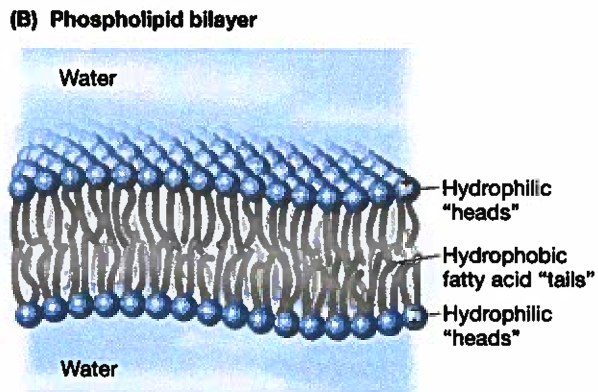
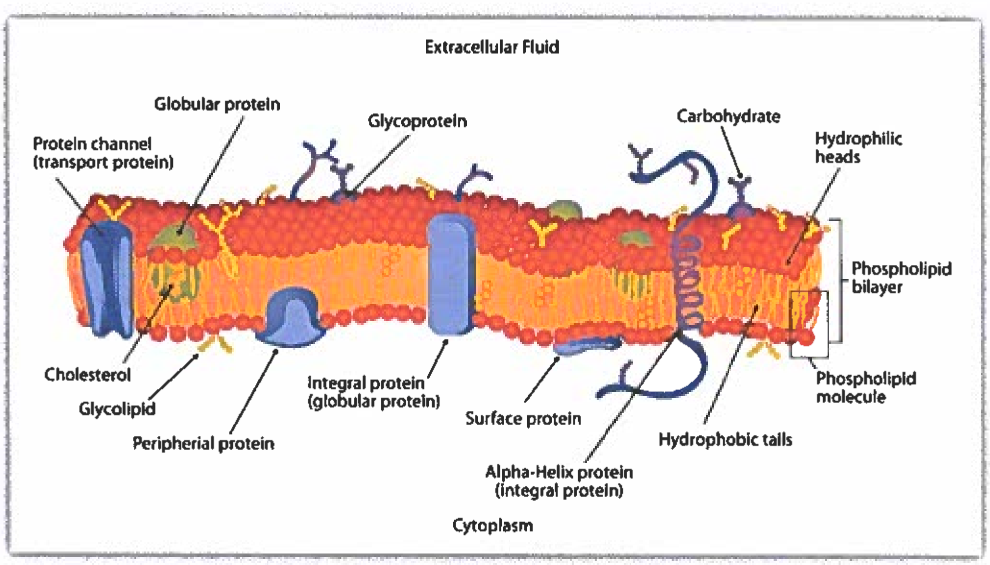
Cell Membrane
Composition & Functions

The cell membrane is also called the plasma membrane and is made of a phospholipid bilayer. Some of the functions of the cell membrane include protecting and enclosing the cell, giving shape to the cell, allowing transportation of materials in and out of the cell, and carry out metabolic reactions near the inner surface of the cell membrane. The phospholipids of the cell membrane have a "hydrophilic" (water loving/attracting) head and two "hydrophobic" (water fearing/repelling) tails. The head of a phospholipid is made of an alcohol and phosphate group, while the tails are chains of fatty acids. The cell membrane is constantly vibrating, creating small openings within the structure. Therefore, the phospholipids can allow water and other smaller molecules to pass through into or out of the cell, without the use of energy. This type of passive transport is known as diffusion because the molecules are moving with the concentration gradient (high to low).



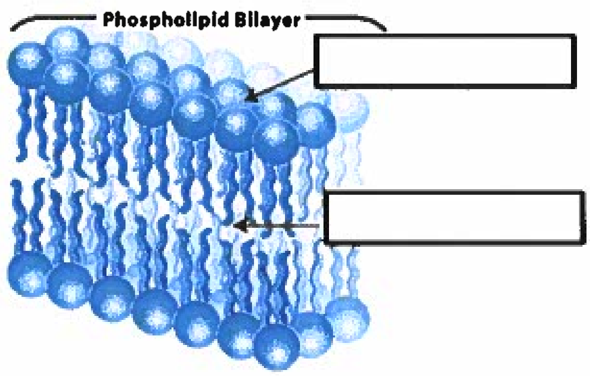
Another type of lipid in the cell membrane is cholesterol that makes the membrane more fluid and adds to its flexibility. Embedded in the phospholipid bilayer are proteins that also aid in diffusion and in cell recognition. Proteins called transport proteins go all the way through the bilayer. Integral proteins, also known as membrane proteins, are found only on one side of the membrane. Large molecules like glucose utilize these channel proteins to help move across cell membranes without the use of energy. Some membrane proteins, called glycoproteins, have carbohydrate chains attached to help cells recognize each other and certain molecules.



<u>**Composition of the Cell Membrane & Functions**</u>

- ✓ I can describe the cell as a functioning open system and describe the role of the cell membrane in maintaining equilibrium while exchanging matter and energy
- ✓ I can describe how knowledge about semi-permeable membranes, diffusion and osmosis is applied in various contexts
- ✓

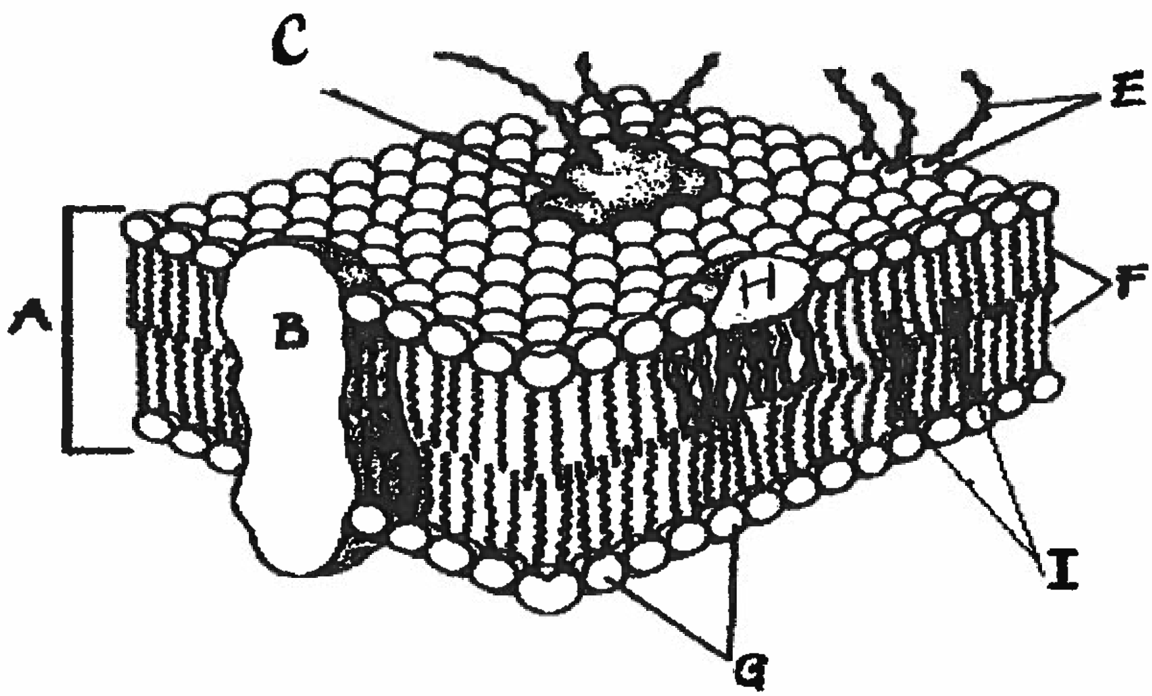
The cell membrane is also called the _______________ membrane and is made of a phospholipid _____________. The phospholipids have a hydrophilic (water attracting) __________ and two hydrophobic (water repelling) ____________. The head of a phospholipid is made of an alcohol and __________ group, while the tails are chains of ____________. Phospholipids allow water and other _________ molecules to pass into or out of the cell. This is known as simple ____________ because it does not require __________ and the water or molecules are moving __________ the concentration gradient.



Another type of lipid in the cell membrane is ______________ that makes the membrane more fluid. Embedded in the phospholipid bilayer are __________ that also aid in diffusion and in cell recognition. Proteins called _____________ proteins go all the way through the bilayer, while ____________ proteins are only on one side. Integral proteins are also called __________ proteins. Large molecules like ___________ or carbohydrates use proteins to help move across cell membranes. Some of the membrane proteins have carbohydrate __________ attached to help cells in recognizing each other and certain molecules.

1. Correctly ***color code and identify*** the name for each part of the cell membrane.

Letter	Name(Color)	Letter	Name(Color)
	Phospholipid bilayer (no color)		Peripheral protein (red)
	Integral protein (pink)		Cholesterol (blue)
	Fatty acid tails (orange)		Glycoprotein (green)
	Phosphate heads (yellow)		Glycolipids (purple)



Match the cell membrane structure or its function with the correct letter from the cell membrane diagram.

Letter	Structure/Function	Letter	Structure/Function
	Attracts water		Repels water
	Helps maintain flexibility of membrane		Make up the bilayer
	Involved in cell-to-cell recognition		Help transport certain materials across the cell membrane

Name ________________________________ Date ______________

Cell Membrane – Structure and Function

Composition of the Cell Membrane & Functions

The **cell membrane** is also called the plasma membrane and is made of a phospholipid bilayer (A). Some of the functions of the cell membrane include protecting and enclosing the cell, giving shape to the cell, allowing transportation of materials in and out of the cell, and carry out metabolic reactions near the inner surface of the cell membrane. The phospholipids of the cell membrane have a "hydrophilic" (water loving/attracting) head (G) and two "hydrophobic" (water fearing/repeling) tails (F). The head of a phospholipid is made of an alcohol and phosphate group, while the tails are chains of fatty acids.

The cell membrane is constantly vibrating, creating small openings within the structure. Therefore, the phospholipids can allow water and other smaller molecules to pass through into or out of the cell, without the use of energy. This type of passive transport is known as diffusion because the molecules are moving with the concentration gradient (high→low).

