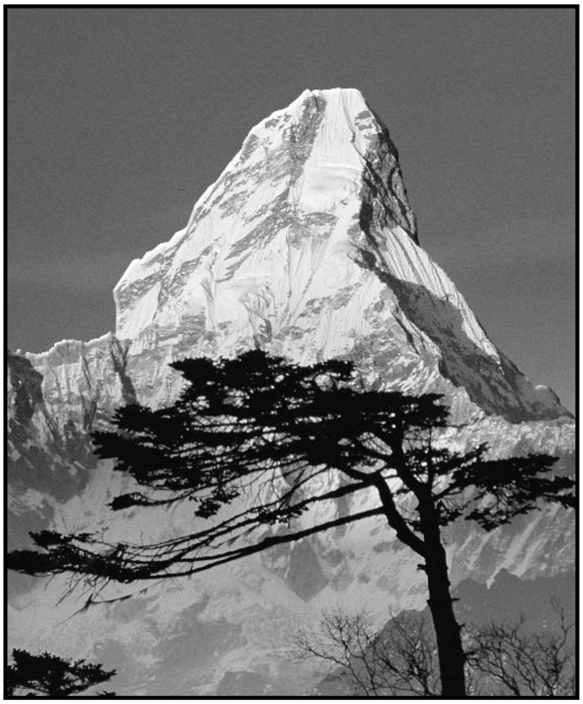
Exploring Environmental Problems
Student Edition

GLENCOE

EARTH SCIENCE
Geology, the Environment, and the Universe



A Glencoe Program

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Contents

How to Use This Laboratory Manual

Working in the laboratory throughout the course of the year can be an enjoyable part of your Earth science experience. ***Earth Science: Geology, the Environment, and the Universe*** *Exploring Environmental Problems* is a tool for making your laboratory work both worthwhile and fun. The laboratory activities are designed to fulfill the following purposes:

- to stimulate your interest in science in general and especially in Earth science
- to reinforce important concepts studied in your textbook
- to allow you to verify some of the scientific information learned during your Earth science course
- to allow you to discover for yourself Earth science concepts and ideas not necessarily covered in class or in the textbook readings
- to acquaint you with a variety of modern tools and techniques used by today's Earth scientists

Most importantly, the laboratory activities will give you firsthand experience in how a scientist works.

The activities in Exploring Environmental Problems are of two types: Calculator-Based Labs and Global Positioning System Labs. In an activity, you will be presented with a problem. Then, through use of scientific methods, you will seek answers. Your conclusions will be based on your observations alone or on those made by the entire class, recorded experimental data, and your interpretation of what the data and observations mean. Some of the Calculator-Based Labs are Design Your Own, which are similar to the Design Your Own labs in your textbook. In Design Your Own labs, you will design your own experiments to find answers to problems.

The Calculator-Based System (CBL) is an interface that collects data from probes and sends the information to a calculator. The calculator, in turn, runs stored data collection and processing programs, which interpret and plot data obtained from the CBL system.

You may substitute a Macintosh or PC computer for a calculator. A computer interface (microcomputer) is then substituted for the CBL System. The computer can run a variety of data analysis programs, which will graph and analyze data collected from the interface.

Global Positioning System, or GPS, is the instrument you will use for the last five labs. This is an instrument for locating your position on Earth. Its main purpose is to provide navigation information. It is designed to pinpoint latitude, longitude, and elevation on Earth.

In addition to the activities, this laboratory manual has several other features—a description of how to write a lab report, diagrams of laboratory equipment, and information on safety that includes first aid and a safety contract. Read the section on safety now. Safety in the laboratory is your responsibility. Working in the laboratory can be a safe and fun learning experience. By using ***Earth Science: Geology, the Environment, and the Universe,*** *Exploring Environmental Problems*, you will find Earth science both understandable and exciting. Have a good year!

Writing a Laboratory Report

When scientists perform experiments, they make observations, collect and analyze data, and formulate generalizations about the data. When you work in the laboratory, you should record all your data in a laboratory report. An analysis of data is easier if all data are recorded in an organized, logical manner. Tables and graphs are often used for this purpose.

A written laboratory report should include all of the following elements.

RESEARCH QUESTION: What exactly do you want to know as a result of conducting this experiment?

HYPOTHESIS: The hypothesis is the guide for the research. Write a clear and concise statement that, based on your prior knowledge and literature review, you think this experiment will confirm.

MATERIALS: List all laboratory equipment and other materials needed to perform the experiment.

PROCEDURE: Describe each step of the procedure so that someone else could perform the experiment following your directions.

DATA AND DATA ANALYSIS: Include in your report all observations, data, tables, graphs, and sketches necessary to test your hypothesis.

CONCLUSION: When testing a hypothesis, there are only three possible conclusions: data support the hypothesis; data reject the hypothesis; or data are inconclusive to support or reject the hypothesis.

DISCUSSION: Describe the implications of your findings. If possible, answer your research question based on your findings. Include error analysis and suggestions for repeating the experiment to better answer the research questions. What still remains unknown?

Read the following description of an environmental experiment. Then answer the questions.

A group of students conducted an experiment to test which flower color attracts insects. They randomly placed six plastic flowers of four colors in a matrix. They observed the flowers for 2 hours and counted the number of insects that flew to each flower. The next day they observed that spider webs were attached to many of the flowers. One student hypothesized that spiders know which flowers attract insects. Spiders then build webs to catch the insects.

Table 1 Insects Attracted to Colored Flowers

Insects	6 Blue Flowers	6 White Flowers	6 Red Flowers	6 Yellow Flowers
Flies	1	5	5	5
Bees	2	10	10	12
Ants	1	0	0	1

Table 2 Spider Web Appearances

	Blue	White	Red	Yellow
Webs	0	4	3	4

1. What was the purpose of the second experiment?

____

2. What materials were needed for the two experiments?

____

Writing a Laboratory Report, *continued*

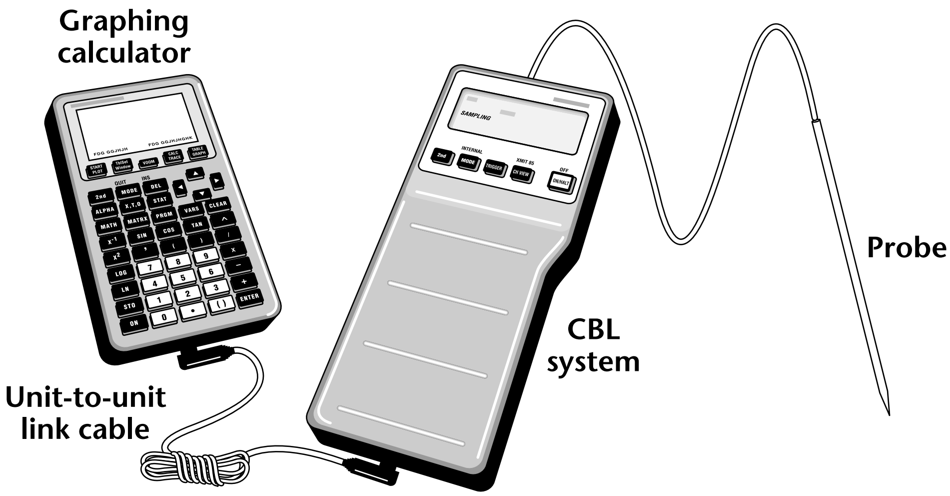
3. Write a step-by-step procedure for testing the first experiment, the color preference of the insects.

4. Table 2 shows the data collected in the spider web experiment. Based on these data, state a conclusion for this experiment.

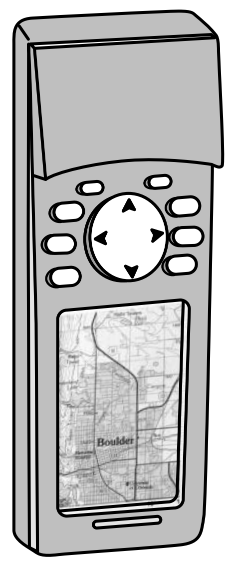
5. Plot the data in Table 1 on a graph. Show total number of insects on the vertical axis and the color on the horizontal axis.

