

Experiment GB-3: Ecological Balance

Background

The Earth is a closed ecosystem in which vital elements and compounds like oxygen, carbon, nitrogen, and water, are consumed and recycled through natural processes.

An element and a compound that move through cycles that are integrated with each other are carbon and water. Carbon, in the form of carbon dioxide from the atmosphere, and water are converted to sugars, starches, and oxygen by plants that are undergoing photosynthesis. In the next stage, the products of photosynthesis are consumed and utilized by animals to provide energy for their life processes. Carbon, as carbon dioxide, returns the atmosphere as animals respire. Water returns to the environment together with nitrogenous compounds through the decomposition of waste products from animals.

The balance of the elements and compounds moving through the cycles of synthesis and utilization is essential to the health of the ecosystem. Changes in the balance of the elements and compounds in the cycles lead to changes in the ecosystem that could be irreparable if the change in the balance is large or sudden. Species could be lost and biomes could be destroyed.

In this experiment, students will create an environment into which a small aquatic animal, a goldfish, is introduced. Students will measure the changes in the dissolved oxygen concentration and the pH level of the water in which the fish is respiring.

Students will also create an environment into which a piece of aquatic plant is introduced. Students will measure the changes in the dissolved oxygen concentration and the pH level of the water when the plant is exposed to light and photosynthesis takes place.

In the third exercise, the goldfish is reintroduced into the environment containing the plant, and the changes in the dissolved oxygen concentration and pH level of the ecosystem are measured. It is also determined if the ecosystem is more or less balanced than the other two environments.

Equipment Required

PC Computer
IWX/214 data acquisition unit
USB cable
IWX/214 power supply
ISE-730 Dissolved oxygen electrode
DO2-100 Current to voltage adapter
ISE-100 combination pH electrode
Magnetic stirrer
Stir bar
Ringstand
Utility clamps (2) for holding electrodes
Lamp with 75 watt bulb
100ml beakers (2)
250 ml beakers (3)
400 ml beaker
1000 ml beaker
Roll of plastic wrap
pH 4 and pH 7 buffer solutions
250 ml graduated cylinder
Thermometer
Pond water
Deionized water
Zero-percent oxygen calibration solution
Goldfish
6" branch of Elodea or similar aquatic plant

IWX/214 Setup

- 1 Place the IWX/214 on the bench, close to the computer.
- 2 Check Figure 1-1 in Chapter 1 for the location of the USB port and the power socket on the IWX/214.
- 3 Use the USB cable to connect the computer to the USB port on the rear panel of the IWX/214.
- 4 Plug the power supply for the IWX/214 into the electrical outlet. Insert the plug on the end of the power supply cable into the labeled socket on the rear of the IWX/214. Use the power switch to turn on the unit. Confirm that the red power light is on.

Start the Software

- 1 Click the **Windows Start menu**, move the cursor to **Programs** and then to the **iWorx** folder and select **LabScribe**; or click on the **LabScribe icon** on the Desktop
- 2 When the program opens, select **Load Group** from the **Settings menu**.
- 3 From the dialog box, select **AddedLabs.iws**. Click **Load**.
- 4 Click on the **Settings menu** again and select the **Ecological Balance** settings file.
- 5 After a short time, **LabScribe** will appear on the computer screen as configured by the **Ecological Balance** settings.
- 6 If you want a digital display of the current dissolved oxygen concentration and pH level to appear on the **Main window** during the recording, open the **View menu** and select **Voltmeter**.

Dissolved Oxygen and pH Electrodes Setup

- 1 Plug one end of the DIN-DIN cable into Channel 3 on the iWorx unit. Plug the other end of this cable into the DIN connector on the DO2-100 current to voltage adapter.
- 2 Attach the cable from the ISE-730 dissolved oxygen electrode to the BNC connector on the current to voltage adapter.
- 3 Plug the DIN connector on the end of the cable of the ISE-100 pH electrode into Channel 4 on the iWorx unit.

