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COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY—COLLEGE OF AGRICULTURE

Weather Variables

Kentucky 4-H Weather Project

Unit III

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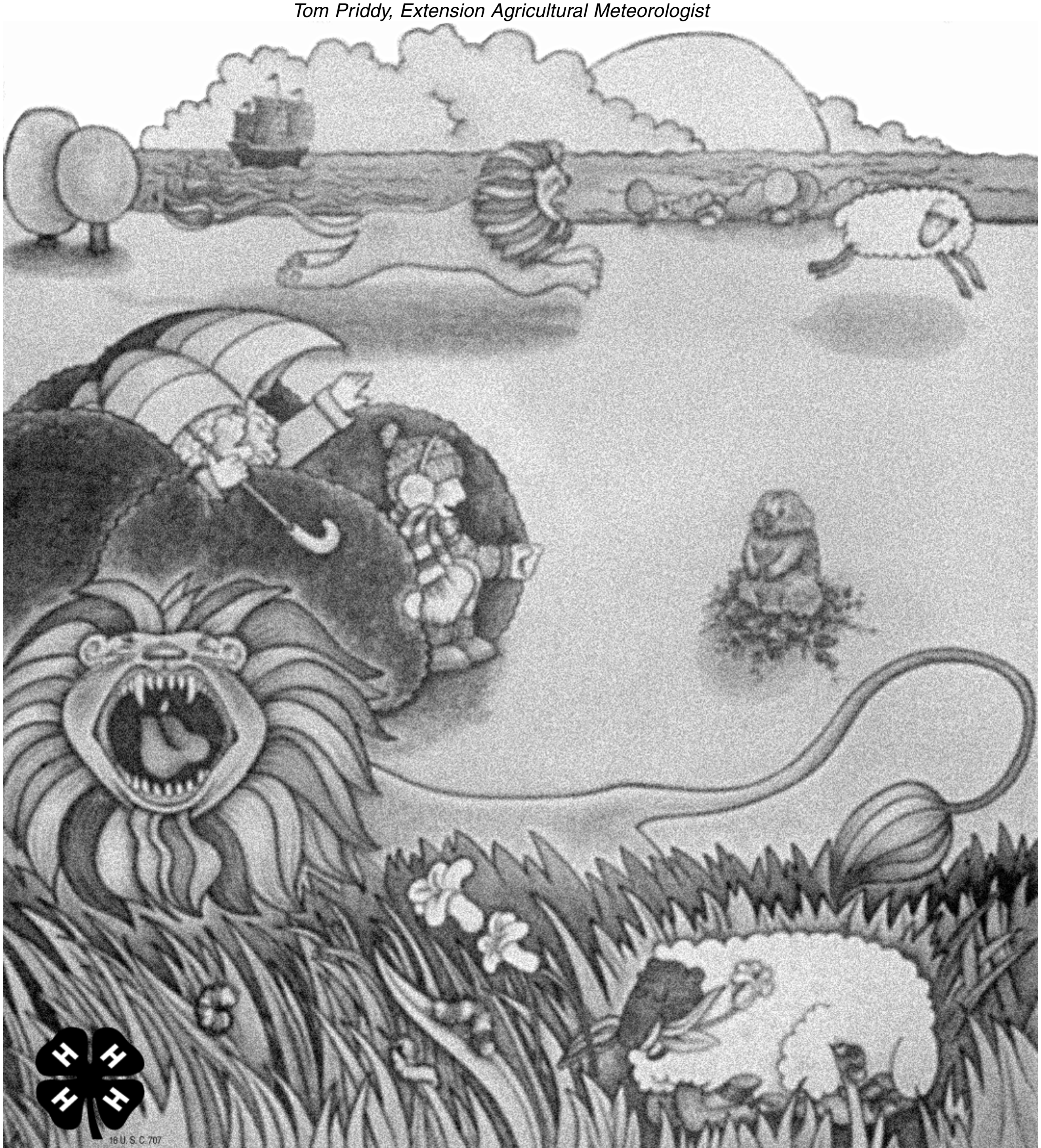


Weather Variables

Contents

Introduction

In this unit of the 4-H weather project, we will be looking at and describing how to measure the different elements that make the weather. These elements, such as air temperature, wind speed and direction, and precipitation, are normally called the weather variables because each element changes with time, yet are all related. We'll look at these relationships and forecasting in detail in Unit IV.

First, let's learn about temperature as a weather variable.

Objectives

- Learn how temperature changes affect other weather conditions.
- Learn how wind patterns affect the weather.
- Learn why humidity is one of the weather variables.

