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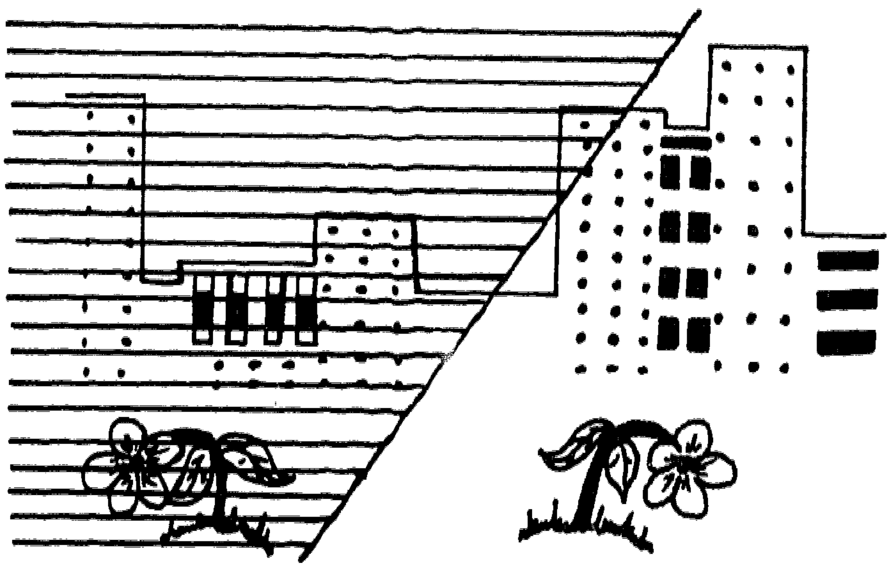
ABSTRACT

This is one of a series of units for environmental education developed by the Highline Public Schools. The unit on air pollution is designed for secondary school students in grades 7 through 12. There are five lessons in the unit; since some of the activities can take as long as 90 days, use of the materials needs to be carefully planned. Each lesson includes the concept of the lesson, materials needed, notes to the teacher, procedure, evaluative activities, and suggested additional activities. (RH)

THOMPSON PAK

AIR POLLUTION



WHAT YOU CAN & CAN'T SEE—

by Dennis W. Thompson

An Environmental Learning Experience for 7th-12th grade levels. One of many "ELE PAKS" available for all areas.

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BACKGROUND INFORMATION

AIR POLLUTION: man-made contamination of the outdoor atmosphere.

INVERSION: cool surface air trapped by a layer of warmer air.

AEROSOLS: tiny suspended solid or liquid particles found in polluted air.

PARTICULATES: particles of solid or liquid matter.

COMBUSTION: the chemical combination of certain substances with oxygen, the result being the production of energy.

HYDROCARBON: any of the many compounds of carbon and hydrogen, which are the elements that produce energy most readily.

PHOTOCHEMICAL SMOG: (Los Angeles type smog) the smog which results from the action of the sun on the emissions of the automobile.

Additional information on the above terms as well as the following lessons can be found in the following sources. Some of the sources have additional experiments on air pollution that can be performed, and are listed separately. If a more complete bibliography is needed than the following supplies, one can be obtained from the Educational Resources and Administrative Center of the Highline School District.

"Air Pollution Primer," National Tuberculosis and Respiratory Disease Association, New York, New York 1971.

"The Effects of Air Pollution," U. S. Department of Health, Education, and Welfare, Public Health Service, Washington, D.C. 20201, 1967. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price, 45¢.)

"The Sources of Air Pollution and Their Control," U.S. Department of Health, Education, and Welfare, Public Health Service, Washington, D.C. 20201, 1966. (For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price, 35¢.)

Those sources that have additional experiments on air pollution as well as additional information are:

Air Pollution Experiments for Junior and Senior High School Science Classes, second edition, Air Pollution Control Association, 4400 Fifth Avenue, Pittsburgh, Pennsylvania 15213, 1972. ($1.50 per copy)

Conserving Our Waters and Clearing the Air, American Petroleum Institute, 1801 K Street, N. W., Washington, D.C. 20006, 1968. (free of charge)

Investigating Air, Land, and Water Pollution, Diane Storin, Pawnee Publishing Co., Inc., One Pondfield Road, Bronxville, New York, 1971.

All of the above sources are available from the Educational Resources and Administration Center of the Highline School District.

CONCEPTUAL OVERVIEW OF UNIT

1. The sources and effects of ozone.
2. The sources and effects of oxides of nitrogen.
3. The sources and effects of particulates.
4. The sources and effects of carbon monoxide.
5. The causes and effects of temperature inversions.

