Ticketase

Focus questions	How do enzymes act upon complex sugars like starch? Does enzyme concentration or substrate concentration affect the rate of enzyme activity?
Vocabulary	Reaction rate, active site, enzyme concentration, substrate concentration, products, reactants

Enzymes work to speed up biological reactions by lowering their activation energy. Certain conditions must be met for enzymes to work efficiently. One of these conditions is **substrate concentration.** The tickets represent the **substrate.** Your thumbs and index fingers represent the **active site** of the enzyme "Ticketase." To **catalyze** the reaction (tearing single tickets off of the string of tickets), you may only tear a single ticket off at a time, then drop the single ticket and the string of tickets back into the pile. Pick the string of tickets up again to tear off another ticket. Tickets must be torn off cleanly to count as **products.**

Materials
• 3 strings of 50 connected tickets to represent the corn flour polysaccharide molecule

Procedure

Part 1
1. Students should work in groups of 4.
2. Choose one of the following parts:
    • Ticketase (person who will tear the tickets)
    • Timer (will tell ticketase when to start/stop)
    • Counter (counts the # of individual tickets)
    • Data Recorder (record all #s in the data tables)
3. Place a string of 50 tickets in front of Ticketase.
4. When told to do so by the Timer, Ticketase will begin by picking up the string of tickets and folding/tearing off one ticket at a time while not looking at the desk and pile of tickets at a constant pace (it is not a race). Ticketase must then drop both the single ticket and string of tickets into the pile before being allowed to pick up the string of tickets to tear off another ticket.
5. As Ticketase tears off the tickets, the Counter will count the number of single tickets and make sure that the single tickets are put back in the pile with the chain of tickets (because products and reactants mix during the reaction).
6. Put 10 seconds on the stopwatch. Count the number of tickets torn off in 10 seconds. Record the data in Table 1.

7. Then, keeping the same pile of single tickets and the remaining string of tickets, count the number of single tickets in 20 seconds. Record the data in Table 1.
8. Repeat #6, but for 30 seconds. Record the data in Table 1.
9. Repeat #6, but for 60 seconds. Record the data in Table 1. * If you run out of tickets, record the amount of time it took Ticketase to do so.

Part 2
Repeat everything in Part 1, but now spread out the tickets so that Ticketase has to reach for them (ticket concentration decreases). Record all data in Table 2.

Part 3
Repeat everything in Part 1, but now have 2 sets of 50 ticket strings and 2 students tear off single tickets (double enzyme concentration). Record all data in Table 3.

Table 1

Interval time (sec)	Cumulative time (sec)	Number of single tickets	Total single tickets
10	10		
20	30		
30	60		
60	120		

## Table 2 (decreased substrate concentration)

Interval time (sec)	Cumulative time (sec)	Number of single tickets	Total single tickets
10	10		
20	30		
30	60		
60	120		

Table 3 (increased enzyme concentration)

Interval time (sec)	Cumulative time (sec)	Number of single tickets	Total single tickets
10	10		
20	30		
30	60		
60	120		

