Objective 3

The student will demonstrate an understanding of the physical sciences.

From your studies in science, you should be able to show an understanding of the physical sciences.

Physical sciences? Could you tell me what the physical sciences are?

Good question. The physical sciences are the study of *matter* and *energy*.

Matter makes up everything you see all around you. A book, a pencil, even your own body—all these are made of matter. Matter is anything that takes up space and has mass.

Matter can move and change. Energy can cause changes in matter. You use energy when you run up stairs. A plant uses energy when it grows taller.

You said that matter has mass. What's mass?

Mass is the amount of matter in an object. An elephant has a larger mass than an ant because an elephant has more matter.

You can use a balance to measure an object's mass. In science, mass is measured in grams or kilograms.

Aren't mass and weight the same thing?

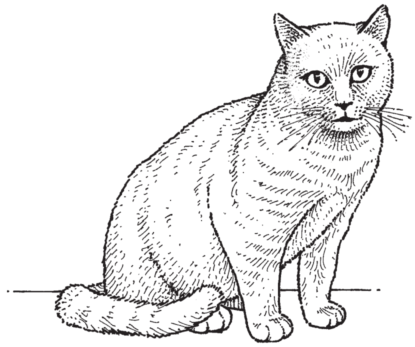
No. Mass and *weight* are related, but they aren't the same. Weight is a measure of the force of gravity on an object. When you step on a scale, you probably measure your weight in pounds. In science, weight is measured in units called *newtons*.

Suppose you travel to the moon. The force of gravity on the moon is much less than it is on Earth, so you would weigh less on the moon than you do on Earth.

Even so, your mass would not change. You would still have as much matter as you did on Earth. You might lose weight by traveling to the moon, but you can't lose mass that way!

Did you know?

In the metric system, weight is measured in units called newtons. The newton is named after Sir Isaac Newton, the scientist who discovered the law of gravity.



Suppose astronauts took this cat to the moon. The cat's mass would not change, but its weight would decrease from 35.3 newtons to 5.8 newtons.

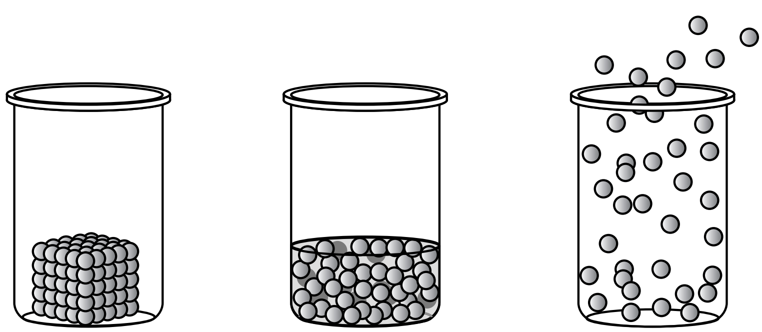
Property	On Earth	On the Moon
Cat's mass	3.6 kilograms	3.6 kilograms
Cat's weight	35.3 newtons	5.8 newtons

Can matter be in different forms?

Yes. Matter has different forms called states. The three states of matter are *solid, liquid,* and *gas*.

Have you ever put an ice cube in hot sunlight? You probably observed that the ice melted to water fairly quickly. Ice is water in its solid state. Water changes state when it absorbs or loses energy. When ice absorbs energy, its state changes from a solid to a liquid. If more energy is added to the liquid water, it becomes a gas called steam. If energy is taken away from the steam, liquid water forms. If more energy is taken away, the liquid water becomes ice.

Now think about the last time you saw a pot of water boiling on the stove. Did you notice steam rising into the air? Steam, also known as water vapor, is water in its gas state.



These drawings model the particles that make up a solid, a liquid, and a gas.

The particles of a solid are packed tightly together. A solid does not change shape when you put it into a container. For example, an ice cube keeps the same shape whether you put it in a glass or in a pitcher.