NOTES TO THE TEACHER

You should let the students perform the experiments associated with each lesson. Not only does this free y our time, but it helps the students realize some of the aspects of setting up a scientific experiment. These students should also make a report to the class on their results at the conclusion of their experiments. You should note that all of these experiments have been performed, and no significant problems were encountered by the students; some of the results were negative, however, due to an insufficient amount of a specific pollutant in the area tested.

Since the time of exposure of the samples in some of the experiments runs as long as 90 days, planning of the experiments must be made well in advance. You might want to have the students give their reports on their experiments at the same time you discuss the topic in class; this would require even more planning, and you should give a brief description of the experiments to the students so they can select one and begin.

You should stress independent research on the areas of study before discussion of each lesson is held in class. Also, you should not limit yourself to the questions listed; these are to be considered as only basic questions to help initiate discussion. The students should be able to continue the discussion from their own research.

MASTER MATERIALS LIST

For complete details on the following materials along with suggested sources, see the appropriate lesson.

OZONE

1. rubber strips, ozone-sensitive
2. two (2) 5/8" medium binder clips
3. lead weight
4. bottle for unexposed rubber strips
5. small shelter box

OXIDES OF NITROGEN

1. AATCC Gas Fading Control Fabric---fastness to NO_x
2. cardboard frame for holding samples
3. contact adhesive
4. small shelter box
5. (optional) AATCC Fabric for Color Fastness to Ozone

PARTICULATES

1. Nylon Deterioration
   a. nylon hose
   b. Polaroid slide mounts #633
   c. frame for holding mounts
   d. slide projector with screen, or low power microscope or magnifying glass
2. Wind-Blown Particulates
   a. glass jar, 75mm dia. by 75mm high with screw-on lid
   b. stand to hold jar
   c. spray can of clear lacquer
   d. Fasson's Pli-A-Print R-135, with removable protective release liner M78
   e. photographic standard for particles per square inch
3. Lead in Auto Exhaust
   a. plastic bucket, 20 liter capacity
   b. hose, 5 meters, diameter to fit in or over auto exhaust
   c. hot plate
   d. beaker or other glass container
   e. Koslow Lead Trace Kit #1282

CARBON MONOXIDE

1. Eduquip Gas Sampling Kit for Carbon Monoxide

TEMPERATURE INVERSIONS

1. aquarium, approximately 60cm x 30cm x 30cm
2. styrofoam insulation to fit bottom of aquarium, 1cm thick
3. small air pump
4. two midget impingers, consisting of two small flasks, rubber stoppers and glass tubing- one with 50% NH_4OH and the other with 50% HCl.
5. tubing, 5mm inside diameter and 3 meters long
6. wash bottle with rubber stopper and glass tubing
7. infrared heat lamp, 150 watts
8. ring stand and swivel clamp to hold heat lamp
9. dry ice in sandwich-size plastic bags, tied with string

LESSON 1

CONCEPT: Ozone, a product of photochemical smog, can harm people, vegetation, fabrics, and rubber.

MATERIALS:

1. rubber strips, ozone-sensitive, Goodyear Specification No. 563-27303, same as supplied for U. S. Public Health Service order # 20374 of April 27, 1965 (order from local Goodyear District Sales Office or Goodyear Tire and Rubber Co., 1356 Tennessee Ave., Cincinnati, Ohio; mark for the attention of Mr. B. L. Mattingly at the Goodyear Los Angeles plant -- $1 per 9" x 9" sheet).
2. Two (2) 5/8" medium binder clips, such as IPKO #5 or IDL #50, available from any office supply store.
3. lead weight to attach to one binder clip; weight of lead and binder clip should be 375 grams.
4. bottle for unexposed rubber strips, approximately 65mm high by 19mm in diameter
5. a small shelter box, roughly a 20cm cube, with louveres to allow air to enter without exposing samples inside to strong sunlight, and with a hook on the ceiling from which to hang the rubber strips.

PROCEDURE:

1. The major components of photochemical or Los Angeles type smog are oxidizing by nature, and are called oxidants. Ozone is an early and continuing product of the photochemical smog reaction, and the presence of ozone in the air assures continuation of the oxidizing process. For these reasons, the term ozone is used almost interchangeably with the term oxidants.

   It seems strange, but ozone generators are available that are supposed to eliminate odors and germs from the air. But is has been shown that the ozone concentrations produced by such equipment must be so large to be efficient (around 10 to 20 ppm) that it also would be rapidly fatal to human beings.

