SCIENCE, TECHNOLOGY, ENGINEERING, AND MATH
COLORADO STATE UNIVERSITY EXTENSION

ST[EMpower]

The Shell-Less Egg

Content Area
Science,

Grade/Age
3rd - Middle School

Tags
Acid-Base Reactions, Osmosis, Chemical Reactions

Learner Outcomes
- Describe acid-base reactions
- Identify parts of the egg and basic functions
- Cite common household acids
- Describe osmosis
- Determine the direction of water movement from higher to lower **potential**
- Explain how a **semipermeable membrane** works

Colorado Academic Standards: *Science*
Third Grade
2. Life Science
    1. Organisms have unique and diverse life cycles.

Fourth Grade
2. Life Science
    1 Organisms have both internal and external structures that serve various functions.

Fifth Grade
1. Physical Science
    2. Chemical reactions

BACKGROUND:
The egg is an amazing component. It has the ability to sustain and grow a chick embryo until hatch time, makes a healthy, protein filled breakfast on the run, or it even has porous properties that make it ideal for color changing fun during holidays!

This 2 part lesson will Introduce students to Acid Base Reactions and the concept of Osmosis.

In the first activity, youth observe the effects of acid on eggshells. At the end of the first experiment, students describe what reactions took place. Each youth uses three shell-less eggs for part 2. (We recommend having 3 shell-less eggs for part 2)

In the second experiment students view the properties of osmosis (water transfer) across the semipermeable egg membrane. Students' experiment with their shell-less eggs in different solvent combinations. Students determine either by mass or measurement, that water moves from high water to low water concentration, eventually reaching equilibrium.

The third experiment, a bonus experiment, uses gummy bears. Like the shell-less egg, they demonstrate the properties of osmosis. This can be used in addition to, or completely separate from the 2 part experiment, depending on your time restraints.

OPENING QUESTIONS:

1. What are the basic parts of an egg? (Chicken Egg): *Shell, Membrane, Egg White, Yolk, and Air Pocket.*

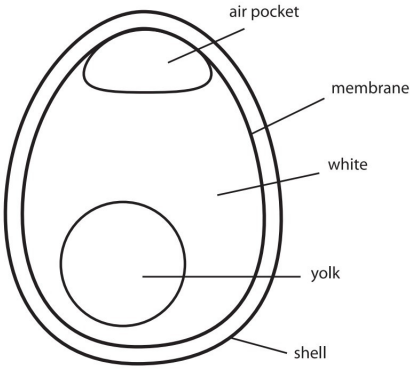
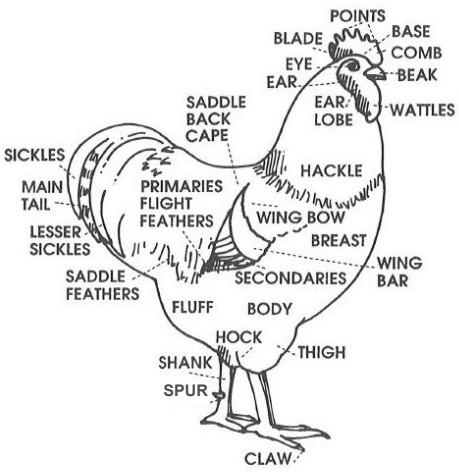


