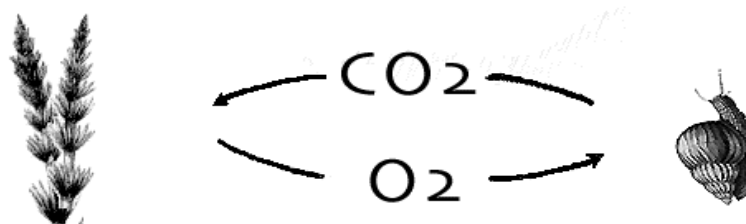


Interdependence of Plants and Animals

Plants and animals share many of the same chemicals throughout their lives. In most ecosystems, oxygen, carbon dioxide, water, food, and nutrients are exchanged between plants and animals. In this lab, you will determine the relationships between two organisms—a plant (elodea) and an animal (a snail).



You will determine how oxygen and carbon dioxide are exchanged among elodea plants, snails, and the water in which both exist.

To perform the necessary tests, you will need to determine the presence of carbon dioxide. An easy way to do this is to monitor the pH of the pond water. If carbon dioxide dissolves in water, it forms carbonic acid, H_2CO_3 , and the pH decreases. If carbon dioxide is removed from pond water, the amount of carbonic acid goes down and the pH increases. A pH Sensor can be used to monitor the pH and determine whether carbon dioxide is released into the pond water or is removed from the water. Dissolved oxygen (DO) can be monitored with the aid of a Dissolved Oxygen Probe. Increases or decreases in the amount of dissolved oxygen can be rapidly assessed with the Dissolved Oxygen Probe.

OBJECTIVES

In this experiment, you will

- Use a Dissolved Oxygen Probe to measure the dissolved oxygen in water.
- Use a pH Sensor to measure the pH of water.
- Use pH measurements to make inferences about the amount of CO_2 dissolved in water.
- Determine whether snails consume or produce oxygen and CO_2 in water.
- Determine whether plants consume or produce oxygen and CO_2 in the light.
- Determine whether plants consume or produce oxygen and CO_2 in the dark.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
Vernier Dissolved Oxygen Probe
Vernier pH Sensor
250 mL beaker
eight 25 x 150 mm screw top test tubes

two test tube racks
distilled wash water
aluminum foil
Parafilm
pond snails
pond water
sprigs of elodea

PRE-LAB PROCEDURE

Important: Prior to each use, the Dissolved Oxygen Probe must warm up for a period of 10 minutes as described below. If the probe is not warmed up properly, inaccurate readings will result. Perform the following steps to prepare the Dissolved Oxygen Probe.

1. Prepare the Dissolved Oxygen Probe for use.
 - a. Remove the protective cap.
 - b. Unscrew the membrane cap from the tip of the probe.
 - c. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling Solution.
 - d. Carefully thread the membrane cap back onto the electrode.
 - e. Place the probe into a 250 mL beaker containing distilled water.

