Grade 6
Basic Life Science
Coursebook

Oak Meadow

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Science and the Scientific Method

What Is Science?
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, we feel. Then we reach conclusions about what it all means: we make sense out of the world.

Scientists and teachers tell us what they have learned, and what they think is important for us to know. Yet, in a way, we are all scientists. We ask questions; we guess what the answers will be; we watch to see what happens; our minds record the results and decide what the results mean; and then we take this knowledge and use it throughout our lives as we decide what to do, how to do it, and, in general, how to lead our lives. This is an example of what is called the scientific method.

The scientific method is the form that scientists use to examine the world. Scientists do experiments to find out why things happen the way they do. There is not much difference between the way we make sense of the world and the way scientists do. In both instances, there are many things that affect what our conclusions will be. How you feel, for instance, may depend on how much sleep you got last night. If you are busy watching TV, you are less likely to notice that someone left the refrigerator door open in the kitchen. If you are in a hurry, you are less likely to notice that you didn’t clean up a

All experiments in this course should be written up using the scientific method format. Please refer to this lesson for guidance when completing assignments in future lessons.

ASSIGNMENT SUMMARY

☐ Analyze the caffeine experiment.
☐ Test your power of observation.
☐ Choice assignment
☐ Complete lesson 1 test.

MATERIALS
☐ pencil
☐ paper
☐ two sets of 13–20 items collected from nature
☐ Choice Assignment
  Animal Observation
  pet

Scientific method: the procedure scientists use when conducting an experiment; it specifically refers to the five steps of asking a question, forming a hypothesis, carrying out a procedure, recording observations, and drawing conclusions.
mess before rushing out the door. There are an endless number of situations or factors that may influence what you notice or what you decide to do.

A scientist, however, is usually trying to determine the effect of a particular factor on something or a specific effect or situation. Therefore, a scientist will try to set up a controlled experiment to test the effect of a particular thing on something else. A controlled experiment attempts to test only one factor, or variable, at a time. A variable can change throughout the experiment, while everything else must remain the same. A scientific experiment will always have the following steps:

1. First, a question is asked for which you do not know the answer. Usually this question comes out of an observation that has been made. The question should be brief, clear, and representative of something that you can test for. Here are some sample questions that might lead to an experiment: Why does steam rise? Can dogs understand human language? What are the effects of caffeine on sleep?

2. A statement is made that tells what the answer to this question might be. This statement is called a hypothesis. It is a statement that the experiment attempts to prove or disprove. Here are some sample hypotheses that you could try to prove in a scientific experiment: Steam rises because water vapor is lighter than air. Dogs do not understand human language. Caffeine intake after 3:00 p.m. disrupts normal sleep patterns.

3. A controlled experiment is set up, and the experiment is performed. This is called the procedure.

4. Observations (sometimes called results) are made during the experiment and recorded. These results tell what we see (or hear, taste, feel, smell) during the experiment.

5. The results are interpreted: the hypothesis is either proved or disproved, and an explanation is given for why the experiment happened the way it did. This is the conclusion, and it tells what we learned during the experiment. Often a conclusion leads to more questions and more experiments.

**Controlled experiment**: an experiment designed to test only one variable at a time while making sure that all other elements will not change or influence the result.

**Variable**: a factor that can show measurable change over the course of an experiment.

**Hypothesis**: a statement about what is expected to happen.

**Procedure**: the way an experiment is set up and carried out.

**Observations**: information perceived through any of the senses (sight, hearing, smell, taste, or touch).

**Conclusion**: what has been discovered or learned as a result of the experiment.
The experiment is evaluated by asking:

- Did it really do what it was intended to do?
- Could the method be improved so that it would have better results?
- Does the experiment suggest other experiments that might be undertaken?
- How can the information or process apply to personal life or experiences?

This would answer the questions: “What does it all mean?” or “So what?”

Here is a very simplified version of an experiment that might be used to test the effects of caffeine on sleep patterns. A typical experiment would be more controlled than this one, but this should give you the basic idea. Notice how the experiment is written using each of the five steps. **When writing up your experiments in this course, please use this format.**

