

Cellular Respiration in Humans

Oxygen and Carbon Dioxide Gas Exchange

Objectives

1. Students will use an O₂ Gas Sensor to determine residual oxygen levels and a CO₂ Gas Sensor to determine carbon dioxide levels in exhaled air.
2. Students will evaluate how internal O₂ and CO₂ concentrations fluctuate while holding their breath.
3. Students will gain understanding of gas exchange at a cellular level and its relationship to cellular energy production.

Oxygen Gas and Human Respiration

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.*

As you saw in the Yeast Respiration lab, the aerobic respiration reaction is written:



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.

PRE-LAB QUESTIONS

1. What is the purpose of today's lab? In 1-2 sentences and in your own words, describe what you are trying to determine by doing this experiment.

2. With the knowledge that your cells are constantly using oxygen that is transported throughout your body by your blood, **what do you think will happen** to the **oxygen** concentration in your lungs? Explain your reasoning.

3. With your answer to question 2 in mind, **what do you will happen** to the **carbon dioxide** concentration in your lungs? Explain your reasoning.

Procedure for today's lab

Students may work in groups of 2 – 3 people today. Each GROUP should start with:

- one ring stand
- one ring stand clamp
- one plastic bag
- O₂ Sensor
- CO₂ Sensor
- LabQuest

Each person in your lab group will take turns being the subject (the person who breathes into the bag assembly) and the tester (the person who operates the LabQuest). When it is your turn to be the subject, your partner will be responsible for operating the equipment.

Note: When breathing into the bag, do not let it touch your mouth. If you are ill, please make sure you are the last "subject" to breathe into the bag assembly.

1) If the O₂ and CO₂ sensors are not already secured to the plastic bag, use tape to do so.

*Make sure the O₂ sensor stays **UPRIGHT** at all times. It needs to be upright and level to work properly.*

2) Connect the O₂ sensor to the CH1 port and CO₂ sensor to the CH2 port on your LabQuest. With the "File Sensors" tab open, you should see both an ambient O₂ and CO₂ reading on your LabQuest screen. If the CO₂ reading is not **~350-450 ppm**, it must be **recalibrated**. Ask your TA for help before proceeding.

3) To set up your sampling rates, use your stylus to tap the "**Rate**" box to the right of the O₂ and CO₂ readings. The following values should be set:

Rate = 1 sample/s
Interval = 1 s/sample
Length = 120 s

If the values need to be changed, tap the incorrect value box once. A small QWERTY keyboard will appear. Use the stylus to erase (“**backspace**” button) the incorrect value. Use the stylus to enter the correct numerical value. When you are finished tap “**OK**”. You are now ready to begin collecting data for the first subject in your group.

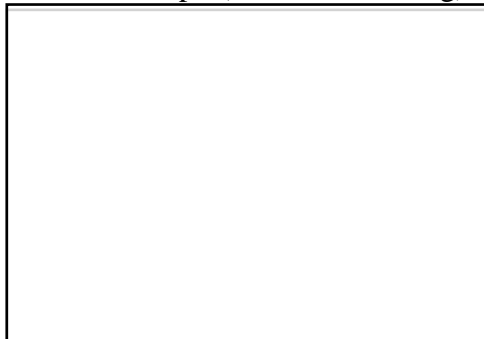
When you begin collecting data, it is important that data collection begins at the same point when the subject begins to hold his or her breath!

- 4) While breathing normally, have the subject take a deep breath and hold it. Immediately tap the “**Collect**” button at the same time. The subject should hold his or her breath as long as possible.
- 5) When the subject can no longer hold his or her breath, the subject should blow the held breath into the plastic bag and securely twist the opening shut so that none of the air escapes. Allow data collection to proceed for the full 120 seconds, after which the LabQuest will stop automatically.
- 6) When the data collection has finished, open the bag and pull it up over the sensors so that they are exposed to ambient air again. Leave the bag in this position until you are prepared to collect data again.
- 7) You will see a graph of the O₂ and CO₂ concentrations (two separate lines) collected over the 120 second period. Use your stylus to tap any point along the graphed lines. The data for that point will be displayed to the right of the graph. (*Hint: The x-axis is time, and the y-axis is gas concentration.*) In this way, inspect your graph to determine how long the subject held his or her breath. Determine the max and min of both the O₂ AND CO₂ concentrations. Record this data in **Tables 1 & 2**. Roughly sketch the graph before proceeding to the next step.
- 8) Next, the subject will need to collect data following mild hyperventilation. Pull the bread bag back down over the sensors. Have the subject take 10 quick breaths, forcefully blowing out all air after each breath. The subject should then take the 11th breath and hold it. Immediately begin data collection by tapping the “**Collect**” button. The LabQuest will ask if you wish to save your previous data; tap “**Discard**” to begin collecting data.
- 10) Repeat steps **5 – 7** to collect hyperventilation data.
- 11) *At this point, group members should switch*, so that the subject is now in charge of operating the LabQuest equipment. The new subject should repeat steps **4 – 10**. Make sure that each group member records his or her own O₂ and CO₂ concentration data for both breathing conditions.

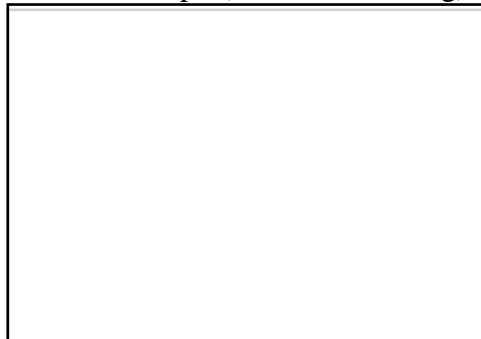
Data

Sketch your graphs here:
Don't forget to label your graph axes!

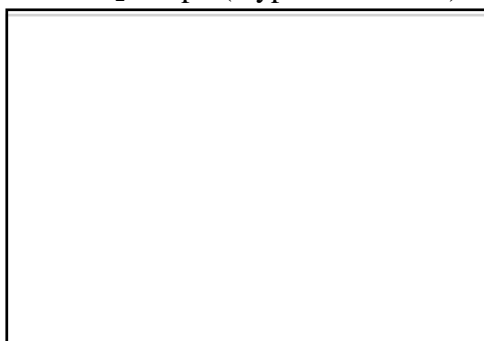
O₂ Graph (Normal breathing)



CO₂ Graph (Normal breathing)



O₂ Graph (Hyperventilation)



CO₂ Graph (Hyperventilation)

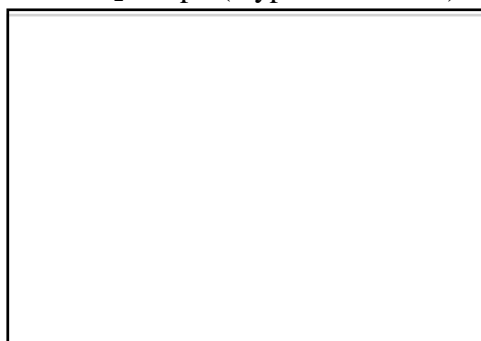


Table 1. Breathing Data

| <u>BREATHING TYPE:</u> | Normal | Hyperventilation |
|---|---------------|-------------------------|
| Total Time Breath Held (s) | | |
| Max O₂ concentration (%) | | |
| Min O₂ concentration (%) | | |
| Max CO₂ concentration (ppm) | | |
| Min CO₂ concentration (ppm) | | |

