Biology with Vernier

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NSTA National 2018
Atlanta, GA

HANDS-ON ACTIVITIES

Grip Strength Comparison
- Go Direct Gas Pressure

Cell Respiration
- Go Direct CO_2 Gas

Enzyme Action
- Go Direct O_2 Gas

Demonstration

Plant Pigments
- Go Direct SpectroVis Plus

Monitoring EKG
- Go Direct EKG

Get a Grip!

In this experiment, you will measure your grip strength. You will see if your grip strength changes as you grip an object for a longer time. You will also compare your grip strength with your classmates.

OBJECTIVES

In this experiment, you will

- Use a LabQuest and a Gas Pressure Sensor to measure your grip strength.
- See which of your hands has the greater grip strength.
- Learn what happens to your grip strength as time passes.
- Compare your grip strength with your classmates.

MATERIALS

LabQuest
LabQuest App
Vernier Gas Pressure Sensor
Gas Pressure Sensor Bulb
Stopper Stem (tapered valve connector)
heavy-wall plastic tubing

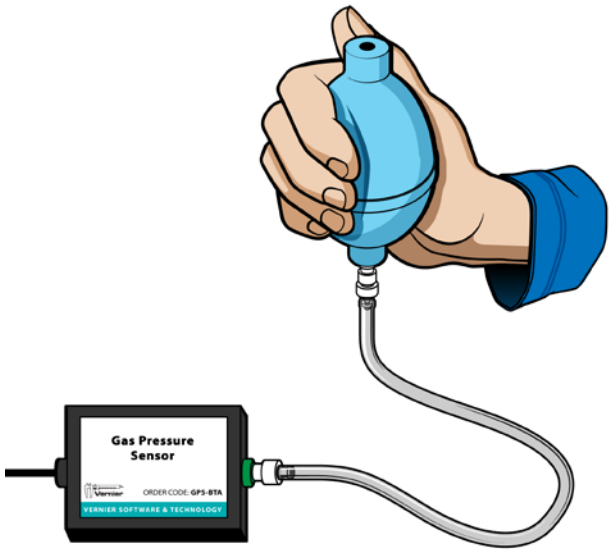

Figure 1

PROCEDURE

1. Squeeze the Gas Pressure Sensor Bulb in your hand. Listen to each end of the bulb to determine which end allows air to flow in and out.

2. Insert the Stem Stopper into the end that allows air flow. Connect the Gas Pressure Sensor Bulb/Stem Stopper combination to the plastic tubing. Connect the tubing to the Gas Pressure Sensor, as shown in Figure 1.

3. Connect the Gas Pressure Sensor to LabQuest and choose New from the File menu.
4. On the Meter screen, tap Rate. Change the data-collection rate to 10 samples/second and the Duration to 60 seconds.
5. Grip the bulb as hard as you can with one hand, then start data collection. Keep gripping as hard as you can. Do not lean your hand or arm on anything. Look away from the screen.
6. Determine and record your 0–60 s grip average.
   a. Choose Statistics from the Analyze menu.
   b. Record the mean (average) pressure (in kPa) for the 60 second period in your data table.
   c. Choose Statistics from the Analyze menu to turn off statistics.
7. Determine and record your 0–10 s grip average.
   a. Tap and drag your stylus across the first 10 seconds of data to select the data.
   b. Choose Statistics from the Analyze menu.
   c. Record the mean (average) pressure (in kPa) for the 0–10 second period in your data table.
   d. Choose Statistics from the Analyze menu to turn off statistics.
8. Determine and record your 50–60 s grip average.
   a. Tap and drag across the last 10 seconds of data (from 50 to 60 seconds) to select the data.
   b. Choose Statistics from the Analyze menu.
   c. Record the mean (average) pressure (in kPa) for the 50–60 second period in your data table.
9. Reset the experimental setup by disconnecting the Gas Pressure Sensor Bulb from the Stem Stopper and then reconnecting it.
10. Choose New from the File menu and repeat Steps 4–8 using your other hand.

DATA

Your Results		
	Left hand	Right hand
0–60 s Grip average (kPa)		
0–10 s Grip average (kPa)		
50–60 s Grip average (kPa)		
Difference between 0–10 s avg. and 50–60 s avg.		

Group and Class Results	
Name	Strong hand average for 0–60 s (kPa)
Group average	
Class average	

PROCESSING THE DATA

1. In the space provided in the data table, subtract to find the difference between your 0–10 s average and your 50–60 s average for each hand.
2. Record the 0–60 s results for the other students in your group. Calculate and record your group average. Calculate and record the class average for 0–60 s.
3. Which of your hands is stronger? Explain your decision.
4. Did your grip strength increase or decrease during the 60 s period? Why did it change?
5. How does your grip strength compare with the class average?
6. What did you learn about your grip strength in this experiment? Were you surprised?

