Grade 8
Physical Science

Oak Meadow
Coursebook

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Grade 8

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Grade 8 2

Controlled Experiments and the Scientific Method

ASSIGNMENT SUMMARY

- ☐ Complete the reading selections.
- ☐ Make a list of variables and how they can be controlled.
- ☐ Lab Investigation: Sink or Float?
- ☐ Complete lesson 2 test.

MATERIALS

☐ Lab Investigation: Sink or Float?

clay (about the size of a baseball)

bucket of water

Learning Objectives

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

- Identify the variable factors in an experiment.
- Design an experiment that controls all variables but one.
- Write a conclusion based on experiment results.
- Differentiate between causation and correlation.

Reading

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

- Scientific Method
- Variable and Constant Factors
- Controlled Versus Uncontrolled Environments
- Using the Scientific Method
- Causation and Correlation

Look over the amount of reading before you begin, and make a plan to divide it up so you aren't trying to absorb too much information at once. If you have any questions about the reading, ask for help or do some extra research on your own.

Assignments

Before you begin your assignments, read through them to get a sense of what you'll be doing and how long it will take. This will help you manage your time better.

1. Take some time to make an observation around your home. Perhaps you notice that your cat naps in different places at different times of day. Or maybe you see that the temperature on one side of your house generally feels colder than on the other. Then make a list of variable factors that you might consider if you were to design an experiment. After each variable you list, explain how you might control that variable to make it a constant in your experiment.

Lab Investigation

Complete the following lab investigation.

- **Lab Investigation: Sink or Float?**

All lab investigations are found in the lab manual, *Lab Investigations: Physical Science*. Read the instructions carefully and 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.

Test

Answer the following questions using scientific terminology. Refer to scientific concepts to support your answer whenever possible.

1. In your own words, explain the steps of the scientific method.
2. What is the difference between a variable and a constant? How many variables are normally in a scientific experiment? How many constants? Why are both part of every experiment? Give an example of each.
3. Define controlled environment and give an example.
4. What does the phrase "correlation does not imply causation" mean? Make sure to define *correlation* and *causation* in 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. Please remember that these skills continue to develop over time.

SKILLS	Developing	Consistent	Competent	Notes
Describe the steps of the scientific method				
Write a concise, testable hypothesis				
Identify variable and constant factors				
Write a step-by-step procedure for an experiment				
Record data with accuracy				
Write a conclusion based on results				
Describe a controlled environment				
Differentiate between causation and correlation				

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 feedback. In the meantime, proceed to the next lesson.

Reading Selections

Scientific Method

The ***scientific method*** is an organized way of testing observed phenomena. However, it is not the only way that scientific progress is made! Scientists observe the world like children do: exploring every new thing, being curious, asking questions. This observation and questioning is scientific inquiry. Sometimes you cannot create experiments around the observed phenomena. If a shower of meteors falls to Earth, how can you devise an experiment to test what happened and why? You can't recreate the event, but you can observe carefully and relate it to what is already known. This is the way science works.

We are all scientists. We ask questions, we guess what the answer will be, and we watch to see what happens. Our minds record the results and then we decide what the results mean. We take this knowledge and use it to guide our future actions or explorations. In the scientific method, observations are made about the world, and then experiments are conducted to explain the observation. How carefully the experiment is designed and conducted determines how accurate the results will be. If the factors influencing the experiment are not controlled, then the experiment will not give us reliable results and an accurate explanation of what was observed. Often a scientist will repeat an experiment, changing different elements each time, in order to gain a clearer understanding of a phenomenon.

When drawing conclusions about what happened and why, it's important to consider the many different factors that may influence the results. Scientists try to keep these influences under control by following very specific procedures of the scientific method:

Ask a question: Questions often arise from observations. The question should be brief, concise, and testable. For example, "Why does my dog eat so fast?" is a question that would be hard to test—it is too open-ended. There could be many factors influencing how fast the dog eats. However, "Does the type of food influence how fast my dog eats?" is a question that is easy to test. There is one factor that is being looked at: the type of food.

Form a hypothesis: A hypothesis is an educated guess about what the answer to the question might be, based on what you already know. The hypothesis forms the focus of your experiment, which will attempt to prove or disprove the statement. For instance, you might hypothesize, "My dog will eat cooked meat faster than dry dog food, fresh fruit, or fresh vegetables."

