2. MEMBRANE PERMEABILITY

What types of substances are able to pass through a cell membrane?

Objectives

- Explain the process of selective permeability by diffusion through a model cell membrane.

Materials and Equipment

- Data collection system
- pH Sensor
- Beaker, 250-mL
- Graduated cylinder, 10-mL
- Graduated cylinder, 25-mL
- Graduated cylinder, 100-mL
- Ring stand or base and support rod
- Test tube clamp or electrode support and
- Magnetic stirrer with magnetic stir bar
- Lugol's iodine, 25 drops
- 0.1 M Hydrochloric acid (HCl), 15 mL
- 0.1 M Sodium hydroxide (NaOH), 15 mL
- 10% Starch solution, 5 mL
- Dialysis tubing, 1" diameter (2), 15-cm length
- Wash bottle filled with distilled water
- Distilled water, 250 mL
- Binder clip
- Thread or dental floss (2), 10-cm length

Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles at all times.
- Dispose of chemicals in the proper waste container as directed by your instructor.
- Hydrochloric acid and sodium hydroxide are irritants. If chemicals get on your skin or in your eyes, immediately rinse thoroughly with running water and notify your instructor.
- Notify your instructor of spills and clean up as directed.
- Wash and dry your hands thoroughly after completing the investigation.

Procedure

1. Wash and dry your hands. Retrieve one piece of soaked dialysis tubing. Tie one end of the tubing with thread to form a bag as shown in Figure 1. Add multiple knots to ensure a tight seal.

2. Rub the tubing between your fingers to open the top of the bag.

3. Pour 15 mL of hydrochloric acid (HCl) and 5 mL of starch solution in the bag.

4. Fold over the open end of the bag several times to prevent leaking. Place a binder clip over the folded end as shown in Figure 1.

5. Place the bag under a gentle stream of running water to rinse off any acid that may be present on the outside of the bag. Set the bag on a clean paper towel. Label the paper towel "HCl".

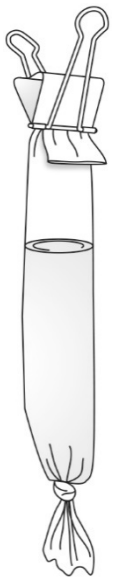


Figure 1:
Bag setup

6. Repeat steps 1-5 making a second bag, substituting HCl with 15 mL of 0.1 sodium hydroxide (NaOH); no starch is needed in the bag. Set the bag on a clean paper towel labeled "NaOH".

Note: Do not allow the bags to contact one another.

7. Remove the storage bottle and cap from the pH sensor. Rinse the probe with distilled water.

8. Place the stir bar in the beaker and set the beaker on a magnetic stirrer near the ring stand.

9. Use a clamp or electrode support to position the pH sensor near the inside edge of the beaker, avoiding the stir bar as shown in Figure 2. Do not place the bag in the beaker until instructed to do so.

10. Add 100 mL of distilled water to the beaker. Adjust the pH sensor so the glass bulb at the end of the probe is submerged in water.

11. Turn on the magnetic stirrer to a low speed.

12. Add 25 drops of iodine to the water. Mix the solution for one minute.

13. Record the initial color of the hydrochloric acid solution inside the bag and the beaker solution color in Table 1.

14. Select Sensor Data in SPARKvue.

15. Connect the pH sensor to your device.

16. Choose the Graph template.

17. Select Start to begin collecting data. Record the initial pH for HCl in Table 2.

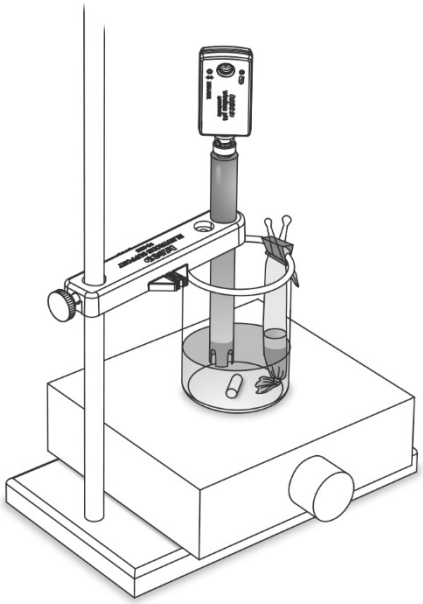


Figure 2: Secure the bag to the beaker with the binder clip

18. Remove the binder clip from the hydrochloric acid bag. Set the bag upright along the inside of the beaker away from the stir bar as shown in Figure 2. Fold the empty portion of the bag over the top of the beaker and secure it in place with the binder clip as shown.

19. Allow the experiment to run for 200 seconds, then stop collecting data. Record the final pH and time elapsed in Table 2.