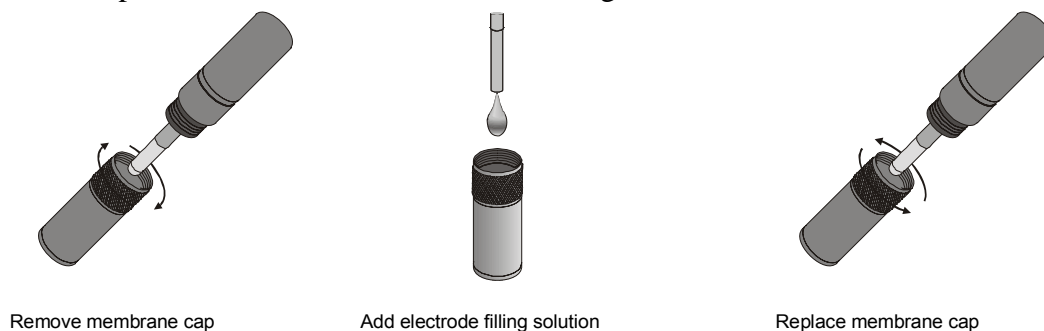





Figure 1

2. Connect the pH Sensor and the Dissolved Oxygen Probe to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.
3. Choose New Experiment from the  Experiment menu. For this experiment, you will monitor the sensor meter and record the data by hand. You will not electronically store the data.
4. It is necessary to warm up the Dissolved Oxygen Probe for 10 minutes before taking readings. With the probe still in the distilled water beaker, wait 10 minutes while the probe warms up. The probe must stay connected at all times to keep it warmed up. If disconnected for a period longer than 5 minutes, it will be necessary to repeat this step. (Note: If you are using the TI-Nspire Lab Cradle, the meter will display the sensor values in light gray until the sensor has warmed up. At that time, the sensor values will display in black.)
5. Calibrate the Dissolved Oxygen Probe.
 - If your instructor directs you to use the stored calibration, proceed directly to Step 6.
 - If your instructor directs you to manually enter the calibration values, choose Set Up Sensors ► Calibrate ► Dissolved Oxygen ► Manual Entry from the  Experiment menu. Enter the values for K0 and K1. Select OK. Proceed directly to Step 6.
 - If your instructor directs you to perform a new calibration, continue with this step to calibrate your sensor.

Zero-Oxygen Calibration Point

- Set Up Sensors ► Calibrate ► Dissolved Oxygen ► Two Point from the  Experiment menu.
- Remove the probe from the water bath and place the tip of the probe into the Sodium Sulfite Calibration Solution. **Important:** No air bubbles can be trapped below the tip of the probe or the probe will sense an inaccurate dissolved oxygen level. If the voltage does not rapidly decrease, tap the side of the bottle with the probe to dislodge the bubble. The readings should be in the 0.2 to 0.6 V range.
- Enter **0** as the first reference value.
- When the voltage stabilizes (~1 minute), select OK.

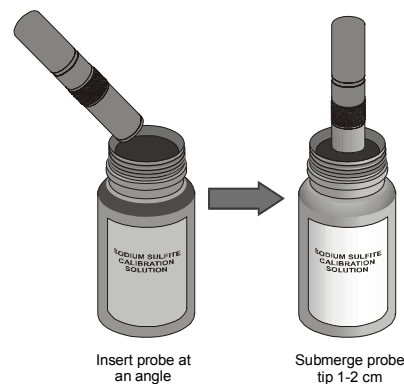


Figure 2

Saturated DO Calibration Point

- Rinse the probe with distilled water and gently blot dry.
- Unscrew the lid of the calibration bottle provided with the probe. Slide the lid and the grommet about 1/2 inch onto the probe body.

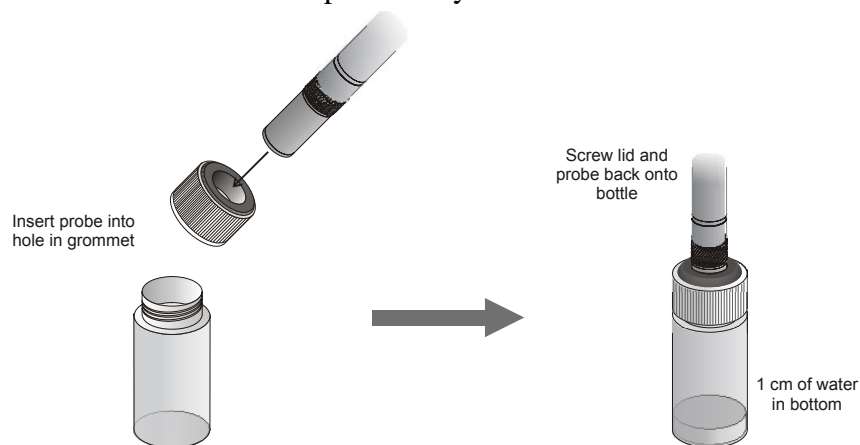


Figure 3

- Add water to the bottle to a depth of about 1/4 inch and screw the bottle into the cap, as shown. **Important:** Do not touch the membrane or get it wet during this step.
- Enter the correct saturated dissolved-oxygen value (in mg/L) from Table 3 (for example, at 18 °C and atmospheric pressure of 690 mmHg enter **8.66**) using the current barometric pressure and air temperature values. If you do not have the current air pressure, use Table 4 to estimate the air pressure at your altitude.
- Keep the probe in this position for about a minute. The readings should be above 2.0 V. When the voltage reading stabilizes, select OK.
- If directed by your instructor, record the values for K0 and K1. Select the Save Calibration with Document option, and then select OK.

PROCEDURE

- Obtain and label eight test tubes 1–8.
- Set test tubes 1–4 in one test tube rack and test tubes 5–8 in a second test tube rack.

DataQuest 15

8. Fill each tube with pond water.
9. Place one snail each in test tubes 2, 4, 6, and 8.
10. Place one sprig of elodea in test tubes 3, 4, 7, and 8. Each set of four tubes should appear similar to those in Figure 4.

