Educational Activities
6th Grade – 8th Grade

Objective:
To help students develop an understanding and interest in air, and its properties. These lessons cover the Michigan Educational Assessment Program (MEAP) objectives in science, mathematics, language and writing.

The West Michigan Clean Air Coalition, in efforts to expand the public education campaign, would like to thank the Clean Air Coalition of Southeast Michigan for the permission to use their packet and adapt it to the needs of West Michigan. The Coalition would also like to thank the individuals or organizations that contributed to the development of the public education campaign.

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What is Ozone? Why is it important?

Objectives
To help students develop an interest in and understanding of air, its properties and the way it is used and impacted by individuals. With these activities, students can study the makeup of the atmosphere; learn about the main gases in the atmosphere and the molecular structure of some of the chemicals that pollute it. The activities focus on the role of naturally occurring ozone (O_3) in the stratosphere as a necessity for the protection of public health and, in the troposphere, as the primary component of urban air pollution. Targeted mainly at science in the classroom, cross-curricular extensions expand the educational impact.

Background information
Our planet is surrounded by a sea of gases we call the atmosphere. We breathe these gases into our bodies over 22,000 times a day. Our atmosphere is made up of 78 percent nitrogen, 21 percent oxygen and a one percent mixture of carbon dioxide, water vapor and other gases. One of these other gases is ozone.

Ozone in the stratosphere is good, protecting us from the sun's harmful ultraviolet rays. Ozone (O_3) is a natural forming gas, formed when molecular oxygen (O_2) combines with a single atom of oxygen (O).

Ozone in the troposphere, where we breathe, is harmful to our health. This is the ozone targeted by the Ozone Action! program. Ground-level ozone is formed when hydrocarbons and nitrogen oxides from emissions (such as from industry, cars, trucks and buses) react with sunlight. The pollution cooks like a soup on hot (temps above the mid-80s), windless days with little cloud cover. At ground-level, ozone can cause lung damage, eye irritation, respiratory tract problems and can damage vegetation.

Weather
Weather - meaning temperature, precipitation and air mass movements- varies daily. Changing weather conditions affect our air quality. When air masses shift, they move air pollutants from one location to another. Stagnant air, conversely, can result in increased concentrations of harmful pollutants. Though precipitation washes pollutants from the air and onto the ground, it often creates land and surface water pollution.

In West Michigan, ozone levels are monitored in several stations throughout the region to make sure that the region continues to meet federal health standards for ground-level ozone. When ozone levels are recorded over the standard, it is called an *exceedance*. On *Ozone Action!* days we all can help minimize ozone formation by voluntarily reducing the amount of hydrocarbons emissions we put into the air. Your *Ozone Action*! tip sheet contains the most helpful Actions! for keeping air clean.

By learning how ozone is formed and how we all contribute to its production, we can begin to think about how to stop this pollution problem. Learning how to keep our air clean is a valuable lesson for today and the future.

Michigan science objectives covered by this activity:

Constructing new scientific knowledge
Students will be able to:

- Generate scientific questions about the work based on observation.
- Design and conduct simple investigations.
- Use various sources of information for problem solving.
- Write and follow procedures in the form of step-by-step instructions, recipes, formulas, flow diagrams, and sketches.

Reflecting on scientific knowledge
Students will:

- Evaluate the strengths and weaknesses of claims, arguments or data.
- Describe limitations in personal knowledge.
- Show how common themes of science, mathematics and technology apply a world context.
- Describe the advantages and risks of new technology.

Using scientific knowledge
Students will:

- Classify substances as elements, compounds or mixtures.
- Describe matter as consisting of extremely small particles (atoms) that bond together to form molecules.
- Describe how waste products accumulating from natural and technological activity create pollution.

Understanding atmosphere and weather
Students will understand:

- Air as a substance,
- Weather warnings – *Ozone Action!*
- Cloud formation and how various types of clouds contribute to ozone pollution and how patterns of air movement in the atmosphere affect weather conditions.

Teachers Resource Page

Are your students curious about air quality in West Michigan? Have they noticed that sometimes the meteorologists on local weather stations talk about *Ozone Action!* days? Do they know the difference between "good" ozone and "bad" ozone? Do they know what to do on an *Ozone Action!* day?

To help answer these and many more questions, the West Michigan Clean Air Coalition has prepared this website guide for you to find lots of information about ozone. Here is a word on "good" and "bad" ozone...

The chemical structure of ozone is O_3 as compared to oxygen which is O_2. The additional oxygen atom makes ozone very reactive which is good in the upper atmosphere (the ozone layer) but harmful in the lower atmosphere (a component of smog). Ozone is produced through complex photochemical reactions involving natural atmospheric gases, volatile organic compounds (VOCs), nitrogen oxides and sunlight. Hot days can accelerate these reactions. Elevated levels of ground-level ozone make breathing more difficult – especially for people with respiratory problems. It can also damage vegetation and materials.

The *Ozone Action!* Program informs people when elevated ground-level ozone values are anticipated and it offers tips for reducing ozone formation. Since vehicle exhaust and gasoline vapor contribute to the chemical mix, many of the "clean air" tips involve reducing emissions from cars and equipment such as gasoline powered lawn mowers.