**SAMPLE EXPERIMENT:**
**The Effects of Caffeine on Sleep Patterns**

1. **Question:** What are the effects of caffeine on sleep?
2. **Hypothesis:** Caffeine intake after 3:00 p.m. disrupts normal sleep patterns.
3. **Procedure:**
   a. Select a group of people who report that they sleep “normally.”
   b. Observe each individual during a normal night’s sleep. Record how many times they wake, roll over, mumble, etc. Make sure they have not had any caffeine that day.
   c. Divide the group into four equal groups and give the first group a cup of coffee at 2:00 p.m.; give the second group a cup of coffee at 3:00 p.m.; give the third group a cup of coffee at 4:00 p.m.; and for the fourth group, give no coffee at all (make sure there is no sugar in the coffee because we are testing for the effects of caffeine on sleep, and sugar might also affect sleep patterns).
   d. Observe each individual during that night’s sleep. Record how many times they wake, roll over, mumble, etc.
   e. Compare observation notes from the first night to the observation notes from the second night.
   f. Draw conclusions.
4. **Observations:**
   a. The group that didn’t get any coffee slept as well the second night as they did the first night.
   b. The group that drank coffee at 2:00 p.m. slept worse the second night.
   c. The group that drank coffee at 3:00 p.m. slept worse the second night.
d. The group that drank coffee at 4:00 p.m. slept worse the second night.

5. Conclusion: After reviewing the observations and all of the data, it seems that caffeine consumed after 2:00 p.m. disrupts normal sleep patterns. This provides a partial answer to the original question about the effects of caffeine on sleep, but it does not prove the hypothesis that caffeine consumed only after 3:00 p.m. disrupts sleep patterns. In order to learn more about the effects of caffeine on sleep, additional experiments are necessary. Possible experiments could include testing whether there is a time of day when caffeine can be consumed without disturbing sleep patterns. Or this same experiment could be repeated with different levels of caffeine. Each experiment will provide more information about the original question: What are the effects of caffeine on sleep?

You will notice in reading through this experiment that it tests only one small part of the original question about the effects of caffeine on sleep. The scientific method is most successful when there is only one variable in an experiment. If a scientist sets out to test the effects of caffeine on sleep by giving different amounts of caffeine to people at different times of the day, it would be impossible to analyze the results and come to a meaningful conclusion. Scientists have learned that it is most effective to test one variable at a time and to complete many smaller experiments so that their results and conclusions are as accurate as possible.

Your Thoughts

What is the variable in this caffeine experiment? Remember, the variable is the part of the experiment that changes while everything else stays the same, or is controlled. Discuss your ideas with a parent or friend.

Science is so important because it is a part of all of us. We are all science in action. And we are all scientists. The way we decide what we do and how we do things is similar to the way scientists conduct their experiments. The scientific method is really no more than a way of giving more formal structure to a process that goes on inside of us and all around us many times every day. The main difference between
a controlled experiment and the way that most people think and draw conclusions is that in a controlled experiment you take precautions to see that all other factors in the experiment remain the same.

**Assignments**

1. Analyze the caffeine experiment. Use the four questions below to assess the caffeine experiment described in the last section. Think carefully about aspects of the experiment that could be more controlled or where errors might arise. Write a few sentences in response to each question.
   a. Did the experiment really do what it was intended to do?
   b. Could the method be improved so that it would have better results? How?
   c. Does the experiment suggest other experiments that might be undertaken? What are they?
   d. How can the information or process apply to personal life or experiences? This would answer the questions: “What does it all mean?” or “So what?”

2. Test your power of observation. Go outside and collect 13 to 20 rocks, sticks, leaves, or other items that can be easily collected. Don’t look at them too carefully. Place them in a box or basket and cover the opening. When you have paper and a pencil at your side and are ready to make your observations, take off the covering and reveal the objects. Give yourself one minute to carefully observe as much as you can about the objects and their placement using only your sight, but don’t write down anything yet. When the minute is up, cover the items again and give yourself three minutes to write as much as you can remember about what you observed. How many objects did you remember? Could you remember very many details about them? Did some objects remain in your memory more vividly than others?

   Now try this again with the same or a different set of items. Give yourself only a minute again, but this time touch the items in addition to looking at them. At the end of the minute, write or draw (or both) what you remember. How did your observation change? How did your sense of touch increase or decrease what you could remember? For an extra challenge, have someone else collect items for you so that until they are revealed, you don’t know what the objects are. Challenge someone else with the objects you gathered and see how their observations differ from yours. Some people are great at remembering lots of detail about a few things, while other people are quick to learn just one thing about many objects.

**Choice Assignment**

Choose one of the following projects.

A. **To Be a Scientist.** If you could be any kind of scientist, what kind would you be? Why? To be the scientist of your dreams, you can imagine you are any age, have any amount of money, and travel anywhere you need to. Aim to write about a page of three to five paragraphs to answer these questions.
B. **Scientific Experiment.** If you were going to conduct any scientific experiment, what would it be? What would your hypothesis be? If you can do the experiment, do it. If not, imagine the outcome and write what you think it would be. Use the five components of the scientific method to describe your experiment and its outcomes: Question, Hypothesis, Procedure, Observations, and Conclusion.