The particles of a liquid can flow past one another. Liquids take on the shape of their containers. When you pour water into a glass, the water takes on the shape of the glass. When you pour water into a pitcher, the water takes on the shape of the pitcher.

The particles of a gas can move about freely. Gases take on both the shape and the volume of their containers. When you boil water in a pot, steam rises out of the pot and spreads out into the room.

So mass, weight, and state are all properties of matter. Does matter have any other properties?

Remember!

Scientists describe matter by describing its properties. Mass and weight are two properties of matter.

Yes! There are many properties that scientists use to classify matter. Color, size, shape, smell, taste—all these are properties that can describe matter.

Here are a few more properties of matter that you need to know:

- **Melting point:** The melting point of a substance is the temperature at which the substance changes from a solid to a liquid. Ice changes to a liquid at its melting point of 0°C.
- **Boiling point:** The boiling point of a substance is the temperature at which the substance changes from a liquid to a gas. Water changes to steam at its boiling point of 100°C.
- **Magnetism:** Magnetic substances are attracted to strong magnets. Iron nails are magnetic, but wooden toothpicks are not.
- **Ability to conduct electricity:** Some substances can *conduct*, or carry, electricity better than others. A metal wire is a good conductor of electricity, but the plastic covering around the wire is not. Matter that does not conduct electricity well is called an *insulator.*

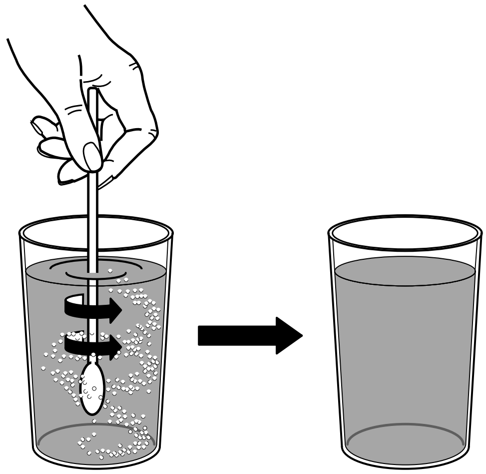
What happens when different kinds of matter are mixed?

When two or more substances are mixed together but can be physically separated, the result is called a *mixture*. Sometimes the substances mix together so well that it looks as if some of the substances have disappeared. In fact, they haven't disappeared at all! Have you ever stirred sugar into iced tea? Suppose you put a spoonful of sugar into a glass of tea and stir. What happens to the sugar? After a while you can no longer see it. But take one sip of the tea, and you'll know it's sweet. The sugar is still there. It has mixed with the water in the tea to form a *solution*.

A solution is a mixture in which one substance dissolves in another. Because sugar dissolves in tea, the mixture of tea and sugar is a solution.

Let's look at this a little closer. When you stir the tea, the grains of sugar dissolve, or separate, into particles of sugar that are too small to be seen. These sugar particles may be tiny, but they're still sugar. They spread out evenly in the water particles of the tea.

Mixture of Tea and Sugar

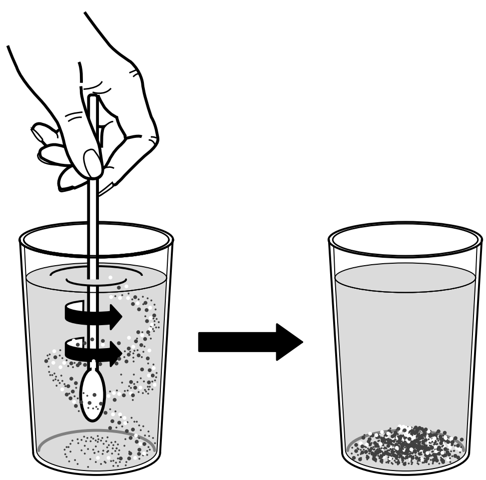


Sugar dissolves in tea to form a solution.

