Enzymes Activity: Chew on This!

Introduction

Carbohydrates in food are an important source of energy for the body. Starch is a complex carbohydrate (polysaccharide) found in plants like potatoes and grains (rice, wheat, corn, etc.). When you eat starch, it must be broken down into simple sugars, also known as monosaccharides, before your body can use it for energy. To perform the reactions that break down starches into sugars, your body uses enzymes called amylases, which are found in your saliva and small intestine.

In this BioGraph Virtual Lab you will use a simulation to explore the breaking down of starch into sugar that begins in your mouth (when you eat something) and is completed in the small intestine. The simulation will enable you to compare and contrast the conversion of starch to sugar both with and without enzymes. This will help you understand the role of enzymes in digestion.

The Simulation

In the simulation, sugars (monosaccharides) are represented by single dark red hexagons .

Starches are represented by chains of three or more gray connected hexagons.

Enzymes are represented by yellow Pac-Man-like spheres. When enzymes encounter starch molecules and break them down into sugars, they temporarily turn red in color then back to yellow.

Experiment 1: The Conversion of Starch to Sugar WITHOUT ENZYMES

In Experiment 1, we'll observe the breakdown ***without enzymes*** of dissolved starch into sugar.

Follow your teacher's instructions to open up the Enzymes activity simulation file on your computer.

Click "Run Code" located at the top of your window on the black bar.

Click on the **Create 50 Starch** button and click **Run for 30.** This will populate the simulation with 50 starch molecules and the simulation will run for 30 computer seconds. Carefully observe what happens.

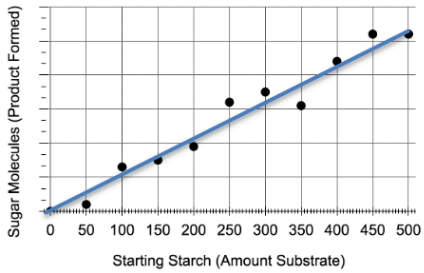
1) Describe what you see.

In our first experiment, we'll determine the relationship between the starting amount of dissolved starch (substrate) and the amount of sugar produced after 30 seconds *without enzymes*.

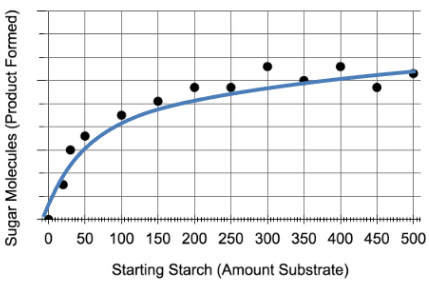
2) Predict: As you increase the starting amount of starch, what do you think will happen to the amount of sugar you end up with?

3) Which of these graphs represents your prediction for Sugar Molecules Produced at 30 seconds?

A)



B)



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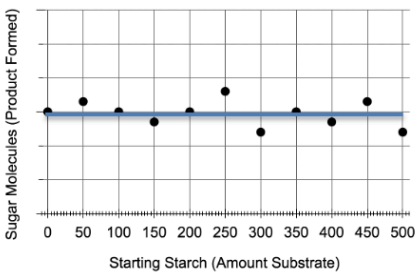

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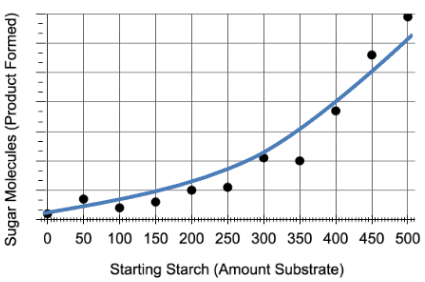


Experiment 1 Data Collection:

To determine the change in the amount of sugar produced as the amount of starting starch is increased, you will vary the amount of starch at setup and record the amount of sugar produced at 30 seconds.

 Click on the **Create 50 Starch** button.

 Click **Run for 30**. The sugar monitor/counter will report how many sugar molecules are produced.

On page 10 of this document, record the number of sugar molecules in the second row in **Table 1**: **Reaction *without* Enzymes.** (Do not fill in Table 2 at this time.)

