CHALLENGER CENTER'S
JOURNEY through the UNIVERSE

Earth Systems Science

This lesson is taken from an education module developed for Challenger Center's *Journey through the Universe* program. *Journey through the Universe* takes entire communities to the space frontier.

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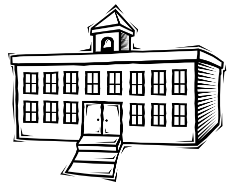
January 2002

Grade Level
5-8



Lesson 3: Weather: It Works, or Not?

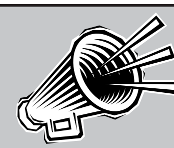
Lesson Summary:

Meteorologists study the atmosphere by recording and analyzing data in order to learn more about weather patterns and behavior. Students can become amateur meteorologists by building their own weather station and keeping a record of measurements. They will notice that many factors influence local weather, including global atmospheric changes, and the interactions among Earth's systems. Students will eventually notice the weather patterns that allow meteorologists to forecast the weather.

Lesson Duration:

Two 45-minute class periods

ESSENTIAL QUESTION
What tools do scientists use to track the weather, and how do they work?



OBJECTIVES
Students will be able to:

- Build a set of weather measurement tools.
- Compare student-made tools to commercial tools.
- Keep a daily weather journal.

STANDARDS

NRC Standards
STANDARD D1:

- Global patterns of atmospheric movement influence local weather. Oceans have a major effect on climate, because water in the oceans hold a large amount of heat.

Science Overview

The Earth's Atmosphere
Looking at the Earth from space, the atmosphere is a thin layer compared to the size of the planet. However, compared to the size of humans, it has an enormous depth reaching over 560 km from the ground up. Although the atmosphere extends that far, almost 99% of the Earth's air molecules are within 30 km of the Earth's surface. If we could shrink the Earth to the size of a volleyball, the breathable part of the atmosphere would be the thickness of a piece of cardstock cardboard.

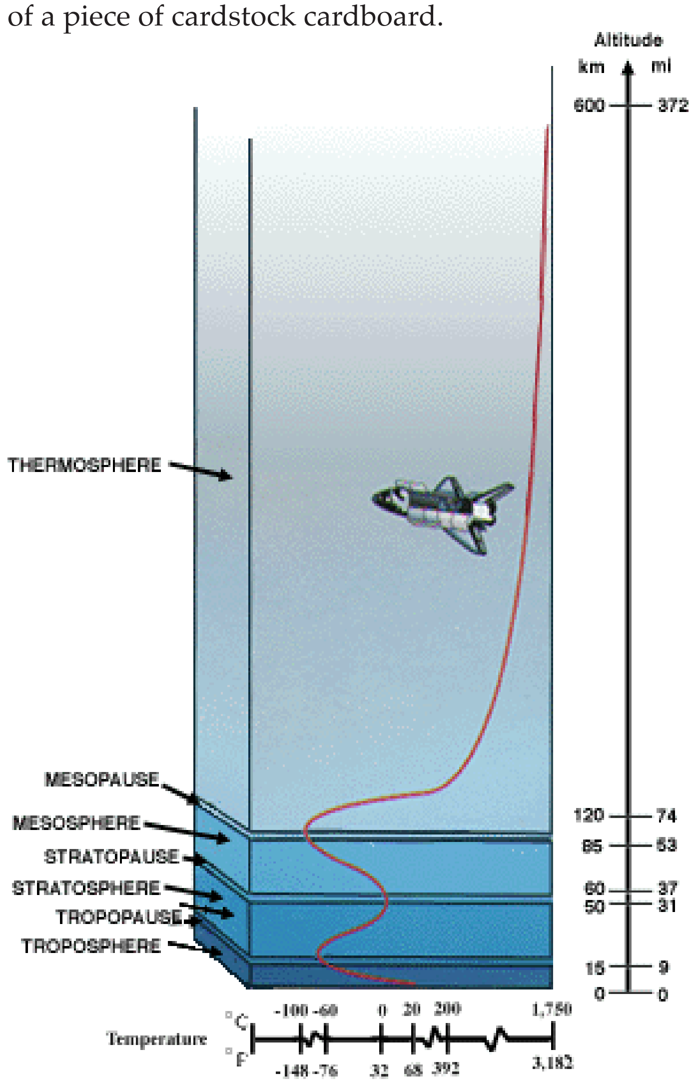


Figure 1: Layers of the Earth's Atmosphere
Source: http://liftoff.msfc.nasa.gov/academy/space/atmosphere.html

