The structure of phospholipid

The inner layer of cell membranes consists of a phospholipid bilayer. Phospholipids have a a hydrophilic polar head and two hydrophobic tails. Phospholipid diversity is based on differences in the two fatty acid tails and in the groups attached to the phosphate group of the head. Phospholipids are polar on one end (the phosphate end) and nonpolar on the other (the fatty acid end). Phospholipids form the core of all biological membranes. They function as being the membranes around cell for protection. They also regulate what goes in and out of the cell.

The basic foundation of biological membranes is a lipid bilayer, which forms spontaneously. Draw a representation of a lipid bilayer.

http://media. web. britannica. com/eb-media/74/53074-004-9F65D813. jpg

http://m. eb. com/assembly/45550

Phospholipid membranes are fluid. How is the fluidity of a membrane modified?

A membrane remains fluid as temperature decreases, until finally the phospholipids settle into a closely packed arrangement and the membrane solidifies. The temperature at which a membrane remains fluid to a lower temperature if it is reach in phospholipids with unsaturated hydrocarbon tails. The degree of membrane fluidity changes with the composition of the membrane itself. Much like triglycerides can be solid or liquid at room temperature, depending on their fatty acid composition, membrane fluidity can be altered by changing the membrane’s fatty acid composition. Saturated fats tend to make the membrane less fluid because they pack

together well. Unsaturated fats make the membrane more fluid= the “ kinks” introduced by the double bonds keep them from packing tightly.

Describe the fluid mosaic model of a biological membrane.

Integral proteins protrude through the plasma membrane, with nonpolar regions that tether them to the membrane’s hydrophobic interior. Carbohydrate chains are often bound to the extracellular portion of these proteins, forming glycoproteins. Peripheral membrane proteins are associated with the surface of the membrane. Membrane phospholipids can be modified by the addition of carbohydrates to form glycolipids. Inside the cell, actin filaments and intermediate filaments interact with membrane proteins. Outside the cell, many animal cells have an elaborate extracellular matrix composed primarily of glycoproteins. Proteins and substances such as cholesterol become embedded in the bilayer, giving the membrane the look of a mosaic. Because the plasma membrane has the consistency of vegetable oil at body temperature, the proteins and other substances are able to move across it. That’s why the plasma membrane is described using the fluid-mosaic model. The molecules that are embedded in the plasma membrane also serve a purpose. For example, the cholesterol that is stuck in there makes the membrane more stable and prevents it from solidifying when your body temperature is low. The model was proposed by Jonathon Singer and garth J. Nicolson and revised in1972. They proposed that the globular proteins are inserted into the lipid bilayer, with their nonpolar segments in contact with the nonpolar interior of the bilayer and their polar portions protruding out form the membrane surface. In this model, called the

fluid mosaic model, a mosaic of proteins floats in or on the fluid lipid bilayer like boats on a pond.

Describe the six key classes of membrane proteins.

The six key classes of membrane proteins include: transporters, Enzymes, cell-surface receptors, cell-surface identity markers, cell= to cell adhesion proteins, and attachments to the cytoskeleton.

- Transporters- Membranes are very selective, allowing only certain solutes to enter and leave the cell, either through channels or carriers composed of proteins.
- Enzymes- Cells carry out many chemical reactions on the interior surface of the plasma membrane, using enzymes attached to the membrane.
- Cell-surface receptors- Membranes are exquisitely sensitive to chemical messages, which are detected by receptor proteins on their surfaces.
- Cell-surface identity markers- Membranes carry cell-surface markers that identify them to other cells. Most cell types carry their own ID tags, specific combinations of cell-surface proteins and protein complexes such as glycoproteins that are characteristic of that cell type.
- Cell-to-cell adhesion proteins- cells use specific proteins to glue themselves to one another. Some act by forming temporary interactions, and others form a more permanent bond.

- Attachments to the cytoskeleton- surface proteins that interact with other cells are often anchored to the cytoskeleton by linking proteins.

Define the term “ anchoring protein”.

The anchoring molecules are modified lipids that have nonpolar regions that insert into the internal portion of the lipid bilayer and chemical bonding domains that link directly to proteins. He part of the protein that extends through the lipid bilayer and that is in contact with the nonpolar interior are Î²-pleated sheets that consist of nonpolar amino acids. Because water avoids nonpolar amino acids, these portions of the protein are held within the interior of the lipid bilayer. The polar ends protrude from both sides of the membrane. Any movement of the protein out of the membrane, in either direction, brings the nonpolar regions of the protein in contact with water, “ which “ shoves’ the protein back into the interior. Therefor the protein is anchored.

Describe the three major classes of transmembrane proteins.

