Dissolved Oxygen

INTRODUCTION

Oxygen gas dissolved in water is vital to the existence of most aquatic organisms. Oxygen is a key component in cellular respiration for both aquatic and terrestrial life. The concentration of dissolved oxygen, DO, in an aquatic environment is an important indicator of the environment's water quality.

Some organisms, such as salmon, mayflies, and trout, require high concentrations of dissolved oxygen. Other organisms, such as catfish, mosquito larvae, and carp, can survive in environments with lower concentrations of dissolved oxygen. The diversity of organisms is greatest at higher DO concentrations. Table 1 lists the minimum dissolved oxygen concentrations necessary to sustain selected animals.

Table 1: Minimum DO Requirements

Organism	Minimum dissolved oxygen (mg/L)
Trout	6.5
Smallmouth bass	6.5
Caddisfly larvae	4.0
Mayfly larvae	4.0
Catfish	2.5
Carp	2.0
Mosquito larvae	1.0

Oxygen gas is dissolved in water by a variety of processes—diffusion between the atmosphere and water at its surface, aeration as water flows over rocks and other debris, churning of water by waves and wind, and photosynthesis of aquatic plants. There are many factors that affect the concentration of dissolved oxygen in an aquatic environment. These factors include: temperature, stream flow, air pressure, aquatic plants, decaying organic matter, and human activities.

As a result of plant activity, DO levels may fluctuate during the day, rising throughout the morning and reaching a peak in the afternoon. At night photosynthesis ceases, but plants and animals continue to respire, causing a decrease in DO levels. Because large daily fluctuations are possible, DO tests should be performed at the same time each day. Large fluctuations in dissolved oxygen levels over a short period of time may be the result of an algal bloom. While the algae population is growing at a fast rate, dissolved oxygen levels increase. Soon the algae begin to die

and are decomposed by aerobic bacteria, which use up the oxygen. As a greater number of algae die, the oxygen requirement of the aerobic decomposers increases, resulting in a sharp drop in dissolved oxygen levels. Following an algal bloom, oxygen levels can be so low that fish and other aquatic organisms can suffocate and die.

Temperature is important to the ability of oxygen to dissolve, because oxygen, like all gases, has different solubilities at different temperatures. Cooler waters have a greater capacity for dissolved oxygen than warmer waters. Human activities, such as the removal of foliage along a stream or the release of warm water used in industrial processes, can cause an increase in water temperature along a given stretch of the stream. This results in a lower dissolved oxygen capacity for the stream.

SUMMARY OF METHODS

Method 1: Optical DO Probe

A Vernier Optical DO Probe is used to measure the dissolved oxygen concentration in the water either on site or after returning to the lab.

Method 2: Dissolved Oxygen Probe

A Vernier Dissolved Oxygen Probe is used to measure the dissolved oxygen concentration in the water either on site or after returning to the lab.

METHOD 1: OPTICAL DO PROBE

MATERIALS

computer
Vernier computer interface
Logger *Pro*
Vernier Optical DO Probe
distilled water
sampling container (optional)
wash bottle (optional)

COLLECTION AND STORAGE OF SAMPLES

- This test can be conducted on site or in the lab.
- If you are going to take readings after returning to the laboratory, make sure that there are no air bubbles in the water-sample container and that the container is tightly stoppered. The sample should be stored in an ice chest or refrigerator until measurements are to be made. Storing water samples for later testing decreases sample accuracy and is only recommended in cases where measuring at the site is not possible.

- It is important to obtain the water sample from below the surface of the water and as far away from shore as is safe. If suitable areas of the body of water appear to be unreachable, samplers consisting of a rod and container can be constructed for collection. At least 100 mL of water is required.
- Avoid mixing the water sample with air. Doing so will change the dissolved oxygen concentration of the sample.
- When taking readings in cold (0–10°C) or warm (25–35°C) water, allow more time for the dissolved oxygen readings to stabilize. Automatic temperature compensation in the dissolved oxygen probe is not instantaneous and readings may take up to 2 minutes to stabilize depending on the temperature.