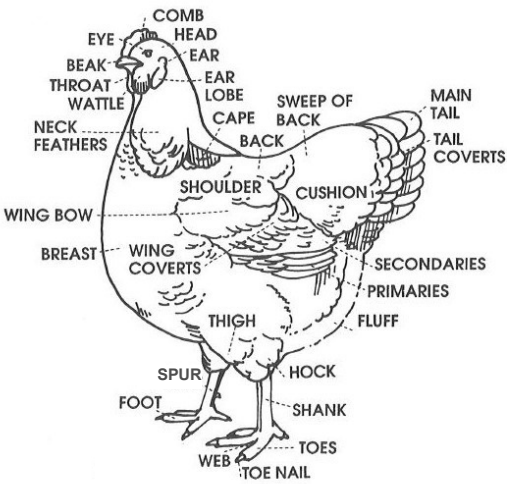
Photo credit: ScienceWorld.ca

2. What does a shell do for the egg? *Protection, Holds things in place, etc.*
3. What is a membrane? What does it do for the egg? *A membrane is a thin line of cells that surround the fragile inner components of the egg. It is semipermeable, meaning it will allow certain solvents to transfer across it.*
4. Why would movement of 'something' through a membrane be important?
5. What happens in a chemical reaction? *A process that involves the rearranging of molecules*
6. What are some uses for Vinegar? *Open discussion*
7. What does vinegar cause? C*hemical Reactions*
8. Does water move freely? This as a comparison: which has a higher concentration of water, and which has a lower concentration of water on each side of the **semi-permeable membrane**. Water will freely move from high to low. An egg's concentration of water is <u>higher</u> than corn syrup. An egg's concentration of water is <u>lower</u> than tap water. An egg has a <u>slightly lower</u> concentration of water than vinegar.
9. What is a pH? What is an acid? What is a base? A pH is an acronym for percent Hydrogen (atoms). If there are a lot of hydrogen atoms in a solution, the solution is acidic. If there is a small amount of hydrogen in the solution, it is basic. The higher the hydrogen content, the lower the pH value, so 0 (the most hydrogen)—6.9 (less hydrogen) is acidic. A pH value of 7 is neutral. Between 7.1 and 14 is basic.

FUN FACTS!

- You can tell if a chicken is going to lay a colored egg or a white egg by the color of her ear lobes.
- Eggnog is a well-known beverage made from eggs and milk. When making eggnog, eggs should be heated to 160°F (71°C) or you can use pasteurized shelled eggs or egg products.
- In 2019, it was estimated the average American ate 289.5 eggs per year.
- Egg White has long been used as a facial.
- An egg is a single cell. The extinct Elephant Bird from Madagascar had the largest known bird egg. The eggs weighed 22 pounds. They had a 36 inch diameter, and were 12 inches tall. It had a 2 gallon volume!
- The Ancient Chinese Stored Eggs up to several years by immersion in a variety of such imaginative mixtures as salt and wet clay; cooked rice, salt and lime; or salt and wood ashes mixed with a tea infusion. *They did not taste good by todays standards.*
- There is no significate difference between white and brown eggs; it is the chicken breed that makes the difference.





The Labeled Chicken from Colorado State University Extension, Pueblo County captured 4/9/2020 https://pueblo.extension.colostate.edu/programs/4-h/4-h-project-areas/livestock/livestock-tests-and-study-guides/

DO: SHELL-LESS EGG ACID / BASE REACTION

Time Needed:
Prep: 30 mins
Rx Time: 7 days

Today we are going to talk about the egg! Eggs come in many shapes and sizes, but most all contain the same basic parts.

- ***Shell:*** *Outer hard surface of the egg made primarily of calcium carbonate crystals.*
- ***Membrane:*** *Layer of cells under the shell that surround the inner fragile parts of the egg. Allows transfer of solvents and air across the membrane (semipermeable).*
- ***Air Pocket:*** *A sac of air within the egg used by chick upon final development.*
- ***Egg White:*** *The clear, viscous substance around the yolk of an egg that turns white when cooked or beaten.*
- ***Egg Yolk:*** *Yellow portion of egg filled with protein and fat.*

In todays experiment, we are going to look at **acid/base chemical reactions**. Specifically vinegar (an acid) and how it affects an egg's shell.

Materials:

- Large mouth pint or quart mason jar (1 per egg)
- White vinegar (enough to cover eggs plus a generous amount in addition)
- Raw egg/s in shell/s
- Mixing spoon
- Tape and pen to label
- Flexible measuring tape OR string and ruler

Procedure (Do for each egg):

1. Designate a "vinegar pouring station" to avoid vinegar waste.
2. Use a string to measure the circumference of the first egg. Use a ruler to find the length of the string.
3. Place that egg in a jar and label it with the string's measurement.
4. Repeat step 2 for each additional egg.
5. Cover the eggs with vinegar and store in a safe place. You should see bubbles forming on the shell.


