High School Lesson Plans

Best-Boiled Plans

Overview:

In this lessons, students investigate popular recipes for hard-boiling eggs with easy-to-peel shells and determine which approach is most scientifically sound. Students explore examples that add baking soda and vinegar as part of their recipe. Students then explain how egg proteins change during physical and chemical reactions.

Time Frame: 3 class periods (45 minutes each)

Objectives:

Students will:

- Identify physical and chemical reactions
- Explain physical and chemical reactions when hard-boiling an egg

Next Generation Science Standards

- **HS-LS1-1** Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells
  - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1)
- **HS-PS1-5** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs
  - Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

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Materials:

- Egg-vestigative Team #1 Investigation sheet
- Egg-vestigative Team #2 Investigation sheet
- Beakers
- Hot plates
- Eggs
- Baking Soda
- Vinegar
- Water
- Ice
- Computer(s) with access to the Internet
- Optional Resource: *The Parts of the Egg*

Background Information:

Scientists divide changes in matter into two categories: physical and chemical. A physical change is a change in the appearance or physical properties of a substance. A physical change does not make a new substance. For example, tearing a piece of paper in pieces is a physical change. A chemical change is a change that makes a new substance. Burning a piece of paper is an example of a chemical change. The ashes left over by the burning process no longer look and feel like the paper you started with. It has been chemically changed into different substances that have different properties.

Students will be able to classify different interactions with an egg into physical and chemical changes. For example, when peeling an egg you are engaging in a physical change. The boiling of the water itself is also a physical change. The egg becoming hard-boiled is a chemical change.

Engage: (10 minutes)

1. Guide students to review the following list of actions and identify similarities:
    - A grape when stepped on
    - Metal rusting
    - Stomach digesting food
    - Blowing up a balloon
    - Liquid water turning to ice
    - Toasting a marshmallow
    - Mixing salt and sugar

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2. Challenge students to reconsider the list and narrow the actions into two categories.
3. Reveal the two categories of ***physical*** and ***chemical*** changes with the correct actions sorted. Ask students to describe similarities and differences between the physical changes and chemical changes.
4. Explain to students they will be investigating physical and chemical changes in eggs as they investigate different methods for cooking an easy-to-peel hard-boiled egg.

Explore: (30 minutes)

1. Explain to students that hard-boiled eggs, egg salad, egg salad sandwiches, Cobb salad, and deviled eggs are all a lot easier to prepare if you can get the stubborn eggshell off! Various recipes insist that the best method for cooking easy-to-peel hard-boiled eggs require fresh eggs, older eggs, the addition of vinegar, the addition of baking soda, bring the water to a boil with eggs in the pot, adding eggs to boiling water, and on and on! So, what is the best method for boiling an egg with an eggshell that is easy to peel? In this lesson, students will be testing two different methods.
2. Group students into teams of 3 or 4. Assign each team either a #1 (Baking soda) or #2 (Vinegar). This will allow for multiple trials.
3. Distribute the ***Egg-vestigation*** recording sheets to each group. Guide students through the directions and clarify any questions. Make sure to point out the rating scale so students understand what to look for when peeling the eggshells.
4. Provide at least 20 minutes for students to investigate. ***Be sure to monitor students' use of the hotplates and hot water as they complete the investigation.*** When all groups are finished, collect and record the class data on the table below. Display the data so all students can see it. Ask students to provide an explanation for their selection.

Group	Baking Soda Rating	Vinegar Rating	Physical or Chemical Change?

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Explain: (30 minutes)

1. Invite students to analyze the results of their class (and other classes if applicable for a larger sample).
2. Have students work in their teams to explain the physical and chemical changes taking place in the egg and eggshell. Encourage students to use the Internet to gather information about the relationship between the properties of the eggshell and their results. (An optional resource is suggested.)
3. If time allows, challenge each group to create and present a paper slide video to explain why vinegar and baking soda helped make the shell easier to peel. Students should use the following vocabulary in their explanation: ***acidic***, ***basic***, ***protein***, ***amino acids***, ***heat***, ***chemical change***, and ***physical change***.

Elaborate: (30 minutes)

1. Invite students to use the Internet to identify other techniques that claim to help make peeling a boiled egg easier. Encourage them to use what they know about chemical and physical changes to select and test new methods. Continue the investigations in class and collect and display the additional data to identify best methods.