Composition of the Atmosphere

The atmosphere is composed essentially of nitrogen (N_2, 78.08%), oxygen (O_2, 20.95%), argon (Ar, 0.93%) and other trace gases such as neon (Ne, 0.0018%), helium (He, 0.0005%), hydrogen (H_2, 0.00006%), and xenon (Xe, 0.000009%). The variable gases and particles in the atmosphere are water vapor (H_2O, 0-4%), carbon dioxide (CO_2, 0.035%), methane (CH_4, 0.0002%), nitrous oxide (N_2O, 0.00003%), ozone (O_3, 0.000004 %), dust or soot particles, etc. (0.000001%), and chlorofluorocarbons (CFCs) (0.00000001%).

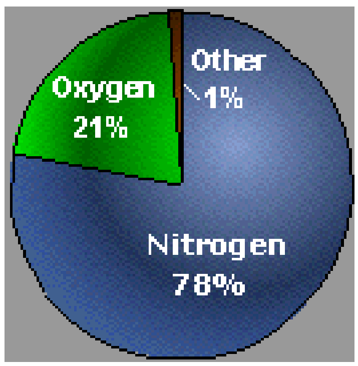


Figure 2: Composition of Earth's Atmosphere
Source: http://kids.msfc.nasa.gov/News/2000/News-StationAir.asp

Energy Transfer in the Atmosphere

The source of almost all the energy that reaches the Earth's surface is the Sun. A vanishingly small share comes from the continued slow cooling of residual heat from the Earth's formation and from the decay of radioactive elements in the Earth's interior; on other planets (e.g., Jupiter) this internal heat source may be quite important. A small part of the solar energy is directly absorbed by ozone and by water vapor. Some of the energy is reflected back to space by clouds and by the surface of the Earth. The rest is absorbed by the solid and liquid surface.

Energy is transferred between the Earth's surface and the atmosphere through conduction, convection, and radiation. Conduction is the process of heat transmission through contact with neighboring molecules. Air and water are relatively poor conductors while metals are good heat conductors. Convection is a transfer of heat by mass motion of fluids, like air and water. Atmospheric and oceanic convection includes the rising and sinking of air and water masses, respectively. Radiation is heat energy transfered by the emission of light to carry away energy, including infrared light from objects too cool to glow with the visible light that human eyes see. It is possible to transfer heat energy through a vacuum via radiation. Solar energy reaches the Earth as radiation via electromagnetic waves or photons — that is, by light — traveling through space.

The Earth constantly plays a balancing act between the energy it absorbs from the Sun, the infrared radiation it emits into space, and the energy it sheds by transforming energy absorbed from the Sun into climate and weather systems. The surface of the Earth does not absorb light evenly — some parts are more reflective than others, some parts are more absorptive than others, some parts rise in temperature only a little from absorbing a lot of energy, some parts rise in temperature enormously from absorbing only a little energy. The surface material transfers its absorbed energy to the nearby air by direct conduction and radiation. The warmed air becomes buoyant and rises through the atmosphere, leaving a void filled by nearby air that comes into contact with the surface. Local and global air circulation patterns result, convectively transferring energy between different regions of the Earth's atmosphere and the Earth's surface. What follows from all this air circulation, and other physical processes that go with it and contribute to making it immensely complicated, is weather.

Weather and Climate

Day-to-day measurements of surface air temperature, rainfall, wind velocity, humidity of the air, atmospheric pressure, and cloudiness make up a description of the weather in a given place. Daily weather observations have a high degree of variability. The climate of an area basically describes the average weather over a period of time and its extremes. Climate also includes global-scale weather patterns that vary slowly (much longer than a day).

Dependence on the Earth Systems

Interactions among the Earth's other systems play a major role in determining how the Earth operates. The atmosphere and, therefore, local and global weather patterns are influenced by the biosphere, hydrosphere, and geosphere.

