# Grade 7
# Earth Science

# Oak Meadow
# Coursebook

**Oak Meadow, Inc.**
Post Office Box 1346
Brattleboro, Vermont 05302-1346
oakmeadow.com

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# 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

    an empty plastic milk container (or any other clear container that you can puncture)

    large pan or bucket

    metric ruler

    marker

    clock or watch

    sewing needle or push pin
- [ ] Option 2 Lab Investigation: Comparing Volume and Mass

    modeling clay

    metric ruler

    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.

- Option A: Human Clock
- Option 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 (one 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 out 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 full body sense as fully as we can. However, most of us depend almost entirely upon 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, 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, MI. (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 at the Door-Waln, NRCS, Resource Conservationist taking an inventory of pasture grasses. (Image credit: Natural Resources Conservation Services)**

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 claim might be "A spay and release program targeting the female cat population can significantly reduce the feral cat

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

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 in the world.

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: 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

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

of the 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 one meter wide and about two meters high. To measure short lengths, scientists use the centimeter (1/100 of a meter) or the millimeter (1/1000 of a meter). To measure longer lengths, scientists use the kilometer, which is equal to 1000 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, 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

## 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

### 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

vegetable peeler

metric ruler

old newspapers or towels (to keep the food coloring from staining the work surface) 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, a writer, a runner, or a 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

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

first in your garden and wonder "Which vegetable seeds have the shortest sprouting time?" Or you 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


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

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?"

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 the 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 different 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

push pin or thumb tack

light source (preferably one that is multi-directional, like a bare lightbulb)

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

# Lab Investigation

Complete the following (see the lab manual for complete 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 be in a spot 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 AM), 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 21st, 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 work load. 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*.

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

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

Coast of the United States about three hours before it comes to San Francisco on the West Coast. When it is 6:00 AM in New York, it is 3:00 AM 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 further you move away from the equator, the slower Earth's rotation, and at the North Pole or the 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.

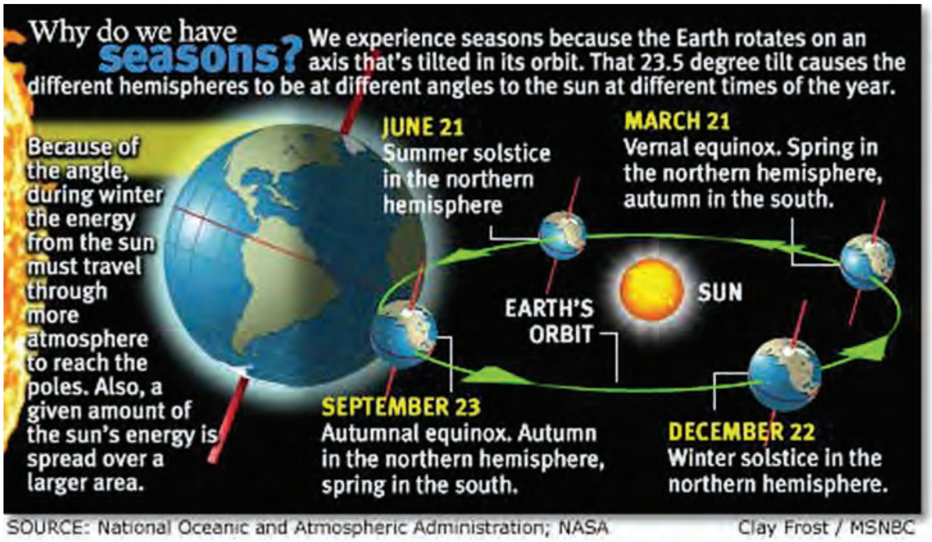
## Seasonal Cycles

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 or fall, and winter.

