

DR. STIRLING MCDOWELL  
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FOR  
RESEARCH INTO TEACHING



# TEACHING AND LEARNING RESEARCH EXCHANGE

## Developing New Learning Experiences

Activities for  
High School Sciences  
that Integrate Computer  
Interface Technology

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We also wish to thank the students at Lumsden High School. These students performed the activities as part of their regular science classes. Their feedback was an important part in the development of activities that are classroom ready.

Finally the researchers wish to acknowledge the personal value of this kind of research project to their own professional development. Being able to develop a use for technological resources in science classrooms has been enormously beneficial to us. We strongly encourage teachers who are afforded an opportunity to take part in this type of project to take it.

- *RHONDA PHILLIPS AND WARREN WESSEL*



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# Introduction

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Computers are capable of collecting, displaying, analyzing and graphing data in new and innovative ways in secondary science laboratory activities. A variety of reasonably priced hardware and software is now available for use in high schools from commercial vendors. This equipment provides classroom teachers with additional means of facilitating hands-on laboratory experiences for secondary science students. Computer-based activities allow teachers to use new instructional strategies, and provide new experiments employing computer-linked measuring devices that were previously unavailable or impractical for secondary school settings. Appropriate use of such new technology in secondary school science laboratories should enhance instruction and student learning.

# Purpose and Objectives

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The central purpose of this project was for the teacher-researchers to develop a number of computer-based laboratory activities that are appropriate for use in secondary science classes, in particular Science 10, and Biology 20 and 30 classes. The guiding question for this project was “How can classroom teachers develop a series of computer assisted/based activities that are appropriate to grade level and course as part of their instructional strategies?” The participants developed and used in their classroom instruction a series of computer-based laboratory activities. The developers attempted to create activities that are both engaging for students and consistent with the goals of Saskatchewan science curricula. Part of the development of the activities included an evaluation of student acceptance of the activities as part of course requirements.

The researchers focused on developing a continuum of skills and knowledge for students in Science 10, and Biology 20 and 30. The technological skills and knowledge are appropriate for and specific to science classrooms rather than ones that are expected to be parts of other courses. For example, measurement probes were used to collect data, and graphing software was used to display and analyze them; however, little emphasis was placed on word processing and related skills that students would be expected to employ in other non-science classrooms. In addition, areas of the science curricula that are appropriate for computer-based activities were identified. As students progress through the continuum, their abilities will progress from an introductory level to a mastery level.

In the design of laboratory activities, aspects of Saskatchewan Learning’s Information and Communication Technology Skill Checkpoints were used as a guide to decide on appropriate levels for each grade. The skills and knowledge required by students for computer applications in science are more specific than the general checkpoints, but attempts were made to use them where appropriate.

The continuum of skills and knowledge was identified to fit with units of the science curricula that were appropriate to the content and the level of knowledge that is expected of students. The activities were presented in such a manner that students develop their abilities with the technology as they progress through the continuum, from the introductory to mastery level. The activities for grade 10 students have less complexity than do the activities for grade 11 and 12 students.

# Methods and Activities

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Once the researchers identified areas of the curricula where computer-based laboratory activities could be used that fit within the units of the courses, they designed experiments that used computer measurement probes and data analysis software. The activities were designed in such a way that students perform increasingly more complex computer software data manipulations as they move through Science 10 to Biology 20 and 30. These computer-based laboratory activities were used during the four semesters of the 2001-2003 school years. The teacher-researcher kept reflective notes to record the positive and negative aspects of each laboratory activity that was used in her classroom. As each activity was tested in a classroom setting, improvements and refinements were made to the student directions before retesting the activity with another group of students. The laboratory instructions were evolved so that they were as teacher and student friendly as possible. The activities were designed in an attempt to ensure that they do not take more class time to complete than more traditional methods and activities in the courses.

# Innovative Approaches and Methods

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Almost all employment now requires that employees use computer hardware and software in some manner. Students can develop technological literacy by using hardware and software to gather data using computer-based probes in science activities. Students who take the grade 10 to 12 sciences in secondary schools are a diverse group of people. They include students of both genders, many cultures and a wide range of socio-economic living conditions. Although the availability of home computers is increasing, many students do not have computers at home for their use. The proposed program of computer-based activities allows all students who take science access to practical applications of sophisticated technology. The use of technology in this manner may help students to develop a comfort and confidence level with technology that they may not experience in other classes. This experience may encourage them in the future to pursue jobs that use computer technology. Female students, who may be less comfortable with technology, are able to approach the use of technology in a less-threatening atmosphere that does not require prior knowledge of computers, or a commitment to a full course in the use of computers, such as computer applications or computer science. This access to computers by female and multi-cultural students may encourage more of them to consider careers in fields using computers and other technologies.

# Science 10 Laboratory Activities

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## 1. WATER CLARITY

### **BACKGROUND INFORMATION – SCIENCE ACTIVITY**

Water becomes clouded with suspended soil particles, effluent or algae. This cloudiness is measured as turbidity. The more turbid the water is, the less light will penetrate the water. With reduced light penetration photosynthesis will be reduced at depth, which affects the food chain as well as oxygen production (and dissolved oxygen concentration) at that level. The particles in turbid water also convert light energy from the sun into heat energy, which causes the water to heat up. Increased temperature can reduce dissolved oxygen concentration and increase the rate of decomposition and the metabolic rate of cold-blooded animals.

### **BACKGROUND INFORMATION – USE OF INTERFACE AND LIGHT SENSOR**

The light sensor measures the quality we refer to as clarity, not turbidity. Calibration of the sensor is done with a sample of distilled water. In the activity the clarity of each sample is measured. The lower the percentage of light transmitted, the more turbid the water. In this activity samples from different locations in the water body can be compared and correlated with different uses of the water in those locations. Turbidity also varies with time of year so that this quality could be measured over an extended time period.

### **SCIENCE OBJECTIVES**

1. To recognize that water that has suspended solids is a mixture.
2. To explain the source of suspended solids in samples with reduced turbidity.
3. To compare land use practices in different sampling locations with respect to water quality as indicated by turbidity.

### **TECHNOLOGY OBJECTIVES**

1. To calibrate a light sensor.
2. To determine clarity of water samples from various locations, in the lab.

## **MATERIALS**

- Glass box for sample
- Light box
- Light sensor
- Water samples
- Distilled water
- Pen light

## **TEACHER INSTRUCTIONS**

1. Review the properties and characteristics of a mixture.
2. Discuss what kinds of materials could be suspended in water to cause turbidity.
3. Explain that the light sensor used in this activity measures clarity, which is the opposite of turbidity.

## **LAB METHODS**

1. Connect the light sensor to the interface.
2. Select S04 Clarity and Turbidity in Water from the Library in Data Studio.
3. Calibrate the sensor by placing distilled water in the light box and taking a reading.
4. Place sample water in the light box and take readings.

## **ASSIGNMENT**

1. Compare the clarity of water samples taken from different locations and try to relate water clarity (or lack of clarity) to land use practices and perhaps the time of year.
2. Suggest what things we might do to reduce the amount of suspended solids in the aquatic ecosystem.

## **EVALUATION**

Assess student ability to calibrate the light sensor.

Assess student ability to determine the clarity of water samples and explain and discuss these measurements with respect to land use practices and time of year.

## 2. INSULATION

### **BACKGROUND INFORMATION – SCIENCE ACTIVITY**

Insulation materials reduce the rate at which energy is lost or transferred to the surroundings. When insulators are tested under identical conditions, their ability to reduce heat loss can be compared.

### **BACKGROUND INFORMATION – USE OF INTERFACE AND TEMPERATURE SENSOR**

Temperature sensors can be used to monitor decrease in temperature as a result of heat loss. This data can be interpreted to provide a comparative evaluation of different insulating materials.

One, two or three temperature sensors can be used at one time in this activity because there are three analog ports on a Science Workshop 500 Interface. The number that you use here depends on the number that is available in your laboratory. Use as many temperature sensors (up to three) as possible because you will have more data to work with in your analysis.

### **SCIENCE OBJECTIVES**

1. To design and set up an experiment to determine the relative insulating values of substances normally used as insulators.

### **TECHNOLOGY OBJECTIVES**

1. To create an experiment in Data Studio.
2. To gather data from two or three analog ports simultaneously.
3. To graph data from the two or three analog ports on the same graph to allow a graphical comparison of the data.

### **MATERIALS**

#### **Experimental Set Up**

- three insulators
- three ice cream pails/containers
- lids with small holes
- 3 – 250 mL beakers
- 100 mL graduated cylinder
- water
- hot plate

### **Interface Temperature Testing**

- Science Workshop 500 Interface
- Three (or two) temperature sensors
- tongs

## **TEACHER INSTRUCTIONS**

Day 1: Have students generate a list of insulating materials. Have students bring examples to class for the activity

Day 2: Collect 4.0 L ice cream pails with the lids. In the lid of each ice cream pail make a hole that is just large enough to receive the temperature sensor. If the hole is too large heat will be lost.

Have students arrange their insulation material in the pail so that there is room in the middle at the top for a 250 mL beaker. The beaker should be positioned so that the temperature sensor will be in the beaker.

Day 3: Students carry out the lab as outlined on the Student Lab Instructions sheet.

## **ASSIGNMENT**

Write a lab report that compares insulation materials and evaluates the best insulator of those tested.

## **EVALUATION**

Lab report.

## **STUDENT LAB INSTRUCTIONS**

### **MATERIALS**

#### **Experimental Set Up**

- three insulation materials
- three 4.0 L ice cream pails
- lids with small holes in center
- 3 – 250 mL beakers
- 100 mL graduated cylinder
- water
- hot plate
- tongs
- Science Workshop 500 Interface
- three temperature sensors

## LAB METHODS

1. Measure 100 mL of water and place into each 250 mL beaker. Place the beakers on a hot plate and bring the water to a boil.
2. While the water is heating plug the temperature sensors into the analog ports on the Science Workshop interface.
3. Start Data Studio on the computer and select “Create a New Experiment”. Drag “temperature” sensor three times to the Interface box in the Set Up screen, in the three different Analog ports, A, B and C. The temperature sensors do not need to be calibrated. Set sampling rate to 300 seconds (5 minutes) and shrink the screen.
4. Drag Temperature Ch A, Ch B, Ch C from Data to Displays – table.
5. Under “Experiment” open Sampling Options and leave on “manual start”. Set stop time for 3610 seconds to allow time for the last readings to be recorded at 3600 seconds. The computer will collect data for one hour at these settings. Adjust the time if you want the data collection to stop sooner.
6. When boiling place the beaker using the tongs into the ice cream pail with insulation as quickly as possible. Repeat for each pail of insulation. Snap on the lids. Insert the temperature sensors. Click “Start”. The computer will count down for 60 minutes, printing a temperature for each of the three sensors in the data table every five minutes.
7. Record which insulation sample is in each channel.
8. Once the data has been collected, draw a graph using the software. Double click on the time, x axis, to change the scale from seconds to minutes. Maximize the size of the graph and adjust the scale on the y axis (double click, set maximum and minimum) to fill the graph paper. Record the insulation material used for each channel on the graph.
9. Print the graph.
10. Save As: InsulatorsStudentName in General Science Folder in Library of Data Studio.

## ASSIGNMENT

Write a lab report that includes the computer-generated graph of the data. Refer to the graph in the observation section and comment on what it shows.

# 3. pH

## BACKGROUND INFORMATION – SCIENCE ACTIVITY

pH is a measure of the concentration of hydrogen ions ( $H^+$ ) in a solution. If there are more hydrogen ions than hydroxyl ions ( $OH^-$ ) present in a solution, then it is acidic and will have a pH of between 1 and 6.9 on the pH scale. If there are fewer hydrogen ions than hydroxyl ions in the solution, then it is basic and will measure between 7.1 and 14 on the pH scale. A neutral solution has a pH of 7 and contains an equal number of hydrogen and hydroxyl ions. The pH scale is a logarithmic scale; so, for every pH unit increase the hydrogen concentration decreases by a factor of 10.