Here are some of the great resources available on ground-level ozone:

West Michigan Clean Air Coalition
http://www.wmcac.org/
A group of concerned businesses, educational institutions, non-profit organizations, and government agencies are spreading the word about the West Michigan ozone problem. This site has specific information on when West Michigan *Ozone Action!* days occur, a list of tips for *Ozone Action!* days, and free materials.

Clean Air Coalition of Southeast Michigan
http://www.semcog.org/Services/OzoneAction/index.htm
Check out the fantastic teacher resources at this site. You are going to want the Spatially Plotted Ozone Tracking System (S.P.O.T.S) program for your computer and there are excellent downloadable lessons complete with grade appropriate lessons. Material was specifically developed (by educators) to tie in with Michigan math and science goals and objectives and MEAP science proficiency standards. Don't miss this one!

Would you like maps that show ozone levels and where the *Ozone Action*! days are happening?

- Take a look at the **U.S. Environmental Protection Agency Region 5** website at: http://www.epa.gov/docs/reg5oair/ozoneday/ozoneday.htm for regional information and links to ozone action day programs.

- The **Michigan Department of Environmental Quality** http://www.deq.state.mi.us/aqi/ozone.shtml provides hour-by-hour ozone readings at selected sites on *Ozone Action*! days and information about air quality in Michigan.

- Also, the **National Weather Service** in Grand Rapids has an interesting site. http://www.crh.noaa.gov/grr/main/weather/current/index_current.html

- One of the best national sites is **AIRNow** at http://www.epa.gov/airnow/ that has information on the Air Quality Index, ozone maps and animation, air quality forecasts, a kid's page, and facts about health issues. This site offers students the opportunity to compare air quality with meteorological events on a national scale.

Some other fun sites with games, activities, and fact sheets include:

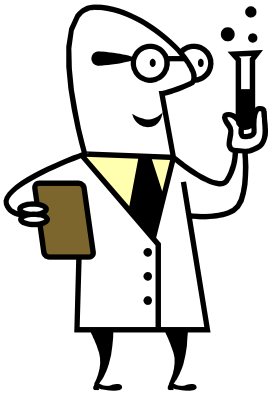
Southeast Texas Regional Planning Commission
http://www.ozoneactionday.org/ozone.asp

Houston-Galveston Area Council
http://www.cleanairaction.org/education/education.html

Air & Waste Management Association
The A&WMA West Michigan Chapter offers teacher workshops and can provide Air Quality Resource Guides upon request.
http://www.wmawma.org/ and
http://www.awma.org/resources/education/ozone.pdf

Many other Internet websites provide information and activities that can help you teach your students about *Ozone Action!* If you find some good links, e-mail the West Michigan CAC at: cleanair@wmcac.org and we can add them to our list. Let us know if you would like to request an *Ozone Action!* speaker to come to your classroom or if we can help you with other resources.

Looking at Data
Lab



Looking at Data

Overview

Understanding the causes of pollution – from industrial to natural sources – can be challenging to students. Studying the atmosphere, urban life and weather helps to put things in perspective, providing opportunities for education in science, math and environment.

Time

Two Class Periods

Materials

- Handout/overhead: Looking at Data: Monitoring Network
- Handout/overhead: Looking at Data: Monitoring Data

Objectives

Participating in this activity, students will be able to:

- Read and interpret collected data.
- Explain the human impact on air quality.
- Identify significant sources of pollution.
- Explain how weather and time of day contribute to the formation of ground-level ozone.

Procedure

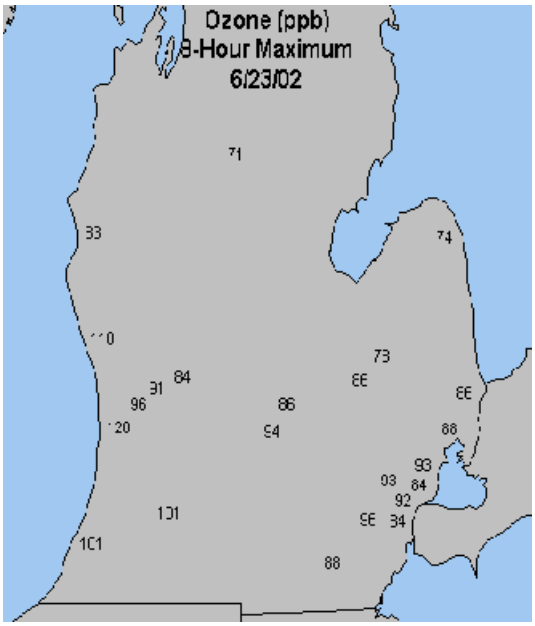
1. Have a class discussion about ozone and the effects on the health, and the environment.

2. Talk to the class about the *Ozone Action*! program and how choices that people make that can contribute to ground level ozone.

3. Distribute the Monitoring Network worksheet. The picture on the left indicates where all the monitors are in Michigan. The pictures on the right indicate the highest eight hour levels that were recorded on June 23, 2002. Have the students answer the questions and then discuss with the whole class. For current ozone levels go to http://www.deq.state.mi.us/aqi/ozone.shtml .

4. Distribute the Monitoring Data worksheet. This sheet shows the ozone levels at different times throughout the day. Have the students answer the questions and then discuss them with the whole class. For current ozone levels go to http://www.deq.state.mi.us/aqi/ozone.shtml .