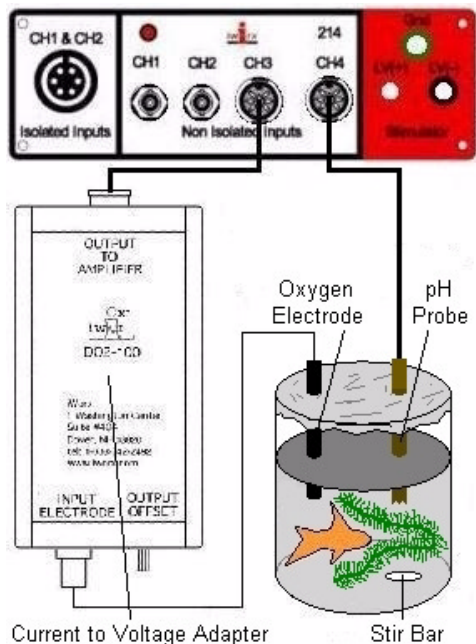


Figure GB-3-1: The setup for recording oxygen concentration levels and pH in a small closed ecosystem using the iWorx/214.

Calibration of the Dissolved Oxygen Electrode

Aim: To calibrate the dissolved oxygen electrode.

The standard used for calibrating the dissolved oxygen electrode is the known concentration of oxygen in air-saturated deionized water. The amount of oxygen that is dissolved in water is known as its solubility (S) and it is dependent upon the temperature, oxygen pressure in the air, and the concentrations of dissolved solutes in the water. Solubility (S) can be determined by using the following equation:

$$S = (\alpha/22.414) ((P-p)/P) (r\%/100).$$

In this equation, α is the absorption coefficient of O_2 at the temperature, p is the vapor pressure of water at the temperature, P is the barometric pressure, and $r\%$ is the percent oxygen in the air. For example, at $26^\circ C$ and 760mmHg and a concentration of oxygen in air of 21% , S equals:

$$(0.02783/22.414\text{L/mole})(734.91\text{mmHg}/760\text{mmHg})(0.21) = 252\mu\text{MO}_2$$

Procedure

- 1 Place the oxygen electrode in a 250 ml beaker containing room temperature deionized water. There needs to be enough water in the beaker to submerge the tip of the oxygen electrode, and keep its tip away from the stir bar in the beaker. Place the beaker on a magnetic stirrer. Adjust the speed of the stirrer so the stir bar is rotating quickly and evenly.
- 2 Click **Start** on the **LabScribe Main window** to begin recording. The trace will eventually reach a stable baseline towards the top of the recording channel. Type the words **Saturation-DI Water** on the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to mark the stable baseline of the recording. This comment marks the output of the oxygen electrode in room temperature deionized water that is saturated with as much oxygen as it can hold.
- 3 Obtain a beaker containing zero-percent oxygen calibration solution at room temperature. Make sure there is enough solution in the beaker to keep the tip of the electrode clear of the stir bar. Continue to record as you remove the oxygen electrode from the deionized water and place it in the beaker with the zero-percent oxygen calibration solution.
- 4 Turn off the magnetic stirrer. Remove the beaker of deionized water from the stirrer, and place the beaker containing zero-percent oxygen calibration solution on the stirrer. Turn on the stirrer and adjust the speed of the stirrer so the stir bar is rotating quickly and evenly.
- 5 The trace will move towards the bottom of the recording channel. Type the words **No Oxygen** on the comment line. Eventually, the trace will reach a stable baseline at the bottom of the recording channel. Press the **Enter** key on the keyboard to mark this new baseline. This comment marks the output of the oxygen electrode in a room temperature solution that is depleted of oxygen.
- 6 Click **Stop** to halt the recording.

- 7 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file (e.g., a class folder). Click the **Save** button to save the file (as an *.iwd file).
- 8 Turn off the stirrer. Remove the electrode from the beaker of calibration solution. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode and place it in a beaker of deionized water.

Units Conversion

- 1 Measure the temperature (°C) in the lab room. Assume the barometric pressure in the lab room is one atmosphere (760mmHg) and the concentration of oxygen in the air is 21%. Look up the concentration of oxygen in deionized water for the temperature in the lab room on Table GB-3-1 on page 3. This value will be used in Step 4 of this units conversion.

Table GB-3-1: Concentration of Oxygen [O₂] in Air-Saturated Deionized Water at 1 Atmosphere.

