PRELIMINARY ACTIVITY FOR

Investigating Dissolved Oxygen

Open Inquiry Version

Dissolved oxygen is one of the primary indicators of the quality of an aquatic environment. Oxygen enters water from the surrounding air, as a product of photosynthesis, and as a result of rapid movement of water. A dissolved oxygen probe can be used in a wide variety of tests or investigations to determine dissolved oxygen concentrations (DO) and changes in dissolved oxygen concentrations.

In this Preliminary Activity, you will gain experience using a dissolved oxygen probe as you determine the DO level of a water sample provided by your teacher.

After completing the Preliminary Activity, you will first use reference sources to find out more about dissolved oxygen issues in the environment before you choose and investigate a researchable question dealing with dissolved oxygen. Some topics to consider in your reference search are:

- water pollution
- eutrophication
- thermal pollution
- photosynthesis
- cellular respiration

PRE-LAB PROCEDURE

Optical DO Probe Users Only

(Dissolved Oxygen Probe users proceed to the Dissolved Oxygen Probe section)

1. Set the switch on the Optical DO Probe to the mg/L setting. The switch is located on the box containing the microSD card.

2. Connect the Optical DO Probe to the interface and open the data-collection program. You are now ready to collect dissolved oxygen concentration data. Continue to the Procedure.

Dissolved Oxygen Probe Users Only

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.

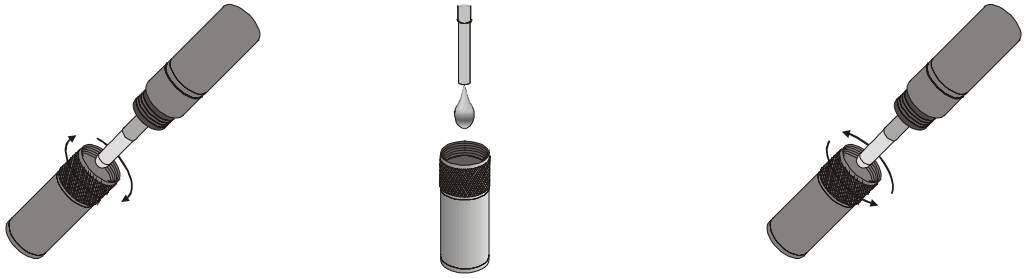

Figure 1

2. Connect the Dissolved Oxygen Probe to the interface and open the data-collection program.

3. Allow the probe to warm up for 10 minutes. The probe must stay connected to the interface at all times to keep it warmed up. If disconnected for more than a few minutes, it will be necessary to warm up the probe again. When the probe is warmed up, continue to the Procedure.

PROCEDURE

1. Collect dissolved oxygen data.
   a. Place the tip of the probe into the water sample being tested. Submerge the probe tip to a depth of 4–6 cm.
   b. Start data collection. **Note**: Dissolved Oxygen Probe users need to gently and continuously stir the sample to allow the water to move past the probe's tip (if using an Optical DO Probe, this is not necessary).
   c. Continue collecting data until the readings have been relatively stable (to the nearest 0.2 mg/L) for about 30 seconds, then stop data collection.
   d. Select the stable region of your graph, then display Statistics for that region. Note and record the mean value for that region as the DO of the water sample (in mg/L).

QUESTIONS

1. What was the DO of the water sample you tested?

2. How is DO level related to the water quality of a stream?

3. List three factors that affect DO levels.

4. What is the role of oxygen in photosynthesis? What is its role in cellular respiration?

5. List at least one researchable question for this investigation.

Investigating Dissolved Oxygen

OVERVIEW

In the Preliminary Activity, your students will gain experience using a dissolved oxygen probe while measuring the concentration of dissolved oxygen (DO) in a water sample. A student handout for the Open Inquiry version of the Preliminary Activity can be found at the end of this investigation. A Guided Inquiry version is found on the CD accompanying this book.

During the subsequent Inquiry Process, students will first learn about dissolved oxygen using the course textbook, other available books, and the Internet. They will then generate and investigate researchable questions concerning dissolved oxygen concentrations inside and outside the classroom. (In the Guided Inquiry approach, students will plan and conduct investigations of the researchable question(s) assigned by you.)