EXTENSION

1. See if you can increase your grip strength with practice.

Cell Respiration

(CO_2 Gas Sensor)

Cell respiration refers to the process of converting the chemical energy of organic molecules into a form immediately usable by organisms. Glucose may be oxidized completely if sufficient oxygen is available by the following equation:

$$C_6H_{12}O_6 + 6\ O_2(g) \rightarrow 6\ H_2O + 6\ CO_2(g) + \text{energy}$$

All organisms, including plants and animals, oxidize glucose for energy. Often, this energy is used to convert ADP and phosphate into ATP. It is known that peas undergo cell respiration during germination. Do peas undergo cell respiration before germination? The results of this experiment will verify that germinating peas do respire. Using your collected data, you will be able to answer the question concerning respiration and non-germinating peas.

Using the CO_2 Gas Sensor, you will monitor the carbon dioxide produced by peas during cell respiration. Both germinating and non-germinating peas will be tested. Additionally, cell respiration of germinating peas at two different temperatures will be tested.

OBJECTIVES

- Use a CO_2 Gas Sensor to measure concentrations of carbon dioxide.
- Study the effect of temperature on cell respiration.
- Determine whether germinating and non-germinating peas respire.
- Compare the rates of cell respiration in germinating and non- germinating peas.

Figure 1

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct CO_2 Gas
250 mL respiration chamber
25 germinating peas
25 non-germinating peas
ice water
thermometer
100 mL beaker
paper towels
goggles

PROCEDURE

1. Launch Graphical Analysis. Connect the CO_2 Gas Sensor to your Chromebook, computer, or mobile device.
2. Set up the data-collection mode.
   a. Click or tap Mode to open Data Collection Settings.
   b. Change End Collection to 300 s. Click or tap Done.
3. Measure the room temperature using a thermometer and record the temperature in Table 1.
4. Obtain 25 germinating peas and blot them dry between two pieces of paper towel.
5. Place the germinating peas into the respiration chamber.
6. Place the shaft of the CO_2 Gas Sensor in the opening of the respiration chamber. Gently push the sensor down into the chamber until it stops. The sensor is designed to seal the chamber without the need for unnecessary force.
7. Wait one minute, then click or tap Collect to start data collection. Data will be collected for 5 minutes.
8. When data collection has finished, remove the CO_2 Gas Sensor and peas from the respiration chamber. Place the peas in a 100 mL beaker filled with cold water and an ice cube.
9. Use a notebook or notepad to fan air across the openings in the probe shaft of the CO_2 Gas Sensor for 1 minute.
10. Fill the respiration chamber with water and then completely empty it to remove residual gas from the peas. Thoroughly dry the inside of the respiration chamber with a paper towel.
11. Perform a linear regression to calculate the rate of respiration.
    a. Click or tap Graph Tools, , and choose Apply Curve Fit.
    b. Select Linear as the curve fit. Click or tap Apply.

c. Enter the slope, *m*, as the rate of respiration in Table 2.

d. Dismiss the Linear curve fit box.

12. Obtain 25 non-germinating peas and place them in the respiration chamber.

13. Repeat Steps 6–11 with non-germinating peas. In Step 8 place the non-germinating peas on a paper towel and not in the ice bath. **Note**: The previous data set is automatically saved.

Part II germinating peas, cool temperatures

14. Remove the peas from the cold water and blot them dry between two paper towels.

15. Use the thermometer to measure the temperature of the ice water. Record the temperature in Table 1.

16. Repeat Steps 5–11 using the cold peas. In Step 9 place the cold germinating peas on a paper towel and not back in the ice bath.

17. To display multiple data sets on a single graph, click or tap the y-axis label and select the data sets you want to display. Dismiss the box to view the graph. Continue to the Analysis Questions.

DATA

Table 1	
Condition	Temperature (°C)
Room	
Ice water	

Table 2	
Peas	Rate of respiration (ppm/s)
Germinating, room temperature	
Non-germinating, room temperature	
Germinating, cool temperature	

QUESTIONS

1. Do you have evidence that cell respiration occurred in peas? Explain.
2. What is the effect of germination on the rate of cell respiration in peas?
3. What is the effect of temperature on the rate of cell respiration in peas?
4. Why do germinating peas undergo cell respiration?

EXTENSIONS

1. Compare the respiration rate among various types of seeds.
2. Compare the respiration rate among seeds that have germinating for different time periods, such as 1, 3, and 5 days.
3. Compare the respiration rates of various small animal types, such as insects or earthworms.

