PURDUE
EXTENSION

4-H-1024-W LEVEL 2

WEATHER AND CLIMATE SCIENCE

4-H Member
Name_______________________________

Club Name___________________________

4-H-1024-W

WEATHER AND CLIMATE SCIENCE

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

AUTHORS

Natalie Carroll (Professor, Youth Development and Agricultural Education), Ted Leuenberger (writer, teacher), and Gretchen Leuenberger (writer, teacher)

ACKNOWLEDGMENTS

Contributors

Students: Natasha Duncan, Olivia Kellner, Jesse Steinweg-Woods

Reviewers: Sam Lashley, Evan Bentley, Courtney Obergfell, Annie and Peggy Keller

Administrative Assistants: Aime Lillard, Sayde Uerkwitz

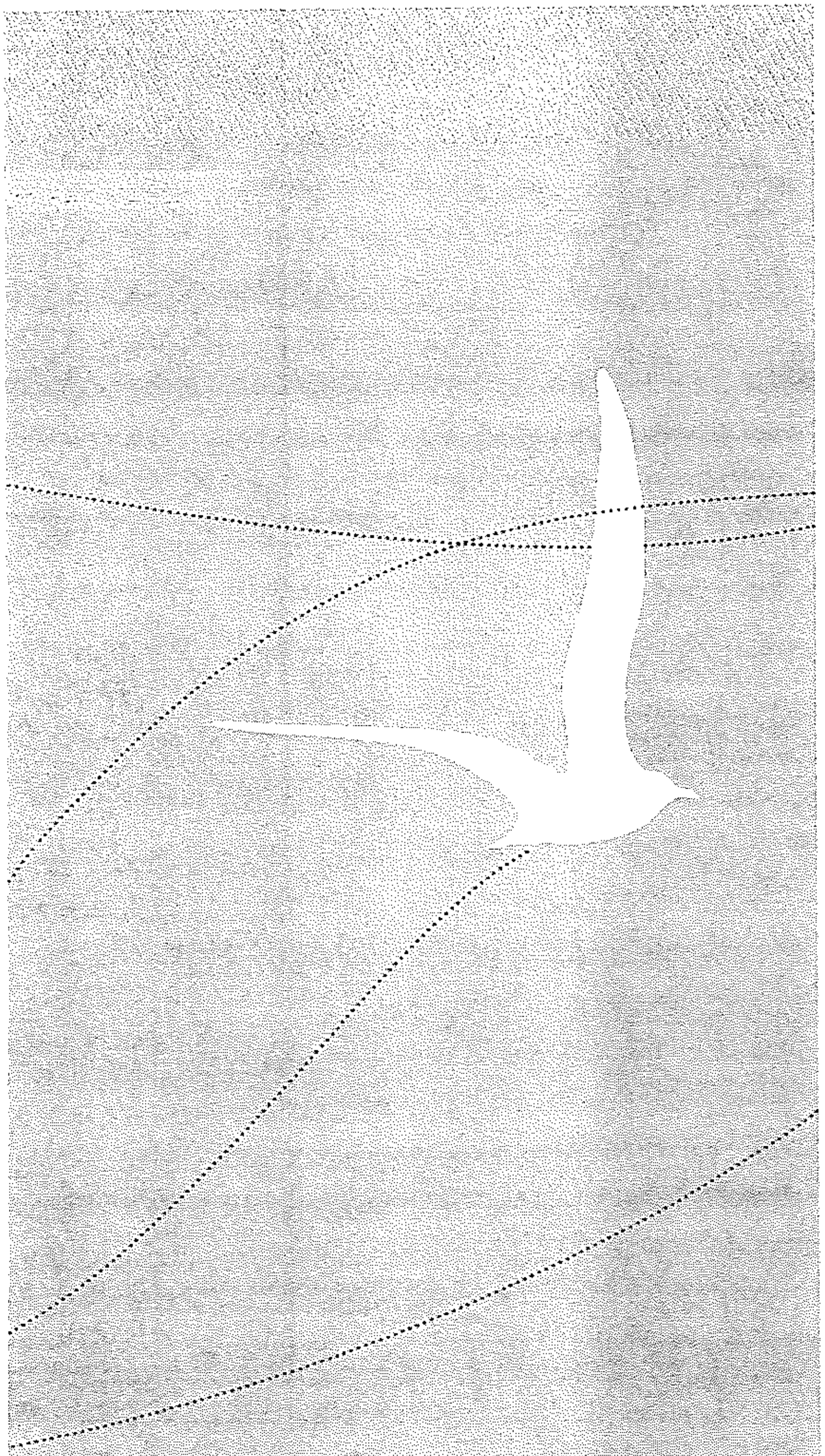
Book Production Team

Copyediting: Carol Bloom, Bloom Ink Editorial

Editor: Nancy Alexander

Design and Layout: Natalie Powell, Just Natalie Graphic Design

4-H-1024-W



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CONTENTS

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.

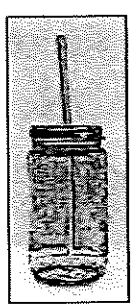
OBJECTIVE: Understand the nature of air pressure.

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?

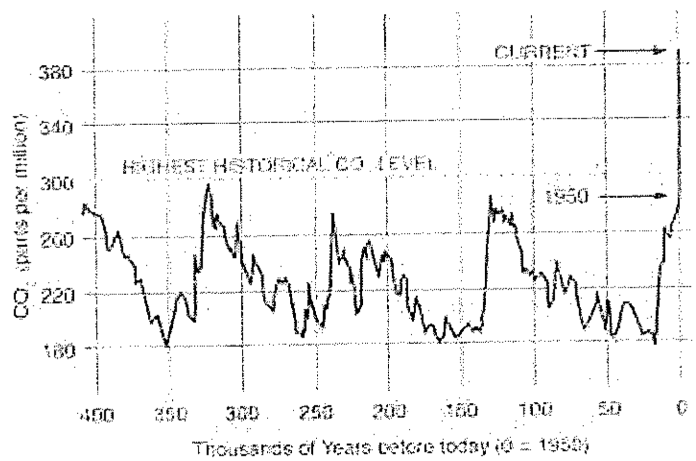
intro Carbon dioxide (CO_2) is a greenhouse gas that is added to the atmosphere through many of our day-to-day activities such as driving cars and running gas-powered lawn mowers, and from power plants. The energy and materials that we use each day come from many sources. Some of these sources are **fossil 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]



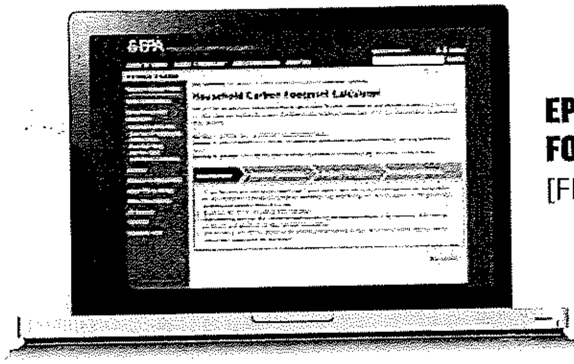
Source: NASA

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 CO2 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?

Water vapor in the atmosphere provides the moisture that makes clouds. Clouds form when water vapor is added, the air is cooled, and in the presence of chemicals such as 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)

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:

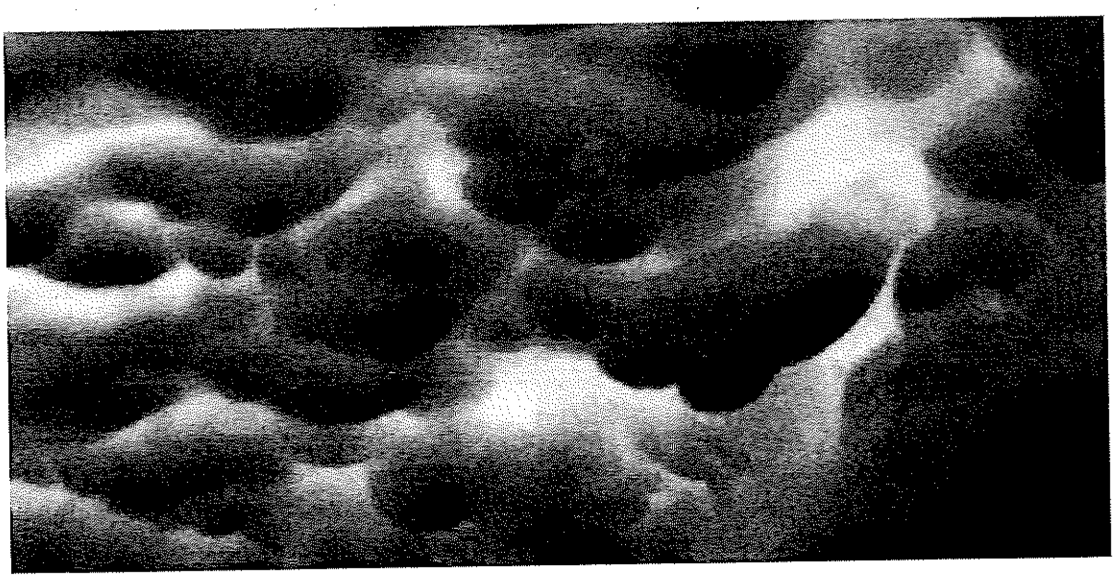
- How many pumps were necessary to get a cloud that flows out of the bottle?
- Why is it important to shake the water in the bottle and let the bottle sit?
- What is changing in the bottle when you pump air into it?
- What kind of results did you get with the dry bottle?
- Why is there a difference between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

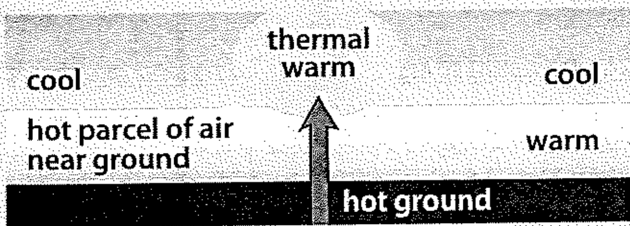
Air at the surface of earth is compacted by the higher air pressure at the surface. If that air is lifted up higher, where the air pressure is lower, it expands and cools, causing condensation to form a cloud. So lifted air causes most cloud formation. Fog and certain special clouds, such as mammatus,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

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

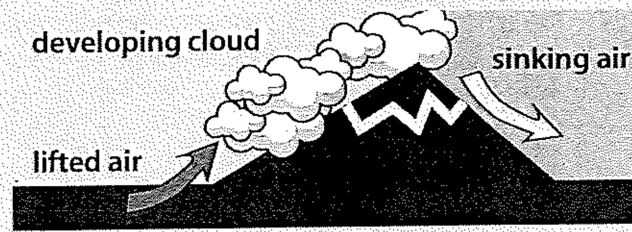


MAMMATUS CLOUDS Source: National Oceanic and Atmospheric Administration/Department of Commerce.

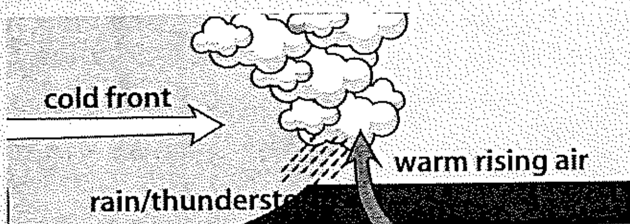
WAYS CLOUDS FORM:



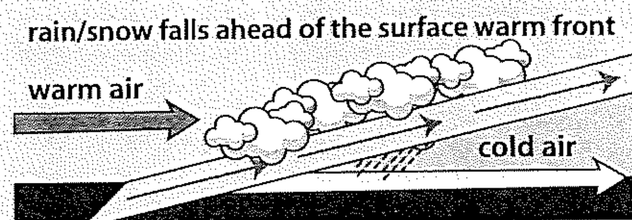
THERMAL [FIGURE 1]
What is causing the air to lift? What is happening to the temperature of that rising air?



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?

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.

CLOUD TYPES

How do we classify different kinds of clouds?

How would you describe the clouds you see in the sky today? Clouds come in all shapes and sizes. Some look puffy and white, while others have no form and seem dark and ominous. Clouds can tell us what is happening in the atmosphere and give us an idea of what kind of weather is approaching. Clouds may carry millions of tons of water or ice, and yet they appear to float in the sky. They bring fresh water to land through precipitation, so life can exist outside the ocean.

Five basic terms are used in naming clouds, which we combine to form the names of the ten basic clouds:

Cirrus or *cirro* — high-level, wispy or hair-like clouds

Stratus or *strato* — layered or flat clouds

Cumulus or *cumulo* — lumpy or fluffy clouds

Alto — midlevel clouds

Nimbus or *nimbo* — clouds holding any type of precipitation

The ten basic clouds are given below with their abbreviations. These clouds and a description of each can be seen on the NOAA website: www.srh.weather.gov/jetstream/clouds/basicten.htm.

You will observe and identify the basic forms of clouds that might appear in your area over the course of several days.

OBJECTIVE: Observe and identify basic cloud types.

Weather Tote

- ☐ NOAA cloud images in one of these downloads. You can print these out.
  - Cloud Chart.pdf
  - Cloud Classifications.pdf
- ☐ Several days with clouds in the sky

HIGH-LEVEL CLOUDS	MID-LEVEL CLOUDS	LOW-LEVEL CLOUDS
Cirrus (Ci)	Cirrocumulus (Cc)	Cirrostratus (Cs)
Altocumulus (Ac)	Altostratus (As)	Nimbostratus (Ns)
Cumulus (Cu)	Cumulonimbus (Cb)	Stratocumulus (Sc)
		Stratus (St)

1 Make a cloud observation table with columns for the date, time, and your cloud observations. Make at least 10 rows under the column headers (date, time, observations).

2 Record the date, time, and name of the clouds you see in the sky by comparing the clouds that you see to those shown on the downloaded PDFs for 10 days.

3 Record all the cloud types you see each time you make an observation. You may see more than one type of cloud.

4 Record your data only on days when clouds are present.

5 You may record data up to three times each day, but the times you choose must be at least five hours apart.

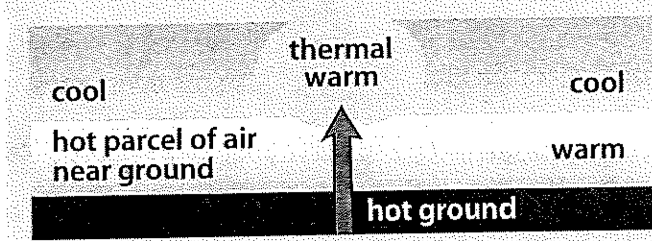
NOTE: You may have trouble identifying the first cloud you observe. It is better to make a "best guess" than make no guess at all. You may see a cloud forming behind a high-flying airplane. Yes, that is actually a cloud, called a contrail, and you should include that in your observation sheet (this type has no abbreviation).

SHARE WHAT HAPPENED:

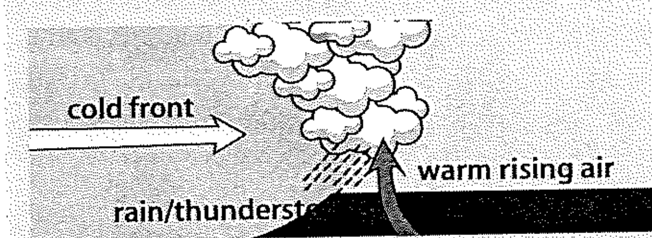
- How difficult was it to identify the clouds?
- Were there clouds that you were uncertain about? Which two types did you think each one could be?
- Did you see any clouds that did not fit any of the ten types?
- Did you observe any clouds with precipitation?

APPLY: When a cloud forms, the air is being lifted by some means. The lifting of the atmosphere can occur due to uneven heating of the surface or along a cold or warm front. A cold front is the boundary between where cold air is being pushed over warmer air. A warm front is the boundary between where warm air is being pushed over cooler air. Here are examples of those three types of lift.