Temp (°C)	O ₂ Abs Coeff (a)	H ₂ O Vapor Press (p in mmHg)	[O ₂] (µM)
20	.03102	17.54	284
21	.03044	18.65	278
22	.02988	19.83	273
23	.02934	21.07	267
24	.02881	22.38	262
25	.02831	23.76	257
26	.02783	25.09	252
27	.02736	26.74	247
28	.02691	28.35	243
29	.02649	30.04	238
30	.02608	31.82	234

- 2 Select the section of the recording before and after the oxygen is removed from the deionized water in the chamber. To view this section of the recording in its entirety on the same window, it may be necessary to click either of the **Display Time** icons in the **LabScribe** toolbar (Figure GB-3-2 on page 3).

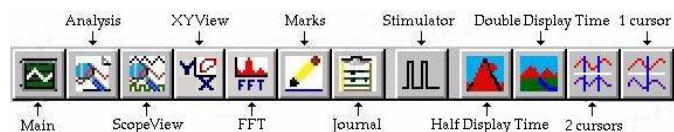


Figure GB-3-2: The **LabScribe** toolbar.

- 3 Click the **2-Cursor** icon (Figure GB-3-2 on page 3) so that two blue vertical lines appear over the recording window. Place one cursor on the left side of the plateau corresponding to the oxygen concentration in air-saturated

deionized water. Place the other cursor on the right side of the plateau corresponding to the oxygen concentration in the zero-percent oxygen calibration solution (Figure GB-3-3 on page 3).

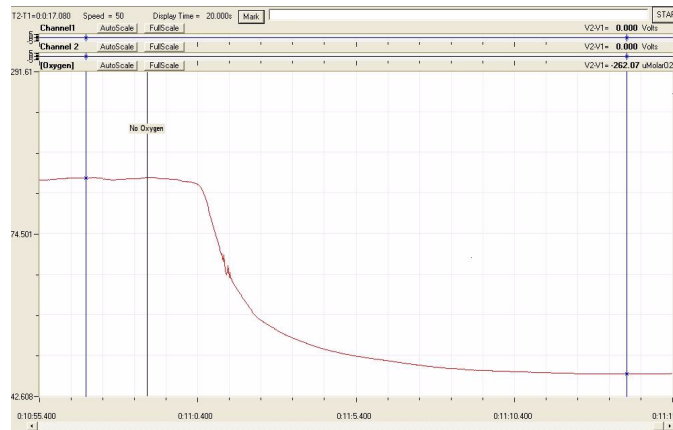


Figure GB-3-3: Recording used to convert units of the Y-axis from voltage to O₂ concentration (µMolar).

- 4 **Right-click** on the Channel 3 window to open the **right-click** menu. Select **Units** from the **right-click** menu. Note that the voltage values for the positions of Cursors 1 and 2 are already entered in the **units conversion** window.

- Next to the voltage value for **Cursor1**, enter **0**.
- Next to the voltage value for **Cursor2**, enter the concentration of oxygen dissolved in deionized water at room temperature found on Table GB-3-1 on page 3.
- Next to the **unit name**, enter **µMolarO₂**.
- Click **OK**. The units on the Y-axis are equal to the **µmoles of oxygen in a liter of deionized water**.

Calibration of the pH Electrode

- 1 If the pH electrode is still stored in its bottle of buffer, remove the electrode from the bottle. Rinse the electrode with deionized water while holding the electrode over a 1000 ml beaker used for the collection of waste liquids.
- 2 Place the tip of the pH electrode in a 250 ml beaker containing enough room temperature deionized water to submerge the tip. Keep the electrode in deionized water for at least ten minutes.
- 3 Prepare two 100 ml beakers filled with the pH buffers used for calibrating the pH electrode. The buffers should be a room temperature. One beaker is filled with pH 7 buffer; and the other is filled with pH 4 buffer. Each beaker should be filled with enough buffer to cover the tip of the pH electrode, and also allow the stir bar in the beaker to spin without touching the pH electrode.
- 4 Place the beaker containing the pH 7 buffer on the magnetic stirrer. Carefully place a stir bar in the beaker. Remove the pH electrode from the deionized water and blot any drops of water from the electrode. Position the tip of the electrode in the beaker of pH 7 buffer so that the tip is away from the stir bar. Adjust the speed of the stirrer so the stir bar is rotating evenly at a moderate speed.

