MIDWEST WILD WEATHER

TEACHER MANUAL

The Midwest Wild Weather Museum Consortium

SciTech Interactive Science Center — **Aurora,** IL
Project Coordinator
Discovery Center — **Rockford,** IL
Co-Project Coordinator
Lakeview Museum of Arts and Sciences — **Peoria,** IL
The Science Center — **Carbondale,** IL

The Science Station — **Cedar Rapids,** IA
Bluedorn Science Imaginariuim — **Waterloo,** IA

Koch Science Center — **Evansville,** IN
Children's Science Center — **Terre Haute,** IN

Hands-On Museum — **Ann Arbor,** MI

Funded in part by the National Science Foundation

www.midwestwildweather.org

Weather, a subject of strong general interest that affects every person's life on a daily basis, will serve as the focus of and stimulus for exploration and learning about science and mathematics.

As a joint endeavor, the Midwest Wild Weather (MWW) collaboration has developed a set of traveling exhibits for 4th through 8th grade students in Midwestern public school systems. Over the grant period, traveling exhibits will afford over 80,000 students a hands-on experience with science and mathematics. Over 2,640 teachers will be able to observe and participate in inquiry-based learning techniques.

To bring MWW to even greater numbers of citizens, each center has permanent exhibits on weather. These standing floor exhibits affect the thousands of people who visit each member institution every week. They also act as a base of continued discovery for students who have experienced the traveling exhibit set in their schools.

There are eight components to the program:

- Stationary exhibits on weather at each collaborating museum site;
- A set of traveling exhibits to be used by each museum at cooperating schools;
- A travel schedule that allows the exhibits to visit many schools per year, per museum institution;
- Instructional materials, including preliminary and follow-up activities for the classroom;
- Teacher In-Service workshops;
- A Teachers' Cadre (one from each museum area) for formative evaluation of the exhibits and for development of pre- and post-activities.
- A year-long follow-up program on the weather activities for interested schools;
- An annual activity at the MWW sites and at some schools for the families of children who experience the weather exhibits.

MWW Project Goals: 1) Improve science literacy of students; 2) Assist teachers in acquiring science content, materials, hands-on techniques; 3) Expose parents and general public to hands-on learning; 4) Provide practice in scientific process elements of science literacy for teachers and students; 5) Serve under-represented and underserved populations..

MIDWEST WILD WEATHER is:
SciTech Interactive Science Center, Aurora, IL
Discovery Center, Rockford, IL
Lakeview Museum of Arts and Sciences, Peoria, IL
The Science Center, Carbondale, IL
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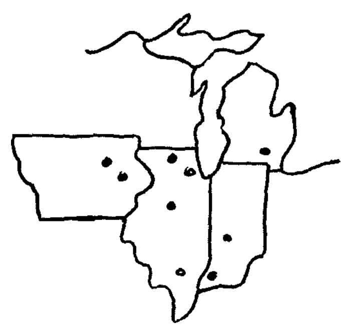
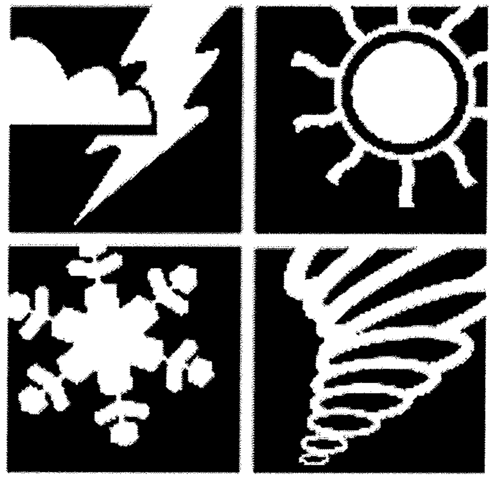


Midwest Wild Weather Project is funded by a grant from the National Science Foundation. Ideas expressed are those of the participants, not necessarily the NSF.

Wild Weather Teachers Guide has been modified for use in
Riding The Whirlwind: Weather in the West exhibition at the National Cowboy & Western Heritage Museum, on exhibit February 5 - May 8, 2016, and for Oklahoma Academic Standards.

Special thanks to Linda McMahan for correlating the Midwest Wild Weather Teacher's Guide with Oklahoma Academic Standards.



Wild Weather
Teacher's Guide

About This Manual

The Midwest Wild Weather (MWW) Teacher Manual is divided into 5 main sections:
(1) Weather Background Information (2) Weather Activities and Matrix (3) Pre- and Post-Test (4) Alternative Assessment Guidelines and State Science Goals (5) Internet, Bibliography.

For assistance or more information on these activities, contact the following MWW staff members.

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Ann Arbor—Hands-On Museum; James Frenza, President: 220 E. Ann St., Ann Arbor, MI 48104; 734/214-6500

This manual includes three types of activities: Teacher Demonstrations, Individual Student Activities, and Cooperative Learning Groups as well as sample Alternative Assessment activities. Consistent with state science goals for Oklahoma (see pages 109-114) this Teacher Manual is designed for late elementary (4th grade) through junior high school/middle school (8th grade).

MWW museums and their teacher cadres have created a manual to assist classroom teachers with many types of hands-on weather experiments. These activities are teacher-tested and approved by our cadres. Many of the experiments have a student activity page ready for copying. All include a list of materials needed and pertinent science background information for the instructor. We hope that this manual will serve as a stimulus for incorporating an entire weather unit into your curriculum.

Project Advisors include: *Gregory Aloia,* special education professor, Illinois State University, Normal (project evaluator); Ann *Butcher*, science teacher, Nicholson School, Aurora, IL; *Dr. Mary Ann Cooper,* Director of Lightning Injury Research Program, University of Illinois at Chicago; *Steve Davis,* Director of Exhibits and Outreach, University of Colorado at Boulder; *Ron Gird,* Satellite and Space Program Leader, National Weather Service, Silver Springs, MD; *Margaret McCalla,* research meteorologist, NOAA, Washington, D.C.; *Michelle Nichols,* Coordinator of Gallery Programs, Adler Planetarium & Astronomy Museum, Chicago, IL; *Phil Schwarz,* meteorologist, WLS-TV Channel 7, Chicago, IL; *Dr. Marvin Wesley,* Senior Meteorologist, Argonne National Laboratory, Argonne, IL; *Liduvina Vivanco,* bilingual science teacher, Joliet High Central Campus, Joliet, IL.

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An Introduction to Weather

BACKGROUND INFORMATION FOR INSTRUCTOR

Weather affects all of us in our day-to-day life. We may make plans for a picnic on a sunny day, decide to go skiing after a snowfall, or cancel a camping trip because of the possibility of severe weather. We hear of the destruction of flooding and tornadoes. We see the beauty of rainbows in the sky after an afternoon shower. The exhibits that come to your school, as well as the activities in this manual, will help relate science and mathematics to the weather phenomena that we see every day.

The following section will give you some background information on weather and the exhibits that are coming to your school. The students do not need to understand all of this information to learn about the weather and to enjoy the exhibits.

What is weather?

Weather results from a complex interaction of air, water, the Earth and the Sun. Although people have been observing and studying the weather for centuries, only in the last hundred years have we been able to begin to understand it. The invention of the telegraph allowed people to learn about current weather conditions all around the world. Meteorologists were then able to put the pieces together to describe such weather phenomena as warm fronts and cold fronts. Radar technology developed during World War II to detect ships and planes was later refined to detect clouds and rain. This enabled the study of localized events like thunderstorms. Computers and improved equipment will continue to enhance the knowledge of and forecasting of the weather.

Air

The Earth's atmosphere is a thin layer that protects the planet from dangerous rays of energy during the day and from plummeting temperatures at night. Most weather occurs in the lowest 7 miles of the atmosphere. This is called the troposphere. On the average, the air in the troposphere consists mostly of nitrogen (78%) and oxygen (21%). The other 1% includes gases such as argon and helium, as well as carbon dioxide, water vapor, and ozone, which vary in concentration from time to time and place to place.

Water

Although water vapor constitutes only a small percentage of the atmosphere, it is an extremely important ingredient of weather. The amount of water vapor in the air varies dramatically. In the winter the air is usually very dry, but in the summer the humidity, a measure of moisture in the air, can be very high. The amount of moisture in the air is limited by the temperature of the air. Warm air can hold more moisture than cold air.

Earth

The Earth's surface is 70% water and 30% land. Oceans and lakes absorb and lose heat more slowly than the land. As a result, the oceans don't vary in temperature as much as the continents over the course of a year. This uneven heating provides an interesting twist to the weather. Mountains and plains also contribute to the Earth's weather. As an air mass travels across a continent, it may encounter a mountain range, such as the Rocky Mountains. In the case of the Rockies, which are too long for the air to travel around, air masses must travel up and over the mountains.

Sun

As the Earth rotates under the Sun, some areas heat up more than others; the equatorial regions are much warmer than the poles. This uneven heating drives all of the weather on Earth. In fact, weather results from the Earth and the atmosphere evening out these differences. Cold air from the poles pushes towards the equator, while tropical air reaches to warm the poles. Illinois is located midway between these two extremes, making the weather extremely changeable depending on whether the cold air or the warm air is winning at the time!

The ways that Air, Water, Earth, and Sun interact give Oklahoma its AWESome, wild weather.

Common Weather Quantities

Temperature

Everything is made up of many tiny molecules that are always moving around in different directions. Because they move at different speeds, they have different amounts of energy. The temperature depends on the average amount of energy that all of the molecules have. On the average, the molecules in warm air have more energy than molecules in cold air. A thermometer detects changes in temperature through the expansion and contraction of a fluid (such as mercury) or a metal strip. Temperature is measured in either degrees Celsius or degrees Fahrenheit. Use the following equations to convert between these two scales:

$$°C = (5/9) \times (°F - 32°) \quad \text{or} \quad °F = [(9/5) \times °C] + 32°$$

Dew Point

Dew point is also measured in degrees, but it is a measurement of the amount of moisture in the air. The dew point tells you to what temperature you would need to cool the air in order for the vapor to begin to condense. This is exemplified by a glass of ice cold lemonade on a summer day. The air right around the glass is cooled by the cold drink. Eventually, the air cools to the point that it can't hold any more water vapor. (Remember, cold air can't hold as much water vapor as warm air). The vapor condenses onto the glass and forms water drops all over the glass of lemonade. If a person measured the temperature of the air right next to the glass just as the water drops begin to form, he or she would find the dew point. When the dew point is lower than 32°F (0°C), then it is called the frost point. If the temperature of the air reaches that point then frost will form instead of dew.

Pressure

Air pressure is the weight of the atmosphere per unit area. As tiny air molecules bounce around and collide with an object, they exert a force on that object. The molecules move in all directions, so the pressure is the same in every direction. It doesn't matter whether the surface is a table or a wall or a person, the air pressure on each is the same.

A barometer measures atmospheric pressure. Pressure is usually measured in inches of mercury. These odd units come from the original barometers, a dish of mercury with a tube sitting upside down in it. As the pressure rises, the air molecules push on the surface of the mercury in the dish and the mercury goes up the tube. The height of the mercury in the tube gives the pressure in inches of mercury. Normal sea level pressure is around 30 inches of mercury. Meteorologists use units called millibars which are seen on some barometers. Thirty inches of mercury is approximately 1016 millibars (mb).

Wind Speed and Direction

Wind results from uneven heating in the atmosphere. When air warms, the molecules move faster and spread out. Fewer molecules in an area means the pressure is lower. The opposite happens when air cools: the molecules move more slowly and remain closer together. More molecules in a given area mean higher pressure. This difference in pressure is called the pressure-gradient and causes the winds to flow from high to low pressure. The larger the pressure-gradient, the faster the winds. Wind speed is measured in miles per hour, kilometers per hour, or knots.

In studying the weather, it is also important to know the direction of the winds. Since we are interested in what weather conditions are approaching, we want to know where the winds are coming *from*. Hence, a north wind comes from the North.

Humidity

Relative humidity is a more common measure of moisture than dew point. If the dew point is very close to the temperature, then the relative humidity is high. This is a ratio of the amount of moisture in the air to the greatest amount that the air could hold. Relative humidity is given in percentages.

Precipitation

Precipitation is any form of water that falls to the ground. This includes rain, drizzle, snow, sleet, and hail. Meteorologists use a rain gauge to measure the amount of precipitation that falls. Any precipitation that is frozen, like snow or hail, is melted before it is measured.

Water Cycle

In the atmosphere, water can be a solid, a liquid, or a gas. For example, on any given day, the air around you has water vapor in it. There may be clouds in the sky which are made up of tiny water droplets and clouds higher in the sky are made up of ice crystals. The transitions between the different states is very important in studying weather.

Evaporation

Evaporation is the change of a liquid to a vapor. It is a cooling process.
The molecules in a glass of water move at different speeds. Some of the faster, high energy ones may escape into the air and become vapor molecules. Since the liquid water has lost some high energy molecules, the temperature of the water decreases. This is the principle behind the chill felt upon stepping out of the shower. The body loses heat as the water drops evaporate from the skin. The energy that is lost by your skin is transferred to the water molecules.

Condensation

Condensation is the change of a vapor to a liquid. It is a warming process. Condensation is the reverse process of evaporation. Some of the slower vapor molecules may bump into the surface of the water and stay there. Since the air has lost a slower molecule, the temperature increases. This warming is due to the air gaining heat from the water molecules.

Melting and Freezing

Melting is the change of a solid to a liquid. Freezing is the change of a liquid to a solid. Melting is similar to evaporation, except an ice molecule changes to a water molecule. Freezing is similar to condensation, except a water molecule changes to an ice molecule.

Sublimation

Sublimation is the change from solid to gas or from gas to solid without passing through the liquid state. For example, "dry ice" (frozen carbon dioxide), sublimes from a solid directly to CO_2 gas.

Clouds

Clouds are an important consequence of evaporation and condensation. When a moist "parcel" of air rises through the atmosphere, it expands because there is less pressure on it. As it expands, the air cools, and the water vapor in the air will condense if the "parcel" rises high enough. This condensation is only possible when there are dust, salt, or other particles in the air. These are called cloud condensation nuclei. Cloud drops are 100 times smaller than a typical raindrop. These cloud drops can grow bigger by collecting more water vapor on them or by colliding with other drops. Eventually they grow big enough and fall to the ground as rain or snow.

Clouds are classified by their appearance and height. *Cumulus* clouds have a flat base and look puffy. They are formed by convection, air currents caused by heating. *Stratus* clouds are layered clouds that look like flat sheets of clouds. They form when air is lifted by another air mass or when it lifts as it goes over a mountain. Wispy clouds made of ice crystals are called cirrus. *Cirro*- is the prefix for the highest clouds, those above 18,000 feet. Middle clouds begin with the prefix *alto*- and form between 6,000 and 18,000 feet. Any cloud that is raining or snowing either starts with *nimbo*- or ends with *nimbus*. Low-level clouds do not have a prefix. Some examples of cloud names are:

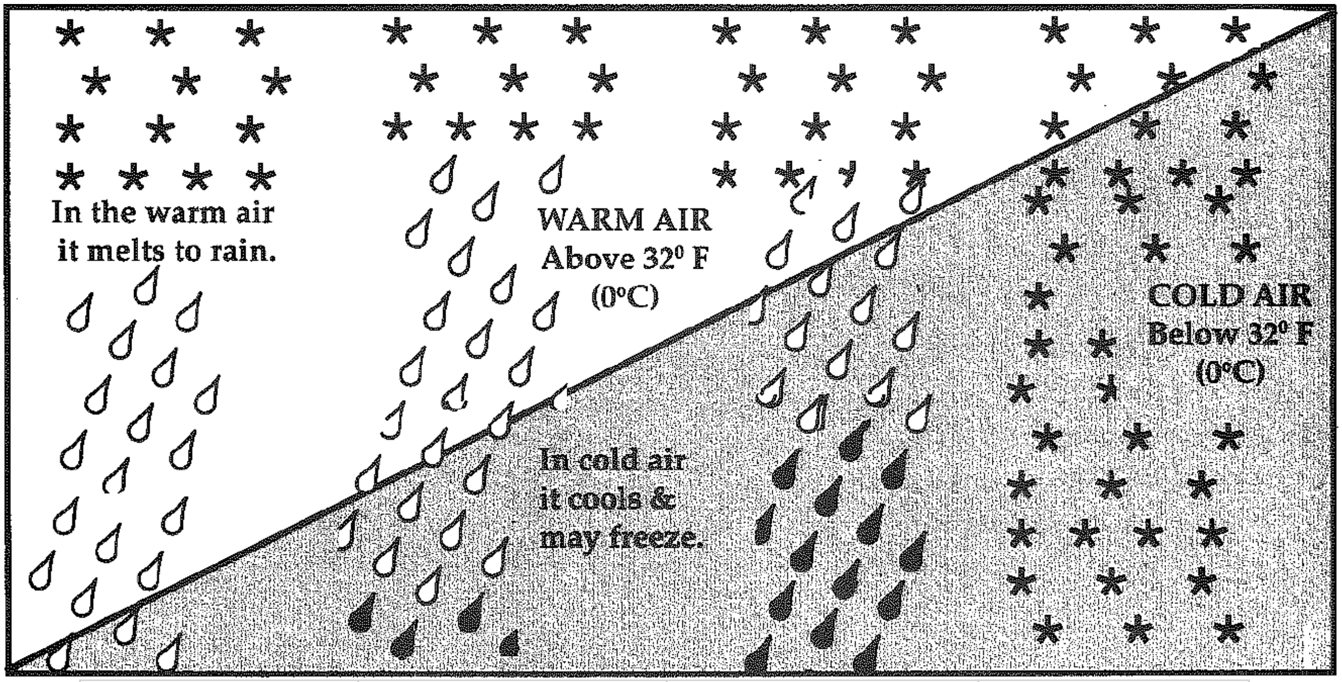
cumulonimbus	puffy cloud that is raining — thunderstorm cloud
stratocumulus	sheets of low puffy clouds
cirrocumulus	high puffy clouds
nimbostratus	dark layer of clouds that is raining or snowing — typical winter-time snow clouds

Precipitation Types

There are five main kinds of precipitation: snow, sleet, freezing rain, rain, and hail. Most clouds that produce precipitation are so high in the sky that almost all precipitation begins as snow - even in July! In order for precipitation to start as snow, the air must be below freezing (32°F or 0°C) where it forms, but the temperature of the air below the cloud can vary. To predict what type of precipitation will make it to the ground, a meteorologist needs to know the temperature of the air between the cloud and the ground.

If the air below the cloud is always below freezing, then the snowflakes will make it all the way to the ground. However, if the temperature fluctuates as the snowflake grows, its shape will change. The classic picture of a snowflake, a six-sided crystal, is called a dendrite. Dendrites form when the temperature is between 3°F and 10°F [-16°C to -12°C. Snowflakes can also be thin plates, hollow columns, needles, or a combination of different types depending on the temperature.

COLD AIR
Below 32° F (0°C)
Precipitation starts as snow



RAIN	FREEZING RAIN	SLEET	SNOW
These drops aren't	*These drops don't*	*These drops freeze*	*These flakes aren't*
in the cold air long	*turn to ice until*	*and fall as ice pellets.*	*in the air long*
enough to refreeze.	*they hit something.*	*enough*	*enough to melt.*

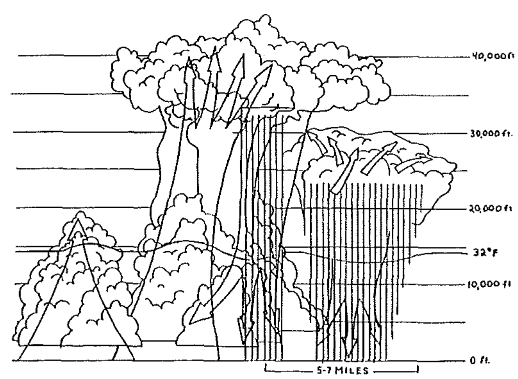
As snow falls from the clouds, it may encounter air that is warmer than the freezing point. The amount of time the snow spends in this warmer air will determine its final state. If the warm layer is very thin, the snow may not have time to melt at all and will remain snow. Sleet occurs when the warm layer is large enough to melt the snow, but the water drops fall into another layer of cold air which freezes the drops into ice. Freezing rain is similar to sleet, except the cold air is not as deep. In this case the water drops don't quite freeze in the air, but freeze when they hit the ground. This can be very dangerous, because it coats streets and sidewalks with a layer of ice. If the snow melts, but does not fall through a cold layer or if the cold layer is very shallow, the precipitation will fall as rain. Hail will be covered in the Thunderstorms section.

Thunderstorms

Thunderstorms are violent storms that always include thunder and lightning. When tornadoes, strong winds, and/ or hail are present, the thunderstorm is considered to be severe. There are two types of thunderstorms: air mass and frontal. Air mass thunderstorms occur in warm, moist air masses. An air mass is a huge body of air that has fairly uniform temperature and humidity throughout. This type of thunderstorm is a common event on summer afternoons. Frontal thunderstorms occur when a cold, dry air mass pushes a warm, moist air mass out of the way. Cold, dry air is more dense, therefore it tends to spread out underneath the warm, moist air. (This is similar to syrup spreading out on a plate.) The boundary between the cold and warm air is called a front and is a good location for thunderstorms to develop. Although the conditions that produce each type are different, the basic mechanisms are the same.

A thunderstorm starts as a large cumulus cloud, formed as the warm, moist air rises. This rising air is called the updraft. As the updrafts continue, the cloud grows. In the upper levels of the cloud it is cold enough so that when the water vapor condenses, ice crystals will form instead of water drops. The ice crystals and water drops stay in the clouds as long as the updrafts can hold them up. (Have you ever seen a beach ball held in mid-air by a fan? How about a bowling ball?) When the crystals and drops grow too large and heavy, they fall back down through the cloud. In the summer, the ice crystals will melt on the way down.

This drags down the air as well, forming downdrafts. When the downdraft reaches the ground, the air spreads out. In the mature thunderstorm, there are updrafts and downdrafts. Eventually, there isn't any warm, moist air to feed the updrafts. This kills the storm, and once all of the ice crystals and water drops have fallen, the storm is over.



Most thunderstorms last less than an hour, occasionally longer. When the cold air in the downdrafts spreads out, it acts like a mini-cold front and can start new thunderstorms several kilometers away. Those new thunderstorms can trigger more new storms and so on. A series of storms like this may last several hours.

Hail is formed in the upper levels of the clouds when ice crystals start to fall in the downdraft, but are caught in the updraft. The crystals get pushed back up and grow even more. They start to fall again and may get caught in the updraft again. Each time the crystals go through this cycle, another layer is added. This gives the hailstones a ringed appearance when cut in half.

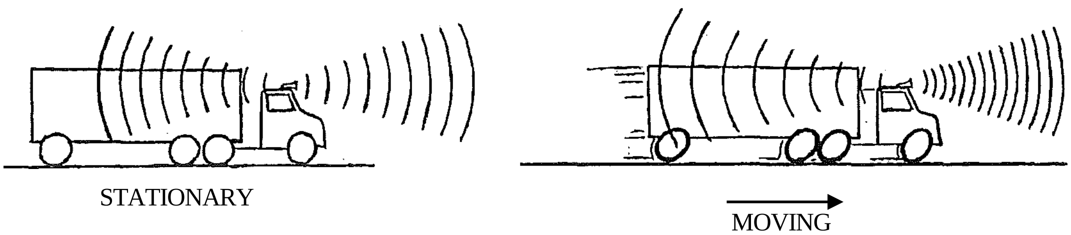
Tornadoes form in thunderstorms in which the winds at different levels in the storm are coming from different directions. The result is a rotating updraft, swirling at speeds up to 200 miles per hour (100 meters per second). Some tornadoes have been clocked at more than 300 mph. As the speed of the air increases, its pressure decreases. The lowered pressure picks up anything in the funnel's path. When the air rises, it cools, and the water vapor condenses to form a funnel-shaped cloud. If the funnel cloud grows large enough to reach the ground it is then called a tornado. Oklahoma composes most of the middle part of Tornado Alley. This is a large area where tornadoes are quite common because of the geography. Warm, moist air from the Gulf of Mexico in the south collides with cold, dry air from the Rocky Mountains in the west to set up good tornado conditions regularly. Tornadoes are most likely to occur in the spring and summer in Oklahoma.

Another possible occurrence in a thunderstorm is a microburst or downburst. As the rain falls down through the thunderstorm, some of it evaporates, cooling the air around it. The cooler air is more dense and falls more rapidly. This downdraft becomes stronger as more rain evaporates and can be very violent when it reaches the ground and spreads out. This 'event' generally occurs when the air below the storm is very dry. A dry downburst is one where all of the precipitation evaporates. When only some of the precipitation evaporates, it is called a wet downburst. Downbursts and microbursts, their smaller version, are very hazardous to air traffic and several airplane accidents have been attributed to them.