C. **Survey Experiment.** Some scientific experiments are surveys, which means the scientists get their answers through interviewing people. Create or design a survey about something you want to know. The survey can be one question or many. Carry out your survey with at least ten people you know. You might want the survey to be confidential and tell the people to put it in your mailbox without their name on it. Sometimes having confidential surveys lets people feel they can be more honest and not be judged for their answers. Use the five components of the scientific method to describe your survey and its outcomes: Question, Hypothesis, Procedure, Observations, and Conclusion.

D. **Animal Observation.** If you have an animal at home, spend some time observing it. When does it like to sleep? To play? Pose a hypothesis about its behavior. Observe it and see if you made correct assumptions. Example: “My dog likes to eat when my family eats,” or “My cat only plays with yarn when someone is moving it.” Do not try experiments that could hurt the animal or make it uncomfortable. Use the five components of the scientific method to describe your informal experiment and its outcomes: Question, Hypothesis, Procedure, Observations, and Conclusion.

**Test Questions**

1. What is controlled in a controlled experiment? Provide an example.

2. Come up with three questions that could lead to a scientific experiment.

3. Come up with a hypothesis to test each of the three questions you posed in the last question.
4. What are the five steps of the scientific method? Briefly explain each step.

5. Explain the difference between results and conclusion in a scientific experiment.

FOR ENROLLED STUDENTS
You will be sending a sample of 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 learning process. You can use your assignment summary checklist and the learning assessment form to keep track of your student’s progress. In addition, use a weekly student planner to help your student develop time management skills and begin taking responsibility for getting their work done each week.

Learning Assessment
These assessment rubrics are intended to help track student progress throughout the year. Please remember that these skills continue to develop over time. Parents and teachers can use this space to make notes about the learning the student demonstrates or any skills that might need work.

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<td>Displays focused observation skills</td>
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<td>Demonstrates knowledge of the scientific method</td>
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<td>Shows understanding of controlled experiments and variables</td>
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<td>Forms a hypothesis based on previous knowledge</td>
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<td>Explains the steps of the scientific method</td>
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<tr>
<td>Reflects on experiment process and ways to gain more accurate results</td>
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Wherever we are, wherever we go, things are going on all around us. It may be hot or cold, it may be noisy or quiet, the sun may be shining brightly, or it may be the dark of night. Many of these things we notice. But there are many, many things that happen that we don’t notice at all.

Everything that is around us is called our environment. It includes everything: from the air we breathe to all the plants and animals living around us. Our environment is where we live and everything that is here with us. Environment means “to surround,” and that is exactly what our environment does; it surrounds us, and we are part of it and dependent upon it for survival.

All living things react to their environment. For example, when temperature, light, the amount of moisture, or other conditions change, organisms will react in certain ways. When a lizard lies in the sun, it warms up and becomes more active. Flower petals close at night. The leaves of many plants change color in the fall. When the sun feels too hot, you might find a shady tree to shelter under.

The environment is the world that all living things share. It consists of all things that act and are acted upon. Yet creatures are not able to perceive everything and all that happens. The
ants living in the ground know nothing of the blooms at the tops of trees that are only a short distance away. In their entire lives they may never travel to the top of a tree, so they may never contact the birds that nest there. But they, like the temperature of the air, and the rain when it falls, are all part of the environment. You can’t possibly feel or know all the parts of your environment. But there’s no doubt that the more you are aware and the more information you have, the better the chances are for your continued survival in your world.

**Observation and Change**

How do we know what is going on around us? What is it that happens when we observe? What is it that we are noticing?

What we notice are changes. Living things grow and die; move; change size, shape, and place; and do many other things. We usually notice things because there has been some change that one or more of our senses have perceived.

Everything changes. Some things change quickly and we notice them easily; some things change so slowly that we don’t notice them at all. Still, change is an important quality by which we identify and describe living and nonliving things.

**Assignments**

1. For this exercise you will be observing three different environments. Pick two places that are natural areas where you can be relatively close to nature. The third place can be anywhere—it’s your choice.

Sit quietly in each of these places for at least 15 minutes. You are to relax and observe your environment. Pay attention to what you see, hear, smell, and feel. When you are finished, record your observations about each place and what types of things you noticed happening around you. Be specific and describe as many details as you can. Be sure to include any thoughts or feelings that you had while you were observing your environments. You will use these observations for an assignment in lesson 3, so keep them in a safe place.

   a. Visit one of the natural places early in the morning before the world is busy.
   
   b. Visit the other natural place at dusk, close to the time when the sun sets.
   
   c. Visit the third place at any time you choose.
Choice Assignment

Choose one of the following projects.

