Denaturing Egg Proteins

Estimated Time: 45 minutes

SUMMARY
Egg whites cook fastest with heat, but that's not the only way to cook an egg. In this activity, students learn about the complex chemistry of proteins by studying different methods of "cooking" eggs with heat and comparing those with other egg white cooking methods.

WHAT YOU'LL LEARN

- About pH
- Basics of protein chemistry
- The effects of various chemicals on proteins

Materials Used	
• Test liquids: Various household liquids, including: water, vinegar, lemon juice, soda (Coke works especially well), rubbing alcohol, nail polish remover, pickle juice, etc. • 1 fork, straw, or toothpick to stir • 1 glass cup or bowl of water	Per test liquid: • 1 small cup (a medicine cup or paper bathroom cup (3 oz) works fine), preferably clear • 1 tablespoon of egg white (a small carton of egg whites from the store works very well) • 1 tablespoon of the test liquid
Resources Used	
Protein Structure Video - https://www.youtube.com/watch?v=hok2hyED9go	

WHAT TO DO

1. Set out cups for each of the liquids you want to test. Set up a glass or bowl of water to use to rinse your stirring utensil.
2. Separate egg whites from yolks. Add 1 tablespoon of egg white to each cup. Let the egg whites sit until they're roughly room temperature.
3. Prepare a data collection table to record the observations you make. Your data collection table might look something like this:

Test Liquid	Color	Initial Notes	Notes After 15 min	Notes After 30 min
Hot Water	Clear	Turned white immediately	Hardened	Almost completely hard and white

Lemon Juice	…	…	…	…

4. Add 1 tablespoon of liquid into each cup, gently stir the liquid into the egg white, and record observations, rinsing the stirring utensil in water to prevent contamination.
    a. Adding room temperature water to one serves as a good "control" to show that it's the special properties of the liquids affecting the egg whites.
    b. Rubbing alcohol, nail polish remover, and hot water (it doesn't need to be boiling, but eggs poach around 160 degrees, which is a good goal) cook eggs pretty thoroughly. These three liquids are recommended in addition to the acidic options.
    c. When you add the egg whites to a carbonated drink, the carbonated drink will foam. This foam does not dissipate and can be confusing. It is best to use flat carbonated drinks. To flatten the carbonated drink, let it sit open overnight or stir the soda to release the carbonation.
5. Stir and record observations again after about 15 minutes and 30 minutes, rinsing the stirring utensil in between liquids.
6. While waiting, the video in the Resources section is a kid-friendly video about protein structure. The video covers college-level concepts, but at a level where kids can understand the concepts. This video does an excellent job of explaining what proteins look like and how they are made. It also helps describe what the various liquids do to the proteins. The last two minutes of the video cover denaturing proteins which is what happens when you expose the proteins in egg whites to the various liquids.
7. Egg whites are made from a few proteins. The proteins at their typical temperatures and pH are a liquid, but when they are "cooked," the proteins are changed from their natural state and are called "denatured." The bonds within and between these proteins are broken, form new bonds, and change the structure of the proteins. The liquids will do this in a few different ways:
    a. Hot water will cook eggs in a traditional way, breaking bonds that keep the protein folded and leaving it solid. The egg white will poach in parts like you're making eggs benedict.
    b. Rubbing alcohol and acetone-based nail polish remover will break bonds in a similar way to heat but can also form bonds directly with the protein to keep it from folding normally.
    c. Acidic liquids (lemon juice, vinegar, hydrochloric acid, carbonated drinks, etc.) add hydrogen ions to the liquid, which changes how bonds form in the proteins. This won't cook the eggs to the extent you're used to with heat unless you're using a strong acid like hydrochloric acid. Instead, what you'll see is strands and chunks of "cooked" egg whites. These show how some of the proteins started to form abnormal bonds, so they were "denatured."
    d. Pickle juice, and other less acidic liquids, will not be strong enough to denature proteins. This is a great way to show that a level of acidity is needed to denature the proteins.

TIPS

- Buying a carton of egg whites at the grocery store can save a lot of work and should provide enough egg whites to do this experiment several times.
- Younger kids may not be able to record observations, but asking them to make observations about what they see in the mixtures is still important.

- Older kids may be able to take more in-depth observations about the proteins they see, the rate at which they are denatured, and may develop further questions.
- An extension starts from your own questions. The structure of the activity provides a framework for testing proteins, but any variation you can come up with forms a brand new experiment. Identifying exactly one independent variable (thing you're changing between each cup) ensures that you can make a valid claim at the end without having to sort through which variable caused the change. Some example follow up experiments can include:
    - Applying different temperatures of water to egg whites.
    - Varying the temperature of one of the test liquids and adding it to each.
    - I did this experiment with different ratios of egg white to test liquid to find a good balance between what works and not using too many materials for this activity, but that would be another useful experiment.
    - Trying egg yolks or a mixture of egg white and egg yolk.
    - Adding water to dilute the protein and test liquid to look for changes.
    - Letting the mixture sit in a cold or warm place to measure the rate at which the proteins denatured.