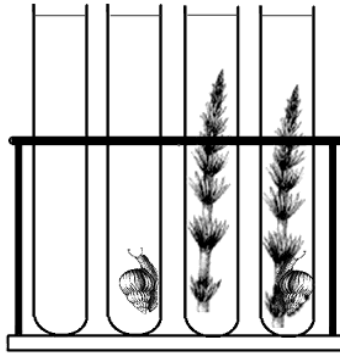


Figure 4

11. Wrap test tubes 5–8 in aluminum foil to make each light tight.
12. Remove the pH Sensor from the storage bottle. Rinse the sensor thoroughly with distilled water. Place the pH Sensor into test tube 1 and gently swirl to allow water to move past the sensor's tip. When the reading stabilizes, record the pH value in Table 1.
13. Repeat Step 12 for each of the other seven test tubes.
14. When all of the pH readings have been taken, rinse the pH Sensor and return it to the pH storage bottle.
15. Place the Dissolved Oxygen Probe into test tube 1 so that it is submerged half the depth of the water. Gently and continuously move the probe up and down a distance of about 1 cm in the tube. This allows water to move past the probe's tip. **Note:** Do not agitate the water, or oxygen from the atmosphere will mix into the water and cause erroneous readings.
16. When the dissolved oxygen reading stabilizes (~30 seconds), record its value in Table 1.
17. Repeat Steps 15–16 for each of the other seven test tubes.
18. When all of the dissolved oxygen readings have been taken, rinse the Dissolved Oxygen Probe and return it to the distilled water beaker.
19. Completely fill each test tube with pond water and tighten the cap onto the tube. Do not allow any air bubbles to remain in any of the test tubes. Unscrew each cap slightly, so that they just barely open. Wrap each tube with Parafilm so that they do not leak water. The Parafilm will expand, if necessary, to accommodate any pressure build-up in a tube. No oxygen or carbon dioxide should enter or leave a tube.
20. Place test tubes 1–8 near the light source, as directed by your instructor.

21. Predict how the pH and dissolved oxygen will change in each tube. Write a short statement that explains your reasoning. Be specific about the roles of both the snail and elodea. Be prepared to discuss your reasoning in class on Day 2.

Day 2

22. Repeat Steps 1–5 to set up the pH Sensor and Dissolved Oxygen Probe.
23. Repeat Steps 12–18 to take pH and DO readings for each of the test tubes.
24. Now, the elodea will use the environment established by the snail and the snail will use the environment established by the elodea. Remove the snail from test tube 2 and the elodea from test tube 3. Place the snail in test tube 3 and the elodea in test tube 2. **Note:** Try not to aerate the water during the transfer.
25. Remove the snail from test tube 6 and the elodea from test tube 7. Place the snail in test tube 7 and the elodea in test tube 6.
26. Measure the pH and DO of test tubes 1–3 and test tubes 5–7. Record the results in Table 2. These values should be similar to those measured before the transfer. If not, the water may have been mixed too vigorously with the atmospheric air.
27. Completely fill test tubes 1–3 and test tubes 5–7 with water and tighten the cap onto each tube, as in Step 19. Wrap each slightly opened test tube with Parafilm. Place test tubes 1–3 and test tubes 5–7 near the light source, as in Step 19.
28. Return the snails and elodea from test tubes 4 and 8, as directed by your instructor. Clean and return the test tubes.

Day 3

29. Repeat Steps 1–5 to set up the pH Sensor and Dissolved Oxygen Probe.
30. Repeat Steps 12–18 for test tubes 1–3 and 5–7. Record the results in Table 2.
31. Return the snails and elodea as directed by your instructor. Clean and return the test tubes.

DATA

| Table 1 | | | | | | |
|-----------|----------|----------|-------------|----------|----------|-------------|
| Test Tube | pH Day 1 | pH Day 2 | Δ pH | DO Day 1 | DO Day 2 | Δ DO |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |

| Table 2 | | | | | | |
|-----------|----------|----------|-------------|----------|----------|-------------|
| Test Tube | pH Day 2 | pH Day 3 | Δ pH | DO Day 2 | DO Day 3 | Δ DO |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |

PROCESSING THE DATA

- Calculate the change in pH for Tables 1–2. Record your results in Tables 1–2.
- Calculate the change in dissolved oxygen for Tables 1–2. Record your results in Tables 1–2.

