

## **Part 3: (Student Handout)**

**Note:** Distribute to students after they complete the *Prediction* in Part 2. See also the NSTA website, where there is a link to *Earth Science Success* resources.

**Anticipation Section Title:** (S-1) Becoming a Scientist

### **Thinking About the Problem**

What do scientists do? Scientists are a bit like detectives. Scientists and detectives try to find out why events happen and they both start with an investigation. This process involves close observation of the facts, making inferences about what was observed, developing an explanation that can be tested, and conducting experiments to see if the hypothesis (*hupotithenai*, “to guess” in Greek) turns out to be true. This method has often led detectives to solve crimes; it has also led scientists to exciting and valuable discoveries.

Scientific investigation for you, in this course, will involve observation, inference, and experimentation to see if your hypotheses are correct. This process can be repeated in case additional experimentation is needed if your hypotheses are found not to be correct.

Your first step in each scientific investigation will always be close and careful observation. Observations are simply information taken in through our five senses. Occasionally this leads to an anomaly. An anomaly (*a + homos*, “not the same” in Greek) means that something unexpected has happened. Scientists often learn much from anomalies.

Based on your observations, you will then make inferences. These involve using your observations to try to come up with an explanation, an educated guess. An inference is therefore your interpretation or explanation of what you observed. This leads you toward formulating a hypothesis, which is an explanation that can be tested in an experiment.

In this first lab, you will experiment with different containers and fluids. Observe carefully what happens. You are encouraged to make educated guesses about your observations, trying to determine which can easily be explained and which cannot. Be especially alert for anomalies that you observe.

### Data Collection Materials:

- Empty tubes with corks
- Set of fluids and tubes

### Data Collection Procedures: (Step-by-step instructions for student lab work)

- (1) Make verbal observations and predictions about the cylinder of fluids and the tubes. Using Data Collection Table #1, draw and label your prediction.
- (2) After your teacher does the demonstration, draw and label the actual results.
- (3) As a small lab group, come to agreement on a hypothesis (an easily testable explanation for one of the observations you made) about what happened.
- (4) Sketch and label an experiment to test your hypothesis.
- (5) Record all hypotheses, experiments, and results on Data Collection Table #2.
- (6) Conduct more experiments to test different hypotheses by following procedures 3–5.
- (7) Present your best results to the class.

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-1) Sizing Up the Planets

### Thinking About the Problem

What do astronomers do? The word *astronomy* (*astron*, “star” in Greek) means literally “the study of stars” and human beings have been gazing in wonder at the sky for a very long time. Careful observations by ancient scientists are what helped reveal “tricks” or “patterns” that explain events in the night sky. These ancient stargazers were from many different cultures, including the Greeks, the Romans, and the Mayans. They developed myths to explain events associated with things they did not understand (movements of the stars and planets, for example). Very careful observers from these cultures were able to explain things mathematically with reliability, predictability, and precision. It helped that there was far less light pollution long ago, which makes the stars harder for us to see today. These observers formulated testable hypotheses and science was born!

One observation that you could make is that Earth seems very large. Yet, Earth is dwarfed by our immense Sun. Earth, with its 12,756-kilometer diameter, is still 109 times smaller than the Sun. Even Jupiter, the largest planet, is only about one-tenth the Sun’s diameter. And Pluto, recently defined as a plutoid, is almost 600 times smaller than the Sun.

Processes and conditions that were at work during the formation of the solar system (*sol*, “sun” in Latin) about 5 billion years ago formed the planets into the sizes that we now observe. The four largest planets (Jupiter, Saturn, Uranus, and Neptune) contain enormous amounts of hydrogen and helium. Earth, and the other smaller planets, do not contain nearly as much of these gases. The quantities of these gases affect how large a planet can become. You will investigate this further in Lab A-4.

In this lab, you will develop your own scale model of the planets to learn about their relative sizes, compared with the Sun.

### Data Collection Materials:

- Calculator
- Metric ruler
- Model Sun (one for entire class)
- Newspaper
- One meter of masking tape

### Data Collection Procedures:

- (1) Find the diameter of our model Sun: \_\_\_ cm
- (2) Use the model Sun's diameter to calculate the Comparison Constant (CC) below. You will use the CC to figure out the diameters for each planet model.

$$\text{Model Sun Diameter} \div 109 = \text{CC}$$

$$\text{___ cm} \div 109 = \text{___}$$

- (3) Use Data Collection Table #1 to calculate the Planet Model Diameters for each planet. Multiply the Comparison Diameter by the CC to get the diameter for each planet model. Use only two decimal places in your answer.
- (4) For each planet, use wadded-up newspaper and tape to make a model with the required diameter.
- (5) Bring your collection of planets near the model Sun. Draw and label the planets, showing planet model sizes.

### **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-2) Estimating With Metrics

#### **Thinking About the Problem**

Can you name any advantages of the metric system (*metricus*, “relating to measurement” in Latin)? Does it make any difference if we measure in yards and feet versus meters and centimeters? Today scientists collaborate with colleagues all over the world, and it is vital that they have similar tools and standards of measurement at their disposal.

Two of the most important process skills that scientists use every day are estimations of measurement and the manipulation of standard laboratory equipment. Without skill in these two areas, accurate observations would be impossible. This is especially true when it comes to modeling the vast distances found in the study of astronomy.

As you have witnessed in Lab A-1, knowledge of the metric system is vital in science. Background knowledge of the metric system lends a globally understood language to findings by scientists. Many scientists from across the world are responsible for discoveries in astronomy and need to communicate effectively for the findings to be widely understood. Most units of scientific measure are defined by universal constants. For example, one meter is defined as the distance traveled by light in a vacuum in  $\frac{1}{299,792,458}$  of a second.

In this lab, you will enhance your skills in the areas of metric conversions, estimations of measurement, and the manipulation of standard laboratory equipment.

**Data Collection Materials:**

- Beakers
- Graduated cylinder
- Metric ruler
- Metric thermometer
- Triple beam balance

**Data Collection Procedures:**

- (1) First estimate, the mass and then use the triple beam balance to measure the mass of 15 miscellaneous objects from around the room.
- (2) Estimate the length of the following and then use a metric ruler to find the exact length: your arm, the room, a textbook, your height, and a desk.
- (3) Estimate the temperature of the following and then use a metric thermometer to find the exact temperature: room temperature, hot tap water, and cold tap water.
- (4) Estimate the volume of water in the bucket provided by your teacher. Then use a graduated cylinder to determine the exact volume.

### **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-3) Keeping Your Distance

#### **Thinking About the Problem**

Have you ever thought about how big our solar system is? With all of the classical planets, the plutoid planets, the dwarf planets, the moons, and the many comets and asteroids you are learning about, it may seem pretty crowded. But space in the solar system is surprisingly empty. Planets (*planasthai*, “to wander” in Greek), which are the largest bodies orbiting the Sun, are tiny compared with the Sun itself.

The distances between the planets are immensely larger than the size of the planets themselves. You may already know that Earth orbits the Sun at an average distance of 150 million kilometers (93 million miles). This distance is called one astronomical unit, or 1 AU. But do you know how far Mars is from the Sun? Do you know how far Neptune is?

Beyond Neptune is a region of icy objects, some with very large diameters, orbiting the Sun in what is called the trans-Neptunian region. The innermost section of this far away region is the Kuiper belt, named after Dutch-American astronomer Gerard Kuiper. It is in this region where some plutoid planets, such as Pluto and Eris, and some dwarf planets, such as Charon, are found. It is also believed that this region could be the source for some comets, such as Comet Halley and Comet Encke. You will investigate comets further in Lab A-7.

In this two-part lab, you will see for yourself how widely separated the planets are. Although, we will use circles to illustrate the orbits of the planets, their actual orbits are elliptical (*elleipein*, “to fall short” in Greek). Elliptical orbits are slightly flattened circles.

**Data Collection Materials:**

- 1m x 1m butcher paper
- Calculator
- Cardboard square
- Drawing compass
- Long stretch of straight land outside
- Metric ruler
- Model Sun
- Pushpin
- Scissors
- Sewing thread
- Ten small landscape flags

**Data Collection Procedures:**

- (1) Use the ruler to find the center of your butcher paper. Draw a small dot in the center, labeling it “Sun.”
- (2) Refer to Data Collection Table #1 for the orbit distance in centimeters (Use the scale of 1AU = 1 cm). For the first five planets, use the drawing compass to make circles of the proper radius on the paper. Label each planet.
- (3) For the other planets, including the plutoid planet Pluto, you will draw the orbits using thread as a compass. Stop when you reach the edge of the paper.
- (4) Draw and label a sketch of the planets and the Sun, showing approximate distances. Your sketch should indicate patterns in the spaces between planets.
- (5) Take a walk through the solar system with your teacher.



## Part 3: (Student Handout)

**Note:** Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-4) Comparing Planetary Compounds

### Thinking About the Problem

What are the planets made of? Isn't the firm ground we stand on basically the same as it would be on any of the other planets? Well, there are some planets that we would have a very hard time "standing" on, because they are composed basically of compressed gases and ice, and their vast size makes their gravitational pulls far too strong for human legs to withstand. These include the biggest of the planets in our solar system: Jupiter, Neptune, Saturn, and Uranus.

Made up mainly of lighter compounds, such as methane and hydrogen, the *Gas Giant* planets are only really solid at their cores. Conversely, the four planets that are closest to the Sun—Earth, Mars, Mercury, and Venus—are solid both at their cores and at their crusts. Because they each have a surface that is hard, they are grouped together as the *Terrestrial* planets (*terra*, "Earth" in Latin, *terre* in French, *tierra* in Spanish). The basic composition of Earth's core is iron, but there are also significant amounts of nickel and sulfur.

The compositions of the planets is dictated in part by their distances from the Sun. Separating the Gas Giants from the Terrestrial planets is a frost line, located 3.4 AU from the Sun, in the main asteroid belt. Inside the frost line, temperatures are high enough that only metallic elements are able to condense into solids. Beyond the frost line, temperatures are cool enough to allow even hydrogen and helium to condense into ices. By comparing the Gas Giants and the Terrestrial planets we can gain insight into the formation of our solar system.

At its start, our solar system was formed with a young star, which we call Sun, plus a considerable amount of matter, within the Sun's gravitational reach, including very hot metals and gasses. As time went by, this matter cooled, and rocks and metals that were closer to the Sun condensed into solids, while gasses did not. In the outermost planets, however, the light compounds as well as the rocks and metals condensed into types of ice. On the Terrestrial planets, light compounds such as hydrogen and methane remained as gasses; on the Gas Giant planets, being much farther from the Sun's warmth, even these light compounds often condensed into solid form.

As a result of their relative distances from the Sun, the planets Earth, Mars, Mercury, and Venus are composed mainly of metal and rock and are therefore smaller than the larger planets that contain a lot of ice and gas in addition to their solid cores. In this two-part lab, you will investigate densities of ice, stone, and iron, to learn about the composition of the planets.

### Data Collection Materials:

- 2 steel bolts (made of iron)
- 250 mL graduated cylinder
- Ice cubes
- Metric ruler
- Obsidian rock
- Triple beam balance

### Data Collection Procedures:

- (1) Fill the graduated cylinder with about 100 mL of water. Read the exact volume and record this value as the “starting water volume” in Data Collection Table #1.
- (2) Measure the mass of the rock in grams. Record results in Data Collection Table #1.
- (3) As soon as you have measured the rock’s mass, place it into the graduated cylinder. Read the “ending water volume” and record it in Data Collection Table #1.
- (4) Subtract the starting water volume from the ending water volume, entering the result as “change in volume” in Data Collection Table #1.
- (5) Remember that density equals mass divided by volume. Use the following equation to calculate the density of the rock:  
$$\text{Mass of Object (g)} \div \text{Change in Volume (mL)} = \text{Density (g/mL)}.$$
- (6) Repeat step #1–#5, using the iron and then the ice. When working with the ice, work quickly. Since it floats, use the tip of your pencil to push it down so that it is just barely submerged. Record your results in Data Collection Table #1.
- (7) Use the data from Data Collection Table #1, to make a vertical line 2 cm high for rock, iron, and ice on Data Collection Table #2.
- (8) Make a vertical line 1 cm high on Data Collection Table #2 for each of the planets listed in Data Collection Table #3. Label the lines for each planet. Earth has been done for you.

### **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-5) Reflecting on the Solar System

#### **Thinking About the Problem**

Have you ever looked up at the Moon on a cloudless night? The Moon seems so bright; you might imagine it to be covered in something highly reflective like snow or bright yellow paint. But looks are deceiving. In fact, if you held a piece of the lunar surface (*luna*, “moon” in Latin and Spanish, *lune* in French) in your hand it would appear very dark. The Moon only appears bright in the sky because it is illuminated by a tremendous amount of light from the Sun. It reflects some of that light back out into space, enabling you to see it so clearly.