Graph the number of single tickets (total) over time (cumulative). Put all 3 sets of data on the same graph and include a key to distinguish them.
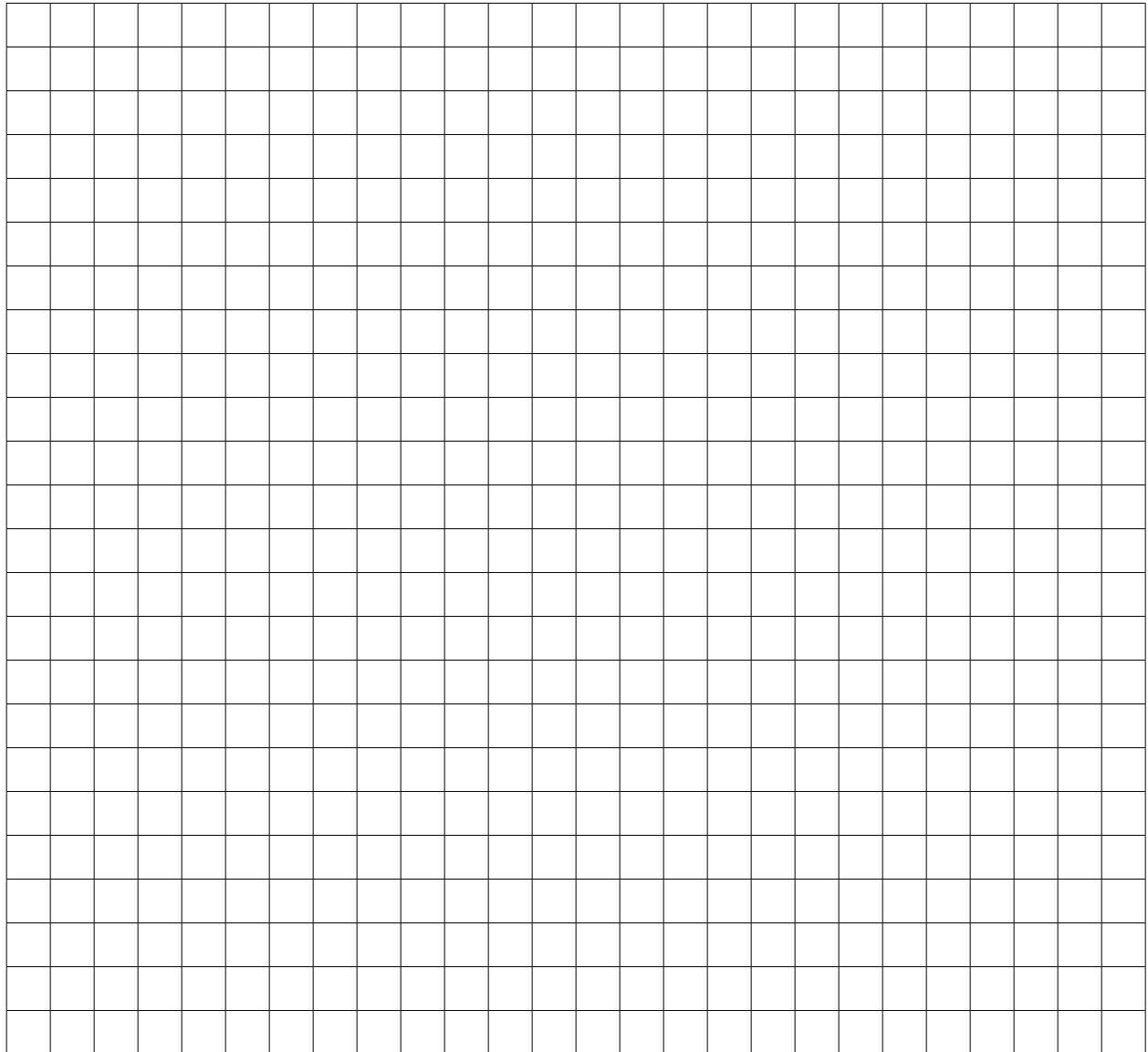
Reflection

1. What happened to the **Reaction Rate** as the availability of **Active Sites** diminishes? Why did this happen?

2. What happened to the reaction rate when the **Enzyme Concentration** increased? Why did this happen?

3. What happened to the reaction rate when the **Substrate Concentration** decreased? Why did this happen?

4. What would happen to the reaction rate if the enzymes could separate the **products** and **reactants**? Why?

5. How can Ticketase help to break starch into glucose molecules for fermentation?
(The string of tickets represents the polysaccharide starch, and the single tickets represent the monosaccharide glucose.)

6. How could the reaction rate increase if a second enzyme (one that tore 2 or 3 ticket segments off at a time) was introduced to work with Ticketase?

Model

Draw a model of ticketase and starch below. Label the model to explain how ticketase interacts with starch to create smaller sugar molecules.

Rubric for self-assessment

Skill	Yes	No	Unsure
I used the tickets to model a starch molecule and demonstrated the action of ticketase.			
I helped to generate data that enabled our prediction about the outcome of the action of ticketase on starch.			
I can explain how the model explains the function of ticketase in fermentation.			