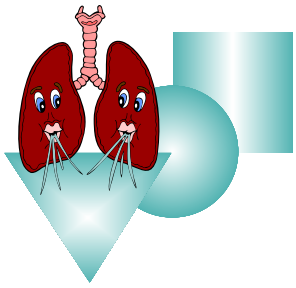
So What's the Matter With Ozone?
Activity 3D



Activity Overview

Activity Objectives:

This activity is written in five parts so students can conduct an in depth study of ozone and its effects on our health or can do each part as a separate activity. By completing all activities, students will be able to:

- make observations and inferences
- revise their inferences upon gathering additional information
- observe that the test paper changes upon environmental exposure
- organize information into concept maps
- relate changes in the test paper to environmental factors
- collect, graph and analyze data
- define ozone and distinguish between stratospheric and tropospheric ozone
- explain how ozone can be simultaneously beneficial and harmful to humans
- demonstrate the impact of ozone on humans
- explain how humans are contributing to the ozone problem
- show the relationship of concepts by creating a concept map
- identify factors in their environment that are responsible for the ozone levels they observe via the test strips
- identify ozone-related issues in their community develop a community action plan based upon analysis of data

Activity Description:

This activity is written into five parts so students can conduct an in depth study of ozone and its effects on our health or with minor modifications can do each part as a separate activity.

Part 1: Students conduct an engagement activity making observations and inferences about "mystery strips" (Schoenbein strips) that change color in response to an unknown substance in the air they breathe. *Note that Ozone Season in many areas begins May 1 and ends October 1. When using the **Schoenbein** strips, the best results will be obtained during this time frame.*

Part 2: Students organize information about ozone into a conceptual framework (concept map).

Part 3: Students learn to analyze the "mystery strips" (Schoenbein strips) using a color chart and graph. The information they collect will allow them to compare ozone levels in their school. *Note that Ozone Season in many areas begins May 1 and ends October 1. When using the **Schoenbein** strips, the best results will be obtained during this time frame.*

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Part 4: Once students know how to use and interpret the "mystery strips" (Schoenbein strips), they can use the technique to design their own inquiry investigation into ozone-related issues in their community. *Note that Ozone Season in many areas begins May 1 and ends October 1. When using the* **Schoenbein** *strips, the best results will be obtained during this time frame.*

Part 5: Students will use the analysis of data from their inquiry investigation to plan a community action project to minimize the ozone problem.

Activity Background:

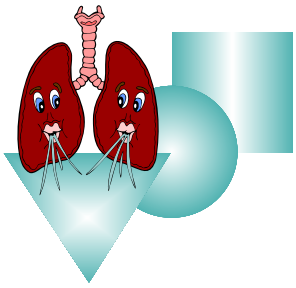
Ozone is a form of oxygen. Unlike oxygen you breathe, which has two atoms of Oxygen bonded together, a molecule of Ozone consists of three atoms of oxygen (***O_3***). This triplet possesses a very important property. It has the ability to absorb ultraviolet (UV) radiation that is streaming in from the sun. This radiation can harm or kill organisms and give you skin cancer. So, O3 (ozone) is very important to us here on Earth.

Ozone is located primarily in the ***stratosphere***; where it absorbs harmful uv radiation. In this sense, ozone is beneficial to living things. However, there is another type of ozone found in the ***troposphere*** and called ***ground-level ozone***. This form of ozone is a type of air pollution that can damage our respiratory system. Ever heard of ***Ozone Action Days?*** Those warnings refer to the O3 down here with us!!

Ozone ***protects*** us in the ***stratosphere***, where ozone is being depleted. Ozone is ***harmful*** to us in the ***troposphere***, where levels have doubled in the last century. Either way you look at the situation, we have a problem with ozone and the problem is manmade!

DEPLETION OF STRATOSPHERIC OZONE (GOOD OZONE)

We know that ozone levels are a problem, so let's look at ***stratospheric ozone*** first. With a little chemistry, we can see how ozone is being depleted. ***Chlorofluorocarbons*** (***CFC***'s) are classified as ***halocarbons***, meaning that they consist of carbon and halogen atoms. (Remember the halogens? They are in Period 7 on the Periodic Table.) Humans have introduced CFC's to the atmosphere through use of aerosol spray cans such as hair spray, cleaning products, coolants, spray paint and many other substances. Since there are many different kinds of CFCs, individual CFC molecules are labeled with a unique system. To check out some of the different kinds of CFC's and other ozone-depleting substances, visit the Environmental Protection Agency website (http://www.epa.gov/ozone/ods.html).