Looking at Data: Monitoring Network



Questions

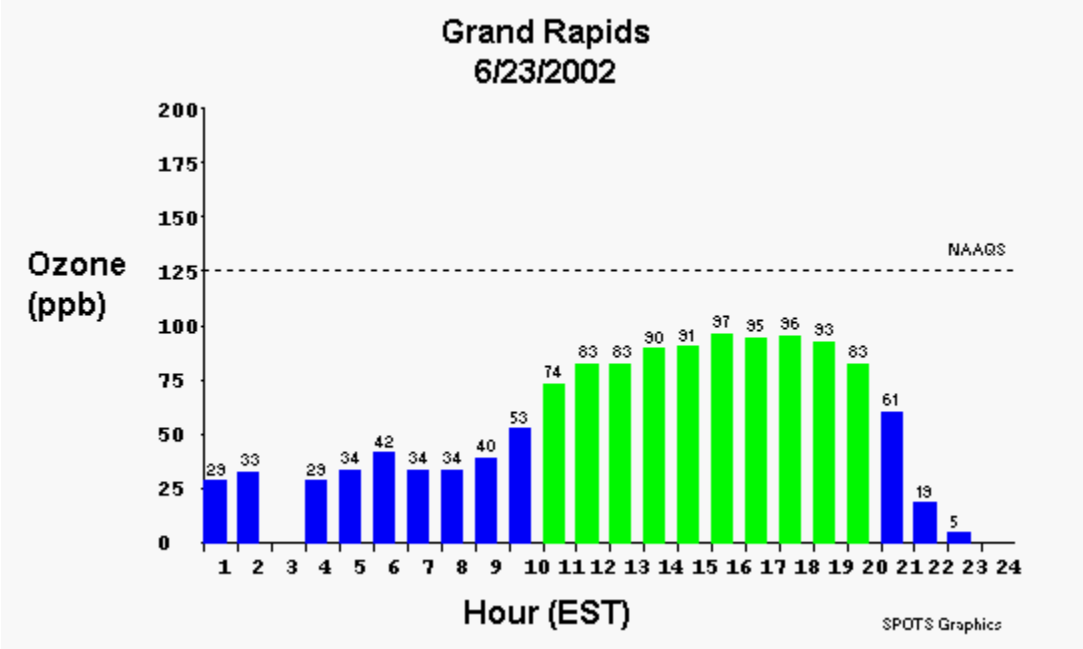
1. What monitor recorded the highest ozone levels?

2. According to the Air Quality Index for ozone what category would the highest monitor fall into (Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy)? Generally, an AQI of 100 for ozone corresponds to an ozone level of 0.08 parts per million

3. What monitor recorded the lowest ozone levels?

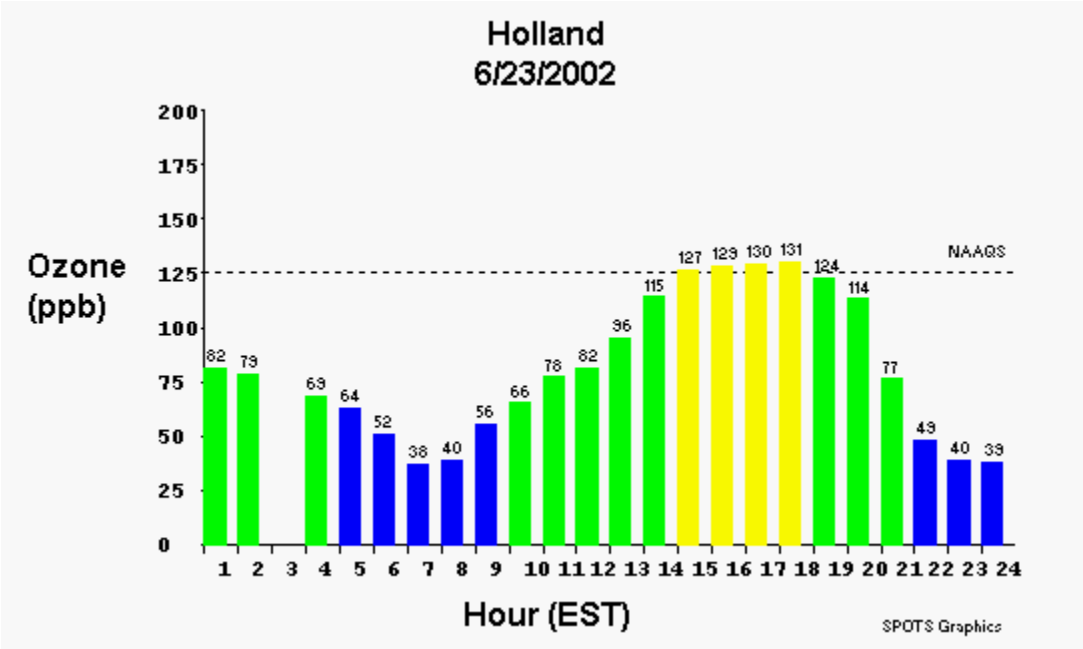
4. According to the Air Quality Index, what category would the lowest monitor fall into (Good, Moderate, Unhealthy for Sensitive Groups, Unhealthy, Very Unhealthy)?