Technology-Based Systems for the Lab

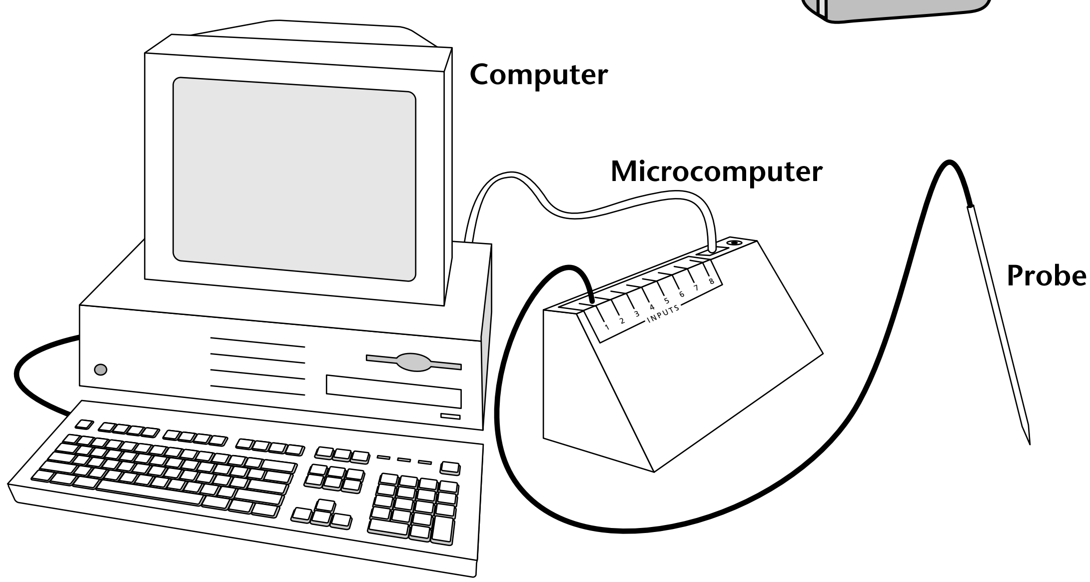
General Calculator-Based Setup



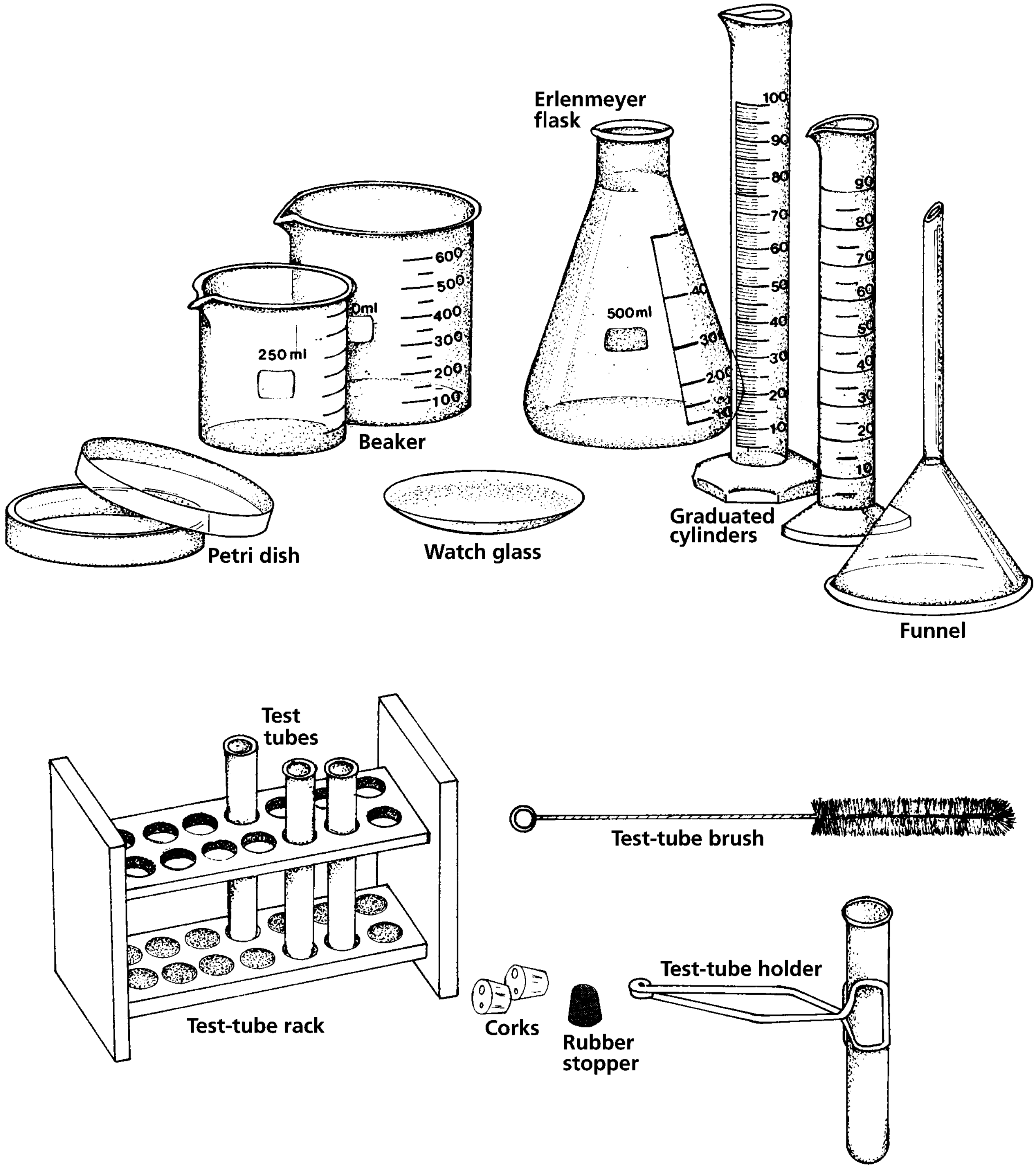
General Global Positioning System



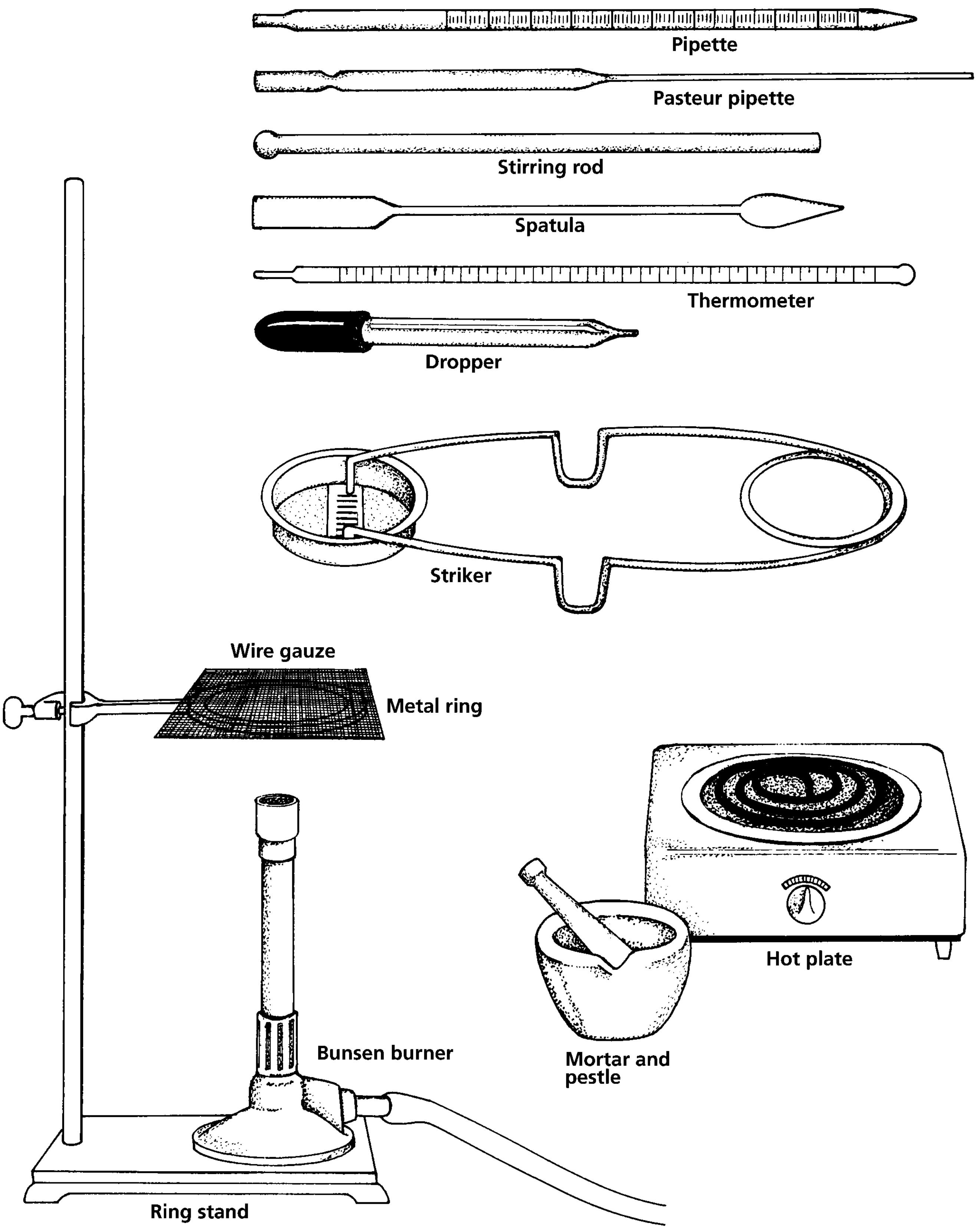
General Microcomputer-Based Setup



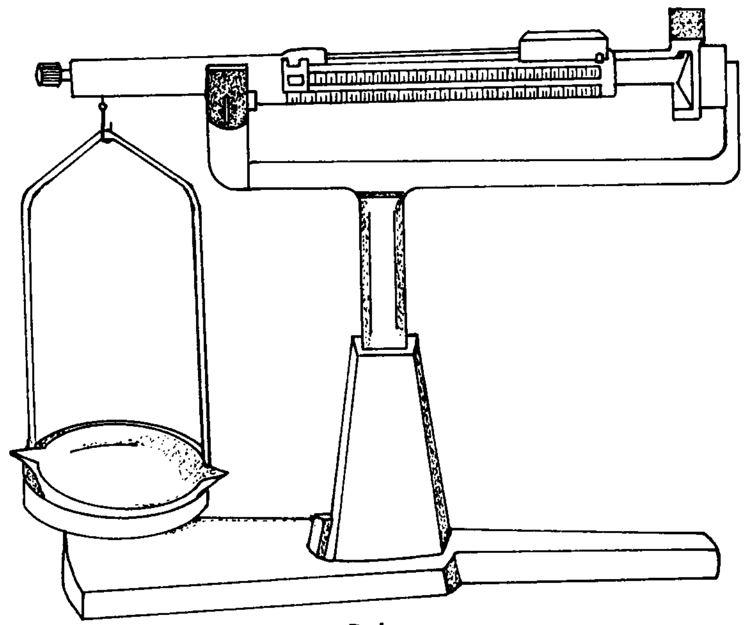
Laboratory Equipment



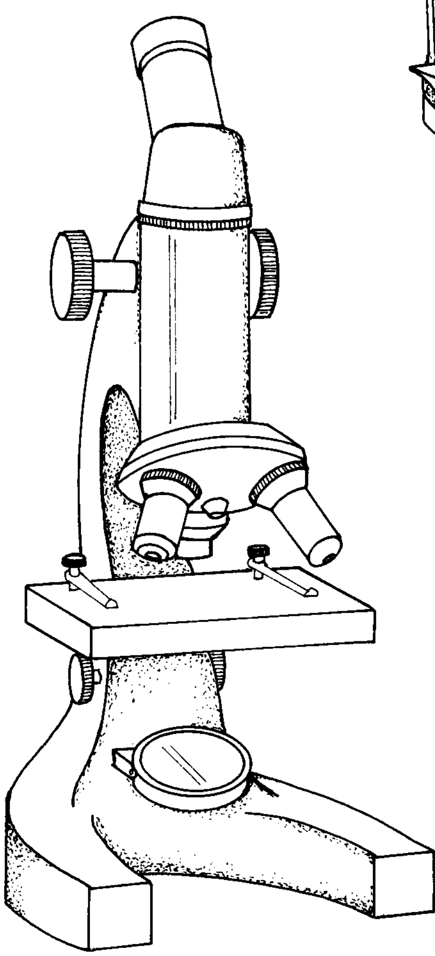
Laboratory Equipment, *continued*



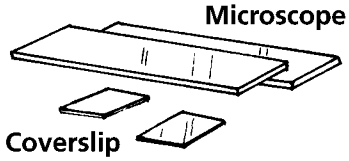
Laboratory Equipment, *continued*



Balance



Compound light microscope



Microscope slide

Coverslip

Safety in the Laboratory

1. Always obtain your teacher's permission to begin a lab.
2. Study the procedure. If you have questions, ask your teacher. Be sure you understand all safety symbols shown.
3. Use the safety equipment provided for you. Goggles and a laboratory apron should be worn when any lab calls for using chemicals.
4. When you are heating a test tube, always slant it so the mouth points away from you and others.
5. Never eat or drink in the lab. Never inhale chemicals. Do not taste any substance or draw any material into your mouth.
6. If you spill any chemical, immediately wash it off with water. Report the spill immediately to your teacher.
7. Know the location and proper use of the fire extinguisher, safety shower, fire blanket, first aid kit, and fire alarm.
8. Keep all materials away from open flames. Tie back long hair and loose clothing.
9. If a fire should break out in the lab, or if your clothing should catch fire, smother it with the fire blanket or a coat, or get under a safety shower. **NEVER RUN.**
10. Report any accident or injury, no matter how small, to your teacher.

Follow these procedures as you clean up your work area.

1. Turn off the water and gas. Disconnect electrical devices.
2. Return materials to their places.
3. Dispose of chemicals and other materials as directed by your teacher. Place broken glass and solid substances in the proper containers. Never discard materials in the sink.
4. Clean your work area.
5. Wash your hands thoroughly after working in the laboratory.

First Aid in the Laboratory

Injury	Safe response
Burns	Apply cold water. Call your teacher immediately.
Cuts and bruises	Stop any bleeding by applying direct pressure. Cover cuts with a clean dressing. Apply cold compresses to bruises. Call your teacher immediately.
Fainting	Leave the person lying down. Loosen any tight clothing and keep crowds away. Call your teacher immediately.
Foreign matter in eye	Flush with plenty of water. Use an eyewash bottle or fountain.
Poisoning	Note the suspected poisoning agent and call your teacher immediately.
Any spills on skin	Flush with large amounts of water or use safety shower. Call your teacher immediately.

Safety Contract

I, ______________________________ , have read and understand the safety rules and first aid information listed above. I recognize my responsibility and pledge to observe all safety rules in the science classroom at all times.

______________________________ ______________

signature *date*

The ***Earth Science: Geology, the Environment, and the Universe*** program uses safety symbols to alert you and your students to possible laboratory dangers. These symbols are provided in the student text in Appendix B and are explained below. Be sure your students understand each symbol before they begin an activity that displays a symbol.

SAFETY SYMBOLS	HAZARD	EXAMPLES	PRECAUTION	REMEDY
DISPOSAL	Special disposal procedures need to be followed.	certain chemicals, living organisms	Do not dispose of these materials in the sink or trash can.	Dispose of wastes as directed by your teacher.
BIOLOGICAL	Organisms or other biological materials that might be harmful to humans	bacteria, fungi, blood, unpreserved tissues, plant materials	Avoid skin contact with these materials. Wear mask or gloves.	Notify your teacher if you suspect contact with material. Wash hands thoroughly.
EXTREME TEMPERATURE	Objects that can burn skin by being too cold or too hot	boiling liquids, hot plates, dry ice, liquid nitrogen	Use proper protection when handling.	Go to your teacher for first aid.
SHARP OBJECT	Use of tools or glassware that can easily puncture or slice skin	razor blades, pins, scalpels, pointed tools, dissecting probes, broken glass	Practice common-sense behavior and follow guidelines for use of the tool.	Go to your teacher for first aid.
FUME	Possible danger to respiratory tract from fumes	ammonia, acetone, nail polish remover, heated sulfur, moth balls	Make sure there is good ventilation. Never smell fumes directly. Wear a mask.	Leave foul area and notify your teacher immediately.
ELECTRICAL	Possible danger from electrical shock or burn	improper grounding, liquid spills, short circuits, exposed wires	Double-check setup with teacher. Check condition of wires and apparatus.	Do not attempt to fix electrical problems. Notify your teacher immediately.
IRRITANT	Substances that can irritate the skin or mucus membranes of the respiratory tract	pollen, moth balls, steel wool, fiber glass, potassium permanganate	Wear dust mask and gloves. Practice extra care when handling these materials.	Go to your teacher for first aid.
CHEMICAL	Chemicals that can react with and destroy tissue and other materials	bleaches such as hydrogen peroxide; acids such as sulfuric acid, hydrochloric acid; bases such as ammonia, sodium hydroxide	Wear goggles, gloves, and an apron.	Immediately flush the affected area with water and notify your teacher.
TOXIC	Substance may be poisonous if touched, inhaled, or swallowed	mercury, many metal compounds, iodine, poinsettia plant parts	Follow your teacher's instructions.	Always wash hands thoroughly after use. Go to your teacher for first aid.
OPEN FLAME	Open flame may ignite flammable chemicals, loose clothing, or hair	alcohol, kerosene, potassium permanganate, hair, clothing	Tie back hair. Avoid wearing loose clothing. Avoid open flames when using flammable chemicals. Be aware of locations of fire safety equipment.	Notify your teacher immediately. Use fire safety equipment if applicable.

Eye Safety
Proper eye protection should be worn at all times by anyone performing or observing science activities.

Clothing Protection
This symbol appears when substances could stain or burn clothing.

Animal Safety
This symbol appears when safety of animals and students must be ensured.

Radioactivity
This symbol appears when radioactive materials are used.

Using Technology to Study Environmental Science

The scientific study of the environment is relatively new. During the 1960s, scientists became increasingly concerned about the impact of the human population on the health of the environment. Many scientists agreed that Earth was becoming polluted and that natural resources were being consumed too quickly. They began to analyze the relationship between humans and the environment. Such study is called environmental science.

Making a Difference

Environmental science incorporates principles of Earth science, the physical sciences, biology, economics, and even political science. Nonetheless, you—as a beginning environmental science student—can make significant contributions to solving environmental problems in your local community. For example, students participating in the GLOBE program are monitoring the environment in their communities and posting their discoveries on the Internet. GLOBE is a worldwide network of teachers, students, and scientists working together to learn about the environment. Go to the Glencoe Science Web Site at science.glencoe.com to find out more about GLOBE.

Exploring Environmental Problems

The labs in *Exploring Environmental Problems* show you how to use some of the latest technology to monitor aquatic and terrestrial ecosystems. You will examine principles involved in global problems such as acid precipitation, global warming, deforestation, and the cost of energy. To study your local environment, you will first have to review the use of Calculator-Based Labs (CBLs) and Global Positioning System (GPS).

The Scientific Method

Scientists make observations, formulate hypotheses, and then test the hypotheses in controlled experiments. This procedure is called the scientific method and you will use this method in your study of environmental issues. Although all scientific investigations do not follow the same methods, all scientists conduct experiments and draw conclusions based on facts, not opinions. The techniques and tools you learn to use in these labs will prepare you to design and conduct environmental experiments.

Calculator-Based Labs

In *Exploring Environmental Problems*, you will be using two technologies to collect data and information. In the first part of this manual, you will use an instrument called a Calculator-Based Lab (CBL) unit. A CBL unit is an electronic device that uses voltage changes to record data. For example, when you use a temperature probe, a change in temperature causes a slight difference in the voltage passing through the probe. The CBL unit has an internal program that converts the change in voltage to a temperature reading. Similarly, a pH probe can be calibrated to use a voltage change to give the pH reading of a solution. The CBL device can be connected to a graphing calculator or a microcomputer, which has programs to store and graph the data that you can then analyze. When using a graphing calculator or a microcomputer with the CBL unit, you will need a set of programs called ChemBio. ChemBio should be saved in Applications or Programs.

The CBL device has an automatic power-down system. Your CBL unit or the calculator attached to it may shut down after 10 minutes to conserve the battery. If this happens, turn the device back on when you are ready to use it. If the CBL is attached to a calculator when the power turns off, the data will be saved in memory. If you are not connected to a calculator and the unit powers down, you will lose the data. When attaching a probe to the CBL unit, you should always put the probe in the lowest numbered channel. There are three channels that allow you to use three probes at the same time.

Global Positioning System

The instrument you will use for the last five labs is a Global Positioning System (GPS) unit, which is used to locate your position on Earth. The United States Department of Defense constructed the system for $12 billion. Its official name is the NAVSTAR Global

Positioning System, but it is most frequently called GPS. Its primary purpose is to provide navigational information for the military. The system is able to establish a position on Earth to the nearest meter. Military planes, tanks, transport systems, and field soldiers utilize GPS units to pinpoint their location.

GPS units have become standard equipment in emergency vehicles and in many cars and boats. Professional uses vary from surveying and field ecology mapping to real estate development and city planning. GPS has three components: satellites orbiting Earth, ground monitoring stations, and receiving units.

Satellites Orbiting Earth

GPS employs 24 satellites orbiting 22 200 km above Earth. Each satellite takes 12 hours to orbit once around the globe. The satellites are positioned so that a signal can be received from six of them at any given time. Each satellite is solar powered and carries four atomic clocks. These clocks can keep time to less than a billionth of a second.

Ground Monitoring Stations

Five unstaffed stations constantly monitor the 24 satellites. Two stations are located in the Pacific Ocean, at Hawaii and Kwajalein. The other three are located at Diego Garcia in the Indian Ocean, Ascension Island in the Atlantic Ocean, and Colorado Springs, Colorado. The main control system is at Falcon Air Force Base in Colorado Springs. The primary purpose of these stations is to track and monitor the operations of the satellites. If a satellite is not operating properly, the main control crew sends correction information to the satellite through large ground antennas.

Receiving Units

GPS can be used with more than 100 different types of receivers. Some are built in cars, airplanes, and boats. Others are large devices that connect to a computer. The receiver you will use is a small handheld device about the size of a calculator. The purpose of the receiver is to detect, decode, and process signals sent by GPS satellites.

Visit sites listed on the Glencoe Science Web Site for more information on CBL and GPS.

