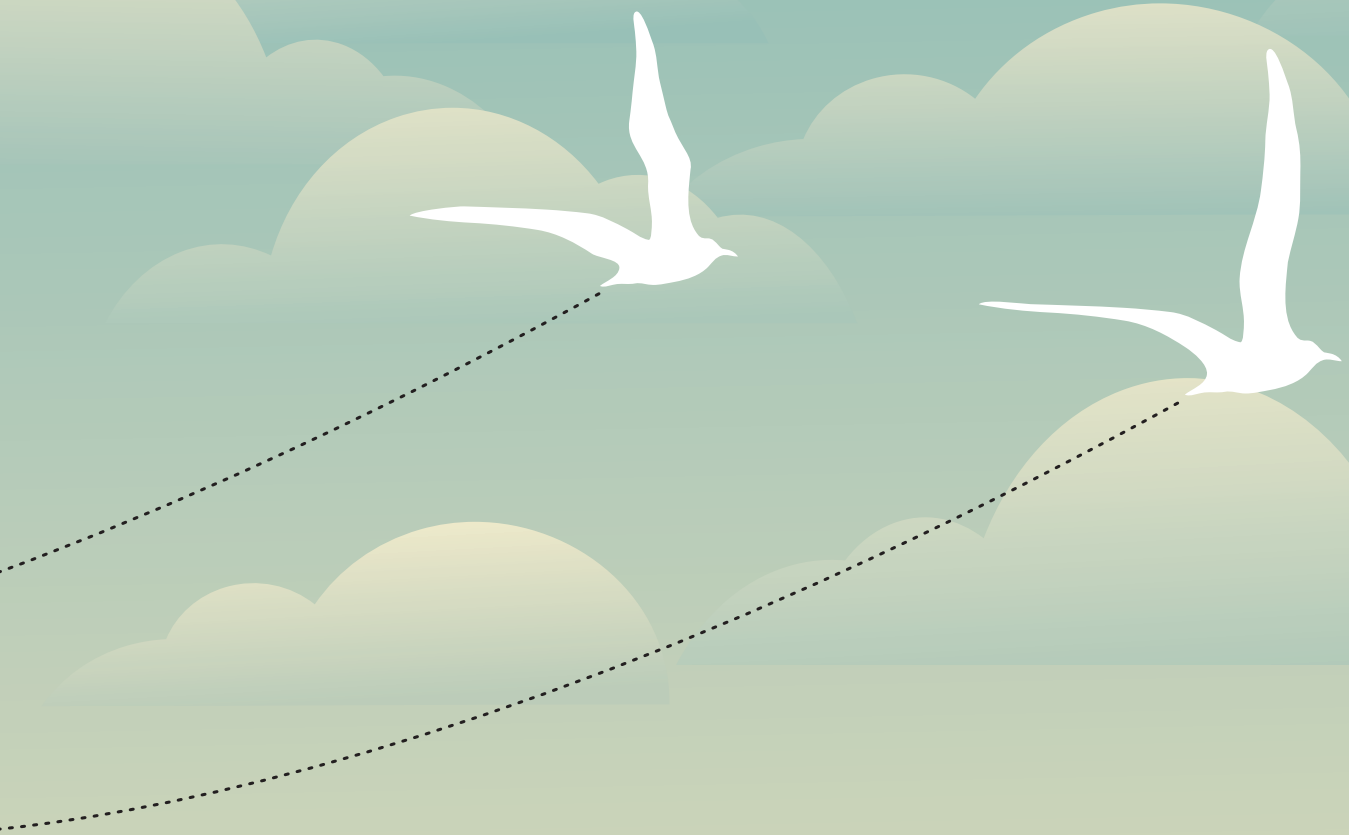
PURDUE EXTENSION

National PEER REVIEWED

WEATHER AND CLIMATE SCIENCE

GRADES 6-8



4-H-1024-W LEVEL 2

WEATHER AND CLIMATE SCIENCE

Science • Level 2 • Grades 6-8

NOTE TO 4-H MEMBER

As you continue your study of weather and climate, you will be increasingly responsible for collecting your own data and gaining information from sources outside this manual. Discoveries from researching weather and earth's climates are often in the news. You will want to keep up to date with what scientists have recently reported.