Looking at Data: Monitoring Data



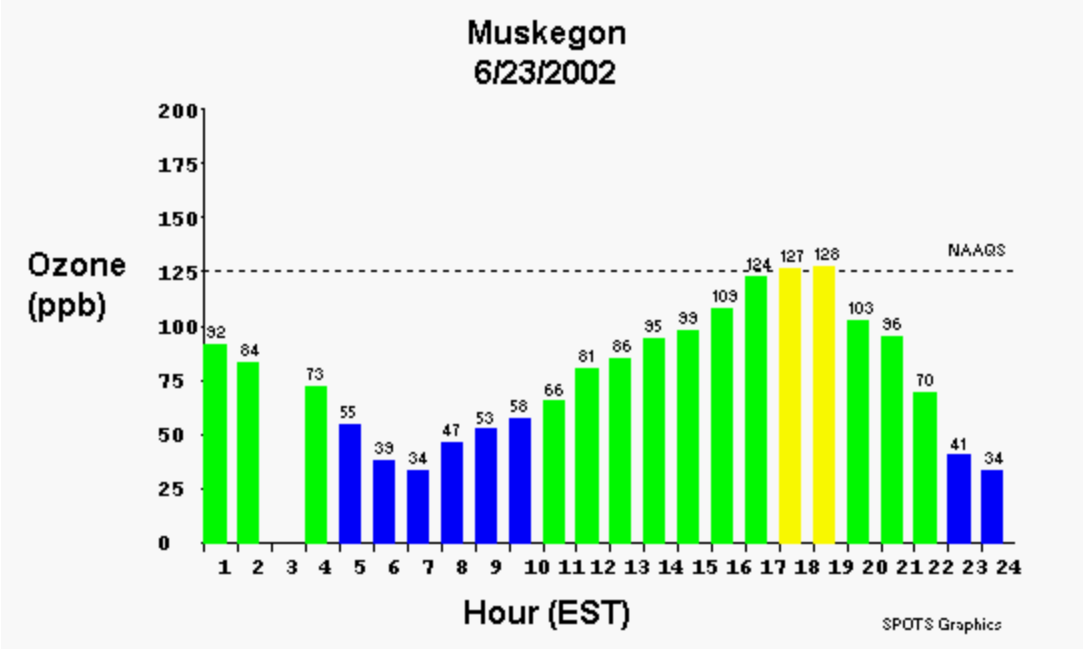
1. At 2:00a.m., what was the ozone level?

2. Why do ozone levels get higher in the afternoon?



1. What was the highest recorded value at the Holland monitor?

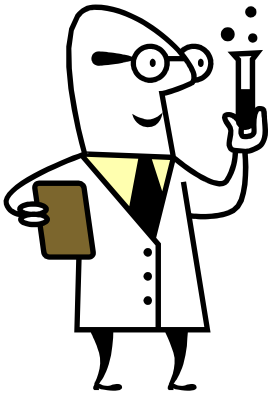
2. Why do the ozone levels go down in the evening?



1. At what time did the Muskegon monitor record its highest reading?

2. What others things are happening at this time that may contribute to higher ozone levels?

Oxygen and Ozone Lab



Looking at Data

Overview

This activity allows students to look at the chemistry of ozone in the upper atmosphere (stratosphere) and ozone formation at ground-level, while learning the difference between good/bad ozone, and the chemical process of its formation.

Time

Two Class Periods

Objectives

Students will be able to:

- Distinguish between ozone in the troposphere and ozone in the stratosphere.
- Describe the chemical make up of ozone.
- Identify the two main pollutants that form ozone and identify their sources.
- Explain the health effects of ground-level ozone.
- Describe the weather conditions that contribute to elevated levels of ozone in the troposphere.

Procedure

1. Provide background information to students (see page 15).
2. Invite them to answer questions (provided on page 16) and to do research *using Ozone Action!* related articles they find. Resourceful websites listed below:

   Michigan DEQ Air page
   http://www.michigan.gov/deq and click on "AIR"

   Project A.I.R.E page:
   http://www.epa.gov/region01/students/teacher/aire.html

   AIRNOW page (regional and national ozone maps):
   http://www.epa.gov/airnow/

   Midwest Hazecam for live pictures and corresponding air quality conditions at:
   http://www.mwhazecam.net/

3. Have students answer the "A.Q." (Air Pollution Quotient) quiz. Then have them quiz friends, fellow students, and families, writing up summaries of their findings and including information about any differences in attitudes towards air quality among these different groups.

Oxygen and Ozone

Background Information

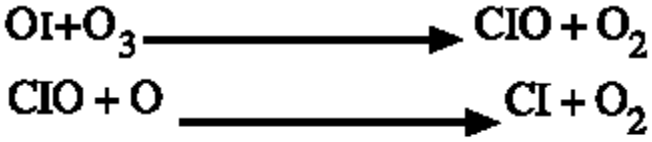
Good ozone: stratospheric ozone is “good” ozone. In 1985, scientists discovered that the ozone layer is thinning. The ozone layer protects us from the harmful rays of the sun. In the stratosphere, ozone (O_3) absorbs ultraviolet radiation and is split into an oxygen molecule and an oxygen atom.

Oxygen molecules can also be split by ultraviolet light to form oxygen atoms

These changes allow ozone to be reformed to react with more ultraviolet light:

This process allows most of the ultraviolet light to be filtered out before it reaches the earth.