The pH of an aqueous solution can be measured using a pH sensor. Grade 10 students may want to measure acidity for a variety of reasons. For example, students may want to measure pH to determine the acidity of common substances. Or, students might test the pH of local aquatic ecosystems. Most waters in southern Saskatchewan are slightly basic, having a pH of about 8. This basic pH is the result of the influence of carbonate minerals in surrounding soils. Waters in northern Saskatchewan are also affected by the geochemistry of their surrounding soils and rocks. In addition some places in Saskatchewan do show the influence of acid precipitation which lowers the pH of an aquatic ecosystem.

Acid precipitation is a result of air pollution. At high temperature in an automobile engine, nitrogen and oxygen from the air combine to form nitrogen oxide. Nitrogen oxide reacts with more oxygen to produce nitrogen dioxide (brown haze). Nitrogen dioxide reacts with water to form nitric acid and nitrogen oxide. This nitric acid is one component of acid rain. Sulfuric acid is produced as the result of similar interactions. Sulfur that is in coal burns when coal is used in power plants. The sulfur combines with oxygen to produce sulfur dioxide. The sulfur dioxide further reacts with oxygen to produce sulfur trioxide. Sulfur trioxide combines with water to form sulfuric acid. Sulfur is also released from smelting processes of certain ores.

## BACKGROUND INFORMATION – USE OF INTERFACE AND pH SENSOR

The pH sensor has to soak in distilled water for at least 10 minutes before use. It must then be calibrated with solutions of known pH (buffer solutions). At the grade 10 level labs, the teacher should have the sensors set up and calibrated before class begins. Advanced Placement students should be taught how to calibrate and the importance of calibrating sensors. Tablets used for making buffer solutions of known pH are available from science suppliers.

For this activity set the low range with a buffer solution of pH 2 and the high range with a buffer solution of pH 10. Thoroughly rinse the sensor between tests using a wash bottle or a large beaker of distilled water. The rinse water in a beaker must be changed often due to contamination. Measuring the pH of distilled water to exactly 7 is difficult because water is not a buffer solution and is affected by extremely small amounts of acid or base. The sensor will pick up any ions present in the water or not rinsed off the sensor from a previous test.

## SCIENCE OBJECTIVES

1. To test the pH of various samples using an interface with pH sensor.
2. To calibrate a pH sensor.
3. To understand the definition of *ion*.
4. To explain that a substance containing a) more hydrogen ions than hydroxyl ions is acidic; b) more hydroxyl ions than hydrogen ions is basic; and, c) equal amounts of hydrogen and hydroxyl ions is neutral.

## TECHNOLOGY OBJECTIVES

1. To calibrate a sensor.
2. To use a pH sensor to measure pH.
3. To record in a data table, the run number, substance tested in that run and the pH.
4. To plot pH of test substances on a pH scale.

## MATERIALS

Set of samples consistent with the unit being taught.

### Drinking Water or Aquatic Ecosystems

- solution of dishwashing liquid and water
- ammonia or Windex with ammonia
- tap water (student supplied – different sources)
- surface water (lakes, rivers, ponds)
- weak solution of sulfuric acid simulating acid rain
- weak solution of nitric acid simulating acid rain
- calcium chloride solution (hard water)
- magnesium chloride solution (hard water)
- sodium bicarbonate (alkalinity)
- sodium hydroxide (common base)

### Common Substances

- tap water
- lemon juice
- vinegar
- soap solution
- cleaners in solution
- milk
- hydrochloric acid (known acid)
- sodium hydroxide (known base)

### Science Workshop Interface

- pH probe
- standard buffer solutions pH 2 and pH 10
- distilled water
- tissue

## TEACHER INSTRUCTIONS

1. Help the student understand the meaning of the terms pH, hydrogen ion, hydroxyl ion, acid, base, neutral, pH scale, logarithmic.
2. Explain that pH is a measure of hydrogen ion concentration.
3. Discuss the relevance of pH to the topics currently being taught. For example, we are concerned about increased acidity in the environment because of the affect on aquatic ecosystems, the ability to leach heavy metals out of rocks and pipes, the inhibition of normal development of fish, and the chemical erosion of man-made structures such as buildings and statues.
4. Select substances to test that are consistent with the focus of the unit being taught. Two sample lists are suggested, one for water quality and one for common substances. These lists could be added to, reduced or changed completely but make sure students will have measured samples with a complete pH scale when the data collection is finished.
5. Explain how the sensor is calibrated. See Student Lab Instructions for details.
6. Show students how to start a run on the computer which will collect data for them.
7. Explain to students that they have to record which test substance correlates with each run in their lab notes while they are doing the lab.
8. The results of this lab should be a pH scale with the names of the test substances on it and supporting evidence in a data table showing run #, substance and pH.

## LAB METHODS

1. Set pH sensor in distilled water for 10 minutes.
2. Open activity *S06 pH of a Stream from the Earth Science Labs in the Data Studio Library*.
3. Create a data table with columns for *sample*, *run #* and *pH* in the observations section of the lab report.
4. Calibrate the sensor at pH 2 for low and pH 10 for high.
5. Rinse the sensor thoroughly between test solutions.
6. Place sensor in solution to be tested and press start. Record the final pH for each test substance with its run number.
7. Save data into a file as *pHstudentnames*.

## ASSIGNMENT

Complete a lab report with data table and pH scale labeled with test substances. Other forms of reporting could be designed, if they meet other instructional goals.

## EVALUATION

A lab report that includes a pH scale and supporting evidence could be part of the assessment. Alternative student submissions could also be used.

Skill evaluation of ability to use the sensor and record data (run#, substance, pH) should be done by teacher as lab is proceeding.

Other forms of submission could be less traditional. For example, students could post their results and graphs on a class web site; or they could create power point presentations to communicate their results to each other.

## STUDENT LAB INSTRUCTIONS

1. Obtain samples and take them to computer work station, select the appropriate list depending on the aspect of pH being considered:

### **Drinking Water or Aquatic Ecosystems**

- dishwashing liquid solution
- ammonia or Windex with ammonia
- tap water (different sources)
- surface water (lakes, rivers, ponds)
- dilute sulfuric acid simulating acid rain
- dilute nitric acid simulating acid rain
- calcium chloride solution (hard water)
- magnesium chloride solution (hard water)
- sodium bicarbonate
- sodium hydroxide (common base)

### **Common Substances**

- tap water
- lemon juice
- vinegar
- soap solution
- cleaners in solution
- milk
- hydrochloric acid (known acid)
- sodium hydroxide (known base)

### **Science Workshop Interface**

- pH sensor
- standard buffer solutions – pH 2 and pH 10
- distilled water for rinsing sensor (in large beaker or wash bottle with beaker)
- tissue or soft paper towel

2. Set up the computer interface system.
  - Start *Data Studio*
  - Select *Open Activity*.
  - From the *Library*, *Earth Science* labs, open activity *S06 pH of a Stream*.
  - Save as *pHstudentnames*

**TO CALIBRATE THE SENSOR (If teacher says you are to do this step)**

Soak pH sensor, electrode portion, in distilled water for 10 minutes. Rinse the pH electrode, dry it gently with tissue or soft paper towel. Open the *Set Up* window, double click on *pH – pH sensor*.

Place the pH electrode in buffer solution pH 10. *Calibrate* the high value. When the voltage displayed as the *Cur Value* stabilizes, type the pH of the buffer solution in the box labeled high value (10), click *Read*, then click *OK*.

Rinse the pH electrode, dry it gently with tissue or soft paper towel.

Place the pH electrode in buffer solution pH 2. *Calibrate* the low value. When the voltage displayed as the *Cur Value* stabilizes, type the pH of the buffer solution in the box labeled low value (2), click on *Read*, then click *OK*.

3. Design a data table similar to the example below. The underlined title should be consistent with the purpose and hypothesis of the lab being done.

Data Table 1: \_\_\_\_\_

Substance	Run #	Interface pH	pH paper
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- *Copy and complete in Observation section of lab report.*

4. Measure the pH.

Determine the pH of each test solution using the Interface system. Place the clean electrode (sensor) in the solution to be tested. Click “Start” on the computer screen. The computer will test the pH of the solution for 30 seconds and display the pH as digits. Record the final pH in the data table. Remember to rinse the pH electrode between each reading and dry with tissue or soft paper towel.

5. Draw a pH Scale.

Record the pH of each of the test substances on a pH scale. Use the data in the data table as supporting evidence. Both the data table and pH scale should be in the lab report.

## ASSIGNMENT

Complete a lab report with data table in observations section followed by the pH scale labeled with test substances as outlined above.

# 4. TOTAL DISSOLVED SOLIDS

## BACKGROUND INFORMATION – SCIENCE ACTIVITY

When ionic substances dissolve in water they form ions; Na<sup>+</sup>, K<sup>+</sup>, and Cl<sup>-</sup> from salts; Ca<sup>2+</sup> and CO<sub>3</sub><sup>2-</sup> from limestone in the soil; NO<sub>3</sub><sup>-</sup>, PO<sub>4</sub><sup>3-</sup>, NH<sub>3</sub><sup>+</sup> from pollutants and the break down of organic matter in the soil. The presence of such ions can be detected by a conductivity sensor, and the readings from different sources can be compared. Soft water (melted snow, rainwater, and surface water) sources can be compared to ground water for total dissolved solids.

Total dissolved solids (TDS) are one parameter to be considered when testing water quality. Dissolved oxygen, nitrogen, and phosphate levels can be measured using Hach kits. pH, clarity and temperature can be measured with an interface system. Total suspended solids are measured by filtering a sample of water and calculating the increase of the mass of the filter paper, once it has been dried, per litre of the water filtered. It is unlikely that a full litre of water could be filtered because the residue in the filter paper reduces flow as it is collected. The filtrate from a total suspended solids test can be used as a sample in this analysis to determine the total dissolved solids in water.

## BACKGROUND INFORMATION – USE OF INTERFACE AND CONDUCTIVITY SENSOR

The conductivity sensor measures the flow of electric current through a solution. The more ions present in the solution, the greater the current flow will be. The current is displayed on the computer using Data Studio. The conductivity sensor does not need to be calibrated because the readings are relative to one another and not measured against a standard concentration.

## SCIENCE OBJECTIVES

1. To compare the concentration of dissolved solids in water from different sources.
2. To recognize dissolved solids as an indicator of water quality.

## TECHNOLOGY OBJECTIVES

1. To use a conductivity sensor.
2. To create an experiment using Data Studio software and a conductivity sensor.
3. To set up sampling options for a test.

## **MATERIALS**

### **Experimental Set Up**

- water samples to compare from:  
2 or more surface water sources OR  
ground water and surface water OR  
rain or melted snow (soft water) and surface or ground water
- 100 mL graduated cylinder

### **Interface Conductivity Testing**

- Science Workshop Interface
- conductivity sensor

## **TEACHER INSTRUCTIONS**

1. Explain to students the source of dissolved ions in water and the reason a conductivity sensor is used to read the number of dissolved ions in a water sample. This information is outlined under Background and can be supplemented from water quality testing books and textbooks. Describe the implications of high conductivity readings as an indication of high water hardness or polluted water.
2. Instruct students to set up the interface and computer following the Student Lab Instructions.
3. The conductivity test is done on filtrate produced from a total suspended solids test or on water samples that do not need to be filtered. Tell students where to get the water samples to be tested. Explain the source of the water samples and why these samples were chosen for testing.
4. Record the conductivity reading with the run # and original source of the sample in a data table.
5. Repeat for each of the tests being done.

## **ASSIGNMENT**

Conductivity testing is usually done in association with other water quality tests. The data collected from this test can be interpreted and reported on its own or with the information gathered from other water quality tests.