Biosphere

The biosphere includes all living things on Earth, from microscopic amoeba to human beings. Most of these creatures perform a gas exchange with the atmosphere in one form or another. For example, animals extract oxygen and release carbon dioxide, while plants do the opposite. Although the amount of air a single living organism breathes may seem small when compared to the entire atmosphere, when the number of creatures on the Earth and the length of time these creatures have inhabited the Earth are taken into account, the effects can be quite considerable. In fact, Earth's atmosphere four billion years ago was very different than today's. It was not until life began and released oxygen into the atmosphere that the composition of the atmosphere became conducive for animal habitation.

Although respiration is a natural process, there are some gases and other materials that are released into the air as a result of human technology. One widely known human pollutant is chlorofluorocarbons (CFCs), which are used in many household and industrial applications. CFCs released into the air break up the Ozone layer in the Earth's atmosphere, which protects the Earth from the Sun's harmful ultra-violet rays.

By changing the composition of the atmosphere, life changes the weather on both local and global levels. Another pollutant is aerosol gases, which are tiny particles that are suspended in the air. Most of these occur naturally as a by-product of volcanic eruptions, dust storms, or forest and grass fires, but about 10% of aerosols are created by humans when, for example, fossil fuels are burned. Massive release of aerosols in a localized area can significantly affect the local weather. Aerosols break up water droplets in clouds, making them too small for precipitation, and result in little to no rain. This effect has been observed in the wake of ship exhaust, as well as in heavily industrialized areas.

Burning fossil fuels also creates carbon dioxide. This is the same gas that humans exhale and plants absorb. However, human industry is creating carbon dioxide at a faster rate than it can be depleted by plants, which causes an increase in the Earth's greenhouse effect. Sunlight is absorbed by the Earth and re-released into space as infrared radiation. However, certain gases (called "greenhouse gases"), one of which is carbon dioxide, prevent the infrared radiation from escaping into space, and therefore trap the heat inside the atmosphere. This is called the greenhouse effect, and is essential to maintaining a moderate temperature on Earth. There is a balance within the system, and too much greenhouse gases in the atmosphere can result in a slight increase of the mean Earth temperature. Although it is generally accepted that human activity can and will influence the global temperature, it is debatable whether recent global warming can be attributed to anything other than natural causes.

Hydrosphere

The Earth's hydrosphere is the water that covers more than 70% of the Earth's surface. Like the biosphere, the hydrosphere influences the atmosphere on both local and global levels.

Clouds are made almost entirely of water droplets, which have evaporated from the surface of the Earth. When they accumulate and reach a certain size, they fall back to the surface in the form of rain or snow. The snowiest areas in the eastern United States are those downwind of the Great Lakes. Cold wind in the winter carries the evaporated water from the lakes to the shores or along mountain slopes, and creates precipitation. Tropical islands have a much higher annual rainfall than desert areas, simply due in part to their proximity to water.

The hydrosphere and atmosphere interaction is apparent on a much larger scale in a phenomenon called El Nino. In normal years, atmospheric pressure is greater in the eastern Pacific than in the western Pacific. Since wind flows from high to low pressure, the winds create waves, which carry warm surface water to the western Pacific. Every two to seven years, the pattern will reverse (for reasons which scientists do not fully understand). Weakened winds allow for the entire tropical Pacific to hold warm surface water. The warm water evaporates and causes rain, which moves eastward rather than westward during an El Nino year. This causes drought in Indonesia and Australia, as well as alters the flow of the Jet Stream, which plays a crucial role in global weather patterns, including North America.

Geosphere

All of Earth's rocks and minerals, as well as the means of shaping the Earth's surface and interior, are contained in the geosphere. The geosphere also interacts with the atmosphere locally, as well as globally.

Many gases and other materials are released by the Earth, originating either from the surface or from the interior of the Earth through the surface. Forest fires, for example, release ash and soot into the air from Earth's surface, which can cover a local area and affect the air quality. This ash may get carried by the wind and dropped far from the site of the fire, changing the pH level of the soil.

