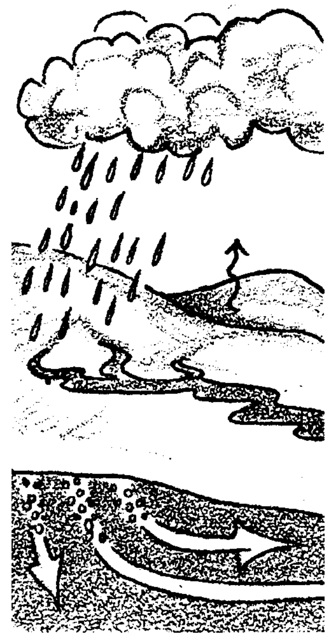
Feels Like Raindrops



Key Concepts

1. The earth's surface water is constantly recycled through the oceans in a process known as the hydrologic cycle.

2. The hydrologic cycle consists of the processes of evaporation, condensation, precipitation, and percolation.

3. Naturally occurring processes and human activities affect the hydrologic cycle.

Background

Powered by energy from the sun, the hydrologic cycle moves water from the sea, over the land where it condenses and falls as rain or snow. The rain and snow we often take for granted provide the water necessary for life as we know it. The hydrologic cycle links all life, including ours, to the sea.

Wastes are carried to the sea in rainwater from the sea. Sand to form new beaches is carried in the same waters. As the sun evaporates the water, the wastes and sand are left behind; the sand to form new beaches, the wastes to change or accumulate.

Global weather and global climate change, topics of much current study, are intimately related to the evaporation, condensation, and precipitation patterns of the hydrologic cycle. Through the hydrologic cycle, we all have a stake in the future of our oceans.

Both the hydrologic cycle and weather deserve more coverage than they have been given in this guide. This material is limited to the effects of the oceans on the hydrologic cycle and on weather. Any good earth science text can supplement the materials found here. The information presented in this activity provides your students with a basic introduction to the concepts involved.

Materials

Activity 1: Water Thermometer

For each group:

- flask (250 ml)
- l-hole rubber stopper (to fit the flask)
- 6 inch glass tubing (to fit the stopper)
- food coloring
- water
- thermometer

Activity 2: Barometer

- small can (similar in size to an evaporated milk can)
- wood base 4" x 12" (any available thickness)
- balsa strip 12" x l/8" x l/8"
- sealing wax (or, if available, some means of soldering)
- dowel stick 1/4"
- cork
- cardboard to make a scale
- barometer - commercial, to use for calibration

Activity 3: Rain Gauge

- one large, straight-sided can (at least six inches in diameter)
- one tall, slender, straight-sided glass bottle (such as an olive bottle)
- masking tape
- ruler

Activity 4: Anemometer

- four half gallon milk cartons
- two 24 inch sticks (approximately 1/4" x 1/4")
- wooden block for base (e.g. 2"x4"x8")
- washers
- waterproof glue
- electrical tape
- finishing nail

Activity 5: Hygrometer

- two thermometers (°C)
- cloth (1" x 1 1/2" works best)
- string or rubberband
- water
- Relative Humidity Chart

Activity 6: Wind Vane

- one wooden dowel or stick (1" x 6-10")
- one flat wooden stick - 12" long (approximately 1/4" x 1/4")
- wooden base (6" x 6" x 3/8")
- cardboard, or aluminum pie plate
- staples or thumbtacks
- washer
- nail
- directional compass
- lubricating oil

Teaching Hints

"Feels Like Raindrops" provides your students with a look at the influence of the oceans on the hydrologic cycle and weather. Ideally, your students will construct the equipment for a weather station and operate this equipment for several weeks to gather original data to use in answering the questions posed.

Directions are included in the student text for the construction of the various instruments mentioned. While it is quite possible to purchase all of the instrumentation, your students can learn a great deal from constructing the equipment. If you have commercial equipment available, you may wish to supplement the observations made by your students with their hand-made equipment.

In this activity, be as concerned with the process as with the product. In other words, the weather service can give you better data. The data, per se, is not the most important issue. Getting the data is as important as the data itself. Although "rule of thumb" forecasting charts such as those found in the following activities tend to trivialize the complicated process that meteorologists use to prepare weather forecasts, they are provided herein as a vehicle for actively engaging students while increasing their observational skills.

Duplicate the activity pages. One set is recommended per student. This activity is best accomplished by teams of 3 or 4 with each team performing a separate task. The data is then pooled at the conclusion and each student is responsible for the “Analysis and Interpretation” questions.

Using this scheme, one group would be responsible for making the thermometer, one for making the barometer, etc. Provide each student with a copy of the “Weather Record” and with a chance to observe the instruments constructed by other groups. Having different groups working on different projects will require some extra supervision on your part to guarantee that the work is being performed.

Plan to allow time for a class discussion of the procedure and results and to provide answers to the text questions.

Key Words

anemometer - an instrument for measuring wind speed

barometer - an instrument for measuring atmospheric pressure, used in weather forecasting

calibrate - to check, adjust, or systematically standardize the graduations of a quantitative measurement instrument

humidity - the amount of water vapor in the air, dampness

hygrometer - an instrument that measures atmospheric humidity

relative humidity - the ratio of the amount of water vapor in the air at a specific temperature to the maximum capacity of the air at that temperature

wind vane - an instrument for indicating wind direction

Answer Key

Text Questions

1. The sources of evaporation shown include: the ocean, soil, ponds, lakes, plants, rivers, and reservoirs. Any three of the above will suffice.