Another type of lipid in the cell membrane is cholesterol (I) that makes the membrane more fluid and adds to its flexibility. Embedded in the phospholipid bilayer are proteins that also aid in diffusion and in cell recognition. Proteins called transport proteins (B) go all the way through the bilayer. Integral proteins, also known as membrane proteins (H), are found only on one side of the membrane. Large molecules like glucose utilize these channel proteins to help move across cell membranes without the use of energy. Some membrane proteins, called glycoproteins (C), have carbohydrate chains (E) attached to help cells recognize each other and certain molecules.

1. What is another name for the cell membrane? Generally speaking, identify the overall structure of the cell membrane.

2. Define hydrophilic. Which portion of the bilayer is hydrophilic?

3. Define hydrophobic. Which portion of the bilayer is hydrophobic?

4. When does the movement of materials in and out of the cell NOT require energy?

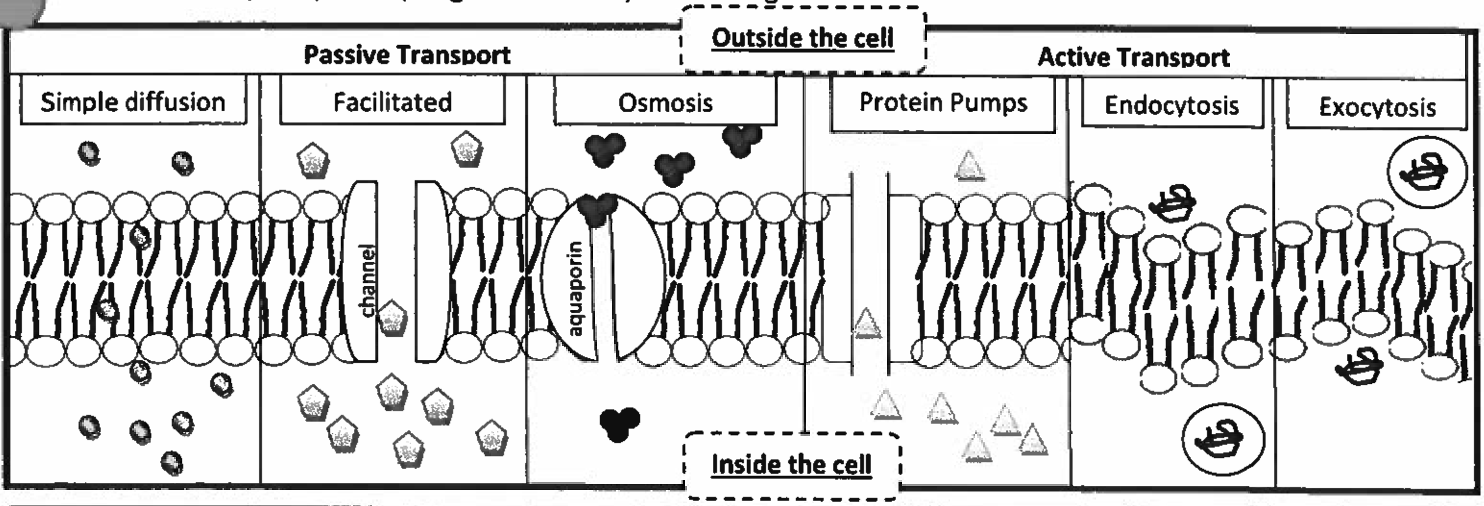
5. List the responsibilities of the cell membrane?

6. Describe the function of the proteins embedded in the cell membrane?

7. How are cells able to recognize various molecules and other types of cells?

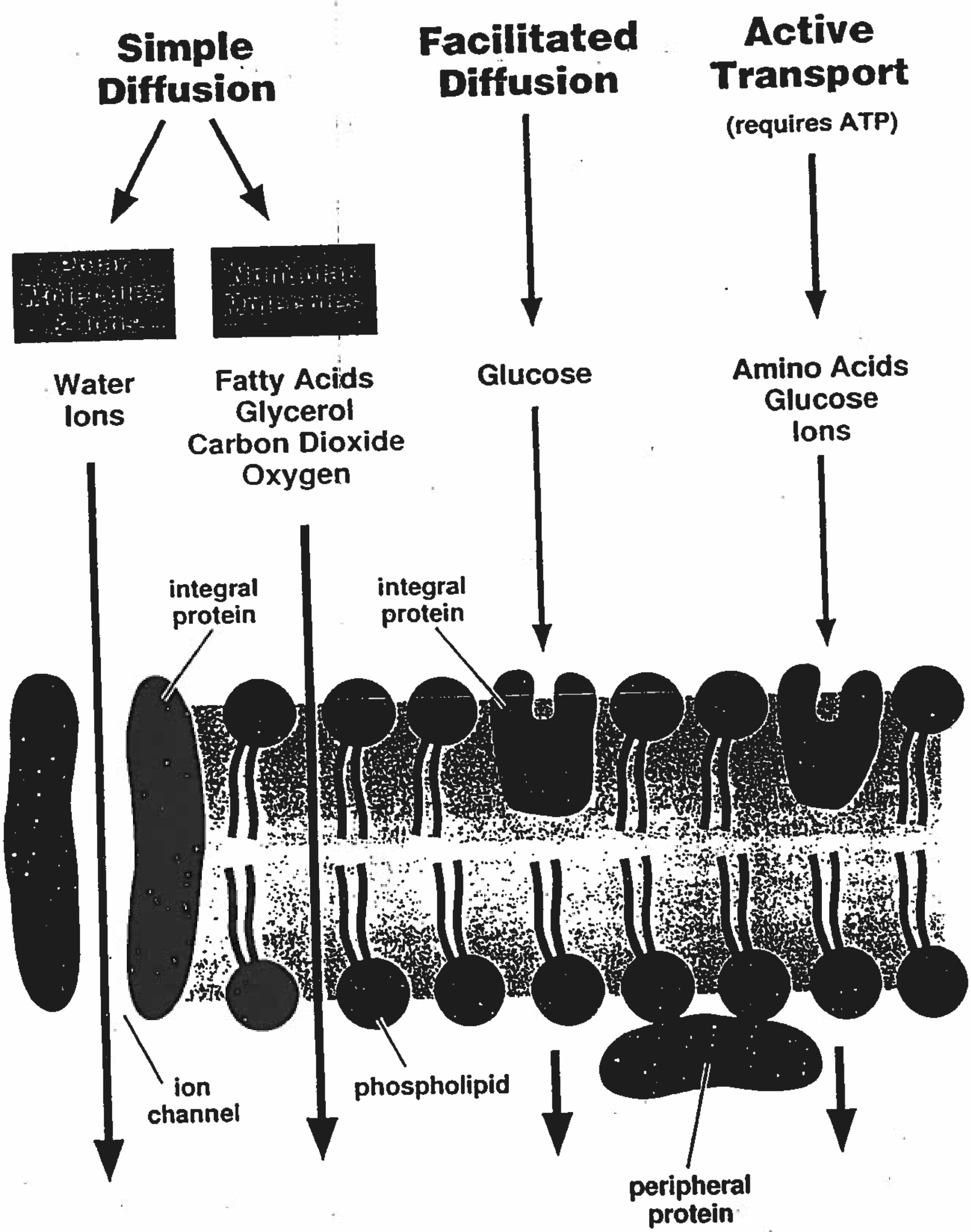
Cell Transport G.O.

- ✓ Circle one **phospholipid** and label – **hydrophilic heads**, **hydrophobic tails.**
- ✓ For each type of transport, use an **arrow** to show the direction the **substances** (small molecules, ions, water, larger molecules) are moving across the membrane.

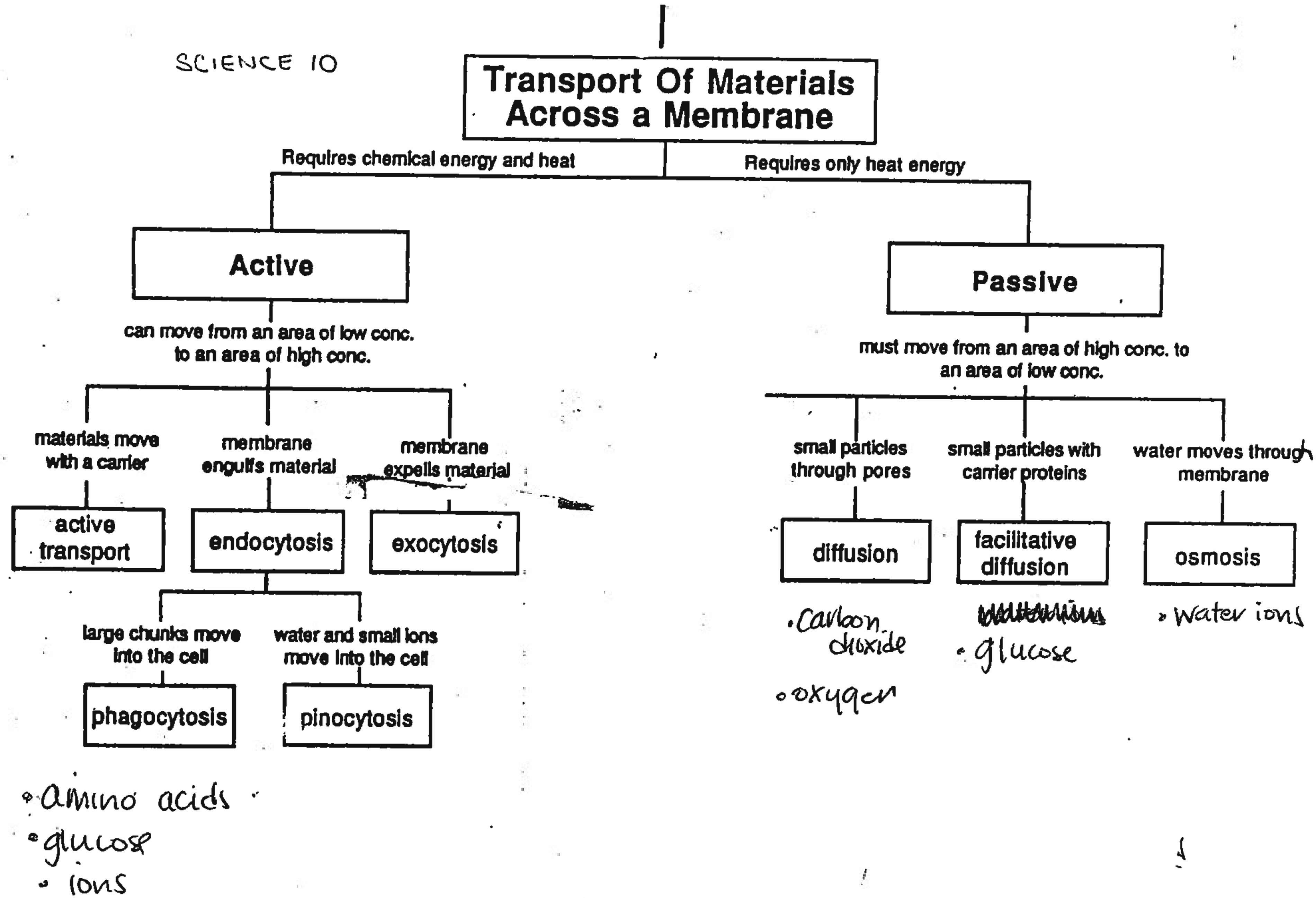


Uses Energy? Yes / No	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Summary:					