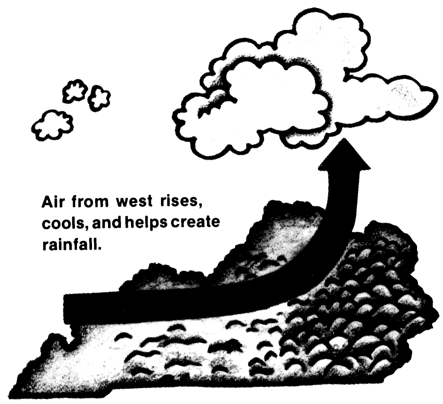
Activities

- Make a weather station.
- Give a weather demonstration.
- Exhibit a weather station at the county fair.
- Submit project records and weather observations.

Temperature

One of the first questions we ask about the weather is, "What is the temperature?" In Unit I, you learned how to keep temperature readings, and in Unit II, you continued to keep those readings. But just what do these readings mean? Temperature affects all other weather conditions. Without changes in temperature, there would be no changes in pressure, wind, or humidity.

For this project, you can use the same thermometer you used in Units I and II. If you need a new thermometer, many feed stores and farm-related businesses give them away free, or you may want to purchase an inexpensive one. Put the thermometer in your weather shelter where it will be out of direct sunlight and yet will have air circulating around it.



Why Kentucky Temperatures Vary

Have you ever participated in 4-H events with 4-H'ers from a different part of the state? In Kentucky, 4-H'ers compete on local, county, area, and state levels. Perhaps when you went to 4-H camp or attended Kentucky 4-H Week in Lexington, you had the opportunity to talk to members from many different 4-H areas. Did you know that their weather may differ from yours? Watch the TV weather brief for one week and record the daily high temperature near your location and one other location across the state. Discuss these differences in the temperature readings. One reason temperature varies throughout Kentucky is that our latitude varies. The farther one travels north, the cooler the temperature will be.

Another major reason for air temperature differences in Kentucky is the wide variety of terrains. In the Blue Grass and Fort Harrod areas, the land is fairly flat. In comparison, the eastern portion of the state has many hills and mountains. These differences in the terrain can readily influence weather changes. The Appalachian Mountains are located in the Northeast, Quicksand, and Wilderness Trail areas. As weather moves from the western sections of Kentucky, the air must rise to travel across the mountains. As the air attains a higher altitude, the temperatures cool. Not only does this produce a temperature change but also helps to create rainfall.

Activity: Making an Accurate Rain Gauge

In Unit II you learned how to use a simple rain gauge. For this unit, you will improve your rain gauge to make it more accurate. First, check your old rain gauge. Make sure the paint has not chipped and the can will not rust. Secondly, cut a circle of plastic foam that will fit inside the can snugly. Now, make a hole in the middle of the plastic large enough for the end of the funnel to be placed. The funnel must be the same diameter (distance across the top) as the can. Why is this so? (Hint: Compare the area of the top of the funnel to that of the can.) Put the funnel in place. By adding the plastic and the funnel, you have made a shield that will prevent evaporation and help you to make more accurate readings.

Now, you are ready to take readings. Measure the precipitation with a plastic ruler just as you did before. Remember to pour out the precipitation after each reading so your next reading will be accurate. (You will be keeping records of the precipitation for three months.) A general rule is to measure precipitation to the nearest tenth of an inch. (What other units of measure could you use? Hint: MM). Comparing your reading with the weather news will help you learn to be more accurate. You may wish to devise a holder for your rain gauge so it will not blow over. Keep your rain gauge on top of your weather station (see Figure 1).

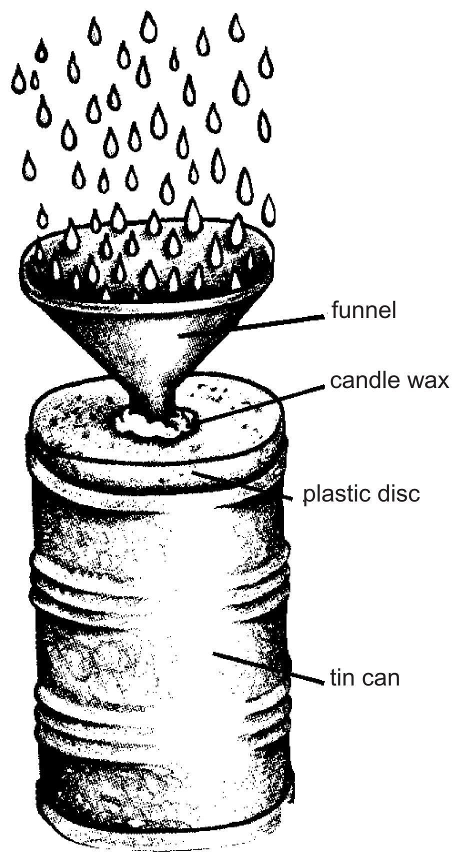


Figure 1. Advanced rain gauge.