Lightning
Lightning is a giant spark of static electricity from one cloud to another cloud, a cloud to the ground, or from one to another part of the same cloud. This spark occurs when two areas build up opposite electrical charges large enough to overcome the air's resistance to the flow of electricity. Meteorologists are still trying to determine what makes the charges build in different parts of the cloud. They do know that the positive charges are found at the top of the cloud, while negative charges build near the bottom. Underneath the cloud, on the ground, positive charges are attracted to these negative charges and are drawn up into high objects like trees and buildings. When negative charges travel down towards the ground and positive charges travel upwards, they meet and allow a powerful surge of electricity to flow along the path they created. Lightning seems to flicker because this process occurs several times per half-second. We see the lightning's light almost instantaneously because light travels so fast — 300 million meters per second! The temperature of a lightning strike may be five times as hot as the surface of the Sun.

Thunder
Thunder is a result of the energy produced by lightning being changed into sound. As the electricity flows during a lightning strike, it heats the nearby air thousands of degrees. This rapid, intense heating causes the air to expand rapidly. As it expands, it cools. This expansion and contraction creates sound waves, which travel much more slowly than light — about 1/5 mile per

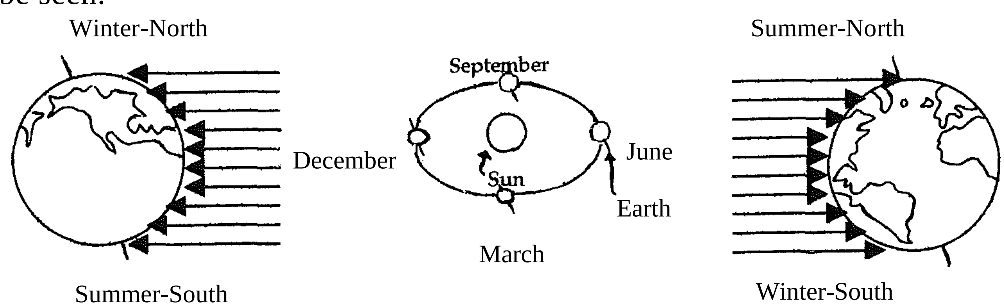
second ($^{1}/_{3}$ km/ s). If a person counts the number of seconds between seeing the lightning flash and hearing the thunder and divides that number by five, the result is the number of miles away the lightning flash occurred. By timing successive thunder-lightning delays, the movement of a storm toward or away from an observer may be determined. Thunder rumbles because the sound from different parts of the lightning strike takes different lengths of time to reach the same point.



Radar

Radar stands for Radio Detection and Ranging. It is a system based on the same ideas as echoes - except that instead of sound waves, it uses radio waves. A machine sends out radio waves, they bounce off of rain drops, snowflakes, and other types of precipitation, and then come back. The machine can tell how far away the precipitation is by how long it took for the echo to come back and how much there is by how strong the echo is when it returns. A computer receives the information and plots it on a screen with a map so that meteorologists can see what is happening in the area.

Doppler radar can do the same thing as normal radar, but it can find smaller particles and even tell the direction in which things are moving. It does this by using the Doppler effect. The Doppler effect is what makes a train whistle or a police siren sound different as it approaches and as it leaves. When the train is approaching, the pitch of the whistle sounds higher. When it is getting farther away, the whistle sounds lower. The same thing happens to the radio waves that a weather radar sends out. When the computer shows this information on the screen, forecasters can look for the early signs of tornadoes and downbursts before they can be seen.

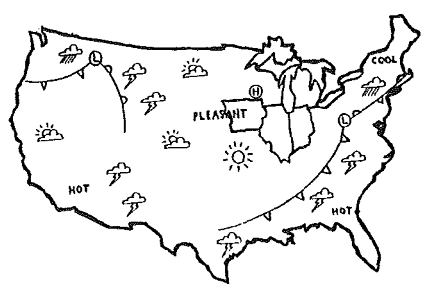


Seasons

The Earth revolves completely around the Sun in an elliptical path (not quite a circle) in 365 ¼ days (one year). As the Earth revolves around the Sun, it spins on its axis, completing one spin every 24 hours (one day). The Earth's axis is tilted at an angle of 23.5° from the perpendicular to the plane of the Earth's orbit. All year, this axis points to the same area in space, where Polaris, the North Star is located. Thus, in June, when the Northern Hemisphere is tilted toward the Sun, the sunlight hits the Earth more directly than in December when the Northern Hemisphere is tilted away from the Sun. Sunlight that strikes the Earth's surface directly is much more intense than sunlight that strikes the same surface at an angle. Sunlight that strikes the Earth at an angle spreads out and heats a larger region than sunlight hitting the Earth directly. All else being equal, an area experiencing more direct solar rays will receive more solar energy than the same size area being struck by sunlight at an angle. Sunlight strikes different parts of the Earth at different angles because the Earth's axis is tilted.

Coriolis Effect

The Coriolis effect describes the deflection of objects, including the atmosphere and the oceans, due to the rotation of the Earth. Suppose a rocket was launched from the North Pole and was planned to reach Illinois in one hour. In that hour, the Earth rotates through 15° of longitude. The rocket would land 15° west of the intended target — somewhere in Iowa. It looks like the rocket turned to the West. This effect turns winds to the right relative to the Earth's surface in the Northern Hemisphere. The faster the winds, the larger the Coriolis effect. The strength of the Coriolis effect also depends on latitude. At the equator, the Coriolis effect is zero, and it is largest at the North and South Poles.

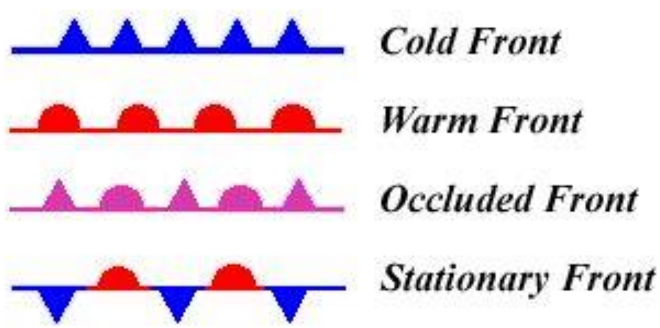


Weather Maps

Weather maps are one of the most common ways people are exposed to learning about the weather. They are useful for knowing what the current weather conditions are, as well as for forecasting future weather events. Like any map, a weather map has its own set of symbols that help everyone, including meteorologists, TV weather forecasters, and airplane pilots, understand the information contained on the map.

H High Pressure **L** Low Pressure

The first things one might notice on a weather map are the letters H and L. These stand for high pressure areas and low pressure areas, respectively. If the Earth weren't spinning, all winds would flow directly from the areas of high pressure to the low pressure areas. Because of the rotation, winds flow clockwise around an area of high pressure and counter-clockwise around an area of low pressure.



The next symbols one is likely to see on a map are fronts. A front is the boundary between two different air masses — warm and cold. If the cold air is pushing on the boundary, meteorologists call that a cold front. The symbol for a cold front is a blue line with triangles on it. The triangles point toward the direction that the cold air is moving. When the warm air pushes, it is called a warm front. A warm front is shown on the map as a red line with half circles on it. If the cold air and the warm air are moving parallel to the boundary, that is a stationary front. It is denoted by alternating cold front and warm front symbols. When there is a system with a warm front and a cold front and the cold front overtakes the warm front, an occluded front forms. An occluded front is shown with a purple line with alternating half-circles and triangles pointing in the direction the front is moving.

Midwest Wild Weather Teacher Manual Activities Matrix

The following activities found in the Midwest Wild Weather Teacher Manual are:

	Support the general concepts:
Air Exerts Pressure	Properties of Air
Air Expansion and Contraction	Properties of Air
Create a Tornado	Thunderstorm Phenomena
Designing a Lightning Calculator	Thunderstorm Phenomena
Simulating a Downdraft	Thunderstorm Phenomena
Static Electricity, Dancing Confetti, and Lightning	Thunderstorm Phenomena
The Geometry and Art of Capturing a Snowflake	Phase Changes
Icicles	Phase Changes
Measuring Frost Point	Phase Changes
How Does Your Cloud Grow?	Phase Changes
Water vs. Land Surfaces	Sun and Our Weather
Why is Summer Hotter Than Winter?	Sun and Our Weather
Make a Cloud Wheel	Weather Observation
Weather Sayings—How True?	Weather Observation
Fast as the Wind—Make an Anemometer	Weather Instruments
Make a Thermometer	Weather Instruments
Make a Wind Vane	Weather Instruments
Measuring Humidity—Make a Psychrometer	Weather Instruments
Precipitation Gauge	Weather Instruments
Weather Recording and Forecasting	Weather Instruments

WEATHER TOPIC: Properties of Air

1 Air Exerts Pressure

This activity is for cooperative learning groups.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES

Students will

* learn that air exerts pressure.
* demonstrate the effects of air pushing on water.
* learn what a barometer is, and how and why it is used.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5

PASS Standards

Grade 5: 3.2a

Grade 6: 5.1c

Grade 7: 5.1

Grade 8: 1.2; 4.3

MATERIALS

Divide students into cooperative learning groups (about three students each). You will need the following materials for each group.

large balloons
food coloring
water
wide rubber bands
paper towels/cloth
clear plastic straws
clear sturdy plastic cups (10-14 oz.), baby food jars, or beakers
safety pin (for making hole in balloon)

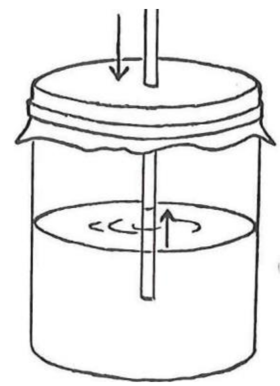
SAFETY PRECAUTIONS

Be prepared for spills and appoint only one child per group to blow on the tubing or straw. Food coloring stains! Adult should handle pin.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Air pressure is the force of air exerted per unit of surface area. A small quantity of air in a large space exerts little pressure because the molecules have more space to move around and encounter other air molecules with less frequency. A large quantity of air in a small space exerts more pressure because the molecules are more compacted and collide with each other more often.

In the atmosphere, high and low pressure areas are caused by the effect of gravity and changes in temperature. As one travels higher in the atmosphere, the force of gravity on air molecules is less; therefore, these air molecules are farther apart, and the air pressure is lower. The closer to sea level one travels, the greater the effect of gravity on air molecules, the closer they are together, and the greater the air pressure. Air pressure at sea level, at New York City's waterfront, for example, is 14.7 pounds per square inch while air pressure at an altitude of 18,000 feet above sea level, atop Europe's Mt. Elbrus, is 7.3 pounds per square inch.



VOCABULARY

Pressure: the force of air exerted per unit of surface area.

- **PROCEDURE**

  Before starting activity have a discussion on air pressure and how it relates to weather using the concepts in background information.

1. Fill the plastic cup or jar 2/3 full with room temperature water.
2. Add 2-3 drops of food coloring to the container of water.
3. Cut off the entire neck of the balloon, discard the neck, and poke a small hole in the center of the remaining piece of balloon.
4. Push the straw through the small hole, making sure that it fits snugly with no gaps.
5. Put the balloon over the mouth of the cup or jar and, if necessary, secure it with a rubber band.
6. Have students go through the series of tests in the discussion question section and have them record their data on the activity sheet provided.
7. Discuss results with students.
8. Show the students a barometer; discuss how a barometer measures air pressure, and how it is different from/similar to the device they've just used.
9. Listen to weather reports on radio or TV, read the newspaper or access the Internet for current weather information, then graph the barometric pressure for a week or longer. Discover what kinds of weather are present during different barometric pressure readings. Discuss how air pressure affects our weather.

DISCUSSION

What happens to the water in the straw when you press on the balloon?
The water goes up the straw because the air is pressing down on the water when you push down on the balloon. The space available for the water becomes smaller due to the increase of air pressure, and the water has nowhere else to go but up the straw.

Are you putting more or less pressure on the air inside the cup when you push down on the balloon? As you push down on the balloon, more pressure is being exerted by the air. The space for the air is made smaller as you press on the balloon, and the air molecules are pushed more closely together.

How do you make the level of the water in the straw fall? The level of water in the straw can be lowered*by pulling up on the balloon.

Is there more or less pressure on the air in the cup when you pull up on the balloon?
There is less pressure, because the amount of space for the air has increased and the air molecules have more space to move around and encounter other air molecules with less frequency.

What happens to the balloon when one student blows gently into the straw? As the student blows into the tube, air is pushed into the water and bubbles are seen as the air rises and escapes out of the water and enters the space already containing some air. Since more air has been put into the jar or cup, the air molecules are pushed more closely together and collide with each other more often. Because the air pushes against the balloon with an increase in pressure, the balloon is pushed up.

Explain the similarities between pressing down on the balloon and blowing air into the straw. When the balloon was pressed down, the air pressure increased. The air molecules had a smaller space in which to move and were more compacted, causing them to collide with each other more frequently, forcing air up the straw. When air was added to the jar or glass, the air pressure also increased. There was a larger quantity of air in the same space. The molecules of air became compacted and collided with each other more frequently, causing the balloon to expand.

EXTENSION ACTIVITIES

*Fill a glass to overflowing with water. Place an index card on top of the glass. Hold the card with one hand while you turn the glass over. Remove the hand holding the card. What happens? The card will stay in place, because the air pressure outside the glass is greater than the weight of the water inside the glass. Note: Container must be glass, not plastic. Use a new index card for each attempt.

*Stretch a deflated balloon over the mouth of a plastic soda bottle. Gently squeeze the bottle. What happens to the balloon? An increase in air pressure allows the balloon to inflate.

References
Air, Delta Education, Nashua, NH., 1989.
The Weather Book, Jack Williams, Vintage Books, New York, 1992.

S T U D E N T   A C T I V I T Y   S H E E T

Air Exerts Pressure

Group ______________________________ **Date** _________________________

MATERIALS PER GROUP

large balloon	food coloring	paper towels (for spills)
wide rubber band	water	
clear plastic straw		
1 aluminum pie pan		
clear sturdy plastic cup (10-14 oz.), baby food jar, or beaker		
safety pin		

PROCEDURE

1. Fill the plastic cup or jar 2/3 full with room temperature water.
2. Add 2-3 drops of food coloring to the container of water.
3. Cut off the entire neck of the balloon, discard the neck, and poke a small hole in the center of the remaining piece of balloon.
4. Push the straw through the small hole, making sure that it fits snugly with no gaps.
5. Put the balloon over the mouth of the cup or jar and, if necessary, secure it with a rubber band.
6. Place cup in pie pan.

DISCUSSION

What happens to the level of the water in the straw when you press on the balloon?

When you press on the balloon are you putting *more* or *less* pressure on the air inside the container when you press on the balloon?

How do you make the level of the water in the straw fall?

Is there *more* or *less* pressure on the air in the cup when you pull up on the balloon?

What happens to the balloon when one student gently blows into the straw?

Explain the similarities between pressing down on the balloon and blowing air into straw.

2 Air Expansion and Contraction

This activity is a teacher demonstration.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES

Students will
- observe that air exerts pressure.
- observe that heated air expands.
- observe that cooled air contracts.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
Grade 4: 1.1; 1.2; 2.2b
Grade 5: 1.2; 1.3; 3.2a
Grade 6: 1.1; 2.1
Grade 7: 1.1; 5.1
Grade 8: 1.2; 4.3

MATERIALS

16-ounce coffee can
rubber cement
1 thick rubber band
candle and matches, or "hot pot"
1 12-inch balloon
2 strips of cardboard or poster board
bowl of ice

SAFETY PRECAUTIONS Safety goggles are suggested are suggested for the demonstration. As always when using an open flame, practice caution!

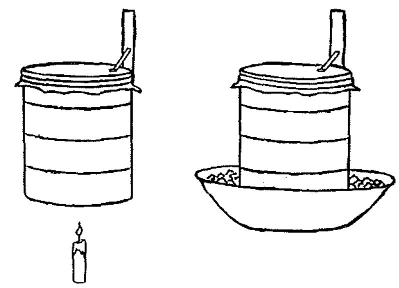
- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Air exerts pressure on everything. Air pressure changes with variations in temperature and elevation. Air molecules are packed together more densely at sea level than on mountain tops. A barometer measures air pressure.

When a mass of air is heated, the molecules within that mass of air, on average, move faster and farther apart. This warmer mass of air rises only to be replaced by a mass of colder, denser air.

Cold air, on the other hand, contracts. When a mass of air is cooled, the molecules within that mass of air, on average, move more slowly and stay closer together. This cooler air is more dense and tends to stay close to the ground.

VOCABULARY



Pressure: the force of air exerted per unit of surface area.

Expand: to increase in volume and area.

Contract: to decrease in volume and area.

Barometer: an instrument used to measure atmospheric pressure.

- **PROCEDURE**

  Because this is a teacher demonstration, the instructor can lead a discussion before, during, and after on air, air pressure, and how it relates to weather.

1. Cut off the entire neck of a 12-inch balloon.
2. Carefully stretch the balloon (minus the neck) over the opening of the coffee can.
3. Cut one piece of cardboard (or posterboard) 2.5 inches long and $^1/_4$ inch wide.
4. Cut a second piece of cardboard (or posterboard) 5 inches long and 1 inch wide.
5. Attach the larger cardboard piece to the side of the can by wrapping the rubber band around the mouth of the coffee can. Make sure that 4 inches of the cardboard stick up next to the mouth of the can. Refer to illustration.
6. On the smaller piece of cardboard, bend back 1/4 inch at one end and rubber cement the bent part to the center of the balloon.
7. The other end of the cardboard should extend up to and touch the larger piece of cardboard. Mark the point with a marker where the two pieces meet.
8. Holding the upper rim of the can, place the can over the candle flame or in the "hot pot" filled with water for a few minutes. Observe the pointer and the balloon. Have students record their observations.
9. Now immerse the can in the bowl of ice. Watch the pointer and the balloon. Have students record their observations.

10. Show the class a common barometer and discuss how a barometer measures air pressure. A barometer is located on the Weather Station exhibit. Compare and graph the daily barometric readings of the barometer. How are they the same or different? Relate these changes in the weather with the changes in air pressure.

11. Ask students the following discussion questions.

DISCUSSION

What happens to the balloon and the pointer when the coffee can is held over the flame? The balloon and pointer both go up.

What makes the balloon and pointer move? When the air is warmed, the air molecules tend to move faster and farther apart. As these air molecules move apart from each other, they take up a greater space and cause an increase of the air pressure exerted upon the balloon, causing it to expand.

What happens to the balloon and the pointer when the coffee can is placed in the bowl of ice? The balloon and pointer move down.

What makes the balloon and pointer move? When the air is cooled, the air molecules move closer together and cause a decrease of air pressure on the balloon. Therefore, the balloon and pointer go down, because the cool air contracts.

When was the air pressure higher: when the can was heated or cooled? The air pressure was higher when the can was heated. The molecules of warm air are more active and move further apart from one another and create a higher pressure against the balloon.

What usually happens to the temperature of air as you go up the side of a mountain? The temperature usually goes down.

Is air pressure higher or lower as you go up a mountain? Air pressure gets lower as you increase elevation above sea level. Air molecules are packed together more densely at sea level than at mountain tops due to gravity and the weight of the air above.

EXTENSION ACTIVITY

Use a plastic soda bottle and attach a deflated balloon to the top of the bottle. Put the bottle in boiling water and let students observe what is happening to the balloon. The balloon will inflate because the air is warmed and the air molecules are moving faster and farther apart from one another. As they move apart, the warm air expands and the balloon inflates. The warm air has caused an increase in the air pressure. Now place the bottle in a bowl of ice water. As the air cools and the air molecules move closer together, the balloon will deflate and the air pressure will decrease. (Do not leave plastic bottle in boiling water too long.)

References

Weather, Elizabeth Kellerman, Millikin Publishing Company, St. Louis, 1984.
The Weather Book, Jack Williams, Vintage Books, New York, 1992.

3 Create a "Tornado"

This activity is for cooperative learning groups.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES
Students will
- demonstrate and understand the principles of a vortex.
- simulate and observe inverted tornado motion.
- understand the weather phenomena of how a tornado originates.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.1; 1.2; 2.2b; 4
Grade 5: 1.3; 1.4; 3.2a
Grade 6: 2.1; 5.1c; 5.1d
Grade 7: 1.1; 5.1; 6.2
Grade 8: 2.1; 2.2; 4.3; 5.1

MATERIALS
Divide students into cooperative groups of two or three. You will need the following supplies *<u>for each group:</u>* *(For grades 4-5, the teacher may want to have water already in the liter bottles.)*
clear liter or 2-liter soda bottles, 2 for each group (remove labels)
Tornado Tube®, (purchase through teacher stores, science catalogs or science centers)
If teacher cannot purchase them, a flat washer with a 3/8" hole in the center and wide duct tape or soft washing machine hose can be substituted.
water
funnel, suggested for ease in pouring, if not filled at sink
food color, fine paper confetti, or paper punch circles

SAFETY PRECAUTIONS
If the tape or Tornado Tube® is not secure, water will leak from the connection.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

A tornado starts when cold dry air coming from the west catches up with unusually warm, moist air from the south. The result is a whirling wind with thick, black clouds and thunderstorms. Water vapor is swept upward as gusts of warm air rise in a spiraling motion. When the air cools, it forms the tornado's twisting, funnel-shaped cloud. The funnel-shaped wind cloud whirls at enormous speeds and picks up anything in its path. The rapidly rising column of air within the funnel lowers the pressure in the funnel's center as the tornado advances. As the speed of air increases, the pressure of the air decreases. (The faster air moves, the less pressure it has. This was discovered in 1738 by the Swiss physicist Daniel Bernoulli.) A tornado seldom lasts more than an hour and usually covers about two city blocks. Only two percent of tornadoes are classified as "violent." They may last longer, with winds of up to 318 miles per hour (509 km), and may cover a path of up to 26 miles (42 km) long and 1/2 mile wide (1.6 km). Tornadoes are sometimes called cyclones or twisters. The color of a tornado is determined by a number of factors such as amount and direction of sunlight and the type of debris being picked up at the surface. The vortex acts like a huge vacuum cleaner, sucking in air from near the ground and carrying it upward.

VOCABULARY

Vortex: a whirling mass of air or water.

Tornado: a strong, rotating column of air extending from the base of a cumulonimbus cloud to the ground. Cumulonimbus clouds are also called thunderheads.

Funnel cloud: a rotating column of air extending from a cloud, but not reaching the ground.

Wind shear: any sudden change in wind speed or direction over a small distance.

Fujita scale: classification scale for tornadoes, comparing wind speed and damage. Developed by Prof. Theodore Fujita and Dr. Allen Pearson.

- **PROCEDURE**

Before beginning activity, discuss tornadoes and review facts and vocabulary.
NOTE: Teacher should check seals before students begin to shake and invert their bottles.

1. Divide students into small groups and pass out liter bottles, Tornado Tubes®, water and confetti or punches.

2. Fill one bottle about $^3/_4$ full with water and screw the Tornado Tube® onto it. Before placing the second bottle on top of the first bottle, the teacher may have the students put several drops of food coloring or dye or, for contrast, and some confetti, if desired, into the bottle to help the students observe the motion of the water. (Paper confetti tends to get waterlogged, so it will have to be replaced often.) Then they will attach the second bottle by screwing the empty bottle to the end of the tube.

3. Placing a hand securely on top and resting the bottom of the empty bottle on a flat surface, shake upper bottle briefly in circular motion. Tornado action will result. The long twirling funnel students see is a vortex.

DISCUSSION

Did you notice how the water near the center of the vortex spins faster than the water at the edges? What happens when confetti/punches come in contact with the vortex? The motion of the water in this tornado bottle models the circular movement of air during a tornado.

Try swirling the top bottle faster or slower, then reverse directions. **What happens?** The vortex spins faster or slower. There is a greater correlation of the time required for drainage to the smoothness of the agitation than to the speed of agitation.

Can you trace the motion more easily with the confetti? Yes.

How is the vortex different from a regular tornado? The vortex motion is down; because of very low pressure a tornado pulls objects up.

E X T E N S I O N   A C T I V I T I E S

- Have students do investigative reporting on how tornadoes have recently affected their community.
- Write poems describing a tornado's motion.
- Design a tornado safety poster.
- Collect newspaper or magazine pictures of tornadoes and write a short story.
- Have students write and produce a play on a tornado and its effect on a small community.
- Calculate average wind speeds for each level of the Fujita Scale.
- Compare the vortex to the spinning of an ice skater when his/her arms start wide and draw close to the body.

FUJITA SCALE

Classification	Miles per hour	Category	Damage
FO	40-72	Weak	Light
Fl	73-112	Weak	Moderate
F2	113-157	Strong	Considerable
F3	158-206	Strong	Severe
F4	207-260	Violent	Devastating
F5	261-318	Violent	Incredible

References

Simple Weather Experiments With Everyday Materials, Muriel Mandell, Sterling Publishing Co., Inc., New York, 1990.

The Weather Book; USA News, Jack Williams, Vintage Books—a division of Random House, Inc., New York, 1992.

The Weather Sourcebook, Ronald L. Wagner and Bill Adler, Jr., Adler & Robin Books, Inc., 1994.

Weather Watcher, Boston Museum of Science, The Nature Company, Berkeley, California, 1992.