## **EVALUATION**

Student ability to set up an experiment using Data Studio software.

Student ability to interpret conductivity data gathered.

## **STUDENT LAB INSTRUCTIONS**

Obtain a sample of water as instructed by your teacher. This sample may be filtrate from a total suspended solids test or a sample such as rainwater or tap water that does not need to be filtered.

## MATERIALS

### Experimental Set Up

- water samples to compare from:  
2 or more surface water sources OR  
ground water and surface water OR  
rain or melted snow (soft water) and surface or ground water
- 100 mL graduated cylinder

### Interface Conductivity Testing

- Science Workshop Interface
- conductivity sensor

## LAB INSTRUCTIONS

1. Set up the interface by plugging the conductivity sensor into port A of the ANALOG CHANNELS.
2. Set up the computer so that it is ready to collect data for you. Start *Data Studio*, and select *Create Experiment*. The active window should be *Experiment Setup* showing a large interface with *Sensors* on the left. If *Experiment Setup* screen is not displayed, click on *Setup*. Click on the *colorimeter* icon and drag it to ANALOG port A since that is where the colorimeter should be plugged in on the interface box. Minimize the *Experiment Setup* window. Select *Digits* under *Displays* and drag it to *Conductivity* under *Data*. Conductivity will be displayed in uS/cm. Pull down the *Experiment* menu. Select *Sampling Options*, set *Automatic Stop* to 10 seconds then click OK.
3. Obtain a sample of the water to be tested. Measure 100 mL of the water into a beaker. Place the conductivity sensor in the beaker and click Start.
4. Record the conductivity reading with the run # and original source of the sample in a data table.
5. Repeat for each sample of water being tested.

## ASSIGNMENT

Record the conductivity of each sample in a data table with run # and source of sample. Analyse the results based on the reason for testing the conductivity of these samples.

# 5. TEMPERATURE

## **BACKGROUND INFORMATION – SCIENCE ACTIVITY**

Temperature has an affect on water quality because it alters the amount of oxygen that can be dissolved in the water, and can change the rate of some chemical and biochemical reactions. These factors are significant because many animals living in aquatic ecosystems are cold-blooded (poikilothermic) so their metabolic rate depends on the ambient water temperature.

Temperature should be measured whenever a test for dissolved oxygen is performed in an aquatic ecosystem. Dissolved oxygen can be tested using a Hach or La Motte kit and the values for dissolved oxygen can be correlated with temperature at each location.

The temperature of water can be affected when warmer water is added to the body of water. This process, called thermal pollution, occurs when enough water is put in to cause the temperature of the lake (or other body) to increase. The temperature of a water body will also increase if an increase in suspended material occurs. Such an increase could result from cattle having been allowed access to a water body, which could cause the bank to erode and siltation to increase.

Alternately this activity could be done with snow at different depths.

## **BACKGROUND INFORMATION – USE OF INTERFACE AND TEMPERATURE SENSOR**

Temperature can be measured in the lab with the interface and sensor connected to the computer. Students could use Data Studio Activity S03 as outlined below, or design and set up their own activity.

It would be preferable to have students measure temperatures of water samples in the field using the remote sensing capabilities of data logging with the interface and temperature sensor.

Four “AA” batteries must be installed in the interface so that it will run without the adapter. To remove batteries, use a small flat-bladed screwdriver. A PASPort Xplorer is a PASCO data collector designed for use in the field. It could be substituted for the science workshop interface used in the design of this activity.

If using the PASCO Science Workshop interface, then print the “Data Logging Checklist” to send with students into the field for reference. If using PASPort Xplorer data logging collector, then no set up ahead of time is required. Select Manual Sampling on the display, then press, start (▶), select (✓) and stop (▶) when each temperature is taken. Although no checklist is required, students need to record the order in which the samples were taken in the field.

## SCIENCE OBJECTIVES

1. To determine the temperature of water in the field at different locations in a body of water.
2. To correlate temperature and dissolved oxygen readings on water samples and compare these to the solubility curve for dissolved oxygen at different temperatures.
3. To observe land use practices, and attempt to relate these practices to temperature and dissolved oxygen levels of the water.

## TECHNOLOGY OBJECTIVES

1. To use an experiment in the Data Studio Library.
2. To remotely record a number of samples and retrieve that data for use in the classroom.
3. To create a graph showing how temperature changes at different locations in a natural water body.

## MATERIALS

### Experimental Set Up

- extendable pole or other method of accessing remote water locations
- duct or fiber tape
- dissolved oxygen test kit

### Interface Temperature Testing

- temperature sensor
- PASCO interface or PASPort Xplorer
- Pentium or greater IBM PC
- four AA batteries per science workshop interface or two for Xplorer

## TEACHER INSTRUCTIONS

### Pre-Lab Instructions to students:

1. Design an experiment by selecting up to eight locations in a flowing river (or other water body) for temperature readings. Students should base the testing locations on different land use practices at those locations.
2. Set up the computer software to data log if using an interface, or become familiar with use of PASPort Xplorer data storage.
3. Prepare a data recording sheet for the field. The sheet should include space to record the location for each trial, notes of field observations, dissolved oxygen readings and temperature measurements.
4. Determine the dissolved oxygen level at each location according to instructions in the dissolved oxygen kit.

## ASSIGNMENT

Assign activity as outlined under Student Lab Instructions and Assignment.

## EVALUATION

Skills should be evaluated as student's ability to collect temperature measurements on computers. Analysis can be evaluated by student's ability to map, graph and explain data as outlined in the assignment.

## STUDENT LAB INSTRUCTIONS

1. Plug temperature sensor into the Science Workshop interface which is connected to the computer. Turn the interface on, indicated by a green light. *Open Data Studio* on the computer. *Open Activity* from the *Library, Earth Science File*. Select activity *SO3 Stream Temp*. The temperature sensor does not need to be calibrated. However, if extremely accurate results are desired for correlation with dissolved oxygen, the sensor can be calibrated. To calibrate the sensor double click on the sensor in the *Setup* window, select *Calibration* and set the low level to 0 when the sensor has stabilized in ice water. Set the high level to 100 when the sensor has stabilized in boiling water.
2. Save the activity using *Save As Watertempstudentname*.
3. Command the program to collect data by remote sensing by clicking on *Logging*. Print the checklist.
4. Make sure the interface box has batteries. Disconnect the interface box from the computer and the power adapter cord but leave the interface turned on. The interface will go into sleep mode, which will be indicated by the LED flashing once every five seconds.
5. When ready to record temperature of water for the first sample, put the temperature sensor in the water making certain that the handle and cable are not immersed in the water. Control the depth at which the temperature is taken at each sampling location. Insert the sensor to the same level each time. This level could be marked with a permanent marker. Approximately 10 cm is recommended.
6. If using the Science Workshop interface, press the log button. Data is recorded as the LED blinks rapidly. Press the log button again to stop recording data. Repeat this procedure to record the next seven samples. If the buffer is full rapid blinking will not begin when the log button is pressed to start data recording.
7. If using PASPort Xplorer simply connect the temperature sensor to the hand-held interface, turn it on when ready to take a temperature reading, select manual sampling, press start (▶) check the temperature to be saved (✓) and press stop (▶).
8. Take temperatures at locations determined in experimental design from the pre-lab. As many as eight different locations could have been selected. Record the number of the run, location, dissolved oxygen and land use observations when each temperature reading is taken.

9. To download the field data reconnect the computer/interface cable and the power adapter plug leaving the power switch on. Open *Data Studio* on the computer. The runs taken in the field will be available from the *Sample* window.

## **ASSIGNMENT**

1. Create a map showing the temperature measurements at different locations in a water body and corresponding land use.
2. Plot temperature and dissolved oxygen as taken in the field, on a dissolved oxygen solubility graph.
3. Write a report to accompany the map and graph. In your report, explain what factors could have influenced water temperature at each location and why dissolved oxygen is above or below the amounts on the solubility curve.

# Biology 20 Laboratory Activities

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## 1. A MEASURE OF BIODIVERSITY

### **BACKGROUND INFORMATION – SCIENCE ACTIVITY**

The diversity of organisms in an ecosystem has an effect on the relative humidity and the temperature of an area.

### **BACKGROUND INFORMATION – USE OF INTERFACE AND TEMPERATURE SENSORS**

*Data Studio, Library file lab, MOS Relative Humidity* can be used as a basis for this lab activity. Set the activity up for data logging.

### **BIOLOGY OBJECTIVES**

1. To understand the definitions of species, biodiversity, temperature, relative humidity.
2. To count the number of plants of each type in a meter square plot. To develop an understanding of the use of the number of different kinds of plants as an indicator of biodiversity.
3. To relate the temperature and relative humidity in an area to its biodiversity.

### **TECHNOLOGY OBJECTIVES:**

1. To set up an interface that measures relative humidity to record every 30 minutes for a 24 hour period.
2. To use a relative humidity sensor.

### **MATERIALS**

#### **Experimental Set Up**

- outdoor study area
- metre square strings
- clipboard and pencil

#### **Interface Relative Humidity Testing**

- interface
- relative humidity sensor

## TEACHER INSTRUCTIONS

Discuss the effect of plants on temperature and relative humidity in natural and man-made environments by explaining that plants generally moderate temperature and increase relative humidity. Discuss the reasons for these effects. This investigation will determine whether it is the plant population or the diversity of plant species in an area that most effects temperature and relative humidity.

## LAB METHODS

1. Before going into the field students should set up an interface for data logging relative humidity as outlined in Student Lab Instructions.
2. Instruct students to select a location in your area for vegetation sampling and relative humidity recording.
3. Give each student 4 metres of string and 4 pegs. The pegs and string are placed on the ground to outline a square area that is 1 metre on each side.
4. Instruct students to determine the number of different plant species in the square metre. (They do not need to identify the species by name.) In addition students should count and record the number of individual plants for each species.
5. After returning to the lab students will reconnect the interface to the computer, start Data Studio, and download the data. This data will be reported to the class with the species diversity data.

## ASSIGNMENT

Compare the data collected by different groups of students from the class and determine if a correlation exists between biodiversity and relative humidity? Discuss this correlation.

How can a shelterbelt make its own micro-climate when planted around buildings?

## EVALUATION

Students' own square metre species data collection.

Students' ability to compare species information at different locations

## STUDENT LAB INSTRUCTIONS

### MATERIALS

#### Experimental Set Up

- select an outdoor study area
- strings to mark out square metre
- four pegs
- clipboard and pencil

#### Interface Relative Humidity Testing

- interface
- relative humidity sensor
- four AA batteries per interface
- extension cord (optional)

### VEGETATION SAMPLING METHODS

1. Select an area for sampling.
2. Mark the square metre area with string and pegs.
3. Count the number of individual species in your marked area, and count the number of plants for each species in your plot. Use the name of the species if you know it. If you do not know the species name, give the species a letter or number and collect a sample to bring back to the lab. Someone in the class may be able to identify it.

### INTERFACE LAB METHODS

1. Attach a relative humidity sensor to the interface in ANALOG A.
2. Make sure the interface has batteries for data logging.
3. Start *Data Studio*, select *Create Activity*. The Experiment window shows a large interface box. If not showing, click on Setup. Click on the Relative Humidity sensor and drag it to ANALOG A. Double click on the icon, under the General tab, set sampling rate to slow then change it to 60 seconds to take samples once every minute. If the time for sampling is very long, have the sampling taken less frequently. Click *Options*, select *Delayed Start*, check *none*, select *Automatic Stop*, check *none* and OK to exit and save selections.
4. Save activity as *relativehumiditystudentnames*.
5. Select *Logging*.
6. Disconnect the interface from the computer and from the power source. The LED blinks once every 5 seconds to indicate that it is asleep.
7. In the field, place the interface with two temperature sensors in the centre of the metre square plot. Press the log button and leave the interface running to collect data. The LED will blink rapidly. Note that an extension cord and the adapter could be used to avoid running out of battery power.