- 5 Click **Start** on the LabScribe Main window to begin recording. The trace will eventually reach a stable baseline toward the top of the recording channel. Type the words **Calibration - pH 7** on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the stable baseline of the recording. This comment marks the output of the pH electrode in pH 7 buffer at room temperature. Continue recording while changing the beakers of buffers.
- 6 Turn off the stirrer and remove the pH electrode from the beaker of pH 7 buffer. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode.
- 7 Remove the beaker of pH 7 buffer from the stirrer and place the beaker of pH 4 buffer on the stirrer. Carefully place a stir bar in the beaker. Position the tip of the pH electrode in the beaker of pH 7 buffer so that the tip of the electrode is away from the stir bar. Adjust the speed of the stirrer so the stir bar is rotating evenly at a moderate speed.
- 8 As you continue to record, the trace will reach a stable baseline toward the bottom of the recording channel. Type the words **Calibration - pH 4** on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the stable baseline of the recording. This comment marks the output of the pH electrode in room temperature pH 4 buffer. Click **Stop** to halt the recording.
- 9 Select **Save As** in the **File menu**, type a name for the file. Choose a destination on the computer in which to save the file (e.g., a class folder). Click the **Save button** to save the file (as an *.iwd file).
- 10 Turn off the stirrer. Remove the pH electrode from the beaker of pH 4 buffer. Hold the electrode over the beaker used for collecting waste liquid, and rinse it with deionized water from a wash bottle. Blot any drops of water from the electrode and place it in a beaker of deionized water.

Exercise 1: Dissolved Oxygen Concentration and pH in an Aquatic Environment with an Animal

Aim: To measure changes in dissolved oxygen concentration and pH of water inhabited by fish.

Procedure

- 1 Place a magnetic stirrer on or next to the base of a ringstand. Place 200 mL of fresh pond water, at room temperature, in a 400 ml beaker. Add a stir bar to the beaker and place the beaker on a magnetic stirrer. Turn on the stirrer and position the stir bar to one side of the beaker bottom.
- 2 Adjust the position of the clamps that will hold the dissolved oxygen and the pH electrodes in the beaker of pond water.
- 3 Remove the dissolved oxygen and the pH electrodes from the beakers of deionized water. Blot the drops of deionized water from each device. Mount the electrodes on the

ringstand using the clamps, and position the tips of the devices in the pond water. Cover the top of the beaker with plastic wrap to prevent the exchange of gases over the pond water with those in the environment.

- 4 Turn on the stirrer so that the stir bar rotates evenly and moderately. Wait two minutes before recording the dissolved oxygen concentration and pH level of the pond water.
- 5 Click **Start** on the LabScribe Main window to begin recording. When the recordings on both channels reach a stable baseline, type the words **Pond Water Alone** on the comment line to the right of the **Mark button**. Press the **Enter key** on the keyboard to mark the recording.
- 6 After recording at least fifteen seconds of stable baseline on each channel, type the words **Goldfish in Pond Water** on the comment line. Peel back the plastic wrap that covers the top of the beaker and place a goldfish in the pond water. Cover the top of the beaker with the plastic wrap, and press the **Enter key** on the keyboard to mark the recording. Lower the speed of the stirrer, if the goldfish seems stressed.
- 7 Record the dissolved oxygen concentration and pH of the pond water for thirty minutes. At the end of thirty minutes, click **Stop** to halt the recording.
- 8 Select **Save** in the **File menu**. Before analyzing the data from this exercise, complete Step 9 and then proceed directly to Exercise 2.
- 9 Remove the dissolved oxygen and the pH electrodes from the beaker of pond water. Remove the goldfish from the beaker and place it in the fish tank. Discard the pond water and refill the beaker with 200 ml of fresh pond water. Reposition the electrodes and the stir bar in the beaker of fresh pond water. Cover the beaker with plastic wrap.