MEMBRANE TRANSPORT
Fluid Mosaic Model



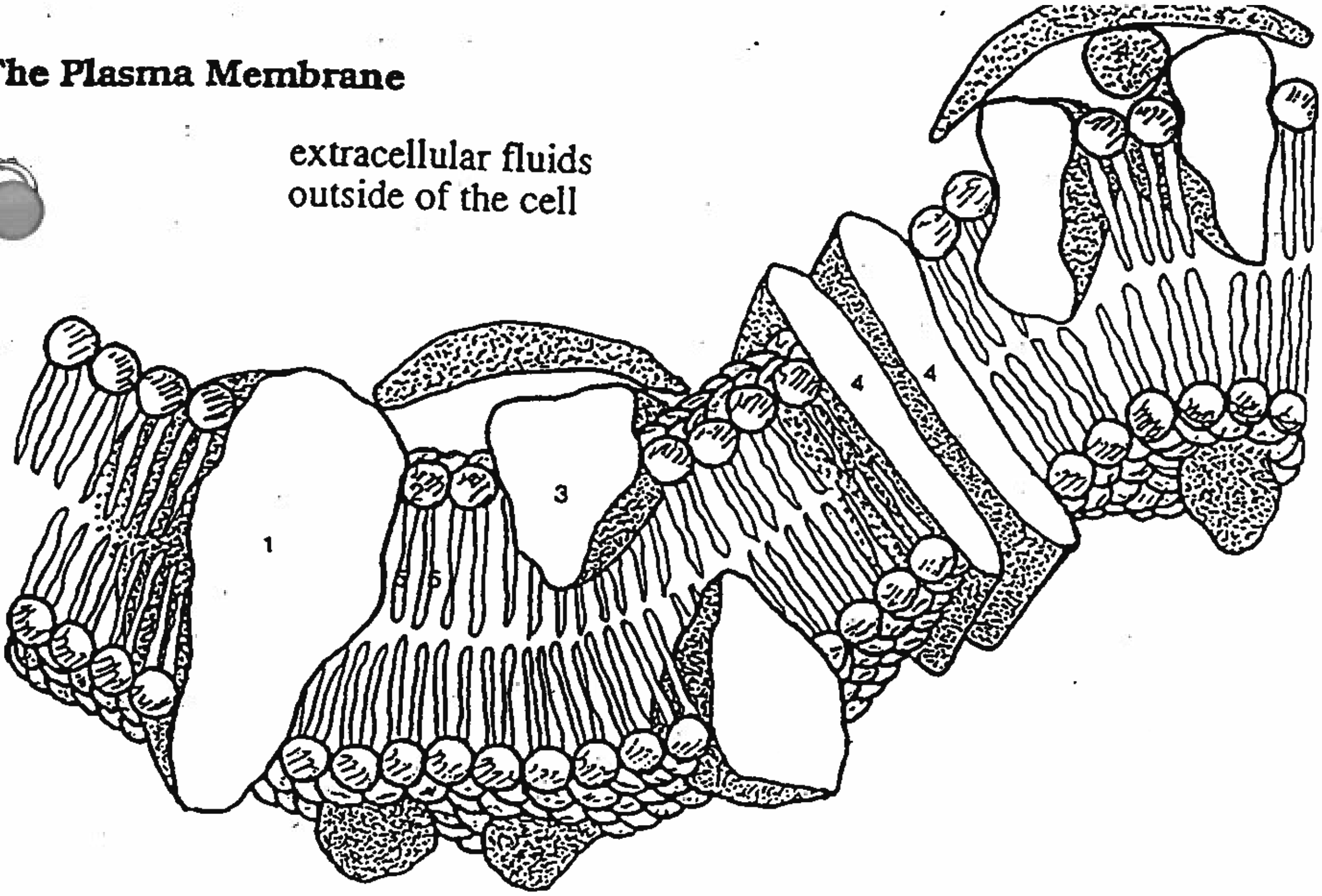
SCIENCE 10



Transport Of Materials Across a Membrane
Requires chemical energy and heat
Requires only heat energy
Active
Passive
can move from an area of low conc. to an area of high conc.
must move from an area of high conc. to an area of low conc.
materials move with a carrier
membrane engulfs material
membrane expells material
small particles through pores
small particles with carrier proteins
water moves through membrane
active transport
endocytosis
exocytosis
diffusion
facilitative diffusion
osmosis
large chunks move into the cell
water and small ions move into the cell
phagocytosis
pinocytosis
• Carbon dioxide
• oxygen
• glucose
• water ions
• amino acids
• glucose
• ions

The Plasma Membrane

extracellular fluids
outside of the cell



cytoplasm
inside of the cell

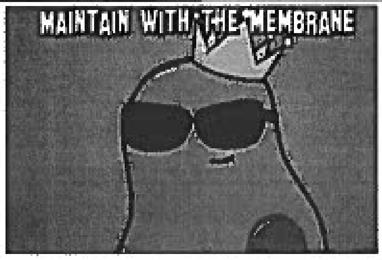
1. integral protein
2. phosphate of the phospholipid
3. peripheral protein
4. proteins of a protein pore
5. fatty acids of the phospholipid

Plasma Membrane Materials

Membrane Material	%	Function
Protein	55%	structure & transport
Phospholipid	25%	water barrier
Cholesterol	13%	strengthens
Other stuff	4%	variety of function
Glycoproteins (sugar-coated proteins)	3%	cellular recognition and communication

Amoeba Sisters Video Recap: *Cell Transport*

The cell membrane is important for maintaining **homeostasis**, because it controls what enters and leaves a cell.



1. Sketch the **phospholipid bilayer** of a cell membrane below and label the **polar heads** and **nonpolar tails**.

2. What is **simple diffusion**?

____

____

____

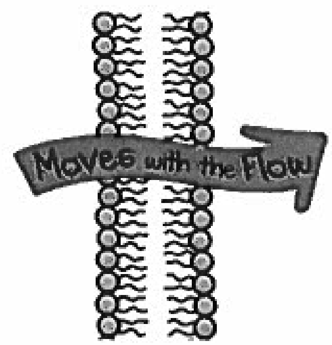
____

3. Circle the statements below that would be TRUE about **simple diffusion**. HINT: There is more than one!

A) It is a form of passive transport.
B) Molecules travel with the concentration gradient.
C) It is how glucose travels across the cell membrane.
D) It is how oxygen and carbon dioxide travel across the membrane.
E) This transport is typical for large molecules.

Moving with the Concentration Gradient

4. "Moving with the flow" (i.e. going with the concentration gradient) is the direction of flow in passive transport. Show this in the diagram on right by **drawing in 10 total circles (to represent molecules)**. You must decide a certain amount to place on the left vs. the right side after viewing the arrow indicating the direction of movement. **Label the high concentration side and low concentration side.**



Endocytosis and Exocytosis

5. Are **endocytosis** and **exocytosis** forms of passive or active transport? ______________________________

6. Give a scenario where a cell may need to perform a form of **endocytosis**. ______________________________

____

____

7. Give a scenario where a cell may need to perform a form of **exocytosis**. ______________________________

____

____

Traveling Molecules

For the following scenarios, determine whether the molecules in the scenario are moving by (S) simple diffusion, (F) facilitated diffusion, or (A) active transport.

8. _____ For water to travel across the cell membrane at a substantial rate, the water molecules travel through protein channels known as **aquaporins**.

9. _____ While water molecules are polar, they are also very small. One fact not mentioned in the video is that some water molecules are able to squeeze directly through the phospholipid bilayer due to their small size.

10. _____ Charged ions are traveling through a cell membrane with the concentration gradient.

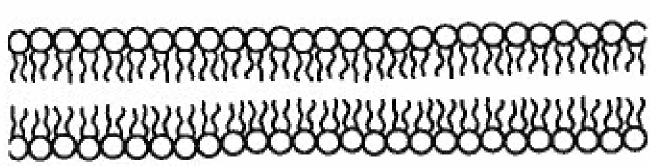
11. _____Cells lining the gut need to take in glucose, but at a certain time, the concentration of extracellular glucose is lower than the concentration already stored in the cells.

12. _____At a certain time, glucose is in a high concentration outside of a cell and needs to travel through the membrane into the cell.

Facilitated Diffusion via a Protein Channel

For the below image, label the **13. polar area** and **14. non-polar area** on the diagram.

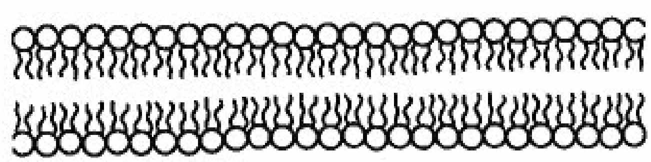
Draw in **15. protein channel** and **16. molecules that would represent a potential concentration gradient in facilitated diffusion** via a protein channel on the diagram.