Evaluate:

1. Review student paper slide videos and explanations using the provided vocabulary.

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Best-Boiled Plans Student Handout

Egg-vestigative Team #1 Investigation Sheet

1. Select two raw eggs.
2. Place one in a beaker with 1000ml of plain cold water.
3. Place one in a beaker with 1000ml of plain cold water plus a half teaspoon or 3 grams of baking soda.
4. Starting with the eggs in cold water, bring the water to a rolling boil using a hotplate.
5. Take them off the hotplate and let the eggs sit, covered, for 10 minutes.
6. Place in an ice bath until they are cool enough to handle.
7. Peel the eggshells off and assign a rating.

Egg	**Rating** *(very easy, easy, moderate, somewhat hard, hard, very hard)*	**Notes**
Plain cold water		
Cold water with baking soda		

Best-Boiled Plans Student Handout

Egg-vestigative Team #2 Investigation Sheet

1. Select two raw eggs.
2. Place one in a pot with 1000ml of plain cold water.
3. Place one in a pot with 1000ml of plain cold water plus 2.5 mL of vinegar.
4. Starting with the eggs in cold water, bring the water to a rolling boil using a hotplate.
5. Take them off the hotplate and let the eggs sit, covered, for 10 minutes.
6. Place in an ice bath until they are cool enough to handle.
7. Peel the eggshells off and assign a rating.

Egg	**Rating** *(very easy, easy, moderate, somewhat hard, hard, very hard)*	**Notes**
Plain cold water		
Cold water with vinegar		

High School Lesson Plans

Walking on Eggshells?

Overview:

Even though eggshells have a reputation for being fragile, they are extremely strong! In this lesson, students balance, float, and step on eggs to test their unique structural properties. They then propose a method to dissolve an egg's strong outer shell, design an experiment, and test their hypothesis to see what can pass through the now exposed membrane.

Time Frame: 3 class periods (45 minutes each)

Objectives:

Students will:

- Determine the direction of water movement based on solution concentrations
- Examine the properties of an eggshell to explain their unique design

Next Generation Science Standards

- **HS-PS1-3** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles
  - The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.

Materials:

- Station Directions handout
- Properties of Eggs recording sheet
- Passing Through! Investigation handout
- Water
- Celery stalks (for the teacher)
- Plastic containers/cups
- Eggs
- Books
- Salt
- Vinegar
- Corn syrup

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Walking on Eggshells?

Background Information:

Eggshells are extremely strong. They are actually a natural example of an arch. The shape of an arch distributes the forces evenly along the weight-bearing piers that support the arch. The overall shape allows it to eliminate tension stress.

Once through this hard outer shell of an egg, you will find a very unique membrane. A selectively permeable membrane allows some types of molecules to pass through, but not all. Organisms have a cell membrane that is selectively permeable and regulates what enters and leaves the cell. Food and oxygen move into cells across the membrane through the process of diffusion. Osmosis diffuses water across a selectively permeable membrane. In this lesson, students will be experimenting with an egg membrane to explore this concept.

Engage: (20 minutes)

1. Students will visit different stations to investigate basic properties of eggs and capture their observations. Invite students to visit several stations in groups of 3 or 4.
2. Guide students to use the information gathered during their station investigations to complete the questions on the ***Properties of Eggs*** recording sheet. Students may also incorporate their prior experiences or background knowledge.

Explore: (40 minutes)

1. Explain to students that eggs need to be strong for adult birds to sit on them (without breaking them) and keep them warm. The eggshell is made of a protein and calcium. This allows oxygen to enter and carbon dioxide to leave. A membrane lines the shell and is very strong. This enables the egg to hold the contents in, even without the shell! Is it possible to see the cell membrane without the shell?
2. Present the following molecule on the board: ***CaCO3***.
3. Invite students to identify the elements that make up the molecule. It is anticipated students will identify ***Calcium***, ***Carbon***, and ***Oxygen***.
4. Explain that eggshells are made of ***calcium carbonate***, CaCO3. When an eggshell is successfully dissolved it produces a ***carbon dioxide*** gas. The equation is shown below.
   CaCO3 + CH2COOH -> Ca2++ H2O + 2CO
5. Ask students to identify what substance was used to dissolve the shell using the following equations:
   - Vinegar: ***CH3COOH***
   - Citric Acid: ***C6H8O7***
   - Ammonia: ***NH3***

Walking on Eggshells?