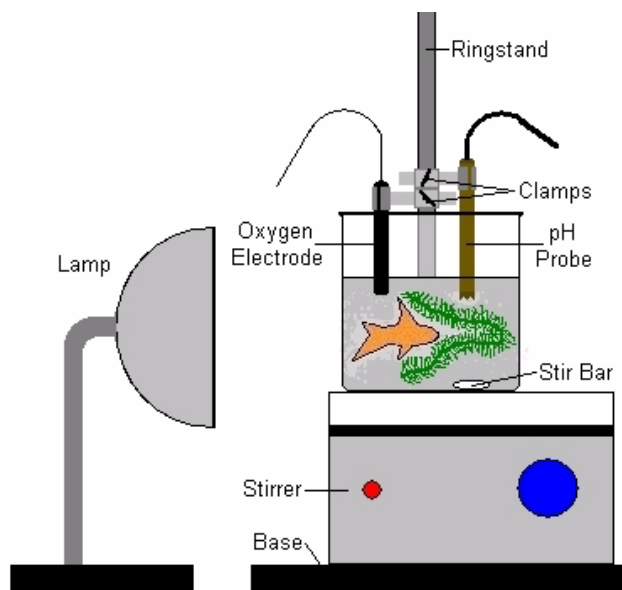


Figure GB-3-4: The arrangement of the light source, stirrer, electrodes, and beaker for measuring the changes in the oxygen concentration and pH in a small closed ecosystem.

Exercise 2: Dissolved Oxygen Concentration and pH in an Aquatic Environment with a Plant

Aim: To measure changes in dissolved oxygen concentration and pH of water in the presence of an aquatic plant.

Procedure

- 1 At the end of Exercise 1, the electrodes and the stir bar were placed in the proper positions to make another recording. Make sure the stir bar rotates evenly and moderately. Wait two minutes before recording the dissolved oxygen concentration and pH level of the pond water.
- 2 Click **Start** on the **LabScribe Main window** to begin recording. When the recordings on both channels reach a stable baseline, type the words **Pond Water Alone** on the comment line to the right of the **Mark** button. Press the **Enter** key on the keyboard to mark the recording.
- 3 After recording at least fifteen seconds of stable baseline on each channel, type the words **Plant in Pond Water** on the comment line. Peel back the plastic wrap that covers the top of the beaker and place a piece of aquatic plant, like *Elodea*, in the beaker. Aim a lamp toward the beaker of pond water containing the plant. Turn on the light to illuminate the plant material in the beaker.

Warning: To prevent the temperature of the pond water from rising while the light is on, you may need to place a large beaker with water, that will act as a heat reservoir, between the light and the beaker of pond water.

- 4 Cover the top of the beaker with the plastic wrap, and press the **Enter** key on the keyboard to mark the recording.
- 5 Record the dissolved oxygen concentration and pH of the pond water containing the aquatic plant for ten minutes.
- 6 At the end of ten minutes, click **Stop** to halt the recording. Select **Save** in the **File menu**; then immediately, click **Start** to begin recording again. Do not turn off the light at any time.
- 7 Proceed directly to Exercise 3.

Exercise 3: Dissolved Oxygen Concentration and pH in an Aquatic Environment with a Plant and an Animal

Aim: To measure changes in dissolved oxygen concentration and pH of water inhabited by a fish in the presence of an aquatic plant.

Procedure

- 1 Type the words **Goldfish & Plant in Pond Water** on the comment line. Peel back the plastic wrap that covers the top of the beaker with the plant. Place a goldfish in the same beaker. Cover the top of the beaker with the plastic wrap, and press the **Enter** key on the keyboard to mark the

recording. Lower the speed of the stirrer, if the goldfish seems stressed.

- 2 Record the dissolved oxygen concentration and pH of the pond water containing the plant and the goldfish for thirty minutes. At the end of thirty minutes, click **Stop** to halt the recording.
- 3 Select **Save** in the **File menu**.
- 4 Turn off the light and carefully move it away from the beaker. Remove the dissolved oxygen and the pH electrodes from the beaker of pond water. Remove the goldfish and the plant material from the beaker and place them in the fish tank. Discard the pond water. Place the electrodes in beakers of deionized water.