LEARNING OUTCOMES

In this inquiry investigation, students will

- Identify variables, design and perform the investigation, collect data, analyze data, draw a conclusion, and formulate a knowledge claim based on evidence from the investigation.
- Investigate factors that influence dissolved oxygen concentrations in the environment.
- Learn about the consequences of dissolved oxygen concentration changes.

THE INQUIRY PROCESS

Suggested Time to Complete the Investigation

See page xiii in the Doing Inquiry Investigations section for more information on carrying out each phase of an inquiry investigation.

	Inquiry Phase	Open Inquiry	Guided Inquiry
I	Preliminary Activity	15 minutes	15 minutes
II	Generating Researchable Questions (Omitted in Guided Inquiry Approach)	15 minutes	0 minutes
III	Planning	15 minutes	15 minutes
IV	Carrying Out the Plan	40 minutes	40 minutes
V	Organizing the Data	15 minutes	15 minutes
VI	Communicating the Results	15 minutes	15 minutes
VII	Conclusion	5 minutes	5 minutes

MATERIALS

Make the following materials available for students to use. Items in bold are needed for the preliminary activity.

data-collection interface
data-collection program
Vernier Optical DO Probe or Dissolved Oxygen Probe
water sample
250 mL beaker
Vernier Temperature Probe
Vernier Water Depth Sampler (optional)
others as requested by students

I Preliminary Activity

This inquiry begins with an activity to reinforce prior knowledge of the use of Vernier data-collection technology and to introduce a method for collecting dissolved oxygen data. Students can use the stored calibration loaded with the dissolved oxygen probe.

Additional Notes for Dissolved Oxygen Probe Users

If you are using Dissolved Oxygen Probes and want to calibrate the probes for better absolute dissolved oxygen readings, follow the calibration instructions for the Dissolved Oxygen Probe in the student instructions of Experiment 19, Long Term Water Monitoring. The instructions from Experiment 19 can be added to this experiment using the files on the CD that accompanies this book. Be sure to include copies of the calibration tables found at the end of the student version of Experiment 19. **Note**: Optical DO Probes do not need to be calibrated.

Sample Results

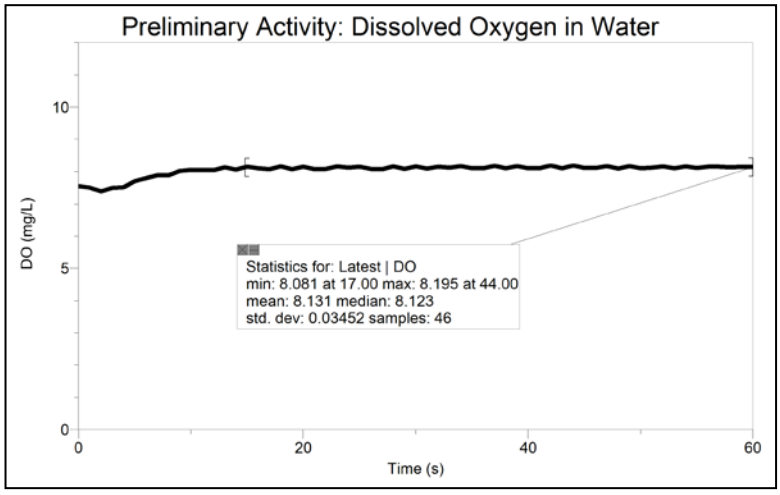

Figure 1 *DO level of a Preliminary Activity water sample*

Answers to the Questions

1. What was the DO of the water sample you tested?

   Answers will vary. The mean DO value in the Sample Results above is 8.1 mg/L.

2. How is DO level related to the water quality of a stream?

   Oxygen available to aquatic organisms is found in the form of dissolved oxygen. Oxygen gas is dissolved in a stream through aeration, diffusion from the atmosphere, and photosynthesis of aquatic

plants and algae. Plants and animals in the stream consume oxygen in order to obtain energy through respiration. In a healthy stream, oxygen is replenished faster than it is used by aquatic organisms, and an adequate DO level is maintained.

3. List three factors that affect DO levels.

   Factors that affect DO levels are:

   - temperature
   - aquatic plant populations
   - decaying organic material in the water
   - stream flow
   - altitude/atmospheric pressure
   - human activities

4. What is the role of oxygen in photosynthesis? What is its role in cellular respiration?.

   Oxygen is a product of photosynthesis. It is a reactant in cellular respiration.