As Earth travels around the sun on its annual journey, the North Pole points nearest to the sun around June 21st. 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 furthest 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 further 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 22nd, 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 twelve hours of sunlight and twelve hours of darkness. In the Northern Hemisphere, this is called the *autumnal equinox*, because it is the transition from summer to winter. In the Southern Hemisphere, this is called the *vernal (or spring) equinox*, because it is 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 21st. It is the day of least daylight and 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 21st. This day marks the vernal or spring equinox in the Northern Hemisphere, which is the transition from winter to summer, and the Southern Hemisphere experiences the autumnal equinox (marking 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 7

# Earth's Moon

## Learning Objectives

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

- Describe the movement of the moon in space.
- Diagram the phases of the moon.
- Model a lunar and solar eclipse.
- Explain the relationship between the gravitational pull of the moon and Earth's tides.

## Reading

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

- Earth's Moon
- Moon's Rotations and Revolutions
- Solar and Lunar Eclipses
- How the Moon Influences Tides

Remember to use library books, newspapers, scientific journals, and online research to learn more about any topic that interests you, or to help you better understand topics that you find confusing. Bookmark the curriculum resource links page on oakmeadow.com for easy access to good resources.

### ASSIGNMENT SUMMARY

☐ Complete the reading selections.

☐ Record changes in the moon over one week.

☐ Draw a diagram of the moon's phases.

☐ Model a solar and lunar eclipse.

☐ Explain how the moon influences Earth's tides.

☐ Lab Investigation: Moon Moves

☐ Optional activities:

Activity A: Moon Story

Activity B: Moonscape

☐ Complete lesson 7 test.

### MATERIALS

☐ Lab Investigation: Moon Moves

objects or people to represent the sun, moon, and Earth

lamp with the shade removed

# Assignments

1. Find out what time the moon rises and sets this week. Try to see the moon every night and make note of its changes. Notice if you can also see it in the daylight hours. Do you see it in the eastern sky (as it is rising) or in the western sky (as it is setting)? When you view the moon at day or night, visualize where the moon, Earth, and sun are in order for you to see the moon in its current phase. (This might be easier after you have done the lab investigation in this lesson.) Write a brief description of your moon sightings for one week. Note any changes you noticed in its appearance and when it rises and sets.
2. Draw a diagram of the moon's phases, showing the moon's position relative to Earth during its orbit. Make sure to include the location of the sun in your diagram as well. Label each phase of the moon and show the corresponding areas of waxing and waning.
3. Explain how a lunar eclipse and a solar eclipse occur. Use objects or people to model what is happening during each type of eclipse. You can video your explanation and modeling, or you can write a description.
4. Make a poster or write a paragraph that explains why we have high tides and low tides and why they happen twice a day. Include information about neap and spring tides.

# Lab Investigation

Complete the following (all labs are found in the lab manual):

- **Lab Investigation: Moon Moves**

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

# Activities

Choose one of the following optional activities to explore more aspects of the moon.

- Activity A: Moon Story
- Activity B: Moonscape

## Activity A: Moon Story

Write a poem or a short story that explains what it would be like to visit or live on the moon. Remember to take into account not only the moon's landscape, but also its gravity, and the great difference in temperature between the side facing the sun and the side facing away from the sun.

### Activity B: Moonscape

Draw your view of a moonscape. This can be realistic, as it is today, or you can use your imagination and draw what the landscape of the moon might look like with a human (or alien!) settlement on it.

# Test

1. Why does the moon shine?
2. Why do we only see one side of the moon?
3. Explain the difference between the far side of the moon and the dark side of the moon. When does the dark side of the moon face Earth?
4. How long is one lunar day (the amount of time it takes for the moon to complete one rotation on its axis)?
5. How long does it take for the moon to make one revolution around Earth?
6. Explain the difference between a solar eclipse and a lunar eclipse.
7. Why does a lunar eclipse only happen during the full moon and a solar eclipse only happen during a new moon?
8. How does the moon influence Earth's tides?
9. Why are the tides higher during a full moon and a new moon?

# 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 |
|---|---|---|---|---|
| Record changes in the moon's appearance | | | | |
| Diagram moon's position relative to Earth during its orbit | | | | |
| Model moon's position relative to Earth during its orbit | | | | |
| Model the difference between a solar and lunar eclipse | | | | |
| Explain the moon's influence on Earth's tides | | | | |

**FOR ENROLLED STUDENTS**

You will share your work from this lesson at the end of the next lesson. In the meantime, please contact your teacher if you have any questions.