 Repeat the experiment, this time clicking on the **Create 100 Starch** button, and then repeating the second step from above by clicking **Run for 30**. Do this for 150 starch molecules, 200 starch molecules, 250 starch molecules, etc., until you have filled out Table 1. For each run, make sure to click **Run for 30** only AFTER having clicked on the 'Create Starch' buttons.

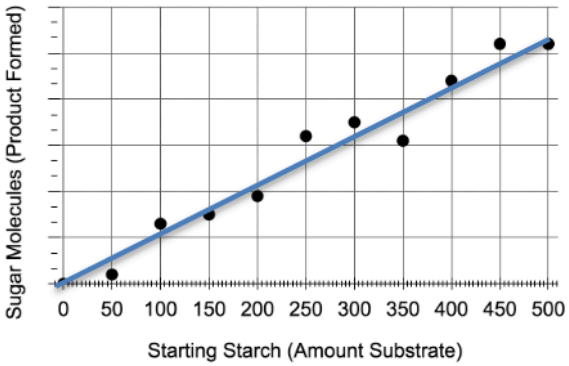
 Your teacher will create a class data table at the front of the room. Enter your group's data. Once the class data has been collected, the sugar produced for each run of increasing starch molecules will be averaged.

 Plot the average number of sugar molecules produced for each starting amount of starch in **Graph 1 (Class Data)**: **Sugar Molecules Produced in 30 Seconds *without* Enzymes** on page 10 of this document (Do not fill in Graph 2 at this time.)

Discuss the questions on the next page with your partner(s) and then write down your answers.

4) 🖊 Based on the experiments you just ran *without enzymes,* the graph of the amount of sugar produced vs. starting amount of starch looks most like:

A)



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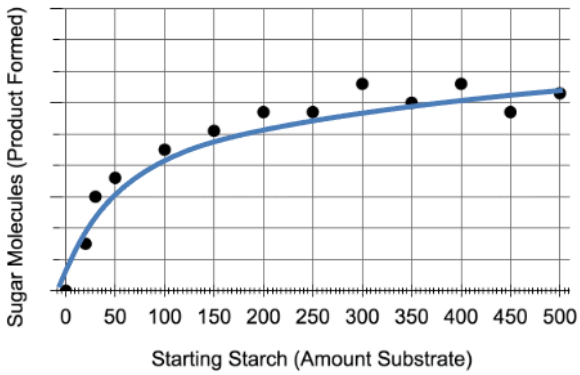

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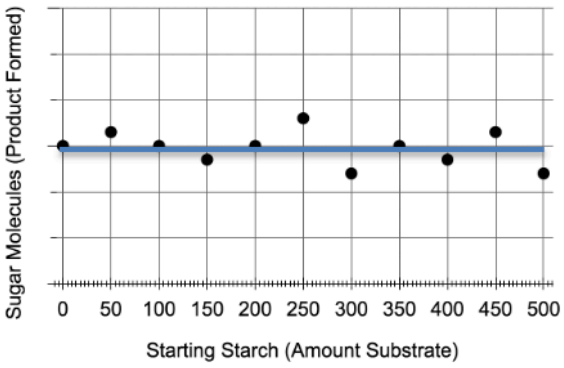
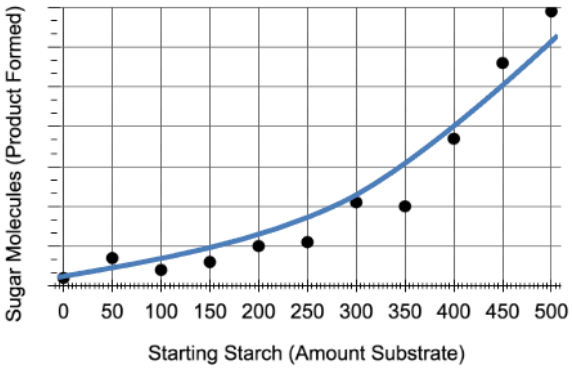


D)



5) 🖊 In the sequence of starch addition experiments that you just completed *without enzymes*, which of the statements below best describes the change in the amount of sugar as the amount of starting starch is increased.

