



Ozone: The Good, the Bad, and the Ugly

In this first lesson of the Clean Air Campaign's unit on Air Pollution and Earth Science, students will study ozone, one of the most significant pollutants in Georgia and a major component of smog. They will learn about the layers of the atmosphere and label a diagram; distinguish between stratospheric ozone, which has beneficial effects and tropospheric or ground-level ozone, which has adverse effects; review maps including one showing the South American ozone hole; design and carry out investigations with ultraviolet detecting beads to show the important role of stratospheric ozone in protecting the Earth; make their own test strips and measure ground-level (tropospheric) ozone levels; simulate the formation of smog in a jar; research sources and causes of smog; identify potential solutions; and create visual displays to use in presenting solutions to the class. (Environmental Education)

<i>Education Committee</i>	<i>The Clean Air Campaign®</i>	<i>Fulton</i>	<i>EEinGEORGIA.org</i>
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Primary Learning Outcomes

What is the difference between “bad” and “good” ozone? What are the layers of the atmosphere, and where are stratospheric and tropospheric (or ground-level) ozone found? What good effect does stratospheric ozone provide? What adverse effects does ground-level ozone cause? How are ozone and smog formed and what is the relationship between the two? What can be done to reduce the amount of ozone pollution?

Additional Learning Outcomes

How can I use the inquiry process to design and carry out an investigation about ultraviolet radiation? Where is the hole in the stratospheric ozone layer? How does the hole affect the Earth in general, and people in South America in particular?

Assessed QCC Standards:

Grade: 8
Science
Earth Science

1

Topic: Scientific Inquiry Process

Standard: Uses process skills of observing, classifying, communicating, measuring, predicting, inferring, identifying and manipulating variables. Also uses skills of recording, analyzing and operationally defining, formulating models, experimenting, constructing hypotheses and drawing conclusions.

5

Topic: Human Interactions with the Environment

Standard: Recognizes the effects human beings have on pollution and the environment. 5.1 Identifies ways human beings cause and can correct pollution of water bodies, the atmosphere (acid rain, ozone layer and greenhouse effect) and the land (soil pollution, and chemical/nuclear waste). 5.2 Examines the effects pollution from cities have on weather and the effect of burning fuels on the atmosphere, melting of polar ice caps and predicting earthquakes.

18

Topic: Meteorology

Standard: Describes the composition and structure of Earth's atmosphere. 18.1 Identifies the layers of the earth's atmosphere. 18.2 Describes the importance of each layer of the Earth's atmosphere. 18.3 Lists the most abundant gases in the Earth's atmosphere.

Procedures/Activities

Step: 1 Duration: Teacher Preparation

Prior to the lesson, make the following preparations: Decide how to divide the class into pairs of students who will serve as lab partners for all of the lesson activities. Refer to the Materials list and assemble all supplies needed for the lesson. Solar or ultraviolet-detecting beads will need to be purchased from a science supply company in advance. Potassium iodide may be available from a local pharmacy, or can be ordered from a science supply company. (See links below). Approximately one week before the lesson, request that students bring in any needed items, which they may have at home, including sunglasses, sunscreen and fabric or construction paper. For best results, schedule the "Bad Ozone Investigation" for a sunny day in August, September or May. Make copies of the diagram worksheet (Step 2), concept map (Step 3) and lab reports (Steps 5 and 6) for each student, as well as a copy of activity directions (Steps 6 and 8) and humidity scale (Step 7) for each pair of students. Print a color copy of the Schoenbein color scale for each pair of students (Step 7).

Determine how the Web resources throughout this lesson will be displayed for students, and arrange for any necessary equipment. For instance, 1) Web pages may be displayed directly using an Internet-connected computer, scan converter, LCD projector and screen or TV monitor hook-up; 2) Web pages may be copied on transparency film and shown on an overhead projector; 3) students

may have access to Internet-connected computers so that they can view the Web pages independently as they are discussed by the teacher; or 4) copies of Web pages can be made and distributed. Prepare for class discussions by reading background material, such as The Clean Air Campaign's Web page on formation of ground level ozone and the Ozone Teacher's Guide to stratospheric ozone, linked below, as well as the Web resources provided at each step.