2. *What is necessary for the formation of photochemical (of L.A. type) smog?*
   (sunlight and combustion products of organic fuels such as gasoline)

3. *How would you describe ozone?*
   a. color (colorless)
   b. odor (pungent)
   c. formula (O_3, an allotropic form of oxygen)

4. *What are some of the effects of ozone?*
   a. fabrics (damages fibers and discolors dyes)
   b. rubber (accelerates its cracking and checking)
   c. vegetation (damages leaves on at least 57 different species of leafy vegetables, field and forage crops, shrubs, and fruit and forest trees)

d. people (severely irritates mucous membranes, produces coughing, choking, headaches and severe fatigue, and at high levels can interfere with lung functions during exposure and after)

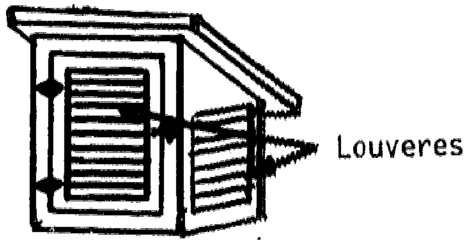
5. *What is the legal maximum allowable ozone concentration that a worker can be exposed to over an eight-hour period?* (0.1 ppm)

6. *What are some natural sources (that is not man-made) of ozone?*
(solar radiation and lightning)

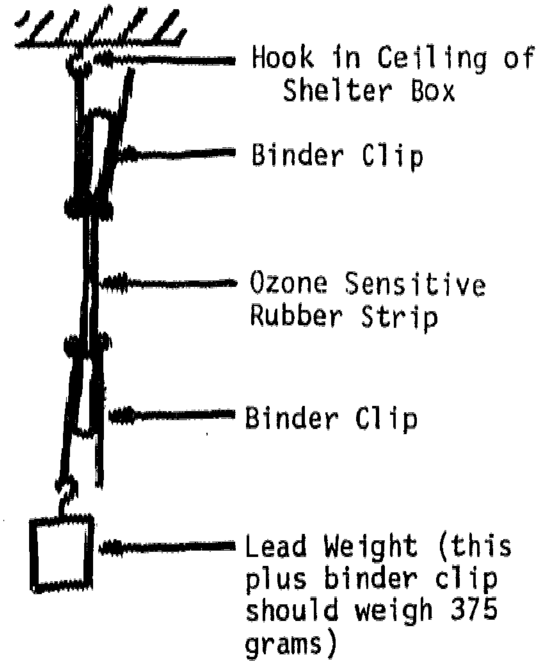
7. *Let's study one of the effects of ozone - that of its accelerating the cracking and checking of rubber.*

CRACKING OF RUBBER BY OZONE

a. Place the shelter box at a convenient, safe, and unobstructed spot, such as the roof of your school; it should be placed on a box or other support to keep it about 3/4 to 1 meter off of any surface.
b. Cut the rubber sheet into strips 8mm x 50mm; place the strips in the bottle to protect them from exposure to ozone.
c. Remove one strip from the bottle and attach a binder clip, gripping the rubber 5mm from one end; hang the clip on the hook in the ceiling of the shelter.
d. Attach the other binder clip, again gripping the rubber 5mm from the end; hang the lead weight on the lower clip, putting the rubber between the clips under tension.
e. After 7 days of exposure to atmosphere passing through the shelter, remove the rubber strip and examine it, while under tension, for degree of cracking or checking; if exposure of 7 days is not sufficient to cause noticeable cracking or other degradation, the period of exposure should be extended.
f. At the end of the exposure period, remove the rubber strip and remove the clips from the strip; cut the strip longitudinally through the middle; place it under a 50 power microscope with a precalibrated eyepiece, and view the freshly cut edge; measure nine cracks, excliding any cracks within 10mm from either end, and report their average depth.



SHELTER BOX



EVALUATIVE ACTIVITY: Write a report on the rubber deterioration experiment including procedures, results, and conclusions.

SUGGESTED EXTRA ACTIVITIES: Perform the rubber deterioration experiment using the following variables:

a. expose the rubber strips at different times of the year;
b. expose the rubber strips at different locations at the same time;
c. compare commercial rubber strips to the special rubber strips from Goodyear used in the above experiment.

LESSON 2

CONCEPT: Nitric oxide, a relatively harmless product of burning fuels at high temperatures, can convert to nitrogen dioxide, especially when subjected to conditions that also form photochemical smog.