The interior of the Earth is very hot, and one way in which the Earth cools itself is through volcanic eruptions. These eruptions spew gas and ash into the atmosphere in large amounts, resulting in global effects. One of the gases released is carbon dioxide, which (as previously mentioned) is a greenhouse gas, and could serve to raise the mean temperature of the Earth. On the other hand, much of the ash and soot that is spewed into the atmosphere blocks more sunlight than usual from coming in through the atmosphere, creating a wide-spread cooling effect in the Earth's troposphere. An example of this is Mount Pinatubo in the Philippines, which erupted in 1991,and whose effects lasted for years. Heavy ash and contaminated rain fell in the area for months after the eruption, causing volcanic mud flows or debris flows (called *lahars*) over the entire area. The consequences from this volcano can still be seen today.

Measuring Weather Conditions

Atmospheric changes and conditions may be measured in various ways. A thermometer measures the temperature of an object or a place. Thermometer types include bulb, bimetallic strip, electrical resistance, or thermocouple. A bulb thermometer contains some kind of fluid, like mercury. It generally uses the principle of thermal expansion and contraction: mercury sealed in a thin glass bulb expands when heated and contracts when cooled, moving the surface of the mercury in the bulb to different calibrated positions. A bimetallic strip thermometer is made up of two different metals bonded together in spirals, where one metal is chosen such that it expands more than the other. The spiral unwinds as temperature increases and contracts as temperature decreases. Thermostats use this property to open or close electrical switches at selected temperature values, controlling the power going to heating or cooling systems. An electrical resistance thermometer has an electrical resistor as a sensor, which changes its resistance as temperature changes. An electronic circuit measures the resistance and converts the measured resistance value to units of temperature. Thermocouple devices use a type of bimetallic sensor that actually creates a small electrical voltage whose value depends on temperature. An electronic circuit measures the voltage and determines the temperature.

Air pressure is the force per unit area exerted by the air pressing on a surface. The air pressure is nearly the same in all directions (up, down, sideways), with small differences that drive air circulation patterns. Air pressure is measured with a device called a barometer. There are two types of barometers: mercury and aneroid. Mercury barometers use a column of mercury filling the bottom of an evacuated tube to measure barometric pressure, while aneroid barometers use a sealed bellows and a heavy spring, which expand and compress with changing air pressure.

Humidity is the amount of moisture in the atmosphere. It is measured with a device called an hygrometer. An hygrometer measures either absolute humidity, which is a measure of how much water the air is holding in the form of vapor, or relative humidity, which is a measure of how much water vapor is in the air relative to the maximum amount it can hold. Relative humidity generally can be measured more easily than absolute humidity and is of more interest relative to the factors influencing weather. Two common types of hygrometers used to measure relative humidity are the wet bulb hygrometer and the hair hygrometer. A wet bulb hygrometer evaporates water from a reservoir, cooling the body of a thermometer attached to that reservoir relative to the local air temperature. In air of lower relative humidity, the water evaporates more readily because the air, "thirsty" for water, is not holding nearly as much water vapor as it could, increasing the evaporative cooling rate and lowering the thermometer's reading. The evaporatively cooled temperature measured at a given air temperature yields a measure of the relative humidity. A similar measurement may be made in reverse, determining the decrease in temperature required to cause water to spontaneously condense from the air — that is, to form dew. This is a dew-point measurement. For humid air, the dew-point is only a little less than the air temperature, for dry air the dew-point is substantially lower. Hair hygrometers work on the premise that hair — actual human or animal hair — is sensitive to relative humidity. Hair curls and shrinks as the air becomes more humid. As the air becomes drier, hair straightens and elongates. Thus, a hygrometer can be constructed from hair and a measurement system.

Lesson Plan

Preparation & Management

- If students are supplying the bottles or other materials, allow a week or so to collect them.
- Copy a class set of the weather section from a recent edition of your local newspaper.
- Note that not all the instruments listed under *Student Materials* may be readily available or affordable. Unavailable instruments may be ignored.

Warm-up

- Distribute the newspaper weather section to the class. Ask students what the forecast for that day is. Ask them if they think weather forecasters are always correct. Why might they be wrong?

Pre-assessment

- Ask students to identify and describe the readings that are familiar to them, for example temperature. Ask them what readings are unfamiliar, for example barometric pressure.