These activities will give you practice in making observations.

A. **Weather Journal.** Keep a weather journal for five days. In each entry, describe the cloud patterns, the times the sun and moon rose and set, the temperature, the wind patterns, and any other observations. When the five days are over, answer the following questions:
   - Was there one day that was your favorite in terms of the weather? Which day was it? What was the weather like?
   - If you had the power to make the weather patterns any way you wanted for a week, what would the days be like? Write up your dream weather report for a week’s time.

B. **Evening Observations.** How often do you observe the outside environment at night? One evening, at least an hour after the sun has set, go outside without any source of light (no flashlight or candle). If you can, stay out for 20 minutes. Take notice of the changes in your eyesight as it adjusts to the dark. Do you hear different noises at night than you do during the day? Count the number of night sounds you hear or night sights you see. Any surprises? Anything new? Write down your observations when you come back inside. (If you live in a place where there are lots of lights at night, try to find a special time to visit a very dark place at night.)

C. **Blindfold Project.** Go outside with someone you really trust who is willing to be blindfolded. Taking turns, one of you will be blindfolded and the other will act as the seeing-eye guide. The partner who can see should remain beside the blindfolded one, and the two of you should take five minutes to take in what is around you. You can then switch roles. Using your senses of hearing, feeling, tasting, and smelling, what do you observe differently when you can’t see? What changes in the environment do you think you would be more aware of during the change of seasons if you were truly blind? What things are you able to notice as a seeing individual? Write two paragraphs describing your observations—one for when you were blindfolded, and one for when you could see. Write a third paragraph explaining the differences between the two ways of observing.

Test Questions

1. Write a definition of environment in your own words.
Lesson 2: The Environment

2. In what ways do YOU react to changes in your environment? List and describe at least three ways. (Example: How do changes in the weather affect you?)

3. Do all living things change? List changes that you have observed in three living things in your environment recently. (Example: If the season is changing, have you noticed animals around you losing or gaining their winter fur?)

4. Do nonliving things change? List changes that you have observed in three nonliving things in your environment recently. (Example: How has the sky changed today?)

FOR ENROLLED STUDENTS
At the end of this lesson, you will be sending the first batch of work to your Oak Meadow teacher along with your assignment summary checklist, learning assessment form, or any alternate form of documentation. Include any additional notes about the lesson work or anything you’d like your teacher to know. Feel free to include questions with your documentation—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.
Learning Assessment

These assessment rubrics are intended to help track student progress throughout the year. Please remember that these skills continue to develop over time. Parents and teachers can use this space to make notes about the learning the student demonstrates or any skills that might need work.

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Now that your seedlings have been growing for a week or more, you can examine them more closely. Remember that green plants are different from animals because they do not eat other plants or animals to get their food. Green plants make their own food. In order to make their food, plants need water, light, nutrients, and a medium in which to grow.

**Roots**

The embryonic root starts the growth of most seeds. Most seeds store more food than the seedling needs for its first days of growth, but they can store very little water. It is important, therefore, that the root, whose job it is to absorb water and dissolved minerals, is the first part that emerges from the seed before the other parts can begin to grow.

As a plant grows, it needs more and more water and nutrients. The roots grow longer and new roots continue to grow. There are two main types of root systems: *fibrous root systems* and *taproot systems*.

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**Fibrous root systems**: roots that are made up of many thin branches, which are all similar in size and spread out underground.

**Taproot systems**: one large, main root that grows straight down beneath the main plant stem.

---

**ASSIGNMENT SUMMARY**

- Observe and describe plant roots.
- Draw and label a picture of the parts of different plants.
- Explain the functions of the parts of a green plant.
- Choice assignment
- Complete lesson 6 test.

**MATERIALS**

- magnifying glass or microscope
- head of cabbage or brussels sprout
- bunch of celery
- bulb of garlic
- knife

- **Choice Assignment**
  Inspect Roots
trowel or small shovel

Research Carnivorous Plants!
research materials about carnivorous plants

Witness Plant Power
several bean seeds
plaster of Paris
paper cup
Fibrous root systems are made up of many thin, branched roots, which are all similar in size. In plants with a taproot system, one main root is larger than the others. Smaller secondary roots grow out from the taproot in all directions, seeking water and nutrients. In both types of root systems, the roots are covered with tiny hairs called **root hairs**. It is through these root hairs that most of the absorption of water and minerals takes place. The water and nutrients travel from the root hairs, through the secondary roots, up through the taproot and up into the stem.