MATERIALS:

1. American Association of Textile Chemists and Colorists (AATCC) Gas Fading Control Fabric---fastness to oxides of nitrogen (available from Test Fabrics, Inc., 55 Vandam Street, N.Y., N.Y. 10013---two 2" x 10 yd. rolls for $5.00)
2. cardboard frame for holding samples
3. contact adhesive for attaching samples to frames
4. small shelter box, similar to that for ozone deterioration of rubber experiment
5. (optional) AATCC Fabric for Color Fastness to Ozone (available from Test Fabrics, Inc., same address as above--two 2" x 10 yd. rolls for $7.50)

PROCEDURE:

1. *There are a number of oxides of nitrogen (NO_x), but the ones we are most interested in are nitric oxide and nitrogen dioxide.*

2. *What are the properties of these two gases?*

		Nitric Oxide	Nitrogen Dioxide
a.	color	colorless	yellow-brown
b.	odor	not known	pungent, sweetish
c.	formula	NO	NO_2
d.	toxicity	slightly	considerably

3. *How are the gases formed?*
   a. NO (combustion at high temperature such as in efficient combustion processes or processes at high pressures, i.e. automobile engines or electric power plants)
   b. NO_2 (as a by-produce of industry -- fertilizer, explosives, etc. -- or by oxidation of NO to NO_2 -- this occurs rapidly when high concentrations of NO occur in the air or when low concentrations are present with hydrocarbons and sunlight -- photochemical smog conditions)

4. *What are some of the effects of NO_2?*
   a. animals (harmful to lungs, decreases oxygen-carrying capacity of bloodstream, increases susceptibility to infection in lab experiments)
   b. vegetation (causes visible harm and inhibits growth)
   c. water (forms nitric acid; one possible reaction is: $H_2O + 3NO_2 \rightarrow 2HNO_3 + NO$)
   d. fabrics (discolors dyes)

5. *What are the major sources of oxides of nitrogen?*

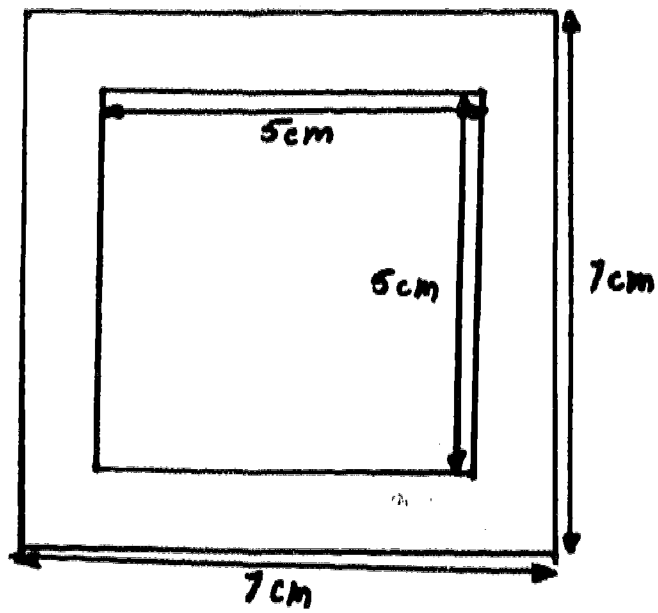
a. power plants and space heating	10.0 million	tons/year	nationwide		
b. transportation	8.1	"	"	"	"
c. solid waste disposal	0.6	"	"	"	"
d. industrial processes	0.2	"	"	"	"

6. *How can production of nitrogen oxides be controlled?* (stationary sources - careful adjustment of flame and stack gas temperatures; automobiles - control is more difficult because reducing other pollutants can increase the output of nitrogen oxides)

7. *We will now perform an experiment to show the effects of NO_2 on dyed fabrics. (optional) Along with this we will run samples to determine the affects of ozone, which we discussed before, on other fabric samples.*

EFFECT OF NITROGEN DIOXIDE
ON DYED FABRICS

a. Make a mount for each fabric sample by cutting a 5cm square window out of a 7cm square piece of cardboard.
b. Place a 7cm square sample of fabric to be tested over the window, and fasten the four sides to the cardboard with the contact adhesive; make sure to mark the samples for later identification.
c. Punch a small hole in one corner of the cardboard frame, tie a length of string to the frame using the hole, and tie the other end of the string to a thumbtack or hook placed on the ceiling of the shelter; the mounted fabric should be hung to prevent strong sunlight from striking it.
d. After 90 days, remove the fabric samples and compare their color brightness with samples that have been sealed and stored to prevent exposure.
e. If a color-difference meter is available, its use would give quantitative results; such a meter is a photoelectric color instrument which measures incandescent light reflected at 45 degrees from the cloth sample; different fabric panels are measured for light reflectance through red, green, yellow, and blue filters before and after exposure to obtain a total color difference.