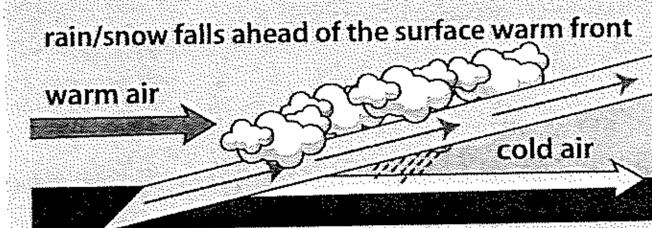
WAYS CLOUDS FORM:



UNEVEN HEATING [FIGURE 1]



COLD FRONT [FIGURE 2]



WARM FRONT [FIGURE 3]

- In which example will you find cumulonimbus clouds?
- In which example will you find fair-weather cumulus clouds?
- In which example will you find nimbostratus clouds?

GENERALIZE TO YOUR LIFE:

Clouds tell us about what is happening in the atmosphere. From your experience of watching and studying clouds, what kind of weather might you expect with the following types of clouds?

- Dark, thick stratus clouds
- Small, puffy cumulus clouds
- Towering dark cumulonimbus clouds
- High wispy cirrus clouds

Fly Higher

There are many other types of clouds than the ten basic cloud types you learned in this activity. Research other types of clouds, and expand your observations to see if you can discover any of them.

Take pictures of clouds, and create a photo gallery of your observations.

NOTES

COLD FRONTS

What is a cold front, and what kind of weather does a cold front produce?

Across many parts of the country, a cold front often comes before precipitation (rain or snow), although a cold front can move though without precipitation. Cold fronts are marked by a shift in wind. A front is a boundary between two air masses and occurs when one air mass moves into the area of another air mass. The difference between the air masses is their temperatures, which creates a change in air density. A cold front is a large boundary of air — generally extending from north to south when fully developed in the Midwest — with colder air behind the front and warmer air ahead of the front. This front, usually moving eastward in the Midwest, can trigger clouds to form, resulting in precipitation. In this activity, you will simulate your own cold front.

OBJECTIVE: Understand the nature of a cold front.

Weather Tote

- ☐ Two identical baby food jars or any two wide-mouth jars with identical rims. You do not need the lids.
- ☐ Waxed paper or an index card
- ☐ Blue food coloring
- ☐ Red food coloring
- ☐ Water
- ☐ Baking pan

Complete this activity in the baking pan to catch spilled water. Place the baking pan near a window or light so that you can easily see what happens in the jars.

1 Place one jar upside down on the other jar to ensure that they are an exact match. If the jars do not match, find a different pair.

2 Fill Jar 1 with cold water.

3 Add one or two drops of blue food coloring to the cold water. Stir the mixture.

4 Add more cold water so that Jar 1 is full to the rim.

5 Fill Jar 2 with hot tap water to about 1 inch below the rim.

6 Add one or two drops of red food coloring to the hot water, and stir the mixture.

7 Add more hot water so that Jar 2 is full to the rim.

8 Place a piece of waxed paper or an index card on the top of the hot-water jar, and press down around the edges of the jar to make a seal.

9 While keeping your hand flat on the paper, slowly turn over the jar until it is upside down in your other hand. Air pressure will hold the paper in place.

10 Place the sealed top of Jar 2 (hot water) on the top of Jar 1 (cold water), so that the rims match. The paper on Jar 2 will act as a boundary between the two jars.

11 Once the jars are stacked on each other, slowly and carefully remove the paper between the jars by pulling gently, while keeping your hand on the two jars to keep the rims matched up. You may need a helper with this part. Do not worry if the paper begins to fall apart and a little water spills out.

12 Carefully lift the two joined jars, keeping the rims together, and slowly tip the jars 90° to the right. Jar 1 (cold water) should be on the left, and Jar 2 (warm water) should be on the right. Keep the jars above the pan, and keep one hand on each jar.

13 Observe how the colored water moves in the jars.

SHARE WHAT HAPPENED:

- What did you observe as the jars were tipped to the right?
- Why did the cold water affect the warm water in this way?

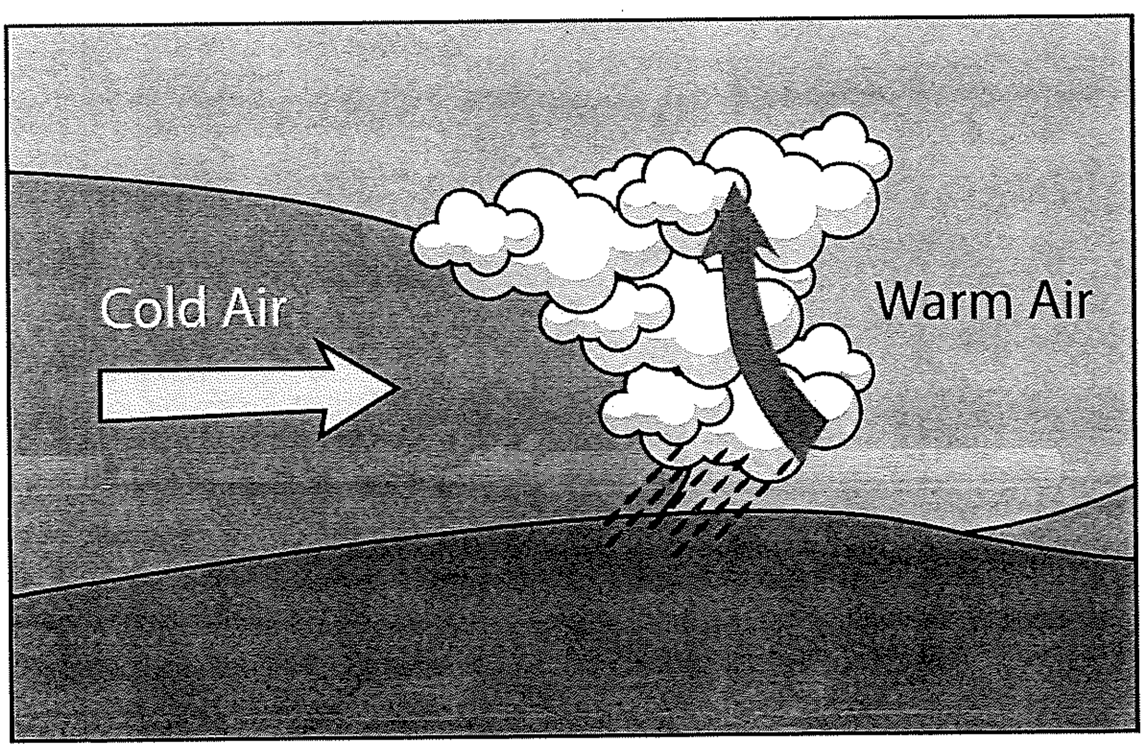
APPLY: Use Figure 1 to answer the following questions:

- How similar is the diagram of a cold front, in Figure 1, to what you observed with the two colored waters in your jars?
- Why are clouds forming at the boundary between the two air masses?

GENERALIZE TO YOUR LIFE: You see an approaching cold front on a weather map. What kind of weather changes are you most likely to observe when the front arrives? Why?

This activity adapted from: http://weather.about.com/od/under10minutes/ht/frontdemo.htm

COLD FRONT [FIGURE 1]



EARTH'S ROTATION

How does the rotation of the earth affect the movement of air across its surface?

The ideas of French physicist Gaspard Coriolis were applied in the early 1900s to the movement of air to explain the rotation of wind in high and low pressure systems. In 1835 he had described the force that results when an object moves across a rotating surface. As earth rotates, objects on its surface at different latitudes move at different speeds. Depending on the direction of earth's rotation, the air turns from its straight path. This force that deflects air, or wind, away from a straight course is called the Coriolis effect.

OBJECTIVE: Identify the cause and effect of earth's rotation on wind movement.

Weather Tote

- ☐ A rotating globe (or a ball with a mark for the North and South Poles if you do not have a globe)
- ☐ Masking tape
- ☐ Pen
- ☐ A clock with second, minute, and hour hands
- ☐ Tennis ball (or any small soft ball)
- ☐ The Coriolis worksheet
- ☐ Access to a playground roundabout (sometimes called a merry-go-round) at a schoolyard or park
- ☐ Two friends to help you with this experiment at the playground.

Rotation 1

1. Place two pieces of masking tape (about 1") on the globe — one just above the equator (Northern Hemisphere) and one just below the equator (Southern Hemisphere).
2. Turn the globe slowly counterclockwise while looking down at the North Pole.
   - Draw an arrow on the tape in the Northern Hemisphere showing the direction it moves.
3. Turn the globe over so you are now looking down at the South Pole.
4. Rotate the globe in the direction of your arrow in the Northern Hemisphere.
   - Draw an arrow on the tape in the Southern Hemisphere showing the direction it moves.
5. Answer the Rotation 1 questions on the worksheet.

Timing

8 Ask a friend to help you while you study the clock.

9 Watch the minute hand for one minute.

10 Answer the question in the data sheet.

11 Watch the hour hand for one minute.

12 Answer the Timing questions on the worksheet.

Position

13 Calculate the speed of earth at different latitudes in the Coriolis data sheet.

14 Answer the Position questions on the worksheet.

Rotation 2

15 Visit a roundabout with two friends, and take a small ball.

16 Ask your friends to do the following:

Sit (do not stand) on the roundabout opposite each other.

Practice tossing the ball back and forth.

17 Turn the roundabout slowly counterclockwise, while your friends continue to toss the ball back and forth five times.

18 Answer the questions on the data sheet.

19 Turn the roundabout slowly clockwise, while your friends continue to toss the ball back and forth five times.

20 Answer the Rotation 2 questions on the worksheet.

SHARE WHAT HAPPENED: Were you surprised about any of your findings?

APPLY: Have you ever walked between surfaces that are moving at different speeds? For example, stepping onto a moving sidewalk at an airport or amusement park ride? How does that affect your balance?

How is wind affected in the Northern Hemisphere, which is rotating counterclockwise? Is the wind being deflected to the right or left?

GENERALIZE TO YOUR LIFE: What objects might be affected by the Coriolis effect?

Fly Higher

Explore other objects that move across earth's surface and might be affected by the Coriolis effect, such as airplanes and missiles. The Internet may be your best resource.

NOTES

CORIOLIS WORKSHEET

Rotation 1

What do you notice about the two arrows? ______________________________

____

____

What is the difference in rotation between the Northern and Southern Hemispheres?

____

____

Timing

Did you see the minute hand move while you were watching it? ______________

Did you see the hour hand move while you were watching it? ______________

The hour hand on a clock rotates once every 12 hours, and it takes earth 24 hours to rotate once. So the hour hand rotates ______________________ as fast as earth.

Position

Calculate the speed of earth at different latitudes: Speed = distance ÷ by time (24 hours). Round to the nearest mile (no decimals).

Location (Latitude)	Distance Traveled (in 24 hours)	Speed (miles/hour)
Equator (0°)	About 25,000 miles	
Indianapolis, Indiana (about 40°)	About 18,000 miles	
Anchorage, Alaska (about 60°)	About 12,000 miles	

Answer the following questions by comparing the speeds you calculated above.

What part of the earth travels the fastest? (circle one)

Equator   Indianapolis   Anchorage

Is Chicago rotating   faster   or   slower   (circle one) than you?

Is New Orleans rotating   faster   or   slower   (circle one) than you?

Rotation 2

What happened when you started rotating the roundabout counterclockwise (similar to the motion of the Northern Hemisphere)?

____

____

Did the ball seem to curve? (circle one)   Yes   No

Which way? (circle one)   No curve   Right   Left

What happened when you started rotating the roundabout clockwise (similar to the motion of the Southern Hemisphere)?

Did the ball seem to curve? (circle one)   Yes   No

Which way? (circle one)   No curve   Right   Left

It is likely that one of your friends will need to retrieve the ball until they get used to tossing and catching it. Watch the apparent motion of the ball. Note how the ball appears to curve (right or left).

Now have your friend turn the roundabout slowly clockwise. This is like the rotation of the Southern Hemisphere. Note how the ball appears to curve (right or left).

Coriolis described the force that results when an object moves across a rotating surface. Because earth rotates, objects on earth's surface at different latitudes move at different speeds and can be deflected. This force, which moves air, or wind, away from a straight course, is called the Coriolis effect.

How do you think the earth's rotational speed affects wind and weather patterns?

____

____

GLOBAL WINDS

How do the sun's energy and earth's rotation combine to create global wind patterns?

While we may experience winds blowing from any direction on any given day, the weather systems in the Midwest usually travel from west to east. People in Indiana can look at Illinois weather to get an idea of what to expect the next day. This predictable weather pattern occurs because the Midwest is in the middle latitudes where the prevailing westerlies, the region's normal winds, push the weather from west to east. The earth has definite wind patterns that are a result of how the sun heats a rotating earth. These patterns influence the different types of climate around the world.

OBJECTIVE: Describe the global wind patterns and how these patterns are a result of the sun's energy and the earth's rotation.

Weather Tote

☐ Global Winds worksheet

1 Read the Global Winds Information.

2 Complete the Global Winds worksheet.

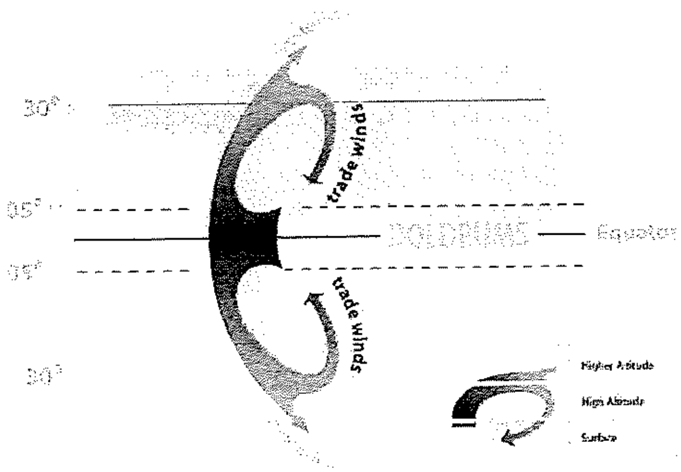
GLOBAL WINDS INFORMATION

Air that moves across the surface of earth is called wind. The sun heats the earth's surface, which warms the air above it. Areas near the equator receive the most direct sunlight and warming. The North and South Poles receive the least amount of sunlight so these areas are cooler. Warm air can hold more water vapor than cooler air. You have probably experienced very warm weather and high humidity (moisture in the air) in the summer. Cooler air is denser (heavier) than warmer air, which is often described as "warm air rises." This phrase often refers to heat rising from the floor toward the ceiling in a room, or from lower floors to upper floors in a house or apartment. This movement is also true globally. The surface at the equator is both warm and humid. The cold, dry air at the North and South Poles is much denser than the warm, humid air near the equator. So warm air tends to move northward in the Northern Hemisphere and southward in the Southern Hemisphere.

WIND PATTERNS

If global winds were affected only by the heating of the sun, they would move only toward the poles. The surfaces near the equator would become very hot and humid, causing that air to rise and flow toward the North and South Poles. The cooled air would sink and return to the region of the equator. But earth is always rotating, which prevents air from traveling in a straight line. The earth's rotation forces the air to the right in the Northern Hemisphere and to the left

GLOBAL WIND PATTERNS



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

in the Southern Hemisphere. But rather than one large global wind from the equator to each pole, there are six bands of circulation — three in the Northern Hemisphere and three in the Southern Hemisphere. These regions, called cells, are described below for the Northern Hemisphere. The same patterns exist in the Southern Hemisphere.

- The Hadley cell region is named after George Hadley (1685–1768), an amateur meteorologist who suggested that surface winds existed. The air rises at the equator (0°) and sinks at about 30° north latitude, moving back toward the equator at the surface. These surface winds are called trade winds, and they generally blow from east to west. Hurricanes develop within the trade winds.
- In the Ferrel cell region, suggested by William Ferrel (1817–1891), the air near the surface at 30° north latitude sinks as it also moves northward. Earth's rotation deflects this northward surface air to the right, and these surface winds begin to blow generally from west to east. In the area between 30° north latitude and 60° north latitude, the surface winds are known as the prevailing westerlies — sometimes called the stormy westerlies.
- The third latitudinal cell is known as the polar cell region. Here, air rises at 60° north latitude and moves toward the North Pole (90°), where the air cools and sinks. This results in surface winds that move generally from east to west. These winds are called the polar easterlies. The sinking air creates polar deserts, but they are not like the deserts that you may have seen or heard about in hot regions of the world. The North and South Poles do not get large amounts of precipitation, but the snow they do receive builds up year after year into deep snow packs.