The process by which ozone is depleted is shown in *Figure 1 Ozone Depletion*.

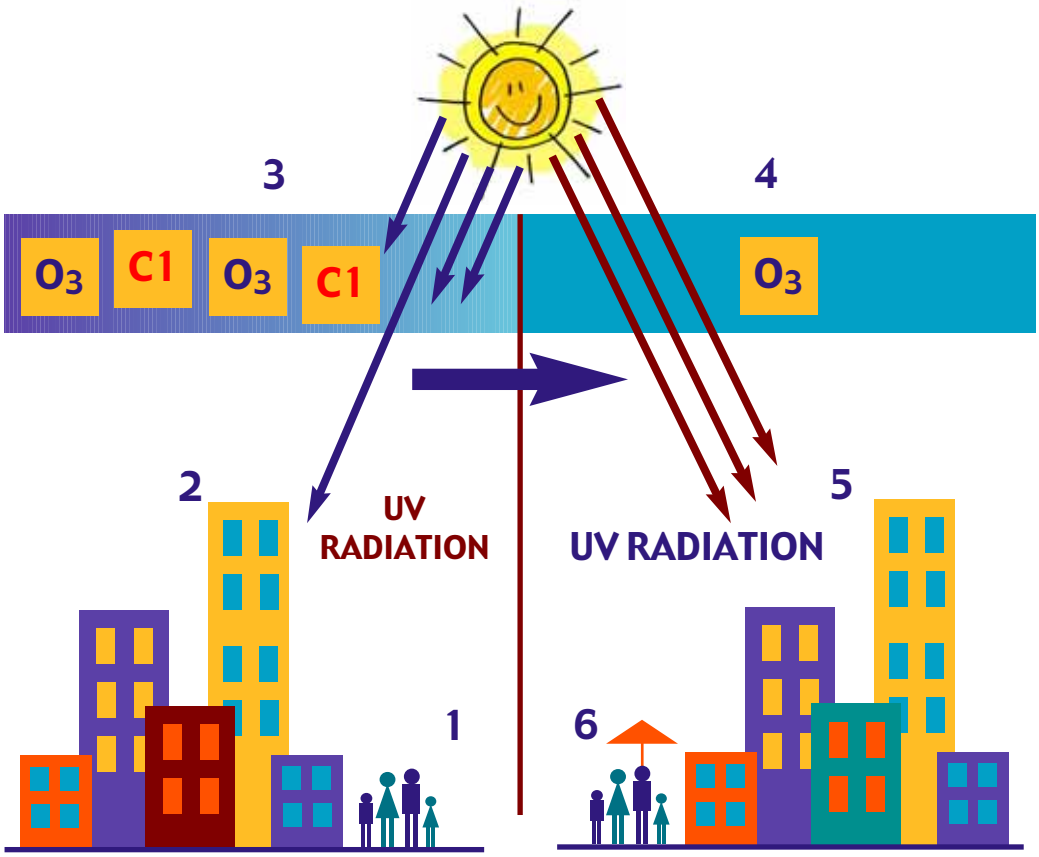
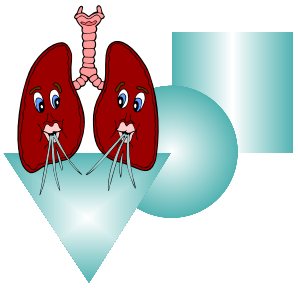


Figure 1 Ozone Depletion

When CFC's rise to the stratosphere, they undergo a significant reaction. UV radiation decomposes the CFC's (a process called *photolysis*) and breaks them into *chlorine* molecules. The chlorine molecules are highly reactive. They can do two things. One, *they can react with the ozone*—thinning it out and forming *chlorine monoxide*, or two, *they can react with nitrogen*—leaving the ozone layer undamaged. Below is an example of the chemical reactions that take place. CF_2Cl_2, one of the CFC's that scientists believe to be responsible for ozone destruction, is used in the example on the following page.