FRAME FOR FABRIC SAMPLES

EVALUATIVE ACTIVITY: Write a report on the dyed fabric experiment including materials, procedures, results, and conclusions.

SUGGESTED EXTRA ACTIVITIES: Repeat the dyed fabric experiment using the following variables

LESSON 3

CONCEPT: Particulates are small solid and liquid matter which remain suspended in air until removed by natural phenomena.

MATERIALS:

1. Nylon Deterioration
   a. good quality (15 denier) nylon hose
   b. standard Polaroid slide mounts #633, size 3¼" x 4" (available from local camera store)
   c. frame for holding mounted nylon to permit air to contact both sides of the nylon
   d. slide projector with screen, or low power microscope or magnifying glass
2. Wind-Blown Particulates
   a. glass jar, approximately 75mm in diameter by 75mm high with metal or plastic screw-on lid (#4378-30 bottle, solid, storage, extra-wide mouth, threaded neck, flint glass, short form, available for local laboratory)
   b. stand to hold jar, see accompanying sketch (can be made in school shop)
   c. spray can of clear lacquer (Jap-A-Lac 4010 clear acrylic, or equivalent)
   d. Fasson's Pli-A-Print R-135 adhesive paper, with removable protective release liner M78 (obtainable from Fasson Products Division of Avery Paper Co., 250 Chester St., Painesville, Ohio)
   e. photographic standard for particles per square inch, obtainable from Technical Associates for Industry, Inc., P. O. Box 116, Park Ridge, New Jersey 07656
3. Lead in Auto Exhaust
   a. pail or bucket, plastic, approximately 20 liter capacity
   b. hose rubber of plastic, approximately 5 meters long and with a diameter appropriate to make a tight fit in or over the automobile tailpipe
   c. hot plate, to concentrate the sample
   d. large beaker or other glass container, to concentrate the sample
   e. Koslow Lead Trace Kit #1282 (available from Koslow Scientific Co., 7800 River Road, North Bergen, N.J. 07047)

PROCEDURE:

1. *Particulates are small solid and liquid matter that remain suspended in air until removal by natural phenomena. Some common names for particulates are fume, dust, smoke, aerosols, and mist. One of the most publicized specific particulates is lead; we will be discussing this pollutant in depth later.*

2. *How big are particulates?*
   (from 0.001 microns -- 1 micron equals 1/1,000 of a millimeter or 1/25,000 of an inch -- to around 100 microns)

3. *What are the sources of particulates?*

a.	power plants and space heating	8.9 million tons/year nationwide
b.	industrial processes	7.5 " " " "
c.	transportation	1.2 " " " "
d.	solid waste disposal	1.1 " " " "

4. *What are the amounts in certain cities?*
(During winter, Kansas City produces 67 tons per square mile per month, New York City produces 335 tons per day; in Los Angeles, cars produce 40 tons of aerosols per day.)

5. *What are some of the affects of particulates?*
   a. weather (act as nuclei on which vapor can condense thereby increasing and/or prolonging fog, ground mist, or rain; can absorb radiant energy and heat surrounding gases that are incapable of absorbing the energy -- this could lessen the amount of heat reaching the earth; this could be caused by high flying jets.)
   b. catalysts (iron oxides aid in the changing of sulfur dioxide into sulfuric acid)
   c. people (harmful chemicals, normally dissolved in the mucous membranes, can be carried deep into the lungs to unprotected tissue by particulates)
   d. Of course there are specific particulates that are well known detriments to health -- arsenic, lead, mercury, asbestos, cadmium, beryllium, and others.

6. *What are some methods for removing particulates from exhaust gases?*
(filtering, washing, centrifugal separation or cyclones, and electrostatic precipitators)

7. *What are some of the costs associated with damages caused by particulates?*
   a. commercial laundering, cleaning, and dyeing of fabrics soiled by air pollution costs about $800 million
   b. washing cars dirtied by air pollution costs about $240 million.