Conduct an experiment (procedure): An experiment is designed and conducted to test the hypothesis. The experiment will try to isolate a single factor to test, controlling all other influences. Often procedure is performed multiple times to see if the results can be repeated.

Record the results: Observations are carefully recorded, and these become the results of the experiment. Results, which can be qualitative or quantitative or both, are recorded as objectively as possible.

Draw a conclusion: The data (results or observations) is compiled and interpreted as you look for patterns and cause-and-effect relationships, and make inferences about what happened and why. The conclusion states whether the hypothesis was proved or disproved.

The conclusion is where you compare your hypothesis with what actually happened:

- Did what you think would happen actually happen?
- Did something unexpected happen?
- Describe the variables and which ones may have impacted your results.
- Consider possible explanations for what happened in your experiment.

The conclusion is a chance to reflect on the experiment and how it might be altered or expanded to produce more accurate or helpful information. Is there an influencing factor that was not properly controlled? Would more trials or a longer time period reveal more patterns of behavior? Is there another factor that needs to be taken into account or tested? When writing a conclusion, scientists will often discuss questions such as these, and propose a relevant follow-up experiment.

Variable and Constant Factors

When we make observations about the world, it is important to understand the factors that may be influencing what we are observing. In an experiment, a ***variable factor*** (or variable) is an aspect of the experiment that can be varied or changed. For instance, temperature might be a variable factor in a plant growth experiment, or the amount of water might be a variable factor. Usually an experiment will have only one variable factor. The variable in the dog food experiment is the type of food.

Factors that are controlled and do not change are called ***constant factors*** (or constants). In a plant growth experiment, you might control the amount and type of soil, the type and number of seeds, how deep the seeds are planted, and the amount of sunshine each plant gets. These constant factors are the same for each plant in the study. The constants in the dog food experiment might be the amount of food, the time of day, the number of people present when the dog is eating, the noise level, the location of the food, and the shape and size of dish the dog eats from. These constant factors are the same throughout the experiment. The only thing that changes is the type of food.

Let's suppose you notice that sometimes the ice cream in your freezer is really hard and sometimes it is a little soft. What are some of the variable factors that could explain this?

- The temperature of the freezer
- The placement or location of the ice cream in the freezer
- The type of ice cream
- How long the ice cream has been in the freezer
- How many times the freezer door has been opened
- How much ice cream is left in the container

If you wanted to conduct an experiment to try to figure out why the ice cream changes its form, you might start by identifying the variables, such as temperature, placement, type of ice cream, and length of time in freezer. To determine which variable is causing the ice cream to be hard or soft at different times, you would have to conduct a series of experiments to look at the influence of each variable, one at a time.

You might put some ice cream in a certain spot in the freezer and then two hours later you test it for hardness. After another two hours, you go to test the ice cream again, but you realize that someone ate it all, and there is another kind of ice cream right in the same spot. Since it is in the same place in the freezer, you do another hardness test and find it much softer than the previous ice cream. When you think about why the ice cream was soft the second time, you come up with several possible reasons:

- The ice cream was a different kind, and it is normally softer than the first kind of ice cream.
- The ice cream had not been in the freezer for very long, and might have been placed there just after sitting in the car on the way home from the grocery store.
- The temperature in the freezer rose because someone left the door open while eating the remainder of the first ice cream.

Your hardness tests of the ice cream didn't really prove anything because there were too many variable factors in your experiment.

This is an example of an ***uncontrolled experiment***—there was not enough control over the variables to find an explanation for the observation. If you really want to find out what causes the ice cream to be harder or softer at different times, you will need to limit the variables. Remember:

- Only one variable factor in each experiment.
- All other factors should be controlled or constant.

How might you design your ice cream experiment to test only one variable? Let's say you want to test the placement of the ice cream in the freezer. That is your one variable. That means you need to control all the other influencing factors.

Here are some things you might do:

- Make sure no one opens the freezer door while your experiment is being conducted. This also means nothing is added or taken out of the freezer. This controls the temperature element and how many items are in the freezer.
- Buy three containers of the same ice cream, all in the same size container. This controls the amount and type of ice cream.

