Scientific Connections through Inquiry

Edition 1

LEVEL 0

Energy Moving

How Does Energy Move?

Review the pattern concerning energy that has emerged thus far:

- Heat, light, electricity, and movement have the common attribute that they can cause things to go, work, move, or change. Therefore, they are grouped together as forms of energy.
- One form of energy may be changed into another form of energy either naturally or through some human-made device.
- Energy may be stored and released from storage by various means.
- Energy is not changed into gas, liquid, or solid, nor is gas, liquid, or solid changed into energy (again, mass-energy conversions are beyond the scope of this level).

The next question to pose is: How does energy move, or how may it be moved, from one place to another? Have your student consider one form of energy at a time. With hints and Q&A discussion as necessary, help them utilize their own observations and experience to reason out and derive the following about how different forms of energy move.

Electrical Energy

Electrical energy is conducted via wires and sometimes by other materials. Why else must lamps, etc., be plugged in? Occasionally, electricity may jump through space, as observed in a spark from static electricity. The extreme case of this happening is lightning.

ACTIVITY NOTE

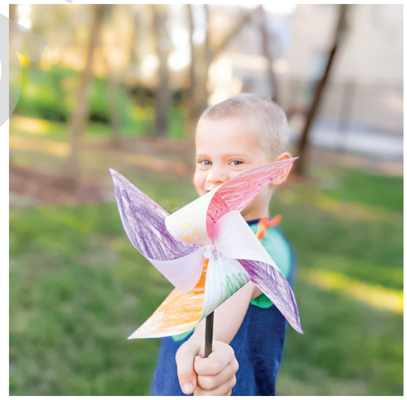
If your student has Snap Circuits or other similar sets you can point out to them that in using these they are building paths for electrical energy to move through.

Watch https://SCI.bz/Sparks0 to see electrical energy jumping between a Van de Graaff generator and a metal wand. Ask your student if this reminds them of anything. (Think Time) This is, essentially, small-scale lightning.

To see electrical energy moving yourself, all you need is a balloon and a metal spoon. Blow up the balloon and tie it off. In a very dark room, rub the balloon on your hair for 30 seconds to a minute. Hold the balloon in front of you, and slowly move the metal spoon closer to the balloon. You will see the flash of a spark jumping!

Place a ball on the ground in front of your student. Challenge them to give it movement energy. They will likely throw or kick the ball. Whatever they do, ask them where the ball's movement energy came from. (Think Time) Movement energy was transferred to the ball from their leg/arm/etc.

When one thing hits another, e.g., a bat hits a ball, the movement energy of the one may be transferred into the other. Depending on the situation, movement energy may do useful work, e.g., moving water turning a waterwheel, or it may cause the wreckage of a crash.



Movement energy is inherent in the movement of air, water, and other objects or materials. Make a pinwheel to see the movement energy of the air moved into another object using Student Book page "Pinwheel." After your pinwheel is built, take it outside and hold it up to wind. When it spins, ask your student: where did the pinwheel's movement energy come from? It came from the movement energy of the air pushing on the pinwheel. If you have no breeze, you can hold the pinwheel up to a fan or blow it with your breath. In these cases, the movement energy of the pinwheel also comes from the movement energy of the air.

Movement energy may also travel as waves. Fill up a bowl or sink with water and allow the water to come to stillness. Ask your student to drop a small pebble into the bowl and observe what happens. The pebble has movement energy as it falls. What happens to some of that movement energy when it hits the water? (Think Time). The movement energy of the stone is transferred to the water and travels outwards in waves.

SCIENCE NOTE

Note that the wave is moving, even though the water is staying in approximately the same place; in a wave, energy travels, but matter does not.

Distinguishing Feature

Identifying the Difference

Return to Student Book page "Plant Kingdom or Animal Kingdom." Point to one card in the animal kingdom column and ask: What do you observe about this living thing that tells you it is an animal rather than a plant? Your student likely did this by gut feeling before; now, you are asking them to take that intuition and explain it. Ask for one or more particular features or attributes. Do the same for additional cards in the plant kingdom and animal kingdom columns. As you proceed with such Q&A, turn to Student Book Page "Plant & Animal Kingdom Attributes" and list the attributes your student gives for animals and those for plants. Of course, they may repeat attributes, but try to draw out: Anything else?

