotides. They are made up of:

- Nitrogenous base
- Pentose sugar
- Phosphate group

Two types of nucleotides are present there: DNA & RNA. The nitrogenous bases are of two types i.e. purines and pyrimidines. Pyrimidines are cytocine (C), thymine (T) and uracil (U).

Purines are adenine (A) and guanine (G). Nucleic acids can preserve and pass on genetic information.

Polysaccharides are macromolecular carbohydrates comprising of 100’s to 1000’s of monosaccharides. They tend to be important as building material of the cell. Cellulose is the main component of the primary wall of plant cells.

Question 4: Photosynthesis and Respiration

Photosynthesis: The process in which glucose is synthesized by plants from CO_2 and H_2O in the presence of daylight and chlorophyll. It is an anabolic pathway. It occurs in the chloroplasts of cells.

Cellular respiration: The process in which oxygen is used by organisms for the breakdown of carbon-hydrogen bond present in food. It does not require sunlight and takes place in the mitochondria of the cell.

Photosynthesis / Respiration

Takes place in green plants. / Takes place in every living cell

Trap sunlight, convert it into chemical energy and store in the form of glucose. / Glucose release the energy stored in it and produce ATP.

It is an anabolic process, in which small molecules like CO_2 & H_2O are utilized to build large molecules like glucose. / It is a catabolic process, in which larger molecules like glucose breaks down to generate carbon dioxide and ATP.

Takes place in chloroplasts / Takes place in cytoplasm and mitochondria

Use CO_2, water and sunlight as reactants / Use glucose and O_2 as reactants

Electron carries via NADPH / Electron carries via NADPH & $FADH_2$

It has two stages:

Light reactions: Takes place in the presence of sun light. ATP and NADPH produced in this reaction.

Calvin Cycle: Energy from ATP and NADPH is used to synthesize glucose by using carbon dioxide.

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

It has three stages:

Glycolysis: It occurs in cytoplasm. In it glucose molecule breaks down into pyruvic acid.

Kreb’s Cycle: Pyruvic acid molecules are oxidized and broken down into acetyl Co-A. And then Acetyl Co-A combine with four C to form six C molecules and produce CO_2, ATP, NADH, $FADH_2$.

Electron Transport Chain: In this electrons are transferred on an electron chain. Energy stored during kreb’s cycle used to produce H_2O, ATP, NAD^+, FAD^+.

$C_6H_{12}O_6 + 6O_2$ ---$6CO_2 + 6H_2O$

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