AIR

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WELCOME

Air is an interactive resource kit composed of laboratory and classroom activities, teacher information and a video. This kit is adaptable to a variety of grade levels, learning styles and teaching methods. It follows Arkansas's Curriculum Frameworks and the National Science Standards and can be integrated into existing school programs as enrichment or as required material. After experiencing **AIR**, students should have a better understanding of the properties of air and of why it is important to keep it clean and pure.

Objectives and Learning Outcomes

The **AIR** kit is designed to capture students' interest and increase their understanding of essential science content as it pertains to air. **AIR** is designed to help eighth graders achieve the following learning outcomes:

- Identify air's unique physical properties
- Identify and investigate global and local air pollution questions
- Develop an awareness of business and local commitments to air quality
- Investigate air quality in specific areas
- Be aware of how individuals impact air quality

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1999 Arkansas Science Curriculum Frameworks, Grades 5-8, applicable to AIR

Strand 1: Physical Systems

Content Standard 1: Students will demonstrate an understanding of physical systems as a process of inquiry.

PS.1.1. Understand that the laws of science are universal.

PS.1.3. Generate written conclusions based on evidence acquired through experimentation.

PS.1.4. Interpret scientific information from graphs and charts.

Content Standard 2: Students will explore, demonstrate, communicate, apply, and evaluate the knowledge of physical systems.

PS.2.1. Demonstrate an understanding of the states of matter and describe the various combinations of matter.

PS.2.4. Experiment and identify physical and chemical changes.

Content Standard 3: Students will demonstrate an understanding of the connections and applications of physical science.

PS.3.1. Design and conduct different kinds of scientific investigations to answer different kinds of questions.

PS.3.2. Demonstrate how physical science is connected to mathematics.

PS.3.3. Apply multiple strategies to problem solving.

PS.3.4. Use appropriate equipment, tools, techniques, technology, mathematics and technical writing in scientific investigation.

PS.3.6. Acknowledge the impact of scientific discoveries upon society.

Strand 2: Life Science Systems

Content Standard 1: Students will demonstrate an understanding of life science as a process of inquiry.

LS.1.1. Recognize that science deals only with inquiry about the natural world.

LS.1.2. Interpret scientific information from graphs and charts.

LS.1.3. Conduct investigative science through use of the scientific method.

LS.1.4. Generate conclusions based on evidence acquired through experimentation.

Content Standard 2: Students will explore, demonstrate, communicate, apply and evaluate the knowledge of life systems.

LS.2.4. Identify the requirements for living organisms.

LS.2.9. Explain how physical and/or behavioral characteristics of organisms help them to adapt and survive in their environments.

LS.1.12. Evaluate human impact on the environment.

Content Standard 3: Students will demonstrate an understanding of the connections and applications in life sciences.

LS.3.2. Correlate life science activities to other curricular areas.

LS.3.3. Apply multiple strategies to problem solving.

LS.3.4. Use appropriate equipment, tools, techniques, technology, mathematics, and technical writing in scientific investigation.

Strand 3: Earth/Space Systems

Content Standard 1: Students will demonstrate an understanding of the inquiry process through the study of Earth and space systems.

ES.1.1. Identify the components of Earth (rocks, water, and air) and their properties.

ES.1.2. Understand that Earth and objects in space constantly undergo changes and/or cycles which can be observed and measured.

ES.1.3. Generate conclusions based on evidence acquired through experimentation.

ES.1.4. Interpret scientific information from graphs and charts.

Content Standard 2: Students will explore, demonstrate, communicate, apply and evaluate knowledge of the properties of Earth and space systems.

ES.2.4. Understand the effects of weathering and erosion on the Earth's surface.

ES.2.6. Describe the energy transfer within the atmosphere as it relates to the development of weather and climate patterns.

Content Standard 3: Students will demonstrate an understanding of the connections and applications of Earth/space systems.

ES.3.1. Design and conduct scientific investigations to answer different kinds of questions.

ES.3.2. Apply multiple strategies to problem solving.

ES.3.3. Use appropriate equipment, tools, techniques, technology, mathematics, and technical writing in scientific investigations.

ES.3.5. Construct models of earth science systems and make real world applications.

ES.3.6. Analyze the impact of human activities on the Earth's crust, hydrosphere, atmosphere, and biosphere and demonstrate methods of conservation and recycling of the Earth's resources.

ES.3.8. Illustrate the positive and negative effects of human use of natural resources on Earth.

ES.3.9. Measure weather conditions using appropriate equipment.

AIR

AIR: SOME PHYSICAL, CHEMICAL AND GEOGRAPHICAL PROPERTIES

Air is the atmospheric ocean surrounding Earth that enables us to live. This ocean of gases exists in layers determined by temperature changes resulting from absorption of energy from the sun. We are most directly affected by Earth's lowest layer, the troposphere. It is only in the 5-6 kilometers closest to earth that there is enough oxygen to make it useful for most organisms.

The troposphere is approximately 17 kilometers thick at the equator; 8 kilometers thick at the poles. We could compare this to the thickness of an average human hair wrapped around a globe 45 centimeters in diameter or the skin of an apple planet. It is Earth's weather generator, filled with shifting clouds, moving fronts (warm and cold) and dancing assemblages of air.

Air is a variable mixture of gases which have changed over time. Today the major volume (99 %) of tropospheric air is around 78 % nitrogen, 21 % oxygen, less than 1 % argon, 0.036 % carbon dioxide and trace amounts of other gases including water vapor.

Air occupies space, effectively preventing another material from occupying the same space at the same time. Air's density depends on its temperature. A rise in temperature causes air molecules to move faster and further apart—air expands, density decreases. A drop in temperature has the opposite effect—air contracts, density increases.

Air's weight follows its temperature and density. The warmer the air, the less it weighs; therefore, warm air rises, cool air sinks. Air pressure varies with temperature change and altitude. Cooling air molecules condense, raising local air pressure while warming air molecules create lower pressures.

As altitude increases density, pressure and temperature usually decrease except at the upper limits of the troposphere where temperature rises to prevent mixing between tropospheric gases and those of the upper atmosphere.

AIR

Activity: Individuals Count

Purpose: To recognize how air pollution issues can be addressed at many levels

Introduction: Ask all the air polluters in the class to stand. Discuss the response you get.

Materials: Copies of "Tips for Reducing/Preventing Air Pollution"

Procedure:

1. Brainstorm different ways to reduce air pollution. List them on the board.
2. Circle those things that the students or their families can do personally. Put a check by those that are the responsibility of towns or communities. The rest should be those of national or worldwide scope.
3. Compare your list to "Tips for Reducing/Preventing Air Pollution."

Extension:

1. Read and discuss books or essays that emphasize the importance of individual responsibility for the environment. Examples might include *Silent Spring* or any other of Rachel Carson's writings; *The Immense Journey* or any other of Loren Eiseley's writings; *A Sand County Almanac* by Aldo Leopold; *American Primitive* or any other poems by Mary Oliver.
2. Have students bring in their favorite environmentally themed children's books to share.
3. Develop a class book to teach/express environmental concepts.

TIPS FOR REDUCING/PREVENTING AIR POLLUTION
THINK GLOBALLY, ACT LOCALLY
INDIVIDUALS COUNT

Most environmental spending in the U.S. goes to pollution cleanup (99%); only 1% goes to pollution prevention. Motor vehicles produce more air pollution than any other human activity.