Winds

Long before weather vanes or wind-measuring instruments had been thought of, early weather watchers recognized that wind direction was important. They didn't understand why, but they knew that wind from one direction generally brought fair skies while wind from another direction brought rain. So they watched the trees sway for a sign of the wind direction.

Making a Weather Vane

Today we have better ways of determining wind direction. A sensitive weather vane can be constructed fairly easily. You will need a piece of wood for an arrow about 12" long, ½" thick, and 3" wide; a mounting stick; a ¾" by 1' board; a nail or screw for attaching the arrow to the mounting stick; and two washers (see Figure 2).

Draw an arrow like the one shown. Then, cut the arrow out of the wood. You may ask your leader to supervise. Find the point where the arrow is equally balanced by steadying it on your finger. This is the balance point. Drill a hole at that point through the shaft of the arrow. Paint the weather vane white to match your weather station. Now, you are ready to attach the weather vane to your weather station. Be sure one side of the mounting stick faces north. Label the stick with the compass points—north, east, south, and west—ensuring that north on the stick points to the north.

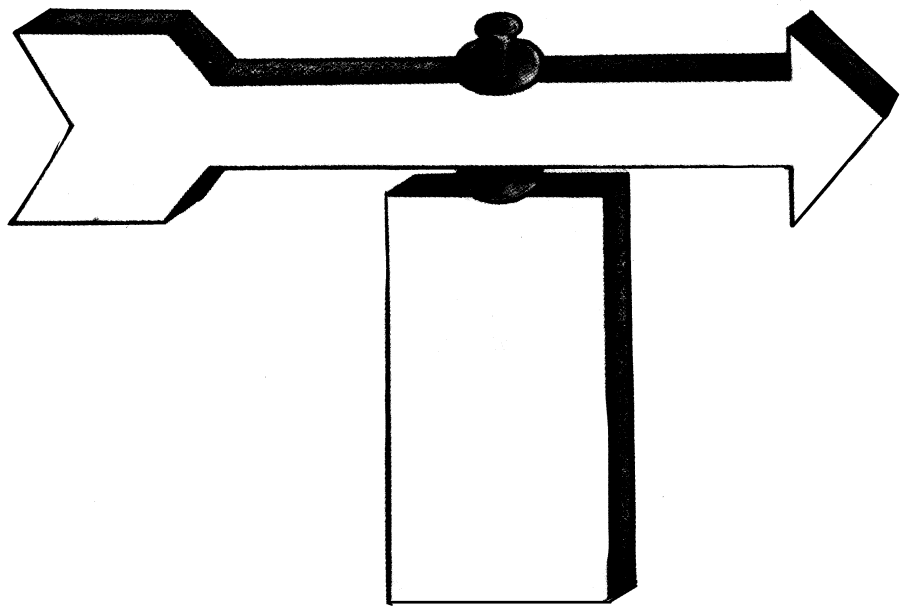


Figure 2. Weather vane.

Thar' She Blows

As you observe the wind for direction, you may start to notice a special wind pattern. Here are a few patterns that apply to many parts of the United States. See if it holds true to where you live.

- Winds from the north, northwest, and west generally bring dry and cooler weather. They blow from cooler masses of air to the north and drier masses of air to the west.
- Winds from the west, southwest, and south bring fair and warmer weather. They blow from warmer lands.
- Winds from the east, southeast, and northeast generally bring rain. They blow in from the ocean.

In Kentucky, the most common wind direction is from the south. However, during February and March, northwesterly winds are common. For the next three months, you will be recording the wind direction.

Where the Winds Come From

Wind is caused by air moving from a high pressure to a low pressure area. Whether the wind is a small gust playfully whirling up dust in the cornfield or a great wind of tornado force, the cause is always the same. Air that is under pressure is trying to escape or balance itself and heads for the nearest area of lower pressure. If the difference in the high and low pressure is great, the wind will be strong. If the difference is slight, the wind will be light.