Enzyme Action: Testing Catalase Activity

(O_2 Gas Sensor)

Many organisms can decompose hydrogen peroxide (H_2O_2) enzymatically. Enzymes are globular proteins, responsible for most of the chemical activities of living organisms. They act as *catalysts*, substances that speed up chemical reactions without being destroyed or altered during the process. Enzymes are extremely efficient and may be used over and over again. One enzyme may catalyze thousands of reactions every second. Both the temperature and the pH at which enzymes function are extremely important. Most organisms have a preferred temperature range in which they survive, and their enzymes typically function best within that temperature range. If the environment of the enzyme is too acidic or too basic, the enzyme may irreversibly *denature*, or unravel, until it no longer has the shape necessary for proper functioning.

H_2O_2 is toxic to most living organisms. Many organisms are capable of enzymatically breaking down the H_2O_2 before it can do much damage. H_2O_2 can be converted to oxygen and water, as follows:

$$2\ H_2O_2 \leftrightarrow 2\ H_2O + O_2$$

Although this reaction occurs spontaneously, the enzyme catalase increases the rate considerably. Catalase is found in most living organisms.

A great deal can be learned about enzymes by studying the rates of enzyme-catalyzed reactions. The rate of a chemical reaction may be studied in a number of ways including:

- Measuring the rate of appearance of a product
- Measuring the rate of disappearance of substrate
- Measuring the pressure of the product as it appears

In this experiment, you will measure the rate of enzyme activity under various conditions, such as different enzyme concentrations, pH values, and temperatures. It is possible to measure the concentration of oxygen gas formed as H_2O_2 is destroyed using an O_2 Gas Sensor.

OBJECTIVES

- Measure the production of oxygen gas as hydrogen peroxide is broken down by the enzyme catalase or peroxidase at various enzyme concentrations.
- Measure and compare the initial rates of reaction for this enzyme when different concentrations of enzyme react with H_2O_2.
- Measure the production of oxygen gas as hydrogen peroxide is broken down by the enzyme catalase or peroxidase at various temperatures.

- Measure and compare the initial rates of reaction for the enzyme at each temperature.
- Measure the production of oxygen gas as hydrogen peroxide is broken down by the enzyme catalase or peroxidase at various pH values.
- Measure and compare the initial rates of reaction for the enzyme at each pH value.

Figure 1

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct O_2 Gas
400 mL beaker
10 mL graduated cylinder
250 mL Nalgene bottle
three Beral pipettes
3.0% H_2O_2
enzyme suspension
three 18 × 150 mm test tubes
ice
pH buffers
test tube rack
thermometer
goggles
(optional) Stir Station with magnetic stir bar

PROCEDURE

1. Obtain and wear goggles.

2. Launch Graphical Analysis. Connect the O_2 Gas Sensor to your Chromebook, computer, or mobile device.

3. Set up the data-collection mode.

   a. Click or tap Mode to open Data Collection Settings.
   b. Change Rate to 0.25 samples/s.
   c. Set End Collection to 180 s. Click or tap Done.

Part I Effect of enzyme concentration

4. Place three test tubes in a rack and label them 1, 2, and 3. Fill each test tube with 5 mL of 3.0% H_2O_2 and 5 mL of water.

5. Initiate the enzyme catalyzed reaction.

   a. Using a clean dropper pipette, add 5 drops of enzyme suspension to test tube 1.
   b. Begin timing with a stopwatch or clock.
   c. Cover the opening of the test tube with a finger and gently invert the test tube two times.
   d. Pour the contents of the test tube into a clean 250 mL Nalgene bottle.
   e. Place the O_2 Gas Sensor into the bottle as shown in Figure 1. Gently push the sensor down into the bottle until it stops. **Note**: The sensor is designed to seal the bottle with minimal force.
   f. When 30 seconds have passed, click or tap Collect to start data collection.

6. When data collection has finished, remove the O_2 gas sensor from the Nalgene bottle. Rinse the bottle with water and dry with a paper towel.

7. Determine the rate of enzyme activity.

   a. Select the data in the most linear region of the graph.
   b. Click or tap Graph Tools, , and choose Apply Curve Fit.
   c. Select Linear as the curve fit. Click or tap Apply.
   d. Record the slope, *m*, as the reaction rate in Table 2.
   e. Dismiss the Curve Fit box.

8. Find the rate of enzyme activity for test tubes 2 and 3:

   a. Add 10 drops of enzyme solution to test tube 2. Repeat Steps 5–7. **Note**: The previous data set is automatically saved.
   b. Add 20 drops of enzyme solution to test tube 3. Repeat Steps 5–7.