This creates what seems like a uniform global system, but several factors combine to make it more complicated. Factors that affect the weather include landmasses, ocean currents, and seasonal changes, which cause otherwise orderly global wind patterns to fluctuate and make predicting weather so complicated.

HIGH AND LOW PRESSURE REGIONS

Areas of high and low pressure exist at earth's surface between each of the cell regions. They are described below.

0° latitude – the doldrums: A band of low pressure runs along the equator between the north and south trade winds. Very little surface wind is present within this band of lifting air. For this reason, sailing ships often got caught in this area and spent days waiting for enough wind to carry them out. This area became known as the doldrums, as ships slowed and floated aimlessly.

30° latitude – the horse latitudes: Along 30° N and S latitude between the trade winds and the prevailing westerlies is an area of high pressure. Within this band of sinking air is very little surface wind. As in the doldrums, sailing ships got caught in this area and spent days waiting for enough wind to carry them out. In the centuries following Christopher Columbus's voyage, sailing ships crossed this band of high pressure on their way to what is now called the Americas. They carried people and supplies, along with horses, which were essential to the settlers but not native to the Americas. When sailing ships got caught in these windless areas and supplies began to disappear, the horses became dispensable and the travelers abandoned them. For this reason, this band became known as the horse latitudes.

Because air is sinking along this band and clouds do not form in sinking air, the major deserts of the world can be found at 30° latitude. Deserts form in areas where air is normally sinking, either along 30° latitude, north or south, or on the leeward side of mountains, which typically receives little precipitation or wind.

At 60° latitude – the subpolar lows: Along the 60° latitudes between the prevailing westerlies and the polar easterlies is a band of low pressure. This area also has no surface winds.

SHARE WHAT HAPPENED: What force causes air to move?

APPLY: Name a city, town, or county that usually gets the same weather you observe in your home's area after you experience it.

GENERALIZE TO YOUR LIFE: How can understanding global wind patterns help you prepare for the next few days' weather?

Fly Higher

Look at a world map or globe. Find all of the major deserts, and explain how sinking air creates each desert.

NOTES

GLOBAL WINDS WORKSHEET

How might the sun have an effect on global wind patterns?

____

____

How might the rotation of the earth affect global wind patterns?

____

____

Why is the air less dense at the surfaces near the equator than those at the North and South Poles?

____

____

Why is warm, moist air rising above the surfaces near the equator?

____

____

In what direction is the surface air shown in Figure 2 moving — toward areas near the equator or those away from the equator?

____

____

In what direction is the air high above the surface moving — toward areas near the equator or those away from the equator?

____

____

Cell Region	Location in Latitudes	Name of Surface Winds	Direction of Winds
Hadley			
Ferrel			
Polar			

Fill in the table above.

What prevents simple global surface winds from blowing from the North and South Poles to the equator?

____

____

Describe how air moves in the Hadley cell region:

____

____

Describe how air moves in the Ferrel cell region:

____

____

Describe how air moves in the polar cell region:

____

____

Why is the area along the equator known as the doldrums?

____

____

Why do deserts form along 30° latitudes?

____

____

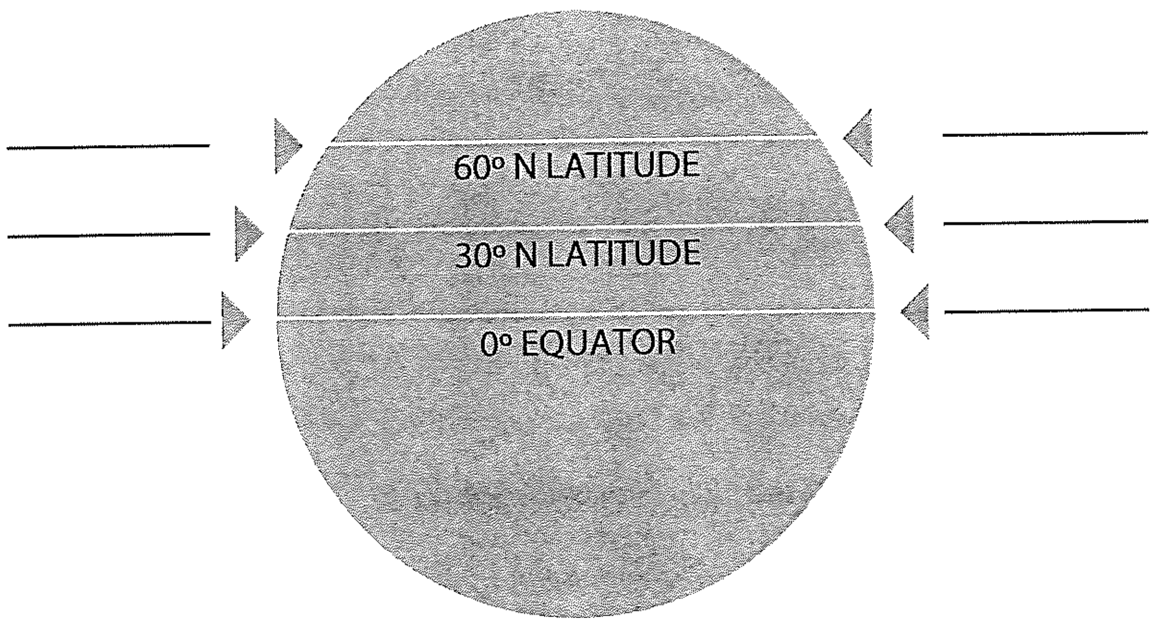
Indicate the locations of the following in Figure 5.

- Doldrums
- Horse latitudes
- Subpolar lows

Show the general wind direction for the following regions in the figure below:

- Polar easterlies
- Prevailing westerlies
- Trade winds

LATITUDE LINES (30 AND 60) [FIGURE 5]



THE GREENHOUSE EFFECT

What is the greenhouse effect, and what impact does it have on earth's atmosphere?

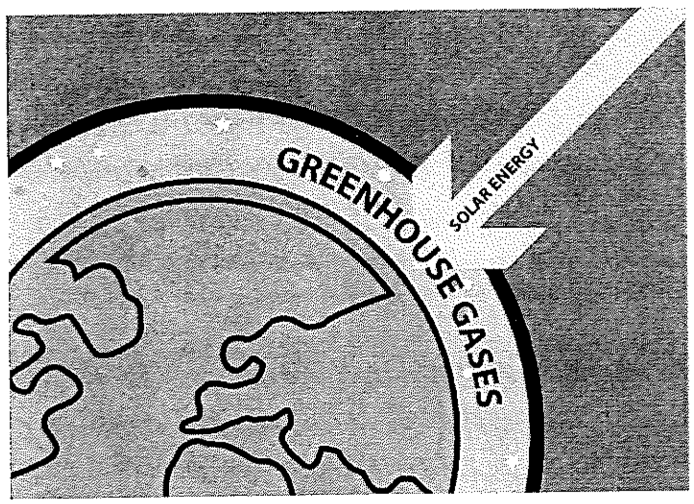
intro

A greenhouse is used to grow plants — sunlight passes through the glass of a greenhouse, and plants inside absorb the sun's rays. The sun's rays warm plants and other objects in a greenhouse. The warmed plants, floors, benches, and other objects give off heat energy. But this heat energy does not pass back through the greenhouse glass very well. Some stays in the greenhouse, making the interior warm. Because of this, greenhouses can be used to grow plants in cold weather.

Earth's atmosphere acts a little like a huge greenhouse, so this analogy is often used to help people understand how heat is trapped. Figure 1 shows the atmospheric "greenhouse effect."

The sun supplies the heat energy that warms earth, but sunlight does not warm the atmosphere, because it doesn't absorb light energy. Objects on earth's surface, on the other hand, absorb the light energy and become warm. They, in turn, give off heat energy, called infrared radiation or longwave radiation.

Most of this heat energy will pass right through the atmosphere and back into space. Some gases in the atmosphere, such as carbon dioxide, nitrous oxide, and methane, absorb heat energy. These gases are called greenhouse gases because they act like the glass in a greenhouse and keep some of the heat energy from escaping. Without these greenhouse gases, earth would be a much colder planet.



GREENHOUSE EFFECT [FIGURE 1]

Do you think that changes in the concentration of greenhouse gases could have an effect on the temperature of the atmosphere?

OBJECTIVE: Describe the greenhouse effect, and demonstrate its ability to increase the temperature of earth's atmosphere.

Weather Tote:

- ☐ A sunny day with calm winds or a desk lamp with a 60- or 75-watt bulb
- ☐ Two shoeboxes
- ☐ Two large glass jars, or any similar containers — lids not required. Note: Choose containers of the same size, each with a large opening.

- ☐ Two thermometers that will fit in the containers
- ☐ Cardboard to make two thermometer stands
- ☐ Clear plastic wrap or a clear plastic bag large enough to hold the containers.
- ☐ A watch or a clock with a second hand
- ☐ A ruler and a pencil
- ☐ Potting soil, enough for about a 1-inch layer in each container
- ☐ Two small labels or sticky notes
- ☐ Graph or grid paper

Predict the following:

Current temperature in the sun or room where you will complete the experiment:

____

Final temperature in an open container:

____

Final temperature in a container sealed in plastic:

____

1. Put an inch of dark soil in the bottom of the containers.
2. Attach the thermometers to pieces of cardboard so the thermometer bulb is not resting on the cardboard, but is about an inch above.
3. Place one cardboard-mounted thermometer on the soil inside each container. Position the thermometers so that they can easily be read during the experiment.
4. Cover one container with plastic wrap to contain greenhouse gases. Make sure the container is sealed well.
5. Label the containers:

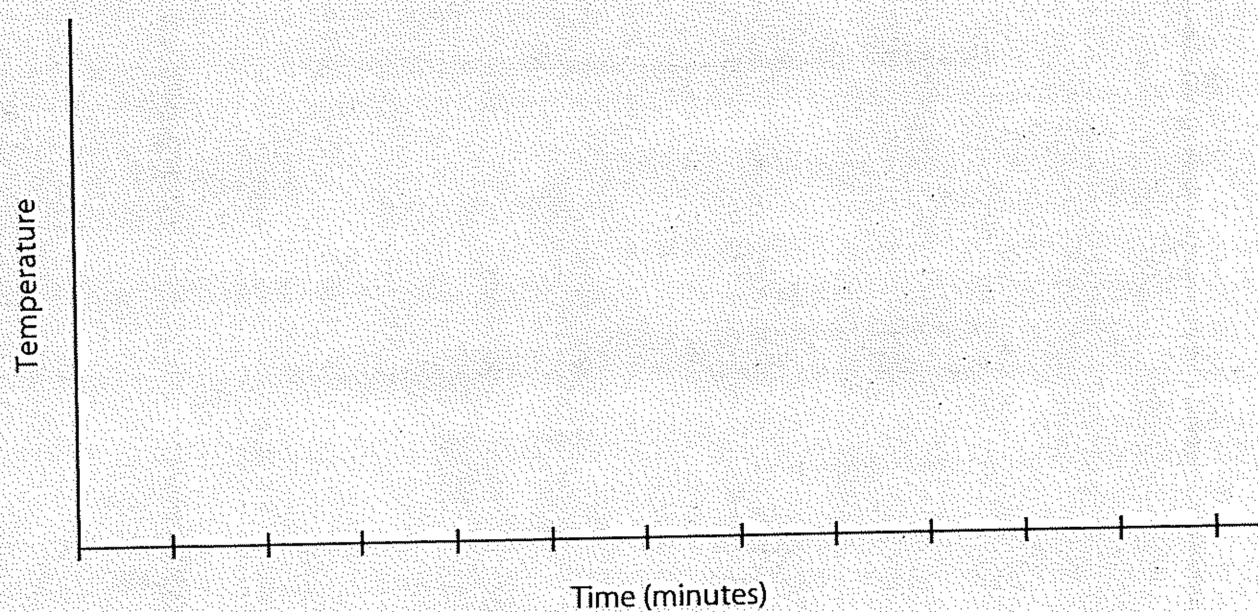
   Covered container: A

   Open container: B
6. Record the temperature on each thermometer. They should be the same temperature. If they are not, you will need to adjust one. For example, if the thermometer in container B is one degree warmer than the initial reading for the thermometer in container A, you will need to subtract one degree from all your readings of thermometer B (calibration).
7. Initial temperature: ______________________
8. Place the containers next to each other in direct sunlight or under a lamp. If you are doing this experiment inside, position the lamp about 6 inches above the containers so the light spreads evenly between them.
9. Record the temperature of each container every five minutes for 30 minutes while the containers are in sunlight or under the lamp.
10. Remove the light source: take the containers inside or turn the light off.
11. Record the temperatures every five minutes for 30 minutes.
    - Create a line graph with your data.
    - Enter the time on the x-axis.
    - Enter the temperature range and units on the y-axis.
    - Enter the temperature data points you collected.
    - Connect the data points.

TEMPERATURE DATA

With Light Source			Without Light Source		
Time (minutes)	Temperature (°F or °C) A	B	Time (minutes)	Temperature (°F or °C) A	B
0			0		
5			5		
10			10		
15			15		
20			20		
25			25		
30			30		

SKETCH YOUR GRAPH BELOW:



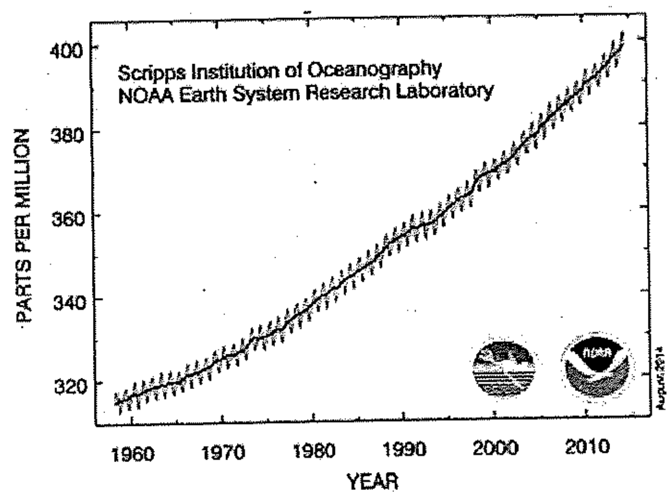
SHARE WHAT HAPPENED:

- Were your predictions correct?
- Which container had the higher temperature after the first 30 minutes — A or B?
- What caused this difference?
- After the second 30-minute period, which container had the higher temperature?
- What caused this difference?
- How is the plastic wrap like greenhouse gases?

APPLY: In March 1958, C. David Keeling, a 30-year-old scientist, began to keep a record of the amount of carbon dioxide present in the atmosphere with a method he devised as a PhD student. Other scientists during the 1950s suspected that human activity might be influencing the amount of this important greenhouse gas, but no one had a way to measure it until Keeling. He decided to do his atmospheric measurements in an area far from the influences of major industrial areas, so he went to Mauna Loa in Hawaii.

Figure 2 displays the carbon-dioxide data collected from March 1958 through July 2014. Study the graph. Then, describe how you think this steady increase in carbon dioxide, an important greenhouse gas, is affecting the temperature of earth's atmosphere.

ATMOSPHERIC CO_2 AT MAUNA LOA OBSERVATORY [FIGURE 2]



Source: National Oceanic and Atmospheric Administration/ Department of Commerce

GENERALIZE TO YOUR LIFE: What is the effect of the increase in atmospheric CO2 on the earth?

Fly Higher

A car acts just like a greenhouse. The windows let sunlight in but trap the heat energy. Experiment with your parent's car on a sunny, hot day by recording the temperature inside the car under different conditions — in direct sunlight, in the shade, with the windows open at different levels, using a windshield shade, and any other ideas you might have. You will need two thermometers: one inside the back seat and one outside near the car but not placed on a hot object. Always keep your thermometers out of direct sunlight. Record your data in both table and graph form.

HUMIDITY

How does moisture in the air affect how you feel?