6. Explain to students that in order to dissolve the shell, they will soak the eggs overnight in vinegar. Guide teams to place a raw egg in a container and submerge it in vinegar.
7. On Day Two, after the membrane is exposed, ask students if they think anything can get in and out of the now-exposed membrane. Students might remember that gasses are able to pass through the shell, but can anything else get in or out?
8. Invite students to read the following explanations and select one that they believe best answers the question, ***How do different solutions effect the movement of water across an egg cell membrane?***:
   - Water molecules move out of the cell because the concentration of water is greater inside the cell than outside the cell.
   - Water molecules move out of the cell because the concentration of water is less inside the cell than outside the cell.

   Ask students to provide an explanation for their selection.

Explain: (30 minutes)

1. Invite students to complete the Passing Through! Investigation using the eggs with the exposed membrane. This will occur over several days.
   Teacher Note: While the students are investigating with their eggs, set up two celery stalks – one in water and one out of water and allow them to sit for three or four days.
2. Once the student investigation is completed (after three or four days), use the celery stalks to create an analogy of what happened in their experiment. One container shows a healthy celery stalk and the other a wilted stalk. Osmosis is the process that causes water to pass through a living cell. When water moves into a plant cell, the cell expands. The full cells allow the plant to stand upright. If there is not enough water the cells will not be full and the plant will wilt. Water molecules will move from areas of high to low concentration to establish equilibrium. Demonstrate this by drawing the movement of molecules in each of the celery stalks.
3. Ask students to use their data to answer the following questions:
   - Which explanation for the movement of water molecules is the most accurate based on your experiment? If necessary, consider the celery stalk analogy.
   - How did you gather your data?
   - How did you analyze or interpret your data?
   - Why does your evidence support claim?

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Walking on Eggshells?

Elaborate: (45 minutes)

1. Invite students to use the same procedure to test other liquids to see if they will pass through the egg membrane.

Evaluate: (10 minutes)

1. Ask students to describe what happened in each container by drawing the molecules passing in and out of the membrane.

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Walking on Eggshells? Student Handout

Properties of Eggs

Before you begin the stations, which of the following statements are true?

1. I can squeeze an egg without breaking it. _____
2. Books can be piled on an egg without it breaking. _____
3. Eggs can float in water. _____
4. Hard boiled eggs will spin faster than a raw egg. _____

Record your observations at each station. When you complete all of the tasks, answer the provided questions.

Station	Observations	Questions
Strength!		Where have you seen arches that have a similar dome shape as the egg?
Do Eggs Float?		Why did the egg float when salt was added to the water (density of the egg versus the salt water)?
Twirl!		Which egg had more inertia (kept moving)?

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Walking on Eggshells? Student Handout

Station Directions

Station #1 Strength!

Test #1:

1. Place a raw egg in the palm of your hand.
2. Squeeze firmly, but with even pressure.

Test #2

1. Place your thumb and index finger on the ends of the egg.
2. Squeeze firmly.

Test #3

1. Collect four raw eggs.
2. Crack off the smaller ends of the eggs and dispose of the inside.
3. Rinse the egg halves with water.
4. Make each shell dome the same size using scissors to trim the edges of the eggshells.
5. Arrange the shells on a flat surface and make a quadrant.
6. Balance a book evenly on the shells. Keep adding books until a shell breaks.

Station #2 Do Eggs Float?

1. Fill a jar with water and place an egg inside.
2. Remove the egg and add salt until the egg floats.

Station #3 Twirl!

1. Collect one raw egg and one hard-boiled egg.
2. Place both eggs on their side.
3. Spin the eggs using your finger.
4. Quickly stop the motion using one finger and lift your finger away.

Source: Adapted from livescience

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Walking on Eggshells? Student Handout

Passing Through! Investigation Sheet

In this activity, you will model how a cell membrane works to let water enter and exit the cell. You will use a chicken egg as a model of a cell membrane. After dissolving the shell in vinegar to expose the membrane, the egg will soak in various liquids. Observe how the size (circumference) of the egg changes as it takes on or loses water through the membrane.