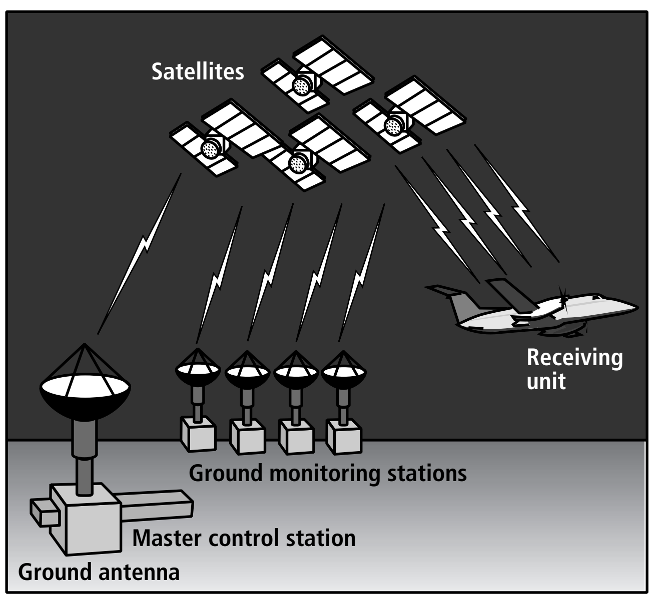
How does GPS work?

In order to pinpoint a specific location, a receiver must locate and receive a strong signal from at least four satellites. The receiver uses the signals to measure the distance between it and three of the satellites. The GPS receiver contains a computer program that uses geometry to find the actual position of the receiver in relationship to the three satellites. The fourth satellite is used to make corrections and to calculate the altitude of the receiver above sea level on Earth.

Using GPS to Find the Distance

The formula for determining distance is "distance = speed × time." We know that the speed of the signal from the satellite to the receiver is 3.00×10^8 meters per second—the speed of light. The four atomic clocks aboard the satellite give us the exact time.

How does the GPS unit know the time from each signal? Think of it this way. You can tell how far away a thunderstorm is by counting the time between lightning and thunder. Sound travels about 344 meters per second, and light travels at 300 000 000 meters per second. If 5 seconds pass between the time you see lightning and hear thunder, the distance to the storm is 344 meters × 5, or 1720 meters. The GPS receiver must measure the delay from each satellite. The receiver picks up the signals from the satellites and calculates the exact distance to each satellite. The receiver's clock is brought in sync with universal time, and a precise location can be determined.



LAB 1

DESIGN YOUR OWN

CALCULATOR-BASED LAB

Use with Chapter 9
Section 9.1

How can certain factors affect the health of an ecosystem?

All bodies of water are affected by the land, air, and human activity around them. Environmental scientists monitor several factors to gauge the health of aquatic ecosystems. Four common measurements are electrical conductivity, transparency, pH, and temperature. Conductivity is the ability of water to conduct electricity. High conductivity means a higher concentration of ions, which could come from dissolved salts and metals. Transparency is the distance light can travel through water. Erosion of soil or wastes can limit water transparency, blocking the sunlight that aquatic organisms at the base of food chains need for photosynthesis. The pH of water also influences where aquatic organisms can live. Most organisms can live within a specific pH range. Water that becomes too acidic or too basic can be deadly. Temperature is also important. As water temperature rises, there is less dissolved oxygen for living organisms.

PROBLEM

How can certain physical and chemical properties of a body of water affect its ability to support life?

OBJECTIVES

- **Hypothesize** how physical and chemical properties of a body of water affect aquatic life.
- **Measure** and **record** the physical and chemical properties in a water sample from a specific body of water.
- **Observe** the area around the body of water to find possible sources of chemical input.
- **Draw conclusions** about whether the body of water is chemically or physically influenced by nearby sources.
- **Infer** how drainage could affect aquatic life in the body of water.

HYPOTHESIS

Hypothesize how certain physical and chemical properties of a body of water would affect aquatic life.

LAB 1 DESIGN YOUR OWN CALCULATOR-BASED LAB

PREPARATION

MATERIALS

CBL unit
TI graphing calculator
link cable
bucket tied to a rope
alcohol-based thermometer
 or CBL temperature sensor
Secchi disc
meterstick
pH probe
standard solution (pH 4)
standard solution (pH 7)
50-mL graduated cylinder
250-mL beakers in which samples can
 be placed for testing (2)
conductivity probe
1000µS standard solution
wash bottle of distilled water

SAFETY PRECAUTIONS

- Watch out for poisonous plants, and avoid contact with ticks and mosquitoes. Wear clothes that cover your legs and arms. Do not wear open-toed shoes.
- Wipe up any spills in the classroom immediately to prevent slipping or falling.
- Acid may irritate your skin. Always use caution and wear gloves when handling acid.

PROCEDURE

1. Select a body of water near your school that you can sample several times during the year. Use a bucket tied to a rope to take a water sample. Do not clean the bucket with soap. Rinse it out three times with the water from your site. Do not stir up your sample area by returning the rinse water to the same place. Do not put your hands in the sample water. Use the bucket to obtain a surface sample as far from shore as you can manage.

2. Record the temperature of the air near your site by holding the thermometer in the shade. Wait several minutes for the temperature to stabilize. Repeat all of your readings until you and your team agree on the temperature to within 0.5°C. Record the temperature of the water using the same procedure.

3. For a transparency determination, lower a Secchi disc into the water until it is no longer visible. Record the depth where it disappeared in cm. Raise the disc until you can just see it again. Record this depth also. These two readings should agree to within 10 cm. Repeat these measurements until your group agrees to within 10 cm. Average the two depths for your final reading.

4. Take the water sample back to the lab to measure pH and conductivity.

5. Soak the tip of the conductivity probe in distilled water while you use the pH probe.

6. To measure pH, connect the CBL unit to the graphing calculator and connect the pH probe to channel 1.
 a. Turn on the calculator and CBL. Select CHEMBIO.
 b. Set up probes.
 c. Enter 1 for number of probes. Press ENTER.
 d. Select pH and ENTER. Enter 1 for the channel. Press ENTER.

7. You are now ready to calibrate the CBL and measure pH.
 a. Select PERFORM NEW and ENTER.
 b. Remove the pH probe from the storage bottle. Rinse the probe with distilled water.
 c. Place the probe in the standard solution (pH 4). When the voltage reading on the CBL stops changing, press TRIGGER on the CBL. Press 4 in the calculator and press ENTER.
 d. Rinse the pH probe again with distilled water. Place the probe in the standard solution (pH 7). When the voltage reading on the CBL stops changing, press TRIGGER. Press 7 on the calculator and press ENTER.

PROCEDURE, *continued*

e. The screen will display the slope and intercept of the calibration line. Press ENTER and select COLLECT DATA.

f. Press ENTER again. Select MONITOR INPUT on the Data Collection menu. Let the device warm up for 30 seconds. Then press ENTER again. The pH probe is now ready to measure the pH of your water sample.

g. Pour 100 mL of water from the bucket into a beaker.

h. Rinse the probe with distilled water and place it in your water sample. When the reading stabilizes, record the pH. Rinse the probe with distilled water, then repeat the reading. Record the pH again. Calculate and record the average.

i. When you finish taking measurements, press + to return to the MAIN MENU. Remove the pH probe, rinse the tip, then return it to the storage bottle.

8. Now measure the conductivity of your sample.

a. After soaking the conductivity probe for at least 10 minutes, attach it to the CBL in channel 1. For freshwater or brackish water (mixture of salt and fresh, as in an estuary or the lower part of a river that meets an ocean), set the switch on the black box of the probe to 0–2000µS. For seawater, set the switch to 0–20,000µS.

b. Press ENTER on the MAIN MENU. The calculator will show the message. BE SURE TO SET SWITCH ON PROBE. CBL SHOWS ONLY 3 SIG. FIGURES. This is just a reminder to read the data from the calculator.

c. In the CALCULATOR MENU, choose channel 1 and PERFORM NEW.

d. When the screen starting with USE [CH VIEW] BUTTON ON CBL TO MONITOR VOLTAGE. WHEN STABLE PRESS CBL TRIGGER appears, remove the probe from the distilled water. Shake off excess water. When the voltage reading on the CBL is stable, press TRIGGER. Because there are no ions present, press 0 in the calculator and press ENTER.

e. Place the probe in the 1000µS standard solution. When the voltage reading on the CBL is stable, press TRIGGER on the CBL. Press a reference value of 1000 in the calculator. Press ENTER.

f. The calculator should show the intercept and slope values for the calibration line. Press ENTER. You should now be back at the MAIN MENU display on the calculator.

g. Rinse the probe with distilled water. Select COLLECT DATA and MONITOR INPUT.

h. Pour 100 mL of water from the bucket into a beaker.

i. Place the probe in your water sample. Read the conductivity of your sample. Rinse the probe in distilled water and repeat the reading. Record it. Then calculate the average and record it.

DATA AND OBSERVATIONS

Air temperature	Water temperature	Transparency	pH	Conductivity
1.	1.	1.	1.	1.
2.	2.	2.	2.	2.
Average				
Readings within 0.5°C	Readings within 0.5°C	Readings within 1 cm	Readings within 0.2 pH units	Readings within 40µS

DATA AND OBSERVATIONS, *continued*

1. Describe the site. What type of water body is it? What organisms did you observe?

2. List sources around the body of water from which substances might enter such as lawns, agriculture, and storm sewers.

ANALYZE AND CONCLUDE

1. Normally, air temperature can be colder than water temperature in the winter. Air temperature can be warmer than water temperature in the summer. How do the air and surface water temperatures compare? Do your readings follow this pattern? If they are very different, what might be the cause?

2. Many aquatic systems have a transparency of a few meters. Very fertile waters can be less transparent because of dense plankton. Waters full of sediment can also have low transparency. Nutrient-poor waters such as open ocean can be highly transparent—to a depth of 30 meters. Is the transparency of the water you tested low or high? Explain what might be the cause.

3. Rainwater is naturally acidic, with a pH of 5.0–6.5. Most organisms prefer a pH of 6.5–8.2. What is the pH of your water sample? Is it within the range that most organisms prefer?

CHECK YOUR HYPOTHESIS

Did your data support your **hypothesis**? Why or why not?

APPLY AND ASSESS

1. Based on temperature, transparency, pH, and conductivity, rate the suitability of this body of water for aquatic life.

Name Class Date

DESIGN YOUR OWN

LAB 2 CALCULATOR-BASED LAB

Use with Chapter 1
Section 1.2

How can you test a hypothesis about the condition of a body of water?

Environmental scientists often plan tests to reveal the water quality of a lake, a stream, a river, or an estuary. Choose a nearby body of water. Decide on a question you would like to answer about its water quality. State a hypothesis, then carefully plan a procedure to collect the data that will test that hypothesis, using observation and some of the sampling techniques you learned in Lab 1.

PROBLEM

How can you test a hypothesis about the condition of a nearby body of water?

OBJECTIVES

- **Hypothesize** how a certain factor affects water quality.
- **Plan** an experiment to test your hypothesis.
- **Measure** the physical or chemical properties you are testing.
- **Make** a data table in which to record measurements.
- **Draw conclusions** about the quality of the water based on your data.

HYPOTHESIS

Hypothesize how a certain factor could affect water quality.

____

____

POSSIBLE MATERIALS

CBL unit
TI graphing calculator
link cable
wash bottle of distilled water
bucket tied to a rope
alcohol-based thermometer
Secchi disc
meterstick
pH probe
standard solution (pH 4)
standard solution (pH 7)
conductivity probe
1000µS standard solution
graduated 50-mL cylinder
250-mL beakers (4–5)

POSSIBLE MATERIALS, *continued*

SAFETY PRECAUTIONS

- Wipe up any spilled liquid.
- Avoid poisonous plants and insects.
- Wear protective clothing and sturdy shoes.
- Handle acid with care.
- Mercury is toxic and hazardous. Do not handle the mercury if a mercury-filled thermometer breaks. Notify your teacher immediately.

PLAN THE EXPERIMENT

- Working with a partner, decide what you would like to know about the body of water, based on the data you collected in Lab 1. For example, are you interested in determining the sources of any pollution? Would you like to know if pollution in the water differs with location or depth? Perhaps you would like to find out if some areas of the water are better suited for aquatic life than others.
- Some methods to consider include taking measurements of the same factor at different times of day or in different weather conditions. The water could also be sampled at different depths or at several different sites on its surface. ***CAUTION: Be careful of fast-moving current when working near a body of water. Take precautions against slipping or falling.***
- Consider using a map or diagram of the body of water on which to plot your data.
- Make a list of the steps you will follow to test your hypothesis. As you plan the experiment, remember to test just one variable at a time.

DATA AND OBSERVATIONS

Make a data table to record your observations and measurements.

LAB 2 DESIGN YOUR OWN CALCULATOR-BASED LAB

ANALYZE AND CONCLUDE

1. What question about the water quality of the body of the water was your experiment set up to test?

2. What procedure did you use to test your hypothesis?

3. Did your procedure produce useful data? Explain.

CHECK YOUR HYPOTHESIS

Do your data support your **hypothesis**? Why or why not?

LAB 2

DESIGN YOUR OWN

CALCULATOR-BASED LAB

APPLY AND ASSESS

1. What conclusions can you draw about the water quality based on your data?

2. How might you redesign the experiment to yield better results?

FURTHER INVESTIGATION

- What new questions were generated as a result of your investigation? How might you design an additional investigation to answer those questions?
- Do research to find out what general standards drinking water must meet. Find out where your drinking water comes from and whether the body of water that supplies it meets these standards. If there have been problems with the body of water, find out what they are. Contact your local water utility to ask how they are dealing with any problems. Share your findings with the class.

Name Class Date

LAB 3 CALCULATOR-BASED LAB

Use with Chapter 11
Section 11.1

How does the presence of water vapor and carbon dioxide affect the temperature of Earth's atmosphere?

If the gases in the atmosphere did not absorb energy, Earth would be too cold to support life as we know it. Earth's atmosphere acts like a huge greenhouse that traps heat. The atmosphere allows short wavelength energy such as visible light and ultraviolet light to enter. Earth's surface absorbs this energy and reemits it as longer-wavelength infrared energy. Like the glass of a greenhouse, Earth's atmosphere prevents much of this infrared energy from escaping, and thus the energy heats the atmosphere.

The atmosphere contains nitrogen, oxygen, water vapor, carbon dioxide, and trace amounts of numerous other gases. Some of these gases help maintain Earth's surface temperatures. They are known as greenhouse gases. Water vapor is the major heat-trapping gas. However, the overall concentration of water vapor in the atmosphere does not seem to be significantly affected by human activities. In contrast, levels of the greenhouse gas carbon dioxide have been increasing over time. How could this affect Earth's temperature?

For this lab, you will produce the carbon dioxide by the following reaction:

$$NaHCO_3(s) + HC_2H_3O_2(aq) \rightarrow NaC_2H_3O_2(aq) + CO_2(g) + H_2O(l)$$

PROBLEM

What effect does the presence of carbon dioxide and water vapor in the air have on temperature of the atmosphere?

OBJECTIVES

- **Hypothesize** how water vapor and carbon dioxide (CO_2) affect air temperature.
- **Measure** and **graph** the effect on temperature when water vapor and carbon dioxide are added to air.
- **Draw conclusions** about how the presence of carbon dioxide and water affects the temperature of the air.
- **Infer** how the data gathered in this experiment might help explain global warming.

HYPOTHESIS

Hypothesize which sample will show the greatest rise in temperature when exposed to solar energy: air alone, air that contains added water vapor, or air that contains added carbon dioxide and water vapor.

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LAB 3 CALCULATOR-BASED LAB

PREPARATION

MATERIALS

black marker
3 pint-size plastic resealable storage bags
water
25-mL graduated cylinder
baking soda
vinegar
balance
CBL unit
TI graphing calculator
link cable
3 temperature probes
flood lamp (if conducting inside)
tape
hand pump

SAFETY PRECAUTIONS

- Wipe up any spilled liquid.
- Vinegar is an acid and may irritate skin.