Humidity refers to the amount of water vapor in the air. Hot air can hold much more water vapor than cold air. When the air is holding a lot of water vapor, we have high humidity. Humidity has significant effect on how comfortable you are because, although your body may try to cool you by sweating, the air can't absorb much water so the moisture does not evaporate. Heat energy is required when water evaporates, so sweating can remove heat from your body as long as the air can absorb more water vapor. That is why people are more comfortable in "dry heat" than when the humidity is high.

When water vapor **condenses** it becomes liquid water through a phase change. Condensed water from the air causes dew, fog, and clouds that can result in rain or snow. Condensation is the opposite of evaporation — gas to liquid vs. liquid to gas. Heat energy is involved during phase changes such as when water evaporates or condenses. Energy exchanges are important in many aspects of our weather.

Humidity is normally reported as two different measures — **relative humidity** and **dew-point temperature**. Both measures tell us how wet or dry the air is. A hygrometer is used to measure humidity by measuring these heat-energy interactions.

This activity has two parts. You will measure relative humidity in Part 1 and study heat energy in Part 2.

OBJECTIVE: Understand the relationship between temperature, humidity, and heat energy.

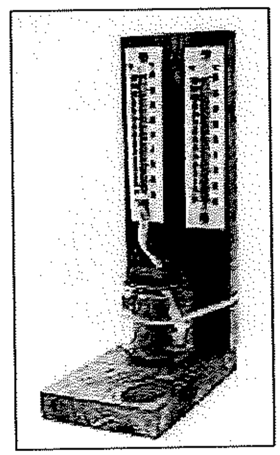
Weather Tote:

Part 1:

- ☐ A hygrometer

  Instructions to make and use this hygrometer are in the Making Weather Instruments activity in this Level 2 manual.

  You may use a purchased hygrometer. If you do, follow the instructions to determine the relative humidity.



- ☐ A thermometer, similar to the hygrometer thermometers
- ☐ Relative Humidity and Dew-Point Temperature Chart

Part 2:

- ☐ A saucepan that holds at least 8 cups (2 qt.) to heat on a stove
- ☐ A high-range thermometer, one that will record a temperature greater than 212°F or 100°C (a lab thermometer or a candy thermometer)

Part 1:

1 Label your thermometers:

Thermometer 1 is called the dry-bulb thermometer.

Thermometer 2, connected to a jar of water, is called the wet-bulb thermometer.

Thermometer 3 will be used to determine the water temperature in the jar.

2 Prediction: Estimate the temperatures that you expect for each of the following:

Dry-bulb temperature (#1): __________

Wet-bulb temperature (#2): __________

Water temperature (#3): __________

Relative humidity: __________

3 Take the lid off the jar of the hygrometer and leave the shoestring in the jar of water.

4 Place Thermometer 3 in the jar of water to determine the temperature of the water.

5 Wait five minutes and record the temperatures on the three thermometers:

Dry-bulb temperature (#1): __________

Wet-bulb temperature (#2): __________

Water temperature (#3): __________

6 Calculate the relative humidity and dew-point temperature using the Relative Humidity and Dew-Point Temperature Chart by following these directions:

Find the dry-bulb temperature (column 1) with your left hand and the temperature difference (row 1) with your right hand.

Move your index fingers (left index finger moves to the right and right index finger moves down) to find the box in the chart where they intersect.

Read the two numbers in the intersecting box.

- The top number (black) gives the relative humidity.
- The bottom number (red) gives the dew-point temperature.

Relative humidity: __________

Notes:

- If Thermometers 1 and 2 have the same temperature, the relative humidity is 100% and the dew-point temperature is the same temperature as your thermometers.
- If the wet-bulb temperature is higher than the dry-bulb temperature, your thermometers may not be calibrated correctly or the temperature has dropped rapidly outside. If this happens, wait an hour and take your reading again.

7 How did the values that you measured compare to the values you predicted?

8 Use your hygrometer in another situation (examples, below) to compare relative humidity levels.

A bathroom before and after a shower

An air-conditioned room compared to outdoors

On a morning with heavy fog or dew compared to later on the same day

At a swim meet, indoor pool compared to outside

Indoors when the heat is on compared to outdoors

9 Where did you measure the relative humidity? How did the values compare?

Temperature and Humidity

The temperature difference between the hygrometer's dry-bulb and wet-bulb thermometers allows you to calculate the humidity. When the air is humid, the difference in temperature is slight. As the air becomes dryer, evaporation of water on the wick increases and the difference between the dry-bulb and wet-bulb thermometers increases.

During the time that water is changing state (phase change), the temperature does not change, even though energy is still being added or removed. This absorption or release of energy is referred to as latent heat. Evaporation has a cooling effect as heat energy is absorbed. Condensation has a warming effect as heat energy is released.

Part 2:

Study heat energy:

1 Put 3 cups of water in a medium-sized saucepan.

2 Put the pan on the stove and bring the water to a boil.

3 Record the temperature of the water every minute from the time you begin until three minutes after the water comes to a rolling boil.

Use the high-range thermometer.

When recording the temperature:

- Hold the thermometer in the water so the bulb of the thermometer does not touch the pan.
- Read the temperature when the mercury stabilizes.
- Remove the thermometer from the water and set the timer for another minute.

4 Record the temperatures below or make your own data sheet.

5 Make a graph of the change in temperature over time (x-axis: time; y-axis: temperature).

6 Note when the water began to boil in your temperature table and graph.

Be careful when you boil water. Boiling water can splash out of a pan and burn your skin, especially if the pan is too small. Make sure the pan has a secure handle and the capacity to hold at least 8 cups of water.

TEMPERATURE READINGS:

Time minutes	Temperature °F or °C	Time minutes	Temperature °F or °C
0			

QUESTIONS:

What energy is used to raise the temperature of the water?

What happened to the temperature readings when the water started boiling?

Why?

SHARE WHAT HAPPENED:

Part 1: Was the wet-bulb or dry-bulb temperature higher?

Part 2: What happened to the temperature once the water began to boil?

APPLY: Why do you think the wet-bulb temperature is generally lower than the dry-bulb temperature?

Will water evaporate slower or more quickly when air is very dry?

When your body begins to overheat, you perspire. Why does perspiration help cool your body?

What happens to perspiration on a hot, humid day?

In desert towns, people often talk about the weather having a "dry heat." Why would low humidity make hot weather more comfortable?

Why do people complain, "It's not the heat. It's the humidity?"

GENERALIZE TO YOUR LIFE: When you go swimming on a hot day your body has to to adjust to the cooler temperature of the water, and then the water feels fine. Why do you feel colder when you get out of the water and into the hot air?

If you are cooking something in boiling water on the stovetop, can you get the water hotter by increasing the burner's heat setting?

NOTES

HURRICANES

How does tracking the path and intensity of a hurricane show how hurricanes strengthen and weaken?

Hurricane Sandy made landfall on the New Jersey shore on October 29, 2012. Hurricane Katrina made landfall on August 29, 2005, on the Louisiana coastline in the Gulf of Mexico, just east of New Orleans. On August 24, 1992, Hurricane Andrew made landfall in southern Florida — first, Elliot Key in the Florida Keys, and then west to Homestead, a suburb of Miami.

The tremendous damage these massive storms caused rank them as three of the four costliest hurricanes in U.S. history. Scientists at the National Hurricane Center correctly predicted the track and intensity of these hurricanes and were able to give accurate warnings that likely saved many thousands of lives.

In this activity, you will track these three hurricanes and learn why they strengthened or weakened. All three storms started as tropical depressions far out in the Atlantic Ocean close to the equator. You will plot their courses to see how they turned from tropical storms into hurricanes.

OBJECTIVE: Track the paths of serious storms and analyze how they became hurricanes.

Weather Tote:

- ☐ A set of colored pencils or pens
- ☐ A blank copy of the Atlantic Basin Hurricane Tracking Chart

1 Use the hurricane data for the days given in Tables 1–3 to plot the path of each hurricane on your Tracking Chart.

Use a different color pencil or pen for each of the three hurricanes.

Mark each point with the day (1, 2, 3...), found in the first column of each table.

Mark each point with the wind speed, found in column 5 of each table.

Mark each point with the air pressure, found in column 6 of each table.

Create a key for your chart, showing the color you used for Andrew, Katrina, and Sandy.

Place your key in the bottom right corner of the chart.

2 Draw a line connecting the hurricane's location each day to mark each hurricane's path. Label the path of each hurricane close to the state it affected.

3 Use the following storm classifications to indicate the classification of each hurricane in the tables and your Tracking Chart.

Tropical depression:
maximum wind speed < 39 mph

Tropical storm:
maximum wind speed 39–73 mph

Category 1 hurricane:
maximum wind speed 74–95 mph

Category 2 hurricane:
maximum wind speed 96–110 mph

Category 3 hurricane:
maximum wind speed 111–130 mph

Category 4 hurricane:
maximum wind speed 131–155 mph

Category 5 hurricane:
maximum wind speed > 155 mph

HURRICANE SANDY | OCTOBER 21–31, 2012 | [TABLE 1] **CATEGORY:**

Day	Date in October 2012	Latitude	Longitude	Wind Speed (MPH)	Air Pressure (millibars)
1	22	13 N	79 W	40	1000
2	23	14 N	78 W	50	993
3	24	18 N	77 W	85	972
4	25	23 N	75 W	105	963
5	26	27 N	77 W	75	971
6	27	30 N	76 W	85	960
7	28	33 N	72 W	75	952
8	29	38 N	73 W	90	940
9	30	40 N	79 W	45	986
10	31	42 N	81 W	35	995

HURRICANE KATRINA | AUGUST 23–31, 2005 [TABLE 2] **CATEGORY:**

Day	Date in August 2005	Latitude	Longitude	Wind Speed (MPH)	Air Pressure (millibars)
1	24	25 N	77 W	45	1003
2	25	26 N	80 W	70	988
3	26	25 N	83 W	95	968
4	27	25 N	85 W	115	948
5	28	26 N	89 W	170	902
6	29	31 N	90 W	90	948
7	30	37 N	87 W	35	990
8	31	40 N	83 W	30	996

HURRICANE ANDREW I AUGUST 16–28, 1992 [TABLE 3]				CATEGORY:	
Day	Date in August 1992	Latitude	Longitude	Wind Speed (MPH)	Air Pressure (millibars)
1	16	11 N	36 W	30	1010
2	17	13 N	44 W	35	1003
3	18	14 N	52 W	50	1000
4	19	19 N	58 W	50	1007
5	20	23 N	62 W	45	1014
6	21	25 N	65 W	55	1004
7	22	26 N	70 W	110	969
8	23	25 N	76 W	170	922
9	24	26 N	83 W	130	947
10	25	28 N	90 W	145	941
11	26	31 N	92 W	55	991
12	27	34 N	88 W	30	999
13	28	35 N	84 W	25	1000

SHARE WHAT HAPPENED:

What happens to the wind speeds as the air pressure falls?

What kind of surface was each hurricane over when it reached its highest wind speeds?

What category did each hurricane reach?

What happened to each storm's intensity as it made landfall? Why do you think this occurred?

What is the major difference between the paths of Hurricane Sandy and the other two hurricanes?

How do you think hurricanes develop when they typically start as strong storms?

APPLY: Figure 1 shows the tropical cyclone formation regions.

What two continents do hurricanes strike the most?

For the most part, at what latitude do hurricanes appear to start? Note: Compare Figure 1 to your tracking chart.

If you want to avoid hurricanes, should you live on the East Coast or the West Coast of the United States?

GENERALIZE TO YOUR LIFE: Do you know anyone who lives along the Gulf of Mexico or the East Coast of the United States? What should be part of a plan to prepare for a hurricane in these areas?

NOAA defines a tropical cyclone as a rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters and has a closed low-level circulation. Classifications:

Tropical Depression: A tropical cyclone with maximum sustained winds of 38 mph (33 knots) or less.

Tropical Storm: A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).

Hurricane: A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones.

Major Hurricane: A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4, or 5 on the Saffir-Simpson Hurricane Wind Scale.

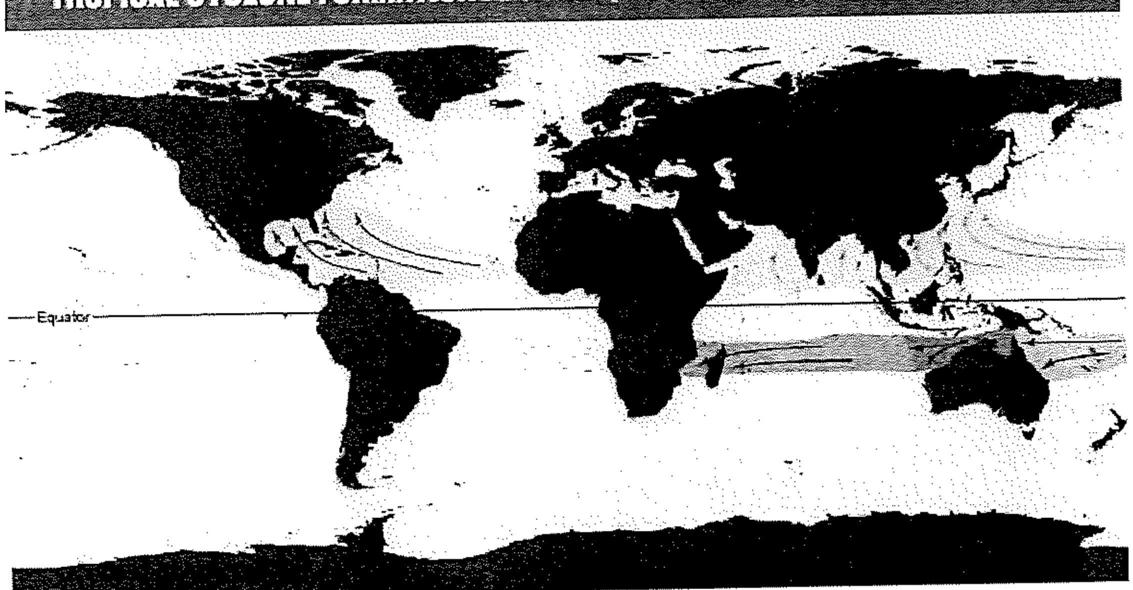
Source: www.nhc.noaa.gov/climo, downloaded August 2014

Fly Higher:

NOAA, The U.S. National Oceanic and Atmospheric Administration, has a lot of information. Visit any of the following websites and review the information available:

- National Hurricane Center, www.nhc.noaa.gov/
- Tropical Cyclone Climatology, www.nhc.noaa.gov/climo/
- Weather Safety webpage, www.weather.gov/safety/
- Hurricane Preparedness webpage, www.nhc.noaa.gov/prepare/

TROPICAL CYCLONE FORMATION REGIONS [FIGURE 1]



Source: National Oceanic and Atmospheric Administration/Department of Commerce

MAKING WEATHER INSTRUMENTS

Can I make my own weather instruments?

Yes, you can make your own weather instruments! While you can also purchase instruments to keep weather data, it is both fun and educational to make your own. You will learn how to make one or more of the following instruments:

1. Rain gauge
2. Wind vane
3. Anemometer
4. Barometer
5. Hygrometer

Each instrument is presented individually. The materials needed to make the instrument are given in the Weather Tote. Instructions to make the instrument follow in Make It. Use It gives a brief description on setting up and using your weather instrument. You can learn how to collect and record weather data in the Using Weather Instruments to Collect Data activity.

OBJECTIVE: Make one or more weather instruments.

Safety First!

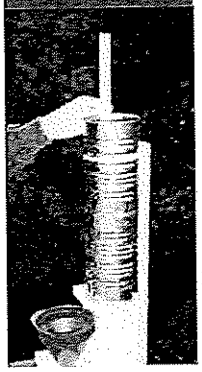
Many of the weather instruments are made using tools that can be dangerous — a saw, knife, hot glue gun and liquid solder. Be particularly careful not to cut yourself when cutting the sheet metal or removing the tin-can lids. The glue gun generates high heat. The liquid solder creates a strong bond instantly, so do not get any on your hands or it might bond your fingers. Ask a parent or other adult to help when you see a safety first icon.

RAIN GAUGE A rain gauge measures the amount of precipitation.