2. The majority of the evaporated water comes from the ocean.

3. Rainfall, falling into the ocean, should be added to the drawing.

4. This question is a check. If your students have been following the logic used in the text, they should have no trouble in recognizing that if the total annual evaporation is 95,000 cubic miles the total annual rainfall must also be 95,000 cubic miles.

5. a. This question also checks how critically your students have been reading. 80,000 cubic miles of water evaporate from the oceans in the course of a year (i.e. total annual precipitation minus amount evaporated from sources other than the oceans = amount evaporated from the oceans; 95,000 mi^3 - 15,000 mi^3 = 80,000 mi^3).

b.

80,000 mi^3	evaporation from oceans	71,000 mi^3	precipitation received by oceans
+	=	+	
15,000 mi^3	evaporation from other sources	24,000 mi^3	precipitation falling on other surfaces

Analysis and Interpretation

1. A., B. The answers depend upon the experimental results but should reflect the data gathered by your class.

   I., II. The answers depend upon the experimental results. There are some general concepts to be kept in mind. While warm air will hold more moisture than cool air, it may appear that relative humidity decreases with increasing temperature. The specific relationship determined will depend upon the data. The temperature curve and the humidity curve may not be similar enough for a good comparison to be made. If this is the case, a general discussion of the relationship between temperature and humidity may be in order.

   III. Ideally, your students should be able to formulate a generalization relating temperature and relative humidity. Increasing the temperature of the air increases the amount of moisture the air can hold. It is possible that the data will make it appear that increased temperatures show lower relative humidities. Since higher temperatures can hold more moisture, their relative humidity could be lower. In other words, a given mass of air will have a higher relative humidity at a lower temperature.

2., 3a., b., c., d., 4. Answers will depend upon the data gathered during the observations on weather.

5. Answers will vary. The kinds of information include the measurements made during the course of the study. While it is difficult to establish the amount of information necessary, it would seem that a minimum of a year's observations would be necessary to develop reliable predictive skills.

6. While the answers will vary, forecasting ability could be improved through the use of more precise instruments, additional instruments and/or information (e.g. satellite pictures), and data over a longer period for the particular site in question.

Analysis and Interpretation - Making a Thermometer

1. The water level changes when the "thermometer" is exposed to different temperatures because of the contraction and expansion of the water.

2. Since water freezes at 0°C, a water thermometer stops registering change below O°C. Alcohol or mercury which have much lower freezing points are better choices for the fluid portion of thermometers for use below 0°C.

Text Questions - Making a Barometer

1. A 12 square inch palm surface is "holding up" 176.4 pounds. This is the logical place for a discussion of air pressure.

2. A falling barometer reading of 30.10 inches indicates rain is likely.

3. Barometric pressures of 29.8 inches of mercury or less would be expected during a tornado.

4. A rising barometer generally forecasts clearing.

Analysis and Interpretation - Making a Barometer

1. When the air pressure **increases** outside of the can, the can expands/<u>contracts.</u> (The correct answer is underlined).

2. As the pressure increases, the pointer moves <u>up</u> .

3. The pointer moves down when there is a <u>decrease</u> in air pressure.

4. A slowly rising pointer indicates a weather forecast of clearing.

Analysis and Interpretation - Making a Rain Gauge

1. The water is deeper in the jar because the cross sectional area of the jar is less than that of the can. This question is designed to do more than test your students' knowledge about conservation of volume. It provides a chance for them to begin thinking about why it is more accurate to read the rainfall in the narrower container.

2. The water is poured from the can into the jar to measure the rainfall to increase the precision with which the rainfall can be measured.

3. Using the large can to catch the rainfall gives a larger area on which the rain can fall. Using the smaller jar to measure the rainfall allows small amounts of rain to be measured accurately because of the fact that a small amount of rain will be measurable on the exaggerated vertical scale.

4. Answers will vary. The distribution of the rainfall over time determines to a large extent the plant populations of a given area. The plant populations in turn determine the animal populations.

Analysis and Interpretation - Making an Anemometer to Measure Wind Speed

1. a. Answers will vary but as the speed of the wind increases, the difficulty of counting the revolutions also increases.

   b. A mechanical counter would facilitate the use of the anemometer.

2. Answers will vary depending upon experimental observations.

3. Low barometric readings (i.e. 28 inches of mercury) are associated with strong winds.

Analysis and Interpretation - Making a Hygrometer to Measure Relative Humidity

l. The water evaporating from the cloth cools the wet thermometer bulb and causes the temperature reading for the wet bulb to be lower than the reading for the dry bulb thermometer.

2. Your students should have numerous ideas regarding sources of error. The two general classifications of error involve errors of observation and mechanical errors of recording.

3. a., b. Answers will depend upon the initial observations but can be easily determined from the chart included in the student pages. These questions are provided to give your students an additional opportunity to use the charts.

4. A decrease in humidity would mean that less water was available to the plant. Less water availability could cause wilting or death.

5. An increase in humidity would reduce the drying risks for the beach-hopper. The beach-hopper would be able to increase its activities and venture in search of food, etc. into areas previously too dry.