# Reading Selections

## Earth's Moon

Aside from the sun, the moon is the most easily recognizable object in the sky. For millennia, human beings have gazed at the moon as it goes through its phases, from new moon to quarter moon to full moon and back to the new moon. Moonlight can be so strong and bright at night that it nearly seems as bright as day. However, that light the moon shines down on Earth is not its own.

While the sun gives off its own light, the moon does not. The light we see from the moon is actually reflected sunlight, like the sun bouncing off a metal surface and shining back in our eyes. Sunlight strikes the moon (just as it strikes Earth) and this "moon" light is reflected back to Earth. While we mostly notice the moon at night, it can be seen during the day as well. In fact, the moon is visible (above the horizon) for about 12 hours per day, and usually some of those hours occur during the daytime. During daylight hours, we can only see the moon when it is not near the sun in the sky—when they are too close together, the sun is so bright it overpowers the light reflected from the moon.

The moon is Earth's only natural *satellite*. A satellite is a body that moves around a larger body in space. The moon revolves around Earth in the same way that Earth revolves around the sun. The moon is kept in its orbit because of the strength of Earth's gravity. Gravity is the attraction that larger bodies have on smaller ones. It is the force that keeps us from flying off the face of Earth. It

**(Image credit: NASA)**

is the force that makes things fall toward the ground and gives things weight. Gravity also keeps Earth's atmosphere from disappearing into space. Because Earth has so much more mass than the moon, it's gravity is much stronger than the moon's.

**(Image credit: NASA)**

The moon is about 3,200 kilometers in diameter, about one-sixth the size of Earth. Gravity on the moon is only one-sixth as strong as it is on Earth; this means you could jump six times as high on the moon as you can on Earth.

You have probably seen pictures of the *lunar landscape* (the terrain of the moon) that show it as a desolate place. The moon has no water, no air, no atmosphere, and, therefore, no life. The landscape of the moon is very different from that of Earth. The lunar landscape is covered by large valleys, mountains, and craters caused by the impacts of meteorites that crashed into the moon from space. While Earth also has valleys, mountains, and craters, most of the landscape is covered with living plants and animals, or water. What a difference this biosphere makes!

**(Image credit: NASA)**

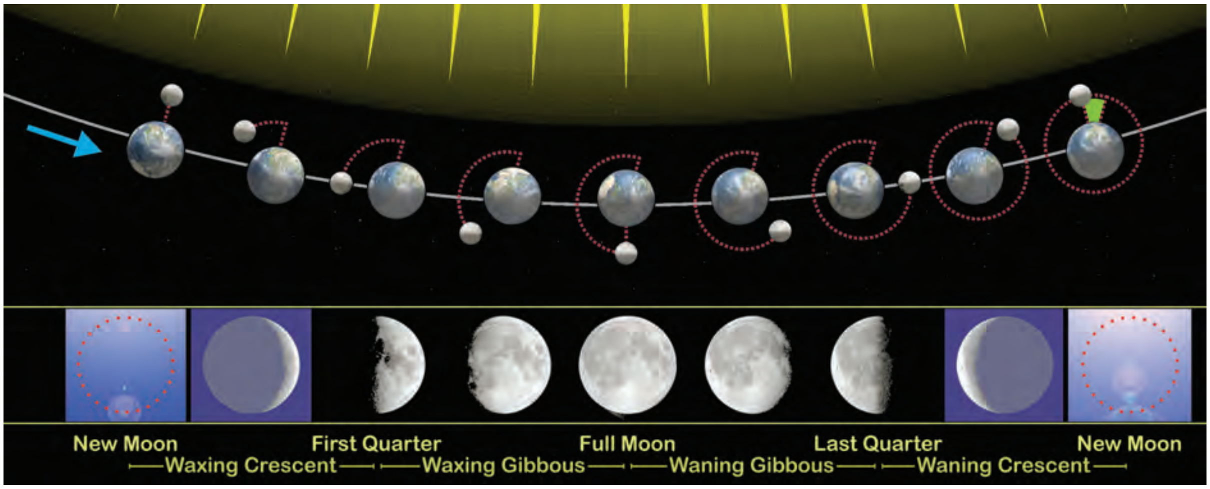
If you have ever seen dry cement powder, you can imagine what the surface of the moon is like. On the surface of the moon, there is no soil, like what we have on Earth (which is teeming with living things). The moon's surface has only rock and dusty soil with glassy particles and fragments. On July 20, 1969, American astronauts completed a 380,000-kilometer journey to the moon, where they walked around, drove vehicles, and collected samples and data. The footprints they left behind will most likely remain unchanged for millions of years. You might wonder how can that be? It's because the surface of the moon is exposed to space. Without an atmosphere, there is no wind, rain, or living things to disturb the footprints. Only a falling meteorite or other matter from space could destroy them.

