Pollution → Health → Ozone

26 March 2007
29th class meeting

READINGS,
Monday 26 March:
Ozone link through EPA
Wednesday 28 March:
Global Climate Change; 2 readings:
National Geographic Article, Nature Paper

Lab 28/30 March:
meet in lab,
bring Mt Lemmon data, notes

Environmental Biology (ECOL 206)
University of Arizona, spring 2007

Kevin Bonine, Ph.D.
Anna Tyler, Graduate TA

http://eebweb.arizona.edu/courses/Ecol206/206_Page2007.html

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SNR Special Seminar Information
Thanks to financial support from the Graduate Student and Professional Council, Institute for the Study of Planet Earth, and USGS, we are honored to welcome **Dr. Sharon Collinge** from The University of Colorado at Boulder for a visit to SNR on March 27th and 28th. Dr. Collinge will be giving a talk entitled Got plague?: Links between landscape change and disease occurrence in western USA grasslands, as part of the School of Natural Resources Seminar Series (Wednesday, March 28th at noon in the Old Chem Bldg (across the quad) room 209).
Dr. Collinges current research focuses on the role of landscape spatial heterogeneity in shaping ecological processes, including responses of individual organisms, populations, and communities to spatial variation in landscape structure. More information on Dr. Collinges lab can be found at <<http://www.colorado.edu/eeb/EEBprojects/CollingeLab/index.html>.

A selection of Dr. Collinges papers can be found by following this link (http://www.u.arizona.edu/~obrienc/research/collinge/collinge.html).

Tuesday, March 27th
Undergraduate student luncheon, 12:00 1:00 pm, room 218 BSE
Break-out session (professional development and research), 1:15 2:15, room 218 BSE

Wednesday, March 28th
SNR Noon Seminar, 12:00-1:00, Old Chem Bldg room 209
Potluck social, 6:00 9:00 (more information to come)

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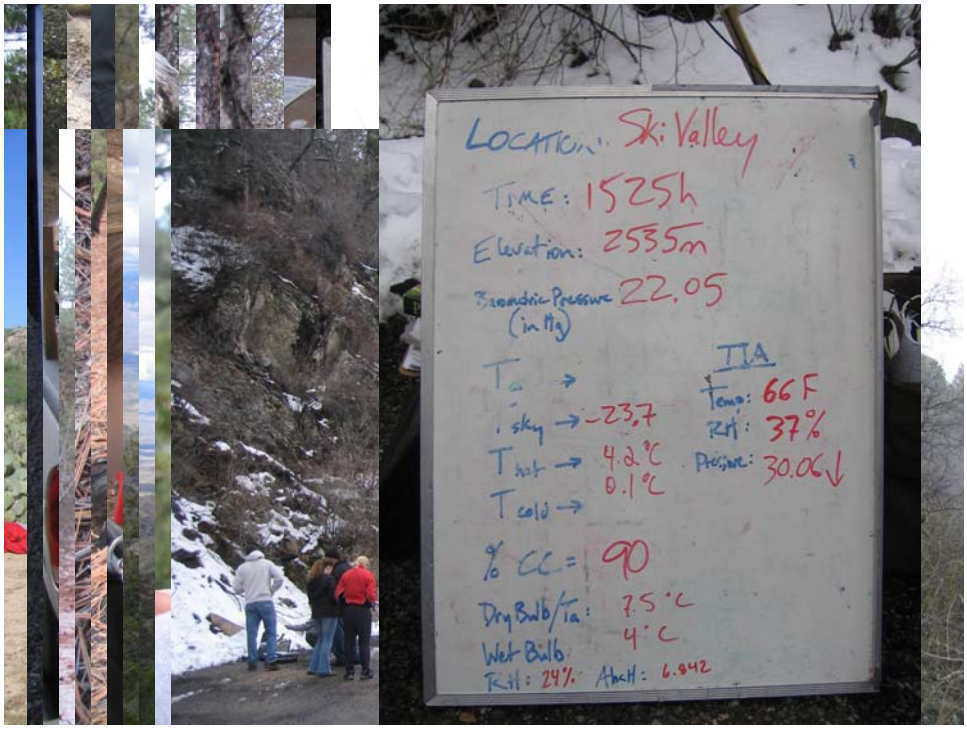


Energy Sources

Solar – passive or active
Hydrogen - (green algae??)
need to decompose water

Hydropower
Wind
Biomass
Geothermal

Fossil Fuels
Oil
Natural Gas
Coal

Nuclear

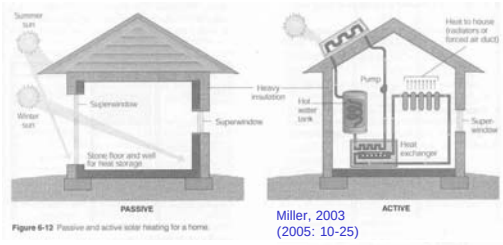
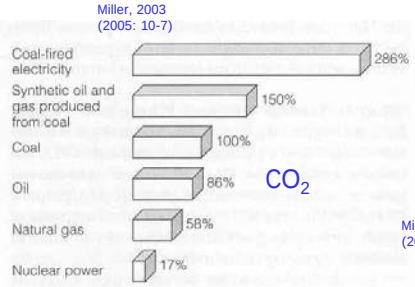


Figure 6-12 Passive and active solar heating for a home.

