Seventh Grade Science Overview

	First Semester	Second Semester
Science	Variables and controlled experiments Movement of Earth and moon Astronomy Geology Weathering and erosion Plate tectonics Student-led scientific theory	Global climate change Meteorology Water cycle Atmosphere pressure and wind patterns Earth's resources Human population growth Biodiversity and habitat loss Student-led scientific inquiry

Grade 7
Earth Science Coursebook

Oak Meadow

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Introduction

Welcome to the Oak Meadow Earth Science course. In this course, we will be studying Earth and the natural processes that function throughout our home planet. Learning more about Earth helps us understand the many ways in which we are connected to its natural processes and become better prepared to protect and preserve the world in which we live.

Course Materials

This course uses the following materials:

- *Grade 7 Earth Science Coursebook*
- *Earth Science Lab Manual*

The coursebook in your hands is your primary resource for completing the course. The lab manual includes all the instructions for completing the lab investigations that are an important part of this course. (The lab manual is sold separately.)

It is often helpful to seek out additional sources to help you better understand a topic. On the Oak Meadow website, you will find a Curriculum Resource Links page for this course at www.oakmeadow.com/curriculum-links/. If you have access to the internet, take a few minutes to look it over and then bookmark the page for future reference.

How the Course Is Set Up

This course is divided into 36 lessons, and each lesson is designed to take about one week to complete.

In most lessons, you will find the following sections:

An **Assignment Summary** is included at the beginning of each lesson so you can see at a glance what is required, and check off assignments as you complete each one. Assignments are fully explained in the lesson.

A **Materials list** shows you what materials will be needed in each lesson so you can collect your supplies ahead of time.

Learning Objectives outline the main goals of the lesson and give you an idea of what to expect.

Assignments are designed to help you understand key concepts and apply your knowledge. These will often include a “choice assignment” where you can choose the one that sounds most interesting to you.

Lab Investigations, which are found in the lab manual, provide hands-on ways to work with the materials and practice your scientific skills. These are a required element of the course.

Optional Activities offer a wide variety of ways to explore the topics you are studying. You can choose any that interest you (none are required).

Tests provide a way for you to demonstrate your mastery of the material.

Learning Checklists are included to help you keep track of your progress and the skills that still need work. These can be filled out by you or by an adult who is supervising your work.

A section **For Enrolled Students** provides reminders and information for students who are enrolled in Oak Meadow School and submitting work to their Oak Meadow teacher.

Reading Selections are found at the end of each lesson. This section contains your primary source of information for the lesson material.

There are five units in the course: Scientific Habits, Space, Earth, Meteorology, and Environmental Science. Each unit begins with a brief introduction, and ends with a two-lesson project called Scientific Inquiry. These projects are designed to let you dive into the material more deeply.

How to Get the Most Out of This Course

When you begin each lesson, scan the entire lesson first. Take a quick look at the assignments and lab description, and then look over the reading sections to get an idea of how much reading there is. It might also help to read the test questions too. Having a sense of the whole lesson before you begin will help you manage your time effectively.

An important element of this course is developing good scientific habits. Here are some tips:

- Take the time to explain your observations and ideas using clear, precise language.
- Use scientific terms whenever possible. These words are in italics in the lesson text; if you don’t understand a term after reading the text, look it up on your own. Science writing requires a certain amount of precision and using the scientific terms will make your writing more exact.
- Make sure you use examples from the reading or from your observations to back up your statements.
- Assume the role of expert, and write out your ideas as though you are explaining them to someone who is just learning about science.

- When making observations, your notes should be as detailed as possible, describing what you observed with your senses. Before you begin your observations, determine whether you can organize the page in such a way to make note-taking easier. Use of a chart or a diagram can help you keep your observations organized.
- Learning to draw accurately is another important scientific skill. Artistic style is not as important as attention to detail. By studying the object carefully, you will be better able to draw an accurate representation. Make sure to label all diagrams and drawings, and add color as necessary so the drawings give more clear or accurate information.

For Students Enrolled in Oak Meadow School

If you are enrolled in Oak Meadow School, you will submit work to your Oak Meadow teacher on a regular basis. Continue working on your next lesson while you are waiting for your teacher to send lesson comments. After you have submitted the first 18 lessons, you will receive a first-semester evaluation and grade. At the end of 36 lessons, you will receive a final evaluation and grade.

Follow the instructions in your teacher's welcome letter about how and when to submit work. Your teacher may also provide information on alternate assignments, and can help you adapt the lesson material or workload, if necessary. Contact your teacher whenever you have a question.

You are expected to submit original work, writing in your own words. When you use other sources, cite them accurately following the guidelines in the appendix. Plagiarism, whether accidental or intentional, is a serious matter.

The appendix of this coursebook includes complete details on Oak Meadow's academic expectations and original work guidelines. It is your responsibility to make sure you understand these academic expectations and abide by them.

Please remember to stay in touch with your Oak Meadow teacher and share your comments, ideas, questions, and challenges. Your teacher is eager to help you!

Spaceship Earth: Home Sweet Home

Our planet is home to an amazing array of living organisms and complex natural processes. It is an exciting world, sometimes mysterious, but always interesting. Scientists are constantly learning more about Earth than ever before. In this course, you will join them on this journey of discovery!

Unit I: Scientific Habits

To see a world in a grain of sand
And a heaven in a wild flower,
Hold infinity in the palm of your hand,
And eternity in an hour.

(excerpt from "Auguries of Innocence" by William Blake)

Science has an element of wonder. It may seem like science tries to take the wonder out of Earth's marvels by objectively studying them and describing them, reducing them to bits of data. But it is our wondering about Earth, the stars, and all things in the universe that drives scientific inquiry. We should never stop wondering and being awed by nature!

We don't want to just be awed, though. We want to search for and find answers, to see patterns and relationships, to make connections. And its important to be as accurate as we can when we communicate what we learn. What if scientists didn't have to do experiments and studies to find out things? What if they could just make statements about what they think is true without testing or proving anything? If you are thinking this would be a terrible idea, you are right! For thousands of years, people have been studying how things work and why, and over time a set of clearly defined methods have been created. In this unit, you'll learn the habits that scientists all over the world use to help ensure that the results of their experiments and studies are accurate.

At the end of this unit, you'll find a double lesson called Scientific Inquiry. This lesson gives you the opportunity to create a project of your own design, based on something you are interested in. As you study and work with the material in this unit, pay attention to what intrigues or inspires you, or what you have questions about or would like to learn more about. Jot down your ideas (you can flip forward to lesson 3/4, your first Scientific Inquiry lesson, and write your ideas there where you'll see them when you get to that lesson).

Each unit begins with a poem (or sometimes two) to help you tap into that sense of wonder that is such an important part of science. Perhaps these poems will inspire you to express your own sense of awe in a creative way.

There was a time when meadow, grove, and stream,
The earth, and every common sight
To me did seem
Apparelled in celestial light,
The glory and the freshness of a dream.

(excerpt from "Ode: Intimations of Immortality from Recollections of Early Childhood" by William Wordsworth)

Lesson 1

Observation and Measurement

ASSIGNMENT SUMMARY

- ☐ Complete the reading selections.
- ☐ Record detailed observations in an outdoor setting.
- ☐ List helpful observation tools and explain their purpose.
- ☐ Demonstrate how volume can change without altering mass.
- ☐ Explain the relationship between volume, mass, and density.
- ☐ Lab Investigation:

  Option 1: Water Clock

  Option 2: Comparing Volume and Mass
- ☐ Optional Activities:

  Activity A: Human Clock

  Activity B: Calculating Density
- ☐ Complete lesson 1 test.