Web Resources for Step 1

Title: Stratospheric ("Good") Ozone Info from NASA

URL:

http://observe.arc.nasa.gov/nasa/education/teach_guide/ozone.htm
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Annotation: Ozone Teacher's Guide from NASA provides background information on stratospheric ozone

Title: Ground-Level ("Bad") Ozone Info from The Clean Air Campaign

URL:

http://www.cleanaircampaign.com/index.php/cac/air_quality_and_health/sources_of_smog

Annotation: Background information for the teacher on ground level ozone and smog.

Title: How to Order Potassium Iodide (KI)

URL: <http://www.flinnsci.com/index.asp>

Annotation: If not available from the local pharmacy, obtain potassium iodide (KI) from any science supply company in powder (crystal) form. Hope to pay about \$8 - \$10 for 25 grams. One gram will be needed for each pair of students, so higher costs may dictate the need to combine pairs of students into groups of 4 – 6 for the "Bad Ozone Investigation." To order from Flinn Scientific, go to the Web page and select Flinn Ordermaker to download a searchable catalog with price lists and order form. Item # PO 278 = 100 g lab grade KI; Item # PO 066 = 25 g reagent KI. (Note: The price of KI varies with demand and increases dramatically in times of concern about national security because it is stockpiled to be ingested for protection against the effects of nuclear radiation).

Title: How to Order UV Detecting Beads

URL: <http://www.stevespanglerscience.com/product/1350>

Annotation: Obtain ultraviolet detecting beads for the Good Ozone Investigation. All major science supply catalogs carry these beads. One such source is Steve Spangler (250 beads for about \$7). For the convenience of ordering all materials from one place, UV detecting beads may also be ordered from Flinn (linked below)

using Item # FB1147), although the price may be higher.

Step: 2 Duration: 25 minutes (15 for intro and 10 for labeling diagram)

Introduction to the Atmosphere

Introduce the lesson by asking students what they have heard about ozone, and specifically, whether it is beneficial or harmful. Write “Beneficial,” “Harmful,” “Neither” and “Both” on the board (or on an overhead projector transparency which is being displayed). Categorize and tally individual student responses in each category. Save these results for further discussion during the Debriefing (Step 10).

Explain that ozone is a molecule consisting of three oxygen atoms. Whether it is harmful or beneficial to human life depends on where ozone is found. To understand ozone better, it is important to know that the atmosphere is divided into layers of air, which are characterized by temperature and density. Encourage students to take notes and make sketches in their Science Journals or notebooks, as you display and review the Enchanted Learning Web page about layers of the atmosphere. Show the NASA Web resource and point out the pie chart showing composition of gases in the atmosphere. Tell students to record the information on the two major gases in their notes. Then distribute blank Atmosphere Diagrams and direct students to label the layers, using their notes, and to use markers of contrasting color to indicate and label the location of both “good” and “bad” ozone. Also, tell students to create a pie chart on the worksheet, showing the proportions of the two major gases in the atmosphere and including a category for “all other gases.”

Web Resources for Step 2

Title: NASA Info on Layers and Composition of Earth’s Atmosphere

URL: <http://liftoff.msfc.nasa.gov/academy/space/atmosphere.html>

Annotation: This Web site provides a description of Earth’s atmosphere, with a diagram of layers to 600 km. Be sure to point out the pie chart showing proportion of gases found in the atmosphere, and remind students to take notes on it, as they will be asked to create a chart on their worksheets.

Title: Student Worksheet- Label the Diagram of the Atmosphere

URL:

<http://www.enchantedlearning.com/subjects/astronomy/activities/lab/el/atmosphere/>

Annotation: Distribute paper copies of the diagram to each student and require that it be labeled and used for future reference during the lesson. Each student should draw in a chart indicating the proportions of the major two gases and “all other” gases. Remind everyone to put their names on the diagrams because they will be scored.