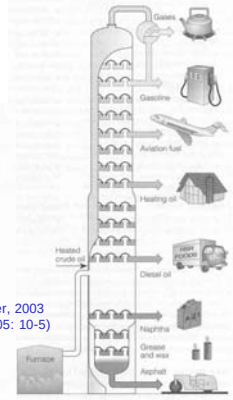
Miller, 2003
(2005: 10-25)

Miller, 2003
(2005: 10-7)



CO_2

Figure 6-25 CO_2 emissions per unit of energy produced by various fuels, expressed as percentages of emissions produced by coal.



Miller, 2003
(2005: 10-5)

Figure 6-24 Refining crude oil. Based on their boiling points, components are removed at various levels in a giant distillation column. The most volatile components with the lowest boiling points are removed at the top of the column.

What is a fuel cell?

A fuel cell is an electrochemical device that combines hydrogen and oxygen to produce electricity, with water and heat as its by-product. As long as fuel is supplied, the fuel cell will continue to generate power. Since the conversion of the fuel to energy takes place via an electrochemical process, not combustion, the process is clean, quiet and highly efficient – two to three times more efficient than fuel burning. No other energy generation technology offers the combination of benefits that fuel cells do. In addition to low or zero emissions, benefits include high efficiency and reliability, multi-fuel capability, siting flexibility, durability, sand ease of maintenance. Fuel cells are also scalable and can be stacked until the desired power output is reached. Since fuel cells operate silently, they reduce noise pollution as well as air pollution and the waste heat from a fuel cell can be used to provide hot water or space heating for a home or office.

http://www.fuelcells.org/

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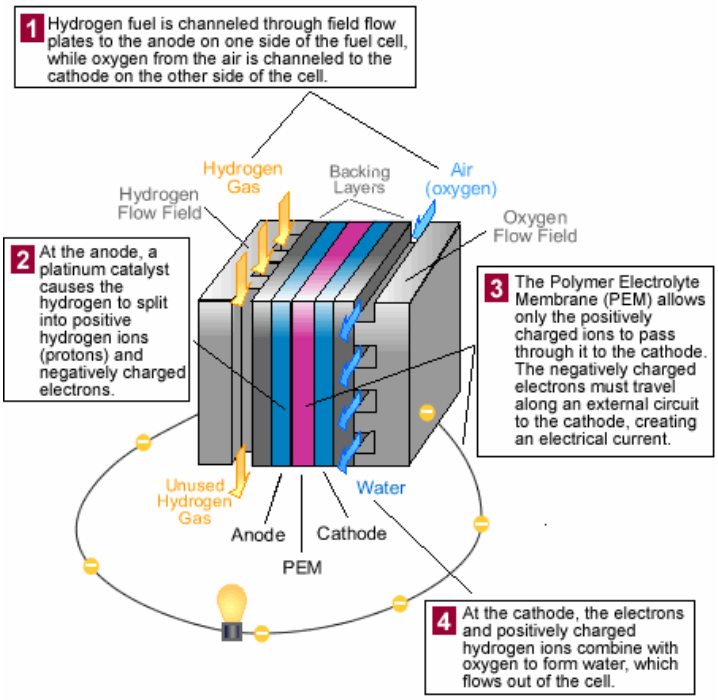

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http://www.chevrolet.com/electriccar/

http://www.chevrolet.com/fuelcell/

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Wednesday, February 16, 2005 / ARIZONA DAILY STAR · A3

Smog linked to cancerous genetic changes in fetuses

KNIGHT RIDDER NEWSPAPERS

WASHINGTON — Air pollution from traffic and power plants seems to cause genetic changes — the kind linked to cancer — in developing fetuses, a federally funded study released Tuesday has concluded.

A first-of-its-kind study of 60 pregnant women in poor areas of New York City used backpacks to monitor the women's exposure to airborne carcinogens and then tested their babies' umbilical-cord blood after birth. Babies whose moms were exposed to higher pollution levels had 53 percent more aberrations in their chromosomes. Other studies have shown that these types of chromosomal changes increase the risk of cancer.

"This finding shows the process can begin as early as the womb as a result of air pollution," said study author Frederica Perera, the director of Columbia University's Center for Children's Environmental Health. "We know that these pollutants make their way across the placenta."

Perera's study didn't determine what parts of the babies' genes changed or if they all changed in the same areas.