MATERIALS

Option 1 Lab Investigation: Water Clock

plastic milk container

large pan or bucket

metric ruler

marker

clock or watch

sewing needle or pushpin

Option 2 Lab Investigation: Comparing Volume and Mass

modeling clay

metric ruler or tape measure

measuring cup

towel

Activity B: Calculating Density

book

scale

metric ruler

Learning Objectives

At the end of this lesson you will be able to:

- Demonstrate good scientific observation skills.
- Record scientific measurements accurately.
- Demonstrate and explain the relationship between mass, volume, weight, and density.

Reading

Read the following sections (found in Reading Selections at the end of this lesson).

- Observation and Change
- Objective Observations and Inferences
- Scientific Argument
- Systems of Measurement
- Mass, Volume, and Density
- States of Matter

Before you begin reading, glance over the length of the reading selections in this week's lesson. You will find quite a bit of reading! You might already be familiar with some of the information, and some of it will probably be new to you. It's a good idea to read one or two sections and then take a break before reading more. That way, you are more likely to remember what you read.

In addition to the reading selections in this coursebook, you are encouraged to learn more about topics you are interested in by visiting the library, reading newspapers and scientific journals, and doing research online. You'll find a list of online resources at www.oakmeadow.com/curriculum-links/. You can use these links to learn more about lesson topics.

Assignments

Before you begin your assignments, read them through to get a sense of what you'll be doing and how long it will take. This will help you manage your time better. Just like with the reading, you may want to do a few assignments at a time and then take a break instead of pushing to get them all done at once. You have a full week to complete these assignments, so there's no rush.

1. For your first assignment, you'll be conducting an outdoor observation in a natural setting. This might be your yard, a nearby park, woods, a tree in the middle of the sidewalk, a pond, or a stream. Bring a notebook and pencil, and sit quietly for a few minutes while you observe the natural surroundings. Use as many senses as you can. Look carefully for all the details you can notice, and then close your eyes for a bit to tune into other senses.

   Write down a general description of the area in which you are observing, and then write a detailed description of one part of the area or an object within the area you are observing. Be as specific as you can, and use clear, objective language.

2. List any tools or instruments that would be useful in making a more detailed analysis of your observation and briefly explain why they would be useful. What would you do with them?

3. Take two pieces of paper of identical size and weight and crumple them into two loose balls of similar size. Demonstrate how you can change the volume of one without changing its mass.

Then, tear a piece off one of the papers, and crumple it back into a ball so that it matches the size of the second ball. Have you changed its mass or volume?

If possible, conduct your demonstration in front of someone else, and explain what is happening in scientific terms. Alternately, you can video your demonstration and explanation, or you can put your explanation in writing or in audio form. Make sure to define mass and volume as you are describing what happened.

4. Explain why it is always true that if two objects have the same volume but one object has a greater mass than the other, the object with the greater mass will also have a greater density. Give an example that is different than the examples in the reading section. You can do a video or audio recording or write down your explanation and example.

Lab Investigation

Choose one of the following lab investigations to complete.

- Option 1 **Lab Investigation: Water Clock**
- Option 2 **Lab Investigation: Comparing Volume and Mass**

All lab investigations are found in the *Earth Science Lab Manual*. Read each through completely before making your choice. Assemble all your materials before you begin. Use good scientific habits by taking careful observations and measurements, recording your data in an organized way, and using precise, detailed language.

Activities

The following activities are optional, and are offered to give you more ways to explore the lesson material. These activities are not required. Feel free to choose whatever looks interesting to you.

- Activity A: Human Clock
- Activity B: Calculating Density

Activity A: Human Clock

Find three people of different ages, preferably at least ten years apart and of the same gender. You might choose yourself, a parent, and a grandparent, or you might choose friends, siblings, and neighbors. Ask these people if you could study their hands, faces, and hair. Look carefully at their hands (both the palm and the back of the hand), and notice the size, lines, knuckles, skin texture, etc. Pay attention to the changes that seem to occur in a person's hands over time. Look carefully at each person's face and hair, noticing the skin texture, hair color, lines, etc. Ask these people to share changes they have been aware of in their own hands, face, and hair over time. Record any findings or patterns. Write or draw a descriptive piece of work that shows how you think your own hands, hair, or face will change over time.

Activity B: Calculating Density

Materials

- book
- scale
- metric ruler

Procedure

1. Measure, in centimeters, the length, width, and height of the book.
2. Using the formula *volume* = *length* × *width* × *height*, calculate the volume of the book in cubic centimeters.
3. Measure the book's mass by weighing it on the scale, and then convert the weight into grams (1 pound = 454 grams).
4. Calculate the book's density using the formula *density* = *mass* ÷ *volume*. Your answer should be in grams per cubic centimeter.

Test

Answer the following questions using the knowledge you have gained in this lesson. Use correct terminology and refer to scientific concepts to support your answer whenever possible.

1. Explain the difference between quantitative and qualitative observations and give an example of each.
2. Explain the relationship between mass, volume, and density. You don't have to give the formulas; just explain things in your own words.
3. What are the three most common states of matter on Earth? Give an example of each, and explain how they are different.
4. Describe the three steps of a scientific argument.
5. What is the difference between an observation and an inference?

Learning Checklist

This learning checklist can be filled out by either you or the adult who is supervising your work. This checklist will help you keep track of how your skills are progressing and what you need to work on. You or your home teacher can also add notes about where you'd like help.

Here is what the different headings mean:

Developing: You still need to work on this skill.

Consistent: You use this skill correctly most of the time.

Competent: You show mastery of this skill.

Please remember that these skills continue to develop over time so you aren't expected to be able to do all of them yet. The main goal is to be aware of which skills you need to focus on.

SKILLS	Developing	Consistent	Competent	Notes
Describe observations in detail				
Record accurate measurements				
Summarize procedure and what it demonstrated				
Demonstrate and explain the relationship between mass, volume, and density				
Use scientific terminology in explanations				

FOR ENROLLED STUDENTS

You will be sending your work from this lesson to your Oak Meadow teacher at the end of lesson 2. In the meantime, feel free to contact your teacher if you have any questions about the assignments or the submission process.

Reading Selections

Observation and Change

Science describes what we know about our world. We learn about the world by observing what is happening all around us. We observe through our senses: we watch, we listen, and we feel. Then we reach conclusions about what it all means—we make sense of the world.

Observing and exploring Earth is about being receptive to what lies all around us. It is observing closely with our eyes, ears, nose, hands, and whole body sense as fully as we can. However, most of us depend almost entirely on our eyes. But there is so much going on that our eyes cannot perceive. What goes on beneath the surface of Earth? What forces are carving and molding the face of Earth? There is the world of little things that we can just barely see. There is the world of things so big, our eyes cannot see the whole.

Lab work is an essential part of scientific study. Pictured here is scientist Erika Flores of NASA's Jet Propulsion Laboratory. (Image credit: NASA/JPL-CalTech/Kim Orr)

What is it that happens when we observe? What is it that we are noticing? How is it that our senses perceive what is happening?

What our senses notice are *changes*. Living things grow, die, move, and change size, shape, and place. When we notice anything, it is usually because there has been some change. Sometimes we notice that there has been no change when one was expected. Changes or lack of change often form the bulk of scientific observation.

With practice, the right tools, and the guidance of teachers and scientists, we can make our senses work more clearly in providing information to our brains. This way we can sense changes and know what to do in a particular situation. The more complete the information, the more sound our conclusions.

