

Modeling Membrane Movements

Pillar: Active Living

Division: IV

Grade Level: 10

Core Curriculum Connections: Science 10

I. Rationale:

The purpose of this activity is to provide a visual and dynamic model of the cell membrane and its role in maintaining equilibrium while exchanging matter. The students pretend they are phospholipid molecules and use their bodies to demonstrate the fluidity of the cell membrane. Through active simulation, students illustrate and compare the complex life processes and transport methods of diffusion, osmosis, and active transport. Physical activity is infused as students throw paper balls and form human bridges to discover and represent the role of the cell membrane in these processes.

II. Activity Objectives:

The students will be able to:

- use their bodies as models to demonstrate complex processes involving the cell membrane through physical activity and active role play.

III. Curriculum Outcomes: Science 10

Unit C: Cycling of Matter in Living Systems

2. Describe the function of cell organelles and structures in a cell, in terms of life processes, and use models to explain these processes and their applications

- compare passive transport of matter by diffusion and osmosis with active transport in terms of the particle model of matter, concentration gradients, equilibrium and protein carrier molecules (*e.g., particle model of matter and fluid-mosaic model*)
- use models to explain and visualize complex processes like diffusion and osmosis, endo- and exocytosis, and the role of cell membrane in these processes
- describe the cell as a functioning open system that acquires nutrients, excretes waste, and exchanges matter and energy
- describe the role of the cell membrane in maintaining equilibrium while exchanging matter
- describe how knowledge about semi-permeable membranes, diffusion and osmosis is applied in various contexts (*e.g., attachment of HIV drugs to cells and liposomes, diffusion of protein hormones into cells, staining of cells, desalination of sea water, peritoneal or mechanical dialysis, separation of bacteria from viruses, purification of water, cheese making, use of honey as an antibacterial agent and berries as a preservative agent by traditional First Nations communities*)

IV. Materials:

Student Materials:

- safety goggles
- blank white paper (about 60 sheets)
- blank, colored paper (about 30 sheets)
- stickers (smiling faces are great)

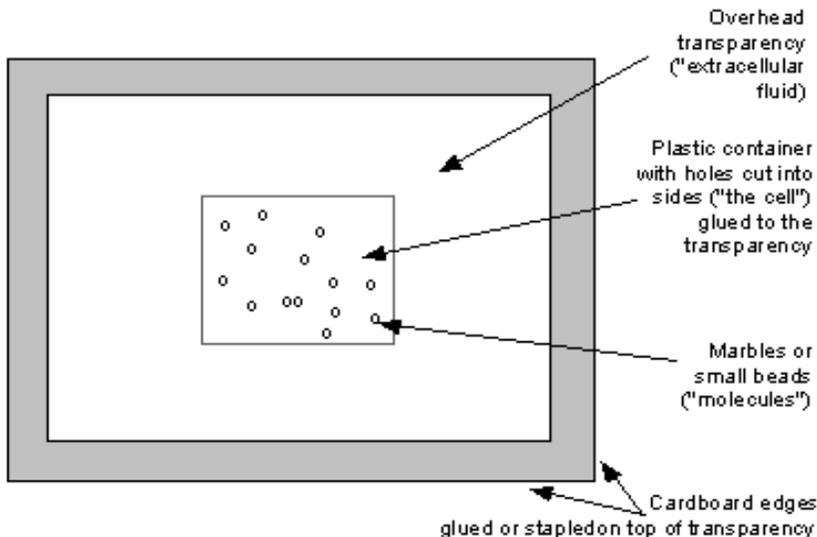
Materials for the Pre-Teaching Activity:

- Clear plastic container (the ones for blueberries or strawberries, approx. 10cm x 10 cm or 17cm x 10cm although smaller is better)
- small beads to represent water molecules (an inexpensive, fake pearl necklace taken apart)
- 2 bags of marbles for larger molecules (small, medium and large sizes needed)
- 4 cardboard pieces 30cm x 2cm
- 4 cardboard pieces 25cm x 2 cm
- 2 very clear overhead transparencies stapled together (those not meant for the photocopier are clear)
- strong, clear glue
- overhead projector

V. Procedure: *(Pre Activity Demonstration)*

Before attempting the dynamic student membrane activity, it may be beneficial to use a visual model first on overhead.