Active Transport via a Protein Channel

For the below image, label the **17. polar area**, and **18. non-polar area**.

Draw in **19. protein channel** and **20. molecules that would represent a potential concentration gradient in active transport** via a protein channel on the diagram.



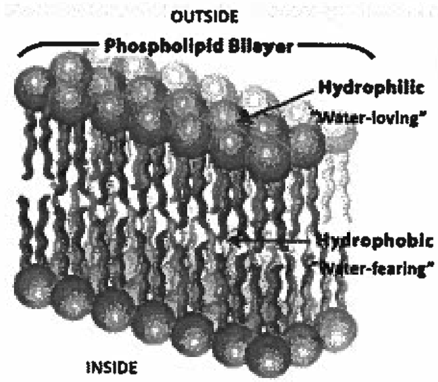
CELLS: Cell Membrane and Passive Tranpsort | **Date:**______________

Study Questions:

What are the main functions of the cell membrane?

Structure

- Lipid Bilayer- A ____________________________ shet of _________________________ that makes up the cell membrane.
- Fluid Mosaic Model- the cell membrane is made of ___________________________ __________ that freely move.
- Selectively Permeable- ____________ substances can ___________ through the cell membrane
    - But ___________________________
    - Permea- means "________________" or "___________________________"



What are the three types of passivve transport?

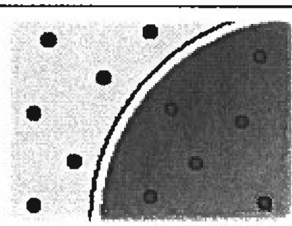
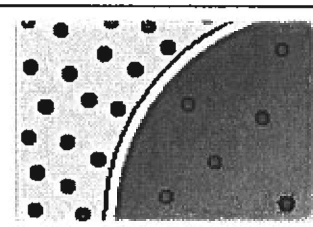
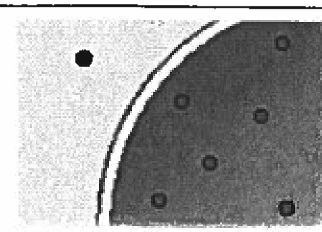
Passive Transport

- movement of substances into/out of cell ______________ using __________________.
- ___________--> _____________ Concentration
- 3 types: _________________________________, ________________________________, and _____________________________

1. *Simple Diffusion*- Molecules move from ______________________________________ (concentration gradient)
    - Until balanced or equal- "______________________________"
2. *Facilitated Diffusion*- Some molcules can't diffuse through the membrane and ______ _____________________________________ to move through
    - Example: ___________, glucose
3. *Osmosis*- Diffusion of water through special channels called ____________________.
    - Moves from ______________________________ concentration.

What are the two parts of a solution?

HOW OSMOSIS WORKS:

Isotonic "____________________"	Hypertonic "____________________"	Hypotonic "____________________"
		
_____________ amounts of solute in/out of cell.	_____________ solute out of cell	____________ solute outside

Cell Transport: Passive Transport
How do cells transport molecules across a membrane without using energy?

Dastardly Diffusion, Freaky Facilitated Diffusion, and Osmosis-pocus

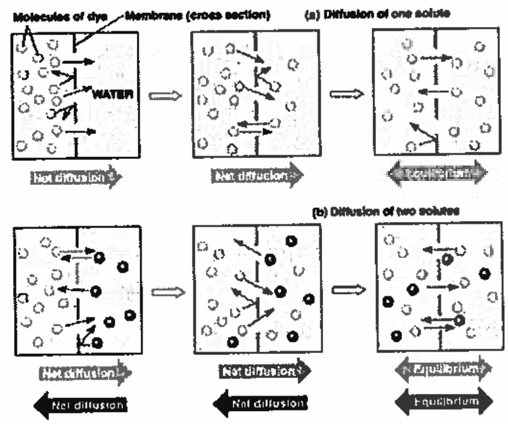
All cells—both eukaryotic and prokaryotic cells—have plasma membranes around them. They serve to separate the contents of the inside of the cell from the extracellular fluid, and are also selectively permeable, picking and choosing what molecules, ions, and other substances can enter or leave the cell. Now that you are familiar with basic plasma membrane structure, we can finally get to the fun and exciting stuff about the plasma membrane—transport across it! There are two main types of transport across a cell's plasma membrane: passive transport and active transport.

Passive transport is a type of molecule transport across plasma membranes whereby molecules move from an area of high concentration (where there's lots of those molecules) to an area of low concentration (where there's not a lot of those molecules). Basically, passive transport is because molecules naturally tend to move from where there is a lot of them to where there's not a lot of them, we say that molecules moving from high to low concentrations are moving **down their concentration gradients** (a concentration gradient is simply a difference in the amount of a substance in two different locations; as far as transport across membranes goes, we're talking about having different amounts of molecules on the different sides of the plasma membrane), or moving "downhill." Also because of the natural tendency of molecules to move down their concentration gradients, it doesn't require any energy expenditure on the part of the cell in the form of ATP.

If there is a high concentration of a molecule outside of the cell and a low concentration inside the cell, that molecule will automatically enter the cell (as long as the membrane is permeable to it in the first place). The opposite is also true--if the membrane is permeable to the substance, if there is a lot of a molecule on the inside of a cell and not a lot on the outside of a cell, that molecule will naturally leave the cell. Passive transport allows cells to obtain needed molecules for chemical reactions inside the cell, and also allows substances such as waste products or other products made by the cell to leave without using any chemical energy in the form of ATP.

There are three specific examples of passive transport—diffusion, facilitated diffusion, and osmosis.

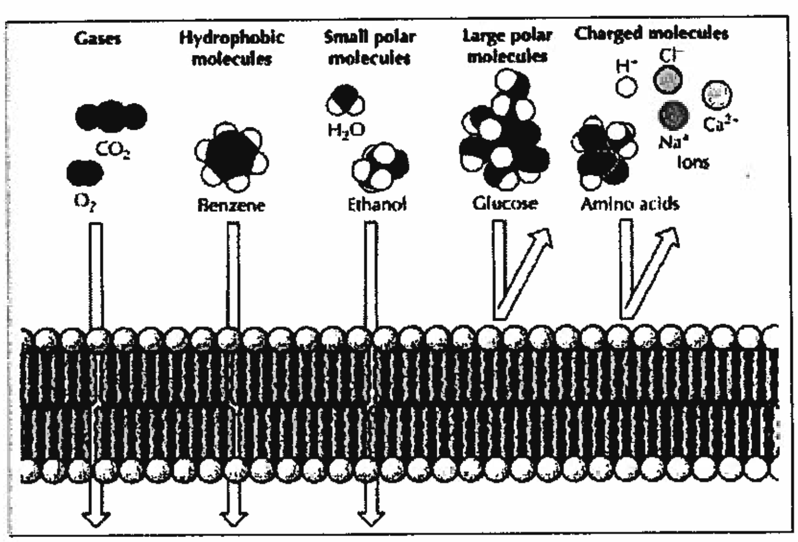
Diffusion is the movement of a substance, usually carbon dioxide gas, oxygen gas, or some other small molecule, across a membrane from high concentration to low concentration (down the substance's concentration gradient). When molecules are moving down their concentration gradients, they do not care about how much of any other substance is on either side of the membrane—molecules only care about their OWN concentrations, not the concentrations of any other substance. For example, look carefully at the diagram below:



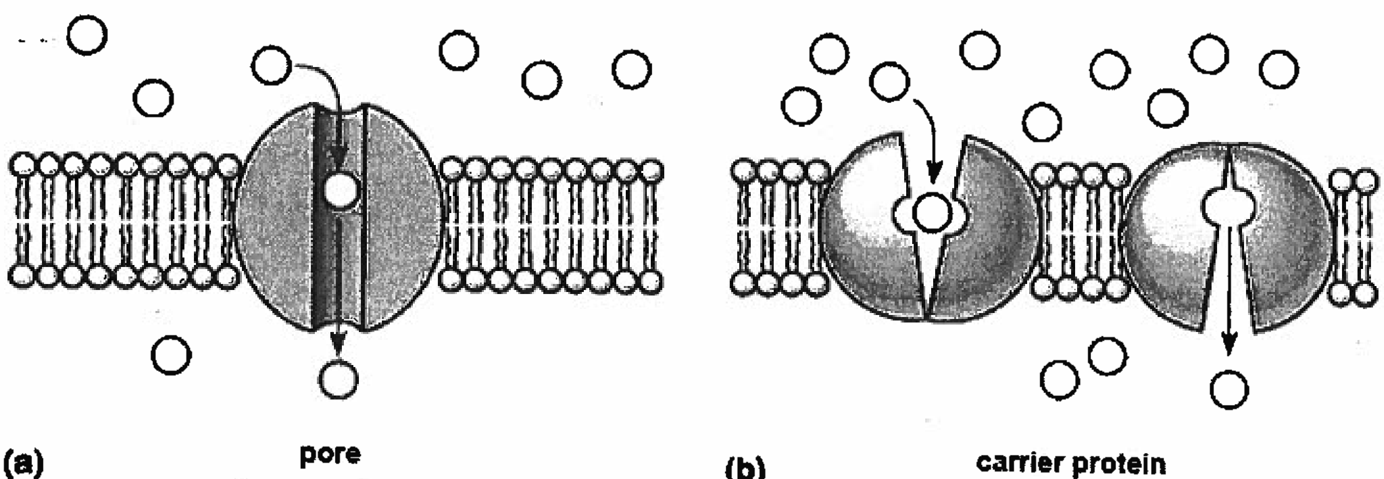
You should notice two important points from the diagram above. First, notice that molecules will diffuse until they reach a **dynamic equilibrium**—while molecules will still be moving across the membrane (the "dynamic" part of this process), an equal amount will move back and forth to maintain the same net amount on both sides of the membrane (the "equilibrium" part of this process). So, after you allow a molecule to diffuse across the membrane, eventually you will have equal amounts of the substance on either side of the membrane, but MOLECULES WILL STILL BE MOVING BACK AND FORTH. This is because molecules are always on the move—they never stay still. So, if one molecule moves to the left across the membrane, one will move to the right across the membrane. This will result in no net increase or decrease in the number of molecules on each side of the membrane, maintaining equilibrium.