TEACHER MATERIALS

Warm-up:

- Class set of weather section from local paper

Activity 2

- Professional Thermometer
- Professional Barometer
- Profession Hygrometer
- Access to local forecast (e.g. newspaper or internet)

STUDENT MATERIALS

Activity 1:

- Research Materials

Hygrometer (per group)

- Hygrometer Worksheet
- Shiny metal can (label and lid removed)
- Bulb thermometer with fine scale, must be calibrated to measure temperatures near freezing
- Crushed ice and water
- One tablespoon of salt
- Lukewarm water (above room temperature)

Thermometer (per group)

- Thermometer Worksheet
- Ice
- Water
- One-liter plastic soda bottle
- Clear plastic drinking straw (or straight glass tubing)
- Modeling clay (or rubber stopper if glass tubing is used)
- Food coloring
- Metric ruler
- Markers

ACTIVITY 1: Build Your Own Tools

Teaching Tips

- *This activity may be done as a demonstration first to show students how to build their tools, but it is more effective if students, or groups of students, build the tools on their own.*

Preparation & Management

- Divide the class into six groups, two groups for each tool.

Procedures

1. Tell students that their are many characteristics of the atmosphere that help us predict the weather. Ask students if they know any. *(Answer: temperature, pressure, and humidity all affect the weather but most students will say temperature)* Ask students how we measure air temperature. *(Answer: we use a thermometer)* Ask students if temperature is the only factor that determines the weather. Lead students to the idea that it can be hot and "dry" or hot and "muggy." Ask students what these terms refer to. *(Answer: these refer to the humidity in the air)* Tell students that a third factor affecting the weather is air pressure.

2. Ask the class if they know what tools meteorologists use to measure the air pressure and humidity. *(Answer: barometer and hygrometer)* Explain that the class will be constructing their own measurement tools to determine the temperature, pressure, and (relative) humidity of the air.

3. Have students follow the directions on the Tool Task Cards to construct their tool.

4. Students should research their instrument and determine how it is used to predict the weather.

STUDENT MATERIALS cont.

Activity 1:

Barometer (per group)

- Barometer Worksheet
- Heavy lump of modeling clay
- Two rulers
- Water
- Large bowl
- Narrow, clear plastic bottle with screw cap
- Pen and paper
- String
- Tape

Activity 2:

- Weather Journal Worksheet
- Instruments constructed in first activity
- Bulb thermometer
- Barometer
- Commercial hygrometer, to measure relative humidity
- Local newspaper or Internet access, to check official weather conditions and forecasts

ACTIVITY 1: Build Your Own Tools

Teaching Tips

Possible Problems with the Thermometer:

- *The modeling clay seal may have cracks in it, allowing water to escape.*
- *Students may forget to mark the beginning level in the straw.*
- *If the 1-liter bottle is not filled to the top, the clay plug will have to be pushed farther into the bottle for the water to move up the straw. There may not be enough clay to force the water to move up the straw at all.*

Reflection & Discussion

Complete the Transfer of Knowledge section before the Reflection and Discussion

Conduct a classroom discussion on dew point, temperature, and air pressure. Ask students what the dew point tells us. *(Answer: it tells us how much moisture is in the air and at what temperature it will condense on objects*) Ask students what the barometric pressure indicates. Would you like to have a pool party on a high pressure day or a low pressure day? *(Answer: high pressure usually indicates good weather. When their is a lot of pressure in the atmosphere it is difficult for clouds to form)* How are dew point, temperature, and air pressure related?

Transfer of Knowledge

Ask each group to present their instrument to the class. Each member of the group should be able to describe how the instrument was made, how it works, and how to read it.

At the end of the presentations, all students should be able to answer the following questions:

- If the level of water rises inside the plastic bottle, what is the barometer indicating about the air pressure? *(Answer: it is going up)* Does that indicate good or bad weather? *(Answer: good weather)*

- How does the thermometer indicate that the temperature has gone down? *(Answer: the level of water inside the straw drops)*

- How do you use the hygrometer to determine the dew point. *(Answer: add warm water to the metal can, then add a slushy of ice and salt, mix these ingredients together using a thermometer, as soon as a drop of water appears on the outside of the can, read the thermometer, this is the dew point)*

ACTIVITY 1: Build Your Own Tools

ASSESSMENT

4 Points

- Demonstrates a thorough understanding of the material.
- Consistently and actively works toward team goals.
- Willingly accepts and fulfills their individual role within the group.
- Consistently and actively contributes knowledge, opinions, and skills.
- Values the knowledge, opinion, and skills of all group members and encourages their contribution.
- Helps group identify necessary changes and encourages group to improve their weather instrument.