Create a Tornado

Group ________________________ **Date** ____________________

MATERIALS PER GROUP
2 clear liter bottles (remove labels)
Tornado Tube®: If teacher cannot purchase them, a flat washer with a 3/8" hole in the center and wide duct tape or soft washing machine hose can be substituted.
water
funnel, suggested for ease in pouring, if not filled at sink
food colors, fine paper confetti, or paper punches

PROCEDURE

1. Fill one bottle about 3/4 full with water and screw the Tornado Tube® onto it. Before placing the second bottle on top of the first bottle, put several drops of food coloring or, for contrast, and some confetti or paper punches, if desired, into the bottle. Then attach the second bottle by screwing the empty bottle to the end of the tube.

2. Placing a hand securely on top and resting the bottom of the empty bottle on a flat surface, shake upper bottle briefly in circular motion. Tornado action will result. The long twirling funnel you see is a vortex.

DISCUSSION

Did you notice how the water near the center of the vortex spins faster than the water at the edges? What happens when the confetti comes in contact with the vortex?

Try swirling the top bottle faster or more slowly. What happens?

Can you trace the motion more easily with the confetti or punches?

How is the vortex different from a regular tornado?

WEATHER TOPIC: Thunderstorm Phenomena

4 Build a Lightning Calculator

This is an individual student activity.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES

Students will

* learn that light travels faster than sound.
* formulate how to predict lightning distances.
* learn thunderstorm safety facts.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.2; 2.1; 2.2; 2.3a; 2.3b
Grade 5: 1.1; 1.2; 1.3; 1.4; 3.2a; 3.2b
Grade 6: 2.1; 2.2; 5.1c
Grade 7: 1.1; 5.1; 6.2
Grade 8: 2.1; 2.2; 4.3; 5.1

MATERIALS

Supplies for each student are recommended.

scissors	copy of Thunder-Lightning Calculator
colored pencils/pens	NOAA Thunder-Lightning booklet (optional. Contact National Oceanic and Atmospheric Administration to obtain: <www.nws.noaa.goy>)
brass brads	

SAFETY PRECAUTIONS

There are no precautions in this activity.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Lightning is one of the most powerful forces of nature. Today scientists are learning more and more about what happens when a flash of lightning streaks across the sky. Lightning is a very large electrical spark. The spark is caused by tiny particles called *electrons.* Electrons are too small to see. However, during a lightning flash, electrons shoot through the air so fast they make the air around them glow. A streak of lightning shows the path the electrons followed as they blasted their way forward. Except for its size and power, lightning is no different from the spark you can create by shuffling your feet on the carpet and touching metal. Both are electrical charges caused by friction (the rubbing of one object against another).

Lightning can travel at speeds up to 93,000 miles per second and may heat the air it passes through to temperatures between 15,000 and 60,000 degrees Fahrenheit in a millionth of a second. This extreme heat causes the air to expand suddenly and violently, producing the sound called *thunder.* Since light and sound travel at different speeds, you can use the sound of thunder to tell the distance in miles between you and the flash. Lightning can be seen almost instantly, but the sound of thunder takes five seconds to travel one mile. Light travels at 300,000 kilometers (km) or 186,000 miles (mi) per second (kps or mps) and reaches the Earth from the Sun in only 8 minutes. Sound travels at 1 km every 3 seconds or 1 mile every 5 seconds.

When you see the flash of lightning, count the seconds until you hear the thunder. Divide the number of seconds by five to determine the distance in miles. If you do not have a watch, count the seconds as "one thousand one, one thousand two, one thousand three," etc. (Another suggestion would be "one Mississippi, two Mississippi," etc.).

For every five seconds you count, the lightning flash is one mile away. The mathematical formula is: **Distance Time** x **Velocity.**

For example: D (3/5 mi) = T (3 seconds) multiplied by V (1/5 mps). 3/5 = 3 x 1/5.
In practice, 3 x 1/5 is the same as 3 divided by 5 (1/5 inverted).

If you count three seconds, the lightning is approximately 3/5 mile away. If you see a flash of lightning but don't hear the thunder, the lightning was probably too far away to hear. Thunder from lightning discharging 15 or more miles away is not usually heard.

VOCABULARY

Thunder: the sound produced by a lightning discharge.

Lightning: a visible discharge of static electricity produced by a thunderstorm.

Thunderstorm: localized storms that produce lightning (and therefore thunder).

Electron: tiny outer part of the atom that has a negative charge.

Friction: the rubbing of opposite electrical charges.

Atom: the tiny particles of which everything is made.

PROCEDURE

Ask students what prior knowledge they may have of thunder, lightning, and thunderstorms. Discuss lightning, thunder, and thunderstorm facts provided in the background information. It is important to discuss thunderstorm safety. NOAA booklets provided for your class can be obtained by calling or writing to the local Red Cross.

1. Two circles are provided for cutting out at the end of this lesson. Duplicate a set for each student. They include appropriate distances and times.

2. Assemble the Lightning Calculator by placing the smaller circle face up on the larger circle. Cut out the "X" in the inner circle before assembling.

3. Push a brass brad through the middle hole to secure the two circles.

4. Have students outline distances and seconds as they wish with colored pencils or pens. Each student may also decorate the calculator's outer circle with thunder, lightning, weather symbols, etc.

5. Inform the students how to use the calculator by explaining the five seconds to one mile formula. Review the formula many times so students will be familiar with how to calculate the distances.

6. For students needing a challenge, distribute the cover sheet only and let the students generate the second sheet through calculations.

DISCUSSION

Why is it important to estimate how far lightning is from you or your family? You will know how far the thunderstorm is from you so that you can prepare for it and be safe.

What safety precautions should you take in a thunderstorm? Give the students several scenarios. (A baseball game, swimming, picnicking, etc.)

Why do you see lightning before you hear thunder? Light and sound travel at different speeds. Light travels more quickly than sound.

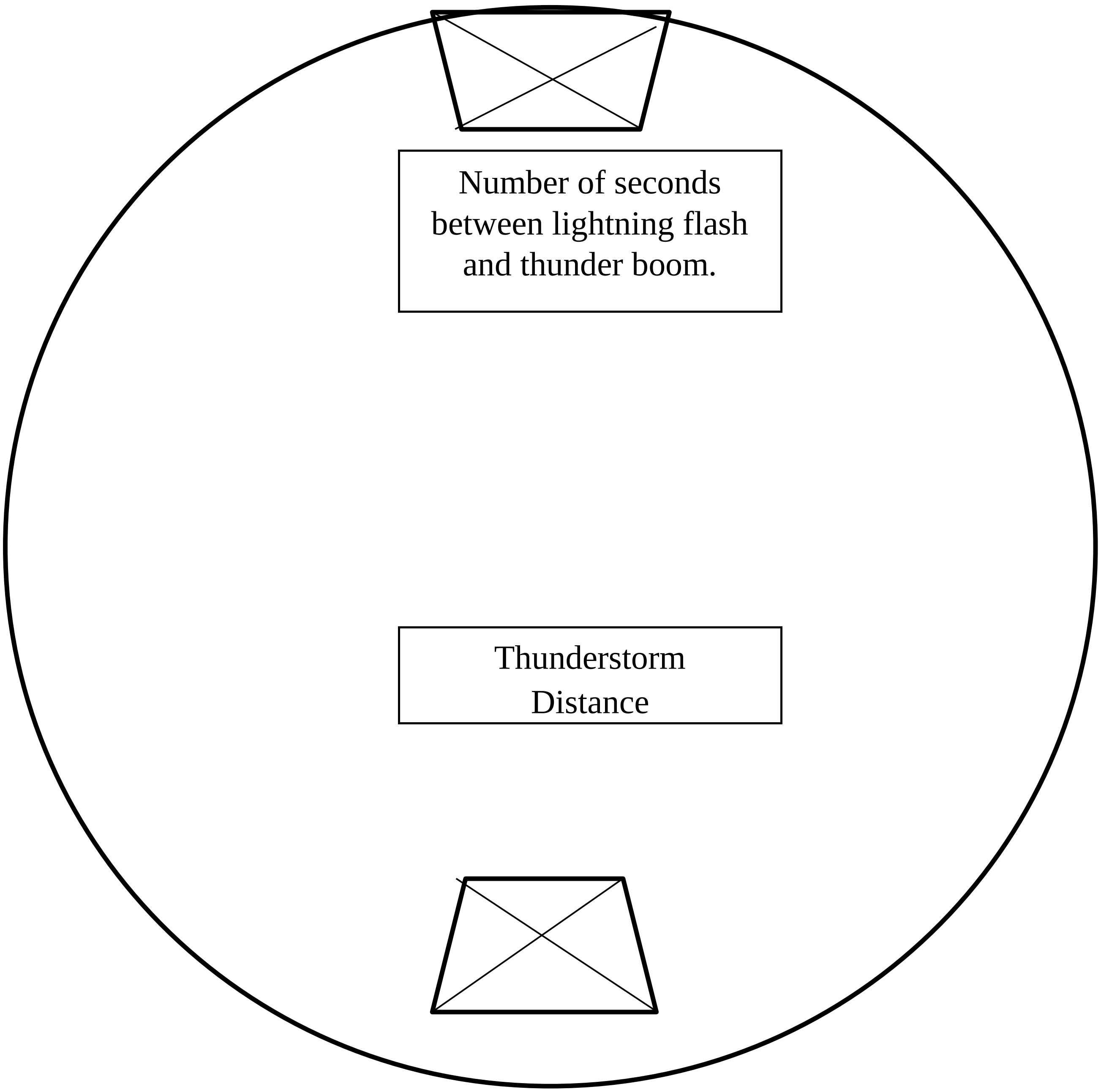
EXTENSION ACTIVITIES

- Design a thunderstorm safety poster or booklet.
- Create a video on thunderstorms. Include facts, safety, and interviews.
- Create five story problems on thunderstorm phenomena.
- Write a thunderstorm poem.
- Using Charlotte Zolotow's "Storm Book," create a storm symphony with your class.

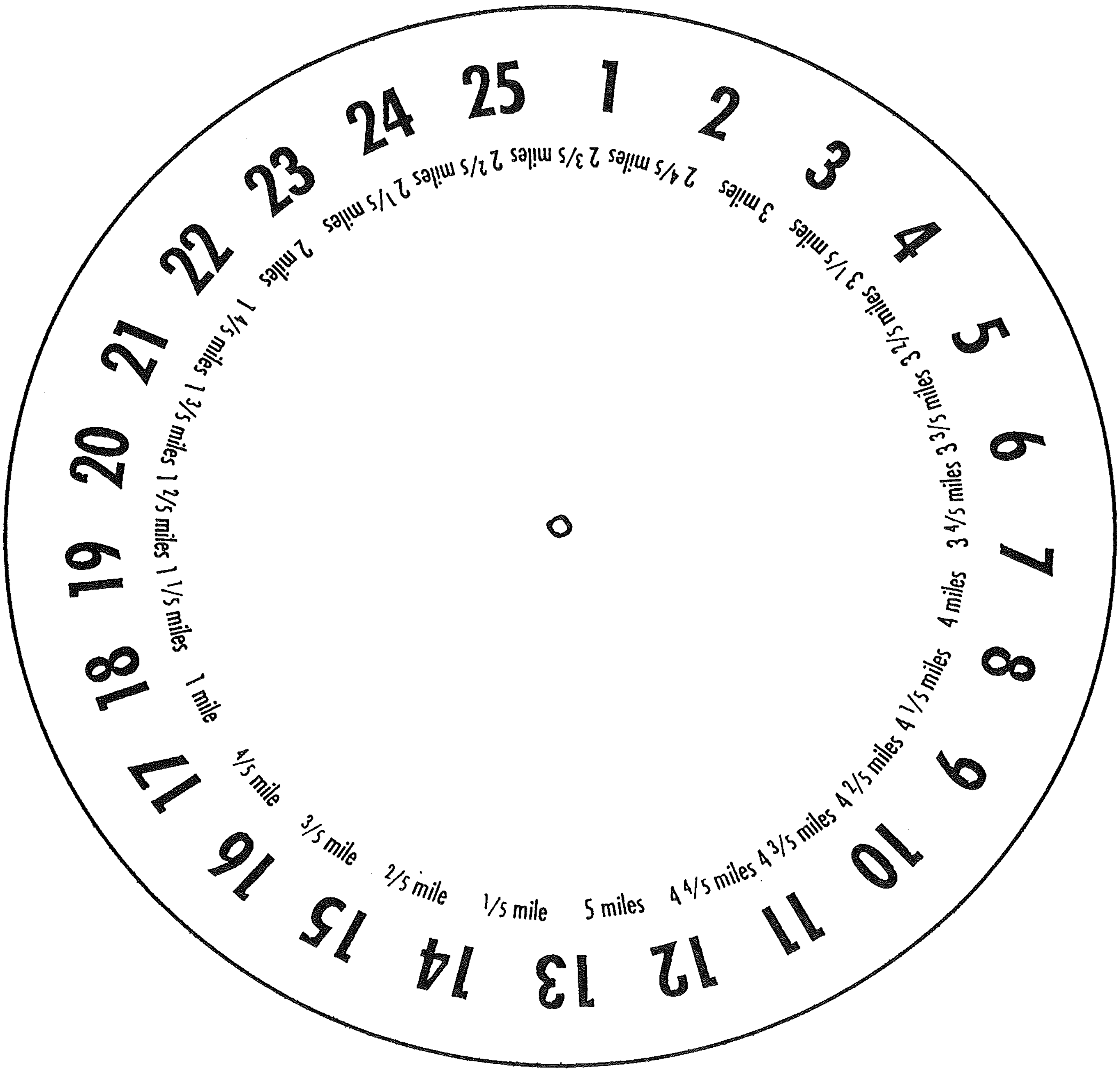
This activity will allow students to make sound effects to accompany the book. Perform the "storm symphony" for another class or parents.

References
Lightning, Stephen Kramer, Carolrhoda Books, Inc., Minneapolis, 1992.
The Weather Book, Jack Williams, Vintage Books, New York, 1992.
Weather Watcher, Alliance for Science; The Nature Company and The Boston Museum of Science, The Nature Company, Berkley, Ca., 1992.

Design a Lightning Calculator



Design a Lightning Calculator



5 Simulating a Thunderstorm Downdraft

This activity is a teacher demonstration.

Grade Levels: 4th - 8th grades

Estimated Time
45-minute class period

OBJECTIVES
Students will
* learn how thunderstorm downdrafts occur.
* observe a simulation of a downdraft.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.1; 1.2; 2.2b
Grade 5: 1.1; 1.2; 1.3; 1.4; 3.2a; 3.2b
Grade 6: 1; 2.1; 5.1b; 5.1c
Grade 7: 1.1; 5.1; 6.2
Grade 8: 1.2; 4.3; 5.1

MATERIALS
Ten gallon aquarium (or any clear container deep enough for down-draft to be seen)
quart of cold milk
water

SAFETY PRECAUTIONS
There are no safety precautions.

• BACKGROUND INFORMATION FOR INSTRUCTOR
To understand what a downdraft is, first visualize how a thunderstorm is formed. When a cumulonimbus tower builds skyward, it's not merely "growing." It is being propelled from within by a convective updraft, a strong pocket of warm, moisture-laden air that usually has been heated from below by warm, sunlit ground. As it rises, it condenses and forms cloud (tiny water) droplets. The condensation process also releases small amounts of "latent heat," adding to the buoyancy of the updraft.

The cloud droplets within the spreading anvil (the wide anvil-shaped top of the cloud) are blown downwind by the existing upper-level winds, which in turn mix air into the anvil. This allows the cloud droplets to start evaporating, changing from droplets to vapor. Since it is the reverse of condensation, latent heat is "taken back," chilling the air, adding to its density and causing it to sink. DOWNDRAFT RESULTS. Cloud droplets skirting the edge of the updraft cross over into the downdraft, fueling more evaporation and causing faster downward motion. Once the downdraft reaches the surface, it spreads out horizontally. As the winds pick up, temperatures drop and rain begins, causing people on the ground to head for cover. If the downdraft is intense enough, it can be life-threatening!

Sometimes the relative density of the downdraft can be so strong that it acquires tremendous amounts of momentum and plummets earthward at phenomenal speeds. When the downdraft reaches the ground and spreads horizontally, winds can kick up to 100 mph or greater. An intense downdraft that creates damage is known as a *downburst.* Fortunately, as the downburst spreads out laterally, its energy thins out and it weakens, confining damage to several square miles. Damage from a downburst is very similar to that of a tornado. In certain cases, it can be worse. The main difference is that tornadoes involve *rotational convergence,* while the downburst is a *divergent phenomena.*

VOCABULARY

Downdraft: a sudden and strong burst of wind caused by a falling mass of cool air.

Downburst: an intense and sudden downdraft that creates damage.

Microburst: a downburst less than 2.5 miles in diameter. They can be the most dangerous downburst. Damaging winds of 160 mph or faster can be produced.

T. Theodore Fujita: best known as the inventor of the tornado damage scale that carries his name, but his place in the history of of science was assured by his discovery of downbursts. Originally a professor in Japan, he has since retired and has a research lab at the University of Chicago.

Wind Shear: a sudden change in wind speed or direction.

- **PROCEDURE**

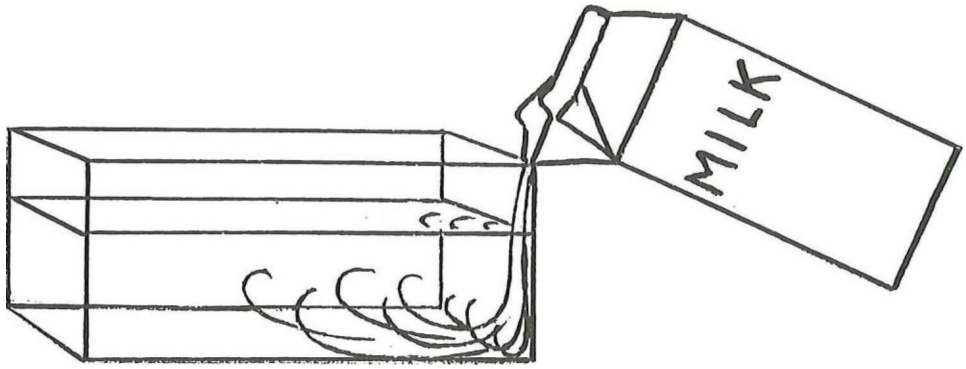
  Before beginning the demonstration, introduce the topic of downbursts and review with students this weather phenomena. Because this demo occurs very fast, it will benefit the students for it to be repeated as you continue the explanation.

1. Fill the aquarium/ container two-thirds full of warm tap water. Allow the water to come to rest.

2. Slowly pour a small amount of cold milk into the corner of the container. Have the students observe what happens by looking through the side of the container.

Observation: The wedge shape that the milk produces *simulates* a cold front. In fact, nearly all thunderstorms have such miniature cold fronts. This front separates the colder air underneath the thunderstorm from the warmer air surrounding it.

3. Repeat several times for best impact and observation.



DISCUSSION

When you were in a storm, did you feel the cold outrush of wind as the storm approached? If you don't experience the wind, you may be on the wrong side of the storm. If you experience very strong winds, you are perhaps being struck by a strong downdraft called a *downburst or a microburst (a small downburst).*

Did you see any unusual cloud formations? Did the clouds take on different colors? Did any hail fall?
Hail forms in thunderstorms when raindrops are caught in a series of updrafts and downdrafts. The hail alternately freezes and melts, adding ice each cycle. For hail to come from a thunderstorm, updrafts must be very strong. Normally, cloud droplets scatter all the colors of sunlight, making clouds appear white. Storm clouds can be thick enough to let only a little light through, thus making the clouds look dark from below

What mode of transportation would be highly affected by a downdraft?
Airplanes. Many air crashes have been studied by NOAA and they have confirmed this thunderstorm phenomena known as wind shear or microbursts to be a hazard of air flight.

References
The Amateur Meteorologist Explorations and Investigations, H. Michael Mogil and Barbara G. Levine, Franklin Watts, New York, 1993.
The Weather Book; USA News, Jack Williams, Vintage Books—a division of Random House, Inc., New York, 1992.
The Weather Sourcebook, Ronald L. Wagner and Bill Adler Jr., The Globe Pequot Press, Connecticut, 1994.

WEATHER TOPIC: Thunderstorm Phenomena

6 Static Electricity, Dancing Confetti, and Lightning

This activity is for cooperative learning groups.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES

Students will

* observe and experiment with static electricity.
* experience first hand the effects of positive and negative charges in static electricity.
* define in basic terms - atoms, protons, neutrons, and electrons.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 2.1; 2.2
Grade 5: 1.1; 1.2; 1.3; 1.4; 3.2
Grade 6: 1.1; 2.1; 2.2; 5c
Grade 7: 1.1; 5.1
Grade 8: 1.2; 2

MATERIALS

Divide the students into cooperative learning groups. You will need the following materials for each group.

Ziploc sandwich bags
hard plastic combs,
3" x 3" wool, silk,
& other cloth scraps
glass or plastic rods
plain puffed rice
balloon
metallic confetti

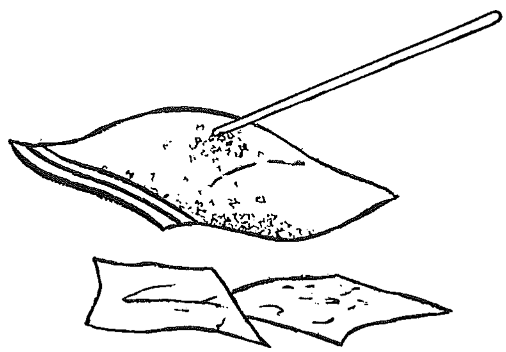
SAFETY PRECAUTION

This activity does not have any safety precautions.

• BACKGROUND INFORMATION FOR INSTRUCTOR

Everything, everywhere in the world contains atoms. These atoms are composed of tiny particles called electrons, neutrons, and protons. Ordinarily each atom contains an equal number of protons and electrons, unless something special happens. Have you ever walked across a carpet, touched a doorknob, and felt a shock? *This is an example* *of static electricity.* What you have done is picked up electrons (negative particles) from the carpeting. The spark produced is a result of the electrons jumping from you to the door knob. What happens is that when the two substances rub together, electrons are knocked off the atoms in one and stick to the atoms in the other. Substances that lose electrons are said to be positively charged; those that have more electrons are said to be negatively charged. Unlike charges attract each other; like charges repel.

Lightning that flashes in a thunderstorm is static electricity, too. The rubbing of ice crystals in clouds may create the charge. The effect is the same: rubbing produces a force called a charge, which either attracts or repels. Lightning flashes when the attraction of positive and negative charges becomes strong enough to overcome the air's high resistance to electrical flow. This electrical charge can occur between opposite electrical charges within a cloud, between clouds, or from a cloud to the ground. As the electrons travel through the air, they cause the air to glow, and the glow is the flash of lightning we see.



VOCABULARY

Atoms: the tiny particles of which everything is made.

Lightning: a visible discharge of static electricity produced during a thunderstorm.

Electrons: parts of an atom "orbiting" the nucleus; they have a negative (-) electrical charge.

Protons: particles found in the nucleus of an atom. They carry a positive charge (+) equal to the negative charge of an electron.

Neutrons: particles with no electrical charge. Found in the nucleus of an atom.

Nucleus: the center of an atom that contains the proton(s) and neutron(s).

Static electricity: the build-up of an electrical charge between two objects.

- **PROCEDURE**
  Discuss with the students the concepts presented in the background information. Also introduce the vocabulary words to them.

1. Divide students into small groups and pass out materials to each group.

2. Have students place 2-3 tablespoons of puffed rice in one bag and 2-4 tablespoons of a metallic confetti in the other.

3. Have a student from each group inflate the bags by waving them in the air and then quickly sealing them.

4. Ask students to see if they can make the cereal/ confetti "dance" using the materials given to them without striking or shaking the bags, Which materials rubbed together, then passed over the bags make the contents "dance?". Inflate the balloon and rub it over your hair, then test on bag.

DISCUSSION

After several minutes of experimenting with the different bags, ask students if any group was able to make the rice or confetti dance. **How did they do it?** (See next answer.)

Why did it work? Rubbing the glass rod with the wool or silk cloth causes electrons to build up on the rod. The rod surface does not conduct electricity, so it simply holds the electrons and their negative charge in place, even though the electrons tend to repel each other. When the charged-up rod is held over the bag of confetti or dry cereal, the electrons attract the pieces. Then some electrons stick to the cereal. Now the rod and cereal both have electrons. These negative charges repel each other and the cereal is pushed away.

What is static electricity? The build-up of an electrical charge between two objects.

How does this experiment relate to thunderstorms? Lightning flashes when the attraction of positive and negative charges becomes strong enough to overcome the air's high resistance to electrical flow. This electrical charge can occur between opposite electrical charges within a cloud, between clouds, or from a cloud to the ground. As the electrons travel through the air, they cause the air to glow as lightning.

What roles did the balloon and pieces of cloth play? Rubbing the glass rod with the wool or silk cloth causes electrical charges to build up in the glass rod.