The peer-reviewed study — funded by the Natio of Environmental ences and publis month's journal demiology Biomarl vention — links chromosome dama ed exposure to po matic hydrocarbon

There are mor PAHs, which are th of combustion, in and truck exhaust, emissions, tobacco even the smoke meats. Fifteen of t mon PAHs are liste gens in the official list of cancer-causi

"This is not s pregnant women a ers to be alarmed Perera, a professo mental health. " mean that their ch get cancer."

But Perera and en, director of the stitute of Environm Sciences, said th should make fed look toward bett prevention method

▶ *Japan marks ena Kyoto global warm*

Health & Science

It's good riddance to Frank, so David is just fine, thank you

THE ASSOCIATED PRESS

WASHINGTON — A 9-year-old boy who nicknamed his brain tumor "Frank" — that's short for Frankenstein — is celebrating the intruder's departure.

"Frank is now dead and gone and never to return," David Dingman-Grover said Tuesday. He was wearing a T-shirt that read, "Cancer is not who I am."

Frank the Tumor gained national attention when David's mother created "Frank Must Die" bumper stickers, which the family auctioned on eBay to defray the costs of surgery.

Biopsy results Tuesday showed the tumor was no longer cancerous.

When the boy from Sterling, Va., outside Washington was diagnosed with a grapefruit-sized tumor in 2003, the family was told the size and location in the center of his skull made it difficult — perhaps impossible — to remove.

Doctors used chemotherapy and radiation to shrink the tumor to the size of a peach pit. That alleviated the child's headaches and temporary blindness, but doctors still needed to remove the tumor.

Traditional brain surgery, called craniotomy, involves cutting through the patient's face and skull. The parents agreed to the operation, but it never occurred — too risky. The tumor was surrounded by three arteries responsible for supplying blood flow to the brain.

David's mother used the Internet to find out about an alternative procedure.

Out through the nose

Dr. Hrayr Shahinian of the Skull Base Institute in Los Angeles used fiber-optic instruments to remove the tumor through the child's nose in a 1½-hour operation Feb. 2 at Cedars-Sinai Medical Center.

"There were no cuts on his face," Shahinian said.

"David would have most likely died if we had done the surgery the other way," said

Damian Dovarganes / The Associate

Tiffani Dingman-Grover, *David's mom: "I'm just so grateful tha have the chance to continue to be David's mother." David nicknamed his brain tumor "Frank." Unusual surgery was success*

Tiffani Dingman-Grover. "I'm just so grateful that I have the chance to continue to be David's mother."

David will be 10 on March 1 and said he had no doubts he would see this birthday.

"I knew the Lord would guide me through this," he said. "I'm very happy. I just want to go home and live a normal life again." He will spend the coming months recovering from chemotherapy and radiation, which has left his immune system low and his muscles weak.

The surgeon did not cl for the procedure, which mally would cost about $1 including hospital fees anesthesiologists.

The family has do $20,000 they received to a ty to help other children cancers.

Asked why he did the gery for free, the doctor sh reporters a pebble the boy him that he now carries wallet. On it is the "courage."

AZDStar, 16 Feb 2005

FRANK MUST DIE!

Perception of Risk

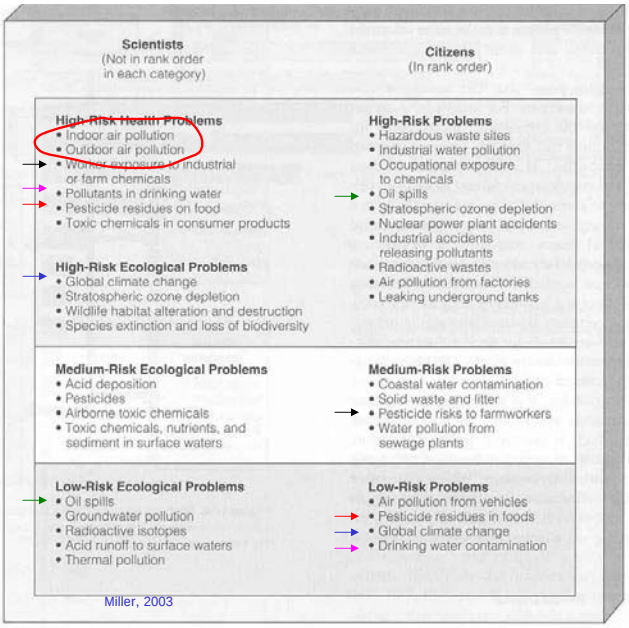
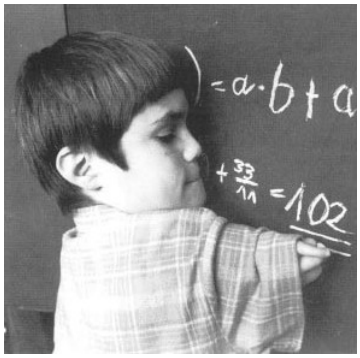