8. When data recording is complete, press the log button again to stop recording. Return to the lab and reconnect the interface to the computer to download data. Click *Connect*.
9. Determine the relative humidity of the area over the sampling period and report it to the class with information on the number of different plant species and the number of plants in each species.

## **ASSIGNMENT**

Report the number of species and the number of plants in each species to the class along with this relative humidity of the area sampled. Compare class data. Does there appear to be a correlation between biodiversity and relative humidity?

## 2. EFFECTS OF FERTILIZER ON ALGAL GROWTH

### BACKGROUND INFORMATION – SCIENCE ACTIVITY

Algae grow in most pond water. The addition of fertilizer to the pond water can cause an increase in algal growth because of the increase in plant nutrients. However, too high a level of fertilizer nutrients may “burn” the algae, and actually kill it. Current agricultural practices include the addition of fertilizers to the land in inorganic (mineral fertilizers) or organic (compost or manure) forms. When these fertilizers wash off or leach from the land into surrounding aquatic ecosystems, this run-off frequently causes an overgrowth of algae in the ecosystem.

### BACKGROUND INFORMATION – USE OF INTERFACE AND LIGHT SENSOR

A water sample with more algae will allow less light to be transmitted through it. One way to measure the amount of algae grown in a water sample is by measuring the decrease in light transmission in a water sample.

### SCIENCE OBJECTIVES

1. To recognize the interconnectedness of agriculture practices and the environment
2. To measure the effect of increasing amounts of fertilizer on plant growth in water.
3. To design a controlled experiment.

### TECHNOLOGY OBJECTIVES

1. To use a light sensor.
2. To calibrate a light sensor.

### MATERIALS

#### Experimental Set up

- pond water
- liquid fertilizer
- grow lights
- 100 mL beakers

### **Interface Clarity Testing**

- light sensor
- interface
- light blocking tube - to be placed over the sample: with 2 holes, directly across from one another at the same height, one hole for the pen light and the other for the light sensor
- pen light

## **TEACHER INSTRUCTIONS**

Review and discuss the effect of fertilizer on plant growth. Speculate about possible effects that fertilizer may have on plant growth in an aquatic ecosystem.

Instruct students to design a controlled experiment with pond water and fertilizer to determine the effect of fertilizer on algal growth. The measurement of algal growth should be determined by measuring the transmission of light through the sample with a light sensor.

Explain to students that a light meter measures the transmission of light through a sample. A blank sample is used to calibrate the meter. The blank is distilled water in the same type of vessel that the test samples will be measured in. The test samples (because they contain algae) block some light and therefore transmit a lower percentage of the light. As the amount of algae growing in a sample increases, the amount of light blocked will increase as well. The increase in blocked light means that the amount of light transmitted will be decreased.

## **LAB METHODS**

Place equal volumes of pond water in the testing vessels that will be used throughout the experiment. Add varying amounts of liquid fertilizer to each test tube. Maintain a control sample that has no fertilizer added to it. Cover each tube with plastic wrap and place it under grow lights. Examine the tubes after three weeks.

## **ASSIGNMENT**

Write a full lab report paying special attention to lab design with controls in methods section. Record your results in a data table. The results include the mean light transmission and the amount of fertilizer added for each sample set up. Illustrate the results by plotting the data on appropriate graphs. Annotations can be added to the graph by clicking the A at the top of the graph screen.

## **EVALUATION**

Lab report with data table and graph. Other means of students demonstrating the knowledge they have gained by doing this activity should also be considered. Data and interpretations could be placed on student or class web sites. Other alternatives include poster displays of the activity results and power point presentations to display the results to the class. Teachers are encouraged to think about alternative ways of helping students to display what they have learned in an activity.

## STUDENT LAB INSTRUCTIONS

This investigation is intended to determine the effect of fertilizers on plant growth. In this activity you will be simulating the effect that run-off from agricultural activity has on the growth of algae in an aquatic ecosystem.

### MATERIALS

#### Experimental Set up

- pond water
- liquid fertilizer
- grow lights
- 100 mL beakers

#### Interface Clarity Testing

- light sensor
- interface
- light blocking tube
- pen light

### LAB METHODS

#### Experimental Set Up

1. Place equal volumes of your samples of pond water in 100 mL beakers.
2. Add increasing amounts of liquid fertilizer to the test beakers. Record the number of drops of fertilizer added to each beaker. Remember to maintain one beaker with no fertilizer added as a control against which to compare the test beakers.
3. Securely cover the beakers with plastic wrap to prevent evaporation of water.
4. Place the covered beakers under grow lights for approximately three weeks.

#### Measuring Growth using the Interface System

1. Connect the light meter to the Science Workshop Interface in ANALOG port A.
2. Start *Data Studio, Open Activity* in the *Library, Earth Science* folder, activity *S04 Clarity*.
3. Place a 100 mL beaker of distilled water inside the light blocking tube, insert the light sensor into one side and the pen light into the other.
4. Open the *Experiment Set Up* window, double click on the light sensor to calibrate. Turn on the pen light so that its beam of light will shine through the beaker of distilled water and be picked up by the light sensor. Type in *100%* for the maximum reading and click on *Take Reading, OK* and close this screen.
5. Replace the distilled water with a beaker from the experimental set up. Click Start and record the clarity for that sample. Be sure to measure your control beaker as well. Be sure to note how much fertilizer was added to that sample in your data table.
6. Repeat the measuring process for each experimental sample.

## **ASSIGNMENT**

Write a lab report that includes a data table of fertilizer treatment and clarity to support a graph of the same data. Describe the data table and graph to show the interconnections between the clarity and fertilizer amount. Identify the dependent variable and independent variable in the purpose and use these in the “if then” statement in the hypothesis to establish cause and effect. In the method section of the report show how all variables were controlled in the experimental set up, except the variable being tested.

# 3. PHOTOSYNTHESIS AND PRESSURE

## BACKGROUND INFORMATION – SCIENCE ACTIVITY

Algae undergoes photosynthesis when exposed to light and releases oxygen into the water as a result of the process. Cellular respiration will take place at the same time within the algae but this process will not consume as much oxygen as is produced by photosynthesis. Carbon dioxide is part of both processes but because it is more soluble in water than oxygen, will not affect the pressure that is measured in this activity.

The amount of algae in an aquatic ecosystem increases with addition of fertilizer up to a certain concentration of nutrients. However, at higher concentrations the fertilizer nutrient can be at such a high level that it actually kills algae. This limit is similar to spilling fertilizer on lawn, which kills the lawn where piles of fertilizer land.

Algae may die in the water after a period of time. When algae die, decomposer organisms act on the algae and use up the oxygen in the water. When decomposition occurs, the process will be observed as a reduction in measured pressure.

## BACKGROUND INFORMATION – USE OF INTERFACE AND PRESSURE SENSOR

Insert the connector attached to plastic tubing and the pressure sensor into a one-hole rubber stopper that has been lubricated with glycerine.

A small amount of sodium bicarbonate can be added to the pond water to produce carbon dioxide which will support photosynthesis.

The pressure sensor does not need to be calibrated.

## SCIENCE OBJECTIVES

1. To write the chemical equation for photosynthesis showing that oxygen is produced and carbon dioxide is consumed.
2. To recognize that algal growth depends on the levels of nutrients in an aquatic ecosystem.

## TECHNOLOGY OBJECTIVES

1. To use a pressure sensor to measure relative pressure in similar samples of pond water.

## **MATERIALS**

### **Experimental Set Up**

- sample of pond water
- fertilizer
- test tubes
- rubber stoppers

### **Interface Pressure Testing**

- one-hole rubber stoppers
- interface
- pressure sensor
- glycerine
- sodium bicarbonate

## **TEACHER INSTRUCTIONS**

1. Review the word and symbol equations for photosynthesis.
2. Relate algal growth to the availability of nutrients in the form of fertilizers.
3. Explain that manure is a natural fertilizer.
4. Have students predict what will happen with increasing amounts of fertilizer in an aquatic ecosystem.
5. Prepare a stock solution of fertilizer following package instructions for regular feeding of indoor plants.
6. Have students set up pond water test tubes with a control for each test and increasing amounts of fertilizer in each set, as outlined in lab methods on Student Lab Instructions sheet.
7. The sealed test tubes will need to be in light for a week.
8. Allow one class period for students to measure the pressure produced by the photosynthesizing algae, using a pressure sensor and write a lab report.
9. Gather class data of mean pressures for each of the six test tubes. Have the students display their data and calculate the average for the class data.

## **ASSIGNMENT**

Write a lab report including data and graphs from the computer program.

Answer the following questions at the end of the lab report.

Consider alternative ways of having students demonstrate their understanding of the activity. For example, Web pages could be created to show the results of this testing and the other water quality activities that are done.

## **EVALUATION**

Lab report and answers to questions.

## STUDENT LAB INSTRUCTIONS

Set up a controlled experiment to investigate the effect of fertilizers on algal growth.

### MATERIALS

#### Experimental Set Up

- pond water
- fertilizer
- test tubes
- rubber stoppers
- sodium bicarbonate
- metric measuring spoons (0.6 mL)
- beaker of water

#### Interface Pressure Testing

- one-hole rubber stoppers
- computer interface
- pressure sensor
- glycerine
- ring stand
- burette clamp
- light source

### LAB METHODS

1. Prepare test solutions of pond (algae) water and fertilizer. Because pressure needs to be measured and compared later, the volumes must be the same to start. Each test tube will have 20 mL of liquid. Each experimental tube will have a control. An example is as follows:
  - (a) 19 mL pond water + 1 mL fertilizer water, control 20 mL pond water
  - (b) 18 mL pond water + 2 mL fertilizer water, control 20 mL pond water
  - (c) 17 mL pond water + 3 mL fertilizer water, control 20 mL pond water
2. Put rubber stoppers in each test tube and place them in the light for a week.
3. On the day of the testing, set up computer, interface and pressure sensor with a one-hole rubber stopper the same size as the stoppers in the test tubes. Open activity *B08 Rate of Photosynthesis* from the *Biology* folder in the *Data Studio Library*. Adjust the sampling time to stop at 5 minutes.
4. Place the test tube to be measured in a burette clamp on a ring stand, behind a beaker of water which will filter heat from the light source used to initiate photosynthesis in the pond water sample. Add 0.6 mL of solid sodium bicarbonate to a test tube. Insert the stopper. Click *Start* to begin recording pressure, turn on the light bulb, and continue to record pressure for 5 minutes. Note the *Run #* for each sample.
5. Repeat step 4 for each of the six test tubes.
6. Compare pressures by putting all six sets of data on one graph. Display maximum, minimum and mean pressures on the graph by selecting the

summation sign. Note the experimental set up for each run on the graph as well.

7. Print summarized data tables and the one graph and include in the lab report.

## **ASSIGNMENT**

Write a lab report including data and graphs from the computer program. Answer the following questions at the end of the lab report.

1. Identify the dependent and independent variables in this experiment.
2. Did the mean pressure increase with increasing amounts of fertilizer in your experiment? Support your answer with numerical evidence.
3. Did the mean pressure increase with increasing amounts of fertilizer according to the class average? Support your answer with class average data.
4. Why did the pressure increase and what role does the sodium bicarbonate play?

# 4. POPULATIONS OF YEAST

## BACKGROUND INFORMATION – SCIENCE ACTIVITY

Population trends can be studied using microscopic organisms such as yeast. Yeast populations are dependant upon the amount of food (sugar) they have to consume, and the length of time in which they are allowed to grow. Yeast reproduce by budding, a process that can be seen using a microscope. Yeast cells can be counted using high power on the microscope. In a test tube (or cuvette) yeast are a closed population, the only factors that will affect population growth are natality and mortality.