PROCEDURE

PRODUCE THE GASES

1. Use the marker to label one plastic bag "control." Use the hand pump to fill it with air. Close the bag.
2. Label the second bag "water vapor." Pour 20 mL of water into the bag. Then use the pump to fill it with air to the same volume as the control.
3. Label the third bag "carbon dioxide and water vapor." Place 10 grams of baking soda in a bottom corner of the bag. Roll the bag so the baking soda will not mix immediately with the vinegar you are about to add. Pour in 20 mL of vinegar and quickly close the bag. If the volume is less than the control, add air with the pump until the volumes are the same.

SET UP THE CBL

4. Connect three temperature probes to one CBL. Link the CBL to the calculator.
5. Select CHEMBIO and a temperature problem in each of the three channels.
6. From COLLECT DATA, select TIME GRAPH. Select TIME BETWEEN SAMPLES = 6 SECONDS; select 80 SAMPLES.
7. A window will appear in which you can check the setting. Press ENTER if the numbers are correct.
8. Ymin should be 15. Ymax should be 80. Scl should be 1. Do not press ENTER until you have your experiment set up and ready to go.

SET UP THE EXPERIMENT

9. Place the temperature probes on a flat surface in the bright sun or under a flood lamp. **CAUTION:** *The surface of the flood lamp may be hot.*
10. Place the bag labeled "control" over the temperature probe in channel 1 so that the black probe tip touches the bag. Tape the probe to the bag.
11. Place the bag labeled "water vapor" over the probe in channel 2, making sure that the probe is not touching the liquid. Tape the probe to the bag.
12. Place the bag labeled "carbon dioxide and water vapor" over the probe in channel 3, making sure the temperature probe is not touching the liquid. Tape the probe to the bag.
13. Check the set-up. Make sure all bags receive the same amount of light and the probes are touching the surfaces of the bags.
14. Press ENTER on the CBL to begin collecting data.
15. When the CBL says DONE, the graph will appear on the calculator screen. Sketch the graph in the data table.

LAB 3 CALCULATOR-BASED LAB

DATA AND OBSERVATIONS

Graphs

Air

Air and water vapor

Air, water vapor, and CO_2

Table

Gases	Initial Temperature	Final Temperature	Change in Temperature
Air			
Air and water vapor			
Air, water vapor, and CO_2			

ANALYZE AND CONCLUDE

1. Describe the contents of each bag.

2. Describe the graphs, including patterns you observe. If the curves are not smooth, what could account for slight dips? (Hint: Was it a cloudy day?)

3. Was there a difference in the change in temperature inside the three bags?

4. Contrast the temperature change for air alone; air and additional water vapor; and air and additional water vapor and carbon dioxide.

CHECK YOUR HYPOTHESIS

Did your data support your **hypothesis**? Why or why not?

APPLY AND ASSESS

1. Based on the data you gathered during this experiment, does the addition of water vapor or carbon dioxide to air affect its ability to retain heat? Explain your answer.

2. Which substance has the greatest effect on the ability of air to retain heat? Explain your answer.

3. The amount of carbon dioxide entering Earth's atmosphere has been increasing since the late nineteenth century, largely as the result of the burning of fossil fuels by industry, in vehicles, and to produce electric power. Based on the results of this experiment, do you think there could be a relationship between the increase in carbon dioxide in the air and global warming? Explain your answer.

FURTHER INVESTIGATION

- Design and conduct an experiment to determine if carbon dioxide or water vapor affects temperature more. How could you get a bag of carbon dioxide without water vapor?
- Do research to identify the major greenhouse gases that help the atmosphere hold in heat. Find major sources of the gases and write a report on what people can do to decrease the amount of these gases that are added to the atmosphere.

Name Class Date

LAB 4 CALCULATOR-BASED LAB

Use with Chapter 8, Section 8.3 and Chapter 14, Section 14.4

How might global warming affect sea level?

Studies indicate that an increase in greenhouse gases can cause an increase in atmospheric temperature. The temperature increase could be about 2–3°C over 100 years. That may not seem like a big problem. But could this small increase affect the level of the world's oceans?

PROBLEM

What effect would an increase in temperature have on water volume?

OBJECTIVES

- **Hypothesize** how temperature increase might affect a volume of water.
- **Measure** any change in the volume of a water sample as temperature increases.
- **Make a table** to display the results of your experiment.
- **Draw conclusions** about how temperature affects water volume.
- **Infer** how an increase in atmospheric temperature could affect sea level on Earth.

HYPOTHESIS

Hypothesize how a rise in temperature would affect the volume of a water sample.

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PREPARATION

MATERIALS

200-mL graduated cylinder
10-mL graduated cylinder
red food coloring
125-mL flask
one-hole stopper to fit the flask
Pasteur pipette
tape
small millimeter ruler
large beaker
hot plate
ring stand and clamp
temperature probe
CBL unit
TI graphing calculator with ChemBio program
pipette bulb

SAFETY PRECAUTIONS

- Wipe up any spills immediately to prevent slips or falls.
- Use caution when handling hot surfaces or liquids. Liquids may spray out if overheated in a flask.

PROCEDURE

You will work with a partner to complete this activity.

SET UP THE EQUIPMENT

1. Mix 200 mL of water with red food coloring to make the water level easier to read.
2. Fill the 125-mL flask to the rim with the colored water, then put the stopper on the flask.
3. Place the pipette in the one-hole stopper. ***CAUTION: Be careful when inserting the pipette into the one-hole stopper. It could puncture or cut your skin.*** The water should rise into the pipette, but there should still be a lot of room for the water to expand up the pipette. If the water rises too far, remove the stopper and take a little water out of the flask.
4. Tape a ruler to the pipette so you can easily read the change in height of the column.
5. Using the ring stand and clamp, connect the clamp to the neck of the flask. Place the flask in the hot water bath setup. The beaker should be on the hot plate, but the heat should *not* yet be turned on. See figure below.
6. Record the level of the water in the pipette in millimeters. Place a mark on the flask at the bottom of the stopper. You will use this later to determine the exact amount of water in the flask.
7. Place the temperature probe in the water bath near but not touching the bottom of the flask.

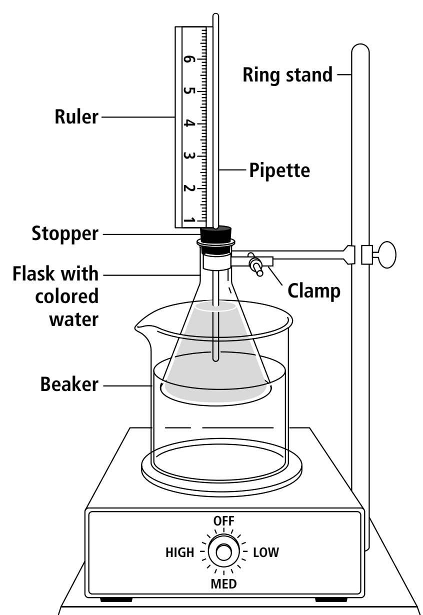
SET UP THE CBL

8. Connect the temperature probe to the CBL in channel 1. Connect the CBL to the calculator.
9. Select CHEMBIO and 1 probe (temperature) in channel 1.
10. Select COLLECT DATA and TRIGGER PROMPT.
11. Allow 1 minute to pass before taking the first data point. When the temperature readings stop changing, press TRIGGER on the CBL. It will prompt you to record a value. Record the level of the liquid in the pipette.
12. Select MORE DATA
13. Turn on the hot plate.
14. When the water level has increased 2 mm, press TRIGGER. The calculator will record the temperature and prompt you to enter the liquid level. Also record the water level and temperature in the data table on the next page.
15. Select MORE DATA.
16. Repeat the procedure until you have collected 10–15 data points or the liquid level is approaching the top of your pipette. This will vary with the pipette you use. If you use a very thin pipette, record about every 5 mm. If you use a thick pipette, record about every 1 mm. Try to measure at least a 5°C temperature change if possible.
17. Select STOP and GRAPH. Sketch the graph in the box on the next page.

FIND THE VOLUME INCREASE

To find the exact volume of the water at maximum temperature, you need to know how much water was in the flask and in the pipette. Use room temperature water for the following three steps.

18. Remove the stopper from the flask. Fill the flask to the mark you made in step 6. Pour the water from the flask into a 200-mL graduated cylinder. Record the volume in your notebook.
19. Remove the pipette from the rubber stopper. Fill the pipette with the same amount of water it held at its maximum during the experiment.
20. Drain the water from the pipette into a 10-mL graduated cylinder.



DATA AND OBSERVATIONS

Data Table

Temperature (°C)	Height of Water (mm)

Graph

Water Rise Due to Temperature

ANALYZE AND CONCLUDE

1. Does the volume of the water sample change with a rise in temperature? Explain.

2. What is the relationship between temperature and volume? By what percentage does volume change for each 1.0°C change in temperature? Show your calculations.

CHECK YOUR HYPOTHESIS

Did your data support your **hypothesis**? Why or why not?

APPLY AND ASSESS

1. Based on the data you collected during this experiment, would a rise in global temperature result in an increase in the volume of oceans? What would be the general effect on sea level?

2. What might be the effect on coastal areas worldwide? Would this present a problem? Explain your answer.

FURTHER INVESTIGATION

Some studies project a possible rise in sea level of about 48 cm (19 in) by the year 2100. Report on possible effects of this rise in one of the major cities at or near the East or Gulf Coast, such as New York City; Charleston, South Carolina; Miami, Florida; or New Orleans, Louisiana.

LAB 5 CALCULATOR-BASED LAB

Use with Chapter 27
Section 27.3

How does increased CO_2 affect the pH of water?

An acid is a substance that produces hydrogen ions (H^+) when dissolved in water. A base is a substance that produces hydroxide ions (OH^-) when dissolved in water. We measure the amounts of H^+ ions and OH^- ions present by the unit pH. The pH scale ranges from 0 to 14. On the pH scale, 7 is neutral. A pH below 7 is considered to be acidic, whereas a pH above 7 is basic.

Carbon dioxide, CO_2, reacts with water to form carbonic acid as indicated in the following reaction:

$$CO_{2(g)} + H_2O_{(l)} \leftrightarrow H_2CO_{3(aq)}$$

Carbonic acid, a weak acid, breaks down to produce H^+ in the following reaction:

$$H_2CO_{3(aq)} \leftrightarrow 2H^+ + CO_3^{2-}$$

Notice that the arrows in the above reactions go both ways. This means that the reaction can go either forward or in reverse. It is possible for $H_2CO_{3(aq)}$ to disassociate into $CO_{2(g)} + H_2O_{(l)}$.

In this experiment, you will test the effect of dissolving CO_2 on the pH of distilled water. The CO_2 for this activity is produced when your body burns the food you eat. The gases you exhale contain CO_2. In the second part of the experiment, you will test the pH of boiled distilled water after heat has driven off the gaseous CO_2.

PROBLEM

How will the pH of water change if carbon dioxide is dissolved in it?

OBJECTIVES

- **Hypothesize** how adding carbon dioxide changes the pH of distilled water.
- **Measure** the change in pH of distilled water as carbon dioxide is added or removed.
- **Contrast** the pH of water with differing amounts of carbon dioxide.
- **Graph** the change in pH as carbon dioxide is dissolved in distilled water.
- **Infer** what is responsible for any difference in the change in pH.

HYPOTHESIS

Hypothesize how adding carbon dioxide to distilled water will change the pH.

PREPARATION

MATERIALS

TI graphing calculator
link cable
CBL unit
plastic bottles with pond or lake water
straws (2)
pH probe
distilled water
100-mL beakers (2)

SAFETY PRECAUTIONS

- Wipe up any spills immediately to help prevent slips or falls.
- Wear an apron and safety goggles during the lab procedure.

PROCEDURE

1. All glassware in this experiment must be clean.
2. Pour 50 mL of distilled water into a clean 100-mL beaker. Pour another 50 mL of distilled water into a second 100-mL beaker.
3. Remove the pH electrode from the storage bottle and rinse it with distilled water. Calibrate the pH probe as instructed by your teacher.
4. After calibrating the pH probe, you should be back to the MAIN MENU.
   a. Select COLLECT DATA. Press ENTER.
   b. Select TIME GRAPH. Press ENTER. The calculator display should read ALLOW 30 SECONDS FOR CBL TO WARM UP. The CBL should display READY and three dashes. Wait 30 seconds. Press ENTER.
   c. Enter 1 for time between samples. Press ENTER.
   d. Enter 60 for the number of samples. Press ENTER.
   e. The screen will show the sample time of 1 second, the number of sample–60, and the experiment length–60 seconds. Press ENTER.
   f. Select USE TIME SETUP. Press ENTER.
   g. Set *Y*-AXIS MINIMUM to 1. Press ENTER.
   h. Set *Y*-AXIS MAXIMUM to 14. Press ENTER.
   i. Set *Y*-SCL to 1. Press ENTER. You will see a message that says you are ready to begin.
5. Press ENTER to begin collecting data. As soon as the CBL starts sampling, place a straw below the surface of the distilled water in the beaker and blow for 1 minute. Swirl the beaker gently as you blow into the water. The CBL will read, graph the pH, and record the values in the calculator.
6. When the CBL displays DONE, TIME IN L1 AND PH IN L2 WILL APPEAR. Press ENTER.
7. Sketch your graph in the space provided in the data table. Record the initial pH and the final pH. Press ENTER.
8. Select NO for repeat experiment. Press ENTER.
9. Return to the main menu and select COLLECT DATA and MONITOR INPUT.
10. Place the pH probe in the water in the second beaker and record the pH. Remove the probe and boil the water for 3 minutes. Allow it to cool for 2–3 minutes. Use the probe to find the pH of the boiled water.
11. Place a clean straw below the surface of the boiled water and blow for 1 minute. ***CAUTION:*** *Avoid splashing any liquid out of the beaker. Hot water can burn your skin.* Measure and record the pH.

DATA AND OBSERVATIONS

EFFECT OF CO_2

Table 1

Distilled Water Graph as CO_2 Is Added

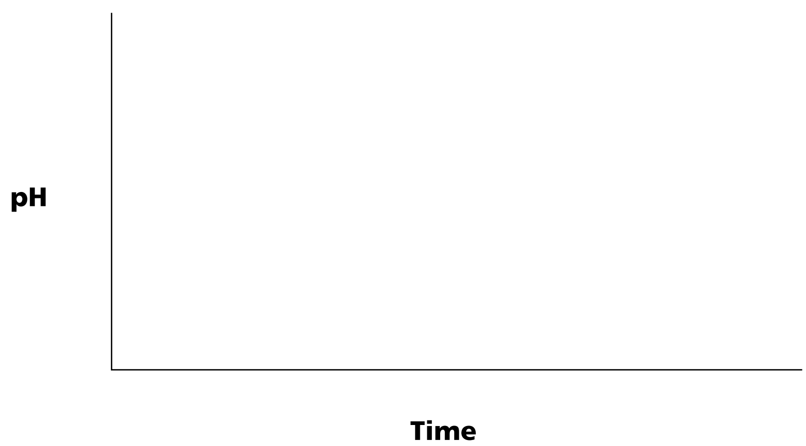


Table 2

	Initial pH	Final pH	ΔpH
Distilled water			
Boiled distilled water			

ANALYZE AND CONCLUDE

1. What is the initial pH of both water samples?

2. What happened to the pH of the distilled water as you added CO_2?

3. Write an equation(s) for the reaction that occurred when you blew in the water.

4. Infer why this happened.

ANALYZE AND CONCLUDE, *continued*

5. Write an equation(s) for the reaction that occurred when you boiled the water.

6. Why did the pH of the boiled water go up?

7. What happened to the pH when you added CO_2 to the water?

8. Infer what accounts for the difference.

CHECK YOUR HYPOTHESIS

Was your **hypothesis** supported by your data? Why or why not?