That handful of rich, lively soil in the cup where you planted a tomato or radish seed is all tied together by hundreds of miles of tiny root hairs, many too tiny to see. The root hairs are constantly absorbing nutrients while holding everything together in the soil.

Roots have two other important functions. They hold the plant in the ground and they keep the plant from falling over. Roots are the foundation that keep the plant in its place and secure it from the forces of wind and rain that would otherwise topple the plant. Since plants are not mobile organisms, they can’t just pack up and move from one place to another. But some plants, like crabgrass and mint, will continue to send out shoots from roots as they grow along or beneath the soil. What may begin as a single seed or seedling may eventually grow into a large, intertwined patch or grove of plants, all connected by a complex web of roots. Aspen trees grow in large groves from one underground root system. What appears to be many plants are actually all one interconnected plant.

Finally, roots are the storage areas of a plant. They store minerals and carbohydrates for the plant to use as fuel (food) in the future. Root vegetables—such as carrots, radishes, beets, potatoes, and turnips—are examples of roots that store large amounts of food to help the plant parts grow above the ground (green, leafy foliage) and below the ground (roots and root hairs).

After the root develops, the young stem and its leaves will emerge from the seed. The first leaves to form are called **cotyledons** or seed leaves. The cotyledons of a bean will be larger and fatter than that of the radish seed, because they store much of the food of the plant. A radish seed will store most of its food in its root, which will eventually grow into the red and white part of the radish that we eat.

**Root hairs:** tiny hair-like fibers that allow a root system to absorb nutrients and water.

**Potato plant**

**Cotyledons:** the first leaves to form on a sprouting plant; also called seed leaves.
The leaves of the seedlings spread themselves out horizontally so they can collect more of the sun’s light energy. Plants need this energy in order to make their food. The stem or shoot connects the leaves to the roots and is the pathway for water, nutrients, and food to move throughout the plant. It also provides the support for all parts of the plant that grow above the ground. The stem grows upward toward the sun and will actually move the leaves of a plant to face in the direction of the sun as the Earth turns on its axis and the sun appears to move across the sky.

**Buds**

Once the roots secure water and are providing stability, *buds* form along the stem. Buds will grow into young leaves and more stems, and in some cases, flowers. A terminal bud is at the tip of a stem, and lateral buds grow along the sides of a stem.

A head of cabbage is a large *terminal bud*. If you cut the head in half from top to bottom, you can see the stem in the center of the bud. The leaves grow out from the stem. If you pull off the leaves, one by one, you will find a very small *lateral bud* just above each leaf.

A head of celery is a large, tall bud. If it were allowed to grow for a second year, it would produce flowers and those flowers would produce seeds. If you cut a bunch of celery open, you will notice each stalk of celery with its leafy top is a leaf. The celery heart is the stem. If you remove a stalk from the stem, you can see lateral buds, which sometimes grow into other branches.

A *bulb* is a large underground bud that can produce new plants. The leaves of a garlic bulb are large and papery. Each of the cloves is a lateral bud. If you cut through a garlic bulb from top to bottom, you can see its leaves and its small stem at the bottom.

Many trees or shrubs (a good example is a lilac) have lateral buds that are protected by special leaves called *bud scales*. Lateral buds will eventually grow into branches with buds of their own. Usually the **Shoot**: the stem of a plant that is just beginning to grow; it connects the roots and the leaves and is the pathway for nutrients to move through the plant.

**Buds**: the developing part of a plant that will grow into leaves, additional stems, or flowers.

**Terminal bud**: bud that forms at the tip of a stem.

**Lateral bud**: a bud that forms along the side of a stem.

**Bulb**: a large underground bud that can produce new plants.

**Bud scales**: special leaves that protect lateral buds on certain plants.
most vigorous growth occurs along the terminal bud, as the plant grows vertically toward the sunlight. Should the terminal bud be broken or removed, growth along the lateral buds will increase. When bushes or hedges are pruned or clipped, growth is stimulated in lateral buds so the plant grows bushier instead of taller and thinner.

**Assignments**

1. Carefully pull up one of each of the seedlings from the last lesson. Notice that they do not look exactly the same, but they are all similar in that they have three main parts. If you have a magnifying glass or a microscope, examine the seedlings' roots to see if you can identify the root hairs. Using the diagrams and text in this lesson, identify each of the parts of each seedling. How are the root structures different? Are they fibrous or taproot systems? Record your observations.