The number of yeast cells per millilitre of solution can be determined using a microscope. To calculate the number of cells per millilitre of solution, the first step is to determine the size of the high power field of view, which is usually 0.4 mm. The size is used to calculate volume of solution with depth. The depth from the slide to the cover slip is 0.1 mm. Volume is calculated using  $v=\pi r^2d$

$$\begin{aligned}\text{Volume} &= \pi (0.2 \text{ mm})^2 \times 0.1 \text{ mm} \\ &= 0.012 \text{ mm}^3 \\ &= 1.2 \times 10^{-5} \text{ mL} (1000 \text{ mm}^3 = 1.0 \text{ mL})\end{aligned}$$

Students visually count the number of yeast cells in the high power field of view. The concentration of yeast is calculated by dividing the number by the volume:

$$\text{Concentration of yeast} = N / 1.25 \times 10^{-5} \text{ mL}$$

Absorbance of each sample can be determined using the Science Workshop interface system and a colorimeter. Beer's Law states that the absorbance of light by a solution has a linear relationship (directly proportional to) to the concentration of a substance in the solution. A Beer's Law standard curve can be created by plotting absorbance vs. concentration. Once drawn, this curve can be used to determine the population of any sample of yeast by reading the absorbance on one axis and the population on the other.

## BACKGROUND INFORMATION – USE OF INTERFACE AND COLORIMETER SENSOR

After starting Data Studio, select Create an Activity. In the Set Up window drag the colorimeter to the ANALOG port on the interface that corresponds to the port the colorimeter is plugged into on the interface box. Double click on colorimeter to open it. Calibrate the colorimeter by turning it on and reading a blank of distilled water.

**To calibrate the colorimeter:**

Fill a cuvette with distilled water, dry the outside with soft paper towel if necessary.

Place cuvette in the colorimeter

Hold down select and start buttons on the colorimeter at the same time.

When prompted, select 630 nm (orange) light.

Press start.

**To calibrate the computer:**

In the colorimeter calibration window on the computer, enter 100 in the second box under *High Point*, this will set transmittance @ 100 for the distilled water blank.

Click on *Take Reading* at the bottom of the high point column.

When stabilized @ 100 click *OK*. You will exit the setup window.

Stop the colorimeter by pressing the stop button.

In the experiment window, drag the digit icon from *Displays* to the absorbency in *Data* to record a reading in absorbency.

The cuvettes that come with the colorimeter can be used to set up this experiment. Because increasing populations of yeast block more light or change the amount of light that can get through the test tube, the colorimeter will pick up varying quantitative data with varying yeast populations. The data logger could be used to record data over an extended time period, or the samples could be tested daily for a set number of days.

A colorimeter projects light from an LED through a cuvette. The light that can get through the cuvette strikes a photocell and the computer interface records the percent transmittance. In this investigation, light is absorbed by yeast cells. According to Beer's Law, the greater the concentration of yeast cells the more light will be absorbed.

Students should save their findings under a file name such as *populationstudentnames*.

**BIOLOGY OBJECTIVES**

1. To develop a Beer's Law Standard Curve for a yeast population.
2. To measure the population of a closed sample of yeast as a function of time.
3. To graph a yeast vs. population curve by plotting the number of yeast cells vs. time.

4. To recognize that amount of food can be a limiting factor in a population.
5. To propose reasons other than food supply for the changes in population.

## **TECHNOLOGY OBJECTIVES**

1. To correlate concentration of a solution (population) with absorbance.
2. To use a colorimeter to measure population, once the Beer's Law Standard Curve is established.
3. To compare yeast populations at different times

## **MATERIALS**

### **Experimental Set Up**

- yeast
- peptone
- dextrose
- distilled water

### **Interface Concentration Testing**

- colorimeter
- interface

## **TEACHER INSTRUCTIONS**

1. Discuss classification of yeast and how it reproduces by budding.
2. Discuss limiting factors in population growth emphasizing the availability of food and the problems with build up of wastes.
3. Instruct students on methods used to determine population of a sample using a microscope on high power, counting the number of yeast cells and calculating concentration (see Background).
4. Instruct students on methods used to calibrate the colorimeter and take readings with the colorimeter. A second option is to calibrate the colorimeter before students begin work on the lab.
5. Explain to students how to construct a Beer's Law Standard Curve and why one is used in this lab to determine yeast populations (see Background).

## **LAB METHODS**

1. Prepare enough Sabaraud culture Medium for use by all lab groups using the following amounts: 100 mL distilled water, 1 g peptone, and 4 g dextrose. Heat and stir to dissolve. Boil or microwave to sterilize the solution.
2. Prepare a yeast suspension using 4 g of dry yeast in 100 mL of Sabaraud Culture Medium.
3. Follow procedures outlined in Student Lab Instructions.

## ASSIGNMENT

Lab Report with analysis and discussion of data.

## EVALUATION

Lab report including graph and analysis.

## STUDENT LAB INSTRUCTIONS

Using a colorimeter and Beer's Law you will determine the change in yeast population growth over a period of time.

## MATERIALS

### Experimental Set Up

- yeast suspension
- 5 test tubes
- 10 mL graduated cylinder
- distilled water
- microscope, slide and cover slip
- capillary tube
- calibrated pipette

### Interface Concentration Testing

- colorimeter
- interface

## LAB METHODS

### Procedure A: Establishing Standard Curve

1. Measure 10 mL of sterilized Sabouraud culture medium and place in a test tube. Add two drops of yeast suspension. Stir gently with a glass stirring rod to ensure even distribution of cells.
2. Using a capillary tube transfer two drops of this yeast mixture to a microscope slide and cover with a cover slip.
3. Examine the yeast cells under high power and look for signs of budding. Count the number of cells in one high power field of view in four different locations on the slide.
4. Calculate the average number of cells in a high power field of view from the four counts made. Convert this number to yeast per mL using the following protocol.

### Determining Yeast Cells per mL of Solution Using a Microscope

First determine the size of the high power field of view, it is usually 0.4 mm.

The size is used to calculate volume of solution, with depth.

The depth from the slide to the cover slip is 0.1 mm.

Volume is calculated using  $v = \pi r^2 d$

$$\begin{aligned}\text{Volume} &= 3.14 (0.2 \text{ mm})^2 \times 0.1 \text{ mm} \\ &= 0.0125 \text{ mm}^3\end{aligned}$$

$$\text{Conversion from mm}^3 \text{ to mL} = 1.25 \times 10^{-5} \text{ mL}$$

The concentration of yeast is calculated by dividing the average number of cells in the high power field of view, by the volume.

$$\text{Concentration} = N / 1.25 \times 10^{-5} \text{ mL}$$

- Using a sterile pipette, transfer 4 mL of the yeast suspension from the test tube to a cuvette.
- Prepare the colorimeter and computer to take readings according to instructions from the teacher.
- Insert the cuvette in the colorimeter and take an absorbency reading for the sample. Turn on and Start the colorimeter. *Start* the software on the computer. *Stop* the computer reading when the digital display stabilizes. Record this reading with the average number of yeast per mL. In step 4. The point will be plotted on the Beer's Law Standard Curve later. Return the yeast suspension to the test tube. Rinse the cuvette with distilled water and dry with a soft towel or tissue.
- Repeat steps 3 to 7 with four dilutions of the suspension from your test tube. Make 1:2, 1:4, 1:8 and 1:16 dilutions by combining 1 mL of suspension with 2, 4, 6, 8 and 16 mL of distilled water in four separate test tubes.
- Prepare a graph with population of yeast per mL plotted against % Absorbance. Plot the points and draw a best-fit line, extrapolate by extending the line slightly above and below the data points. The resulting graph is a Beer's Law Standard curve.

### Procedure B: Estimating a Population

- Put 4 mL of yeast suspension in a cuvette. Place the cuvette in the colorimeter.
- On the computer, select Setup. Double click on the colorimeter icon, under the General tab, select slow and type 300 in the box to command the computer to take readings every 5 minutes.
- Return to the experiment window and drag Table from Displays to Absorbance in Data to generate a table of data that can be printed later.
- Click on Start. The computer will run, taking readings, until you stop it.
- Print the data table generated.

6. Using the Beer's Law Graph, determine the population for the absorbance readings and record these numbers beside their corresponding absorbance readings.
7. Calculate the times in minutes and record these times beside the times in seconds on the data table.
8. Create a population curve by graphing population vs. time (minutes).

## **ASSIGNMENT**

Write a full lab report with data tables inserted in the observations section and graphs in analysis. Answer the following questions after the Conclusion.

### **Questions:**

1. How did the yeast population change over time? What were the causes of these changes in yeast population?
2. Would you consider the population growth over time to be exponential? Explain.
3. What factors, if any, limited this population growth?
4. Is human population controlled by the same limiting factors? Explain.
5. How would increasing the food supply of the yeast affect the population curve? Explain.
6. Why is increasing the food production only a temporary solution to the human overpopulation problem?

# 5. MEASURING ORGANIC MATTER IN SOIL SAMPLES

## BACKGROUND INFORMATION – SCIENCE ACTIVITY

Living organisms contain catalase, an enzyme that breaks down hydrogen peroxide to form water and oxygen. Even after death some catalase remains in the cells. The oxygen that is produced by the enzyme facilitated breakdown of hydrogen peroxide builds up in a closed system and creates pressure. This pressure is directly proportional to the amount of living materials in the soil.



It is important for students to analyze soil samples because soil is responsible for the productivity of plants. Good soil is loam, which is composed of 40% silt, 40% sand and 20% clay. Loam is porous enough to allow water to pass through leaving ample air spaces for oxygen absorption by roots. Loam has enough clay to hold moisture and make it available to roots as needed. Most soils labs instruct students in methods of feeling soil with their hands and interpreting the soil as predominantly clay, sand or silt. Soil analysis involves testing soil samples for nitrogen (N), phosphorus (P), potassium (K) and pH and usually use a soil test kit such as those produced by LaMotte. Good soil has a high level of organic matter, which is very difficult to test for. This lab allows us to test for organic matter in soil.

## BACKGROUND INFORMATION – USE OF INTERFACE AND PRESSURE SENSOR

The pressure sensor records the amount of oxygen given off by each soil sample. Oxygen is produced by enzymes in biotic material in the soil sample. We can use the pressure measurements as a direct indication of the amount of organic matter in each soil sample.

## BIOLOGY OBJECTIVES

1. To compare the amount of organic matter in different soil samples.
2. To correlate the amount of organic matter with:
  - (a) land use in the area the soil was taken from, and
  - (b) the level of the soil profile from which the sample was taken.
3. To relate amount of organic matter in the soil to soil nutrients.

## TECHNOLOGY OBJECTIVES

1. To use a pressure sensor in this activity.
2. To set up the apparatus to collect oxygen without allowing any oxygen to escape.

## **MATERIALS**

### **Experimental Set Up – Soil Collection**

- soil bore or hand spade
- collecting bag or pail
- labels for soil samples
- sand

### **Interface Pressure Testing**

- pressure sensor
- interface
- 3% hydrogen peroxide
- distilled water
- 100 mL graduated cylinder
- 250 mL Erlenmeyer Flask
- electronic balance

## **TEACHER INSTRUCTIONS**

Before the activity, describe the different living things found in soil and speculate about which soils would have the most decomposers. This lab can be combined with a lab that measures texture, nitrogen, phosphorus and potassium as well as colour, pH and porosity of soil samples. If a complete soil analysis is being done, then instruct students how to test soil for texture, porosity and nutrient content.

Have students determine the amount of organic matter in different soils by completing the interface activity outlined under Student Lab Instructions. The amount of pressure each soil sample produces should be measured and compared with others. The soils generating the most pressure normally have the most organic matter.

Comparisons could be made between similar soils from areas with different farming practices, different land use practices, or different layers of soil in the same soil profile. Any of these samples can be compared with sand, which can be considered a control because it is not likely to have very much organic matter in it.