## Moon's Rotations and Revolutions

The moon moves in the same ways that Earth moves: it rotates on its axis, it revolves in an elliptical orbit around Earth (while Earth is revolving around the sun), and it moves through the galaxy along with the sun and the rest of the solar system.

It takes the moon 27.3 Earth days to complete a single rotation on its axis. One complete rotation is one lunar day. (By comparison, it takes Earth just one day to complete a single rotation on its axis.) As the moon rotates, half of it is facing the sun and half is facing away from the sun, just like Earth. Because the moon has no atmosphere to filter the sunlight and trap its heat, the temperature on the moon varies wildly. Where the sun hits the surface of the moon, the temperature can reach about 250° F (121° C). On the "dark side" of the moon, the temperature can drop to about –250° F (–156° C).

The moon also takes 27.3 days to complete one revolution around Earth. Because the moon's rotations and revolutions take the same amount of time, the same *lunar hemisphere* (same half of the moon) is always facing our planet. Imagine yourself walking around someone else, but as you




**(Image credit: orion8)**

walk, you are turning to always face the other person, so the other person only sees the front of you. That is what is happening with the moon. From Earth, we can only see the near side of the moon. It was not until spaceships traveled to the moon that we were able to see what the *far side* of the moon looked like. The far side is different from the dark side of the moon: the far side is the side that never faces Earth; the dark side is the side that is facing away from the sun.

Although the moon is a sphere, it doesn't always look round when we see it in the sky. Just as only one half of Earth at a time is lit by the sun (half of the planet is in daylight and half in night at all times), the same is true of the moon. From Earth, we see the "daylight" side of the moon in varying fractions as it moves in orbit around us. Sometimes we see a round, full moon, and sometimes we see just a sliver, or no moon, which we call the *new moon*. As we watch the moon's reflected light change from night to night, we see the amount of light increase (or *wax*) from the time of the new moon until the time of the full moon, and then decrease (or *wane*) back to a new moon as the moon completes its 27-day orbit around Earth. Just like the sun, the moon appears to rise in the east and set in the west (because of the direction Earth is rotating on its axis).

The changes we see in the moon's shape are called *phases of the moon*. Imagine the moon is between Earth and the sun. We are not able to see the lighted side of the moon because it is facing the sun; we don't see any of this reflected light so it looks like there is no moon (we are really looking at the back side of the moon). This is the new moon phase.

As the moon continues to revolve around Earth, it moves away from the sun and we start to see the side that is lit by the sun, a little more each day. It takes about seven days for the moon to appear as a half-circle, shaped like a D. This phase is called the *first quarter* of the moon.

When the moon is halfway around Earth, 14 days into its orbital cycle, we can see all of its lighted side. This is the *full moon* phase. For the next 14 days, the moon's phase will wane and continue to diminish in size. It appears again as a semi-circle (with the semi-circle facing in the opposite direction than before, in the shape of a C) in its *third (or last) quarter* phase, and then once more moves between Earth and the sun, until finally its lighted side cannot be seen from Earth, and it starts a new orbital cycle with the new moon phase.