Analysis and Interpretation - Making a Wind Vane to Measure Wind Direction

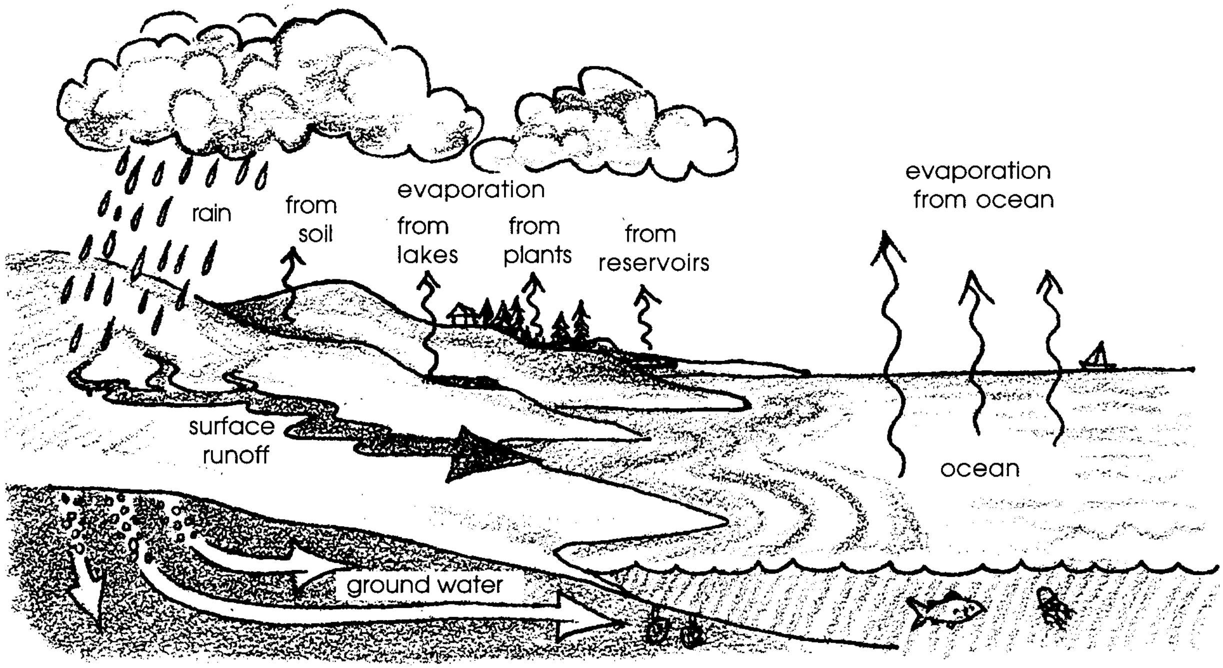
1. The arrow head always points into the wind because the arrow tail is significantly larger than the head and therefore, has a greater wind force against it.

2. Placing the wind vane high off the ground reduces the local turbulence and disruptions caused by trees, buildings, etc.

3. a. Winds blowing from the southeast coupled with a rapidly falling air pressure indicate increased probability of winds and rain.

   b. Winds moving west and rising air pressure usually indicate a clear trend with fair skies and cooler temperatures.

Feels Like Raindrops



The first rainstorms came from water vapor released from the molten surface of a primitive earth. What about today's rainstorms? Where do they come from? What role does the ocean play in weather?

As the sun shines on the surface of the oceans, the water is warmed. Some of this warmed water **evaporates**. The evaporated water behaves like the water vapor of the primitive earth; it rises. As the water rises it cools and condenses to form clouds. These clouds build until they can hold no more moisture. At this point the water falls as rain or snow. Some of the rain falls back into the ocean. Some of the rain and snow falls on the land. A portion of this water flows over the surface while the rest sinks into the ground. The flowing surface water tends to move toward the oceans. The water below the surface also tends to move toward the oceans. If the water does not evaporate on the way to the oceans, it will return to the ocean to be available for evaporation there. This series of events, called the hydrologic cycle or water cycle, is shown in the figure above.

1. What are three sources of water for evaporation?

2. Which source provides the majority of the water evaporated?

3. The drawing is missing rainfall over the ocean. Add this rainfall to your drawing.

The amount of water produced in a year through the action of volcanoes is usually small. Essentially the amount of water on the earth remains the same from year to year. For any year, the amount of water evaporating from the ocean must equal the amount of water that falls as rain.

4. If the total annual evaporation is 95,000 cubic miles (mi^3), what is the total annual rainfall?

The hydrologic cycle is actually more complicated than what we have seen. Plants move water through their tissues and give off water vapor. This water vapor is part of the 15,000 cubic miles of water which evaporates each year from sources other than the oceans.

5. a. How many cubic miles of water evaporate from the oceans during the course of a year? (Hint: You know the total annual evaporation **and** the amount evaporated from sources other than the oceans.)

b. Use the above information and the diagram of the hydrologic cycle to complete the following equation:

________ mi^3 evaporation from oceans		71,000 mi^3 precipitation received from oceans
+	=	+
________ mi^3 evaporation from other sources		______ mi^3 precipitation falling on other surfaces

How can you investigate roles of the ocean and water cycle in determining your local weather? The following activities will give you an opportunity to make and use a weather station. A well-equipped weather station will have:

thermometer to measure the temperature

barometer to measure air pressure

rain gauge to measure rainfall

anemometer to measure wind speed

hygrometer to measure the amount of water vapor in the air (relative humidity)

wind vane to tell the direction of the wind.

Where can you find all of these items? You can make them using the directions that follow. After you collect the equipment, you may want to establish a permanent weather station or you may want to make your daily measurements by taking your equipment out to your measuring site. The following chart will help you summarize your daily weather observations. After you have completed the chart, answer the questions in the “Analysis and Interpretation” section.

WEATHER RECORD

Date & Day	Hour of Day	Amount of Rainfall	Barometric Pressure	Temperature	Relative Humidity	Wind Direction	Wind Speed	Type of Clouds	Probable Weather Conditions
Mon.									
Tues.									
Wed.									
Thur.									
Fri.									
Sat.									
Sun.									