## **ASSIGNMENT**

Students write a lab report as outlined under Student Lab Instructions. Each group can print a graph of their data for the report. Lab reports can be submitted for a group or individually at the discretion of the teacher.

## **EVALUATION**

Submitted lab report or some other product that shows students have understood the concepts and ideas presented in this activity.

## STUDENT LAB INSTRUCTIONS

In this experiment soil samples are tested for amount of living materials and compared. The amount of living material in soil can be determined with a pressure sensor because all living material contains catalase, which is an enzyme that can break down hydrogen peroxide producing water and oxygen gas. The oxygen gas builds up and creates pressure that can be measured by the pressure sensor.

### MATERIALS

#### Experimental Set Up – Soil Collection

- soil bore or hand spade
- collecting bag or pail
- label soil samples from different areas depending on the purpose of the investigation
- sand

#### Interface Pressure Testing

- pressure sensor
- interface
- 3% hydrogen peroxide
- distilled water
- 100 mL graduated cylinder
- 250 mL Erlenmeyer Flask
- electronic balance

### LAB METHODS

1. Collect a variety of soil samples being careful to record the land use and other anecdotal information about the area from which the samples are taken.
2. Set up the interface system by attaching the pressure sensor to the interface box in port A. Start *Data Studio*, Select *Open Activity*. Open *Library* folder, *Earth Science* activities, *M10 Test for Life*. The pressure sensor is ready to go. It does not need to be calibrated.
3. Prepare a data table to record observations. Include three columns, one for the sample locations, one for run #, and one for pressure (Kpa).
4. Using an electronic balance, measure 5.0 g of each soil sample.
5. Put the sample to be tested in a 250 mL flask.
6. Prepare dilute hydrogen peroxide by combining 25 mL of 3% hydrogen peroxide with 75 mL of distilled water. Add 100 mL of dilute hydrogen peroxide to the flask and soil sample.
7. Insert stopper. Click *Start* on the screen. Swirl flask gently to insure contact of the hydrogen peroxide with all organic matter. Hold the stopper on because pressure from the released oxygen may push the stopper out.
8. Record the pressure with the sample location and Run # in a data table.
9. Repeat steps 5 to 8 for each of the samples to be tested.
10. *Save as soilstudentnames*

11. Compare samples from different locations by dragging the Run # to the graph. Note the sample location for each run number on the graph. Display maximum, minimum and mean pressure for each run on the graph.
12. Print at least one copy of the graph to hand in with the lab report(s).

## **ASSIGNMENT**

Write a lab report that compares pressures and farming practice, land use or soil profile depending on purpose of the lab. The graph created in Data Studio should be printed and included as part of the observations section of the lab report.

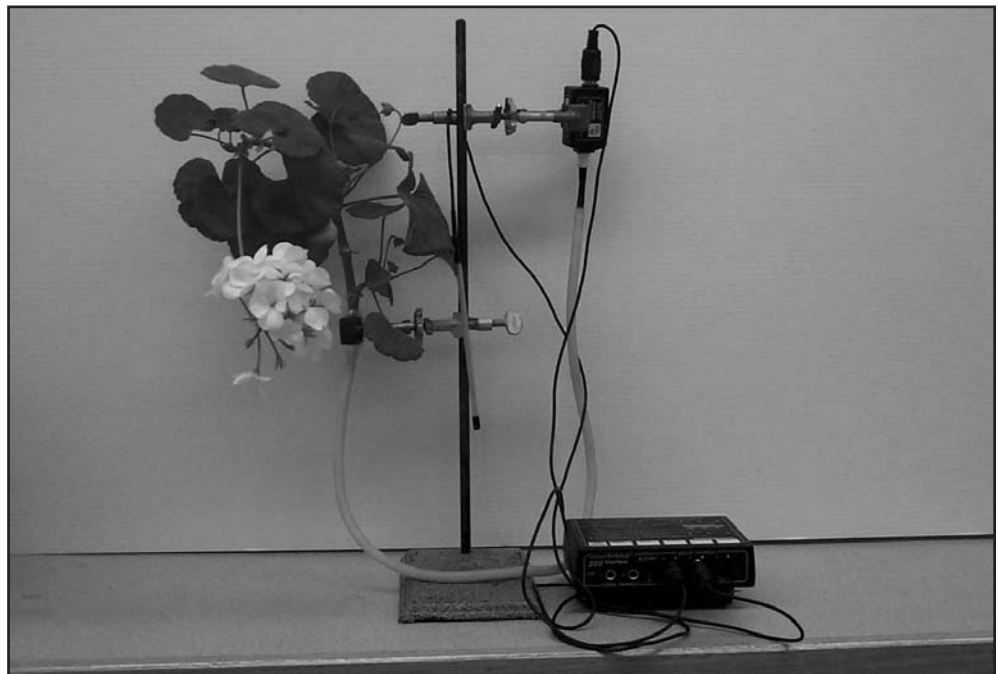
## 6. SUPPORTING THE TRANSPIRATION COHESION THEORY

### BACKGROUND INFORMATION – SCIENCE ACTIVITY

The Transpiration Cohesion Theory explains how plants move water from their roots and up their stem by physical means without employing any physical pumping mechanism. Plants use xylem tissue to bring water and nutrients from their roots to their leaves. This water can be used for either photosynthesis or to transport dissolved nutrients within the plant. Waste water escapes through the leaves of the plant in a process called transpiration. As each water molecule transpires from the leaf, it exerts a pulling force on the next molecule in the system. The exerted force is due to the force of cohesion, which is the tendency of water molecules to attract each other. Inside the walls of xylem tissue, water molecules use forces of adhesion to ascend the stems to the leaves. The force of adhesion is the tendency for water molecules to be attracted to other materials. Plants use and release of water available to them supports the Transpiration Cohesion Theory.

### BACKGROUND INFORMATION – USE OF INTERFACE AND PRESSURE SENSOR

A pressure sensor can be used to indicate that water has left a closed system because as water volume decreases, the pressure decreases. The water will be used by a plant initially to replace water lost when the plant sample is being manipulated. Once the turgor pressure in the leaves of the plant has stabilized, the plant has all the water its cells can absorb. Subsequent water lost by the closed system must be leaving the plant through transpiration out the stomata of the leaves.



## **BIOLOGY OBJECTIVES**

1. To explain the Transpiration Cohesion Theory as a means of transporting solutions in plants.

## **TECHNOLOGY OBJECTIVES**

1. To illustrate that water is lost from the leaves of a plant (transpired) using a pressure sensor.

## **MATERIALS**

### **Experimental Set Up**

- plant cutting with 5 or 6 leaves
- glycerine
- vaseline
- scalpel
- surgical rubber tubing
- ring stand
- two clamps

### **Interface Pressure Testing**

- interface
- quick release connector
- short length of small diameter tubing
- pressure sensor (absolute)

## **TEACHER INSTRUCTIONS**

This lab could be set up as a demonstration used by a group of students as a science project. As a demonstration, the teacher would set up the plant cutting in the apparatus prior to class. To set up the demonstration see Student Lab Instructions. As a project, the conditions for the set-up could be varied and the amounts of transpiration compared from one set-up to another. The initial set-up should follow that outlined in Student Lab Instructions. Suggestions for changing conditions are listed.

## **ASSIGNMENT**

Students should compare the differences in the initial pressure to the final pressure. They should attempt to explain why a drop in pressure occurred over the time tested. If done as a demonstration, students could also propose other conditions for the plant cutting and predict whether the change in pressure would be greater or less.

## EVALUATION

Written report of pressure change, explanation and predictions handed in and marked by the teacher. Other student products that demonstrate students have learned the concepts examined in the activity.

## STUDENT LAB INSTRUCTIONS

These instructions are for using a large cutting from a geranium plant. The geranium plant is used because it has a very sturdy stem which can withstand cutting and forcing into surgical tubing. Also, the large leaves of a geranium give off more moisture than smaller leaves would so a more significant pressure change can be observed.

## MATERIALS

### Experimental Set Up

- plant cutting with 5 or 6 leaves
- glycerine
- Vaseline
- scalpel
- surgical rubber tubing
- ring stand
- two clamps

### Interface Pressure Testing

- interface
- quick release connector
- large connector
- short length of small diameter tubing
- pressure sensor (absolute)

## LAB METHODS

1. Put the pressure sensor in one clamp attached to the ring stand. Undo the quick release connector so that you can work with the connector and the tubing without risk of getting the pressure sensor wet. The apparatus is shown in the picture under Background Information.
2. Put glycerine on the connector and insert it into the small diameter rubber tubing.
3. Use a larger connector with glycerine on it to connect the small diameter tubing to the surgical tubing.
4. Connect the quick release to the pressure sensor.
5. Fill the surgical tubing with water but do not allow it to go into the small diameter tubing because such a step would put the water too close to the pressure sensor.
6. The cutting used in this activity should have at least five or six large leaves. Cut the stem of the cutting at a 45° angle. Place a large ring of vaseline around the stem about 2 cm from the cut end.

7. Use a pipette to fill the tube level full with water.
8. Insert the stem and seal with vaseline.
9. Wrap the joint between the stem and the rubber tubing with plastic wrap making it thick enough to be held by the clamp without the plant tissue being damaged.
10. Place the plant in the second clamp.
11. Connect the pressure sensor to the interface in Analog Port A.
12. Start *Data Studio*, Select *Create an Experiment*. In the *Experiment Setup* window drag the *Pressure Sensor (Absolute)* to Analog Port A. The pressure sensor does not need to be calibrated. Under *Sensor Properties* select *General* and change the sampling rate. Select *slow*, which changes the units to seconds. Set the sample rate to 60 seconds. Close these windows.
13. Display digits and graph. Double click on the x axis. Change the display to 3600 seconds to show the pressure change over one hour. Click start and begin recording pressure. You have not set a stop condition. You will have to stop the run when you have gathered enough data. You could let it run for a very long time, six hours, 24 hours or longer. However, you can't let the plant run out of water.

# Biology 30 Laboratory Activities

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## 1. QUANTITATIVE CATALASE ACTIVITY

### **BACKGROUND INFORMATION – SCIENCE ACTIVITY**

Catalase is an enzyme found in all living things. Its function is to breakdown hydrogen peroxide ( $\text{H}_2\text{O}_2$ ), which is toxic to living cells, into water ( $\text{H}_2\text{O}$ ) and ( $\text{O}_2$ ). Catalase is concentrated in liver tissue (of organisms that have a liver) because a major function of this organ is to detoxify substances in the blood or remove toxic substances from circulation. Fresh liver will provide the greatest concentrations of catalase; however, frozen liver samples normally have sufficient catalase for this experiment.

### **BACKGROUND INFORMATION – USE OF INTERFACE AND PRESSURE SENSOR**

The pressure sensor is used to detect oxygen produced as an end product of this enzymatic reaction. The pressure sensor does not need to be calibrated. In the lab, each numeric reading is compared to the others. A large stopper for a flask needs to be fitted on the end of the tubing to the pressure sensor. Students record maximum and minimum pressure because sometimes the stopper pops off causing a dip in pressure.

### **BIOLOGY OBJECTIVES**

1. To recognize that enzymes catalyze chemical reactions in living systems.
2. To write a word equation for the breakdown of hydrogen peroxide in the presence of catalase, identifying enzyme, substrate and end products of the reaction.
3. To identify the most ideal conditions for enzymatic function.
4. To compile a data table comparing pressure results as a function of the conditions under which catalase was functioning.
5. To use Data Studio software to graph the curves of enzymatic action on the same graph.
6. To perform an experiment showing cause and effect with controls and variables.
7. To submit a report or other product to demonstrate that they have learned the objectives of this experiment.

## TECHNOLOGY OBJECTIVES

1. To use interface and pressure sensor to determine the amount of gas pressure produced by an enzymatic reaction in a flask.
2. To use Data Studio software to create a data table of results.
3. To generate a graph of all data.
4. To insert the data table and graph into a Word document, the lab report.