9. Display all three runs of data on a single graph.

   a. To display multiple data sets on a single graph, click or tap the y-axis label and select the data sets you want to display. Dismiss the box to view the graph.
   b. Use the graph and the data in Table 2 to answer the questions for Part I.

Part II Effect of temperature

Your teacher will assign a temperature range for your lab group to test. Depending on your assigned temperature range, set up your water bath as described below. Place a thermometer in your water bath to assist in maintaining the proper temperature.

- 0–5°C: 400 mL beaker filled with ice and water
- 20–25°C: No water bath needed to maintain room temperature
- 30–35°C: 400 mL beaker filled with warm water
- 50–55°C: 400 mL beaker filled with hot water

10. Rinse the three numbered test tubes used for Part I. Fill each test tube with 5 mL of 3.0% H_2O_2 and 5 mL of water then place the test tubes in the water bath. The test tubes should be in the water bath for 5 minutes before proceeding to Step 11. Record the temperature of the water bath, as indicated on the thermometer, in the space provided in Table 3.

11. Find the rate of enzyme activity for test tubes 1, 2, and 3:

    a. Add 10 drops of enzyme solution to test tube 1. Repeat Steps 5–7. Record the reaction rate in Table 3.

    b. Add 10 drops of enzyme solution to test tube 2. Repeat Steps 5–7. Record the reaction rate in Table 3.

    c. Add 10 drops of enzyme solution to test tube 3. Repeat Steps 5–7. Record the reaction rate in Table 3.

12. Calculate the average rate for the three trials you tested. Record the average in Table 3.

13. Record the average rate and the temperature of your water bath from Table 3 on the class data table. When the entire class has reported their data, record the class data in Table 4.

Part III Effect of pH

14. Place three clean test tubes in a rack and label them pH 4, pH 7, and pH 10.

15. Add 5 mL of 3% H_2O_2 and 5 mL of a pH buffer to each test tube, as in Table 1.

Table 1

pH of buffer	Volume of 3% H_2O_2 (mL)	Volume of buffer (mL)
pH 4	5	5
pH 7	5	5
pH 10	5	5

16. Find the rate of enzyme activity for test tubes labeled pH 4, pH 7, and pH 10:
    - Add 10 drops of enzyme suspension to test tube pH 4. Repeat Steps 5–7. Record the reaction rate in Table 5.
    - Add 10 drops of enzyme suspension to test tube pH 7. Repeat Steps 5–7. Record the reaction rate in Table 5.
    - Add 10 drops of enzyme suspension to test tube pH 10. Repeat Steps 5–7. Record the reaction rate in Table 5.
17. Displayed all three runs of data on a single graph. Use the graph and the data in Table 5 to answer the questions for Part III.

DATA

Part I Effect of enzyme concentration

Table 2	
Sample	Reaction rate (%/min)
5 drops	
10 drops	
20 drops	

Part II Effect of temperature

Table 3	
Sample	Reaction rate (%/min)
Trial 1	
Trial 2	
Trial 3	
Average	
Temperature range: _____° C	

Table 4: Class Data	
Temperature tested (°C)	Average rate (%/min)

Part III Effect of pH

Table 5	
Sample	Reaction rate (%/min)
pH 4	
pH 7	
pH 10	

PROCESSING THE DATA

For Part II of this experiment, make a graph of the rate of enzyme activity *vs.* temperature in Graphical Analysis or by hand. Plot the rate values for the class data in Table 4 on the y-axis and the temperature on the x-axis. Use this graph to answer the questions for Part II.

QUESTIONS

Part I Effect of enzyme concentration

1. How does changing the concentration of enzyme affect the rate of decomposition of H_2O_2?

2. What do you think will happen to the rate of reaction if one increases the concentration of enzyme to 25 drops? Predict what the rate would be for 30 drops.

Part II Effect of temperature

3. At what temperature is the rate of enzyme activity the highest? Lowest? Explain.

4. How does changing the temperature affect the rate of enzyme activity? Does this follow a pattern you anticipated?

5. Why might the enzyme activity decrease at very high temperatures?

Part III Effect of pH

6. At what pH is the rate of enzyme activity the highest? Lowest?

7. How does changing the pH affect the rate of enzyme activity? Does this follow a pattern you anticipated?

EXTENSIONS

1. Determine the reaction rates of trials in Part I for each 30 second interval. What patterns do you see? What could explain the different rates you determined?

2. Different organisms often live in very different habitats. Design a series of experiments to investigate how different types of organisms might affect the rate of enzyme activity. Consider testing a plant, an animal, and a protist.