Mon.									
Tues.									
Wed.									
Thur.									
Fri.									
Sat.									
Sun.									

Temperature Graph

Relative Humidity Graph

Analysis and Interpretation

1. Relative humidity compares the amount of water actually in the air and the amount the air could hold at that temperature. Temperature and relative humidity must be closely related.

   A. In the space above, use the data in your weather record to make a graph plotting temperatures (vertical axis) against day (horizontal axis).

   B. Next, use the data in your weather record to make a graph plotting relative humidity (vertical axis) against day (horizontal axis).

I. How does the shape of the temperature curve compare with that of the relative humidity?

II. From the graphs, it appears that as the temperature increased during the day, the humidity__________________. Conversely, as it got cooler, the humidity____________________.

III. What is the relationship between temperature and relative humidity?

2. a. What kind of weather did you have during the second week?

b. Look at your air pressure and wind direction data for the second week. What kind of weather would you have predicted using your air pressure and wind information? (Hint: See the chart showing “How Wind and Air Pressure May Indicate Weather” in “Making a Wind Vane to Measure Wind Direction”).

c. How does the weather predicted by the chart compare with the weather you actually had?

3. a. What was the total amount of rainfall?

b. What was the **average** rainfall per week? (Hint: This is easy. The average rainfall per week is the total rainfall divided by the number of weeks.)

c. If the weekly average found in question b. were typical, how much rain would fall in a year (52 weeks)?

d. How does your calculated yearly rainfall compare with your actual annual rainfall?

4. Did wind from any particular direction seem to indicate the coming of a storm? If so, what was the relationship?

5. What <u>kind</u> of information and how <u>much</u> information would you require before you put much faith in your weather predictions?

6. How could you improve your forecasting ability?

MAKING A THERMOMETER

A basic piece of equipment for your weather station is the thermometer. Thermometers measure temperature, the hotness or coldness of something. All thermometers work on the basis that things **expand** when warmed and **contract** when cooled. Instead of using a standard thermometer, you may wish to make one using the directions below.

Water Thermometer

Materials:

- flask (250 ml)
- l-hole rubber stopper (to fit the flask)
- 6 inch glass tubing (to fit the stopper)
- food coloring
- water
- thermometer

Procedure:

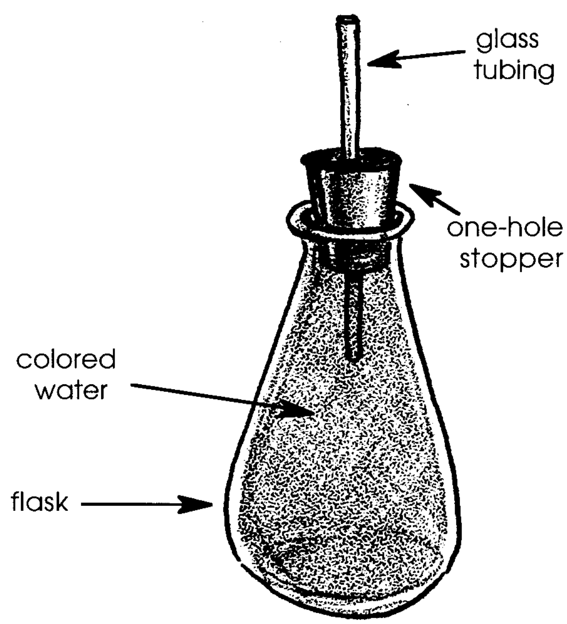
1. Fill the flask with water.

2. Add food coloring to make the water easier to see.

3. Using liquid soap or petroleum jelly as a lubricant, fit the glass tubing into the rubber stopper so it barely extends beyond the stopper bottom. **Be very careful not to break the glass!**

4. Put the stopper into the flask neck as shown.

5. Expose this homemade thermometer to different temperatures. Mark the water level for each of these temperatures and label the marks in degrees.



Analysis and Interpretation

1. Does the water level in the glass tube change when the “thermometer” is exposed to different temperatures? Explain why.

2. Why should alcohol or mercury be used instead of water if this thermometer is to be used to measure temperatures lower than 0°C?

MAKING A BAROMETER

A **barometer** is an instrument that measures air pressure. Air pressure is due to the weight of the blanket of air pushing on the earth's surface. The weight of a one square inch column of air which reaches from sea level to the top of the atmosphere weighs about 14.7 pounds.

1. Turn your hand so that your palm is facing upwards. Your palm has a surface area of about 12 square inches. At sea level, about how many pounds of air are you holding up with one hand?

You don't feel this weight pushing on every square inch of you for several reasons. The weight is uniformly distributed over your body. More importantly the contents of your body cells are pushing outward with the same pressure. The pressure on the outside equals the pressure on the inside.

What is the relationship between air pressure and weather? An equal volume of warm air weighs less than cold air. Warm air forms low pressure areas while cold air forms high pressure areas. The movement of these low and high pressure areas results in changes in our local weather. Barometer readings are given in units of "inches of mercury". (For comparison, temperature readings are given in units of degrees). The following barometer readings give an idea of the weather forecast accompanying different barometric pressures.

BAROMETER READING	WEATHER FORECAST
30.1-30.2 Rising rapidly	Fair, rain within 48 hours
30.1-30.2 Steady	Fair, little change
30.1-30.2 Falling slowly	Rain within 24 hours
30.1-30.2 Falling rapidly	Rain within 12 hours
30.1 or below Rising slowly	Clearing
30.0 or below Falling slowly	Rain for 24-48 hours
30.0 or below Falling rapidly	Rain with winds
29.8 or below Falling rapidly	Storm with strong winds

2. The TV weather person announces that the barometer reading is 30.10 inches and falling. What weather change is suggested?