Cells contain a variety of different transmembrane proteins, which differ in the way they traverse the bilayer, depending on their functions. The three major classes of transmembrane proteins are Anchors, Channels and Carriers, and Pores.

Anchors: A single nonpolar segment is adequate to anchor a protein in the membrane. Anchoring proteins of this sort attach the spectrin network of the cytoskeleton to the interior of the plasma membrane. Many proteins that function as receptors for extracellular signals are also “ single-pass” anchors that pass through the membrane only once. The portion of the receptor that

extends out from the cell surface binds to specific hormones or other molecules when the cell encounters them; the binding induces changes at the other end of the protein, in the cell’s interior. In this way, information outside the cell is translated into action within the cell.

Channels and Carriers: Other proteins have several helical segments that thread their way back and forth through the membrane, forming a channel like the hole in a doughnut. Other transmembrane proteins do not create channels but rather act as carriers to transport molecules across the membrane.

Pores: Some transmembrane proteins have extensive nonpolar regions with secondary configurations of Î²-pleated sheets instead of Î± helices. The Î² sheets form a characteristic motif, folding back and forth in a circle so the sheets come to be arranged like the staves of a barrel. This so-called Î² barrel, open on both ends, is a common feature of the porin class of proteins that are found within the outer membrane of some bacteria.

Define the term facilitated transport.

-Many important molecules required by cells cannot easily cross the plasma membrane. These molecules can still enter the cell by diffusion through specific channel proteins or carrier proteins embedded in the plasma membrane, provided there is a higher concentration of the molecule outside the cell than inside. This process is called facilitated transport. It does not require energy. The concentration is moving from a high concentration to a low concentration.

Define the terms ion and ion channels.

Ions are atoms that have an unequal number of protons and electrons and have an electric charge. Those that carry a positive charge are called cations and those that carry a negative charge are called anions. Because of their charge, ions interact well with molar molecules such as water. but are repelled by non polar molecules such as the interior of the plasma membrane. Therefore, ions cannot move between the cytoplasm of a cell and the extracellular fluid without the assistance of membrane transport proteins. Ion channels possess a hydrated interior that spans the membrane. Ions can diffuse through the channel in either direction, depending on their relative concentration across the membrane. Some channel proteins can be opened or closed in response to a stimulus. These channels are called gated channels, and depending on the nature of the channel, the stimulus can be either chemical or electrical.

Define the term “ membrane carrier proteins” and discuss their role in facilitated diffusion

Carrier proteins are proteins involved in the movement of ions, small molecules, or macromolecules, such as another protein, across a biological membrane. Carrier proteins are integral membrane proteins. Carrier proteins can help transport both ions and other solutes, such as some sugars and amino acids, across the membrane. Transport through a carrier is still a form of diffusion and therefore requires a concentration difference across the membrane. Carriers must bind to the molecule they transport, so the relationship between concentrations and rate of transport differs from that

due to simple diffusion. As concentration increases, transport by simple diffusion shows a linear increase in rate of transport. But when a carrier protein is involved, a concentration increase means that more of the carriers are bound to the transported molecule. At high enough concentrations all carriers will be occupied, and the rate of transport will be constant. This means that he carrier exhibits saturation. Thus, Carrier proteins help with the movement with facilitated diffusion.

Define the term Endocytosis and differentiate between the process between Phagocytosis, Pinocytosis, and receptor mediated Endocytosis and Exocytosis.

Two processes are involved in bulk transport are endocytosis and exocytosis. In endocytosis, the plasma membrane envelops food particles and fluids. Cells use three major types of endocytosis: phagocytosis, pinocytosis, and receptor-mediated endocytosis. Like active transport, these processes also require energy expenditure. If the material the cell takes in is particulate (made up of discrete particles), such as an organism or some other fragment of organic matter, the process is called phagocytosis. If the material the cell takes in is liquid, the process is called pinocytosis. Pinocytosis is common among animal cells. Mammalian egg cells, for example, “ nurse” from surrounding cells; the nearby cells secrete nutrients that the maturing egg cell takes up by pinocytosis. Virtually all eukaryotic cells constantly carry out these kinds of endocytosis processes, trapping particles and extracellular fluid in vesicles and ingesting them. Molecules are often transported into eukaryotic cells through receptor-mediated endocytosis. These molecules first bind to specific receptors in the plasma membrane-they have a

conformation that fits snugly into the receptor. Different cell types contain a characteristic battery of receptor types, each for a different kind of molecule in their membranes. The portion of the receptor molecule that lies inside the membrane is trapped in an indented pit coated on the cytoplasmic side with the protein clathrin. Each pit acts like a molecular mousetrap, closing over the form an internal vesicle when the right molecule enters the pit. The trigger that releases the trap is the binding of the properly fitted target molecule to the embedded receptor. When binding occurs, the cell reacts by initiating endocytosis; the process is highly specific and very fast. The vesicle is now inside the cell carrying its cargo. Endocytosis in itself does not bring substances directly into the cytoplasm of a cell. The material taken in is still separated from the cytoplasm by the membrane of the vesicle. The reverse of endocytosis is exocytosis, the discharge of material from vesicles at the cell surface. In the plant cells, exocytosis is an important means of exporting the materials needed to construct the cell wall through the plasma membrane.