3. Presumably, at higher concentrations of H_2O_2, there is a greater chance that an enzyme molecule might collide with H_2O_2. If so, the concentration of H_2O_2 might alter the rate of oxygen production. Design a series of experiments to investigate how differing concentrations of the substrate hydrogen peroxide might affect the rate of enzyme activity.

4. Design an experiment to determine the effect of boiling the catalase on the rate of reaction.

5. Explain how environmental factors affect the rate of enzyme-catalyzed reactions.

Enzyme Action: Testing Catalase Activity

(O_2 Gas Sensor)

Many organisms can decompose hydrogen peroxide (H_2O_2) enzymatically. Enzymes are globular proteins, responsible for most of the chemical activities of living organisms. They act as *catalysts*, substances that speed up chemical reactions without being destroyed or altered during the process. Enzymes are extremely efficient and may be used over and over again. One enzyme may catalyze thousands of reactions every second. Both the temperature and the pH at which enzymes function are extremely important. Most organisms have a preferred temperature range in which they survive, and their enzymes typically function best within that temperature range. If the environment of the enzyme is too acidic or too basic, the enzyme may irreversibly *denature*, or unravel, until it no longer has the shape necessary for proper functioning.

H_2O_2 is toxic to most living organisms. Many organisms are capable of enzymatically breaking down the H_2O_2 before it can do much damage. H_2O_2 can be converted to oxygen and water, as follows:

$$2\ H_2O_2 \leftrightarrow 2\ H_2O + O_2$$

Although this reaction occurs spontaneously, the enzyme catalase increases the rate considerably. Catalase is found in most living organisms.

A great deal can be learned about enzymes by studying the rates of enzyme-catalyzed reactions. The rate of a chemical reaction may be studied in a number of ways including:

- Measuring the rate of appearance of a product
- Measuring the rate of disappearance of substrate
- Measuring the pressure of the product as it appears

In this experiment, you will measure the rate of enzyme activity under various conditions, such as different enzyme concentrations, pH values, and temperatures. It is possible to measure the concentration of oxygen gas formed as H_2O_2 is destroyed using an O_2 Gas Sensor.

OBJECTIVES

- Measure the production of oxygen gas as hydrogen peroxide is broken down by the enzyme catalase or peroxidase at various enzyme concentrations.
- Measure and compare the initial rates of reaction for this enzyme when different concentrations of enzyme react with H_2O_2.
- Measure the production of oxygen gas as hydrogen peroxide is broken down by the enzyme catalase or peroxidase at various temperatures.

- Measure and compare the initial rates of reaction for the enzyme at each temperature.
- Measure the production of oxygen gas as hydrogen peroxide is broken down by the enzyme catalase or peroxidase at various pH values.
- Measure and compare the initial rates of reaction for the enzyme at each pH value.

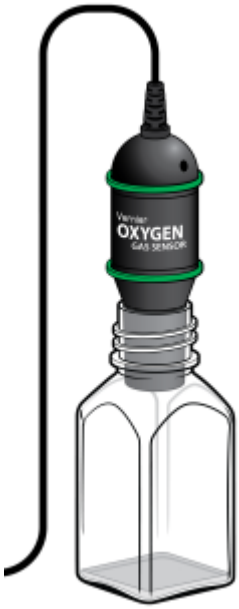

Figure 1

MATERIALS

LabQuest
LabQuest App
O_2 Gas Sensor
400 mL beaker
10 mL graduated cylinder
250 mL Nalgene bottle
three Beral pipettes
3.0% H_2O_2
enzyme suspension
three 18 × 150 mm test tubes
ice
pH buffers
test tube rack
thermometer
goggles
(optional) Stir Station with magnetic stir bar

PROCEDURE

1. Obtain and wear goggles.
2. Connect the O_2 Gas Sensor to LabQuest and choose New from the File menu.
3. On the Meter screen, tap Rate. Change the data-collection rate to 0.25 samples/second and the data-collection duration to 180 seconds.