CALIBRATION

1. Calibrate the Optical DO Probe.
   - If your instructor directs you to use the stored calibration, proceed directly to Step 3.
   - If your instructor directs you to perform a new calibration for the Optical DO Probe, proceed to Step 1a. **Note:** It is recommended that the calibration be performed prior to going into the field.

   a. Set the switch on the Optical DO Probe to mg/L or % saturation, as directed by your instructor. The switch is located on the box containing the microSD card.

   b. Connect the Optical DO Probe to the Vernier interface and choose New from the File menu.

   c. Choose Calibrate ▸ Optical DO Probe from the Experiment menu. Select the check box to select One Point Calibration, and then click Calibrate Now.

   d. Remove the entire storage bottle and add distilled water to the top of the sponge. Insert the probe back into the bottle. The tip of the probe should not be touching the water or the sponge. Keep the probe in this position for minimum of 60 seconds.

   e. Type **100** if using percent saturation, or the mg/L value from Table 2 using the current barometric pressure and air temperature values. If you do not have the current air pressure, use Table 3 to estimate the air pressure at your altitude.

   f. When the voltage reading stabilizes, click Keep.

2. Save the calibration onto the sensor.
   a. Select the Calibration Storage tab.

   b. Click the Set Sensor Calibration button and follow the onscreen instructions to save the calibration.

   c. Click Done.

PROCEDURE

3. Ensure that the switch on the Optical DO Probe is set to mg/L or % saturation, as directed by your instructor. The switch is located on the box containing the microSD card.
4. Connect the Optical DO Probe to the Vernier interface.
5. Open the file "05 Dissolved Oxygen" from the *Water Quality with Vernier* folder of Logger *Pro*.
6. Remove the entire storage bottle.
7. Place the tip of the sensor into the sample water. **Note:** The probe itself is waterproof, but the box with the switch is not.
8. Click Collect to begin data collection.
9. Once the reading has stabilized, click Keep to begin a 10 s sampling run. **Important:** Leave the probe tip submerged for the 10 seconds that data are being collected.
10. When finished, click Stop.
11. Record the dissolved oxygen value on the Data sheet.
12. Rinse the tip thoroughly with distilled water into a waste container and return to its storage bottle.

DATA

Site Information

Name of site	
Date of collection	
Time of collection	
Group members	

Field Observations (e.g., weather, geography, and vegetation along stream)

Test Results

Dissolved oxygen (mg/L)	
Percent saturation (%)	
Date test completed	
Time test completed	
Test completed by	

METHOD 2: DISSOLVED OXYGEN PROBE

MATERIALS

computer
Vernier computer interface
Logger *Pro*
Vernier Dissolved Oxygen Probe
pipet
DO Electrode Filling Solution
distilled water
sampling container
container of water (for warm-up period)
wash bottle (optional)

Calibration Materials (optional)

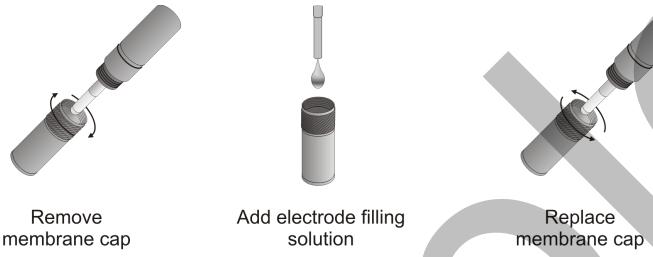
Sodium Sulfite Calibration Solution
100% calibration bottle
tissues or paper towels

COLLECTION AND STORAGE OF SAMPLES

- This test can be conducted on site or in the lab.
- If you are going to take readings after returning to the laboratory, make sure that there are no air bubbles in the water-sample container and that the container is tightly stoppered. The sample should be stored in an ice chest or refrigerator until measurements are to be made. Storing water samples for later testing decreases sample accuracy and is only recommended in cases where measuring at the site is not possible.
- It is important to obtain the water sample from below the surface of the water and as far away from shore as is safe. If suitable areas of the body of water appear to be unreachable, samplers consisting of a rod and container can be constructed for collection. At least 100 mL of water is required.
- Avoid mixing the water sample with air. Doing so will change the dissolved oxygen concentration of the sample.
- When taking readings in cold (0–10°C) or warm (25–35°C) water, allow more time for the dissolved oxygen readings to stabilize. Automatic temperature compensation in the dissolved oxygen probe is not instantaneous and readings may take up to 2 minutes to stabilize depending on the temperature.

