**Introduction**: Enzymes are protein catalysts that increase the rate of chemical reactions in living cells.  In this activity, we will model the impact of an enzyme on a chemical reaction.  Your fingers will behave as the enzyme with your thumb and fingers the active site, and the substrate they work on is wooden round toothpicks.  The reaction your enzyme fingers are speeding up is the breaking of the round toothpicks, one at a time.  Good luck!

**Focus Questions and Hypotheses**: be sure to use If/Then statements!!

1. If there is only a certain amount of substrate present to be converted into a product, what will happen to the rate of the enzyme-catalyzed reaction as time passes?

**Hypothesis**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. If the concentration of substrate available is increased, what will happen to the rate of the enzyme-catalyzed reaction?

**Hypothesis**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Materials:**

Paper clips

 Timer

 Ice Cubes

 Water

 Tray

 Bowl

 Toothpicks (~150)

**Roles:**

 Assign the following roles in your lab team:

1. Toothpickase enzyme
2. Counter– keep track of time and count all toothpicks
3. Recorder – record total number of toothpicks broken

**RULES:** Toothpickase enzyme must follow these rules:

* + Close your eyes (to make a random pick)
	+ Only use one hand
	+ Only break one toothpick at a time
	+ Only break each toothpick once
	+ Once a toothpick has been broken, it must be dropped back into the tray

Trial 1:

1. Counter: Count out 10 toothpicks and place them in a tray
2. Toothpickase: Practice simulating the reaction by breaking 10 toothpicks in half using the rules above
3. Recorder: Clean up the 10 broken toothpicks

**Experiment 1: Enzyme Activity Over Time**

**Procedure:**

1. Counter: Place 50 toothpicks into a tray.
2. Recorder: Set a timer for 5 seconds
3. Toothpickase: Start breaking the toothpicks in the tray at the same time the timer starts. You must follow the rules above.
4. Counter: When the timer goes off, count the BROKEN toothpicks
5. Recorder: Record the results in the table below
6. Counter: Put all broken and unbroken toothpicks back into the tray
7. Repeat procedure for all rounds listed. \* Be sure to always reuse the broken and unbroken toothpicks from the previous round

**Results:**

|  |  |  |  |
| --- | --- | --- | --- |
| Round | Timer Setting | Total # of broken Toothpicks | Reaction Rate per round  |
| 1 | 5s |  |  |
| 2 | 10s |  |  |
| 3 | 20s |  |  |
| 4 | 40s |  |  |

Reaction rate # of broken toothpicks in round

 Per round = # of seconds in round

**Conclusion:** Be sure to use complete sentences.

1. Does the enzyme activity change or stay the same over time? Please explain your answer.

2. What type of chemical was represented by:

a. Your fingers:

1. Wooden round toothpicks:

**Experiment 2: Effect of Substrate Concentration**

**Procedure:**

1. Counter: Place 50 paperclips into a tray. – The paperclips represent the solvent for your substrate
2. Counter: Add 10 unbroken toothpicks to the paper clips and mix
3. Recorder: Set a timer for **20** seconds
4. Toothpickase: Start breaking the toothpicks in the tray at the same time the timer starts. You must follow the rules above.
5. Counter: When the timer goes off, count the BROKEN toothpicks
6. Recorder: Record the results in the table below
7. Counter: Count out the correct number of unbroken toothpicks according to the number listed below and put them in the tray
8. Repeat procedure for all rounds listed. \* Be sure to always reuse the broken and unbroken toothpicks from the previous round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Substrate concentration | Timer Setting | # of paper clips | # of unbroken toothpicks | Total # of broken Toothpicks |
| Low | 20s | 50 | 10 |  |
| Medium | 20s | 50 | 20 |  |
| High | 20s | 50 | 50 |  |

**Conclusion**: Be sure to use complete sentences.

1. How does the enzyme activity change with the substrate concentration?

2. When you added extra substrate, what happened to the rate of the reaction?  Did this support or reject your second hypothesis?  Explain.

**Experiment 3: Effect of Temperature**

**Procedure:**

1. Toothpickase: Fill a bowl with cold water and ice cubes set aside.
2. Counter: Place 20 toothpicks into a tray
3. Recorder: Time how quickly toothpickase can break all 20 toothpicks following the same rules as before
4. Toothpickase: Start breaking the toothpicks in the tray at the same time the timer starts. You must follow the rules above.
5. Recorder: Record the time it took toothpickase to break all 20 toothpick
6. Toothpickase: empty the tray into the trash
7. Counter: Count out 20 new toothpicks and put in the tray
8. Toothpickase: Place your hand in the Ice-Cold water bath for 1 minute (Recorder keeps track of the time)
9. Toothpickase: After a minute is up, start breaking the toothpicks in the tray at the same time the timer starts. You must follow the rules above.
10. Recorder: Time how quickly toothpickase can break all 20 toothpicks following the same rules as before
11. Recorder: Record the time it took toothpickase to break all 20 toothpicks, record the answer

|  |  |
| --- | --- |
| Time to break 20 toothpicks (warm hand) |  |
| Time to break 20 toothpicks (ice bath hand) |  |

**Conclusion**: Be sure to use complete sentences.

1. How does the enzyme activity change with temperature?

2. Describe how a chemical reaction occurs. Use the words: activation energy, reactants, and products.