Part I Effect of enzyme concentration

4. Place three test tubes in a rack and label them 1, 2, and 3. Fill each test tube with 5 mL of 3.0% H_2O_2 and 5 mL of water.
5. Initiate the enzyme catalyzed reaction.
   a. Using a clean dropper pipette, add 5 drops of enzyme suspension to test tube 1.
   b. Begin timing with a stopwatch or clock.
   c. Cover the opening of the test tube with a finger and gently invert the test tube two times.
   d. Pour the contents of the test tube into a clean 250 mL Nalgene bottle.
   e. Place the O_2 Gas Sensor into the bottle as shown in Figure 1. Gently push the sensor down into the bottle until it stops. **Note**: The sensor is designed to seal the bottle with minimal force.
   f. When 30 seconds have passed, start data collection.
6. When data collection has finished, remove the O_2 gas sensor from the Nalgene bottle. Rinse the bottle with water and dry with a paper towel.
7. Determine the rate of enzyme activity.
   a. Tap and drag your stylus across the most linear region of the graph to select these data points.
   b. Choose Curve Fit from the Analyze menu.
   c. Select Linear for the Fit Equation.
   d. Record the slope, *m*, as the reaction rate in Table 2.
   e. Select OK.
8. Store the data from the first run by tapping the File Cabinet icon.
9. Find the rate of enzyme activity for test tubes 2 and 3:
   a. Add 10 drops of enzyme solution to test tube 2. Repeat Steps 5–8.
   b. Add 20 drops of enzyme solution to test tube 3. Repeat Steps 5–7.
10. Display all three runs of data on a single graph.
    a. Tap Run 3, and select All Runs. All three runs will now be displayed on the same graph axes.
    b. Use the graph and the data in Table 2 to answer the questions for Part I.

Part II Effect of temperature

Your teacher will assign a temperature range for your lab group to test. Depending on your assigned temperature range, set up your water bath as described below. Place a thermometer in your water bath to assist in maintaining the proper temperature.

- 0–5°C: 400 mL beaker filled with ice and water
- 20–25°C: No water bath needed to maintain room temperature
- 30–35°C: 400 mL beaker filled with warm water
- 50–55°C: 400 mL beaker filled with hot water

11. Rinse the three numbered test tubes used for Part I. Fill each test tube with 5 mL of 3.0% H_2O_2 and 5 mL of water then place the test tubes in the water bath. The test tubes should be in the water bath for 5 minutes before proceeding to Step 14. Record the temperature of the water bath, as indicated on the thermometer, in the space provided in Table 3.

12. Tap Table. Choose Clear All Data from the Table menu.

13. Tap Graph to display the graph.

14. Find the rate of enzyme activity for test tubes 1, 2, and 3:

    - Add 10 drops of enzyme solution to test tube 1. Repeat Steps 5–8. Record the reaction rate in Table 3.
    - Add 10 drops of enzyme solution to test tube 2. Repeat Steps 5–8. Record the reaction rate in Table 3.
    - Add 10 drops of enzyme solution to test tube 3. Repeat Steps 5–7. Record the reaction rate in Table 3.

15. Calculate the average rate for the three trials you tested. Record the average in Table 3.

16. Record the average rate and the temperature of your water bath from Table 3 on the class data table. When the entire class has reported their data, record the class data in Table 4.

Part III Effect of pH

17. Place three clean test tubes in a rack and label them pH 4, pH 7, and pH 10.

18. Add 5 mL of 3% H_2O_2 and 5 mL of a pH buffer to each test tube, as in Table 1.

Table 1

pH of buffer	Volume of 3% H_2O_2 (mL)	Volume of buffer (mL)
pH 4	5	5
pH 7	5	5
pH 10	5	5

19. Tap Table. Choose Clear All Data from the Table menu.

20. Tap Graph to display the graph.

21. Find the rate of enzyme activity for test tubes labeled pH 4, pH 7, and pH 10:

    - Add 10 drops of enzyme solution to test tube pH 4. Repeat Steps 5–8. Record the reaction rate in Table 5.
    - Add 10 drops of enzyme solution to test tube pH 7. Repeat Steps 5–8. Record the reaction rate in Table 5.
    - Add 10 drops of enzyme solution to test tube pH 10. Repeat Steps 5–7. Record the reaction rate in Table 5.

22. Observe all three runs of data on a single graph.

    a. Tap Run 3 and select All Runs. All three runs will now be displayed on the same graph axes.

    b. Use the displayed graph and the data in Table 5 to answer the questions for Part III.

DATA

Part I Effect of enzyme concentration

Table 2

Sample	Reaction rate (%/min)
5 drops	
10 drops	
20 drops	

Part II Effect of temperature

Table 3	
Sample	Reaction rate (%/min)
Trial 1	
Trial 2	
Trial 3	
Average	
Temperature range: _____° C	

Table 4: Class Data	
Temperature tested (°C)	Average rate (%/min)

Part III Effect of pH

Table 5	
Sample	Reaction rate (%/min)
pH 4	
pH 7	
pH 10	

PROCESSING THE DATA

For Part II of this experiment, make a graph of the rate of enzyme activity *vs.* temperature in Graphical Analysis or by hand. Plot the rate values for the class data in Table 4 on the y-axis and the temperature on the x-axis. Use this graph to answer the questions for Part II.

