Lesson Plan for Enzymes

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Introduction/Background Info

Enzymes are "biological catalysts." "Biological" means the substance in question is produced or is derived from some living organism. "Catalyst" denotes a substance that has the ability to increase the rate of a chemical reaction, and is not changed or destroyed by the chemical reaction that it accelerates.

Many chemical reactions do proceed but at such a slow rate that their progress would seem to be imperceptible at normally encountered environmental temperature. Consider for example, the oxidation of glucose or other sugars to useable energy by animals and plants. For a living organism to derive heat and other energy from sugar, the sugar must be oxidized (combined with oxygen) or metabolically "burned." Enzymes allow reactions that are necessary to sustain life proceed relatively quickly at the normal environmental temperatures.

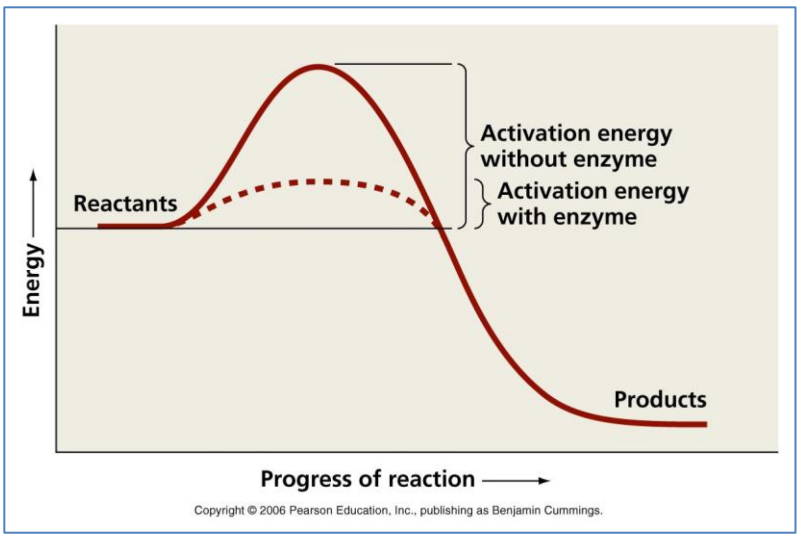

Figure 1. An enzyme reduces the activation energy of a reaction.

Some enzymes, like those we will discuss in this lesson, are important for breaking down large macromolecules, such as carbohydrates, proteins, lipids, and nucleic acids into smaller molecules, such as sugars, water, and the carbon dioxide that we breathe back into the atmosphere. Such enzymes are essential for digestion of foods. A common enzyme that may be familiar is lactase; people lacking this enzyme cannot digest milk, since they are unable to break down the milk sugar, lactose.

Enzymes are very specific in nature. Each enzyme can act to catalyze only very select chemical reactions and only with very select substances. An enzyme has been described as a "key" which can "unlock" complex compounds. An enzyme, as the key, must have a certain structure or multi-dimensional shape that matches a specific section of the "substrate" (a substrate is the compound or substance which undergoes the change). Once these two components come together, certain chemical bonds within the substrate molecule change much as a lock is released, and just like the key in this illustration, the enzyme is free to execute its duty once again.

Catalysts are also important in non-living things. For example, inside a car, one of the key body parts is catalytic converter. This part uses combustion reaction. Catalytic combustion is a chemical process that uses a catalyst to speed desired oxidation reactions of a fuel and so reduces the formation of undesired products, especially pollutant nitrogen oxide gases (NO_x) far below what can be achieved without catalysts.

Student Objectives

- Learn about the role of a catalyst.
- List examples of catalysts in both living things and nonliving things.
- Learn about the function of enzyme inside our body.
- Learn how enzymes break down macromolecules during digestion.