The sun sets the stage for the world's great winds. At the equator, where the sun shines constantly each day, warm air rises in a mighty stream. The constant heat forms a low pressure belt of rising air known as the **Doldrums.**

According to Figure 3, as air rises from the Doldrums, it cools and drifts toward the poles. Some of it falls in the **Horse Latitudes,** around the 30° latitude, and piles up to create a belt of high pressure. The constant pressure of the Doldrums and the Horse Latitudes makes these regions of calm or very light winds. But in between them, air is on the move. Rushing from high pressure to low pressure, the air flows back toward the equator as the strong and steady northeasterly **Trade Winds.**

Some of the air that rises from the equator continues on to the poles. There it sinks, becomes compressed, and rushes out toward the 60° latitude. These icy blasts from the poles are the **Polar Easterlies.** If these icy winds dip into the middle latitudes, they can bring snow to Florida. The rest of the winds, between the Horse Latitudes and the Polar Easterlies, are blown back toward the poles. These are called the **Prevailing Westerlies.** They control the major wind currents for the United States and Europe.

Equator Doldrums are caused by warm air rushing over the equator area. Sailing ships often went on for days and days in this region without so much as a breeze of wind to fill

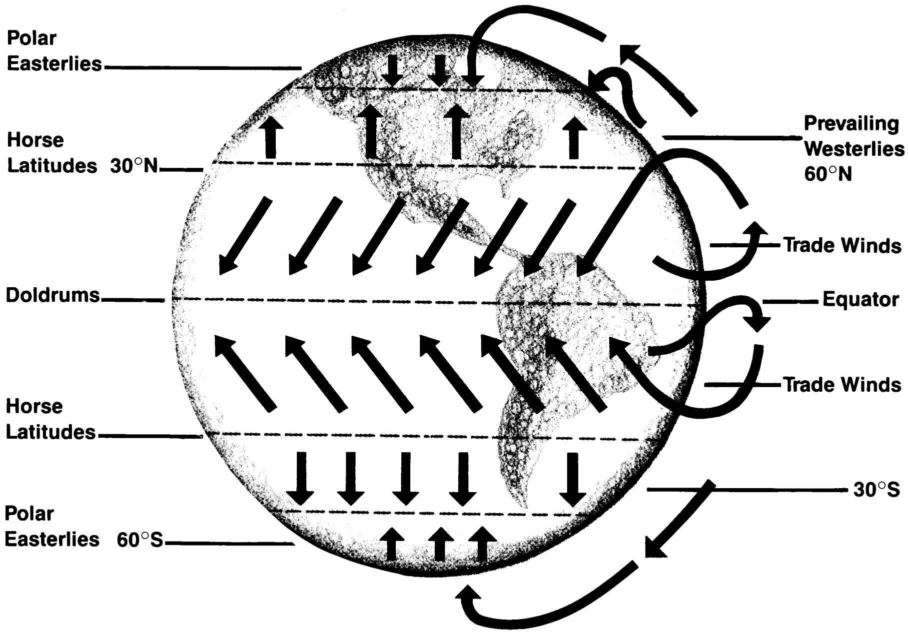


Figure 3. Earth's wind circulation pattern.

their sails. Heavy rainfall, summer typhoons, and hurricanes are typical for this region.

Trade Winds are so named because many years ago sailing vessels traveled the seas carrying cargo, and the winds of this region aided them in transporting their goods to other trade centers. The skies are mostly clear in this area.

The Horse Latitudes are a very calm, warm region. Winds there are very weak. The skies there are clear. Sailing ships carrying horses to the new world were often delayed in this area because of the lack of wind. The story goes that when food for the animals ran out, the animals starved to death and were thrown overboard.

The Prevailing Westerlies control the major air flows in the United States. If interference from polar fronts did not occur, the United States would have fair weather with clear skies and occasional rains.

Why Our Winds Blow from West to East

What would happen if the earth were not rotating? We already know that warm air rises. If the earth stopped spinning, the warm air would rise to the poles. There, the warm air would cool down and sink. The pressure of this sinking cool air would force surface air toward the equator at an even speed. This could drastically alter our normal weather patterns.

However, we know the earth rotates. It takes 24 hours for the globe to make one complete turn. At its widest point, the equator, the earth is approximately 25,000 miles around. The earth rotates eastward at 1,000 miles per hour. At locations north or south of the equator, the earth becomes fewer miles around. The equator must move faster than the poles to maintain the one rotation per 24 hour motion. Let's see how these different rates of rotation change the nature of our winds.

You will need an old phonograph record, a turntable, and a piece of chalk. Place the record on the turntable spindle. Now, pretend the center hole is the North Pole and the outer edge of the record is the equator. Take the phonograph record and rotate it counter-clockwise on the spindle. This represents the way the earth turns as seen from the North Pole. With a piece of chalk, try to draw a straight line from the spindle to the edge of the record while the record is in motion. What happens? All you can draw is a curve, as in Figure 4.

This is called the **Coriolis Effect.** Our winds move just like the chalk line. Winds coming in from the north curve to the right. From south, the winds curve to the left.