Forest Service botanist Mark Jaunzems takes a close look at one of the plants in the Sand Dunes area of the Hiawatha National Forest in Michigan. (Image credit: U.S. National Forest Service)

Objective Observations and Inferences

By closely observing something, we gather information about it. This information becomes *evidence* or *data*, which we need to record as accurately as possible. When gathering data, it's important to remain *objective*. This means reporting only what you observe, rather than what you think to be true or guess might be happening. Scientists use very careful, detailed language to describe their observations. This helps them make sure their data is accurate.

Observations often have an element of measurement in them; these are *quantitative* observations. Measurements of quantity, weight, volume, or speed are all measurable observations. Quantitative data always involve numbers and require accuracy. *Qualitative* observations describe the attributes of something, such as its texture, color, smell, or sound. These observations require very detailed, precise, descriptive language.

Once data is collected through qualitative and/or quantitative observations, scientists often study it to find patterns or differences. They make *inferences* based on their interpretation of the data. Inferences are explanations or conclusions that are based on reason and evidence rather than opinion or feeling. Even though inferences are based on factual evidence, they are not fact but rather an educated conclusion about why something might have happened or what might happen in the future.

Roylene Rides, of the Natural Resources Conservation Service, taking an inventory of pasture grasses. (Image credit: NRCS)

Scientists are careful not to claim these inferences are fact because they may or may not be correct. For instance, a scientist might say, “In the feral cat population studied, female cats had an average of 3.5 litters per year, resulting in an average of 22 kittens per year per cat being introduced into the feral cat population. This suggests that a spay and release program targeting the female feral cats will significantly reduce the overall feral cat population.” The first statement is factual information that is objectively observable, and the second statement is an inference, a logically drawn conclusion about what the data indicates might happen. It is correct to say that the data “suggests” that the population would be reduced but it would be incorrect to claim that the population *would* be reduced; there’s no way of knowing for sure what will happen until they try it.

Scientific Argument

In developing your scientific skills, pay particular attention to honing your objective observations, using accurate details and careful measurements. At the same time, work on drawing conclusions based on your interpretation of the data, and using your data to support your claims. This is called a *scientific argument*; you should be able to “argue” or prove every inference or conclusion you state using the data you collected. Here are the steps to making a scientific argument:

Observation is part of research projects. (Image credit: USDA)

1. Make a claim based on your research.
2. Provide evidence (data) to support your claim.
3. State your reasoning for how the data supports the claim.

The first step, the claim, is your inference or conclusion, based on reason and data. Make sure your inferences are specifically identified with phrases such as “this suggests,” “it appears,” and “it seems likely.” Never state an inference or claim as a fact—scientists are very careful about that! If you did the feral cat study above, your

Soil scientist Eton Codling observes the changes in corn growth on manured soil treated with alum residue. (Image credit: USDA)

claim might be "A spay and release program targeting the female cat population can significantly reduce the feral cat population in one year." Notice this claim says it "can," not that it "will" ("can" means it might or it might not).

In the second step, you compile your data into a form that is easy to grasp and make sense of. For instance, rather than sharing a collection of numbers from your research, you might find an average of the number of feral kittens born in one year, or show the percentage of the feral cat population that is female. Charts, graphs, and data tables are excellent ways to provide evidence to support your claim.

The third step requires you to communicate clearly the logical reasoning process behind your claim. You'll explain what the data "tells" you, and why this makes you think that your claim is accurate.

Just like everyone, scientists have opinions and biases. Each person has a unique point of view, based on their life experiences. However, even when making observations, interpreting data, making claims, and providing scientific argumentation, scientists try very hard to keep their opinions and feelings separate from their scientific study. This is another important quality of a scientist.

Systems of Measurement

To communicate what we learn about the world, we must have a common language. Measuring is a way of comparing different aspects of the world using a common language. We make comparisons to measure changes and differences.

Imagine that you are holding a rock in your hand. If you were asked to describe it, how would you do it? You might describe its color, shape, size, or weight. It might be hard or crumbling, rough or smooth. Scientists make these same types of observations, then describe what they have observed. They do this through measurements. Units of measure make it possible to compare things according to certain qualities they possess.

When we think of measuring, we often think of size or weight or quantity. Time is another important measurement for science. Many experiments are designed to record observations over a period of time. Clocks and watches are common tools used to measure time. Old ways of measuring time utilized different tools, such as the sun's shadow falling on the face of a sundial, or the sand falling through a tiny opening in an hourglass. Hours, minutes, and seconds are the common units of the measure of time.

Scientists all over the world use the metric system as the common language of measurement. A meter is the basic unit of length in the metric system. It was originally defined as one ten-millionth of the

There are thousands of measuring tools that have been invented. This rainfall simulator and test plot in Cottonwood, South Dakota, enabled technicians to measure water runoff rates and collect soil samples in a WEPP cropland field study. (Image credit: ARS/Tim McCabe)

distance on Earth's surface from the North Pole to the equator. To understand just how much distance there is in a meter, look at a doorway in your house—most doorways are about 1 meter wide and about 2 meters high. To measure short lengths, scientists use the centimeter (1/100 of a meter) or the millimeter (1/1,000 of a meter). To measure longer lengths, scientists use the kilometer, which is equal to 1,000 meters. If you are unfamiliar with the metric system, take some time to learn about it or review what you know.

Measurements of all types rely on accurate numbers as well as a unit label. If we say something travels at a rate of 15, what does that mean? 15 kilometers per hour? 15 meters per second? We would need to include the unit label in order for the measurement to make sense.

Mass, Volume, and Density

Mass, *volume*, and *density* are three measurements that scientists frequently make. The *mass* of an object is the amount of "stuff" it contains. It is often measured in grams or kilograms. Many people think of mass and weight as the same because you can easily convert your weight in pounds to metric units and you will have mass. But they really are different. Weight can be defined as the measure of the pull of gravity on a particular object. The mass of a car does not change if you crush the car. It will take up a smaller amount of space (volume) but it will still have the same mass and weight. It you took that same car up into space, away from Earth's gravity, it would have a different weight, but still have the same mass. Mass is the same at any altitude, on the moon, in the water, or anywhere!

Volume is a scientific measurement of size, the amount of space that an object takes up. It is measured in cubic units, such as cubic centimeters. Here is the formula for calculating volume:

$$\text{Volume} = \text{length} \times \text{width} \times \text{height}$$

If two objects have the same size and shape, they will have the same volume. They may have a different mass or weight, but they will have the same volume. That means they both take up the same amount of space. Imagine you had a balloon the exact shape and size of a soccer ball. The balloon would be a lot lighter and its mass would be less than the ball, but its volume would be the same.

Density is the relationship of mass to volume. Objects that have more substance per volume have a greater density than objects with less substance per volume. Density is a measure of how tightly the molecules of whatever it is (gas, liquid, or solid) are packed into a space. The matter in a tennis ball is more compact than the matter in a balloon of the same size, so we say the tennis ball has more density. Or think about a rock that is the exact size and shape of a ping-pong ball. The two objects have the same volume, but their mass per volume is very different. The rock is denser than the hollow ping-pong ball, so it has more mass and weight. If you crush the ping-pong ball, its volume is reduced—it takes up less space, even though it still weighs the same and has the same mass because we didn't take away any of its substance; we just changed its shape. However, because we changed its volume, we also changed its density. The ping-pong ball is now much more dense than it was before because it is the same amount of substance packed into a smaller space.

Liquids take the shape of their containers. In a chemistry lab, liquid measurement tools are calibrated in the metric system. (Image credit: Horia Varlan)

Density is calculated by dividing an object's mass by its volume:

$$\text{Density} = \text{mass} \div \text{volume}$$

Many people confuse mass with volume. They think that if an object has a large volume (size) it must have a large mass (weight). If you have a pillow and a rock of the same size (volume), it is easy to tell which has the greater mass. If two objects have the same volume but one has a greater mass, it will have a greater density. You can probably guess which has the greater density: rock or pillow? What happens if you kick the pillow? What happens if you kick the rock? The pillow will not put up much resistance, but you are liable to break your toe on the rock. Not only does the rock have more mass, but it also has a greater density.