Second, notice what occurs in the bottom diagram as far as the diffusion of two substances. The two substances diffuse down their OWN concentration gradients—they do not care about the concentration of each other in the solution.

The picture below shows what types of substances can directly cross the phospholipid bilayer through diffusion. As you can see from the picture above, if a molecule is small (even if it is polar, such as water), it can slip past the hydrophilic heads and hydrophobic tails of the phospholipids and enter or leave the cell. Since the plasma membrane is a fluid, these substances are literally dissolved in the membrane as the pass through it, and the membrane is always permeable to these substances.



Small ions cannot cross the hydrophobic interior of the membrane directly because of their charge. And large polar molecules cannot cross the hydrophobic interior because of their charge AND because they cannot fit in between the phospholipids. However, we know that all of these molecules can diffuse (move from high concentration to low concentration) across the membrane—but how do they do it? The process of **facilitated diffusion.** In facilitated diffusion, molecules are transported across a plasma membrane from high to low concentrations (down their concentration gradients), but this time, they must move through a transport protein of some kind—either a carrier protein or a channel protein. For example, one way for the small ions to cross the phospholipid bilayer is through a membrane protein; specifically, through a **channel protein** (also called a **ion channel**). Some ion channels are very specific as to what ion they will transport (as is the case for sodium (Na+) ions and potassium (K+) ions). Other ion channels aren't as specific. See diagram (a) in the picture below for a visual example:

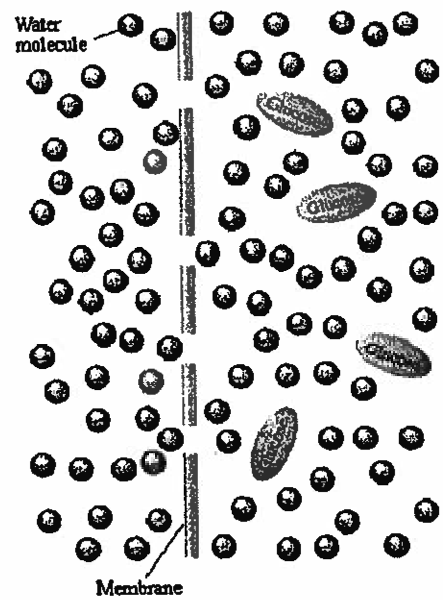


But what about smaller, polar (hydrophilic) substances that aren't ions, such as glucose (needed for cell respiration to make ATP) and amino acids (which are needed to make proteins)? How can they cross the membrane? These molecules are transported across the membrane via a specific carrier protein that will ONLY transport that molecule. In diagram (b) above, a molecule is being diffused across the membrane from high to low via a carrier protein that will only transport that specific molecule. The circular binding site in the purple carrier protein will ONLY fit the yellow circular molecule being transported—that's what makes these proteins so specific. Only the molecules that can bond with, or "fit," into that site, can be transported by the carrier protein.

Thus, in facilitated diffusion, polar or charged molecules cross the membrane via a transport protein—either a carrier protein, or a channel protein. Just like in diffusion, molecules in facilitated diffusion are transported down their own concentration gradients, and no energy is used.

Osmosis is also very similar to diffusion—it is the movement of molecules from high concentration to low concentration, but, in osmosis, we are specifically referring to WATER MOLECULES ONLY. Really, osmosis is a special case of diffusion involving only water molecules. In cells, the movement of water is very important—it will determine if the cell will have enough water to function correctly, have too little water, or have too much (and, in animal cells, too much will cause our cells—which have no cell walls--to burst!).

Determining where the high concentration of water is and where the low concentration of water is can be a little tricky. You see, the fluid inside cells and the fluids in which they are bathed are known as aqueous solutions; that is, solutions where the solvent is water, with many different solutes dissolved in it. To determine the amount of water inside a cell (on one side of a plasma membrane) and the amount of water outside the cell (on the other side of the membrane), you must first look at the concentration of solute. From there, you can infer the amount of water, and then determine which way water will move—either inside the cell, or out of the cell.



From the diagram it looks like there is a LOT of water on both sides of the membrane (and, in cells, that is usually the case). In determining which way water will move across a cell's membrane, you must not look at the amount of water on either side of the membrane—<u>you must look at the amount of solute on each side</u>. In the diagram, notice there is glucose on the right side of the membrane, but none on the left side. Because there is more glucose on the right side, that automatically means there is less "room" for water molecules to be there (because the glucose molecules are taking up space that could be occupied by water molecules). Thus, there is actually LESS water on the right side of the membrane. This means that water will diffuse from the left side to the right side of the membrane.

There are names for the types of solutions on either side of the membrane above. The solution on the RIGHT SIDE of the membrane (the one with more solute than solvent) is called a **hypertonic solution**. The solution on the LEFT SIDE of the membrane (that contains more water than solvent) is called a **hypotonic solution**. If the two solutions had equal amounts of solute and solvent, we call the solutions **isotonic** to each other. (All these "tonics" are comparative terms—they can only be used when comparing TWO different solutions to each other.) If you have a hypotonic solution on one side of a plasma membrane, and you have a hypertonic solution on the other side of the membrane, <u>water will always move from a hypotonic solution (where there's a HIGHER CONCENTRATION of water) to a hypertonic solution (where there's a LOWER CONCENTRATION of water)</u>. Thus, water still moves from high to low; however, in order to determine where the high and low concentrations are, you must first determine which solution has more or less solute in it.
In case you're still confused about all these words ending in "tonic" and/or osmosis itself, view the animation at the website below. Go ahead and answer the questions below the animation when the animation is finished playing. http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation__how_osmosis_works.html

Cell Transport: Passive Transport

How do cells transport molecules across a membrane without using energy?

- ✓ I can describe the cell as a functioning open system and describe the role of the cell membrane in maintaining equilibrium while exchanging matter and energy
- ✓ I can compare passive transport (diffusion and osmosis) with active transport
- ✓ I can explain cellular transportation in terms of the particle model of matter, concentration gradients, equilibrium and protein carrier molecules
- ✓ I can use a model to explain and visualize complex processes like diffusion and osmosis, endo- and exocytosis, and the role of cell membrane in these processes

After reading the material provided and watching the animations summarize your understanding of Passive Transport by completing the following questions.

1. What is Passive Transport?

2. Read the definition of passive transport below. Then, explain two things that are wrong with it below the definition.

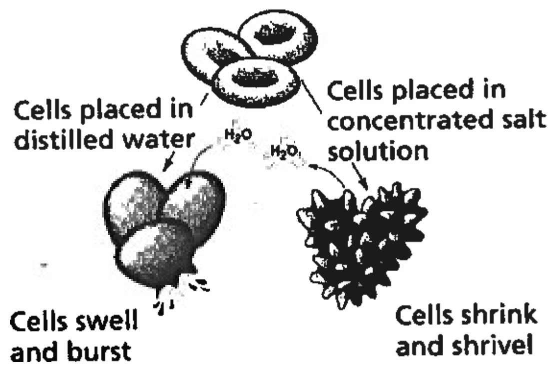
Passive transport is the movement of molecules from low concentration to high concentration across a plasma membrane. It does not require the use of chemical energy in the form of ATP, and if there is more of a molecule on the outside of the membrane and less on the inside of the membrane, the molecule will always move into the cell.

3. Why do cells need passive transport to occur?

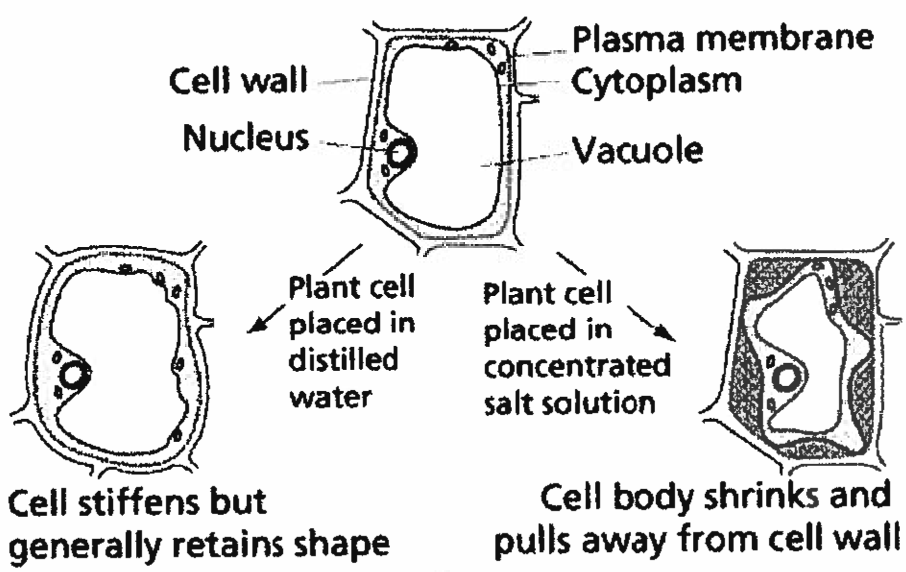
4. In the chart below, describe what EACH of the types of passive transport are

	Explain
Diffusion	
Facilitated diffusion	
Osmosis	

5. Look at the diagram below then using the following words (*hypotonic solution, hypertonic solution, solute, solvent, water, salt, distilled water, osmosis, concentration gradient*) EXPLAIN why:
   a. The red blood cell placed in distilled water BURST (or lysed).
   b. The red blood cell placed in a concentrated salt solution shrank and shriveled.