Why doesn't this activity work as well when the humidity is high? Static electricity is conducted (drained) away from a charged surface by the water in humid air

EXTENSION ACTIVITIES

• Blow up a balloon. Rub it against a student's hair and stick the balloon to a wall.
• Identify the scientific principle involved.
• Write a newspaper article detailing Ben Franklin's experiment with electricity.
• Write a poem about the dancing rice/ confetti.
• Be alert for electricity and weather themes in museums or science centers.

References
Lightning, Stephen Kramer, Carolrhoda Books, Inc., Minneapolis, 1992.
Fun Science: Learn and Discover Book, David L. Drotar, Playmore Inc., Publishers and Waldman Publishing Corp., New York, 1987.
NOAA Literature, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Rockville, MD 20852. (weather and weather safety)

Static Electricity, Dancing Confetti, and Lightning

Group ________________________ Date______________

MATERIALS		
Ziploc sandwich bags	glass or plastic rods	metallic confetti
hard plastic combs,	plain puffed rice	
3" x 3" wool, silk,balloon & other cloth scraps		

PROCEDURE

I. Place 2-3 tablespoons of puffed rice in one bag and 2-4 tablespoons of a metallic confetti in the other.

2. One person in each group should inflate the bags by waving them through the air, and then quickly sealing them.

3. Experiment with the cereal/ confetti by using them in the bags. Which materials, when rubbed together, then passed over the bag <u>without striking or shaking the bags</u> make the cereal/confetti dance? Inflate the balloon and rub over your hair, then test on bag.

DISCUSSION

Did your group make the rice or confetti dance? How?

What roles did the pieces of cloth play?

What is static electricity?

Why doesn't this activity work well on humid days?

How does this experiment relate to thunderstorms?

WEATHER TOPIC: Phase Changes

7 The Geometry and Art of Capturing a Snowflake

This is an individual student activity.
Note: This activity must be done on a snowy day.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES
Students will
* observe the geometry of a snowflake.
* learn about crystal patterns that form snow.
* discover how snow is formed.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 2.2b
Grade 5: 1.1; 1.2; 1.3; 3.2a
Grade 6: 1.1; 1.2; 2.1; 5b; 5c
Grade 7: 1.1; 1.2
Grade 8: 1.1; 1.2

MATERIALS
Supplies for each student are recommended. NOTE: *The black paper and slides or dishes should be placed outdoors for 10 minutes or until they are cold.*

Glass/plastic slides or flat-bottomed dishes
1 sheet of black paper
plastic magnifying glass
pencils
drawing paper

SAFETY PRECAUTIONS
Students should be dressed appropriately. Use extra caution when handling glass slides and/or dishes. For younger students, black paper is less dangerous.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Snow is solid precipitation in the form of white six-sided ice crystals. The Midwest Wild Weather region is an area of the U.S. where snow falls. Average annual snowfalls vary from more than 150 inches in northern Michigan to 12 inches or less in southern Illinois and southern Indiana. Snow can only form from water vapor that deposits directly as a solid, bypassing the liquid state. A snowflake forms first as a very tiny six-sided (hexagonal) crystal. The crystal then grows fastest at the six points because the points are exposed to water vapor coming from more directions than locations along the sides. This accentuates the points and develops the six-sided snowflake.

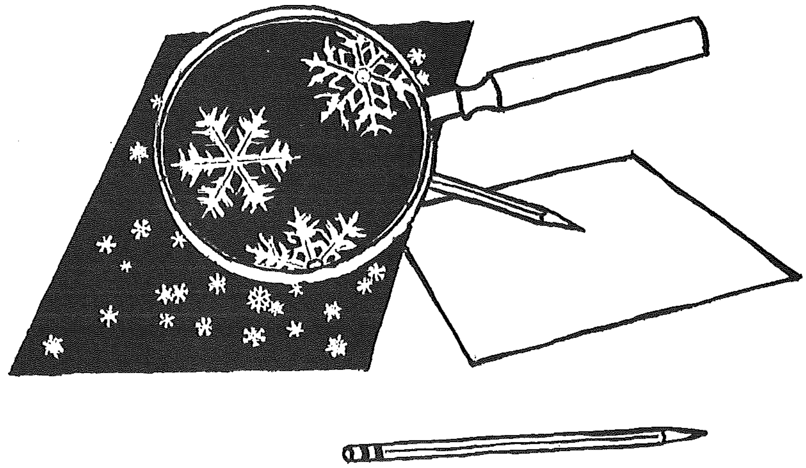
VOCABULARY

Snow: solid precipitation in the form of six-sided ice crystals.
Hexagon: a six-sided geometric figure.
Crystals: a solidified form of a substance in which atoms or molecules are arranged in a definite pattern that is repeated regularly.

- **PROCEDURE**

NOTE: Obviously, this activity can be done only during a snowfall. Therefore, it is impossible for the teacher to plan it in his/her weekly schedule. It is suggested that you prepare the materials for this activity ahead of time and have them in a storage container, so when a light snowfall occurs you and your class will be ready to investigate snow.

1. Ask students to respond to the first discussion question in this activity. Spend 5 minutes on the birth of a snowflake. Explain to students that this activity will allow them to observe the geometry of a snowflake.
2. Pass out a magnifying glass and pencil to each student.
3. Once outside, pass out the black paper or slides. Since the materials are cold, the snowflake will not melt. As they catch a snowflake, caution students to be very careful not to breathe directly on them.
4. With a magnifying glass, have the students really look at how the snowflakes are composed. Ask students to then make a simple line drawing of the snowflake.
5. When students return to the classroom, continue discussion on the composition of snowflakes, referring often to their geometry.
6. For fun, have the class make a snowflake collage poster, with each student contributing a snowflake drawing or cutout; use white paper and mount drawings/ cutouts on large blue or black poster board.



DISCUSSION

How does a snowflake begin/grow?

The shape of snow depends on the temperature and to some extent on the amount of water vapor in the air. Crystals often take on complex forms because they spend time in areas with different conditions.

Are all snowflakes different?

According to research scientists studying crystals and snow, many snow crystals share the same early development of the hexagon with no obvious difference in shape.

FUN FACTS

- **About 10 inches of wet snow will melt down to the equivalent of an inch of rain.**
- **Outside Alaska, Blue Canyon, California has the most snowfall of any place in the United States: about 241 inches per year.**
- **Sometimes more than 50 inches of dry, powdery snow can melt to just an inch of precipitation**
- **Qannik (con-EEK) is the Eskimo name for snowflake.**

EXTENSION ACTIVITIES

- Investigate Eskimo culture.
- Write a story/poem about winter's first snowfall.
- Look at other crystals under a microscope.
- Cut six-sided snowflakes from paper. (Can you figure how to fold them?)

References

The Weather Classroom, Karen Wening Moore, The Weather Channel, Atlanta, Georgia, 1992. *The Weather Book, USA NEWS,* jack Williams, Vintage Books—a division of Random House, Inc., New York, 1992.
The Weather Sourcebook, Ronald L. Wagner and Bill Adler, Jr., Adler & Robin Books, Inc., 1994.

WEATHER TOPIC: Phase Changes

8 Icicles

This activity is for cooperative learning groups.
Note: This activity can only be done during the winter.

Grade Levels: 4th-8th grades

Estimated Time:
40-minute class period,
then follow-up recording time.

OBJECTIVES

Students will
* observe liquid to solid state changes.
* demonstrate the variables which lead to phase changes in water.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 2.2
Grade 5: 1.1; 1.2; 1.3; 1.4
Grade 6: 1.1; 1.2; 2.1; 5.1c
Grade 7: 1.1; 1.2
Grade 8: 1.2

MATERIALS

Divide students into cooperative learning groups.
You will need the following materials for each group.

2-liter plastic soda bottle, clear
scissors
food coloring
ruler
string
thumbtacks

SAFETY PRECAUTIONS

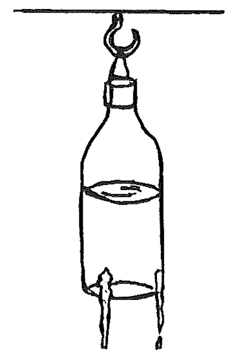
Icicles can be dangerous when they fall, so practice caution when taking measurements Inform your students that they should never stand under icicles hanging from a building or tree but should stand back at a safe distance to observe them

• BACKGROUND INFORMATION FOR INSTRUCTOR

There are three states of matter: solid, liquid, and gas. Water is a versatile substance because it experiences each of these states within a temperature range tolerable to human beings.

Ice is water in solid form and is created by the freezing of liquid water or sublimation of water vapor. When a liquid or gas freezes the molecules move more slowly and are much closer together causing them to have a more definite shape. Icicles are formed as liquid water slowly freezes. The length and width of any icicle are dependent upon temperature fluctuations.

VOCABULARY



Solid: having a definite shape and volume.

Liquid: a substance capable of flowing or being poured.

Gas: a state of matter characterized by low density and viscosity.

Sublimation: the act of changing from a solid to a gas or a gas to a solid without becoming a liquid.

Freezing: to pass from a liquid to a solid state by loss of heat.

• PROCEDURE

Before beginning procedure, introduce the subject of icicles and lead a discussion on how and why they are formed.

1. Fill the soda bottle $^{3}/_{4}$ full of cold water. Add a few drops of food coloring.

2. Put the cap tightly on the bottle. Take the bottle outside and make a couple small holes near the bottom with scissors or tack. Have each group of students try to vary the hole sizes and take a measurement of the diameter of the hole they made.

3. Hang the bottle from a string by wrapping it around the neck of the container.

4. Check your bottle hourly and record length/diameter of icicles. Graph the results.

DISCUSSION

What happens to the water in the soda bottle as it drips out of the hole you made?
Are the molecules moving faster or slower as the water begins to freeze? Slower.
Is there a variation in the size of the icicles dependent on the size of the hole? Yes.
Why?
Some icicles will be longer and thicker depending on the size of the hole and the temperature outside.
Would changing the size or shape of the container have an effect on the icicle produced? A larger container will allow more liquid to flow, if the temperature is not too low. The shape will not affect the icicle as long as the liquid is allowed to flow freely.

E X T E N S I O N   A C T I V I T I E S

• Graph and compare the temperature of the air and the length of the icicles for one week.
• Graph and compare the length of the icicles and the diameter of the hole.

References
Science Is, Susan Bosak, Scholastic, Ontario, 1991.
The Weather Book, Jack Williams, Vintage Books, New York, 1992.

Icicle Activity

Group ______________________________ Date ____________________

MATERIAL LIST		
2-liter plastic soda bottle, clear	food coloring	string
scissors	ruler	thumbtacks

Procedure

1. Fill the soda bottle 3/4 full of cold water. Add a few drops of food coloring.

2. Put the cap tightly on the bottle. Take the bottle outside and make a couple small holes near the bottom with scissors or tack. Try to vary the hole sizes and take a measurement of the diameter of the holes. Record that measurement.
   ____

3. Hang the bottle from a string by wrapping the string around the neck of the container.

4. Check your bottle hourly and record length/diameter of icicles.

Hour _________________________ Hour __________________

Hour _____________________________ Hour_______________________

Hour _____________________________ Hour_______________________

DISCUSSION

What happens to the water in the soda bottle as it drips out of the hole you made?

Are the molecules moving faster or slower as the water begins to freeze?

Is there a variation in the size of the icicles dependent on the size of the hole? Why?

Would changing the size or shape of the container have an effect on the icicle produced? Why or why not?

9 Supercooled Water to Ice

This activity is for cooperative learning groups.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES

Students will

* learn that cloud droplets are frequently supercooled due to altitude, temperature, and pressure.
* learn that supercooled water is the basis for hail, freezing rain, and sleet.
* demonstrate that salt brings the temperature of liquid water to below freezing.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5

PASS Standards

Grade 4: 2.2b

Grade 5: 1.1; 1.2; 1.3; 1.4; 3.2a

Grade 6: 1.1; 1.2; 2.1; 5.1c

Grade 7: 1.1; 5.1

Grade 8: 1.2; 4.3

MATERIALS

Divide the students into cooperative learning groups.
You will need the following materials for each group.

wide-mouthed glass jar
rock salt
thermometer
water
timer or clock

small test tube
test tube tongs
test tube holder
ice, crushed is preferred

SAFETY PRECAUTIONS.

The ice water that results from the Salt and ice mixture is extremely cold
Tell your students to avoid submerging their hands in the water.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Water can cool below 32° Fahrenheit without freezing. In the upper atmosphere this is possible due to altitude, temperature, and air pressure. Water in this state is supercooled. Supercooled drops of water range in size, but all will freeze when they come into contact with ice or anything solid. Supercooled rain leaves a layer of ice on everything and is commonly called freezing rain.

Hail is another form of freezing precipitation caused by supercooled water. Hail begins as a frozen raindrop that is kept from falling by a strong updraft of air. Supercooled drops in the updraft freeze to the growing hailstone, causing it to increase in size. Hailstones fall when they get too heavy for the updraft or the updraft begins to dissipate.

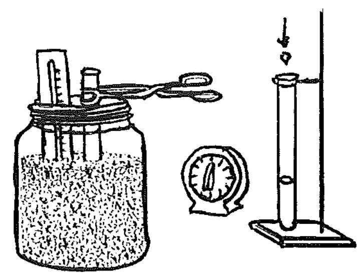
VOCABULARY

Supercooled: a state when a substance remains in the liquid phase below its normal freezing point.

Solid: having a definite shape and volume.

Liquid: a substance capable of flowing or being poured.

Freezing: to pass from a liquid to a solid state by loss of heat.



- **PROCEDURE**

  Before beginning activity, discuss with students the subject of phase changes.

1. Layer the glass jar with ice and salt, using one cup of salt and filling the jar 3/4 full with the ice and salt. Record the temperature of the water after five minutes.

2. Using the test tube tongs, gently place the test tube, which contains a small amount of water (less than half full), in the middle of the glass jar.

3. Allow the test tube to remain in the jar for ten minutes.

4. After ten minutes have passed, use the tongs to remove the test tube from the jar and place it in the test tube holder. The water in the test tube should be supercooled.

5. Drop a tiny piece of ice into the test tube and watch what happens.

6. Record the temperature of the ice and salt mixture in the jar now.

DISCUSSION

What happened when you dropped the ice into the test tube?
The supercooled water froze when it came in contact with the ice.

What was the temperature of the ice and salt mixture in the jar?

What do you think was the temperature of the water in the test tube before you added the ice? The water was supercooled. Therefore, it was below the normal freezing temperature of 32 degrees Fahrenheit or 0 degrees Celsius.

Why did the water in the test tube react the way it did when you added the ice?
Supercooled water will freeze instantly when it comes in contact with ice or anything solid. Cloud droplets frequently exist in a supercooled state because of conditions made possible in the higher atmosphere. On Earth, water can be supercooled only by artificial means.

Can you think of some different types of frozen precipitation?
Hail, sleet, snow, and freezing rain are different types of frozen precipitation.

EXTENSION ACTIVITIES

• Discuss how hail is formed. Use the information from the Background Information section of this activity.
• Discuss how "icing" on an airplane's wings might cause problems for the pilot. Discuss how this "icing" is formed and what is done during the "de-icing" procedure in preparation for a plane's departure during the cold weather months.
• Look at weather reports in the newspaper or on television to determine the type of precipitation that is falling in different parts of the world. Let your students make a connection between temperature and different types of precipitation.
• Learn about other types of precipitation. Observe snowflakes by catching them on a cooled piece of black paper. Observe them through a magnifying glass and notice that each snowflake is different.
• Bring a cut of snow into the classroom and let it melt. Measure how much water made up the cut of snow.

References
Science Is, Susan Bosak, Scholastic, Ontario, 1991.
The Weather Book, Jack Williams, Vintage Books, New York, 1992.
The Weather Report, Mike Graf, Fearon Teacher Aids, Carthage, 1989.

Supercooled Water to Ice Activity

Group ______________________________ **Date** _____________________

MATERIALS
wide-mouthed glass jar rock salt thermometer water timer or clock
small test tube test tube tongs test tube holder ice--crushed is preferred

PROCEDURE

1. Layer the glass jar with ice and rock salt, using one cup of rock salt and filling the jar 3/4 full with the ice and rock salt. Record the temperature of the water after five minutes.

   Temperature ___________________

2. Using the test tube tongs, gently place the test tube, which contains a small amount of water (less than half full), in the middle of the glass jar.

3. Allow the test tube to remain in the jar for ten minutes.

4. After the timer rings, use the tongs to remove the test tube from the jar and place it in the test tube holder. The water in the test tube should be *supercooled.* Record the temperature of the ice and salt mixture.

   Temperature ___________________

5. Drop a tiny piece of ice into the test tube and watch what happens. Record your observations.

6. Record the temperature of the ice and salt mixture in the jar now.

   Temperature _________________

7. Can you think of some different types of freezing precipitation?

10 Measuring Frost Point

This activity is for cooperative learning groups.

Grade Levels: 4th -8th grades

Estimated Time:
45-minute class period

OBJECTIVES
Students will
* demonstrate that air contains water vapor.
* learn water cycle terminology.
* demonstrate how to measure frost point.
* learn about vapor to solid phase changes.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 2.2
Grade 5: 1.1; 1.2; 1.3; 1.4; 3.2a
Grade 6: 1.1; 1.2; 2.1; 5.1b; 5.1c
Grade 7: 1.1; 1.2; 5.1
Grade 8: 1.1; 1.2; 4.3

MATERIALS
Divide students into cooperative learning groups.
You will need the following materials for each group.

tin cans   ice   rock salt   thermometers

SAFETY PRECAUTIONS
The ice water that results from the salt and ice mixture is extremely cold. Tell your students to avoid submerging their hands in the water.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Dew point is a measure of the amount of water vapor in the air. The dew point is the temperature at which the air must be cooled in order for the vapor to begin to condense. This is exemplified by a glass of ice lemonade on a summer day. The air right around the glass is cooled by the cold drink. Eventually the air cools to the point that it can't hold any more water vapor (remember, cold air can't hold as much water vapor as warm air). The vapor condenses onto the glass and forms water drops all over the glass of lemonade. The frost point is when the temperature of the air reaches 0° C and frost begins to form instead of dew.

VOCABULARY

Dew point: the temperature at which water vapor condenses out of air, becoming a liquid.

Frost point: the point at which water vapor condenses out of air, bypassing the liquid phase, and freezes.

Condensation: the act by which a gas becomes a liquid.

Sublimation: the act of changing from a solid to a gas or a gas to a solid without becoming a liquid.

Saturated: to soak or fill thoroughly, to be full.

- **PROCEDURE**

  Before beginning this activity, introduce and review the subject of water properties in the background information.

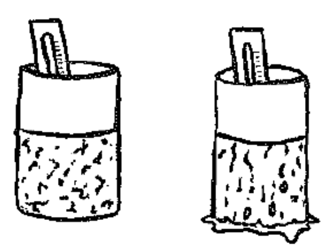
1. Layer the interior of one can with ice and rock salt, using 1 cup of salt and filling the can half full.

2. Fill the other can half full of ice, but don't add any salt.

3. Record the temperature of both cans by holding the thermometer on the inside of the cans.
   Temperature of can with salt and ice: ________
   Temperature of can with ice only:

4. Record the temperature when you first see frost forming on the outside of the can containing the salt and ice.________

5. Record the temperature when you first see water condensing on the can containing only ice. ________



Rock Salt & Ice   Ice Only

DISCUSSION

What was the temperature at which you noticed water freezing on the outside of your can? Is everyone's data the same? Most answers should be fairly similar.

When does the outside air usually seem to have the most water vapor in it, during the summer or the winter? Summer.

Why is there more water vapor in the outside air during that particular time of the year? Warm air can hold more water vapor than cold air. Therefore, there is more humidity, or the amount of water vapor in the air, in the warmer days of summer, than the colder days of winter.

What would the conditions outside have to be like in order for frost to form instantly on the surface of your bicycle? There would have to be a lot of water vapor in the air and the temperature outside would have to drop quickly to the freezing temperature of 32 degrees Fahrenheit or 0 degrees Celsius. The water vapor would condense and instantly go from gas to solid.

What happened to the ice when you put salt in the can? The ice began to melt and the water/ salt/ice mixture was cooled to a temperature below 32 degrees Fahrenheit or 0 degrees Celsius without freezing. The temperature of the outside of the can was lowered and the air surrounding the can was cooled. Since cold air cannot hold as much water vapor as warm air, the water vapor in the air condensed. Because of the low temperature of the air, water vapor condensed into a solid form.

How is this different from the can containing only ice? The temperature of the ice was not lowered below the freezing level. As the air outside of the can was cooled, the water vapor condensed into a liquid. This is known as dew. The temperature at which the air cannot hold any more water and the water condenses as a liquid is called dew point.

Why is salt put on roads and sidewalks in the winter? The salt melts ice and snow by lowering the freezing temperature below its normal freezing point of 32 degrees Fahrenheit or 0 degrees Celsius.

EXTENSION ACTIVITIES

• Let the students graph the changes in temperature of both cans at one minute intervals. Before starting the activity, have them predict which can will have the lowest temperature and which can will change in temperature more quickly than the other.
• When using the can containing only ice, review information about dew and dew point. Discuss why dew occurs. Relate this information to frost and frost point and discuss why frost occurs.
• Introduce a hygrometer or humidity meter and discuss how both of these instruments measure humidity, or the amount of water present in the air.
• Make ice cream. Experiment by placing a small container of the ice cream mixture inside a larger container filled with ice and salt. Discuss how the salt is lowering the temperature to a point below the normal freezing temperature.

References

Science Is, Susan Bosak, Scholastic, Ontario, 1991.
The Weather Book, Jack Williams, Vintage Books, New York, 1992.
The Weather Report, Mike Graf, Fearon Teacher Aids, Carthage, 1989.

Measuring Frost Point

Group ___________________________ Date _________________

MATERIALS			
tin cans	ice	rock salt	thermometers

PROCEDURE

1. Layer the interior of one can with ice and rock salt, using 1 cup of salt and filling the can half full.

2. Fill the other can half full of ice, but don't add any salt.

3. Record the temperature of both cans by holding the thermometer on the inside of the cans.

   Temperature of can with salt and ice:

   Temperature of can with ice only:

4. Record the time and temperature when you first see frost forming on the outside of the can containing the salt and ice.

   Time: ____________________

   Temperature: ________________

5. Record the time and temperature when you first see water condensing on the can containing only ice.

   Time: ____________________

   Temperature: ________________

Observations

____

____

____

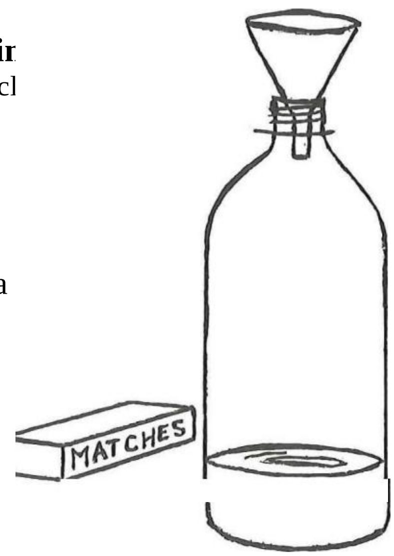
____

WEATHER TOPIC: Phase Changes

11 How Does Your Cloud Grow?

This activity is for cooperative learning groups.

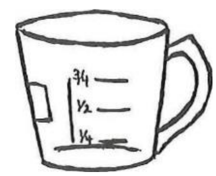
Grade Levels: 4th - 8th grades **Estimated Tir**
45-minute cl



OBJECTIVES
Students will
- learn the relationship between temperature and cloud formation.
- formulate a prediction.
- relate the result of an experiment in the form of a data chart.
- formulate a conclusion based upon direct observations and measurements.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 2.2b
Grade 5: 1.1; 1.2; 1.3; 3.2a
Grade 6: 1.1; 2.1; 5.1b; 5.1c
Grade 7: 1.1; 5.1
Grade 8: 1.2; 2.1

MATERIALS
Divide students into cooperative learning groups.
You will need the following materials for each group.



large clear, colorless plastic bottle (a 2 liter soda bottle is ideal)
100 ml graduated cylinder or measuring cup, 1 or 1/2 cup size

cold water	matches
hot water	funnel

SAFETY PRECAUTIONS
This activity requires the use of matches. Care must be taken to close the matchbook cover when striking the match. Care must also be taken when placing the match in the bottle.

• BACKGROUND INFORMATION FOR INSTRUCTOR
Clouds are formed when water vapor precipitates about nuclei of dust, pollen, salt spray, or other solid material in the air. The cloud droplets may form as liquid water or as ice, depending on temperature. High clouds, because of their lower temperature, consist of ice crystals. For more information on the classification of clouds, see activity: *14- Make a Cloud Wheel.*

VOCABULARY

Air pressure: the force of air exerted per unit of surface area.

Water droplets: water in the liquid state.

Water vapor: water in the gaseous state.

PROCEDURE

Before beginning activity, review with students the information on cloud formation in the background information.