Figure 10-7 *Comparative risk analysis* of the most serious ecological and health problems according to scientists acting as advisers to the U.S. Environmental Protection Agency (left column). Risks in each of these categories are not listed in rank order. The right side of this figure represents polls showing how U.S. citizens rank the ecological and health risks they perceive as the most serious. Why do you think there is such a great difference between the ranking by risk experts and by the general public? (Data from Science

Thalidomide

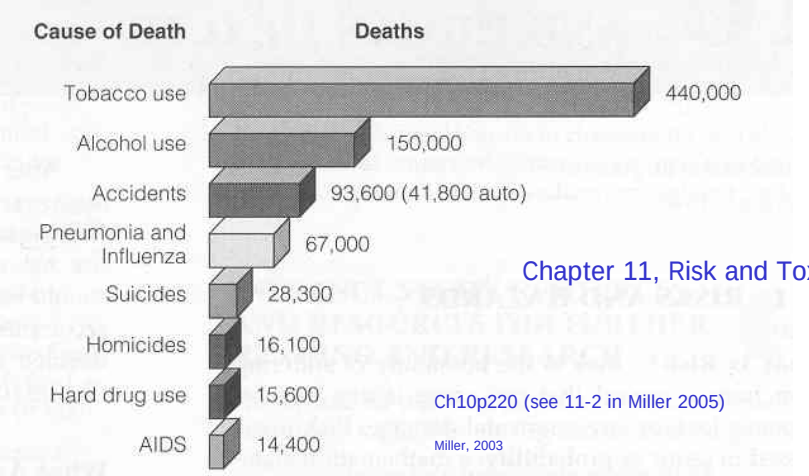


Thalidomide is a drug that was introduced on to the market on October 1, 1957 in West Germany. Thalidomide soon became a drug prescribed to pregnant women to combat symptoms associated with morning sickness. When taken during the first trimester of pregnancy, Thalidomide prevented the proper growth of the foetus resulting in horrific birth defects in thousands of children around the world. These children were born in the late 1950's and early 1960's and became known as "*Thalidomide babies*".

Of the 10,000 babies with "seal-like" limbs, only seventeen were born in the United States. The number was low because Dr. Frances Kelsey blocked the sale of the drug in this country.

Precautionary Principle

What are humans dying from?



Annual deaths in the United States from tobacco use and other causes. Smoking is by far the nation's leading cause of preventable death, causing more premature deaths each year than all the other categories in this figure combined. (Data from National Center for Health Statistics)

Chapter 11, Risk and Toxins

Ch10p220 (see 11-2 in Miller 2005)

Miller, 2003

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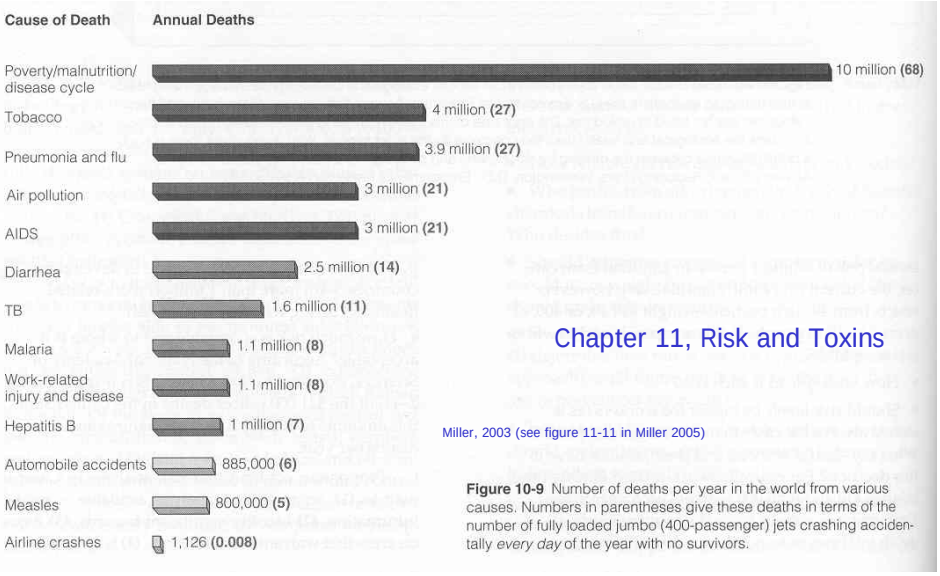
What are humans dying from?



Chapter 11, Risk and Toxins

Miller, 2003 (see figure 11-11 in Miller 2005)

Figure 10-9 Number of deaths per year in the world from various causes. Numbers in parentheses give these deaths in terms of the number of fully loaded jumbo (400-passenger) jets crashing accidentally *every day* of the year with no survivors.

Miller, 2003

Shortening Lifespan in the U.S.