QUESTIONS

Part I Effect of enzyme concentration

1. How does changing the concentration of enzyme affect the rate of decomposition of H_2O_2?

2. What do you think will happen to the rate of reaction if one increases the concentration of enzyme to 25 drops? Predict what the rate would be for 30 drops.

Part II Effect of temperature

3. At what temperature is the rate of enzyme activity the highest? Lowest? Explain.

4. How does changing the temperature affect the rate of enzyme activity? Does this follow a pattern you anticipated?

5. Why might the enzyme activity decrease at very high temperatures?

Part III Effect of pH

6. At what pH is the rate of enzyme activity the highest? Lowest?

7. How does changing the pH affect the rate of enzyme activity? Does this follow a pattern you anticipated?

EXTENSIONS

1. Determine the reaction rates of trials in Part I for each 30 second interval. What patterns do you see? What could explain the different rates you determined?

2. Different organisms often live in very different habitats. Design a series of experiments to investigate how different types of organisms might affect the rate of enzyme activity. Consider testing a plant, an animal, and a protist.

3. Presumably, at higher concentrations of H_2O_2, there is a greater chance that an enzyme molecule might collide with H_2O_2. If so, the concentration of H_2O_2 might alter the rate of oxygen production. Design a series of experiments to investigate how differing concentrations of the substrate hydrogen peroxide might affect the rate of enzyme activity.

4. Design an experiment to determine the effect of boiling the catalase on the rate of reaction.

5. Explain how environmental factors affect the rate of enzyme-catalyzed reactions.

Monitoring EKG

An electrocardiogram, or EKG, is a graphical recording of the electrical events occurring within the heart. A typical EKG tracing consists of five identifiable deflections. Each deflection is noted by one of the letters P, Q, R, S, or T. The P wave is the first waveform in a tracing and represents the depolarization of the heart's atria. The next waveform is a complex and consists of the Q, R, and S deflection. The QRS complex represents the depolarization of the heart's ventricles. The deflection that represents the repolarization of the atria is usually undetectable because of the intensity of the QRS waveform. The final waveform is the T wave and it represents the repolarization of the ventricles.

Because an EKG is a recording of the heart's electrical events, it is valuable in diagnosing diseases or ailments that damage the conductive abilities of the heart muscle. When cardiac muscle cells are damaged or destroyed, they are no longer able to conduct the electrical impulses that flow through them. This causes the electrical signal to terminate at the damaged tissue or directed away from the signal flow. The termination or redirection of the electrical signal will alter the manner in which the heart contracts. A cardiologist can look at a patient's electrocardiogram and determine the presence of damaged cardiac muscle based on the waveform as well as the time interval between electrical events.

In this activity, you will use the EKG sensor to make a five-second graphical recording of your heart's electrical events. From this recording, you will identify the previously mentioned waveform components and determine the time intervals associated with each.

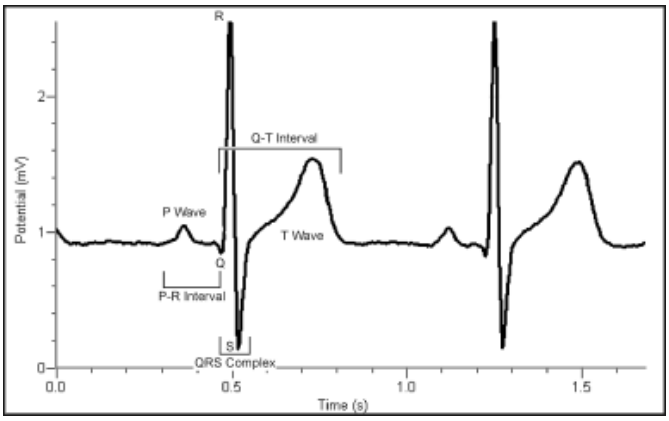

Figure 1

OBJECTIVES

- Use the EKG Sensor to graph your heart's electrical activity.
- Determine the time interval between EKG events.
- Calculate heart rate based on your EKG recording.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct EKG
disposable electrode tabs