The Level 1 manual introduced you to basic weather terminology and concepts. This Level 2 4-H Weather and Climate Science manual will introduce you to much more complex weather topics, such as air pressure, clouds, winds, humidity, and fronts. To better understand climate, you may choose to learn about earth's rotation and its connection to the high and low pressure systems that the weather reporter points out on the weather map. You may also choose to calculate your family's carbon footprint or study how what we do every day may create a "greenhouse effect" on earth's atmosphere that changes its temperature. The Level 3 4-H manual will delve even deeper into weather and climate science concepts to help you fully understand weather and climate that you will use over your lifetime.

The key to learning in this, or any 4-H project, is to enjoy your studies and to learn at your own pace. We hope this project is just the start of a lifetime enjoyment of understanding the climate you live in and watching the weather!

Safety First!

Ask a parent or other adult to help when you see a safety first icon.

Knowing the Difference

Weather The current weather conditions, including temperature, wind, cloudiness, precipitation, and relative humidity

Climate The average weather over time

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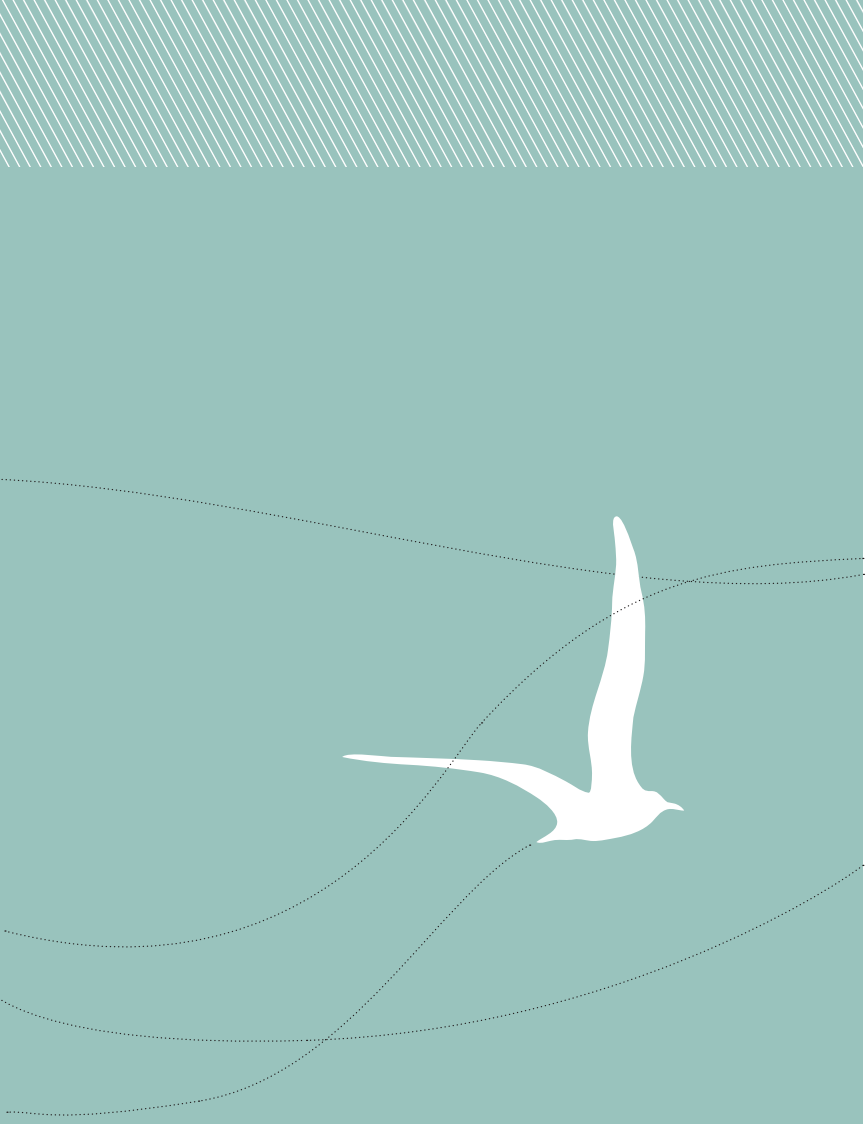

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NGSS indicates the Next Generation Science Standards for each activity. See www.nextgenscience.org/next-generation-science-standards for more information.

See Purdue Extension's Education Store, www.edustore.purdue.edu, for additional resources on many of the topics covered in the 4-H manuals.

AIR PRESSURE

How does a change in air pressure affect liquid in a straw?