Data Analysis

Exercise 1: Environment with Animal

- 1 Scroll to the section of data recorded during Exercise 1. Use the **Display Time icons** on the **LabScribe toolbar** (Figure GB-3-2 on page 3) to complete recording from Exercise 1 on the **Main window**.
- 2 Click on the **2-Cursor icon** in the **LabScribe toolbar** (Figure GB-3-2 on page 3), so that two blue cursors appear over the **Main window**.
- 3 Place a cursor on the stable baseline recorded just before the goldfish was added to the beaker of pond water. Place the second cursor at the point in the recording that is thirty minutes after the goldfish was added to the beaker.
- 4 Click the **Analysis icon** on the **LabScribe toolbar** (Figure GB-3-2 on page 3) to transfer the data between the cursors to the **Analysis window**.
- 5 In the table across the top of the data display on the **Analysis window**, the parameters, **Title**, **Value1**, **Value2**, **V2-V1**, and **T2-T1** should appear. Any functions that does not appear in the table can be selected from the list of functions on the left side of the **Analysis window** by holding down the **Control** key on the keyboard as the name of the function is clicked (**Control-Click**).
- 6 Place a cursor at the point in the recording when the goldfish was placed in the beaker of pond water (**Time = 0**). Place the second cursor at the point in the recording that is thirty minutes after the goldfish was placed in the beaker (**Time = 30**). Select **[Oxygen]** on the **Value from Ch** menu in the upper left corner of the **Analysis window**.
- 7 Measure the values for the following parameters from the **[Oxygen] channel** for the region of data selected:
 - **Dissolved Oxygen Concentration at Time = 0**, which is **Value1** on the **[Oxygen] channel**.
 - **Dissolved Oxygen Concentration at Time = 30**, which is **Value2** on the **[Oxygen] channel**.
 - **Change (Δ) in Dissolved Oxygen Concentration after 30 Minutes**, which is **V2-V1** on the **[Oxygen] channel**.

8 Record the names and values of the parameters, **Title**, **Value1**, **Value2**, **V2-V1**, and **T2-T1** for the data of interest in the on-line notebook of LabScribe that is known as the **Journal**. The information can be entered by typing the names and values directly into the **Journal**. The measurements can also be entered into the **Journal** using the functions in the **right-click menu** of the **Analysis window**:

- Place the cursors in the appropriate locations for making measurements.
- Select **Add Title to Journal**, from the **right-click menu**, to add the names of the parameters measured to a table in the **Journal**.
- Select **Add Data to Journal**, from the **right-click menu**, to add the values of the parameters to the **Journal**.

9 Record the values for these parameters in Table GB-3-2 on page 7.

10 After the recording the data from the **[Oxygen] channel**, select **pH** on the **Value from Ch menu**. Use one of the techniques described in Step 8 to record the values for the following parameters in the **Journal**:

- **pH at Time = 0**, which is **Value1** on the **pH channel**.
- **pH at Time = 30**, which is **Value2** on the **pH channel**.
- **Change (Δ) in pH after 30 Minutes**, which is **V2-V1** on the **pH channel**.

11 Record the values for these parameters in Table GB-3-2 on page 7.

12 Click the **Save button** to save the file.

13 Click on the **Main icon** in the LabScribe toolbar (Figure GB-3-2 on page 3) to return to the **Main window**.

Exercise 2: Environment with Plant

- 1 Scroll to the section of data recorded during Exercise 2. Display the complete recording from Exercise 2 on the **Main window**.
- 2 Place a cursor on the stable baseline recorded just before the plant was added to the beaker of pond water. Place the second cursor at the point in the recording that is ten minutes after the plant was added to the beaker
- 3 Transfer the data between the cursors to the **Analysis window**.
- 4 Make sure the same parameters used in Exercise 1 appear in the table across the top of the data display on the **Analysis window**.
- 5 Place a cursor at the point in the recording when the plant was placed in the beaker of pond water (**Time = 0**). Place the second cursor at the point in the recording that is ten minutes after the plant was placed in the beaker (**Time = 10**). Select **[Oxygen]** on the **Value from Ch menu** in the upper left corner of the **Analysis window**.

6 Measure the values for the following parameters from the **[Oxygen] channel** for the region of data selected:

- **Dissolved Oxygen Concentration at Time = 0**, which is **Value1** on the **[Oxygen] channel**.
- **Dissolved Oxygen Concentration at Time = 10**, which is **Value2** on the **[Oxygen] channel**.
- **Change (Δ) in Dissolved Oxygen Concentration after 10 Minutes**, which is **V2-V1** on the **[Oxygen] channel**.

7 Use the one of the techniques described in Step 8 of Exercise 1 to record the values of the parameters in the **Journal**.