Global	**Local**	**Personal**
Emphasize prevention rather than rely on cleanup	Use the latest technology to reduce emissions; require regular vehicle emissions testing; avoid formaldehyde emitting carpets, furniture & building materials; have wood/tile floors; plant trees & preserve green spaces; efficient chimneys & exhaust hoods;	Car pool, mass transit, walk, skate or bike; combine errands; refuel when cool & don't top the tank; avoid the drive-through; don't smoke; use vinegar, etc. for cleaning; avoid aerosols; Ventilate/open windows; use muscle power over power tools; don't burn trash/leaves; have pollution-reducing plants; store & dispose of solvents properly; limit outdoor grilling; use natural cosmetics;
Improve energy efficiency & conserve energy	Tax incentives for energy efficient appliances & vehicles;	Maintain vehicle, home heating & power tools; reduce heat/AC-wear sweaters & use fans; insulate; shade with plants;
Reduce fossil fuel use, increase use of renewables	Use low sulfur coal/oil; produce electricity, heat & cool with wood, solar, geothermal or wind; tax write-offs for high mileage and hybrid vehicles;	Reduce total energy use; turn off lights; recycle & reuse;
Regulate air quality by large regions	Ban/reduce vehicles in polluted areas; control/relocate plants & businesses that release large amounts of pollutants;	Follow air quality regulations; use pollution detectors (CO, radon);

Global	**Local**	**Personal**
Integrate land use & economics with pollution control policies	Pass tax effective policies that include incentives & subsidies; manage pollution credit policies; well regulated emissions reporting;	Vote for strict pollution control laws; Contact elected officials;
Share pollution control technologies; negotiate international treaties to reduce emissions of greenhouse gas, etc; regulate trade policies with other countries	Mandate government use of nonpollutants; trade agreements that support nonpollution policies; reduce population growth; support research & development on substitutes for problem causing consumer products;	Make elected officials aware of your views; vote for pollution control laws & development incentives; help educate others; join environmental groups;
Relate air pollution to health costs & concerns	Ban smoking in public areas; office machines in ventilated areas; adjustable air vents; covered ceiling tiles & AC ducts; CO & radon detectors; insurance incentives for healthy lifestyles;	Don't smoke; vent natural gas stoves; educate yourself; report signs of pollution;

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Activity: Air—Things You Want and Things You Don't

Purpose: This activity utilizes a scavenger hunt as a means to determine/review factors that have a positive or negative effect on air quality or that indicate air quality. May be used as an air/air quality introduction or as an activity to reinforce previous air quality learning.

Introduction: Below is a list of items common to most communities. Each item has a connection to air. Some items are obvious; others may require a little research or creative thinking. If you have already covered properties, pollution and bioindicators, you may wish to go straight to step two. Also you may wish to vary the time given to search for items or you may wish to vary the listed items or divide them up so that each student team has a different list.

Materials: Scavenger hunt list for each student team
Optional—One or more digital cameras per team (Polaroids, disposables or other)
Notebooks for notes and/or sketches

Procedure:
1. Brainstorm and discuss properties of air; air pollutants and examples of things that create/cause such pollutants; bioindicators of air quality, and things naturally found in air (pollen, etc).
2. Find an example of each item on your scavenger hunt list. Sketch the item on location and/or take its picture. Make a list of its traits, location and the date you observed it. You will have one week to locate as many items on your list as possible. Some items will require research and/or creative thinking.
3. Be prepared at the end of the week to display your photos/sketches and discuss how each item is connected to the air around us (positively, negatively or as an indicator of quality).
4. You may add two items not on your list that fit the criteria of this activity.

THINGS YOU WANT AND THINGS YOU DON'T

-Lichen
-Ash/soot
-Spiderwort
-Clouds
-Lightning
-Aerosol sprays
-Farm
-Carbon monoxide
-Catalytic converter
-Combustion
-Tombstone
-Green plant
-Limestone/marble statue
-Vehicles
-Milkweed
-Carbon dioxide
-Factory
-Battery
-Landfill
-Greenhouse
-Hydrocarbon
-Dust
-Airborne organisms
-Amphibian
-Fossil fuel
-Methane
-Power plant
-Paint
-Benzene
-Chlorofluorocarbons
-Stomata

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Activity: It's the Vocabulary, Man

Purpose: To familiarize students with common air quality terms and definitions.

Introduction: Show students a variety of household items such as an aerosol can, charcoal briquettes, paint thinner, a house plant, etc. Have them brainstorm air quality terms that might relate to each item.

Materials: Common items as listed above
Magazines
Paper and markers
Reference materials for air quality definitions

Procedure:

1. Divide the class into teams of 3-4 students each. Give each team one of the term lists given below. Have each team define their terms using references, science textbooks or the Internet.
2. Teams should use the magazines to find an example for each term on their list (if they cannot find a picture, they may draw one using the reference books).
3. Each team should produce a word web showing the relationships among the terms on their list.
4. Teams will share their products and discuss the overall relationship of all the terms.

Term Sets

Set One	Set Two	Set Three
-Air pollution	-Carbon dioxide	-Nitrogen oxides
-Emissions	-Stomata	-Sulfur oxides
-Environment	-Fossil fuels	-pH
-Ambient air	-Respiration	-Acid aerosols
-Hydrocarbons	-Acid rain	-EPA

Set Four	Set Five	Set Six
-CFCs	-Carbon monoxide	-Photochemical process
-Ozone layer	-Combustion	-Smog
-Greenhouse effect	-Catalytic converter	-Meteorology
-Atmosphere	-Smoke	-Troposphere
-Biogeochemical cycles	-Primary pollutant	-Secondary pollutant

Set Seven
- Plume
- Particulate matter
- Chronic respiratory disease
- Dispersion
- Temperature inversion

Set Eight
- Volatile organic compounds (VOCs)
- Benzene
- Toxin
- Sick building syndrome
- Formaldehyde

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Activity: Aerorama

Purpose: To demonstrate air's physical properties

Introduction: Blow up a balloon and tie it shut or wave a plastic bag around and twist it closed. Air's there—inside the container filling up space, exerting pressure on the sides, throwing its weight around and exhibiting density.

Procedure:
Divide the students into groups of 2-4 students each. Have each group run the following tests and describe their results. After each group has finished all five tests, discuss their findings.

Test One: Air is Spacey

Materials: Clear jar
Paper towel
Bucket or sink filled with water
Optional-tape, glue

Procedure:
1. Stuff the paper towel into the bottom of the jar. If necessary use tape/glue to hold it in place.
2. Hold the jar mouth down and perfectly straight. Push the jar all the way under the water in a water-filled sink or bucket.
3. What happens to the paper towel? Why? What property of air does this experiment exhibit?
4. Repeat the procedure holding the jar right side up. Explain your results.

Test Two: Blow up

Materials: Two balloons
Meter stick
String
Tape
Pin

Procedure:
Note: This experiment can also be done using a balance, by simply placing a blown-up balloon on one pan and an empty one on the other.
1. Blow up the balloons, keeping them as close to the same size as possible.
2. Tie string around the middle of the meter stick and suspend so that the stick is balanced.
3. Tape one balloon to each end of the stick. Adjust the center string, if necessary, so that the stick remains horizontal.
4. Puncture one of the balloons with the pin.

5. What happens to the meter stick? Why? What property of air does this experiment exhibit?

Test Three: Oh, the pressure!

Materials: Paper
Scissors
Ruler
Small clear glass
Poster board

Procedure:
1. Trim two strips about two centimeters wide from the long edge of a sheet of notebook paper.
2. Hold the strips about fifteen centimeters apart and facing each other. Blow gently and constantly between the bottom third of the strips.
3. What happens to the strips? Why? What property of air does this experiment exhibit?
4. Fill the glass about three-fourths full of water. Wet its rim. Hold a piece of poster board tightly over the mouth of the glass. Slowly turn the glass upside down, not allowing any air bubbles between the poster board and the glass. Gently release the poster board. You may need to try this more than once.
5. What happens to the water in the glass? Why? What property of air does this experiment exhibit?

Test Four: Up and Down

Materials: Two-liter plastic drink bottle
Balloon
Bucket of ice
Bucket of hot water

Procedure:
1. Set a two liter plastic drink bottle in a bucket of ice. Let it cool for fifteen minutes.
2. Fit the neck of a balloon over the mouth of the bottle. You may want to blow the balloon up several times first to loosen it.
3. Place the apparatus in a bucket of hot water and observe what happens.
4. Place the apparatus back in the bucket of ice and observe what happens.
5. What happened to the balloon in each case? Why? What property of air did this experiment exhibit?