- Place each of the three ice cream containers in the freezer at the same time and you make a note of the time you put them into the freezer. You will test the hardness of each at the same time, and the same number of times (say, one time per hour for three hours). This controls the element of time.

Since you are varying the location of the ice cream in the freezer, you will place each container in a different spot. You then conduct the experiment by checking the hardness in each of the three containers on a set schedule and you write your results down each time. As you do the experiment, you are careful not to change the location of any of the three containers.

If the results showed that the ice cream in one of the containers was soft and the ice cream in the other two containers was hard, then the placement of the ice cream in the freezer affects the hardness of the ice cream. If the results were that the ice cream in all the containers was equally hard or soft in all locations, then the placement of the ice cream in the freezer is not the variable that affects the hardness and softness of the ice cream. You will have to design another experiment that has a different factor as a variable, and where the placement of the ice cream in the freezer is a constant. You would continue to test different variables, one at a time, until your question was answered.

Controlled Versus Uncontrolled Environments

The environment or circumstances in which an experiment is conducted has an effect on the outcome of a scientific experiment. It is important to control the environmental factors (the variables), or you will not get reliable results or an accurate explanation for your observation or question.

A ***controlled environment*** is an environment where there is only one variable factor (or at most, a few). Most scientists, when they are working to explain an observation they have made, strive to design and conduct experiments in a controlled environment and to limit the variable factors as much as possible. An example of a controlled environment is a science laboratory where the scientist can control the temperature, the humidity, and the materials that are used.

An ***uncontrolled environment*** is an environment where there are many variable factors or factors that are hard to control. For example, when dealing with experiments in a natural setting, such as a forest, it is impossible to isolate a single variable—there are simply too many environmental factors that can influence the experiment. Good, careful scientific experiments can still be conducted, however; by having scientists do their best to notice and take into account the many varying influences.

Sometimes variables work together, and isolating them doesn't give you an accurate assessment. This has been the case when studying the human body. Scientists have isolated different organs and studied them individually and made conclusions, only to find later that each organ is quite connected to the whole body/mind system. They interact with the system in many complex ways, and controlled systematic study of each organ separately can give an incomplete picture.

It is always important to remember that your observations and/or experiment may have variable factors that are affecting your results. Try to limit the number of variables so you can figure out what you are actually measuring.

Remember that scientific observations must be measurable, repeatable, and objective. Whenever you use the scientific method for a controlled experiment, it should be written clearly so that others can repeat exactly what you did. You need to document your method or procedure precisely! This allows other scientists to verify your results, and it is how scientific theories are proven.

National Weather Service observation platform being installed at the lighthouse in Safinaw Bay, Michigan (Image credit: NOAA)

A repeatable experiment doesn't mean that the same results will be observed each time. We do experiments to see what the results will be rather than expecting them to be one way or another. If someone else repeats the experiment exactly and gets different results, you have a new question: Why did the results differ? You'd probably want to repeat the experiment many more times, and have others repeat it, to see if the data begins to show a pattern. If not, perhaps there is another variable influencing the results which hasn't yet been taken into account or controlled. Science is all about asking questions and looking for answers!

Using the Scientific Method

Let's look at an example of the scientific method in action. Pretend that you are washing the dishes in the sink one day, and you notice something about them. This is how the scientific method would be used to make a conclusion about your observation:

1. **Observation:** You have noticed that some objects sink when put in water, and that others float. You decide to test several items to see if you can figure why certain things sink and others don't.
2. **Hypothesis:** There are several variables that you need to identify, so that you can test one of them at a time. Some variables that might affect whether an object sinks or floats are shape, size, weight, and density. You decide to test density (which is mass per unit volume). You need to state your hypothesis quite specifically: "Objects that are the same shape and size, but different densities, will act differently in water. Objects that are less dense will float, and the more dense objects will sink. Wood will float and clay will sink."

3. **Experiment:** Now you need to clearly document your method, identifying how you will control each variable: "I will take a small block of wood and a lump of clay. I will form the clay to be the exact shape and size as the block of wood. I will put each of them in a sink with water in it and observe whether they sink or float. Both are exposed to the exact same conditions in the room and the water. The only difference is the material they are made of."
4. **Results:** Write your results in detail: "The block of wood floated and the clay block sank."
5. **Conclusion:** First review your original observation (that some objects sink and others float), and your hypothesis. Your results indicate that what you predicted did actually happen. But what is your conclusion? Basically, all you can conclude from this is that wood floats and clay sinks. You would like to make the theory that objects that are less dense will float and those that are more dense will sink. As you think about it more, though, you wonder whether this is always true. "Less dense" and "more dense" are vague terms. Less dense than what? What about ships that sail on the ocean? They are metal and quite dense, but they don't sink. Will clay always sink, no matter what shape it's in? There are many more questions raised by this experiment than answers obtained—this is the way science works!