Air has weight because it is composed of tiny particles (molecules) in a gaseous state. The weight of those molecules creates air pressure. Air is pressing against you, even though you cannot see or feel it. This pressure does not press straight down, but all around you. The force pressing against you from every angle is, on average, 14.7 pounds, on every square inch of your body. This force is known as **air pressure**.

Most people understand that water is a **fluid** but don't realize that air is also a fluid. Air has the same fluid properties as water. Pressure in a fluid is caused by the weight of that fluid. The deeper you go into that fluid, the greater the pressure created by its weight. If you ever dived into a pool of water, you may have noticed an increase of pressure against your eardrums that is sometimes painful. This is caused by the increased weight of water above you. The force of this increased weight presses all around you, even on your ears.

Air pressure is greatest at the surface of the earth. Air pressure can indicate what kind of weather is coming. Changes in the **barometric pressure** indicate changes in the weather. When air pressure is rising, a *high pressure system* is on the way, possibly bringing cooler temperatures and clear skies. If a *low pressure system* is coming, look for relatively warmer temperatures and precipitation.

OBJECTIVE: Understand the nature of air pressure.

Weather Tote

- ☐ Clean glass jar (not plastic) with a metal screw-on lid (pint or similar size will work)
- ☐ Plastic straw, a clear skinny straw like some restaurants use
- ☐ Hot glue gun or Play-Doh
- ☐ Electric drill with a bit the same diameter as the straw

Follow these steps to construct a testing jar:

1 Drill a hole in the center of the metal lid that is the same diameter as the straw. Get help for this step, if you want, and make sure you drill the hole with the lid held on a block of thick wood so that you drill through the lid and into the wood.

2 Place the lid on the jar, and put the straw through the hole so that the bottom of the straw is about ½ inch from the bottom.

3 Seal the straw onto the lid, using a hot glue gun or Play-Doh. Seal it both inside and outside. Get help for this step, if you use the hot glue gun.

Test 1: Fill the jar to the brim with water and firmly place the lid on the bottle.

- Make sure no air bubbles are in the bottle. If bubbles appear, try again.
- Try to drink the water through the straw.
- Now try to blow air into the bottle.

Test 2: Take the lid off, and pour a little of the water out so about 1 inch of air is in the top of the bottle. Put the lid back on, and try again to drink the water. Drink as much water as you can without stopping. Notice what happens when you stop.

Now try to blow air into the bottle — do this part over a sink. Blow as much air as you can into the jar, and notice what happens after you stop.

SHARE WHAT HAPPENED:

Test 1:

- What happened as you tried to use the straw to drink the water?
- What happened when you tried to blow bubbles into the jar?
- Why do you think this happened?

Test 2:

- What happened as you tried to use the straw to drink the water?
- When you tried to drink the water, were you putting air into or taking air out of the straw?
- What happened to the water in the straw immediately after drinking some water?
- What happened when you tried to blow bubbles into the jar?
- When you tried to blow into the straw, were you putting air into or taking air out of the straw?
- What happened in the straw after you blew bubbles into the jar?

APPLY: When using a straw, differences in air pressure cause the water to move in the straw. In Test 1 of your experiment, no air pressure was in the jar, so there was no difference in air pressure to move the water in the straw in either direction. In Test 2 of your experiment, there was air in the jar, so you could create a difference in air pressure to push the water in the straw. Think about what happened in Test 2, and fill out the chart below.

Which direction does the water move? Circle one:

From low pressure to high pressure

From high pressure to low pressure

Action	Pressure in straw: high or low	Pressure in jar: high or low	Movement of water: up the straw or down the straw
Drinking some water from the straw			
Immediately after drinking some of the water			
Blowing air through the straw into the jar			
Immediately after blowing air into the jar			

GENERALIZE TO YOUR LIFE: Since air pressure is caused by the weight of air, where will air pressure be the greatest, at the base of a mountain or at the top of a mountain?

How can watching a change in air pressure help in predicting the weather?

In the atmosphere, does air move from high pressure toward low pressure or from low pressure toward high pressure?

Fly Higher

Use your testing jar as a *barometer.* Put about 2 inches of colored water in the jar. If the temperature around the jar stays the same, the jar will act as a barometer and the liquid in the straw will move as air pressure changes: pushing the liquid down with higher pressure and allowing the liquid to rise with lower pressure. You may need to blow a few bubbles of air into the jar to raise the level of the liquid within the straw. Keep a record of how this barometer changes with changes in air pressure by checking the pressure on a real barometer or a daily weather source.