Topics

Catalyst a substance that enables a chemical reaction to proceed at a usually faster rate or under different conditions (e.g. at a lower temperature) than otherwise possible.
Enzyme a biological catalyst.
Activation Energy the minimum amount of energy required to undergo a chemical reaction.
Macromolecule a very large molecule built up from smaller chemical structures.
Catalytic Converter an automobile exhaust-system component containing a catalyst that causes conversion of harmful gases (e.g. carbon monoxide) into mostly harmless products (e.g. water, carbon dioxide).

Overview of Lesson Process

- Introduction: pictures of catalyst, car catalytic converter, background lecturing (5-10 minutes).
- Part 1: Match catalyst demonstration and discussion (5 minutes).
- Part 2: Lock and key demonstration and discussion (5 minutes).
- Part 3: Enzyme reaction/competition activity (10 minutes).
- Part 4: Enzyme role play activity (15 minutes).
- Part 5: Enzymes in action cracker activity (5 minutes).
- (Optional) video demonstrations if time permits.
- Conclusion: Wrap-up discussion and clean-up (5-10 minutes).

Materials

Matches (Optional)	Smart&Final	$5
Locker with a Key	Grainger (Item# 1A377)	$5
Saltine crackers	Smart&Final	$10
Paper/cardstock	OfficeMax (Item# 21151496)	$10
Puzzle pieces	Prepared by mentors	
Enzyme/sugar diagrams	Prepared by mentors	
		Total $30

Procedures

Part 1. Demonstration of a Catalyst in "Combustion"

1. Discuss the concept of a match.
2. (Optional) Strike the matchbox until light flashes. *Only mentors can handle the matches!*
3. Tell the class striking the match is serving the role of a catalyst and it reduces the activation energy. Quickly show the energy diagram and use an analogy of a man hiking up the hill. It takes a lot of time to hike a big hill. Fortunately, the catalyst reduces the height of that hill and thus it takes less time to hike the hill now. In our illustration, it would take "forever" to light a match without striking. We were able to "speed" the reaction by striking.

Part 2: Key and Lock Demonstration- Specificity of an Enzyme

1. Start with an introduction that catalyst acts like a lock with a key.
2. Insert the right key to the lock and open it.
3. Pick another random keys, from mentors or students, and insert them into the locker.
4. Ask students why the lock didn't open this time.
5. Tie in the discussion to the catalyst. Catalysts need the right "key" to react

Part 3: Enzyme/Substrate Reaction and Competition

Activity A

1. Distribute any puzzle piece to students. *There is one unique puzzle set per pair of students.*
2. Decide what their "reaction" will be when they found their partners. (i.e. specific dance type, specific facial expression, rock paper scissor, etc.)
3. Allow students to go around the classroom and figure out their partners.
4. When two students find complementary puzzle pieces, they can start reaction.

Activity B

1. Now, tell the class that substrates can compete with each other.
2. Distribute the same puzzle piece to students to play the role of substrate. This activity can be done in small groups or in a big group. *There is just one set of puzzle pieces distributed to all the students.*
3. Students have to tag their mentors who will play the role of the enzyme (binding site) by holding the complementary puzzle piece.
4. Only the first student who tags his or her mentor can react. The mentor and that student can then start "reacting" as decided in #2. Afterward, that student sits down to represent the chemical reaction that has changed the substrate.
5. Repeat this process until all the "substrate" students have reacted with the "enzyme" mentor and notice that the "enzyme" mentor can still react with different students holding the same shape. This demonstrates that one enzyme can keep reacting with different substrates over and over as long as substrates can fit into binding site of the enzyme.

Part 4: Role Play

1. Decide who will play sugars (substrate) and who will play enzymes. There should be about 4 times more sugars than enzymes in this activity.
2. Distribute papers with icons representing sugar and enzyme.

3. Students playing the role of simple sugars link hands to form a long chain. This chain of simple sugars represents a complex carbohydrate (starch).
4. The remaining students acting as enzymes come up to the chain of sugars and, with a scissor-like motion, cut links between simple sugars.
5. Simple sugars sit down as they are cut from the chain.

