

Topic 4: Energetics – 4h. Enzymes

Resources: Campbell, N. et al. *Biology: Exploring Life*, Prentice Hall, pp. 103-104.

Campbell, N. et al. *Biology: Concepts and Connections*, Pearson, pp. 76-78.

Miller and Levine. *Biology*. Prentice Hall, pp. 51-55.

Building on: The numerous chemical reactions of the body require enzymes to regulate their speed, temperature, and activation energy. Basic chemistry and chemical reactions should have been explored, as well as protein structure.

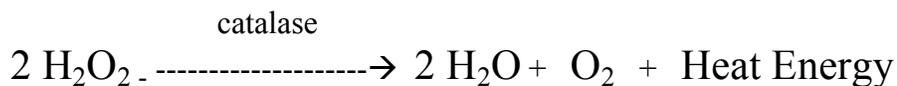
Links to Chemistry: Heat energy/calorimetry
Chemical bonds
Chemical reactions
Organic chemistry

Links to Physics: Kinetic and potential energy
Activation energy

Stories: Many students will be familiar with the use of hydrogen peroxide as a topical disinfectant. Some may be familiar with its use as hair bleach. Others may understand that it is often used to whiten teeth. All of these experiences can be seized upon to show that hydrogen peroxide is “highly reactive,” unstable, and even poisonous. Be careful though, as some students will overgeneralize this lab and walk away thinking that all enzymes bubble and fizz, or heat up or disinfect cuts!

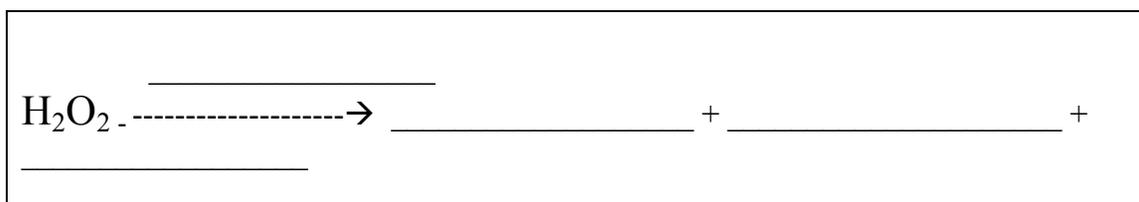
Lab Instructions and Materials for the Teacher:

The lab prep is very simple; you just need to buy a package of frozen liver from the grocery store (it is very cheap and you don't need much). I mix about one slice with 250 mL of water in a beaker for the stock enzyme solution and then I cut the liver into “pill-sized” pieces (about the size of a Tylenol tablet). Slightly frozen liver is easier to slice than completely thawed. Be sure to use 3% peroxide and check it beforehand; sometimes it breaks down on its own (when old). Solutions of 6% and even 30% are available, but they will bubble up more than you want them to. The overall reaction that occurs in the lab is:



Enzyme Lab

Enzymes are proteins that act as biological *catalysts*. There are many different enzymes, each of which reacts with a different molecule called a *substrate*. The enzyme fits together with its substrate like a key fits a lock, thus there is only one enzyme that catalyzes a particular chemical reaction in the body. One such reaction is between an enzyme called *catalase* (which is found in beef liver and within your skin) and hydrogen peroxide. Hydrogen peroxide is a poisonous substance that sometimes accumulates within cells; it has the chemical formula H_2O_2 . Catalase helps to break hydrogen peroxide down into harmless substances. Your job in this lab is to find out what these harmless substances are and then complete the chemical equation listed below:



Materials:

- 3% hydrogen peroxide solution
- Stock enzyme solution (liver juice)
- Raw liver chunks
- Glass stirring rod
- 2 test tubes – 20 x 150 mm
- Test tube rack
- Paper towels

Part 1:

1. Put 10 mL of 3% hydrogen peroxide solution in a CLEAN test tube. Put the test tube into the rack and place paper towels underneath it.
2. Add 5 drops of the stock enzyme solution. Mix with the glass stirring rod.
Record your observations:

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Feel the bottom of the test tube. What temperature change did you feel?

What might be the source of the temperature change?

Hypothesize: What is a possible explanation of the bubbles that formed?

The stock enzyme solution was made by blending a piece of beef liver with a small amount of water. This released many molecules of the enzyme from the liver into the water. The reaction mixture in your test tube contained hydrogen peroxide and the enzyme. To explain this reaction, three hypotheses are possible.

Circle the one that you think is correct:

- A) Catalase and hydrogen peroxide react together to form one or more new products.
- B) The hydrogen peroxide is changed in the presence of the enzyme, but the enzyme itself does not change.
- C) The enzyme is changed in the presence of hydrogen peroxide, which does not change.

Part 2:

Now, we will conduct an experiment to test these hypotheses.

1. Place a small raw liver chunk into each of two CLEAN test tubes.
2. Put these two test tubes on a rack with paper towels under it and add 2 mL of hydrogen peroxide to the first test tube. Keep stirring with the glass rod until the mixture has reacted completely (no new bubbles form). You may need to keep pushing the liver down into the liquid as it bubbles.

Record your observations:

3. Pour this reacted liquid onto the fresh liver chunk in the second test tube.

Record your observations:

4. Now pour 2 mL of fresh hydrogen peroxide onto the “old” liver chunk of the first test tube.

Record your observations:

Analysis Questions:

1. Go back and check the hypothesis that you circled just before starting Part 2 (A, B or C). Were you correct?
2. What is the correct hypothesis (circle it below)? How do you know?
 - A) Catalase and hydrogen peroxide react together to form one or more new products.
 - B) The hydrogen peroxide is changed in the presence of the enzyme, but the enzyme itself does not change
 - C) The enzyme is changed in the presence of hydrogen peroxide, which does not change

because:

3. What does this tell you about what an enzyme does in a chemical reaction?
4. Hydrogen peroxide is a poisonous chemical that is continually formed by certain chemical reactions within cells. Left unchecked, it could kill the cell. Catalase is found in the cells of higher organisms (including cows and humans); it breaks hydrogen peroxide down into water (the liquid that was left after reacting in the test tube) and oxygen (the bubbles that formed within the test tube).
 - What role does catalase play within the cell?
 - Is catalase found only in beef liver?
 - Hydrogen peroxide will bubble if placed on a cut finger. What does this tell you about the enzyme?
 - So why is hydrogen peroxide used to disinfect cuts (what **can't** break down H_2O_2 with catalase?)

5. If left out in the sunlight, a bottle of hydrogen peroxide will slowly change into water and oxygen (that is why peroxide bottles are often brown). Under these conditions, it takes a very long time for the reaction to occur. When catalase is present, the reaction takes place very quickly.

- What does this tell you about the function of an enzyme?

6. List three properties of all enzymes. (Use the introductory paragraph and your textbook.)

a. _____

b. _____

c. _____

7. Now go back to the front page of your lab and complete the chemical reaction that occurred in this experiment. Place a \checkmark on the line below when completed.