QUESTIONS

- Consider the snails. Comparing the readings from day 1 to day 2, answer the following:
 - Do snails produce or consume CO_2 when in the light?
 - Do snails produce or consume oxygen when in the light?
 - Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?
 - Do snails produce or consume CO_2 when in the dark?
 - Do snails produce or consume oxygen when in the dark?
 - Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?

2. Consider the elodea. Comparing the readings from day 1 to day 2, answer the following:
 - a. Do elodea produce or consume CO₂ when in the light?
 - b. Do elodea produce or consume oxygen when in the light?
 - c. Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?
 - d. Do elodea produce or consume CO₂ when in the dark?
 - e. Do elodea produce or consume oxygen when in the dark?
 - f. Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?
3. Consider the elodea placed in the snail's water on days 2–3. Comparing the readings from day 2 to day 3, answer the following:
 - a. Do elodea produce or consume CO₂ when in the light?
 - b. Do elodea produce or consume oxygen when in the light?
 - c. Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?
 - d. Do elodea produce or consume CO₂ when in the dark?
 - e. Do elodea produce or consume oxygen when in the dark?
 - f. Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?
4. Consider the snail placed in the elodea's water on days 2–3. Comparing the readings from day 2 to day 3, answer the following:
 - a. Do snails produce or consume CO₂ when in the light?
 - b. Do snails produce or consume oxygen when in the light?
 - c. Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?
 - d. Do snails produce or consume CO₂ when in the dark?
 - e. Do snails produce or consume oxygen when in the dark?
 - f. Which test tubes allow you to answer this? Which test tube is the experimental test tube? Which test tube is the control test tube?
5. Summarize the relationship between snails and plants in a pond. Explain your reasoning.
6. Interpret the results of Test Tube 4 and Test Tube 8. Compare your findings to the results obtained from Table 2.
7. How do your conclusions compare to your predictions in Step 21?

CALIBRATION TABLES

Table 3: 100% Dissolved Oxygen Capacity (mg/L)