Kentucky Breezes and Winds

Kentucky has a number of lake and mountain areas. The varied temperatures of these geographical locations can affect the air current of these places. For example, there is almost

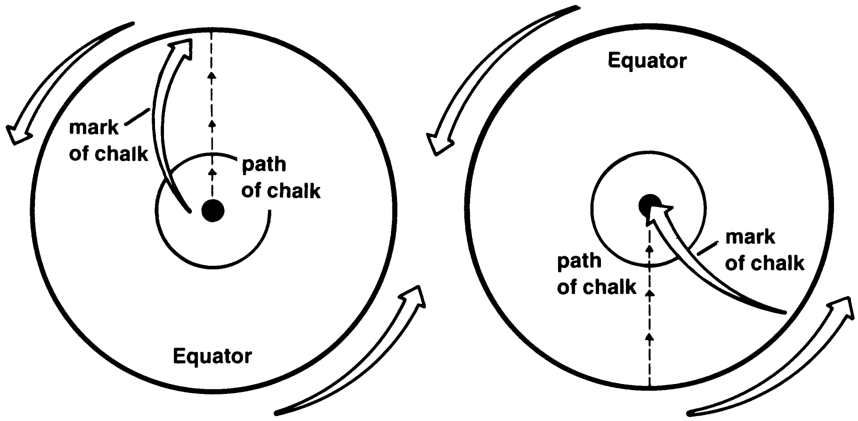


Figure 4. The Coriolis Effect.

always a breeze at Kentucky Lake. Do you know why? It blows one way during the day and the opposite way at night. During the day, the land heats faster than the water. Cooler, heavier air from the water blows toward the land. At night, the land cools faster than the water. The cool, heavier land air blows toward the lake.

Have you ever been to the top of Black Mountain, Kentucky's highest peak? If you have, you may have wondered about another special set of winds. During the day, these winds blow up the mountain. At night, they come whistling down. Can you figure out why? (Hint: Warm air rises upslope during the day; at night, cool air sinks.)

How Fast Is the Wind Blowing?

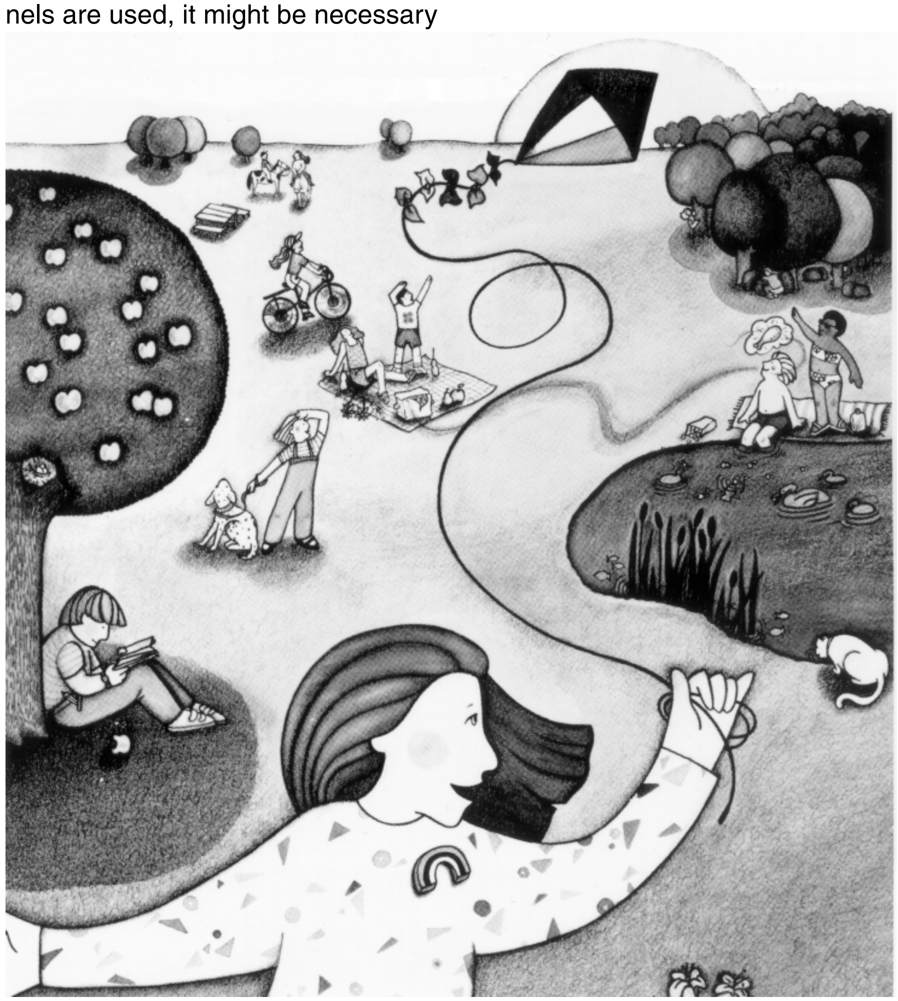
The speed of the wind tells us how great the pressure difference is between two masses of air. To measure wind speed, we can use a scale set up by Admiral Beaufort of the British Navy in 1805. (See the Beaufort Scale for Measuring Wind Speed on the next page.) However, to make our weather station more complete, we can build an **anemometer** to measure wind speed.

