The Role of the Cell Membrane in Transport

Many people, young and old, enjoy a nice cup of tea now and then; but how many view making a cup of tea from a scientific point of view? Have you ever watched what happens when you place a tea bag into a cup of hot water? Even without stirring, colour immediately begins to seep from the tea bag to the water and spread throughout the cup. This movement of colour is evidence of diffusion—particles of tea moving from an area of higher tea concentration to an area of lower tea concentration.

Diffusion also plays an important role in the movement of various substances into and out of the cell through the cell membrane. You can better understand diffusion and other methods of transport through the cell membrane if you relate them to the particle model of matter.

Turn to page 274 of the textbook and read the introduction to “The Role of the Cell Membrane in Transport” and “The Particle Model of Matter.”

1. What are all the substances that enter and leave the cell regarded as?

2. Hypothesize how the four main points in the particle model of matter relate to how substances can move through a cell membrane.

Check your answers with those on page 66.
Have you been in a room when someone has opened a new package or container of coffee? How long did it take for the smell of fresh coffee to waft over to you? How did the smell of the coffee get from the package to you if you’re across the room?

Particles move from an area of higher concentration to an area of lower concentration through a process called diffusion. Since particles of air are in constant motion, the aroma molecules released by the coffee travel through the air in all directions. Diffusion of substances also occurs through the cell membrane when there is a difference in concentration inside and outside the cell membrane.

Turn to page 275 of the textbook and read “Diffusion.” You will study more about diffusion and how it occurs through the cell membrane.

3. What happens to the coffee aroma molecules released into a room after a period of time?

4. a. What is rate of diffusion?
   b. How can rate of diffusion be changed?

5. Define concentration gradient.

6. Why is the movement of a substance through diffusion called passive transport?

7. Why is the cell membrane considered to be a selectively permeable membrane?

8. State three conditions that determine whether materials will pass through a cell membrane.

9. Why does carbon dioxide leave a cell and oxygen enter a cell?

Check your answers with those on page 66.
Inquiry Lab

Movement Across a Semi-Permeable Membrane

Turn to page 276 of the textbook and read the entire activity.

10. Write a hypothesis for this activity.

   Check your answer with the one on page 66.

If you have access to a supervised laboratory, do Part A. If you do not have access to a supervised laboratory, do Part B.

Part A

Carefully follow the steps of the procedure outlined on page 276 of the textbook. In this activity you will test the movement of iodine through a semi-permeable membrane. Pay close attention to the safety precautions mentioned.

11. Copy and complete the following table to record your observations in steps 5, 6, and 7 of the procedure.

<table>
<thead>
<tr>
<th>Container</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Tube 1</td>
<td></td>
</tr>
<tr>
<td>Test Tube 2</td>
<td></td>
</tr>
<tr>
<td>Test Tube 3</td>
<td></td>
</tr>
<tr>
<td>Test Tube 4</td>
<td></td>
</tr>
<tr>
<td>starch solution in bag</td>
<td></td>
</tr>
<tr>
<td>beaker with water and iodine</td>
<td></td>
</tr>
</tbody>
</table>

12. Answer the following on page 276 of the textbook.

   a. questions 1 to 4 of “Analyzing and Interpreting”
   
   b. question 5 of “Forming Conclusions”

   Check your answers with those on page 67.
Part B

Insert the Science 10 Multimedia CD into your computer, and view the segment “Movement Across a Semi-Permeable Membrane.” Answer the following questions as you view the segment. You may have to stop or go back as you answer the questions.

13. Copy and complete the following table.

<table>
<thead>
<tr>
<th>Container</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Tube 1</td>
<td></td>
</tr>
<tr>
<td>Test Tube 2</td>
<td></td>
</tr>
<tr>
<td>Test Tube 3</td>
<td></td>
</tr>
<tr>
<td>Test Tube 4</td>
<td></td>
</tr>
<tr>
<td>Test Tube 5</td>
<td></td>
</tr>
<tr>
<td>Test Tube 6</td>
<td></td>
</tr>
<tr>
<td>beaker with water and iodine</td>
<td></td>
</tr>
<tr>
<td>starch solution in bag</td>
<td></td>
</tr>
</tbody>
</table>

14. What colour did the solution in the beaker and the solution in the plastic bag change to?

15. What does the change in colour indicate about what exchange took place between the solution in the beaker and the solution in the plastic bag?

16. Do the results of the experiment support the hypothesis made by the student in the video?

17. What is the purpose of Test Tubes 1 and 3?

Check your answers with those on page 68.
The term **concentration gradient** was used in the preceding activity. There are a number of concepts related to this term.