Test Five: Pour Me a Glass of Air

Materials: Two clear glasses
Container of water large enough to submerge both glasses

Procedure:

1. Hold a glass upside down and straight. Push it under water. Why doesn't the glass fill with water? (It's full of air)
2. Lower the other glass under the water, holding it at a slant. Why does this glass fill with water? (The slant enables air to escape from the glass and water replaces it).
3. Move the water-filled glass straight above and close to the air-filled glass. Tilt the air-filled glass so that air bubbles rise into the one above. Why did this happen? What property of air did this experiment exhibit?

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Activity: Your Air Bags—The Lungs

Purpose: To relate the properties of air to a natural function, breathing

Introduction: Pour a puddle of liquid soap solution onto a wet surface. Use a straw to blow a bubble in the puddle. Stick a wet ruler down the bubble's center and measure its height (also its radius). If the bubble pops, measure the diameter of its soap film trace and half this number to get the radius. Find the volume of the bubble (a hemisphere or half sphere) using the formula $V = 2/3 \text{ Pi } r^3$. Ask students if this is an accurate way to measure the volume of air in your lungs. Why/why not? Brainstorm ways that might prove more accurate, then do the experiment below.

Materials: Clear glass gallon jar with a lid
Measuring cup or graduated cylinder
Optional-Funnel
Marker or tape
Aquarium tubing/rubber hose
Large sink or bucket

Procedure:
NOTE: Normal inhale or exhale = 500 ml; forced inhale = 3000-3300 ml + 500 ml; forced exhale = 1000-1200 ml + 500 ml; residual volume always in the respiratory tract = 1200 ml. Normal breathing rate = 12-17 breaths per minute. Humans use around 10,000 L of air per day.

1. Calibrate the jar by pouring in set amounts (1/4 cup = 60 ml) of water and marking the side until the jar is full. Put the lid on (or cover with your thumb or hand) and turn the full jar upside down in a water filled sink or bucket. If your jar has a small mouth, balance it on the funnel. Take off the cap/remove thumb without letting any water escape from the jar.
2. Stick the tubing underwater and into the jar. If you get bubbles in the jar, stick the tubing into them and suck the air out. Stop sucking when water begins to enter the tubing. Pinch the tubing shut.
3. Take a normal breath. Blow a normal exhale into the tube. Pinch the tube shut.
4. Determine your lung capacity by reading the amount of water displaced from the jar.
5. Repeat using an extra large breath and blowing until you run out of air.
6. Compare the lung capacity of various students in the class. Be sure to disinfect the tubing (or use different tubes for each student) and refill the jar each time.

Questions for Discussion:

1. What causes the water to leave the jar?
2. What are some factors that might affect the results of this experiment?
3. What are some factors that might affect the lung capacity of individuals?
4. What are some factors that might affect the available oxygen in the air?

5. What things can we do to make sure both human lung capacity and available oxygen remain optimum?
6. Running the 100-yard dash takes about seven quarts of oxygen; there is one quart available in your blood. How does your body make up for the deficit?

Extension:
Build a lung model; Cut away the bottom of a plastic drink bottle. Stretch a cut-open balloon tightly over the open bottom and attach it with a rubber band. Punch a hole in the bottle lid and insert a plastic straw. Push the balloon diaphragm—air will rush out the top of the straws and the lungs will contract-relax-contract. Check your own diaphragm. How is it going? Why can't you exhale when you close both your nose and your mouth?

AIR

Activity: What's in The Air?

Purpose: To become familiar with common air pollutants

Introduction: Ask students if they've ever blown their nose and seen black/brown stuff on the tissue (not green stuff from a bad cold). Discuss what this could be and how it got in their nose (dust, soot, etc. from the air). Discuss what might happen to their respiratory tubes and their lungs if the nose didn't screen out some of these larger particles.

Materials: Copies of "Air Pollution—Should You be Worried?" and "Common Air Pollutants"

Procedure:

1. Read over "Air Pollution—Should you be Worried?"
2. Brainstorm types of possible air pollution and write them on the board/chart. Group them into five or six categories.
3. Look over "Common Air Pollutants." Compare your categories to those of the EPA. Mark those that you think are a problem in your area. What could you do to reduce air pollution in your community?

AIR POLLUTION—SHOULD YOU BE WORRIED?

Air pollution is a problem for everyone. The average adult breathes over 3,000 gallons of air every day. Children breathe even more air per pound of body weight and they are more vulnerable to air pollution than older people. According to the World Health Organization, over one billion people (one out of five) live in areas where pollution causes health problems such as burning eyes, an irritated throat or difficulty breathing. Long-term exposure can cause cancer, damage to the immune, nervous, reproductive or respiratory systems; maybe even death.

An air pollutant is a chemical in the wrong place and of the wrong concentration; there is too much of it and it stays in an area long enough to harm humans and other living things (animals, plants) or materials (buildings, tombstones, etc.). Air pollutants such as urban smog and toxic compounds tend to stick around for a very long time and may be carried on the wind for hundreds of miles before they return to earth's surface as solid particles or dissolve in precipitation like rain, fog, sleet or snow.

Many areas in the U.S. are being contaminated by the burning of fossil fuels (coal, oil, natural gas) in homes, power plants and factories (stationary sources) and in motor vehicles (mobile sources). Industries often release toxic gases referred to as hazardous air pollutants. Even individuals add gases and particulate matter to the air through daily activities such as dry cleaning, gassing up cars and painting houses. When these materials become concentrated enough, they become air pollution, harmful to us and our environment. As our population increases and more countries become industrialized, pollution increases also.

Air pollution is not a new phenomenon, but it has increased greatly since the industrial revolution. As clean air moves across earth's surface it picks up products from natural events such as dust storms and volcanoes, as well as those of human activities such as car and smokestack emissions. As these potential or primary pollutants are mixed and dispersed by moving air in the atmosphere, they can combine with each other or with other of air's components to produce new secondary pollutants. Once pollution sources are identified, ways to prevent or reduce their release should be explored.

COMMON AIR POLLUTANTS

The Environmental Protection Agency (EPA) has set National Ambient Air Quality Standards for six common pollutants—ozone, particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide and lead. These are known as criteria air pollutants. In addition to these pollutants, there are VOCs (volatile organic compounds). VOCs are hazardous pollutants which escape into the air very easily and can form smog or cause serious illness. EPA doesn't list VOCs with the criteria air pollutants, but they are included in air pollution information because of their serious nature.

OZONE

- **Composition**: O_3
- **Sources**: Chemical reaction of pollutants; VOCs and NOx
- **Health Concerns**: Respiratory irritant, reduced immune response
- **Environmental Concerns**: Smog component, decreased visibility (haze in cities, parks and scenic areas), plant damage
- **Property Concerns**: Damages rubber and fabrics

VOCs

- **Composition**: Includes 188 pollutants such as benzene, toluene, methylene chloride, methyl chloroform, dioxin, mercury
- **Sources**: Released from burning fuels (gasoline, oil, wood coal, natural gas, etc.), solvents, paints, glues
- **Health Concerns**: Smog, carcinogens
- **Environmental Concerns**: Smog effects, plant damage
- **Property Concerns**:

Nitrogen Dioxide

- **Composition**: NO_2, one of the NOx
- **Sources**: Burning gasoline, natural gas, coal, oil; automobiles especially
- **Health Concerns**: Respiratory system damage
- **Environmental Concerns**: Component of acid rain which damages plants and water sources (upsets nutrient balance and depletes oxygen), haze
- **Property Concerns**: Erodes building and monument stones

Carbon Monoxide

- **Composition**: CO
- **Sources**: Burning gasoline, natural gas, coal, oil
- **Health Concerns**: Binds to hemoglobin in red blood cells causing reduced oxygen for cell work
- **Environmental Concerns**:
- **Property Concerns**:

Particulate Matter

- **Composition**: Dust, smoke, soot, ash
- **Sources**: Burning fuels such as wood or diesel, industries, agriculture, unpaved roads
- **Health Concerns**: Respiratory irritation and damage
- **Environmental Concerns**: Haze, can coat plant leaves causing reduced light absorption
- **Property Concerns**: Can dirty or discolor structures, clothes, furniture, etc.