The fraction of the light falling on a solar system object that is then reflected back into space is called its “albedo.” The albedo (*albus*, “white” in Latin) of an object can range from nearly zero (no light reflected back) to almost one (all light reflected back).

Observing the albedo of an object can help us determine what materials make up the object. A low albedo probably indicates a surface composed of dark rocks, as on the Moon. A high albedo is often due to the presence of clouds, as on Venus, or of a frozen icy surface, as on Neptune.

Earth’s albedo is less predictable because of large variations in cloud cover. The wide variation in Earth’s albedo is an important factor in studies of long-term climate and global warming. Any light energy that does penetrate the clouds gets trapped below them, a condition called the “greenhouse effect.”

A low albedo means that much of the incoming light and heat energy from the Sun is absorbed. The object that absorbs most of this energy will be warmer than an object that reflects away most of its light energy.

**Data Collection Materials:**

- Metric thermometer
- Various household objects used to build your low albedo device

**Data Collection Procedures:**

- (1) Build a low albedo device (LAD) out of simple materials. It will be due: \_\_\_\_\_.
- (2) Examine your LAD. Make mental observations about its size, color, and construction materials. Draw a labeled sketch of your LAD.
- (3) Magnifying glasses (and heat sources) will not be allowed and your device must hold one metric thermometer.
- (4) Record the temperature (in degrees Celsius) versus time (in minutes) results of your LAD investigation for 20 minutes in Data Collection Table #1.
- (5) Use the information in Data Collection Table #2 to organize and compare the albedos of various solar system objects in Data Collection Table #3.

### **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-6) Landing on the Moon

#### **Thinking About the Problem**

Have you ever thought about going to the Moon? This lab involves problem-solving in a simulated landing on the Moon.

Imagine that you are an astronaut and you are a member of a crew traveling to the Moon. Your spaceship is part of a convoy and each ship has its own crew (a group of your classmates). The convoy, unfortunately, is forced to land a considerable distance from the lunar base, and because the landing area is rough, all the ships receive minor damage during landing. None of the crewmembers is seriously hurt, but because the spaceship is disabled and the radios are broken, there is no way to signal for help. The travel distance from the crash point to the nearest base is 50 km. Each crew must get to the base without outside help.

Your main task in this activity is to decide which emergency supplies to take with you. Only the background knowledge of your fellow crewmembers can be used to help you make choices. No outside resources can be used, yet.

**Data Collection Materials:**

- Compass
- Extra oxygen
- First aid kit
- Flashlight
- Freeze-dried food
- Fuel for stove
- Inflatable raft
- Map of Moon
- Matches
- Mirror
- Parachute
- Pressure suits
- Raincoats
- Signal flares
- Sleeping bags
- Small stove
- Standard tent
- Suit repair kit
- Ten meters of rope
- Torches
- Water

**Data Collection Procedures:**

- (1) As a lab group you must discuss the importance or usefulness of each item.
- (2) Each group member must make a list of the items, in order of priority, on his/her lab report.
- (3) Each group member must write a statement next to each item, which justifies why he/she ranked the item in that position.

## Part 3: (Student Handout)

**Note:** Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-7) Orbiting Snowballs

### Thinking About the Problem

Have you ever made a snowball that started falling apart as soon as you threw it? Temperature, moisture levels, and debris within the snow all play a role in allowing the snowball to remain compacted when you throw it. That analogy may help in our study of comets during this lab.

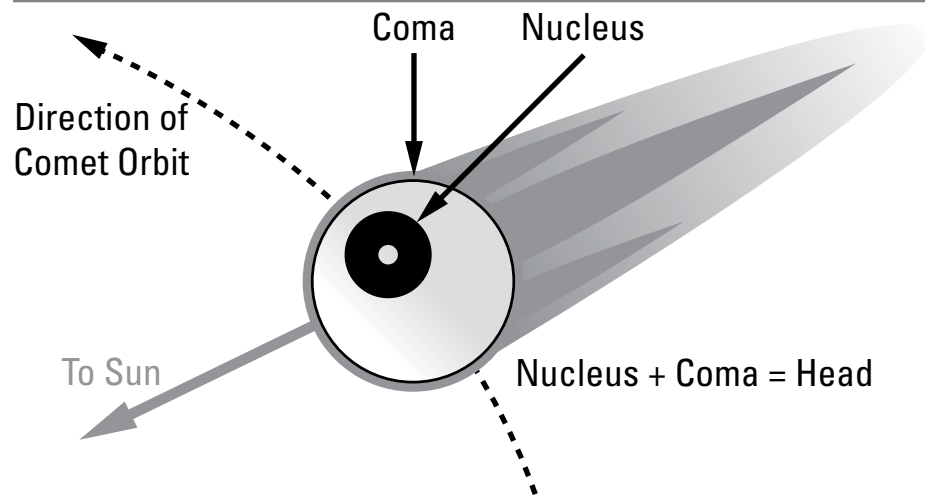
The stars in the night sky seem unchanging. The constellations your parents and grandparents knew are the same ones you can see tonight. The stable orbits of the planets carry them around the sky in predictable ways. Everything is orderly. But once in a while, something spectacular appears. A comet (*kome*, “hair,” and *aster*, “star,” in Greek) is a leftover remnant of the early formation of the solar system. It blazes in the sky for a few weeks as it passes through our section of the solar system.

In relatively recent years there have been some spectacular comets, easily visible with the naked eye. There were, for example, Comet Halley in 1986, Comet Hyakutake in 1995, and Comet Hale-Bopp in 1996. Extending outward from the bright head of the comet, the magnificent tail can stretch halfway across the sky. No wonder comets have been regarded with fear, awe, and suspicion throughout history.

Far from the Sun, a comet is dark. It has only a small “nucleus” (2–3 km diameter) made up of an icy sphere mixed with rock and dust. The frozen gases in the ice include water, carbon dioxide, ammonia, and some organic compounds. As comet approaches the Sun, the “coma” and the “tail” begin to develop (see Illustration 2.1). The Sun’s radiation heats the ices on the nucleus, but they don’t melt directly into liquid. Instead of melting, the ices “sublime” directly from a solid to a gas. Light from the Sun then reflects off of these gases, making them appear to glow.

Some of the glowing gas forms the “coma,” which surrounds and hides the nucleus. The rest of the gas streams back behind the comet (always in a direction away from the Sun) forming the “tail.” As the ices sublime, some of the dust and broken pieces of rock mix in, adding to the length of the tail. Comet tails can stretch for many millions of kilometers across space.

Illustration 2.1. Comet



### Data Collection Materials:

- Carbonated dark cola (15 mL)
- Dry ice (1 kg)
- Hammer
- Newspaper
- Protective gloves (worn always)
- Soil (10 g)
- Three resealable plastic sandwich bags
- Water (200 mL)



**Data Collection Procedures:**

- (1) Each lab group should place the set of plastic bags inside another to form a triple-layer bag.
- (2) Place the dry ice in the bag, carefully crumbling it with the hammer.
- (3) Hold bag while your partner adds dirt and cola.
- (4) Squeeze the bottom of the bag to mix the ingredients evenly.
- (5) Add the water. Immediately begin packing the materials inside the bag into a snowball shape.
- (6) Remove the comet from the bag and place it on the newspaper.
- (7) Observe and record the changes that your comet undergoes for 20 minutes. Draw and label a sketch of your comet.

### **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (A-8) Hunting for Space Flight History

#### **Thinking About the Problem**

Have you ever been part of a team on a scavenger hunt? Thanks to this lesson plan, with symbols borrowed from NASA, you are invited to participate on a hunt in (cyber) space. In some way, each of the objects in this scavenger hunt relates to a space flight history event that occurred between 1945 and 1979. Your task is to determine how each object is symbolic of something that happened in space flight history.

You and your group may use classroom computers (with internet connections) as a resource. You will have two class periods with computers to determine how each object relates to space flight history. This search can be very challenging, so use each of your group members for helpful advice during your searches.

At the end of our computer lab time, your group will compile its findings and hand them in to your teacher. We will then have a discussion about what aspect of space flight each object represents.

#### **Data Collection Materials:**

- Computers with internet access
- List of 20 scavenger hunt items (4 lists with 5 items on each, 1 per group)

#### **Data Collection Procedures:**

- (1) Sit side by side with your group members in front of a computer.
- (2) Review your list of objects. Use the internet to begin hunting for connections between the listed items and space flight history (1945–1979).
- (3) Record the results of your search in Table 2.21. Data Collection Table #1.

## Part 3: (Student Handout)

**Note:** Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (G-1) Weighing In on Minerals

### Thinking About the Problem

How can scientists figure out which mineral they are examining? Minerals are Earth materials that have four main characteristics: They are solid, inorganic (not a mixture of carbon, hydrogen, and oxygen), and naturally occurring, and they have a definite chemical structure. Minerals are identifiable based on a number of different properties. One is the mineral's particular crystal structure. For example, quartz has a hexagonal (*hexa*, "six" in Greek) crystal form. One is the planes, or cleavage lines, along which a mineral is weakest and tends to fracture easily. Another is the luster, or the way that light tends to reflect off a mineral's surface. Still another is the color left behind, called streak, when a mineral scratches a porcelain surface.

Scientists use these methods to identify minerals. In this geology (*geo*, "earth" in Greek) unit, you will learn about two diagnostic tests for minerals: density (in Lab G-1) and hardness (in Lab G-2).

How can you tell how dense rocks and minerals are? Geologists have developed tools that help measure density. A triple beam balance is used for this purpose. In addition, if the mineral to be measured is a regularly shaped object, such as a cube, its volume can be determined with a mathematical formula,  $L \times W \times H$ , where the letters represent length, width, and height.

To measure the volume of objects that do not have a regular shape, the mathematical formula given above for volume does not work. In those cases, a water displacement method can be used. Density (often referred to as "specific gravity" in geology) determines the mass of the mineral in relation to the mass of an equal volume of water. Mineral densities can range from 1 to 20. For example, quartz has a density of 2.65 and is 2.65 times as heavy as the same volume of water. Density values under 2 for minerals are regarded as *light* (amber is 1.0). *Normal* is the term given to minerals with density values from 2 to 3 (calcite is 2.7). All minerals above 3.0 are considered *heavy* (galena is 7.4). Testing for density is how people determined if they had found gold during the Gold Rush in early American history.

### Data Collection Materials:

- Graduated cylinder
- Six unknown mineral samples
- Triple beam balance
- Water

### Data Collection Procedures:

- (1) Determine and record the mass of all six minerals.
- (2) Use the water displacement method with the graduated cylinder to determine the volume of all six minerals.
- (3) Determine the density of each object ( $D = M / V$ ).
- (4) Record your density results in the class average data table.
- (5) Complete the Edible Stalactites and Stalagmites project (see Appendix B), presenting your results to the class.

## Part 3: (Student Handout)

**Note:** Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (G-2) Knowing Mohs

### Thinking About the Problem

Do you know why diamonds are often used as industrial tools? The answer is that they are so hard that they can be used to cut metals and other hard objects. In fact, the gemstone diamond is the hardest known mineral. Other hard minerals include topaz and quartz. On the other hand, do you know why talcum powder is so soft? This powder comes from pulverizing the mineral talc, which is very soft. Other soft minerals include graphite and gypsum. For geologists, the hardness of a mineral is determined by how easily it can be scratched compared with other minerals on a scale called the Mohs's Hardness Scale.

Scientists use various properties—such as hardness, luster, color, and, as you already know from our Lab G-1, specific gravity (density)—to help identify minerals. In this lab, you will learn to identify a set of minerals by comparing their hardness values against known standards. Glass (with a hardness value of 5.5), copper (hardness of 3.5), and a fingernail (hardness of 2.5) are frequently used by geologists as standards.

#### Data Collection Materials:

- Copper (Cu) plate
- Glass (SiO<sub>2</sub>) plate
- Hand lenses
- Iron (Fe) nail
- Six unknown mineral samples

#### Data Collection Procedures:

- (1) Test the hardness of each mineral by using the tools at your lab station. Record your results as “yes” or “no” in Data Collection Table #1.
- (2) Use Data Collection Table #2 and Data Collection Table #3 to help you estimate the Mohs's hardness value based upon your experiment results. Record your answer in each case as less than (<) or greater than (>).
- (3) Check the mineral; don't wreck the mineral.

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (G-3) Classifying Rocks and Geologic Role

### Thinking About the Problem

What are rocks made of? A rock is a natural mixture of minerals. Of the 3,000 known minerals, only a few dozen are essential constituents of rocks. A “felsic” mineral, which is a combination of the terms *feldspar* and *silica*, is among the most common minerals that make up rocks. Examples of felsic minerals are quartz, feldspar, and mica. The other most common mineral that makes up rocks is a “mafic” mineral, which is a combination of the terms that describe magnesium and iron. Examples of mafic minerals are olivine, pyroxene, and amphibole.