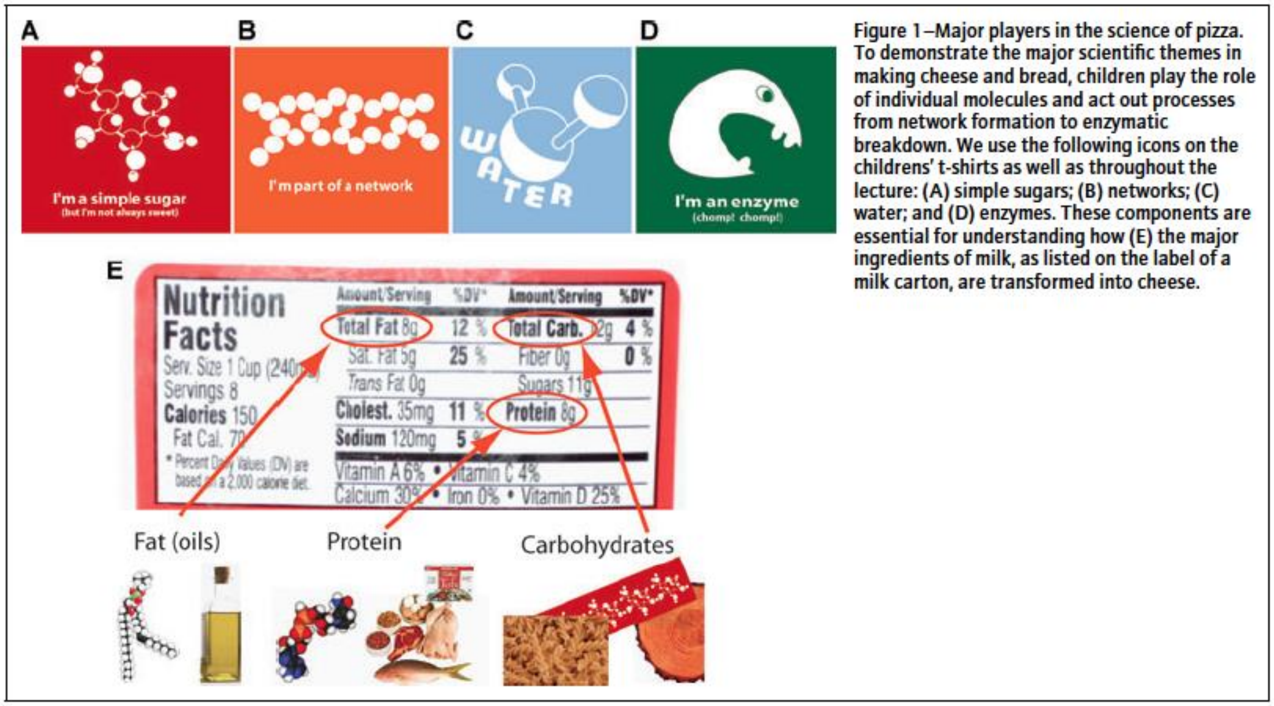

Figure 2: Role play of enzyme digestion. (from Rowat et al.)

Part 5: Enzyme in Action

1. Distribute one cracker to each students.
2. Instruct the students to put the cracker into their mouth and chew it up without swallowing.
3. You will notice that as enzymes break down the carbohydrates in the cracker, the cracker actually starts to taste sweeter.

Optional Activity: Video Demonstration

1. Show Youtube videos in the Reference section.

Reference

Cool classroom demonstration of enzymes in saliva: **http://www.youtube.com/watch?v=6VN9nS65sFs**

Catalase reaction: **http://www.youtube.com/watch?v=VbEH25wT39E**

Catalytic converter: **http://www.youtube.com/watch?v=1zH22Qpe2GA**

Rowat et al. (2010) *The Science of Pizza: The Molecular Origins of Cheese, Bread, and Digestion Using Interactive Activities for the General Public.* J Food Sci Ed. Vol. 9 doi: 10.1111/j.1541-4329.2010.00101.x