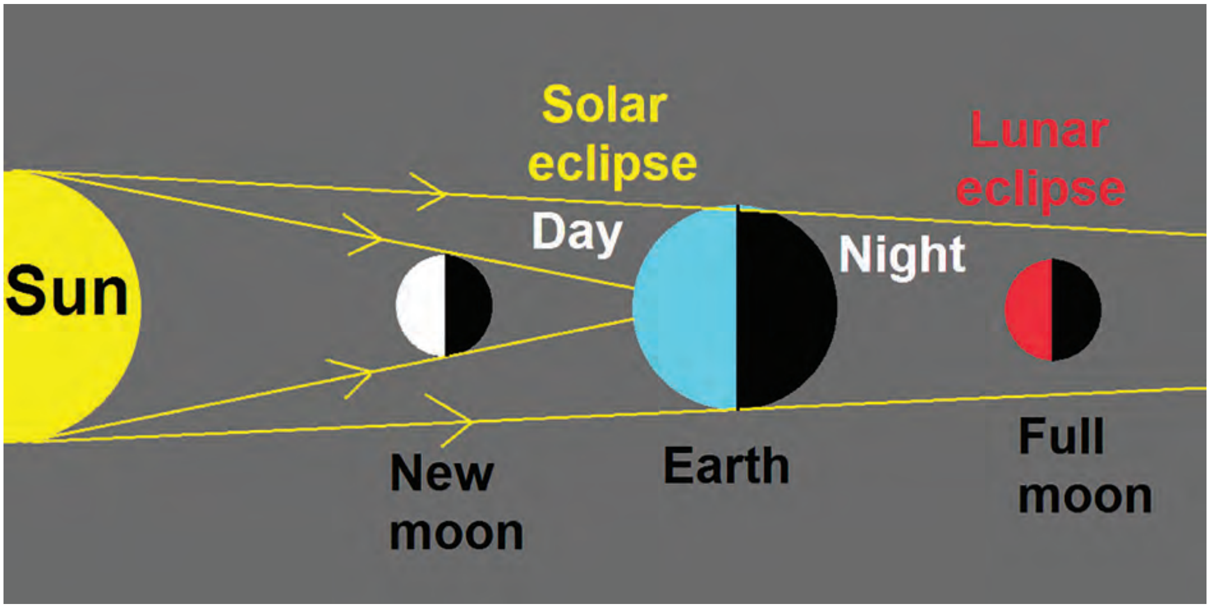
It actually takes 29.5 days for the moon to go through all of its phases. This is a little longer than the time for one revolution of the moon around Earth. This is because Earth's movement around the sun causes the moon to have to travel just a little bit more than a full rotation for its light to be reflected in a full moon cycle. If Earth stayed still instead of revolving around the sun, we would see all the moon's phases, from full moon to full moon, in the 27.3 days it takes for the moon to make one complete rotation. Because we've moved, the moon has to rotate a little further (for two more days) in order to look full again.

When you look at the moon, think about where the sun is. The moon's phase—how much of its daylight side can be seen from Earth—shows exactly the direction that the sun lies in relation to the moon and Earth.

## Solar and Lunar Eclipses

Occasionally the paths of Earth and the moon cross to cause a spectacular event called an *eclipse* (the word *eclipse* means to hide or cover). A *lunar eclipse* is when Earth *aligns* (or lines up) with the sun and the moon in a straight line, with Earth in the middle. A lunar eclipse can only happen during a full moon (when the part of the moon facing the sun is directly facing Earth as well). When this happens, Earth blocks the light that would usually illuminate the full moon. As the moon moves around our planet, Earth's shadow is seen to slowly cross the full moon, eventually blocking sunlight from reaching it. What we see looks like a dark circle slowly covering the moon and then moving past until the moon is totally illuminated again. A lunar eclipse is fun to watch. It usually takes about two or three hours from start to finish, and the sun is blocked out completely for just a few minutes. Thanks to Earth's atmosphere, the moon often appears red during a lunar eclipse.

The same type of alignment is in play during a *solar eclipse*, only this time the moon is in the center, between Earth and the sun. When that happens, the moon covers the sun as seen from Earth. This can only happen at the new moon (when the part of the moon facing the sun is turned away from Earth). In a total solar eclipse the moon blocks the path of the sun's light so that only the light surrounding the sun can be seen shining around the edges of the circular black disk of the moon. In a partial solar eclipse, the moon does not quite block the sun. A solar eclipse is impossible to see with the naked eye because we can't stare directly at the sun without harming our eyes. However, there are many safe ways to view a solar eclipse by looking at a reflection of the sun rather than the sun itself. Like the lunar eclipse, a solar eclipse lasts a few hours. Both take about the same amount of time because they are based on the moon's orbital movement around Earth, which remains at a stable pace.