Title: Enchanted Learning's Info and Diagram of Atmospheric Layers

URL:

<http://www.enchantedlearning.com/subjects/astronomy/planets/earth/Atmosphere.shtml>

Annotation: Display this Web resource first and read or paraphrase the information to the class. Note that the ozone layer shown on the chart is stratospheric "good" ozone. Tell students that ground-level or "bad" ozone forms in the troposphere. (This is not shown on the diagram). Point out the temperature changes from level to level, as indicated by red and blue on left side of diagram. Then show the additional Web resource.

Step: 3 Duration: 30-45 minutes

The Difference between "Good" and "Bad" Ozone

Ask students how stratospheric ozone is beneficial? (protects Earth from ultraviolet radiation). Ask how ground-level ozone is harmful? (can irritate lungs, aggravate respiratory conditions). Distribute copies of the Ozone Concept Map, linked below. Display the linked Web sites to provide students with an overview of how stratospheric (good) and tropospheric or ground-level (bad) ozone are formed and what effects they have on human health and the environment.

Emphasize the following points about "good" ozone: 1) Stratospheric ozone is also known as "upper level" or "good" ozone because it blocks some ultraviolet light, providing partial protection from sunburn, skin cancer, and blindness; 2) Ozone is a molecule which consists of three oxygen atoms. It is constantly being created and destroyed through natural processes; 3) Ozone-depleting substances speed up the destruction processes. For example, when ultraviolet light splits a chlorofluorocarbon molecule, it sets a chlorine atom free. The chlorine atom (Cl) bangs into an ozone molecule (O₃) and breaks it up, 'stealing' one oxygen atom to create chlorine monoxide (ClO) and leaving behind plain old diatomic oxygen (O₂).

Make the following points about "bad" ozone: 1) Ground level ozone, also known as "bad" or "tropospheric" ozone, is not emitted by cars or power plants. It is created when nitrogen oxides (from vehicle exhaust and power plants which burn fossil fuels) chemically react with volatile organic compounds (vapors from gasoline, cleaning solvents and even trees) and sunlight to make different molecules, including ozone (O₃); 2) Ground level ozone can be harmful to plants and animals. Humans can experience inflamed airways, shortness of breath, and chest tightness; 3) Smog is formed by ground-level ozone and very small particulates, such as soot, in the presence of sunlight. It is most likely to form in the afternoon and early evening on summer days.

Web Resources for Step 3

Title: How Ozone Is Formed

URL: <http://health.howstuffworks.com/ozone-pollution1.htm>

Annotation: This Web page shows, with diagrams, maps and text, how stratospheric and ground level ozone are formed. Note the last paragraph, which documents that ground level ozone is not only formed in urban areas, but also affects rural areas because it can be swept as far as 250 miles downwind. Click on “Effects of Ozone” or “Next Page” to view information on health effects of ground-level ozone.

Title: How Stratospheric Ozone is Depleted by Chlorofluorocarbons (CFCs)

URL:

http://www.bom.gov.au/lam/Students_Teachers/ozanim/ozoanim.shtml

Annotation: Animated and accessible explanation of the chemical reactions which cause stratospheric ozone depletion.

Title: Effects of Bad Ozone on Health

URL:

http://www.cleanaircampaign.com/index.php/cac/air_quality_and_health/smog_and_your_health

Annotation: This Web page from The Clean Air Campaign describes health effects of ground-level ozone.

Title: Effects of Bad Ozone on the Environment

URL:

http://www.cleanaircampaign.com/index.php/cac/air_quality_and_health/smog_hurts_georgia

Annotation: This Web page from The Clean Air Campaign describes environmental effects of ground-level ozone.

Title: Ozone Concept Map

URL: <http://www.ed.psu.edu/ci/Papers/STS/gac-3/f3-in04-p117.gif>

Annotation: This concept map outlines the differences among good and bad ozone and smog. Make a copy and distribute to each student, at the beginning of this step. Encourage students to write notes on this graphic organizer, as they are shown the rest of the Web resources.