Define the term active transport.

Active transport uses energy to move materials against a concentration gradient. It involves a highly selective protein carrier within the membrane that binds to the transported substance, which could be an ion or a simple molecule. Active transport is one of the most important functions of any cell. It enables a cell to take up additional molecules of a substance that is already present in its cytoplasm in concentrations higher than in the extracellular fluid. Active transport also enables a cell to move substances

out of its cytoplasm and into the extracellular fluid, despite higher external concentrations.

Describe the sodium-potassium pump as an example of active transport.

More than 1/3 of all of the energy expended by an animal cell that is not actively dividing is used in the active transport of sodium and potassium ions. Most animal cells have a low internal concentration of sodium ion, relative to their surroundings, and a high internal concentration of the potassium ion. They maintain these concentration differences by actively pumping sodium ions out of the cell and potassium ions into the cell. The remarkable protein that transports these two ions across the cell membrane is known as the sodium-potassium pump. This carrier protein uses the energy stored in ATP to move these two ions. In this case, the energy is used to change the conformation of the carrier protein, which changes its affinity for either Sodium ions or Potassium ions. This is an excellent illustration of how subtle changes in the structure of a protein affect its function.

The important characteristic of the sodium-potassium pump is that it is an active transport mechanism, transporting Sodium ion and Potassium ion from areas of low concentration to areas of high concentration. This transport is the opposite of passive transport by diffusion; it is achieved only by the constant expenditure of metabolic energy. The sodium-potassium pump works through the following series of conformational changes in the transmembrane protein.

In the process first, three Sodium ions bind to the cytoplasmic side of the protein, causing the protein to change its conformation. Then in the next

stop, in its new conformation, the protein binds a molecule of ATP and cleaves it into adenosine diphosphate (ADP) and phosphate. ADP is released, but the phosphate group is covalently linked to the protein. The protein is now phosphorylated. After that the phosphorylation of the protein induces a second conformational change in the protein this change translocates the three Sodium ions across the membrane, so they now face the exterior. In this new conformation, the protein has a low affinity for Sodium, and the three bound Sodium ions break away from the protein and diffuse into the extracellular fluid. Next, the new conformation has a high affinity for Potassium ion, two of which bind to the extracellular side of the protein as soon as it is free of the Sodium. After that the binding of the Potassium ions causes another conformational change in the protein, this time resulting in the hydrolysis of the bound phosphate group. Finally, freed of the phosphate group, the protein reverts to its original shape, exposing the two Potassium ions to the cytoplasm. This conformation has a low affinity for Potassium ion, so the two bound Potassium ions dissociate from the protein and diffuse into the interior of the cell. The original conformation has a high affinity for Sodium ion. When these ions bind, they initiate another cycle. In every cycle, three Sodium ions leave the cell and two Potassium ions enter. The changes in protein conformation that occur during the cycle are rapid, enabling each carrier to transport as many as 300 Sodium ions per second.

Define the term coupled transport.

-Some molecules are moved against the concentration gradient by using the energy stored in a gradient of a different molecule. In this process, called coupled transport, the energy released as one molecule moves down its

concentration gradient is captured and used to move a different molecule against its gradient. As you just saw, the energy stored in ATP molecules can be used to create a gradient of Sodium ion and Potassium ion across the membrane. These gradients can then be used to power the transport of other molecules across the membrane. Many molecules are transported into cells up a concentration gradient through a process that uses ATP indirectly. The molecules move hand-in-hand with sodium ions or protons that are moving down their concentration gradients. This type of active transport, called coupled transport, has two components. One of which is establishing the down gradient; ATP is used to establish the sodium ion or proton down gradient, which is greater than the up gradient of the molecule to be transported. The second one is traversing the up gradient: Coupled transport proteins carry the molecule and either a sodium ion or a proton together across the membrane.