Humans have introduced chlorofluorocarbons (CFCs) to the atmosphere and the chlorine in CFCs reacts with the ozone and changes the whole process. CFCs can be found in aerosol spray cans such as hair spray, cleaning products and spray paint.



In these reactions, the chlorine also acts as a catalyst. Before the chlorine is finally removed from the atmosphere (in one to two years by precipitation), each chlorine atom will have destroyed approximately 100,000 “good” ozone molecules-exposing the earth to more harmful ultraviolet rays.

Oxygen and Ozone
Continued

Bad Ozone

Troposphere (ground-level) ozone is “bad”. When ozone forms in high concentrations down here where we breathe, it can be a health hazard. Ozone is formed in a photochemical reaction between volatile organic compounds (such as hydrocarbon emissions from factories, automobiles, trucks, boats and gasoline-powered lawn equipment), nitrogen oxides and the sun. High temperatures, with minimal or no cloud cover, and stagnant winds are perfect conditions for ground-level ozone formation.

Hydrocarbon emissions + nitrogen oxides + sunlight + weather factors = ozone (O_3)

Linking activity to *Ozone Action*!

1. What are the differences between “good” ozone and “bad” ozone?
2. When are *Ozone Action*! days declared?
3. What is the purpose of *Ozone Action!* days?
4. What actions can you take to protect the stratospheric ozone layer?
5. What actions can you take to reduce ozone in the troposphere?

What is your A.Q. (Air Pollution Quotient)?

For students, their parents, and friends

1.	Air pollution is only a problem in big cities.	True	False
2.	Dirty air is costly to each American.	True	False
3.	When the air is polluted, you can always see and smell it.	True	False
4.	Clean air is the responsibility of industry alone.	True	False
5.	The only effect of ozone air pollution is on the human body.	True	False
6.	Cars contribute little to the air pollution problem.	True	False
7.	Air pollution is now under control and will not be a problem in the future.	True	False

See next page for answers

Source: Adapted from Clean Air Kentucky

What is your A.Q. (Air Pollution Quotient?)
Answer Sheet

1. Air pollution is a problem only in big cities.

   False. Everyone is affected by air pollution. The air we breathe does not stay in the same place, hovering over us. It moves. Wind carries pollution to us from all over the world as weather systems travel. Likewise, the pollution that we produce, no matter how small an amount it may seem, is significant when we combine it with everyone else's "small amounts".

2. Dirty air is costly to each American.

   True. We pay in health problems caused by air pollution. As consumers, we pay costs hidden in the price of things we buy…the cost of new technology to prevent air pollution.

3. When air is polluted, you can always see and smell it.

   False. Some pollutants are odorless and colorless. That is why it is important to look in the newspaper, listen to or watch your favorite news station or call 1-800-65-OZONE (656-0663)

4. Clean air is the responsibility of industry alone.

   False. We all have an important role to play in clearing our air. What choices can you make (and what actions can you take) to start clearing the air today?

5. The only effect of ozone air pollution is on the human body.

   False. Ozone pollution affects our lungs and can irritate our eyes. It also deteriorates materials, damages vegetation, effects animals and contaminates ground water.

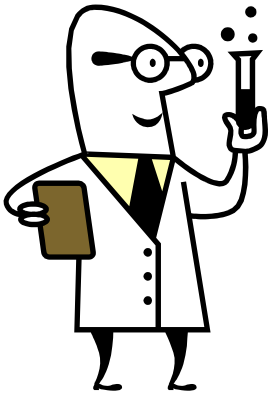
6. Cars contribute little to the air pollution problem.

   False. The automobile industry has made some improvements in pollution-control devices – individual cars and buses emit fewer hydrocarbons emission into the air today than ever before. However, more people are driving today than ever, and that adds up to a lot of pollution.

7. Air pollution is now under control and will not be a problem in the future.

   False. If what we do in the morning can become pollution in the afternoon, imagine how what we are doing today will affect us tomorrow. We need to be aware of how our activities contribute to pollution.

Highs and Lows
Lab



Highs and Lows

Overview

The movement of air masses can be confusing and difficult for students to conceptualize. This activity aids in the understanding of high and low pressure behavior, vacuums and molecular structure, assisting in student education in the subjects of science and environmental studies.

Time

One Class Period

Materials

- Teacher-made/student-made signs indicating “High” or “Low”
- Balloons
- Scissors or pins

Objectives

After participating in this hands-on activity, the students will be able to do the following to:

- Describe a high pressure area.
- Describe a low pressure area.
- Identify a front.
- Explain why a high pressure area seeks a low pressure area.
- Explain how *Ozone Action*! day forecasters use highs and lows in forecasting *Ozone Action*! days.

Highs and Lows

Background Information

The formation of ground-level ozone is a photochemical process that requires energy in the form of ultraviolet radiation (also known as solar isolation) to complete the chemical process that turns pollutants (like hydrocarbon emissions from factories, lawn mowers, automobiles and fueling activities) into ozone. The meteorologists in forecasting *Ozone Action*! days, must be very attentive to high and low pressure systems that are associated with destructive weather conditions.

Typically, high pressure systems bring high temperatures and clear skies to areas, creating the potential for high amounts of ultraviolet radiation which enhances ground-level ozone production. Low pressure systems, associated with cloudy skies and rain, are not at all conductive to ground-level ozone formation and can help dissipate amounts of the pollutant already in the air.