A. The amount of sugar changed by approximately the same amount each time the starting starch was increased. The graph produced a straight line sloping upward from left to right.
B. The change in the amount of sugar produced was greater between the first few trials, when the starting amount of starch was low, than it was between later trials, when the starting amount of starch was high. The graph produced a curve that became less steep from left to right.
C. The amount of sugar did not change when the amount of starting starch was increased. The graph produced a flat, horizontal line.
D. The change in the amount of sugar produced was smaller between the first few trials, when the starting amount of starch was low, than it was between later trials, when the starting amount of starch was high. The graph produced a curve that became steeper from left to right.

6) 🖊 **Hypothesize:** If you started with 600 starch molecules, how many sugar molecules would you expect to form? Use your graph to help make a prediction. Use the simulation to test your prediction.

Group prediction (# Sugar Molecules)	**Simulation Result** (# Sugar Molecules)

Experiment 2: The Conversion of Starch to Sugar WITH ENZYMES

In Experiment 1, without enzymes, you observed the production of sugar molecules over time as they occasionally broke off from starch molecules. When more starch molecules were present, more sugar molecules were produced. The straight-line graph of starch to sugar produced represents this concept visually and mathematically.

Now you will run the simulation *with enzymes* present. This more closely represents the real-life conversion of starch to sugar in living systems.

In the next steps, you will observe the conversion of dissolved starch to sugar ***with enzymes***.

Click on the **Create 50 Starch** button, click the **Add Enzymes** button and click **Run for 30**. This will populate the simulation with 50 starch molecules and 50 enzymes and the simulation will run for 30 computer seconds. Be sure to click the buttons in the order described above. Observe what happens.

7) 🖊️ Describe what you see.

(Move on to the next page)

Group Discussion

How do the enzyme and starch (substrate) come together to interact? Discuss the following possibilities with your group, choose the **ONE** claim (either A, B, or C) you think is most likely, and write down your group's evidence and reasoning for that choice. Run the Experiment 2 simulation as many times as necessary to establish your claim.]

🖊 *Our Claim is… (Select ONE):*

Claim A: Enzymes are *drawn to* substrates, like a hungry traveler without a map, in a new town, who smells pizza from distance and heads towards the scent.

Claim B: Enzymes find substrates, like a hungry traveler without a map, in a new town, *actively looking for* thick crust pizza as they walk down the street.

Claim C: Enzymes find substrates, like a traveler without a map, in a new town, *wandering* the streets *in no particular direction*, until they bump into a pizza place. Pizza happens to be the only food they like, so they go inside to eat.

🖊 *Our evidence for this is…*

🖊 *Our reasons are that…*

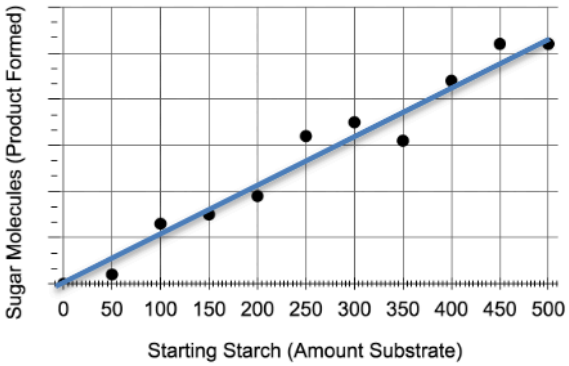
Discuss the questions below with your partner(s) and answer them.

8) 🖊 *Circle your choice*: For a given amount of starting starch, the amount of sugar formed after 30 seconds *with enzymes* present will be (greater than, equal to, less than) the amount of sugar formed without enzymes.

9) 🖊 Predict: As you increase the starting amount of starch *with enzymes* present, what do you think will happen to the amount of sugar you end up with?

10) 🖊 Which of these graphs represents your prediction?