There are three main groups of rocks: igneous, sedimentary, and metamorphic. These are classified by the role that the Earth played in their development. Igneous (*igneus*, “fire” in Latin) rocks develop when liquid molten rock, called magma, solidifies in the Earth’s crust or on the Earth’s surface. The rate at which the magma cools plays a big role in the crystal size and mineral composition.

Sedimentary (*sedere*, “to settle” in Latin) rocks develop at the Earth’s surface as the weathering result of rocks exposed to wind, water, or ice. When weather and other forces of erosion wear away rocks, sediments form. Those sediments can be compacted, through the process of lithification (*lithos*, “stone” in Greek), to form sedimentary rocks.

Metamorphic (*metamorphoun*, “to change” in Greek) rocks develop through the transformation of other rocks due to great pressures or high temperatures. Those tremendously strong forces can change preexisting rocks through the process of metamorphism. Rocks remain solid during the entire process.

The rock cycle describes the roles and relationships among all three rock groups. We will study this in more detail at the end of Lab G-3. In this lab, you will use a rock classification system, called the Rock and Role Key, to determine into which group several unknown rocks fit.

**Data Collection Materials:**

- 9 rock samples
- Hand lens
- “Rock and Role Key”

**Data Collection Procedures:**

- (1) Examine each rock sample carefully. Check the rock; don’t wreck the rock.
- (2) Complete Data Collection Table #1 with detail, using the Rock and Role Key.
- (3) Determine if each rock sample is igneous, sedimentary, or metamorphic.

Figure 3.2. Rock and Role Key

### Rock and Role Key

Directions: Answer each question in sequence. Observe your rock sample carefully.

- (1) Is the rock made up of easily visible, separate particles (for example, crystals or sand)?
  - A. Particles are easily visible. [Go to step 3]
  - B. It is not composed of easily visible, separate particles. [Go to step 2]
- (2) Is the rock completely solid, glassy, or porous (sponge-like)?
  - A. The rock is completely solid. [Go to step 5]
  - B. The rock is glassy or porous. [The rock is igneous]
- (3) What types of particles make up your rock?
  - A. The rock is made of easily visible, shiny mineral crystals. [Go to step 4]
  - B. The rock is made up of sand or pebbles that appear to be cemented together. [The rock is sedimentary]
- (4) Do the mineral crystals of your rock tend to line up or form different-colored bands?
  - A. The mineral crystals are not lined up in a particular direction. [Go to step 7]
  - B. The mineral crystals tend to line up or form bands. [The rock is metamorphic]
- (5) Is your rock made up of visible layers, or does it tend to break into layers?
  - A. The rock has visible layers or tends to break into layers. [Go to step 6]
  - B. The rock has no layers nor does it break into layers. [The rock is igneous]
- (6) How reflective or shiny is your rock?
  - A. The rock is quite dull, not reflective or shiny. [The rock is sedimentary]
  - B. The rock is fairly shiny or reflective. [The rock is metamorphic]
- (7) Is your rock is made up of one or more different types or colors of mineral crystals?
  - A. There appear to be two or more types of mineral crystals. [The rock is igneous]
  - B. All of the crystals appear to be the same mineral. [The rock is metamorphic]



## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

Anticipation Section Title: (G-4) Unearthing History

### Thinking About the Problem

How old is the Earth? Geologists use information from rocks, rock layers, fossils (*fossus*, “dug up” in Latin), and other natural evidence to piece together the history of our planet. Geologists consider time from the formation of the Earth to today, following a geologic timescale that breaks Earth’s history into manageable pieces. Geologic time is divided and subdivided into eons, eras, periods, epochs, and ages. They have used this information to put geologic events and fossil organisms (evidence of living things) in their correct sequence on this time line. The boundaries are set by major events that have been preserved in the rock record.

More recent events can be measured in the soil, as well. For example, Earth scientists now believe that an early culture of humans, known as the Clovis people who wandered North America hunting mammoths and sloths, were wiped out by a mile-wide comet. They believe this due to evidence found in a thin layer of black soil, containing iridium from comets, which coats more than 50 sites in North America, especially near the Great Lakes.

Through research, including the use of the geologic timescale, most scientists conclude that the Earth is approximately 4.6 billion years old. You will learn more about what evidence scientists use to determine this age in Lab G-5. Compared to 4.6 billion years, living things have been around for a relatively short time. This lab will help you learn about the geologic time line for Earth and more clearly understand the various geological periods and events you will hear described in the media.

### Data Collection Materials:

- Earth History on a Rope scale model measurements
- Masking tape
- Rope or twine (5 m long)
- Ruler
- Scrap paper for labels

### Data Collection Procedures:

- (1) Lay the rope out on the ground in front of you. At the far right end, tape the label “Present Day.”
- (2) Starting from the Present Day mark, measure back exactly 4.6 meters. Label this “Formation of the Earth.”
- (3) Measure from the Present Day mark and label each eon, era, period, and epoch (with a different color code).
- (4) Use Data Collection Table #1 to label each event in Earth’s history.

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (G-5) Drilling Through the Ages

### Thinking About the Problem

Why are geologists interested in drilling? Geologists work together with engineers when drilling for groundwater wells. Drilling allows geologists to examine where different layers of rock begin and end. In the search for water, geologists frequently look for a layer of sandstone perched above a layer of impermeable shale.

Geologists also have an interest in drilling, because rock layers provide a record of events that have occurred on Earth. They can contain the remains and/or imprints of the different plants and animals that have lived on Earth.

As you learned in Lab G-4, scientists estimate that the Earth is approximately 4.6 billion years old. There are many pieces of supporting evidence for this. One piece of supporting evidence is the thickness of the rock layers on Earth. Although, in terms of accuracy, it is not the most effective method, scientists can perform experiments to determine how long it takes to create one meter of a particular rock type. They then multiply this time by the actual thickness of those particular rock layers on Earth. This allows scientists to roughly estimate the age of the Earth. Most geologists believe that it would have taken approximately 4.6 billion years to generate all the layers of rock found on Earth. This study of rock layer depths has been backed up by much more accurate evidence from radioactive minerals and index fossils in the rocks.

Earth scientists study the evidence associated with when the continents began to solidify. Newly discovered Greenland outcrops (an ancient piece of the sea floor, which was raised up by crustal movement) are among the oldest measured, at 3.8 billion years, while most of the continents are much younger, at 2.5 billion years old.

By understanding some simple rules about rock layer formation, we can use the layers and the associated rock types to measure the amount of time that has passed. One important thing to remember is that rock layers form horizontally. A second important factor is that the older rocks will normally be found farther beneath the surface, while younger rocks will normally be closer to the top. This allows scientists to use the positions underground to determine the “age based on position.” (cont.)

**Thinking About the Problem (cont.)**

Scientists can use index fossils to determine the “relative age” of layers. Index fossils are the remains of a single species that are so widespread and well-known (age-wise) that its fossils enable geologists to correlate environments and time. They can also measure the radioactive minerals found in a rock layer to determine the “absolute age” of the layer.

There are many deep wells (water, oil, etc.) available for geologists to examine. This lab uses the scenario of three water wells, drilled within five kilometers of each other.

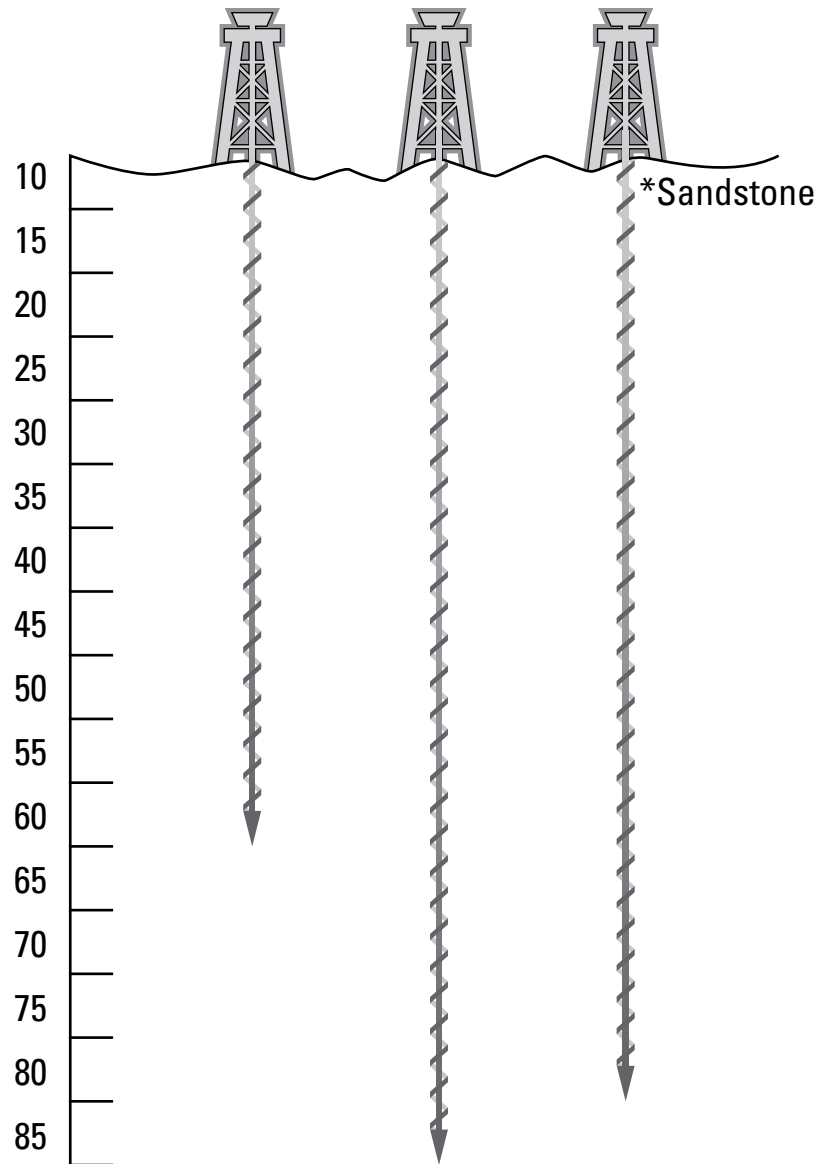
**Data Collection Materials:**

- Drilling Through the Ages Diagram (Figure 3.3)
- Metric ruler

**Data Collection Procedures:**

- (1) At each drilling site marked on the Drilling Through the Ages diagram, place a small horizontal line at the depths described in Data Collection Table #1. Write the name of the rock on that line. The first line for Water Well C, sandstone, has been done for you.
- (2) Draw a line across the page to connect the areas on all three wells where the rock layers are the same.
- (3) Use the notes from Data Collection Table #1 to determine the age of each rock layer. Write the age underneath each line.
- (4) Complete Data Collection Table #2 in order from youngest (1) to oldest (11).

Figure 3.3. Drilling Through the Ages Diagram



## Part 3: (Student Handout)

**Note:** Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (G-6) Hunting Through the Sand

### Thinking About the Problem

Why do flowers grow well in one soil but not in another? Soils are typically composed of 45% minerals, 25% air, 25% water, and 5% organic matter. In general, the more organic matter, the better the flowers grow, but proper amounts of air, water, and trace minerals are important too.

Soil textures (*textus*, “woven” in Latin) are determined by the percentages of clay, silt, and sand that are found in the soil. In Lab G-5 we studied rock layers. Like rocks, soils are also found in layers. A description of this layering is called a “soil profile.”

As you go deeper in the soil, you find lesser amounts of partly decayed organic matter and greater amounts of partially weathered bedrock material. All rocks that are exposed at Earth’s surface are subject to weathering, which leads to the formation of sediments. Forces of erosion (primarily water and wind) can transport sediments around Earth’s surface. Erosion and weathering form soil. In this lab you will examine the various materials that make up the sand that is found in a soil sample.

#### Data Collection Materials:

- Glue
- Hand lens
- Hunting Through the Sand data table
- Pinch of sand
- Toothpick

#### Data Collection Procedures:

- (1) Place a pinch of sand in the center of your Hunting Through the Sand data table.
- (2) Put a small drop of glue on a paper towel, using the toothpick to apply it when needed.
- (3) Use the hand lens to sort the sand grains according to the descriptions on your Hunting Through the Sand data table. Glue each grain down to the proper spot.

## Part 3: (Student Handout)

**Note:** Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (G-7) Shaking Things Up

### Thinking About the Problem

Can you predict earthquakes? Scientists have never predicted a major earthquake. They do not know how, and they do not expect to know how any time soon. However, probabilities, based on scientific data, can be calculated for potential future earthquakes. Scientists are becoming better and better at predicting the likelihood of potential earthquakes.