2. For this assignment, you will need a head of cabbage or a Brussels sprout (which is like a tiny cabbage and is closely related), a bunch of celery, and a bulb of garlic. Ask for parental assistance, if needed, to slice each of them in half, top to bottom. Draw a picture of the exposed parts of each and label the parts that you can identify. (Then use the vegetables for your dinner, if you like!)

3. Explain the functions of the parts of a green plant:
   a. Leaves
   b. Stem
   c. Roots
   d. Root hairs
   e. Bud
   f. Bud scale

**Choice Assignment**

Choose one of the following projects.

A. **Inspect Roots.** If you have a yard or access to a nearby field, go outdoors with a trowel or small shovel and find some common grasses and weeds that you can recognize, such as dandelions, clover, and the grass in your lawn or field. Dig up a small clump or a single plant of at least three different types. (Be careful not to break off the root when you dig it up.) Gently shake off the soil and examine the root structures. Look more closely with a magnifying glass. Does it have one main taproot, or many smaller, fibrous roots? Draw a color picture of each plant with its roots and label the type of root structure for each plant. (After you finish, you can replant the plants if they are not too wilted. Be sure to give them some water, as they will have dried out.)
B. **Research Carnivorous Plants!** In the beginning of this lesson, you learned that plants are the only organisms that can make their own food. While this is true, there are some plants that trap and digest other organisms (usually insects). Using books found at your local library, or internet resources, find out what specialized mechanisms these plants have that enable them to capture and eat bugs. Write a three-paragraph paper describing how they do this. Use the names of some of the plants you learned about. Do any of these plants live near you? Have you ever seen any? Please refer to the introduction for suggestions about how to complete a research paper. Don’t forget to proofread your work and to write a works cited page.

C. **Identify Edible Roots and Shoots.** Make a list of all the vegetables, grains, and fruits that your family eats. Then take a trip to a grocery store and look for the plants on your list. Try to identify what part of a plant each of the food items represents. Write down the part next to each name. Some foods might be hard to figure out. When you eat broccoli, for example, you are eating clusters of tiny flower buds. If that green broccoli head had been left in the field where it grew, in a few days it would have become a mass of yellow flowers! Which plant parts are there more of on your list? Probably, your family eats a mixture of roots, stems, leaves, buds, flowers, and seeds of all types.

D. **Witness Plant Power.** Try a true test of the amazing power of roots. For this activity you will need several beans, plaster of Paris, and a paper cup. Soak the beans overnight to prepare them.

When the beans have been soaked, pour plaster of Paris (which should be prepared as a liquid according to the instructions on the package) into a paper cup, filling it about halfway. Then place a few beans on the plaster and continue to fill the cup. Be sure the beans are located halfway down.

In a few days, you will be witness to a plant’s strength and determination to grow! (The plants should have broken through the plaster of Paris. If they did not, be sure you soaked the beans overnight and prepared the plaster correctly.)

**Test Questions**

1. What are the two main types of root systems? Describe each one in your own words.

2. What are the main functions of roots in green plants? Name and describe three functions.
3. What role do leaves play in the function of a plant?

4. Name at least three parts of plants that are commonly eaten by humans. Give two examples of each.

FOR ENROLLED STUDENTS
Please submit your student’s work to your Oak Meadow teacher at the end of this lesson. Make sure all the assignments are completed (you can use the assignment checklist to help you organize your submission). Contact your teacher if you have any questions.

Learning Assessment
Use assessment rubrics to track student progress and to make notes about the learning the student demonstrates or any skills that might need work.

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<td>Creates accurate, labeled, scientific drawings</td>
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<td>Demonstrates knowledge of root structure and function in plants</td>
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ASSIGNMENT SUMMARY

☐ Research three different types of fertilizers.
☐ Consider different elements of gardening.
☐ Identify soil composition.
☐ Choice assignment
☐ Complete lesson 7 test.

MATERIALS

☐ three different types of fertilizer from a local nursery
☐ your own flower or vegetable garden or a person you can interview who has a flower or vegetable garden

Choice Assignment

Create Compost
clear containers (plastic bags or clear jars)
notepad
garden soil
fruit and vegetable matter
glass clippings, leaves
small twigs
nonliving matter such as Styrofoam or plastic

Soil Squirmers
funnel
small piece of steel wool (without cleanser in it)
clear glass jar
water
magnifying glass
light with an incandescent bulb

Soil is the environment in which a plant’s roots grow. It provides many important functions for the plant. Soil provides stability for the plant so that it can grow securely above the surface of the ground. Soil holds water around the roots so that it can be absorbed and used by the plant. It also holds tiny amounts of air that allow roots to breathe and to keep roots from being totally immersed in water. The soil also provides nutrients in the form of minerals that the plant needs to maintain good health. Nutrients affect the plant in much the same way that vitamins are used in your body. The water in the soil dissolves these minerals from the sand, rotted leaves, and decomposing stems and twigs that are in the soil. Microscopic bacteria that live in the soil help break down minerals into a form that roots can use. The water in the soil is then absorbed, along with these minerals, by the roots.