Did You Know? The value of 14.7 pounds of air pressure mentioned in the introduction is the **average** weight of 1 square inch of air measured from the earth's surface to the outer edge of our atmosphere.

Notes

CARBON FOOTPRINTS

What is your family's carbon footprint? What can you do to reduce it?

intro

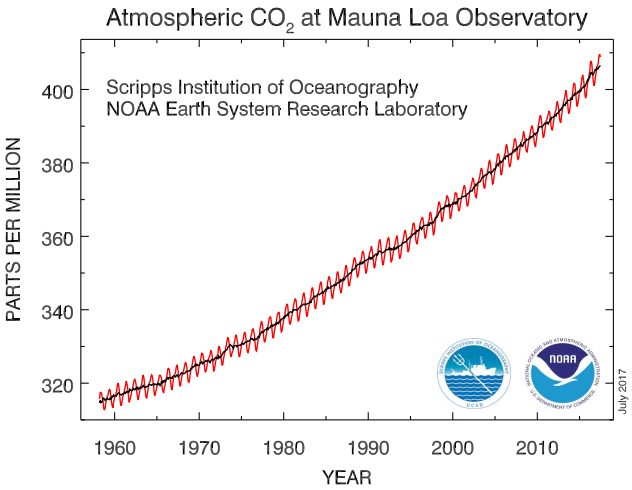
Carbon dioxide (CO_2) is a greenhouse gas that is added to the atmosphere through many of our day-to-day activities such as driving cars and running gas-powered lawn mowers, and from power plants. The energy and materials that we use each day come from many sources. Some of these sources are **fossil fuels**. Fossil fuels contain carbon that is not part of the natural carbon cycle. The carbon has been stored in fossil fuels for a long time — in most cases, millions of years.

When we use fossil fuels, such as oil or natural gas, we are adding carbon dioxide to earth's atmosphere. Many products, including plastics, are made from or using fossil fuels, which also adds CO_2 to the atmosphere. Scientists have measured and recorded the atmosphere's CO_2 levels since 1958, and the levels continue to increase (see Figure 1). Carbon dioxide is a **greenhouse gas,** and the extra CO_2 in the air causes it to warm.

Whenever your family uses any of these energy sources or products, you have contributed to the additional carbon dioxide in the atmosphere. We call this your carbon footprint. The U.S. Environmental Protection Agency (EPA) has created a website to help you determine your family's carbon footprint.

OBJECTIVE: Determine your family's carbon footprint, and consider ways to reduce it.

CARBON DIOXIDE LEVELS [FIGURE 1]



Source: National Oceanic and Atmospheric Administration | Department of Commerce

Weather Tote

- ☐ Access to the EPA website: www.epa.gov/climatechange/ghgemissions/ind-calculator.html
- ☐ Household information (good estimates, not exact totals):

  Average monthly energy bills

  For each vehicle your family owns, an estimated average miles driven per week and miles per gallon of each vehicle. To find each car's gas mileage, go to www.fueleconomy.gov/feg/findacar.shtml

EPA CARBON FOOTPRINT WEBSITE [FIGURE 2]

1 Go to the EPA Carbon Footprint website, shown in Figure 2. This page starts with a list of instructions. These instructions are under Instructions>Current Emissions>Reduce Emissions> Estimated Savings. Follow the instructions. To advance to the next section, click Next Section in the lower right corner. Follow through the calculator, using the instructions given in each section.

2 After entering your information, press your computer's tab key to get calculated results for each entry.

3 Enter the data in Table 1, Pounds of Carbon Dioxide Equivalent Emitted Per Year, by using the information on each page found in the right-hand column. Do not use the total in the Your Total Estimated Emissions (at the bottom), because those totals are a total of all the pages.

4 If you need to go back to a previous section, click on the icon at the bottom for Previous Section.

5 Complete Table 1, column 3.

6 Explore the Reduce Emissions section of the EPA webpage. See how much CO_2 your family can save by choosing to do the following activities. Enter the value in column 2.

POUNDS OF CARBON DIOXIDE EQUIVALENT EMITTED PER YEAR [TABLE 1]

	Family activity	Total CO_2 (pounds)
Household vehicles	Add the totals for each vehicle in the right-hand column.	
Home energy	Add the totals for each energy source in the right-hand column.	
Total waste emissions after recycling	Enter the total at the bottom of the right-hand column.	
Total	Add these three together, which totals the CO_2 from your family's actions.	
Estimated emissions	Enter your total from the bottom of the last screen. This total includes family size and location factors.	
The U.S. average for a household your size	Found in the bottom section, under your total estimated emissions.	