Miller, 2003 (see figure 11-12 in Miller 2005)

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Ending Hunger and Disease (Miller p. 155):

-Immunizations

-Breast Feeding

-Sugar+Salt+Water to fight dehydration from diarrhea

-Vitamin A 2x/year to prevent blindness

-Family planning services

-Educate women
nutrition, sterilize drinking water, child care

Cost: $5-10/child/year

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Speth
Red Sky at Morning
Chapter 2, Lost in Eden

Biophilia (Kellert&Wilson)

Threats:

1. Land Use Conversion (1/3 forests gone, ½ wetlands)
2. Land Degradation
3. Freshwater Shortages
4. Watercourse Modifications
5. Invasive Species
6. Overharvesting
7. Climate Change
8. Ozone Depletion
9. Pollution

Only need ~$30 billion/year to set aside 15% land area

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Blaustein

Pollution

1-natural
2-anthropogenic
urban and industrial areas
industrial agriculture

Sources:

a. Point (smokestack, drainpipe, exhaust pipe)
b. Nonpoint (runoff with fertilizers and pesticides)

Characteristics of Pollution:

1. Chemical nature
2. Concentration
3. Persistence
   -Degradable (human waste)
   -Persistent (DDT, plastics)
   -Nondegradable (lead, mercury)

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Air Pollution

- Primary
- Secondary

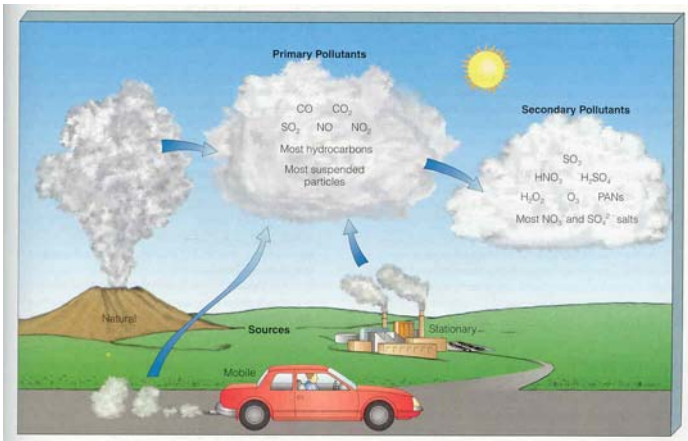

Figure 12-4 Sources and types of air pollutants. Human inputs of air pollutants may come from *mobile sources* (such as cars) and *stationary sources* (such as industrial and power plants). Some *primary air pollutants* may react with one another or with other chemicals in the air to form *secondary air pollutants*.

Miller 11-22, 2003
See Miller 2005 Fig. 12-20

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Air Pollution

Table 11-2 Major Classes of Air Pollutants

Class	Examples
Carbon oxides	Carbon monoxide (CO), carbon dioxide (CO_2)
Sulfur oxides	Sulfur dioxide (SO_2), sulfur trioxide (SO_3)
Nitrogen oxides	Nitric oxide (NO), nitrogen dioxide (NO_2), nitrous oxide (N_2O) (NO and NO_2 often are lumped together and labeled NO_x)
Volatile organic compounds (VOCs)	Methane (CH_4), propane (C_3H_8), chlorofluorocarbons (CFCs)
Suspended particulate matter (SPM)	Solid particles (dust, soot, asbestos, lead, nitrate and sulfate salts), liquid droplets (sulfuric acid, PCBs, dioxins, pesticides)
Photochemical oxidants	Ozone (O_3), peroxyacyl nitrates (PANs), hydrogen peroxide (H_2O_2), aldehydes
Radioactive substances	Radon-222, iodine-131, strontium-90, plutonium-239
Hazardous air pollutants (HAPs), which cause health effects such as cancer, birth defects, and nervous system problems	Carbon tetrachloride (CCl_4), methyl chloride (CH_3Cl), chloroform ($CHCl_3$), benzene (C_6H_6), ethylene dibromide ($C_2H_2Br_2$), formaldehyde (CH_2O_2)

Miller, 2003, see Miller 2005 Table 12-2

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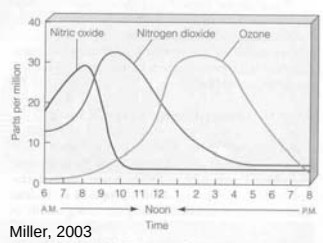
Photochemical Smog

