Dissolved Oxygen in Water

Although water is composed of oxygen and hydrogen atoms, biological life in water depends upon another form of oxygen—molecular oxygen. Oxygen is used by organisms in aerobic respiration, where energy is released by the combustion of sugar in the mitochondria. This form of oxygen can fit into the spaces between water molecules and is available to aquatic organisms.

Fish, invertebrates, and other aquatic animals depend upon the oxygen dissolved in water. Without this oxygen, they would suffocate. Some organisms, such as salmon, mayflies, and trout, require high concentrations of oxygen in their water. Other organisms, such as catfish, midge fly larvae, and carp can survive with much less oxygen. The ecological quality of the water depends largely upon the amount of oxygen the water can hold.

The following table indicates the normal tolerance of selected animals to temperature and oxygen levels. The quality of the water can be assessed with fair accuracy by observing the aquatic animal populations in a stream.

Table 1

Animal	Temperature Range (°C)	Minimum Dissolved Oxygen (mg/L)
Trout	5–20	6.5
Smallmouth bass	5–28	6.5
Caddisfly larvae	10–25	4.0
Mayfly larvae	10–25	4.0
Stonefly larvae	10–25	4.0
Catfish	20–25	2.5
Carp	10–25	2.0
Mosquito	10–25	1.0
Water boatmen	10–25	2.0

OBJECTIVES

In this experiment, you will

- Use a Dissolved Oxygen Probe to measure the concentration of dissolved oxygen in water.
- Study the effect of temperature on the amount of dissolved oxygen in water.
- Predict the effect of water temperature on aquatic life.

MATERIALS

computer
Vernier computer interface
Vernier Dissolved Oxygen Probe
Vernier Temperature Probe
Logger*Pro*
100 mL beaker
two 250 mL beakers
hot and cold water
1 gallon plastic milk container
Styrofoam cup

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 blue 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 container of water.

Figure 1

2. Connect the Dissolved Oxygen Probe to Channel 1 of the Vernier interface. Connect the Temperature Probe to Channel 2.

3. Prepare the computer for data collection by opening the file "12A Dissolved Oxygen" from the *Advanced Biology with Vernier* folder of Logger*Pro*.

4. It is necessary to warm up the Dissolved Oxygen Probe for 10 minutes before taking readings. To warm up the probe, leave it connected to the interface, with Logger *Pro* running, for 10 minutes. The probe must stay connected at all times to keep it warmed up. If disconnected for a few minutes, it will be necessary to warm up the probe again.

5. You are now ready to calibrate the Dissolved Oxygen Probe.
   - If your instructor directs you to use the calibration stored in the experiment file, then proceed to Step 6.
   - If your instructor directs you to perform a new calibration for the Dissolved Oxygen Probe, use the procedure at the end of this lab.

PROCEDURE

6. Prepare for data collection by clicking ▶ Collect.

7. Obtain two 250 mL beakers. Fill one beaker with ice and cold water. Fill the second beaker with warm water about 40–50°C.

8. Place approximately 100 mL of cold water and a couple small pieces of ice, from the beaker filled with ice, into a clean plastic one-gallon milk container. Seal the container and vigorously shake the water for a period of 2 minutes. This will allow the air inside the container to dissolve into the water sample. Pour the water into the Styrofoam cup.

9. Place the Temperature Probe in the Styrofoam cup as shown in Figure 2. Place the shaft of the Dissolved Oxygen Probe into the water and gently stir. Avoid hitting the edge of the cup with the probe.

10. Monitor the dissolved oxygen readings in the meter. Give the dissolved oxygen readings ample time to stabilize (90–120 seconds). At colder temperatures the probe will require a greater amount of time to stabilize. When the readings have stabilized, click Keep.

11. Remove the probes from the water sample and place the Dissolved Oxygen Probe into a beaker filled with distilled water.

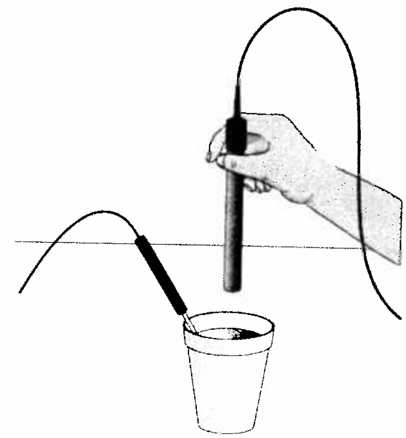

Figure 2

12. Pour the water from the Styrofoam cup back into the milk container. Seal the container and shake the water vigorously for 1 minute.

