ANSWERS

CONCEPT MAP

Concept Map on the structure and function of membranes. All of these terms are defined in the last section of this workshop:

a. lipids, proteins, and carbohydrates
b. passive transport
c. active transport
d. exocytosis
e. diffusion
f. concentration gradient
g. water and small hydrophobic molecules
h. cotransport
i. cellular energy

THOUGHT QUESTIONS:

A. The fluidity of the membrane allows for extensive flexibility during movement. Any breaks that do occur would expose the hydrophobic core of the membrane to an aqueous environment. Hydrophobic interactions immediately and spontaneously move the broken ends back together and in combination with certain other components of the cell's membrane resealing mechanism (e.g., the cytoskeleton and calcium ions), the broken membrane reseals itself.

B. In order for a phospholipid molecule to move from one side of a membrane bilayer to the other side of the membrane bilayer, the polar head of the phospholipid must move through the hydrophobic portion of the phospholipid membrane. This process would require a significant amount of energy and is therefore relatively slow or rarely occurs.

C. Many transmembrane and peripheral proteins are directly attached to the cytoskeleton and therefore are not free to move laterally in the phospholipid bilayer.

D. Ions and large polar molecules, such as glucose, are impeded by the hydrophobic center of a membrane's phospholipid bilayer. Additionally, large molecular weight molecules are impeded.

STRUCTURE OF MEMBRANES (figure labels)

a. glycoprotein — any of a group of conjugated proteins that contain a carbohydrate as the nonprotein component, and function in a membrane.
b. carbohydrate — any of a group of organic compounds that includes sugars, starches, cellulose, and gums that may serve as a major energy source or as a component part of a function protein.
c. glycolipid — a lipid that contain carbohydrate groups and may function as part of a membrane
d. fibronectin — an adhesive glycoprotein that helps attach the extra-cellular matrix to the plasma membrane of a cell
e. collagen fiber — a glycoprotein fibrous protein constituent of bone, cartilage, tendon, and other connective tissue, that also can make up part of the extra-cellular matrix .
f. microfilaments — solid rods of actin protein making up part of the cytoskeleton providing contractile motility and intracellular structure
g. cholesterol — a lipid found in animal tissues and various foods, that is normally synthesized by the liver that is an important constituent of cell membranes and a precursor to steroid hormones
h. peripheral protein — proteins not embedded into the phospholipid bilayer of a cell membrane, but intimately attached to the surface of the membrane providing support and functionality
i. integral protein — proteins that penetrate far enough into a membrane for their hydrophobic regions to be surrounded by the hydrocarbon tails of the phospholipid molecules

OSMOLARITY - Answers to Graph Questions.

1. **Line C** best represents the dialysis bag containing the isotonic solution, for it shows neither a gain or a loss of water by osmosis suggesting that its initial internal concentration was equal to that of the beaker (0.6 M) into which the bag was placed.

2. **Line A** represents the bag with the highest initial internal concentration for it is the bag that shows the greatest gain in weight (mass). With the greatest internal sucrose concentration it would favor a movement of water from the beaker into the bag with he greatest rate of net movement.

3. The shape of **line E** after 50 minute reveals that the bag is no longer gaining net mass (weight) by osmosis, i.e., there is a flat rate of change in weight, which means that at 50 minutes this bag is isotonic to its medium and therefore water at this time is leaving and entering the bag at the same rate.

4. **Line B** best represents a dialysis bag that is hypertonic to its medium at 60 minutes, which means that the sucrose concentration inside Bag B is still more concentrated than the medium (0.6 M) that the Bag B is suspended in, and therefore the rate of influx of water by osmosis continues to increase the Bag B's mass. In the same way we should realize that Line D represents a dialysis bag that is hypotonic to the medium (0.6 M sucrose) in which it is suspended

OSMOLARITY - Answers to U-Tube questions.

1. **isotonic** - i.e., the U-tubes have the same concentration of solutes on either side; but as the membrane is permeable to both water and glucose, these molecules will soon begin to move by osmosis, which is the spontaneous transfer of a liquid solvent through a semipermeable membrane that does not allow dissolved solids (solutes) to pass and by diffusion which is the transfer of a solute from an area of higher concentration to one of lower concentration through the membrane.