Nutrients: the nourishment plants need to grow.
Soil is much more than just dirt; healthy soil is full of life. A handful of truly rich soil contains about 5 billion microorganisms (organisms that are too small to be seen by our eyes without a microscope), and a million other tiny organisms. In addition, the same handful also contains insects, worms, and other animals that burrow in the soil, add nutrients through their waste, and help keep the soil loose enough for a plant’s roots to grow into. In fact, a handful of rich soil may have as many living organisms in it as there are people on Earth!

**Fertilizers, Bacteria, and Compost**

Have you ever had a houseplant that was not very healthy? Perhaps it turned yellow; perhaps many of its leaves fell off. The plant may have gotten too much water or too little water, causing the roots to rot or to dry out too much. It may have been chewed up by insects, or it may have been infected with a plant virus or bacterial disease. Often houseplants don’t get all of the nutrients they need to stay healthy and grow.

The nutrients that a plant needs depend upon the type of environment its ancestors evolved in. The natural environment in which a plant grows, generation after generation, usually contains all the nutrients necessary for growth to continue. When a plant is moved to a new environment, such as a pot or a garden, that environment may not meet all of the needs of the plant.

In nature, minerals follow cycles as they change from one form to another. Minerals and nutrients are present in limited amounts on Earth. More of them cannot be created, but they can change the form in
which they appear. For instance, the amount of oxygen on Earth always remains the same. But the oxygen may be in the form of water, air, clouds, or ice. The same is true for all minerals.

**Fertilizer** is usually defined as a material that is added to the soil to help plants grow. It contains nutrients (which may be missing from the soil) that the plant needs to maintain its health. **Nitrogen**, a gas that is plentiful in the air all around us, is necessary for plants to make proteins and grow. But plants cannot take their nitrogen directly from the air. They can use nitrogen only when it is combined with other elements.

Certain bacteria in the soil change nitrogen from the air into compounds that can be absorbed by a plant's roots. Bacteria are tiny, single-celled organisms that are found almost anywhere. **Fertile** (or healthy) soil is teeming with many types of bacteria, fungi, and other tiny organisms. As they consume dead plant material, soil bacteria and other organisms transform minerals in soil into forms that root hairs can easily absorb. These soil organisms are essential to the life of our planet; without these decomposers, we would all suffocate in our own wastes, and natural plant systems, such as forests, would not be able to get the nutrients they need to grow.

Man-made, chemical fertilizers can also be added to soil, to provide minerals in a form readily accessible to plants. Most chemical fertilizers are high in the minerals nitrogen, phosphorus, and potassium. (These are the three nutrients that plants use the most.) But chemical fertilizers can cause mineral imbalances in the soil, which then can cause chemical imbalances in the plants that are grown in them. Even though these plants can display vigorous and quick growth, they are often found to contain significantly lesser amounts of minerals essential to animal, plant, and soil health. After years of addition of chemical fertilizers, farm soils can become depleted of **organic matter** as well, if farmers or gardeners do not add compost, mulch, or other plant material to the soil. (In a forest, prairie, or other natural ecosystem, organic matter is constantly cycling as old plants and animals die and new ones grow.) Organic matter, which includes any dead and decaying organism that was once living, is essential to healthy soil. Soil organisms feed on it; they cannot feed on chemical fertilizers. Over time, if used exclusively, chemical fertilizers can disrupt natural mineral cycles.

Decayed plants, vegetable or fruit scraps, grass clippings, or leaves can provide the same benefits to your plants as fertilizer, without harmful side-effects. This happens when they are mixed with air and water and are exposed to soil organisms. Decaying plants break down naturally into light, nutrient-rich compost. Composting can recycle many common kitchen and yard "wastes" that might otherwise end up in a landfill.
Assignments

1. Go to a local garden center or nursery, and find three different types of fertilizers, both man-made (chemical) types and natural (organic) types made from earth and ocean materials, such as composted manure and seaweed. For each type, list the name, then research and write down the following:
   a. Recommended uses
   b. Source of the materials and types of minerals in each
   c. How to apply and how much should be applied

2. Do you have a flower or vegetable garden? If your answer is yes, answer the following questions. If your answer is no, your exercise will take the form of an interview. Find a friend or neighbor who has a garden. Write down this person’s name and relationship to you. (If you cannot find a friend or neighbor who gardens, you may call a local nursery and interview a worker or manager there.) Answer the following questions:
   a. What kinds of plants (vegetables, flowers, etc.) do you grow?
   b. How do you keep the soil in your garden healthy and fertile so that plants will grow?
   c. Do you use fertilizers? If so, what types are used? How often are they used?
   d. Do you compost your kitchen or other wastes? If so, what types of things do you put into your compost?

