"TOOTHPICKASE" ACTIVITY

INTRODUCTION

This is a "hands-on" lesson in enzyme action, demonstrating the natural increase in reaction rate, the leveling off of the reaction and the subsequent drop in products produced as the substrate is used up. You are to pretend that toothpicks are the substrate to be broken down and your hands are an enzyme, complete with an "active site" (between your fingers and thumb.) Notice that the enzyme (your hand) is much larger than the substrate (toothpicks.) As you will be performing the activity with your eyes closed, this simulates the random contact made between substrate and enzyme. ***The object of the activity is to break as many toothpicks in half as possible in two minutes to test the "enzyme".***

During the activity, you will also notice that the substrate will not break unless you find *just* the right spot (the bonding site) and that you will naturally find a maximum rate of reaction, the top speed at which your hands can find and break an enzyme. This speed may lower during the activity as your hands become tired, the pieces are all too small to break and the substrates get more and more scattered in the "solution" (your playing field.) Throughout the activity, notice that the enzyme (your hands) remains unchanged throughout the reaction.

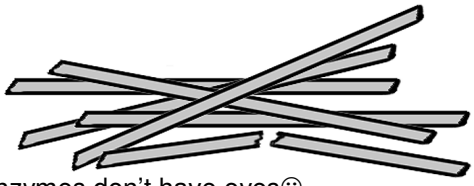
MATERIALS

FLAT Toothpicks, approx 50 per student
Stopwatch
Calculator

PROCEDURE

The Rules:

1. You must break each toothpick one at a time
2. You must break each toothpick with one hand ONLY.
3. You must break each toothpick completely in half.
4. You cannot begin before the teacher calls "Go!"
5. You must stop <u>precisely</u> when teacher says "STOP!"
6. You must <u>keep your eyes closed</u> throughout the entire activity. Enzymes don't have eyes☺



The Activity

1 Spread the toothpicks on the lab table in a random pile.
2. When the timer says "GO!", begin breaking toothpicks.
3. After ***10 seconds***, the timer will say "STOP!"
4. Count and record the number of toothpicks broken.
5. When the timer says "GO!", begin breaking toothpicks again.
6. At end of ***20 <u>more</u> seconds*** (30 sec. accumulated), the timer will say "STOP!"
7. Count and record the total number of toothpicks broken
8. When the timer says "GO!", begin breaking toothpicks again.
9. At end of ***30 <u>more</u> seconds*** (60 sec. accumulated), the timer will say "STOP!"
10. Count and record the total number of toothpicks broken
11. When the timer says "GO!", begin breaking toothpicks again.
12. At end of ***60 <u>more</u> seconds*** (120 sec. accumulated), the timer will say "STOP!"
13. Count and record the total number of toothpicks broken

ANALYSIS

1. Calculate the initial rate of enzyme activity by dividing the number of toothpicks broken by the change in time (10 seconds). Record the initial rate. Remember, no naked numbers!

$$\text{Formula:} \quad \frac{\Delta M}{\Delta t} = \frac{\Delta \text{ in amount}}{\Delta \text{ in time}}$$

2. Now, calculate the rate of enzyme activity between 10-40 seconds. Remember, the rate is the # broken/change in time in seconds. Record this rate.

3. What happens to the reaction rate as the supply of unbroken toothpicks runs out?

4. How does the "active site" of toothpickase fit the concept of induced fit? The induced fit concept says that there is a change in the shape of the active site of an enzyme so that it binds more snugly to the substrate, induced by the entry of the substrate.

Adapted from an activity☺ adapted by Anne Maben, UCLA Science Coach, from an activity at AP Bio Summer Institutes

Data Table

Reaction Rate of "Toothpickase"

TIME (SEC)	# OF TOOTHPICKS Broken	REACTION RATE
0		**----------**
10		
30		
60		
120		

Construct a graph (properly labeled and titled) and plot the data

Part B - Additional applications:

Your group will select one additional test to perform. Your group must state a hypothesis and then devise a method to test the hypothesis. Record your data in a table in the space below and graph your results in your notebook.

A. Determine what happens to the rate if the toothpicks are spread out so the enzyme has to reach for them.

B. What happens to the rate if the original number of toothpicks is doubled?

C. What happens if the "enzyme" is held in ice water for 1 minute before acting on the toothpicks?

D. What happens to the rate if dried beans or macaroni noodles are mixed with the original bundle of toothpicks?

E. What happens if the "enzyme" wears bulky gloves or wraps tape around her/his finger tips?

DISCUSSION (answer on a separate sheet of paper)

1. Predict what would happen if we used 100 toothpicks/student?
2. Predict what would happen if the toothpicks were more spread out on bigger table?
3. Predict what would happen if *two* pairs of hands acted as enzymes at table?
4. Predict what would happen if your hands were very cold?
5. Predict what would happen if the teacher had added some plastic toothpicks to your desk?
6. Predict what would happen your thumbs had been taped to your "pointee" (index) finger?

DISCUSSION QUESTION ANSWERS FOR TEACHERS

1. What if we used 100 toothpicks/student?
   a. Increase initial substrate conc. ---> $_V$max same but longer
2. What if toothpicks were more spread out on bigger table?
   a. Lower initial substrate conc. ---> slower reaction rate
3. What if two pairs of hands at table?
   a. Increase initial enzyme conc. ---> increase $_V$max; level off quicker
4. What if hands were very cold?
   a. Lower temp --- > lower $_V$max
5. What if I had added some plastic toothpicks to your desk?
   a. Competitive inhibitors slow reaction rate
6. What if I had taped your thumbs to your "pointee" finger?
   a. Noncompetitive inhibitors also slow reaction rate