Read “Concentration Gradients” on page 277 of the textbook. Study Figure C2.15 closely.

18. State the five points related to concentration gradients.

19. How did the plastic bag in the preceding Inquiry Lab behave like a semi-permeable membrane?

**Check** Check your answers with those on page 68.

The process by which water enters a cell through the membrane is given a special name. You may have heard this term used with water filters. The diffusion of water from an area of lower solute (higher water) concentration to an area of higher solute (lower water) concentration across a cell membrane is called **osmosis**.

Read the information in “Osmosis” on pages 277 and 278 of the textbook. Carefully examine Figure C2.16.

20. Explain, in terms of water concentrations, why water flows from left to right in Figure C2.16.

21. Define the following terms with reference to concentration of solutions outside and inside a cell.

- **hypertonic**
- **isotonic**
- **hypotonic**

**Check** Check your answers with those on pages 68 and 69.
The following question will help extend your understanding of hypertonic, isotonic, and hypotonic.

22. Answer questions 1 to 4 of “Skill Practice: Linking Conclusions to Hypotheses” on page 279 of the textbook.

Check your answers with those on page 69.

The lipid bilayer in the cell membrane allows only molecules of substances that are soluble in lipids to pass through. Substances that are not soluble in lipids need some other mechanism to pass through the membrane.

The lipid bilayer in the cell membrane allows only molecules of substances that are soluble in lipids to pass through. Substances that are not soluble in lipids need some other mechanism to pass through the membrane.

In the next activity you use a hen’s egg to demonstrate osmosis. You will either measure the change in mass of the egg due to osmosis or you will observe the effect of osmosis on the size and shape of the egg.

23. Define the terms channel proteins, carrier proteins, and facilitate diffusion.

24. a. What is active transport?
b. Where does the energy for active transport come from?
c. How is active transport different from diffusion and facilitated diffusion?

Check your answers with those on page 69.
QuickLab

The Incredible Egg

Turn to page 280 of the textbook and read the entire activity.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

**Part A**

Obtain all the required materials and equipment, and carefully follow the steps outlined in the procedure. **Pay special attention to the safety precautions mentioned.**

25. Copy and complete the table given at the bottom of page 280.

26. Answer questions 1 to 5 of “Questions.”

![Check]

Check your answers with those on page 70.

**Part B**

Complete the activity as described in the procedure on page 280 of the textbook; but do not measure the mass of the egg. Observe the changes in appearance and size as the egg is placed in the salt solution and, then, in the distilled water. Use vinegar to dissolve the egg shell. Place the egg in enough vinegar to submerge it for at least 24 hours.

27. Copy and complete the following table.

<table>
<thead>
<tr>
<th>Step</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submerge egg in 10% salt solution.</td>
<td></td>
</tr>
<tr>
<td>Submerge egg in distilled water.</td>
<td></td>
</tr>
</tbody>
</table>

28. Answer questions 1 to 5 of “Questions” on page 280 of the textbook.

![Check]

Check your answers with those on page 71.
From the preceding activity you can see that the concentration gradient is reversible. When the concentration of particles that are able to cross the semi-permeable membrane is higher on the inside, the substance will move from inside to outside. The movement is from outside to inside if the concentration is higher on the outside.

In some cases, molecules or particles that need to be taken in or moved out of the cell are too large for any of the previous processes. Large molecules and particles can be taken in by endocytosis and excreted by exocytosis.

Turn to page 281 of the textbook and read “Endocytosis and Exocytosis.”

29. Describe endocytosis and exocytosis.

For more information on endocytosis and exocytosis, first read “Research” at the top of page 281 of the textbook. Then, if possible, visit the following website:

   http://www.scenceman.com/science10

Once there, click on “Unit C: Hot Links” and scroll down to Text Page 281. You will find a number of animations on endocytosis and exocytosis as well as diffusion, osmosis, and active transport.
Looking Back

You have now covered all the concepts for this lesson. You described how the cell membrane moves molecules and particles in and out of the cell.

30. Answer questions 2, 3, 4, and 8 of “Check and Reflect” on page 283 of the textbook.

Check your answers with those on page 71.

Go to pages 3 to 5 of Assignment Booklet 3B and answer questions 10 to 18.