**(Image credit: Tomruen)**

A lunar eclipse is only viewed at night, and a solar eclipse is only seen during the day. Because of the placement of the moon and Earth in relation to the sun and one another, all in a straight line at a certain angle, solar and lunar eclipses always happen in pairs, about two weeks apart. This makes sense because the lunar eclipse happens during the full moon and the solar eclipse happens at the new moon, and the new moon and full moon are 14 days apart.

So why don't we see a lunar eclipse every month when Earth comes between the sun and the moon, and why don't we see a solar eclipse every month when the moon comes between Earth and the sun? The moon's orbit is slightly tilted in relation to Earth's orbit, so although Earth, sun, and moon are basically in a straight line twice a month, at the new and full moon, they are not usually aligned fully enough to cause an eclipse. The moon is usually higher or lower than the line between Earth and the sun. On average, this alignment that results in eclipses occurs only about every 18 months.

## How the Moon Influences Tides

If you have ever visited a beach, you may have noticed the results of the changing tides. Sometimes the water is so high that much, or maybe all, of the beach is covered by water. Sometimes the water recedes, leaving large areas of beach, rocks, or tide pools uncovered and easy to explore. These changes are primarily the work of the moon.

**(Image credit: Max Pixel)**

The density of the moon is much less than that of Earth, so Earth exerts a relatively strong gravitation pull on the moon. This is what keeps the moon in orbit around Earth. However, even though the moon is much smaller than Earth, it is still a very large *celestial* body (object in space), and its mass creates its own gravitational force that influences Earth. The moon doesn't really affect Earth's orbit—that's influenced by the immense sun's mass and gravity—but the moon does affect Earth's oceans.

Since the bodies of water on the surface of Earth are liquid, they are greatly affected by the gravitational pull of the moon. As the moon revolves around Earth, its gravity pulls on the planet and on the water that is on the surface of Earth that is closest to the moon (the part facing the moon). The water is pulled toward the moon in the same sort of way that water will slosh side to side in a bucket when it is carried.

The sun also affects the movement of the ocean tides, but the effect of the moon is stronger than that of the sun because the moon is so much closer to Earth. In fact, the moon's gravitational pull on Earth is about 2.4 times that of the sun, but because the moon is tiny compared to the sun, it's gravitational force primarily affects the liquid part of the planet.

Picture the water sloshing in a bucket. When the moon's gravity pulls on the water, it moves toward the moon. This creates a high tide in areas that are facing the moon. As Earth rotates on its axis, turning away from the moon, the water is at low tide when an area is at a 90° angle (a right angle) from the moon—basically sideways to the moon). There is a second high tide during each Earth rotation when each area is facing directly away from the moon, and a second low tide when an area of the planet is once again angled 90° from the moon. On the whole planet, there are two high tides happening at once on opposite sides of the globe and two low tides happening at once.

Keep in mind, when the tide is high in one part of the planet, it is low in another. While the water sloshes up the side of the bucket in one place, it is at a low point in another place. In both high and low tides, the volume of water in the oceans remains the same—it just moves around. The gravitational pull of the moon is strong enough to pull the volume of water towards it (high tide) as it pulls water from the sides (low tide) of Earth. Two high tides and two low tides each day sweep around Earth as it rotates on its axis and changes its position in relation to the moon.

When the moon is new, the sun and the moon line up on the same side of Earth, and when the moon is full, Earth is between the sun and the moon. In either case, all three celestial bodies are in a line. When this happens, the gravitational pull of the moon and the sun combine to create the highest high tides and the lowest low tides. This is called a *spring (or king) tide* (so called because the water is pulled so hard it seems to "spring" forth). This happens twice a month all throughout the year. When the moon is at the first or third quarter, *neap tides* will occur, which show the smallest changes between high and low tides.