When the Plant & Animal Kingdom Attributes page has reached its limit—your student is unable to add further defining features—change the course of the discussion. Ask your student to reflect on the animal kingdom list and see if there are one or more features on the list that will define each and every member of the animal kingdom, i.e., will define an organism as an animal as opposed to a plant.

For example, legs may be on the list. Ask: Does each and every animal have legs? Let your student review the total collection of animals and observe that things such as slugs and snakes don't have legs. Eyes might be another candidate. Observations will lead to the same conclusion; some do have eyes, and others don't.

This may go on until it comes down to some sort of mechanism for feeding, like a mouth. A feeding mechanism may not have made it onto the original list; if that's the case, suggest it be added now. Take time to allow your student to re-examine their various organisms and confirm that everything that they have assigned to the animal kingdom has some sort of way of taking food into itself. If needed, you can research some animals they are less familiar with to learn about their mouth or way of taking food in.

Follow the same procedure in addressing the plant kingdom. As before, guide your student in whittling down the list of plant features to a single feature that applies to all members they have assigned to the plant kingdom and to none of the members assigned to the animal kingdom. With examination and reflection, they should come down to leaves or leaf-like structures—needles are a leaf-like structure; broad green stems of cacti are another. In contrast to animals, members of the plant kingdom don't have a mouth or specialized parts for eating.

Your student may be familiar with some "oddballs," e.g., an insectivorous plant (Venus flytrap) or a parasitic plant (dodder). Point out that, as they have experienced before, not everything fits neatly into the classification system we have devised. Suggest that they set these aside for the time being and keep them in mind for further investigation.

Energy

In summary, a key defining feature for every member of the animal kingdom is a means of ingesting food. A defining feature for every member of the plant kingdom is broad, usually green surface areas.

Let your student ponder this distinction while asking: Why should this be the case? What does it mean? What does it tell us about members of the animal kingdom versus those of the plant kingdom?

Without hints, your student is unlikely to come up with an answer. The hint is to have them recall the core idea from the Energy I unit. Everything needs a source of energy to go, work, move, or change; plants and animals are no exception. Can your student relate the mouth and feeding of animals and the leaves or leaf-like structures of plants to two fundamentally different methods of getting energy? (Think Time)

If necessary, engage your student in further Q&A discussion that guides them to the conclusion that plants (members of the plant kingdom) obtain the energy they need directly from light. Leaves or leaf-like structures provide the surface area required for the absorption of sufficient light energy. Animals (members of the animal kingdom), on the other hand, obtain their energy from the food they eat. Hence, they have a mechanism for ingesting food.

Encourage your student to review the diversity cards and look at further examples of plants and animals. Allow them to ponder how, despite the fantastic diversity within the plant and animal kingdoms, the basic distinction comes down to where/how the organism obtains its source of energy.

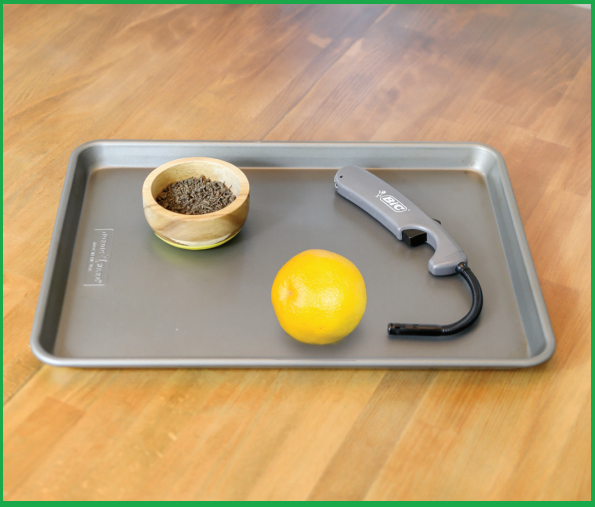
Plant & Animal Wrap-Up

At the end of this unit, students should be able to:

- Correctly assign plants and animals to the plant kingdom or the animal kingdom. Tell what feature(s) is/are observed that lead to such placement.
- Describe, with the aid of photographs, the broad diversity of plants and animals.
- Describe how the basic distinction between a member of the plant kingdom and a member of the animal kingdom lies in how the organism obtains energy. Describe the observable features that enable this distinction.
- Use observation and analysis to discern that everything an animal (including human) eats is derived directly or indirectly from plants.
- Describe or diagram how energy flows from the sun, to plants, to animals, and finally exits as heat.
- Give evidence that all life on Earth depends on sunlight.
- Compare and contrast the food requirements of animals with what is marketed as “plant food.”
- Explain how the energy content of animal food differs from that of “plant food.” Considering the 3 categories: living/biological, natural Earth, human-made materials; which category would animal food be placed in? Which category would “plant food” be placed in?
- Explain how all living things we know of depend on water.

Topics for Further Investigation:

- Biological classification
- Diversity of plants and animals
- Functions of various plant and animal traits
- Photosynthesis
- Plant respiration



Air is Matter

Nothing or Something?

Pose the question: Is air (or gas) "real stuff" like a solid or liquid, or is it really nothing at all? Allow your student to express their opinion, but then ask them: How can they prove it? Can they conduct tests that will provide evidence showing that air is real stuff versus nothing at all? Allow them to suggest whatever they do, but in the absence of workable solutions, guide their recall and reasoning back to the concept of the common attributes of matter: it occupies space and has weight (mass). Can we show that air occupies space and has weight (mass)? If so, it must be a form of matter, e.g., "real stuff."

SCIENCE NOTE

Mass is a property of matter, and is the same everywhere; weight is the force of gravity acting on that mass, and depends on the size of the object toward which the mass is being pulled. However, at this level we do not draw this distinction. It will be explored in later levels.

Air Occupies Space

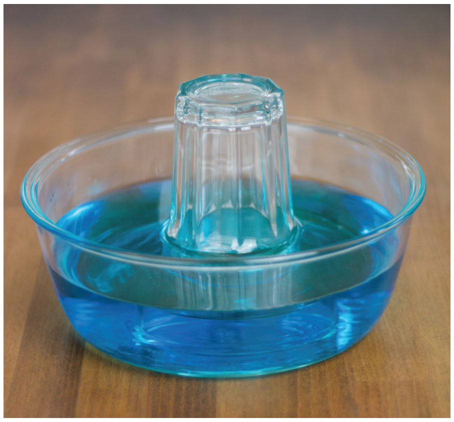
Challenge your student to suggest ways in which they can show that air occupies space. Allow time for them to ponder, and if needed, introduce these simple demonstrations.

First, blow up a balloon, blow some bubbles using bubble mixture, or blow bubbles in a glass of water using a straw. Ask: How would the surface of the balloon or bubble mixture be pushed out, or how would bubbles form in the water, if air was not taking up space and pushing the surrounding material away?

ACTIVITY NOTE

Make sure the edge of the glass touches the water all the way around at the same time; if the glass is tipped, this activity will not work because the air will escape, allowing the water to flow in.

Another simple demonstration is to fill a bowl with water. Invert a clear glass over the bowl and place it in the water, open side down. You will see that the water does not come up and fill the glass. Why not? Because air is taking up that space in the glass.



So far as possible, allow your student to think of and demonstrate other ways that show that air takes up space. In each case, have them explain how their demonstration shows that air takes up space.

Air Has Mass

Moving on to air's property of weight (mass): air certainly appears to us to have no weight; hence, children will generally answer "no" to the question, "Does air have weight?" Again, stress that inves-

ACTIVITY NOTE

If you have a sensitive balance you can use it instead of constructing a balance with a hanging ruler.