REDUCE EMISSIONS [TABLE 2]

Action	CO_2 saved each year (pounds)
Reduce the miles driven by Vehicle 1 by 10 miles per week.	
Reduce the miles driven by Vehicle 2 by 10 miles per week.	
Turn down your household's heating thermostat by 2 degrees.	
Turn up your household's air-conditioner thermostat by 2 degrees.	
Replace five 60-watt incandescent bulbs with 13-watt energy-saving light bulbs — compact fluorescent bulbs.	
Describe one more action you and your family could take.	

SHARE WHAT HAPPENED:

- Do you contribute more carbon dioxide from your household's vehicles or from your home energy?
- How did your family's total compare with the U.S. average?
- How much total savings would you gain by the suggested actions?
- If 100 households in your neighborhood took these same actions, what would the total neighborhood reduction of carbon dioxide be per year?
- Would having a whole community follow these changes help reduce emissions?

APPLY: Make a list of actions you and your family can take to help reduce your carbon footprint.

How much carbon dioxide reduction will your actions create?

Ask your friends and relatives to take the carbon footprint test and compare your results. Are some people doing better than others? How?

GENERALIZE TO YOUR LIFE: How will your actions to reduce your family's carbon footprint affect your daily routine?

Fly Higher

Use online resources (*.gov or *.edu) or books on ecology or earth science to research other actions that you could take to help reduce your family's carbon footprint.

CLOUD FORMATION

How does air cool to form a cloud even on a warm, sunny day?

intro

Water vapor in the atmosphere provides the moisture that makes clouds. Clouds form when air is cooled, which will cause water vapor to condense on particles in the air called aerosols. When the air becomes **saturated** (full of water), any additional water is shed and condenses into a cloud. This process is called **condensation**. Water vapor is an invisible gas, so if you see water in the air as a mist or cloud, you are really seeing water droplets or ice crystals, not water vapor.

More water vapor can exist in warm air than in cool air. When warm, moist air is cooled, the air becomes saturated, and some water vapor must condense out of the air to form droplets or ice crystals. There are many examples of air saturation at the surface of earth. Whenever warm, moist air is cooled by colder air, you can see a mist forming, like you do when you breathe out warm, moist air on a cold day, open a freezer door with warm, moist air outside, or see the air above a boiling pan of water cool the warm, moist air rising from the boiling water. Cold objects may cool the air to force saturation, like water condensing on a glass of ice water, dew forming on the cool grass, or frost forming on a cold windshield.

What causes cloud formation? To form a cloud, the air has to be cooled to cause condensation. Even on a warm, sunny day, clouds can form in the sky.

OBJECTIVE: Explain how cooling occurs in the atmosphere to form a cloud.

Weather Tote

- ☐ Two clear, empty 2-liter bottles — one bottle must be completely dry
- ☐ A Fizz-Keeper Pump Cap, which you can find at some grocery stores or online (Amazon.com)

do it

1. Put about 2 inches of water in a 2-liter bottle, keeping the completely dry bottle for later.
2. Place the Fizz-Keeper Pump Cap securely on the bottle.
3. Shake the water in the bottle to cause as much evaporation as possible.
4. Pump air into the bottle.
   - Pump at least 100 times.
   - As you pump air into the bottle, you are increasing the air pressure and adding air that is relatively drier than the air in the bottle.
   - Shake the water some more after pumping to encourage more evaporation.
   - Let the bottle sit for at least 30 minutes, if possible, for maximum evaporation.

5 Unscrew the Fizz-Keeper Pump Cap from the bottle. Be careful to keep your hand on it **because it will pop off the bottle.**

6 Look for a cloud in the bottle.

- Chances are that you did not get a cloud flowing out of the bottle the first time, so try again.
- Add at least 25 more pumps each time you repeat the activity.
- Keep track of the number of pumps you use each time so that you can determine how many pumps will make the best cloud.
- The greater the pressure in the bottle, the better the cloud.

7 Place the Fizz-Keeper Pump Cap on the dry bottle, and try the experiment again with the number of pumps that made the best cloud in number 6.

QUESTIONS:

- How many pumps were necessary to get a cloud that flows out of the bottle?
- Why is it important to shake the water in the bottle and let the bottle sit?
- What is changing in the bottle when you pump air into it?
- What kind of results did you get with the dry bottle?
- Why is there a difference between your results with the dry bottle and the wet bottle?