1. Provide copies of the student activity sheet.
2. Measure and pour 60 ml (2 oz.) of cold water into the plastic bottle. Replace cap.
3. Shake the bottle quickly for about 10-15 seconds. Set the bottle on a flat surface.
4. Remove the cap. Light a match, blow it out, then immediately drop it through the mouth of the bottle.
5. Quickly replace the cap and gently squeeze the bottle using both hands to increase the pressure. Release the pressure. Repeat this step.
6. Observe and record your results.
7. Discuss and hypothesize how a *cloud* formed by <u>hot</u> water will differ from a *cloud* formed by <u>cold</u> water.
8. Pour out the cold water and replace it with an equal volume of hot water.
9. Replace cap and repeat steps 3 through 6.

DISCUSSION

Were your predictions correct? (Answers may vary.)

What were the major findings of the experiment? That a cloud could be made.

How do they compare to what you knew before? (Answers may vary.)

What difference did you observe when the match was added? There is more cloud formed. **Why?** Because the smoke particles provide a nucleus around which the water droplets can collect.

Why did releasing the pressure on the bottle cause a cloud to form? Releasing the pressure also causes a sudden lowering of the temperature. Less water vapor can be held in colder air than in warmer air so more water droplets were formed.

Does this one experiment prove what would happen each time the experiment is done? No. **Explain how clouds are formed.** Water evaporates from ground sources and rises in the atmosphere. As the vapor moves higher, the temperature of the air is cooler, so less water can remain in the vapor form. The water vapor condenses to small droplets of water. When sufficient water collects, visible clouds form.

EXTENSION ACTIVITIES

- Write a history of a drop of water as it completes the water cycle.
- Draw a picture or create a poster to illustrate your story.
- Give two reasons why seaside locations are often foggy and cloudy.
- Research the cloudiest locations in the country.
- Do your experiment and explain the results to a younger child.
- Record the barometric pressure and cloud cover for a period of several days. **Do you find any relationship?**
- Design an experiment to show the effect of adding or not adding a match to your cloud making bottle.

References

The Weather Book, Jack Williams, Vintage Books, New York, 1992.

Science Connections, Blue Book, Merrill Publishing Company, Columbus, Ohio, 1990.

How Does Your Cloud Grow?

	Cold Water	Hot Water
Observations when match is dropped in		
Observations when pressure is increased		
Observations when pressure is decreased		

PROCEDURE

1. Measure and pour 60 ml (2 oz.) of cold water into the plastic bottle. Replace cap.
2. Shake the bottle quickly for 10-15 seconds. Set the bottle on a flat surface.
3. Remove the cap. Light a match, blow it out, then immediately drop it through the mouth of the bottle.
4. Quickly replace the cap and gently squeeze the bottle using both hands to increase the pressure. Release the pressure. Repeat this step.
5. Observe and record your results on the chart above.
6. Discuss and hypothesize how a *cloud* formed by hot water will differ from a *cloud* formed by cold water.
7. Pour out the cold water and replace it with an equal volume of hot water.
8. Replace cap and repeat steps 2 through 5.

DISCUSSION

Were your predictions correct?

What were the major findings of the experiment?

How do they compare to what you knew before?

What difference did you observe when the match was added? Why?

Why did releasing the pressure on the bottle cause a cloud to form?

Does this one experiment prove what would happen each time the experiment is done? Explain how clouds are formed.

WEATHER TOPIC: Sun and Our Weather

12 Water vs. Land Surfaces

This activity is for cooperative learning groups

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES

Students will
* observe the differences in heat absorption in water and other substances.
* observe how long these substances retain heat.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 2.2b; 2.3b; 4.1; 4.2
Grade 5: 1.1; 1.2; 1.3; 1.4; 3.1; 3.2a
Grade 6: 1.1; 2.1; 5.1a; 5.1b; 5.1c; 5.1d; 5.2
Grade 7: 5.1
Grade 8: 1.2; 4.3

MATERIALS

Divide students into cooperative learning groups.
You will need the following supplies for each group.

4 small beakers or jars	4 thermometers	dry sand
4 ring stands with clamps	lamp with bright bulb soil	salt water, ratio: 3 Tbsp./ cup
water	watch or clock	

If you do not have ring stands, you can use glass jars instead. Taping them to the correct height works well. You can also set these containers in the Sun if you don't have access to a bright lamp.

SAFETY PRECAUTIONS

Care should be taken when using the thermometers. The heat lamp will get very hot.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Water and land warm up and cool off at different rates. Water warms and cools more slowly than land for a variety of reasons. In water, the Sun's rays go to a depth of many meters, spreading heat through a greater depth. On land, the Sun's rays heat only the top few centimeters of soil. Water can also spread heat more easily because it is a fluid. In addition, water needs more energy than land to raise its temperature the same amount and it must lose more energy for the same temperature drop.

VOCABULARY

Opaque: not allowing light to pass through

Translucent: admitting and diffusing light so that objects beyond cannot be clearly distinguished.

Transparent: allowing light to pass through so that objects can be clearly distinguished.

- **PROCEDURE**

  Before beginning activity, review background information with students.

1. Fill a beaker (jar) about half full of packed dry soil.
2. Fill the second beaker half full with sand.
3. Fill beaker #3 half full with clear water.
4. Fill the last beaker half full with salt water.
5. Place a thermometer in each beaker. Hold each thermometer in place with the ring stand and clamps. Be sure that the thermometer is not touching the sides of the beaker.
6. Position the beakers under the lamp so that each beaker receives the same amount of light.
7. Read the temperature on each thermometer. Record your data on the table.
8. Turn on the lamp. Read the temperature each minute for 10 minutes and record your data. If you are in the Sun, take readings every 2 minutes for a total of 20 minutes.
9. Turn the lamp off. If you are in the Sun, remove the beakers from the Sun.
10. Record the temperature of your containers on a second data table every minute for 10 minutes after the lamp is turned off or after the beakers are taken out of the Sun.

DISCUSSION

Did the temperature of the liquids go down more slowly than the temperature of the sand and the dirt? Yes. Why or why not? Water has a greater heat capacity than land.

What, if any, difference in cooling or heating happened with the salt water vs. the regular water? No difference. **Why do you think this happened?** The salt does not affect the heat capacity of the water.

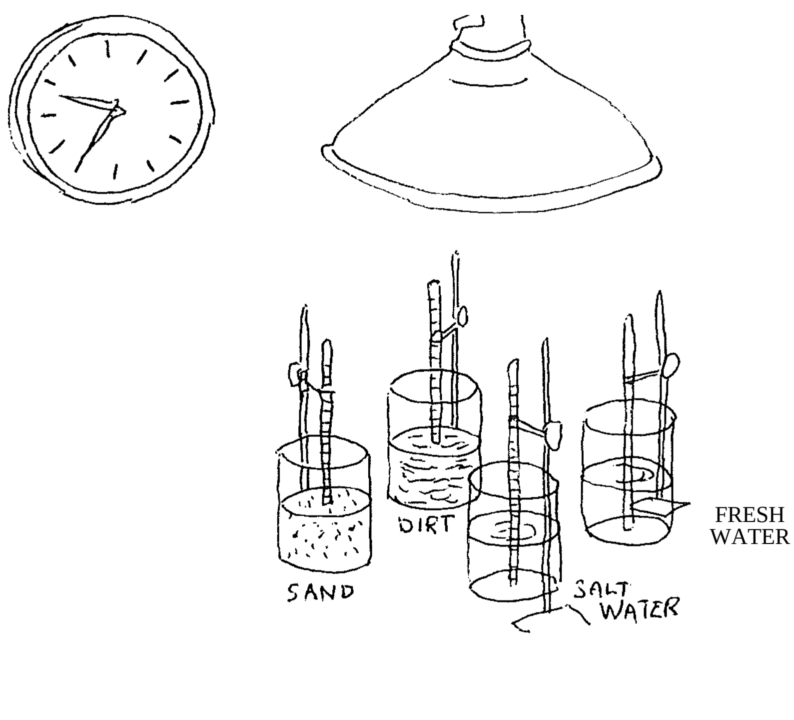
What do these differences tell you about the heating of the Earth and its effect on weather? Your answer should include a reference to soil or ground, sand or beach, water or fresh water, salt water or ocean. The Earth is unevenly heated.

Would you expect daytime summer temperatures near a large lake to be warmer or cooler than temperatures away from the lake? Cooler. **Why?** The land heats up more quickly than water.

The desert is quite hot during the day and quite cool at night. What do you think causes this range in temperature? The dry climate gains and loses heat more rapidly.

E X T E N S I O N   A C T I V I T Y

Put water in a small plastic container, add a little milk or food coloring and freeze. Fill a large, clear plastic or glass container with tepid water. Place the "ice cube" into the larger container. What happens when the ice cube starts to melt?



S T U D E N T   A C T I V I T Y   S H E E T

Water vs. Land Surfaces

Name ________________________ **Date** ____________________________

- PROCEDURE

1. Fill a beaker (jar) about half full of packed dry soil.
2. Fill the second beaker half full with sand.
3. Fill the third beaker half full with clear water.
4. Fill the last beaker half full with salt water.
5. Place a thermometer in each beaker. Hold each thermometer in place with the ring stand and clamps. Be sure that the thermometer is not touching the sides of the beaker.
6. Position the beakers under the lamp so that each beaker receives the same amount of light.
7. Read the temperature on each thermometer. Record your data on the table below.
8. Turn on the lamp. Read the temperature each minute for 10 minutes and record your data. If you are in the Sun, take readings every 2 minutes for a total of 20 minutes. Create your chart for recording on a separate sheet.
9. Turn the lamp off. If you are in the Sun, remove the beakers from the Sun.
10. Record the temperature of your containers on a second data table every minute for 10 minutes after the lamp is turned off or after the beakers are taken out of the Sun.

Data Table #1		*Data Table #2*	
Soil	__________________	Soil	_________________
Sand	__________________	Sand	________________
Water	__________________	Water	________________
Salt Water	___________________	Salt Water	_________________

DISCUSSION

Did the temperature of the liquid go down more slowly than the sand and the dirt? Why or why not?

What, if any, difference in cooling or heating happened with the salt water vs. the regular water? Why do you think this happened?

What do these differences tell you about the heating of the Earth and its effect on weather? Your answer should include a reference to soil or ground, sand or beach, water or fresh water, salt water or ocean.

Would you expect daytime temperatures near a large lake to be warmer or cooler than temperatures away from the lake? Why?

The desert is quite hot during the day and quite cool at night. **What do you think causes this range in temperature?**

13 Why Is Summer Hotter Than Winter?

This activity is for cooperative learning groups.

Grade Levels: 4th - 8th grades

Estimated Time:
Two 40-minute class periods

OBJECTIVE
Students will
* determine how the tilt of the Earth and the angle of the Sun relate to seasons and the temperature of the Earth.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 2.3a; 2.3b
Grade 5: 1.2; 1.3; 3.2
Grade 6: 2.1; 5.1b; 5.1c; 5.2
Grade 7: 5.1; 6.1; 6.2
Grade 8: 4.3

MATERIALS
Divide students into cooperative learning groups.
You will need the following material for each group.

Part I
flashlight
sheet of dark paper
ruler
ball of modeling clay or
foam ball, 4"
2 pencils

Part II
watch or clock
3 thermometers
masking tape
high wattage incandescent lamp
3 right triangular blocks of wood
each with 30°, 60°, 90^0 angles

SAFETY PRECAUTIONS
There are no safety precautions.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

The Earth revolves completely around the Sun in an elliptical path (not quite a circle) in 365 1/4 days (one year). As Earth revolves around the Sun, it spins on its own axis, completing one spin every 24 hours (one day). The Earth's axis is tilted by an angle of 23.5° from the perpendicular to the plane of the Earth's orbit. Throughout the year the axis points to the same area in space. Thus, in June, when the Northern Hemisphere is tilted toward the Sun, the sunlight hits the Earth more directly than in December, when the Northern Hemisphere is tilted away from the Sun. Sunlight that strikes the Earth's surface directly is much more intense than sunlight that strikes the same surface at an angle. Sunlight that strikes the Earth at an angle spreads out and heats a larger region than sunlight hitting the Earth directly. All else being equal, an area experiencing more direct solar rays will receive more solar energy than the same size area being struck by sunlight at an angle. Sunlight strikes different parts of the Earth at different angles because the Earth's axis is tilted. See page 9 for diagram.

VOCABULARY

Axis: a straight line about which an object rotates.

Diameter: a straight line that passes through the center of a circle and divides it in half.

Earth's axis: the line running between the North and South Poles through the center of Earth, and around which Earth rotates.

Hemisphere: one of the halves of Earth as divided by the equator into Northern and Southern parts.

Insolation: the *incoming* solar radiation that reaches the Earth and the atmosphere.

- **PROCEDURE**

Before beginning this activity, discuss the topic of the position of the Sun and Earth and how it affects our weather.

PART I

1. a. In a darkroom, hold a flashlight about 15 cm (6") directly above the dark paper.
   b. Observe and measure the diameter of the light on the paper.
   c. Record the measurement. Is the light bright or dim?

2. a. Tilt the flashlight at an angle.
   b. Again, observe and measure the length of the light.
   c. Record the results.

3. a. Insert one pencil through the center of the ball of clay or foam. Use the second pencil to mark the equator line around the middle of the ball, perpendicular to the pencil axis.

   b. Position the ball on a table so that the pencil eraser is leaning slightly to the right. Place the flashlight about 15 cm (6") from the left side of the ball.

   c. Observe where the light strikes the ball. Which hemisphere is getting light?

   d. Keeping the ball tilted with the tilt pointed in the same direction, move the ball to the other side of the light about 15 cm (6").

   e. Observe where the light strikes the ball.

PART II

1. a. Attach a thermometer to the 30^0 angle of one of the blocks.
   b. Attach a thermometer to the 60° angle of another block.
   c. Attach a thermometer to the 90° angle of the last block.

2. Position the blocks along an arc of 20 cm (8") radius from the light.

3. a. Turn on the light and record the temperature of each thermometer.
   b. Record the temperature of each thermometer every minute for 15 minutes.
   c. Turn off the light.

4. Graph your data using a key to indicate the results from the various angles.

DISCUSSION

PART I

Was there a difference in the diameter of the light? Yes.

Was there any difference in intensity of the light in the two trials? Yes

What did you notice about where the light hit the ball? How did it change? The light was shining on the bottom part of the ball during the first try and shining on the top part of the ball during the second try.

What do you think caused these changes? The way the light was hitting the sphere.

What conclusions can you make from your results? Light hitting a sphere more directly is more intense. Light hitting a sphere at an angle spreads out.

PART II

Which angle caused the temperature to increase the most in 15 minutes? 90°
The least? 30°

What conclusion can you make from your results? More direct light causes higher temperatures.

How does this affect the weather where you live? Temperature is affected by where we live on Earth and how far North or South we are from the equator.

GENERAL

What areas of the Earth receives the most sunlight? The equator, because the Sun hits the Earth more directly.

What areas are at the greatest angle relative to direct sunlight? The poles.

How do their average temperatures compare? It is warmer near the equator and colder near the poles.

Is the angle of sunlight or the distance between the Earth and Sun more important in determining the seasons? Hint: The Earth is closer to the Sun in early January.
The angle.

EXTENSION ACTIVITY

Test different soils in relation to rate of heating:

a) Make mounds of different soil arranged at the same angle (use a protractor)
b) Place a thermometer in each mound.
c) Keep a record for 15 minutes and graph.

Part 1 Why Is Summer Hotter Than Winter?

Name ______________________________ **Date** ____________________

MATERIALS		
flashlight	black construction paper	ruler
2 pencils	ball of modeling clay or foam, ball, 4"	

PROCEDURE

1. a. In a dark room, hold a flashlight about 15 cm (6") directly above the dark paper.
   b. Observe and measure the diameter of the light on the paper.
   c. Record the measurement. Is the light bright or dim?
2. a. Tilt the flashlight at an angle.
   b. Again, observe and measure the length of the light.
   c. Record the results.
3. a. Insert one pencil through the center of the ball of clay or foam. Use the second pencil to mark the equator line around the middle of the ball, perpendicular to the pencil axis.
   b. Position the ball on a table so that the pencil eraser is leaning slightly to the right. Place the flashlight about 15 cm (6") from the left side of the ball.
   c. Observe where the light strikes the ball. Which hemisphere is getting light?
   d. Keeping the ball tilted with the tilt pointed in the same direction, move the ball to the other side of the light about 15 cm (6").
   e. Observe where the light strikes the ball.

DISCUSSION

Was there a difference in the diameter of the light?

Was there any difference in intensity of the light in the two trials?

What did you notice about where the light hit the ball?

How did the light change?

What do you think caused all of these changes?

What conclusions can you make from your results?

GENERAL

What areas of Earth receive the most sunlight?

What areas are at the greatest angle relative to direct sunlight?

How do their average temperatures compare?

Is the angle of sunlight or the distance between Earth and the Sun more important in determining the seasons?
Hint: The Earth is closer to the Sun in early January.

Part 2 Why Is Summer Hotter Than Winter?

Name ________________________________ **Date** ______________

MATERIALS
watch or clock
three thermometers
masking tape
high wattage incandescent lamp
three right triangular blocks of wood, each with 30°, 60^0, and 90° angles

PROCEDURE

1. a. Attach a thermometer to the 30° angle of one of the blocks.
   b. Attach a thermometer to the 60° angle of another block.
   c. Attach a thermometer to the 90° angle of the last block.
2. Position the blocks along an arc of 20 cm (8") radius from the light.
3. a. Turn on the light and record the temperature of each thermometer.
   b. Record the temperature of each thermometer every minute for 15 minutes.
   c. Turn off the light.
4. Graph your data using a key to indicate the results from the various angles.

DISCUSSION

Which angle caused the temperature to increase the most in 15 minutes? The least?

What conclusion can you make from your results?

How does this affect the weather where you live?

GENERAL

What areas of Earth receive the most sunlight?

What areas are at the greatest angle relative to direct sunlight?

How do their average temperatures compare?

Is the angle of sunlight or the distance between Earth and the Sun more important in determining the seasons?

Hint: The Earth is closer to the Sun in early January

WEATHER TOPIC: Weather Observation

14 Make a Cloud Wheel

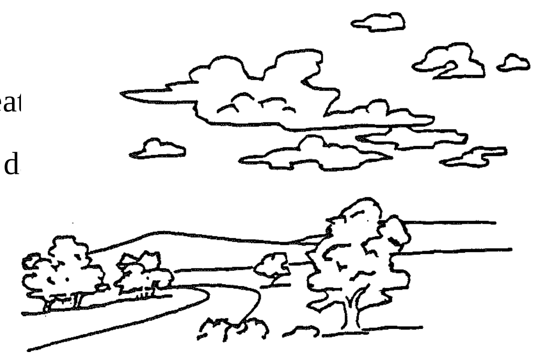
This is an individual student activity.

Grade Levels: 4th -8th grades

Estimated Time:
45-minute class period, and 10 minutes of class time each day for several days

OBJECTIVES
Students will learn to

* identify cloud types.
* determine wind direction.
* use cloud types and wind direction to predict weat
* formulate a prediction.
* relate the result of an experiment in the form of a d chart.
* use recorded data to conclude validity of predictions.



STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.1; 1.2
Grade 5: 1.1; 3.2a; 3.2b; 3.3a
Grade 6: 1.1; 5.1c
Grade 7: 1.1; 5.1; 6.2
Grade 8: 1.2; 2.1; 4.3

MATERIALS
The following supplies for each student are recommended.

pencil/ pen	scissors	paper fastener	data sheet
wind vane	photocopies of cloud wheel		

SAFTYY PRECAUTIONS
Care in using the scissors.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Clouds are classified by several factors: **height, shape,** and **condition.**

High-Level Clouds

Cirrus

The name of these high, wispy clouds is from Latin for "curled hair." These are commonly found at 20,000 to 30,000 feet and at that height, they are cold clouds consisting of ice crystals. Commonly called "mares' tails" because they look like a horse's tail, cirrus clouds are often the first sign of approaching rain or snow. They also can cause the Sun or moon to have a halo as it shines through these thin clouds. The thicker the cloud, the smaller the halo and the sooner the storm can be expected.

Cirrostratus

At 20,000 feet, these clouds form closer together than cirrus clouds and usually mean rain or snow within 24 hours. They take their name from the Latin words for "curled hair" *cirrus,* and "sheetlike" *stratus.* Because they are formed high in the atmosphere, these cold clouds are composed of ice particles.

Mid-Level Clouds

Altostratus

These mid-level clouds usually precede a storm. Named for the Latin words for "high", *alto,* and "sheetlike," *stratus,* they are found between 15,000 and 20,000 feet, low enough for their moisture to be in the form of water droplets. These clouds have a heavy gray look about them and usually block the sunlight.

Nimbostratus

Found between 3,000 and 10,000 feet, these mid-level to low-level clouds are smooth layer-like rain clouds that block the Sun. Their name comes from *nimbus,* Latin for "rain," and *stratus,* Latin for "sheetlike."

Altocumulus

Found between 6,000 and 20,000 feet, these water droplet clouds are often referred to as a "mackerel sky" because it looks as if the sky is covered with fish scales. The name comes from *alto,* Latin for "high," and *cumu/o,* meaning "heaped."

Low-Level Clouds

Stratus

Found up to 5,000 feet, these water droplet clouds may extend to the ground as fog. They can produce drizzle or small flakes of snow, but heavy precipitation comes from higher clouds above them. *Stratus* comes from the Latin word for "sheetlike."

Stratocumulus

The name for this cloud combines two type names, *stratus* from the Latin word for "sheetlike," and *cumulus,* meaning "heaped." Low, lumpy and gray, they often follow a storm and may produce a light drizzle or snow shower. They are found up to 6,000 feet.

<u>Vertical clouds</u>

Cumulus

The name for these clouds, often associated with fair weather, comes from the Latin word for "heaped." These clouds may start as low as 3,000 feet above the ground and grow upward through the day, sometimes reaching as high as 20,000 feet. They grow over rising warm air currents. Between them, in the clear areas, cool air currents sink. Usually they do not mean rain, but occasionally they turn into *cumulonimbus* meaning "heaped rain cloud."

Cumulonimbus

From the Latin words *cumulo* meaning "heaped" and *nimbus,* "rain," these towering clouds bring some of the most violent weather. Known to stretch as high as 60,000 feet it is in these clouds that thunderstorms and tornadoes are born. Cumulonimbus clouds form where there is sufficient moisture in the air and strong warm currents rising upward.

VOCABULARY

Condition name: Nimbus -- applied to a cloud that is producing precipitation.

Height names: Cirro -- high clouds, generally above 20,000 feet.
Alto -- mid-level, usually around 6,000 to 20,000 feet.
Used as a prefix; no prefix for low clouds.)

Shape names: Cirrus -- curly or wispy
Stratus -- layered
Cumulus -- heaped up or cottony

- **PROCEDURE**

Before beginning this activity discuss clouds: the various types and their shapes. A cloud poster is recommended.

1. Put together the cloud prediction wheel.
2. Meteorologists predict weather by observing relationships. One such relationship might be cloud type and wind direction. State a hypothesis.
3. Go outside.
4. Determine wind direction using a wind vane and record it on the data sheet. (Wind direction equals direction from which wind is coming.)
5. Observe the cloud type and record on your data table.
6. Using the cloud prediction wheel, predict the weather, and record your predictions. (Face into the wind. Turn cloud wheel so that text shows below letter corresponding to the direction you are facing.)
7. Return to your classroom.
8. The next day, record actual weather conditions on your data sheet.
9. Repeat the procedure for 10 days.
10. Evaluate your procedure, and state your conclusion.

DISCUSSION

Were your predictions correct? Answers will vary.

Did your conclusions support or refute your hypothesis? Answers will vary.

If wind direction and cloud type can predict weather, why do you think this is so?
Answers will vary.

If they did not predict weather, what do you think might be a better predictor?
Answers will vary.

E X T E N S I O N   A C T I V I T I E S

*Design a simple cloud wheel for younger children that ignores wind direction.
*Create a poster or picture showing cloud types.
*Write a poem or story about clouds.
*Write a letter to a 2nd grader and tell her/him about your experiment.
*Collect weather maps from the newspaper and try to decide what areas of the country are cloudy. **Are there any clues to suggest types of douds?**
*Research altitudes of clouds and compare their heights to objects such as mountains, birds, airplanes or other things.

