CO_2 Gas and Human Respiration – Comp

The process of breathing accomplishes two important tasks for the body. During inhalation, oxygen-rich air is brought into your lungs. During exhalation, air depleted in oxygen and rich in carbon dioxide is forced out. Oxygen is then transported to the cells where it is used in the process of respiration, yielding carbon dioxide as a product.

$$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + \text{energy}$$
glucose + oxygen -> carbon dioxide + water

Gas exchange takes place in the lungs at the membrane between the alveoli and the pulmonary capillaries. It is here that oxygen diffuses into the bloodstream and carbon dioxide diffuses out. Under normal circumstances, there is an equilibrium between the oxygen and carbon dioxide levels in the blood. Several mechanisms are involved in maintaining this balance. One such mechanism involves chemoreceptors. These specialized cells respond to changes in carbon dioxide, oxygen and H^+ concentrations and influence the body's ventilation patterns to maintain the proper balance of blood gases.

In this experiment, you will determine what factors affect how long you can hold your breath. You will be tested under two different conditions. The first condition is normal breathing. The second condition is immediately following hyperventilation. Hyperventilation is when your breathing rate is greater than what is necessary for proper exchange of oxygen and carbon dioxide. This will be achieved by a period of rapid breathing prior to holding your breath.

OBJECTIVES

In this experiment, you will

- Use a CO_2 Gas Sensor to determine carbon dioxide levels in exhaled air.
- Evaluate how internal O_2 and CO_2 concentrations influence breathing patterns.

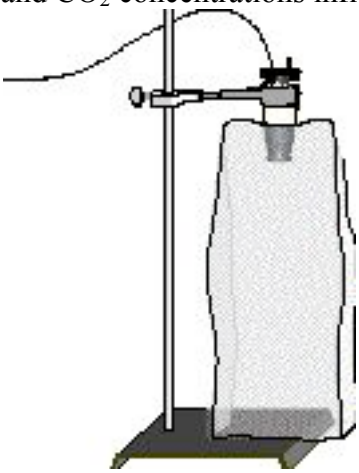

Figure 1

MATERIALS

Computer	Ring stand
Vernier computer interface (Go! Link or LabPro or LabQuest)	Test tube clamp
Logger *Pro*	Produce bag
Newer Vernier CO_2 Sensor *	Masking tape

Preliminary questions

1. How long do you think you can hold your breath?
2. When you hold your breath, what do you think happens to the carbon dioxide concentration in your lungs? Explain.
3. When you hold your breath, what do you think happens to the oxygen concentration in your lungs? Explain.
4. On average, people can hold their breath for a minute. What do you think prevents people from holding their breath for 2 or 3 minutes?

PROCEDURE

Each person in a lab group will take turns being the subject and the tester. When it is your turn to be the subject, your partner will be responsible for operating the equipment.

1. Secure the CO_2 Gas Sensor using a test tube clamp and ring stand as shown in Figure 1. The plastic produce bag should already be taped to the sensor that has been inserted into the bag through a small hole in the bottom.
2. Set the switch on the CO_2 Gas Sensor to the 100,000 ppm range then connect to the Vernier computer interface.
3. Launch Logger *Pro*. Make the following settings:
    - Under the "stopwatch" icon:
        - Sample Rate: 4 s/sample
        - Length: 480 s
    - Insert > Meter > Digital Meter
    - Double-click on the meter and choose "Time" from the drop-down menu.
    - Under Page choose Auto Arrange.
4. When you begin collecting data, it is important that data collection begins at the same point the subject begins to hold his breath.
    a. Have the subject take a deep breath and hold it. Immediately click to begin data collection. The subject should hold his breath as long as possible.
    b. When the subject can no longer hold his breath, he should blow his breath into the produce bag and twist the open end shut. This should result in the produce bag filling with the air the subject was holding in his lungs. Allow data collection to proceed for the full 480 seconds or until the graph has reached a steady value.
    c. When data collection has finished, open the produce bag and pull it back from the sensor exposing the sensor to room air. Leave the bag in that position until you are ready to collect data again.
    d. Click the Examine button, . The cursor will become a vertical line. As you move the mouse pointer across the screen, the CO_2 concentration and time values corresponding to its position will be displayed in the box at the upper-left corner of the graph. Scroll across the data to determine how long the subject held his breath. Record the time in Table 1. Determine the maximum

and minimum CO_2 concentrations and record them in Table 1. To remove the examine box, click the Examine button again.

5. Store your data. To do this, choose Experiment > Store Latest Run.

NOTE: The recovery of the CO_2 Sensor is very slow. It may take a full 5-7 minutes before the readings drop to the background level of CO_2 you observed in step 4.

6. Collect data following mild hyperventilation.
    a. Pull the produce bag back down off the sensor in preparation for data collection.
    b. Have the subject take 10 quick deep breaths, forcefully blowing out all air after each breath. The subject should then take an 11th breath and hold it. Immediately click to begin data collection. The subject should hold his breath as long as possible.
    c. When the subject can no longer hold his breath, he should blow his breath into the produce bag and twist the open end shut. This results in the produce bag filled with the air the subject was holding in his lungs. Allow data collection to proceed for the full 480 seconds.
    d. When data collection has finished, open the produce bag and pull it back from the sensor exposing the sensor to room air.
    e. Click the Examine button,. The cursor will become a vertical line. As you move the mouse pointer across the screen, the CO_2 concentration and time values corresponding to its position will be displayed in the box at the upper-left corner of the graph. Scroll across the data to determine how long the subject held his breath. Record the time in Table 1. Determine the maximum and minimum CO_2 concentrations and record them in Table 1. To remove the examine box, click the Examine button again.
7. Both runs should now be displayed on the same graph. Use the displayed graph and the data in Table 1 to answer the questions below.

DATA

Table 1

	Breath held (s)	Maximum CO_2 concentration (ppm)	Minimum CO_2 concentration (ppm)	Change in CO_2 (ppm)
Normal				
Hyperventilation				

QUESTIONS

1. Did the CO_2 concentration change as you expected? If not, explain how it was different.
2. Did the amount of time you held your breath change after hyperventilation (taking the 10 quick breaths)? If so, did the time increase or decrease? Explain.

3. After hyperventilation, was the resulting concentration of CO_2 in your exhaled breath higher or lower than in the first attempt? How much did it change? What do you contribute this to?
4. On the first trial, what do you believe forced you to start breathing again?
5. On the second trial, what do you believe forced you to start breathing again?
6. Based on your answers to questions 4 and 5, does the concentration of oxygen or carbon dioxide have a greater influence on how long one can hold his breath?

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* The newer CO_2 Sensor must be used for this lab, as the older sensors have only one scale that doesn't go high enough to record the CO_2 level in human breath.

 Newer Sensor	 Older Sensor

This lab is based on the experiment in Biology with Vernier, "Oxygen Gas and Human Respiration". That experiment uses the O_2 Gas Sensor and is a great lab to do in conjunction with this one.

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