AP Bio
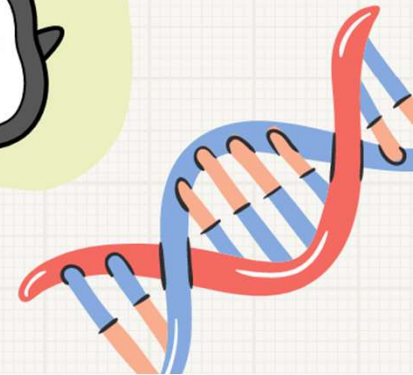# FRQ Fridays

2010 #2
Enzyme Lab

Hi!

An experiment was conducted to measure the reaction rate of the human salivary enzyme α-amylase. Ten mL of a concentrated starch solution and 1.0 mL of α-amylase solution were placed in a test tube. The test tube was inverted several times to mix the solution and then incubated at 25°C. The amount of product (maltose) present was measured every 10 minutes for an hour. The results are given in the table below.
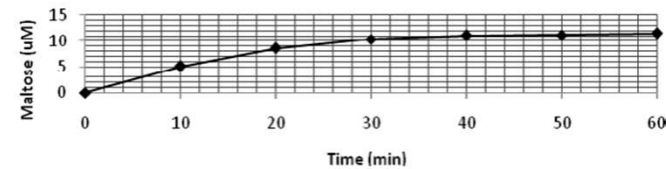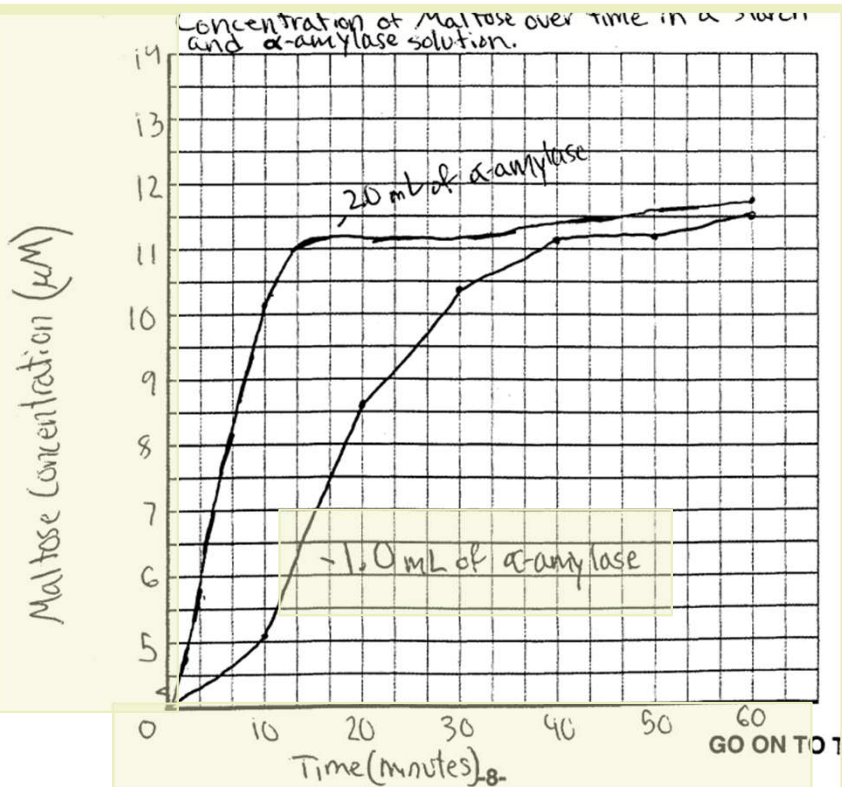
Time (minutes)	Maltose Concentration (μM)
0	0
10	5.1
20	8.6
30	10.4
40	11.1
50	11.2
60	11.5

Hi!

(a) **Graph** the data on the axes provided and **calculate** the rate of the reaction for the time period 0 to 30 minutes.

Concentration of Maltose over time in a starch and α-amylase solution.

2.0 mL of α-amylase

~1.0 mL of α-amylase

Maltose Concentration (μM)

Time (minutes)

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Maltose (uM)

Time (min)

Graph
1 point each
(3 points maximum)

- Correct orientation of the independent (time) and dependent (maltose) variables.
- Correct display of units and intervals **(scale and labels)**.
- Correct graphing of **all** data points on a properly scaled and oriented graph **(0–60 minutes)**.

Hi!

FRQ Friday #3

(a) **Graph** the data on the axes provided and **calculate** the rate of the reaction for the time period 0 to 30 minutes.