Knowing why and when areas experience systems of high and low pressure is very important to both weather forecasting and air quality concerns.

Procedure

1. Read the background information to the class and tell them to imagine that all of the students in every class in the school were tightly packed into their classroom with standing room only**.** All doors and windows are closed. The heat they would feel is indicative of a high pressure area.

   Now, imagine that no one is in the hall outside the classroom. It is completely empty and is indicative of a low pressure area.

   If someone opened the door, where would the students in the classroom want to go? Out the door! Yes, that is exactly what happens with pressure systems. High pressure always seeks to move to low pressure areas.

   Discuss the activity at the doorway. Would the flow be slow and easy or fast and furious?

2. Now imagine that some students are moving from right to left, or in a counter-clockwise direction in the hallway. As the students moved out of the classroom, they were allowed to exit only by moving left to right or clockwise direction. Ask for ideas about what might happen. There could be pile ups (clouds); bumping and rubbing friction (lightning) may occur if everyone was not moving in one direction. .

3. Explain the following facts to the students.

   Geographic areas, caught between high and low pressure systems, often experience violent storms as areas of high pressure seek to relieve pressure by

moving toward the low pressure area, causing cumulonimbus clouds that produce lightning, thunder, heavy rains, hail, strong winds, and tornadoes. Cumulonimbus clouds are the tallest of all clouds and can span all cloud layers and extend above 60,000 feet. They usually have large, anvil-shaped tops which form because of the stronger winds at those higher levels of atmosphere.

Have the students in pairs; blow up balloons leaving a peak in the top of the balloon. The first student ties the end and holds the balloon securely. They have just made a cumulonimbus cloud. The second student will then either cut off the peak (anvil cloud) or prick it with a pin as the first student, simultaneously, let's go of the balloon. This activity represents the behavior of a cumulonimbus cloud, with the peak of the balloon representing the part of the cloud that becomes the anvil that occurs when the jet stream passes over. This could cause a tornado like the one they just experienced.

4. Students may actively participate by wearing signs indicating they are part of the high or low pressure area. They would then move in the clockwise or counter-clockwise direction. Other students could represent the front that occurs where they meet.

Extension

1. Use newspaper weather maps to give students practice in predicting the weather.

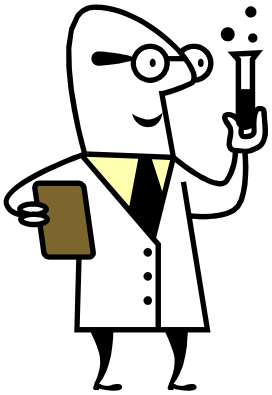
2. Allow students to examine an aneroid barometer, used to measure air pressure.

3. Design a map with an imaginary area showing highs and lows. Each student must predict the weather for the spot marked "X" on the map and explain in several sentences, using the correct vocabulary, why he/she believes this prediction to be correct.

4. Students will decide which areas of the map experienced conditions conductive to ozone formation and explain what the conditions were and how they contributed.

5. Have students describe things they and their families can do to reduce the threat of ground-level ozone in high pressure systems.

How Does A Cloud Form?
Lab



How Does A Cloud Form

Overview

Cloud formation and its effect on weather are important to scientific understanding of both weather forecasting and air quality concerns. This activity aids in the understanding of cloud formation, assisting in student education in the subjects of science, environmental studies and mathematics.

Time

Aspects of this lesson plan can stand alone, in one class session, or extend for a number of days worth of study and follow up.

Materials

- Jar
- Warm water
- A plastic bag of ice that fits over jar opening
- A sheet of black paper
- Flashlight
- Matches

Objectives

After participating in this activity, the students will have an understanding of, or gain skills in:

- Observation
- Controlling variables
- Gathering and recording data
- Interpreting data
- Applying and generalizing
- Forecasting *Ozone Action*! days including information about cloud cover and cloud types.

How Does a Cloud Form?

Background

Air warmed by the earth rises into the sky. The water in the air condenses as the air cools to form clouds.

Clouds are part of weather. A cloud is a mass of fine drops of water or tiny crystals floating in the air above the earth, formed by water vapor in cool air. The three main types of clouds are cirrus, cumulus, and stratus. Cirrus clouds are located high in the sky, where temperatures are well below freezing; they are white, thin and look like feathers because they are made up of tiny crystals. Cumulus clouds are white clouds that form closer to the earth and are thin, with a cotton-like appearance. Due to their closeness to the earth, these clouds primarily consist of water droplets. They can produce showers and thunderstorms when they get bigger and thicker. Stratus clouds are grey, flat clouds that spread out over the sky. They are located low in the sky and are usually associated with widespread rain. These clouds do not grow bigger and thicker but usually spread wider.

When *Ozone Action!* meteorologists forecast *Ozone Action*! days, one of the things they consider is cloud cover and cloud type. *Ozone Action*! days are days that experience a lot of sun and ultraviolet radiation, considering cloud cover is crucial. Clouds can block the sun, create rain or allow the sun to shine through and create conditions favorable for ground-level ozone formation.

Typically, the thickness and low position of cumulus clouds are capable of blocking the sun and stopping formation of high amounts of ground-level ozone. On the other hand, cirrus clouds in the sky, thin and high, can allow enough sunlight in to engage the photochemical process that turns pollutants in the air into ozone.