Glossary

active transport: the movement of molecules or ions across a semi-permeable membrane against the concentration gradient that requires energy

carrier protein: a protein present in the cell membrane that binds to a specific molecule and transports it across the membrane

channel protein: a protein present in the cell membrane that forms a passageway for specific molecules or ions to pass through

concentration gradient: the difference within a given area or region of the highest and lowest concentrations of a substance

diffusion: the spontaneous movement of particles from an area of higher concentration to an area of lower concentration

endocytosis: a process of moving molecules or particles into a cell using a vesicle formed from the cell membrane

equilibrium: a state of balance between opposite actions

exocytosis: a process of removing molecules or particles from a cell through vesicles that fuse to the cell membrane and rupture

facilitated diffusion: diffusion across a semi-permeable membrane through carrier proteins; does not require energy

hypertonic: having a higher concentration of solute than another solution

hypotonic: having a lower concentration of solute than another solution

isotonic: having the same concentration of solute as another solution
**Suggested Answers**

1. Substances that enter and leave the cell are regarded as particles.

2. The particle model of matter states that all matter is made up of particles that are attracted or bonded to one another, that the particles are constantly moving, and that the particles have spaces between them. From this you can hypothesize that particles can move through a cell membrane, which is also made up of particles.

3. The coffee aroma molecules spread out until they are equally spaced throughout the room.

4. a. Rate of diffusion is the relative movement of particles in response to the concentration gradient.

   b. Rate of diffusion can be changed by adding or removing energy, thereby increasing or decreasing molecular movement.

5. *Concentration gradient* is the difference in concentration of a particular substance in two areas.

6. Movement of a substance through diffusion is called passive transport because no energy has to be added for it to occur.

7. The cell membrane is considered to be a selectively permeable membrane because it allows only certain particles through, not all particles.

8. The passage of materials through the cell membrane are determined by the size of the molecules, the charge of the molecules, and whether they are soluble in lipids.

9. Carbon dioxide leaves a cell because the concentration inside the cell is higher than outside the cell. Oxygen enters the cell because the concentration of oxygen is higher outside the cell than inside the cell.

10. Answers will vary. A sample hypothesis is given.

   Some substances will go into the bag and some substances will come out of the bag. The plastic bag behaves like a semi-permeable membrane that allows some particles to pass in or out.
11. Your table should be similar to the following.

<table>
<thead>
<tr>
<th>Container</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Tube 1</td>
<td>no change</td>
</tr>
<tr>
<td>Test Tube 2</td>
<td>water turns pale gold after adding iodine</td>
</tr>
<tr>
<td>Test Tube 3</td>
<td>no change, remains cream coloured</td>
</tr>
<tr>
<td>Test Tube 4</td>
<td>starch solution turns black after adding iodine</td>
</tr>
<tr>
<td>starch solution in bag</td>
<td>starch solution turns black, indicating that iodine penetrated the bag</td>
</tr>
<tr>
<td>Beaker with water and iodine</td>
<td>no black colour shows up in the beaker with iodine, indicating that no starch left the bag</td>
</tr>
</tbody>
</table>

12. a. **Textbook questions 1 to 4 of “Analyzing and Interpreting,” p. 276**

1. Adding iodine to Test Tube 2 turned the water pale gold. Adding iodine to Test Tube 4 turned the solution black. These results show that iodine turns black in the presence of starch. This makes iodine an indicator for the presence of starch.

2. Test Tubes 1 and 3 are controls. Test Tube 1 shows that water stays the same throughout the experiment when nothing is added to it. Test Tube 3 shows that a starch solution is cream coloured.

3. When the bag of starch is placed in the beaker of water and iodine, initially the water and iodine in the beaker are pale gold and the starch in the bag is cream coloured. The water and iodine in the beaker remained pale gold, indicating that no starch passed through the bag. The starch inside the bag turned black, indicating that iodine passed through the bag. There is a concentration gradient for iodine molecules to move from outside the bag to inside the bag. Iodine molecules must be small enough to move through the semi-permeable, plastic membrane. There is a concentration gradient for starch molecules to move from inside the bag to the water and iodine solution outside the bag. Starch molecules must be too large to move through the semi-permeable, plastic membrane.

4. The bag containing the starch solution became more tightly stretched over time and showed a volume of liquid inside the bag. Since there was only a dropper full of iodine in the beaker, this indicates that water molecules and iodine molecules entered the bag.

b. **Textbook question 5 of “Forming Conclusions,” p. 276**

5. Answers will vary. A sample answer is given. The plastic membrane is semi-permeable, and iodine and water molecules were able to enter the bag while starch molecules did not leave the bag. The hypothesis was correct regarding some substances going into the bag, but not correct about substances coming out of the bag.
13. 