CHEMICAL REACTIONS INVOLVED IN DESTRUCTION OF "GOOD" OZONE

1. $CF_2Cl_2 + hv \longrightarrow CF_2Cl + Cl$
   CFC plus UV light
2. $Cl + O_3 \longrightarrow ClO + O_2$
   Chlorine from #1 plus the ozone
3. $ClO + O \longrightarrow Cl + O_2$
   Chlorine monoxide plus free O (O2 is broken apart by UV light also)
4. $O + O_3 \longrightarrow O_2 + O_2$
   Do you see ozone in the product?

It is estimated that ***one molecule of chlorine can degrade over 100,000 molecules of good ozone***. So as you can see, the more CFCs released into the air, the more ozone destroyed. This is what all of the concern is about.

Increase In Tropospheric ozone (Bad ozone)

In many areas of the United States, ozone levels in the air around us are measured, sometimes leading to *"Ozone Action Days"*. These are days when ozone levels are high and can be harmful to people. ***Ground-level ozone (GLO)***, affects our health directly by:

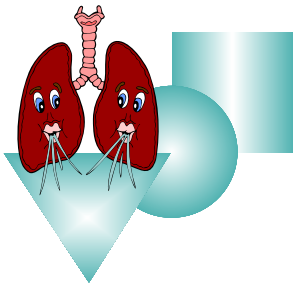
- irritating lungs and airways causing wheezing, coughing, pain upon breathing, and breathing problems during exercise
- permanent lung damage with repeated exposure to GLO
- GLO, even at low levels, causes reduced lung capacity, increased likelihood of contracting pneumonia and bronchitis, and increased severity of asthma symptoms GLO affects us indirectly by damaging trees, crops, and ecosystems.

So, where does GLO come from? It is created by a chemical reaction between ***nitrogen oxides*** and ***volatile organic compounds*** (VOCs) in the presence of sunlight. Motor vehicle exhaust and industrial plant pollution, gasoline vapors, and chemical solvents release nitrogen oxides and VOCs. Sunlight and hot weather cause them to form ground level ozone. Unfortunately, wind carries ozone hundreds of miles away, where it also causes damage.

Ozone levels can be observed by making ***Schoenbein paper***. This test is based upon the oxidation capability of ozone. Ozone in the air will oxidize ***potassium iodide*** **(KI)** on a piece of test paper to produce ***iodine***. The iodine reacts with starch and produces a blue color. The darker or more purple the color, the higher the amount of ozone present in the air.

This reaction is shown by the following chemical equation:

$$\underset{\text{Potassium Iodide}}{2KI} + \underset{\text{Ozone}}{O_3} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Potassium Hydroxide}}{2KOH} + \underset{\text{Oxygen}}{O_2} + \underset{\text{Iodide}}{I_2}$$



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Activity Materials (to make and use the strips:)

(makes approximately 60 Schoenbein test strips 2 cm X 12 cm)

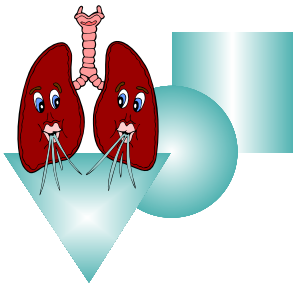
- 250 ml beaker
- 5 g Corn starch
- 100 ml distilled water ***(must be distilled)***
- 150 ml graduated cylinder
- 1 g potassium iodide, (lab grade is sufficient and less expensive)
- 1 triple beam balance
- Filter paper (such as # 615. 33 cm diameter, although the paper will be cut into strips, so the starting size is not significant)
- Heat source (preferably a hot plate)
- Glass stirring rod ***(do not use metal)***
- Small foam paint brush
- Psychrometer (instructions for homemade psychrometer at http://www.almanac.com/weathercenter/sling.php
- Spray bottle
- Pencil
- Printed and laminated color scale found on the following website: http://teachertech.rice.edu/Participants/lee/colorscale.html

Note: Ozone test strips available for purchase at the following website:
http://www.uvprocess.com/product.asp?code=GASDET+++C

***Instructions* for making the *Schoenbein paper test strips*:**
Note: Instead of making 2 cm x 12 cm strips, consider making the test strips lung-shaped by using a lung-shaped die cutter or asking students to trace one set of lungs from the ***Lung Template Page*** (included in the teacher section of this activity) onto the filter paper using a ***pencil*** **(do not use ink of any kind)** and then cut out the shape. Using only pencil, on the back of the paper, students should write their names, class period, and location they plan to hang the strip. These can be turned in so the teacher can prepare them for testing. Using a lung shape will provide context clues to help students determine the purpose of these test strips.