Do all mixtures form solutions?

No. Not all mixtures are solutions. What would happen if you were to mix sand and water? Would the sand dissolve? No, it wouldn't. The grains of sand would remain large enough to see. After a while the sand would settle to the bottom of the water.

Mixture of Sand and Water



Sand does not dissolve in water.

Did you know?

The bubbles that appear when you open a soda are carbon dioxide escaping from solution.

O.K., so you explained matter. What about energy? I'm still not quite sure what energy is. Can you tell me more?

Energy is what makes things happen. You probably already know this from experience. Having a lot of energy makes it easier to do your homework. Homework isn't so easy when you're tired.

You get energy from the food you eat. You use that energy every second of the day, even when you are sleeping. Your body needs energy just to stay alive.

You already have some idea of what energy is. But to scientists energy is the ability to move or change matter.

Anything that is moving has energy. Energy can also be stored. Have you ever stretched a spring, held it, and then let it go? As you stretched the spring, you gave it energy. That energy was stored until you let go. Then it turned into energy of motion.

Is energy really that important?

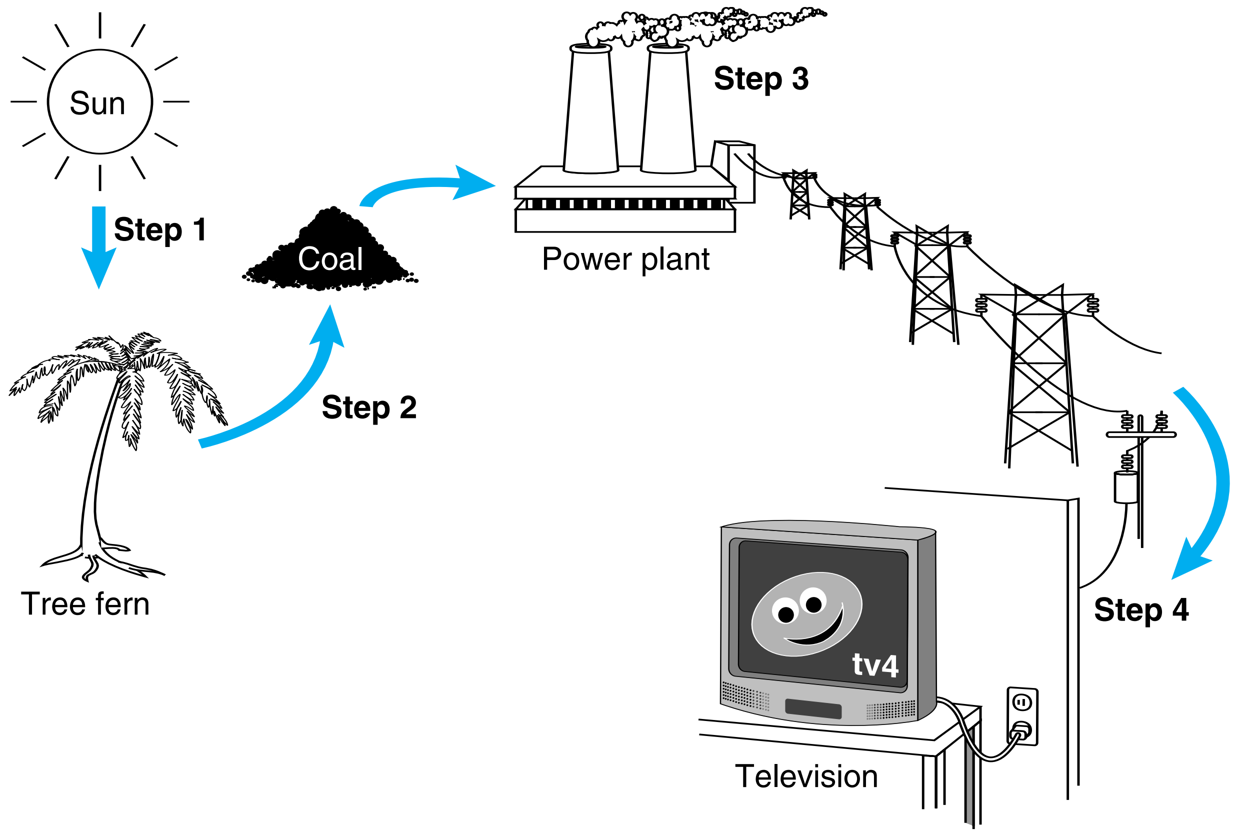
Sure! Without energy from the sun, Earth would be a lifeless planet. There would be no animals, no plants, and no people. What a boring place!