Sulfur Dioxide

- **Composition**: SO_2
- **Sources**: Burning coal (especially high-sulfur) and oil, industry such as paper or metals
- **Health Concerns**: Respiratory damage
- **Environmental Concerns**: Ingredient of acid rain which can damage trees and water sources and reduce visibility
- **Property Concerns**: Can erode stone used in buildings and monuments

Lead

- **Composition**: Pb
- **Sources**: Leaded gasoline, paint, metal refineries, lead storage batteries
- **Health Concerns**: Nervous system damage (especially for children), carcinogen, digestive problems
- **Environmental Concerns**: Can harm wildlife
- **Property Concerns:**

AIR

Activity: Your Community's Air

Purpose: Identify sources of air pollution in your community, how they are measured and what is being done to combat them. Devise ways to educate others about air pollution

Introduction: Do a quick show of hands survey on the following or similar questions. How many have two or more vehicles in your family? How many know someone who has asthma, bronchitis or other respiratory problems? How many have noticed that some days are much hazier than others? How many are familiar with carbon monoxide or radon detectors? How many use a fireplace or a wood burning stove? How many have heard warnings about global warming or ozone layer damage?

Materials: Access to phone, Internet, fax, mail, newspapers and/or television
Area maps
Markers and chart paper
Optional-video equipment

Procedure:
Teacher note: Do this activity after "What's in the Air?" so students will be familiar with common air pollutants.

1. Divide the class into five teams.
    - **Team One**: Design and administer surveys to other students, community members and leaders, and state Legislators to find out how much most people know about air pollution. Illustrate the data graphically.
    - **Team Two**: Contact local businesses and industries to find out about their air pollution policies. Use your information to identify and map possible sources of air pollution in your area.
    - **Team Three**: Find out which authority is responsible for monitoring pollution levels in your area. Find out how pollutant concentrations are measured, where they are measured and when they are measured. Find out how this data fits with statewide standards. Check the newspaper each day, when the Legislature is in session, for bills relating to air pollution.
    - **Team Four**: Determine how pollution levels are reported in your newspaper and/or on television. Record pollutant concentrations and indexes each day for a month. If possible, note measurement time, position, and weather conditions. Use your record to map which areas of your community are susceptible to what types of pollution and under what kinds of conditions.
    - **Team Five**: Choose several locations around town and conduct an on-site count of how many vehicles pass per hour at different times of the day and week. Note the number of people in each vehicle. If your town has a bus system, find out how many people ride each day.
2. Collect data for one month. At the end of the month, students should combine their data and determine community areas with possible air pollution problems. For each problem, students should devise a number of possible solutions.

3. Design and produce videos, fliers, billboards, radio and TV spots, etc. to showcase the information collected. Make these available to the school and community as an education tool.

Extensions: Have guest speakers from EPA, environmental organizations and from industry. Write editorials for the school and community newspaper. Write to Legislators in support of clean air standards. Develop materials for a teaching unit on air pollution and use them to present a program to younger students.

AIR

Activity: Reading Lichens

Purpose: To demonstrate how bioindicators can show air quality

Introduction: Have specimens of the three major lichen forms (crustose, foliose and fruticose) available for student examination. You may wish to separate the microscopic algal cells (greenish color) from the white/colorless fungal strands that make up the bulk of the lichen body and view them under a microscope.

Materials: Lichen specimens
Copies of "Lichen Lingo" and the "Lichen Meter"
Optional-magnifying glasses, microscopes

Procedure:

1. Use the Lichen Meter to survey varied locations in your area. Check out the lichen populations around town and your home, in wooded areas, farms, parks, along highways, near industries or power plants, etc. Compile your data and compare it to possible sources of air pollution in your part of the state. Analyze your results to determine if the lichens are warning of pollution problems.
2. Contact students at other schools around the state to compare results and work up a Lichen Index for Arkansas.

Extensions:

1. Research known instances of air pollution studies involving bioindicators such as the Geysers Geothermal Plant in Sonoma, California, and the Chernobyl nuclear power-plant disaster.
2. Investigate additional bioindicators such as milkweed, spiderwort, morning glory, tobacco and aspen.

LICHEN LINGO

Lichens are a special life form made up of a chlorophyll-containing green or blue-green algae growing in association with a fungus. The algae produces food for itself and its fungal partner through photosynthesis, while the fungus (which makes up the main body of the lichen) absorbs moisture, secretes acids that keep the lichen attached to its substrate and dissolves needed minerals from the substrate. Lichens are pioneer organisms, able to grow almost anywhere. Most are temperate or arctic, some tropical or desert living. Over 20,000 known species have been found on rocks, trees, bare soil, buildings, tombstones and even sun-bleached bones. Lichens are slow-growing, but long-lived; some over 4,000 years old.

Lichens often share habitats with mosses, but can be distinguished by their lack of leaves and paler colors (mostly pale greens, yellows or grays). Color determination should be made on air-dry lichens since moisture causes the opaque upper layer of lichens to become translucent causing wet lichens to appear greener as the algal color shows through. Lichens are usually round in outline and scattered about their substrate, but may overlap into broad masses. Shape and color are easily recognized and often enable identification to genus level. Lichens occur in three major growth forms:

- **Crustose**: Crust-like, growing flat against the substrate. Cannot be detached without being destroyed. Unlobed margins are indistinct and fade into the substrate. Most numerous lichens, but least useful as bioindicators. Examples include toad skin, dog tongue
- **Foliose**: Leaf-like or lobed with a distinguishable upper and lower surface. May be fairly flat or semi-erect; attached by many root-like rhizomes or a single stalk. Examples include *Lecanora*/crusty lichen
- **Fruticose**: Bush-like or hairy and dangling. Attached to the substrate at their base. Examples include *Usnea*/Old Man's Beard, *Cladonia*/British Soldier and Pixie Cup, *Cladina*/Raindeer Lichen, *Evernia*/yellow lichen, *Ramalina*/

Lichens are constantly absorbing air and, along with it, certain elements that may be pollutants. Because certain species are sensitive to specific chemicals, they are potential indicators of air pollution and are used in studies throughout the world. Being wide-spread, long-lived and stationary, they can not only detect pollution but help trace a pollutant to its source. Assays of lichens show that they reflect the contaminant level of their environment as accurately as expensive monitoring equipment can do.

The Lichen Community Indicator, as part of The Forest Inventory and Analysis Program (FIA), currently collects data on epiphytic lichens (those growing on trees and shrubs) in 32 states. Ways to measure pollution impact on lichens include population studies, chemical analysis and visible physical damage. Studies are also being done on moths and caterpillars that feed on lichens. According to a 1996 study, air pollution has wiped out up to 80% of the lichens in at least a dozen sites in North America, producing lichen deserts.

LICHEN METER

Foliose and Fruticose lichens only thrive in clean air; crustose lichens are more tolerant of pollutants. *Usnea* is most sensitive to SO2, *Evernia* is moderately sensitive and *Lecanora* is tolerant of it. *Cladina* absorbs radiation and *Ramalina* is sensitive to nitrates and fluoride salts. Look for lichens on trees, walls, rocks and use the following scale as a general measure of air quality in an area.