Don't worry if you find these concepts challenging at first! We will be working with them throughout the course and you will have plenty of time to develop a solid understanding of these important scientific measurements.

States of Matter

Matter is anything that has mass and volume. Matter is anything that takes up space, no matter how small. It includes everything of substance in the universe. Matter exists in several different forms. The types we find most commonly on Earth are solid, liquid, and gas, so it's essential to have a clear idea of the difference between them.

A *solid* has a definite shape, size, and volume. A rock, a piece of ice, and a block of wood are all considered solids.

A *liquid* has a definite volume, but will always assume the shape of its container. Water or oil will change shape as you pour it from one container to another. A round bowl will give the water inside it the same round shape. But put the same amount of water in a tube or hose, and its shape will change to be the same as its enclosure. The volume has not changed but the shape has.

A *gas* has no definite volume or shape. A gas will take the same shape as its container, but it will spread out to fill the entire volume of any shape container, so its volume can change, depending on the conditions.

Lesson 2

Scientific Method

ASSIGNMENT SUMMARY

- ☐ Complete the reading selections.
- ☐ Apply the scientific method.
- ☐ Identify the difference between correlation and causation.
- ☐ Lab Investigation: Celery Experiment
- ☐ Complete lesson 2 test.

MATERIALS

Lab Investigation: Celery Experiment

4 stalks of fresh celery with leaves
knife
4 jars
red or blue food coloring
measuring cup
4 paper towels
timer
peeler
metric ruler
old newspapers or towels

Learning Objectives

At the end of this lesson you will be able to:

- Explain the steps of the scientific method.
- Identify the variables being controlled and the variable being tested in a controlled experiment.
- Differentiate between causation and correlation.

Reading

Read the following sections (found in Reading Selections at the end of this lesson).

- Scientific Method
- Variables and Controlled Experiments
- Causation and Correlation

Remember to check the curriculum resource links at www.oakmeadow.com/curriculum-links/ to learn more about lesson topics.

Assignments

Scan through the assignments, lab investigation, test, and reading selections before you begin to get a sense of what you'll be doing and how long it will take. It's best to do a few assignments at a time and then take a break instead of trying to get everything done at once.

1. Imagine you are conducting an experiment to answer the question "Can a paper bag hold more weight when it is dry or when it is wet?" Answer the following questions about how you would apply the scientific method to conduct this experiment.

   a. State a hypothesis for this experiment.

   b. Create a list of materials. Be as precise as possible. For instance, what size paper bag would you use? How many would you need for your experiment? What would you use for a weight?

   c. Explain the procedure you'd follow for testing your hypothesis. What would you do first? What next? Write down the procedure step by step, including how long to soak the bags that you are getting wet, and how many times you will try the experiment (how many wet bags will you test? How many dry bags?). Will you try the experiment with two or more types of wet bags (for instance, bags that have soaked for 5 minutes, bags that have soaked for 15 minutes, and bags that have soaked for 30 minutes)? Remember, every aspect of the experiment needs to be controlled as much as possible, so write down your procedure very clearly.

   d. What observations will be recorded? This experiment uses two different groups: dry bags and wet bags. Imagine you are doing the experiment—what will you write down? If possible, create a data table that has labeled rows and columns that show what data will be collected.

   e. In this experiment, what are the elements that you controlled? What would be exactly the same each time the experiment is repeated?

   f. If all the elements are exactly the same each time you do the experiment, what is the one thing that is different? What is the variable you are testing?

2. A cause-and-effect relationship or causality (A always leads to B) is difficult to prove because there are often many factors involved. Answer the following questions about causation and correlation.

   a. More ice cream is sold during the summer than during the winter. Does this show correlation or causation? Does A (hot weather) always lead to B (eating ice cream)? Explain your answer.

   b. People who stand in line use their cell phones more often than people who are not standing in line. Does this show correlation or causation? Does A (waiting in line) always lead to B (using a cell phone)? Explain your answer.

3. In the early 1900s, it was noticed that villages with a high number of babies being born also had a high number of storks in the town. Did the presence of more storks cause more babies to be born? Did more babies being born cause more storks to appear? Was there correlation or causation? (Actually, there were more houses in these villages to house all the new families, and storks like to nest near chimneys, so more storks lived there.) Draw a comic, poster, or illustration that uses this example (or another one) to explain the statement "Correlation does not imply causation."

Lab Investigation

Complete the following lab investigation using the steps of the scientific method (full instructions are found in the lab manual).

- **Lab Investigation: Celery Experiment**

Use good scientific habits by taking careful observations and measurements, recording your data in an organized way, and using precise, detailed language.

Test

Answer the following questions using the knowledge you have gained in this lesson. Use correct terminology and refer to scientific concepts to support your answer whenever possible.

1. List and explain each of the steps in the scientific method.
2. How is the scientific method similar to the logical thinking one does for the accomplishment of any project or task? Give an example from your own experience.
3. What is a controlled experiment? What is being "controlled"? Include an example with your explanation.
4. In your own words, explain the difference between correlation and causation.
5. How can causation be proved?

Learning Checklist

This learning checklist can be filled out by either you or the adult who is supervising your work. This checklist will help you keep track of how your skills are progressing and what you need to work on. You or your home teacher can also add notes about where you'd like help.

Here is what the different headings mean:

Developing: You still need to work on this skill.

Consistent: You use this skill correctly most of the time.

Competent: You show mastery of this skill.

Please remember that these skills continue to develop over time so you aren't expected to be able to do all of them yet. The main goal is to be aware of which skills you need to focus on.

SKILLS	Developing	Consistent	Competent	Notes
Follow the steps of the scientific method				
Identify variables in a controlled experiment				
Record accurate measurements				
Differentiate between correlation and causation				
Use scientific terminology in explanations				

FOR ENROLLED STUDENTS

When you have completed this lesson, please send lessons 1 and 2 to your Oak Meadow teacher. Include any additional notes about the lesson work or anything you'd like your teacher to know. Feel free to include any questions you have—your teacher is eager to help.

If you have any questions about what to send or how to send it, please refer to your parent handbook and your teacher's welcome letter. Your teacher will respond to your submission of student work with detailed comments and individualized guidance. In the meantime, proceed to lesson 3 and continue your work.

Reading Selections

Scientific Method

We are all scientists in our own ways. We ask questions, guess what the answers will be, watch to see what happens, record the results in our minds, decide what the results mean, then take this knowledge and use it to make decisions about our lives. This is an example of what is called the *scientific method*. Scientific thinking is a part of all of us.

Careful observations and procedures are part of the scientific process. Florida A&M University student Johnnene Addison helps sort aquatic insects used in biological monitoring of water quality. (Image credit: ARS/Keith Weller)

People make sense of the world using some of the same processes that scientists use to conduct experiments. Most people are not aware of their scientific thinking, but there is little difference of thought for an artist, writer, runner, or scientist. Each problem we solve is like an experiment. We do not always know what the outcome will be, but we can make a guess, or *hypothesis*. Then we go through the steps to test our hypothesis. We draw conclusions about what worked, what didn't, and why. Then we ask more questions, and create a new hypothesis to test.

Consider a painter who starts a painting with an idea, makes a guess about how to approach the idea, and finds this approach or experiment did not produce the desired results. A painter may paint the same thing over with a new technique or different colors or more attention to detail, experimenting repeatedly until the desired result is achieved. This is similar to a scientist who repeats an experiment, changing different elements each time, in order to gain a clear understanding of a phenomenon.