Safety note: Use gloves and goggles.

1. Mix 5 g cornstarch and 100 ml water in a large beaker; heat and stir constantly with a glass stirring rod until mixture gelatinizes.
2. Remove the mixture from heat and dissolve 1 potassium iodide in the mixture. Stir well and cool.
3. Use a foam paint brush to apply the gel to both sides of a piece of filter paper–apply as evenly as possible.
4. Dry the paper out of direct light and air circulation.



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5. Once dry, cut the paper into strips or lung shapes and store in zip lock bags out of direct sunlight.

6. To use the test paper, spray with *distilled water* until saturated and hang it at the test site with a PLASTIC clothes pin. The paper should be out of direct sun and hang freely. Expose for at least 8 hours.

7. After exposure, spray the paper with distilled water and observe the color. Arrange the test paper strips from lightest to darkest for relative color comparisons.

8. You will also need to determine the relative humidity using a *psychrometer*. *Use Figure 2 Schoenbein Color Scale* to determine the *Schoenbein number*. The more intense purple, the higher *Schoenbein number*, indicating a higher level of ozone.

9. Find the relative humidity and round it to the nearest 10 percent. (High humidity causes a better reaction with the paper, so humidity must be factored in when determining the ozone levels.)

10. Use *Figure 3 Relative Humidity Schoenbein Number Chart* to find the *Schoenbein number* along the bottom of the graph on the x (horizontal) axis. Find the point on the humidity curve that corresponds to your *Schoenbein number* to read the concentration of ozone on the y (vertical) axis.

    Note: Procedure adapted from:
    http://www.ucar.edu/learn/1_7_2_29t.htm

Figure 2 Schoenbein Color Scale

SCHOENBEIN NUMBER	COLOR CHANGE
0-3	Little or no change
4-6	Pink/lavender hue
7-10	Blue/purple hue

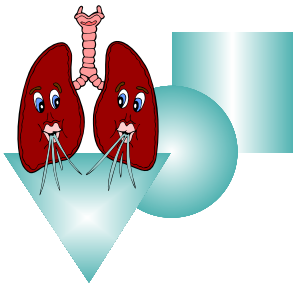

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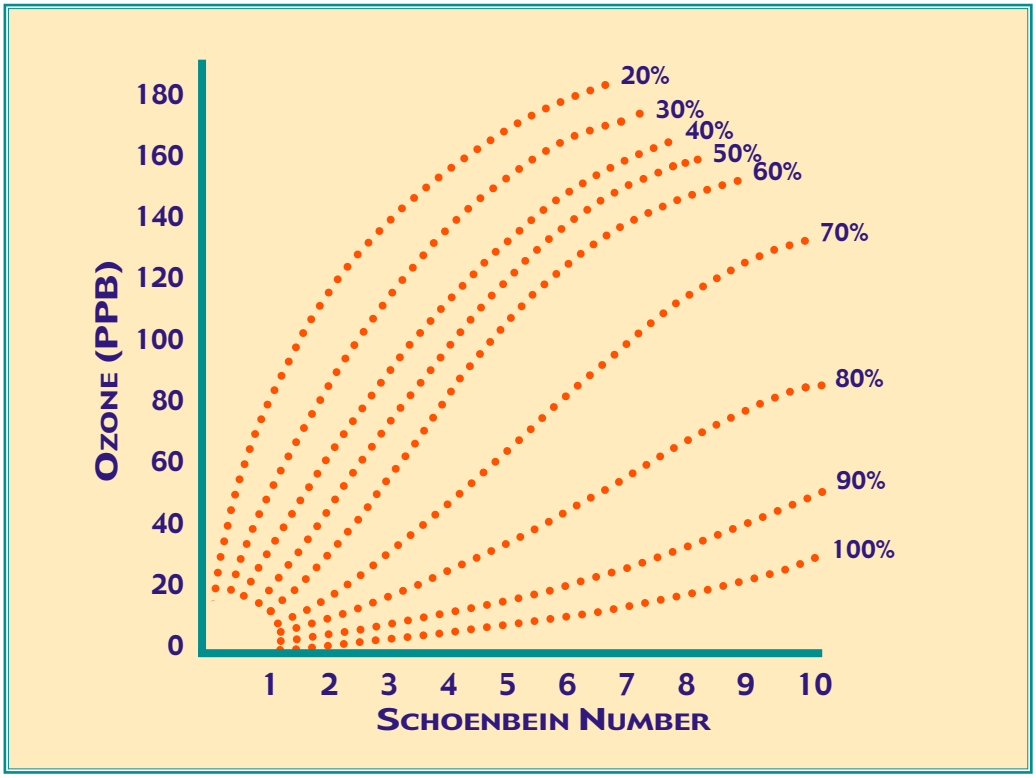
Figure 3 Relative Humidity Schoenbein Number Chart