3 Points

- Demonstrates a good understanding of the material.
- Works toward team goals.
- Accepts and fulfills their individual role within the group.
- Contributes knowledge, opinions, and skills without prompting.
- Willingly participates in needed changes to improve their weather instrument.

2 Points

- Demonstrates a satisfactory understanding of the material.
- Works toward team goals.
- Contributes to the group with occasional prompting.
- Participates in needed changes to improve their weather instrument with occasional prompting.

1 Point

- Team work needs improvement.
- Works toward group goals only when prompted.
- Contributes to the group only when prompted.
- Participates in needed changes to improve their weather instrument when prompted and encouraged.

0 Points

- Does not participate in group work.

Placing the Activity Within the Lesson

Discuss with students the importance of accuracy in the tools scientists use to gather data. Ask students to come up with a way to test the accuracy of their weather instruments. Ask students if there are other tools that meteorologists may use to create a forecast, and why. Ask what other things scientists may want to test that could influence the weather.

ACTIVITY 2: Weather Journal

ACTIVITY 2: Weather Journal

TEACHING TIPS

- *This should be a long-term project (five or more days) so that students will have time to observe patterns.*

Preparation & Management

- Prior to beginning the weather journals, students need to complete the Build Your Own Tools activity.
- Collect professional weather tools.

Procedures

1. Introduce the activity by asking students to describe the current weather in your area. Write all comments on the board.
2. Ask students why someone would want to know the weather ahead of time.
3. Inform students that they will use the class instruments to measure weather conditions and compare their results/observations with professional instruments and with official weather condition announcements. Ideally, the class should measure the weather for at least five consecutive days.
4. Students will measure the following data, at the same time each day, and record it on their Weather Log:
   - Temperature — measured by thermometer
   - Air Pressure — measured with barometer
   - Dew Point — measured with dew-point hygrometer
   - Type of Precipitation and General Conditions: Is there any rain or snow? This is measured by observation.
5. Students then can use local newspapers or visit the weather.com web site to get the current weather conditions.

ACTIVITY 2: Weather Journal

Reflection & Discussion
At the end of the week, review the data that the students have gathered. Ask students if their instruments provided the same or similar results to the professional instruments. Discuss how the combination of temperature, relative humidity, and air pressure affect the weather.

Transfer of Knowledge
See the Analysis section of the Weather Log.
Answers will vary according to your local weather.

Create a simple graph for each set of data collected (temperature, pressure, and dew point).

How did the results from your instruments compare to the professional insturments?

Were there any patterns during the week? Explain.

Does humidity affect pressure? Explain.

Does pressure affect clouds? Explain.

Based on the weather from the week, make some predictions about weather for the following week in your hometown.

ACTIVITY 2: Weather Journal

ASSESSMENT

4 Points
- Work is dated, sequenced, and complete.
- Work is well organized so that the reader can understand it.
- Weather observations are clearly stated.
- Student demonstrates a solid understanding through well-developed and creative responses with meaningful conclusions.

3 Points
- Work is dated, sequenced, and complete.
- Work is organized so that the reader can understand it.
- Some weather observations are stated.
- Student demonstrates a solid understanding through well-developed and creative responses with meaningful conclusions.

2 Points
- Some attempt at organization, but weather observations are incomplete.
- Reader can understand the work.
- Communication of some correct ideas.

1 Point
- Weather observations are incomplete or unreadable.
- Little or no understanding is demonstrated.

0 Points
- No work is turned in or weather observations are completely unrelated.

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Placing the Activity Within the Lesson

Have each group of students review the data they have gathered over the past week and create a report to explain the success or failure of the weather instrument they created. The reports should include actual data points to reinforce the students' evaluation of their tools.

Lesson Closure

Discuss possible explanations for discrepancies among the data and why it may be difficult for meteorologists to predict the weather. For example, did they take into account any global trends, or the interactions with other Earth systems? Global phenomena can influence local weather and modify the outcome, making predictions complicated.