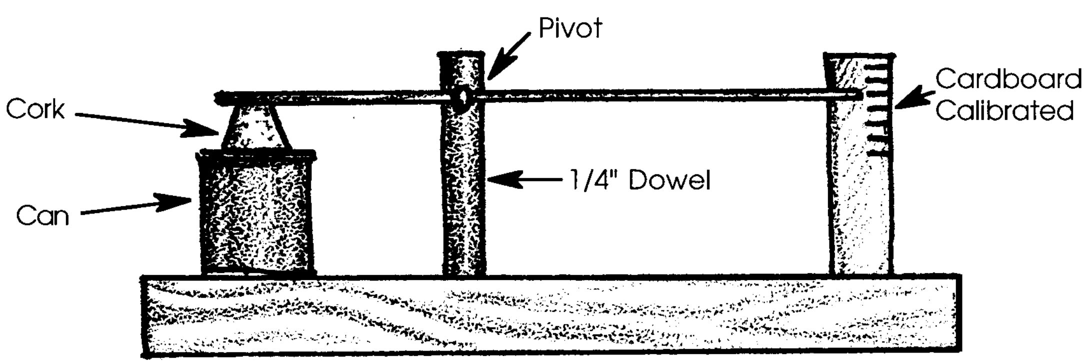
3. What would be the approximate barometer reading during a tornado?

4. What type of weather will generally follow a rising barometer reading?

The barometer you will make can be calibrated by comparison with a mercury barometer. If you cannot calibrate your barometer, you can use the descriptions on the chart (e.g. rising rapidly, etc.) to predict weather changes.

Materials:

- small can (similar in size to an evaporated milk can)
- wood base 4" x 12" (any available thickness)
- balsa strip 12" x l/8" x l/8"
- sealing wax (or, if available, some means of soldering)
- dowel stick 1/4"
- cork
- cardboard to make a scale
- barometer - commercial to use for calibration



Procedure:

l. Seal the holes in the can top with sealing wax or, if available, with a soldering gun.

2. Position the cork on the center of the can top. Next, cement the cork to the top.

3. Place the can on the wood base.

4. Drill a 1/4" hole in the base next to the can for the dowel and glue the dowel in its place.

5. Fasten the balsa strip onto the dowel by means of a straight pin while making sure the balsa strip can move freely.

6. Rest one end of the strip on the cork while the other is near the cardboard scale.

7. If possible, calibrate the barometer by using a store-bought barometer.

Analysis and Interpretation

1. When the air pressure **increases** outside of the can, the can
   expands / contracts (Circle the correct term).

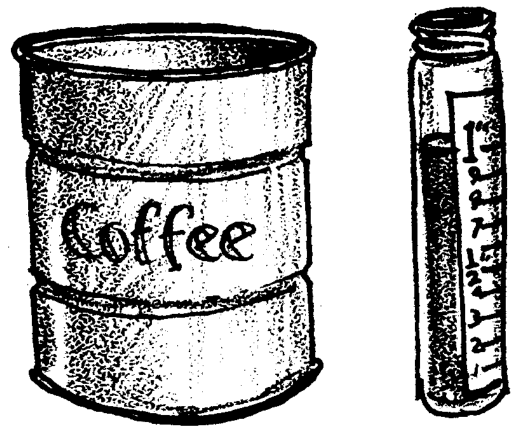
2. As the pressure increases the pointer moves________________.

3. The pointer moves down when there is a________________air pressure.

4. You observe the pointer slowly rising. What weather forecast would you make based on this observation?

MAKING A RAIN GAUGE

Rainfall is influenced by the distance to the ocean and by the direction of the wind. You can make a simple rain gauge that will give you an idea of the amount of rainfall during your weather investigation. A rain gauge is used to measure the amount of moisture that falls from clouds. To accurately measure this moisture to within a hundredth of an inch, it is necessary to use two containers of different size.



Materials:

- one large straight-sided can (at least six inches in diameter)
- one tall, slender, straight-sided glass bottle (such as an olive bottle)
- masking tape
- ruler

Procedure:

1. Stick a piece of masking tape vertically along the entire height of the glass jar.

2. Pour water to a depth of exactly one inch into the large can.

3. Pour the water from the can into the tall glass jar.

4. Mark the depth of the water on the masking tape and divide the tape, below the mark, into ten (10) equal parts. Label these divisions as tenths of an inch.

5. Set the can outdoors in an open area away from trees and buildings.

6. After a rain, pour the water from the can into the jar and read the amount of rainfall to the nearest tenth or even hundredth of an inch.

Analysis and Interpretation

1. Why was the water deeper than one inch when it was poured from the can into the jar?

2. Why is the water poured from the can into the jar when the amount of rainfall is being measured?

3. Explain why using the large can and the skinny jar together will give you a more accurate measurement of rainfall than using the can by itself.

4. Would you expect areas with ocean breezes to have more rainfall or less rainfall than areas where the air flows off of the land? Why?

5. In general, the distribution of rainfall over time is at least as important as the total amount of rainfall. How does the distribution of rainfall over time affect living things?

MAKING AN ANEMOMETER TO MEASURE WIND SPEED

The pattern of high and low pressure areas on the earth's surface determines the speed of the wind. The speed of the wind affects the movement of clouds. It also affects evaporation. In general, the stronger the wind, the more rapid the evaporation. You may have experienced wind evaporation first hand. At a given temperature you will feel colder if a wind is blowing. This is because the small amount of water on your skin evaporates faster in a wind. The device below will let you measure the wind speed at your weather station.