Photo credit: Stephanie Lamm

6. The next day, use the big spoon to scoop out each egg from the vinegar.
7. Pour out the old vinegar and place the egg back in the jar.
8. Cover the egg/s with fresh vinegar and store in a safe place.
9. Every morning, check on the state of the egg/s without taking out of the jar, for about 3–7 days. **You only need to replace the vinegar after the first day.*
10. After a week, the egg/s should be translucent but still pretty much egg-shaped.
11. Carefully measure the circumference of the middle portion of the egg/s and record.

Do not break the eggs; you need them for the experiment!

that occur when substances are mixed can be identified by the emergence of substances with different properties; the total mass remains the same.

Middle School

1. Physical Science
   7. When two objects interact, each one exerts a force on the other that can cause energy to be transferred to and from the object.

POWER WORDS

- **acid**: a chemical compound that tastes sour and forms a water solution which turns blue litmus paper red
- **base:** a chemical that has a pH above 7. Usually substances like ammonia, bleach, or baking soda.
- **chemical reaction:** a process that involves rearrangement of the molecular or ionic structure of a substance, as opposed to a change in physical form.
- **circumference:** the enclosing boundary of a curved geometric figure
- **Rx**: reaction abbreviation
- **water potential**: a measure of how freely water molecules can move in a particular environment or system

Teacher Tip!
Make several extra "shell-less eggs" to use as a control in the next activity.

REFLECT:

- What occurs between the vinegar and the egg?
- When you first covered your egg with vinegar, what were the bubbles on the shell's surface? What evidence is there of chemical change?
- What reaction is involved to make the shell dissolve?
- What helps keep the egg's insides from pouring out?
- Is there a difference between the size of the egg at the beginning and at the end of the experiment? What do you think caused this change?

Explanation:

Describe an acid base reaction and what effects took place to egg shell. When you submerge an egg in vinegar, the shell dissolves, leaving the inner semi-permeable membrane intact.

Vinegar, the acid, breaks apart the solid calcium carbonate crystals (base) in the eggshell, separating them down to their calcium and carbonate parts. The calcium ions stay dissolved in the vinegar (calcium ions are atoms that are missing some or all of their electrons), while the carbonate molecules go on to make carbon dioxide gas. This is released in the form of the bubbles that were noticed both on the shell and in the solution of vinegar within the first 24hrs of the egg being submerged in the acid.

The acidic vinegar breaks down the shell but leaves the membrane that lines the inside of the shell intact. Some of the vinegar will cross the membrane and cause the egg to swell slightly. This is osmosis. If you gently shake the egg, you can see the yolk sloshing around in the white. If the membrane tears, the egg contents will spill just as a normal cracked egg, however the egg will taste 'pickled' if cooked* (*perfectly acceptable if kids want to taste a **Fully Cooked**, pickled egg).

Note to Teachers: Younger students may think that the outer shell has "transformed" into the membrane. Remind them that the outer shell and the inner membrane are two completely different layers.

APPLY AND EXTEND:

Take this experiment to the next level! Try these fun ideas to extend the learning for this activity.

- Try using different acid and base solutions. Compare the effects of vinegar, plain water, cola, and orange juice on the eggshell. What do the three liquids have in common? What about baking soda? *(**WARNING**: Never use bleach and ammonia. If you mix them, they react to make a poisonous gas that can kill you. One or the other should only be used in the presence of an adult!)* How do they differ?
- Repeat the same experiment with a hard-boiled egg. The eggshell will dissolve in the same way, leaving behind a rubbery egg that should actually bounce as long as it is only dropped from less than 50cm.

CHICKEN and EGG JOKES

Q: The egg police entered the crime scene. They stood horrified at the atrocity committed against the egg victim. What was the crime?
A: Poaching!

Q: What does a meditation egg say?
A: OHM-let!

Q: Who tells the funniest egg jokes?
A: A Comedi—hen!