SENSOR PREPARATION

1. Prepare the Dissolved Oxygen Probe for use.
   a. Remove the blue protective cap if it is still on the tip of the probe.
   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.



2. Connect the Dissolved Oxygen Probe to the Vernier interface.
3. Warm up the probe by leaving it connected to the interface, with Logger *Pro* running, for 10 minutes. **Note:** 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.

CALIBRATION (OPTIONAL)

4. 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 perform a new calibration for the Dissolved Oxygen Probe, proceed to Step 4a. **Note:** It is recommended that the calibration be performed prior to going into the field.

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. **WARNING**: *Causes skin and eye irritation*.

c. Type **0** as the known DO value for Reading 1.

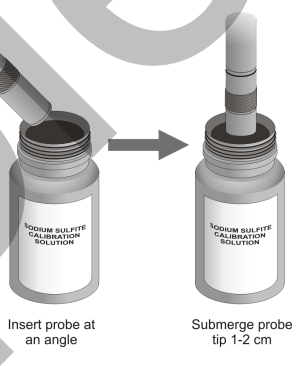
d. When the displayed voltage stabilizes, click Keep.

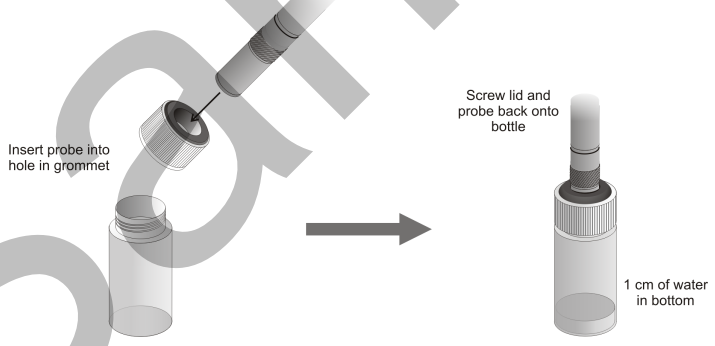
Saturated DO Calibration Point

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.

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.





h. In the Reading 2 field, type the correct saturated dissolved-oxygen value (in mg/L) from Table 2 (for example, **8.66**) using the current barometric pressure and air temperature values. If you do not have the current air pressure, use Table 3 to estimate the air pressure at your altitude.

i. Keep the probe in this position for about a minute. The voltage should be above 2.0 V. Once the voltage stabilizes, click Keep.

5. Save the calibration onto the sensor.
   a. Select the Calibration Storage tab.
   b. Click the Set Sensor Calibration button and follow the onscreen instructions to save the calibration.
   c. Click Done.
   d. Rinse the probe with distilled water into a waste container.
   e. If the test will not be completed immediately, place the sensor in water.

PROCEDURE

6. Ensure the Dissolved Oxygen Probe is connected to the interface and has warmed up for at least 10 minutes.
7. Open "05 Dissolved Oxygen" from the *Water Quality with Vernier* folder of Logger *Pro*.
8. Prepare the Dissolved Oxygen Probe.
   a. Rinse the tip of the probe with sample water.
   b. Place the tip of the probe into the sample water. Submerge the probe tip to a depth of 4–6 cm. **Note:** The handle is not waterproof.
9. Click Collect to begin data collection.
10. Gently stir the probe in the water sample. Once the DO reading as stabilized, click Keep to begin a 10 s sampling run. **Important:** Leave the probe tip submerged for the 10 seconds that data are being collected.
11. When finished, click Stop.
12. Record the dissolved oxygen value on the Data sheet.
13. When finished with the Dissolved Oxygen Probe, thoroughly rinse the tip with distilled water into a waste container and return to a container of water or disassemble as instructed.