<table>
<thead>
<tr>
<th>Container</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Tube 1</td>
<td>The solution is clear.</td>
</tr>
<tr>
<td>Test Tube 2</td>
<td>The water turns pale gold colour after the iodine is added.</td>
</tr>
<tr>
<td>Test Tube 3</td>
<td>The solution is milky white or cream coloured.</td>
</tr>
<tr>
<td>Test Tube 4</td>
<td>The starch solution turns black after iodine is added.</td>
</tr>
<tr>
<td>Test Tube 5</td>
<td>The solution is pale yellow.</td>
</tr>
<tr>
<td>Test Tube 6</td>
<td>The solution is pale black.</td>
</tr>
<tr>
<td>beaker with water and iodine</td>
<td>No black colour shows up in the beaker with iodine.</td>
</tr>
<tr>
<td>starch solution in bag</td>
<td>The starch solution turns black.</td>
</tr>
</tbody>
</table>

14. The solution in the beaker did not change colour; it remained the pale yellow. The solution in the plastic bag changed from a milky white, or cream coloured, to a pale black.

15. The change in colour indicates that iodine passed through the plastic bag into the starch solution. There was no change in colour in the solution in the beaker, so starch did not pass through the plastic bag into the iodine solution.

16. The student in the video said that nothing would pass through the plastic bag. The results indicate that the iodine did pass through the plastic bag and entered the starch solution. So, the results do not support the student’s hypothesis. **Note:** It is difficult to tell from the video if the volume of the bag increased, showing that water moved into the bag.

17. Test Tubes 1 and 3 were controls for the experiment.

18. Five key points related to concentration gradients are:

- must involve different concentrations
- in cells, different concentrations may be separated by a membrane
- involves molecules or ions of a single type
- drives diffusion and osmosis
- different molecules move along their concentration gradient independently of other molecules

19. The plastic bag behaved like a semi-permeable membrane because it has pores that are large enough to allow small molecules and ions through.

20. The water flows from left to right because the addition of solute on the right side makes the water concentration lower on the right side relative to the left side. In osmosis, water flows from an area of higher water concentration to an area of lower water concentration.
21. **Hypertonic** refers to a solution with a higher solute concentration outside a cell than inside the cell.

**Isotonic** refers to a solution with the same solute concentration outside a cell as inside the cell.

**Hypotonic** refers to a solution with a lower solute concentration outside a cell than inside the cell.

22. **Textbook questions 1 to 4 of “Skill Practice: Linking Conclusions to Hypotheses,” p. 279**

1. Vegetables, like carrots and celery, become crispy when placed in a container of water because they absorb water. Normally, the vegetables are placed in water while still crisp and, thus, retain their water and maintain their crispness.

2. a. A zero mass change would indicate that no water was absorbed or lost by the potato slices. You could infer that the solution the potato slices were placed in was isotonic relative to the contents of the potato cells.

   b. A positive percent change in mass indicates that more water entered the potato slices than left. You can infer that the solution the potato slices were placed in was hypotonic relative to the contents of the potato cells.

   c. A negative percent change in mass indicates that less water entered the potato slices than left. You can infer that the solution the potato slices were placed in was hypertonic relative to the contents of the potato cells.

3. The graph shows that potato slices lose mass in a hypertonic solution, show no change in mass in an isotonic solution, and gain mass in a hypotonic solution.

4. The hypothesis was accepted. Vegetables remain or become crispy when placed in water because they retain or gain water.

23. **Channel proteins** are proteins that create pores or channels in the cell membrane through which small, water-soluble molecules can pass.

**Carrier molecules** are molecules that attach to larger molecules and move these molecules through the cell membrane by physically changing shape.

**Facilitated diffusion** is diffusion that involves a protein assisting the movement of a molecule that is responding to a concentration gradient.

24. a. Active transport is the movement of molecules against the concentration gradient. Active transport requires the input of energy to move the molecules from one area to another.

   b. The energy for active transport is produced from adenosine triphosphate (ATP) in the cell by the mitochondria. The ATP is produced from glucose through a series of chemical reactions.

   c. Active transport is different from diffusion and facilitated diffusion in that active transport moves molecules against the concentration gradient and requires energy.
25. Your completed table should be similar to the following.