8. *What is the largest source of lead particulates?*
(tetraethyl lead used to make higher octane gasoline; over 310,000 tons of lead is given off each year; in Chicago, 2 3/4 tons of lead fall on each square mile)

9. *How does lead enter the body?*
(about 10% of ingested lead is absorbed into the blood stream; from 25 to 50% of inhaled lead is absorbed into the blood stream)

10. *How much lead is present in many of our bloodstreams?*
(about 0.25 ppm; classical lead poisoning is considered to occur when the lead level reaches 0.5 to 0.8 ppm)

11. *We will now do three experiments that show the amount of particulates present, from what direction they come, and how they affect nylon.*

NYLON DETERIORATION

(1) Cut a square piece of nylon hose of sufficient size for the Polaroid slide mount.
(2) Apply adhesive to the two halves of the mount, stretch the nylon over one half, and place the other half of the mount on top.
(3) Place the mounted nylon in a holder in an unobstructed and safe place so that the nylon is held in a horizontal position.
(4) Expose one nylon sample for 30 days and a second sample for 90 days.
(5) At the end of the exposure period, examine each sample for broken threads by either projecting the mounted sample on a screen or examining the sample with a low power microscope or magnifying glass.
(6) Use a similar sample stored inside for the same period as a control for comparison.

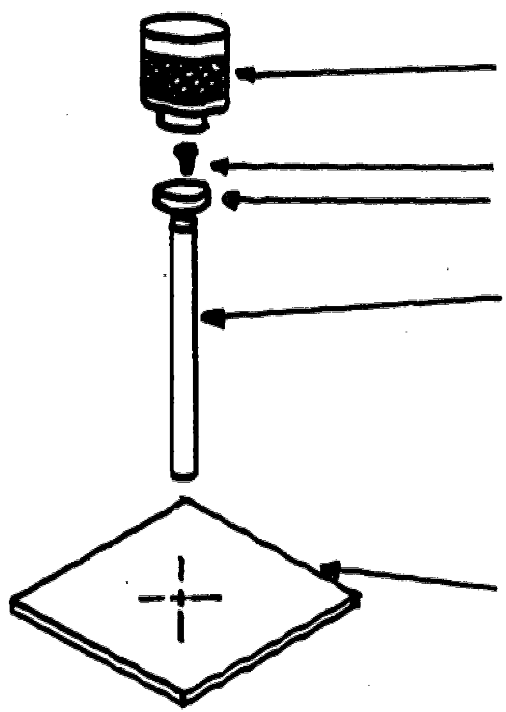
EVALUATIVE ACTIVITY: Write a report on the above experiment including materials, procedures, results, and conclusions.

SUGGESTED EXTRA ACTIVITIES: Perform the nylon deterioration experiment near a source of high particulate density, such as a heavily traveled road, an airport, a burning trash dump, etc.

WIND-BLOWN PARTICULATES

(1) Cut the adhesive paper into 5cm x 25cm strips.
(2) Set up the stand for holding the glass jar on a flat and safe area, such as your school roof; make sure to place it as far away from obstructions as possible to allow a clear path from all directions.
(3) Fasten one end of the strip of sticky paper to the jar with a small piece of cellophane tape, wrap the paper around the jar, remove the release liner to expose the sticky surface, and overlap the ends of the paper so they stick together and hold the paper in position on the jar.
(4) Screw the jar onto the holder and mark the paper to indicate the side facing North; expose the paper for seven days.
(5) Spray the paper with clear lacquer to fix the particles collected and to avoid having additional particles adhere to the paper.

(6) Take the exposed paper to the lab and divide the sample into the eight principal parts of the compass, marking the proper compass point on each part of the sample.
(7) Compare each part with the photographic standard; estimate the number of particles per square inch from each direction.



Stand for Wind-Blown Particulates Experiment

EVALUATIVE ACTIVITY: Write a report on the above experiment including materials, procedures, results, and conclusions.

SUGGESTED EXTRA ACTIVITIES: Perform the wind-blown particulates experiment near a source of high particulate density and considering the prevalent winds.

LEAD IN AUTO EXHAUST

(1) NOTE: The collection of the lead from the auto exhaust involves an idling engine: the collecting should be performed outside to avoid possible carbon monoxide poisoning.
(2) Attach the hose to the tailpipe of the car while it is cold; make sure the hose forms an airtight seal (the car should have normal---that is leaded---gas in its tank).

(3) Start the engine and let it idle until it reaches operating temperature.
(4) Pour approximately 12 liters of clean water (preferably distilled or deionized) into a clean bucket or pail.
(5) Insert the end of the hose in the water, and let the exhaust gases from the idling engine bubble through the water for 15 to 30 minutes, keep careful track of the time.
(6) Remove the hose from the water, and turn off the engine.
(7) Pour part of the water in the beaker placed on the hot plate, and boil the volume down to around 200cc; add more water and continue the boiling until only about 200cc of the original 12 liters of water remain.
(8) Rinse the bucket with clean water, and pour the rinse water into the beaker; repeat the rinse procedure one more time.
(9) Follow the instructions included with the Koslow Lead Trace Kit to determine the total amount of lead in the water.