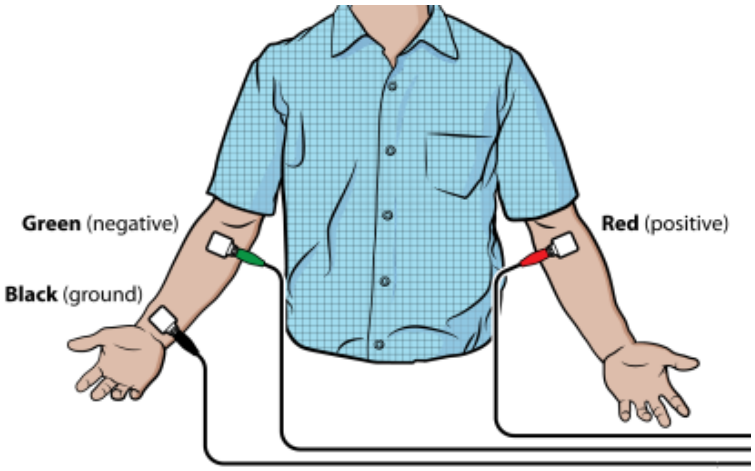

Figure 2

PROCEDURE

1. Launch Graphical Analysis. Connect the EKG Sensor to your Chromebook, computer, or mobile device.

2. Click or tap Mode to open Data Collection Settings. Change End Collection to 5 s. Click or tap Done.

3. Attach three electrode tabs to your arms, as shown in Figure 2. A single tab should be placed on the inside of the right wrist, on the inside of the right upper forearm (below elbow), and on the inside of the left upper forearm (below elbow).

4. Connect the three sensor leads to the electrode tabs as shown in Figure 2. Sit in a reclined position in a chair or lay flat on top of a lab table. Your arms should be hanging at the side unsupported.

5. Another member of the lab group should click or tap Collect to start data collection.

6. Once data have been collected, a graph with voltage and time values will be displayed. Click or tap the graph to examine the data. **Note**: You can also adjust the Examine line by dragging the line.

7. For at least two heartbeats, identify the various EKG waveforms using Figure 1 and determine the time intervals listed below.

8. Record the average for each set of time intervals in Table 2.

Table 1	
Waveform	Time interval
P-R interval	Time from the beginning of P wave to the start of the QRS complex
QRS complex	Time from Q deflection to S deflection
Q-T interval	Time from Q deflection to the end of the T

9. Calculate the heart rate in beats/min using the EKG data. Remember to include the time between the end of the T Wave and the beginning of the next P Wave. Use the total number of seconds for one full heart cycle in the equation. Record the heart rate in Table 2.

$$\frac{\#\ \text{beats}}{\text{minute}} = \frac{1\ \text{beat}}{\_\_\ \text{seconds}} \times \frac{60\ \text{seconds}}{1\ \text{minute}}$$

10. If your EKG was unsatisfactory, repeat Steps 4–6.

11. (optional) Print a copy of your EKG graph. Identify and label the various waveforms on the graph.

DATA

Table 2	
Interval	Time (s)
P - R	
QRS	
Q - T	
Heart rate: _____ beats/min	

QUESTIONS

1. The electrocardiogram is a powerful tool used to diagnose certain types of heart disease. Why is it important to look at the time intervals of the different waveforms?

2. What property of heart muscle must be altered for an EKG to detect a problem? Explain.

3. Based on what you have learned regarding electrocardiograms, can they be used to diagnose all heart diseases or defects? Explain.

4. Describe a cardiovascular problem that could be diagnosed by a cardiologist using an electrocardiogram.

EXTENSION

Using data collected with the EKG Sensor, it is possible to determine a more accurate maximum heart rate value for a person. The commonly used formula for calculating maximum heart rate is:

220 bpm – Individual's Age = Max Heart Rate

While this formula is sufficient for general purposes, it fails to take into account physical differences such as size, and fitness level. For example, an individual that engages in regular exercise will likely have a heart that operates more efficiently due to the effects of athletic training.

To calculate your maximum heart rate, do the following:

a. Run in place or perform some type of exercise, such as jump-n-jacks, for 1-minute.
b. Repeat Steps 1–8 to collect and analyze your electrocardiogram. When analyzing the data in Step 8, only determine the average Q-T interval.
c. Divide 60 seconds by the Q-T interval to calculate your maximum heart rate.

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USB Digital Microscope	BD-EDU-100 ($119)	Computer Chromebook LabQuest 2	▪ Stand alone ▪ Independent light source
ProScope Micro Mobile Microscope	BD-PMM ($149)	iPad iPhone iPod Touch Galaxy S4	▪ Uses imaging apps on mobile device ▪ Independent light source ▪ Different sleeve for each device
ProScope 5MP Microscope Camera	BD-PS-MC5UW ($299)	Computer Chromebook iOS Devices Android Devices	▪ Existing Microscopes ▪ Replaces an eyepiece ▪ Connects to iOS and Android devices via Wi-Fi ▪ Connects to computers and Chromebooks via USB