Experiment: Making a Cup Anemometer

You will need either three aluminum funnels (2½" in diameter) or three small gelatin molds, three 3/16" dowel rods (17" long), one metal (or plastic) pencil or pen cap, one metal lid 1¾" to 2" in diameter, one small washer 3/8" in diameter, one 3" nail, waterproof heavy-duty glue, paint, and liquid solder (see Figure 5).

Wind speed is often measured by a cup anemometer. There are many ways to build an anemometer of this kind. Cups can be made using either funnels or gelatin molds. If small funnels are used, it might be necessary to close the ends where the spouts were cut off with liquid solder. Construction details for the rest of the assembly are about the same regardless of the cups used.

1. Punch holes on opposite sides of the cups so that dowel rods fit tightly through them. Then, position as shown in the illustration and fasten with waterproof glue.
2. Make the hub assembly by using a small bottle lid about 1½" to 2" in diameter. The lid from an ink bottle or other small jar will work very well. Punch or drill three equally spaced holes in the rim of the lid to receive the cup spokes. Punch another hole in the center of the top. Glue a ballpoint pen cap into this hole as shown.
3. Glue a small washer over the opening of the pen cap.



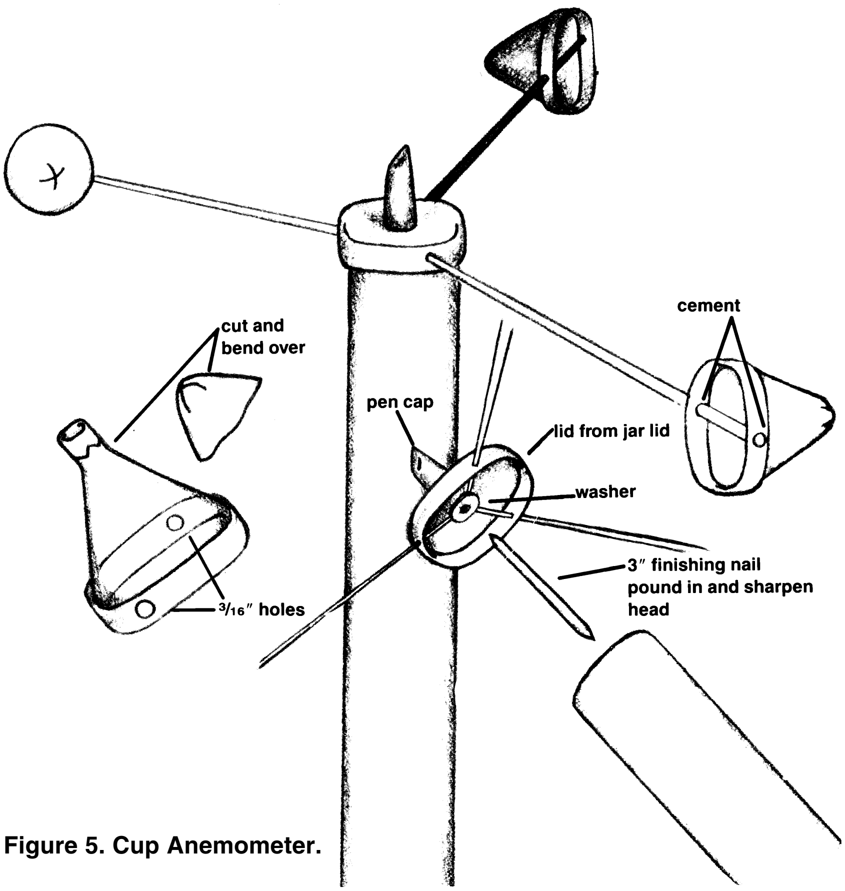


Figure 5. Cup Anemometer.

4. Insert the cup spokes through the holes in the rim of the lid until the ends touch the pen cap.
5. Glue the cup spokes to the cap and the underside of the washer.
6. Paint one cup and spoke a different color.