Plates are the slabs of the Earth's crust that make up the lithosphere (*lithos*, "stone" in Greek). Geologists developed the plate tectonic theory as a model of movement of Earth's crust on the surface. Earth's crust is composed of the continental crust (30 to 100 km thick) and the oceanic crust (about 10 km thick). Faults (*fallere*, "to fail" in Latin) are fractures in the Earth's crust caused by the stresses of plate movements.

The word *earthquake* is used to describe any seismic (*seismos*, "earthquake" in Greek) event—whether a natural phenomenon or something caused by humans—that generates seismic waves. Seismic waves are caused mostly by the rupture of geological faults, but also by volcanic activity, landslides, mine blasts, and nuclear experiments. An earthquake is usually the result of a sudden release of energy in Earth's crust, due to slippage along geologic faults, causing a vibration of the Earth.

There are many misconceptions about earthquakes. Some believe that animals predict earthquakes. Unresearched evidence does exist of animals, such as fish, birds, reptiles, and insects, exhibiting strange behavior anywhere from weeks to seconds before an earthquake occurs. However, consistent and reliable behavior prior to seismic events has never been shown.

Earthquakes may occur near a volcanic eruption, but they are the result of the active forces connected with the eruption, and not the cause of volcanic activity. Also, contrary to some beliefs, earthquakes are equally as likely to occur at any time of the day or month or year.

Geologists use the Richter scale to assign magnitude to earthquakes by the height of the largest seismic wave that each earthquake creates. Each unit of additional magnitude refers to a tenfold increase in the level of ground shaking and an even more dramatic increase in energy. For example, a magnitude 7.0 earthquake has more than 30 times more energy than a magnitude 6.0.

### Data Collection Materials:

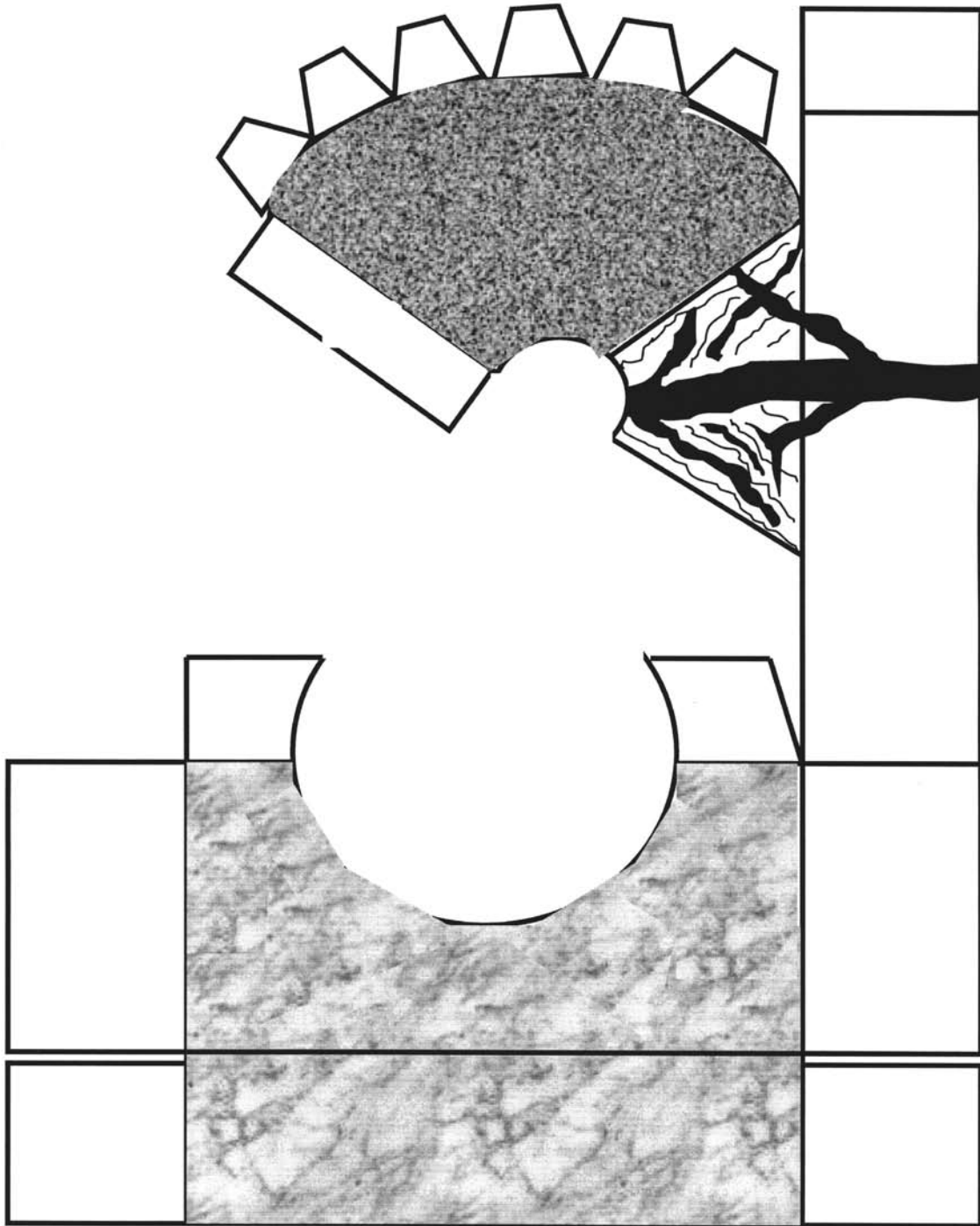
- Colored pencils
- Internet access to the U.S. Geological Survey's earthquake page
- Pushpins of different colors
- Wall-size map of the world

### Data Collection Procedures:

- (1) Post a map of the world on a bulletin board in the classroom.
- (2) Each student should glue a smaller world map in his or her lab notebook (Figure 3.5).
- (3) Visit the U.S. Geological Survey's "Current Worldwide Earthquake List" on the internet (<http://earthquake.usgs.gov/regional/neic>).
- (4) Put a pushpin in the wall map where any earthquakes have occurred that day. Repeat this pattern daily (assign students this job at the beginning of class time).
- (5) Students use colored pencils to indicate the same information in their lab notebooks.
- (6) Use different colors to indicate magnitudes of earthquakes (strong, medium, and weak).



Figure 3.6. Data Collection Table #1: Volcano Pattern



## Part 3: (Student Handout)

**Note:** Distribute to students after they complete the Prediction in Part 2.

**Anticipation Section Title:** (G-8) Mounting Magma

### Thinking About the Problem

Are all volcanoes alike? Volcanoes form where magma burns through the crust, at subduction (*sub + ducere*, “to lead under” in Latin) zones, at spreading centers, or at “hot spots” like Hawaii. Volcanoes have two major sections. The crater is the pit at the top portion of the volcano. The vent is a pipelike structure that connects the underground magma chamber to the crater.

Scientists classify the three types of volcanoes as shield volcanoes, cinder cones, and stratovolcanoes (also known as composite volcanoes). Shield volcanoes are the largest of all volcano types. They are generally not explosive and are built by the accumulation of lava flows that spread out widely. Lava flows that spread are very fluid and are described as having low viscosity. Viscosity refers to the level of ease with which a fluid flows. Shield volcanoes form broad, gentle slopes, and can be tens of kilometers across and thousands of meters high. Kilauea and Mauna Loa Volcanoes in Hawaii are examples of active shield volcanoes.

Cinder cones are the smallest. They have steep sides that are formed mainly by the piling up of ash, cinders, and rocks. All of these materials explosively erupted from the vent of the volcano and are called pyroclastic, which means “fire-broken.” The cinders shoot out of the volcano like fireworks, and then fall back to the ground. As they fall, they pile up to form a symmetrical, steep-sided cone around the vent. Sunset Crater in Arizona and Parícutin in Mexico are well-known examples of cinder cones.

A stratovolcano is the most common type of volcano on Earth. Also called a composite volcano, it is built up of lava flows layered with pyroclastic material. Scientists believe that the layering represents a history of alternating explosive and quiet eruptions. Young stratovolcanoes are typically steep-sided and symmetrically cone-shaped. There are many active stratovolcanoes in North America, including Mount St. Helens in Washington. Other well-known stratovolcanoes include Mount Ranier, Mount Shasta, Mount Mazama (Crater Lake), Redoubt Volcano in Alaska, Mount Fuji in Japan, and Mount Vesuvius in Italy.

In this lab, you will put together a model of a volcano. You will use it to test what type of volcano results from your simulated chemical volcanic eruption.

**Data Collection Materials:**

- Film canister (one per lab group)
- Scissors
- Two Alka-Seltzer tablets
- Volcano pattern (one per student)
- Water (both warm and cold)

**Data Collection Procedures:**

- (1) Cut out the volcano pattern, along the outer lines.
- (2) Fold the model volcano along the inner lines, and then tape the tabs together.
- (3) Place the empty film canister in the center of the cone.
- (4) Cut your Alka-Seltzer tablets in half, enabling you to conduct repeated trials. Place one Alka-Seltzer piece and one drop of red food coloring into the film canister.
- (5) Quickly add some cold water to the canister and watch the mounting magma.
- (6) Use your lab partner's volcano model, and repeat step 4. Then quickly add some warm water to the canister and watch.
- (7) Study the results and, along with determining the effect of water temperature on reaction rates, also determine which type of volcano your model represents.

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (M-1) Wondering About Water

### Thinking About the Problem

Where does the water in rain come from and where does it go? Our seemingly inexhaustible supply of water is actually used over and over again. Water moves from the ocean to air and land, and from the land to ocean and air. This continuous movement of water in a cyclic pattern is called the hydrologic (*hydro*, “water” in Greek) cycle. And it is very important in the science of meteorology (*meteoron*, “astronomical phenomenon” in Greek).

In nature, the Sun warms the water in the oceans, causing surface water to evaporate. As the water vapor rises in the atmosphere (*atmos*, “vapor” in Greek), it cools and condenses into liquid droplets. Most of these droplets continue cooling to ice crystals and snowflakes. Evaporation continues as the droplets and crystals grow in size, until they eventually fall back to Earth. Precipitation falling on Earth’s surface is dependent on the temperature changes below the clouds. The precipitation collects on the land surface and may flow back to the oceans, completing the cycle.

Most of the Earth’s total amount of water is contained in the oceans, a volume estimated at 1,350,000,000 km<sup>3</sup>. Other reservoirs, for example, glaciers (27,500,000 km<sup>3</sup>), groundwater (8,200,000 km<sup>3</sup>), and lakes and streams (206,700 km<sup>3</sup>), hold significant water as well. Although it is in a continuous state of change due to evaporation and precipitation, our atmosphere is estimated to hold 13,000 km<sup>3</sup> of water.

In this lab, you will study a model of how the hydrologic cycle occurs. As far as water is concerned, Earth is basically a closed system that, in this case, is represented by a clear plastic bin. A soil bag serves as a continent, a lamp as the Sun, and water as the oceans. A beaker of ice represents the cold regions of the upper atmosphere, where water vapor condenses into water droplets.

**Data Collection Materials:**

- Clear plastic bin
- Glass pitcher
- Ice cubes
- Lamp
- Resealable plastic bag with sand
- Water

**Data Collection Procedures:**

- (1) Label each of the materials in the demonstration diagram shown in Data Collection Table #1, showing not only what they materials truly are, but also what each material represents in terms of the hydrologic cycle.
- (2) Carefully observe the progression of events. Draw and label a sketch showing the movement of water through the hydrologic cycle by showing what the demonstration model actually represents.

## **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (M-2) Dealing With Pressure

### **Thinking About the Problem**

How much does air weigh? If the question seems funny at first, it's because we have lived our whole lives exposed to the weight of the atmosphere and therefore we are usually oblivious to its effect on us. Air does have weight, yet we don't often notice it. We are much more aware of the weight of water when we dive underwater, and deep-sea divers need to protect themselves in order to avoid the life-threatening respiratory and circulatory system condition called the bends. Divers suffer from the bends because the high pressure of the water causes the nitrogen to dissolve in their blood. If the diver rises too quickly, the nitrogen bursts out of solution.

The weight of the air on Earth's surface produces air pressure. Pressure (*pressus*, "pressed" in Latin) is a measure of the force over a certain area that the air is exerting due to its weight. Without it, we would certainly notice the results. Basically, we, as well as every other closed system on Earth, would soon explode without any atmospheric pressure. The instrument used to measure atmospheric pressure is called a barometer and it is essential in weather forecasting. This lab will give you an opportunity to see that air pressure, caused by the weight of the atmosphere, can produce some amazing results.