| | 770 mm | 760 mm | 750 mm | 740 mm | 730 mm | 720 mm | 710 mm | 700 mm | 690 mm | 680 mm | 670 mm | 660 mm |
|------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 0°C | 14.76 | 14.57 | 14.38 | 14.19 | 13.99 | 13.80 | 13.61 | 13.42 | 13.23 | 13.04 | 12.84 | 12.65 |
| 1°C | 14.38 | 14.19 | 14.00 | 13.82 | 13.63 | 13.44 | 13.26 | 13.07 | 12.88 | 12.70 | 12.51 | 12.32 |
| 2°C | 14.01 | 13.82 | 13.64 | 13.46 | 13.28 | 13.10 | 12.92 | 12.73 | 12.55 | 12.37 | 12.19 | 12.01 |
| 3°C | 13.65 | 13.47 | 13.29 | 13.12 | 12.94 | 12.76 | 12.59 | 12.41 | 12.23 | 12.05 | 11.88 | 11.70 |
| 4°C | 13.31 | 13.13 | 12.96 | 12.79 | 12.61 | 12.44 | 12.27 | 12.10 | 11.92 | 11.75 | 11.58 | 11.40 |
| 5°C | 12.97 | 12.81 | 12.64 | 12.47 | 12.30 | 12.13 | 11.96 | 11.80 | 11.63 | 11.46 | 11.29 | 11.12 |
| 6°C | 12.66 | 12.49 | 12.33 | 12.16 | 12.00 | 11.83 | 11.67 | 11.51 | 11.34 | 11.18 | 11.01 | 10.85 |
| 7°C | 12.35 | 12.19 | 12.03 | 11.87 | 11.71 | 11.55 | 11.39 | 11.23 | 11.07 | 10.91 | 10.75 | 10.59 |
| 8°C | 12.05 | 11.90 | 11.74 | 11.58 | 11.43 | 11.27 | 11.11 | 10.96 | 10.80 | 10.65 | 10.49 | 10.33 |
| 9°C | 11.77 | 11.62 | 11.46 | 11.31 | 11.16 | 11.01 | 10.85 | 10.70 | 10.55 | 10.39 | 10.24 | 10.09 |
| 10°C | 11.50 | 11.35 | 11.20 | 11.05 | 10.90 | 10.75 | 10.60 | 10.45 | 10.30 | 10.15 | 10.00 | 9.86 |
| 11°C | 11.24 | 11.09 | 10.94 | 10.80 | 10.65 | 10.51 | 10.36 | 10.21 | 10.07 | 9.92 | 9.78 | 9.63 |
| 12°C | 10.98 | 10.84 | 10.70 | 10.56 | 10.41 | 10.27 | 10.13 | 9.99 | 9.84 | 9.70 | 9.56 | 9.41 |
| 13°C | 10.74 | 10.60 | 10.46 | 10.32 | 10.18 | 10.04 | 9.90 | 9.77 | 9.63 | 9.49 | 9.35 | 9.21 |
| 14°C | 10.51 | 10.37 | 10.24 | 10.10 | 9.96 | 9.83 | 9.69 | 9.55 | 9.42 | 9.28 | 9.14 | 9.01 |
| 15°C | 10.29 | 10.15 | 10.02 | 9.88 | 9.75 | 9.62 | 9.48 | 9.35 | 9.22 | 9.08 | 8.95 | 8.82 |
| 16°C | 10.07 | 9.94 | 9.81 | 9.68 | 9.55 | 9.42 | 9.29 | 9.15 | 9.02 | 8.89 | 8.76 | 8.63 |
| 17°C | 9.86 | 9.74 | 9.61 | 9.48 | 9.35 | 9.22 | 9.10 | 8.97 | 8.84 | 8.71 | 8.58 | 8.45 |
| 18°C | 9.67 | 9.54 | 9.41 | 9.29 | 9.16 | 9.04 | 8.91 | 8.79 | 8.66 | 8.54 | 8.41 | 8.28 |
| 19°C | 9.47 | 9.35 | 9.23 | 9.11 | 8.98 | 8.86 | 8.74 | 8.61 | 8.49 | 8.37 | 8.24 | 8.12 |
| 20°C | 9.29 | 9.17 | 9.05 | 8.93 | 8.81 | 8.69 | 8.57 | 8.45 | 8.33 | 8.20 | 8.08 | 7.96 |
| 21°C | 9.11 | 9.00 | 8.88 | 8.76 | 8.64 | 8.52 | 8.40 | 8.28 | 8.17 | 8.05 | 7.93 | 7.81 |
| 22°C | 8.94 | 8.83 | 8.71 | 8.59 | 8.48 | 8.36 | 8.25 | 8.13 | 8.01 | 7.90 | 7.78 | 7.67 |
| 23°C | 8.78 | 8.66 | 8.55 | 8.44 | 8.32 | 8.21 | 8.09 | 7.98 | 7.87 | 7.75 | 7.64 | 7.52 |
| 24°C | 8.62 | 8.51 | 8.40 | 8.28 | 8.17 | 8.06 | 7.95 | 7.84 | 7.72 | 7.61 | 7.50 | 7.39 |
| 25°C | 8.47 | 8.36 | 8.25 | 8.14 | 8.03 | 7.92 | 7.81 | 7.70 | 7.59 | 7.48 | 7.37 | 7.26 |
| 26°C | 8.32 | 8.21 | 8.10 | 7.99 | 7.89 | 7.78 | 7.67 | 7.56 | 7.45 | 7.35 | 7.24 | 7.13 |
| 27°C | 8.17 | 8.07 | 7.96 | 7.86 | 7.75 | 7.64 | 7.54 | 7.43 | 7.33 | 7.22 | 7.11 | 7.01 |
| 28°C | 8.04 | 7.93 | 7.83 | 7.72 | 7.62 | 7.51 | 7.41 | 7.30 | 7.20 | 7.10 | 6.99 | 6.89 |
| 29°C | 7.90 | 7.80 | 7.69 | 7.59 | 7.49 | 7.39 | 7.28 | 7.18 | 7.08 | 6.98 | 6.87 | 6.77 |
| 30°C | 7.77 | 7.67 | 7.57 | 7.47 | 7.36 | 7.26 | 7.16 | 7.06 | 6.96 | 6.86 | 6.76 | 6.66 |

Table 4: Approximate Barometric Pressure at Different Elevations

| Elevation (m) | Pressure (mm Hg) | Elevation (m) | Pressure (mm Hg) | Elevation (m) | Pressure (mm Hg) |
|---------------|------------------|---------------|------------------|---------------|------------------|
| 0 | 760 | 800 | 693 | 1600 | 628 |
| 100 | 748 | 900 | 685 | 1700 | 620 |
| 200 | 741 | 1000 | 676 | 1800 | 612 |
| 300 | 733 | 1100 | 669 | 1900 | 604 |
| 400 | 725 | 1200 | 661 | 2000 | 596 |
| 500 | 717 | 1300 | 652 | 2100 | 588 |
| 600 | 709 | 1400 | 643 | 2200 | 580 |
| 700 | 701 | 1500 | 636 | 2300 | 571 |