Toothpickase Enzyme Activity

Name: _____ Date: _____ Period: _____

Background Information

Enzymes are (mostly) proteins in cells that are biological catalysts—that is, they help a reaction proceed but are not consumed in the reaction. For this activity, Toothpickase is the enzyme that breaks toothpicks. The substrate for the reaction is toothpicks, and the product is the halved toothpicks. The toothpick can break without Toothpickase (you will likely find a few broken toothpicks in the box), but Toothpickase increases the rate at which toothpicks break. The Toothpickase itself does not get altered by the reaction, so it can go and find more toothpicks and continue the process.

This activity allows you to study the kinetics of enzyme activity. It further allows you to see how different conditions can affect how the enzyme functions. Starting with a set number of substrate molecules (toothpicks) in the cell (bowl), you can measure how many toothpicks the Toothpickase breaks at different times.

Typically, the activity is very fast at early time points, but as the amount of product increases in the cell, the rate decreases. This can be seen by plotting a graph of the students' data (time vs. number of toothpicks broken). Additionally, if you have more time, there is a list of conditions that can be changed to see how that affects Toothpickase.

Toothpickase Procedure

You are going to simulate the action of an enzyme by breaking toothpicks during this activity. Hold a toothpick between your thumbs and fingers and break it. Your index fingers and thumbs represent the enzyme and the toothpick represents the substrate, the substance that the enzyme works on. The place where the toothpick fits between your fingers represents the active site of the enzyme. The active site is where the enzyme and substrate "fit together."

Procedure A:

Choose one group member to be the enzyme. Only one student will be acting as the enzyme.

Count out 40 toothpicks and drop them in a pile in front of you. Pick up one toothpick and break it using your thumb and index finger. Repeat this process as fast as you can for ten seconds.

Drop the two broken pieces back onto the pile after you break the toothpick. Record the number of reactions (broken toothpicks) that occur during the ten seconds. Record your data in Table 1.

Repeat this procedure for 11 more time so that the total amount of time elapsed is 120 seconds. One group member counts the number of reactions and records them at ten second intervals.

Procedure B: Increasing Substrate Concentration

Hypothesis: Predict what will happen to the rate of reaction when the substrate concentration is increased.

Choose a new group member to be the enzyme. Only one student will be acting as the enzyme.

Count out 80 toothpicks and drop them in a pile in front of you. Pick up one toothpick and break it using your thumb and index finger. Repeat this process as fast as you can for ten seconds.

Drop the two broken pieces back onto the pile after you break the toothpick. Record the number of reactions (broken toothpicks) that occur during the ten seconds. Record your data in Table 2.

Repeat this procedure for 11 more times so that the total amount of time elapsed is 120 seconds. One group member counts the number of reactions and records them at ten second intervals.

Procedure C: Increasing Enzyme Concentration

Hypothesis: Predict what will happen to the rate of reaction when the enzyme concentration is increased.

Choose two new group members to be enzymes (thus doubling the enzyme concentration. Two students will be acting as the enzyme.

Count out 40 toothpicks and drop them in a pile in front of you. Pick up one toothpick and break it using your thumb and index finger. Repeat this process as fast as you can for ten seconds.

Drop the two broken pieces back onto the pile after you break the toothpick. Record the number of reactions (broken toothpicks) that occur during the ten seconds. Record your data in Table 3.

Repeat this procedure for 11 more time so that the total amount of time elapsed is 120 seconds. One group member counts the number of reactions and records them at ten second intervals.

Procedure D: Change of temperature or pH

Extreme temperatures or in unfavorable pH conditions can cause an enzyme to denature and change shape. To simulate denaturation, tape the fingers together of the group member who was the first enzyme with athletic tape.

Hypothesis: Predict what will happen to the rate of reaction when the enzyme is denatured.

Count out 40 toothpicks and drop them in a pile in front of you. Pick up one toothpick and break it using your thumb and index finger. Repeat this process as fast as you can for ten seconds.

Drop the two broken pieces back onto the pile after you break the toothpick. Record the number of reactions (broken toothpicks) that occur during the ten seconds. Record your data in Table 4.

Repeat this procedure for 11 more time so that the total amount of time elapsed is 120 seconds. One group member counts the number of reactions and records them at ten second intervals.

Data and Observations:

Table 1: Normal enzyme action.

Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions
10		50		90	
20		60		100	
30		70		110	
40		80		120	

Table 2: Increased concentration of substrate.

Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions
10		50		90	
20		60		100	
30		70		110	
40		80		120	

Table 3: Increased concentration of enzyme.

Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions
10		50		90	
20		60		100	
30		70		110	
40		80		120	

Table 4: Denatured enzyme action due to changes in temperature or pH.

Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions	Time (Seconds)	Number of Reactions
10		50		90	
20		60		100	
30		70		110	
40		80		120	

Data analysis:

1. Define the following terms: enzyme, substrate, product, active site, and allostaric site.

2. In this lab you simulated enzyme action. Identify what was used to simulate each of the following: enzyme, substrate, product, active site, and cell.

3. Create a graph for each of the four data tables. Plot the Number of reactions verses time. Be sure to label x and y axis and provide a title for each graph.

Cumulative →

4. Describe the trend of the line for graph and explain the relationship between number of reactions and time.

5. What effect did increasing the substrate concentration have on the reaction rate?

6. What effect did increasing the enzyme concentration have on the reaction rate?

7. What effect did denaturation of the enzyme have on the reaction rate?

8. Explain with regard to enzyme action why is important to maintain homeostasis within a living organism.

9. Hold a tennis ball in your hand. Now try to break a toothpick as you did before. Are you able to break the toothpick? Why not?

10. In terms of enzyme action the tennis ball would represent a _____ because it is preventing the action of the enzyme. And the palm or your hand would represent _____ the place where the _____ binds to the enzyme.