Toothpickase: A Study of Enzyme Activity

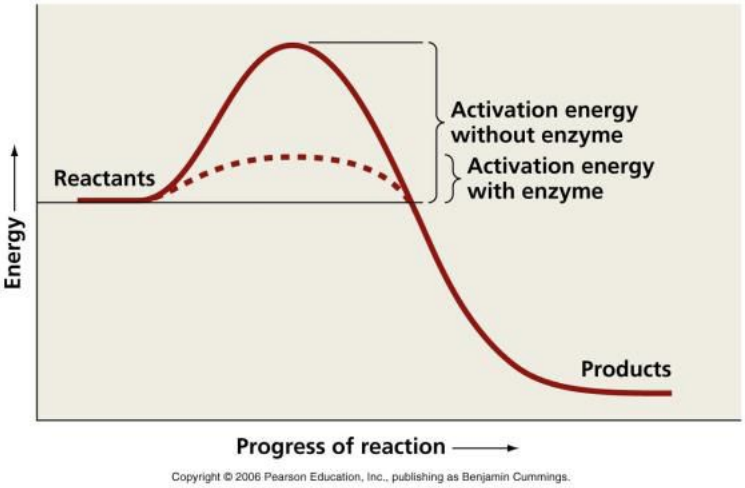
AP Biology

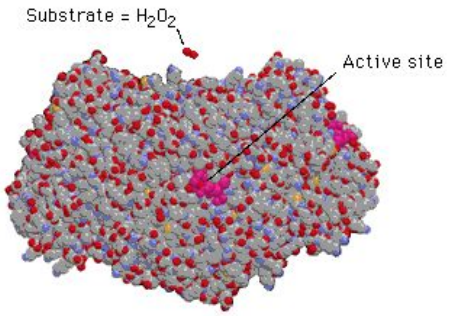
Objectives: Upon completion of this activity, you will learn that

- Analyze data to identify how molecular interactions affect structure and function.
- Use models to predict and justify that changes in the subcomponents of a biological polymer affect the functionality of the molecule.
- Learn that shape of enzymes, active sites and interaction with specific molecules are essential for basic functioning of the enzyme.
- Use mathematics appropriately.
- Use representations and models to communicate scientific phenomena.
- Perform data analysis and evaluation of evidence.

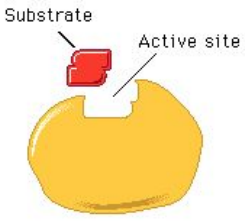
Introduction

Recall that **enzymes** are globular proteins which act as organic catalysts for biochemical reactions. Remember that a catalyst is a substance that speeds up a chemical reaction without being used up during the reaction. Catalysts work to speed up or slow down a chemical reaction by increasing or decreasing the activation energy of a chemical reaction. Activation energy is the energy needed for a chemical reaction to start. Enzymes can lower the amount of **activation energy** needed for a biochemical reaction to start by placing physical stress on the bonds holding the substrate together.





Molecular model of catalase



Schematic model of an enzyme

Enzymes are specific as to the substrate they break up. The structure of an enzyme includes an **active site**, which is where the substrate binds (usually through weak hydrogen bonding) when a substrate-enzyme complex is formed. The amino acids that make up the active site are configured in such a way that only certain substrates can fit into it. This is commonly referred to as the "lock and key" theory of enzyme binding. However, because some enzymes are quite flexible and can bind around their substrates, an alternative theory about enzyme binding called **induced-fit theory** states that the enzyme can wrap itself around the substrate for a more snug fit.

Enzyme reaction rates can be calculated by determining the number of substrates consumed (or products produced) during the reaction.

There are many factors that affect the rate of an enzyme reaction. Break a toothpick. Can a toothpick be broken faster? Can it be broken infinitely faster? Given a pile of toothpicks and ideal conditions, it still takes some time for the enzyme to break the toothpick. In this activity you will model enzyme behavior, and the various conditions that can affect the effectiveness of an enzyme as it binds to its substrate.

Materials:

round toothpicks straight pins oven mitts rubber bands timer

Safety Considerations:

1. Be careful not to poke yourself with the toothpicks OR the pins.
2. Do not fasten the rubber bands too tightly around your fingers.

Before beginning, think about the following:

- You are modeling an enzyme-substrate interaction. In this model, what represents:
    - The enzyme?
    - The substrate?
- Given the materials provided, how can you model the following factors:
    - Effect of temperature on enzyme activity?
    - Effect of pH on enzyme activity?
    - Effect of substrate concentration on enzyme activity?
    - Effect of enzyme concentration on enzyme activity?
    - Effect of an inhibitor on enzyme activity?

Procedure:

The procedure for collecting baseline data is as follows:

1. Get a box of toothpicks from your teacher. Count out a stack of 40 toothpicks.

2. The stack of toothpicks will then be broken for the time interval from 0 to 60 seconds in 10 second increments. For example, you would record the number of toothpicks broken at 0 seconds as zero.

3. You will need to start each time increment with 40 toothpicks. So for example, if you are running the experiment for the 20 second time interval and you broke only 15 toothpicks, when you run the experiment for the 30 second interval, you will need to count out enough toothpicks to begin the new experiment with 40 toothpicks.

4. Record the results recorded in a simple data table noting time and toothpicks metabolized. Calculate the rate of reaction for this baseline reaction. Remember that rate is calculated by determining the number of toothpicks metabolized per second.

Once you have collected baseline data, choose **two** conditions from the above bulleted list. Write out a procedure for each one. You need to consider the following:

- What is your independent variable?
- What is your dependent variable?
- What conditions will you hold constant?
- What is your **hypothesis**? The hypothesis is a tentative, testable statement that explains an observed natural phenomenon. This is NOT written as an "if-then" statement. The hypothesis is often followed by a prediction which can be made if the hypothesis is valid (Strode, 2014). **The hypothesis should be based on scientific principles/concepts.**

Identify each of the above for the conditions that you will test in your experiment. Before beginning your new experiment, get your teacher's approval.

Be sure to record appropriate data in a clearly constructed table that indicates:

- What data you are collecting
- The conditions you are testing
- The number of trials you are running
- The rate of reaction for the condition you are testing

Additionally, you need to do the following for each condition you test:

- State a **claim**: determine whether or not you support the null OR alternative hypothesis.
- Determine whether the **evidence** you have supports the hypotheses you have generated.

- Provide **reasoning** for why the hypothesis you support is true. Refer to the reasoning you generated with your explanatory hypothesis as well as your prediction.

WHAT YOU WILL TURN IN AND HOW:

As individuals, in Canvas as a file upload (use Google Docs) Create a printed copy for your BILL	**As a pair, in your BILL**
● Hypothesis generation ● Processed data (properly constructed graphs with explanation of data, statistical analysis) ● CER	● Create data tables (this is the ONLY thing that should be identical)