Functions of Cell Membranes

1. Protect cell, isolates cell interior from exterior
2. Regulate incoming and outgoing substances
3. Maintain ion concentrations
4. Regulates by being selectively permeable - some atoms or molecules can pass through the cell membrane, others cannot.

Structure of Cell Membranes

The Phospholipid Bilayer

Like all other cellular membranes, the plasma membrane consists of both lipids and proteins. The fundamental structure of the membrane is the phospholipid bilayer, which forms a stable barrier between two aqueous environments. In the case of the plasma membrane, these environments are the cytosol inside the cell and the interstitial fluid outside of the cell. Proteins and other molecules embedded within the phospholipid bilayer carry out the specific functions of the plasma membrane, including selective transport of molecules and cell-cell recognition.

Mechanisms of Transport Across Cell Membranes

1. Diffusion – The passive movement of molecules from a region of higher concentration to a region of lower concentration (down a concentration gradient). The differences in concentration imply differences in potential energy. Random motion drives diffusion. Movement is based, in part, on the
conversion of potential energy to kinetic energy (temperature) and on the charge of molecules. Passive transport means no added energy is expended in moving molecules.

2. **Osmosis** – A special case of diffusion, osmosis is the passive transport of water across membranes from a region of higher concentration to a region of lower concentration (down a concentration gradient) where water concentration is inversely related to solute concentration.

3. **Facilitated Diffusion** – As with simple diffusion, polar molecules or ions move down a concentration gradient through imbedded proteins that regulate (facilitate) their movement across a membrane. Membrane proteins act as “gates” to allow or prevent a molecule from moving across a membrane.

4. **Active Transport** – Unlike (passive) diffusion, active transport is an energy-requiring process that transports molecules across a membrane against a concentration gradient from a region of lower concentration to a region of higher concentration using energy provided by ATP.

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**Solutions**

*Solutions* are made of a solute and a solvent

**Solvent** - the liquid into which the solute is poured and dissolved. We will use water as the solvent in this exercise.

**Solute** – a charged substance that is dissolved or put into the solvent. Sucrose (table sugar) is the solute we will use in this exercise.

**Tonicity** is a relative term for comparing solutions

- **Hypotonic Solution** – A hypotonic solution has a lower concentration of solute compared to another solution.
- **Hypertonic Solution** - A hypertonic solution has a higher concentration of solute compared to another solution.
- **Isotonic Solution(s)** - both solutions being compared have the same concentration of solute.
Passive transport is the movement of material by free energy based upon a concentration gradient. Passive transport uses energy taken from the environment and the materials doing the relocation; it does not use ATP energy or enzyme energy from a cell.

The passive transport of water is known as osmosis and the passive transport of anything else is called diffusion. Cells are made of chemicals reacting in water: this explains our interest in learning about osmosis and diffusion!

The membrane of a cell is selectively permeable and allows water to pass in and out. In this experiment, you will observe both osmosis and diffusion.

Dialysis tubing is an artificial material that serves as a selectively permeable membrane and can be used to model the passive transport of a living cell. It is permeable to small molecules such as water, but not to larger molecules such as sucrose.

Observation of Osmosis

Cell membranes are mostly lipids, and water is able to pass through them easily, but many other materials cannot go in and out as freely. That is why we describe the cell membrane as selectively permeable.

This exercise will illustrate how the difference in solute concentrations, and therefore concentration gradients, affects the rate of osmosis.

Procedure:

Work in groups of three.

1. In a beaker with water, obtain five 3” pieces of dialysis tubing/bags that have been soaking in water for at least 10 minutes. Obtain 10 pieces of string that have also been soaking for 10 minutes or more. Keep all of these items wet in beakers of water.

2. Separate five tubes/bags, tie one end of each separate bag with the wet string and fill each bag from the open end with one of these test solutions:

<table>
<thead>
<tr>
<th>BAG #1</th>
<th>Distilled Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAG #2</td>
<td>25% sucrose solution</td>
</tr>
<tr>
<td>BAG #3</td>
<td>50% sucrose solution</td>
</tr>
<tr>
<td>BAG #4</td>
<td>75% sucrose solution</td>
</tr>
<tr>
<td>BAG #5</td>
<td>Distilled Water</td>
</tr>
</tbody>
</table>

3. Fill each bag only until it is almost completely full then twist and fold the open end over and tie it shut with the wet string.

4. Carefully pat dry the outside of each bag and weigh each bag separately on one of the balances provided. Use this same balance each time you weigh the bags.

5. Place bags 1 - 4 in separate beakers half-filled with distilled water and let them soak for 10 minutes. Be certain that the bags are totally covered by the water.

6. Place bag 5 into a beaker containing just enough 75% sucrose (table sugar) solution to cover the bag and let it soak for 10 minutes.

7. After 10 minutes, remove the bags from the soaking solutions, carefully pat them dry and weigh them using the same balance you used to determine their initial weight. Repeat two more times (every 10 minutes) for a total of 30 minutes.

8. Record your observations (to 0.1g) in Table 1 below.
9. Convert the weight for each observation to normalized values (weight change per unit weight) by dividing each value by the initial value for that bag. Record the normalized values in Table 2.

**TABLE 1**

<table>
<thead>
<tr>
<th>TIME</th>
<th>Bag 1</th>
<th>Bag 2</th>
<th>Bag 3</th>
<th>Bag 4</th>
<th>Bag 5</th>
</tr>
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<tbody>
<tr>
<td>0 minutes</td>
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<tr>
<td>(Initial)</td>
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<td>10 minutes</td>
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<td>30 minutes</td>
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</tbody>
</table>

**TABLE 2**

<table>
<thead>
<tr>
<th>TIME</th>
<th>Bag 1</th>
<th>Bag 2</th>
<th>Bag 3</th>
<th>Bag 4</th>
<th>Bag 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 minutes</td>
<td>1</td>
<td>1</td>
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<td>1</td>
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10. Plot the normalized weight change values of each bag against time in Graph 1. Use the symbols: • for Bag 1, I for Bag 2, — for Bag 3, △ for Bag 4, and ○ for Bag 5. Observe the lines the plots produce.

11. Which bag(s) demonstrated the highest rate(s) of osmosis? How do you know this? Explain this in terms of concentration gradients.

12. Which bag(s) demonstrated the lowest rate(s) of osmosis? How do you know this? Explain this in terms of concentration gradients.
13. Describe the relationship between solute (sucrose) concentrations, concentration gradients and the rate of osmosis.
1. The existence of a concentration gradient in the Part I experiment and hence, diffusion, implies the presence of potential energy. What are some other examples of concentration gradients or of diffusion that you know of which demonstrate potential energy.

2. In Part II, water or a water/sucrose solution is placed in a model cell (dialysis tubing bag) which, in turn, is immersed in tap water or a 75% sucrose solution.
   a. Explain what your observations tell you about the permeability of dialysis tubing to water?
   
   b. Explain what your observations tell you about the permeability of dialysis tubing to sucrose?
3. What results would you expect if the permeabilities observed in Part II (Question 2, above) were reversed?

From the graphs you produced in this exercise, how can you tell which set of solutions had the steepest (or the shallowest) concentration gradient?