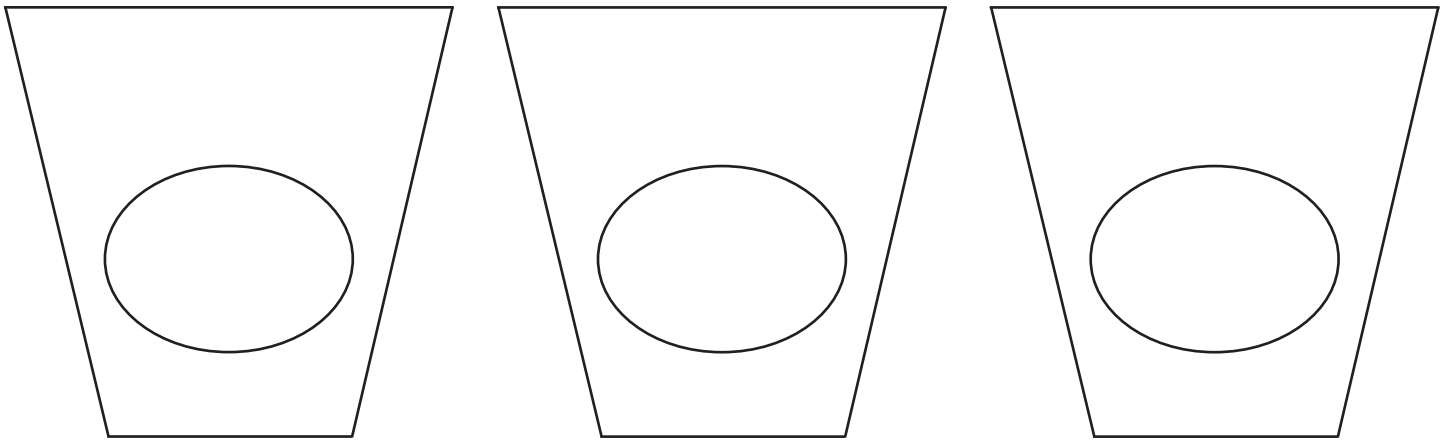
1. Observe the features of an egg and measure its mass. Record your observations and measurements on the table provided.
2. Place your egg in a cup.
3. Cover the egg entirely with **vinegar**. After one day, record your observations and measurements.
4. Pour the vinegar down the sink. Wash and rinse the cup thoroughly.
5. Place your same egg back into the empty cup.
6. Cover the egg entirely with **maple syrup**. After two days, record your observations and measurements.
7. Pour the maple syrup down the sink. Wash and rinse the cup thoroughly.
8. Place your same egg back into the empty cup.
9. Cover your egg entirely with **distilled water**. After two days, record your observations and measurements.

Date	Liquid	Circumference of egg in mm	Other Observations

Walking on Eggshells? Student Handout

Summary

Directions: Describe what happened in each container by drawing the molecules passing in and out of the membrane.



High School Lesson Plans

Whites and Yolks

Overview:

In this lesson, students compare nutritional benefits of egg yolks and egg whites and determine the health benefits and nutrients of each. Students build understanding that both the egg yolk and egg white have unique chemical and physical properties and explore how and why eggs are used in different applications, such as cooking and baking.

Time Frame: 2 class periods (45 minutes each)

Objectives:

Students will:

- Identify the properties of proteins and amino acids
- Examine how egg whites and yolks are used in preparation methods
- Explain how chemical and physical reactions are used to cook and bake using eggs

Next Generation Science Standards

- **HS-LS1-1** Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells
  - All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells. (HS-LS1-1)

Materials:

- Paper
- ***Sketch it Out!*** student handout
- ***Egg Preparation Chemistry*** student handout
- Optional Image: *http://biosocialmethods.isr.umich.edu/epigenetics-tutorial/epigenetics-tutorial-gene-expression-from-dna-to-protein/*

High School Lesson Plans

Whites and Yolks

Background Information:

Proteins are macromolecules made of amino acids and they are coded by our genes. A gene is a segment of a DNA molecule that contains the instructions needed to make a protein. All of our cells contain the same DNA molecules, but each cell uses a different combination of genes to build the specific proteins it needs to perform its specialized functions. Proteins are more than 50% of the dry weight of most cells and are important in every cellular process. Proteins are folded into shapes and held by chemical bonds. Proteins can be classified according to their structure or function. Their three dimensional shape is critical to its function. Eggs are a great source of protein. An egg's protein structure changes in different ways depending on how it is cooked. This makes eggs ideal for use in a variety of recipes and preparations.