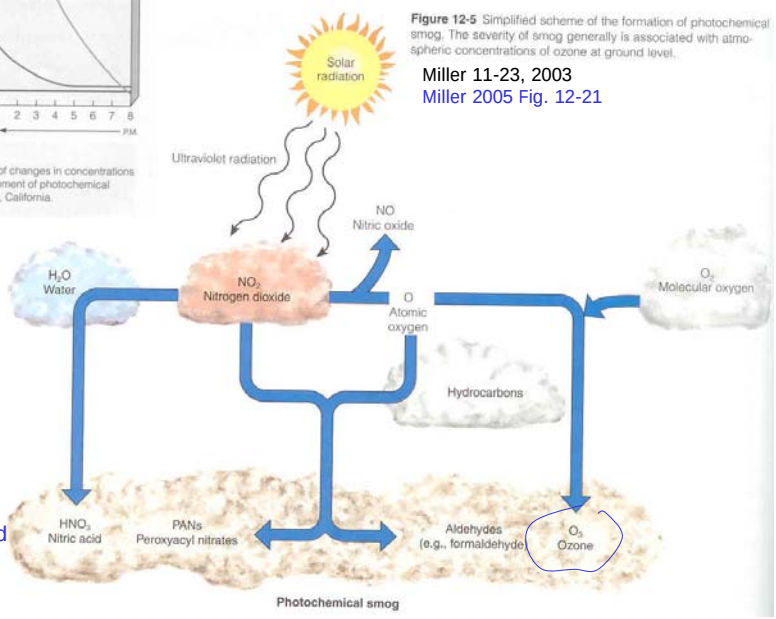


Miller, 2003

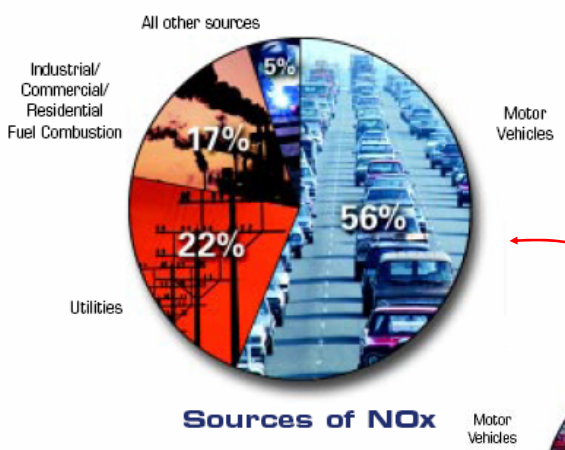
Figure 11-24 Typical daily pattern of changes in concentrations of air pollutants that lead to development of photochemical smog in a city such as Los Angeles, California.

Figure 12-5 Simplified scheme of the formation of photochemical smog. The severity of smog generally is associated with atmospheric concentrations of ozone at ground level.

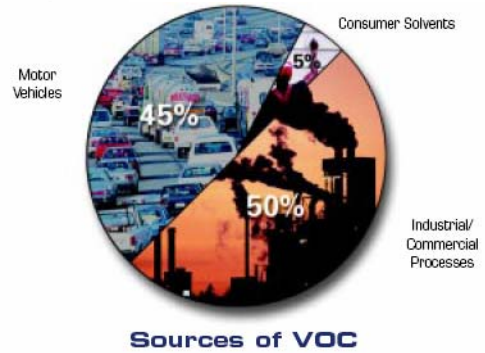
Miller 11-23, 2003
Miller 2005 Fig. 12-21



Ozone in troposphere = bad



Ozone forms when these interact in air in presence of light.



http://www.epa.gov/oar/oaqps/gooduphigh/ozone.pdf

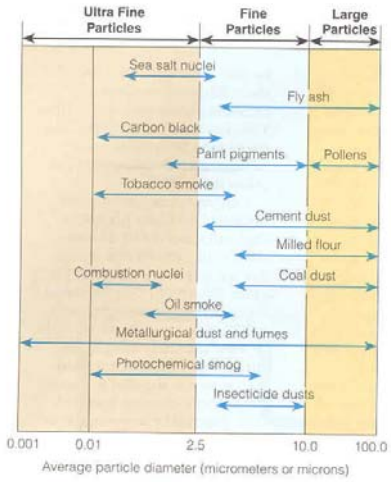


Figure 12-6 Suspended particulate matter consists of particles of solid matter and droplets of liquid that are small and light enough to remain suspended in the atmosphere for short periods (large particles) to long periods (small particles). Suspended particles are found in a wide variety of types and sizes, ranging in diameter from 0.001 micrometer to 100 micrometers (a micrometer, or micron, is one millionth of a meter, or about 0.00004 inches). Since 1987, the EPA has focused on *fine particles* smaller than 10 microns (known as *PM-10*). In 1997, the agency began focusing on reducing emissions of *ultrafine particles* with diameters less than 2.5 microns (known as *PM-2.5*) because these particles are small enough to reach the lower part of human lungs and contribute to respiratory diseases.