Your experiment is an important start. Information was learned, and now further testing can be done. You see that you need to clarify your hypothesis even more, perhaps adding that those objects that are more dense than water will sink, and those less dense than water will float. But what about the ships that float? You might consider that there is more than one variable that determines whether an object will float. There could be variables that you haven't thought of yet. It's important to remain inquisitive and keep questioning.

Causation and Correlation

When scientists draw conclusions or make statements based on data, they are often looking for a connection or cause-and-effect relationship between factors. However, proving that one thing causes another can be harder than it sounds. Just because two things happen together or under the same circumstances doesn't mean that one caused the other. In fact, science studies are often misunderstood by the public because of the confusion between correlation and causation.

Imagine that you trip on the sidewalk every time you wear a certain pair of shoes. You notice a correlation because the two events—wearing that pair of shoes and tripping on the sidewalk—seem to always happen together. This might lead you to believe that the shoes are the cause of your stumbles. But hold on—that's a big assumption to make. Perhaps you only wear those shoes to walk to your grandmother's house, and the sidewalk near her house is cracked and broken. Or perhaps you only wear those shoes in the rain and the sidewalk is always slippery in the rain, or you only wear those shoes at night, and you are more likely to trip in the dark. On the other hand, maybe the shoes are new and stiff or uncomfortable or too large, and they actually are the cause of all that tripping! However, without a comprehensive experiment, it's hard to prove it—there are just too many other factors involved. You can't say for certain that one thing (the shoes) causes another (tripping), so you can't claim causality. There is not enough evidence to prove it.

"Correlation does not imply causation" is a well-known phrase in science, and it is repeated often with good reason. Many people think correlation and causation are the same thing. If two things always seem to happen together, ask yourself, "Does *A* always lead to *B*?" And then try to answer the question through careful, methodical scientific inquiry and repeated trials.

This is how scientists try to determine cause and effect. When experiment results seem to indicate causation (one thing causing another), scientists look carefully at whether uncontrolled variables might have influenced the results.

Grade 8

5

Mixtures and Compounds

ASSIGNMENT SUMMARY

- ☐ Complete the reading selections.
- ☐ Give examples of mixtures.
- ☐ Identify and explain the chemical formula for common compounds.
- ☐ Illustrate and explain the process of oxidation.
- ☐ Identify the number and type of atoms in different molecules.
- ☐ Lab Investigation: Oxidation and Combustion
- ☐ Complete lesson 5 test.

MATERIALS

☐ Lab Investigation: Oxidation and Combustion

glass jar

candle (small enough to fit inside the jar)

matches or lighter

toothpick

butter knife

metric ruler or tape measure

clock, watch, or stopwatch

Learning Objectives

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

- Demonstrate the role of oxygen in combustion.
- Differentiate between mixtures and compounds.
- Illustrate and explain the process of oxidation.
- Interpret a chemical formula.

Reading

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

- Mixtures
- Compounds
- Chemical Composition of Molecules
- Oxidation
- Chemical Reactions in Photosynthesis

If you find a section of the reading to be challenging or confusing, take the time to read it a second time. Look at one sentence at a time and make sure it makes sense to you before moving on. If you are still having trouble, ask for help.

Assignments

Take a look at all the assignments before you begin working.