**Data Collection Materials:**

- Beaker tongs
- Bucket
- Empty pop cans
- Hot plate
- Index card
- Pushpin
- Shallow pan of water
- Test tube
- Water

**Data Collection Procedures:**

- (1) Fill your test tube to the rim with water. Make a prediction about what will happen when you turn the test tube upside down.
- (2) Turn the test tube over. What did you observe?
- (3) Fill it with water again. Cover it with the index card, and make a tight seal. Predict what will happen when you turn the test tube upside down.
- (4) Use your finger to hold the index card on, and then flip the test tube upside down. Slowly remove your hand from the index card. What did you observe?
- (5) Slowly, lean the test tube on its side and record your observations.
- (6) Slowly turn the test tube so that it is upside-down again. Poke a hole in it with the pin, and record your observations.
- (7) Observe the imploding pop can demo by your teacher.

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

Anticipation Section Title: (M-3) Phasing In Changes

### Thinking About the Problem

What happens when you heat water? There are two main things that happen when heat is added to water. The first is that the temperature of the water rises, or increases. The second is that a “change of phase” may occur. A phase change refers to whether a substance, like water, is a solid (ice), liquid (water), or a gas (water vapor).

Several familiar terms are associated with changes of phase. *Freezing* refers to a change from liquid to solid. *Melting* refers to a change from solid to liquid. *Boiling* refers to a change from liquid to gas. *Condensing* refers to a change from gas to liquid. In the introductory activity, you saw that sometimes a substance, like carbon dioxide (its solid form is called *dry ice* because it does not melt into a liquid) may skip a step. *Sublimation* refers to these cases, when a substance goes directly from solid to gas.

In each phase change, it is the spacing between the molecules that make up the substance that changes. In a solid, the molecules (*molecula*, “small bit” in Latin) are packed very closely together. The molecules are still moving, in a shivering fashion, vibrating back and forth. In a liquid (such as water or steam), the space between molecules increases to the point where they can flow around one another. In a gas, like the invisible water vapor in our air, the molecules dart around freely, occasionally colliding with each other.

A graph of your data from this lab will show that temperatures stop increasing when phase changes are occurring. There is a leveling out of the temperature because all of the heat energy is going into the motion of the molecules. Once the molecules have separated to the distance needed for the substance to become a different phase, the temperature begins to measure this new molecular motion.



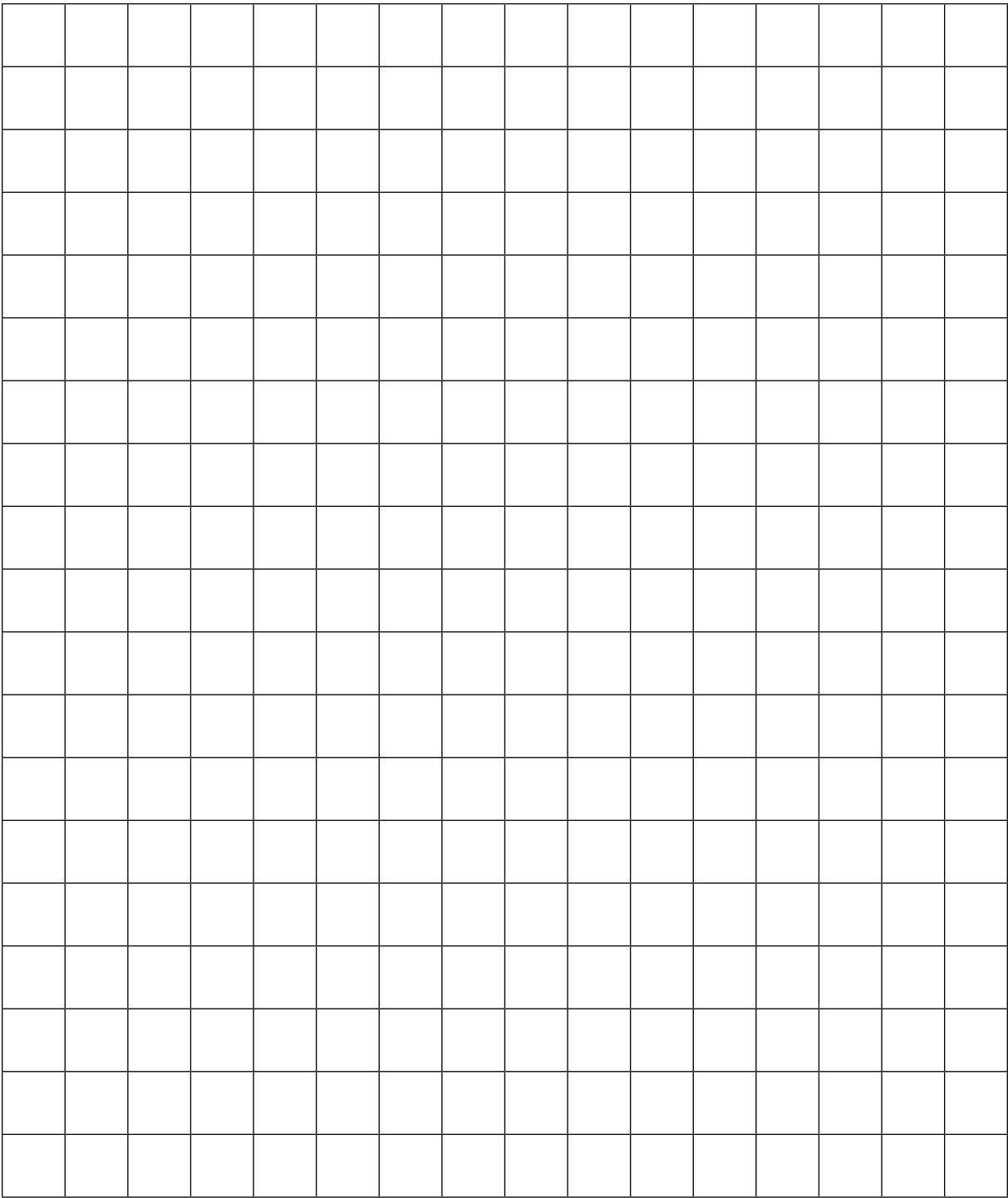
### Data Collection Materials:

- Air
- Apron
- Beakers
- Bunsen burner
- Bunsen burner
- Dry ice (solid carbon dioxide)
- Gloves
- Goggles
- Helium
- Ice (or snow, as a substitute)
- Metal thermometer
- Methane
- Propane
- Small aquarium
- Soap-blown bubbles
- Water

### Data Collection Procedures:

- (1) Create two of your own data collection tables, giving them titles. One should show temperature versus time for water boiling. The other should show temperature versus time for ice/snow melting. Time should be recorded in 30-second intervals.
- (2) Begin to measure water going from room temperature to a rolling boil. Record data on temperature every 30 seconds. The water should be allowed to boil for three minutes.
- (3) At the same time, measure water with ice cubes, or snow, going to water with all the ice/snow melted. The water should continue to be measured for temperature until all the ice has been melted for three minutes.
- (4) Make a line graph showing the data from both experiments with temperature versus time.
- (5) Draw and label two sketches, showing your apparatus for both experiments.

Figure 4.4. Graph Title for Procedure #4



### **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (M-4) Sweating About Science

#### **Thinking About the Problem**

Why do we seem to perspire more when it is humid? This is actually a misconception that many people share. The truth has to do with evaporation. In dry air, it is easier for water to evaporate and enter the air as water vapor. On very humid days, the air is already holding as much water vapor as it can, so perspiration is unable to evaporate as easily. The perspiration sits on our skin, rather than evaporating off, as it does on a dry day.

Hot, dry air is normally more comfortable than warm, humid air. Similarly, cold, dry air is often more comfortable than cool, damp air. While there is always at least a small amount of moisture in the air we breathe, the amount makes a big difference on our comfort level. Why? Temperature plays the primary role in determining the amount of water vapor present in the air at any given time. Warm air can hold more water vapor than cool air. But every temperature has its limit and once the air is saturated, it can hold no more water vapor. Saturated air has a relative humidity of 100% and clouds or fog begin to form. When relative humidity is high, our perspiration cannot evaporate quickly, it is much harder for us to cool down, and we become uncomfortable.

Relative humidity is a measure of how much water vapor is actually in the air compared to the amount the air could possibly hold. In desert areas, relative humidity is low, but in jungles it is high. Relative humidity can be measured with two different instruments. One is called a hygrometer (*hugros*, “wet, moist” in Greek); the other is called a sling psychrometer (*psukhros*, “cold” in Greek). Since the sling psychrometer is easily portable, that is the one we will use in this lab.

**Data Collection Materials:**

- Data Table: Percentage of Relative Humidity
- Sling psychrometer
- Thermometer

**Data Collection Procedures:**

- (1) Read and record the “dry bulb temperature” on the metal thermometer.
- (2) Carefully swing the sling psychrometer around for two to three minutes and record the lowest temperature reached by its thermometer. Record this “wet bulb temperature.”
- (3) Subtract the wet bulb temperature from the dry bulb temperature, and record.
- (4) From your calculation in step 3, determine the relative humidity using Data Collection Table #2.
- (5) Use this same method to determine the relative humidity in four more locations around the school.



Topic: Weather Patterns

Go to: [www.scilinks.org](http://www.scilinks.org)

Code: ESS029

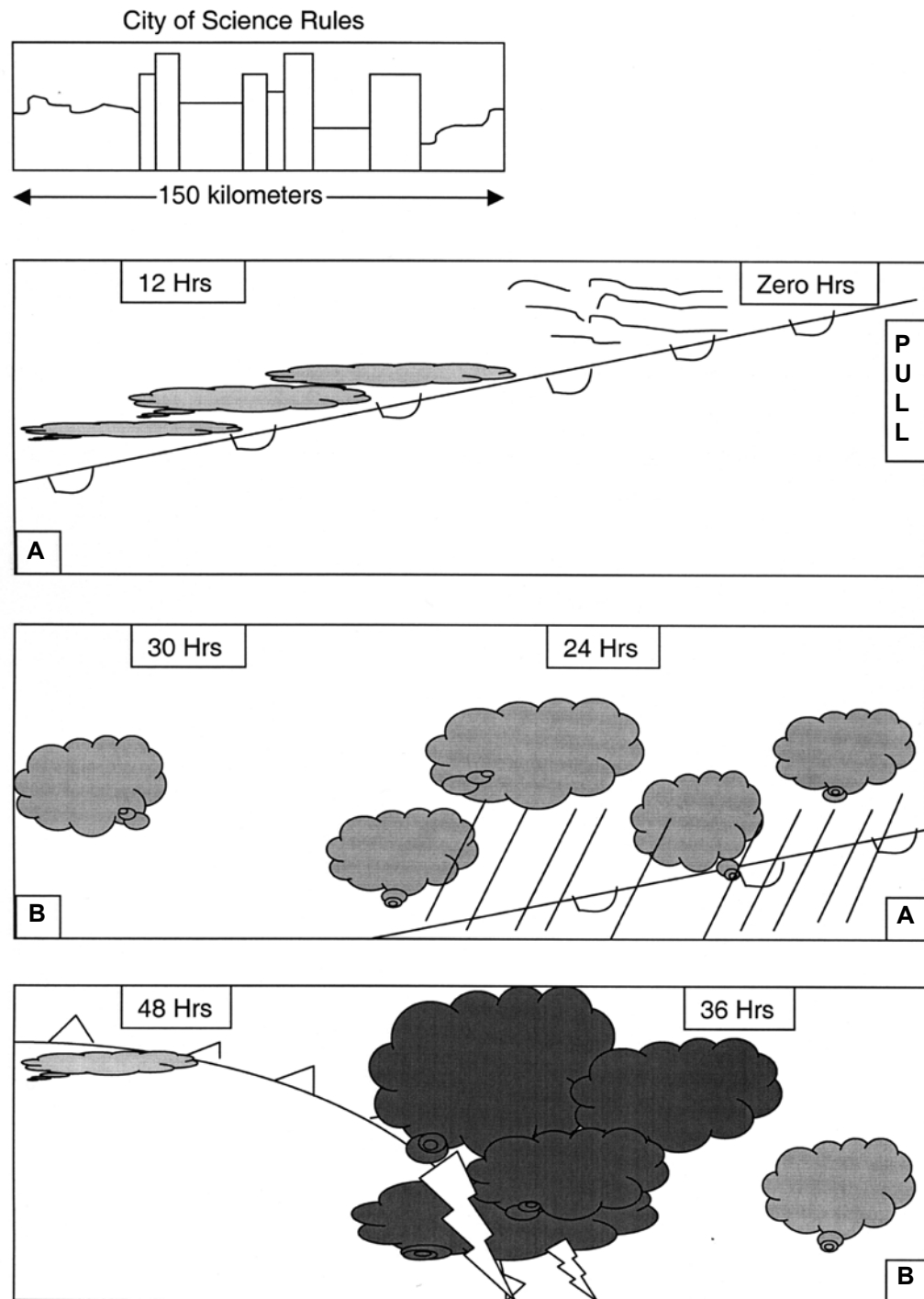


Topic: Air Masses and Fronts

Go to: [www.scilinks.org](http://www.scilinks.org)

Code: ESS030

Figure 4.5. Data Collection Table #1: Front Lines Data Page



## **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (M-5) Lining Up in Front

### **Thinking About the Problem**

What is a weather front? When a warm air mass meets a cool air mass, two distinct bodies of air are brought in contact, each with its own temperature and relative humidity. Normally, when this “collision” happens, the warm air mass rides up and over the cool air mass, because warm air is less dense. A front is, then, the boundary, or line, between these two air masses.