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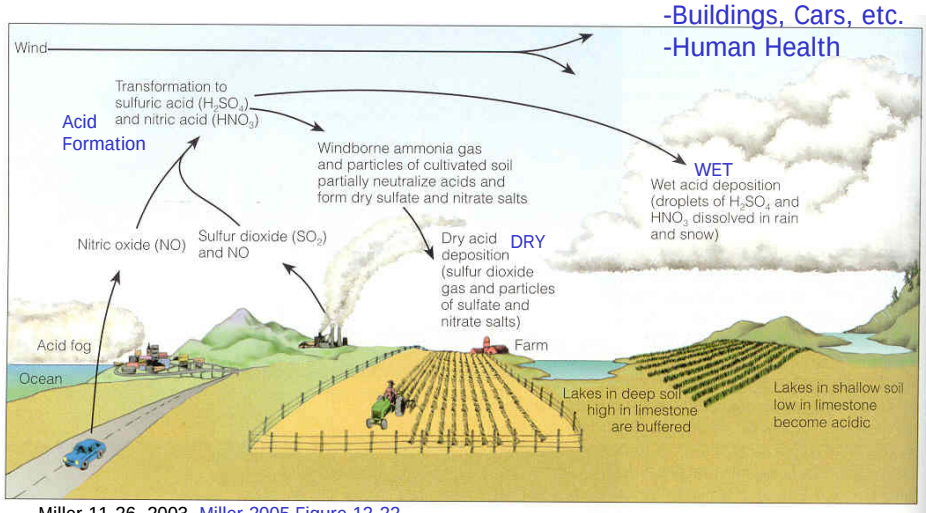
Acid Deposition

-Soil
-Water
-Fish
-Buildings, Cars, etc.
-Human Health



Miller 11-26, 2003, Miller 2005 Figure 12-22

Figure 12-8 Acid deposition, which consists of rain, snow, dust, or gas with a pH lower than 5.6, is commonly called acid rain. Soils and lakes vary in their ability to buffer or remove excess acidity.

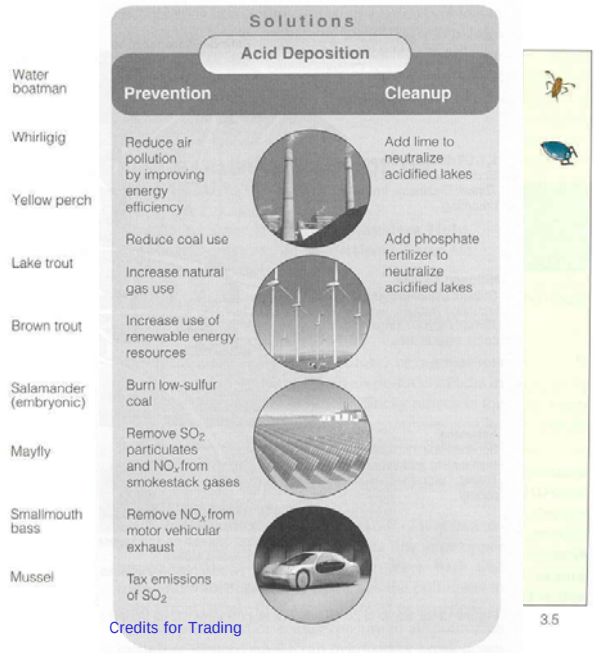


Figure 12-10 Fish and other aquatic organisms vary in their sensitivity to acidity. The figure shows the lowest pH (highest acidity) at which the various species can survive. Note that the greatest effects occur when the pH drops below 5.5.

Credits for Trading

Figure 12-24 Solutions: methods for reducing acid deposition and its damage. Miller, 2005

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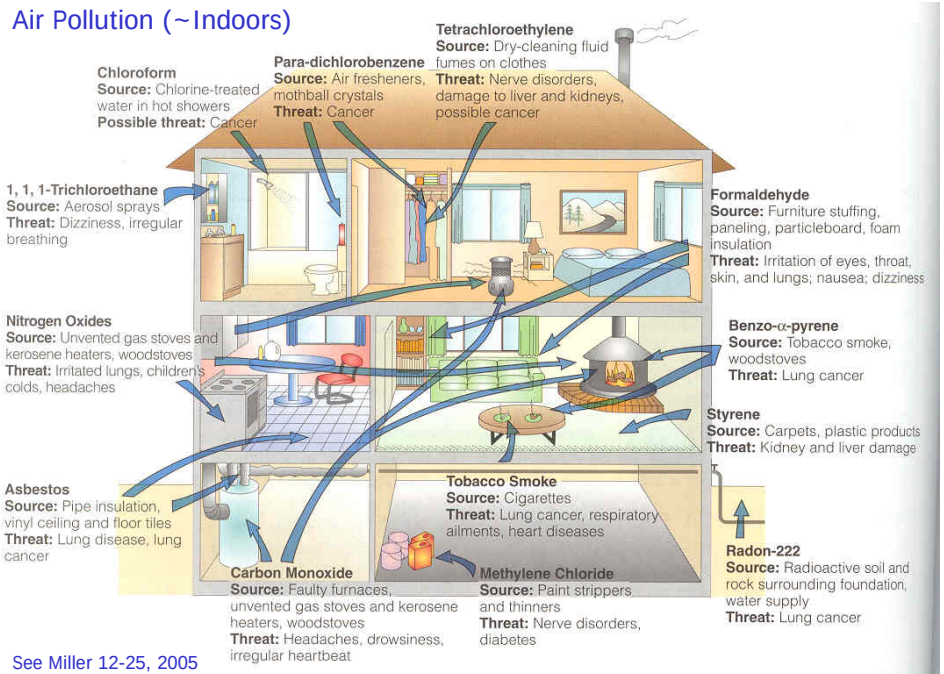
Air Pollution (~Indoors)