Materials:

- four half gallon milk cartons
- two 24 inch sticks (approximately 1/4" x 1/4")
- wooden block for base (e.g. 2"x4"x8")
- washers
- waterproof glue
- electrical tape
- finishing nail

Procedure:

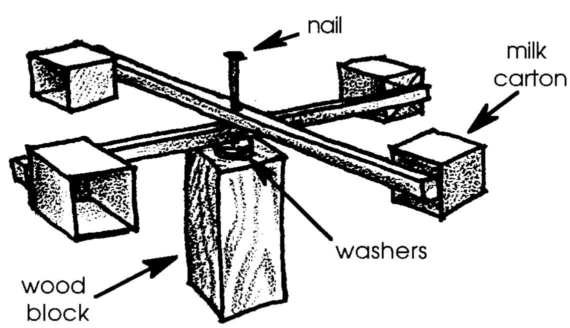
1. Cut the tops off of the milk cartons leaving about four inches to the bottom. Make all of the cartons the same size.

2. Mount the milk carton bottoms with some thumbtacks to the pair of sticks.

3. Cross the sticks in the middle and fasten with glue and a piece of electrical tape.

4. Drive the nail into the crossed sticks and move back and forth until the sticks rotate freely. (If a drill and bit are available, you can drill a hole through the sticks).

5. Mount the apparatus on the piece of wood by placing the washers between the cross piece and the block of wood. Drive the nail (through the washer holes) into the block. Your anemometer should look something like the figure to the right.



6. Calibrate the anemometer by comparing it with your teacher's. You can do this by counting the number of revolutions per minute made by the apparatus at different wind speeds. (Your teacher calibrated her anemometer by counting the number of revolutions per minute made by the apparatus as a friend drove her car at 5 and 10 m.p.h. around an empty parking lot).

Analysis and Interpretation

1. a. When you calibrated the instrument, was it hard to count the number of turns?

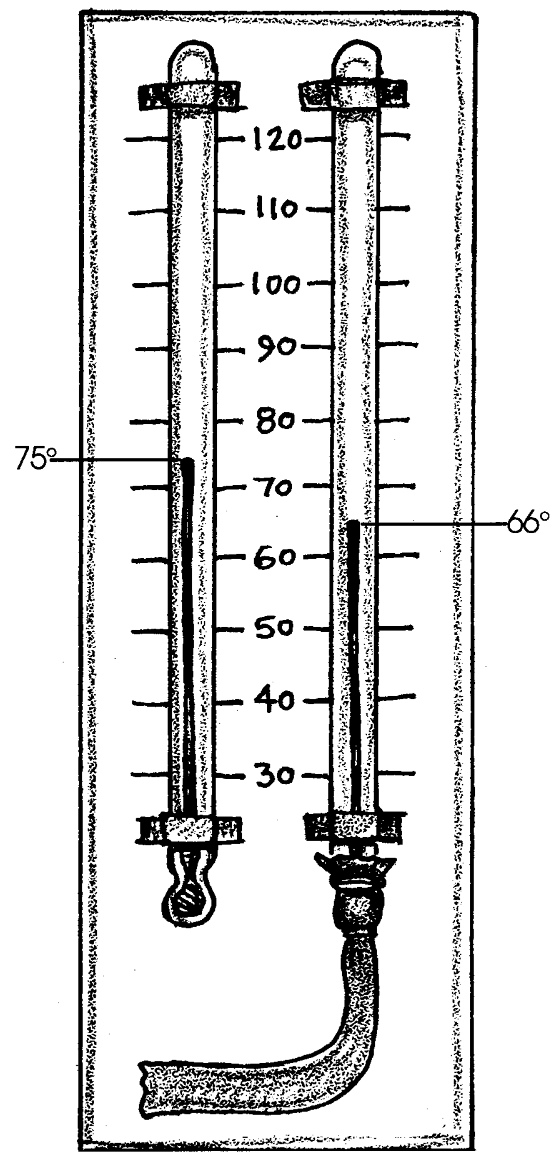
   b. What would you suggest in order to improve the design?

2. At what speed did you find it impossible to count the number of turns?

3. What kind of barometric readings are associated with strong winds? (Hint: see the section "Making a Barometer").

MAKING A HYGROMETER TO MEASURE RELATIVE HUMIDITY

Relative humidity is a measure of the amount of moisture in the air. The higher the relative humidity the more moisture in the air. Relative humidity is measured in percent. The percentage shows the amount of moisture in the air compared to the maximum amount of moisture air at that specific temperature could hold.



Relative humidity of 100%, usually indicates that it is raining. Very dry locations may have relative humidities as low as 1 or 2 percent. A wet-bulb and dry-bulb hygrometer is the most accurate instrument to use in measuring humidity. This instrument is made of two thermometers. One thermometer has a wet cloth around its bulb. The drier the air the more water that will evaporate from the cloth and the lower the wet-bulb temperature will become. The difference in temperature between the dry-bulb and wet-bulb thermometers, along with the dry-bulb temperature, is used in finding the relative humidity on a Relative Humidity Chart.

The following activity will enable you to make a wet-bulb/dry-bulb hygrometer to measure the relative humidity at your weather station.

Materials:

- two thermometers (°C)
- cloth (1" x 1 1/2" works best)
- string or rubberband
- water
- Relative Humidity Chart

Procedure:

1. Wrap a small piece of cloth once around the bulb of one thermometer. Hold the cloth in place with a string or rubberband.