When a weather front results in warm air getting pushed above cool air, the warm air mass swells as it goes higher and higher. This happens because the air pressure is lower at higher altitudes. As the warm air rises and expands, it begins to cool and the moisture it contains condenses to form clouds and, often, rain, ice, or snow. Clouds come in different shapes and sizes and this is a factor that meteorologists use to help predict the weather.

Dew is the result of air reaching a certain temperature at which it becomes saturated. As you learned in Lab M-4, saturation occurs when the air can hold no more water vapor. This vapor will begin to change to liquid, as, for example, often happens in early morning when moist air condenses on cooler grass, rocks, and trees. If the temperature of the grass, etc., is below freezing, the condensation (*densare*, “to thicken” in Latin) is known as frost. The temperature at which the processes of evaporation and condensation are equal is called the dew point.

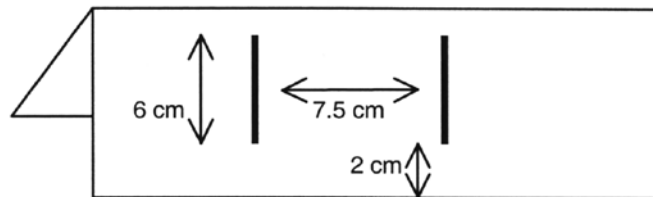
**Data Collection Materials:**

- Front lines data page (Figure 4.5)
- Glue
- Notebook paper
- Scissors

**Data Collection Procedures:**

- (1) Find the data page. Separate the three strips, cutting along the lines. Also cut out the “city” (the smaller box on top).
- (2) Shade in the cold air masses, so they are easier for you to see.
- (3) Glue the three strips together by matching up the letters.
- (4) To make the viewer, fold a piece of notebook paper in half and make two 6 cm cuts that are vertical, as shown in Figure 4.6.

Figure 4.6. Frame for Viewer



- (5) Glue the city below the two cuts.
- (6) Feed the strip through the two cuts so that it passes over the city, starting with Zero Hrs.

## **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (M-6) Dewing Science

### **Thinking About the Problem**

Can the dew point influence how we feel? On muggy days, meteorologists often include the dew point in the facts and figures that they share. Why? The answer is that the dew point is a good indication of how much moisture (invisible water vapor gas) is in the air. The closer the dew point is to the actual air temperature, the more moisture the air is holding. We are most likely to notice water vapor on very humid, warm days, when we feel clammy or sticky because, as you learned in Lab M-4, all the water vapor surrounding us prevents our perspiration from evaporating easily.

On days when the air temperature and the dew point are very close to each other, we say the air is “humid.” If, for example, the air temperature is 31°C and the dew point is 29°C, this means that there is much more water vapor in the air than on a day when the temperature is the same but the dew point is only 10°C.

As you learned in Lab M-1, most of the water in the atmosphere got there by evaporation, largely from the ocean but also from lakes, rivers, ponds, and even puddles. Temperature is a major factor in determining how much and how rapidly water will evaporate from these places. When the air is cool, it cannot hold as much water vapor as when the air is warm, and therefore, less water will evaporate. Because of this, at any location, there will probably be more water vapor in the air during warm weather than during cold weather. In this lab, you will investigate the relationship between air temperature and dew point.



### Data Collection Materials:

- Empty soup can
- Ice
- Metal thermometer
- Water

### Data Collection Procedures:

- (1) Measure and record the air temperature.
- (2) Fill the can half full with water. Allow the can to sit for three minutes. If condensation forms on the outside of the can, replace the water with slightly warmer water. Repeat until no condensation forms on the outside of the can.
- (3) Place the thermometer in the can with the water.
- (4) Slowly, add small pieces of ice to the can while carefully stirring with the thermometer. Watch the outside of the can for the first sign of condensation.
- (5) When condensation begins, immediately record the “dew point” temperature of the water in the can.
- (6) Repeat steps 2 through 5 twice more and record. Find the average and record.

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (M-7) Deciphering a Weather Map

### Thinking About the Problem

What do we need to know to interpret weather maps? These maps report meteorological data collected from several weather stations at a specific point in time. Weather stations can be in many places, including airports, TV and radio broadcasting stations, schools, private homes, and remote areas maintained by the National Oceanic and Atmospheric Administration (NOAA).

Normally weather maps show an outline of a specific area (local, state, national), the cities where the reporting stations are located, and symbols to show what the weather is. By including information from a number of different stations, the map will give a good idea of what the weather is across the whole area represented.

Data Collection Table #1 shows an example of a weather station's symbol and the information given by each part of the symbol. Although this current system may change, weather station symbols in the United States are still expressed with the English Standard units of measurement, rather than the metric system. Data Collection Tables #2, #3, #4, and #5 show examples of specific information presented by weather station symbols.

#### Data Collection Materials:

- Data collection tables of weather station symbols (Figures 4.7–4.10; 4.12)
- Weather map (Figure 4.11)

#### Data Collection Procedures:

- (1) Refer to the data collection tables and to the weather map in answering the Analysis questions.

Figure 4.11. Weather Map

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Figure 4.12. Weather Station Symbols for Each City on the National Map

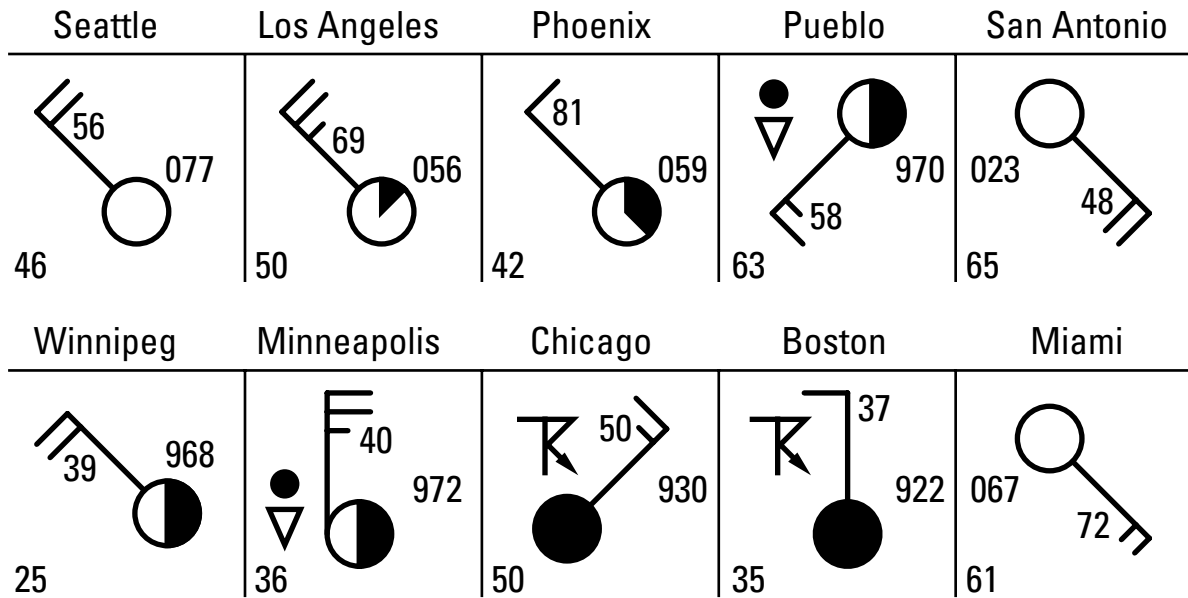


Table 4.14. Data Collection Table #1: Watching the Weather

Today's Day and Date: \_\_\_\_\_



Watching the Weather	
Cloud types	Morning: Noon: Evening:
Precipitation	Type: Total amount: Duration:
Temperature	High: Temp at noon: Low:
Air pressure	Morning: Noon: Evening:

## **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (M-8) Watching the Weather

### **Thinking About the Problem**

What is the weather like outside right now? Can you answer the question without looking out the window to check? What type of cloud cover was in the sky when you woke up this morning? If you have trouble answering these questions, you are not alone. Most people today do not pay very much attention to the weather until it interferes with something they plan to do. Rain can cancel a soccer game. Snow can make a commute unbearable. When these things happen we notice the weather, but much of the time we ignore it.

This is not the case, of course, for everyone. Receiving proper amounts of rain and sun is vital for those who grow the food we eat. Sailors, pilots, truck drivers, and a number of other professions depend on accurate weather reports to be able to safely carry out the work they do. "Red sky at night, sailor's delight; red sky in the morning, sailors take warning" is only one of the many sayings in our language that prove that our ancestors were very concerned with the weather and that they knew how to read natural signs in order to predict what the weather would be.

By not paying attention, we miss many of the interesting things that go on in the atmosphere. For example, it is possible to predict short-term weather changes with some accuracy just by looking at the clouds. The purpose of this lab is to help you observe the weather around you more carefully and to help you relate the weather you're experiencing to weather in other parts of the country. One way to predict weather changes is to look at the weather in nearby places. You can become an excellent forecaster by carefully observing what is happening around you.

## Data Collection Materials:

- Classroom weather station
- Internet sites for monitoring current and forecasted weather
- North American weather maps from local newspapers
- Watching the Weather data collection tables (4.14)

## Data Collection Procedures:

- (1) Create one Watching the Weather data collection table for each day, for 10 days total. Glue in the 10 North American maps and draw one data table beneath them per page.
- (2) Record the information from the internet/newspaper weather maps onto your weather map data sheet each day. Include the temperatures in major cities across North America, as well as the various types and locations of fronts.
- (3) Record the daily weather conditions at your location.

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

Anticipation Section Title: (O-1) Piling Up the Water

### Thinking About the Problem

What does  $H_2O$  mean? As you learned in Lab M-1, each molecule (*molecula*, “small bit” in Latin) of water is made of two hydrogen atoms ( $H_2$ ) and one oxygen atom (O). What is special about water molecules is that they tend to “stick” to each other (cohesion) and to other molecules (adhesion). They do this because water is built like a magnet, with a positive end and a negative end. This helps it bond well. During this lab, you will explore this bonding ability of water.

Water makes life on Earth possible. It covers almost three-fourths of the surface of our planet. Because there is so much of it, water may seem very ordinary to us, and yet it is unique when compared with all other substances. For example, water is the only substance on Earth that occurs naturally in all three states—solid, liquid, and gas. Solid  $H_2O$  (ice) is less dense than its liquid form (water) so it floats. Most other solids are denser than their liquid form, so they sink! Another difference, with respect to water, is that large amounts of energy must be added to water to achieve even a relatively small change in temperature.



## Data Collection Materials:

- Beaker
- Dish soap
- Eyedropper
- Large water containers (assortment of five beakers, buckets, or bowls)
- Many pennies
- Other coins

## Data Collection Procedures:

- (1) Predict which of your five large containers (each full to the rim with water) will be able to withstand the addition of the greatest number of pennies without spilling over. Test and record your results.
- (2) Place a dry penny on a piece of paper towel.
- (3) Predict the number of drops you can pile on the penny before water runs over the edge.
- (4) Test and record for each particular coin.
- (5) Draw and label a sketch of the water on the surface of the coin just before the water spilled over.
- (6) Conduct the same tests with the soapy water.



Topic: Properties of  
Ocean Water

Go to: [www.scilinks.org](http://www.scilinks.org)

Code: ESS034

## **Part 3: (Student Handout)**

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

**Anticipation Section Title:** (O-2) Layering Around on the Beach

### **Thinking About the Problem**

What makes the water in the sea different from the water in a river? Water has different properties depending on the environment in which it is found. We call water in the ocean saltwater because it has a lot of salts dissolved in it. Water in streams and rivers is called freshwater because it does not contain many dissolved salts. When rivers flow into the ocean, the mouth of the river is called an estuary (*aestus*, “tidal surge” in Latin). Water in an estuary is “brackish,” meaning it has a higher amount of salts than freshwater but a lower amount than the open ocean.