Title: Ozone: Good Up High ~ Bad Nearby

URL: <http://www.epa.gov/oar/oaqps/gooduphigh/>

Annotation: This EPA Web site provides information about the difference between “good” and “bad” ozone, including the causes and effects of each. Teach students the phrase: “Good up high -- Bad nearby.” Show graphics and briefly paraphrase this Web

resource to help students distinguish between “good” and “bad” ozone.

Title: Ground-Level Ozone Map Archives

URL:

<http://www.airnow.gov/index.cfm?action=airnow.archives&RegionID=0>

Annotation: To see daily color-coded maps of ozone or particulate levels for different parts of the U.S., just click on the region and the date.

Title: Ground Level Ozone Map for a Sample ‘Code Red’ Day (7/21/04)

URL:

<http://airnow.gov/index.cfm?action=airnow.showmap&pollutant=OZONE&domain=se&map=archives&date=7/21/2004&standard=US&language=EN>

Annotation: Animated maps show ozone formation throughout the day, over the southeastern U.S., with a corresponding clock. This Web site is most effective if viewed with computer, scan converter and LCD projector, so students can track growth and movement of ozone, and they will see it can affect areas far from where it is formed.

Title: The Ozone Layer and Chlorofluorocarbons

URL: <http://www.theozonehole.com/cfc.htm>

Annotation: The Background Information section of this lesson plan uses maps and graphics to explain the differences between “good” and “bad” ozone, as well as the formation and depletion of stratospheric ozone. Requires Adobe Acrobat Reader.

Step: 4 Duration: 0-15 minutes

Finding, Mapping and Measuring Ozone

Optional social studies connection

Display the map of the ozone hole over South America and explain that human activity, including use of Chlorofluorocarbons [refrigerants] and Halons [foam propellants], has contributed to thinning of the ozone layer, which is also caused by a natural process involving ice crystal formation in the atmosphere over the Poles. The ozone hole over Antarctica extends to southern South America during part of the year, allowing higher levels of ultraviolet radiation to reach the Earth below, and results in cooler temperatures in the stratosphere. Display the maps contained in Web resources below.

Web Resources for Step 4

Title: Scientists Divided Over Ozone Hole Depth

URL:

<http://archives.cnn.com/2000/NATURE/10/10/ozone.hole.enn/>

Annotation: Article on causes and effects of ozone hole over population centers in South America.

Title: Total Ozone Mapping Spectrometer (TOMS) Web Site

URL: http://toms.gsfc.nasa.gov/index_v8.html

Annotation: Satellite maps show stratospheric ozone, aerosol levels, reflectivity and ultraviolet radiation.

Title: Ozone and Climate Change

URL: <http://www.theozonehole.com/climate.htm>

Annotation: Optional Web resource, which outlines research on climate changes caused by stratospheric and ground-level ozone, as well as the effect of climate on ozone.

Title: The Ozone Hole over South America

URL: <http://www.theozonehole.com/southamericaozone.htm>

Annotation: The Ozone Hole is a non-profit organization which presents this Web site. Scroll down below site index to see maps of the ozone hole as it stretches over South America, and read about its impact on the people of Chile, Argentina, and the Falkland Islands. (This Web resource directly relates to new social studies standard SS6G2)

Step: 5 Duration: 30 minutes

Investigating “Good” Ozone

Divide the class into lab partner-pairs and distribute a set of supplies to each pair, including two pipe cleaners (for making bead bracelets, if desired) and at least six to ten UV-detecting beads to share. Provide each individual student with a copy of the lab report form, attached below. Then allow each pair of students to select two or three similar items from a stash including different brands or types of sunglasses, various kinds of sunscreen, a variety of fabric swatches and different colors or weights of construction paper.

Explain that the beads only react in the presence of ultraviolet light. Tell students that their assignment is to design and conduct an investigation to explore various materials, which may have the potential to block ultraviolet light. Students should be able to draw parallels between the results of their investigations and the role of stratospheric ozone in absorbing ultraviolet light, thereby shielding the Earth from its effects.