Supplemental Resources

Maimi Museum Weather Tools
http://www.miamisci.org/hurricane/weathertools.html

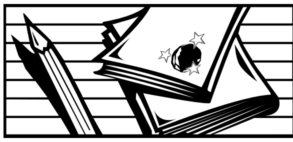
Weather Channell Online
www.weather.com

Weather for Kids
http://www.srh.noaa.gov/tulsa/weather_kids.html

Weather Tools
http://www.weathertools.com/

Weather Wiz Kids
http://www.weatherwizkids.com/

Web Weather for Kids
http://www.ucar.edu/40th/webweather/



BUILD YOUR OWN TOOLS - HYGROMETER

Name ______________________________________ Date__________

Building a Hygrometer

Background Information:
A hygrometer is an instrument that is use to measure dew point.

Materials:
- Shiny metal can (label and lid removed)
- Bulb thermometer
- Crushed ice
- Tablespon of salt
- Warm water (above room temperature)

Directions:
1. Using the thermometer, measure the air temperature.

2. Select a shiny metal can, make sure that the outside of the can is clean and dry. It must be kept that way for the measurement tool to work.

3. Pour warm water into the can, keeping the can's exterior clean and dry. Measure the temperature of the water, make sure that it is warmer than the air temperature.

4. Add a slush mixture of crushed ice and salt to the water in the can and slowly stir the mixture with the thermometer, keeping the thermometer's bulb in contact with the can's interior surface.

5. Record the temperature at the precise moment that small water drops first appear on the can's exterior. This is the dew point temperature. When the drop of water appears on the can, the atmosphere can hold no more water. It is saturated. The closer the dew point temperature is to the actual air temperature, to higher the humidity. The farther away the dewpoint temperature is from the actual air temperature, the lower the humidity.

Research:
Record your answers on a sheet of paper. You will present your findings to the class.

1. What data does your instrument provide?
2. How does your instrument work?
3. What does dewpoint tell us about humidity?

BUILD YOUR OWN TOOLS - THERMOMETER

Name____ Date___________

Building a Thermometer

Background Information:
A thermometer is an instrument that is used to measure temperature.

Materials:
- 1-liter soda bottle
- Food coloring (blue, green, or red works best)
- Modeling clay (preferably a rubber stopper that fits snugly into the bottle neck)
- Straw (preferably glass tubing that fits in the rubber stopper)
- Marker

Directions:
1. Fill a 1-liter soda bottle to the very top with cold tap water. Add eight drops of food coloring.

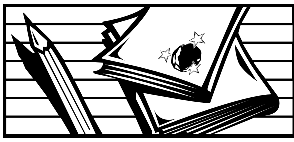
2. Roll some modeling clay into a small ball about 25 mm in diameter. Then roll it out so that it forms a cylinder about the length and diameter of a pencil. Flatten the pencil-shaped clay into a thick ribbon. (A rubber stopper that fits snugly into the bottle is preferable.) Wrap the clay ribbon around the mid-point of a straw.

3. Place the straw into the bottle and use the clay to seal off the bottle. Be careful not to pinch the straw closed. You also do not want any holes or cracks in the clay that would allow water to escape. One half of the straw will be inside the bottle and one half will be outside the bottle. (Straight glass tubing used with a rubber stopper is also preferable.)

4. Press the clay plug into the neck of the bottle far enough to force the water level up into the straw so that it can be seen. (If glass tubing and rubber stopper are used, make sure the rubber stopper fits tightly into the bottle, making it air tight.)

5. Mark the initial water level on the straw. As temperature goes up, the water will expand and raise the water level above this point; as temperature goes down, the water will contract and lower the water level below the initial level. Measure the temperature value relative to your starting temperature according to the distance, in millimeters, that the water level is raised (positive numbers) or lowered (negative numbers). It is not necessary to convert from these units to any standard units of temperature like ˚C or ˚F. Calibrate your thermometer properly based on your initial reading.

Research:
Record your answers on a sheet of paper. You will present your findings to the class.
1. What data does your instrument provide?
2. How does your instrument work?



BUILD YOUR OWN TOOLS - BAROMETER

Name____ Date__________

Building a Barometer

Background Information:

A barometer is an instrument that is used to measure air pressure.