There are an endless number of situations or factors that influence what we observe, what we decide to do, or how we decide to approach the problem to be solved. When drawing conclusions about what happened and why, there are many factors that affect our perceptions. Scientists try to keep these influences under control by following very specific procedures.

Here are the steps of the scientific method:

> **Ask a question:** Usually this question is the result of an observation that makes you wonder about something. For instance, you might notice that peas and beans always sprout first in your garden and wonder "Which vegetable seeds have the shortest sprouting time?" Or you

ARS lab technician Debra Williams and Kennedy High School student Sean Gros label cotton bolls for identification. (Image credit: USDA/Scott Bauer)

might notice that the water in a shallow puddle freezes before the water in a bucket and wonder "What is the freezing time for water of different depths?" The question should be brief, concise, and testable.

Form a hypothesis: A statement is made that is an educated guess about what the answer to this question might be. This statement is called a hypothesis and is based on what you already know. Your experiment will attempt to prove or disprove your hypothesis. For the seed sprouting question, your hypothesis might be "Large vegetable seeds sprout more quickly than smaller ones." For the question about freezing water, your hypothesis might be "The time it takes water to freeze increases in regular increments as the depth of the water increases."

Conduct an experiment (procedure): An experiment is set up and performed. This is called the procedure. Often experiments are performed multiple times to see if the results can be repeated.

Record the results: Observations are made during the experiment and the results are carefully recorded. These results tell what we notice with our senses during the experiment. Results, which can be qualitative or quantitative or both, are recorded as objectively as possible.

Draw a conclusion: The data is compiled and the results are interpreted as you make inferences about what happened and why. The hypothesis is either proved or disproved. The conclusion explains what you learned during the experiment.

Often a conclusion leads to more questions and more experiments. Did the procedure really do what it was intended to do? Could the method be improved so that it would have more accurate results? What uncontrolled conditions might have influenced the data? Do you need to repeat the experiment with a variation to gain more accurate data? How can the information or process apply to personal life or experiences? The conclusion answers the questions, "What does it all mean?" or "So what?"

Students in Egypt demonstrate an experiment of their own design. (Image credit: USAID/Claudia Gutierrez)

The conclusion gives you the opportunity to reflect on the experiment and to make note of ways in which the experiment might be changed. For instance, you might think of ways to improve the experiment's effectiveness, perhaps by controlling a different variable or doing more trials (more repeats of the experiment to see if you get the same results). You might think of new ways to gather data or different details to look for. You might think of ways to gather additional data (for instance, do the results change if you use smaller or larger amounts of material, or do the tests in smaller or larger amounts of time?). Or you might think of a new, related experiment that looks at another element of the process. Any ideas you have about how to improve the experiment or about doing follow-up experiments are included in the conclusion.

Variables and Controlled Experiments

Experiments are designed to try to determine the effect of a particular factor or *variable*. A scientist sets up a *controlled experiment* to test the effect of a variable on something else. A controlled experiment attempts to test only one factor at a time while keeping everything else exactly the same—same volume, same temperature, same procedure, same light source, same everything! The scientist observes how the variable changes (or doesn't change) throughout the experiment.

For instance, if you were doing an experiment on how temperature affects seed germination, you would use the same type of seed and soil, and the same amount of water, and only vary the temperature. If you tested carrot seeds at 68° F and pea seeds at 70° F, you have changed two variables (seeds and temperature) and it will be hard to draw clear conclusions. If the pea seeds sprout first, you won't know for sure if that was because of the temperature or because pea seeds sprout more quickly than carrot seeds. This is why controlling the conditions and isolating a single variable is an important part of designing and setting up an experiment.

Causation and Correlation

A controlled experiment attempts to isolate individual factors to determine what happens or changes as a result of that factor. This is called cause and effect or *causality*. Scientists use the scientific method to try to identify both the cause and effect of a particular event or *phenomenon*. However, this can be harder than it sounds. Just because two things happen at the same time doesn't mean that one caused the other. In fact, this is one of the most common ways that science studies are misreported in the news.

Imagine that you are doing your math homework and your pencil breaks. Maybe this happens two days in a row. You might think there is a relationship between doing your math homework and your pencil breaking. This is called a *correlation*—these two events seem to be related (they might be related and they might not be). But does one event cause the other? Does doing your math homework cause your pencil to break? Probably not. Your pencil could have broken when you were doing your English homework or when you were writing a note to yourself to buy more pencils. There may or may not be causality between the two events (doing math and breaking pencils). Maybe math stresses you out, and you press harder, and your pencil breaks! That would indicate a cause-and-effect relationship. But without a comprehensive experiment, it's hard to prove it—there are just too many other factors involved—so you can't claim causality. There is not enough evidence to determine for sure that doing math causes pencils to break.

"Correlation does not imply causation" is a well-known phrase in science, and it is repeated often with good reason. Many people are quick to assume that correlation and causation are the same thing. It is easy to jump to conclusions and cite a cause and effect relationship where only correlation exists. Having two things happen at the same time doesn't prove that one caused the other, even if it seems to make perfect sense. Ask yourself, does A always lead to B? For instance, maybe you took a walk in the rain and the next day you caught a cold. Did walking in the rain cause you to catch a cold? Not necessarily. It could have been any number of things. There is no way to prove that the weather caused your illness. Does A (walking in the rain) always lead to B (getting sick)? No. Your health and the weather may be correlated but you can't assume causality.

How do scientists establish causality? It's not easy! Conducting a controlled experiment is the best way to identify cause and effect. Even when experiment results seem to prove causation (one thing causing another), scientists are very careful to look for ways that the experiment could have been influenced by uncontrolled variables or how the data might be flawed. Often an experiment is repeated multiple times to see if the results will be the same.

Lesson

6

Earth's Movement

Learning Objectives

At the end of this lesson, you will be able to:

- Describe the three motions of Earth.
- Explain the relationship between the tilt of Earth's axis and the seasons.
- Demonstrate how day and night and the seasons occur on Earth.

Reading

Read the following sections (found in Reading Selections at the end of this lesson).

- Earth's Rotations and Revolutions
- Seasonal Cycles

If you come across a concept that you have trouble grasping, discuss it with an adult or ask questions. Another way to help you understand a concept more clearly is to explain it to someone. Their questions will help you realize which elements you understand and can explain fully and which elements are still murky in your mind.

Assignments

1. What is the difference between an equinox and a solstice?
2. What is the difference between the vernal equinox and the autumnal equinox?

ASSIGNMENT SUMMARY

- [ ] Complete the reading selections.
- [ ] Explain the difference between an equinox and a solstice.
- [ ] Explain the difference between the two equinoxes.
- [ ] Draw a diagram showing Earth's position relative to the sun at different times of the year.
- [ ] Lab Investigation: Earth's Movement
- [ ] Optional Activity: Sundial
- [ ] Complete lesson 6 test.

MATERIALS

Lab Investigation: Earth's Movement

orange

knitting needle or sharpened pencil

pushpin or thumbtack

lamp with the shade removed

Activity: Sundial

white paper plate or piece of paper

pencil

marker

timer

3. Draw a diagram that shows Earth's positioning in relation to the sun during the equinoxes and solstices.

Lab Investigation

Complete the following (see the lab manual for instructions).

- **Lab Investigation: Earth's Movement**

If possible, perform your demonstration in front of an audience (or videotape it) and explain what is happening. (You might want to practice this first.) You can answer the questions on video or in writing. Remember to use correct terminology and precise language.

Activities

The following activity is optional.

Activity: Sundial

In this activity, you'll construct a simple sundial to track the movement of the sun in increments of time. Choose a sunny day to do this activity.