EVALUATIVE ACTIVITY: Write a report on the above experiment including materials, procedures, results, and conclusions.

SUGGESTED EXTRA ACTIVITIES: Perform the lead in auto exhaust experiment using the same car but with unleaded or low-lead gasoline; perform the experiment while the car is warming up.

LESSON 4

CONCEPT: Carbon monoxide levels in traffic are often great enough to cause fatigue, headaches, confusion, and dizziness.

MATERIALS: Eduquip Gas Sampling Kit for Carbon Monoxide (available from Eduquip Inc., 1220 Adams Street, Boston, Massachusetts 02124)

PROCEDURE:

1. *We know that carbon monoxide can be fatal in high concentrations; 1000 ppm can produce unconsciousness in 1 hour and death in 4 hours. But most studies by air pollution scientists are concerned with long term effects of lesser concentrations of carbon monoxide. For example, the level of CO inside a car in heavy traffic on a multilane highway will be about 25 to 50 ppm; the concentration in tunnels can exceed 100 ppm.*

2. *What are some of the effects of contact with low level concentrations (100 ppm) or carbon monoxide?*
   (fatigue, headaches, confusion, and dizziness)

3. *What are the properties of carbon monoxide?*
   a. color (colorless)
   b. odor (odorless)
   c. formula (CO)
   d. toxicity (kills quickly at high concentrations)

4. *What process produces CO?*
   (the incomplete combustion of any carbon material)

5. *What are the prime sources of CO?*

a. transportation	63.8	million	tons/year	nationwide	
b. industrial processes	9.7	"	"	"	"
c. solid waste disposal	7.8	"	"	"	"
d. power plants and space heating	1.9	"	"	"	"

6. *How can CO be eliminated?*
   (by making combustion processes more complete, such as external combustion and gas turbine power sources which utilize an excess of air; devices on internal combustion engines that oxidize the CO to CO_2 before being released to the atmosphere)

7. *We will now perform an experiment to measure the concentration of carbon monoxide in the air.*

CARBON MONOXIDE IN AIR

(a) Carefully break both ends off of a detector tube using a pair of needle nose pliers or scissors; be careful not to cut yourself on the broken tips.
(b) Place one end of the detector tube into the rubber bushing (stopper) and insert the syringe tip into the other end of the bushing.

(c) Place the tube tip into the environment to be sampled, and pull the syringe plunger back slowly to the 25cc mark (take approximately 15 seconds to pull the plunger back)

(d) If color change occurs, repeat step c. three more times.

(e) Compare the color change with the chart enclosed with the tubes; if only 25cc of gas were analyzed, multiply the observed concentration by four; if 100cc of gas were analyzed, use the observed concentration as read directly off the chart.

(f) If no color change occurs even after step c, has been performed four times, refer to the instructions supplied with the tubes for additional procedures.

EVALUATIVE ACTIVITY: Write a report on the carbon monoxide experiment including materials, procedures, results, and conclusions.

SUGGESTED EXTRA ACTIVITIES: Perform the carbon monoxide experiment in a number of locations, such as:

1. the exhaust of an idling automobile
2. the exhaust of a cigarette
3. near a burning source
4. near the boiler smokestack of the school
5. near a heavily travelled street during rush hour.

LESSON 5

CONCEPT: Air-trapping inversions form easily and trap ever increasing quantities of pollutants.

MATERIALS:

1. aquarium, or similar glass or plastic enclosure, approximately 60cm long by 30cm wide by 30cm high
2. sheet of styrofoam insulation, approximately 1cm thick, cut to fit the bottom of the aquarium
3. small pump to propel smoke
4. source of smoke, such as an ammonium chloride generator -- made from the pump above and two midget impingers, one of which contains approximately 50% ammonium hydroxide, and the other of which contains approximately 50% hydrochloric acid; the rate of air flow is adjusted by means of pinch cocks on the air tubing from the pump (see sketch)
5. rubber of plastic tubing, approximately 5mm inside diameter, about 3 meters are needed
6. wash bottle to prevent HCl and NH_4OH from backing up into the pump (see sketch)
7. infrared heat lamp, 150 watts
8. ring stand and swivel clamp to hold and position the lamp
9. dry ice placed in plastic bags (sandwich size) and tied with strings.