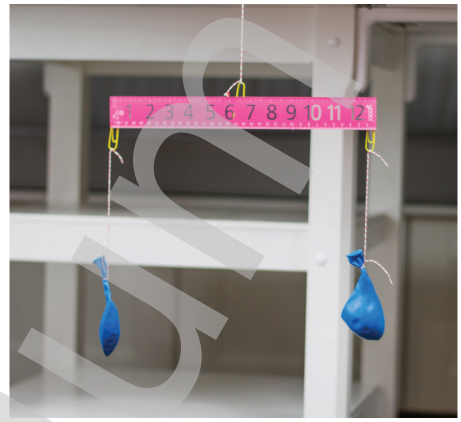
SCIENCE NOTE

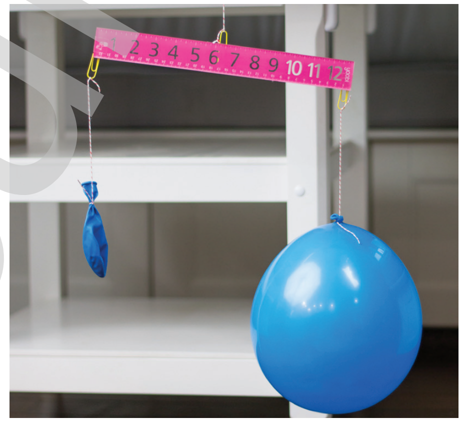
Older students may reason that air is air. Therefore, the air inside the balloon should not weigh more than air outside the balloon. If this question arises, explain that the air inside is somewhat compressed, as witnessed in the pressure we had to exert in blowing it up. Therefore, there actually is more air inside the balloon than would be in an equal space outside. We are seeing the weight of this extra air that we forced into the balloon.

ACTIVITY NOTE

If desired, your student can repeat the balloon balance activity using a reverse approach, as shown in this video.

tigation is the key. Conduct the following experiment:





Take a 12-inch ruler, three paperclips, and thin string or floss and proceed as follows. Tape a paper clip to the ruler at the 6-inch point such that one end of the paper clip protrudes just beyond the edge of the ruler. Similarly, tape a paper clip at the zero and another at the 12-inch mark so that their ends just protrude to the opposite side of the ruler. Use the same amount of tape for fastening each of these paper clips.

Attach a string to the center paperclip and use it to dangle the ruler's straight edge off the edge of a table where it will hang freely. This is your balance. Take two equal lengths of thin string and attach a new, deflated balloon lightly to each of the end paperclips. Ensure the ruler is hanging completely level at this point. Since the two balloons are identical, the balance should be level. If needed, add small pieces of tape to one end or the other to make it hang level.

Now gently detach and blow up one of the balloons to its full capacity and tie off the opening without using additional string. Gently reattach the inflated balloon to its paperclip on the balance using the previous string. You can observe that the inflated balloon now pulls its end of the balance down somewhat, indicating that it is heavier. Guide your student to reason how the balloons weighed the same when they were empty, and everything else is the same. Therefore, the heavier weight of the inflated balloon must be the weight of the air.

To observe someone doing this demonstration using a reverse approach, watch https://SCI.bz/Air0.

Guide your student in reasoning: the attributes of matter are occupying space and having weight. We have now demonstrated that air takes up space and has weight. Therefore, air must be matter. It is the state of matter we call gas.