If students are unfamiliar with inquiry investigations, scientific method and experimental design, use the Web resources linked at this step to share information with the class before they begin.

Web Resources for Step 5

Title: Intermediate Level Guide to Experimental Science Projects

URL: <http://www.isd77.k12.mn.us/resources/cf/SciProjInter.html>

Annotation: Tips for designing experiments and investigations, using scientific method.

Title: Scientific Method Explained through Re-enactment of a Galileo Experiment

URL:

http://www.visionlearning.com/library/flash_viewer.php?oid=1884&mid=45

Annotation: An introduction to scientific method through simulation of Galileo's classic experiment to compare the rate at which two different objects would fall to the ground from the Leaning Tower of Pisa. Includes clickable link to an animation, which may require pop-up controls to be disabled, in order to display and play.

Title: Science Inquiry- What It Is and How to Do It

URL: http://www.nwrel.org/msec/science_inq/whatisinq.html

Annotation: Background information for teacher or class about engaging students in the process of science inquiry.

Attachments for Step 5

Title: Lab Report for Investigating Good Ozone **FileName:** [Lab Report for Investigation into Good Ozone.doc](#)

Description: Each student should use this form to design an experiment and record results. Answer key and scoring rubric are provided in the Assessment section. Graphics from Microsoft Design Gallery and The Clean Air Campaign (with permission).

Step: 6 Duration: 45 minutes

Investigating "Bad" Ozone: Make Your Own Ozone Test Strips

The teacher may wish to wear an EcoBadge (ozone monitoring device) to class; to spark discussion and introduce this activity. The badge results may be compared to students' homemade test strip results. Ordering information is linked below.

Distribute copies of Directions for Making Ozone Test Strips to each pair of students. Provide a copy of the Lab Report to each individual student. Become familiar with the guidelines for handling potassium-iodide (linked below) and discuss safety precautions with students, such as these: wear goggles when handling chemicals; wash hands thoroughly after handling chemicals. Provide heat source such as a hot plate (or a dispenser of pre-heated water to use in lieu

of heating the solution). Provide each pair of students with supplies needed for the activity, as indicated in the Materials section of this lesson plan. (Note: If scales and gram weights not available, you may substitute measuring spoons and tell students to use 1/8 teaspoon as the approximate equivalent for one gram).

Explain that this experiment duplicates the work of a scientist named Dr. Schoenbein from almost 200 years ago, when he first discovered and measured ozone. Instruct the students to prepare ozone test paper according to the directions. Air-dry the test paper in a dark place, or fast-dry it in a microwave oven, according to the directions. Attach strings and hang the strips with tape outside the school, in locations, which do not receive strong, direct sunlight (or fashion and attach construction paper shades). Wait at least eight hours before checking results.

Web Resources for Step 6

Title: How to Order EcoBadge

URL:

http://www.ecobadge.com/Merchant2/merchant.mv?Screen=PLST&Store_Code=ecobadge

Annotation: Ordering Information for EcoBadge test cards, badge holders, and colorimetric charts. This may be used by the teacher to spark interest in ozone monitoring or by students, as an alternative to making their own ozone test strips.

Title: Safety Notes: MSDS for iodine- potassium iodide solution

URL: <http://www.flinnsci.com/Documents/MSDS/IJ/IoPoloSo.pdf>

Annotation: Safety precautions and first aid instructions for teacher to review and share with students.

Title: Directions for Making Ozone Test Strips

URL: <http://www.howstuffworks.com/framed.htm?parent=ozone-pollution.htm&url=http://teachertech.rice.edu/Participants/lee/tropo.html>

Annotation: Make one copy of the directions for each team of students.

Attachments for Step 6

Title: Lab Report for Investigating Bad and Ugly Ozone **FileName:** [Lab Report for the Bad and the Ugly.doc](#)

Description: Each student should use this form to record results and answer lab-related questions. Answer key and scoring rubric provided in the Assessment section. Graphics from Microsoft Design Gallery and The Clean Air Campaign (with permission).