POLLUTED

No lichens. Green or blue-green algae may be present on trees, rocks and soil

Grey or gray-green crusty/crustose lichens present on tombstones, rocks and walls

Orange crusty/crustose lichens present on tombstones, rocks and walls

Leafy/foliose lichens present on walls, stones and trees

Shrubby/fruticose lichens present on trees and rocks

CLEAN

AIR

Activity: Blowin' in the Wind

Purpose: To investigate particulate matter in the air

Introduction: Air is supposed to be invisible. Ask students if there is ever a time when you can see air (when it contains dust, soot, etc.). Use three glasses of cold water to demonstrate how air-borne particles impact visibility. Glass one should contain water only, glass two-water plus one teaspoon milk, glass three-water plus three teaspoons milk. Milk is a good stand-in for the sky because both contain tiny suspended particles that cause them to appear blue when light shines through at a certain angle (more of the sun's blue light is scattered). Darken the room and shine a flashlight through the side of each jar; all should appear bluish in color. Now direct the light so that the beam is pointed directly at the students through each jar in turn. The contents of the first glass will appear clear and colorless no matter the light direction. Jar two's contents will appear yellow, jar three's pink. More milk causes more dispersal of the blue light creating a more reddish tint.

Procedure:
Read and discuss "It's There in the Air." Use one or more of the methods given to test for particulate matter. Samples may be collected and compared at different times of the day or year, during various weather conditions and in various locations. Choose some sites you feel are "clean" areas and others with obvious pollution problems; keep one sample in the classroom as a control. Site examples include busy road, side street, gravel/dirt road, park, under a bridge, stream/pond bank, field/vacant lot, school parking lot or playground, near stockyards, factories, railroads or construction sites.

Possible Discussion Questions for any/all of the Tests:

1. Can you identify any of the particles you collected by sight? (Dust is usually brown, carton containing particles such as soot, black).
2. Do all samples contain the same type particles (size, shape, color, etc.)? Explain why/why not.
3. Which location yielded the most particles? Discuss why.
4. Try to determine a possible source for the particles collected at each location (road dust, car exhaust, soot from fires or factories, etc.).
5. What can be done to reduce particulate pollution in affected areas?

Test One: Icky Sticky:

Materials: 8-12 ounce can
Brick or board base
Hammer & nail or glue
Double-sided tape
Magnifying glass or microscope
Hairspray or other fixative

Procedure:
Particles carried in the air tend to move horizontally with the breeze. This means that the most efficient collecting surfaces are vertical ones.

1. Nail or glue the can to a stable base such as a brick or piece of lumber. Wrap a strip of double-sided tape securely around the can. Label the tape on each side of the can as North, South, East or West.
2. Set the apparatus in an area exposed to the wind, where it will not be disturbed. Use a compass to align your jar according to the directions you labeled. Leave it 5-7 days, checking periodically to make sure it hasn't been moved.
3. After 5-7 days, spray the exposed tape with hair spray or another fixative. Let it dry and remove it from the can, being careful not to disturb your particles or your direction markers. Fasten the tape, particle side up, to a piece of poster board for stability. The strip of poster board should be narrow enough to fit on a microscope stage if you plan on using one for particle identification.
4. Estimate and record the percentage particle coverage for each of your tape sections as shown on the table below.
5. Examine your tape with a magnifying glass or microscope. Try to identify as many types of particles as possible (pollen, dust, soot, etc.). Record your results on the table below.

Direction	N	NW	W	SW	S	SE	E	NE
% Cover								
Major type								
of particles								

6. Graph your data, using the scale of 1 centimeter = 10% cover, on the graph below.

NW N NE

W Sample Site E

SW S SE

Collection site__________________________________
Collection dates__________________________________

Alternative: Use the following procedure for a quick one-day sampling of the school grounds or a nearby location: Coat the upper surfaces of a number of microscope slides with a thin layer of petroleum jelly. Place the slides in selected locations during the early morning. Collect and examine the slides at the end of the day.

Test Two: Sock it to Me

Materials: White sock
Car or other vehicle
Magnifying glass

Procedure:

1. Slip a white sock over the cool tailpipe of a car.
2. Start the car and run it for a few minutes. Carefully remove the sock from the now hot tailpipe.
3. Examine the sock with a magnifying glass.
4. You may want to compare different makes and/or ages of vehicles.

Test Three: Suck it Up

Materials: Can with lid
Hammer & nail
Filter paper
Cylinder vacuum cleaner
Old scissors
Duct tape
Extension cord to reach test site

Procedure:

1. Use old scissors to cut a hole in a lidded can's side that will fit a cylinder vacuum cleaner hose. Insert the hose and tape it securely. Punch a number of nail holes in the lid.
2. Put the lid on the can. Tape a piece of filter paper on top of the lid. Turn the vacuum on so that its suction pulls air through the lid into the can leaving particulate matter on the filter paper.
3. Use this device to compare air quality in a number of places your extension cord will reach.
4. Advanced Extension: How to Sample Black Carbon Air Pollution at http://www.lbl.gov/education/elsi/frames/pollution-measure-bc-f.html

IT'S THERE—IN THE AIR

A variety of solid particles and liquid droplets can be found suspended in air. Sizes range from 0.001 micron to 100 microns. You can easily see those from 20-100 microns in size (a human hair is approximately 70 microns in diameter).

These particles become pollution when they are so concentrated or widespread that they lower air quality, impact human health and/or hurt the environment. The EPA concentrates on particles under 10 microns since these are small enough to pass through the respiratory passages to the lower lungs and cause/irritate respiratory diseases and conditions. Continued exposure to polluted air can reduce lung capacity or reduce lung ability to absorb oxygen from the air and throw off carbon dioxide.

Sources of pollution arise from both natural processes and man-caused processes or activities. Gasoline-burning vehicles are a major pollutant, with over 140 million in the U.S. alone. Others are fossil fuel burning factories and coal-burning power plants. Look over and add to the following chart.

NATURAL PARTICULATES	**HUMAN CAUSED PARTICULATES**
Volcanic ash & soot, sea salt, pollen, forest or brush fires, dust storms, meteorites	Smoke & soot from tobacco, oil, coal, fireplaces, burning leaves or trash; dust from plowing, unpaved roads, pesticides, cement, milling flour, coal; metallurgical processes; asbestos from brake linings or building cleanup

Sometimes particulates and their effects on visible light can cause beauty. Think about red sunsets, twilight, rainbows, halos around the moon or sun, the northern lights. Can you discover any other atmospheric related phenomena along with their causes?

AIR

Activity: Air and Weather

Purpose: To become familiar with some of the ways air produces weather

Introduction: Pop the top on a carbonated drink can. Explain to students that they have just heard an explosion caused by the rapid expansion of air. This phenomenon is heard as thunder when a sudden bolt of lightning heats the air. Review air's characteristics, then brainstorm how it might impact weather in light of these traits. Compare your list with the "Awesome Air" handout.

Test One: Windy Ways

Materials: Research materials—print and Internet

Procedure:

1. Research and use on-line satellite images of cloud pattern to map famous local winds such as the Indian Ocean monsoons, the cold air mistral of France, Chinooks and Santa anis—the hot dry mountains gales of western North America, and the fens of the Alps.
2. Determine how these winds have shaped the land and the lives of people who live with their effect.
3. Where does air pollution go? Does it ever go away? Explain

Test Two: Whirlin' and Twirlin'

Materials: Notebook paper
Needle and thread
Scissors
Lamp

Procedure:

1. Construct an air current indicator. Cut a 15 cm circle from a sheet of notebook paper. Punch a needle hole in the circle's center. Cut the circle into a spiral (like that of a snail shell) and hang it from a knotted piece of thread.
2. Dangle the spiral above a light bulb (that has been on for awhile) so that you are looking down at it. Hold it there for about 30 seconds. A clockwise motion of the spiral indicates an updraft, counterclockwise indicates a downdraft. Which do you have? (up) How do updrafts and downdrafts relate to air temperature?
3. Use your indicator to locate other air currents in or out of the classroom. Try testing at various times during the day.