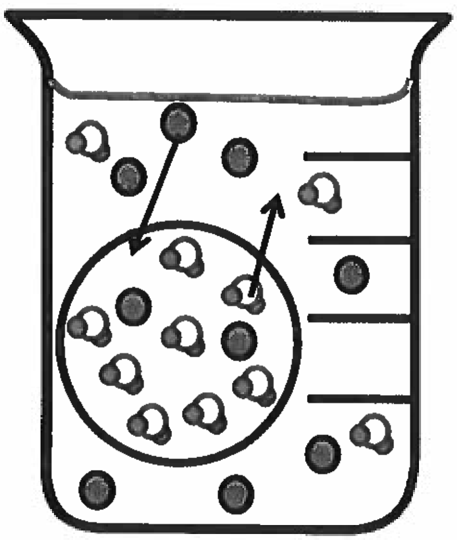
6. Look at the diagram below then using the following words (*hypotonic solution, hypertonic solution, solute, solvent, water, salt, distilled water, osmosis, concentration gradient*) EXPLAIN why:
   a. The plant cell placed in the distilled water becomes swollen, but does not burst.
   b. The plant cell placed in a concentrated salt solution shrinks, and the plasma membrane pulls away from the cell wall.



Name:______________________________________Pd:________Date:____________

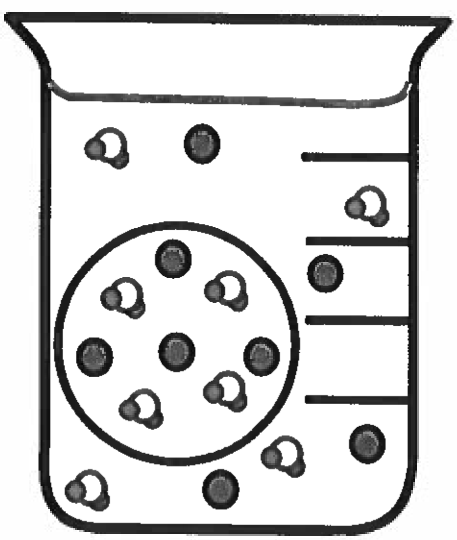
Diffusion and Osmosis Beaker Worksheet

The images that follow show cells of different concentrations placed in beakers of different concentrations. Using a pencil DRAW an ARROW to indicate the direction that the solution will flow AND DRAW an ARROW with a "W" to indicate the direction that the water will flow. Answer the questions that follow. Below are two examples.



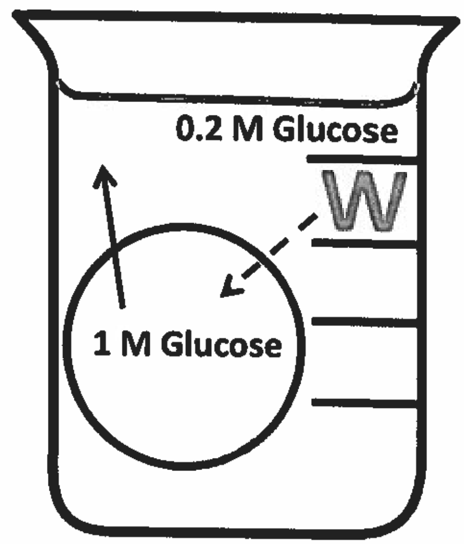
The solution of the beaker is:

____



The solution of the beaker is:

____



The solution of the beaker is:

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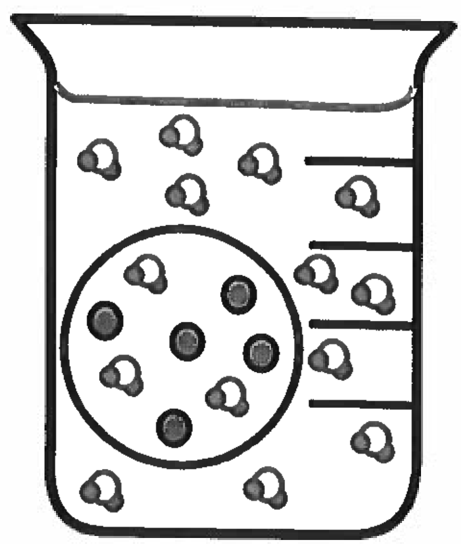

The solution of the beaker is:

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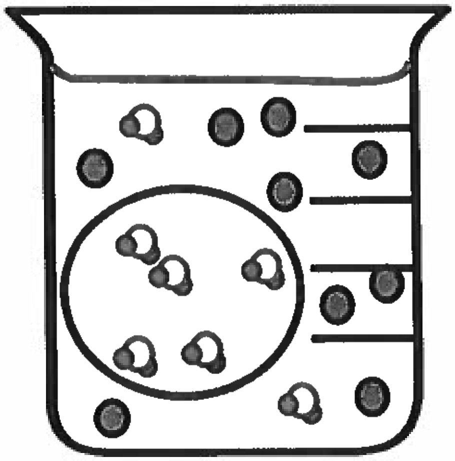

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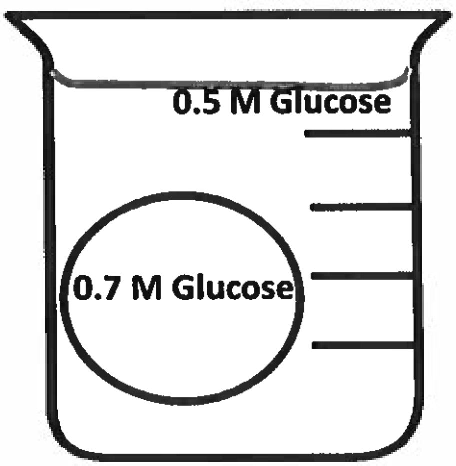

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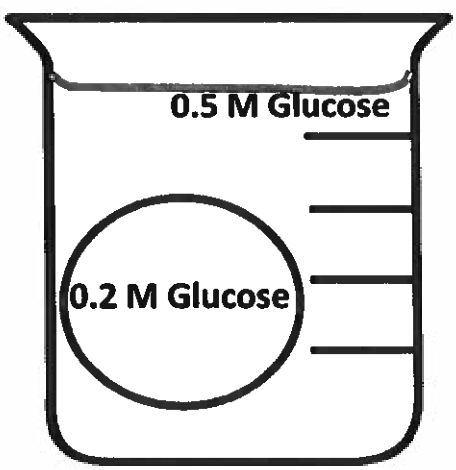
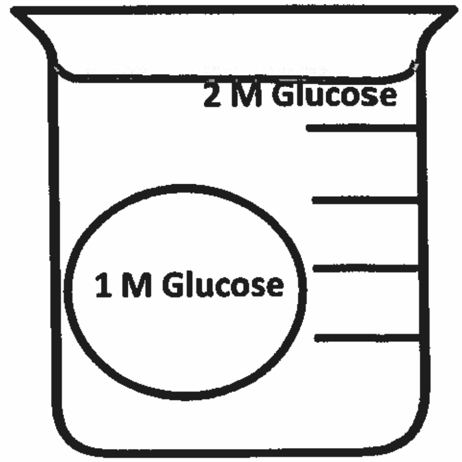
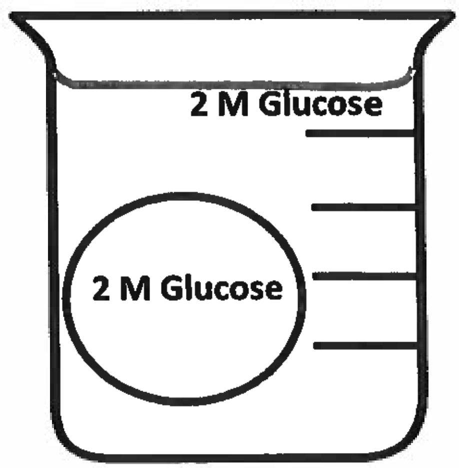


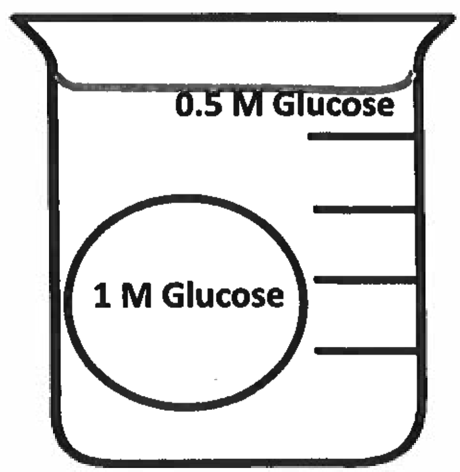
The solution of the *cell* is:



The solution of the beaker is:



The solution of the beaker is:



The solution of the *cell* is:

Osmosis and Tonicity

Define osmosis. ______________________________________

In which direction does water move across membranes, up or down the concentration gradient? ________________

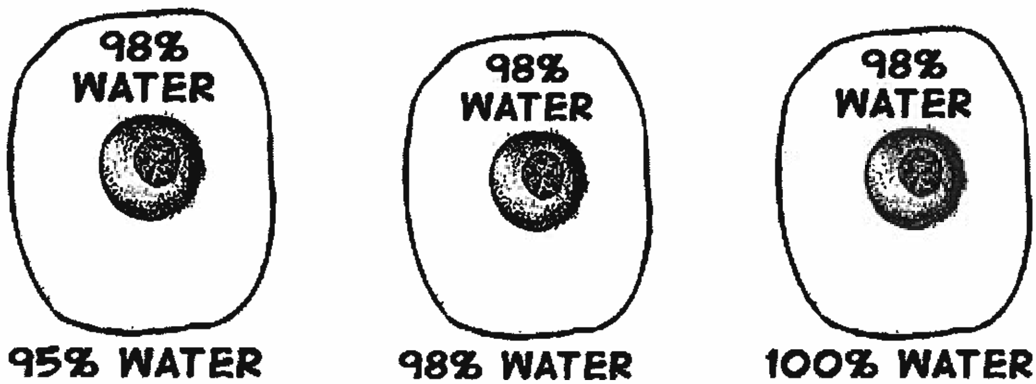
Define these 3 terms:

a. isotonic- ______________________________________

b. hypertonic ______________________________________

c. hypotonic ______________________________________

Use arrows to show the direction of water movement into or out of each cell. ***Color and label*** the cell in an isotonic environment light blue, the hypotonic environment yellow, and the hypertonic environment light green.