PROCEDURE:

1. *Weather plays an important part in air pollution since meteorological conditions can affect the dispersion of air pollutants. On a few days a year, strong winde may disperse even the heaviest layer of pollution. But on other days, weak winds and highly stable conditions allow small quantities of pollutants to accumulate to serious proportions.*

2. *What normally happens to air temperature with an increase in altitude?*
   (because pressure decreases, temperature also decreases at the rate of 1°C for every 100m, of 5.4°F for every 1,000 ft.; this is called the adiabatic lapse rate)

3. *What will happen when the actual lapse rate is greater than the adiabatic lapse rate -- that is, when the decrease in temperature is* ***greater*** *that 1°C for every 100m?*
   (The air will begin to rise, and the atmosphere condition is said to be unstable)

4. *What will happen when the actual lapse rate is less than the adiabatic lapse rate -- or the decrease is* ***less*** *that 1°C for every 100m?*
   (the surface air remains near the surface, and the condition is said to be stable)

5. *When the conditions exist where the decrease in temperature with an increase in altitude does not occur, then a temperature inversion occurs.*

6. *One type of inversion, called a subsidence inversion, occurs when a high-pressure air mass sinks down upon an area. What happens to the bottom layers of air during this sinking?*
(They are compressed, and therefore increase in temperature)
If the ground air does not increase in temperature, an inversion occurs. This is a common occurance of the western coast of the U. S. for some 340 days each year.

7. *Another type of inversion, called a radiation inversion, is a normal night time formation. On clear nights, the ground radiates heat quickly and cools. How would the surface air temperature compare to the temperature of air at a higher altitude?*
(the surface air would be cooler)
A temperature inversion occurs, but it should become unstable when the morning sun heats the ground again.

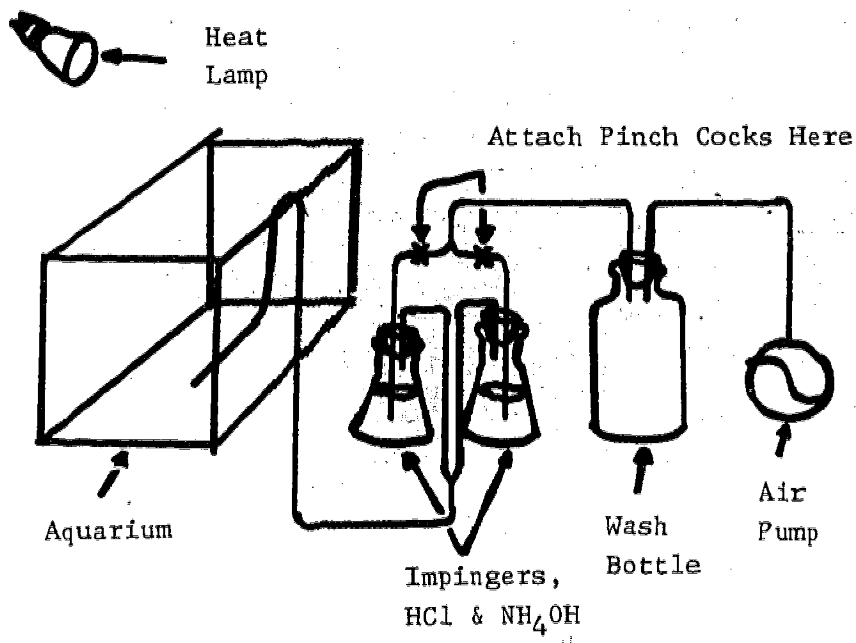
8. *Topography can add to the effects of inversions. Consider a valley: what happens to the cool air formed on the sides of the mountains at night?*
(it flows down into the valley)
If warm air exists at higher elevation, is the condition stable or unstable?
(stable, and an inversion occurs)

9. *We're now prepared to do the following experiment on temperature inversions.*

TEMPERATURE INVERSION MODEL

a. Set up the apparatus as shown in the sketch; place the styrofoam insulation in the bottom of the aquarium, and distribute the bags of dry ice to cool the air in the bottom of the aquarium -- run the strings from the bags of dry ice over the sides of the aquarium.
b. Start the air pump and adjust the pinch cocks to the impinger to produce smoke in the bottom of the aquarium.
c. As soon as the bottom of the aquarium becomes filled with smoke, turn off the air pump; this condition represents a radiation inversion.
d. Now slowly remove the bags of dry ice using the attached strings, trying not to disturb the air in the aquarium.

e. Turn on the heat lamp and direct it to the bottom of the aquarium; this represents the sun's warming of the earth that aids in the break-up of the radiation inversion.



EVALUATIVE ACTIVITY: Write a report on the temperature inversion experiment including materials, procedures, results, and conclusions.

SUGGESTED EXTRA ACTIVITIES: Perform the experiment "Temperature Inversion in a Populated Valley" from Air Pollution Experiments for Junior and Senior High School Science Classes to observe the additional effects that a valley places on a radiation inversion.