Time (minutes)	Maltose Concentration (μM)
0	0
10	5.1
20	8.6
30	10.4
40	
50	
60	

Calculation
(1 point maximum)

- Correct setup **or** rate calculation (0.3–0.4 μM/min or, e.g., 1μM/3 min, 10.4 μM/30 min or 10.4–0.0 /30–0 μM/min), **with units**. (No points if setup is incorrect or if calculated number is wrong and contradicts a correct setup.)

$$rate = \frac{y_2 - y_1}{x_2 - x_1}$$

$$rate = \frac{10.4 - 0}{30 - 0}$$

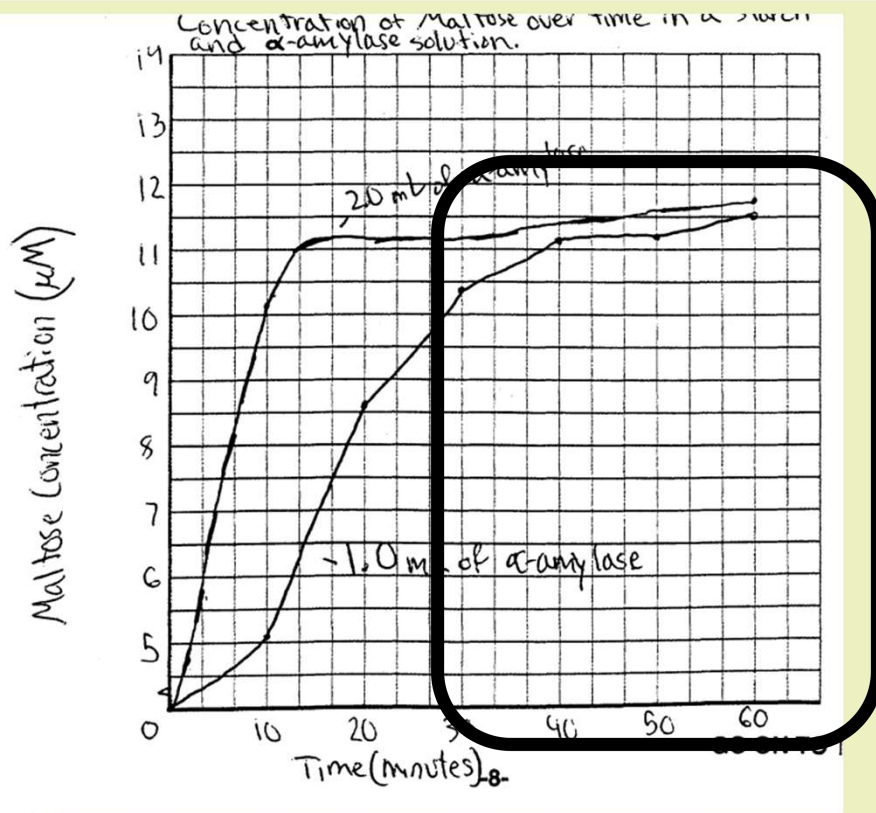$$rate = \frac{10.4}{30} = 0.3467\mu M/min$$

Hi!

(b) **Explain** why a change in the reaction rate was observed after 30 minutes.

Concentration of Maltose over time in a starch and α-amylase solution.

2.0 ml of amylase

~1.0 ml of α-amylase

Maltose Concentration (μM)

Time (minutes)

**Change
(1 point maximum)**

- Reaction rate slows/levels off.

**Explanation of change
(1 point maximum)**

- Rate slows as substrate concentration declines (substrate used).
- Enzyme inactive by about 40 minutes — enzyme loses activity over time (labile enzyme).
- Product inhibition.

Hi!

(b) Explain why a change in the reaction rate was observed after 30 minutes.
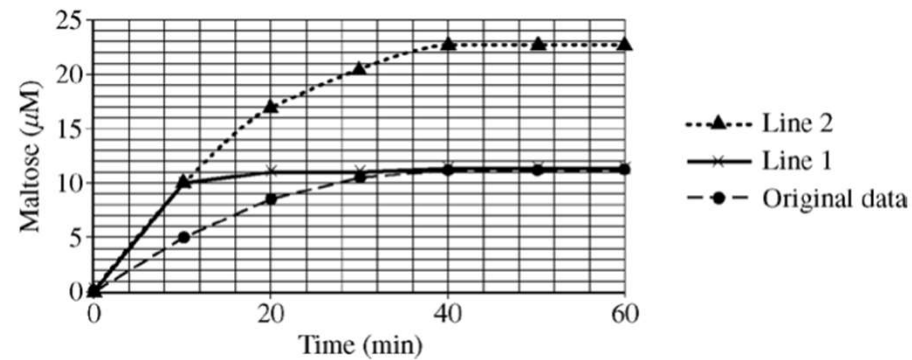
b) A change in the reaction rate was observed after 30 minutes because the reaction rate levels off after 30 minutes. The rate of reaction most likely levels off after 30 minutes because the substrate which in this case is the starch has been exhausted by the enzyme. This means that the enzyme has already broken down most of the starch, so the chance of the enzyme and substrate encountering eachother to form an enzyme-substrate complex is very low, after 30 min. So the effectiveness of the enzyme should be measured during the first 30 minutes while the substrate is still abundant.

Hi!