Ocean water is not the same everywhere. In some places the water is colder or deeper than in others. Some bodies of water are denser or contain differing amounts of dissolved salts than others. All of these factors influence the way ocean water behaves.

Although water is the most abundant substance on Earth’s surface, very little of it is pure. In addition to hydrogen and oxygen—the only two elements in pure water—there are many other elements mixed in with the water on our planet. Tap water, for example, contains chemicals used to disinfect the water and prevent bacterial growth.

In this lab we will explore how different types of water—salt, brackish, and fresh—form layers and mix. This will help us to understand the effects that this “layering around on the beach” has on Earth’s environment.

**Data Collection Materials:**

- Three 250 mL beakers
- Three colored solutions
- Three eyedroppers
- Clear straw
- Small block of clay
- Waste container

**Data Collection Procedures:**

- (1) Stick the straw into the clay at an angle, so there are no leaks.
- (2) You know only the following two facts about your solutions:
  - The only difference between the solutions is their color and the amount of salt they contain.
  - If you add small amounts of each solution to the straw in the correct order, you will produce three distinct layers that do not mix.
- (3) Your goal is to determine which colors correspond to salt, fresh, and brackish water.
- (4) Make a hypothesis in Data Collection Table #1.
- (5) Test your hypothesis by adding a small amount of each solution to the straw in the order that you guessed. Record your observations in Data Collection Table #1.
- (6) If you did not see three distinct layers, revise your hypothesis. Empty the contents of your straw into the waste container, and test the new hypothesis. Record your observations in Data Collection Table #1.
- (7) Draw and label a sketch, showing your final layered results.






Topic: Tides

Go to: [www.scilinks.org](http://www.scilinks.org)

Code: ESS035

Table 5.8. Data Collection Table #1: Tide Chart for Milford, Connecticut

Day	Times	Sea Level (m)	Day	Times	Sea Level (m)
1 	A. 0523 B. 1130 C. 1752 D. 2351	A. 0.9 B. 3.7 C. 0.9 D. 4.0	16	C. 0657 D. 1115 A. 1832 B. 0031	C. 0.8 D. 3.6 A. 0.9 B. 3.8
2	A. 0601 B. 1247 C. 1807 D. 2345	A. 0.8 B. 3.7 C. 0.9 D. 3.9	17	C. 0647 D. 1254 A. 1942	C. 0.7 D. 3.7 A. 0.8
3	A. 0647 B. 1203 C. 1807 D. 2359	A. 0.8 B. 3.6 C. 0.9 D. 3.8	18	B. 0140 C. 0705 D. 1638 A. 2052	B. 3.7 C. 0.7 D. 3.8 A. 0.5
4	A. 0728 B. 1316 C. 1905	A. 0.8 B. 3.7 C. 1.0	19	B. 0240 C. 0834 D. 1454 A. 2123	B. 3.8 C. 0.7 D. 3.9 A. 0.6
5	D. 0003 A. 0831 B. 1407 C. 2005	D. 3.7 A. 0.7 B. 3.8 C. 0.5	20	B. 0340 C. 0953 D. 1534 A. 2253	B. 3.5 C. 0.8 D. 3.9 A. 0.6
6	D. 0232 A. 0920 B. 1530 C. 2115	D. 3.8 A. 0.7 B. 3.9 C. 0.6	21	B. 0220 C. 1037 D. 1614 A. 2313	B. 3.8 C. 0.7 D. 3.9 A. 0.6
7	D. 0322 A. 0945 B. 1558 C. 2245	D. 3.7 A. 0.7 B. 3.8 C. 0.5	22 	B. 0458 C. 1138 D. 1723 A. 0052	B. 4.1 C. 0.7 D. 4.0 A. 0.7
8 	D. 0412 A. 1049 B. 1645 C. 2333	D. 3.5 A. 0.4 B. 3.9 C. 0.5	23	B. 0505 C. 1239 D. 1802	B. 3.5 C. 0.8 D. 3.9
9	D. 0536 A. 1154 B. 1705	D. 3.8 A. 0.7 B. 3.9	24	A. 0140 B. 0633 C. 1235 D. 1940	A. 0.8 B. 3.6 C. 0.9 D. 3.8

10	C. 0025 D. 0636 A. 1204 B. 1844	C. 0.8 D. 3.7 A. 0.9 B. 3.9		25	A. 0159 B. 0732 C. 1343 D. 1956	A. 0.7 B. 3.7 C. 0.8 D. 4.0
11	C. 0137 D. 0751 A. 1353 B. 1924	C. 0.8 D. 3.6 A. 0.9 B. 3.8		26	A. 0249 B. 0850 C. 1432 D. 2042	A. 0.8 B. 3.7 C. 0.9 D. 3.9
12	C. 0214 D. 0801 A. 1413 B. 2136	C. 0.8 D. 3.6 A. 0.9 B. 3.8		27	A. 0351 B. 0854 C. 1530 D. 2110	A. 0.7 B. 3.7 C. 0.8 D. 4.0
13	C. 0322 D. 0950 A. 1547 B. 2103	C. 0.7 D. 3.7 A. 0.8 B. 4.0		28	A. 0345 B. 0952 C. 1534 D. 2153	A. 0.8 B. 3.6 C. 0.9 D. 3.8
14	C. 0442 D. 1000 A. 1642 B. 2232	C. 0.8 D. 3.7 A. 0.9 B. 3.9		29	A. 0429 B. 1020 C. 1642 D. 2221	A. 0.8 B. 3.4 C. 0.9 D. 3.5
15	C. 0551 D. 1005 A. 1732 B. 2341	C. 0.9 D. 3.6 A. 1.0 B. 3.8		30	A. 0530 B. 1004 C. 1710 D. 2254	A. 0.7 B. 3.7 C. 0.8 D. 4.0

**Analysis:**

- (1) About how much time passes between one low tide (A) and the next low tide (C)?
- (2) About how much time passes between one high tide (B) and the next high tide (D)?
- (3) When did the lowest low tide occur? When did the highest high tide occur?
- (4) To which Moon phases did your two answers to #3 correspond?
- (5) When did the highest low tide occur? When did the lowest high tide occur?
- (6) To which Moon phases did your two answers to #5 correspond?

## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

Anticipation Section Title: (O-3) Changing Lunar Tides

### Thinking About the Problem

Have you ever spent time watching the tide come in or go out? Sitting on a beach and focusing on the tide helps us realize that there is a definite rhythm to the ocean. Sandbars may appear at low tide and rocks may be covered when the tide is high. The pattern repeats itself twice each day. Why?

Tides are the daily changes in ocean surface height caused by the powerful attraction between the Earth and the Moon. The Earth and the Moon are attracted to each other due to gravity (*gravis*, “heavy” in Latin). Since Earth has a much greater mass, the effect of the Earth’s gravity is stronger. But the Moon does exert a strong gravitational force on Earth. This gravitational attraction leads to rhythmic rising and falling of the waterline along the beach. Since water is more easily moved than land, ocean water gets pulled over the land area that happens to be facing the Moon. This means the side of the Earth closest to the Moon will experience higher tides.

Tides are predictable changes in sea level that occur at regular intervals. There is a “high tide” when the sea level has risen to its highest point and a “low tide” when it falls to its lowest point. These tide changes affect humans in many ways. One of the impacts of tides is on ocean shipping. In many locations, ships can come to shore only at high tide. If they come in at low tide, they may be grounded.

Because tides affect us in so many ways, it is important to know when they will occur, and fortunately this can be predicted with accuracy. By making a graph of the tides and the sea level, you can see the pattern of changes over time. The data used in this activity is from the shore of a small island (Charles Island) off the coast of Milford, Connecticut, where the authors of this book spent many summers. It is located in Long Island Sound on the Atlantic Ocean, across from Port Jefferson, New York.

### Data Collection Materials:

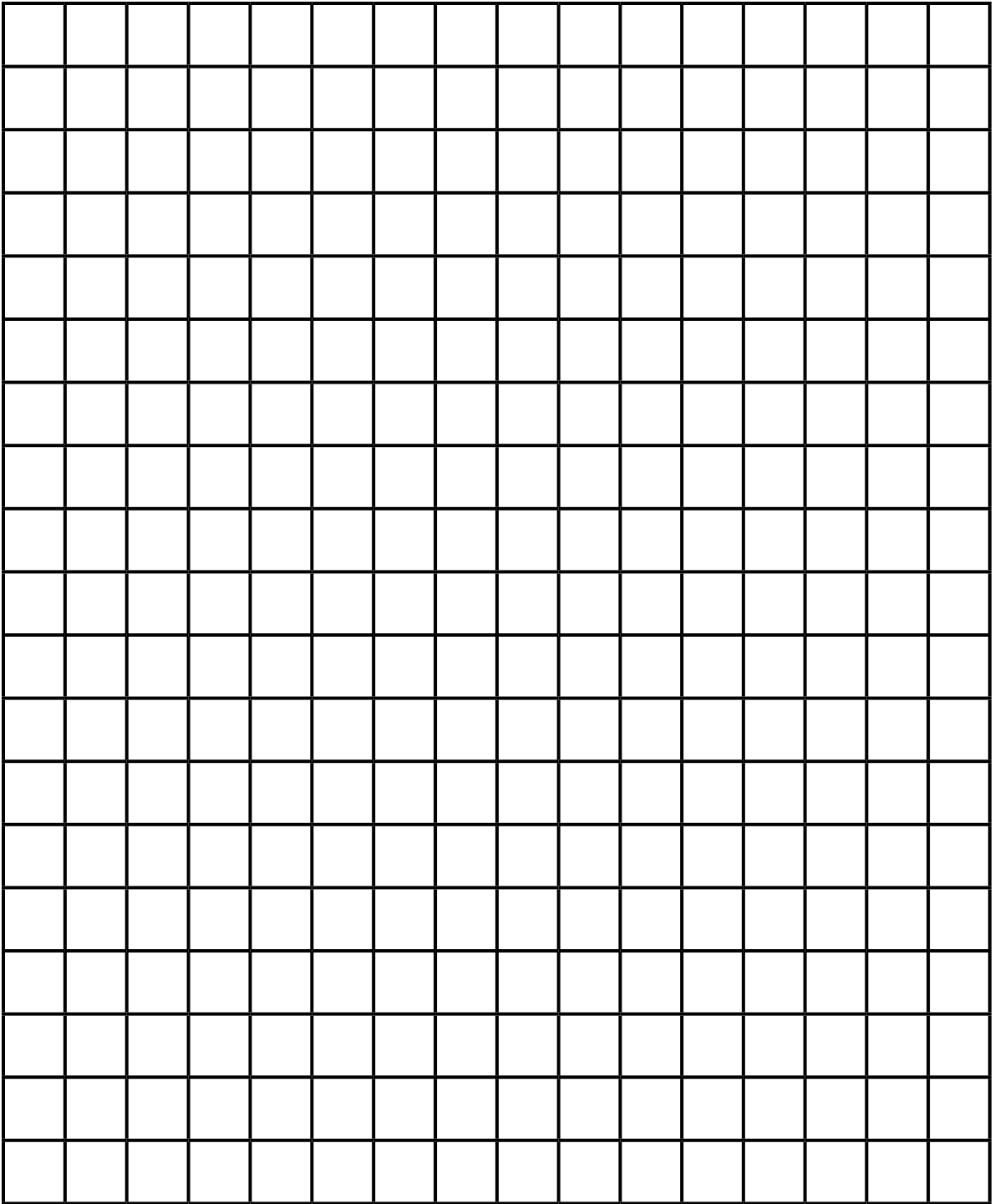
- Bright colored pencils
- Data sheets and graphing charts for Charles Island in Milford, Connecticut
- Glue
- Metric ruler
- Pencil
- Scissors

### Data Collection Procedures:

- (1) Locate the tide chart for Charles Island in Milford, Connecticut. Note that all times are in military (24-hour) time. For example, 0530 refers to 5:30 AM, and 1522 refers to 3:22 PM. An average of two low tides (A and C) and two high tides (B and D) occur each day.
- (2) Number the horizontal axis so that you can fit 30 days worth of data across the bottom. The vertical axis will be height of sea level. Give the graph a descriptive title.
- (3) Plot your data for Sea Level versus Time (in days) by first plotting all of the data for “A” (earliest low tide). Draw a line to connect all of the “A” points in the order that they were plotted.
- (4) Repeat step 3 by plotting the data and drawing the lines for “B,” “C,” and “D.” Use a different colored pencil for each line.

Figure 5.1. Graph Title:

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## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

Anticipation Section Title: (O-4) Sinking Film Canisters

### Thinking About the Problem

How well do things float? To understand why something floats and how well, we need to understand *buoyancy*. Buoyancy is actually a result of the water pushing upward on objects. We will study buoyancy by experimenting with a floating film canister into which pennies can be placed.