Note: Graphics adapted from:
http://teachertech.rice.edu/Participants/lee/colorscale.html

Modifications:

1. Using KWL chart, assess the knowledge students bring to the activity and allow highly able students to start at a point in the activity that will bring new understanding to them.

2. Monitor all students carefully to ensure student success.

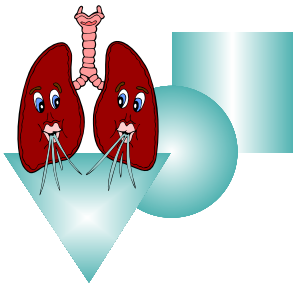
Extensions:

1. Have some students research and contact environmental agencies to find out about jobs and salaries available in the field of environmental science.

2. Have students take turns going into the *AACOG* website and making schoolwide morning and afternoon announcements about *Ozone Alert Days*.

3. For highly able students, allow students to relate ozone depletion in the stratosphere to the industrial development of nations. Ask students to relate this same growth effect to tropospheric ozone.

4. Have students find out why motorists are asked to reduce idling time and to not fill up the gas tank during the hottest part of the day.



Activity References Used:

American Lung Association website: Ozone Fact Sheet
http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=50328

Alamo Area Council of Governments website at:
http://www.aacog.com/air/default.asp

Christian Schoenbein biographical information:
http://scienceworld.wolfram.com/search/

EPA Website on Reasons for concern about ground level ozone:
http://www.epa.gov/air/urbanair/ozone/index.html

Fukushima, Noelle. ***Classroom Ozone***. (Cited in unpublished paper by Deborah Weissling)

Leaf, A. (1993). Loss of stratospheric ozone and health effects of increased ultraviolet radiation. In ***Critical condition: Human health and environment***, ed. E. Chivian, M. McCally, H. Hu, and A. Haines, (pp. 139-50). Cambridge, MA: The MIT Press.

Old Farmers Almanac
http://www.almanac.com/weathercenter/sling.php

Ozone Test Paper Color Scale
http://teachertech.rice.edu/participants/lee/colorscale.html

Reports to the Nation: Our Ozone Shield. (1992). Retrieved from
http://www.noaa.gov/ozone.html

Rubin. M.B. (2001). The history of ozone: The Schoenbein period (1839-1868). ***Bull Hist Chem***, 26(1), 40-56.
Note: This article is also available on the following website:
http://www.scs.uiuc.edu/~mainzv/HIST/awards/OPA%20Papers/2001-Rubin.pdf

The Environmental Protection Agency Website:
http://www.epa.gov/ozone/ods.html

The Globe Program website:
http://www.globe.gov

The National Center for Atmospheric Research & the UCAR Office of Programs Operated by the University Corporation for Atmospheric Research; Making and Using Schoenbein Paper
http://www.ucar.edu/learn/1_7_2_29t.htm

The National Oceanic & Atmospheric Association website:
http://www.noaa.gov

Visual Learning Resources from Inspiration Software®, Inc.
http://www.inspiration.com/vlearning/index.cfm

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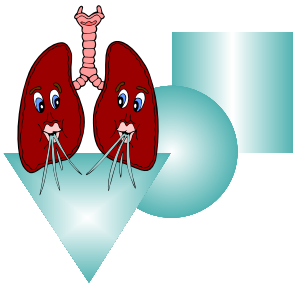

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