Cell Diffusion & Permeability: See-Through Eggs
Teacher Version

In this lab, students will learn about the permeability of the cell membrane. By studying the ability of a shell-less egg to absorb various solutions, students can see how membranes can regulate a cell's interaction with its environment.

California Science Content Standards:
- **1. Cell Biology: The fundamental life processes of plants and animals depend on a variety of chemical reactions that occur in specialized areas of the organism's cells.**
- 1a. Students know cells are enclosed within semi-permeable membranes that regulate their interactions with their surroundings.

Materials (per group):
Part 1
- Graduated Cylinder (or 25mL beaker)
- Plastic Sandwich Bag
- Twist Tie
- 500mL Beaker or Flask
- Iodine Solution
- Liquid Starch

Part 2
- 3 chicken eggs with shells dissolved by vinegar
- White vinegar
- 3 clear plastic cups
- *Light* Corn Syrup (enough to completely cover eggs)
- Liquid egg whites (enough to completely cover eggs)
- Distilled Water (enough to completely cover eggs)
- String
- Rulers
- Triple-beam balance OR Rudimentary scale with jelly belly beans [consists of 2 sandwich bags, 3 pieces of string, and one 3-hole punched ruler, and a pack of jelly beans]. If scale is unavailable, only measure circumference.

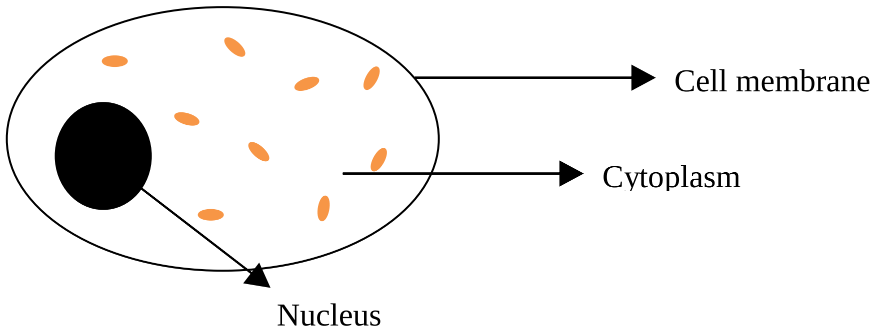
Preparation and Lab Notes:
TEACHER NOTE
Preparation for shell-less eggs must be done three days in advance.

1. Submerge chicken eggs (3 per group, plus 5+ spares) completely in a tub full of vinegar.
2. Allow eggs to soak for about 24 hours so the calcium on the shells partially dissolves.
3. After each 24 hours, replace with fresh vinegar.
4. Do not rinse eggs after removing them from tub of vinegar. If necessary, manually remove shell remnants. Gently rub each egg in circular motions with fingers and palm of hand to remove the shell of each egg. Careful not to puncture the egg, as that will ruin experiment.

5. One day before the lab, put one set of shell-less eggs in the various solutions (after measuring the circumference of each egg); this can serve as the “cooking show” method of preparing the eggs prior to the lab in order to observe potential size differences on the day of the lab.

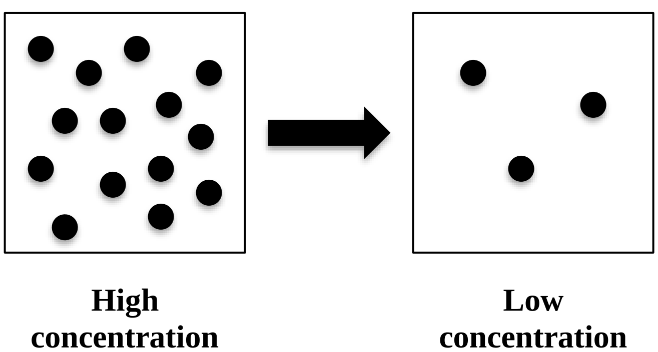
Key Concepts:

- A human cell has a protective layer called a **cell membrane.**

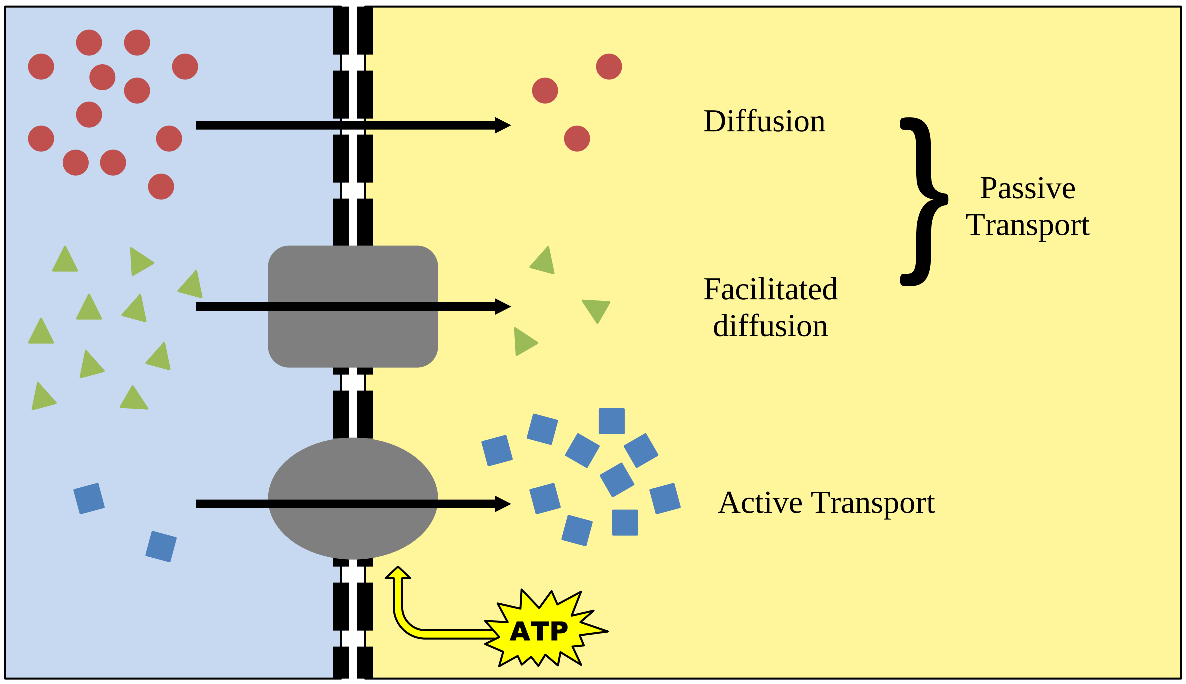


- This cell membrane is **semi-permeable**, meaning that some molecules easily move across the cell membrane, some cannot.
- When solutions containing different amounts of ingredients are separated by a semi-permeable membrane, **diffusion** of molecules occurs. Diffusion is the movement of molecules from an area of high concentration to an area of low concentration. For example, diffusion can occur across biological membranes or down concentration gradients.

Diffusion



- There are 3 main types of diffusion:
  - **Passive Transport** is when molecules diffuse without the use of energy from the cell, from areas of high amounts to areas of low amounts.
  - **Active Transport** is when molecules diffuse with the use of energy from the cell (and a special pump), from areas of low amounts to areas of high amounts.
  - **Facilitated Transport** is when molecules diffuse from areas of high amounts to areas of low amounts without the use of energy from the cell, but with the help of proteins that form channels across the cell membrane. Remember that to facilitate means to "help" so sometimes molecules need help getting across the cell membrane and special proteins facilitate this!



Part 1 – Modeling Cell Semi-Permeability

Even though a membrane may appear to be impermeable, certain molecules may still be able to pass through. In this section, students will simulate the semi-permeability of a membrane using plastic bags.

1. **Pour approximately 50mL of water into a plastic sandwich bag and add 10mL of starch**

2. **Secure bag** with the twist tie and **shake gently** to mix the starch.

3. **Put on gloves.**

4. **Pour 250mL of water into a 500mL beaker. Add 15 drops of iodine**.

5. **Place the sandwich bag of starch solution into the beaker of iodine solution.**

6. Allow the sandwich bag to soak in the iodine solution for at least 20 minutes.

7. **Record any observations** noted at the beginning, during, and at the end of the experiment.

8. In between observations, please continue to Part 2: Cell Diffusion.

9. Once you are finished with recording your observations for Part 1: Semi-Permeability, you may **answer the concept questions below the data table**.

Cell Permeability Observations

Initial	During	End

Concept Questions

Q1. What cellular structure is modeled by the sandwich bag?
The sandwich bag models the cell's semi-permeable membrane.

Q2. What observations did you make that occurred outside of the sandwich bag? What observations did you make that occurred inside the sandwich bag?
Inside of the bag observations should be that the color of the starch is now blue-black instead of opaque white. Outside of the bag observations should be that the iodine retained its original color of dark (blackish) orange.

QS3. What property of the sandwich bag allows for the results you observed during the experiment and recorded for Concept Questions #2 above?
The sandwich bag is semi-permeable which allowed for certain molecules to diffuse across the biological membrane (iodine), but not others (starch).