Energy that comes from the sun is called *solar energy*. The sun is the source of almost all our energy. This statement might not seem true. You're probably wondering, "How does the energy used to run a television come from the sun?" Here's one way it can happen:

- **Step 1:** Plants use light energy from the sun to make food and grow.
- **Step 2:** Dead plant material gets buried. Over millions of years, it turns into fossil fuels. Energy from the plants is stored in the fossil fuels.
- **Step 3:** When fossil fuels are burned, they release stored energy as heat energy. Power plants turn that heat energy into electrical energy.
- **Step 4:** Electrical energy moves from power plants to homes. When someone turns on a television, electrical energy is changed to light and sound energy.

Remember!

Fossil fuels include oil, coal, and natural gas.



How does electricity move through wires?

Electricity moves through wires only when the wires are part of an *electric circuit*. A circuit begins and ends at a source of electricity. A battery is a source of electricity in some electric circuits.

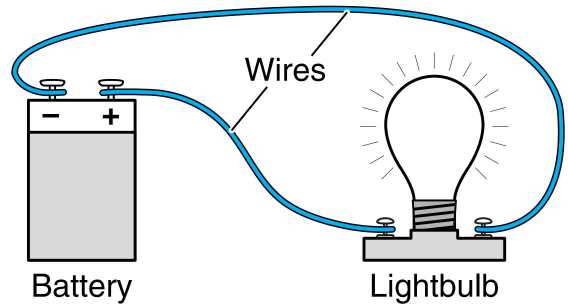
A battery has a positive end (+) and a negative end (–). If one end of a wire is connected to the negative end of a battery and the other end of the wire is connected to the battery's positive end, electricity will move through the wire. An electric circuit is the path that electricity takes from one end of the battery to the other.

Objective 3

Remember!

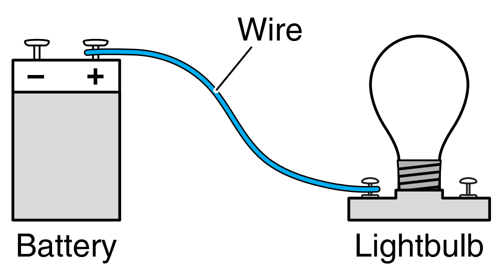
Electric current is the movement of electricity through an electric circuit.

Complete Circuit



This drawing shows a complete circuit. An electric current moves from one end of the battery to the lightbulb and then back to the other end of the battery. Because the circuit is complete, electricity moves through the wires, and the lightbulb lights up.

Incomplete Circuit



This drawing shows an incomplete circuit. Only one pole of the battery is connected to the lightbulb. Electricity does not move through the wire, and the lightbulb does not light up.

When you plug a television into a wall, you complete an electric circuit. The wall outlet is the source of electricity for this circuit. Electric current travels from the outlet, through the wires in the television's cord, to the television, and back again.

O.K., now I understand a bit about electrical energy. What about sound energy?

Every sound begins as motion. When you speak, your vocal cords move. When you play a guitar, the strings move. When you hit a drum, the drumhead moves.