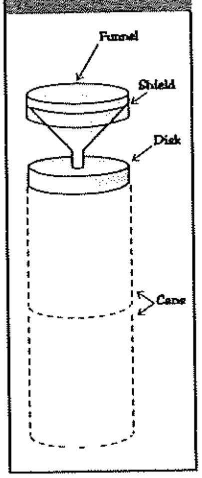
Weather Tote:

- ☐ Two identical large tin cans or coffee containers, about 7" high x 4⅛" in diameter
- ☐ A funnel, about 5" to 5½" in diameter. The largest part should be wider than the can, or rainwater will bypass the funnel.
- ☐ A piece of wood, about 5" x 5" x ¾"
- ☐ A piece of wood, about 4" x 4" x ½" or foam (4" x 4" x 1")
- ☐ Jigsaw and drill if you use wood; knife if you use foam
- ☐ A 2" x 15" strip of metal or plastic
- ☐ A large rubber band, or an 18" length of wire
- ☐ A thin, straight measuring stick, about ⅛" x 3/16" x 12"
- ☐ Two or three tin cans, each with no more than 2" in diameter
- ☐ Nails
- ☐ Glue
- ☐ Ruler
- ☐ Hot glue gun and glue stick, or a small tube of liquid solder (pronounced "sod-er" and used to join metal pieces)
- ☐ A wooden post, 1½" x 2" in its cross section and 3'–4' long
- ☐ Permanent marker

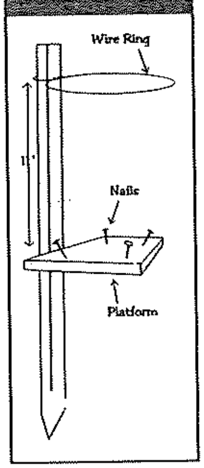
RAIN GAUGE
FIGURE 1-1



RAIN GAUGE FUNNEL
FIGURE 1-2



RAIN GAUGE HOLDER
FIGURE 1-3



it Rain Gauge

1. Remove the tops from your containers.
2. Remove the bottom from one of the containers, and stack that can on top of the can with the bottom to make one 14" high can (see Figure 1-2).
3. Use the liquid solder or hot glue to bond the two cans together. **NOTE:** You only need to apply the liquid solder to one can.
4. Set the cans aside for 20–30 minutes to dry.
5. Cut the 4" x 4" piece of wood or plastic into a disc (circle) with a diameter about 3⅞".
   - Drill or cut a hole in the center of the disc, so the spout of the funnel just fits through.
   - Glue the wood or foam to the spout of the funnel.
   - This will weigh the funnel down, so it will not blow off or become tilted.
6. Apply the liquid solder or hot glue to the 2" x 15" piece of metal or plastic to the top of the funnel to form a shield to direct all rain through the funnel.
7. Place the funnel inside the top of the tall bonded can.
8. Mount your rain gauge on the post, as shown in Figure 1-3, by attaching the 5" x 5" x ¾" piece of wood to the post about 11" from the top. Hold it in place with 4 nails. Figure 1-3 shows how the nails are driven at an angle (toenailed) to hold the can.

CALCULATING RAINFALL [TABLE 1]

RAIN GAUGE FORMULA

P = M (d/D)2

where:

- P precipitation (inches)
- M measured depth (inches)
- d diameter of the smaller measuring can
- D diameter of the funnel top

Using the rain gauge formula and M = 4"; d = 1"; and D = 5":

P = 4 x (1/5)2 inches

P = 4 x (0.2)2 = 4 x (0.04) inches

P = 0.16"

The rainfall depth was approximately 2/10 inches (0.2), rounded to the nearest tenth of an inch.

9 Attach a wire ring to the post about 1" from the top.

Rain Gauge

Measuring Precipitation

1 Drive your rain gauge post into the ground in an open area away from trees and buildings that might affect your data.

- You can attach the post to a fence post if one is available in an open area.

2 Check your rain gauge shortly after a rainfall.

- Mark the rainfall depth on the outside of the container.
- Measure the rainfall depth in your rain gauge.

3 Use the rain gauge formula and instructions below to get a more precise rainfall reading.

- Remove the funnel from your rain gauge, and pour the water into another cylindrical can with a small diameter, preferably less than 2". NOTE: You can make a taller measuring can by cementing two cans together as you did for the rain gauge.
- Place the ruler in the can so it touches its bottom (like a dipstick); remove the measuring ruler and note the measurement, M, where the water wet the measuring stick.
- Use the rain gauge formula (Table 1) to calculate the amount of precipitation (P) that your area received.
- Indicate the amount of rainfall (P) on your container. Was P close to the amount that you measured?

4 Replace your rain gauge so it is ready for the next rainfall.

NOTE: Using the smaller diameter cylinder and rain gauge formula allows a more precise rainfall reading using multiplication. A smaller diameter cylinder is not used to collect rain because wind, which often accompanies rainfall, can cause too little rain to be collected for an accurate reading.

Fly Higher

Study how the diameter of a rain gauge affects your rainfall measurement by making three rain gauges with different diameters. You might try using your 2" measurement cylinder, your 5" diameter gauge, and a 5-gallon bucket or pail.

WIND VANE A wind vane measures the direction that the wind is blowing.

Weather Tote:

- ☐ Pieces of metal
  - 4" x 15"
  - 4½" x 5"
  - ½" x 12"
  - You can cut these metal pieces from a tin can.
- ☐ One ½" x 18" dowel, or a 1" x 1" x 18" stick
- ☐ Waterproof glue
- ☐ Nails, small
- ☐ Liquid solder or hot glue gun and glue stick
- ☐ Glass bead or washer
- ☐ Dowel or stick for mounting your vane

Wind Vane

1 **VANE TAIL:** Fold the 4" x 15" piece of metal in half. See Figure 2-1 to see how to cut the folded end with a concave cut, so that the center 1.5" of the fold remains.

2 **ARROW POINT:** Fold the 4½" x 5" metal to form a triangle with sides 4½" x 2½" (see Figure 2-2).

3 Cut parallel 1" slots on each end of the dowel rod, about 1" long and ½" thick. Be sure that the slots are parallel (lined up).

4 Attach the arrow point and vane tail using small nails and waterproof glue.

5 **TAIL SEPARATOR:** Fold the ends of the 12" x ½" piece of metal to form a V that is 2.5" high. See Figure 2-4 to see how to solder or hot-glue the tail separator.

6 Place the shaft (dowel) on the edge of a knife. This is called the balancing point.

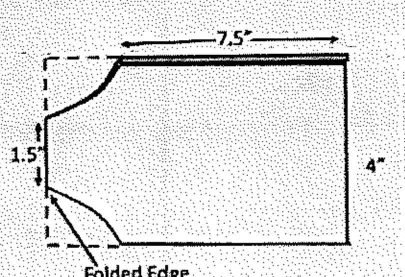
7 Drill a small hole through the shaft at the balancing point and parallel to the folded edge of the vane.

- If the balancing point is too far back, shift it forward by adding weight to the arrowhead end by wrapping heavy wire or a similar material to the front of the shaft.
- If the balancing point is too far forward, shift it backward by adding weight to the arrowhead end by wrapping heavy wire or a similar material to the tail end of the shaft.

8 Mount the wind vane on an upright post or stick with a nail that fits loosely through the small hole that was drilled at the balancing point.

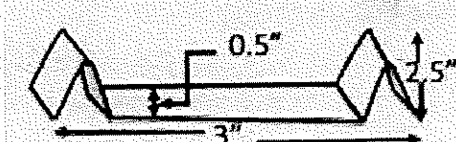
9 You may attach a glass bead or washer between the vane shaft and the post as a bearing to make the vane move more freely. See Figures 2-4 and 2-5 for assembly details.

VANE TAIL FIGURE 2-1



ARROW POINT FIGURE 2-2

TAIL SEPARATOR FIGURE 2-3



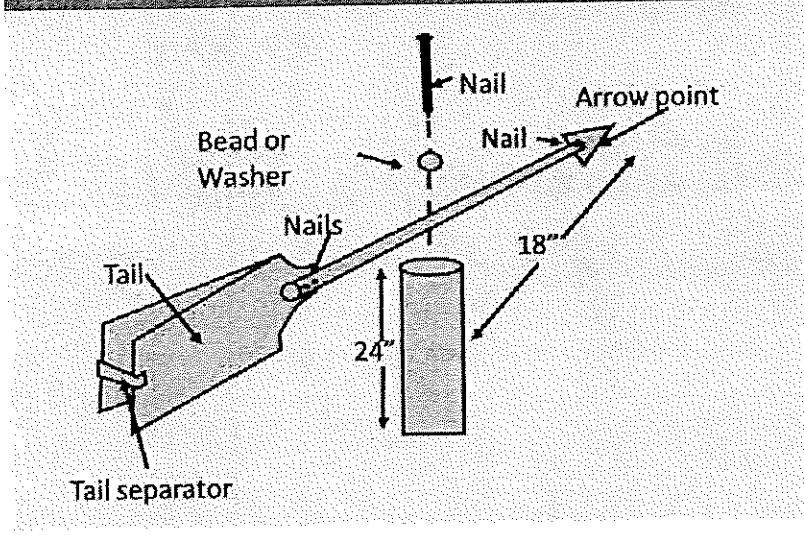
Wind Vane

Determining Wind Direction

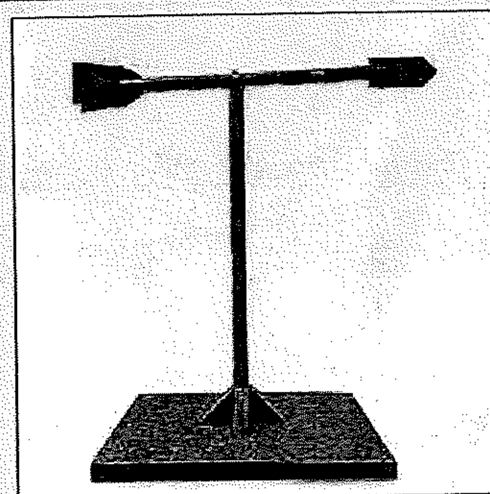
1 Mount or place your wind vane in an open area. Try to avoid obstructions such as trees or buildings that can affect the wind.

2 The arrowhead will point in the direction that the wind is blowing: north, south, east, west, or in between.

WEATHER VANE CONSTRUCTION FIGURE 2-4



WEATHER VANE FIGURE 2-5



ANEMOMETER Wind speed is often measured by a cup anemometer. Cup anemometers can be made from funnels, tin cans, or plastic cups.

Weather Tote:

- ☐ Three metal funnels, approximately 2½" in diameter (See Figures 2-1 and 2-2.)
  - Or: three pieces of sheet metal, approximately 2½" x 5"
  - Or: three plastic cups, approximately 2½" in diameter
- ☐ Dowel, 3/16"x 17"
- ☐ A metal or plastic pencil or pen cap
- ☐ A metal lid with 1¾"–2" diameter
- ☐ A small washer with ⅜" diameter, or a piece of tin
- ☐ A 3" finishing nail
- ☐ Paint
- ☐ Waterproof glue
- ☐ Liquid solder or hot glue gun and glue stick
- ☐ Commercial anemometer (borrowed) or radio, TV, or online weather source for daily wind-speed report

Anemometer

NOTE: An anemometer made with plastic cups will be fairly sensitive to light winds, so it may be difficult to count the revolutions if the wind is blowing very hard. One made of flat metal or metal funnels will turn more slowly and therefore may measure higher winds more easily.

1 Cut and shape the spout, if you are using metal funnels. See Figure 3-1.

- Cut the spout, leaving only about ½".
- Cut three V-shaped slits in the ½" spout, and bend the pieces toward the neck of the funnel.

2 Solder or hot glue the opening shut to keep wind from blowing through.

3 Punch a hole on opposite sides of your three funnels so that the 3/16" dowel rods fit tightly through, as shown in Figures 3-1 and 3-2. Fasten each with waterproof glue.

4 Use a small bottle lid to assemble the hub of the anemometer by drilling or punching three equally spaced holes in the rim, as shown in Figure 3-3.

5 Drill or punch a hole in the center of the lid, and glue a ballpoint pen cap or other plastic cap in the hole.

6 Glue the washer to the opening of the pen cap.

7 Insert the funnel-and-dowel spokes into the lid so they touch the pen cap and rest on top of the washer. See Figures 3-3 and 3-4.

8 Check that the funnel is parallel to the axis of the pen cap and all point in the same direction.

9 Glue the spokes to the cap and the washer.

10 Paint one funnel so that it is easy to see (and count) when your anemometer is spinning.

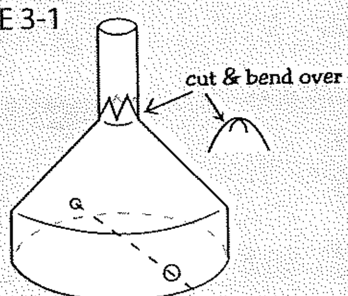
11 Mount the anemometer to the wood post by pounding a 3" finishing nail into the post and placing the anemometer on top of the nail.

12 Check to see that your anemometer turns freely.

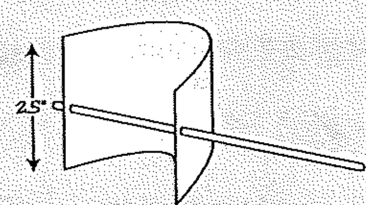
- If it does not, try cutting off the head of the nail and sharpening it to a point with a file.
- Lubricating this point with oil may help the anemometer move more easily.

HANDMADE ANEMOMETER

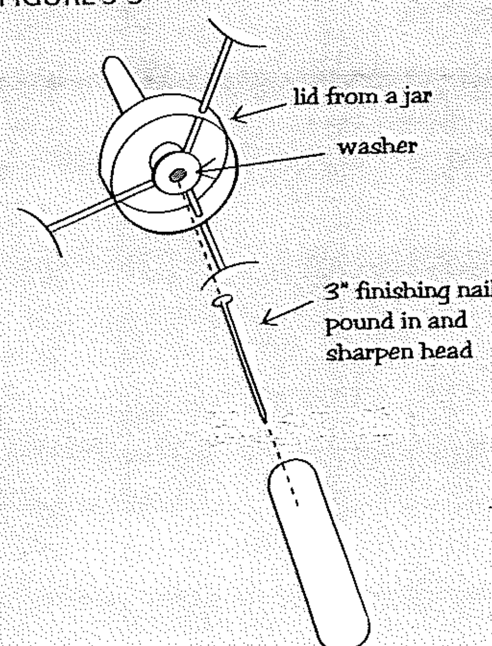
FUNNEL WIND CATCHER
FIGURE 3-1



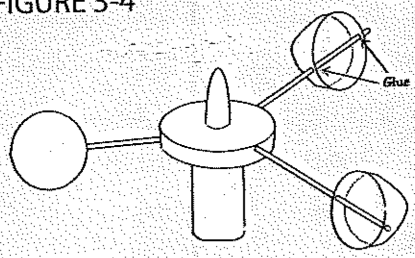
SHEET METAL WIND CATCHER
FIGURE 3-2



ATTACH BASE TO TOP
FIGURE 3-3



TOP WITH CUPS/FUNNELS
FIGURE 3-4



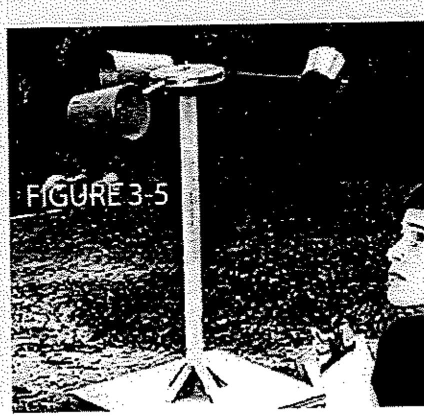


FIGURE 3-5

Anemometer
Determining Wind Speed

1 Mount or place your anemometer in an open area. Try to avoid obstructions such as trees or buildings that can affect the wind.

2 Before using your anemometer you must calibrate or calculate the wind speed in miles per hour, mph, as described below.