APPLY AND ASSESS

1. Most textbooks say water has a neutral pH of 7. Why is that most often not the case?

2. If normal rainwater has a pH of between 5.6 and 6.0, is this an indicator of pollution in the air?

3. What do you think would happen if increased carbon dioxide is present in the air?

FURTHER INVESTIGATION

Collect rainwater and measure its pH. Contrast your results with room temperature distilled water.

Name Class Date

LAB 6 **CALCULATOR-BASED LAB**

Use with Chapter 27
Section 27.3

Simulating Acid Precipitation Using H_2SO_4

Rainwater is slightly acidic naturally. But human activities can make it even more acidic, with harmful environmental effects. The problem starts with the burning of fossil fuels in power plants and motor vehicles. Burning these fuels produces sulfur dioxide and nitrogen oxide emissions. They combine with moisture in the air to produce sulfuric and nitric acid, which fall from the sky as acid precipitation. Acid precipitation enters surface water bodies such as lakes, ponds, streams, and oceans, where it can change the water's pH levels. How much of a change there is in pH depends in part on substances dissolved in the water. Some bodies of water contain natural substances, called buffers, which help neutralize the acid that comes from acid precipitation. In water bodies without these buffers, acid precipitation can cause excessive and harmful levels of acidity that can disrupt aquatic ecosystems.

PROBLEM

What effect does the addition of acid have on water taken from various sources? What accounts for the difference? What effect can this have in the natural environment?

OBJECTIVES

- **Measure** the change in pH levels of different water samples as acid is added.
- **Record** the results in a data table.
- **Compare** and **contrast** the change in pH of water samples recorded in the table.
- **Draw conclusions** about what is responsible for the difference in the change in pH levels among water samples.
- **Infer** why some bodies of water are more sensitive to acid precipitation than others.

PREPARATION

MATERIALS

TI graphing calculator
link cable
CBL unit
pH probe attached to port in CBL
container of distilled water
50-mL graduated cylinders (4)
100-mL beakers (4)
bottle of 0.1 M sulfuric acid
dropper
50 mL distilled water
50 mL ocean water
50 mL lake or pond water
50 mL buffer solution

SAFETY PRECAUTIONS

Handle acid with care. If acid spills, wipe it up right away. Dispose of the cloth as directed by your teacher.

PROCEDURE

Work in groups of three. Calibrate the CBL according to your teacher's instructions.

Test the change in pH of distilled water.

1. Remove the pH electrode from the case. Pour some distilled water from the container over the pH electrode to rinse it.
2. Measure 50 mL of distilled water with the graduated cylinder. Pour it into a 100-mL beaker.
3. Place the pH probe in the sample of distilled water.
4. Select COLLECT DATA. Press ENTER.
5. Select TRIGGER/PROMPT. Press ENTER. The calculator should read ALLOW 30 SECONDS FOR CBL TO WARM UP. The CBL should display READY and three numbers. Wait 30 seconds. Press ENTER.
6. Read the CBL display. When the numbers on the display stop changing, press TRIGGER. ENTER VALUE should appear on the calculator's display.
7. Enter 0, the number of drops of sulfuric acid added so far.
8. Press ENTER. The calculator now displays a DATA COLLECTION menu.
9. Select MORE DATA. Press ENTER.
10. Add 1 drop of sulfuric acid to the beaker. Swirl the contents of the beaker thoroughly. Do not spill the contents. When numbers on the CBL display stop changing, press TRIGGER. Enter the total drops of sulfuric acid that have been added to the beaker to this point (1 drop).
11. The DATA COLLECTION menu appears. Select MORE DATA. Press ENTER.
12. Repeat steps 10–11 until 10 drops of sulfuric acid have been added to the beaker. Select STOP AND GRAPH. A graph should appear. Press ENTER.
13. Select NO for repeat experiment. Press ENTER.
14. Select QUIT. Press ENTER. The calculator will display DONE.
15. Press STAT. EDIT will be highlighted.
16. Press ENTER. The drops will be in L1 and the pH in L2. Record the pH values for each drop (rounded to two decimal places) in Table 1.

Test the change in pH levels of ocean water.

Repeat steps 1 through 16 above with 50 mL of ocean water using a clean graduated cylinder and beaker.

Test the change in pH levels of lake or pond water.

Repeat steps 1 through 16 above with 50 mL of lake or pond water using a clean graduated cylinder and beaker.

Test the change in pH levels of buffer solution.

Repeat steps 1 through 16 above with 50 mL of a buffer solution using a clean graduated cylinder and beaker.

Name Class Date

LAB 6 CALCULATOR-BASED LAB

DATA AND OBSERVATIONS

Table 1 Changes in pH Levels

Drops	Distilled Water	Ocean Water	Lake or Pond Water	Buffer Solution
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

ANALYZE AND CONCLUDE

1. Which water samples maintained a fairly stable pH for the longest period after you started to add acid?

2. How many drops of acid were added to each sample before a pH change greater than 2.0 occurred?

3. In which water samples did the pH drop most quickly when you began to add acid?

4. Based on the rate of change in pH for each sample, which sample(s) respond most similar to the buffer solution? Explain your answer.

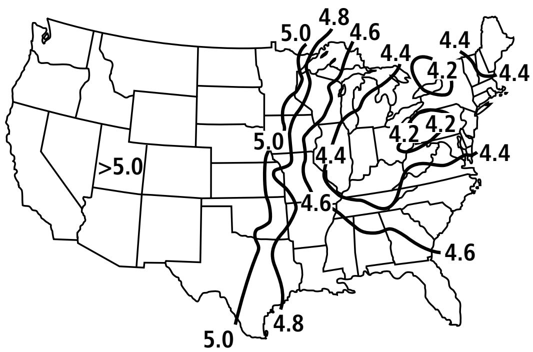
APPLY AND ASSESS

1. Infer why the sample(s) in question 4 above responded like the buffered solution.

APPLY AND ASSESS, *continued*

2. Many aquatic organisms can survive in water only within a narrow range of pH values. In which type of body of water—lakes, ponds, or oceans—would organisms be more affected by acid precipitation? Explain.

pH of Rainwater Falling on the United States



3. Use the map above to determine which part of the country has the most acidic precipitation.

4. Acid precipitation falls in both Indiana and New York. But lakes in New York suffer more negative effects of the acid precipitation than do those in Indiana. Why do you think this is the case?

Table 2 pH Range in Which Various Organisms Can Survive

	pH 6.5	pH 6.0	pH 5.5	pH 5.0	pH 4.5	pH 4.0
Trout	■	■	■	■		
Bass	■	■	■			
Perch	■	■	■	■	■	
Frogs	■	■	■	■	■	■
Salamanders	■	■	■	■		
Clams	■	■				
Crayfish	■	■	■			
Snails	■	■				
Mayfly	■	■	■			

Source: EPA Website *http://www.epa.gov/acidrain/student/water.html*

5. Use Table 2 to determine the organism that would be best able to withstand the negative effects of acid precipitation in a lake. Explain your answer. Then use Table 1 on page 23 to determine whether that organism would survive in pond water after five drops of acid were added. After ten drops were added?

Name Class Date

LAB 7

DESIGN YOUR OWN

CALCULATOR-BASED LAB

Use with Chapter 3, Section 3.2 and Chapter 7, Section 7.1

How does exposure to acid solutions affect metal and stone?

Many important structures in the United States are made of metal and stone. These include bridges and significant buildings. When acid precipitation falls on these structures, problems can result.

PROBLEM

How does exposure to acid solutions affect metal and stone?

OBJECTIVES

- **Design** an experiment to test the way the pH of a solution affects materials exposed to it.
- **Compare** and **contrast** the effect of pH on various materials.
- **Record** the results in a data table.
- **Infer** how acid precipitation would affect bridges, buildings, and other structures made of metal and stone.

HYPOTHESIS

Write a hypothesis about how exposure to solutions of different pH will affect various metal and stone samples.

PREPARATION

POSSIBLE MATERIALS

CBL unit
TI graphing calculator
pH probe
container of distilled water
hydrochloric acid
tap water
baking soda
spoon
dropper
100-mL beakers (3)
iron sample
copper sample
zinc sample
marble sample
limestone sample
mass balance

PREPARATION, *continued*

SAFETY PRECAUTIONS

- Be careful when pouring liquids, and avoid splashing liquids onto skin. Acid solutions can burn and irritate skin.

PLAN THE EXPERIMENT

- Working with a partner, make a list of the steps you will follow to test your hypothesis. As you plan the experiment, remember to test just one variable at a time.
- If you intend to use the pH probe, plan to calibrate it as your teacher directs.
- If you intend to use acid solutions, decide how you will make them and test their pH.
- You might plan an experiment to test the effect of several solutions (each with a different pH) on one type of material. In that case, you will have to find a way to prepare the solutions and confirm the pH of each one with the CBL and pH probe.
- You might also plan an experiment that tests the effect of a solution of one pH on several of the available materials.
- Decide how you might use the mass balance to measure the effect of the solutions on the materials you test.

DATA AND OBSERVATIONS

Use the data table below to record your measurements.

Solution	Material Tested	Mass Before Test	Mass After Test

ANALYZE AND CONCLUDE

1. Did the material samples change after exposure to the solutions? How did they change?

2. Did the pH of the solution in which the material samples were placed affect how much the material changed over time? How?

3. Did the type of material tested affect the results? If so, how?

4. Which sample changed the most after exposure to the solution? Which changed the least? Explain your results.

5. What is the relationship between the pH of the solution and the amount of change in the exposed material?

CHECK YOUR HYPOTHESIS

Did your experiment prove your **hypothesis**? If not, what might have caused the error?

APPLY AND ASSESS

1. How are the solutions you used in this experiment like acid precipitation?

2. Based on your experiment, how would acid precipitation with a low pH affect metal bridges or stone buildings?

3. How would the pH of the acid precipitation change its effect on buildings and other structures?

4. Would the effects of acid precipitation change depending on the type of stone or metal exposed to it? Explain your answer.

5. How could builders use this information to decrease the effects of acid precipitation on structures made of metal or stone?

FURTHER INVESTIGATION

Test additional materials and add your observations to the data table. Share your findings with the rest of the class.

LAB 8 CALCULATOR-BASED LAB

Use with Chapter 25, Section 25.3 and Chapter 27, Section 27.2

What is the effect of deforestation on the microclimate of an area?

Microclimates are local climate conditions that differ from the general climate of an area. Places with heavy vegetation, such as forests, create microclimates for many reasons. The trees cast shadows and block low-level winds. Trees also take in water from the ground and release it through their leaves, affecting humidity. The forest provides habitats for small mammals, birds, reptiles, amphibians, insects, and many invertebrates. The trees provide a place to live that is sheltered from the elements as well as from predators. The forest is both cooler in the hot summer and warmer in the cold winter. The shade of the forest means greater humidity than in open areas where direct sunlight increases rates of evaporation. Animals living in the forest enjoy a more moderate environment than animals in the open areas.

In this lab, you will find out how a forest microclimate differs in terms of temperature, humidity, and light intensity from treeless areas nearby. Then you will consider how the loss of trees could affect both the microclimate and wildlife population of a forest ecosystem.

PROBLEM

What is the difference in microclimate of a forest, a field, and a paved area?

OBJECTIVES

- **Hypothesize** how three microclimates differ.
- **Apply** knowledge of the CBL to collect temperature, relative humidity, and light-intensity data.
- **Use a table** to record data gathered during the lab.
- **Construct graphs** with data gathered during the lab.

HYPOTHESIS

Hypothesize how the microclimate of a forest, a field, and a paved area might differ.

LAB 8 CALCULATOR-BASED LAB

PREPARATION

MATERIALS

meterstick
CBL unit
TI graphing calculator
link cable
temperature probe
relative humidity sensor
light sensor
garden trowel

SAFETY PRECAUTIONS

Be sure to wear long sleeves, long pants, and closed-toe shoes when working in wooded areas to protect your skin from poisonous plants, tick bites, and mosquito bites.

PROCEDURE

You will work with a group.

SETTING UP THE CBL AND PROBES

1. Connect the CBL unit to the graphing calculator using the link cable.
2. Insert the temperature probe into channel 1 of the CBL, the relative humidity sensor into channel 2, and the light sensor into channel 3.
3. Turn on the calculator and CBL. Select CHEMBIO.
4. Press ENTER two times to go to the MAIN MENU. Select SET UP PROBES. Type in 3 for the number of probes and sensors.
5. Select TEMPERATURE and press ENTER. Type in 1 for the channel. Press ENTER.
6. In the Select Probe Menu, select MORE PROBES and then select RELATIVE HUMIDITY. Select 2 for the channel number. Press ENTER. For calibration, use STORED. Press ENTER.
7. In the Select Probe Menu, select MORE PROBES and then select LIGHT. Select 3 for the channel number. Press ENTER. For calibration, use STORED. The calculator screen will remind you to switch on the probe (sensor). Turn the switch on the light sensor to 1–150,000 LUX. Press ENTER. Select the same light setting on the calculator. Press ENTER.
8. Select DATA in the MAIN MENU. Select MONITOR INPUT. The calculator screen will display temperature in CH 1, relative humidity in CH 2, and light in CH 3. (Wait for the probes or sensors to stabilize when collecting readings, especially with the relative humidity sensor.)

COLLECTING THE DATA

9. You will be measuring temperature, humidity, and light intensity in three environments: a forested area, an open field or a lawn, and a paved area such as a parking lot. The calculator will remain on the Monitor Input screen while you are in the field. It will display all three readings simultaneously, but focus on measuring only one variable at a time. Occasionally a link cable will dislodge or the data readings will freeze. You will then have to reset the calculator.
10. Take measurements in the forested area and the field or lawn at three heights: 1 meter above the ground, at ground level, and 5 centimeters below the surface. Use a meterstick to measure heights and a garden trowel to dig the area below the surface. Skip the below-ground reading in the paved area.
11. To take each measurement, hold the probe or sensor at the desired height until the reading stabilizes, usually less than a minute. Point the light sensor toward the ground—not the sky. A reading will appear on the Monitor Input screen of the calculator. When each reading stabilizes, copy it into your notebook.
12. Start with the forested area. Repeat the measurements for the field or lawn. Then collect data in the paved area.
13. Enter the data from your notebook in the tables on the next page.

Name Class Date

LAB 8 CALCULATOR-BASED LAB

DATA AND OBSERVATIONS

Table 1

Height	Forest Temperature (°C)	Field Temperature (°C)	Paved Area Temperature (°C)
1 m			
0 m			
−5 cm			—

Table 2

Height	Forest Relative Humidity (%)	Field Relative Humidity (%)	Paved Area Relative Humidity (%)
1 m			
0 m			
−5 cm			—

Table 3

Height	Forest Light Intensity (Lux)	Field Light Intensity (Lux)	Paved Area Light Intensity (Lux)
1 m			
0 m			
−5 cm			—

On a separate sheet of paper, draw bar graphs that compare the temperature of the three sites at the same height. Repeat for relative humidity and light intensity.

ANALYZE AND CONCLUDE

1. How does the temperature vary with height at each site?

Forest ____________________

Field ____________________

Paved Area ____________________

2. Compare the temperature change among the three sites.

____

3. How does the relative humidity change with height at each site?

Forest ____________________

Field ____________________

Paved Area ____________________

ANALYZE AND CONCLUDE, *continued*

4. Compare the relative humidity change among the three sites.

5. How does the light intensity change with height at each site?

Forest

Field

Paved Area

6. Compare the light intensity change among the three sites.

7. Summarize the difference in microclimate between the forested and nonforested areas.

CHECK YOUR HYPOTHESIS

Did your data help you support your **hypothesis**? Explain your answer.

APPLY AND ASSESS

1. Based on your findings of differences in microclimate, which of these sites would a small mammal prefer? Explain your answer.

2. What effect would removing the forest have on the microclimate of the area?

3. How would removal of the forest and the changes you described in question 2 affect wildlife in the forested area? Explain your answer.