Knowing how, why and when certain clouds form help meteorologists determine whether or not “tomorrow is an *Ozone Action*! day”.

More information on studying clouds can be found at
http://asd-www.larc.nasa.gov/SCOOL/ .

http://www.globe.gov

How Does a Cloud Form?

Procedure

1. Do this activity on a dry day when the sky includes a variety of clouds. Take the students outside and have them lie on the grass and look up at the sky. Have them observe the sky for one minute, then ask them about the clouds they see. Are they the same or different? What characteristics do they notice about the clouds? Are they high or low, thick or thin, fat or skinny, etc.? What do they know about how clouds form? List answers on the blackboard.

2. Point to the responses listed on the board. Tell the students that the activity they will participate in today will show them a little bit more about how clouds form.

3. Cut out or draw pictures of five different types of clouds and then give each student a picture of a cloud. Have the student walk around the room and try to find other pictures that look like their own. The groups that the students end up in will be their group for the lesson.

   Note: There are three main cloud types – cirrus (light, feathery/curly and high in the sky, they are common in fair weather), cumulus (puffy, flat and low, they are seen in fair weather and in foul), and stratus (flat like blankets and usually grey, they are associated with fog, drizzle and snow, depending on their temperature, size and thickness) – and alterations of each: cirrostratus, nimbostratus, altostratus, stratocumulus, altocumulus, cirrocumulus and cumulonimbus ("alto" means "high"; "nimbo" means precipitation (rain or snow); "cirro" means it is layered, made up of many parts).

4. Once they are in their groups, have the students count off: one, through five (if necessary). Pass out role labels according to numbers: all of the ones are "technician", twos are "principal scientist", threes are "timekeepers", fours are "recorders", and fives are "reviewers".

5. Explain the instruction and discuss safety precautions (i.e. the importance of being careful with glass, what to do if glass breaks, etc.). Only teachers and other adult assistants will handle broken glass and matches.

How Does a Cloud Form?

Student Instructions: The "technicians" will go to the front of the room and gather the materials necessary for the investigation. "Principal scientists" will place the jar on the sheet of black paper or tape the paper on the back of the jar so they can not see through it. With the bag of ice nearby, they will fill about one third of the jar with warm water. The teacher or assistant will light the match and hold it over the jar opening. After a few seconds, the match is dropped into the jar and the "Taskmaster" will cover the top of the jar with the ice bag. While the "encourager" shines the flashlight into the jar, "Timekeepers" record the length of time that it takes to create a cloud inside the jar. What is happening? "Recorders" will write observations on a separate piece of paper.

6. Ask if anything needs to be repeated. When there are no more questions, ask the "technicians" to come up and gather the materials.

7. Perform the experiment. Discuss observations. Questions and anticipated answers:

- What did you see in the jar? A cloud, smoke, dust, fog.

- Thinking about your observations, how might a cloud form? The warm air is cooled (by the ice cubes) and little drops of water come out of the air (water condenses). The drops of water are so little that they stay in the air. We see them as clouds.

- Why was the smoke from the match important to cloud formation? So you could see the cloud better. It provided particles for vapor to "grab on to".

- From our investigation could we say that "a cloud is visible body of very fine droplets of water which hang in the atmosphere above the earth's surface?" Yes.

- What makes up weather? Clouds, wind, rain, temperature.

- The "reviewers" as the group the following questions:

    - Why might the weather forecast be important? It helps us plan our daily activities, which helps us determine what to wear, whether or not it is going to be an *Ozone Action! day*.

    - What do the students know about how clouds affect sunlight? Blocks the sun or filters the sun.

    - How do clouds influence ground-level ozone and *Ozone Action*!? When they block the sun, clouds can stop the formation of pollution. They can cause rain, clearing the air of ozone. Meteorologists have to see what kind of clouds are in the sky before calling an *Ozone Action*! day.

How Does a Cloud Form?

8. Invite the different groups to gather as much information as possible about their type of cloud, using sources in the library.

9. Have each group make a large poster of their cloud type.

10. Have each "Cloud Club" present their cloud to the class by displaying the poster and sharing the information they have learned.

11. After their research, ask the students about other types of clouds (cirrocumulus, cirrostratus, altostratus, altocumulus, nimbostratus, and cumulonimbus). What types of weather do the other clouds bring? Rain, snow, steady rain or snow, thunderstorms and fog. How does each of these weather systems affect ground-level ozone?

Extension

- Every morning have each student go outside and look at the clouds. Have them draw the clouds on the page and tell what types of cloud it is. Have students try to predict the weather by looking at the clouds. Do this for two weeks. At the end of that time, have the students look at their journals and see how accurate their weather predications were.

- Have the students draw a picture which shows the process (es) that lead(s) to cloud formation.

- Have the students draw and/or label three main types of clouds.

- Have the students write a story about a cloud which includes where in the sky it is found and what type of weather it might bring.

How Does a Cloud Form?
Cross Curricular Activities

Math/Cloud Graph

Have students observe and record cloud types daily for a month on a graph, by making a space next to the appropriate cloud name. Make a graph analyzing the amount of each type of cloud cover per day, week, month, etc. provides essential skills in mathematics.

Our cloud chart for May

Type of Cloud	1	2	3	4	5	6	7	8	9	10
Cirrus	X			X	X					
Cumulus	X	X	X	X			X			
Stratus	X									

In the first week of May, 57 percent of the days experienced cirrus clouds, 71 percent experienced cumulus clouds and 14 percent experienced stratus clouds.