3. Retrieve a sample of the soil you used for your seedling experiment in lesson 5. Examine it closely with a magnifying glass. Identify as many different “things” in it as you can. Try to determine the composition of the soil using fractions (e.g., sticks and twigs make up about $\frac{1}{3}$ of the soil) or percentages (e.g., rotted leaves are about 50% of the total). Draw or describe your findings below.

Choice Assignment

Choose one of the following projects.

A. Create Compost. It is often difficult to imagine banana peels, eggshells, orange rinds, apple cores, leaves, and live plants turning into nutrient-rich compost for your garden. To witness the beginning stages of the breakdown of organic matter, try the composting ideas listed below. Feel free to create your own combinations!

For all of these combinations, use clear containers that can be sealed, such as plastic bags or clear jars. Number your samples and record what is in each of them. Leave a notepad by the samples so you can record the changes you observe over time. For this experiment, you will need to use rich garden soil, because it contains the microorganisms necessary to break down the plant material. Potting soil has been sterilized and won’t work as well.
Sample #1: For this sample, use a variety of fruit and vegetable matter, such as vegetable peels, banana peels, apple cores, etc. Do not add any meat or dairy products to your compost. Add a handful of soil to this container.

Sample #2: Instead of food waste, collect grass clippings, leaves, small twigs, any small dead plants you may have indoors or out, and a handful of soil.

Sample #3: Fill the third container with nonorganic (not living) matter, such as tin, plastic, Styrofoam, or other similar items. Add a handful of soil.

Sample #4: (Optional) Create your own mixture and add a handful of soil.

Space the containers and put them in a place that receives sunlight, such as by a window. You can hang the containers so that you can watch what happens at the bottom, but don’t worry if you’re unable to do this. Once the samples are made and sealed, make predictions (hypotheses) as to which will break down first, then second, then third, and then fourth. Record your predictions. Observe and make recordings every few days for about three weeks. After three weeks, look at your results and write a conclusion for each hypothesis you made. Explain whether your predictions were correct and describe your observations. Write up your report using the scientific method format. When you are through with your samples, deposit them in the appropriate places.

B. Research Different Home-Composting Methods. There are many different ways to use your kitchen and garden wastes to create “black gold” (as gardeners call compost), including worm composting, which has become quite popular with people who live in apartments and don’t have a big garden space! Using books found at your local library or using internet resources, research different home-composting methods and write a one- or two-page report describing each method. Be sure to begin your report with a basic explanation of how microorganisms create compost. Draw diagrams or sketches of different types of compost structures. Include a paragraph describing which type of composting method would work best for your family.

C. Soil Squirmers. For this activity you will need the following:

- Funnel
- Small piece of steel wool (without cleanser in it)
- Clear glass jar or cup filled with an inch or two of water
- Two cups of rich garden soil
- Magnifying glass
- Light with an incandescent bulb

Once you have the materials, put the steel wool into the wide end of the funnel. The narrow end of the funnel should face down in the clear container with water. Arrange it so the funnel is a few inches above the water, not touching it, and in a balanced position. (One way is to use a wire
clothes hanger to make a stand for the funnel to sit in.) Then put the soil on top of the steel wool in the funnel.

The whole setup should be placed about six to ten inches under the light. You should find that the creatures from the garden soil, in attempting to move away from the heat of the light, fall into the water. Use your magnifying glass to examine the water and soil. Write up your observations into a one-page paper. Include descriptions of any living organisms as well as a few sketches.

Test Questions

1. Explain the functions of soil in terms of how it is used by a plant.

2. Explain the difference between "dirt" and healthy, living soil.

3. How do organisms in soil help plants get nutrients that they need to grow? Give an example of one type of organism that does this.

4. Why is organic matter important to healthy soil?

FOR ENROLLED STUDENTS
Continue to document your student's progress using the weekly planner, assignment checklist, and learning assessment form in each lesson. Feel free to contact your teacher if you have any questions about the assignments or the learning process.
Learning Assessment

Use assessment rubrics to track student progress and to make notes about the learning the student demonstrates or any skills that might need work.

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