13. Repeat Steps 9–12 until the water sample reaches room temperature. When room temperature has been reached then begin adding about 25 mL of warm water (40°C–50°C) prior to shaking the water sample. This will allow you to take warmer water readings. Take dissolved oxygen readings until the water temperature reaches 35°C.

14. When all readings have been taken click ■ Stop.

15. In Table 2, record the dissolved oxygen and temperature readings from the table.

16. Print the graph of dissolved oxygen *vs.* temperature. Enter your name(s) and the number of copies of the graph.

DATA

Table 2	
Temperature (°C)	Dissolved Oxygen (mg/L)

QUESTIONS

1. At what temperature was the dissolved oxygen concentration the highest? Lowest?
2. Does your data indicate how the amount of dissolved oxygen in the water is affected by the temperature of water? Explain.
3. If you analyzed the invertebrates in a stream and found an abundant supply of caddisflies, mayflies, dragonfly larvae, and trout, what minimum concentration of dissolved oxygen would be present in the stream? What maximum temperature would you expect the stream to sustain?
4. Mosquito larvae can tolerate extremely low dissolved oxygen concentrations, yet cannot survive at temperatures above approximately 25°C. How might you account for dissolved oxygen concentrations of such a low value at a temperature of 25°C? Explain.
5. Why might trout be found in pools of water shaded by trees and shrubs more commonly than in water where the trees have been cleared?

CALIBRATION PROCEDURE

1. Perform the calibration.

Zero-Oxygen Calibration Point

a. Choose Calibrate ▸ CH1: Dissolved Oxygen (mg/L) from the Experiment menu and then click [Calibrate Now].

b. Remove the probe from the water 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 any bubbles. The readings should be in the 0.2 to 0.5 V range.

c. Type **0** (the known value in mg/L) in the edit box.

d. When the displayed voltage reading for Reading 1 stabilizes, click [Keep].

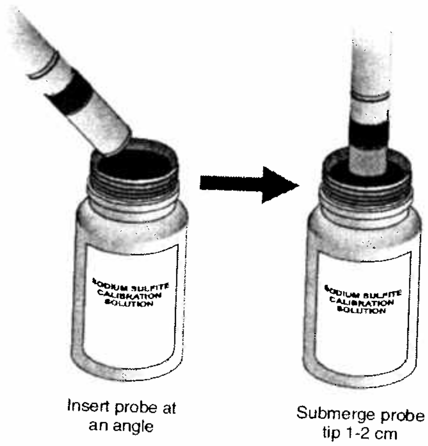

Figure 3

Saturated DO Calibration Point

e. Rinse the probe with distilled water and gently blot dry.

f. Unscrew the lid of the calibration bottle provided with the probe. Slide the lid and the grommet about 2 cm onto the probe body.

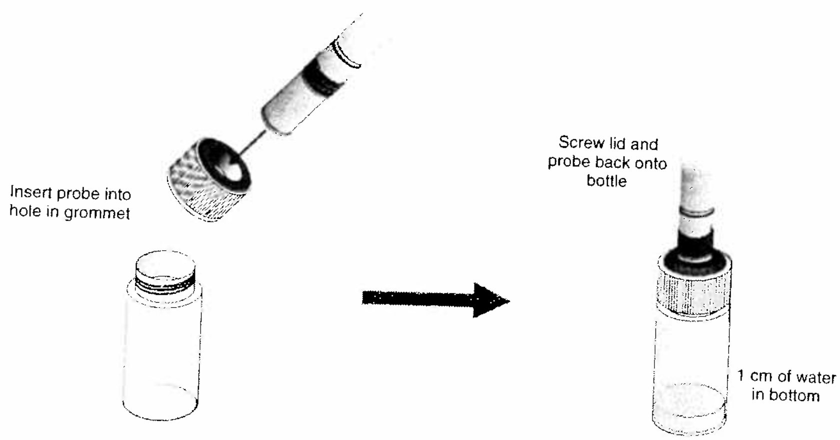

Figure 4

g. Add water to the bottle to a depth of about 1 cm and screw the bottle into the cap, as shown. **Important:** Do not touch the membrane or get it wet during this step. Keep the probe in this position for about a minute.

h. Type the correct saturated dissolved-oxygen value (in mg/L) from Table 3 (for example, **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.

i. When the displayed voltage reading for Reading 2 stabilizes (readings should be above 2.0 V), click [Keep].

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