DATA

Site Information

Name of site	
Date of collection	
Time of collection	
Group members	

Field Observations (e.g., weather, geography, and vegetation along stream)

Test Results

Dissolved oxygen (mg/L)	Water temperature (°C)	Atmospheric pressure (mmHg)	100% dissolved oxygen (mg/L)	Percent saturation (%)

Date test completed	
Time test completed	
Test completed by	

Table 2: 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
31°C	7.64	7.54	7.44	7.34	7.24	7.14	7.04	6.94	6.85	6.75	6.65	6.55

Table 3: Approximate Barometric Pressure at Different Elevations					
Elevation (feet)	Pressure (mm Hg)	Elevation (feet)	Pressure (mm Hg)	Elevation (feet)	Pressure (mm Hg)
0	760	2000	708	4000	659
250	753	2250	702	4250	653
500	746	2500	695	4500	647
750	739	2750	689	4750	641
1000	733	3000	683	5000	635
1250	727	3250	677	5250	629
1500	720	3500	671	5500	624
1750	714	3750	665	5750	618

Dissolved Oxygen

In this test, students measure the dissolved oxygen content of the water source. Dissolved oxygen can be measured directly at the site or from water samples transported from the site. The preferred data-collection method is to make on-site measurements. Measurements can be made at the site by either placing the probe directly into the stream away from the shore or by collecting a water sample with a container or cup and then taking measurements with the probe back on the shore. As an alternative, water samples can be collected from the site in capped, air-tight bottles with no head space, and store it in an ice chest to be transported back to the lab. After returning to the lab, allow samples to reach room temperature, and then measure the dissolved oxygen. Transporting samples is not recommended, because it reduces the accuracy of test results.

Note: The printed book provides student instructions for data collection using LabQuest App (LabQuest). The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), and EasyData (calculators) can be found on the CD that accompanies this book. See *Appendix A* for more information.

If you are using Logger *Pro*, the auto-ID files necessary for this experiment can be found in Logger *Pro* 3.10, or newer. If you are using LabQuest App, you must use LabQuest App version 2.2.1, or newer. If you are using EasyData, version 2.0 or newer is needed. If you have an older version of the software, please update to the most recent version. Updates can be found at www.vernier.com/downloads

ESTIMATED TIME

Once you have your water sample, we estimate that data collection for this test can be completed in 5 minutes if using the Optical DO Probe and 15 minutes if using the Dissolved Oxygen Probe.

SAFETY TIPS

1. Always follow safety guidelines when working in or near water.
   - Before using a site, survey the area for unseen dangers, such as unstable banks, dangerous obstacles in the stream, or fallen trees. Avoid these possible dangers.
   - Avoid sites where the water is deep or swift. Water with a depth greater than the top of your knee should be considered deep. Water with a flow velocity of 0.5 m/s or greater is considered to be swift.
   - Students should always wear proper flotation equipment when in or around water.
2. Students should always work in groups of at least two to three. Do not allow students to wander away from the site. It is important to know where student groups are at all times. Students should not change locations without first notifying their instructor.

3. Students should wear warm, waterproof clothes when working in a stream. If possible, they should bring spare items, such as dry socks, that can be worn after working in the water. Prolonged exposure to cold water can result in hypothermia, which can be a life-threatening condition.

4. Keep electronics a safe distance away from all water. To prevent water damage, it is best to store all probes and electronic equipment in plastic bags or containers when not in use.

EQUIPMENT TIPS

Optical DO Probe

1. If collecting data using EasyLink (calculators), the Optical DO Probe is not supported. A Dissolved Oxygen Probe must be used.

2. The body of the Optical DO probe and the cable is waterproof up to the box. The box is not waterproof.

3. For the automatic temperature compensation to work, the metal dot near the tip of the Optical DO Probe must be immersed in the water.

4. If you are taking readings at temperatures below 15°C or above 30°C, allow more time for the temperature compensation to adjust and provide a stable reading.

5. The Optical DO Probe is automatically pressure compensated using an internal barometer. The pressure output of this barometer is used to automatically compensate for the change in diffusion rate of oxygen through the cap and oxygen solubility in water. This eliminates the need to recalibrate at different pressures or elevations.

6. The Optical DO Probe is calibrated prior to being shipped. If you find that you need to calibrate the Optical DO Probe, perform a one-point calibration using the saturated DO value. **Note**: This calibration method is different from the usual two-point calibration performed with other Vernier sensors.