Q: How can you drop an egg 6 feet without breaking it?
A: By dropping it seven feet. It won't break for the first six feet!

At a party, a magician was producing egg after egg from a little boy's ear. "There!" he said proudly. "I bet your Mom can't produce eggs without hens, can she?"
"Oh yes, she can," said the boy. "She keeps ducks."

Q: What happens when you tell an egg a joke?
A: It cracks-up!

Q: Why did the chicken cross the road?
A: To get to the other side!

Q: Why did the chicken cross the playground?
A: To get to the other slide!

Q: Why did the chicken cross the internet?
A: To get to the other site!

DO: SHELL-LESS EGG OSMOSIS

Time Needed:

Prep: 30 mins
Rx Time: 12 hours
Analyze: 20 mins

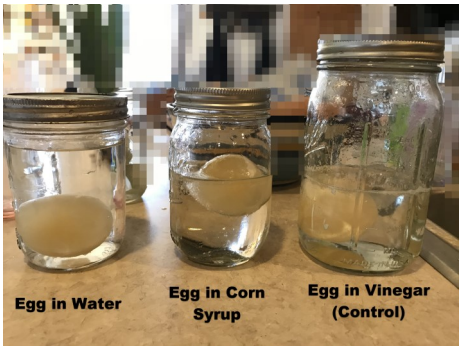
*In todays experiment, we are going to look at your egg's membrane and see how **osmosis** occurs.*

Materials:

- 3 large mouth quart mason jar (1 per egg)
- 3 shell-less eggs from part 1
- Corn syrup - enough to cover 1 egg
- 50% sucrose (sugar) solution (½ cup sugar dissolved into 1 cup of boiling water)
- Kitchen scale or string and ruler
- Tape to label each jar
- Pencil, pen, or marker
- Large spoon that fits into the jar mouth

Procedure:

1. Designate a "corn syrup and sugar solution pouring station" on your counter or desk to avoid waste.
2. To make your sugar solution, add 1 cup of water in a sauce pan and heat to boiling. Once boiling, slowly add sugar and stir. Continue until all 1/2 cup sugar is dissolved while boiling/ stirring. Set aside and completely cool before beginning experiment.
3. Carefully dry each egg. Weigh and record the initial weight. If you do not have a kitchen scale you can measure the circumference of the egg with a string and ruler.
4. Place 1 egg in 1 pint/quart jar. Repeat for other 2 eggs.
5. Label each jar with one of the following: Control (water), Corn Syrup, Sugar.



6. Cover each egg with the labeled solution. Place in the refrigerator.
7. Leave eggs fully submerged overnight or for a minimum of 12hrs.
8. After 12hrs, scoop out egg and observe the changes.
9. Weigh the egg again and record the differences.

REFLECT:

- Why is your naked egg that was soaked in vinegar bigger than a shelled egg?
- Why does the egg in corn syrup change shape and weight?
- Does the egg soaked in water change shape and weight?
- What happened to the egg soaked in the sugar solution?
- What is the purpose of a semipermeable membrane? What does it do for the egg?
- What could you do to return the egg to its original form?

POWER WORDS

- **diffusion:** the process of a substance spreading out to evenly fill its container or environment in order to obtain equilibrium (does not require a membrane)
- **equilibrium:** a state in which opposing forces or influences are balanced or equal
- **osmosis:** process by which water passes through a membrane from a high concentration into a lower concentration, thus equalizing the amounts of water on each side of the membrane.
- **semipermeable:** material or membrane, allowing certain substances to pass through it but not others, especially allowing the passage of a solvent but not of certain solutes.
- **solute:** the minor component in a solution, dissolved in the solvent.
- **solution:** a liquid mixture in which the minor component (the solute) is uniformly distributed within the major component (the solvent).
- **water potential:** the tendency of water to move from one area to another

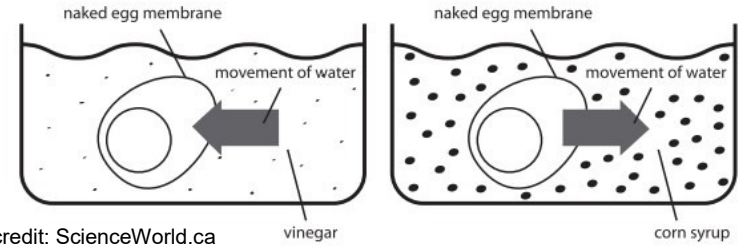


Photo credit: ScienceWorld.ca

Explanation:
Osmosis is a process where water moves through the use of water potential and a membrane. It is a special case of **diffusion**; which is the spreading of any substance from a higher concentration to a lower concentration and no membrane need be present.