TOP VIEW



SIDE VIEW OF THE PLASTIC CONTAINER



Holes cut into sides represent pores in the phospholipid bilayer that only allow small molecules in by simple diffusion; cut just a tiny bit smaller than the size of the medium marbles so that only the small marbles fit in easily and the medium marbles could be pushed through by hand

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Using the Membrane Model to Teach Transport Methods

Simple Diffusion:

1. Put the model on the overhead projector.
2. Place the small marbles both inside the box ("cell") and outside the "cell" on the overhead transparency ("extracellular fluid"). Place many more on one side than the other.
3. Grab opposite corners of the transparency and carefully begin moving the entire model so that the molecules move about. Marbles should move along the concentration gradient. Discuss this with respect to the relative number collisions occurring on each side of the membrane.
4. Count the number of molecules on each side when you can see that they have clearly moved along the gradient. Continue until you reach equilibrium (same number on each side--this may not happen perfectly).

Facilitated Diffusion:

This time the medium sized-marbles ("glucose") are used.

1. Shake the model as before. The marbles will not fit through the pores.
2. You will have to push them through the openings. This pushing process represents the assistance of a protein in the membrane.

Osmosis

1. Place the medium-sized marbles (glucose) and the small, blue beads (water) both inside and outside of the box.
2. Place many more water molecules inside than outside. Shake the molecules about again as before. Discuss the fact that osmosis represents situations where only the water is moving across and not the larger molecules.
3. Note that the water molecules collide more often on the inside of the membrane than with the outside of the membrane and hence, net movement is out of the cell.
4. This is why they flow from high to low concentration and also why the cell will lose water when placed in a hypertonic environment. The reverse can also be done to show the cell placed in a hypotonic environment (more water molecules outside than inside the box or "cell").

ACTIVITY: LIVE STUDENT MODEL OF THE CELL MEMBRANE

1. Move the desks and chairs to the sides of the room.
2. Each student takes one or two pieces of white and blue paper and crumples them into small balls.
3. Have several students (use the 10 tallest ones) line up along the centre of the room. The students represent phospholipid molecules. These students must wear safety goggles to represent the phosphate head (also safer) and stand with feet apart to represent the lipid tails. They are very close but not touching each other.
4. They now practice moving their upper body side to side to (without bumping each other--for safety consideration). This movement displays the fluidity of the membrane that creates the pores that allow for simple diffusion to occur. Their feet must be stationary to avoid excess movement that might result in bumping into each other.

Note: Because of the limitations inherent in this model to fully represent the cell's bilayer phospholipid membrane, students should be reminded that this model is designed to illustrate the **dynamics** of equilibrium, not the exact structure of the cell or its membranes.

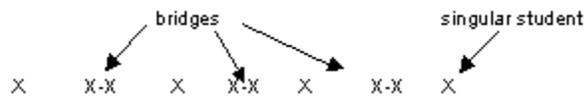
Simple Diffusion:

In simple diffusion small molecules such as oxygen, pass through membrane pores that are created as phospholipids move about.

1. To illustrate this, place 20 white balls on one side and 40 white balls on the other side of the membrane on the floor.
2. On the board draw a dotted line and on each side of the line write in the words "intracellular fluid" or "extracellular fluid".
3. Place the number 20 on the appropriate side of the line and the number 40 on the other side of the line. The rest of the students in the classroom stand on either side of the membrane. Place more of them on the side with the greater number of balls.
4. They will throw paper balls at the membrane. They must attempt to do this randomly, to display the random collision between molecules and the membrane. They should not try to aim for the gap between students or for particular students (a mature class is required for this).
5. After 5 seconds, halt the process and count the number of molecules on each side. Record these below the original numbers on the appropriate side.
6. Repeat again for 5 seconds and do the count again. If students are following instructions this random collision process should show the paper balls moving naturally from high to low concentrations until equilibrium is established. You will have to decide when to stop the process to show this as best as possible.