1. Go on a hunt for mixtures. How many mixtures can you find around your house or outdoors? Make a list, and identify what each is made of.
2. Choose two of the following common compounds. Give the chemical formula for each and explain what the chemical formula shows. Write a brief description of the process that formed the compound and what the compound is used for.
    - methane
    - ammonia
    - hydrochloric acid
    - isopropyl alcohol (rubbing alcohol)
3. Illustrate and explain the process of oxidation. You can draw a diagram, create a cartoon-style drawing, or write a simple children's book explaining the process of oxidation using either rust or fire as your example. Explain the process as simply as possible, with illustrations and words. Make sure to define *oxidation*.
4. The chemical formula for water is H_2O, which means there are two atoms of hydrogen and one atom of oxygen in each water molecule. Using the following chemical formulas for

ordinary household products, list how many atoms of each type are in each molecule. (You will need to refer to a periodic table of elements to identify the chemical symbols for each atom.)

a. Chalk: $CaCO_3$

b. Sugar: $C_{12}H_{22}O_{11}$

c. Sodium bicarbonate (baking soda): $NaHCO_3$

d. Monosodium glutamate (MSG): $C_5H_8NNaO_4$

Lab Investigation

Complete the following lab investigation.

- **Lab Investigation: Oxidation and Combustion**

All lab investigations are found in the lab manual, *Lab Investigations: Physical Science*.

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. Imagine carefully weighing a metal can, leaving it out in the rain for weeks and weeks until it was very rusted, and then carefully weighing it again. Would the can be heavier or lighter after it was rusted? Why?
2. What is the difference between a mixture and a compound?
3. What is oxidation?
4. Based on the following equation for the chemical process of photosynthesis, explain what is occurring chemically.

   $6CO_2 + 6H_2O$ + light energy and chlorophyll $\rightarrow C_6H_{12}O_6 + 6O_2$

5. When a piece of paper or wood is burned, you are left with ashes that seem to weigh less than the paper or wood before it was burned. Yet when a substance is burned, it is oxidized and therefore must weigh more than it did before it was burned. Explain what happened to the "missing" weight.

Learning Checklist

Use this learning checklist to track how your skills are developing over time and identify skills that need more work.

SKILLS	Developing	Consistent	Competent	Notes
Interpret a chemical formula				
Follow a lab procedure accurately				
Take accurate measurements and compile data				
Use data as evidence to support a claim				
Illustrate and explain the process of oxidation				

For Enrolled Students

Contact your teacher if you have any questions about the material. You will submit your work after the next lesson.

Reading Selections

Mixtures

Elements join together to make molecules that form all matter on Earth. But how do they join together? There are different ways this can happen.

When elements are mixed, their properties do not change. For instance, sulfur (S) is a solid that can be ground into yellow powder. Iron (Fe), which a metal that is attracted to magnets, can be ground up into little gray-black pieces that we call iron filings. Now imagine that you mix the sulfur powder with the iron filings. You would still be able to see the yellow sulfur powder and the gray-black iron filings. The two elements have been combined into a ***mixture***. If you wanted to separate the two, you could hold a magnet over the pile and the iron would stick to the magnet and leave the sulfur behind. The individual properties of the elements sulfur and iron did not change when they were mixed together.

You also have a mixture if you take salt and dissolve it in water. You can't see the salt, but by a simple physical process (evaporating the water), you can separate the salt and water again, and you end up with the same molecules you started with. The two substances in the mixtures—salt and water—haven't lost any of their chemical properties.

You have seen and used many mixtures. For instance, what do you get when you mix dirt and water together? Mud! Have you ever had a salad with a vinegar and oil dressing? That's a mixture, too. A fruit salad is a mixture of different types of fruit combined together. Soda water or seltzer is water mixed with carbon dioxide. If you open a bottle of seltzer and leave it sitting, the carbon dioxide will slowly separate and drift into the air, leaving the soda flat. All these mixtures share a common property: they can be separated into their original parts again.

There are different types of mixtures and they are called different names depending on how the components of the mixture are interacting (you'll learn more about that in the next lesson).

Compounds

Now imagine that you have mixed sulfur and iron together and you have placed them in a test tube (a small glass container that is used to perform chemical experiments). If you were to apply heat, the mixed elements would begin to glow. After removing them from the heat, the substance would cool and instead of yellow sulfur and iron filings, you would find a black glob of metal. This black glob is a new material called iron sulfide. If you held a magnet to it, the iron sulfide would not be attracted to the magnet even though the iron filings were used to make it. What happened?

When elements are combined to make a new substance with its own properties, the resulting new substance is called a ***compound***. Compounds do not have the properties of the elements that were used to make them. Iron sulfide is not like sulfur and it is not like iron; iron sulfide is a compound with its own unique properties. In order to separate the iron from the sulfur and get back their original properties, you need another chemical reaction. You cannot just physically separate them.