DISCUSSION:

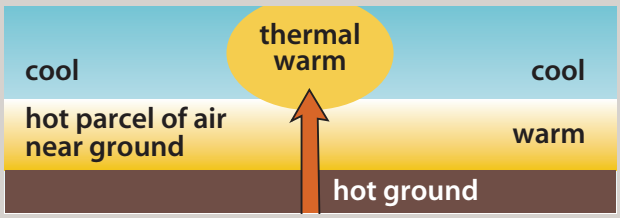
When you removed the Fizz-Keeper Pump Cap, the air in the bottle expanded. The air must be cooled to make a cloud. If air is forced to expand, that air will cool. Have you ever used a spray paint can? As the air expands out of the can, you feel the can getting colder. When you released the air pressure in the bottle, the expanding air cooled, causing the water vapor in that air to condense into a cloud. When you did the same thing using the dry bottle, you did not add any moisture to the air, so there was not enough water vapor for condensation to take place.

Air at the surface of earth is compacted by the higher air pressure at the surface. If that air is lifted up higher, where the air pressure is lower, it expands and cools, causing condensation to form a cloud. So lifted air causes most cloud formation. Fog and certain special clouds, such as mammatus, are exceptions and do not require lift to develop.

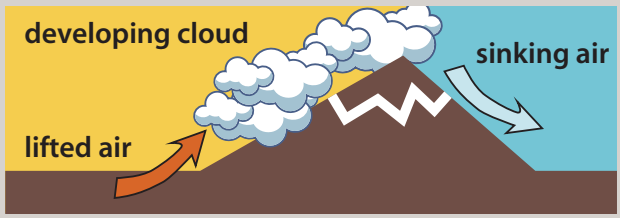
Look at the following diagrams that show ways air is lifted to form a cloud.

MAMMATUS CLOUDS Source: National Oceanic and Atmospheric Administration/Department of Commerce.

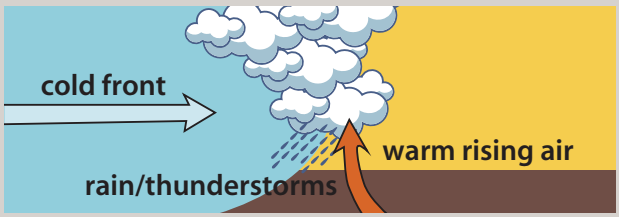
WAYS CLOUDS FORM:



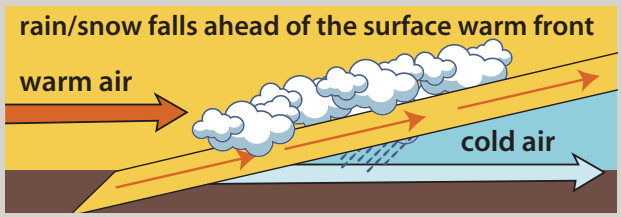
THERMAL [FIGURE 1]
What is causing the air to lift? What is happening to the temperature of that rising air?



MOUNTAIN EFFECT [FIGURE 2]
What is causing the air to lift? What is happening to the temperature of that rising air?



COLD FRONT [FIGURE 3]
What is causing the air to lift? What is happening to the temperature of that rising air?



WARM FRONT [FIGURE 4]
What is causing the air to lift? What is happening to the temperature of that rising air?

Have you ever seen a hawk or buzzard soaring in the sky? On sunny days these birds soar for long periods of time without flapping their wings! They often rise higher as they soar. Glider pilots look for small puffy clouds forming on a sunny day because they know by getting under them, they gain lift and stay aloft for a longer period of time.

Why can birds soar and even climb higher without flapping their wings?

Chat **SHARE WHAT HAPPENED:** Which part of this activity did you enjoy the most? Why?

APPLY: How does the bottle and Fizz-Keeper Pump Cap activity relate to the four figures?

GENERALIZE TO YOUR LIFE: Why do glider pilots look for small puffy clouds on a sunny day?

Fly Higher

In this activity, you observed clouds formed by thermals. Any clouds present in the morning or after sunset are not there because of a thermal, but because of some frontal activity. On a clear, sunny day, watch for the formation of fair-weather cumulus clouds — small puffy clouds. Check a weather report to see today's dew-point temperature. The higher the dew point, the more likely clouds will form. Watch at different times during the day to see how these clouds develop. Search for birds that might be riding the thermals. Observe these clouds in the evening — near, at, and after sunset. Record your observations in a journal, noting the time of day for each one.