## MATERIALS

### Experimental Set Up

- liver
- distilled water
- 3% hydrogen peroxide
- 1M hydrochloric acid (HCl)
- 1M sodium hydroxide (NaOH)
- sodium fluoride (solid)
- hot water bath
- ice water bath
- 100 mL graduated cylinder
- 10 mL graduated cylinder
- 2 mL pipette
- blender (one per class)
- hot plate (one per class)
- balance (one per class)

### Interface Pressure Testing

- interface
- pressure sensor (one per group of 4)
- 250 mL flask
- one hole stopper for flask
- Data Studio software

## TEACHER INSTRUCTIONS

1. Insert connectors in rubber tubing and one-hole stopper using glycerine to have sensors ready for student use.
2. Prepare the liver extract:
  - (a) For a piece of liver approximately 3cm x 3cm x 2cm (about 15 mL) use 100 mL of distilled water. These amounts will produce enough extract for two computer stations. Adjust quantities as necessary.
  - (b) Put water and liver in a blender. Blend until liquefied, usually three, 10 second bursts.
  - (c) Filter the blended liver and water through a fine mesh sieve or cheese cloth. The filtrate will be used by students in this experiment.
3. Prepare chilled extract by putting at least 2 mL per group in a small beaker in the lab fridge or an ice bath. Students will need to keep the extract cool during the experiment so ice should be available to them and a container in which the flask can be immersed in ice water to the level of the contents.

4. Prepare heated extract by immersing a small beaker or test tube of extract in a boiling water bath. A small test tube of heated extract per lab group facilitates students' access to the heated extract. Because the extract solidifies when heated, students should use a small lab measuring spoon to take out 2 mL.
5. Prepare 1M HCl by diluting 90 mL of concentrated HCl to 1.0 litre of solution. The teacher should make this solution prior to the lab activity.
6. Prepare 1M NaOH by dissolving 40 g of NaOH (solid) to make 1.0 litre of solution. The teacher should make this solution prior to the lab activity.
7. Each lab group will need 600 mL of dilute hydrogen peroxide solution. 100 mL of dilute hydrogen peroxide is prepared by combining 15 mL of 3% H<sub>2</sub>O<sub>2</sub> with 85 mL distilled water. Groups can make this solution for themselves or the teacher might make enough for all lab groups ahead of time.

Safety Note: Students may choose by mistake to experiment with undiluted 3% H<sub>2</sub>O<sub>2</sub>, which produces so much pressure that glassware could explode. Supplying only enough of the already diluted hydrogen peroxide reduces the risk of inquiring minds causing a safety hazard.

## ASSIGNMENT

Students complete a lab report as outlined in Student Lab Instructions. Other student products such as presentations or web page reports can be used to evaluate students.

## EVALUATION

Skills assessment in the use of the computer interface system.

Skills assessment in the setting up and carrying out of the experiment.

Marking the lab report or other student product.

Student Lab Instructions

## MATERIALS

### Experimental Set Up

- liver extract
- dilute hydrogen peroxide
- 1M hydrochloric acid (HCl)
- 1M sodium hydroxide (NaOH)
- sodium fluoride (solid)
- chilled liver extract
- ice water bath
- heated liver extract
- 100 mL graduated cylinder
- 10 mL graduated cylinder
- 2 mL pipette

### Interface Pressure Testing

- interface
- pressure sensor (one per group of 4)
- 250 mL flask
- one hole stopper for flask
- Data Studio software

## LAB METHODS

Start *Data Studio* software, *Open Activity*, open the *Library, Biology Activities, B04 Catalase Enzyme Activity*. Set up a data table in the Observations section of your lab report similar to Data Table 1.

### 1. Basic Experimental Protocol:

Put 100 mL dilute hydrogen peroxide solution (15 mL H<sub>2</sub>O<sub>2</sub> + 85 mL distilled water) in a 250 mL Erlenmeyer flask. Add 2 mL liver extract. Insert the stopper and hold on tightly. Click *Start* immediately. The program will count down, record pressure in digits and graph pressure. Display maximum and minimum pressure by clicking on the summation symbol. For each run record the condition, run #, maximum pressure and minimum pressure in the data table.

**Variation A:** Add 10 mL of 1M HCl to the 100 mL dilute H<sub>2</sub>O<sub>2</sub> in the flask. Continue as outlined in Basic Protocol above.

**Variation B:** Add 10 mL 1M of NaOH to the 100 mL dilute H<sub>2</sub>O<sub>2</sub> in the flask. Continue as outlined in Basic Protocol above.

**Variation C:** Add 0.1 g of sodium fluoride (NaF which is an inhibitor) to the 100 mL dilute H<sub>2</sub>O<sub>2</sub> in the flask. Continue as outlined in Basic Protocol above.

**Variation D:** Use chilled liver extract in the enzyme addition part of the Basic Protocol above. Place flask in an ice water bath for the duration of the run.

**Variation E:** Measure 2 mL of heated liver extract with a measuring spoon and add this substance to the dilute H<sub>2</sub>O<sub>2</sub>. Continue as outlined in the Basic Protocol above.

## ASSIGNMENT

Write a complete lab report as outlined below, using Word as a word processor. Insert data tables and graphs from Data Studio. This process can be done by exporting them as picture files.

**Purpose:** Develop a statement showing cause and effect, that is the effect of the independent variable or manipulated variable on the dependent variable. Note what the dependent variable is indicating.

**Hypothesis:** Predict what will happen when conditions change. Use generalities such as pH and temperature rather than specific variable changes. Note the control in this hypothesis statement. Use a word equation for the breakdown of hydrogen peroxide by catalase to produce water and oxygen, to support predictions in hypothesis.

**Materials and Method:** Summarize the method in point form. Identify controls and variables.

**Observations:**

**Data Table 1: Establishing Optimum Conditions for Enzyme Activity**

Activity	Condition	Run #	Maximum Pressure	Minimum Pressure	Change in Pressure
Basic Protocol	Liver extract room temp pH = 7				
Variation A	HCl				
Variation B	NaOH				
Variation C	Inhibitor (NaF)				
Variation D	Cooled				
Variation E	Heated				

**Analysis:**

1. Rank the conditions under which enzyme activity proceeded from largest change in pressure to least change in pressure on a Data Table similar to Data Table 2.

**Data Table 2: Ranking Optimum Conditions for Enzyme Activity**

Condition	Change in Pressure	Rank

2. Generate a graph showing all runs that can be correlated with Data Table 1. Refer to this graph from the Analysis section of the lab report, commenting on the results.

**Conclusion:** The purpose and hypothesis of this lab should be set up to show cause and effect. The statements in the conclusion should establish cause and effect showing the result of changing pH, adding inhibitor and changing temperature on enzymatic action. Support statements in conclusion with numeric data.

## 2. CELL MEMBRANES

### BACKGROUND INFORMATION – SCIENCE ACTIVITY

The cell membrane is a phospholipid bilayer with hydrophilic heads on the outside and hydrophobic tails forced to the inside of the bilayer by the polar properties of water. To determine if it is polarity that maintains the integrity of the cell membrane, we can immerse cells in liquids of differing polarities and determine the effect. Alcohols have varying polarity depending upon the type of alcohol. The effect of differing polarities can be shown with beets because the deep red colour leaks out of the cells if the cell membrane is not intact.

### BACKGROUND INFORMATION – USE OF INTERFACE AND PRESSURE SENSOR

The colorimeter is a sensor that measures the amount of light absorbed or transmitted through a solution. The colorimeter can be set to measure light absorbance or transmittance at different wavelengths of light. Therefore it can measure any color to which it is set. A solution with more red dye would have less transmittance of light and more absorbance, than distilled water, or a solution with less red dye. Either property (transmittance or absorbance) could be measured. The colorimeter is connected to the Science Workshop Interface in ANALOG CHANNEL A because only one sensor is being used. The colorimeter has to be set to the appropriate wavelength for the experiment and must also be calibrated. The teacher may wish to calibrate the equipment and set up the experiment on the computer or, because this lab is designed for grade 12 students, they may be expected to calibrate and set up the experiment. Therefore, the instructions for calibration and setup are included in both the Background and Student Lab Instructions sections.

Start *Data Studio* on the computer, *Create an Experiment*. Drag the colorimeter to port A on the interface that is displayed on the *Setup* screen. Double click on the colorimeter icon. Select *Calibration* and continue to calibrate both the computer interface system and the colorimeter.

#### To calibrate the colorimeter:

- Fill a cuvette with distilled water, dry the outside with soft paper tissue if necessary.
- Place cuvette in the colorimeter
- Hold down select and start buttons on the colorimeter at the same time.
- When prompted, select blue light.
- Press start.

#### To calibrate the computer:

- In the colorimeter calibration window on the computer, enter 100 in the second box under *High Point*, which sets the transmittance @ 100 for the distilled water blank.
- Click on *Take Reading* at the bottom of the high point column.
- When stabilized @ 100 click *OK*. You will exit the setup window.
- Stop the colorimeter by pressing the stop button.

**To set up the data recording screen:**

Click on *Absorbance* under *Data* and drag it to *Digits* under *Displays* so that absorbance is displayed for each sample. Set the *Stop Time* for readings at 10 seconds by selecting *Set Sampling Options* from the *Experiment* pull down menu. The sampling and display screens appear on the left side of the computer monitor. Drag absorbance from sampling to graph in display, to graph absorbance of all samples on the same graph.

## BIOLOGY OBJECTIVES

1. To describe the structure of a cell membrane as a phospholipids bilayer.
2. To measure precise volumes to make solutions of different concentrations.
3. To observe and quantitatively measure the effect of alcohol on a cell membrane.
4. To graph data and interpret the graph.

## TECHNOLOGY OBJECTIVES

1. To create an activity with a timer and displays required.
2. To calibrate a sensor.

## MATERIALS

### Experimental Set Up

- beets (canned or fresh)
- isopropyl alcohol (50% and 100%)
- methanol (50% and 100%)
- ethanol (50% and 100%)
- distilled water
- sharp knife or scalpel
- pipettes

### Interface Colorimeter Testing

- interface
- colorimeter
- cuvettes (9 per lab group)

## TEACHER INSTRUCTIONS

1. Describe the structure of a cell membrane as a phospholipids bilayer that remains intact in a polar, water environment.
2. Explain that the pigment in beet cells is water based and is repelled by the lipids of the cell membrane. This repulsion causes the pigment to stay inside the cells.

3. Have the students speculate or predict what would happen if the cell membrane were disrupted. Discuss ways of disrupting the membrane.
4. Explain how to make needed dilutions of the alcohols as outlined in Student Lab Instructions.
5. Explain how to calibrate the sensor as outlined in Background.
6. Describe and discuss the Students Lab Instructions and expectations.

## ASSIGNMENT

Students must complete data table, print graph generated by the Data Studio software and analyze findings. The student product can take any form that demonstrates students have mastered the concepts in this activity.

## EVALUATION

Assess student ability to set up varying concentrations of alcohol solutions.

Give credit for ability to set up the experiment on the computer if that is expected.

Mark analysis of data and graph.

## STUDENT LAB INSTRUCTIONS

The cell membrane holds a water soluble pigment inside a beet cell. If the cell membrane is disrupted, the red pigment leaks out. A colorimeter can be used to detect relative amounts of pigment in solutions by measuring absorbance. In this lab, beets will be soaked in different concentrations of isopropyl alcohol ( $\text{CH}_3\text{CHOHCH}_3$ ), ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ), and methanol ( $\text{CH}_3\text{OH}$ ). Normally cells are in a water ( $\text{H}_2\text{O}$ ) environment. Water is a polar molecule. Molecules of alcohol are polar but become less polar as they increase in length (the number of carbon atoms increases).