Dissolved Oxygen Probe

7. In order for the Dissolved Oxygen Probe to warm up and stay polarized, power to the sensor must be continuous. If power to the sensor is disrupted, the sensor must be warmed up for another 5–10 minutes before calibrating or collecting data. If you are using EasyLink connected to a calculator, EasyLink stops powering the sensor if the calculator goes to sleep. To avoid the need to warm up the sensor again, instruct students to press a button on the calculator every few minutes to keep the calculator awake (the calculator goes to sleep when it has been inactive for 3 minutes).

   If you are using LabQuest or LabPro, this is less of a concern. LabQuest delivers continuous power once LabQuest App is started, even if the screen goes to sleep. LabPro also delivers continuous power once the Dissolved Oxygen Probe has been identified.

8. The tip of the Dissolved Oxygen Probe should be in water during the warm-up period. You can use the DO calibration bottle or you can place the probe into a cup or beaker of water. Simply fill the DO calibration bottle with water, fit the probe down into the lid, and tighten the lid onto the bottle. The probe tip should be submerged in the water until you calibrate or collect data.

9. If using Logger *Pro* or LabQuest App, we recommend that you calibrate before going into the field. After the calibration is completed, save the calibration onto the sensor as directed in the student instructions.

10. When calibrating the Dissolved Oxygen Probe, it is important to be patient and permit the readings to stabilize.
    - At the zero oxygen point, the voltage should be somewhere between 0.2 V and 0.5 V. If it is not, make sure that air bubbles are not trapped at the tip of the electrode. If you suspect your sodium sulfite solution may have gone bad, mix up some fresh or obtain a new bottle from Vernier (order code: DO-CAL). **WARNING**: *Causes skin and eye irritation*.
    - At the saturated oxygen point, the voltage should be above 2.0 V. If it is not, make sure the electrode is not actually touching the water in the bottle. Thoroughly rinse the electrode with distilled water again and gently blotted it dry with a paper towel, being careful not to touch the membrane.

11. The Dissolved Oxygen Probe contains a thermistor. Measurements from the thermistor are used to automatically compensate for changes in permeability of the membrane due to changes in temperature.

12. As the Dissolved Oxygen Probe measures dissolved oxygen, it removes O_2 from the water sample at the junction of the probe membrane. If you leave the probe in one spot in the water sample, you will see your dissolved oxygen readings drop. To prevent this, it is important that students stir the probe gently and slowly through the sample as they take readings.

13. The gas-permeable, plastic membrane on the Dissolved Oxygen Probe can become clogged by dirt and oil over time. Advise students to avoid touching the membrane at any time. If the water being sampled is murky or dirty, rinse the probe tip with distilled water after each use. A replacement membrane can be purchased from Vernier (order code: MEM).

14. The electrode of the Dissolved Oxygen Probe is water tight. The junction at the top of the electrode, where the cable enters, is not water tight and should not be submerged in water for any period of time. To take dissolved oxygen readings at various depths, use a Water Depth Sampler (order code: WDS). This device can be lowered to any desired depth and triggered to collect a representative water sample.

15. Follow these procedures when storing the Dissolved Oxygen Probe.
    - **Short-term storage (less than a week)**: Store the Dissolved Oxygen Probe with the membrane end submerged in about 1 inch of distilled water. The calibration bottle that

came with the probe works well for this purpose.

- **Long-term storage (more than a week)**: Remove the membrane cap and rinse the inside and outside of the cap with distilled water. Shake the membrane cap dry. Also rinse and dry the exposed anode and cathode inner elements (blot dry with a lab wipe). Reinstall the membrane cap loosely onto the electrode body for storage. Do not screw it on tightly.

DATA-COLLECTION AND ANALYSIS TIPS

1. The Single Point data-collection mode (EasyData) and "Use 10 second average" option (Logger *Pro*) were designed to make measurements easier and more accurate. When they are used, the interface takes readings for 10 seconds and calculates an average value. This has several advantages:
   - It eliminates the need for students to choose one value over another if the readings are fluctuating.
   - If the readings are fluctuating a little, an average of the values is desirable.
   - It requires the students to hold the sensor in the water longer than they might tend to.
2. Use the following information if you are sampling ocean water, tidal estuaries, or any type of water with salinity levels greater than 1000 mg/L.