QSA3. Iodine is an indicator solution that turns blue-black in the presence of starch. What process do you think occurred that caused the results you observed? Explain.
Iodine is an indicator that turns blue-black in the presence of starch. If the two ingredients are kept separate at the start of the experiment, but the starch changes color by the end of it, iodine molecules diffused across the "biological membrane" (plastic bag) and came into contact with starch molecules, turning blue/black instead of remaining its original color of dark orange. This means that the plastic bag was semi-permeable because the larger starch molecules were not permitted to diffuse out and affect the original color of iodine outside the bag, but the smaller iodine molecules were permitted to diffuse in.

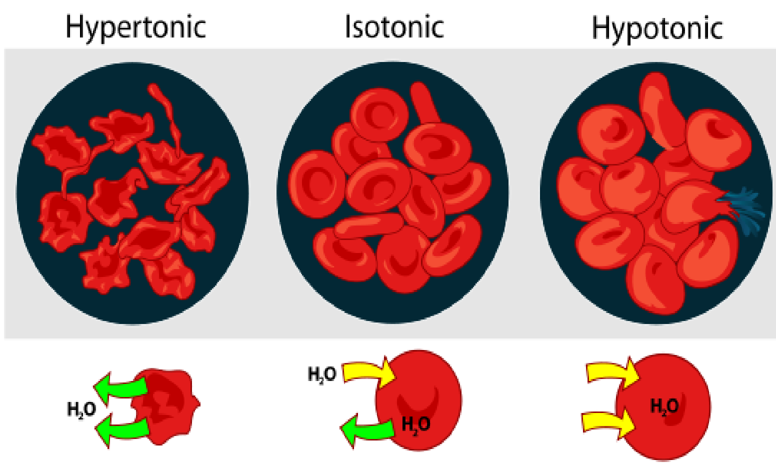
Part 2 – Cell Diffusion

** TEACHER NOTE**
Initial observations and set up for this part (Day 1) can be conducted a day <u>before</u> the rest of the lab is completed. This serves as the "cooking show" method to the lab to observe changes in egg size on the day that the lab is conducted rather than having to wait for an additional day.

Key Concepts:

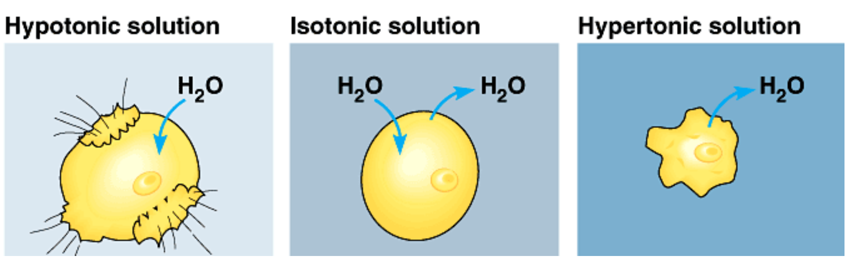
- The prefix **hyper**- refers to "high" as in hypertension (high blood pressure). A **hypertonic** solution has a higher amount of **solute** (the solid that is being dissolved) and a lower amount of **solvent** (the liquid that is dissolving the solute). As diffusion of molecules takes place across a biological membrane, the high amounts of solvent (water) from inside the cell rushes out toward the low amounts of solvent and high amounts of solute outside the cell, thus causing the cell to shrink.
- The prefix **hypo**- refers to "low" as in hypotension (low blood pressure). A **hypotonic** solution has a lower amount of solute and a higher amount of solvent. As diffusion of molecules takes place across a biological membrane, the high amounts of solvent (water) from outside the cell rushes toward the low amounts of solvent and high amounts of solute inside the cell, thus causing the cell to gorge and possibly explode.
- **Isotonic** solutions have equal concentrations of solvent and solute on both sides of the biological membrane, thus the molecules diffuse through the cell at a steady and balanced rate maintaining cellular equilibrium.

In the Cell:



http://paramedicine101.com/files/2010/10/Osmotic_pressure.png

In the Egg:



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Q4. What will happen to eggs (cells) that are separately placed in syrup, distilled water, and liquid egg whites?

If I place an egg in syrup, then ______(ANSWERS MAY VARY)____________________,

because ____.

If I place an egg in distilled water, then _______________________________________,

because ____.

If I place an egg in liquid egg whites, then _____________________________________,

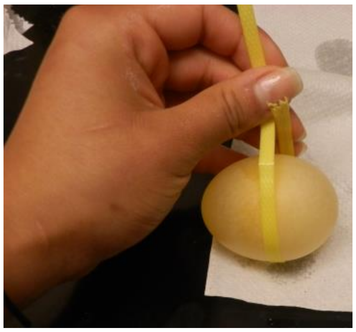
because ____.