Compounds are everywhere. Most of the matter that surrounds you is made up of compounds. Common compounds that you probably use every day are water (H + O), salt (Na + Cl), and sugar (C + H + O). Often a compound includes a metallic element combined with a non-metallic element. Baking soda, chalk, rubbing alcohol, bleach, and sand are all compounds.

Chemical Composition of Molecules

A molecule is the smallest piece of a substance that is still that particular substance. For example, salt is a compound made of sodium (Na) and chlorine (Cl). If you took salt apart, you would end up with one atom of Na and one atom of Cl, but it wouldn't be salt anymore. The smallest particle of salt that is possible is a molecule of salt, which is a combination of atoms: one atom of Na and one atom of Cl. There are millions of molecules of salt in one grain of salt.

Molecules are made of two or more atoms of one or more elements. Molecules of compounds like sugar, salt, and baking soda are made of two or three different elements. Some of the elements have more than one atom in the molecule. For example, we know there are four elements in one molecule of baking soda. The chemical formula looks like this: $NaHCO_3$. That tells us there is one sodium (Na) atom, one hydrogen (H) atom, one carbon (C) atom, and three oxygen (O) atoms. The small $_3$ next to the O shows the number of oxygen atoms. If there is no number, that means it is just one atom of that element. So the chemical formula $NaHCO_3$ shows that there are a total of six atoms in one molecule of baking soda. If you removed any one of these atoms, it wouldn't be baking soda any more.

Most elements have just one atom as the basic structure, but some elements consist of two or more atoms—one atom of the material doesn't create the element. If an element consists of more than one atom, it is called a molecule (a group of atoms). There are only seven elements that actually exist as molecules. For example, one molecule of hydrogen (H_2) contains two atoms of hydrogen that are chemically joined. One molecule of oxygen gas (O_2) consists of two atoms of oxygen that are chemically joined. Have you ever heard of H_2O? That's the chemical formula for water: two atoms of hydrogen and one atom of oxygen. Oxygen is in every water molecule, but not in its gas state—it takes two atoms of oxygen to make oxygen gas. There are five other elements (fluorine, nitrogen, chlorine, bromine, and iodine) that exist as ***diatomic*** molecules, which means there needs to be two atoms joined to make the element.

Oxidation

Chemical reactions combine two or more elements together into a compound. Chemical reactions are occurring all around you all the time; they are even occurring inside your body. One common chemical reaction is a process called ***oxidation***. Oxidation occurs whenever oxygen reacts with an element. The compound that is formed is called an ***oxide***.

When you leave a metal garden tool outside in the rain, or paint chips away from an old car allowing rain and air to get to the metal, after a time the metal rusts. Rust is a chemical reaction between oxygen and any metal containing iron. Remember how oxygen is in every water molecule? Oxygen in moist air or rain water reacts very slowly with iron to produce the compound iron oxide (Fe_2O_3). Rust is iron oxide, and it is a form of oxidation.

We use oxygen to breath, so is breathing a chemical reaction? Not in itself, but you may know that when you breathe, you are bringing oxygen (O_2) into your body, and ridding your body of carbon dioxide (CO_2). The foods we eat contain carbon, oxygen, and hydrogen. These foods get oxidized inside our bodies using the oxygen that we breathe in. The oxidation of the food produces energy that we use to live, work, and play. The oxidation also releases carbon and hydrogen in our bodies. The carbon and hydrogen combine with the oxygen and are released as carbon dioxide (CO_2) and water vapor (H_2O) when we breathe out.

Oxygen also combines with different elements in food and can cause the food to spoil. That is why canned foods (and some other foods) are packed in a vacuum—all the air is sucked out of the container before it is sealed to prevent oxidation. This is also why we add preservatives to food; some preservatives combat the effects of oxygen on food.

Naturally decomposing leaves and wood in the forest (and plants in your compost) are also undergoing a slow process of oxidation. The oxygen is taken in by bacteria, which use it to decompose the plant material. Eventually the wood breaks down into organic material, releasing nutrients that are used by other plants as food. The soil is full of bacteria, and they are busy all the time in the process of oxidation!

