Ticketase

Focus question	What role do enzymes play in the fermentation of starch?
Vocabulary	Reaction rate, active site, enzyme concentration, substrate concentration, products, reactants
Learning target	Students will explain how enzymes perform in the process of fermentation.

MS-LS1: From Molecules to Organisms: Structures and Processes

Performance expectation MS-LS1.7	**Classroom connection:** Students will create a model to describe the action of enzymes.

Science and engineering practices

Developing and Using Models	**Classroom connection:** Students use tickets to model how the enzyme *ticketase* interacts with starch.

Disciplinary core ideas

LS1.C: Organization for Matter and Energy Flow in Organisms	**Classroom connection:** Students examine enzyme and sugar reactions to determine how molecules are changed.

Cross-cutting concepts

Energy & Matter	**Classroom connection:** Students observe that matter is conserved as starch is cut into smaller molecules by enzymes.

This lesson builds upon Lesson 1, Fermentation Factories, where students utilize different components (enzymes, yeast, feedstocks, and water) to produce ethanol and carbon dioxide through the process of fermentation.

Materials

- 3 strings of 50 connected tickets per student group to represent the corn flour polysaccharide molecule
- *Optional:* timer
- *Optional:* blindfold

Teacher preparation

Remind the students of the 4 fermentation bags used in lesson 1. What was occurring in each of the four bags? You can help guide students' discussion by asking questions as you record their observations/questions.

- How did the amylase and/or glucoamylase impact the fermentation reaction?
- What are the roles of amylase and glucoamylase?
- Did amylase/glucoamylase help the fermentation process occur more slowly, rapidly, or have no net effect?

To begin investigating these questions/observations and learn more about enzymes, have the students work through the enzyme lab, Ticketase.

Students create a model to explain the unobservable relationship between the enzyme, ticketase, and the complex sugar, starch. Students should demonstrate how the enzyme cuts the starch molecule into smaller molecules. Students should label each component of the model and describe its function in the enzymatic reaction.

Procedure

Students should work in groups of 4. Provide each group with 3 strings of 50 connected tickets.

Student handout

Reflection

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

Possible answers: The reaction rate decreases due to the decrease in active sites. This happens because the Ticketase does not readily connect with the substrate as the products (single tickets) increase in number.

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

Possible answers: The reaction rate increased because there were 2 enzymes reacting with the starch molecules.

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

Possible answers: The reaction rate decreased due to a greater distance between available substrates.

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

Possible answers: The reaction rate would increase because of the increase in substrate concentration.

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

Possible answers: Ticketase separates the glucose molecules from the starch molecule. Glucose is the building block of starch.

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?

Possible answers: It would increase the reaction rate; it would decrease the reaction rate. It is important that the students provide evidence for their conclusions using data from their experiments.

Differentiation

Other ways to connect with students with various needs:

- **Local community:** Students may investigate the use of enzymes in digestion. How can the amylase found in human saliva help to break apart food molecules in preparation for digestion? Students can communicate their findings with their local community.
  Video: youtu.be/Lmma9Fwx7KY
- **Students with special needs (auditory/visual/language/reading):** See the extra support below.
- **Extra Support:** Video: How ethanol is made (youtu.be/59R-NqykoXs) This video helps demonstrate relationships between the components of the ethanol fermentation ecosystem. Infographic: vitalbypoet.com/infographics/ethanol-process-2 This infographic represents the process of corn flour breakdown into glucose for fermentation.
- **Extensions:** Students can research the current use of enzymes in corn ethanol production. Students can also research additional feedstocks for ethanol such as cellulosic switchgrass and the enzymes that would be necessary for carbohydrate breakdown.

Additional resources for student research:

- vitalbypoet.com/infographics/ethanol-process-2
- youtu.be/59R-NqykoXs

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Develop and/or use a model to generate data.	Use a model to test cause-and-effect relationships or interactions concerning the functioning of a natural or designed system.	Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.	Develop and/or use a model to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

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.			