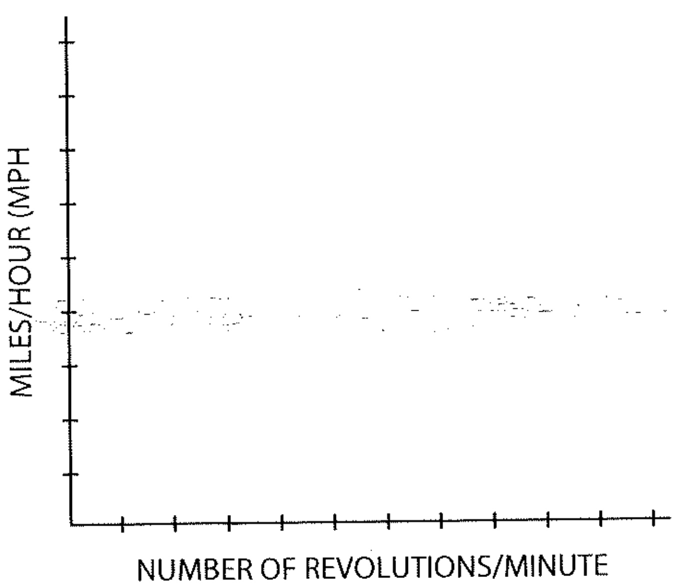
3 Count the number of revolutions in one minute.

4 Record the date, time, and wind speed.

WIND SPEED DATA CHART [TABLE 1]

Reading	Date	Time	Revolutions Per Minute (RPM) x-axis	Miles Per Hour (MPH) y-axis
1				
2				
3				
4				
5				
6				

WIND SPEED GRAPH



DETERMINING THE WIND SPEED

Wind speed is reported in miles per hour, mph, so you need to convert the number of revolutions of your cup anemometer to wind speed in mph. Choose one of the following three methods to determine wind speed from your anemometer: anemometer calibration; calculation; or vehicle calibration. Calibration is a process of comparing an unknown value to a known value. The three methods are described below.

Anemometer Calibration

This method uses a second anemometer for calibration. You can purchase or borrow an anemometer or use the wind speed that is reported in the media from a source near you. Choose how you would like to calibrate your anemometer (A or B) and follow the steps to create a Wind Speed Data Chart for your anemometer.

A Use a purchased or borrowed anemometer that records the wind speed in mph.

- Count the number of revolutions for one minute (RPM) on your handmade anemometer.
- Note the purchased anemometer's wind-speed reading in mph.
- Record your data in the Wind Speed Data Chart following the directions for recording data. (page 9).
- Collect 10 data points.
- Make a Wind Speed Graph following the directions for recording data (page 9).

B Check a local weather source on radio or TV or online for the reported current wind speed. Using a weather report will not be as accurate as reading from another anemometer in your location because the weather station that is reporting may be miles away from your anemometer, and winds can vary from place to place.

- Count the number of revolutions for one minute (RPM) on your handmade anemometer.
- Obtain the wind speed reported in mph by your weather source.
- Record your data in the Wind Speed Data Chart following the directions for recording data.
- Collect 10 data points at least 4 hours apart.
- Make a Wind Speed Graph following the directions for recording data (page 9).

Calculation

Use mathematics to calculate the wind speed.

1 Measure the radius of the circle described by the funnels — the distance from the center of your anemometer to the center of one of the funnels, cups, or flat metal pieces. They should each measure the same distance.

2 Count the number of anemometer revolutions for one minute.

3 Calculate the wind speed using the following formula:

0.00595 x the radius of the anemometer in inches x number of revolutions per minute

This formula was determined by multiplying the distance traveled by the funnels or cups ($2\pi r$, the circumference, or distance traveled) by 60 (minutes in an hour); dividing this value by 12 (inches in a foot); and dividing that by 5,389 (feet in a mile), which will convert the rpm to mph. The radius, r, is measured in inches.

4 Record your data in the Wind Speed Data Chart following the directions for recording data (page 9).

5 Collect 10 data points at least 4 hours apart.

6 Make a Wind Speed Graph following the directions for recording data (page 9).

Vehicle Calibration

Use an automobile's speedometer (mph) to calibrate your anemometer. This method is the last choice because of safety considerations. It can be used, however, if you enlist the help of a careful, competent adult driver and have access to a straight stretch of a deserted country road.

1 Mount your anemometer securely on the handle of a broomstick or a similar rod.

2 Ask the adult to drive at a constant speed for one minute at each speed — 5, 10, 15, and 20 mph.

3 Hold your anemometer out of the car window, well above the car roof, and count the number of revolutions at each speed. Note: If the wind is blowing when you are calibrating your anemometer, you must repeat the procedure at the same speed in the reverse direction. The average of the two measurements will give you a more accurate calibration.

4 Record your data in the Wind Speed Data Chart following the directions for recording data.

5 Collect 10 data points at least 4 hours apart.

6 Make a Wind Speed Graph following the directions for recording data.

Recording Data

Record data in the Wind Speed Data Chart and make a Wind Speed Graph following the directions below. Then you can use your Wind Speed Graph to find the wind speed in mph based on the number of revolutions of your cup anemometer.

1 Take at least 10 readings at least 4 hours apart.

2 Record the following data on the Wind Speed Data Chart.

- Date, time, and RPM (from your handmade anemometer)
- Wind speed from the anemometer or media report

3 Graph the 10 data points (RPM, MPH) on the Wind Speed Graph.

- Point to the RPM on the x-axis and the MPH on the y-axis and draw an imaginary straight line from each until they intersect. Place a data point there.

4 Connect the data points and extend the line.

5 Use the Wind Speed Graph to determine the wind speed:

- Count your anemometer's RPM.
- Find that value on your graph.
- Follow an imaginary vertical line up to your data line.
- Follow an imaginary horizontal line to the y-axis.
- Read the wind speed in mph.

BAROMETER A barometer measures pressure changes but will respond to both pressure changes and temperature changes, so it must be kept at a constant temperature to measure pressure accurately. Barometers indicate if the air pressure is rising or falling.

Weather Tote:

NOTE: There are two methods for making a barometer using either a tin can or baby food jar. You may make either one.

- ☐ Relative Humidity and Dew-Point Temperature Chart
- ☐ Aneroid barometer or weather source for the report of the current barometric pressure
- ☐ 1" x 8" x ¾" piece of wood
- ☐ Glue or rubber cement
- ☐ Pointer made from a small stick, Popsicle stick, or small flattened drinking straw
- ☐ Index card
- ☐ Choose the type of barometer you want to make, and gather the additional items listed.
    - The baby food jar barometer is easiest to make.
    - Do not use plastic containers because they will give inaccurate readings.

TIN-CAN BAROMETER

- ☐ Tin can with two metal ends
- ☐ Wood, 6" x 15 x ¾"
- ☐ Wood, 1" x 8" x ½"
- ☐ Cork from a small bottle
- ☐ Thin stick or broom straw
- ☐ Toothpick
- ☐ Three screws
- ☐ Nails
- ☐ Liquid solder or hot glue gun and glue stick

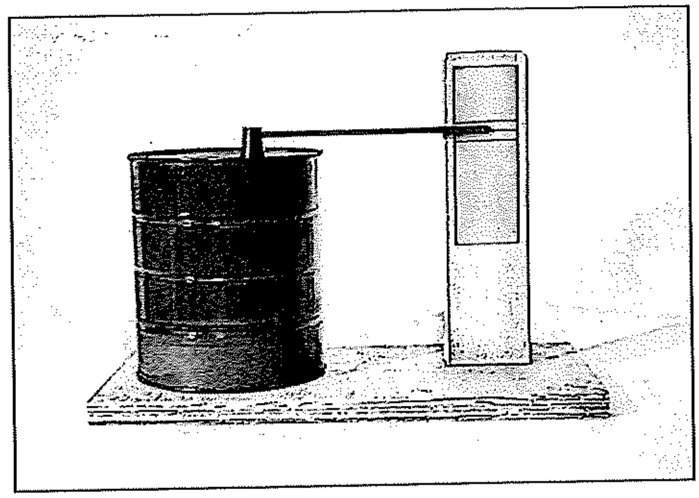


Figure 4-1

BABY FOOD JAR BAROMETER

- ☐ Baby food jar
- ☐ Wood, 6" x 6" x ¾"
- ☐ Wood, 1" x 8" x ½"
- ☐ Piece of rubber — a balloon cut open will work
- ☐ Rubber band(s)

NOTE: Balloon rubber is thin and will slowly lose air, so this barometer will only be accurate for a couple of weeks. You will need to replace the balloon rubber every two weeks.

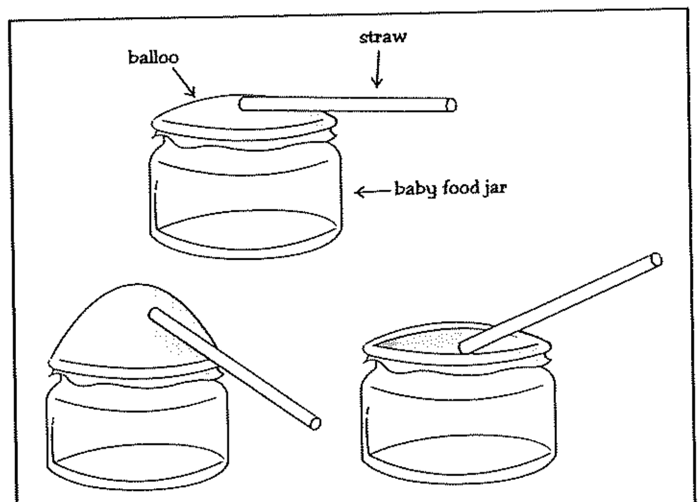


Figure 4-2

Barometer

NOTE: You can use any size of can for this instrument, but a larger can (such as a coffee can) will give better readings. It is more sensitive because it has a wider surface for the air pressure to act on.

TIN-CAN BAROMETER

1. Nail the 1" x 8" piece of wood to the 6" x 15" baseboard. See Figure 4-1.
2. Attach the can to the baseboard with three equally spaced screws around the outside of the can. The screw heads will hold the can in place. Or glue a piece of foam, the size of the can, to the wood and place the can on top of it.
3. Attach the lid to the tin can using liquid solder or hot glue, leaving one small hole for air to escape.

4 Heat the can in hot or boiling water to force out as much air as possible.

5 Seal the hole immediately with liquid solder or hot glue.

6 Glue the cork on the top of the can just to the right of center.

7 Glue a thin stick or broom straw to the cork. Glue a toothpick to the end of the stick/broom straw. This is the "pointer."

8 Glue an index card to the piece of wood, positioned so the pointer is near the center of the card.

BABY FOOD JAR BAROMETER

1 Remove the lid from the jar. See Figure 4-2.

2 Stretch the piece of rubber over the opening, and attach it to the jar tightly with one or more rubber bands.

3 Nail the 1" x 8" piece of wood to the baseboard to form an upright stand.

4 Glue the jar to the 6" x 6" baseboard, so it won't move.

5 Glue the drinking straw to the top of the jar. This is the "pointer."

6 Glue the index card to the stand, positioned so the pointer is near the center of the card.

Barometer

Determining Air Pressure Trends

You can use your barometer to determine if the air pressure is rising or falling. But before you use your barometer you will need to calibrate it. Calibration is a process of comparing an unknown value to a known value (standard).

- Compare your barometer daily for a month by using a borrowed aneroid barometer or your radio, TV, or online weather source as your standard.
- Mark the index card where the pointer indicates and write the value.
- Note if the pressure is rising or falling.

NOTES:

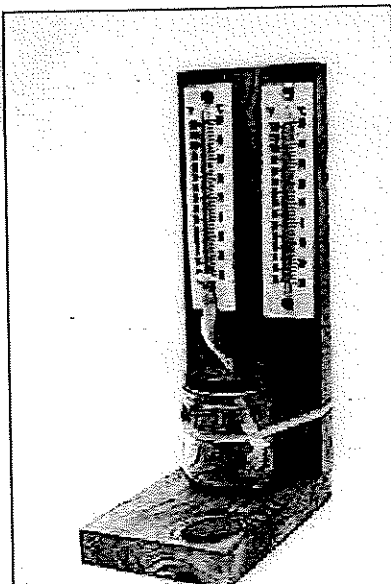
- When the air pressure is low, the air inside the jar will expand and press on the rubber. This will cause the straw to point down.
- When the air pressure is high, the straw will depress the rubber and cause the straw to point up.
- Barometer changes are generally slight. They are most interesting when the temperature is rising or a storm is approaching.

HYGROMETER

A hygrometer is used for measuring the moisture content in the air.

You will use two thermometers to make a hygrometer that can be used to determine humidity, the amount of moisture in the air. Most scientists use a sling psychrometer, which also uses two thermometers, one of which is covered by wet cloth. It is twirled in a circular pattern. The dry psychrometer determines the temperature of evaporation more quickly than the hygrometer in this activity. Both methods use the Relative Humidity and Dew-Point Temperature Chart to determine the relative humidity and dew-point temperature.

HYGROMETER
[FIGURE 5-1]



Weather Tote:

- ☐ Wood, 1" x 6" and about 2 feet long
- ☐ Piece of hollow shoestring, about 6" long
- ☐ Scrap wood, about 2" x 4", for drilling
- ☐ Saw
- ☐ Hammer
- ☐ Nails (1⅝" panel nails work well)
- ☐ Jar with lid — a baby food jar or similar glass or plastic jar
- ☐ Two similar thermometers, purchased or borrowed
- ☐ A long twist tie
- ☐ Scissors
- ☐ Drill and ¼" drill bit
- ☐ Relative Humidity and Dew-Point Temperature Chart

Hygrometer

1 Cut the wood to form a stand (see Figure 5-1).
   - The baseboard should be about 6", large enough to hold your jar and to give the stand stability.
   - The upright board needs to be tall enough to hold the thermometers about an inch or two above the jar placed on the baseboard.

2 Set the jar on the wooden stand.

3 Mount the thermometers side by side on the upright board, so they are an inch or two above the top of the jar.

4 Compare the temperature readings on the two thermometers.
   - If they do not record the same temperature, you may be able to adjust one thermometer.
   - If you cannot adjust the temperature on your second thermometer (Thermometer 2), note the difference in temperature and add or subtract that difference for all your readings for this thermometer.

5 Drill a ¼" hole in the center of the jar lid, with the lid held on a block of wood so that you drill through the lid and into the wood.

6 Place the hollow shoestring over the bulb of Thermometer 2.
   - Secure the shoestring with a twist tie above the bulb of the thermometer.
   - Cut off the excess twist tie with scissors.

7 Fill the jar with water.

8 Push the shoestring through the hole in the jar lid, so it lays on the bottom of the jar.

9 Attach the lid to the jar.

10 Secure the bottle to the stand with a rubber band.
   - Push any extra shoestring into the jar so the shoestring above the lid does not sag.
   - Make sure the shoestring is drawing water to Thermometer 2.

Hygrometer
Measuring Temperature and Relative Humidity

1 Place the hygrometer outdoors in the shade, away from the sun.

2 Make your own table with 8 rows and 5 columns. You can use a piece of paper or computer.
   - Row 1, column headers: Dry-Bulb Temperature (°F), Wet-Bulb Temperature (°F), Temperature Difference (°F), Relative Humidity (%), and Dew-Point Temperature (°F)
   - Rows 2–8, columns: the dates for collecting this data for a week, starting with the current date.

3 Read the dry-bulb temperature and wet-bulb temperature from your hygrometer.

4 Record data each day for a week.

- Thermometer 1 records the dry-bulb temperature and gives the air temperature.
- Thermometer 2 records the wet-bulb temperature. Remember to correct the temperature on thermometer 2, if needed.
- Calculate the temperature difference between your readings of Thermometer 1 and thermometer 2.
- Follow these directions to find the relative humidity and dew-point temperature using the Relative Humidity and Dew-Point Temperature chart.

  Find the dry-bulb temperature (column 1) with your left hand and the temperature difference (row 1) with your right hand.

  Move your index fingers (left index finger moves to the right and right index finger moves down) to find the box in the chart where they intersect.

  Read the value of the relative humidity and dew-point.

  - The top number (black) gives the relative humidity.
  - The bottom number (red) gives the dew-point temperature.

  EXAMPLE: If the dry-bulb temperature is 62°F and the wet-bulb temperature is 55°F, the difference is 62 minus 55=7.

  - Column 1: mark 62 with your left index finger.
  - Row 1: mark 7 with your right index finger.
  - Move your fingers (left to the right; right moves down) to find the intersecting box.
  - Read the relative humidity as 64 and the dew-point temperature as 49.