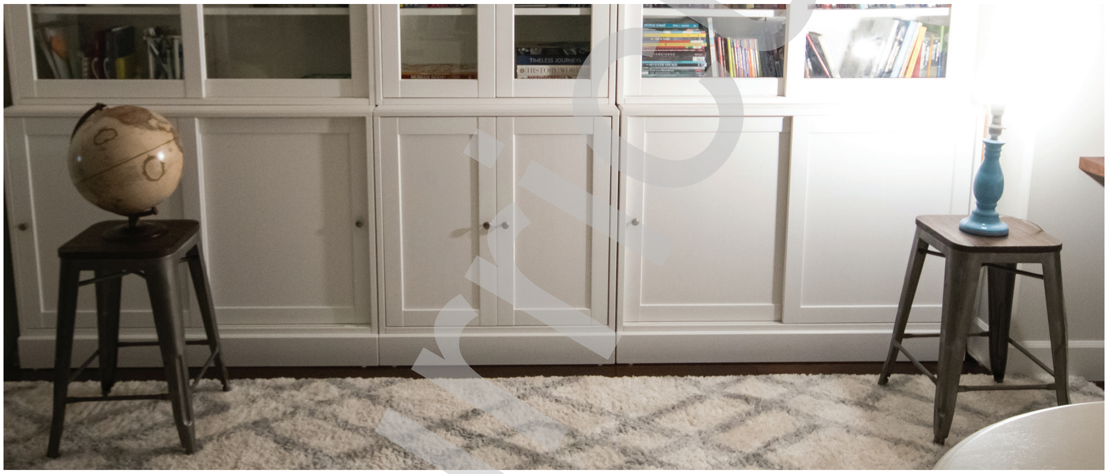
SCIENCE NOTE

Actually, air is a mixture of gases, as will be explored further in Level 1.

The Cause of Day & Night

The Turning Earth

Guide your student to focus on the fact that every day includes a time when the sun comes up, starting the day, and goes down, bringing on the night. Pose the question: What causes this day-night cycle?



Set up a lamp with a naked bulb on a stand near the center of your room and a globe on another small table, ten or so feet away. Have the room set up so it can be easily darkened. Ensure that when the room is darkened and the lamp is turned on, it is conspicuous that one side of the globe is well illuminated, and the side away from the lamp is in shadow.

Turn on the lamp, darken the room, and allow your student to stand near the globe so they can see it clearly but not shade it. Explain that the light represents the sun, and the globe represents the Earth millions of miles away in space. Put a small sticky note or piece of colored tape on the globe somewhere near the equator. The sticky note represents a person standing on the Earth. Your child can name them; we will call them "Joe."

Invite your student to spin the globe counterclockwise as viewed from above the North Pole. Note how it always spins around the same AXIS, or imaginary straight line around which an object rotates. Inform your student that just as this model of the Earth can spin, the Earth actually does rotate, always in the same direction, about an axis that runs through the poles.

Slowly turn the globe counterclockwise—the direction is significant because this is the direction the Earth does turn, and it becomes critical in determining east and west from observing sunrises and sunsets in Level 1.

As you slowly turn the globe, have your student observe and describe how Joe would perceive the sun. If necessary, have your student put their eye right next to the globe so that they get a better perspective of how Joe would see the sun in relation to the horizon of the Earth. As your student proceeds with this activity, their observations and discussion should lead them to something approximating the following:

- As the Earth's turning brings Joe from the darker side toward the lighted side, he will first see the sun, i.e., sunrise, on the horizon. (It is the eastern horizon, but save that for another lesson.)
- As the Earth turns further, Joe will perceive the sun as getting higher and higher in the sky until he will be viewing it more or less overhead.
- As the Earth's turning takes Joe on around, he will see the sun as getting progressively lower in the sky, but toward the opposite horizon from which it rose.
- As the Earth's turning takes Joe into the darker side, he will see the sun as going down to and then below the horizon opposite from which it rose, i.e., sunset.
- Nighttime is when the sun is not visible to Joe.

Ask your student how this corresponds to their actual experience. A point of hesitation and confusion may lie in the fact that they may have had fun playing with a globe, spinning it on its axis, so they may have a false notion of how fast the Earth turns. Emphasize that the Earth actually rotates very slowly; it takes a full day and night to make one complete turn.

With this emphasis, repeat the activity. Have your student describe how they would perceive the sun's position and apparent movement as the Earth turns. Have them relate this to their daily activities and actual experience of the sun's location at those times. For example, as their sticky note moves into the lighted side, your student might say things such as: I see the sun rising; I am waking up, getting dressed, having breakfast, and so on, over the course of a day. Nighttime is when the sun is out of view from their location on the Earth.

To review this concept, enjoy this song: https://SCI.bz/Day0.