2. **Diffusion** of fluid through a semi-permeable membrane continues until there is an equal concentration of fluid on both sides of the membrane. Therefore, glucose (2 M) will diffuse from side B to side A [higher to lower], while water will flow from the area of higher concentration (side A - 1 M) to the area of lower concentration (side B - 2 M).

   Osmosis refers only to the transfer of solvent; transfer of solute is often called dialysis. In either case, the direction of transfer is from the area of higher concentration of the material transferred to the area of lower concentration. If a vessel is separated into two compartments by a semi-permeable membrane, if both compartments are filled to the same level with a solvent, and if solute is added to one side, then osmosis will occur, and the level of the liquid on the side containing the solute will rise. If an external pressure is exerted on the side containing the solute, the transfer of solvent can be stopped. The minimum pressure to stop solvent transfer is called the osmotic pressure. Osmosis plays an important role in the control of the flow of liquids in and out of a living cell.

3. After equilibrium is reached the molarity of glucose will be equal on both sides (1.5 M). Since sucrose impermeant and the concentration of sucrose is higher on side A, water will diffuse by osmosis from side B to side A. This passive transport of water reduces the difference in sucrose concentration and results in the water level being higher on side a than side B at equilibrium.

4. After the system reaches equilibrium there will equal concentrations of sucrose and glucose on either side, i.e., side A will have 1.5 M sucrose and 1.5 M glucose, as will side B. The water level on both side should be equal at equilibrium.

SIGNAL TRANSDUCTION (figure labels)

a. ***Inducer (first messenger)***, which is an extracellular molecule that can ① bind to a specific cell membrane receptor protein; not unlike an allosteric regulator's ability to bind to the allosteric site on an allosteric enzyme.
b. ***Receptor protein*** is usually an integral membrane protein that is designed specifically to recognize and bind an extracellular inducer molecule.
c. A ***relay protein***, which may often be an internal peripheral membrane protein, that is intermediary ② between the binding of an extracellular signal molecule and the initiation of a cytoplasmic ③ response to the binding of an inducer.
d. ***Effector protein***, which is usually an enzyme that is capable of converting ④ an inactive cytoplasmic molecule (second messenger) into an active form of that molecule.
e. ***Second messenger***, which is the active form of a cytoplasmic molecule that can facilitate further intracellular metabolic processes ⑤ .
f. Unique ***cellular metabolic and/or physiologic process*** that are elicited in response to the second messenger molecule.

STRUCTURE YOUR KNOWLEDGE

1. Portion II of the diagram represents facilitated diffusion because the solute is moving through a transport protein and down its concentration gradient as it crosses the membrane. The cell does not expend any energy in facilitated diffusion. Most often it is polar molecules and ions that are moved by facilitated diffusion.

2. Portion III of the diagram represents active transport because the solute is clearly moving against its concentration gradient. The must expend energy to exhibit a net movement of a molecule by active transport.

3. Portion I of the diagram illustrates simple diffusion of a molecule through a lipid bilayer. These solute molecules must be nonpolar or small polar molecules.

4. Both diffusion and facilitated diffusion are considered to be passive transport mechanisms because the solute moves down its concentration gradient and the cell does not expend any energy in this form of transport.

MORE THOUGHT QUESTIONS

A. As the concentration of **glu** and **g6p** were both 1 M outside and 0.1 M inside the cells at the initiation of the experiment, there was a strong diffusive gradient favoring the movement of **glu** and **g6p** from outside to inside the cells. The root cells showed no change from initial internal concentrations of **glu** or **g6p** and therefore the membrane is not permeable to these molecules and in all likelihood, there is no cellular membrane protein in plant root cells favoring its facilitated diffusion of either **glu** or **g6p**. Muscle cell, however, appear to gain in internal concentration of **glu** but not **g6p**, which suggest that the muscle cells have a transport system for glucose, but not g6p. Since we can speculate that the lipid bilayer is impermeant to both **glu** and **g6p**, we might be able to speculate that there is a transport protein in muscle cells that binds glucose and favors its facilitated diffusion.