2. Hold both thermometers so they hang a few inches apart (about 3 to 5 inches).

3. Dip the cloth-tipped thermometer in water to wet the cloth.

4. Fan both thermometers vigorously with a notebook for at least five minutes.

5. Record the temperatures from both thermometers in the "Data" section.

6. Find the difference between the two readings.

7. Use the "Relative Humidity Chart" to find the relative humidity. Here's how:
   a. Circle the horizontal line which shows your difference in temperature.
   b. Circle the vertical row which shows your dry-bulb temperature.
   c. Read the number where the two circles overlap. This number is the relative humidity.

DATA

Dry-bulb temperature: ___________________

Wet-bulb temperature: _________________

Difference: _____________________________

Relative Humidity: ______________________

Relative Humidity (percentage)

Dry-bulb temperture (degrees C)

Difference between dry-bulb and wet-bulb readings	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0.5	94	94	94	95	95	95	95	95	95	95	96	96	96	96	96	96	96	96	96	96	96
1.0	88	89	89	89	90	90	90	90	91	91	91	91	92	92	92	92	92	92	93	93	93
1.5	82	83	83	84	85	85	85	86	86	87	87	87	87	88	88	88	88	89	89	89	89
2.0	77	78	78	79	79	80	81	81	82	82	83	83	83	84	84	84	85	85	85	86	86
2.5	71	72	73	74	75	75	76	76	77	78	78	79	80	80	80	81	81	82	82	82	83
3.0	66	67	68	69	70	71	71	72	73	74	74	75	76	76	77	77	78	78	78	79	79
3.5	60	61	63	64	65	66	67	68	69	70	70	71	72	72	73	74	74	75	75	76	76
4.0	55	56	58	59	60	61	63	64	65	65	66	67	68	69	69	70	71	71	72	72	73
4.5	50	51	53	54	56	57	58	60	61	62	63	64	64	65	66	67	67	68	69	69	70
5.0	44	46	48	50	51	53	54	55	57	58	59	60	61	62	62	63	64	65	65	66	67
5.5	39	41	43	45	47	48	50	51	53	54	55	56	57	58	59	60	61	62	62	63	64
6.0	34	36	39	41	42	44	46	47	49	50	51	53	54	55	56	57	58	58	59	60	61
6.5	29	32	34	36	38	40	42	43	45	46	48	49	50	52	53	54	54	56	56	57	58
7.0	24	27	29	32	34	36	38	40	41	43	44	46	47	48	49	50	51	52	53	54	55
7.5	20	22	25	28	30	32	34	36	38	39	41	42	44	45	46	47	49	50	51	52	52
8.0	15	18	21	23	26	27	30	32	34	36	37	39	40	42	43	44	46	47	48	49	50
8.5	10	13	16	19	22	24	26	28	30	32	34	36	37	39	40	41	43	44	45	46	47
9.0	6	9	12	15	18	20	23	25	27	29	31	32	34	36	37	39	40	41	42	43	44
9.5		5	8	11	14	16	19	21	23	26	28	29	31	33	34	36	37	38	40	41	42
10.0				7	10	13	15	18	20	22	24	26	28	30	31	33	34	36	37	38	39
10.5					6	9	12	14	17	19	21	23	25	27	29	30	32	33	34	36	37
11.0						6	8	11	14	16	18	20	22	24	26	28	29	31	32	33	35
11.5							5	8	10	13	15	17	19	21	23	25	26	28	29	31	32
12.0									7	10	12	14	17	19	20	22	24	26	27	28	30
12.5										7	9	12	14	16	18	20	21	23	25	26	28
13.0											6	9	11	13	15	17	19	21	22	24	25
13.5												6	8	11	13	15	17	18	20	22	23
14.0													6	8	10	12	14	16	18	19	21
14.5														6	8	10	12	14	16	17	19
15.0															5	8	10	12	13	15	17
16.0																	5	7	9	11	13
17.0																			5	7	9
18.0																					5
19.0																					
20.0																					

Analysis and Interpretation

1. What accounts for the difference between readings of the two thermometers?

2. What are two possible errors that could have been made while doing this investigation?

3. What would the relative humidity be if:

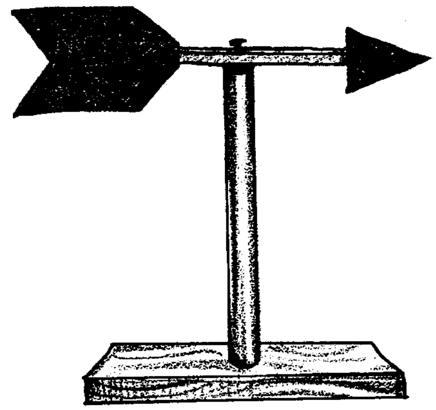
   a. both thermometer readings were 5 degrees higher?

   b. only the dry thermometer reading was 5 degrees higher?

4. How could a decrease in humidity effect a land plant which depends upon the air for part of the water it requires?

5. How could an increase in humidity effect the activities of a small animal called a beach-hopper which must keep the outside of its body moist at all times?

MAKING A WIND VANE TO MEASURE WIND DIRECTION



The direction of the wind is determined by the patterns of high and low pressure areas. Observation of the wind directions and changes in directions are used to help forecast changes in local weather. In the following activity you will make a wind vane. The wind vane will help you to tell the direction of the wind at your weather station. The wind direction is measured by an instrument called a wind vane. Although wind vanes come in many styles, shapes, and sizes, they all have three features in common:

1) They are always well balanced so they may turn easily in the wind.

2) They always have one end about four or five times larger than the other.