Facilitated Diffusion:

In facilitated diffusion the molecules are too large and polar (such as glucose) to cross through the phospholipid pores. In this case, a protein molecule is needed to facilitate passage. I have two students link hands to form a bridge. There will be one student separating each bridge formation. So if your membrane has 10 students in it then you will have 3 bridges formed.



1. Tape two small paper balls together to represent a larger molecule.
2. The same process is repeated as before but now with 20 paper balls on one side and 10 paper balls on the other.
3. Students are to aim for the protein pore only. Again, after 5 seconds, the results are recorded.
4. Continue this process until the molecules show movement from high to low concentration and equilibrium is established.

Osmosis

With osmosis, the membrane pores are again used as a means for transport, but this time only water is moving. When a larger molecule, such as an amino acid, cannot cross without the expenditure of energy, then only water will cross the membrane passively.

1. To illustrate this further, group together the balls of paper such that each ball is now composed of four pieces of paper joined together. This will represent an amino acid that cannot move across passively.
2. Place these on the floor with seven large balls on both side of the membrane.
3. The protein molecules remain on the floor. The small, blue, paper balls will represent water.
4. Place 10 on one side and 20 on the other side. Students are to aim for the spaces between phospholipids and not for the bridges (water does not have the correct shape to cross the protein).
5. Again after 5 seconds the results are recorded. Continue this process until the molecules show movement from high to low concentration and equilibrium is established.

Active Transport

Active transport will move large molecules, such as amino acids, against the concentration gradient until there is a larger concentration on one side of the membrane. ***Note: Equilibrium will not be established.**

1. The large amino acid molecules from the previous activity will be used.
2. Place 6 molecules on one side and 9 molecules on the other side.
3. This time, the students who held hands to form a protein channel will now face the lower concentrated side and each puts one hand out in front to receive a molecule. Before they can accept a molecule, a sticker must be placed on their shoulder. This sticker represents a phosphate molecule donated by ATP. This energizing of the protein allows the protein to receive the amino acid.
4. With the amino acid in hand, the student rotates 180° and faces the other side of the membrane. The sticker and the paper ball are dropped off on this side and the student rotates back to the original position.
5. All four molecules will be moved to the other side such that all 15 molecules are now on one side only.

APPLICATION QUESTIONS:

Simple Diffusion:

1. Why was the net movement of molecules from high to low concentration? (hint: think collisions!!)
2. How do molecules move across the membrane in simple diffusion? What are some examples?
3. How could we use this model to demonstrate the effects of adding heat to our molecules?
4. How would an increase in the concentration of molecules affect the rate of diffusion?

Facilitated Diffusion:

5. How do molecules move across the membrane?
6. What are some examples of molecules that move by facilitated diffusion? Why do these molecules need "help" getting across the membrane?

7. What represented the protein in our model of the membrane? How else might we have represented this protein channel in our model?
8. How is facilitated diffusion different from simple diffusion? Are there any similarities?

Osmosis:

9. Only the water molecules moved across the membrane. Why?
10. Why do the molecules move from where they are in higher concentration to where they are in lower concentration?
11. What happens when there is a higher concentration of water inside the cell than outside the cell?
What kind of environment is this? What will happen to the cell?
12. What happens when there is a higher concentration of water outside the cell than inside the cell?
What kind of environment is this? What will happen to the cell?

Active Transport:

13. What did the sticker represent in our model? Why was this necessary?
14. In what direction will molecules move? Will equilibrium be established?
15. How is active transport different from passive transport? Are there any similarities?

VII. Assessment Ideas:

- The application questions could be used as a form of assessment following this activity.

VIII. Source:

- [Access Excellence: The National Health Museum](#)