4. Would the loss of the forested area affect the climate of the area around it? Explain your answer.

FURTHER INVESTIGATION

Find a fourth type of microclimate area (such as a hilltop, a gully, or an area bordering water) to test. Collect data there and compare this microclimate with the others previously tested in the lab.

LAB 9 CALCULATOR-BASED LAB

Use with Chapter 7, Section 7.2 and Chapter 27, Section 27.2

How can runoff affect the water quality of streams and rivers?

As the number of housing developments, shopping centers, roads, and office complexes increases, more forests, wetlands, and grasslands disappear. Aside from the beauty of these natural environments, what is lost? Are there negative environmental effects when vegetation is replaced by impervious surfaces such as parking lots, highways, and sidewalks? Does the type of land use along a body of water affect the type and the amount of runoff that flows in?

In this lab, you will survey your community to find developed areas where runoff into streams or rivers is occurring. What effect is that runoff having on the water into which it flows?

PROBLEM

How does the removal of vegetation near a river or stream affect water quality?

OBJECTIVES

- **Hypothesize** how removal of nearby vegetation affects water quality of a river or stream.
- **Apply knowledge of the CBL** to collect water conductivity data.
- **Use a table** to record data gathered during the lab.
- **Make a map** of your study area.
- **Infer** the reason for the determined water quality.

HYPOTHESIS

Hypothesize how the removal of vegetation near a river or stream affects its water quality.

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___

___

LAB 9 CALCULATOR-BASED LAB

PREPARATION

MATERIALS

CBL unit
TI graphing calculator
link cable
conductivity probe
8 water sampling bottles
containers with distilled water for soaking probes
notebook
pencil

SAFETY PRECAUTIONS

- Be sure to wear long sleeves, long pants, and closed-toe shoes when working in wooded areas to protect your skin from poisonous plants, tick bites, and mosquito bites.
- Use caution when working near streams to avoid falling in water.

PROCEDURE

You will work with a group to determine the chemical input to streams or rivers by using a conductivity meter.

SETTING UP THE CBL AND PROBES

1. As a group, look at a map and choose the area along a river or stream that you want to sample. Draw a map of the area on a separate sheet of paper and note where there are land uses such as farms, golf courses, parking lots, parks, forests, lawns, stores, or factories. *CAUTION: Avoid construction sites.*
2. Identify several sampling sites in the area you choose. Add them to your map. On the table on the next page, note the conditions of the banks along the river or stream at each site. Also note the weather conditions (such as recent precipitation) when you sample.
3. Collect water samples from the sites. Make sure the water sampling bottles are clean and there is no soap residue inside. Before using the conductivity probe, soak its tip in distilled water for 10 minutes.
4. Connect the CBL unit to the calculator by the link cable. Insert the conductivity probe into Channel 1.
5. Turn on the CBL and calculator. Select CHEMBIO (under PRGM on the TI-83, or APPS on the TI-83+). Press ENTER twice to get the Main Menu.
6. Select SET UP PROBES. Type in 1 for the number of probes. Press ENTER. In the Select Probe Menu, select CONDUCTIVITY. This is a freshwater activity, so set the probe on 0–2000 microsiemens (MICS). The screen will remind you to read the calculator rather than the CBL screen.
7. Select 1 for the Channel Number. Press ENTER. For calibration, use STORED. You are only interested in comparing sites, not the actual conductivity of each site.
8. On the Conductivity Menu, select 0–2000 MICS. In the Main Menu, select COLLECT DATA. On the Data Collection screen, select MONITOR INPUT. Be sure to rinse the probes between samples.

Name Class Date

LAB 9 CALCULATOR-BASED LAB

DATA AND OBSERVATIONS

Site Number	Site Description	Weather Conditions	Conductivity Reading
(upstream) 1			
2			
3			
4			
5			
6			
7			
8 (downstream)			

ANALYZE AND CONCLUDE

1. Which site has the greatest level of conductivity, or dissolved ions?

2. What could account for this level of conductivity?

3. How is conductivity affected as you move from upstream to downstream sites?

4. How did conductivity next to shores with vegetation compare to those with bare soil?

LAB 9 CALCULATOR-BASED LAB

CHECK YOUR HYPOTHESIS

Did your data help you support your **hypothesis**? Explain your answer.

APPLY AND ASSESS

1. What are the possible sources of the ions (pollution) that entered the water in your sampling area?

2. Why should sites near vegetation have fewer ions (less pollution) than those sites near bare soil?

3. Why do increased ions in a body of water often mean water that is more polluted?

FURTHER INVESTIGATION

Repeat this activity, taking samples from several sites before and after a heavy rainstorm. Determine whether conductivity is connected with rainfall.

Name Class Date

LAB 10 CALCULATOR-BASED LAB

Use with Chapter 26, Section 26.3 and Chapter 27, Section 27.1

How much wasted energy goes out the window?

Heat flows from hotter objects to cooler objects. This fact can become a problem when you are trying to keep a room warm in cold weather or cold in warm weather. In winter, warm air flows out of buildings, largely through windows. In very hot weather, heat can enter buildings through windows, making air-conditioning less efficient. The energy lost through windows alone accounts for 17 percent of a building's heating and cooling costs.

In this lab, you will measure the amount of energy lost through the windows of your classroom and determine the cost of this wasted energy.

PROBLEM

How much energy is lost through classroom windows, and what does it cost?

OBJECTIVES

- **Hypothesize** how much energy is lost through classroom windows.
- **Measure** the area of windows in your classroom.
- **Use the CBL** to determine the temperature inside and outside of classroom windows.
- **Calculate** the energy lost through your classroom windows.

HYPOTHESIS

Hypothesize how much energy is lost through the windows of your classroom.

____

____

PREPARATION

MATERIALS

CBL unit
TI graphing calculator
link cable
temperature probe
yardstick (because of units used to measure energy, yards must be used instead of meters)
notebook

SAFETY PRECAUTIONS

LAB 10 CALCULATOR-BASED LAB

PROCEDURE

You will work with a group of three to four people.

1. Measure the length and width of each window in your classroom. Calculate the area of the windows, as illustrated in Table 2 below.
2. You will now use the temperature probe to determine the temperature on the inside and outside of the windows. Connect the CBL unit and the calculator with the link cable. Turn on the unit.
3. Insert the temperature probe in Channel 1. Select CHEMBIO.
4. Press ENTER twice to get the MAIN MENU. Select SET UP PROBE. Type 1 for the number of probes. Under SELECT PROBE, choose TEMPERATURE. Type 1 for the channel number. Press ENTER.
5. In the MAIN MENU, select COLLECT DATA. Press ENTER. In the DATA COLLECTION MENU select MONITOR INPUT. Press ENTER. The temperature will be displayed on the calculator.
6. Select five areas of your window from which to collect temperature data. You will take the readings at these five spots both inside and outside. To take each reading, hold the temperature probe two centimeters away from the window for 1 minute. Record the temperature. Convert the Celsius temperature to Fahrenheit using the following formula: $F = 9/5\ C + 32$. Record the temperatures in Table 3 on the next page. Take the five inside readings. Then repeat this procedure outside. Find the difference in temperature by subtracting the outside from the inside.
7. To calculate the energy lost or gained through a window in BTUs (British Thermal Units), use the following formula:

   To calculate heat loss or gain in BTUs per hour:

   $$\text{BTUs per hour} = \frac{\text{feet}^2 \times \text{difference in temperature}}{\text{R-value}}$$

   To convert BTUs/hour to kilowatt-hours (units of energy use):

   $$\text{kilowatt hours} = \frac{\text{BTU}}{3412}$$

8. To calculate the cost of these kilowatt-hours, find out what you are charged per kilowatt-hour in your area. You can also use the average price charged for a kilowatt-hour in the United States, which is $.07.
9. Finish the calculations for the lab, using Table 4 on the next page. Use the example in the first column of the table to see how the calculations are done.

DATA AND OBSERVATIONS

Table 1 R-values for Different Types of Windows

Units	Single-pane windows	Double-pane windows	Triple-pane windows	Low emission windows
R-value	0.9	1.85	2.8	4.0

Table 2 Data Table for Area of Windows

Window type	Length	Width	Area in square feet	Number of windows of this type	Total square feet
Example	6 ft.	3 ft.	18 ft^2	6	108 ft^2
				Total area of all windows	

DATA AND OBSERVATIONS, *continued*

Table 3 Temperature Readings

Location	Inside Temperature	Outside Temperature
1		
2		
3		
4		
5		
Average		

Table 4* Results of Calculations

Units	Example	Actual classroom area for single-pane windows	If area of windows was cut in half	Cold day with a 40° temperature	Double-pane windows	Triple-pane windows	Low-emission windows
ft^2	108 ft^2						
Average inside temperature °F	70° F						
Average outside temperature °F	60° F						
Temperature difference	10						
R-value	0.9	0.9	0.9	0.9	1.85	2.8	40
Heat loss or gain in BTU/hr	$\frac{108 \times 10}{0.9} = 1200$						
Heat loss or gain in BTU/year**	$1200 \times 8760 = 10512000$						
Kilowatt-hours per year	$\frac{10512000}{3412} = 3081$						
Annual cost of kilowatt-hour (.07)	$.07 \times 3081 = \$215.70$						

* *Table 4 assumes that the classroom windows are single panes. If this is not the case, start on the appropriate column.*
** *This is based on the assumption that the temperature differences will be 10 degrees on an annual basis.*

ANALYZE AND CONCLUDE

1. Based on your calculations, list two ways that windows can be designed to reduce energy loss.

2. Heat exchanged through windows is affected by the difference between the inside and outside temperatures. How would your calculations be affected by taking these measurements at a different time of year?

CHECK YOUR HYPOTHESIS

Did your data help you support your **hypothesis**? Explain your answer.

APPLY AND ASSESS

1. Homes and offices often have many windows because they let in light and provide a pleasant view of outside scenery. Are there some climates in which large windows are not a good idea, in terms of energy efficiency? Explain your answer.

2. Because more light comes in through south-facing windows than north-facing windows, how would the placement of windows in the building affect heat loss or gain in your climate?

FURTHER INVESTIGATION

Estimate the amount of money your school could save by replacing its present windows with more energy-efficient ones. For example, if your school has single-pane windows, how much could be saved by changing to double-pane windows? If it has double-pane windows, how much would be saved by changing to triple-pane or low-emission windows? Include the cost of window replacement in your budget.

Name Class Date

LAB 11 CALCULATOR-BASED LAB

Use with Chapter 26
Section 26.3

Which type of lightbulb is more efficient?

When you see a lightbulb, chances are it's either incandescent or fluorescent. But each type of lightbulb works in a different way. In an incandescent lightbulb, electric current (a series of electrons) passes through a tungsten filament. Because the filament resists the flow of electrons, it heats up and glows, producing light. A fluorescent lightbulb contains mercury vapor. When electric current passes through the lightbulb, atoms of mercury vapor become excited and give off energy in the ultraviolet (UV) range. This UV energy makes a phosphorus coating inside the lightbulb glow, giving off light. Incandescent lightbulbs are much more common than fluorescent lightbulbs. In fact, there's a good chance that most of the lightbulbs in your home are incandescent lightbulbs. But which type of lightbulb is better to use?

In this lab, you will compare the energy efficiency of incandescent and fluorescent lightbulbs to see which type wastes more energy.

PROBLEM

How do incandescent and fluorescent lightbulbs compare in terms of energy efficiency?

OBJECTIVES

- **Hypothesize** how the energy efficiency of incandescent and fluorescent lightbulbs compares.
- **Use the CBL** to determine the light and heat energy given off by incandescent and fluorescent lightbulbs.
- **Calculate** energy efficiency.
- **Calculate** money saved by using the more efficient lightbulb.

HYPOTHESIS

Hypothesize how the energy efficiency of incandescent and fluorescent lightbulbs compares.

LAB 11 — CALCULATOR-BASED LAB

PREPARATION

MATERIALS

CBL unit
TI graphing calculator
link cable
light sensor
20-watt fluorescent lightbulb
20-watt incandescent lightbulb
2 disposable aluminum pie pans
2 alcohol-based thermometers
2 light fixtures
meterstick
pencil
notebook

SAFETY PRECAUTIONS

- Use alcohol-based thermometers during the lab procedure. Mercury is toxic and hazardous.
- Use caution when handling lightbulbs. Hot lightbulbs could burn your skin.

PROCEDURE

You will work with a partner.

COLLECTING LIGHT DATA

1. Connect the CBL unit to the graphing calculator using the link cable. Insert the light sensor into CHANNEL 1 on the CBL.
2. Turn the CBL and calculator on. Select CHEMBIO (under PRGM on the TI-83 or APPS on the TI-83+).
3. Press ENTER twice to reach the MAIN MENU. Select SET UP PROBES. Type 1 for the number of probes. Select LIGHT and press ENTER. Type 1 for the channel number. For calibration, use STORED. The calculator screen will tell you to set the switch on the light sensor. Place the switch on 0–600 LUX for indoor lighting. (The light sensor measures the visible energy emitted per m^2 or Lux.) Press ENTER. Select the same light range on the calculator. Press ENTER.
4. In the MAIN MENU, select COLLECT DATA. Then select MONITOR INPUT.
5. You must take readings in a dark room. The light source must be a bare lightbulb with no shade. Set up both lightbulbs in separate fixtures on a tabletop. To take readings, aim the light sensor directly at the lightbulb from a distance of 1 meter away. First, turn on the incandescent lightbulb and take a light sensor reading. Then turn that lightbulb off and turn on the fluorescent lightbulb. Take a reading from that lightbulb as well. Record the light readings in the Data Table on the next page.

COLLECTING TEMPERATURE DATA

6. The lightbulbs emit heat as well as light, and you will now measure the heat they give off. You will do this part of the lab with the room lights on. First, make a metal shade for each lightbulb by bending an aluminum pie pan so that it fits loosely over the lightbulb. Do this while the lightbulb is turned off.
7. Use the thermometer to record the initial room temperature.
8. Turn on the incandescent lightbulb and let the metal shade heat up for 2 minutes. Touch the thermometer gently to the metal shade covering the lightbulb. Record the temperature and the time it has taken the lightbulb to reach this temperature in the Data Table.
9. Repeat this procedure with the fluorescent lightbulb.

DATA AND OBSERVATIONS

Data Table

	Lux	Initial Temperature	Final Temperature	Time for Temperature to Stabilize
Fluorescent				
Incandescent				

ANALYZE AND CONCLUDE

1. Which lightbulb gives off more light?

2. How much more efficient is the brighter lightbulb? To find which is more efficient, use the following formula:

$$\frac{\text{Lux of brighter lightbulb} - \text{Lux of dimmer lightbulb}}{\text{Lux of dimmer lightbulb}} \times 100 = \%\ \text{more efficient}$$

(or energy of lightbulb)

3. Which lightbulb heats the metal shade to a higher temperature?

4. Which lightbulb raises the temperature more quickly?

CHECK YOUR HYPOTHESIS

Did your data help you support your **hypothesis**? Explain your answer.

APPLY AND ASSESS

1. Because both lightbulbs use the same wattage but produce different amounts of light, how is the extra energy lost? Explain your answer.

2. In order to have equivalent luminosity to a 25-watt fluorescent lightbulb, an incandescent lightbulb must be 100 watts. This fluorescent lightbulb costs $14 and uses $25 in electricity over its 10,000-hour life span. The 100-watt lightbulb costs $.40 but uses $100 in electricity if it had an equivalent life span. Actually, because the 100-watt lightbulb only lasts 750 hours, 13 lightbulbs would be used per fluorescent lightbulb.

a. What is the cost of using the fluorescent lightbulb? (price + cost of electricity = ?)

b. What is the cost of using the incandescent lightbulb? (price + cost of electricity = ?)

c. How much did you save by using the fluorescent lightbulb?