Language/Writing

Creative Writing: Have students write a story about the cloud, including its location in the sky and what type of weather it might bring; have students write poems and rhymes about clouds.

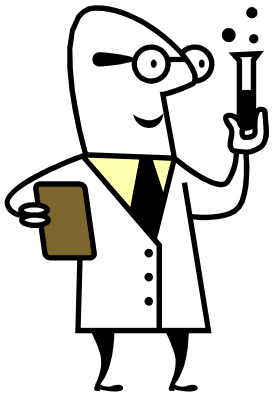
Integrated language arts and social studies

- Display the weather pages from the newspaper and read them aloud daily. Discuss with students the elements of a weather report. Have students write weather reports to broadcast at the beginning or end of the school day. They may want to draw a picture to include with their forecast.

- Have students write poems or rhymes about clouds.

- On a day the sky has cumulus clouds, take the students outside to observe the clouds and the changing shapes and then have them write stories about the cloud figures they see.

Temperature Inversions Lab



Temperature Inversions

Air temperature can play an important role in the buildup or dispersion of surface air pollution. In general, air temperature decreases as you move upward in the atmosphere. Under most circumstances, the air close to the earth warms as it absorbs surface heat and begins to rise. Wind is caused when air rushes in to take the place of the rising warm air. Wind movements cause “mixing” in the atmosphere and thereby carry away and dilute pollution.

During a temperature inversion, a layer of warm air aloft acts as a lid above a layer of cold air. The colder, denser air close to the ground does not readily circulate (mix). Pollutants such as carbon monoxide and particulate matter and ozone-producing hydrocarbons are “trapped” in the cold air by the lid. The quantity of pollution tends to increase until the lid is destroyed by heating or by wind.

Materials

- 4 identical small, clear glass jars (baby food jars work well)
- very hot tap water
- ice water (about 50 degrees Fahrenheit)
- thin, stiff plastic square or index cards
- red food coloring
- shallow pans or baking dishes (for spillage)

The following exercises simulate both normal atmospheric conditions and an inversion.

Procedure – Normal Conditions

Place two jars in a shallow pan or baking dish. Fill one jar with hot water and the other jar with ice water (Note: fill jars to brim). If you use ice cubes to cool the water, do not leave any ice in jar. Put several drops of red food coloring in jar with cold water. Place the plastic square over the top of the jar with the cold (red) water and quickly flip the jar on top of the jar with the hot (clear) water. Align the jar openings. Carefully pull the plastic square or index card out. Let the jars stand.

Temperature Inversions

Procedure – Temperature Inversion

Note: fill jars to the brim. Place the remaining two jars in a shallow pan. Fill one jar with hot water and the other jar with ice water. Add several drops of red food coloring to the ice water. Place the plastic square or index card over the jar with the hot (clear) water and quickly flip the jar on top of the cold (red) water jar. Align the jar openings. Carefully pull the plastic square or index card out. Observe.

Questions & Answers

1. What happens? In the first instance, the hot (clear) and cold (red) water mix immediately and water in both jars turn red. In the second instance, the cold (red) water is trapped and can not escape upward. The jar on top (hot) stays clear.

2. Why do the hot and cold water mix in the first instance (normal conditions)? The cold water (air) is on top of the hot water (air). In this case the water colors mix, illustrating that the air can move upward and disperse pollution during normal temperature conditions.

3. Why don't the hot and cold water mix in the second instance (temperature inversion)? The hot water (air) prevents the cooler water beneath (air close to the ground) from rising and dispersing into the atmosphere-trapping the pollution down where we breathe.

4. Ask students to identify sources of pollution that might get trapped down near ground-level during a temperature inversion.

Source: Oregon Department of Environmental Quality

Teacher Evaluation Form

Your feedback is necessary to make these resource guides a success.
Remain anonymous, if you wish, but please do complete the following items and return this form to the West Michigan Clean Air Coalition:

Name _____

School _____

Address _____

City _____ State _____ Zip _____

Phone Number (____) (____ - _____) Email:_____

Please tell us what grade level and/or subjects you teach: _____

Total number of students participating in class using
Ozone Action! classroom materials _____

Which *Ozone Action!* Resource Guide(s) did you use?

- ? K-5
- ? Grade 6-8
- ? Grade 9-12

Please rate your agreement with the following statements using a scale of 1 to 5.

Ozone Action! background information is complete and helpful.

1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

Ozone Action! classroom science activities are useful and relevant to class room needs.

1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

Ozone Action! classroom science activities are complete and easy-to-follow.

1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

Ozone Action! classroom activities are easy to integrate into daily lessons.

1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

Activities are well-received by students.

1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

I would teach *Ozone Action!* activities in my classroom again.

1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

I will use *Ozone Action!* classroom activities and lessons again next year.

1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

Please share your thoughts on the *Ozone Action!* education packet. What I liked best about the Ozone Action! Teacher Resource Kit. (Please give us an idea of what worked well for you).

What I liked least about the *Ozone Action!* Teacher Resource Kit. (Please give us an idea of what did not work well for you, any information you felt was missing, etc.)

What changes would most help you meet you teaching needs? Please use a separate sheet for additional comments if necessary.

Fax or send completed form to
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