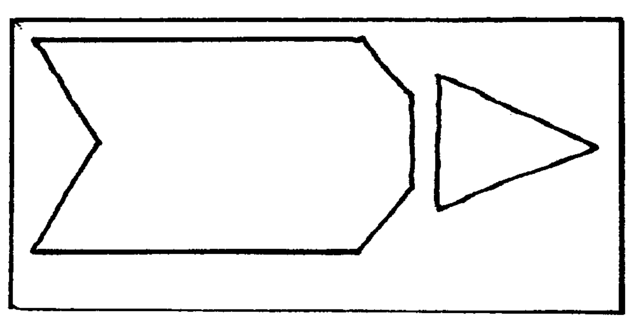
3) The small end always points in the direction from which the wind is coming. The most common wind vane shape is the arrow described below.

Materials:

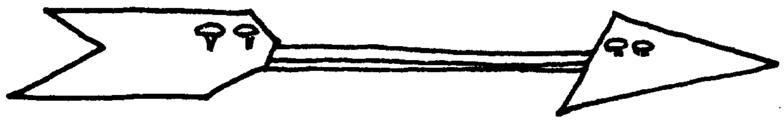
- one wooden dowel or stick (1" x 6-10")
- one flat wooden stick - 12" long (approximately 1/4" x 1/4")
- wooden base (6" x 6" x 3/8")
- cardboard, or aluminum pie plate
- staples or thumbtacks
- washer
- nail
- directional compass
- lubricating oil

Procedure:

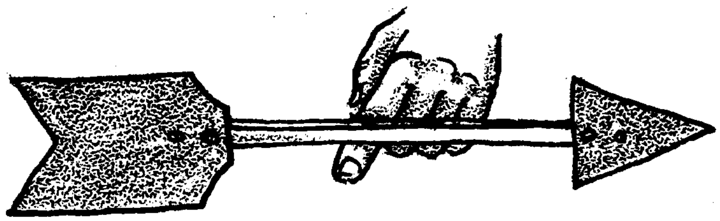
1. Cut out the arrow's point and tail from the cardboard or aluminum pie plate following the pattern.



2. Staple or thumbtack the pointer and tail of the arrow to the stick.



3. Find the center of balance for the arrow. You can do this easily by holding the arrow on the back of your index finger. At the center of balance the arrow will stay without falling or leaning.

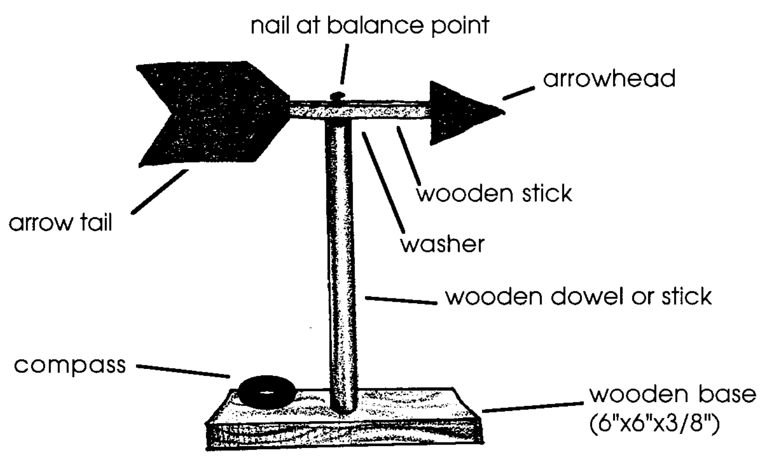


4. Drive the nail through the center of balance of the arrow. Make sure the wind vane can move freely. (If you have access to a drill and bit you can drill a hole in the stick).

5. Place a washer between the wind vane and the short piece of wood, drive the nail into the wooden block.

6. Mount a small compass on the wooden base. The compass will help you name the direction from which the wind blows.

Your finished wind vane should look like this:



7. Lubricate the nail and washer with a drop of oil so the arrow will turn easily.

Analysis and Interpretation

1. Thinking carefully about how a wind vane is designed, explain why the arrow head always points into the wind.

2. Why is it necessary to locate the wind vane as high as possible from the ground?

3. The combination of wind direction and air pressure let us make better weather predictions than air pressure alone. The chart below shows how wind and air pressure may indicate weather.

HOW WIND AND AIR PRESSURE MAY INDICATE WEATHER

Wind	Air Pressure	Kind of Weather
SW to NW	Steady near 30.1 inches	Fair for 1 or 2 days
	Rising above 30.1	Fair, but rain in 2 days
	Stationary above 30.2	Fair
	Falling slowly from near 30.2	Fair, rising temperature for 2 days
SE to S	Falling slowly from near 30.2	Rain within 24 hours
	Falling rapidly from near 30.2	Increasing winds, rain soon
NE to SE	Falling slowly from near 30.2	Rain soon
	Falling rapidly from near 30.2	Increasing winds, rain soon
NE to E	Falling slowly, but above 30.0	In summer, rain within 24 hr. In winter, rain or snow in 1-3 days
	Falling rapidly below 30.0	Rain soon
NE to SE	Falling slowly below 30.0	Continued rain
	Falling rapidly below 30.0	Rain, high winds
S to SW	Rising slowly	Clearing, fair
E to S	Falling rapidly	Storm
N to E	Falling rapidly	Severe storm
Moves W	Rising	Clearing, fair, cooler

3 a. What do winds blowing from the southeast and a rapidly falling air pressure usually indicate?

b. What do winds moving west and rising air pressure usually indicate?

Optional Activity

Make another wind vane. This time, use your imagination to design one of a different shape. Don't forget the principles of wind vane construction mentioned above.