20. Record the final colors seen in the beaker and the bag in Table 1. A blue-black color forms when both starch and iodine are present. Indicate the presence or absence of starch in the Result column in Table 1.

21. Record the final pH of the beaker solution and time elapsed in Table 2.

22. Dispose of the dialysis tubing bag and its contents as directed. Remove the pH sensor from the water. Thoroughly rinse the end of the pH probe with distilled water.

23. Remove the stir bar from the beaker and dispose of the beaker contents as directed. Thoroughly rinse and dry the beaker and stir bar.

24. Repeat Steps 8-11 and Steps 17-23 with sodium hydroxide bag. Record results in Table 2 and replace the storage bottle and cap after rinsing the pH probe.

25. Make sure both data runs are visible and scale the graph. Sketch your results in Graph 1. Include numbers, labels, and units on the x- and y-axes. Fill out the key to identify each run.

26. Calculate the change in pH of the beaker solution for each run. Use the following equation and enter the result in Table 2.

    Change in pH in Beaker = Final pH - Initial pH

27. Calculate the rate pH change for each run. Use the following equation and enter the result in Table 2.

    Rate of pH Change = Change in pH ÷ Time

Data Collection

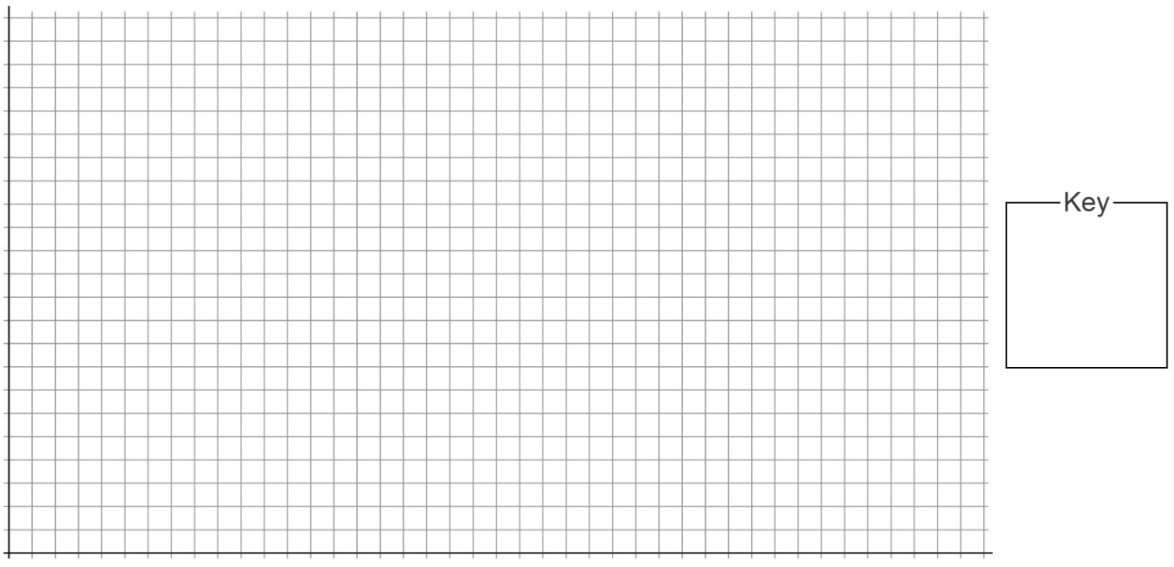
Table 1: Initial and final colors in the hydrochloric acid – starch – iodine – water system

	Initial Color	Final Color	Result
Beaker			
Bag			

Table 2: Change in pH over time

Substance in Bag	Initial pH in Beaker	Final pH in Beaker	Time Elapsed (s)	Change in pH in Beaker	Rate of pH Change (s^{-1})
HCl					
NaOH					

Graph 1: Change in pH over time



Questions and Analysis

1. Describe what happened to the pH in the beaker during the time the HCl bag was lowered into the water. What does this indicate about the permeability of the membrane to H^+ ions?

2. Describe what happened to the pH in the beaker during the time the NaOH bag was lowered into the water. What does this indicate about the permeability of the membrane to OH^- ions?

3. Describe what happened between the starch solution and iodine. Was iodine able to move into the bag? Was starch able to move out of the bag? Support your answer with data.

4. You made observations of how diffusion and semi-permeable membranes work together during this investigation. Use your observations and data to describe the role of diffusion and semi-permeable membranes in a cell, and draw a model that demonstrates how ions move across a semi-permeable membrane.

5. Cell membranes are one type of structure in a larger system made up of many parts that work together to maintain homeostasis in multicellular organisms. Explain how the cell membrane connects one system or function to another in a multicellular organism.