(c) **Draw** and **label** another line on the graph to predict the results if the concentration of α-amylase was doubled. **Explain** your predicted results.
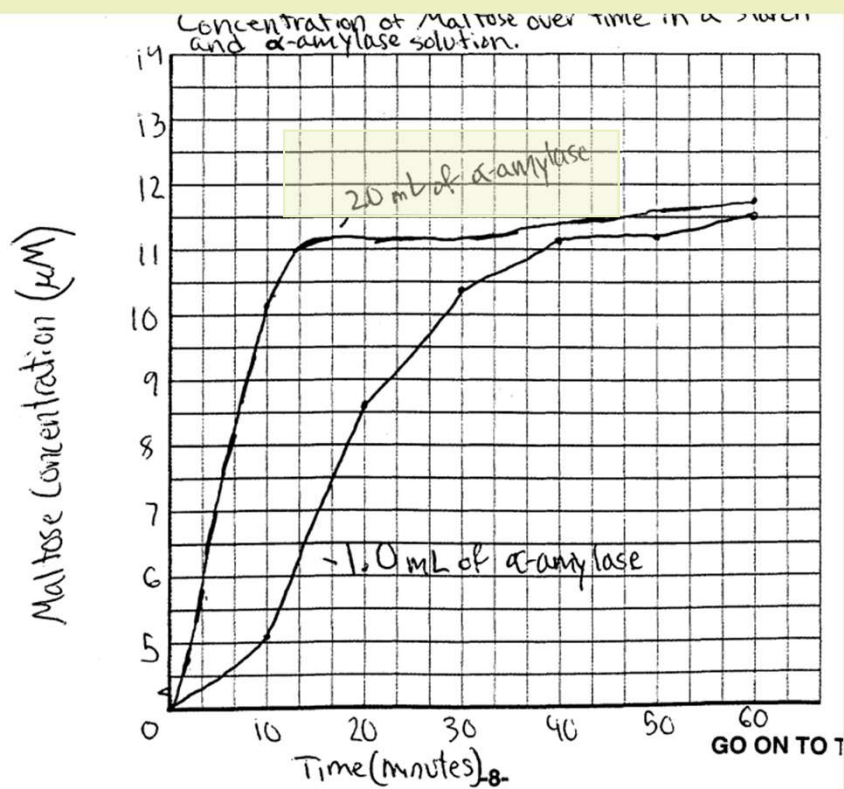

Drawing and labeling point (1 point maximum)	Explanation point (1 point maximum)
• Drawing and labeling of new line showing appropriate prediction (increased initial rate). ○ **Draw either line 1 OR line 2.**	• Line 1: Substrate is consumed more quickly because twice as much enzyme is present, but overall final product concentration remains the same. • Line 2: More product is formed at each time point because twice as much enzyme is present; product formation levels off as enzyme loses activity.

Hi!

(c) **Draw** and **label** another line on the graph to predict the results if the concentration of α-amylase was doubled. **Explain** your predicted results.

Concentration of Maltose over time in a starch and α-amylase solution.

Maltose Concentration (µM) vs Time (minutes)

20 mL of α-amylase

~1.0 mL of α-amylase

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(c) **Draw** and **label** another line on the graph to predict the results if the concentration of α-amylase was doubled. **Explain** your predicted results.

c) If the concentration of α-amylase was doubled, the starch would by broken down twice as fast during the first 10 minutes. Since the starch would be broken down faster, the concentration of maltose would double as well ~~strikethrough~~ because the rate of reaction is being doubled. However, the rate of reaction would level off much sooner because the substrate (starch) would be exhausted sooner, and the enzyme and substrate would only have a small chance of colliding to create an enzyme-substrate complex.

Hi!

(d) **Identify** TWO environmental factors that can change the rate of an enzyme-mediated reaction. **Discuss** how each of those two factors would affect the reaction rate of an enzyme.

Identification point (1 point maximum)	Discussion points (3 points maximum)
• Identification of **TWO** environmental factors. (e.g., temperature, pH, salinity, inhibitors, stirring/mixing, pressure, O_2, light).	• Temperature factor — temperature ↑, rate ↑; temperature ↓, rate ↓; high temperature causes denaturation. • Other factors — how that factor changes the rate of the enzymatic reaction. • Detailed explanation point — description of temperature denaturation (improper folding, change of active site), altered kinetics (temperature alters rate of collisions) or pH inactivation or ionic (salinity) inactivation (active site charge changes).

Hi!

(d) **Identify** TWO environmental factors that can change the rate of an enzyme-mediated reaction. **Discuss** how each of those two factors would affect the reaction rate of an enzyme.

d) Temperature is one environmental factor that can change the rate of an enzyme-mediated reaction. As temperature increases, ~~enzymes~~ the enzymes and substrates will move around faster causing them to collide and form and enzyme-substrate complex which leads to the product. However, if the temperature becomes too high, the proteins that make up the enzyme will become denatured and the enzyme will be ineffective. In summary, temperature increases the rate of reaction up until the temperature is too high and the ~~enzymes~~ enzymes are denatured, resulting in no reactions at all.

(d) **Identify** TWO environmental factors that can change the rate of an enzyme-mediated reaction. **Discuss** how each of those two factors would affect the reaction rate of an enzyme.

Another environmental factor that would affect the rate of an enzyme mediated reaction is the pH of the environment. Certain enzymes work better at specific pHs, and may not work at all at other pH levels, due to denaturization.

Hi!