Step: 7 Duration: 20 minutes

“Bad” Ozone Investigation Test Results

Distribute a copy of the Relative Humidity Adjustment Chart and a color copy of the Color Scale to each pair of students. Tell students to collect the ozone test strips and review the results using the Color Scale. They should then use a bulb psychrometer (if available) to measure the current, local relative humidity, or obtain this measurement from a news report of local weather, and convert results according to the Relative Humidity Adjustment Chart. Each individual should complete a Lab Report.

Web Resources for Step 7

Title: Schoenbein Color Scale and Relative Humidity Adjustment Chart for Ozone Test Strips

URL: <http://www.howstuffworks.com/framed.htm?parent=ozone-pollution.htm&url=http://teachertech.rice.edu/Participants/lee/tropo.html>

Annotation: Scroll down to “Schoenbein Color Scale,” click on the link, and print (or make a color copy of) this scale for each team of students. Click the browser’s Back button and then the link for the “Relative

Step: 8 Duration: 20 minutes

“Ugly” Ozone: Make your Own Smog-in-a-Jar

Encourage students to take notes while you explain that smog forms after sunlight, vehicle emissions and volatile organic compounds (such as gasoline fumes) have chemically reacted to create ozone. When fine particulate matter such as soot or smoke from power plant emissions and water vapor in the air combine with ozone, smog is created. Divide the class into teams of two and provide each team with a copy of the directions contained in the Web resource below as well as the supplies needed for this activity (see Materials list). Refer students to the previously distributed (at step 7) Lab Report on the Bad and the Ugly, where results of this investigation should be recorded. Review safety precautions, including the need to wear goggles. Instruct students to follow the directions to make their own “smog.” Depending on the school’s policy regarding student handling of matches or lighters and the maturity level of the class, the teacher may need to assist each group with this part of the investigation.

Web Resources for Step 8

Title: Directions for Making Smog-in-a-Jar

URL: <http://bellnetweb.brc.tamus.edu/pg14.htm>

Annotation: Copy and distribute these instructions (Background and Procedures sections only) to each pair of students.

Step: 9 Duration: Homework Assignment

Pollution Solutions

Each student should identify one problem, which contributes to the formation or abundance of ground-level ozone, and then research or brainstorm corresponding ozone pollution solutions. Next the student should select one specific solution and create a poster to encourage classmates to adopt or support that solution. It should be noted that there are many possible solutions, and no one solution should be expected to completely eliminate ground-level ozone.

Solutions may include strategies for reducing the number of cars on the road each day (to reduce vehicle emissions); strategies for producing fewer emissions by changing the way people travel or the type of transportation or fuels used; strategies for reducing volatile organic compounds released into the air; strategies for conserving energy to reduce demand for power and thus reduce power plant emissions; strategies for reducing particulates from power plants by cleaning the emissions or switching to a different type of fuel or method of generating power; and other strategies for reducing ground-level ozone. Refer students to the Web sites linked below for ideas and information.

Inform students that the poster will be evaluated in terms of the following essential criteria: 1) topic is on-task (related to ozone pollution); 2) a specific problem is identified; 3) a solution is proposed; 4) benefits of the solution are cited; and 5) the solution is persuasively marketed. The teacher may want to distribute copies of the Scoring Rubric for Ozone Lesson, which lists these criteria in the row titled "Pollution Solutions Poster."

Web Resources for Step 9

Title: Sources of Smog, presented by The Clean Air Campaign

URL:

http://www.cleanaircampaign.com/index.php/cac/air_quality_and_health/sources_of_smog

Annotation: This Web site provides succinct information on the sources of smog. .

Title: Fighting Smog, presented by The Clean Air Campaign

URL:

http://www.cleanaircampaign.com/index.php/cac/your_commute/clean_air_lifestyle

Annotation: Strategies for fighting smog are listed on left side of Web page. Click on each link for details.