Extension: Create a thermograph or heat map of your classroom. Measure air temperature at floor level, knee level, waist level, shoulder level, head level, and then at one foot intervals to ceiling level. Indicate the changing temperatures with colors on a strip of paper that hangs from floor to ceiling. Does your thermograph agree with the results you got from your air current indicator?

Test Three: Huff and Puff

Materials: 2 Ziploc bags
Freezer or ice chest

Procedure: Breathe out on a cold winter day and watch your warm moist breath condense into a short-lived little cloud (use the freezer if it's summer).

1. Blow up the bags and zip them shut. Put one in the freezer/ice chest, leave the other out. Wait twenty minutes then remove the cold bag.
2. Compare the bags. Which bag contains condensed water vapor? Why? (Supercooled water droplets may linger well below freezing temperatures)
3. Let both bags sit at room temperature for twenty minutes. What happens to the condensed water vapor? Why?

Discussion:

1. Ever heard the expression "as light as a cloud?" Actually a medium-sized cloud might outweigh five or six elephants.
2. Clouds composed of drops of water have well-defined edges. Clouds composed of ice crystals are fuzzy around the edges. Relate this information to the idea that a ring around the moon promises rain.

Extension: Write a poem that expresses what you think it would be like inside a cloud (think very foggy day).

AWESOME AIR AND WEATHER

Weather is considered to be the short-term properties of the troposphere (lower atmosphere) at any given time. These changeable physical properties include temperature, pressure, humidity, precipitation, sunshine, cloud cover, wind speed and direction. Climate is a long-term average of an area's weather over many years. Average temperature and average precipitation, the major factors in climate determination, are caused mainly by air circulation across earth's surface.

So why does weather change so often (especially in Arkansas it seems)? Because different kinds of air masses are always moving, bumping into one another. For instance, when a warm mass meets a cooler mass at a boundary called a front, the warm lighter air rises above the heavier cool air. The air cools as it rises, causing the water molecules it carries to condense into clouds that thicken and descend to release moisture as rain.

Movement of large highs and lows can quickly change a sunny day rainy and vice versa. A heavy high pressure mass falling toward earth warms as it drops to bring fair weather, while a lighter low typically produces stormy weather as its low pressure center rises, expands, cools and releases precipitation. As air moves from high pressure areas to those of lower pressure, the greater the pressure difference the stronger the winds.

Moving air is wind. Wind evens out earth's temperatures—without it the tropics would be too hot while the rest of the earth would freeze. Regular wind patterns are a big part of earth's circulatory system for heat, moisture and nutrients. They form as earth spins and its gravity drags a mass of air along with it and by the ongoing interaction between tropical air and polar air. Wind connects all life on earth through the transportation of good things like nutrients (iron and phosphates) and harmful things like pollutants.

35,000 feet is the altitude of jet streams and jet planes; above clouds that form ripples like sand on a beach. Earth's atmosphere is an ocean of air, the jet stream a west to east (generally) river of rushing air; a river that separates cold polar air from warmer air to its south. Air pollution moves with the wind and if it moves high enough, it will enter the fast flowing jet stream (57+ mph) and maybe travel thousands of miles. Air currents are so similar to those of water that some EPA labs test pattern of air pollution flow in water tanks.

There is no "away" from the good things or the bad things carried on the wind. It travels over earth's surface carrying ash from Hawaiian volcanoes to Arkansas, DDT and PCBs from industrialized countries to Antarctica, and radioactive particles from the Ukraine's Chernobyl to the reindeer lichen in Lapland.

AIR

Activity: Don't Exhale

Purpose: To become familiar with the greenhouse effect

Introduction: Use a terrarium, with a thermometer inside and one outside, to demonstrate the greenhouse effect. In a greenhouse, sunlight easily enters the glass/plastic covering where it is converted into heat. Heat has a longer wavelength than sunlight, causing it to be trapped inside the greenhouse. Ask students to describe the effects of this phenomenon and how they could be useful or harmful. Share with them the information given in "Living in a Greenhouse is Hot Stuff."

Materials: 6 large test tubes
3 healthy sprigs of Elodea
Bromothymol blue indicator
4 straws

Procedure:

1. Fill the test tubes about 2/3 full of water. Add a few drops of bromothymol blue to each one.
2. Place a strand of Elodea into three of the tubes. As a control, set aside one tube with Elodea and one without.
3. Exhale carbon dioxide through a straw into the remaining four tubes until you see a color change in each. Bromothymol blue turns from dark blue to light blue to green to yellow in the presence of increasing amounts of carbon dioxide.
4. Set the test tubes near a light source and observe what happens. (The Elodea-containing tubes should return to their original blue color much faster than the plantless ones as the Elodea takes up carbon dioxide from the water and releases visible bubbles of oxygen during the process of photosynthesis).
5. Discussion:
   - Discuss this experiment in light of the deforestation that is going on in much of the world, especially the tropical rainforests.
   - Brainstorm ways to reduce the amount of carbon dioxide put into the atmosphere by human activities.
   - What lifestyle changes would you be willing to make in order to slow global warming due to the greenhouse effect and reduce other types of air pollution?

Extension: There is evidence that leaf stomatal densities change in response to changing atmospheric levels of carbon dioxide. Visit http://www.accessexcellence.org/ae/aec/aef/1994/case_leaf.html for the experiment "Leaf Stomata as Bioindicators of Environment Change."

LIVING IN A GREENHOUSE IS HOT STUFF

Earth's atmosphere contains small amounts of carbon dioxide and water vapor, and traces of ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and perflurocarbons (PFCs) among others. These are called greenhouse gases because they act like the walls of a greenhouse, trapping heat in the troposphere and redirecting it back toward earth.

Water vapor is the atmosphere's major heat sink, but because it exists in fairly large amounts (1-5% of the atmosphere), release of water vapor by human activities doesn't noticeably affect its impact. Carbon dioxide, however, has a low atmospheric concentration (0.36%) and is greatly affected by the heavy amounts of carbon dioxide that human activities generate.

Without the greenhouse gases earth would be too cold to support life, but the excess amounts being added to the atmosphere (atmospheric carbon dioxide has doubled in the last century) may encourage global warming. Only a few degrees rise in the global temperature could lead to huge climate shifts and polar ice cap melts that would cause massive habitat changes and elevation of current sea levels.

The buildup of atmospheric carbon dioxide is mainly caused by the burning of fossil fuels in transportation, power plants, factories, businesses and homes, and by the cutting down and burning of the tropical rain forests.

AIR

Activity: O_2 To O_3

Purpose: To show how a temperature inversion works

Introduction: Show students a bottle of sunscreen and ask them what it has to do with air pollution. The ozone layer is earth's stratospheric sunscreen that keeps 99% of the sun's damaging ultraviolet rays from hitting earth. One set of problems arise when CFCs (chlorofluorocarbons) and other chemicals are released into the air to eat holes in our ozone shield. Another set comes about when ozone is formed as a dangerous component of low-lying smog. This ozone can't reach the protective ozone layer and can harm living organisms. Show pictures of the three types of skin cancer, squamous cell carcinoma, basal cell carcinoma and melanoma. Discuss human skin structure and the relationship of skin cancer to UV-A and UV-B.

Materials: 2 aquariums or 2 gallon jars
Food coloring
Ice cubes
Ziploc bags
Pin
Water
Optional-hot plate and pans for heating water

Procedure:
NOTE: Temperature inversions are created by a cold air sandwich in which the cold, dense air is trapped between two layers of warmer, lighter air. The bottom layer of warm air is often polluted by discharge from cars, smokestacks or power plants and is prevented from rising up to be dispersed by the wind. This happens most often in urban basins or valleys. An inversion usually lasts only a few hours but, in extreme cases, may go on for days causing harmful (even lethal) levels of pollutants to accumulate.