In our experiment, water moves across the egg's **semipermeable** membrane until it reaches **equilibrium**. Simply stated, if there is a selectively permeable membrane separating two different concentrations of **solutes** in a **solution**, water will move from the side with the least number of solutes to the side with the greatest number of solutes. The higher water potential is the side of the membrane with the fewest solutes. The lower water potential is the side of the membrane with the most solutes. This can be confusing.

Remember that osmosis is simply the movement of water from a solution of high water content toward a solution of lower water content until the water is equally shared between the two solutions.

After dissolving the eggshell, students are left with a membrane that holds the insides of the egg. This membrane is selectively permeable. This means that it lets some molecules move through it and blocks out other molecules. Water, however, can move through the membrane easily. Bigger molecules, like the sugar molecules in the corn syrup, do not pass through the membrane.

Students may have noticed that the egg expanded in the initial vinegar solution when they dissolved the shell. This is because the vinegar has a higher concentration of water than the inside of the egg. To reach equilibrium, water molecules moved from the vinegar into the egg through the semipermeable membrane. If the membrane were completely permeable, water molecules would move in and protein would move out until both solutions were the same concentration. Since the egg membrane is semi-permeable, water can move in but proteins cannot move out.

When a shell-less egg is placed in the corn syrup, the egg will shrink. This is also due to osmosis, but in the opposite direction. The corn syrup is mostly sugar. It has a lower

FUN FACTS!

- It takes a hen between 24 and 26 hours to develop an egg. Once she lays an egg, the development of a new egg normally starts within 30 minutes.
- Chickens don't produce one egg at a time. Instead, producing hens normally have several eggs in various stages of development.
- The hen's diet determines the color of the yolk. Some producers feed natural supplements like marigold petals so that their hens lay eggs with brighter yolks.
- Because older eggs have larger air cells, they're much easier to peel than fresh eggs.
- Can't tell if that egg in the refrigerator is raw or hardboiled? Try spinning it! Raw eggs wobble as the liquid inside shifts, but hardboiled eggs spin smoothly.

Farmer's Almanac: https://www.farmersalmanac.com/15-egg-facts-you-may-not-know-21232

concentration of water than the egg. To reach equilibrium, osmosis causes the water molecules to move out of the egg and into the corn syrup until both solutions have the same concentration of water. The outward movement of water causes the egg to shrivel.

APPLY AND EXTEND:

Take this experiment to the next level! Try these fun ideas to extend the learning for this activity.

- Try submerging your shell-less eggs in other liquids. Make hypothesis about which direction water will travel and see what happens. Try food coloring, salt water, etc...
- Try returning the shriveled egg that was in the corn syrup back to normal. Carefully lift the flabby egg from the corn syrup and place it in a container of water. Leave the egg in the water for 24 hours. Osmosis will occur! After 24 hours, the egg will be plump again!
- Draw diagrams of each jar and the directions osmosis is occurring. Did osmosis occur with the vinegar from part 1? Diagram that movement as well.

CHICKEN ID

On page 2, there was a diagram of a rooster and hen, labeling the different chicken parts. Identify the following terms on the hen in the image on this page:

- head and neck
  - earlobe
  - ear
  - comb
  - eye
  - beak
  - throat wattle
  - neck feathers
  - cape
- body
  - back
  - sweep of back
  - fluff
  - breast
  - cushion
- wing
  - wing bow
  - wing coverts
  - primaries
  - secondaries
- tail feathers
  - main tail
  - tail coverts
- leg and foot
  - hock
  - thigh
  - shank
  - toe
  - spur
  - toe nail
  - web

DO: BONUS ACTIVITY! GUMMY BEAR SCIENCE!