<table>
<thead>
<tr>
<th>Step</th>
<th>Starting Mass of Egg (g)</th>
<th>Final Mass of Egg (g)</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submerge in 10% salt solution.</td>
<td>56.3 g</td>
<td>48.6 g</td>
<td>The membrane of the egg wrinkled, and the egg appeared to decrease in size.</td>
</tr>
<tr>
<td>Submerge in distilled water.</td>
<td>48.6 g</td>
<td>55.2 g</td>
<td>The membrane of the egg became smooth again, and the egg appeared to increase in size.</td>
</tr>
</tbody>
</table>

26. **Textbook questions 1 to 5 of “Questions,” p. 280**

1. When the egg was placed in the salt solution, the membrane began to loosen and wrinkle. After 8 min, it appeared that the egg was smaller in size. The salt solution must have had a lower concentration of water than the inside of the egg, so water moved from inside the egg to the salt water solution.

2. After the egg was moved to the distilled water for about 15 min, it appeared to increase in size and the membrane became smooth. The contents of the egg had less water in it than the surroundings, so water moved from outside the egg to inside the egg. This increased the mass and volume of the egg.

3. a. ![Diagram of egg in salt water solution](image1)
    b. ![Diagram of egg in distilled water](image2)

The arrows show water molecules moving from inside the egg to the outside. The arrows show water molecules moving from outside to inside the egg.

4. Particles move from an area of higher concentration to an area of lower concentration. In this case, the concentration of water molecules was higher inside the egg at the start, so water molecules moved from inside to outside. After the egg was moved from the salt solution to the distilled water, the concentration of water molecules was higher on the outside of the egg. This caused the water molecules to move from outside the egg to inside the egg.

5. Water is able to move across the egg membrane by diffusion. The sodium and chlorine ions require a transport protein to move across the membrane. The results of the experiment with the egg in a 10% salt solution indicate that water is moving out of the egg since the egg membrane shrivels. If salt could move across the membrane, both salt and water would move across until equilibrium is reached.
27. Your completed table should be similar to the following.

<table>
<thead>
<tr>
<th>Step</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submerge egg in 10% salt solution.</td>
<td>The membrane of the egg wrinkled, and the egg appeared to decrease in size.</td>
</tr>
<tr>
<td>Submerge egg in distilled water.</td>
<td>The membrane of the egg became smooth again, and the egg appeared to increase in size.</td>
</tr>
</tbody>
</table>

28. Refer to the answer to question 26.

29. In endocytosis, the cell membrane folds and forms a sac that surrounds the molecules or particles that need to be brought into the cell. The sac then becomes a vesicle inside the cell.

In exocytosis, molecules or particles to be excreted are transported within a vesicle that fuses with the cell membrane. The vesicle then ruptures, releasing the contents outside the cell.

30. **Textbook questions 2, 3, 4, and 8 of “Check and Reflect,” p. 283**

2. The process of diffusion occurs as a result of the natural movement of particles from an area of higher concentration to an area of lower concentration.

   Facilitated diffusion is the movement of large particles across the membrane by carrier molecules that attach to these particles and physically move them across the membrane. Facilitated diffusion is in response to the concentration gradient.

   Active transport is the movement of particles from an area of lower concentration to an area of higher concentration and requires the input of energy.

   Diffusion is necessary to the cell as it does not require energy. Facilitated diffusion also does not require energy, but it is useful to the cell as large particles can be moved across the membrane. Active transport is necessary to the cell as the movement is against the concentration gradient.

3. A concentration gradient is a difference in concentration between an area of higher concentration and an area of lower concentration of a particular substance. Equilibrium is a state of balance resulting in no net movement of particles.

4. To keep the celery crisp, cut the end of the celery stalk and immerse it into water. The celery will absorb water as necessary to maintain its crispness.

8. a. The salt or syrup solutions would be hypertonic to the micro-organisms, resulting in a loss of water by the micro-organisms.

   b. The effect would be that the micro-organisms would lose so much water that they eventually die.
Applications of Cellular Transport in Industry and Medicine

When you insert your key into the lock on the door of your house, you are able to unlock and open the door and enter your house. If you go to your neighbour’s house and try your key, you will find it won’t unlock the door. A key works by having parts that are shaped in a certain way that allows it to work only for that lock.

Similarly, cell membranes have proteins that have specific shapes. Often, viruses have parts with specific shapes that fit the specific shape of the protein on the cell membrane. If the virus has the part with the correct shape, it can gain entry into the cell through the protein. Scientists, today, are using technology to find ways of having cells combat diseases that have no cure by changing the way proteins on the cell membrane work.

Turn to pages 284 and 285 of the textbook and read the introduction to “Applications of Cellular Transport in Industry and Medicine” and the information in “Membrane Proteins and Disease.” You will examine recognition proteins and receptor proteins and how viruses can be blocked from entering a cell. Study Figure C2.24 closely.