Simulate Normal Atmospheric Conditions
1. Fill one jar ¾ full of cold water. Add several ice cubes.
2. Fill a Ziploc bag ½ full of water you have heated or use very warm tap water. Add a few drops of food coloring. Expel all air possible from the bag and seal it.
3. Remove the ice from your jar and gently place the bag of warm colored water into the cold water.
4. Disturbing the water in the jar as little as possible, use a pin to poke a hole in the bag allowing the two waters to mix.
5. Describe what you see.

Simulate a Temperature Inversion
1. Fill the second jar ¾ full of very warm water.
2. Fill a Ziploc bag ½ full of cold water. Add food coloring. Expel the air and seal.
3. Place the bag of cold colored water into the jar of warm water.

4. Puncture the bag with a pin and allow the warm and cold waters to mix.
5. Describe what you see.

Discussion:

1. What part of the experiment set-up represents the unpolluted air in each case? The polluted air?
2. What are two primary sources of air pollutants that may become trapped in a temperature inversion?
3. Research sources of CFCs and other ozone-eating chemicals in your area. (Insulation & packaging, coolants, cleaners for electronics, sterilants, solvents, fumigants, aerosol sprays)
4. Visit http://www.epa.gov/air/data/monvals.html?st~arkansas to generate reports for pollutant criteria by year.

Extension:

1. Keep a record of ozone forecasts and ozone action days during ozone season from May through September. Ozone action days follow the format of the EPA's Air Quality Index (AQI) and are declared when the Little Rock area ozone concentration exceeds national ambient air quality standards. http://www.adeq.state.ar.us/air/ozone/ozonedays.asp
2. Research the connection between the ozone layer and the evolution of photosynthetic bacteria.

AIR

Activity: Smogulous Smog

Purpose: To simulate conditions that create smog

Introduction: Read/watch the video and discuss *The Lorax*, Dr. Seuss, Ramdom House, 1971.

Materials: Glass jar
Aluminum foil
Ice cubes
Paper
Scissors
Matches
Water

Procedure:
NOTE: Do not inhale smog. Release it outdoors when the experiment is finished.

1. Shape a jar cap out of aluminum foil. Set a couple of ice cubes on top of the foil and set it aside.
2. Pour enough water in your jar to wet the inside walls. Pour out any excess.
3. Cut a one centimeter strip from the long edge of a sheet of notebook paper. Fold it in half and shape into a twist.
4. <u>WORK QUICKLY</u>: Light the paper, drop it and the match into the jar. Clamp the foil cap tightly around the jar's mouth—leave the ice on top of the foil.
5. Describe what happens.
6. Discussion:
   - How is this like real smog? (Moisture condenses on smoke particles)
   - Where do you think the term smog came from? (1900s, London smoke & fog)
   - Is your smog more like photochemical smog or industrial smog? Explain.

Extension: Read *The Wump World*, Bill Peet, Houghton Mifflin, 1970. Divide the students into groups of 3-4 and give them the following dilemma. After 15 minutes, have each group present their solution.

Earth has become so polluted it will no longer support life. All the trees, flowers and animals are gone. The people of earth are traveling in huge spaceships to a far-off unpolluted planet to make a new home. Your group is the crew in charge of the last ship to leave earth. Among those on your passenger list are some farmers who refused to follow good conservation techniques and who used pesticides carelessly; some factory owners who dumped poisonous waste into the air; some power plant executives who saved money by using high-sulfur coal; some lumber company managers who ordered the clear-cutting of many forests. You are afraid these people will treat the new planet as they treated earth, but if you leave them on earth they will die. What will you do?

SMOGULOUS SMOG

Remember how air is supposed to be an invisible mixture of gases? Not so when smog's around—you can see it. Originally smog was a smoke-fog combination that hung in the air around industrial areas. Today we talk about industrial smog (gray-air) and photochemical or brown-air smog.

Industrial smog is mainly a suspended soup of sulfur oxides, sulfuric acid droplets and other solid particles such as dust, ash and soot. Industrial smog, which results from the burning of sulfur-containing coal and oil, is not so much of a problem in most developed countries that employ pollution-control devices.

Photochemical smog is a mixture of mostly hydrocarbons and nitrogen oxides cooked by the sun to ozone, peroxyacyl nitrates (PANs), hydrogen peroxides, nitric acid, and assorted aldehydes such as formaldehyde. This smog hangs over most cities today, especially those with warm, dry, sunny climates and lots of traffic. Peak smog times bring about eye and respiratory tract irritation and damage to trees and crops.

Ordinarily the sinking and rising of air masses of different temperatures and pressures keep the lower atmosphere well mixed, preventing pollution from accumulating. But when you occasionally get a layer of warm air above a layer of cool air with another warm layer beneath, it creates a temperature inversion trapping pollutants in the lowest layer near earth's surface and allowing them to reach dangerous levels of concentration.

Activity: Hey—My Umbrella Melted

Purpose: To make the connection between the effects of acid deposition and air pollution.

Introduction: Several days before you start the activity, set up several containers of vinegar (or another weak acid) and an equal number of water. Immerse common objects in your containers, some that are acid sensitive and others that aren't (snail shell, limestone rock, chunk of marble countertop or gravestone, pieces of egg shell, a fresh twig with leaves, paper clip, piece of brick, cloth, piece of quartz, etc.). Each day have students look at and jot down a brief description of what is happening in each container. When you are ready to start the acid rain activity, have students share their observations and what they think this activity has to do with air pollution. Read "Hey—My Umbrella Melted" and look over pictures of acid precipitation damage to buildings, statues, forests and bodies of water.

Materials: City map for urban areas, county map for rural
pH paper
Water samples
Containers to collect & transport water samples
Copies of "Hey—My Umbrella Melted"

Procedure:
NOTE: The rainwater portion of the activity must take place the day after a rain. Other water samples may be tested at any time. Normal rain has a pH of below 5.6, acid rain has a pH below 5.6.

1. Students should collect water samples and bring them to class. Label each sample with student name, collection location and collection date.
   - Rainwater should be collected as falling rain, not runoff from trees or buildings.
   - Other samples may be obtained from creeks, ponds and puddles. You may wish to also test tap water and distilled water. Be sure some sources are standing and some flowing.
2. Use pH paper to determine the approximate pH of each sample.
3. Mark the pH for each sample on the appropriate map location. Analyze the map, attempting to identify the source of the pollution for acidic areas.
4. Research methods utilized by area industries, factories or utilities to reduce/prevent acid precipitation.

Extensions: Discuss why caves are more likely to form in the limestone/dolomite areas of the Ozark Mountains than in the mainly sandstone/shale Ouachitas.

HEY—MY UMBRELLA MELTED

Acid deposition falls to earth's surface wet (as acidic rain, frost, dew, mist, sleet, snow, fog and cloud vapor) or dry (dust-like acidic particles). Acidity is measured by the pH scale that considers hydrogen ion concentration. The scale runs from 0-14, with 7 considered neutral; solutions with pH under 7 are acidic, those over 7 are basic. The pH scale is logarithmic, with each step increasing10X. Normal precipitation is slightly acid, pH around 5.0-5.6 because atmospheric water vapor and carbon dioxide combine to form weak carbonic acid.

The two main acid-producing chemicals come from the burning of sulfur-containing coal or oil and the nitrous oxides from car exhaust. The sulfur dioxide combines with atmospheric water vapor to form sulfuric acid, the nitrogen oxides form nitric acid. Your umbrella probably wouldn't melt during a slightly acid rain, but its long-term effects can be quite serious. Acid precipitation can harm the respiratory system, kill/damage plants, change the pH of water bodies so that they can no longer support fish, frogs and other aquatic life, damage buildings and roads, contaminate public water supplies and sap soil nutrients.