- If the dry bulb and wet bulb have the same temperature, the relative humidity is 100%, and the dew-point temperature is the same temperature as your thermometers.
- If the wet bulb is higher than the dry bulb, your thermometers may not be calibrated correctly or the temperature has dropped rapidly outside and it will take some time for the wet bulb to adjust. If this happens, wait an hour and take your reading again.

SHARE WHAT HAPPENED:

- What weather instrument(s) did you make?
- Which instrument was the most fun to make or use?
- What was most challenging?

APPLY: What did you learn about the weather while you were making your instruments?

GENERALIZE TO YOUR LIFE: Why do you think people are so interested in the weather?

Fly Higher:

Review and compare the instructions in the NOAA publication, Build Your Own Weather Station, with the instructions given in this activity.

Purchase or make a sling psychrometer (instructions can be found online) and compare relative humidity readings with the hygrometer you made.

Collect pictures of different ornamental wind vanes.

MINI-TORNADO

How can a water vortex created in a bottle help you understand tornadoes?

intro Tornadoes have always been both fascinating and dangerous. Capable of destroying entire cities, tornadoes can produce the highest wind speeds on earth. A tornado striking near Moore, Oklahoma, on May 3, 1999, had a measured wind speed of 318 mph, the highest wind speed ever recorded.

Our understanding of weather has increased significantly during the past thirty years, allowing earlier warning of potential or imminent tornadoes. Nevertheless, questions remain about why some severe thunderstorms produce tornadoes and others do not.

This activity demonstrates how water, like air, can create a vortex. A vortex illustrates the forces that help create a tornado's visual structure.

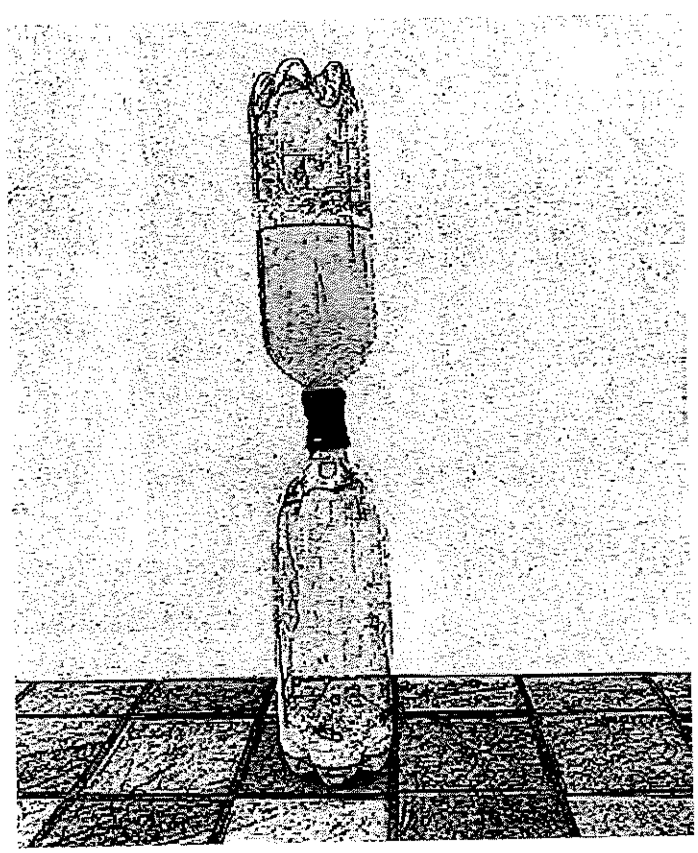
OBJECTIVE: Generate a water vortex that simulates a tornado and observe its progression.

Weather Tote:

- ☐ Two clear 2-liter plastic soda bottles, empty and clean
- ☐ Tornado Tube plastic connector

  Available from science museums, science stores, novelty stores, scientific supply companies, and teacher-materials shops

  Or make your own with a metal washer, about 1 inch in diameter with a 3/8-inch diameter hole, and plastic electrical tape.



- ☐ Liquid dishwashing detergent
- ☐ Food coloring, (optional)
- ☐ Stopwatch or clock with a second hand

1 Fill one soda bottle about two-thirds full with water.

2 Add a drop of dishwashing detergent and a couple drops of food coloring to make the vortex easier to see.

3 Screw the plastic connector onto the top of the bottle.

4 Attach the empty bottle to the open end of the connector or flat washer (between the bottles) and electrical tape.

5 Turn the two-bottle assembly over, and replace the assembly on the flat surface with the filled bottle on top.

6 Watch the water drip down into the lower bottle as air simultaneously bubbles up into the top bottle. The flow of water may even come to a complete stop.

7 Rapidly spin the bottles in a circle a few times, keeping the bottom bottle in contact with the flat surface.

8 Observe what happens in the bottles.

EXPERIMENT WITH YOUR VORTEX CREATOR:

- Change how you spin the bottles. What happens?
- Change how long you spin the bottles. What happens?
- Observe any differences in the shape and length of time the vortex lasts.

Almost 99 percent of tornadoes spin counter-clockwise in the Northern Hemisphere. Test both rotations (counterclockwise or clockwise) with a stopwatch to see which has a longer-lasting funnel. Was there a difference, or were they the same?

SHARE WHAT HAPPENED:

- What caused the funnel to form inside the bottle?
- How did the funnel change as time passed?
- Did the "tornado" continue until the water flowed out, or did it stop before the water ran out? Explain why you think this happened.
- Did experimenting with the initial force cause differences in the shape and length of time the vortex lasted? Explain your findings.

APPLY: Look at the photos of tornadoes below and answer the questions that follow.

NOAA - Source: National Oceanic and Atmospheric Administration/Department of Commerce.

- Which image is most like the vortex you observed in the bottle?
- What is different about the images?

GENERALIZE TO YOUR LIFE: If a tornado warning is issued for your area, where is the safest place to go in your school? Your home? While in a car or bus on the road?

OUT OF THE DUST

What was the Dust Bowl? How did it affect the people who lived through it?

The Dust Bowl is the name given to a period characterized by severe dust storms that occurred in the Great Plains of the United States and Canada. From 1930 to 1949 — primarily 1930-1936 — the prairie soil dried, turned to dust, and blew eastward and southward in large dark clouds.

Decades of extensive farming, without conservation to prevent erosion, caused the Dust Bowl. The Great Plains were very fertile during times of adequate rainfall. When farmers plowed and planted, they unknowingly dislodged the natural grasses that kept the soil in place and trapped moisture.

The Dust Bowl affected 100 million U.S. acres, especially in the panhandles of Texas and Oklahoma, and adjacent land in New Mexico, Colorado, and Kansas. Immense dust storms with names like "Black Blizzards" and "Black Rollers" reduced visibility to a few feet. At times storms deposited soil into the Atlantic Ocean, and clouds blackened the sky as far away as New York City and Washington, DC.

Dust storms caused major ecological and agricultural damage and occurred during this country's worst economic depression. Many people had to leave the farms that they had built. Some even died.

The novel *Out of the Dust*, by Karen Hesse, is a Newbery Medal-winning story about the Dust Bowl. It is a work of fiction based on actual events and actual people, and tells the story of a young girl who stayed in Oklahoma and persevered. Note: This book has very graphic images of injuries the young girl's family suffered after a kerosene-fueled fire.

Dust storm

OBJECTIVE: Understand that weather can change people's lives and fortunes.

Weather Tote:

☐ *Out of the Dust* by Karen Hesse.
[Hesse, Karen. *Out of the Dust*. New York: Scholastic, 1999. (ISBN: 978-0-590-37125-4)]

1 Read *Out of the Dust* by Karen Hesse.

2 Discuss the Chat questions with your adult leader, parent, or guardian.

SHARE WHAT HAPPENED:

How did the drought and dust storms affect Billie Jo's day-to-day life?

In any life experience, factors like the weather are only partial causes for changes. What other circumstances contributed to the changes in Billie Jo's life?

What kind of student was Billie Jo, and what were her talents? In what ways were her talents like yours?

How were Billie Jo's teachers important?

What did Billie Jo learn when she tried to run away?

What did you think was the most interesting part of the book? Why?

APPLY: How did the Dust Bowl change agricultural practices? Are any of these practices used today?

GENERALIZE TO YOUR LIFE: Can you think of weather events — either positive or negative — that have changed things in your life or the lives of your family members? Explain your answer.

Fly Higher:

Read more about the Dust Bowl. For example, research what happened to the many Dust Bowl families who moved to California with the hope of finding a new life.

Learn more about the Dust Bowl by watching the PBS documentary, *The Dust Bowl*, by Ken Burns, www.pbs.org/kenburns/dustbowl/.

NOTES

SEASONS

What causes the changes in the yearly weather patterns we call seasons?

intro We are used to seeing many different kinds of weather in the Midwest. Although we might experience a thunderstorm in January or snow in May, we know that winters are usually cold and snowy, and summers, hot and humid. We anticipate the general weather pattern that is based on our climate. The weather changes as the seasons change, and nature responds to the changes in weather. For example, we expect the trees to grow leaves in the spring and to lose them in the fall.

The sun provides the energy that warms earth. Variations in the tilt of earth as it revolves around the sun are responsible for seasonal changes. Many people mistakenly assume that summers are warmer because earth is closer to the sun at that time of the year. Because earth's orbit is not a perfect circle — it is an **ellipse** — earth is actually closest to the sun in January and farthest from the sun in July! This 3 percent difference in distance is very slight and has little or no effect on our seasons.

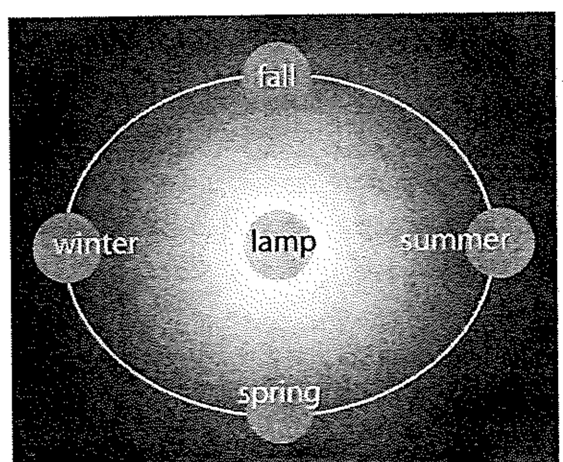
The tilt of earth is responsible for seasonal changes. The axis of earth is tilted at 23.5° in relation to earth's orbit around the sun. You will explore how this tilt causes the seasons.

OBJECTIVE: Understand how changes in the earth-sun relationship cause seasons.

Weather Tote

- ☐ A table
- ☐ A standard world globe on a tilted stand. You may borrow one from your school or library.
- ☐ A light source, such as a lamp, without its shade
- ☐ A dark room
- ☐ A protractor to measure the tilt of the globe.

do it Perform this activity in a dark room, using the lamp as the only light source.



EARTH'S ORBIT [FIGURE 1]

1 Place the lamp in the center of a table.

2 Set the globe on the right side of the table at the "summer" position shown in Figure 1.

3 Tilt the North Pole toward the lamp about 23 degrees.

The globe must be at the same height as the light bulb.

Raise the level of the globe by placing it on a stack of books, if necessary.

The resulting light shine represents the first day of summer, known as the summer **solstice**.

4 Turn the globe slowly counterclockwise to experience one day.

Find where you live on the globe. Observe what happens to the light there.

Observe how the light shines on both the North Pole and the South Pole.

5 Move the globe to the other three positions shown in the figure: Autumnal **Equinox** (fall), Winter Solstice (winter), and Vernal Equinox (spring).

Keep the tilt of the globe at 23 degrees, always leaning toward the left. This will track the actual progress of earth through the seasons.

8 Observe and record what happens to the light where you live and at both poles as you rotate the globe.

OBSERVATIONS:

Summer ______________________________

____

Fall ______________________________

____

Winter ______________________________

____

Spring ______________________________

____

SHARE WHAT HAPPENED:

- Do people in the Midwest receive more sunlight in the summer or winter?
- During the summer is it ever dark at the North Pole? If so, when and why?
- How might these differences affect our seasons?
- Contrast the difference between the summer and winter sunlight at the North Pole.
- Your globe might have the Tropic of Cancer marked at 23.5° north of the equator. If it does, notice that on the first day of summer, the sun stays directly over that line. What line does the sun stay over on the first day of winter?

APPLY: Calculate the total amount of daylight for each city:

FIRST DAY OF SUMMER:

Summer Solstice	Sunrise	Sunset	Daylight Length
Indianapolis, IN	6:17 AM	9:21 PM	
Miami, FL	6:30 AM	8:15 PM	
Anchorage, AK	4:20 AM	11:42 PM	

Note: Summer times are daylight saving time

FIRST DAY OF FALL:

Autumal Equinox	Sunrise	Sunset	Daylight Length
Indianapolis, IN	7:33 AM	7:40 PM	
Miami, FL	7:10 AM	7:15 PM	
Anchorage, AK	7:47 AM	7:55 PM	

Note: Daylight saving time

FIRST DAY OF WINTER:

Winter Solstice	Sunrise	Sunset	Daylight Length
Indianapolis, IN	8:06 AM	5:23 PM	
Miami, FL	7:03 AM	5:35 PM	
Anchorage, AK	10:14 AM	3:42 PM	

Note: Winter times are standard times

- Using your globe and lamp, explain why daylight lengths are different at these three locations at the summer solstice and the winter solstice.
- Using your globe and lamp, explain why daylight lengths are similar at these three locations at the autumnal equinox.
- What would be the daylight length on the first day of spring (vernal equinox)?
- We have seasonal changes in the Midwest. Do you think seasonal changes are more or less obvious in Alaska? Explain your answer.
- Why do you think Miami, Florida, has little seasonal change?

GENERALIZE TO YOUR LIFE: The actual **scale** of the earth and sun cannot be shown in diagrams used to explain the seasons. This is because the distances that are involved are so large. The sun has a diameter of 865,000 miles, which is more than 100 times the diameter of earth (7,900 miles). If the sun was the size of a basketball, earth would be about the size of a BB pellet, and the moon would be the size of a speck of dust. Earth is also in orbit 93,000,000 miles away from the sun. That would put the BB that represents earth 74 feet away from the basketball!

- Where could you use the actual earth/sun scale to help people visualize how far we are from the sun? Sketch it.
- How might you use scale in planning the layout of your bedroom when adding a new dresser or larger bed?

Fly Higher

- Compare the actual location of the rising and setting sun at different times of the year from your house — especially on the first day of each season.
- Record the length of a shadow at about noon during different seasons throughout the year. Use an existing pole or the shadow your house makes.

NOTES

USING WEATHER INSTRUMENTS TO COLLECT DATA

What can your weather instruments tell you?

Weather observers record weather conditions all over the world. Some people have kept records for many years. They may keep data on temperature, **precipitation**, wind speed and direction, cloud conditions and types, **air pressure**, humidity levels, and when conditions create fog, haze, and smoke. In this activity you will join other weather watchers when you use your weather instruments to keep daily records of one or more of the following: precipitation, temperature, wind direction and speed, relative humidity, and **barometric pressure.**

OBJECTIVE: Learn the fun and value of keeping weather data.

Weather Tote:

Weather instruments that you made (see activity, Making Weather Instruments) or purchased. Choose the weather instruments you wish to use.

- ☐ Rain gauge
- ☐ Wind vane
- ☐ Anemometer
- ☐ Barometer
- ☐ Hygrometer
- ☐ Thermometer

See the Making Weather Instruments activity in this manual for instructions to make many of the instruments listed in the Weather Tote.

1 Set up your weather instruments where they will not be disturbed and away from trees and buildings that might affect wind direction and speed. Your thermometer, hygrometer, and barometer must be in the shade.

2 Make a Weather Data Sheet with enough rows for one month. (See example in Table 1.) Include a column for the date and each data type that you wish to collect: precipitation, temperature, wind (direction and speed), barometric pressure, and **relative humidity.**

3 Title your Weather Data Sheet with the month and year that you will be recording data.

4 Record weather data for a month using your weather instruments.

SHARE WHAT HAPPENED: Was your weather station in a good place? Why, or why not?

APPLY: How might you use your weather data?