Match the description or picture with the osmotic condition:

A. Isotonic

B. Hypertonic

C. Hypotonic

_____ solution with a lower solute concentration

_____ solution in which the solute concentration is the same

_____ condition plant cells require

_____ condition that animal cells require

_____ red blood cell bursts (cytolysis)

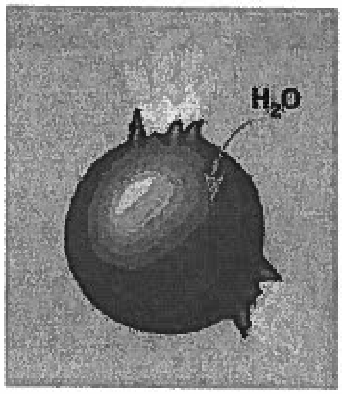
_____ plant cell loses turgor pressure (Plasmolysis)

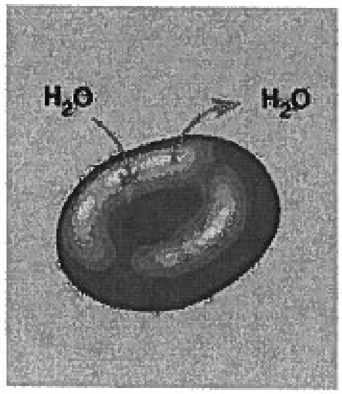
_____ solution with a higher solute concentration

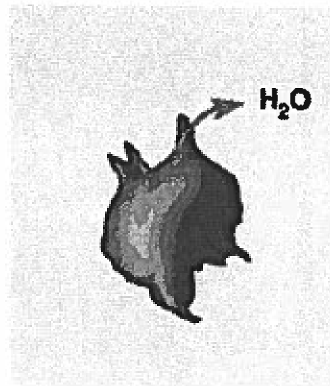
_____ plant cell with good turgor pressure

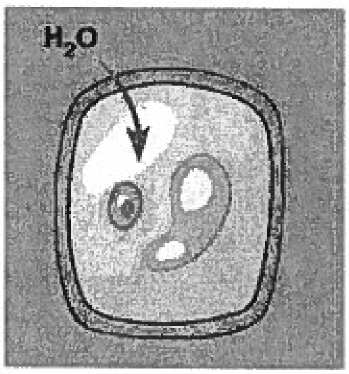
_____ solution with a high water concentration

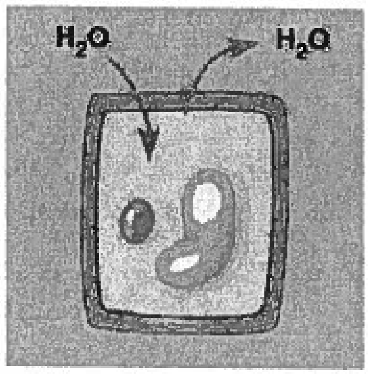
Label the tonicity for each solution (isotonic, hypotonic, or hypertonic):

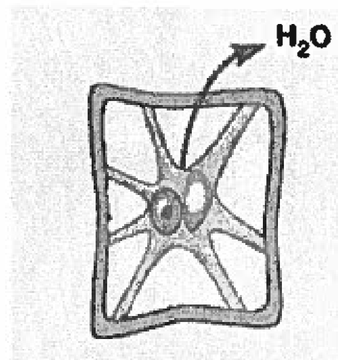












CELLS: Active Transport and Homeostasis Date:__________

Study Questions:

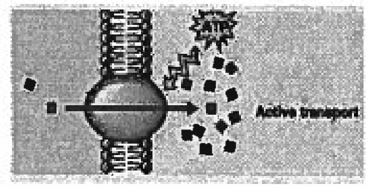
What is the difference between passive and active transport?

How does a cell maintain homeostasis both within itself and as part of a multicellular organism?

Active Transport

- Molecules move across the membrane ______________ their ______________ ______________.
  - (__________________)
  - ______________ is required

  2 Types:
  1. ______________________
  2. ______________________



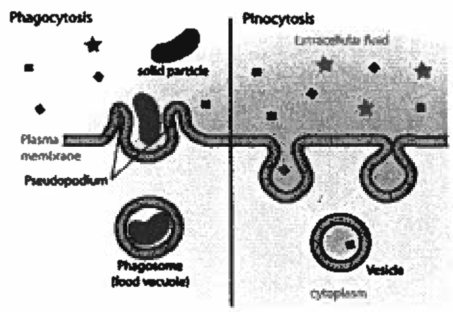
Protein Pumps

- Transport small molecules and ions AGAINST their concentration gradients (______________) using ____________________.

Bulk Transport

- Larger Molecules (proteins, starch) are transports by ______________.
  - ______________________- vesicles move substances _____.
  - ______________________- vesicles move substances _____.

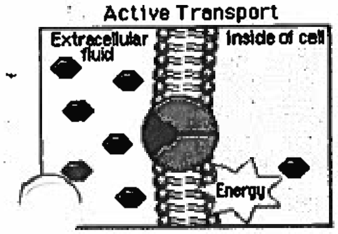
  Phagocytosis "________________" and Pinocytosis "________________"
  - These are special types of ______________________.



Homeostasis

- The process by which an ______________________ is kept in ______________, or stable, in spite of changes in the external environment.

  Examples:
  - Internal Temperature (______________________________)
  - ______________________ (kidneys adjust water amount in urine)
  - A physical response to ________ (breathing & heart rate increases, pupils dialate, sweating)
  - **Homeo** = like or similar **Stasis** = balance or equilibrium



Cell Transport: Active Transport

How do cells transport molecules across a membrane using energy?

Osmosis, Freshwater Fish, & Kidneys: It's All About Active Transport!

Cells take advantage of passive transport at every opportunity to move molecules back and forth across membranes, because passive transport doesn't cost cells any energy; in other words, cells take advantage of the fact that molecules will naturally move from high concentrations to low concentrations so they can move needed nutrients into cells and waste products out of cells. However, sometimes cells want to move molecules from where they are less crowded to where they are more crowded, usually because they want to build up higher concentrations of molecules on one side of the membrane than on the other. Unfortunately, because molecules do not want to naturally move from where there is less of them to where there are more of them, it will take energy on the part of the cell to move these molecules to where they really don't want to go. This transport of molecules from low concentrations to high concentrations using energy (in the form of the molecule ATP) is called **active transport**.

So, why would cells want to use a process that SPENDS energy to move molecules across their plasma membranes, when they can already use the energy-free passive transport? Before that question can be answered, we must first examine what active transport is in a little more detail. Active transport, as stated before, moves molecules from low concentration to high concentration using energy in the form of ATP. This means that the cell is expending energy to make a concentration gradient (a difference in the amount of a molecule on either side of the membrane), because it doesn't want the molecules to move down their concentration gradients on their own. Why not? Because a concentration gradient represents stored potential energy (PE). (*Recall that potential energy is the energy an object—or molecule, ion, or atom—has due to its position or location. When more of a molecule is located on one side of the membrane than the other, those molecules have a LOT of potential energy. This is because they have a HIGH POTENTIAL to move across the membrane, because molecules naturally want to move from high concentrations to low concentrations.*) Cells will expend ATP energy to create a concentration gradient just to store this potential energy—it will use this energy later to do any work it needs to do. For example, the picture on the next page shows energy being used by a carrier protein in order to build a concentration of red solute molecules outside the cell.

The cell will keep expending energy to make sure there is more of the red solute on the outside of the cell than on the inside of the cell, because the buildup of red solute on the outside of the cell is storing energy. The more of the red solute that is concentrated outside of the cell, the more potential energy there is. Eventually, a cell will use this stored energy by allowing those solute molecules to flow back into the cell through passive transport. When the solute molecules move, their potential energy is converted into kinetic energy, which helps do a cell's work, or jobs. For example, neurons in your nervous system first build up concentrations of sodium and potassium on either side of the neuron's membrane. Then, when a nerve impulse is being transmitted from neuron to neuron, it lets the built-up concentrations of those ions move down their concentration gradients, doing the "work" of transmitting the nerve impulse. Your neurons store potential energy in the gradients of sodium and potassium first, and then use the kinetic energy of the molecules' motion across the membrane to help transmit the nerve signal. All cells, however, work to maintain concentration gradients of different solutes most of the time, so they can convert the potential energy of the solutes' concentration gradients to kinetic energy. This maintaining of, or working to keep, a concentration gradient (different amounts of a solute on either side of a plasma membrane) of specific substances is an example of one way that cells maintain **homeostasis**. Homeostasis describes when your body (or cell) tries to keep something steady, or the same, all of the time. In active transport, your cells try to keep a concentration gradient of certain molecules or ions most of the time, so they can use the energy of that gradient when they need it.

While active transport can maintain homeostasis through creating and keeping a concentration gradient across a membrane, at other times it creates a concentration gradient to maintain a certain amount of water on either side of the plasma membrane. As you know from your journey into passive transport, osmosis is the movement of water from high concentration to low concentration. In animal cells, maintaining equal amounts of water on either side of the membrane is very important, because animal cells have the potential to burst if they take up too much water. Both plant and animal cells risk not being able to function properly if they take up too little water. So, to help maintain the right amount of water on either side of a plasma membrane (the fancy way to say this is, "maintaining the cell's osmotic balance,"), cells will use active transport. For example, your kidney cells use active transport in this way in order to regulate the amount of water in your bloodstream, and, in essence, your body. If your kidneys receive signals that your blood contains too little water, it will actively transport solutes in the form of sodium ions (Na+) out of the kidney cells and into the blood flowing through the kidney. When it does this, the increased solute concentration makes the blood hypertonic to the kidney cells, which causes water to flow out of the kidney cells and into your blood. Other organisms besides humans also use active transport to maintain their osmotic balance. Freshwater fish, for example, are immersed in a hypotonic environment, so are in constant danger of taking up too much water via osmosis. To prevent this, these fish (among other things) actively transport salt out of their gills. Transporting the salts out of their gills makes the water surrounding them more hypertonic than hypotonic, and prevents them from taking up too much water.

While there are many specific types of active transport, there are, in general, three main examples with which you should be familiar—the **sodium-potassium pump**, **endocytosis**, and **exocytosis**. Since they are all types of active transport, they all use energy to move molecules from low concentrations to high concentrations. However, what they move and the size of molecules being transported differs between these three examples.