Fire is also the process of oxidation. Fuels such as wood, coal, gasoline, and natural gas contain carbon (C). When the fuel is heated enough to burn (its ***ignition temperature***), the carbon (C) in these materials chemically reacts with oxygen in the air (O_2). This chemical reaction produces more heat, and light and carbon dioxide (CO_2) are released. When things burn, they are oxidizing very rapidly.

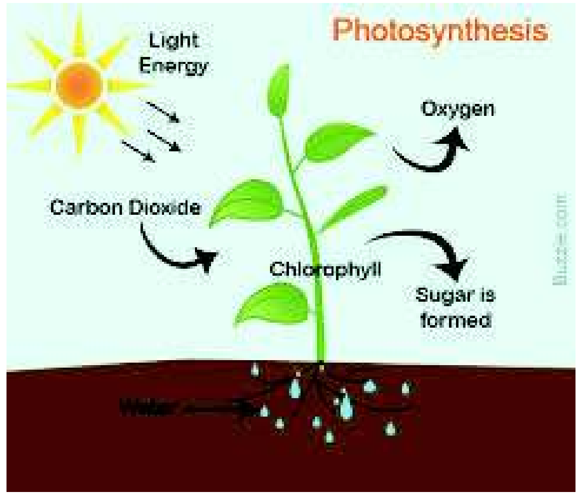
Combustion (another word for burning) cannot occur without oxygen. If there is no oxygen, a fire won't burn. Combustion is a chemical reaction or change. When paper burns, carbon dioxide and other gases, water vapor, soot, and other ***particulates*** (very fine pieces of matter, like dust and ash) are produced. None of these are paper, as the paper has been chemically changed into these other components. The flame that you see during combustion is actually the chemical process of this change. Fire itself is not a substance, but a chemical process. It changes matter from one thing into another.

When a substance or object is burned, the particulates and elements you are left with actually weigh more than the substance. This is because elements are reacting with oxygen during the chemical process of oxidation and forming new compounds. The compounds weigh more than the element alone.

Chemical Reactions in Photosynthesis

Almost all energy on Earth comes from the sun. Green plants are the only living things that can directly capture the sun's energy, however, so they are very important for all living things. Green plants convert the sun's energy into food. They do this through the chemical process of ***photosynthesis***. However, for photosynthesis to happen, a plant needs more than just sunlight; it also needs water and air. Let's look at how the chemical reaction of photosynthesis occurs.

The food that is produced through photosynthesis is a kind of sugar called a ***carbohydrate***. In order to make a carbohydrate, there are several necessary steps. First, plants get the water they need from the soil. The water enters the plant through its roots and travels up the stem to the leaves. At the same time, plant leaves absorb carbon dioxide from the air. The energy from the sunlight allows the leaves to do two important things: the chlorophyll in the leaves takes carbon dioxide (CO_2) molecules from the air and breaks them down into their elements: carbon (C) and oxygen (O_2). The leaves also break down the water into its two component elements, hydrogen (H_2) and oxygen (O). Through chemical reactions, leaves combine the carbon (from the CO_2) and the hydrogen (from the H_2O) with the oxygen and form a carbohydrate: $C_6H_{12}O_6$. This chemical reaction produces leftover oxygen molecules, and this extra oxygen is released as a byproduct. This is the oxygen that we use when we breathe!



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Here is the chemical equation for photosynthesis:

$$6CO_2 + 6H_2O + \text{light energy and chlorophyll} \rightarrow C_6H_{12}O_6 + 6O_2$$

This shows that 6 molecules of CO_2 (carbon dioxide) and six molecules of H_2O (water) combined with light energy from the sun and chlorophyll from the green plants results in the chemical compound of a carbohydrate ($C_6H_{12}O_6$) with six molecules of O_2 or oxygen left over. Every time a plant converts sunlight into energy, oxygen is released. You can see why by looking at the chemical equation.

Antoine Laurent Lavoisier (1743–1794)
French Chemist

Regarded as the father of modern Chemistry, LaVoisier was the first person to give accurate scientific explanations of the mysteries of fire. Lavoisier worked as a public servant and a chemist. His public service work involved improving gunpowder, promoting scientific agriculture, and improving social and economic conditions. LaVoisier's initial scientific achievements dealt with gain or loss of weight when substances are burned. He said the changes came about due to absorption or loss of air. He proposed the name *oxygen*. He believed that all acids were a result of air combining with other substances.