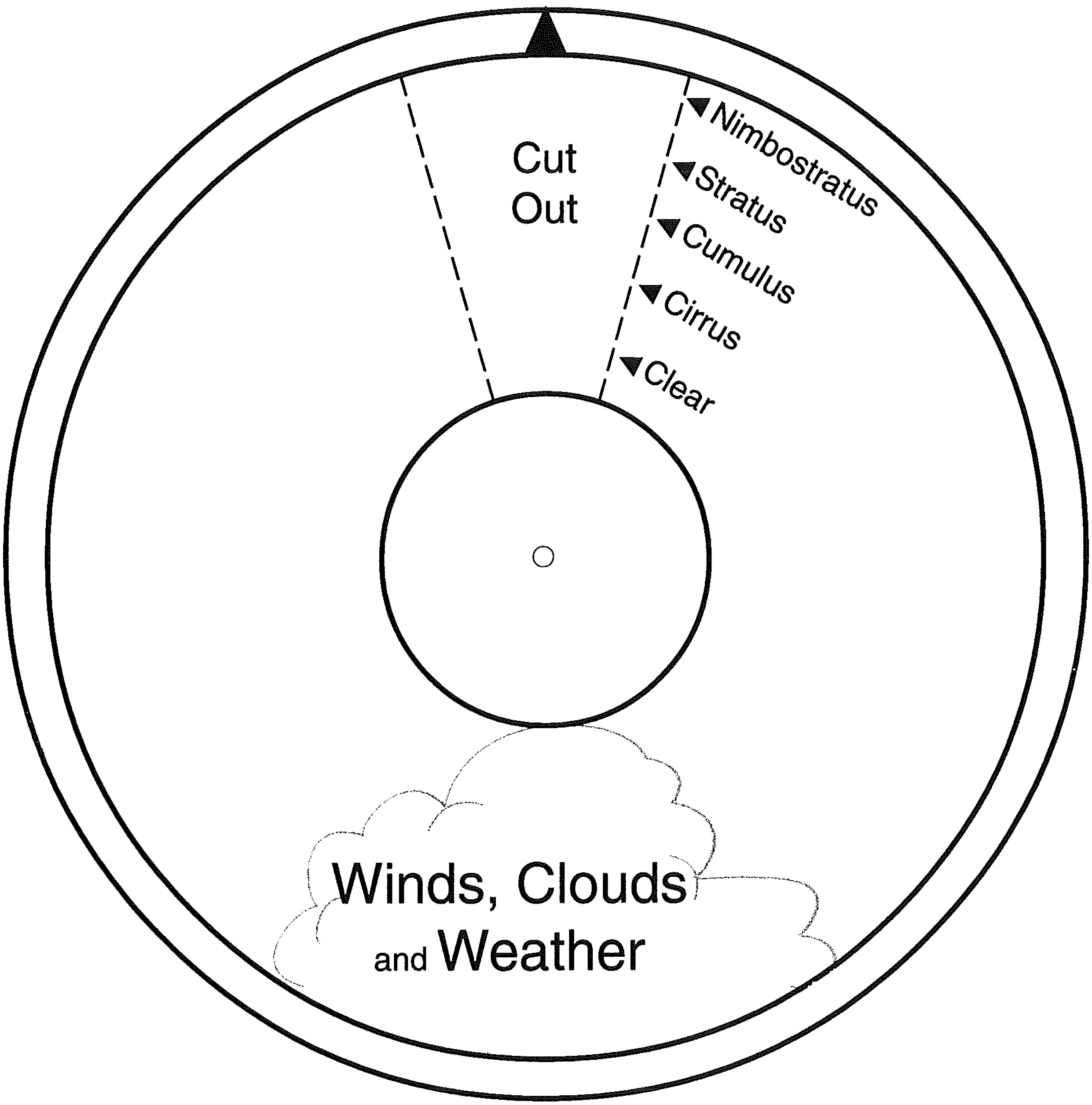
References
The Weather Classroom, Moore, Karen Wenning, The Weather Channel, 2600 Cumberland Parkway, Atlanta, GA, 1992.
Idea Cards, Charles E. Merrill Publishing Division, Bell St Howell, Canada Ltd., 1972.

Name ______________________________ **Date** ____________________

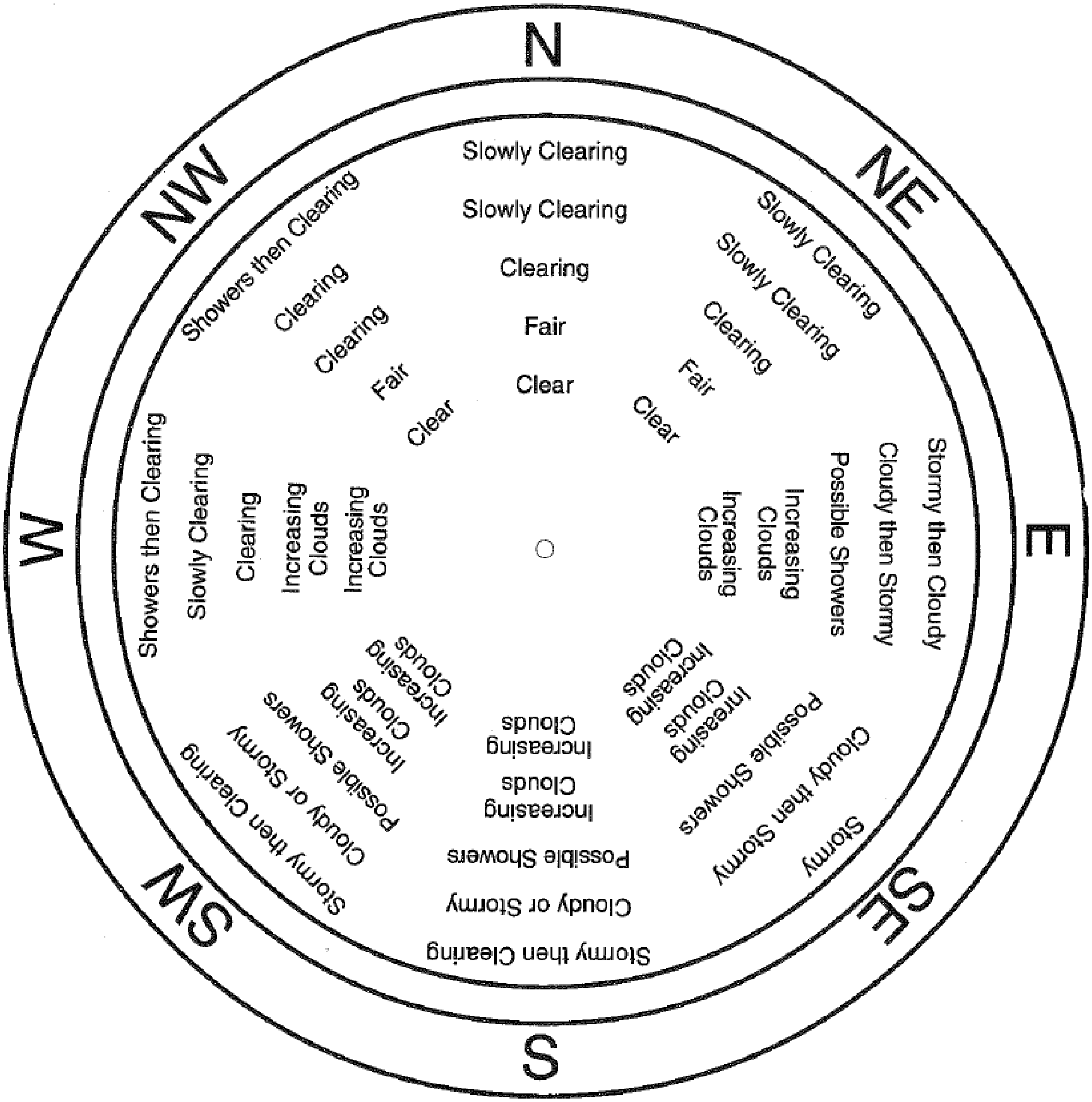
PREDICTION WHEEL DATA TABLE

DATE	Wind Direction	Cloud Type	Prediction	Weather Observed

Make a Cloud Wheel



Make a Cloud Wheel



WEATHER TOPIC: Weather Observation

15 Weather Sayings: How True?

This is an individual student activity.

Grade Levels: 4th - 8th grades

Estimated Time:
One 45-minute class period

OBJECTIVES
Students will learn how to
* evaluate the truth of weather proverbs.
* derive the principles behind some folk wisdom.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.1; 1.2
Grade 5: 1.3; 3.2a; 3.2b
Grade 6: 1.1; 2.1; 5.1b; 5.1c; 5.2
Grade 7: 5.1; 6.1; 6.2
Grade 8: 1.1; 1.2; 2.1; 4.3; 5.1

MATERIALS
list of weather proverbs

SAFETY PRECAUTIONS
There are no safety

• BACKGROUND INFORMATION FOR INSTRUCTOR

Since certain characteristics predict the onset of weather changes, folk wisdom has used observations of events to predict those changes in the weather. For example, falling atmospheric pressure is associated with weather becoming stormier. The amount of gas dissolved in a liquid is a function, in part, of atmospheric pressure. Natural events associated with some gas being released, i.e. increased odors, feeding behaviors of water animals, greater pressure on arthritic joints, have been seen to predict rain.

The prevailing winds in an area, coupled with the direction of sunrise and sunset, allow observers to note fronts coming or going.

High clouds (cirrus) usually indicate an approaching front and can affect the light of the Sun or moon, causing fuzziness or rings. Increased humidity affects various materials, such as salt (making it sticky), and increased humidity is associated with increasing chances of rain.

VOCABULARY

Air pressure: the force of air exerted per unit of surface area.

Prevailing winds: the usual direction of wind in a given area.

Humidity: a measure of the amount of moisture in the air.

- **PROCEDURE**

Before beginning activity, introduce and discuss the subject of weather folklore.

1. Choose a weather proverb from the list provided.
2. Decide if you think your proverb is true or not.
3. Try to find some scientific, weather-related reason why or why not.
4. Discuss your reasons with your class and try to convince them.

DISCUSSION

Why did weather folklore arise? People observed that some weather situations occurred together, i.e. Red sunrises followed by rainy days. These were repeated over time until someone would make a catchy saying out of the information. This would be more easily remembered and went into common usage.

Who needs to predict the weather? Everyone.

Why? Because it affects many aspects of everyone's lives.

EXTENSION ACTIVITIES

• Find weather proverbs from other parts of the world and compare them to yours. Are the other proverbs applicable to your area?
• Write your own proverb. Be prepared to defend its truth with weather science you know.
• Find a story about the weather and draw an illustration to go with it.
• Survey older people about weather proverbs. Compile and illustrate a book from their interviews.

References
Weather Proverbs, George D. Freier, Ph.D., Fisher Books, Tucson, AZ, 1992.
Evening Gray, Morning Red; A Handbook of American Weather Wisdom, Barbara Wolf, MacMillan Publishing Co., 1976.

Some Weather Proverbs

(Note: Some sayings are not true.)

- *Birds flying low, expect rain and a blow.*

Birds are sensitive to air pressure. When the lowest air density is closer to the ground because of high humidity, the birds fly low. High humidity is associated with rain.

- *Fish bite best before a rain.*

The decreased air pressure before a rain allows dissolved gas to escape from the vegetable matter in the bottom of bodies of water. This escaping gas carries insects and other food to the top of the water and the fish feed on them.

- *Sunshine and shower won't last half an hour.*

If a storm is associated with a fast-moving front, the front is usually smaller, and is past quickly.

- *The width of the band on the woolly caterpillar predicts the severity of the winter to come.*

Not true, because the width of woolly band caterpillars' bands varies greatly every year, depending on the individual caterpillar. You may find specimens with very wide and very narrow bands in any given autumn.

- *If the moon rises in a halo, expect rain.*

Halos around the Sun or moon are caused by ice crystals in high, thin clouds. These clouds usually precede a front which causes a change in the weather. The larger the halo the longer the time till the front arrives.

- *If the groundhog sees his shadow on February 2nd, expect 6 more weeks of winter.*

Feb. 2nd is half-way between the beginning of winter and the beginning of spring. Whether the groundhog sees his shadow or not, there are about 6 weeks left of winter on the calendar.

- *Red sky at night, sailors' delight.*
  Red sky at morning, sailors take warning.

Weather changes in the Midwest usually come from the west. Since the Sun sets in the west, a red sky means that there is some clear sky to the west allowing the rays of the setting Sun to light the clouds. The clearing sky is future weather. A red sunrise means that there are clouds in the western sky for the east-rising Sun to light. Cloudy weather is coming for the day.

- *Evening gray and morning red, sends the traveler back to bed.*
  Evening red and morning gray, sends the traveler on her way.

Weather changes in the Midwest usually come from the west. Since the Sun sets in the west, a red sky means that there is some clear sky to the west allowing the rays of the setting Sun to light the clouds. The clearing sky is future weather. A red sunrise means that there are clouds in the western sky for the east-rising Sun to light. Cloudy weather is coming for the day.

- *Guitar strings tighten before a rain.*

Nylon or gut strings are more likely to loosen in the higher humidity preceding a rain.

- *Bad knees ache before a rain.*

Decreased air pressure before a rain causes tiny gas bubbles to form in bodily fluids. These tiny bubbles irritate nerve endings, thus causing aching joints and restless behavior.

- *When the weather changes, children misbehave more.*

Air pressure before a rain is decreased because of increased humidity. This can cause aches in joints, and restless behavior.

- *A storm that comes fast, passes fast.*

If a storm is associated with a fast-moving front, the front is usually smaller, and is past quickly.

- *'When the Big Dipper is upside down, expect rain.*

Not true, because the Big Dipper rotates around the sky every night as the Earth turns, so it might be upside down during the hours of darkness anytime from November to July. It is upside down right after dark late in the spring, when the weather is often rainy.

- *If you can see the old moon in the young moon's arms, the weather will be fair.*

Possibly because the moon is caused by reflected earth-light, and the reflection is only visible when the sky is clear.

- *March comes in like a lion and goes out like a lamb,*
  or comes in like a lamb and goes out like a lion.

Not necessarily, because it can also come in like a lamb and go out like a lamb, or like a lion both ways. March is the month covering late winter and early Spring, a time when the weather is very unpredictable. The weather in March varies greatly in the Midwest.

- *The mourning dove coos before a rain.*

Low air pressure before a rain may cause tiny gas bubbles to form in animal bodily fluids. These small bubbles tend to affect nerve impulses at synapses, making the creature somewhat more irritable—and vocal.

Some Weather Proverbs

(Note: Some sayings are not true.)

- *Birds flying low, expect rain and a blow.*
- *Fish bite best before a rain.*
- *Sunshine and shower won't last half an hour.*
- *The width of the band on the woolly caterpillar predicts the severity of the winter to come.*
- *If the moon rises in a halo, expect rain.*
- *If the groundhog sees his shadow on February 2nd, expect six more weeks of winter.*
- *Red sky at night, sailors' delight.*
Red sky at morning, sailors take warning.
- *Evening gray and morning red, sends the traveler back to bed.*
Evening red and morning gray, sends the traveler on her way.
- *Guitar strings tighten before a rain.*
- *Bad knees ache before a rain.*
- *When the weather changes, children misbehave more.*
- *A storm that comes fast, passes fast.*
- *When the Big Dipper is upside down, expect rain.*
- *If you can see the old moon in the young moon's arms, the weather will be fair.*
- *March comes in like a lion and goes out like a lamb,*
or comes in like a lamb and goes out like a lion.
- *The mourning dove coos before a rain.*

Weather Sayings - How True?

Name ______________________________ **Date** ____________________

- **PROCEDURE**

1. Choose a weather proverb from the list provided. Write it below.

____

____

2. Decide if you think your proverb is true or not.

True False

3. Try to find some scientific, weather-related reason why or why not.

____

____

4. Discuss your reasons with your class and try to convince them.

DISCUSSION

Why did weather folklore arise?

____

____

Who needs to predict the weather? Why?

____

____

WEATHER TOPIC: Weather Instruments

16 Fast as the Wind – Make an Anemometer

This activity is for cooperative learning groups.

NOTE: Another option would be for each group to make a different weather instrument for recording.

Grade Levels: 4th - 8th grades

Estimated Time:
40-minute class period and two 5-minute readings per day

OBJECTIVES

Students will

* measure the speed of the wind.
* graph the speed of the wind.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.2
Grade 5: 1.2; 3.2a
Grade 6; 1.1; 5.1c
Grade 7: 5.1; 6.1
Grade 8: 1.2; 2.1

MATERIALS

Divide students into cooperative learning groups. You will need these materials for each group.

wooden stick (such as a meter stick)	protractor	ping pong ball
level or balance bubble	1 long needle	tape or glue
wind conversion chart	carpet thread or fishing line	weather chart

SAFETY PRECAUTIONS There are no safety precautions.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Wind is air in motion. Wind movement is primarily the result of differences in air pressure, with air moving from higher pressure areas to lower pressure areas. Wind speeds can be simply estimated by observing the wind's effect on trees, flags, or water. The Beaufort scale is a traditional scale that uses such visual signs to indicate relative wind speed. (See page 105.) Instruments used to measure wind speed are called anemometers. This lesson involves the construction of a simple anemometer to measure wind speed.

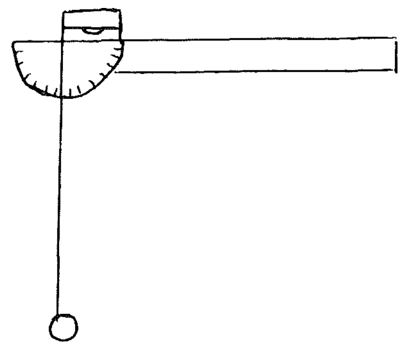
VOCABULARY

Anemometer: an instrument used to measure the speed of the wind.

Level: an instrument used for determining whether a surface is on an even horizontal plane.

Wind speed: moving air.

Air pressure: the force of air exerted per unit of surface area.



PROCEDURE

Before beginning activity, introduce the subject of wind and how meteorologists measure it for weather forecasting. If possible, show the students an anemometer.

1. Glue or tape the protractor to the wooden stick.

2. Measure 25 centimeters of carpet thread or fishing line. Use the sewing needle to thread the fishing line through the center of ping pong ball. Tie a knot at the end of the thread so he ball will not fall off.

3. Tape the other end of the fishing line to the center of the protractor. See the diagram.

Students should work in groups of two. One student holds the wind speedometer level. This allows the ball to swing freely and provides an accurate reading. The other student observes the movement of the string on the protractor to find the approximate angle at which the wind is moving the ball. He/she records this data on a weather chart. The two students change this angle measurement to wind speed using the conversion chart.

DISCUSSION

How can you tell whether the air is moving? The ping pong ball moves.
What effects might the wind have at different speeds? The higher the wind speed the greater the angle the ball moves.
How much does the wind speed change during the day and from day to day?
Why does the wind change speed? A pressure change in the low & high pressure areas that drive the wind.

E X T E N S I O N   A C T I V I T I E S

• Write a poem using words to describe various wind speeds: gale, hurricane, typhoon, tornado, and gentle breeze.
• Take four readings at four different times during the day. Add the four readings and divide by four to find the average daily reading.
• Check the wind conversion chart for accuracy. Hold your wind speedometer outside a car window at various speeds and record your observations. Note: Your anemometer only measures low speeds. **How does this data compare with the wind conversion chart?** How would the direction of the wind and speed of the wind affect your experiment?

Fast as the Wind Activity
Make an Anemometer

MATERIAL LIST		
wooden stick (such as a meter stick)	protractor	ping pong ball
level or balance bubble	1 long needle	tape or glue
wind conversion chart	carpet thread or fishing line	

1. Glue or tape the protractor to the wooden stick.

3. Measure 25 centimeters of carpet thread or fishing line. Use the sewing needle to thread the fishing line through the ping pong ball. Tie a knot at the end of the thread so the ball will not fall off.

3. Tape the other end of the fishing line to the center of the protractor. See the diagram.

4. Take readings at different times during the day. Record data on the weather chart. If possible, continue taking readings for 3 days and then average the readings. (Add all the readings, then divide by the number of readings.)

Wind Conversion Table

(Calibration Table)

ANGLE	KILOMETERS PER HOUR	MPH
90°	0	0
85°	6	10
80°	8	13
75°	10	16
70°	12	19
65°	13	21
60°	15	24
55°	16	26
50°	18	29
45°	20	32
40°	21	34
35°	23	37
30°	26	42
25°	29	47
20°	33	53

WEATHER TOPIC: Weather Instruments

17 Make a Thermometer

This activity is for cooperative learning groups.
NOTE: Another option would be for each group to make a different weather instrument for recording.

Grade Levels: 4th - 8th grades

Estimated Time:
40-minute class period and 5-minutes daily to record data

OBJECTIVES

Students will

- learn to how to measure temperature and how a thermometer works.
- understand the relationship between a change in temperature and a change in the properties of a liquid.
- learn how to calibrate a scale.
- explore cause and effect relationships.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.1; 1.2; 2.2b
Grade 5: 1.2; 1.3; 3.2a
Grade 6: 1.1; 2.1; 5.1c; 5.2
Grade 7: 1.1; 5.1

MATERIALS

Divide students into cooperative learning groups. You will need the following materials for each group.

drinking straw	small-mouthed glass bottle
food coloring	water
marker	deep pan
clay	

SAFETY PRECAUTIONS

Care should be taken when using glass and heated water.

- **BACKGROUND INFORMATION**

One of the first things most people notice about the weather is how hot or cold it is. This is the temperature. A thermometer is used to measure temperature. Typically, thermometers measure the heat content of the air by the expansion or contraction of a fluid in a tube. Liquids expand when they are heated and contract when they are cooled. When the air temperature increases, the liquid in the thermometer expands, and rises up the tube. When the air temperature decreases, the liquid in the thermometer contracts and moves down the tube. Thermometers can be made with a range of different liquids such as mercury and alcohol. For the thermometer in this activity, the liquid is water. Thermometers can also be made with thin strips of metal that expand and contract when heated or cooled or with liquid crystals that change color with temperature. In order to quantify temperature, a calibrated scale is needed. Two common temperature scales are Fahrenheit and Celsius. On the Fahrenheit scale, fresh water boils at 212° and freezes at 32°. On the Celsius scale, water freezes at 0° and boils at 100^0. (See p. 86 for conversion formula.) A Fahrenheit degree is therefore smaller than a Celsius degree.

VOCABULARY

Calibrate: to devise a scale for an instrument.

Celsius: a scale used to measure temperature (°C); on this scale, fresh water boils at 100° and freezes at 0^0.

Contract: to decrease in size.

Expand: to increase in size.

Fahrenheit: a scale used to measure temperature (°F); on this scale, fresh water boils at 212° and freezes at 32°.

Temperature: degree of hotness or coldness.

Thermometer an instrument for measuring temperature, typically calibrated in units of Fahrenheit and Celsius.

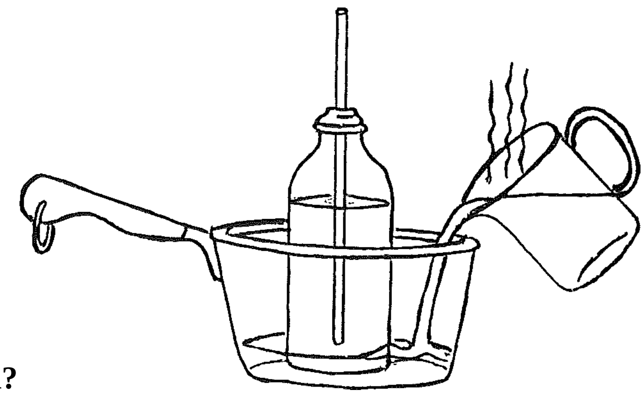
- **PROCEDURE**

  Introduce the subject of thermometers and how we use them.

1. Fill the bottle with cold water. Add a few drops of food coloring.
2. Place the straw in the water so that it is in the water about halfway.
3. Tightly seal the opening of the bottle with clay. (Rubber stopper with center hole can also be used.)
4. Mark off the water level in the straw with the marker.
5. Place the bottle into the pan. Pour hot water into the pan.
6. Let the bottle stand a few minutes. Watch the water in the straw. What happens? Mark the level of the water in the straw.
7. Empty the pan. Place the bottle into the pan and pour cold water into the pan.

8. Let the bottle stand a few minutes. Watch the water in the straw. What happens? Mark the level of the water in the straw.

The bottle thermometer can be calibrated so that the levels in the straw correspond to specific temperatures. Place the bottle in melting ice and mark the water level. This is the level for 0° C (32° F). Leave the bottle at room temperature for some time and mark the water level in the straw. Measure room temperature with a thermometer. This is the level for room temperature. The space between the two marks (0° and room temperature) can be divided into one degree marks—yielding one space for each degree temperature rise.



DISCUSSION

What happens to a liquid when it is heated?
It expands.

What happens to a liquid when it is cooled? It contracts.

What other liquids could have been used to make the thermometer?
Alcohol and mercury are also used to make a thermometer.

EXTENSION ACTIVITIES

• Calibrate your bottle thermometer by using a commercial thermometer to first determine a high temperature, then a low temperature. Predict where the marks for the degrees should be drawn. Use the commercial thermometer to check your results.

• Make thermometers out of different bottles and/or different size straws (such as a thin cocktail straw and a thicker regular drinking straw).

• Use other liquids such as colored rubbing alcohol. Calibrate each thermometer and determine the differences, if any, in the scales.

• Find and record the temperature of the air in different places.

• Record the temperature at different times of the day for several days. Graph your observations. **Can you draw any conclusions?**
Such as: **When is the hottest time of the day? the coldest? Does the temperature of the air change more rapidly on a sunny day or a cloudy day? Does the graph look the same at different seasons of the year?**

• Figure out the formula for the conversion between Fahrenheit and Celsius.

$$°C = (5/9) \times (°F - 32°)$$

$$°F = [(9/5) \times °C] + 32°$$

Make a Thermometer

Group ____ Date ___________________

MATERIAL LIST

straw	glass bottle	clay
food coloring	water	deep pan
marker		

- **PROCEDURE**

1. Fill the bottle with cold water. Add a few drops of food coloring.
2. Place the straw in the water so that it is in the water about halfway.
3. Tightly seal the opening of the bottle with clay.
4. Mark off the water level in the straw with the marker.
5. Place the bottle into the pan. Pour hot water into the pan.
6. Let the bottle stand a few minutes. Watch the water in the straw. What happens? Mark the level of the water in the straw.
7. Empty the pan. Place the bottle into the pan and pour cold water into the pan.
8. Let the bottle stand a few minutes. Watch the water in the straw. What happens? Mark the level of the water in the straw.