Go to the website to watch animations on the three common types of Active Transport; Sodium/Potassium Pump , Active Transport, Endocytosis/Exocytosis
http://glencoe.mcgraw-hill.com/sites/0078802849/student_view0/unit2/chapter7/concepts_in_motion.html#

While you are watching, look for what is happening in each example, what is being transported for each example, as well as the sizes of the molecules being transported.

Cell Transport: Active Transport

How do cells transport molecules across a membrane using energy?

- ✓ I can describe the cell as a functioning open system and describe the role of the cell membrane in maintaining equilibrium while exchanging matter and energy
- ✓ I can compare passive transport (diffusion and osmosis) with active transport
- ✓ I can explain cellular transportation in terms of the particle model of matter, concentration gradients, equilibrium and protein carrier molecules
- ✓ I can use a model to explain and visualize complex processes like diffusion and osmosis, endo- and exocytosis, and the role of cell membrane in these processes

After reading the material provided and watching the animations summarize your understanding of Active Transport by completing the following questions.

1. What is active transport?
2. Why do cells do active transport? (give at least two reasons)
3. Fill out the chart below after watching the animations listed above:

	Sodium-potassium pump	**Endocytosis**	**Exocytosis**
What is it? (Describe the steps of what happens)			
Size of molecules transported: (large/small)			

4. Write down at least one difference between each pair of words :

Endocytosis	Exocytosis
Exocytosis	Sodium-potassium pump

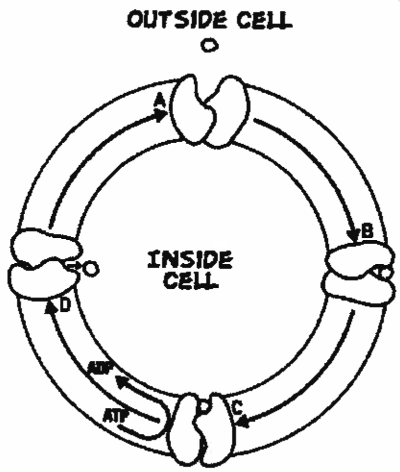
Transport Requiring Energy

What type of transport is represented by the following picture? ______________________

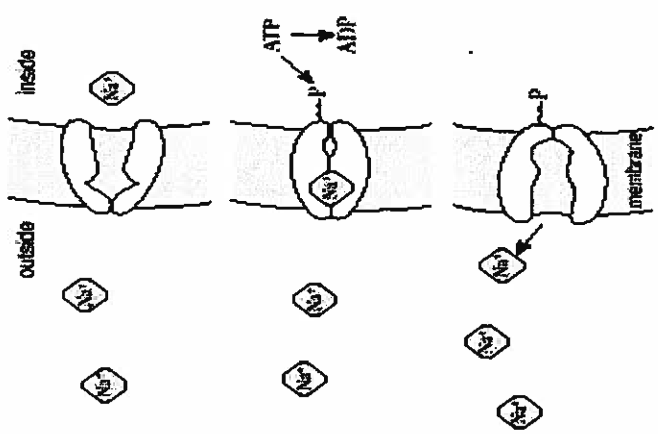
What energy is being used? _____________

In which direction (concentration gradient), is the movement occurring? __________________

Color the internal environment of the cell yellow. ***Color and Label*** the transport proteins red and the substance being moved blue.

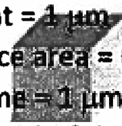


One type of active transport is called the _______________ pump which helps muscle cells contract. This pump uses ___________ to move ions __________ the concentration gradient. The protein that is used to pump the ions through is called a ____________ protein and it changes its __________ to move the ions across the cell membrane. ***Label and color*** the carrier proteins red and the ions green.

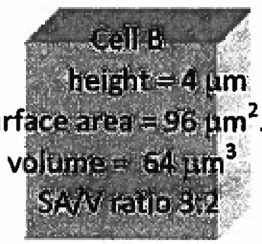


Multicellular organisms are made of millions of tiny cells, all organized into tissues, organs, and organ systems, which then make up you, the organism. But why are you made of so many little cells? Wouldn't it just be easier if your entire body was made out of just one really big cell?

Consider two cells that, for simplicity, are cube-shaped. Since cells are so small, we measure them in very small units—called micrometers (µm; 1 µm = 1/1,000,000 of 1 meter). The first cube-shaped cell has a height of 1 µm, and the second cube-shaped cell has a height of 4 µm.



Cell A
height = 1 µm
surface area = 6 μm^2
volume = 1 μm^3
SA:V ratio 6:1



Cell B
height = 4 µm
surface area = 96 μm^2.
volume = 64 μm^3
SA/V ratio 3:2

While both of the cells above are really small, Cell A is actually more efficient at functioning as a cell than Cell B. This is because of the relationship between two concepts surrounding cell size—a cell's **surface area** and its **volume**.

The surface area of a cell is, simply put, the total area of all a cell's surfaces. The more surface a cell has, the more openings it has in that surface to allow nutrients in and wastes out.

A cell's total volume is how much can fit inside it, just like the total volume of a beaker is how much liquid you can pour inside of it. The larger the volume the more cytoplasm you can fit in a cell.

A cell's **surface area to volume ratio** compares how many surface openings a cell has compared to how much cytoplasm is inside the cell. A cell's **surface area-to-volume** ratio needs to be large (have a lot more surface area than volume) in order for it to diffuse substances in and out efficiently. Having a large amount of surface area means cells have more openings for nutrients and wastes to enter and leave. And, by not having large volume (amounts of cytoplasm), those nutrients and wastes don't have a long distance to travel after they enter or are trying to leave the cell.

Cells need to stay small in order to have a large surface area-to-volume ratio. Once cells reach a certain surface area-to-volume ratio, will divide so they can stay small, and have the proper surface area-to-volume ratio to allow for adequate diffusion of molecules into and out of the cell.

To calculate surface area: (l x w of one side) (total # of sides) units²

To calculate ~~area~~ volume: (l x w x h) units³

**Don't forget about units. . you must multiply them just like you would an "x" in algebra!

A ratio is simply another way to write a fraction; it has two numbers with a colon (:) in-between them. The purpose of a ratio is to compare two numbers. Since it is a fraction, it needs to be reduced just like a "normal" fraction. To calculate the surface area-to-volume ratio, put the surface area # you calculated first, then write a colon next to it. Next, write the volume # you calculated after the colon. Finally, reduce the ratio.

Example: Surface area = 6; Volume = 2 → 6:2 → 3:1

1. What is surface area?
2. What is volume?

Why Cells Are Small?

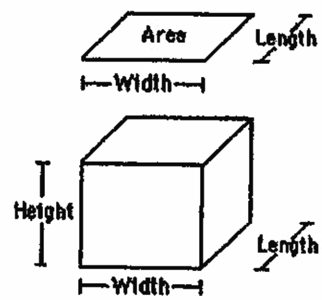
✓ I can describe cell size and shape as they relate to the function of the cell

estigating Surface Area to Volume Ratios

All organisms are composed of cells. The size and shape of a cell determines how well it can deliver nutrients to its interior. Since all cells and organisms depend upon the efficient delivery of gases, nutrients, and other important molecules, the relationship between a cell's surface area and its volume is an important regulating concept. Cells are limited in how large they can be. This is because the surface area and volume ratio does not stay the same as their size increases. Because of this, it is harder for a large cell to pass materials in and out of the membrane, and to move materials through the cell. In this lab, you will make cube shaped models to represent cells. The dimension along one side will be doubled with each model. You will then calculate the surface area, volume, and the ratio between the two. The surface area and volume are calculated as shown in the figure below:

Area of side = Length x Width

Area of Cube = Length x Width x 6
Volume of Cube = Length x Width x Height



Surface Area to Volume RATIO, which is: **Ratio = Surface Area / Volume.**

Construct the four cell models. Measure, calculate and record the dimensions in the table.

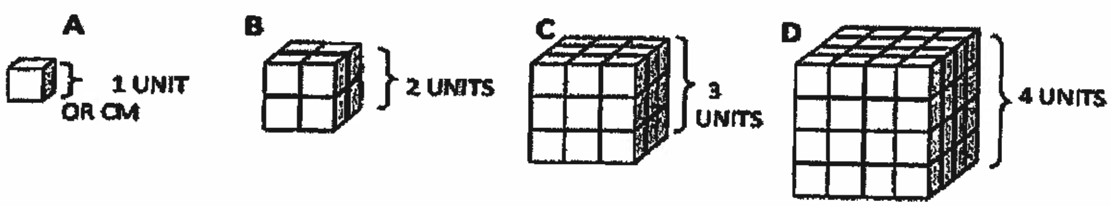


FIGURE	TOTAL # OF CUBES	SURFACE AREA	VOLUME	SURFACE AREA TO VOLUME RATIO
A				
B				
C				
D				

Summary Questions

Which model has the largest surface area? the largest volume? the largest surface area to volume ratio?

What is happening to the surface area to volume ratio as the cell size increases?

To maintain life, and carry-out cellular functions, materials must be able to move into and out of the cell. Also, material needs to be able to move within the cell.

a. What are some materials that would need to move in and out of a cell?

b. What might be the advantage of having a large surface area?

c. Since transport of materials in and out of the cell can only happen at the cell's surface, what problem does this pose for larger cells?

d. If a cell has a high concentration of waste that it wants to get rid of, which do you predict will be able to get rid of the waste sooner – a smaller cell or a large one? Explain your answer, make sure to use the following terms in your answer: *plasma membrane* and *surface area to volume ratio*.

e. Chemical reactions in a cell cause the build up of heat which can have a negative effect on the operation of enzymes in a cell. Would a larger cell or a smaller cell more easily release heat? Explain why.

4. Do larger organisms have larger cells than smaller organisms, or more cells than smaller organisms? Explain.

5. What is the advantage of having folded membrane surrounding the cell (i.e. plasma membrane), or within the cytoplasm (i.e. endoplasmic reticulum) or within organelles (i.e. chloroplast)?

6. Do you think it is better for cells to have a larger surface area to volume ratio or a smaller one? Explain.

7. Why is surface area to volume ratio important to cells? What can cells do about it?

8. Choose the shapes of cells that would have more favourable surface area to volume ratio? Explain your choices.