Materials

- white paper plate or piece of paper
- pencil
- marker
- timer

Procedure

1. Find a spot outside to place your sundial on the ground. It should be free of shadows, and in a place where it can sit all day without being moved.
2. Put the pencil directly through the center of the plate and push the point into the ground firmly so the pencil is sticking straight up.
3. Starting as early as possible and on the hour (for instance, 8:00 a.m.), mark on the paper plate where the line of the pencil's shadow falls. Write the time next to the mark.
4. Set a timer, and repeat this process at the beginning of each hour. Make sure the plate and pencil don't move in between measurements.
5. By the end of the day, the sun will provide you with your own primitive clock.

6. The following day, without looking at the clock, go outside and read the time using your sundial. Check your answer with a clock and see how accurate you were.

Test

1. Explain why we have day and night.
2. How long does it take Earth to make one rotation on its axis? How long to make one revolution around the sun?
3. If it is the summer solstice in the Northern Hemisphere, is it also the summer solstice in the Southern Hemisphere? Explain your answer.
4. Describe the three ways that Earth moves through space.
5. Explain the relationship of the tilt of Earth's axis and the seasons. What would happen if Earth's axis were perpendicular and not tilted?
6. When it is March 21, is it the vernal equinox or the autumnal equinox? Explain your answer.

Learning Checklist

Use this learning checklist to keep track of how your skills are progressing. Include notes about what you need to work on.

SKILLS	Developing	Consistent	Competent	Notes
Differentiate between Earth's rotations and revolutions				
Model how Earth's tilt and orbit create seasonal cycles				
Model how Earth's rotation creates sunrise and sunset				
Demonstrate how the seasons differ in the Northern and Southern Hemisphere				

FOR ENROLLED STUDENTS

At the end of this lesson, you will be sending work to your Oak Meadow teacher. Include any additional notes or questions you may have, and make a note if you have altered any assignments or the workload. Please make sure your submission is organized and well labeled, and that complete lessons and assignments are submitted.

Reading Selections

Earth's Rotations and Revolutions

Earth moves through space in two different ways. It *rotates* or spins around its *axis*. Picture Earth's axis as a pencil or knitting needle that pierces through Earth from the North Pole to the South Pole. The planet rotates around this axis, spinning like a top. Earth's axis is tilted slightly in relation to the sun (it is tilted at an angle of about 23.5°). This is why most globes are slightly tilted when they are mounted on frames that allow the globe to spin.

In addition to rotating on its axis, Earth also *revolves* around the sun in a large, *elliptical* orbit (it is not a perfect circle, but more like an oval). As Earth rotates on its axis, only one side of Earth faces the sun at any particular time. Sunlight cannot reach the other side, so that side will be dark until Earth spins and that side is facing the sun. As Earth spins, facing away from and toward the sun every 24 hours, the sun appears to rise in the east and set in the west. The sun isn't actually moving around Earth; it just appears that way because of Earth's rotation.

It takes 24 hours for the planet to make one complete *rotation* on its axis. We measure that as one day. Other planets in the solar system take more or less time to complete one full rotation, so they have longer or shorter days than we do on Earth. Picture yourself standing on Earth as it rotates. As you pass through the light of the sun, it is daytime. As the part of Earth on which you are standing moves away from the sun, it becomes nighttime. The technical terms for the line on Earth separating day from night is the *terminator*; it is also called the *grey line* and the *twilight zone*.

Astronaut Ron Garan photographed this sunrise from the International Space Station. (Image credit: NASA)

The continental United States is divided into four time zones to compensate for the changes in time due to the rotation of Earth. For instance, daybreak comes to New York City on the East Coast of the United States about three hours before it comes to San Francisco on the West Coast. When it is 6:00 a.m. in New York, it is 3:00 a.m. in San Francisco. There is always a three-hour difference between the time at these two places, due to the rotation of Earth on its axis. Since New York City and San Francisco are about 3,000 miles apart, that means Earth is spinning at about 1,000 miles an hour.

However, the farther you move away from the equator, the slower Earth's rotation, and at the North Pole or South Pole, this rotation is virtually nonexistent. Think about Earth's axis as a pencil going through the planet from the North Pole to the South Pole. If you spin Earth on its axis, the top and bottom points are basically staying still. The closer you are to the equator—the widest part of the planet—the faster the rotation.

There is actually a third way that Earth moves. The sun moves through the galaxy at an astounding 483,000 miles per hour. Our solar system is anchored to the sun by gravity, and so we move through the universe along with it.

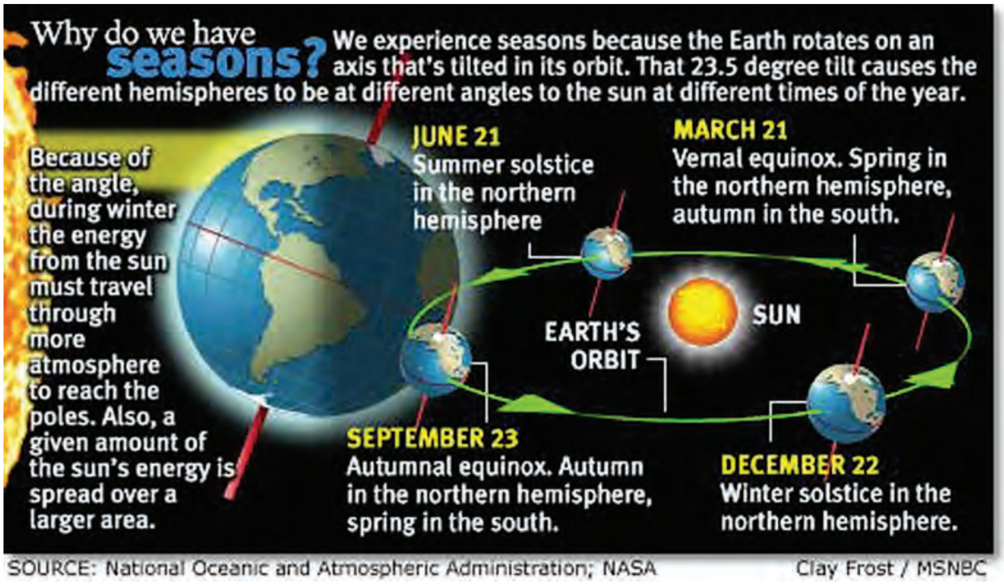
Seasonal Cycles

Earth revolves around the sun in a huge elliptical orbit. It takes one year for Earth to complete one entire orbit of the sun. Other planets in the solar system take more or less time to orbit the sun, so one year on another planet will be longer or shorter than one year on Earth. Earth is tilted on its axis at a fixed angle of about 23.5 degrees as it revolves around the sun; it doesn't tilt one way and then the other as it rotates or revolves. Because of this fixed tilt, most places on Earth experience different seasons: spring, summer, autumn, and winter.

As Earth travels around the sun on its annual journey, the North Pole points nearest to the sun around June 21. This marks the beginning of summer in the Northern Hemisphere. This day, the summer solstice, has the longest period of light and the shortest period of darkness of any day of the year. It is when the path the sun traces in the sky of the Northern Hemisphere is at its highest point.

Of course, in the Southern Hemisphere, the exact opposite is happening: when the North Pole is closest to the sun, the South Pole is farthest from the sun and the Southern Hemisphere is experiencing the winter solstice, with the longest period of darkness and shortest period of light. These differences in light and dark are more pronounced the farther away you are from equator.

