Discovering Enzymes

Author(s): Pascale Chenevier and Gil Toombes (Updated by Andrea De Micheli and Tim Bumpus)

Date Created: 2000/Updated October, 2015

Subject: Chemistry

Grade Level: Middle & High School

Standards: *Next Generation Science Standards (www.nextgenscience.org)*

MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.

Schedule: One or two 40-minute class periods

CCMR Lending Library Connected Activities:

Objectives:	**Vocabulary:**
Learn the principles of how enzymes work by showing the breakdown of proteins with household enzymes like hydrogen peroxide.	Enzyme Protein Catalyst Control
Students Will: Explore and discover the properties of proteins Demonstrate the breakdown of proteins with hydrogen peroxide Review and discuss the concepts they learned	**Materials:** **For Each Group (3-4 students):** Hydrogen Peroxide (3%) Plastic Pipettes Baking soda Vegetable oil Bleach Acetone Vinegar Salt Cheesecloth ***Glass test tubes**** ***Test tube rack**** ***Blender**** ***Raw Meats**** ***Soil*** ***Sand*** ***Potatoes (4 or 5)**** ***Eggs (3 or 4)**** ***Hot Water**** ***Ice**** **For Each Student:** Reading: "What the Heck is an Enzyme?" Activity Sheet 1:*Enzyme Activities* Gloves Safety Goggles ***Provided by the teacher***
Safety	Hydrogen peroxide should be handled with care as it is a dangerous chemical. Students should protect their eyes, skin and clothing to prevent injury.


Science Content for the Teacher and Class:

What the Heck is an Enzyme? *Bugs in the News*. 29 Jan. 2007.
http://people.ku.edu/~igmdoc/enzyme.html

Preparation:

1. See the Supplemental Information section to better understand the experiment.
2. Photocopy print materials (Reading: What the Heck is an Enzyme? and *Activity Sheet 1*) for each student.
3. Give Reading out to students prior to class.
4. Prepare potato juice using blender and centrifuge or cheesecloth.
5. Distribute materials evenly to each student.

Classroom Procedure:

Day One

Engage (Time: 10 mins)
Discuss background information on enzymes and define vocabulary terms with the students. Make sure they understand the concepts just learned.

Explore (Time: 30 mins)

Hand out materials (including Activity Sheet 1) to each student. Tell students they will be conducting 3 experiments to test which foods and household products produce chemical reactions, as well as how to change the speed of those reactions. Allow students to work on each activity at their own pace. Assist as necessary. If students have not completed all of Activity Sheet 1 by the end of the class period, then use time on day 2 to do so.

Day Two

Explore (Time: 25 mins)
Finish up any of the lab activities. Review the concepts that were learned during the previous class time and discuss the experiments they completed. Allow students to continue working on the activities.

Explain (Time: 15 mins)
Engage in a question and answer session about the assignment. Discuss the basic principles of enzymes and proteins. Make sure students understand all of the vocabulary terms learned during this activity.

Assessment:

The following rubric can be used to assess students during each part of the activity. The term “expectations” here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

1= exceeds expectations
2= meets expectations consistently
3= meets expectations occasionally
4= not meeting expectations

	Engage	Explore	Explain
1	Shows leadership in the discussion and an in depth understanding of proteins and enzymes.	Completes work accurately while providing an explanation for what is observed.	Provides and in-depth explanation of findings and makes excellent use of vocabulary terms. Fills out worksheet clearly.
2	Participates in the demo and shows an understanding of proteins and enzymes.	Completes work accurately.	Provides clear explanation of findings and uses vocabulary terms. Fills out worksheet clearly.
3	Contributes to the discussion, but shows little understanding of proteins and enzymes.	Makes some mistakes with the procedure.	Provides a limited explanation of findings, uses some vocabulary terms. Fills out some of the worksheet.
4	Does not participate in discussion. Shows no understanding of proteins or enzymes.	Does little to complete the procedure.	Is not clear in explanation of findings, does not use vocabulary terms. Does not fill out worksheet.

Supplemental Information:

Notes for Instructors:

Safety Information:
The adult should insist that hydrogen peroxide is a dangerous chemical: the students must protect their eyes with safety glasses and to avoid contact with the skin (and with their clothes, as far as possible, some colors could fade away), for example by wearing gloves, using pipettes to count hydrogen peroxide solution drops, and closing the bottles as soon as they are finished.
If a student spills chemicals on themselves, wash away the chemical with excess water.