GENERALIZE TO YOUR LIFE: What do you think you could learn by averaging weather data from 30 years of records?

Fly Higher

Learn about CoCoRaHS — the **Co**mmunity **Co**llaborative **Ra**in, **H**ail & **S**now Network. A brief overview is given below. Learn more by visiting www.cocorahs.org or reading the *Be a Weather Monitor* activity in the Level 3 4-H Soil and Water Science manual.

- CoCoRaHS is a network of **grassroots** volunteers who are dedicated to measuring and recording the rain, hail, and snow from their backyards.
- CoCoRaHS is the largest provider of daily precipitation observations in the country.
- Organizations involved in agriculture, public safety, and natural-resources management find great benefit from the data the network volunteers collect.
- Data is available free of charge at the Network's website, www.cocorahs.org.

WEATHER DATA SHEET FOR MONTH, YEAR [TABLE 1]

Date	Temperature	Precipitation	Wind Speed/ Wind Direction	Cloud Conditions	Air Pressure	Humidity	Other

GLOSSARY, LEVELS 2 & 3

Absorb: To take in all or part of a substance: The earth's surfaces absorb radiant energy.

Aerosol: Particles suspended in the air.

Air mass: A large body of air with similar temperature and moisture characteristics.

Air pressure: The force that air exerts on any surface in contact with it.

Albedo: The ratio of reflected light energy to absorbed light energy; ability to reflect sunlight.

Albedo effect: A measure of how much solar radiation is reflected.

Atmosphere: A layer of gases surrounding the earth, held in place by gravity.

Barometric pressure: Atmospheric pressure as measured by a barometer, usually in millibars or inches of mercury.

Calibrate: To check and adjust a measurement precisely against a standard measure.

Climograph: A graphic depiction of the precipitation and temperature for a certain location.

Clockwise: The rotational direction of the hands of a clock.

Cold front: A front formed by a cold air mass pushing into an area of warmer air.

Concentration: The amount of a substance in a given amount of another substance.

Condense: To convert a vapor or gas to a liquid.

Conduction: Energy transferred directly from one object to another through contact.

Contract: To become drawn together or reduced; shrink.

Contrail: Water droplets or ice crystals condensing in the supersaturated air of the upper atmosphere as a result of an aircraft's passage.

Convection: The transfer of energy through circulation within a liquid or gas.

Counterclockwise: Opposite to the rotational direction of the hands of a clock.

Deflect: To turn aside from a course.

Density: The degree of compactness of a substance; mass/unit measure ~ weight.

Dew-point temperature: The temperature to which air must be cooled to reach the point of saturation of water vapor; the temperature at which dew forms.

El Niño: A band of warm ocean water temperatures that periodically develops off the western coast of South America. It can cause climatic changes such as floods and droughts in many regions of the world, particularly along the coasts of Chile, Peru, New Zealand, and Australia.

Ellipse: A closed, symmetric curve shaped like an oval.

Equilibrium: A state of balance between opposing forces or actions.

Equinox: The time when the sun crosses over the equator, making night and day approximately equal in length all over the earth.

Evaporate: To convert a liquid to a gas or vapor.

Evapotranspiration: The combination of water being evaporated and transpired.

Fluid: A substance, gas or liquid, that is capable of flowing.

GLOSSARY, LEVELS 2 & 3

Fossil fuel: Any naturally occurring carbon or hydrocarbon fuel, such as coal, petroleum, peat, and natural gas, formed by the decomposition of prehistoric organisms.

Front: A boundary at ground level between two different air masses as one air mass moves into the area of the other.

Grassroots: Used to describe organizations that begin and operate at the local or community level.

Greenhouse gases: Gases in the earth's atmosphere that absorb and emit radiation, or heat energy, in the thermal infrared range.

Hardiness: The ability of a plant to withstand cold temperatures.

Heat index: An addition to temperature data during hot and humid weather to indicate health risks more accurately than temperature alone.

Infrared radiation: A form of longwave radiation, or heat energy, given off by warm objects.

Isobar: A line on a weather map connecting points of equal barometric pressure.

Isoline: A line on a map or chart connecting points of equal value.

Isotherm: A line on a weather map connecting points of equal temperature.

Jet stream: Fast-flowing, narrow currents of air. The main jet streams are located near the tropopause.

La Niña: A cold phase in which the sea surface temperature across the equatorial eastern central Atlantic Ocean is lower than normal by 3–5°C. La Niña often follows El Niño.

Latent heat: Heat absorbed or radiated during a phase change.

Longwave radiation: Radiant energy emitted by lower energy objects, like a warm body giving off heat.

Mammatus: An ominous-looking cloud forming at the bottom of cumulonimbus clouds, with a sagging, pouch-like appearance.

Overwinter: To survive freezing conditions, often applied to perennial plants.

Precipitation: The amount of water that falls to earth as hail, drizzle, rain, sleet, or snow.

Radiant energy: Energy emitted in waves.

Relative humidity: The ratio, given as a percentage, of the amount of water vapor in the air compared to the amount of water vapor in saturated air.

Saturation: An atmospheric condition at which the moisture level is at 100% relative humidity.

Scale: A proportion that shows the relative size between objects but that is not the same size as the original objects.

Shortwave radiation: Radiant energy emitted by high-energy sources like the sun or a light bulb, which emit light energy.

Solar maximum: A time of great solar activity identified by the occurrence of many sunspots.

Solar minimum: A time of low solar activity identified by the occurrence of few sunspots.

Solstice: Either of two times a year when the sun is at its greatest distance north or south of the equator.

Sunspot: Dark, cool patches that appear on the surface of the sun.

Sunspot cycle: An approximately 11-year cycle of the occurrence of sunspots.

GLOSSARY, LEVELS 2 & 3

Thermal: A rising warm current of air caused by uneven heating of the surface.

Tropopause: The transition between the troposphere (where temperature decreases with altitude) and the stratosphere (where temperature increases with altitude).

Troposphere: The lowest portion of the earth's atmosphere.

Vortex: A whirling mass of water or air that forms a visible column or spiral.

Water vapor: Water in the form of an invisible, colorless gas.

Weather map: A daily report of observations and probable changes in the weather.

Weather station: One of 1,500 locations where the National Oceanic and Atmospheric Administration (NOAA) collects weather data.

Weather station model: A symbolic illustration showing weather conditions at a weather station recorded using abbreviations and symbols.

Windchill: Addition to temperature data during cold and windy weather to indicate health risks more accurately than temperature alone.

Zone: An area where the average annual minimum temperature is within a set temperature range.

WEATHER AND CLIMATE SCIENCE

PHOTO AND GRAPHIC CREDITS

NOAA • Source: National Oceanic and Atmospheric Administration/Department of Commerce, www.noaa.gov

NASA • Source: NASA, www.nasa.gov

NWS, NOAA • NOAA National Weather Service, www.weather.gov

USDA ARS • United States Department of Agriculture, Agricultural Research Service, www.ars.usda.gov/

LEVEL 1

Comparing Climates • Page 3 • Trees, cactus, etc. • Jessica Harsh

Country of Colors • Page 7 • Plant hardiness zones • Adapted from the USDA Hardiness Zone map, courtesy USDA ARS,

Country of Colors • Page 7 • Indiana counties • Courtesy Purdue Cooperative Extension

Earth's Surfaces • Page 10 • Thermometer • Jessica Harsh

Earth's Surfaces • Page 11 • Sun's Heat • Adapted from

H_2O • Page 13 • Water cycle • Courtesy NOAA,

LEVEL 2

Carbon Footprints • Page 1 • CO_2 Levels • Courtesy NASA, http://climate.nasa.gov/vital-signs/carbon-dioxide/

Carbon Footprints • Page 2 • CO_2 Calculator • Website courtesy U.S. EPA, www.epa.gov/climatechange/ghgemissions/ind-calculator.html, downloaded 6/2014.

Cloud Formation • Page 2 • Mammatus clouds • Courtesy NOAA, www.srh.noaa.gov/jetstream/clouds/mam.htm, downloaded 9/2014

Global Winds • Page 2 • Global wind pattern • Courtesy NWS NOAA, www.goes-r.gov/users/comet/tropical/textbook_2nd_editon/print_3.htm, downloaded 8/2014

Greenhouse Effect • Page 4 • CO_2 at Mauna Loa • Courtesy NOAA, www.esrl.noaa.gov/gmd/ccgg/trends/#mlo_full, downloaded 8/2014

Hurricanes • Page 5 • Cyclone formation regions • Courtesy NWS NOAA, www.srh.noaa.gov/jetstream/tropics/tc_basins.htm, downloaded 10/2014

Out of the Dust • Page 1 • Dust storm • Courtesy of www.dreamstime.com (purchased by designer), 10/2014

Making Weather Instruments • Page 2 • Rain gauge • Purdue Extension Service

Making Weather Instruments • Page 4 • Wind vane • Purdue Extension Service

Making Weather Instruments • Page 5 • Wind vane construction • Figure 2-4: Purdue Extension Service

Making Weather Instruments • Page 6 • Anemometer • Purdue Extension Service

Making Weather Instruments • Page 10 • Barometer • Figure 4-2: Purdue Extension Service

Mini-Tornado • Page 2 • Tornados • Courtesy NOAA, downloaded 10/2014

LEVEL 3

Weather activities

Air Masses and Fronts • Page 1 • North American Air Masses • NOAA, www.srh.noaa.gov/crp/?n=education-airmasses, downloaded August, 2014

Air Masses and Fronts • Page 2 • Cold front • Natalie Powell, Just Natalie Graphic Design, adapted from http://www.srh.noaa.gov/crp/?n=education-airmasses , downloaded 9/2014

Air Masses • Page 3 • Warm front • Natalie Powell, Just Natalie Graphic Design, adapted from http://www.srh.noaa.gov/crp/?n=education-airmasses , downloaded 9/2014

Air Masses • Page 4 • Cold front sketch • Adapted from http://www.srh.noaa.gov/crp/?n=education-airmasses , downloaded 9/2014

Pressure Systems • Page 1 • Air response to pressure • Ted Leuenberger

Pressure Systems • Page 2 • Air movement Coriolis effect • Ted Leuenberger

Pressure Systems • Page 3 • Friction effects Typical US weather pattern • Courtesy NOAA, www.srh.noaa.gov/crp/?n=education-wind , downloaded 8/2014

Pressure Systems • Page 3 • Opt. • High and low pressure system • Courtesy NOAA, www.srh.noaa.gov/crp/?n=education-wind, downloaded 8/2014 (high & low, graphic)

Weather Station Models • Page 1 • Weather map • NWS, www.hpc.ncep.noaa.gov/noaa/noaa.gif, downloaded September, 2014.

Weather Station Models • Page 2 • Weather station model • Purdue Extension Service

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Weather in the Troposphere worksheet • Page 4 • Wind patterns & Jet streams • Courtesy NOAA, www.srh.noaa.gov/jetstream/global/circ.htm, downloaded 9/2014

Windchill and Heat Index worksheet • Page 3 • Windchill chart • Courtesy NOAA, www.nws.noaa.gov/om/windchill/index.shtml, downloaded 8/2014.

Windchill and Heat Index worksheet • Page 4 • Heat index chart • Courtesy NOAA, www.nws.noaa.gov/om/heat/index.shtml#wwa, downloaded 9/2014

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Climate and Climographs worksheet • Climographs • Natalie Carroll

Drought Monitoring • Page 3 • Palmer Z Index conditions • Courtesy NOAA, www.ncdc.noaa.gov/sotc/drought

Sun-Earth Relationship worksheet • Page 1 • Variations in temperature and CO_2 • Courtesy U.S. EPA, www.epa.gov/climatestudents/basics/past.html, downloaded, 9/2014

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Sunspot Cycle worksheet • Page 1 • Sunspot • Courtesy NASA, www.crh.noaa.gov/fsd/?n=sunspots, downloaded 9/2014

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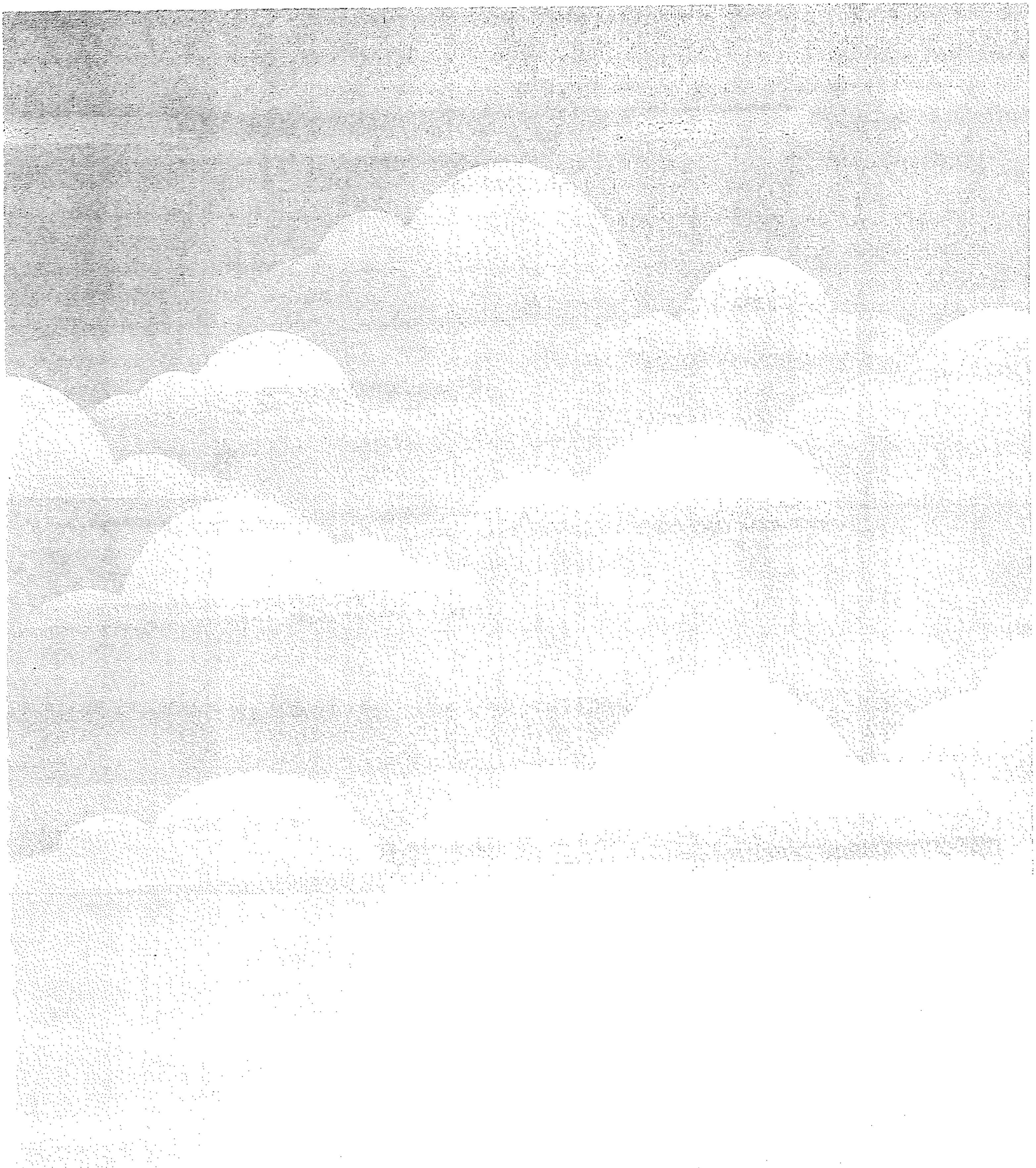
Sunspot Cycle worksheet • Page 3 • Yearly averaged sunspot numbers • Courtesy NASA, www.nasa.gov/mission_pages/sunearth/news/solarcycle-primer.html#.VAidE_ldWSo, downloaded 9/2014

Sunspot Cycle • Page 4 • Sunspot cycles • Courtesy NOAA, www.swpc.noaa.gov/SolarCycle/, downloaded 9/2014.

Sunspot Cycle • Page 4 • Mean annual temperature • Courtesy NASA, www.earthobservatory.nasa.gov/IOTD/view.php?id=76975, downloaded, 9/2014



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