   Dissolved oxygen concentration for air saturated water at various salinity values, $DO_{(salt)}$, can be calculated using the formula:

$$DO_{(salt)} = DO - (k \bullet S)$$

   - $DO_{(salt)}$ is the concentration of dissolved oxygen (in mg/L) in salt-water solutions.
   - DO is the dissolved oxygen concentration for air-saturated distilled water as determined from Table 2 in the student version of the test.
   - S is the salinity value (in ppt). Salinity values can be determined using the Vernier Chloride Ion-Selective Electrode or Conductivity Probe as described in Test 15.
   - k is a constant. The value of k varies according to the sample temperature, and can be determined from Table 1.

Table 1: Salinity Correction Constant Values							
Temp. (°C)	Constant, *k*	Temp. (°C)	Constant, *k*	Temp. (°C)	Constant, *k*	Temp. (°C)	Constant, *k*
1	0.08796	8	0.06916	15	0.05602	22	0.04754
2	0.08485	9	0.06697	16	0.05456	23	0.04662
3	0.08184	10	0.06478	17	0.05328	24	0.04580
4	0.07911	11	0.06286	18	0.05201	25	0.04498
5	0.07646	12	0.06104	19	0.05073	26	0.04425
6	0.07391	13	0.05931	20	0.04964	27	0.04361
7	0.07135	14	0.05757	21	0.04854	28	0.04296

Example

Determine the saturated DO calibration value at a temperature of 23°C and a pressure of 750 mm Hg. Salinity value of was measured to be 35.0 ppt.

First, find the dissolved oxygen value in Table 2 in the student version of the test (DO = 8.55 mg/L). Then, find *k* in Table 1 at 23°C (*k* = 0.04662). Substitute these values, as well as the salinity value, into the previous equation:

$$DO_{(salt)} = DO - (k \bullet S) = 8.55 - (0.04662 \times 35.0) = 8.55 - 1.63 = 6.92 \text{ mg/L}$$

Use the value 6.92 mg/L when performing the saturated DO calibration point (water-saturated air). The Dissolved Oxygen Probe will now be calibrated to give correct DO readings in salt-water samples with a salinity of 35.0 ppt.

Important: For most dissolved oxygen testing, it is *not* necessary to compensate for salinity; for example, if the salinity value is 0.5 ppt, using 25°C and 760 mm Hg, the calculation for DO(salt) would be:

$$DO_{(salt)} = DO - (k \bullet S) = 8.36 - (0.04498 \times 0.5) = 8.36 - 0.023 = 8.34 \text{ mg/L}$$

At salinity levels less than 1.0 ppt, neglecting this correction results in an error of less than 0.2%.

EXPECTED LEVELS

The unit mg/L[1] is the quantity of oxygen gas dissolved in one liter of water. When relating DO measurements to minimum levels required by aquatic organisms, mg/L is used. Dissolved oxygen concentrations can range from 0 to 15 mg/L. Cold mountain streams are likely to have DO

[1] The unit of mg/L is numerically equal to parts per million, or ppm.

readings ranging from 7 to 15 mg/L, depending on the water temperature and air pressure. In their lower reaches, rivers and streams can have DO readings between 2 and 11 mg/L.

When discussing water quality of a stream or river, it can be helpful to use a unit other than mg/L. Percent saturation is the unit most often used for water quality comparisons. Percent saturation is the dissolved oxygen reading in mg/L divided by the 100% dissolved oxygen value for water (at the same temperature and air pressure). The manner in which percent saturation relates to water quality is summarized in Table 2. In some cases, water can exceed 100% saturation and become supersaturated for short periods of time.

Table 2

DO Level	Percent saturation of DO
Supersaturation[2]	≥ 101%
Excellent	90–100%
Adequate	80–89%
Acceptable	60–79%
Poor	< 60%

[2] Supersaturation can be harmful to aquatic organisms. It can result in a disease known as Gas Bubble Disease.