5. List at least one researchable question for this investigation.

   Answers will vary. See the Researchable Questions list below for some possible answers.

II Generating Researchable Questions

Note: Researchable questions are assigned by the instructor in the Guided Inquiry approach. See page xiii in the Doing Inquiry Investigations section for a list of suggestions for generating researchable questions. Some possible researchable questions for this investigation are listed below:

Recommended for Open Inquiry or Guided Inquiry (sample results provided)

- How is DO affected by temperature?
- How does DO in a non-eutrophic (eutrophic) body of water vary with depth?
- How is DO affected by photosynthesis and respiration of aquatic plants?

Recommended for Open Inquiry or Guided Inquiry (no sample results provided)

- How does DO in a non-eutrophic (eutrophic) body of water vary over a 24-hour period?
- How do the DO levels at points on a local stream before, at, and after a power plant (factory, wastewater treatment plant, feedlot, poultry farm, or septic system) compare?
- How do the DO levels of various local bodies of water compare?
- How does DO in an aquarium vary over a 24-hour period?
- How does turbulence affect DO?
- How do the DO levels of a stream vary from source to mouth?

There are many more possible researchable questions. Students should choose a researchable question that addresses the learning outcomes of your specific standards. Be sure to emphasize experimental control and variables. (Instructors using the Guided Inquiry approach select the researchable questions to be investigated by their students. We encourage you to assign multiple researchable questions because this strategy enhances student interaction and learning during phases IV–VII.)

III Planning

During this phase students should formulate a hypothesis, determine the experimental design and setup, and write a method they will use to collect data. The plan should list laboratory safety concerns and specify how they will be addressed during the investigation. Circulate among the student groups asking questions and making helpful suggestions.

IV Carrying out the Plan

During this phase, students use their plan to carry out the investigation and collect data. Circulate among the student groups asking questions and making helpful suggestions.

V Organizing the Data

See page xv in the Doing Inquiry Investigations section for suggestions concerning how students can organize their data for their inquiry presentations.

VI Communicating the Results

See page xv in the Doing Inquiry Investigations section for a list of inquiry-presentation strategies.

VII Conclusion

Using your notes recorded during the Communicating the Results phase, summarize the group results for the experiment and tell how they will fit into the upcoming instruction.

VIII Assessment

See page xv in the Doing Inquiry Investigations section for ideas on assessment strategies.

SAMPLE RESULTS

Student results will vary depending on experimental design.

The Effect of Temperature on Dissolved Oxygen

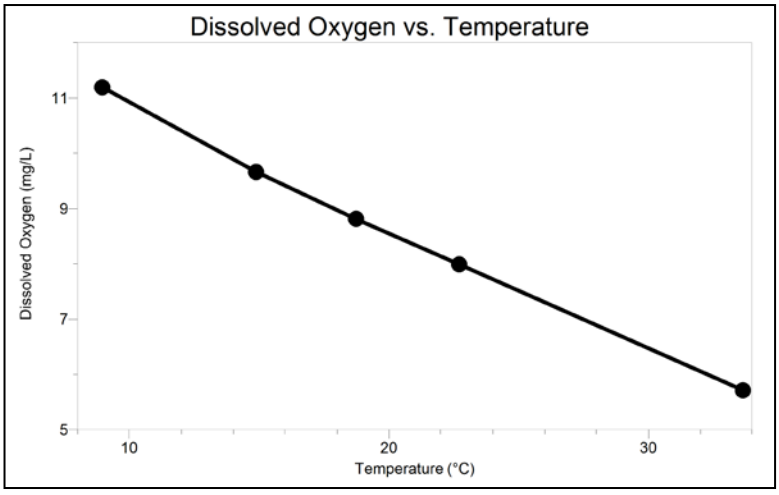

Figure 2 *The effect of temperature on DO level*

Table 1	
Temperature (ºC)	Dissolved oxygen (mg/L)
8.96	11.19
14.89	9.66
18.74	8.81
22.71	7.99
33.65	5.71

This investigation addresses the question, "How is DO affected by temperature?" DO decreases as water temperature increases.