Engage: (15 minutes)

1. Ask students to write "proteins, eggs, cooking, baking" at the top of a sheet of paper.
2. Have them list as many terms, facts, ideas, concepts, definitions, or experiences as they can in two minutes.
3. After two minutes have passed, have students turn to a partner and compare lists.
4. Ask each group to share one or two items they wrote down and write their ideas on the board.
   Teacher Note: You may want to collect the lists to use as a pre-assessment of what the students recall and what critical ideas are missing.

Explore: (20 minutes)

1. Explain to students that eggs are a good source of protein, are prepared in many dishes, and have a variety of applications in consumer products. The key to understanding how eggs are so versatile lies in understanding their protein structure.
2. Explain that there are 20 different amino acids that are the basic building blocks for proteins. They may already be in your body or in something you can eat, but all have a similar structure. If possible, show students an image of protein composed of amino acids. (An optional image is provided.)
3. Invite students to review the descriptions of different cooking methods in the ***Sketching it Out!*** handout. Each preparation method describes a different way to cook or prepare food with an egg.
4. For each method, ask students to first sketch out the method being described.
5. Next, ask students to predict what type of preparation is being described in each method. Present the three methods: ***cooking***, ***emulsification***, and ***mixing*** to check their predictions. Each method describes a unique property eggs exhibit when manipulated for different recipes. Sometimes a completely new substance is formed with the egg and other times the egg is part of a mixture. Scientists describe these changes as ***physical*** and ***chemical***.

Whites and Yolks

6. Provide the following definitions that help describe the processes happening as the egg is prepared:
   - **Chemical change:** Any change that results in the formation of new chemical substances
     - At the molecular level, chemical change involves making or breaking of bonds between atoms.
   - **Physical change:** Rearranges molecules but does not affect their internal structures
7. Ask students to classify which cooking method is being explained and illustrated in each description as either a chemical or physical change.
8. Explain to students that no matter the preparation method, the protein structure changes in some way.

Explain: (40 minutes)

1. Share with students a variety of images of foods in which eggs are a main ingredient, such as crème brulee, flan, Hollandaise sauce, Pavlova, mayonnaise, huevos rancheros, soufflé.
2. Invite students to briefly research each food item and identify which parts of the egg are being used: the yolk, the egg white, or both.
3. Tell students that eggs are used in dishes everyone enjoys throughout the day, from hearty breakfasts to rich desserts. Chefs and home cooks use the properties of eggs to create delicious dishes. Using ***Egg Preparation Chemistry*** (and any other resources available in the classroom), guide students to use their learning about proteins, amino acids, and bonding to describe how each dish uses a different preparation method.

Elaborate: (20 minutes)

1. Ask students to consider the health benefits of both parts of the egg and predict whether egg whites are healthier than egg yolks by displaying the major contents of each. Engage students in a discussion about the meaning of “healthier” and ask them to support their predictions with evidence.
   - Egg yolk: 48% water and 17.5% protein
   - Egg white: 88% water and 11% protein
2. Invite students to check their prediction by researching if egg whites are healthier than egg yolks.

Evaluate: (5 minutes)

1. Collect student explanations included on ***Egg Preparation Chemistry***.

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Whites and Yolks

Sketch it Out!

Directions: Using the descriptions below, sketch out what is happening in each egg preparation method below.

Preparation Method #1	Preparation Method #2	Preparation Method #3
As the egg is cooked, the molecules vibrate. The bonds break and the proteins unravel. They form new bonds and the egg becomes a solid.	Some amino acids are attracted to water while others are repelled by water. Egg proteins include both types. When the egg is exposed to the air and part of it is in water the proteins uncurl and bond with each other. This holds the air bubbles in place. Even when you cook them the bubbles will stay intact.	Amino acids that repel and attract water are found in egg yolk. Since they have both types they can act as emulsifiers. This means the eggs in proteins can stick to the water and oil, making a uniformed substance.

Whites and Yolks Student Handout

Egg Preparation Chemistry

Preparation Method	Description	Example and description of preparation in that dish
Cooking	When the egg is cooked the molecules vibrate. The bonds break and the proteins unravel. They form new bonds and the egg becomes a solid.	
Mixing	Some amino acids are attracted to water while others are repelled by water. Egg proteins include both types. When the egg is exposed to the air and part of it is in water, the proteins uncurl and bond with each other. This holds the air bubbles in place. Even when you cook them, the bubbles will stay intact.	
Emulsifier	Amino acids that repel and attract water are found in egg yolk. Since they have both types they can act as emulsifiers. This means the eggs in proteins can stick to the water and oil, making a uniformed substance.	