Title: Information on Vehicle Emissions

URL:

<http://www.tceq.state.tx.us/implementation/air/mobilesource/vim/overview.html>

Annotation: This Texas Web site contains statistics on vehicle emissions and suggestions for reducing air pollution related to emissions

Step: 10 Duration: 30-60 Minutes

Debriefing

Have students present their posters and explain benefits of the solutions they propose. Then, refer back to their ideas about the effects of ozone from Step 2 and compare it to the class's understanding of ozone now.

Reiterate the Big Ideas covered in this lesson:

1. "Good" ozone, found in the stratosphere, is beneficial because it shields the Earth from ultraviolet radiation.
2. Ozone is a molecule with three oxygen atoms. Stratospheric ozone is constantly being created and destroyed naturally. Human activity, including use of halons (propellants) and chlorofluorocarbons (refrigerants), can speed the process of breaking down ozone.
3. A seasonal hole in the stratospheric ozone layer is caused by the polar vortex but accelerated by human activity, such as use of chlorofluorocarbons and halons.
4. If there were no stratospheric ozone layer, health problems such as skin cancers and blindness could result from exposure to ultraviolet radiation.
5. "Bad" (ground-level) ozone is not directly emitted from cars or power plants, but formed when nitrogen oxides (gases from vehicle exhaust and power plant emissions) and volatile organic compounds (gasoline vapors and cleaning solvent fumes) chemically react in the presence of sunlight.
6. "Smog" is formed when ground-level ozone combines with fine particulates (e.g. soot) in sunlight. It is most likely to form on summer afternoons.
7. Breathing ozone can cause respiratory health problems. Breathing smog, which includes particulates, has been linked to both respiratory and cardiovascular health problems.
8. The part of stratospheric ozone depletion, which is due to human activity can be reduced by limiting use of chlorofluorocarbons and halons.
9. Ground level ozone can be reduced by limiting/cleaning vehicle and power plant emissions; reducing number of vehicle-trips; using alternative transportation; conserving electricity; avoiding refueling on summer days, etc.

Step: 11 Duration:

Feedback

The Clean Air Campaign is pleased to provide standards-based air quality lesson plans for 4th through 8th grades. Please offer your feedback after implementing

this lesson plan, as there is no substitute for real classroom experience. Send teacher name, school name and address, grade level, lesson name, comments or suggestions and the number of students who completed the lesson to: mail@cleanaircampaign.com. Each teacher who responds will receive a Clean Air Campaign goody bag as a 'thank you.'

Materials and Equipment

Worksheets and Lab Reports

1. One copy per student of concept map, worksheets, and lab reports (at Steps 2, 3, 5 and 6)

2. One copy per pair of students of directions and scales (at Steps 6, 7, and 8)

For good ozone investigation, per pair:

3. 2 pipe cleaners

4. 6-10 UV-detecting beads

5. Various sunglasses, sunscreens, fabrics, papers

For bad ozone investigation, per pair:

6. Distilled water, 150 ml

7. Corn starch, 5 g

8. Filter paper, 1

9. Potassium iodide, 1 g (see Step 1)

10. Scale with 1 + 5 g wts or 1/8 t meas spoon

11. Graduated cylinder, 100+ ml

12. Beaker, 250 ml

13. Hot plate OR dispenser with hot water

14. Glass plate

15. Paint brush

16. Tape or string, 12"

17. Construction paper

18. Bulb psychrometer or weather report

For smog in a jar, per pair:

19. Glass jar

20. Foil, 12"

21. Ice cubes, 2-3

Standards (Local and/or National)

Georgia Performance Standards

Science

S6CS9. Students will investigate the features of the process of scientific inquiry.

S6CS6. Students will communicate scientific ideas and activities clearly.

S6E5. Students will investigate the scientific view of how the earth's surface is

formed.

i. Describe methods for conserving natural resources such as water, soil, and air.

S6E6. Students will describe various sources of energy, their uses, and the conservation of sources of energy.