As Earth continues on its path around the sun, the number of daylight and nighttime hours begin to equalize. By September 22, neither hemisphere is tilted toward the sun. Did Earth's tilt "straighten up"? No, but Earth moved around the sun until the North Pole wasn't tilted toward or away from the sun, but was basically sideways to it. On this day, every point on Earth will have 12 hours of sunlight and 12 hours of darkness. In the Northern Hemisphere, this is called the *autumnal equinox*, because it is the halfway point in the transition from summer to winter. In the Southern Hemisphere, this is called the *vernal (or spring) equinox*, because it is the halfway point in the transition from winter to summer.



As Earth's revolution around its orbit continues, daylight hours continue to decrease in the Northern Hemisphere, and so does the angle at which the sun's rays hit the northern half of the planet, until the winter solstice, when the North Pole is pointed farthest away from the sun. This happens on or around December 21. It is the day with the least daylight and the longest period of darkness in the Northern Hemisphere, when the sun's path is lowest in the sky. At the same time, the South Pole is at its closest point to the sun, and the Southern Hemisphere is experiencing its summer solstice, with the longest amount of daylight and the highest arc of sun in the sky.

As Earth's orbit continues, it soon reaches another period of equal days and nights for the entire planet. It is the second equinox of the year, and it happens around March 21. This day marks the vernal or spring equinox in the Northern Hemisphere, which is the halfway point in the transition from winter to summer, and the Southern Hemisphere experiences the autumnal equinox (marking the halfway point in the transition from summer to winter). The days are equal everywhere during the two equinoxes, but what they are called is determined by which season that part of the world is entering.

Lesson 17/18

Scientific Inquiry: Modeling Design and Procedure

Lesson Objectives

- Research ways to model a natural phenomenon.
- Design and create a model.
- Reflect on project design and learning experience.

Assignments

For your third Scientific Inquiry, you will create a model of a natural phenomenon. This unit focused on Earth's structure, the rock cycle, weathering, fossilization, erosion, plate tectonics, and mountains. You can model a landslide, tsunami, earthquake, volcano, crystallization, liquefaction, or any other phenomenon that intrigues you! As always, you have two weeks to complete your project. Feel free to work with others to make this a collaborative modeling project.

See the lab manual for full instructions.

- **Scientific Inquiry: Modeling Design and Procedure**

In this project, you will be designing, creating, and testing a model, and then having someone else create an identical model by following the procedures you have written down. You will need two sets of materials (one set for your initial model, and another for the second model).

Complete the project reflection afterward.

FOR ENROLLED STUDENTS

When you have completed your project and reflection, please share them with your Oak Meadow teacher. Feel free to contact your teacher if you have any questions about your project ideas or design, or how to share your project.

Congratulations on completing the first semester! Your teacher will review your work and write a semester evaluation, which will be posted on the OM Gateway. In the meantime, please move on to lesson 19 to begin the second semester.

ASSIGNMENT SUMMARY

- ☐ Research a natural phenomenon and ways to model it.
- ☐ Design your own modeling project and discuss your ideas to refine the design.
- ☐ Create a model and record your procedure in detail.
- ☐ Share the project with others.
- ☐ Reflect on project design and learning experience.

Lesson 23

Wind and Atmospheric Pressure

Learning Objectives

At the end of this lesson you will be able to:

- Draw a diagram showing the relationship between air pressure and wind patterns.
- Explain why wind currents move in a circular pattern.
- Identify how temperature affects air pressure.

Reading

Read the following sections (found in Reading Selections at the end of this lesson).

- Atmospheric Pressure
- Wind Patterns

View additional resources on the curriculum resource links page.

Assignments

1. Scientists often use diagrams to help illustrate different concepts. Draw labeled diagrams or pictures that explain the following statements. Use additional resources to get ideas about how to represent these statements visually.

   a. Air has weight and exerts pressure on everything with which it comes in contact.

ASSIGNMENT SUMMARY

- ☐ Complete the reading selections.
- ☐ Draw diagrams to illustrate concepts related to wind patterns.
- ☐ Use the science behind wind patterns in a creative assignment.
- ☐ Predict a result based on air pressure.
- ☐ Lab Investigation: Homemade Barometer
- ☐ Lab Investigation: Expanding Air
- ☐ Complete lesson 23 test.

MATERIALS

Lab Investigation: Homemade Barometer

clear long-neck glass bottle (such as a soda bottle)

quart glass jar (small-mouth Mason jar)

food coloring

rubber band

paper

Lab Investigation: Expanding Air

plastic bottle

balloon

2 large bowls

ice

b. The atmosphere is like an ocean of air above us, exerting air pressure equally in all directions.

c. Earth's rotation influences the direction of wind currents.

d. Atmospheric pressure decreases as altitude increases because warm air molecules expand and rise and cold air molecules condense and sink.

2. Write a story, poem, song, or play that takes place either on an ocean shore, a mountain, or in a valley where air currents behave in a generally predictable way. In your story or poem, the wind should play an important role. Include the scientific explanation of what is happening with the wind as part of your story.

3. Try to imagine the following, keeping in mind that warm air expands and cool air contracts. What do you think would happen if you poured a few ounces of very hot water into an empty plastic bottle (such as a gallon milk jug or one liter bottle), screwed on the top very tightly, and then allowed the bottle to cool? Can you predict the results? Write down your prediction, and then explain the science behind it. If possible, try this experiment after you make your prediction and see what happens. Include your actual results with your prediction and explanation.

Lab Investigation

Complete both of the following labs.

- **Lab Investigation: Homemade Barometer**
- **Lab Investigation: Expanding Air**

Full instructions are in the lab manual. Use specific language and scientific terminology when writing your conclusions.

Test

1. What is air pressure?
2. How does the air pressure change as you go up into higher elevations?
3. Why is the air pressure of cool air greater than the air pressure of warm air?
4. What does air pressure have to do with wind currents?
5. Why do the winds on this planet move in circular patterns?
6. Imagine you are in a sailboat. Since you have only the wind to propel your boat, what time of day would it be easiest for you to set sail from shore into the ocean? What time of day would be easiest to return to shore, based on the wind? Explain your answer.
7. Describe the difference between a mountain breeze and a valley breeze. Why do these wind currents behave as they do? Include information about related scientific concepts to support your answer.

8. If a low pressure air mass was approaching, would you expect rain or sun in the forecast? Why?
9. Which barometer would you expect to have the higher reading, one at sea level or one at the top of a mountain? Why?

Learning Checklist

Use this learning checklist to keep track of how your skills are progressing. Include notes about what you need to work on.

SKILLS	Developing	Consistent	Competent	Notes
Define air pressure				
Explain how temperature affects air pressure				
Relate air pressure to wind currents				
Identify causes of offshore and onshore breezes				
Identify causes of valley and mountain breezes				
Use knowledge of air pressure to predict weather				
Diagram concepts related to wind currents and air pressure				

Reading Selections

Atmospheric Pressure

Have you ever swum underwater? Water has pressure. As you swim deeper, you can feel the pressure increasing, pressing on your body. The weight of the water above you is the pressure that you feel. The deeper you go, the more water there is above you, and the increased weight of that water increases the pressure on your body.

Air has weight and pressure in the same way water has weight and pressure, and we live at the bottom of a great ocean of air. *Air pressure* or *atmospheric pressure* is the force exerted by the weight of air. Atmospheric pressure decreases as altitude increases. As you climb a mountain, air pressure will decrease, since there is less of that ocean of air above you.

Air exerts pressure in all directions, not simply downward. In a gas, molecules are always moving and hitting the surface of whatever they encounter. When air in the atmosphere is warmed, the molecules in the warm air move faster. As they move faster, the molecules naturally spread farther apart.

The warm air expands and becomes less dense (because there are fewer molecules in a given space), resulting in lower air pressure. When the air cools, the molecules slow down and move closer together, increasing the density of the air, resulting in greater air pressure. This is why warm air rises—it is lighter than cool air.