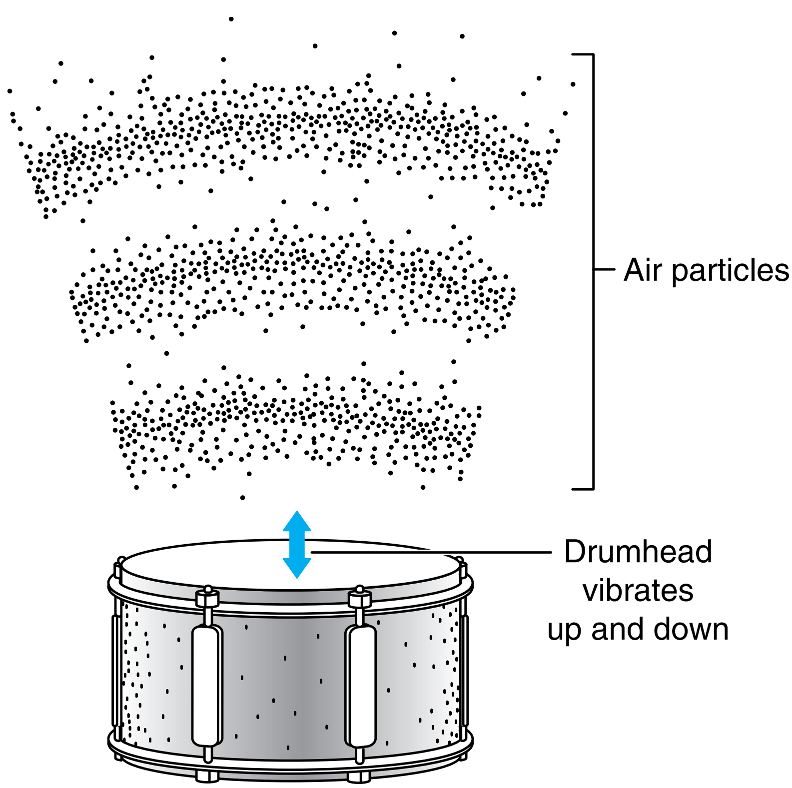
Each of these movements is a back-and-forth motion. This type of motion is called a *vibration*. Every sound comes from a vibrating object.

But how does a vibration turn into sound?

Let's look at a vibrating drumhead. When you strike a drum, the drumhead moves up and down. Each time it moves up, it pushes nearby air particles closer together.

As the drumhead continues to move up and down, it makes a pattern in the air that spreads out in all directions. In some places the air particles are closer together. In other places they are farther apart. This is a sound wave!

Sound Wave



A vibrating drumhead produces a sound wave in the air.

What? Are you saying that sounds are just air?

Well, in a way. When these patterns in the air strike your ear, your brain recognizes them as sound. Different patterns make different sounds. Some are loud, and others are soft. Some are pleasing, and others are just annoying. But they are all caused by vibrations.

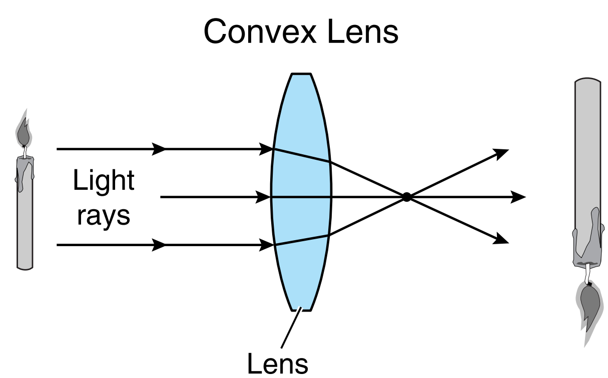
Can you tell me more about light energy?

Of course! Light energy travels in waves much like sound energy does. Light waves can travel through certain types of matter, such as air, glass, and water. They can even travel through space.