Define the term Chemiosmosis

-Chemiosmosis is an energy-coupling mechanism that uses energy stored in the form of a hydrogen ion gradient across a membrane to drive cellular work, such as the synthesis of ATP. Most ATP synthesis in cells occurs by chemiosmosis. The newly formed ATP is transported by facilitated diffusion to the many places in the cell where enzymes require energy to drive endergonic reaction. This chemiosmosis mechanism for the coupling of electron transport and ATP synthesis was controversial when it was proposed. High-energy electrons harvested from catabolized molecules are transported by mobile electron carriers between three complexes of membrane proteins. These three complexes use portions of the electrons'

energy to pump protons out of the matrix and into the intermembrane space. The electrons are finally used to reduce oxygen, forming water. This creates a concentration gradient of protons across the inner membrane. This electrochemical gradient is a form of potential energy that can be used by ATP synthase. This enzyme couples the reentry of protons to the phosphorylation of ADP to form ATP.

Cell to Cell Communication

Read Chapter 4. 8 and chapter 9. Answer the following questions or perform the following tasks.

- Define the term signal

It is like a coded message sent from one place in a part of a body or cell to another.

- Briefly describe the four types of cell signaling

The four types of cell signaling are, direct contact, Paracrine signaling, endocrine signaling and Synaptic signaling.

Direct contact: When cells are very close to one another, some of the molecules on the plasma membrane of one cell can be recognized by receptors on the plasma membrane of an adjacent cell. Many of the important interactions between cells in early development occur by means of direct contact between cell surfaces. Cells also signal through gap junctions.

Paracrine signaling: Signal molecules released by cells can diffuse through the extra-cellular fluid to other cells. If those molecules are taken up by neighboring cells, destroyed by extracellular enzymes, or quickly removed

from the extracellular fluid in some other way, their influence is restricted to cells in the immediate vicinity of the releasing cell. Signals with such short-lived, local effects are called paracrine signals. Paracrine signaling plays an important role in early development, coordinating the activities of clusters of neighboring cells.

Endocrine signaling: A released signal molecule that remains in the extracellular fluid may enter the organism’s circulatory system and travel widely throughout the body. These longer-lived signals molecules, which may affect cells very distant from the releasing cell, are called hormones, and this type of intercellular communication is known as endocrine signaling.

Synaptic signaling: In animals, the cells of the nervous system provide rapid communication with distant cells. Their signal molecules, neurotransmitters, do not travel to the distant cells through the circulatory system as hormones do. Rather, the long, fiber like extensions of nerve cells release neurotransmitters from their tips very close to the target cells. The association of a neuron and its target cell is called a chemical synapse, and this type of intercellular communication is called synaptic signaling. Neuro-transmitters cross the synaptic gap and persist only briefly.

- Describe the mechanisms of cell signaling that uses intracellular receptors

-Many cell signals are lipid-soluble or very small molecules that can readily pass through the plasma membrane of the target cell and into the cell, where they interact with an intracellular receptor. Some of these ligands bind to protein receptors located in the cytoplasm; others pass across the nuclear

membrane as well and bind to receptors within the nucleus. Hydrophobic signaling molecules can cross the membrane and bind to intracellular receptors. The steroid hormone receptors act by directly influencing gene expression. On binding hormone, the hormone-receptor moves into the nucleus to turn on or sometimes turn off gene expression. This also requires another protein called a coactivator that functions with the hormaon-receptor. Thus, the cell's response to a hormone depends on the presence of a receptor and coactivators as well.

- Describe the mechanisms of cell signaling that employee cell surface receptors. Include a brief description of the three receptor super families

-When a receptor is a transmembrane protein, the ligand binds to the receptor outside of the cell and never actually crosses the plasma membrane. In this case, the receptor itself, and not the signaling molecule is responsible for information crossing the membrane. Such receptor transmits information from the extracellular environment to the inside of the cell by changing shape or aggregating when a specific ligand binds to it. Membrane receptors can be categorized based on their structure and function. The three receptor super families are: Chemically gated ion channels, enzymatic receptors and G protein-coupled receptors. IN the center of the protein is a pore that connects the extracellular fluid with the cytoplasm. The pore is big enough for ions to pass through, so the protein functions as an ion channel. Chemically gated ion channels are made up of multipass transmembrane protein forming a central pore and the way they function is that the molecular " gates" are triggered chemically to open or close. The Enzymatic

receptors are made of Single-pass transmembrane protein and the way they function is by binding signal extracellularly, and catalyzing response intracellularly. The G protein-coupled receptors are made up of Seven-pass transmembrane protein with cytoplasmic binding site for G protein and the way they function in the following way: Binding of signal to receptor causes GTP to bind a G protein; G protein, with attached GTP, detaches to deliver the signal inside the cell.