The anemometer can be calibrated in different ways. One way is to mount it on the handle of a broom stick or other suitable board that can be held out a car window well above the car roof while driving along a straight stretch of road. Have your parent or older brother or sister drive down the road, first at 5, then at 10, and finally at 15 miles per hour while you count the turns it makes in ten seconds. Multiply this number by six to get the number of rounds it makes per minute for 5, 10, and 15 miles per hour. Unless the calibration is made when the wind is not blowing, the procedure must then be repeated going at the same speed in the reverse direction. Then the average of these two measurements will give the more accurate calibration. The **Beaufort Scale** below may help you to interpret the readings you take. You will be recording the wind speed for the next three months.

The Beaufort Scale for Measuring Wind Speed

Description	Speed (mph)	Observation
Calm	less than 1	Smoke rises straight up. Trees are still. Water is mirror calm.
Light air	1-3	Smoke drifts in direction of wind. Leaves on trees move slightly.
Light breeze	4-7	Wind can be felt on face. Leaves rustle.
Gentle breeze	8-12	Leaves in constant motion. Light flags flap.
Moderate breeze	13-18	Small branches move. Dust is stirred up.
Fresh breeze	19-24	Young, leafy trees sway. Dust is stirred up in clouds. Crested wavelets on lakes and ponds.
Strong breeze	25-31	Tree boughs swing. Wind whistles through telephone wires.
Moderate gale	32-38	Tree trunks swing. Difficult walking against the wind.
Fresh gale	39-46	Walking requires effort. Small branches break.
Strong gale	47-54	Slight damage to buildings, signs, and windows.
Whole gale	55-63	Trees are blown down. Considerable damage to buildings (more often experienced at sea).
Storm	64-74	Wide damage (rare).
Hurricane	75 or more	Great damage, wide destruction.

Humidity

Understanding Water Vapor in the Atmosphere

In the previous units, you have learned about humidity in the air—mainly in the saturated state. When the air is completely saturated, clouds and possibly precipitation occur. Usually these are the only times when many people are aware of moisture in the air. But even in the coldest air, moisture, in the form of water vapor, is present. If you've ever stripped tobacco, you can physically feel and see the effect of humidity in the air; if humidity has been high, tobacco will be *in case.* If humidity has been low, the tobacco leaves are brittle and not *in case.*

There are many terms used to describe the amount of humidity in the air. Two of the most commonly used terms are:

Humidity: The amount of water vapor in the air.

Relative Humidity: The percentage of water vapor the air is holding based on the amount the air can hold at that particular temperature.

100% Relative Humidity or Saturated Air?

What's the difference between 100 percent relative humidity as compared with saturated air? The answer: none. Air that is completely saturated has a relative humidity of 100 percent and **cannot** hold any more water vapor at that temperature. How does the water fall out of the air? It takes one of two processes for this to occur:

1. By cooling the saturated air.
2. By adding more water.

As moist air rises, it slowly cools. As the temperature drops, the relative amount of moisture the air can hold decreases to a point where any further cooling would cause condensation. The air is said to be completely saturated, and the relative humidity of this air is 100 percent. Any further cooling would cause precipitation.

During the summer months, we can see this occur almost every day. In the morning, the puffy cumulus clouds dot the sky. By midday, sunshine heats the earth's surface causing the air near the surface to warm and begin to rise. The cumulus clouds build vertically into towering cumulus and often into cumulonimbus—the true thunderhead (see clouds in Unit II).

The second process can occur as follows: if the air is near saturation and a southerly wind is pumping more moist warm air into the region, the air will become saturated, and precipitation will occur.

The Hair Hygrometer

What happens to your hair when you go swimming? Of course it gets wet, but it also stretches. Now, what happens after you blow-dry your hair? You get the frizzies! This very simple process of hair contracting and expanding, depending on the humidity, is the principle by which a very simple but accurate hygrometer is constructed. This word comes from Latin and means *to measure water.*

Invented in the mid-17th century, hygrometers indicate how damp, or humid, the air is. Earlier, simpler hydrometers contained a substance that changed drastically with changes in the amount of moisture in the air. Hair is such a substance. Can you think of other substances that are similarly affected?

As the air becomes more humid, the long strand of human hair in the hygrometer, shown in Figure 6, stretches. This causes the suspended penny to slowly drop, and the needle turns, indicating the relative amount of moisture in the air.