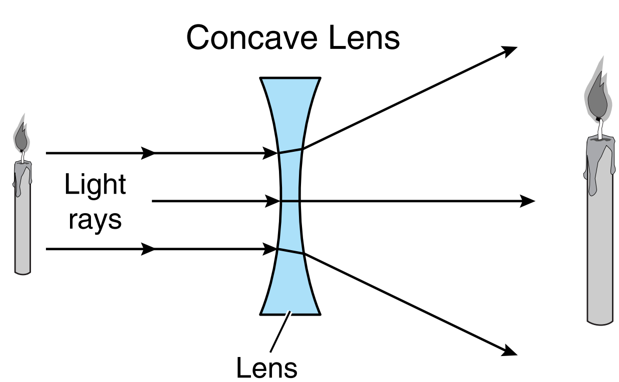
When light passes from one type of matter to another at an angle, the light bends. This bending of light is called *refraction*.

So light waves can bend?

Yes, you can see because your eyes are able to bend light rays with a lens. A lens is a curved piece of glass or other material that is used to refract light. The front of your eye is a lens. It focuses light rays on the back of the eye. The back of the eye is called the retina.



A lens that is thicker in the middle than at the edges bends light rays toward one another. This is the type of lens found in your eye and in a telescope.

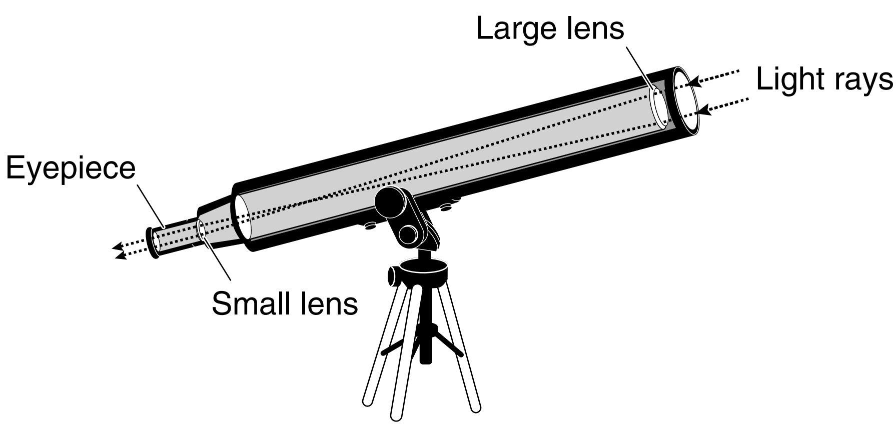


A lens that is thicker at the edges than in the middle bends light rays away from one another.

How about telescopes? Do they use lenses?

Yes! A refracting telescope uses lenses to focus light from faraway objects. There is a second but smaller lens in the eyepiece of the telescope. The eyepiece lens makes the image appear larger so that you can see it clearly.

Refracting Telescope



Remember!

To focus light rays means to bring them together at one point.

We've talked about matter and different types of energy. Is there anything else I need to know about the physical sciences?

You've seen what matter is. You've also seen how energy can move or change matter. So what's left? Forces! Forces are what set matter in motion. For example, a child standing on a skateboard at the top of a hill has stored energy. All that's needed to set the skateboard in motion is a push. Well, that push is a force!

Remember!

Any push or pull is a force.

Here are some examples of how forces can cause motion:

- Pulling a cart
- Kicking a soccer ball
- Pushing a book across a desk

Forces can stop motion, too. They can also change the direction of a moving object. For instance:

- When you catch a baseball, you are using force to stop the ball's motion.
- When you hit a volleyball with your hand, you are using force to change the ball's direction.

Why should I bother learning about forces?

Well, if you understand how forces work, you can use them to make work easier. Suppose you wanted to lift a large rock. You could use a lever like the one shown below to make this work easier.

When you push down on one end of the lever, the other end goes up. The fixed point that the lever rests on is called the fulcrum. You've probably seen a lever at school. What was it? A balance, of course!

Lever