Tips for the Activity:
The aim of this activity is to play with proteins and discover their properties such as catalytic activity, structural features and stability/fragility. We will use proteins from very common sources:

Potato Juice	We are interested in catalase, an enzyme which catalyses the dismutation (break-down) of hydrogen peroxide,
Egg White	We are especially interested in albumin, the main component, which has a structural role in the egg white gel,
Anything we can find in the room	

Fresh potato shows an interesting chemical activity. When dipped in a solution of hydrogen peroxide, it triggers bubbling of oxygen. This activity is due to a special protein produced by the potato to protect itself against oxidative stress. Oxidative stress is very common on our planet because of our oxygen rich atmosphere. Children could be invited to tell what they know about oxidation and give practical examples: they may know, for example, that iron is oxidized into rust by oxygen from the air, a process accelerated by water and salt. Or they may know that the skin is sensitive to oxidative agents called “free radicals” for which cosmetic manufacturers design special “anti-age” creams (often containing vitamin C as the anti-oxidizer). Or they may know that UV light shining on oxygen (O_2) turns it into an even stronger oxidant, ozone (O_3), which is in the ozone layer or in copiers, and that ozone is dangerous (everybody can recognize the smell of ozone because of copiers). The enzyme in potato is called catalase. An enzyme makes a reaction happen faster. If you let hydrogen peroxide sit in a container


for long enough (months at room temperature) bubbles of oxygen would be released. The catalase in potato juice breaks the hydrogen peroxide down much, much faster.

What is nice with this activity is that the children are free to build their own experiment and to discover by themselves, so that you should not tell in advance what the result will be (very often, anyway, we would not know…).

For activity one, students should feel free to try many different materials. Adults should guide students to build a protocol for testing each substance in a safe and accurate way.

Students should write a short description of the test, predict (or guess) the result they expect (and why, if possible), carry out the experiment and record the result. For example, a test of grass, salt and potato might go like,

Example: Activity of grass and salt

Test Tube One	Three blades of grass + 10 drops of hydrogen peroxide solution.
Test Tube Two	Volume of salt (approximately equal to volume of grass) + 10 drops of hydrogen peroxide solution.
Test Tube Three	Slice of potato (same volume as salt and grass) + 10 drops of hydrogen peroxide.

Measurement:
Watch each test tube carefully for 2-3 minutes to see how many bubbles form.

Prediction:
The salt won't do anything. Salt isn't alive. Grass will work just like potatoes.

Result:

We included the potato so we could compare the activity of each substance to potato, as we know that works!

In general, catalase and other peroxidases are present in all plants and animals living under aerobic conditions for detoxification (although their exact roles are not well understood, in part because the role of oxidants in living organisms are not well understood either). They contain an iron atom in a heme, just as


hemoglobin, the oxygen carrier in the blood.

To make potato juice for activity two, we will puree several potatoes in a blender. The puree works well, but the juice (with catalase) and the solids are still mixed. We can separate the juice with a small centrifuge. This part should be quite fun. You can also use cheesecloth.

For activity two, the adults should lead the children to build a protocol that resembles the following one.

In a test tube we will first add the enzyme source (potato juice or object to test for catalase activity). Next, we do something to the enzyme that could change its activity (change temperature, add a chemical…). Finally, we add hydrogen peroxide to see whether bubbling happens or not and when the reaction is done, measure "the extent of bubbling" (foam height for example). To make sure we can compare things together, each test must be accompanied by controls:

Example: Testing potato juice with vinegar

Tube "test"	Potato juice (10 drops) + vinegar (10 drops) + hydrogen peroxide solution (20 drops)
Tube "control catalase"	P.J. (10 drops) + water (10 drops) + hydrogen peroxide (20 drops).
Tube "control vinegar"	Water (10 drops) +vinegar (10 drops) + hydrogen peroxide (20 drops).

Measurement:
Measure the height of the foam in each tube.

Prediction:
Vinegar will speed up the reaction because vinegar makes bubbles with baking soda.

Result:

The controls let us compare the effects of vinegar and water on potato juice. It also lets us see whether vinegar has an effect of its own on hydrogen peroxide. The number of drops is purely indicative. What is important is to use the same quantities in the test and controls. As a hint to help you have varied results in a group, I can tell you that catalase is easily inhibited by cooking in hot water or in a flame, by the cold, by acid, by acetone.