For our investigation of buoyancy to be as accurate as possible, we need to isolate our variables and look at just one at a time. We will be sharing our data with the whole class to minimize errors. No measurement is exact and every measurement contains some uncertainty. Uncertainty in measurement is due partly to 1) instrument error because no instrument is perfect, and 2) human error because each person measures a little differently. One of the best ways to show all of the measurements is to make a graph.

A graph (*graphein*, “to write” in Greek) is a large picture of your data, which helps show regularities and patterns. From these patterns, we can predict events. For example, we can use the graph of the class data in *Part 1* of Lab O-4 to predict the quantity of pennies needed to sink a film canister to different depths. You will notice that the canister sinks a little, even with no pennies in it, so the pennies and the canister may have some similar property or properties. Remember that a property of an object is any quality that can be observed or measured. You will learn in *Part 2* of Lab O-4 that both the canister and the pennies have the property of mass, which under the pull of gravity gives them weight. Mass is the measure of the physical bulk of an object (the amount of matter in it), simulated by the pennies in this lab.

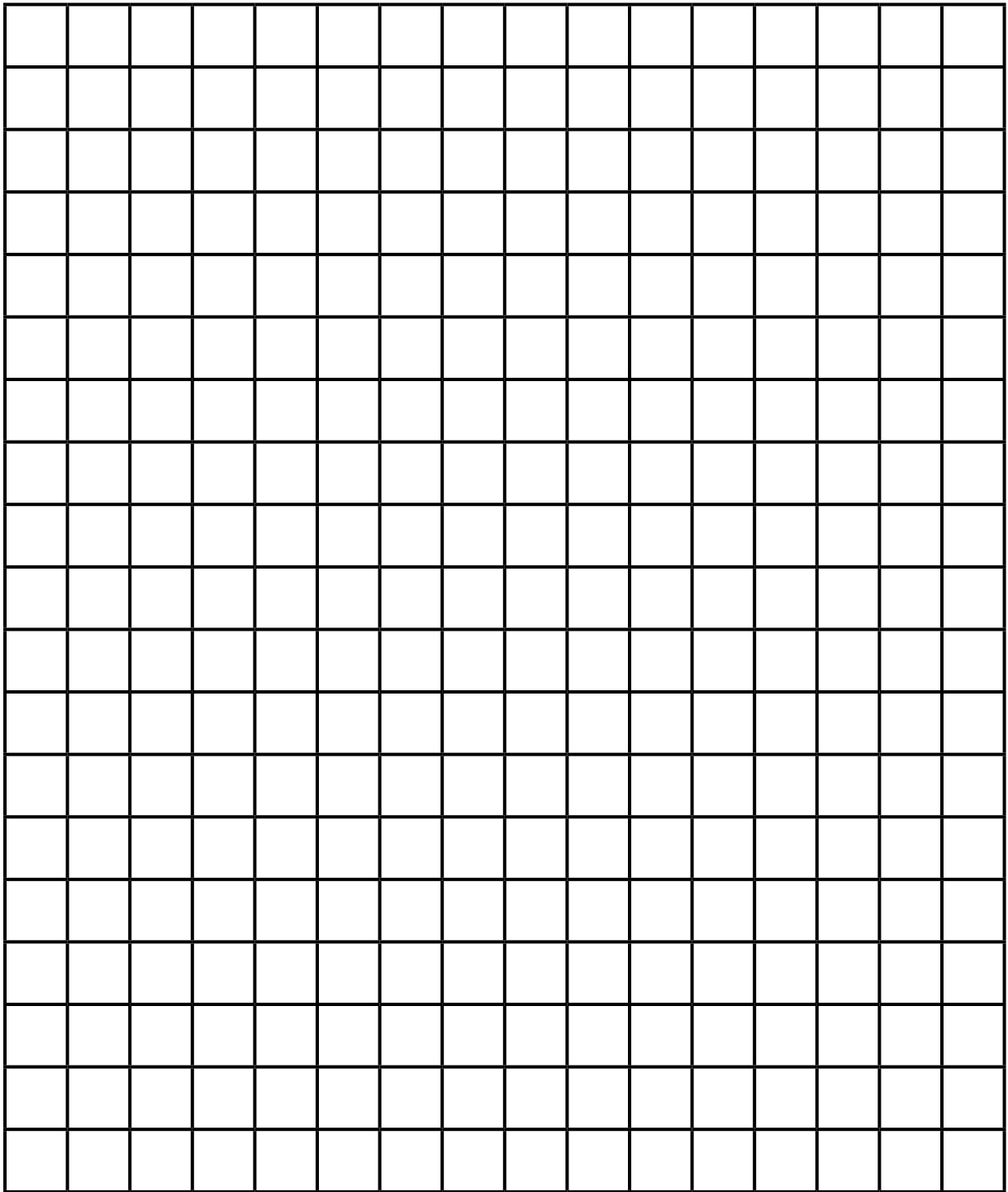
### Data Collection Materials:

- Pennies
- Metric ruler
- Triple beam balance
- Water
- Beakers
- Film canisters
- Graph paper

### Procedures for Part 1:

- (1) Move the rubber band around the canister so that it is 1 cm from the bottom end.
- (2) Predict the quantity of pennies it takes to sink the canister to the 1 cm mark. Think carefully about your predictions—is there a pattern?
- (3) Test and record in Data Collection Table #1 for each of the different cm marks.
- (4) Record the whole-class data in Data Collection Table #2.
- (5) Graph the data from Data Collection Table #2, with “Number of Pennies” on the vertical axis and “Depth of Canister” on the horizontal axis.
- (6) Put a circle around all points. Draw a straight line, called the “Best Fit Line,” through or between the pattern of points, showing the average class data.

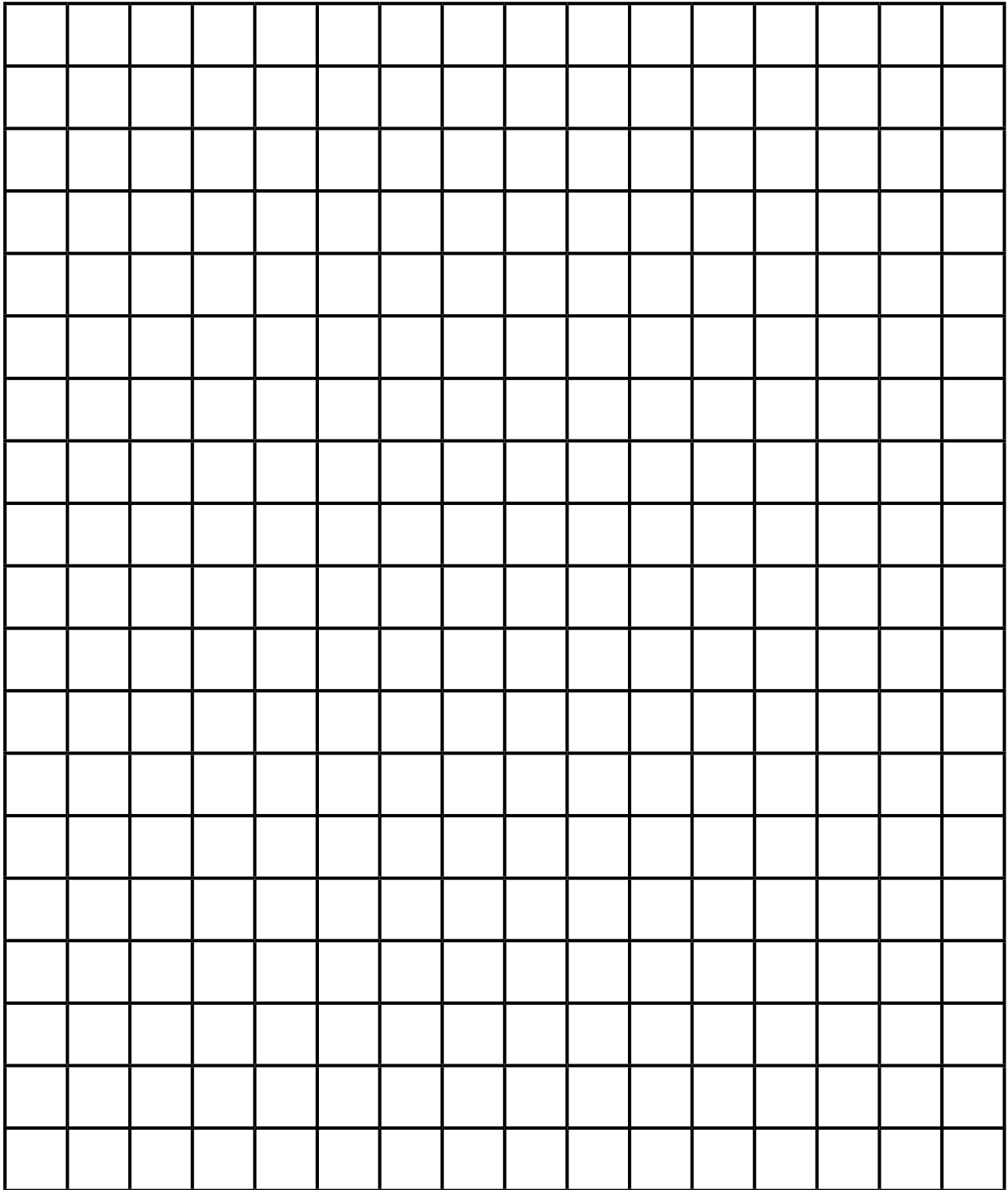
Figure 5.2. Graph Title for Part 1:



### Procedures for Part 2:

- (1) Use the Best Fit Line on your graph from Part 1 of Lab O-4 to find the average number of pennies for each depth. Record your observations in Data Collection Table #3.
- (2) Predict the associated masses and record.
- (3) Place the required amount of pennies for 1 cm in the canister. Measure the total mass of the canister and pennies. Record your observations.
- (4) Test and adjust the mass with pennies to get the exact mass needed to sink the canister. Repeat for other lengths.
- (5) Add your data to the whole-class data, in Data Collection Table #4.
- (6) Make a graph of Data Collection Table #4, with the “Total Mass” on the vertical axis and “Length of Cylinder” on the horizontal axis. Draw a Best Fit Line to show the average line of data.

Figure 5.3. Graph Title for Part 2:



## Part 3: (Student Handout)

*Note:* Distribute to students after they complete the Prediction in *Part 2*.

Anticipation Section Title: (O-5) Barging Down the River

### Thinking About the Problem

What is a barge? It is a large, flat-bottomed boat used primarily for the transportation of goods down a river. What is the purpose of ballast? *Ballast* is a nautical (*nauta*, “sailor” in Latin) term for mass carried by any floating ship. Any material added to a floating object to make it sit lower in the water is called ballast. Since ancient times, sailors have added ballast to their ships to make them more seaworthy. When the amount of ballast is kept constant, careful observers can begin to notice other characteristics of floating objects that influence how low they sit in water.

Knowing how high or low your boat will sit in water is vital for some occupations. Imagine the need for this knowledge as you journey down a long river on a barge, passing under bridges without hitting them. Imagine the need for navigating a large ocean vessel into a harbor, without hitting bottom. It is important to know the effect of ballast while floating any boat.

In the sinking canister experiment (Lab O-4) that you just completed, both the canister and the pennies had mass. You learned that the greater the mass of an object, the deeper it sinks. From the barges inquiry activity, you now know that the size of a barge (base area) can also play a role in how deep the barge sinks. In this lab you will investigate another property (volume) that might help us determine the depth of sinking.

## Data Collection Materials:

- Bucket
- 600 mL barge
- 900 mL barge
- Metric ruler
- Rubber bands
- Water

## Data Collection Procedures:

- (1) Fill the smaller barge with 50 g of water. The water is ballast (50 mL of water has a mass of 50 g).
- (2) Predict and record how deep the barge will sink in a bucket of water.
- (3) Put the barge into a bucket of water. Move the rubber band to mark the depth to which the barge sinks when it is held level.
- (4) Measure and record the actual depth of sinking, from the bottom of the barge to the rubber band.
- (5) Put 50 g of water into the larger barge. Predict, how deep the larger barge will sink, then measure, and record how deep the larger barge actually sank.
- (6) Fill the smaller barge 100 g of water and perform the same procedure as #2–#5. Then use 150 g of water.
- (7) Measure and record the length and width of each barge. Calculate and record the base area of each barge.
- (8) Transfer the appropriate data for the 100 g ballast barges into Data Collection Table #3. Calculate and record the submerged volume (the amount of space taken up by the barge underwater) of each barge.



Topic: Mass

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Code: ESS037



Topic: Mass and Volume

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Code: ESS038