The atmosphere is hundreds of kilometers thick, and the weight of all that air will feel greater at *sea level*—the elevation of the land where it meets the sea—than at higher elevations, where less air is above it. Near the top of the atmosphere, air pressure is very low because the area is so big and air molecules are farther apart.

A *barometer* is an instrument that measures atmospheric pressure. It uses *mercury*, which is a liquid that is denser at sea level than water. Atmospheric pressure is most often measured in centimeters (or inches) of mercury. A column of mercury in a barometer will be held 76 centimeters high by the force of air pressure at sea level. At the top of Mount Everest, air pressure will only support 25 centimeters of mercury because the air is so much less dense that far above sea level.

Wind Patterns

The ocean of air above us is constantly moving. Air changes depending on elevation and where you are on Earth. Around the equator, the sun's rays hit Earth directly, which warms the surface. Because of the curve of Earth and the tilt of Earth's axis, the sun's rays at higher latitudes are spread over a larger area. This affects how the air is heated and, because warm air rises and cool air sinks, how it moves.

As air is heated, it expands. As air molecules spread out, they become less dense. As the air becomes lighter, air pressure decreases. Changes in air pressure on the surface of Earth have a great effect on the movement of air masses in the atmosphere.

Air above the warmer regions heats and expands, and air in cooler areas sinks downward. The cool air actually moves in under the warm air and pushes the warm air upward. As warm air rises, it eventually cools and then drops earthward. These *air currents* move in a circular pattern. Scientists use an *anemometer* to measure wind direction and speed. Wind is measured in kilometers or miles per hour.

Areas of cold, heavy air have higher air pressure than areas of warm, light air. Scientists describe these areas as *high pressure areas* and *low pressure areas*. A low pressure system tends to produce rainy weather because the rising warm air collects moisture, which condenses into clouds; when enough moisture collects in the clouds, they reach the saturation point and begin to rain. A high pressure system will often produce fair weather as the sinking cooler air tends to be dryer; a sunny day can be the result.

Air always moves from areas of high pressure to areas of low pressure. Massive sections of air that are horizontally uniform in temperature and humidity are called *air masses*. The speed or intensity of winds depends on the difference in air pressure as air masses approach each other.

Winds do not move in straight lines because the rotation of Earth causes winds to curve. As Earth spins, it causes winds to curve to the right in the Northern Hemisphere and to the left in the Southern Hemisphere. This is called the *Coriolis effect*.

Scientists describe the wind's direction by determining from which direction the wind comes. If a wind comes from the north, it is a *northerly wind*. A wind that comes from the southwest is called a *south-westerly wind*. A *weather vane* will always point into an oncoming wind; it points into the direction from which the wind is coming.

Winds in a local area are affected by bodies of water and local landforms. On sunny days, the sun will heat both land and water. Land heats faster than water. As the land heats, the air over the land will become warmer and lighter, allowing the cooler, heavier air over the water to move toward the land. These winds are called *onshore breezes*.

In the evenings, land releases its heat faster than water. As the land cools, so does the air above the land. The cooler, heavier air over the land moves toward the warmer, lighter air over the water and pushes it upward. This creates *offshore breezes*.

Onshore and offshore breezes are created by differences in temperature between the land and sea. (Image credit: Bharat Choudhary)

Mountains also cause local winds to form. During the day when the sun shines, the air at higher elevations is warmer than the air in the valley below. The warm air on the mountaintop has a lower pressure than the cooler, high pressure air in the valley. During the day, a *valley breeze* will move air uphill. At night, the air patterns are reversed. The air at the top of a mountain cools faster than the air in the valley. A *mountain breeze* moves from the cooler mountaintop (high pressure) to the warmer valleys (low pressure). Air usually moves downhill at nighttime and uphill during the day.

Appendix

Materials List

Lesson	Lab or Activity	Materials
1	**Option 1 Lab Investigation: Water Clock**	plastic milk container large pan or bucket metric ruler marker clock or watch sewing needle or pushpin
	Option 2 Lab Investigation: Comparing Volume and Mass	modeling clay metric ruler or tape measure measuring cup towel
	Activity B: Calculating Density	book scale metric ruler
2	**Lab Investigation: Celery Experiment**	4 stalks of fresh celery with leaves knife 4 jars red or blue food coloring measuring cup 4 paper towels timer peeler metric ruler old newspapers or towels
6	**Lab Investigation: Earth's Movement**	orange knitting needle or sharpened pencil pushpin or thumbtack lamp with the shade removed
	Activity: Sundial	white paper plate or piece of paper pencil marker timer
7	**Lab Investigation: Moon Moves**	objects or people to represent the moon and Earth lamp with the shade removed

Lesson	Lab or Activity	Materials
12	**Lab Investigation: Sedimentation**	sand, dirt, and tiny pebbles glass jar water spoon
	Lab Investigation: Rock Cycle	beeswax, crayons, or chewy candy in several colors (such as jelly beans or Starburst) knife, peeler, or grater small plastic bag dish towel wooden mallet or small hammer tin foil metal spatula cast-iron skillet or heavy oven-proof pan
13	**Activity C: Fossil Impressions**	clay or plaster of Paris leaves, shells, rocks, or other objects for making impressions
14	**Option 1 Lab Investigation: Erosion Observations**	soil, 1 cubic foot dead leaves, dried grass, and small rocks grass with root systems intact, approximately 15 cm or 6-inch square large rectangular plastic container or baking dish ruler bucket or large bowl measuring cup
	Option 2 Lab Investigation: Soil Observations	shovel tweezers magnifying glass
15	**Lab Investigation: Seismic Activity**	8 pancakes or clay (enough to make 8 pancake shapes) knife nut butter, cream cheese, sour cream, or other spreadable topping 2 small objects, such as dice

Lesson	Lab or Activity	Materials
19	**Lab Investigation: Oxygen and Fire**	candle (less than 4 inches tall) matches 2 glass jars of different sizes (both large enough to cover the candle completely) pie pan or bowl watch, clock, or stopwatch
21	**Lab Investigation: Transpiration**	houseplant plastic bag (large enough to cover the plant) string
21	**Lab Investigation: Terrarium**	clear glass jar with a lid one or two small plants (small enough to fit in the jar) bottle cap soil sand small rocks
22	**Lab Investigation: Dew Point**	metal can with no lid (such as a soup can) thermometer water ice spoon
23	**Lab Investigation: Homemade Barometer**	clear long-neck glass bottle (such as a soda bottle) quart glass jar (small-mouth Mason jar) food coloring rubber band paper
23	**Lab Investigation: Expanding Air**	plastic bottle balloon 2 large bowls ice

Lesson	Lab or Activity	Materials
24	**Lab Investigation: Wind Vane**	card stock or index card drinking straw tape pencil with an eraser pushpin or thumbtack paper plate or piece of paper modeling clay compass
24	**Lab Investigation: Weather Station**	outdoor thermometer barometer (homemade or store-bought) wind vane rain gauge (optional)
29	**Lab Investigation: Groundwater Filtration**	clear plastic bottle scissors small rock sand gravel bowl or plastic container soil
30	**Lab Investigation: Salinity and Density**	$\frac{1}{4}$ cup salt 2 cups water 2 clear jars or glasses spoon food coloring 2 eggs eyedropper (optional)
32	**Lab Investigation: Acid Rain**	12 radish seeds grapefruit juice or lemon juice 2 small pots or paper cups planting soil spray bottle (optional)
33	**Lab Investigation: Biodiversity**	4 wooden stakes hammer string journal or notebook ruler or measuring tape