A)



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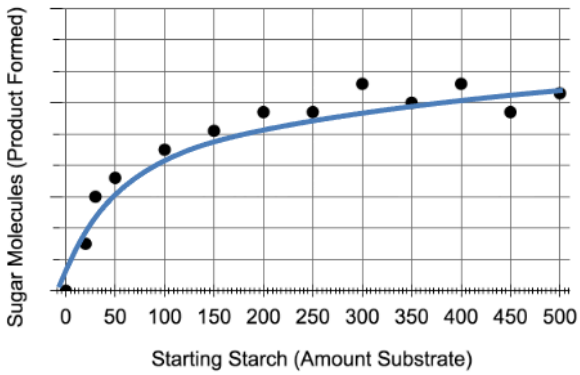

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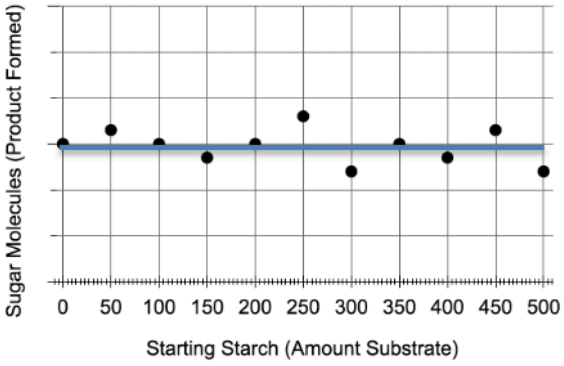
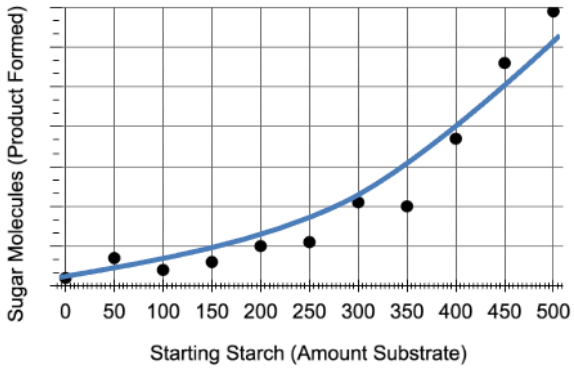


D)



Experiment 2 Data Collection:

To determine the relationship between the starting amount of starch (substrate) and the amount of sugar (product) produced ***with enzymes***, you will vary the amount of starch at setup and record the amount of sugar produced at 30 seconds.

Click on the **Create 50 Starch** button. Click **Add Enzymes** and then **Run for 30**. This will populate the simulation with 50 starch molecules and 50 enzyme molecules and

the simulation will run for 30 computer seconds. The sugar monitor will report how many sugar molecules are produced.

Record the number of sugar molecules in **Table 2**: **Reaction *with* Enzymes** on page 11 of this document**.**

Repeat the experiment, this time clicking on the **Create 100 Starch** button, and repeat step 'a' above. Do this for 150 starch molecules, 200 starch molecules, 250 starch molecules, etc., until you have filled out Table 2. For each run, make sure to click **Add Enzymes** and **Run for 30** only AFTER having clicked on the 'Create Starch' buttons.

Your teacher will create a class data table at the front of the room. Enter your group's data. Once the class data has been collected, the sugar produced for each run of increasing starch molecules will be averaged.

Plot the average number of sugar molecules produced for each starting amount of starch in **Graph 2 (Class Data): Sugar Molecules Produced in 30 Seconds *with* Enzymes**.

In the sequence of starch addition experiments that you and your partners just completed *with enzymes*, which of the statements below best describes the relationship between the amount of sugar produced and the amount of starting starch?

11) Circle the **ONE** claim below (either A, B, C or D) you think is most likely, and explain your choice here. You may want to refer to the class data graph (WITH enzymes) on page 11 before making your prediction.

Claim A: The amount of sugar changed by approximately the same amount each time the starting starch was increased. The graph produced a straight line sloping upward from left to right.

Claim B: The change in the amount of sugar produced was greater between the first few trials, when the starting amount of starch was low, than it was between later trials, when the starting amount of starch was high. The graph produced a curve that became less steep from left to right.

Claim C: The amount of sugar did not change when the amount of starting starch was increased. The graph produced a flat, horizontal line.

Claim D: The change in the amount of sugar produced was smaller between the first few trials, when the starting amount of starch was low, than it was between later trials, when the starting amount of starch was high. The graph produced a curve that became steeper from left to right.