The only way to control acid deposition is to reduce the air pollution that causes it.
The best solution is prevention: reduce energy use and increase energy efficiency, use renewable energy sources or those that are cleaner burning (natural gas, low-sulfur coal), remove pollutants and particulates from smokestacks and car exhaust. Other methods involve cleanup, but this is usually expensive and does not address the source of the problem.

AIR

Activity: Are You Safe Inside?

Purpose: To become familiar with forms of indoor air pollution, their sources and effects

Introduction: Air quality affects how we live and breathe. Like weather, it can change from day to day (or oftener) and from place to place. Exposure to air pollution can cause or aggravate such conditions as lung cancer, asthma, chronic bronchitis, emphysema, heart problems. It may cause chest pain, coughing, shortness of breath, eye, nose and throat irritation, loss of lung capacity/smaller lungs, increased susceptibility to colds, flu, pneumonia and other respiratory infections and impair the ability of blood hemoglobin to combine with oxygen.

Materials: Research materials

Procedure:
NOTE: EPA studies show that levels of some pollutants in U.S. homes and commercial buildings are usually 2-5X higher than outside and sometimes up to 70X higher. Those at increased risk include smokers, infants and children under five, the elderly, pregnant women, those with respiratory or heart problems and factory workers.

1. Conduct a school survey for indoor pollutants. Assign each pollutant/several pollutants to class teams who will determine, through search and interview, which of these may be a problem in your school. Also have them research the type of harm that can result to the human body from continued exposure to their particular pollutant(s).
2. Combine the class survey information. Evaluate the exposure danger to students, teachers and others. Determine possible ways to reduce or eliminate these dangers.
3. You may also wish to interview students, teachers and others about any symptoms they might have noticed after spending a great deal of time in the school.

Extension: Research “sick building syndrome.” Determine if there are any buildings in your area that have this designation.

TEACHER INFORMATION
IMPORTANT INDOOR AIR POLLUTANTS
*Top Four According to the EPA

POLLUTANT	SOURCE	THREAT/SYMPTOMS
*Tobacco smoke	Cigarettes, cigars, pipes	Lung cancer, respiratory diseases, heart disease
*Formaldehyde	Carpet & wallpaper adhesives, furniture padding & upholstery, plywood, paneling, particle board, insulation	Irritation of skin, eyes, throat, sinuses, lungs, nausea, dizziness, lung cancer
*Radon-222	Radioactive soil & rock, water supply	Lung cancer
*Asbestos	Insulation, ceiling & floor tiles	Lung disease/cancer
Fiberglass	Insulation	Cancer
Carbon monoxide	Faulty/unvented stoves & furnaces, kerosene heaters/lanterns, wood stoves	Headache, drowsiness, brain damage, death
Molds	AC ducts, damp spots	Respiratory irritation, headaches
Styrene	Carpets, plastics	Kidney/liver damage, cancer
Benzo- -pyrene	Tobacco & wood smoke	Lung cancer
Tetrachloroethylene	Dry-cleaning fumes	Nerve, liver & kidney damage, cancer
Chloroform	Chlorine treated hot water	Cancer
1,1,1-trichloroethane	Aerosols	Dizziness, irregular breathing
Nitrogen oxides	Unvented/faulty gas, kerosene & wood heaters	Lung irritation, colds, headaches
Methylene chloride	Paint solvents	Nerve damage, diabetes

AIR: EXTENSION ACTIVITIES

1. Read *The Magic School Bus Inside a Hurricane* by Joanna Cole, Scholastic Inc., 1995. Write and illustrate your own children's book about some aspect of air pollution.
2. Design an air pollution unit for elementary students. Visit a classroom and lead an activity from your unit.
3. Visit a weather station or have a weather forecaster visit your classroom.
4. Build all of the apparatus necessary for a class weather station from the activities on pages 433-452 in the book *Science Is* by Susan Bosak, Scholastic Canada, 2000.
5. Trace a pollution molecule from its source through the atmosphere to a human lung.
6. Trace the path of radiation from the Chernobyl accident as it traveled from one area to another across Europe and beyond.
   http://www.tnrcc.state.tx.us/exec/sbea/tes/lessons99/path_pollution.html
7. See if you can pass an environmental quiz at http://www.epa.gov/omswww/quiz/. Make up your own quiz specifically for Arkansas or your area of Arkansas. Use this resource guide from the Arkansas Environmental Federation to help in designing the quiz:
   Arkansas and its Environment: A Status Report 2003. Download this report at www.environmentark.org/news.htm.
8. Evaluate the Clean Air Act of 1990. What are its major strengths and/or accomplishments, weaknesses and/or failures. The Plain English Guide to the Clean Air Act from the EPA. http://www.epa.gov/oar/oaqps/peg_caa/pegcaain.html
9. An international treaty dictates that the nation's chemical weapons stockpile, including blister and nerve agents, mustard gas, rockets and land mines, must be safely eliminated by 2007. Currently about 25% has been incinerated. States employing incineration are Oregon, Utah, Colorado, Arkansas and Alabama; those using neutralization are Kentucky, Indiana and Maryland. Research the disposal of chemical weapons through incineration to determine if it can occur without the risk of releasing harmful/deadly air emissions during burning. Have a class debate or role play situation with students representing environmental groups, the military, community activists, conservatives, medical personnel and others.
10. Compare earth's atmosphere with that of the other planets in the solar system. Why is it likely that only earth can support life as we define it?
11. Use a Moebius strip to show the endless nature of earth's cycles—air (oxygen-carbon dioxide), water, carbon, nitrogen, etc.
12. Compare and contrast normal surface winds with those that occur during the periodic climate shift known as El Nino. Describe ways El Nino could affect air pollution in a positive or a negative way.

AIR: REFERENCES AND RESOURCES

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St. Clair, Larry, Home Remedy for Earth, Discover, March '03

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Heck, W.W., The Use of Plants as Indicators of Air Pollution, Air, Water, Pollution International Journal 10:99-111, 1966

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Miller, G. Tyler Jr., *Living in the Environment: Principles, Connections and Solutions*, Wadsworth Publishing Co., 1998

Bosak, Susan V., *Science Is: A source book of fascinating facts, projects and activities*, Scholastic Canada, 2000

Arkansas and its Evironment: A Status Report 2003, Arkansas Environmental Federation, 1400 W. Markham, Ste. 250, Little Rock AR 72201, 501-374-0263; go to www.environmentark.org/new.htm to download a copy of this report.

AIR: WEB RESOURCES

Lichens: Life History & Ecology
http://www.ucmp.berkeley.edu/fungi/lichens/lichenlh.html
http://www.mgd.nacse.org/hypersql/lichenland/index.html

Forest Inventory and Analysis Program http://fia.fs.fed.us/lichen/

The Use of Plants as Bioindicators of Ozone http://www.rfl.psw.fs.fed.us/pubs/psw-gtr-164/fulltext/manning/manning.html

U.S. Environmental Protection Agency, Education & Outreach http://www.epa.gov

Access Excellence Activities Exchange http://www.accessexcellence.org

Easy Breathers classroom activities at http://www.easybreathers.org/teacher/classact.html

Lesson plans on the web at Lesson planet.
http://lessonplanet.teacherwebtools.com/search/science/environment/air_pollution/

Lesson plans from the Foundation for Clean Air Progress at
http://www.cleanairprogress.org/clean-air-pollution/air-pollution-lesson-plan.asp

How weather affects your life—can be accessed for each state.
http://www.weather.com/activities/health/airquality/?from=healfl

The Plain English Guide to the Clean Air Act from the EPA.
http://www.epa.gov/oar/oaqps/peg_caa/pegcaain.html

Ask Dr. Global Change offers a collection of answers to questions about global warming, ozone depletion, greenhouse gases and other climate change issues.
http://www.ed.gov/free/new.html

American Lung Association State of the Air, http://www.lungusa.org/air/

2003 Model Year Guide to Passenger Cars, emissions standards,
http://www.arb.ca.gov/msprog/ccbg/2003pc.htm