- Describe how signal can be amplified by protein kinase cascades

One important class of cytoplasmic kinases are mitogen activated protein (MAP) kinases. A mitogen is a chemical that stimulates cell division by activating the normal pathways that control division. The MAP kinases are activated by a signaling module called a phosphorylation cascade or a kinases cascade. This module is a series of protein kinases that phosphorylate each other in succession. The final step in the cascade is the activation by phosphorylation of MAP kinase itself. One function of a kinase cascade is to amplify the original signal. Because each step in the cascade is an enzyme, it can act on a number of substrate molecules. With each enzyme in the cascade acting on many substrates this produces a large amount of the final product. This allows a small number of initial signaling molecules to produce a large response. The cellular response to this cascade in any particular cell depends on the targets of the MAP kinase, but usually involves phosphorylating transcription factors that then activate gent expression. An example of this kind of signaling through growth factor receptors is provided in chapter 10 and illustrates how signal transduction initiated by a growth factor can control the process of cell division through a

kinase cascade. The proteins in a kinase cascade need to act sequentially to be effective. One way the efficiency of this process can be increased is to organize them in the cytoplasm. Proteins called scaffold proteins are thought to organize the components of a kinase cascade into a single protein complex, the ultimate in a signaling module. The scaffold protein binds to each individual kinase such that they are spatially organized for optimal function. There is a receptor in the plasma membrane. Each kinase is named starting with the last, the MAP kinase (MK), which is phosphorylated by a MAP kinase (MKK), which is in turn phosphorylated by a MAP kinase kinase kinase (MKKK). The cascade is linked to the receptor protein by an activator protein. At each step the enzymatic action of the kinase on multiple substrates leads to amplification of the signal.

A. Define the term cell junction

-A cell junction is a long-lasting or permanent connection between one cell and another.

b. Briefly describe the three categories of cell junction

– Tight junctions- Tight junctions connect the plasma membranes of adjacent cells in a sheet. This sheet of cells acts as a wall within the organ, keeping molecules on one side or the other. The junctions between neighboring cells are so securely attached that there is no space between them for leakage. Hence, nutrients absorbed from the food in the digestive tract must pass directly through the cells in the sheet to enter the bloodstream because they cannot pass through spaces between cells. The tight junctions between the cells lining the digestive tract also partititon the plasma membranes of these

cells into separate compartments. Transport proteins in the membrane facing the inside of the tract carry nutrients from that side to the cytoplasm of the cells. Other proteins located in the membrane on the opposite side of the cells, transport those nutrients from the cytoplasm to the extracellular fluid, where they can enter the bloodstream. For the sheet to absorb nutrients properly, these proteins must remain in the correct locations within the fluid membrane. Tight junctions effectively segregate the proteins on opposite sides of the sheet, preventing them from drifting within the membrane from one side of the sheet to the other. When tight junctions are experimentally disrupted, just this sort of migration occurs.

Anchoring junctions: Anchoring junctions mechanically attach the cytoskeleton of a cell to the cytoskeletons of other cells or to the extracellular matrix. Anchoring junctions called adherens junctions connect the actin filaments of one cell with those of neighboring cells or with the extracellular matrix. The linking proteins in these junctions are members of a large superfamily of cell-surface receptors called integrins that bind to a protein component of the extracellular matrix. At least 20 different integrins exist each with a differently shaped binding domain.

Communicating Junctions: Many cells communicate with adjacent cells through direct connections called communicating junctions. In these junctions, a chemical or electrical signal passes directly from one cell to an adjacent one. Communicating junctions permit small molecules or ions to pass from one cell to the other in animals, these direct communication channels between cells are called gap junctions, and in plants, plasmodesmata. A gap junction forms when the connexons of two cells align

perfectly, creating an open channel that spans the plasma membranes of both cells. Gap junctions provide passageways large enough to permit small substances, such as simple sugars and amino acids, to pass from one cell to the next. Yet the passages are small enough to prevent the passage of larger molecules, such as proteins. Gap junction channels are dynamic structures that can open or close in response to a variety of factors, including Calcium and Hydrogen ions. This gating serves at least one important function. When a cell is damaged, its plasma membrane often becomes leaky. Ions in high concentrations outside the cell, such as Calcium ion, flow into the damaged cell and close its gap junction channels. This isolates the cell and so prevents the damage from spreading to other cells. In plants, cell walls separate every cell from all others. Cell-cell junctions occur only at holes or gaps in the walls, where the plasma membranes of adjacent cells can come into contact with one another. Cytoplasmic connections that form across the touching plasma membranes are called plasmodesmata. The majority of living cells within a higher plant at connected to their neighbors by these junctions.