Conclusions:

Group Discussion

Compare and contrast the conversion of starch to sugar with and without enzymes in Experiment 1 (without enzymes) and Experiment 2 (with enzymes).

Do enzymes speed up the conversion of starch to sugar? Explain your reasoning.

🖊 *Our claim is…*

🖊 *Our evidence for this is…*

🖊 *Our reasons are that…*

Extension Activity: What affects the rate of sugar production?

Think about what determines the amount of sugar that is produced from starch *when enzymes are present*. Does the amount of starch determine the amount of sugar produced? Does the amount of enzyme determine the amount of sugar produced?

Your challenge is to design and carry out an experiment to test the following hypothesis:

The amount of enzyme determines the amount of sugar (product) produced when there is a large amount of starch (substrate) present.

Your teacher can help you with experimental design and data presentation. [Hint: Click the **Extra Enzyme** button to increase the enzyme amount by 5 molecules at a time.]

DATA AND RESULTS

Table 1: Reaction WITHOUT Enzymes (# sugar produced)		
#Starch	**Your Group**	**Class Average**
50		
100		
150		
200		
250		
300		
350		
400		
450		
500		

Class Data: Average # of Sugar Molecules Produced after 30 seconds *WITHOUT* Enzymes

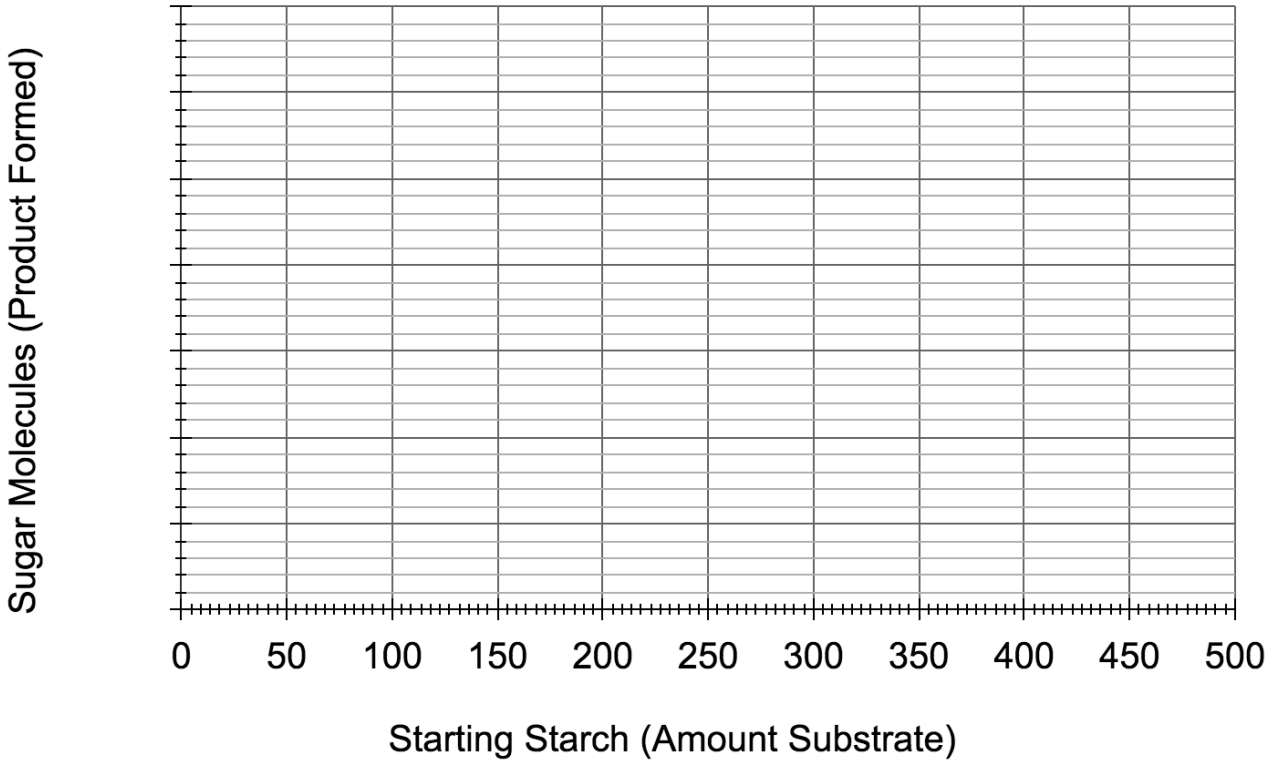
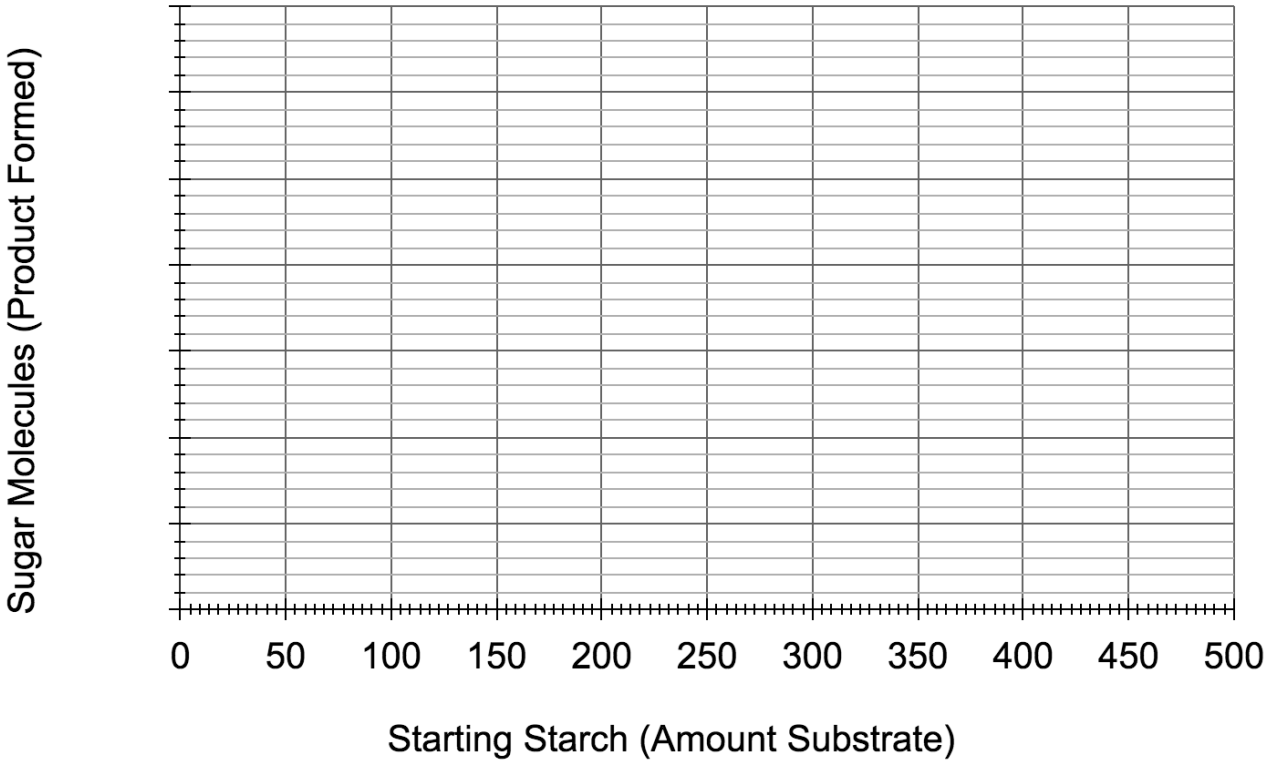


Table 2: Reaction WITH Enzymes (# sugar produced)		
#Starch	**Your Group**	**Class Average**
50		
100		
150		
200		
250		
300		
350		
400		
450		
500		

Class Data: Average # of Sugar Molecules Produced after 30 seconds *WITH* Enzymes


Sugar Molecules (Product Formed)
0
50
100
150
200
250
300
350
400
450
500
Starting Starch (Amount Substrate)