3. Taking into account what you found out about the two types of lightbulbs in this lab, why are incandescent lightbulbs used much more widely than fluorescent lightbulbs?

FURTHER INVESTIGATION

Are there incandescent lightbulbs in use in your home? Could your family save money by replacing all or some of them with fluorescent lightbulbs? Find out and compare your findings with those of other students in your class.

Use with Chapter 2
Section 2.3

How can you use a GPS receiver to find your position on Earth's surface?

Global Positioning System, or GPS, is a satellite system for locating your position on Earth. It was developed by the U.S. military to provide navigation information for the armed forces. The U.S. government now provides the system to anyone in the world who wants to use it, free of charge. As a result, GPS now has many uses worldwide. For example, GPS units are now standard equipment in ambulances, as well as in some cars and boats. GPS also has many applications in mapmaking, science, and aviation.

GPS has three parts: ground monitoring stations, satellites, and receivers. Ground monitoring stations keep track of the 24 GPS satellites and beam information up to them to correct any errors in their orbits. The satellites orbit Earth, sending signals to the ground that allow receivers to determine a user's location. The receiver is an electronic unit that shows the user's location on Earth's surface. You will learn how to use a GPS receiver in this lab.

PROBLEM

How can you use a GPS unit to find your exact location on Earth's surface?

OBJECTIVES

- **Hypothesize** how knowing your location could be useful.
- **Determine** your location using a GPS receiver.
- **Record** your location's latitude, longitude, and elevation using the GPS receiver.
- **Use a table** to record data showing your location.

HYPOTHESIS

Hypothesize how GPS can be used to determine location.

____

____

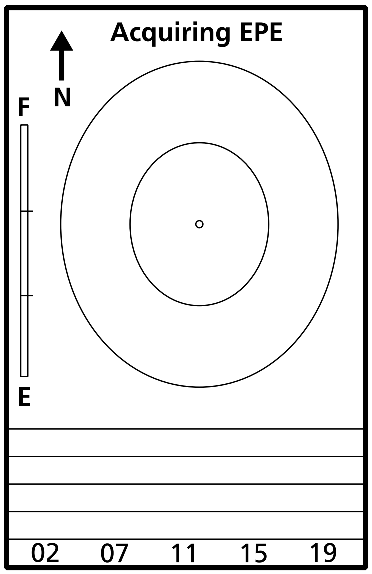
PREPARATION

MATERIALS

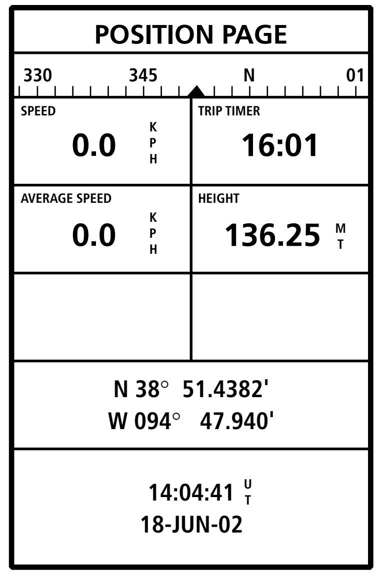
GPS unit notebook pencil

PROCEDURE

1. Turn on the GPS unit. You will see a display such as the one below. As the unit receives satellite signals, they will appear on the circles (representing the sky) relative to their position in the sky. Gray signal bars, such as those below, will appear on the bottom of the screen. The gray bars turn black when the receiver gets four strong signals.



2. On the diagram above, record the number of each satellite that appears on your display and draw in the satellites.
3. Observe the black bars on the display. The taller the bar, the stronger the satellite signal. Show the strengths of the signals by drawing black bars on the diagram.
4. You must receive strong signals from four satellites. After the bars become black, look at the top of the screen. If the unit reads 2D NAVIGATION, it is not getting a strong signal. Make sure you are not near a building that would obstruct the signal. If you see 3D, you are getting four strong signals. Decide whether you are receiving strong signals from enough satellites to determine your location.
5. Press the PAGE key to move to the position page, as you see in the next column. You will see your latitude, longitude, and elevation on the GPS display. Record them in the space provided under Data and Observations.
   The screen also displays the direction in which you are moving (heading), your speed, the time, and the date. The graphic compass tape across the top of the display shows your heading *only while you are moving.*



6. Walk in any direction for about 10 seconds. Observe what happens to the display as you walk. Record your observations on the next page. Also record your direction and speed as you walk.
7. Page to MAIN MENU. Select SETUP MENU. Press ENTER and highlight NAVIGATION.
8. Press ENTER. Under POSITION FRMT, you should see your location displayed in one of the three ways shown in the table below. Record your location in all three ways in the table in Data and Observations.

Latitude and Longitude

Reading	Example	Meaning
hddd°mm'ss.s	N36°00'50.4"	North 36 degrees 0 minutes and 50.4 sec
hddd°mm.mmm	N36°00.840'	North 36 degrees and .84 minutes
hddd.ddddd	N36.01399°	North 36.01399 degrees

PROCEDURE, *continued*

9. Press PAGE again and move to MAP PAGE. This page allows you to locate nearby cities or draw maps that you can display on the screen. (We will use this in Lab 13.) The receiver stores locations as "waypoints." To save a location, press MARK. The receiver will save the latitude and longitude of the location and store it in numerical order.
10. Press PAGE again to get to the NAVIGATION PAGE. This page looks like a compass. It shows the destination waypoint with the bearing (BRG) or the direction in which you should go, as well as the distance (DST) to the waypoint. Both are at the top of the page. The center contains a compass ring and an arrow to show you the direction of the waypoint in relation to the direction in which you are moving.
11. Press PAGE again and move back to the MAIN MENU page. You should now be familiar with the GPS unit and ready to go on to other lab assignments.

DATA AND OBSERVATIONS

1. What are your latitude, longitude, and elevation? (step 5)

2. What was your direction and speed as you walked? (step 6)

3. Record your position in the three ways described in the table below.

hddd°mm'ss.s	
hddd°mm.mmm	
hddd.ddddd	

ANALYZE AND CONCLUDE

1. Why should you record elevation as well as latitude and longitude?

2. What happened to the GPS display as you walked?

CHECK YOUR HYPOTHESIS

Did your data support your **hypothesis**? Explain your answer.

APPLY AND ASSESS

1. Why might scientists find it useful to use a GPS unit to find latitude, longitude, or elevation?

2. What conditions might make it difficult to use a GPS unit to find location?

FURTHER INVESTIGATION

Find the latitude and longitude of the school. Visit sites listed on the Glencoe Science Web Site for more information.

LAB 13 GLOBAL POSITIONING SYSTEM LAB

Use with Chapter 2
Section 2.1

How can you use GPS to make a map and find direction?

A map is a bird's-eye view of the landscape. If you were able to fly over an area, mapping it would be fairly easy. You would be able to see the buildings, streets, and major landforms in their proper shapes and in the correct locations. When you are on the ground, you have to use other means to find locations and map objects. One means is to use a tool that can give you data on locations, almost as if you had a bird's-eye view of an area. Using a GPS unit allows you to stay on the ground while using satellite data that determines the exact locations of the objects around you. How do you think this would affect your ability to make an accurate map or find your way from one location to another?

PROBLEM

How can you use a GPS unit as a mapmaking or direction-finding tool?

OBJECTIVES

- **Hypothesize** how a GPS unit can be used as a tool for making maps and finding direction.
- **Measure** latitude and longitude of locations using a GPS unit.
- **Make a map** based on observations.
- **Make a map** using data from the GPS unit.
- **Compare** and **contrast** a map made by observation with one made using GPS data.
- **Use a GPS unit** to find direction.

HYPOTHESIS

Hypothesize how a GPS unit can be used to produce a map and find direction.

____

____

PREPARATION

MATERIALS

GPS unit
medium-size rock or other marker
pencil
notebook

PROCEDURE

PART I: MAKING THE MAP

1. Make a rough sketch of the overall site you wish to map in your notebook. Decide where you will take GPS readings. Place an X on the map to mark the sites of these readings. Number the locations X1, X2, X3, and so on.
2. Turn on your GPS unit. Wait until you acquire four good satellite signals and the bars at the bottom of the display turn black. This is the same procedure you used at the beginning of Lab 12.
3. Select a “home” site. This might be your school entrance. When you have a good signal, press the MARK key, then press ENTER. The receiver stores the latitude and longitude of the site as a waypoint. Record the latitude and longitude in your notebook.
4. To draw a map on your GPS unit, press PAGE until you return to the MAIN MENU page. Highlight WAYPOINT. Press ENTER. The waypoint number you just entered is highlighted. Press ENTER again. If there are other waypoints stored, this latest waypoint should be the last number that appears.
5. The first digit in the three-digit number is highlighted. Press the UP or DOWN arrow key until you get to “H.” Press the RIGHT arrow to move to the second digit. Repeat the procedure to spell HOME. (You can skip this step and just record the waypoint number in your notebook.)
6. Press ENTER to save and end the name. Press ENTER again to highlight the small symbol to the right of HOME. Press ENTER again and a table with symbols will appear. Highlight the little house. Press ENTER. Arrow to DONE and press ENTER again.
7. Press ENTER until you return to the map screen. You should see a little house near the center of the screen.
8. Walk to the spot where you have drawn X1. Press MARK, then press ENTER. You may rename the point as you did with HOME in step 5 above, or record the waypoint number in your notebook. Record the latitude and longitude for X1 in your notebook. Place a marker here.
9. Continue the procedure by walking to and marking all of the planned X points for your map. Record the latitude and longitude for each waypoint in Table 1 on the next page.
10. Return to the spot you called HOME. Mark a waypoint at the return site for comparison. Do not delete the waypoints. You will use them in the next lab.
11. On the sketch of the map you drew in step 1 above, add the latitude and longitude of each waypoint to complete your map. Sketch the map displayed on the GPS screen for comparison.

PART II: FINDING DIRECTION ON YOUR MAP

12. Go to the starting point above called HOME. Turn on the GPS unit and wait for a strong signal.
13. Press GO TO. A list of waypoints should appear.
14. Press the DOWN arrow key to get to the waypoint your teacher has assigned you.
15. Press ENTER. A screen will appear that has BRG (bearing) and DST (distance) at the top. Bearing tells you the direction in which to go in order to get to the assigned waypoint. Distance tells you how far you are from the waypoint.
16. Walk in the direction as given by BRG and the compass. Observe and take notes on what happens as you walk. Locate the marker left by the last group.
17. Trade GPS units with another group. See if you can find your way to their waypoint 2 by following the BRG and compass. Take notes on how you decided which way to walk.
18. Press PAGE repeatedly to return to the map page.
19. Press ENTER. Use the arrow keys to increase the distance covered by the map (located at the top of the screen). After you change the scale, the GPS unit draws a new map. Record the cities that appear on the screen within 200 km of your location in Table 2 on the next page.

DATA AND OBSERVATIONS

Part I

Table 1

Waypoint	Latitude	Longitude
HOME		
X1		
X2		
X3		
X4		
X5		
X6		
X7		

1. Using only your latitude and longitude value, determine north, south, east, and west on your map. Draw a symbol on your map to show the north-south direction. Explain your procedure for determining direction.

2. How close were you able to come to your assigned waypoint?

3. How close were you able to come to the waypoint selected by another group of students?

Part II

Table 2

Cities Within 200 km
1
2
3
4
5
6
7
8
9

4. What happened when you walked in the direction indicated by BRG and the compass in step 16 in Part II on the previous page?

5. How did you decide which way to walk when looking at the BRG and compass readings on the GPS display?

ANALYZE AND CONCLUDE

Part I

1. How does your map compare to the map drawn by the GPS receiver?

2. How closely did your last waypoint's latitude and longitude match that of your home latitude and longitude? Explain.

Part II

3. Write instructions that someone else could use to find a location using bearing (BRG reading) on the GPS receiver.

4. What happened to the map when you changed the map scale?

CHECK YOUR HYPOTHESIS

Did your data support your **hypothesis**? Why or why not?

APPLY AND ASSESS

1. In this activity, you constructed a map using the GPS unit and then used the GPS unit to locate an object. What would you expect to see on the GPS-drawn map if a fence stood between waypoints 2 and 3 that you had walked around?

FURTHER INVESTIGATION

How is GPS used by police officers and firefighters in your area? Interview someone at your local police or fire department to find out. Write a short report on what you learn.

Name ______________________ Class ________ Date ________

LAB 14 GLOBAL POSITIONING SYSTEM LAB

Use with Chapter 2
Section 2.2

GPS Scavenger Hunt

In this activity, you will use GPS to plan a scavenger hunt, then use it again for a second hunt to find hidden objects. The activity is a game. But it allows you to use two skills you have learned with the GPS receiver: making maps and finding direction. Scientists also use this procedure to pinpoint a certain site and then return many times to it to collect data. In the first part of the activity, you will make a map that shows where you have hidden six objects. In the activity's second part, you will use your ability to read a map and find direction with a GPS receiver to find six objects hidden by classmates.

PROBLEMS

How can you use GPS to draw and store a map that other students can use in a scavenger hunt? How can you use a stored map drawn by other students to find the objects they have hidden?

OBJECTIVES

- **Apply** knowledge of the GPS unit to plan and draw a map.
- **Use a map** to create and complete a scavenger hunt.
- **Apply** knowledge of the GPS unit to find direction to hidden objects.

PREPARATION

MATERIALS

GPS unit
6 medium-size rocks
large marking pen
notebook

PROCEDURE

PART I: CREATING THE SCAVENGER HUNT AND MAP

1. Mark each rock with numbers 1 through 6. The numbers should be large enough to be seen from 2 or 3 m away.
2. Observe the area you will use for the hunt. As a team, plan where to place each rock. The rocks should be at least 10 m apart. Also, remember the GPS unit will give the direction as the shortest distance between two points. If a fence or building is in the direct line of sight, people may have difficulty following your map.
3. On a separate sheet of graph paper, plan where you will place the rocks by making a sketch of the campus and marking where you will place each rock.
4. Select a starting point and mark that point as the first waypoint. Record the latitude and longitude in Table 1 on the next page in case the batteries fail in the GPS unit or a different unit is used to relocate the rocks.
5. Place rock #1 at this starting point.
6. Walk to point #2. Press MARK to record that location. Record the latitude and longitude in Table 1. Then place rock #2 at that location.
7. Repeat this procedure for the four remaining rocks.
8. Now check your map. Return to rock #1. Press the GO TO key and select waypoint #2. Follow the directions on the GPS unit display to find waypoint #2. When you have a reading of 0 distance, the rock is nearby. Look around for it. Remember the readings may be off by several meters. Don't move the rock unless it is hard to see. If you have time, check the other four locations. Do not erase any of the waypoints.
9. Take the GPS unit to your teacher for further instructions.

PART II: USING THE GPS UNIT TO LOCATE OBJECTS

10. Turn on the GPS unit. Wait for a strong signal.
11. Page to the list of waypoints you are to find.
12. Press the GO TO button and select the first waypoint. The GPS unit may give you an option for HIGHWAY or COMPASS. Select COMPASS. Walk until the compass reading changes. Follow the arrow to waypoint #1.
13. As you approach waypoint #1, the GPS unit will beep. You should see a flash on the screen that says you have a message. Press PAGE and the message will read "approaching waypoint #1." You may still be 0.2 km away. Because the program is designed primarily for vehicles, this message will not be very helpful. Continue to follow the directional arrow and scan the ground when the distance reads "0." The GPS unit is accurate to about 10 m, so you may not be right next to the rock. But you should be close. When you find the rock, hold the GPS unit over it and record the latitude and longitude in Table 2.
14. Pick up the rock.
15. Press GO TO and select waypoint #2. Follow the directional arrow and locate rock #2. Collect the rock. Record the latitude and longitude of its location in Table 2.
16. Repeat the same procedure to collect and record the location of all the rocks.