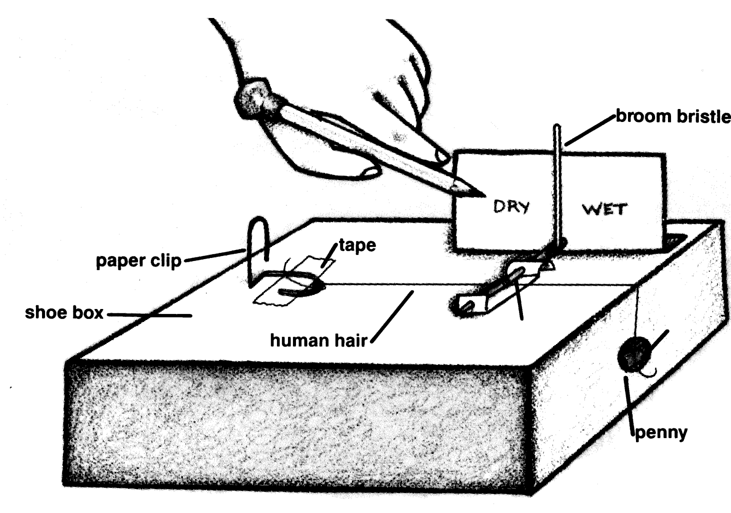


Figure 6. Hair hygrometer.

Summing Up

Building a Hygrometer

To build your own hygrometer, you will need one shoe box, one hair (long strand), one paper clip, transparent tape, one match stick or broom bristle, one file card (3" x 5"), one needle, and one penny.

Construct your hygrometer as shown in Figure 6. If the pointer does not move very much, the needle is probably stuck. What would you do to help the needle move more easily? (Hint: reduce friction.)

If, after building a hair hygrometer, you keep it in your house, what humidity will you measure? Is humidity different inside your home as compared to outside? If you want to measure relative humidity outside, where should you keep your hygrometer? (Hint: Did you build a weather shelter?)

YOU DID IT! You have made a basic weather station! You have learned how to use the basic tools of a meteorologist: a rain gauge, a barometer, a thermometer, a weather vane, an anemometer, and the Beaufort Scale. Now that you have an understanding of these tools and what they indicate, you can make observations of weather for your local area with a fair amount of accuracy. Keep records for three months to observe the weather trends.

Give demonstrations and talks showing how these instruments work. Visit a local weather center and see just how predictions are made for the news media.

Exhibit your weather station and instruments at the county fair. Include at least one month's observation with your exhibit.

Be sure to submit your record book, including the project story, weather observations, photo sheet, and record sheets.

What's Next?

In the next unit, you will learn how to read weather maps, how to give a weather forecast, and how to qualify as a Storm Spotter's Guide for your local area.

Talks & Demonstrations

Giving a talk or demonstration is an excellent experience. First, it helps you learn to organize a helpful, logical piece of information to share with someone else. Then, it gives you experience in speaking in front of a group. This can be a small or large group. It also helps your audience by teaching them about weather—possibly giving them information that could save their lives. So as you go through this project, be thinking about what you would like to share with a group.

You may want to do a demonstration on how to build some of the weather instruments that you put in your weather station. Or you may want to help your audience learn about weather variables so they can be prepared to predict the weather for themselves.

Citizenship & Leadership Activities

1. Help your leader organize a weather workshop for another 4-H club or any other appropriate group.
2. Prepare posters showing Kentucky's wind or other weather patterns. Use your 3-month records to develop these posters. Display them in your school or bank or other public place.
3. Serve as a leader for a younger group of 4-H'ers. Help them with their weather experiments or in any way that you can be of service to the group.
4. Take a group to visit a weather station, or invite a meteorologist to talk to your group or another group about weather instruments.

Observations Sheet

Date	Time	Temperature	Cloud Cover	Precip	Humidity	Direction	Wind Speed	Prediction

Observations Sheet

Date	Time	Temperature	Cloud Cover	Precip	Humidity	Direction	Wind Speed	Prediction

Weather Variables
Kentucky 4-H Weather Project Unit III
Record Sheet

Name ______________________________ **Birth Date** __________ **Grade** ____________

Address ____
(Street & Number/P.O. Box) (City) (Zip)

Name of Club or School ______________________________ **County** ____________________

Number of Years in 4-H ______________________________ **Current Date** ________________

1. Describe the weather station you constructed.

____

____

2. Did you complete the weather observation chart for three months? ______________________________

3. List the experiments you completed. ______________________________

____

4. Indicate talks and demonstrations you gave for your weather project.

Title	Audience	No. of People	Date	Award/Recognition

5. Indicate the leadership/citizenship activities you completed as part of this weather project.

Type of Activity	Where	Number of People	Date

6. Did you submit weather records for county competition? ______________ Award or recognition: ______________

7. On a separate sheet of paper, write about the things you have learned and done in this project. Include three to five photographs of you working on your project.

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Member's Signature Leader's Signature

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