Materials:

- Ruler
- Narrow plastic bottle with a screw cap
- Large bowl
- Water
- Permanent marker

Directions:

1. Using a ruler, start at the cap and mark every 5 mm along the side of a bottle with a permanent marker. Label the top of the bottle.

2. Fill the narrow clear plastic bottle three-quarters of the way with water.

3. Screw down the cap tight enough so the bottle won't leak when upended, not so tight that it is difficult to unscrew.

4. Pour about 3 inches of water into a large bowl. Put the neck of the bottle below the water's surface in the bowl. Unscrew and remove the cap without removing the bottle mouth from the water.

5. Add water to the bowl so that the water level is even with one of the marks on the bottle.

6. If air the pressure rises, the air will press down more on the surface of the water in the bowl and raise the level in the bottle. If the air pressure falls, the air will press down less on the water in the bowl and lower the level in the bottle. A drop in air pressure usually signifies bad weather approaching, while an increase usually indicates a change for the better.

7. You can measure the air pressure value relative to your starting air pressure according to the distance in millimeters that the water level is raised (positive numbers) or lowered (negative numbers) from the initial position. It is not necessary to convert from these units to any standard units of air pressure like atmospheres, bar, mm Hg, etc.Your units will be mm H_2O, the number of millimeters that the level is shifted in a water-based (H_2O) barometer.

Research:

Record your answers on a sheet of paper. You will present your findings to the class.

1. What data does your instrument provide?
2. How does your instrument work?
3. What type of pressure indicates good weather is on the way?

STUDENT WORKSHEET - WEATHER JOURNAL

Name______________________________________ **Location** ________________________

At least once each day, you should record the measurements from the class weather instruments, professional instruments provided by your teacher, and the data from the daily forecast for your area. Keep an orderly chart so that you'll be able to notice patterns in your weather data.

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**
Class Tool Temperature					
Professional Tool Temperature					
Class Tool Pressure					
Professional Tool Pressure					
Class Tool Dew Point					
Professional Tool Dew Point					
Forecast					

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Analysis

Create a simple graph for each set of data collected (temperature, pressure, and dew point).

How did the results from your instruments compare to the professional instruments?

Were there any patterns during the week? Explain.

Does humidity affect pressure? Explain.

Does pressure affect clouds? Explain.

Based on the weather from the week, make some predictions about weather for the following week in your hometown.

Challenger Center Programs

The internationally acclaimed **Challenger Learning Center** Network currently consists of state-of-the-art, innovative educational simulators located at 49 sites across 29 states, Canada, and the United Kingdom. Staffed by master teachers, the core of each Center is a two-room simulator consisting of a space station, complete with communications, medical, life, and computer science equipment, and a mission control room patterned after NASA's Johnson Space Center. See *www.challenger.org* for information.

A joint initiative of Challenger Center for Space Science Education, the Smithsonian Institution, and NASA, ***Voyage — A Journey through our Solar System*** is a space science exhibition project that includes permanent placement of a scale model solar system on the National Mall in Washington, DC, and at locations all over the world. See *www.voyageonline.org* for information.

Space Day^{SM} launches new *Design Challenges* created by Challenger Center each school year. The inquiry-based challenges are designed to inspire students in grades 4-8 to create innovative solutions that could aid future exploration of our solar system. See *www.spaceday.org* for information.

Challenger Center's ***Journey through the Universe*** program provides under-served communities with diverse national resources, including K-12 curriculum materials, teacher workshops, classroom visits by scientists from all over the country, and Family Science Nights. See *www.challenger.org/journey* for information.

The **MESSENGER** spacecraft (MErcury Surface, Space ENvironment, GEochemistry and Ranging) is to be launched in 2004 and go into Mercurian orbit in 2009. Challenger Center is one of the partner organizations charged with MESSENGER education and public outreach activities. See *www.messenger.jhuapl.edu* for information.

Through the Challenger Center **Speakers Bureau, Voyages Across the Universe**, staff members speak to student audiences of 30-1,000, conduct workshops for 100-300 educators, give keynote and featured presentations at conferences, as well as conduct Family Science Nights at the National Air and Space Museum, and other facilities across the nation, for audiences of 300-1,000 parents, students, and teachers. See *www.challenger.org/speakers* for information.

For information about other Challenger Center programs,
or to purchase our classroom resources, visit www.challenger.org/store.