B. Since the addition of cyanide, an inhibitor of energy continued production in cells, had no effect on the accumulation of **glu** by the muscle cells we may speculate that active transport (requiring continued energy production) is not involved; therefore, the movement of **glu** into muscle cells is by passive diffusion.

THE **ALPHABET** of SOME IMPORTANT TRANSPORT CONCEPTUAL TERMS… Definitions.

a. peripheral protein	protein not embedded into the lipid bilayer of the plasma membrane, often loosely attached to the surface of a membrane, which on the cytoplasmic side may be held in place by the cytoskeletal elements
b. integral protein	a membrane protein embedded in the hydrophobic matrix of a lipid bilayer, which function in active transport and structure of membranes
c. diffusion	a passive process in which a solute is transported from higher concentration to lower concentrations
d. osmosis	net movement of water molecules a cross a semipermeable membrane driven by the difference in concentration of solute on either side. The membrane must be permeable to water, but not to the solute.
e. active transport	the net movement of molecules from low concentration to a higher concentration which requires expenditure of energy, usually by hydrolysis of ATP.
f. facilitated diffusion	spontaneous passage of molecules and ions, bound to specific carrier proteins, across a biological membrane down their concentration gradient
g. Na-pump	the Na-K-ATPase system that transport Na out and K into a cell, against their concentration gradients, which requires expenditure of energy via ATP hydrolysis; is electrogenic (3 Na out for 2 K in) and contribute to the cells membrane potential, and is mediated by a carrier protein that undergoes a conformational change.
h. exocytosis	packaging of intracellular products into membrane bound vesicles for eventual export and release of substance out of a cell by the fusion of the vesicle with the plasma membrane.
i. endocytosis	uptake of material into a cell by an invagination of the cell membrane and its internalization into a membrane-bounded vesicle (see pinocytosis and phagocytosis).
j. concentration gradient	a difference in concentration on the two sides of a membrane; provides driving force for diffusion & osmosis
k. membrane potential	an electrical voltage across a cell membrane due to an unequal distribution of ions and a differential permeable membrane
l. electrochemical gradient	a driving force that causes an ion to move across a membrane due to the combined influence of a difference in concentration on the two sides of a membrane and the electrical charge difference across the membrane.
m. hypotonic	any medium with sufficiently low concentration of solutes to cause water to move into a cell via osmosis.
n. hypertonic	any medium with a sufficiently high concentration of solutes to cause water to move out of a cell via osmosis
o. isotonic	isotonic solutions are ones of equal solute concentration having no osmotic or solute gradient
p. plasmolysis	a phenomena in cellulosic walled cells in which the cytoplasm shrivels and the plasma membrane pulls away from the cell wall when the cell loses water to a hypertonic solution
q. electrogenic pump	an ion transport protein which generates a voltage across a membrane
r. phagocytosis	movement of solid (food) particle form outside to inside a cell where the particle is encapsulated into a membrane bound vesicle called a food vacuole.
s. carrier protein	a integral membrane bound protein that exhibits a specificity for a particular type of molecule and which is required for both facilitated diffusion and active transport by binding the specific solute and aiding in its transport through the hydrophobic lipid bilayer.
t. cotransport	(coupled transport) a membrane transport process in which the transfer of one solute depends upon the simultaneous or sequential transfer of a second solute.
u. uniport	unidirectional/one way transport of a solute across a biological membrane usually by a carrier protein
v. pinocytosis	a type of endocytosis in which soluble materials (liquid) is taken up from the environment and incorporated into a membrane vesicle for eventual intracellular digestion; literally ‘cell drinking’.
w. ion channel	a transmembrane protein complex that forms a aqueous filled channel across a lipid bilayer through which specific inorganic ions can diffuse down their electrochemical gradient.
x. extracellular matrix	complex network of polysaccharides (as glycoaminoglycans or cellulose) and proteins (mostly collagen) secreted by cells which serve as a structural, protective, and recognition element for the cell.
y. cell recognition	ability of cells to recognize like and or different cells due to the presence of membrane surface molecules, glycoproteins and glycolipids, in animal cell membranes which can cross react
z. cholesterol	a steroid like molecule, classified as a lipid, that can integrate into a phospholipid bilayer and help maintain membrane fluidity, especially when cell temperatures drop.