Student Worksheet

Understanding Movement of Molecules across the Cell Membrane

Introduction:

Despite differences in structure and function, all living cells in multicellular organisms have a surrounding cell membrane. This cell membrane is known as the plasma membrane. Just as the the outer layer of your skin separates your body from the environment, the cell membrane separates the inner contents of a cell from its outer or exterior environment. This cell membrane provides a protective barrier around the cell and regulates which materials can pass in or out. With continuing research, we now know that membrane interactions are very complex and consist of a mix of interactions that are not fully understood. These interactions result in a membrane *nanostructure* that regulates diffusion and mobility of membrane biomolecules.

The human body is a very complex and intricate structure mainly composed of trillions of tiny cells all nano in size organized into many levels of structural organization. Nano means one billionth (10^{-9}) and one meter is equal to a billion nanometers. Most cells in your body are about 5,000 nm across or less, which is about $1/20^{th}$ the width of a strand of hair. Cell membranes are only 10 nm thick!!

The ultimate goal of our body is to maintain a constant state of balance more formerly known as *homeostasis*. Whenever the body goes out of this state of balance, disease can occur.

The task of maintaining homeostasis is carried out by cell transport, moving molecules into and out of a cell. This phenomenon occurs across the outer covering of a cell, the plasma membrane. The membrane is selectively permeable meaning that it only allows select nano-sized molecules to move across. Transport through the plasma membrane occurs in two basic ways: passive and active transport. *Active transport* is carried out with the help of ATP, an intracellular source of energy. *Passive transport* is carried out when the concentration or pressure differences influence movement. A concentration gradient exists when there is a difference in concentration between the inside and outside of the cell. The numbers of molecules present influence the cells concentration on either side. The greater the numbers of molecules, the higher the concentration on that side.

Diffusion, a passive process, is the movement of molecules from an area of higher concentration to an area of lower concentration. *Osmosis*, a special form of diffusion, is the movement of solvent; usually water, down its concentration gradient. When cells move molecules from one side to the other, it can possibly cause the cell to change shape and or/weight. A solution surrounding the cell that contains the same solute/water concentration as the inside of the cell is considered isotonic. There is no water movement because equilibrium already exists. A solution surrounding the cell that contains a higher concentration of solutes than are present inside the cells is considered *hypertonic*. The cell will loose weight or crenate and shrink in an effort to establish equilibrium. A solution surrounding the cell that contains a lower concentration of solutes than are present in cells is considered *hypotonic*. The cell will gain weight and possibly lyse or burst in an effort to establish equilibrium.

Both diffusion and osmosis occurs naturally in many places within the human body. The kidneys, which filter blood, carry out both of these processes on a regular basis. Sometimes, matter limits our body such as in kidney failure. When matter limits the body, it can no longer conduct those functions necessary to maintain life. Imbalance of variable factors such as blood pressure, pulse, respiration rates, and glucose levels, can eventually lead to organ failure if not addressed. If organs fail, the body is no longer be able to maintain life. Nanotechnology is the study of manipulating matter on an atomic and molecular scale. It is used to make incredibly small things the size of organelles or even smaller.

Nanotechnology is the study of manipulating matter on an atomic and molecular scale. It is used to make incredibly small things the size of organelles or even smaller. With the usage of nanotechnology, we are now able to aid in cell transport to help sustain life. The interactions of nanoparticles with cellular membranes and transport processes have major implications for the biology, toxicology, and pharmacology of nanoscale materials. Nanoparticles and nanodevices are able to enter the body and help maintain functioning of tissues and organs that are no longer able to perform on their own. Many different types of nanoparticles are being explored for drug delivery. Several types are already in FDA approved use. Many different types of nanoparticles are being explored for drug delivery. Several types are already in FDA approved use. Nanoparticles can be functionalized to attach to only certain types of cells giving targeted drug delivery. They can also be functionalized to be soluble in body fluid obviating drug insolubility problems. This experiment will demonstrate the movement of molecules into and out of a cell in a manner such as will be used by nanoparticles and nanodevices.

Your teacher may ask you to define these before proceeding to the activity.

Vocabulary and Definitions:

1. *Selectively permeable*
2. *Active transport*
3. *Passive transport*
4. *Diffusion*
5. *Osmosis*
6. *Homeostasis*
7. *Hypertonic*
8. *Hypotonic*
9. *Isotonic*
10. *Nanoscale*
11. *Nanometer*
12. *Nanotechnology*

Make a prediction: What will occur to a deshelled egg (14% concentration) if placed in a 30% sucrose solution? What is the same egg is placed in distilled water? Write your answers in your lab notebook.

Materials:

- 2 deshelled eggs (procedure below)
- 400-ml beaker

- weight boat
- wax markers
- laboratory balance
- 2L distilled water
- 2L 30% sucrose solution
- paper towels
- timer/stop watch

Directions for the Activity:

1. Obtain two deshelled eggs and two 400-mL beakers. **Note**: the relative concentration of solutes in deshelled eggs is about 14%. Number the beakers 1 and 2 with the wax marking pencil. Half fill beaker 1 with distilled water and beaker 2 with 30% sucrose solution.
2. Carefully blot each egg by rolling it **gently** on a paper towel. Place a weight boat on a laboratory balance and tare balance (that is, make sure the scale reads 0.0 with the weigh boat on the scale). Weigh egg 1 in the weigh boat, record the initial weight in the data chart and gently place it into beaker 1. Repeat for egg 2, placing it in beaker 2.
3. After 20 minutes, remove egg 1 and gently blot it and weigh it. Record the weight, and return it into beaker 1. Repeat for egg 2, returning it into beaker 2. Repeat this procedure at 40 minutes and 60 minutes.
4. Calculate the change in weight of each egg at each time period, and enter that number in the data chart below. Also, calculate the percent change in weight for each time period and enter that number in the data table.

Record your Observations: (may put in your lab notebook)

Data from Experiment						
Time	**Egg 1 (in distilled H2O)**	**Weight change**	**%Change**	**Egg 2 (in 30% sucrose)**	**Weight change**	**% Change**
Initial weight (g)		-	-		-	-
20 min.						
40 min.						
60 min.						

Analyze the Results:

1. Did you observe what you predicted? If not, how did your observation differ from your prediction?

2. Do your observations leave you with any more questions? Do they enable you to make predictions? If so, what are they?

Draw Conclusions:

3. Based on your results, do you feel that egg 1 and/or egg 2 displayed properties of hypertonicity, hypotonicity or iostonicity? Explain your answer.

Design Challenge:
Design an experiment to test other molecules that you would like to examine their movement across the cell membrane. What other variables would you test? Would you want to use the same eggs or ones that have not been tested? What type of molecules would you examine? Large versus small? Vitamins, minerals, salts? Design your experiment and have the instructor approve your design before testing. Follow the experimental procedures of above. Write up your results and then share as a short presentation to the class.

Cleanup: Discard eggs in the trash. Wash chemicals down the sink unless instructor indicates other method of disposal.