Time Needed:

Prep: 30 mins
Rx Time: 12 hours

For younger kids or those looking to continue their fun with osmosis, try this similar experiment with gummy bears! You can also mix up your solutions and experiment with what direction water will flow in other types of mixtures.

Materials:

- Large mouth pint mason jar (1 per gummy bear)
- At least 4 gummy bears
- Corn Syrup - enough to cover each gummy bear
- Highly concentrated salt solution
- Tape
- 4 marker colors for outlining
- Large spoon

Make a prediction about what direction water will flow in each of your solutions; into or out of the gummy bear? Write these down for review at the end of the experiment!

Procedure:

1. Designate a "corn syrup and salt solution pouring station."
2. To make your salt solution, add 1 cup of water in a sauce pan and heat to boiling. Once boiling, slowly add salt and stir. Continue until salt will no longer dissolve while boiling/ stirring. Set aside and completely cool before beginning experiment.
3. Place 1 gummy bear in 1 pint jar. Repeat for other gummy bears.
4. Label each jar with one of the following: Control (No solution), Water, Corn Syrup, Salt.
5. Cover each gummy bear with the labeled solution. *Salt solution must be cool to avoid melting the gummy bear! Place in a safe spot.
6. Leave bears fully submerged for a few hours. We don't recommend waiting longer than 12 hrs.
7. After 12 hours, observe changes in gummy bears. You may scoop them out and place them side by side to compare sizes.
8. Hand out paper and colors to have youth outline a control (non soaked gummy bear), and then outline the other experimental gummies under the control to compare size changes. Label each bear's solution name.

REFLECT:

- What is a control? Which gummy bear was our control?
- What happened to the other gummy bears? (Discuss individually)
- What direction/s was water moving?
- What could we do to return the gummy bears to their original sizes?

Explanation:

Osmosis is a process where water moves from high concentration to a low concentration in the solutions. It is a special case of diffusion; which is the spreading of any substance from a higher concentration to a lower concentration and no membrane need be present.

In this experiment, the gummy bear is more sugar than water containing, Therefore, higher water containing solutions

OSMOSIS

Osmosis is a special case of diffusion.

- Diffusion is the free movement of molecules from a high concentration to low concentration.
- Free movement means that no energy is required for movement.

Diffusion makes sense.

- You are in a room and someone peels an orange. You can smell the orange. The smell diffuses through the air.
- You have a cup of water, and add some food color, at first the color swirls in the water, but eventually spreads out evenly in the entire cup of water. The color diffuses in water.

Without the semi-permeable membrane, the solutes in water (or any other liquid) would move from a high concentration to low concentration of solutes. Eventually the solutes (salt or sugar in our example) will be distributed uniformly throughout the water.

Osmosis requires a semi-permeable membrane. The membrane allows water to move through, but blocks any solutes (like sugar or salt dissolved in the water. Water will move into a higher concentration of solutes.

Note: Some expansion may be noted with the salt solution since you might not be able to completely saturate the solution with salt.

should travel into the gummy bear (expanding it) while high sugar or salt containing solutions should, ideally, not have a large effect on the size of the gummy bear.

APPLY:

Guide your sibling or parent to do the Gummy Bear Science experiment. Help your "student" understand the experiment by explaining what happened.

"The Great Gummy Bear Migration"
by Stephanie Lamm

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ACKNOWLDGMENTS:

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- Chicken and Egg images: Kate Edmunds

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⇒ Shaw, B. J. (2005). *Osmosis Lab.doc;* Portland State University.

Supplemental Information

Activity 1 & 2 Worksheet:

The worksheet for these activities can be downloaded from our website: www.tra.extension.colostate.edu

Please click the below link to be directed to our STEM Teacher Resources - where you can download a Word or PDF version of the worksheets that follow along with this Lesson Plan.
https://tra.extension.colostate.edu/stem-teacher-resources/

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