Day 1 – Initial Observations and Set Up

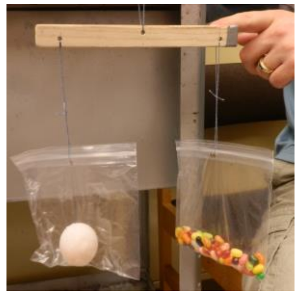
1. Take the three cups and label them "syrup", "distilled water", and "liquid egg whites", respectively.

2. Take the three eggs with shells dissolved by vinegar, and place an egg in each cup.

3. Measure circumference (in centimeters) of the "syrup" egg. Record in the data table. For circumference, wrap a piece of string around the width of the egg until both ends meet. Then straighten the string and align against a ruler to record the circumference.



4. Measure mass (in grams) of the "syrup" egg. Record in the data table. For mass, if not using a triple beam balance, then use the rudimentary scale by placing egg in one bag while you balance the bags with jelly beans in the other bag.



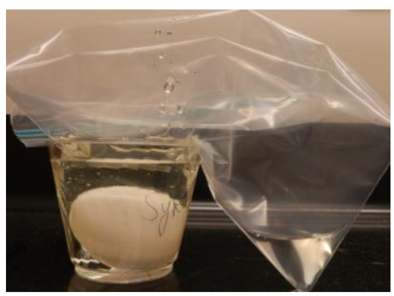
5. **Measure circumference (in centimeters) of the "distilled water" egg. Record in the data table.**

6. **Measure mass (in grams) of the "distilled water" egg. Record in the data table**.
7. **Measure circumference (in centimeters) of the "liquid egg whites" egg. Record in the data table.**

8. **Measure mass (in grams) of the "liquid egg whites" egg. Record in the data table.**

9. Gently **place each egg back into their proper cups**.

10. **Cover the "corn syrup" egg with corn syrup, completely filling it.** If the egg floats in the corn syrup, add a small amount of corn syrup into a plastic sandwich bag and place over egg to add weight on top of it.



11. **Cover the other two eggs with their respective solution.**

12. Let the eggs soak in their cups overnight.

Day 2 – Final Observations and Clean Up

1. **Gently remove each egg from their respective beaker. Gently rinse the eggs** that were in the corn syrup and liquid egg whites under running water.

2. **Gently dry all three eggs** by blotting with a paper towel.

3. **Measure the circumference in centimeters and mass in grams for each egg just as you did previously.** *Record in the data table.*

4. **Calculate** in the data table the CHANGE in circumference and mass for each egg. *Record in the data table.*

CHANGE = Final Circumference – Initial Circumference

AND

CHANGE = Final Mass – Initial Mass

Note: Be sure to include a (+) sign if it is a positive change or a (-) sign if it is a negative change.

5. **Calculate the PERCENT CHANGE in circumference and mass for each egg using the formula below.** *Record in the data table.*

$$\text{Percent Change} = \frac{\text{Final circumference} - \text{Initial circumference}}{\text{Initial circumference}} \times 100$$

AND

$$\text{Percent Change} = \frac{\text{Final Mass} - \text{Initial Mass}}{\text{Initial Mass}} \times 100$$

Data Table: Advanced Students Should Create Their Own Data Table Title!

		Initial Measurement	Final Measurement	Change (cm/g)	Percent (%) Change
Egg #1: Corn Syrup	**Circumference (cm)**	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary
	Mass (g)	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary
Egg #2: Distilled Water	**Circumference (cm)**	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary
	Mass (g)	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary
Egg #3: Liquid Egg Whites	**Circumference (cm)**	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary
	Mass (g)	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary	Measurements Will Vary

Concept Questions

Q5. What role does vinegar play in the investigation? In other words, what did the vinegar "do" to the eggshells?
In the most simplistic terms, soaking in vinegar makes the eggshell semi-permeable so that molecules can pass between the external and internal environments of the egg.

Q6. Circle one word in each set of parentheses.
A cell placed in a syrup solution is in a(n) (hypertonic/hypotonic/isotonic) environment.
This will cause the cell to (gain/lose) water because the cell is
(hypertonic/hypotonic/isotonic) when compared to its environment.

Q7. Circle one word in each set of parentheses.
A cell placed in distilled water is in a(n) (hypertonic/hypotonic/isotonic)
environment. This will cause the cell to (gain/lose) water because the cell is
(hypertonic/hypotonic/isotonic) when compared to its environment.

Q8. Circle one word in each set of parentheses.
A cell placed in egg whites is in a(n) (hypertonic/hypotonic/isotonic)
environment. This will cause the cell to maintain equilibrium because the flow of water is
(the same/different) on both sides of the biological membrane.

Q9. Draw illustrations depicting the final outcomes of each egg after soaking in their respective solutions. Answers will vary.

Egg in corn syrup	Egg in liquid egg whites	Egg in distilled water