The bottle thermometer can be calibrated so that the levels in the straw correspond to specific temperatures. Place the bottle in melting ice and mark the water level. This is the level for 0° C (32° F). Leave the bottle at room temperature for some time and mark the water level in the straw. Measure room temperature with a thermometer. This is the level for room temperature. The space between the two marks (0^0 and room temperature) can be divided into one degree marks—yielding one space for each degree temperature rise.

DISCUSSION

What happens to a liquid when it is heated?

What happens to a liquid when it is cooled?

What other liquids could have been used to make the thermometer?

WEATHER TOPIC: Weather Instruments

18 Make a Wind Vane

This activity is for cooperative learning groups.
NOTE: Another option would be for each group to make a different weather instrument for recording.

Grade Levels: 4th - 8th grade

Estimated Time:
40-minute class period and 5-minutes daily to record data

OBJECTIVES
Students will
* learn to tell the direction of the wind using a wind vane.
* observe and chart data.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.1
Grade 5: 1.1; 1.2; 3.2a
Grade 6: 1.1; 5.1c
Grade 7: 1.1; 5.1; 6.2
Grade 8: 2.1; 2.2; 4.3

MATERIALS
Divide students into cooperative learning groups. You will need the following materials for each group.

2 drinking straws
2 pieces cardboard, about 4"x6"
modeling clay
bamboo shish kabob skewer or thin dowel rods, cut shorter than straws
square piece of paper, about 6" (to fit top of flower pot)
masking tape
clay flowerpot
ruler
pencil/pen
scissors
glue
toothpicks
compass
marker

SAFETY PRECAUTIQNS
There are no safety precautions:

- BACKGROUND INFORMATION FOR INSTRUCTOR

Wind is primarily the result of differences in air pressure, with air moving from higher pressure areas to lower pressure areas. A wind vane is used to measure the direction from which the wind is blowing. A prevailing wind is the wind most common to the region. It is named after the direction of its origin. Wind direction is a key factor used to determine the movement of weather systems.

VOCABULARY

Compass: an instrument for showing direction, especially one consisting of a magnetic needle swinging on a pivot point and pointing to magnetic north.

Wind: movement of air over the Earth's surface.

- PROCEDURE

Before beginning the activity, introduce the subject of wind and how meteorologists measure it for forecasting.

1. Using the cardboard, cut out a large triangle. Cut off the top of the triangle to make the point and tail for the wind vane.

2. Cut slits into both ends of the same straw. Slide the point and the tail onto the two slits. Use a bit of glue to secure the cardboard pieces.

3. Using the same straw, push the bamboo skewer/ dowel rod through the middle.

4. Draw two diagonal lines between the corners of the square piece of paper. Center the clay pot over the lines and trace around the pot's bottom outer edge. Also trace the inner hole at the bottom of the pot.

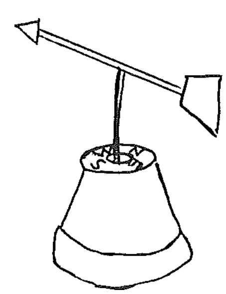
5. Cut out the large circle and the inner circle. Turn the pot over and glue the circle to the base of the pot, with lines facing away from pot.

6. Use marker to label lines: N (12:00), S (6:00), E (3:00), W (9:00).

7. Put the other straw through the hole in the pot, sealing it in place with clay. Insert the bamboo stick and pointer into the straw. Fasten rest of clay to center of cardboard circle with toothpicks, then push bottom of vertical straw into clay. Tape cardboard to pot.

Hints: The arrow of the wind vane must move freely. If necessary, attach one or more paper clips to the head or point of the vane so that the head and tail balance. Try to keep the center of gravity in the center of the straw.

To use the wind vane, place it in an open area free from obstacles such as trees or buildings. Turn the base to that "N" lines up with compass North. Four readings should be taken, then averaged to produce a prevailing wind direction for the day. For example, readings of West, West, Northwest would equal West for the day.



DISCUSSION QUESTIONS

What were the prevailing winds for each day? Answers will vary.

Did the wind change direction from day to day? Answers will vary.

Where was today's weather yesterday? Answers will vary.

E X T E N S I O N   A C T I V I T I E S

- Read stories about kites and kite flying. Study Wilbur and Orville Wright and their wind studies.

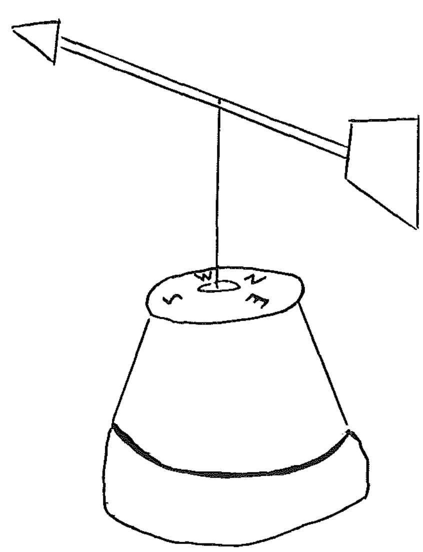
- Choose a city or cities north, south, east, and west of your town. After collecting data on prevailing winds for several days, check on the weather in the city from which the winds originated. Write a weather forecast for your city based on the weather from a city where the wind originated.

'What is the best way to communicate the information on prevailing winds? Try a bar graph, line graph, or design a circle graph.

'Does the design of a wind vane influence how it works? What part does friction play in making your wind vane work accurately? Try to design a wind vane that is unique or will turn the fastest into the wind. Answer these questions: **What is the difference between the front and rear part of the wind vane? What must the horizontal bar be able to do to turn in the direction of the wind? Where must the pivot of the horizontal bar be located? What could be used as a base or a stand for a wind vane?**

References

The Science Book of Weather, Neil Ardley, Harcourt Brace Jovanovich Publishers, New York, 1992.



STUDENT ACTIVITY SHEET

Make a Wind Vane

Group ______________________________ **Date** _______________________________

MATERIAL LIST	
2 drinking straws	clay flowerpot
2 pieces cardboard (about 4"x6" each)	ruler
modeling clay	pencil/pen
bamboo shish kabob skewer or thin dowel rods	scissors
cut shorter than straws	glue square piece of paper
(about 6"--to fit top of flower pot) toothpicks	
compass	marker masking tape

PROCEDURE

1. Using the cardboard, cut out a large triangle. Cut off the top of the triangle to make the point and tail for the wind vane.

2. Cut slits into both ends of the same straw. Slide the point and the tail onto the two slits. Use a bit of glue to secure the cardboard pieces.

3. Using the same straw, push the bamboo skewer/dowel rod through the middle.

4. Draw two diagonal lines between the corners of the square piece of paper. Center the pot over the lines and trace around the pot's bottom outer edge. Also trace the inner hole at the bottom of the pot.

5. Cut out large and inner circles. Turn the pot over and glue large circle to base.

6. Use marker to label lines: N (12:00 o'clock), S (6:00), E (3:00), W (9:00).

7. Put the other straw through the hole in the pot, sealing it in place with clay. Insert the bamboo stick and pointer into the straw. Fasten rest of clay to center of card-board circle with toothpicks, then push bottom of vertical straw into clay. Tape cardboard to pot.

Hints: The arrow of the wind vane must move freely. If necessary attach one or more paper clips to the head or point of the vane so that the head and tail balance. To use the wind vane, place it in an open area free from obstacles. Turn the base so that "N" lines up with compass North. Four readings should be taken and then averaged to make a decision regarding prevailing winds for the day. As an example, readings of West, West, Northwest would result in a direction of West for the day.

DISCUSSION QUESTIONS
What were the prevailing winds for each day?

Did the wind change direction from day to day?

Where was today's weather yesterday?

WEATHER TOPIC: Weather Instruments

19 Measuring Humidity–Make a Psychrometer

This activity is for cooperative learning groups.
NOTE: Another option would be for each group to make a different weather instrument for recording.

Grade Levels: 4th - 8th grades

Estimated Time:
45-minute class period

OBJECTIVES
Students will
* measure the amount of water vapor in the air.
* learn how moisture in the air affects weather.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 5: 1.2; 3.2a
Grade 6: 1.1; 5.1b; 5.1c
Grade 7: 1.1; 1.2; 5.1
Grade 8: 1.2; 4.3

MATERIALS
Divide students into cooperative learning groups.You will need the following materials for each group.

2 thermometers, alcohol	gauze	water (in a dropper)
cardboard	string (1 meter)	scissors
hole punch	rubber bands	1 or 2 metal washers

SAFETY PRECAUTION
Check to be sure the thermometers are secured. String should be just long enough to swing and students should swing them above their heads, not around face.

• **BACKGROUND INFORMATION FOR INSTRUCTOR**

Humidity is the amount of water vapor in the air. It determines the kind of weather we may have as well as regulates our comfort. Humidity is most commonly expressed as relative humidity: the ratio of the amount of moisture in the air to the amount the air would contain if it were saturated at a given temperature.

A hygrometer is an instrument designed to measure humidity. Some hygrometers use a sensor made of a material, such as treated paper or human hair, that stretches, contracts, or bends with changes in humidity. Another standard hygrometer is the sling psychrometer, consisting of two identical thermometers. One thermometer has its bulb covered with a moist cloth (wet bulb); the other thermometer is left uncovered (dry bulb). To take a reading, the two thermometers are whirled in the air on a hand-held swivel. Since evaporation of water causes cooling of an object, the wet bulb thermometer is cooled by the evaporation of the water from the cloth. The drier the air, the greater the evaporation and the lower the wet bulb reading. The dry bulb simply measures the current air temperature. Both thermometers are then read, and the humidity is determined by consulting a table.

VOCABULARY

Evaporation: liquid changes to a gas (water to water vapor).

Humidity: general term referring to the content of water in the air.

Relative humidity: ratio of the amount of water vapor actually in the air compared to the amount of water vapor the air can hold at that temperature and pressure.

Saturation: a condition of the air in which it holds all the moisture it can at a given temperature.

- **PROCEDURE**

  Introduce the students to humidity and how it relates to weather before beginning the activity.

1. Cut a rectangle of cardboard slightly larger than the two thermometers.
2. Cut a small piece of gauze and secure it around the bulb of one of the thermometers.
3. Place the thermometers side by side on the cardboard and attach them to the cardboard with several rubber bands.
4. Punch a hole through the center top of the cardboard and thread the string through it. Also thread the string through any holes in the top of the thermometers. Attaching one or two washers to the bottom will produce a better swing.
5. Place a few drops of water on the gauze so that it is wet, not drippy.
6. Read and record the temperature of the dry bulb. Use Celsius for all temperatures.
7. Swing the psychrometer in the air for about 15 seconds. Do not whirl the psychrometer too much, only enough to keep it spinning.

8. Record the temperature of the dry bulb and wet bulb.

9. Repeat steps 7 and 8 until the wet bulb reading has reached its lowest recording and no longer changes. Record the wet bulb temperature.

10. Find the difference between the dry and wet bulb temperatures.

11. Use the chart to determine the relative humidity of the air. Read down the left column on the chart to find the temperature of the dry bulb. Move across the top row until you find the degrees of difference between the dry and wet bulb temperatures. Move down from the latter number and across from the former; the number in the square where the two meet is the percent relative humidity.

12. Take readings from three locations and average them.

DISCUSSION QUESTIONS

What if relative humidity was greater than 100%? It can't be. You would have precipitation. Dew or clouds would form.

If both thermometers were the same, what would the relative humidity be? 100%.

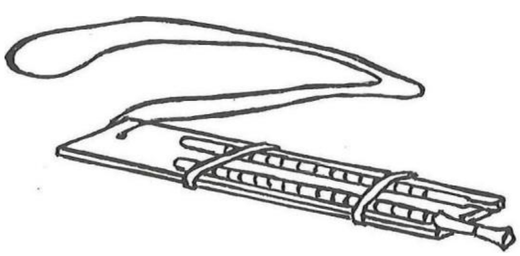
Do you think the relative humidity would change if you were in a deep wooded area? The temperature would be lower and the air would not be able to hold as much water vapor.

If you are perspiring, would you cool off more quickly if it was more humid or less humid? Less humid.

E X T E N S I O N   A C T I V I T I E S

Make a hair hygrometer.

Cut a 12" X 12" square of heavy cardboard. Cut a 6-inch-long arrow from thin cardboard. Punch two holes near the square end of the arrow. Into the lower hole, tie one end of a hair that is at least 10 inches long (horse hair, if it's available, is sturdier than human hair). Loosely attach the arrow to the cardboard square by putting a tack through the top hole. Push another tack part way into the cardboard square 6 inches below the bottom hole in the arrow. Pull the hair until it's straight and then tie it onto the lower tack and push the tack all the way into the cardboard. The hair will expand or contract slightly depending on the amount of moisture in the air. Calibrate the movement of the pointed end of the arrow with a real hygrometer. Mark these readings on the cardboard square. NOTE: It's hard to make this experiment successful, but it's an interesting idea to share with your students.



Measuring Humidity - Making a Psychrometer

Group ____ Date_______________

MATERIAL LIST		
thermometers, plastic	gauze	water (in a dropper)
cardboard	string (1 meter)	scissors
hole punch	rubber bands	1 or 2 metal washers

- **PROCEDURE**

1. Cut a rectangle of cardboard slightly larger than the two thermometers.
2. Place the thermometers side by side on the cardboard and attach them to the cardboard with several rubber bands.
3. Cut a small piece of gauze and secure it around the bulb of one of the thermometers.
4. Punch a hole through the center top of the cardboard and thread the string through it. Also thread the string through any holes in the top of the thermometers. Attaching washers to bottom will produce a better swing.
5. Place a few drops of water on the gauze so that it is wet, but not drippy.
6. Read and record the temperature of the dry bulb. Use Celsius for all temperatures.
7. Swing the psychrometer in the air for about 15 seconds. Do not whirl the psychrometer too much, only enough to keep it spinning.
8. Record the temperature of the dry bulb and wet bulb.
9. Repeat steps 7 and 8 until the wet bulb reading has reached its lowest recording and no longer changes. Record the wet bulb temperature.
10. Find the difference between the dry and wet bulb temperatures.
11. Use the chart to determine the relative humidity of the air. Read down the left column on the chart to find the temperature of the dry bulb. Move across the top row until you find the degrees of difference between the dry and wet bulb temperatures. Move down from the latter number and across from the former; the number in the square where the two meet is the percent relative humidity.
12. Take readings from three locations and average them.

DATA

Location 1 _____________ **Location 2** _____________ **Location 3** _____________

Average _____________

RELATIVE HUMIDITY (%)

Find your dry bulb temperature in Celsius in the first column. Move right across columns to find one with same value as difference between dry and wet bulb temperatures. Number in box is relative humidity.

	Dry-Wet Bulb Difference														
˚C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
-7	73	48	20												
-6	74	49	25												
-5	76	52	29	7											
-4	77	55	33	12											
-3	78	57	37	17											
-2	79	60	40	22											
-1	81	62	43	26	8										
0	$1	64	46	29	13										
1	83	66	49	33	17										
2	84	68	52	37	22	7									
3	84	70	55	40	26	12									
4	85	71	57	43	29	16									
5	86	72	58	45	33	20	7								
6	86	73	60	48	35	24	11								
7	87	74	62	50	38	26	15								
8	87	75	63	51	40	29	19	8							
9	88	76	64	53	42	32	22	12							
10	88	77	66	55	44	34	24	15	6						
11	89	78	67	56	46	36	27	18	9						
12	89	78	68	58	48	39	29	21	12						
13	89	79	69	59	50	41	32	23	15	7					
14	90	79	70	60	51	42	34	26	18	10					
15	90	80	71	61	53	44	36	27	20	13	6				
16	90	81	71	63	54	46	38	30	23	15	8				
17	90	81	72	64	55	47	40	32	25	18	11				
18	91	82	73	65	57	49	41	34	27	20	14	7			
19	91	82	74	65	58	50	43	36	29	22	16	10			
20	91	83	74	66	59	51	44	37	31	24	18	12	6		
21	91	83	75	67	60	53	46	39	32	26	20	14	9		
22	92	83	76	68	61	54	47	40	34	28	22	17	11	6	
23	92	84	76	69	62	55	48	42	36	30	24	19	13	8	
24	92	84	77	69	62	56	49	43	37	31	26	20	15	10	5
25	92	84	77	70	63	57	50	44	39	33	28	22	17	12	8
26	92	85	78	71	64	58	51	46	40	34	29	24	19	14	10
27	92	85	18	71	65	58	52	47	41	36	31	26	21	16	12
28	93	85	78	72	65	59	53	48	42	37	32	27	22	18	13
29	93	86	79	72	66	60	54	49	43	38	33	28	24	19	15
30	93	86	79	73	67	61	55	SO	44	39	35	30	26	21	17

WEATHER TOPIC: Weather Instruments

20 Precipitation Gauge

This activity is for cooperative learning groups. Each group could also make a different weather instrument for recording.

Grade Levels: 4th - 8th grades

Estimated Time:
30-minute class period and
5-minute periods daily

OBJECTIVES
Students will learn
* to measure the amount of precipitation.
* to record and interpret data on precipitation.

STATE SCIENCE GOALS
All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 5: 1.1; 1.2; 3.2a
Grade 6: 1.1; 1.2; 5.1b; 5.1c
Grade 7: 1.1; 5.1
Grade 8: 1.2; 4.3

MATERIALS
Divide students into cooperative learning groups. You will need the following materials for each group.

1 or 2 liter bottle with clear flat bottom (pour melted paraffin wax in bottle to create level bottom, if necessary)
plastic ruler
clear plastic packing & masking tape
scissors
data collection sheet

SAFETY PRECAUTIONS
Use caution when handling hot wax.

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Precipitation is any form of water particles, liquid or solid, that falls from the atmosphere and reaches the ground. Rain is precipitation in the form of liquid water drops, snow is frozen water vapor that falls as snowflakes, sleet is frozen rain, and hail is a mixture of either snow or hail and rain. A precipitation gauge measures the amount of rain, snow, hail, or sleet that has fallen—in cm or mm, inches, or fractions of an inch.

VOCABULARY

Precipitation: any form of water particles, liquid or solid, that falls from the atmosphere and reaches the ground.

Rain: precipitation in the form of liquid water drops.

Sleet: precipitation consisting of pellets of ice 5 mm or less in diameter.

Snow: a solid form of precipitation composed of ice crystals in complex hexagonal shapes.

Hail: particles of ice that range in size from that of a pea to that of golf balls.

- **PROCEDURE**

  Before beginning the activity, introduce the students to what precipitation is, the various forms, and how it is measured.

RAINFALL

1. Use sharp scissors to cut the top off the 1 or 2-liter flat-bottomed bottle just before the bottle begins to taper towards the lid. Use masking tape to mark cutting line.

2. Place the top piece of the bottle upside down in the bottom piece (tape if necessary). The top piece acts as the funnel for the precipitation and forms a barrier to prevent evaporation. Tape ruler to side of bottle with 0" mark at level bottom.

3. Place the modified bottle in an open area away from trees and buildings.

4. Measure the amount of precipitation with the ruler.

5. Record data daily on a chart.

SNOWFALL

1. This type of gauge can be used to measure snowfall as well. In below freezing weather when snow is expected, remove the funnel and leave only the bottom piece of the bottle outdoors in an open area away from trees and buildings.

2. To measure the liquid equivalent of the snowfall, bring the snow-filled collector indoors. Let the snow melt and measure the amount of liquid with a ruler.

Variation

1. To directly measure the depth of snowfall in inches or centimeters, only a ruler is needed.

2. Measure the height of the snow in an open yard or field where there does not appear to be much drifting in several locations and average the measurements together.

DISCUSSION

What is precipitation? Precipitation is any form of water particles, liquid or solid, that falls from the atmosphere and reaches the ground.

How much precipitation has fallen? Answers will vary.

Estimate how much precipitation will fall in one month. Answers will vary.

Explain the difference between rain, hail, snow, and sleet. See Background Information, pages 5 and 6.

Graph the data collected into a bar graph or line graph.

Collect data from other regions in the country and create a graph for this data.

EXTENSION ACTIVITIES

- Leave the precipitation gauge out for a week or a month and record the data.
- Study musical patterns of rain.
- Make a rain stick.

MAKING A PRECIPITATION GAUGE

Group ______________________________________ **Date** ___________________

MATERIAL LIST		
1 or 2-liter bottle with clear flat bottom (use melted paraffin wax to create level bottom, if necessary)	plastic ruler	
clear plastic packing & masking tape	scissors	data collection sheet

- **PROCEDURES**

RAINFALL

1. Use sharp scissors to cut the top off the 1 or 2 liter bottle just before the bottle begins to taper toward the lid. Mark cut line with masking tape, if necessary.

2. Place the top piece of the bottle upside down in the bottom piece (tape if necessary). The top piece acts as the funnel for the precipitation and forms a barrier to prevent evaporation. Tape ruler to side of bottle with 0" mark at level bottom.

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VARIATION

1. To directly measure the depth of snowfall in inches or centimeters, only a ruler is needed.

2. Measure the height of the snow in an open yard or field where there does not appear to be much drifting in several locations and average the measurements together.

DISCUSSION QUESTIONS
What is precipitation?

How much precipitation has fallen?

Estimate how much precipitation will fall in one month.

Explain the difference between rain, hail, snow, and sleet.

Graph the data collected into a bar graph or line graph.

Collect data from other regions in the country and create a graph for this data.

Making a Precipitation Gauge

Data Collection Sheet

Group ______________________________ **Date** ________________

Rainfall: Monday ____________________ **Thursday** _________

Tuesday ____________________ **Friday** ______________

Wednesday _____________

Snowfall: Monday ____________________ **Thursday** _____________

Tuesday ____________________ **Friday** _________________

Wednesday ________________

Average Rainfall: ______________________

Average Snowfall: ____________________

Graph Results

21 Recording Weather Data

This is an individual student activity.

Grade Levels: 4th - 8th grades

Estimated Time:
40-minute class period and
5-minute periods daily

OBJECTIVES

Students will

* learn to record weather data.
* predict weather conditions based on statistical readings.
* learn to graph data.
* compare data for different geographical regions.

STATE SCIENCE GOALS

All Grade Levels: Process and Inquiry Standards 1-5
PASS Standards
Grade 4: 1.2; 2.2b
Grade 5: 1.1; 1.2; 1.3; 1.4; 3.2a; 3.2b
Grade 6: 1.1; 5.1b; 5.1c; 5.1d; 5.2
Grade 7: 1.1; 1.2; 5.1; 6.2
Grade 8: 1.2; 2.1; 4.3; 5.1; 5.2

MATERIALS

newspaper: weather reports, charts, and graphs
Optional: radio, television, weather station, Internet

SAFETY PRECAUTIONS
There are no safety precautions

- **BACKGROUND INFORMATION FOR INSTRUCTOR**

Local newspapers provide daily weather reports with the high and low temperatures for the day. They also provide information concerning weather and temperatures in other cities and countries. A national temperature map will include such weather information as barometric pressure, amounts of precipitation, and location of warm and cold fronts. This data can be collected and recorded on a chart to use for graphing and averaging temperatures. Radio and television also give this information daily. This information can also be obtained by using your own weather station. This may be a good way to begin collecting data. Then it can be carried out further by using news-papers, radio, and television. Begin with the temperature, then experiment with other weather data.

VOCABULARY

Celsius: a scale used to measure temperature (°C). On this scale, fresh water boils at 100^0 and freezes at 0^0.

Fahrenheit: a scale used to measure temperature (°F). On this scale, fresh water boils at 212° and freezes at 32°.

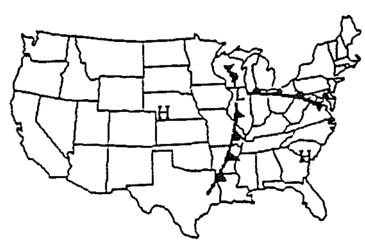
Temperature: degree of hotness or coldness.

Isotherms: lines on a weather map connecting areas of equal temperature.

PROCEDURE

Have a discussion on weather forecasting, meteorologists, and weather reports with the class before beginning this activity. If possible show older students the weather reports on the Internet.

1. Introduce students to the features of newspaper weather reports (radio or television may be substituted).
2. Record predicted and actual temperatures for seven days for a chosen city. Put information on tables and graphs. A prediction chart is provided for copying.
3. Compute average high and low temperature.
4. Make a graph of high and low temperatures.
5. Compare the actual temperature with the predicted temperature.



DISCUSSION

Discuss and compare results (show data for other cities). For example: **What types of clothing will be needed for certain cities or regions?**

Discuss reasons for the differences among cities or regions.

Study different biomes in each region according to weather conditions.