The above data were collected with the use of a one-gallon plastic milk container. Water sample size was 100 mL, and vigorous shaking of the container was used to saturate the water with oxygen. Ice and warm water were added to change the temperature. **Note**: After each temperature change, the entire solution must have an opportunity to outgas or up gas, to reach saturation. This process takes some time and some shaking.

The Effect of Eutrophic Lake Depth on Dissolved Oxygen

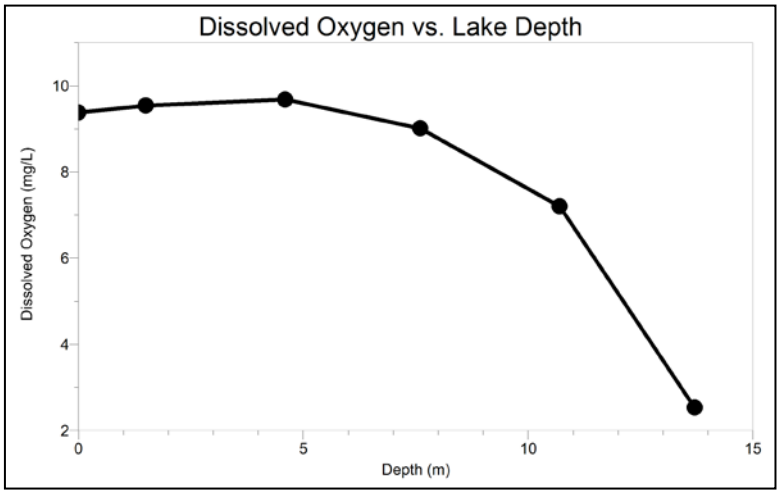

Figure 3 *The effect of eutrophic lake depth*

Table 2	
Depth (m)	Dissolved oxygen (mg/L)
0	9.38
1.5	9.54
4.6	9.68
7.6	9.01
10.7	7.20
13.7	2.53

This investigation addresses the question, "How does DO in a eutrophic body of water vary with depth?" Generally, DO decreased with depth."

The above data were collected in October at Hagg Lake, Oregon. Hagg Lake is a human-made reservoir classified as a eutrophic lake. DO readings were taken from raised samples using the Vernier Water Depth Sampler.

The Effect of Photosynthesis and Respiration of Aquatic Plants on DO

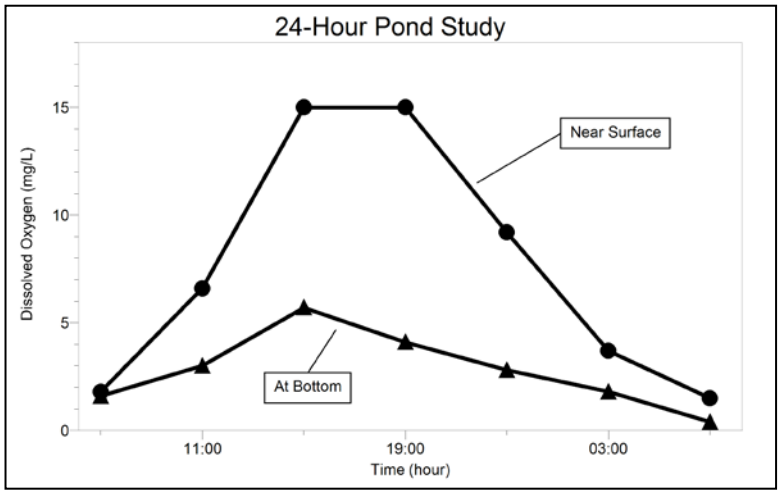

Figure 4 *24-hour study of dissolved oxygen in a eutrophic pond*

Table 3				
Time	5 cm below surface		At bottom	
	Dissolved oxygen (mg/L)	Water temperature (ºC)	Dissolved oxygen (mg/L)	Water temperature (ºC)
07:00	1.8	21.9	1.6	21.7
11:00	6.6	22.3	3.0	21.7
15:00	>15.0	26.7	5.7	23.0
19:00	>15.0	25.7	4.1	23.1
23:00	9.2	23.4	2.8	22.5
03:00	3.7	22.5	1.8	22.6
07:00	1.5	21.8	0.4	21.6

This investigation addresses the question, "How is DO affected by photosynthesis and respiration of aquatic plants?"