Social Studies

SS6G2 The student will discuss the impact of government policies and individual behaviors on the region's environment.

c. explain the effect global concerns such as global warming, ozone depletion, and nuclear waste have on the region

Total Duration

3 1/3 to 4 1/3 hours plus homework

Technology Connection

The teacher will use an Internet-connected computer to view Web sites for background information. In addition, Web resources will be displayed for the class using an Internet-connected computer, scan converter and LCD projector or TV hook-up; or transparencies of Web pages will be shown on an overhead projector; or students will be provided with access to Internet-connected computers to view the Web sites.

Assessment

The labeled diagram, two lab reports, and the pollution solutions poster will be used to assess student performance and understanding of primary learning outcomes. Answer keys are attached for the diagram and lab reports are attached below. An overall scoring rubric is provided to combine results of student assessments in each of the lesson activity areas. This rubric also contains criteria for evaluating the posters.

Web Resources

Title: Answer Key for Labeling the Atmospheric Layers Diagram

URL:

<http://www.enchantedlearning.com/subjects/astronomy/activities/lab/el/atmosphere/answers.shtml>

Annotation: Use this answer key to check the Atmosphere Diagram. In addition, students should have drawn in a pie chart, which shows atmospheric gases in correct proportions (N 78%, O 21%, other gases 1%).

Attachments

Title: Answer Key to Lab Report on Investigation into the Effects of 'Good' Ozone **FileName:** [Answer Key for Investigation of Good Ozone.doc](#)

Description: This key can be used to score the lab report. Graphics from Microsoft Design Gallery and The Clean Air Campaign (with permission).

Title: Answer Key to Lab Report on Investigations into 'Bad' and 'Ugly' Ozone **FileName:** [Answer Key to Lab Report for the Bad and the Ugly.doc](#)

Description: This key can be used to score the lab report. Graphics from Microsoft Design Gallery and The Clean Air Campaign (with permission).

Title: Scoring Rubric for The Good, the Bad, and the Ugly Lesson **FileName:** [Scoring Rubric for Ozone- the Good, the Bad and the Ugly.doc](#)

Description: This rubric can be used to evaluate the posters and to combine results of other assessed activities. Graphics from Microsoft Design Gallery and The Clean Air Campaign (with permission).

Extension

Students may make and use test devices for measurement of particle pollution, a major component of smog. Background information, directions for making test devices, and a lesson on particle size are linked below.

Web Resources

Title: Instructions for Making Particle Pollution Test Devices

URL:

<http://enviromysteries.thinkport.org/breakingthemold/lessonplans/indoorairprint.html>

Annotation: Instructions for making and using particle pollution test devices from Petri dishes and graph paper.

Title: Background Info on Particulate Pollution

URL:

http://www.cleanaircampaign.com/index.php/cac/air_quality_and_health/sources_of_smog

Annotation: Scroll to the second half of this article from The Clean Air Campaign, to learn about particulate pollution.

Remediation

Accommodation

For students with exceptional needs, what changes can be made in instruction and teaching delivery to enhance student participation and learning? Each area below is a direct link to general classroom accommodations.

[Non-readers](#) [Physical Impairments](#) [Sensory Impairments](#)
[Attention/Behavior](#) [Gifted](#)

Each disability below is a direct link to general classroom accommodations specific for that disability.

[Autism](#)

[Deaf - Blind](#)

[Deaf/Hard of Hearing](#)

[Emotional and Behavioral Disorder](#)

[Mild Intellectual Disability](#)

[Orthopedic Impairment](#)

Other Health Impairments:

[Attention Deficit Disorder/Attention Deficit Hyperactivity Disorder](#)

[Tourette Syndrome](#)

[Significant Development Delay](#)

[Specific Learning Disability](#)

[Speech - Language Impairment](#)

[Traumatic Brain Injury](#)

[Visual Impairment](#)

Modification

For students with significant disabilities, what changes can be made in instruction and teaching delivery to allow students to participate in classroom instruction while working on IEP objectives and off grade level QCC standards. Below are suggested modifications correlated to the procedures of this lesson plan.