E X T E N S I O N   A C T I V I T I E S

• Examine and record other weather variables such as wind speed, levels of precipitation, barometric pressure, and cold and warm fronts.

• Make daily studies of the weather for an entire school year.

• Study the weather from different regions of the country and the world. Use purchased or self-made instruments to collect data.

WEATHER PREDICTION CHART

SUNDAY	Predict	Actual	MONDAY	Predict	Actual	TUESDAY	Predict	Actual	WEDNESDAY	Predict	Actual
Temperature			Temperature			Temperature			Temperature		
Precipitation			Precipitation			Precipitation			Precipitation		
Wind Direction			Wind Direction			Wind Direction			Wind Direction		
Humidity			Humidity			Humidity			Humidity		
Skies			Skies			Skies			Skies		
Prediction Points			Prediction Points			Prediction Points			Prediction Points		

THURSDAY	Predict	Actual	FRIDAY	Predict	Actual	SATURDAY	Predict	Actual
Temperature			Temperature			Temperature		
Precipitation			Precipitation			Precipitation		
Wind Direction			Wind Direction			Wind Direction		
Humidity			Humidity			Humidity		
Skies			Skies			Skies		
Prediction Points			Prediction Points			Prediction Points		

PREDICTION GUIDE

• Temperature: Indicate a range of 5 degrees (for example 55-60).
• Precipitation: drizzle, rain, thunderstorm, hail, snow, sleet. "Wind Direction: From the N, NE, E, SE, S, SW, W, NW.
•Humidity: Indicate a percentage, such as 70%.
• Skies: sunny, partly cloudy, high clouds, low overcast.

BEAUFORT SCALE

Numbe r	Description	M.p.h.	Km/p/h
0	Calm, smoke rises straight up	00	00
1	Light Air, smoke drifts gently	1-3	1-5
2	Light Breeze, leaves rustle	4-7	6-11
3	Gentle Breeze, flags flutter	8-12	12-19
4	Moderate Wind, twigs move	13-18	20-29
5	Fresh Wind, small trees sway	19-24	30-39
6	Strong Wind, large branches move	25-30	40-50
7	Near Gale, whole trees sway	32-38	51-61
8	Gale, difficult to walk in wind	39-46	62-74
9	Severe Wind, slates and branches break	47-54	75-87
10	Storm, houses damaged, trees blown	55-63	88-102
11	Severe Storm, buildings heavily damaged	64-74	103-109
12	Hurricanes, devastating damage	75+	102 +
13	Tornado, devastating damage	up to 300+	503 +

Midwest Wild Weather Pre- and Post-Test

Name ____________________ **Date** ______________

1. The shape of a tornado is called a(n):
A. cumulus. B. vortex. C. vertigo. D. inversion.

2. Cold air
A. rises. B. falls. C. holds more water than warm air.
D. causes rainbows.

3. Water vapor is a
A. gas. B. solid C. liquid. D. A, B, & C.

4. Downbursts are
A. colorful. B. associated with blizzards. C. common. D. dangerous.

5. Tornadoes occur
A. only in the Midwest. B. mostly in the fall.
C. all over the world. D. never in the mountains.

6. Lightning is a discharge of
A. static electricity. B. AC (alternating current).
C. DC (direct current). D. excess heat.

7. A tornado warning means
A. a tornado has been sighted. B. a tornado could form.
C. there will not be a tornado. D. go outside.

8. The water of the oceans
A. heats faster than the land. B. cools faster than the land.
C. cools and heats more slowly than the land.
D. heats and cools at the same rate as the land.

9. The change of water from liquid to gas to liquid in the atmosphere is
A. the heat cycle. B. the water cycle. C. sublimation. D. dew point.

10. Doppler radar tells
A. the speed rain is moving. B. the direction rain is moving.
C. the temperature of rising air. D. A & B.

11. As the speed of air increases, the pressure it exerts
A. also increases. B. does not change.
C. decreases. D. at first increases, then decreases.

12. Compared to measurements in degrees Celsius, temperature above zero measured in degrees Fahrenheit
A. has a higher numerical value. B. has lower numerical value.
C. is the same. D. is not related.

13. Weather results from a complex interaction of
A. air and water. B. air, water, and sun.
C. air, water, earth, and sun. D. sun and water.

14. The change of water from a gas to a liquid happens as
A. the water vapor cools. B. the water vapor warms.
C. the water vapor expands D. the water vapor falls.

15. Define "weather."

____

____

____

Pre- and Post-Test Answers

1. The shape of a tornado is called a(n):
A. cumulus. B. vortex. C. vertigo. D. inversion.

2. Cold air
A. rises. B. falls. C. holds more water than warm air.
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A. air and water B. air, water, and sun
C. air, water, earth, and sun. D. Sun and water.

14. The change of water from a gas to a liquid happens as

A. the water vapor cools. B. the water vapor warms.
C. the water vapor expands. D. the water vapor falls.

15. Define "weather."

The condition of the atmosphere at any given time for a specific location.

Alternative Assessment Section

This section addresses alternative means of student assessment. For the instructor a checklist has been prepared; it can be used for five students. Topics include: Weather Report, Weather Control, Cloud Types and Weather Patterns, The Speed of Sound and Light, Weather Data. Several options for Alternative Assessment in Language Arts, Mathematics, Art, and Science are presented.

Rubric Scoring For Midwest Wild Weather Activities

Outstanding	**Midrange**	**Needs Work**	**No Response**
3	**2**	**1**	**0**
All basic elements present	Some elements missing	Attempt	No response
Relationships correct	Some error in relationships	Significant error in relationships	No response
Demonstrates understanding	Demonstrates incomplete	No understanding	No response

NAME OF STUDENT		a.	b.	c.	d.	e.
During the Discovery Session:						
Reads instructions						
Follows instructions						
Completes activity						
Participates positively in discussions						
With the exhibits						
In the classroom						
Fills out own Guided Discovery sheet						
During the Explainer Session:						
Attentive to speaker						
Raises hand for Q & A						
In the Classroom:						
Participates positively in class						
Fills out teacher-made classroom						
Supplemental activities:						
Reads directions	1st try					
Follows directions						
Takes a positive role in the experiment						
Remains on task						
Completes follow-up						
Reads directions	2nd try					
Follows directions						
Takes a positive role in the experiment						
Remains on task						
Completes follow-up						
Reads directions	3rd					
Follows directions						
Takes a positive role in the experiment						
Remains on task						
Completes follow-up						

Alternative Assessment

This checklist of student behaviors may be used with the Midwest Wild Weather visit. It includes observations to be made as the students interact with the exhibited, discuss them in the classroom, observe the explainer session, and while doing supplemental activities. Because the supplemental activity list has accommodations for three attempts, it may be done with multiple activities or with the same activity repeated thrice. This may be adapted for quality review and improvement planning.

Cross Curriculum Assessment: Science and Language Arts
Weather Report

To the Students;
Given the following information, plan a weather report that you could give to the class. Be as complete as possible, including a prediction for the next day's weather. Use the resources of your school library. Write out your plan. Make a clean and corrected copy and turn it in. Be complete. Practice your report, making changes if needed. Use visual materials to make your information more understandable to your classmates.

To the Teacher:
This assessment is presumed to follow a unit on weather. This activity might best be done in groups of two-three students, and will require several days of time to prepare. Make copies of the weather materials provided, including the blank maps. Optionally, videotape your students' reports for self-scoring.

As a variation, ask the students to collect their own weather data using instruments they have built or from the MWW Weather Station exhibit. This may be done over a period of time with the students making predictions each day for the next. The disadvantage to this method is that some of the students will probably use the weather predictions provided by the media.

If you do this, provide the weather maps with fronts marked from the paper for the days on which the data is gathered. Also, give the students a required length for their plan, based upon the grade level and abilities of the group.

Scoring the presentation:

- Science

Outstanding (3)
A report that includes at least four of the elements, such as high and low temperatures, wind speed and direction, relative humidity, and dew point. A prediction which is consistent with meteorological principles.

Mid Range (2)
The report includes two or three elements.
A prediction which is consistent with meteorological principles.

Needs Work (1)
Includes less than two elements.
or
The prediction is not consistent with meteorological principles.

No Response (0)
No attempt.

Cross Curriculum Assessment: Science and Language Arts
Weather Report

• Language Arts

Written Plan

Outstanding (3)

The written plan
should be of a specified length at the expected level of the student, and will have more detail than minimum requirements.

Grammar and punctuation, language use, and organization are above grade-level (i.e. no more than four mistakes in grammar, punctuation, and usage).

Mid Range (2)

The written plan is at the required length and expected level of the students and will have the level of detail expected.

Grammar, punctuation, sentence usage, and vocabulary are at the expected grade level (i.e. from four to six mistakes in grammar, punctuation, and usage).

Needs Work (1)

The written plan is not of the required length and expected detail for the achievement level of the student.

Grammar, punctuation, etc. are below the expected grade level (i.e. more than six mistakes in grammar, punctuation, and usage).

No Response (0)

Visual Presentation

Outstanding (3)
Includes at least four examples of predictive information.
Is clearly (neatly) presented.
Uses weather symbols.

Mid Range (2)
Includes two-three examples of predictive information.
Is clearly (neatly) presented.
Doesn't use weather symbols.

Needs Work (1)
Includes less than two examples.
Is not neatly presented.

No Response (0)

Oral Presentation

Outstanding (3)
Good eye contact.
Minimum use of notes.
Adds a human interest factor or interesting facts.
Has four or more elements.

Mid Range (2)
Uses notes almost 1/ 2 the time. No interesting facts.
Has three elements.

Needs Work (1)
Uses notes more than 1 / 2 the time.
No interesting facts.

No Response (0)

Cross Curriculum Assessment: Science and Language Arts

Weather Control

To the Students:

In the future, technology may exist to control the weather. Discuss the advantages and disadvantages. Evaluate what you think are the good and bad effects. Write and present an argument supporting what you think should be done.

To the Teacher:

Remind students that this is a hypothetical future. Discuss in class such topics as, "Who decides what weather happens around the planet? How would changing the weather in one place affect the weather in another place? How does an area's political influence affect the distribution of desirable weather? Would changing the weather affect the planet-wide climate?"

Present the students with this scenario: The people of Farnorthlandia want a longer growing season. Without it, they feel they are too dependent on imports. This warming would melt ice caps and raise the ocean level. The people of Islandia would lose a part of their islands to flooding produced by raising average world temperatures. However, the area near the world's largest desert would have increased rainfall and would be able to grow crops. This could prevent famine most years.

Scoring the Written Work:

Outstanding (3)

Student demonstrates a knowledge of planet-wide weather interaction.
Student presents points pro and con for weather control (two points for younger children and three points for the Junior High student).
Student makes a viable assessment for his/her decision based on arguments.
Student clearly states a decision.

Mid Range (2)

Student demonstrates some knowledge of planet-wide weather interaction.
Student presents points (One for younger, two for older) pro and con for weather control.
Student makes a viable assessment, but not necessarily based upon his/her arguments.
Students states decision, not necessarily clearly.

Needs Work (1)

Student demonstrates little or no knowledge of planetary interdependency of weather.
Student presents only pros or cons, not both, for weather control.
Student makes a non-viable assessment or none at all.

No Response (0)

Cross Curriculum Assessment Science and Fine Arts
Cloud Types and Weather Patterns

Materials -- Cloud chart, data table, art supplies (as appropriate).

Vocabulary

Cirrus	A high, wispy, cloud, usually made of ice crystals.
Cumulus	A cottony, fluffy looking cloud type.
Nimbostratus	A layer-like cloud form that produces rain.
Precipitation	Rain, snow, hail, or other moisture falling from the sky.
Stratus	A heavy appearing, layered looking cloud.
Weather conditions	The precipitation, temperature, and other factors present at a given time.

<u>To the Students:</u>

For the next two weeks, record the clouds in the sky and the type of precipitation.
Be sure to identify the clouds. Use the cloud chart if needed.
Keep your observations in a usable form.

<u>To the Teacher:</u>

1. For at least two weeks, have the class record daily cloud and precipitation type.
2. Using data collected, instruct the students to draw a picture showing clouds and the resulting weather conditions.
3. Ask them to identify their cloud type.

Basic elements: Drawing of correct cloud type. Drawing of appropriate resulting weather.

Relationships: Observed cloud/precipitation to interpretive/drawing of cloud/precipitation.

Understanding: Some clouds produce precipitation.

Scoring the Demonstration:

Outstanding(3)
- Recognizable cloud type in the drawing.
- Correct resulting weather.

Mid Range (2)
- Correct drawing of cloud.
- Resulting weather is not correct.

Needs Work (1)
- Incorrect drawing of the cloud.
- Incorrect resulting weather.

No Response (0)

Fine Arts:

Outstanding	**(3)**
Mid Range	**(2)**
Needs Work	**(1)**
No Response	**(0)**

Assessment may be done on the drawing produced for artistic merit, as well as for cloud/precipitation accuracy. Since artistic merit varies greatly with age level, the key is left to the discretion of the individual teacher.

Cross Curriculum Assessment: Science and Language Arts
The Speed of Sound and Light

To the Students:
Design a demonstration to present to other students at the school that demonstrates the physics principle that light and sound travel at different speeds. Plan to use only9 equipment that is safe and reasonably available. Write out a plan that tells what you would do and how you would do it. Practice your demonstration to see if it works. Revise your plan if it does not. Be prepared to give your demonstration to your class or to another class.

To the Teacher:
The teacher may wish to require a preview of the plan to demonstrate the concept in order to check for safety.

Scoring the demonstration:

Outstanding (3)

Used same source for visual and audio elements.
Used different sign for the audience to indicate reception of the visual and the audio elements.
Has tried the demonstration and made appropriate corrections to the procedure.

Mid Range (2)

Used different sources for the audio and visual elements.
Used only one means for the audience to indicate reception of the audio and visual elements.
Tested, but did not make needed revisions in demonstration.

Needs Work (1)

Used different sources for visual and audio elements.
Used no means for evaluating audience reception of the elements.
Not tested.

No Response (0)

Language Arts

Scoring the written plan:

Outstanding (3)

The written plan should be of a specified length to the expected level of the students, and will have more detail than minimum requirements.
Grammar and punctuation, language use, and organization are above grade-level (i.e. no more than four mistakes in grammar, punctuation, and usage).

Mid Range (2)

The written plan is at the required length and expected level of the students and will have the level of detail expected.
Grammar, punctuation, sentence usage, and vocabulary are at the expected grade level (i.e. from four to six mistakes in grammar, punctuation, and usage).

Needs Work (1)

The written plan is not of the required length and expected detail for the achievement level of the student.
Grammar, punctuation, etc. are below the expected grade level (i.e. more than six mistakes in grammar, punctuation, and usage).

No Response (0)

Cross Curriculum Assessment: Science and Mathematics

Weather Data

To the Students:

Using data gathered from the weather instruments from the Weather Station exhibit, develop one or more graphs, charts, tables, or other means of display to clearly show the information.

Or, collect the data from your local newspaper, or the television weather reports, or a weather station, and develop one or more graphs, charts, tables or other means of display for at least two weeks, such as temperature, wind direction, relative humidity, and/ or other factors.

To the Teacher:

To facilitate this activity, the teacher may collect the weather information beforehand.

Scoring the demonstration:

Outstanding (3)

Student produced more than two means of displaying the data.
Student incorporated at least five types of data in the display.
Student's graph or chart was accurately and neatly done. Student's displays were understandable.

Mid Range (2)

Student produced two means of displaying the data.
Student showed three or four factors in the display.
Student's work was neatly done but included some inaccuracies.
Student's displays needed some clarification to be understood.

Needs Work (1)

Student produced only one means of displaying the data.
Student showed two factors in the display.
Student's work was inaccurate and not neatly done.
Student's displays needed some clarification to be understood.

No Response (0)

OKLAHOMA SCIENCE GOALS

State academic standards outline goals/proficiencies/ strands for learning and clarify the knowledge and skills necessary to meet each. The standards will allow teachers to measure more accurately student achievement at designated grade levels.

The following pages show details of state science standards for the learning areas of science. Each activity in this manual identifies which standards it meets. Many activities address more than one goal, proficiency, strand, standard, or benchmark. In presenting the activity in the classroom, the instructor will address important assessment goals for the student and school.

State Goals used:
Oklahoma Priority Academic Student Skills—March 2011

Science Process and Inquiry Standards-----All Grade Levels

Process Standard 1: Observe and Measure
Process Standard 2: Classify
Process Standard 3: Experiment
Process Standard 4: Interpret and Communicate
Process Standard 5: Inquiry

Content Standards

Grade 4

Standard 1: Position and Motion of Objects – The position of a moving object can be described relative to a stationary object or the background. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:
1. The position and motion of objects can be changed by pushing or pulling. The size of the change is related to the strength of the push or pull.
2. The motion of an object can be described by tracing and measuring its position over time.

Standard 2: Energy – Energy is the ability to do work or to cause a change in matter. Forms of energy include electricity, heat (thermal), light and sound. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:
1. Electricity is the flow of electrical power or charge.
a. The flow of electricity is controlled by open and closed circuits.
b. Some materials are conductors of electricity while others are insulators.
2. Heat results when substances burn, when certain kinds of materials rub against each other, and when electricity flows through wires.
a. Metals are good conductors of heat and electricity.
b. Increasing the temperature of any substance requires the addition of heat energy.
3. Light is a form of energy made of electromagnetic waves.
a. Light waves travel in a straight line.
b. Substances may cause light waves to change direction of travel (e.g., reflection, refraction).

Standard 4: Properties of Earth and Moon - The Earth and its Moon have specific properties. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:
1. Earth materials consist of rock, soils, water, and air.
2. The processes of erosion, weathering, and sedimentation affect Earth materials (e.g., earthquakes, floods, landslides, volcanic eruptions).
3. Fossils provide evidence about the plants and animals that lives long ago and the nature of the environment at that time (e.g., the formation of fossils).

Grade 5

Standard 1: Properties of Matter and Energy – Describe characteristics of objects based on physical qualities such as size, shape, color, mass, temperature, and texture. Energy can produce changes in properties of objects such as changes in temperature. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Matter has physical properties that can be used for identification (e.g., color, texture, shape).
2. Physical properties of objects can be observed, described, and measured using tools such as simple microscopes, gram spring scales, metric rulers, metric balances, and Celsius thermometers.
3. Energy can be transferred in many ways (e.g., energy from the Sun to air, water, and metal).
4. Energy can be classified as either potential or kinetic.

Standard 3: Structure of Earth and the Solar System – Interaction between air, water, rock/soil, and all living things. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soils are often found in layers.
2. Weather exhibits daily and seasonal patterns (i.e., air temperature, basic cloud types – cumulus, cirrus, stratus, and nimbus, wind direction, wind speed, humidity, precipitation).
   a. Weather measurement tools include thermometer, barometer, anemometer, and rain gauge.
   b. Weather maps are used to display current weather and weather predictions.
3. Earth is the third planet from the Sun in a system that includes the moon, the Sun, and seven other planets.
   a. Most objects in the solar system are in regular and predictable motion (e.g., phases of the moon).

Grade 6

Standard 1: Physical Properties in Matter - Physical characteristics of objects can be described using shape, size, and mass whereas the materials from which objects are made can be described using color and texture. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, and texture). Changes in physical properties of objects can be observed, described, and measured using tools such as simple microscopes, gram spring scales, metric rulers, metric balances, and Celsius thermometers.
2. The mass of an object is not altered due to changes in shape.

Standard 2: Transfer of Energy - Change from one form of energy to another. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Energy exists in many forms such as heat, light, electricity, mechanical motion, and sound. Energy can be transferred in various ways (e.g., potential to kinetic, electrical to light, chemical to electrical, mechanical to electrical).
2. Electrical circuits provide a means of transferring electrical energy when heat, light, and sound are produced (e.g., open and closed circuits, parallel and series circuits).

Standard 5: Structures of the Earth and the Solar System - The earth is mostly rock, three-fourths of its surface is covered by a relatively thin layer of water, and the entire planet is surrounded by a relatively thin blanket of air, and is able to support life. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Earth has four main systems that interact: the geosphere, the hydrosphere, the atmosphere, and the biosphere.

a. The geosphere is the portion of the Earth system that includes the Earth's interior, rocks and minerals, landforms, and the processes that shape the Earth's surface.

b. The hydrosphere is the liquid water component of the Earth. Water covers the majority of the Earth's surface and circulates through the crust, oceans and atmosphere in what is known as the water cycle.

c. The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor. The atmosphere has a different physical and chemical composition at different elevations.

d. The biosphere is made up of all that is living on the Earth. It is a life-supporting global ecosystem, where living things depend on other organisms and the environment.

2. The sun provides the light and heat necessary to maintain life on Earth and is the ultimate source of energy (i.e., producers receive their energy from the sun).

Grade 7

Standard 1: Properties and Physical changes in Matter – Physical characteristics of objects can be described using shape, size, and mass whereas the materials from which objects are made can be described using color and texture. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, texture, and density). Physical changes of a substance do not alter the chemical nature of a substance (e.g., phase changes of water, sanding wood).
2. Mixtures can be classified as homogeneous or heterogeneous and can be separated by physical means

Standard 5: Structures of the Earth Structures of the Earth System - The Earth is mostly rock, three-fourths of its surface is covered by a relatively thin layer of water, and the entire planet is surrounded by a relatively thin blanket of air, and is able to support life. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Global patterns of atmospheric movement influence local weather such as oceans' effect on climate (e.g., sea breezes, land breezes, ocean currents). Clouds, formed by the condensation of water vapor, affect local weather and climate.

Standard 6: Earth and the Solar System - The earth is the third planet from the sun in a system that includes the moon, the sun, seven other planets and their moons, and smaller objects (e.g., asteroids, comets, dwarf planets. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Most objects in the solar system are in regular and predictable motion. Those motions explain such phenomena as the day, the year, phases of the moon, and eclipses.
2. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day. The relationship of motion of the Sun, Earth, and Earth's Moon is a result of the force of gravity.

Grade 8

Standard 1: Properties and Chemical Changes in Matter - Physical characteristics of objects can be described using shape, size, and mass. The materials from which objects are made can be described using color, texture, and hardness. These properties can be used to distinguish and separate one substance from another. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Substances react chemically with other substances to form new substances with different characteristics (e.g., oxidation, combustion, acid/base reactions).
2. Matter has physical properties that can be measured (i.e., mass, volume, temperature, color, texture, density, and hardness) and chemical properties. In chemical reactions and physical changes, matter is conserved (e.g., compare and contrast physical and chemical changes).

Standard 2: Motions and Forces - The motion of an object can be described by its position, direction of motion, and speed as prescribed by Newton's Laws of Motion. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. The motion of an object can be measured. The position of an object, its speed, and direction can be represented on a graph.
2. An object that is not being subjected to a net force will continue to move at a constant velocity (i.e., inertia, balanced and unbalanced forces).

Standard 4: Structures and Forces of the Earth and Solar System - The earth is mostly rock, three-fourths of its surface is covered by a relatively thin layer of water, and the entire planet is surrounded by a relatively thin blanket of air, and is able to support life. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

3. Atmospheric and ocean circulation patterns affect weather on a global scale (e.g., El Ninõ, La Ninã, Gulf Stream).

Standard 5: Earth's History - The Earth's history involves periodic changes in the structures of the earth over time. The student will engage in investigations that integrate the process standards and lead to the discovery of the following objectives:

1. Earth's history has been punctuated by occasional catastrophic events (e.g., the impact of asteroids or comets, enormous volcanic eruptions, periods of continental glaciation, and the rise and fall of sea level).
2. Fossils provide important evidence of how life and environmental conditions have changed (e.g., Law of Superposition, index fossil, geologic time period, extinction).

Internet Information

Midwest Wild Weather's web site is www.midwestwildweather.org
Weather Information on the internet from the University of Illinois:
http://www.atmos.uiuc.edu Other selected sites include:

- beprepared.com (emergency education quiz)
- copsrus.com (world-wide weather)
- elibrary.com (database for all types of weather publications)
- ems.psu.edu (weather myths and misinformation)
- free-ed.net (free meteorological education materials)
- 4weather.com (weather information)
- infoplease.com (weather and climate information)
- lib.ox.ac.uk (weather data from the United Kingdom)
- mcnar.org (Multi-Communications Environmental Storm Observatory)
- met.fsu.edu (meteorological information, especially about tropical storms)
- ncdc.noaa.gov (National Climate Data Center. Bills itself as the world's largest archive of weather data.)
- net-cities.com (forecasts)
- psu.edu/weather (Penn. State Univ. weather information.)
- scd.ucar.edu (weather data)
- theweathercompany.com (forecasts)
- typhoon.atmos.colostate.edu (Colo. State Univ. weather information)
- weather.about.com (forecasts and weather basics)
- weather.com (education ideas and global conditions)
- wx.com (forecasts, maps, alerts)
- zoft.com (weather tests, games, etc.)

Searching under the topic "education: meteorology" will yield more sites than teachers/students can visit in a year. Two examples:

dir.yahoo.com/Science/Earth_Sciences/Meteorology/Education/K-12
www.go2net.com/directory/Science/Earth_Sciences/Meteorology/Education

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