## MATERIALS

### Experimental Set Up

- beets (canned sliced or fresh)
- isopropyl alcohol (50% and 100%)
- methanol (50% and 100%)
- ethanol (50% and 100%)
- distilled water
- sharp knife or scalpel
- pipettes

### Interface Pressure Testing

- interface
- colorimeter
- cuvettes (9 per lab group)

## LAB METHODS

1. Cut 9 - 1cm x 1cm x 0.5 cm pieces of beet, rinse each piece in distilled water and place one piece of beet in each cuvette.
2. Fill cuvettes with test solutions; three with distilled water, the other six with each of the following: 50% isopropyl alcohol, 100% isopropyl alcohol, 50% methanol, 100% methanol, 50% ethanol and 100% ethanol.
3. Allow the cuvettes with beet pieces and water or alcohol to sit for at least 10 minutes.
4. Set up the interface system and sensor.

Start *Data Studio* on the computer and *Create an Experiment*. Drag the *colorimeter* under *Sensors in Experiment Setup* window to A on the interface.

### To calibrate the colorimeter:

- Fill a cuvette with distilled water, dry the outside with soft paper towel if necessary.
- Place cuvette in the colorimeter.
- Hold down select and start buttons.
- Select blue light.
- Press the start button again.

### To calibrate the computer:

- Double click on the *colorimeter icon* attached to the interface box in the *Experiment Setup* window. In the colorimeter calibration window on the computer, enter 100 in the second box under *High Point*, this will set transmittance @ 100 for the distilled water blank. Click on *Take Reading* at the bottom of the high point column. When stabilized @ 100 click *OK*. You will exit the setup window.
- Stop the colorimeter by pressing the stop button.
- To set up the data recording screen:
- Click on *Absorbance* under *Data* and drag it to *Digits* under *Displays* so that absorbance is displayed for each sample. Set the *time* for readings at 10 seconds by selecting *Set Sampling Options* from the Experiment pull down menu.

5. Run tests on the methanol samples, 0 (ie: water) then 50% then 100%. Place a cuvette in the colorimeter. Start the colorimeter, it will read transmittance. Start the computer, it will read absorbance. Record the maximum absorbance in a table similar to Data Table 1. Repeat for each of the other two alcohols.

Data Table 1: Absorbance of Light by Pigments Released From Cells

Concentration	Methanol	Ethanol	Isopropanol
0 (water)			
50 %			
100 %			

## ASSIGNMENT

Once all nine runs are complete, double click on the graph icon in the *Displays* window. Annotate the graph by selecting A at the top of the graph then clicking on the location you wish to insert words. Use this function to label the alcohols and their concentrations in the key and note any necessary information on the x and y axis that is not displayed. Print the graph. Under the graph answer the following analysis questions.

## ANALYSIS

1. Does the cell membrane lose integrity and allow pigments to escape from the cell? Discuss this loss of integrity with respect to increasing concentrations of alcohol?
2. Does the polarity of the solution affect the cell membrane? Give evidence to support your answer.

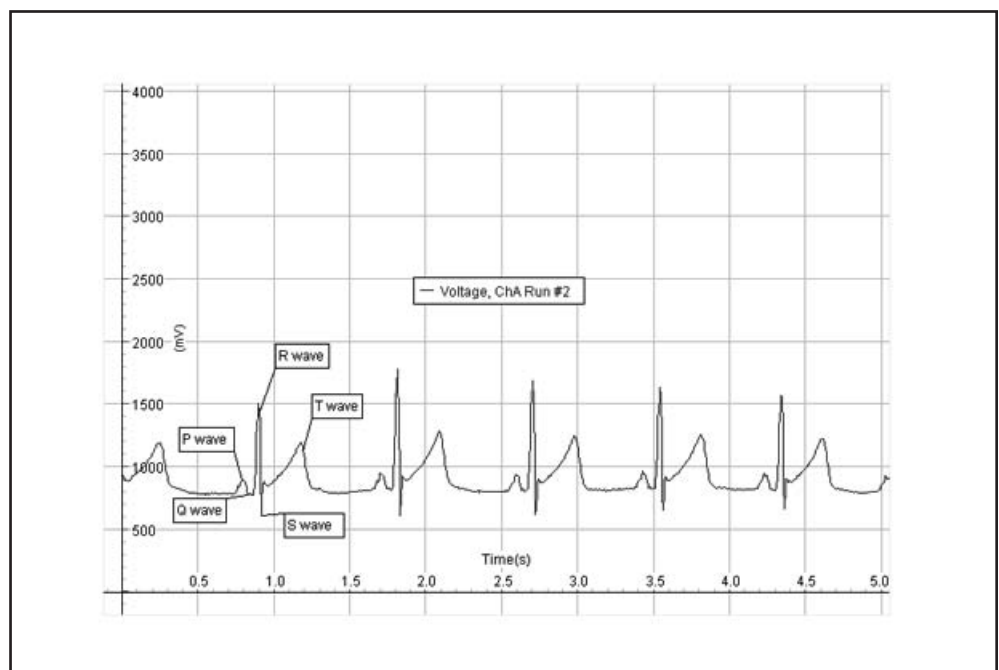
# 3. HEART RATE (EKG)

## BACKGROUND INFORMATION – SCIENCE ACTIVITY

One heart beat involves contraction of the atria and then the ventricles as a result of polarized muscle cells becoming depolarized by the migration of ions in the heart muscle. Heart muscles are polarized when at rest which means that they will have a small potential difference from one side of the cell membrane to the other. The sinoatrial node in the right atrium initiates depolarization of the muscles of both atria so that the atria contract. Contraction of the atria sends blood to the ventricles. The atrioventricular node, also in the right atrium, then conducts an impulse that causes depolarization of the ventricles and they contract. Contraction of the right ventricle sends blood to the lungs to be oxygenated. Contraction of the left ventricle sends blood out the aorta, and on to general circulation. The heart then repolarizes with the migration of ions back to their original locations.

## BACKGROUND INFORMATION – USE OF INTERFACE AND EKG SENSOR

The electrodes on the inside of the elbows and wrist pick up an electrical current sent out by the heart when it contracts and display this voltage as an electrocardiogram (EKG). When heart muscles are at rest and have a small potential difference, they will not conduct an electric current; which will be shown on the EKG graph as the isoelectric line. The first increase in current from the isoelectric line is the P wave (refer to graph below), which results from depolarization and contraction of the atria. The Q wave is a slight depression after the P wave, followed by a large R wave resulting from depolarization and contraction of the ventricles. The S wave ends the cycle of one heart beat. The graph will return to the isoelectric line and then show one more wave which represents the repolarization of the heart muscles.



## **BIOLOGY OBJECTIVES**

1. To describe the function of the heart.
2. To evaluate the process of taking a heart rate for 15 seconds.
3. To interpret graphical information.
4. To appreciate the value and limitations of technology as represented by an EKG sensor.
5. To work cooperatively, one lab partner as a subject and the other as a technician.

## **TECHNOLOGY OBJECTIVES**

1. To use an EKG sensor.
2. To adjust the sampling time.
3. To print a graph of results.

## **MATERIALS**

### **Experimental Set Up**

- student
- chair
- soap & water
- paper towel

### **Interface EKG Testing**

- interface
- 3 electrode patches
- EKG sensor

## **TEACHER INSTRUCTIONS**

Review with students the parts of the heart prior to this lab being started. In the pre lab for the activity, show students where the atrioventricular node and the sinoatrial node are. Explain the role of these nodes in depolarization of heart muscles as outlined in the background information.

Explain to students that the EKG sensor does not need to be calibrated. Students are comparing heart rates over specified periods of time to each other and from one graph to another but never to an external set of data.

## **ASSIGNMENT**

Students should complete the activity as outlined in Student Lab Instructions.

## EVALUATION

Mark students' ability to use the interface and sensor as a skill.

Mark the "Assignment" for students' ability to take information off a graph, sort the information in the data table, calculate a mean, evaluate data with respect to the mean, and interpret that data through their answers to questions 2, 3 and 4.

## STUDENT LAB INSTRUCTIONS

In this lab, students use an electrocardiogram (EKG) to measure their heart rate and create a print out. Because we often take our pulse for 15 seconds, we will use this activity to test whether taking a pulse for a short period of time (15 seconds), and multiplying by four, is an accurate measure of heart rate. We will use this EKG print out to compare one person's heart rate at different levels of activity. Reading the EKG print out starts with identifying the isoelectric line, which is the flat horizontal line at about 1.0 v. From the isoelectric line, the first movement upwards is a P wave, resulting from the depolarisation and contraction of the atria right after a pulse goes out from the SA node or pacemaker. Next the AV node sends a pulse to the ventricles represented on the graph by a downward pulse, the Q wave and then an upward swing, the R wave, followed by a downward pulse, the S wave. The QRS complex represents ventricular contraction resulting from depolarization of the ventricles. The recovery is represented by the T wave, which is recorded when the ions move back to their original positions. Following the T wave is a sustained return to the isoelectric line. Heart rate per minute is determined by the number of P or R waves in a minute.

## MATERIALS

### Experimental Set Up

- student
- chair
- soap & water
- paper towel

### Interface Pressure Testing

- interface
- 3 electrode patches
- EKG sensor

## LAB METHODS

1. Start *Data Studio*. *Open Activity*. From the *Library* file, *Biology Labs* select *B14 EKG – Exercise.ds*.
2. Have the student being tested sit near the computer and instruct him or her to relax. Clean the inside of both elbows and the right wrist with soap and water. Dry these areas with paper towel.
3. Attach the electrode patches to the inside of each elbow and the inside of the right wrist, with the tab pointing down.

4. Attach the black alligator clip to the tab on the right wrist, attach the green alligator clip to the patch on the inside of the right elbow, and attach the red alligator clip to the patch on the inside of the left elbow.
5. Select *Experiment* from the pull down screens, change the *Sampling Options, Automatic Stop Time* to 60 seconds.
6. Under the *File* menu, *Save Activity As EKG studentname*.
7. Under the *File* menu select *Print Options* and change to landscape from portrait.
8. Double click on the x axis of the *Voltage Graph* to access *Graph Settings*. Change the x axis scale to minimum of 0 seconds and maximum of 60 seconds. Click on the appearance tab, unselect *Show Minor Grid*. Make the same changes to the Heart Rate Graph.
9. Click *Start* to record the heart rate of a person who has been resting calmly.
10. Print the graph.
11. Have the same student stand with the alligator clips still attached to the electrode patches. Record and print their heart rate as recorded while standing.
12. Remove the alligator clips. Have the same student run on the spot for one minute. Reattach the alligator clips and record their heart rate for 60 seconds by clicking *Start*. Print the graph.

## ASSIGNMENT

1. On each graph, draw a vertical line at the 15, 30, 45 and 60 seconds marks. Count and record the heart rate for each 15 second interval in the data table below.

**Data Table 1: Analysis of EKG Graphs**

Heart Rate	Sitting	Standing	Increase over Sitting	After Running	Increase over Sitting
1 full minute					
1st 15 seconds			xxxxxxx		xxxxxxx
2nd 15 seconds			xxxxxxx		xxxxxxx
3rd 15 seconds			xxxxxxx		xxxxxxx
4th 15 seconds			xxxxxxx		xxxxxxx
Mean (15 sec.)			xxxxxxx		xxxxxxx
Deviation above mean.			xxxxxxx		xxxxxxx
Deviation below mean.			xxxxxxx		xxxxxxx
Maximum deviation over one minute.			xxxxxxx		xxxxxxx

Support your answers to the following questions with facts from the graphs or data table analysis.

2. If someone takes their heart rate while exercising for 15 seconds and multiplies by four to determine their heart rate for a minute, is it accurate? Explain.
3. Does a person's heart rate increase when they are standing as compared to the same person sitting? Why?
4. How much did the heart rate increase after the subject of this investigation ran on the spot for one minute? Why?







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