8 Record the values for these parameters in Table GB-3-2 on page 7.

9 After the recording the data from the **[Oxygen] channel**, select **pH** on the **Value from Ch menu**. Use one of the techniques described in Exercise 1 to record the values for the following parameters in the **Journal**:

- **pH at Time = 0**, which is **Value1** on the **pH channel**.
- **pH at Time = 10**, which is **Value2** on the **pH channel**.
- **Change (Δ) in pH after 10 Minutes**, which is **V2-V1** on the **pH channel**.

10 Record the values for these parameters in Table GB-3-2 on page 7.

11 Click the **Save button** to save the file.

12 Click on the **Main icon** in the LabScribe toolbar (Figure GB-3-2 on page 3) to return to the **Main window**.

Exercise 3: Environment with Plant and Animal

- 1 Scroll to the section of data recorded during Exercise 3. Display the complete recording from Exercise 3 on the **Main window**.
- 2 Place a cursor on the stable baseline recorded just before the goldfish was added to the beaker with the plant and pond water. Place the second cursor at the point in the recording that is thirty minutes after the goldfish was added to the beaker
- 3 Transfer the data between the cursors to the **Analysis window**.
- 4 Make sure the same parameters used in Exercises 1 and 2 appear in the table across the top of the data display on the **Analysis window**.
- 5 Place a cursor at the point in the recording when the goldfish was placed in the beaker with the plant and pond water (**Time = 0**). Place the second cursor at the point in the recording that is thirty minutes after the goldfish was placed in the beaker (**Time = 30**). Select **[Oxygen]** on the **Value from Ch menu** in the upper left corner of the **Analysis window**.

- 6 Measure the values for the following parameters from the **[Oxygen] channel** for the region of data selected:
 - **Dissolved Oxygen Concentration at Time = 0**, which is **Value1** on the **[Oxygen] channel**.
 - **Dissolved Oxygen Concentration at Time = 30**, which is **Value2** on the **[Oxygen] channel**.
 - **Change (Δ) in Dissolved Oxygen Concentration after 30 Minutes**, which is **V2-V1** on the **[Oxygen] channel**.
- 7 Use the one of the techniques described in Step 8 of Exercise 1 to record the values of the parameters in the **Journal**.
- 8 Record the values for these parameters in Table GB-3-2 on page 7.
- 9 After the recording the data from the **[Oxygen] channel**, select **pH** on the **Value from Ch menu**. Use one of the techniques described in Exercise 1 to record the values for the following parameters in the **Journal**:
 - **pH at Time = 0**, which is **Value1** on the **pH channel**.
 - **pH at Time = 30**, which is **Value2** on the **pH channel**.
 - **Change (Δ) in pH after 30 Minutes**, which is **V2-V1** on the **pH channel**.
- 10 Record the values for these parameters in Table GB-3-2 on page 7.
- 11 Click the **Save button** to save the file.

Table GB-3-2: Changes in Dissolved Oxygen Concentrations and pH While Organisms Are in a Closed Ecosystem.

Organisms in Pond Water	pH Level			Dissolved Oxygen Concentration (μ Molar O ₂)			
	Initial	Ending	Change (Δ)	Initial	Ending	Change (Δ)	Rate (μ MO ₂ /min)
Animal, 30 Mins							
Plant, 10 Mins							
Plant & Animal, 30 Mins							

Questions

Exercise 1: Environment with Animal

- 1 Do any changes in the dissolved oxygen concentration and pH of the pond water take place while the fish is in the beaker?
- 2 What are the causes of the changes or the lack of changes?

Exercise 2: Environment with Plant

- 1 Do any changes in the dissolved oxygen concentration and pH of the pond water take place while the plant is in the beaker?
- 2 What are the causes of the changes or the lack of changes?

Exercise 3: Environment with Plant and Animal

- 1 Do any changes in the dissolved oxygen concentration and pH of the pond water take place while the fish and the plant are in the beaker together?
- 2 What are the causes of the changes or the lack of changes?
- 3 If increases or decreases in the oxygen concentration and pH of large bodies of water (lakes, seas, oceans) took place, what would be some of the causes of these changes? Make sure you indicate whether the cause would create an increase or decrease in pH or dissolved oxygen concentration.

Appendix

Zero-Percent Oxygen Calibration Solution is 15mM Sodium Hydrosulfite in deionized water.

