Shell Porosity

Grade Level: 4-8

Lesson Overview

Shell porosity? Osmosis? Egg magic? By conducting and observing these “egg”speriments, students will gain a deeper understanding of some parts of an egg.

Student Objectives

1. Observe the movement of liquid through pores of an eggshell and shell membrane.
2. Describe the role of pores in the eggshell in allowing air and water to reach the embryo.

Materials

- ✓ blue food coloring
- ✓ toothpicks
- ✓ magnifying lenses – 1 per student
- ✓ corn syrup
- ✓ paper towels
- ✓ cups
- ✓ Shell Porosity Observation Sheet
- ✓ Membrane Permeability Observation Sheet
- ✓ hard-boiled egg – 1 per group
- ✓ 3 or 4 uncooked eggs, soaked in vinegar for 48 – 72 hours
- ✓ balance scale

Vocabulary

- **permeable** - that can be permeated or penetrated, especially by liquids or gases.
- **porosity** - a structure or part that is porous.
- **shell** - outer covering of an egg, composed largely of calcium carbonate; provides protection and has pores for air exchange.
- **embryo** - an animal in the early stages of development.
- **decalcified** - the removal of calcium or calcium compounds.
- **osmosis** - movement of a solvent through a semi permeable membrane (as of a living cell) into a solution of higher solute concentration and absolute temperature: as a: the maximum pressure that develops in a solution separated

from a solvent by a membrane permeable only to the solvent b: the pressure that must be applied to a solution to prevent osmosis.

Background Information

The protective covering of the egg, known as the shell, is primarily composed of a porous form of calcium carbonate. This shell contains between 6,000 and 8,000 microscopic pores permitting volatile components to travel through the shell. These volatile components include air, water, oxygen, and carbon dioxide.

An enrichment activity involves demonstrating that the membrane which exists directly within the shell (shell membrane), is permeable to allow passage of volatile substances. The eggshell can be removed fr0m the egg by soaking the egg in vinegar. Vinegar is a weak solution of acetic acid and this acid reacts to dissolve the calcium in the egg shell. The shell membrane that is exposed is a semipermeable membrane, which means that substances with small molecular formulas such as oxygen (O2), carbon dioxide (CO2) and water (H20) can pass through the membrane. Fructose and sucrose are forms of sugar. This demonstrates the process of osmosis which is defined as the flow of fluid through a semipermeable membrane separating two solutions, which permits the passage of the solvent but not the dissolved substance. In this activity the solvent is water in the corn syrup and the dissolved substance is sugar in the corn syrup. The liquid will flow from a weaker to a stronger solution, thus tending to equalize concentrations of solutions. In this activity, an egg placed in water will shrink as water moves out of the egg. The water is moving to and from the egg in an attempt to equalize the osmotic pressure inside and outside the egg.

Procedure

Shell Porosity

1. Pass out the magnifying lenses and hard-boiled eggs. Have students examine the eggs with and without the lenses.
2. Have students explain what they see.
3. Ask the students why there are pores in the shell of the egg. If necessary, explain that air and water will pass through the air holes in the shell of the egg to the embryo.
4. If the hard-boiled egg is wet, dry it. With a toothpick, place a small dot of food coloring on the eggshell, avoiding any cracks that may be the result of cooking. Let the egg dry for at least one hour, longer if possible.

5. Using the Shell Porosity Observation Sheet, ask the students to write down what they think will happen. Observe the eggshell. Note any changes.
6. Remove the shell and observe the blue area on the cooked egg white.

Membrane Permeability

1. Prepare eggs beforehand by soaking them in vinegar for 48 – 72 hours. The acid leaches the calcium out of the shell and leaves an intact, soft, semi-permeable membrane that feels like rubber and can be seen through. *(Note: If short on time, you can change the vinegar a couple times and gently rub some of the calcium off the shell gently to speed up the process.)*
2. Let the students gently handle the softened eggs so that they can compare ordinary eggshell and decalcified ones. Open a softened egg to show the students the eggs are the same inside (you may want to open an egg that still has the shell).
3. Have students form hypotheses and note them on the Membrane Permeability Observation Sheet.
4. Select two softened eggs about the same size and dry them to remove any surface moisture. Weigh eggs on a balance scale (they should be comparable). Place one egg in a cup of water and the other in a cup of corn syrup. (Egg will float in corn syrup, but there will be enough contact for the experiment to work.) Keep the eggs in the water and corn syrup for at least 45 minutes, removing, blotting and weighing at 15-minute intervals.

   What is happening? As the eggs soak, the egg placed in water will swell; becoming noticeably larger and heavier as the water diffuses through the membrane into the egg. The egg placed in the corn syrup will become smaller and lighter as the water inside it moves out through the membrane and into the corn syrup. The liquid will flow from a weaker to a stronger solution in an attempt to equalize the osmotic pressure inside and outside the egg.

5. Put a few drops of blue food coloring (until the water is dark blue) into a cup of water with the egg. The movement of water into the egg will become apparent as the egg takes on the color of the dye.
6. Next, move the egg into a cup of corn syrup, so the students can observe the colored water pass through the membrane and into the corn syrup.

   Note: The softened eggs can handle a good amount of handling and will keep for several weeks in a refrigerator; so, the activities may be done over several class periods. Results may vary from egg to egg.

   Note: The eggs can be switched back and forth between the corn syrup and water many times.

Extension Activities

1. *Test the freshness of eggs* - Place an egg carefully in a clear glass bowl of cold water. How old is the egg? A fresh egg will lie on its side on the bottom. At one week, it will seem to stand on its narrower end at the bottom. A very old egg will rise to the top and float in the water.

2. *Floating Egg* **-** Add salt to a glass of water until no more salt will dissolve. Gently put an egg in the salty water. The egg, fresh or old, will float because salty water is heavier than tap water. A heavier liquid easily supports more weight than a light one. That is the reason you float in the ocean.

3. *Hard-boiled vs. Raw* - Here's how to tell a hard-boiled egg from a raw one. On a flat surface, spin one egg, then another. The egg with the faster spin is the hard-boiled one—it's solid inside and spins evenly. The raw egg has a slower, wobbly spin because the raw insides are sloshing around.

Additional Resources

- http://www.agintheclassroom.org/TeacherResources/TeacherResources.shtml Illinois Agriculture in the Classroom Poultry Ag Mag & Reader
- http://co4h.colostate.edu/resources/covid/TheShell-lessEgg.pdf The Shell-Less Egg – Colorado 4-H – Colorado State University

Standards

Illinois Science Standard

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

Illinois English Language Arts Standard

RST 1: Cite specific textual evidence to support analysis of science and technical texts.

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Name ___________________________

Shell Porosity Observation Sheet

Hypothesis:

observation of shell with naked eye	
observation of shell with magnifying lens	
observation of shell with food coloring (wet)	
observation of shell with food coloring (dry)	
observation of egg white	

Name ___________________________

Membrane Permeability Observation Sheet

	corn syrup	water
hypothesis		
beginning weight		
15-minute weight		
30-minute weight		
45-minute weight		
60-minute weight		
75-minute weight		
90-minute weight		

Were your hypotheses correct? Form a conclusion as to why or why not.