Name Class Date

DATA AND OBSERVATIONS

Table 1

Hidden Rock #	Latitude	Longitude
1		
2		
3		
4		
5		
6		

Table 2

Found Rock #	Latitude	Longitude
1		
2		
3		
4		
5		
6		

ANALYZE AND CONCLUDE

Part I

1. Describe the method your group used to keep the reading on the compass geared toward a specific location.

2. What additional clues might you give the team that will use the map?

Part II

3. What problems did you have in checking your map?

4. How far were you from rock #2 when the GPS unit reported zero distance?

CHECK YOUR HYPOTHESIS

Did your data support your **hypothesis**? Why or why not?

APPLY AND ASSESS

Part I

1. Using the GPS unit, view the map by pressing PAGE repeatedly. How does this map compare to your planned sketch?

2. How could you make your scavenger hunt easier?

3. Other than making the rocks harder to find, how could you make your hunt more challenging?

Part II

4. What could the makers of the map have told you, other than the waypoints, that would have made this task easier?

5. Describe two ways GPS might be used to locate something.

FURTHER INVESTIGATION

Using the same waypoints from the scavenger hunt, draw a map of the area to scale that shows where the rocks were hidden.

Name Class Date

LAB 15 GLOBAL POSITIONING SYSTEM LAB

Use with Chapter 2
Section 2.1

GPS Scavenger Hunt for Experts

Here is an opportunity for even more practice with the GPS receiver. Find out how good you are at using the unit to find your way from point to point in a really advanced scavenger hunt. When you finish, you should have mastered the skill of using maps and finding direction with GPS.

PROBLEM

How can you use a GPS receiver to complete an advanced scavenger hunt?

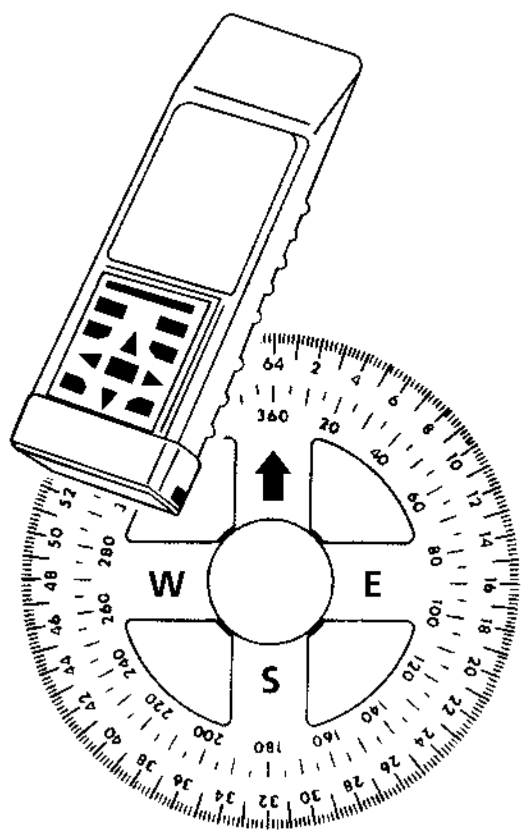
OBJECTIVE

Demonstrate an understanding of latitude and longitude when using a GPS unit to find objects.

PREPARATION

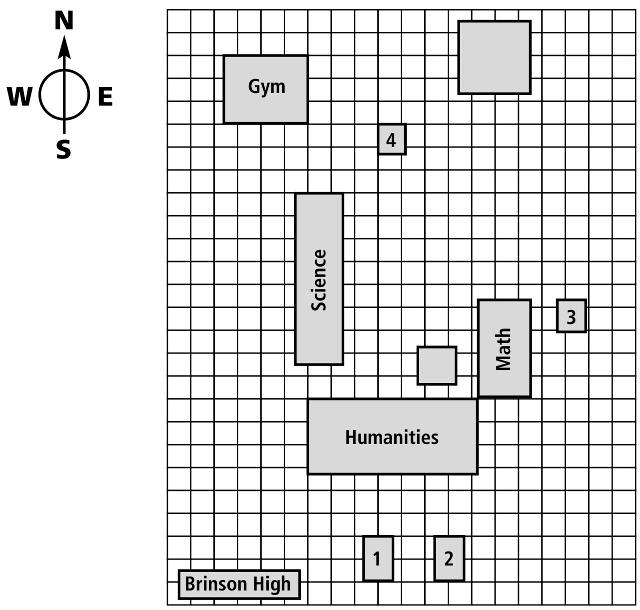
MATERIALS

GPS unit
pencil
notebook
6 rocks



PROCEDURE

PRE-LAB ACTIVITY



Practice Plan

1. N 36.01772° W 078.92089°
2. N 36.01772° W 078.92025°
3. N 36.01862° W 078.91983°
4. N 36.01904° W 078.92084°

1. In which direction should you walk to go from Point #1 to Point #2? Write your answer in Table 1.
2. In which direction should you walk to go from Point #2 to Point #3?
3. In which direction should you walk to go from Point #3 to Point #4?
4. In which direction should you walk to go from Point #4 back to Point #1?

COMPLETING THE LAB

5. Turn on your GPS unit. Wait until the unit receives strong signals from four satellites. Go to the latitude and longitude assigned to you by your teacher.
6. Record your coordinates (latitude and longitude) in Table 2.
7. With your GPS unit, walk to the first set of coordinates and look for rock #1. Remember the GPS will only record direction after you start moving.
8. Mark this first waypoint. Record the waypoint number. Then record both your assigned coordinates (latitude and longitude) and those from the GPS unit in Table 2. The GPS coordinates may be slightly different from the assigned values due to the limits of your unit. After you complete the activity, you will compare the readings from different teams.
9. Pick up the rock and look on the back for coordinates for the second location. Record the assigned coordinates. Replace the rock.
10. Repeat the steps until you get to the message on the last rock. Record the last message.
11. Return the GPS unit to your teacher with the saved waypoints for your route.

DATA AND OBSERVATIONS

Table 1

Route Traveled	Direction Walked
Point #1 to Point #2	
Point #2 to Point #3	
Point #3 to Point #4	
Point #4 to Point #1	

Table 2

Waypoint Number	Assigned Latitude	Assigned Longitude	Actual Latitude	Actual Longitude
Starting point				

1. In the pre-lab, how did you decide the direction in which to walk to get from point #1 to point #2?

____

____

2. In the lab, how did you decide the direction in which to walk to get from rock #1 to rock #2?

____

____

3. How far off was rock #2 from the assigned latitude and longitude?

____

____

ANALYZE AND CONCLUDE

1. Calculate the average error of the GPS unit for latitude. For each rock, subtract the actual latitude from the assigned latitude. Add each of these figures together and divide by the number of rocks.

2. Calculate the average error of the GPS unit for longitude.

3. Compare the average error of latitude to the average error of longitude.

APPLY AND ASSESS

1. Use the actual latitude and longitude you recorded to construct a map on a separate sheet of paper. List your latitude and longitude values on the map.

2. Make a set of rules that explain how to use latitude and longitude to find location.

FURTHER INVESTIGATION

GPS units in some cars can tell drivers how to find a street address. Research how the process works and write a brief report.

Name Class Date

LAB 16 GLOBAL POSITIONING SYSTEM LAB

Use with Chapter 2
Section 2.3

How does runoff in a watershed affect the water quality of a wetland?

A watershed is the area around a wetland that contributes surface runoff to the wetland. The type of runoff that enters a wetland depends on the land uses in its watershed. Rainwater washing over farmland or golf courses may produce polluted runoff that includes fertilizers and pesticides. There is a good chance that urban runoff contains pollutants such as grease, oil, street waste, and toxic chemicals used in vehicles and households.

Wetlands are among the most productive of ecosystems. The types of substances that enter wetland watersheds in runoff affect the health of these ecosystems. In this lab, you will determine the water quality in a wetland watershed by analyzing the types of runoff that enter it. You will work in groups to assess sources of pollution and water quality in part of a wetland watershed.

PROBLEM

How do adjacent land uses affect the water quality of a wetland watershed?

OBJECTIVES

- **Hypothesize** how land use around a wetland watershed affects the amount of nitrogen, phosphorus, and sediment in the water.
- **Measure** latitude and longitude of locations using a GPS unit.
- **Make a map** using GPS latitude, longitude, and distance between waypoints.

HYPOTHESIS

Hypothesize how different land uses around a wetland watershed affect its water quality.

____

____

PREPARATION

MATERIALS

GPS unit
pencil
notebook
calculator
internet access

PROCEDURE

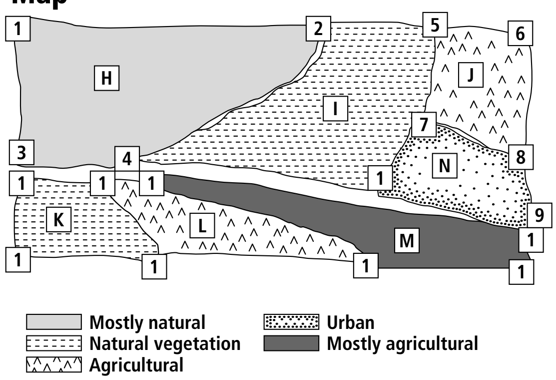
PART I: IDENTIFYING THE WATERSHED

- Choose a specific part of a watershed for study.
- Find an aerial photo and a topographic map of the watershed. Visit sites listed on the Glencoe Science Web Site for more information on aerial photos or topographic maps. Select SEARCH. Enter your latitude and longitude and press GO for a map of your area. On the menu bar at the left, select TOPOGRAPHIC, AERIAL, and SATELLITE to see all three views.

PART II: FINDING THE AREA AROUND THE WATERSHED THAT CONTRIBUTES RUNOFF

1. Make a draft land use map for your study area, similar to the sketch below.

Map



2. Find the area of each type of land that contributes runoff to the body of water in the watershed. To do this, you must measure the boundaries of each land-use area. You will need to walk these boundaries, so make sure you have permission to enter private property. Record the latitude and longitude of each land-use type at the intersections, *not* along its boundary lines. Press MARK to record these spots as waypoints. Record each land-use type and waypoint number in your notebook.

3. Determine the area of each land-use type. Some GPS units have a feature that will calculate the area for you. If your unit does this, follow the instructions in the manual. Then go to Part III. If your unit does not calculate area, continue with step 4.

4. In your notebook, list each waypoint in your study area, with its latitude and longitude.

5. Visit a site listed on the Glencoe Science Web Site for a calculator to determine distances between waypoints. This calculator will use the latitude and longitude figures you enter for each waypoint to determine the distances between them. Record the distance between waypoints on your map. You may also use the following formula to determine the distance between the waypoints on your map:

The great circle distance, *d*, between two points with coordinates {lat1, lon1} and {lat2, lon2} is given by:

$d = \mathrm{acos}(\sin(\mathrm{lat1}) \times \sin(\mathrm{lat2}) + \cos(\mathrm{lat2}) \times \cos(\mathrm{lat2}) \times \cos(\mathrm{lon1} - \mathrm{lon2}))$

A mathematically equivalent formula, which is less subject to rounding error for short distance is:

$d = 2 \times \mathrm{asin}(\mathrm{sqrt}((\mathrm{lat1} - \mathrm{lat2})/2))^2 + \cos(\mathrm{lat1}) \times \cos(\mathrm{lat2}) \times (\sin((\mathrm{lon1} - \mathrm{lon2})/2))^2))$

6. Use the length of each boundary line (distance between waypoints) to calculate the area of each land-use type. Record your results in your notebook. Ask your teacher for help if necessary.

PART III: CALCULATING THE NUTRIENT LOSS INDEX FOR THE WATERSHED

7. Use Table 1 to calculate the Nitrogen Loss Index for the watershed. This index indicates how much nitrogen enters the water through runoff. Fill in the third and fourth columns.

8. Use Table 2 to calculate the Phosphorus Loss Index for the watershed. This index indicates how much phosphorus enters the water through runoff. Fill in the third and fourth columns.

9. Calculate the Sediment Risk Index for the watershed. This index indicates how much sediment is lost through runoff. Use the formula Sediment Risk = F + G where

F = area of all agricultural land ÷ total area of land × 100% and

G = area of all agricultural land adjacent to watershed ÷ total area of land × 100%.

DATA AND OBSERVATIONS

Table 1

Land Type	Nitrogen Loss Rate (A) (in kg/ha/yr)	Area (B) (in ha)	Nitrogen Loss (C) C = A × B (in kg/yr)	$km^2 = 1\ 000\ 000\ m^2$ C × 100 = kg/ha/yr
Natural vegetation	0.44			
Mostly natural	0.45			
Agricultural	0.98			
Mostly agricultural	0.63			
Mostly urban	0.79			
Mixed	0.55			
Total	—			

Nitrogen Loss Index = $C_{Total} / (B_{total} \times 0.44)$

Table 2

Land Type	Phosphorus Loss Rate (D) (in kg/ha/yr)	Area (B) (in ha)	Phosphorus Loss (E) E = D × B (in kg/yr)	$km^2 = 1\ 000\ 000\ m^2$ E × 100 = kg/ha/yr
Natural vegetation	0.0085			
Mostly natural	0.018			
Agricultural	0.031			
Mostly agricultural	0.028			
Mostly urban	0.030			
Mixed	0.019			
Total	—			

Phosphorus Loss Index = $E_{Total} / (B_{total} \times 0.0085)$

(March 1998)
Natural vegetation > 75% forest and/or grassland
Mostly natural 50–75% forest and/or grassland
Agricultural > 75% agriculture
Mostly agricultural 50–75% agriculture
Mostly urban > 40% developed
Mixed—does not fall into one of the above categories

1. What is the predominant type of land use in your watershed? ______________________

2. What land-use type has the highest nitrogen and phosphorus loss? ______________________

3. Explain how you determined the area for each land-use type.

____

____

____

4. What was the Nitrogen Loss Index for the watershed? ______________________

5. What was the Phosphorus Loss Index? ______________________

6. What was the Sediment Risk Index? ______________________

ANALYZE AND CONCLUDE

1. What can you conclude from your data?

2. Infer why agricultural land is the only factor used in the Sediment Risk Index.

CHECK YOUR HYPOTHESIS

Did your data support your **hypothesis**? Explain your answer.

APPLY AND ASSESS

You can predict the amount of annual nitrogen or phosphorus loss by converting your area to hectares (ha). One ha equals 10 000 m^2. You can multiply the loss factor for nitrogen or phosphorus by the number of hectares to estimate the annual loss in kilograms.

For example, if your watershed has 870 000 m^2 of natural vegetation, then 870 000 $m^2 \div$ 10 000 m^2/ha = 87 ha; 87 ha $\times$ 0.44 kg/ha/yr = 38 kg/yr nitrogen lost.

1. Predict the amount of nitrogen lost annually for each land-use type. Then calculate the total loss for your area of study. Record your calculations in the fifth column on Table 1.
2. Predict the amount of phosphorus lost annually for each land-use type. Then calculate the total loss for your area of study. Record your calculations in the fifth column on Table 2.
3. An increase in nitrogen and phosphorus in waterways can cause plants in the water to grow too quickly and extensively. Explain why this would be a problem.

FURTHER INVESTIGATION

Research the land-use changes in the watershed area you studied over a period of several years. Research water-quality monitoring data for this body of water over the same period. Consult the Environmental Protection Agency or Natural Resources Conservation Service for information. Write a report that suggests how changes in land use affected water quality.