Apparently, plant and algae photosynthesis caused water near the surface to become supersaturated with oxygen during the afternoon, and their respiration subsequently caused a drastic drop in DO during the night. Decomposition of dead algae by aerobic bacteria can cause the DO at the bottom of a eutrophic pond to be much lower than at the surface.

The above data were collected in a small, algae-covered yard pond on a partly cloudy day. The pond is 1.8 m in diameter and is 25 cm deep. The actual near-the-surface Dissolved Oxygen values at 15:00 and 19:00 were greater than 15.0 mg/L. The range of the DO Probe is 0 to 15.0 mg/L.

TIPS

Investigation Information

1. One-gallon plastic milk containers work well in a study of the effect of temperature on DO. A 100 mL water sample can be saturated with two minutes of vigorous shaking.

2. Students should always wear proper flotation equipment when in or around water in the field.

3. To prevent water damage in the field, it is best to store all probes and electronic equipment in plastic bags or containers when not in use.

4. If students are going to collect samples in the field and take readings after returning to the laboratory, they should 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 accuracy and is recommended in cases where measuring at the site is not possible.

5. If your students design investigations using the Water Depth Sampler, we suggest that you take them to a swimming pool to practice using the device. Swimming pools are great for testing because the clear water enables students to see what is necessary to trigger the sampler and how to prevent triggering before the sampler reaches the designated depth.

6. When the Water Depth Sampler is being lowered, it is important that plenty of slack rope be placed in the water with the sampler. This will prevent the rope from becoming taut before it reaches the correct depth. If the rope does become taut before reaching the measuring depth, it could possible trigger the sampler prematurely.

7. The plans that your students submit for approval should list laboratory safety concerns, including chemical safety concerns, and specify how they will address these safety concerns during their investigations.

Sensor Information

Vernier sells two types of dissolved oxygen probes: the Dissolved Oxygen Probe and the Vernier Optical DO Probe. The calibration, use, and storage procedures vary between the two probes. Before giving the lab to students, you may want to delete preparation instructions for the probe you are not using. More information about each probe can be found below.

Vernier Optical DO Probe Users Only
(Dissolved Oxygen Probe users proceed to the Dissolved Oxygen Probe section)

1. The Optical DO Probe requires Logger *Pro* 3.8.6 or newer. Updates are available at the Vernier web site.
2. Optical DO Probes are not compatible with EasyLink or Go!Link.
3. The Optical DO Probe does not require calibration. Follow the probe preparation instructions for the Optical DO Probe.
4. The Optical DO Probe has a switch on the box containing the microSD card which changes the units from mg/L to % saturation. For this experiment, ensure the switch is set to mg/L before connecting to the interface.

Dissolved Oxygen Probe Users Only

1. As the Dissolved Oxygen Probe measures dissolved oxygen, it removes O_2 from the water sample at the junction of the probe membrane. If the probe remains in one spot in the water sample, the DO readings drop. To prevent this, it is important that students stir the probe gently and slowly through the sample as they take readings.
2. In order for the Dissolved Oxygen Probe to warm up and stay polarized, power to the probe must be continuous. LabPro, LabQuest, and CBL 2 deliver continuous power once the data-collection software is started even if the screen goes to sleep. However, EasyLink used with a TI-84 graphing calculator and the EasyData App stops powering the sensor when the calculator goes to sleep. The calculator goes to sleep to conserve battery power if no user interaction is detected for 3 minutes. If power to the sensor is disrupted for more than a few minutes, the sensor must be warmed up again before calibrating or taking readings. To avoid having to warm up the sensor again, students must press a button on the calculator every few minutes to keep the calculator awake.
3. When the Dissolved Oxygen Probe is being transported to a field site, it should be stored in the plastic calibration bottle filled with distilled water. This plastic bottle is shipped with the Dissolved Oxygen Probe. It is important that your students understand the fragile nature of the electrode membrane and proper handling procedures. These are described in the Dissolved Oxygen Probe booklet that accompanies the probe.
4. Between classes store the Dissolved Oxygen Probes in a beaker of distilled water. At the end of the day be sure to empty out the electrode filling solution in the Dissolved Oxygen Probe and rinse the inside of the membrane cap with distilled water.