See Miller 12-25, 2005

Figure 12-13 Some important indoor air pollutants. (Data from U.S. Environmental Protection Agency)

What Can You Do?

Indoor Air Pollution

- Test for radon and formaldehyde inside your home and take corrective measures as needed.
- Do not buy furniture and other products containing formaldehyde.
- Remove your shoes before entering your house to reduce inputs of dust, lead, and pesticides.
- Test your house or workplace for asbestos fiber levels and for any crumbling asbestos materials if it was built before 1980.
- Don't live in a pre-1980 house without having its indoor air tested for asbestos and lead.
- Do not store gasoline, solvents, or other volatile hazardous chemicals inside a home or attached garage.
- If you smoke, do it outside or in a closed room vented to the outside.
- Make sure that wood-burning stoves, fireplaces, and kerosene- and gas-burning heaters are properly installed, vented, and maintained.
- Install carbon monoxide detectors in all sleeping areas.

Figure 12-30 What can you do? Ways to reduce your exposure to air pollution. Miller 2005

27

Table 12-2 Major Outdoor Air Pollutants*

CARBON MONOXIDE (CO)

Description: Colorless, odorless gas that is poisonous to air-breathing animals; forms during the incomplete combustion of carbon-containing fuels ($2\,C + O_2 \longrightarrow 2\,CO$).

Major human sources: Cigarette smoking (Case Study, p. 238), incomplete burning of fossil fuels. About 77% (95% in cities) comes from motor vehicle exhaust.

Health effects: Reacts with hemoglobin in red blood cells and reduces the ability of blood to bring oxygen to body cells and tissues. This impairs perception and thinking; slows reflexes; causes headaches, drowsiness, dizziness, and nausea; can trigger heart attacks and angina; damages the development of fetuses and young children; and aggravates chronic bronchitis, emphysema, and anemia. At high levels it causes collapse, coma, irreversible brain cell damage, and death.

NITROGEN DIOXIDE (NO_2)

Description: Reddish-brown irritating gas that gives photochemical smog its brownish color; in the atmosphere can be converted to nitric acid (HNO_3), a major component of acid deposition.

Major human sources: Fossil fuel burning in motor vehicles (49%) and power and industrial plants (49%).

Health effects: Lung irritation and damage; aggravates asthma and chronic bronchitis; increases susceptibility to respiratory infections such as the flu and common colds (especially in young children and older adults).

Environmental effects: Reduces visibility; acid deposition of HNO_3 can damage trees, soils, and aquatic life in lakes.

Property damage: HNO_3 can corrode metals and eat away stone on buildings, statues, and monuments; NO_2 can damage fabrics.

SULFUR DIOXIDE (SO_2)

Description: Colorless, irritating; forms mostly from the combustion of sulfur-containing fossil fuels such as coal and oil ($S + O_2 \longrightarrow SO_2$); in the atmosphere can be converted to sulfuric acid (H_2SO_4), a major component of acid deposition.

Major human sources: Coal burning in power plants (88%) and industrial processes (10%).

Health effects: Breathing problems for healthy people; restriction of airways in people with asthma; chronic exposure can cause a permanent condition similar to bronchitis. According to the WHO, at least 625 million people are exposed to unsafe levels of sulfur dioxide from fossil fuel burning.

Environmental effects: Reduces visibility; acid deposition of H_2SO_4 can damage trees, soils, and aquatic life in lakes.

Property damage: SO_2 and H_2SO_4 can corrode metals and eat away stone on buildings, statues, and monuments; SO_2 can damage paint, paper, and leather.

SUSPENDED PARTICULATE MATTER (SPM)

Description: Variety of particles and droplets (aerosols) small and light enough to remain suspended in atmosphere for short periods (large particles) to long periods; cause smoke, dust, and haze.

Major human sources: Burning coal in power and industrial plants (40%), burning diesel and other fuels in vehicles (17%), agriculture (plowing, burning off fields), unpaved roads, construction.

Health effects: Nose and throat irritation, lung damage, and bronchitis; aggravates bronchitis and asthma; shortens life; toxic particulates (such as lead, cadmium, PCBs, and dioxins) can cause mutations, reproductive problems, cancer.

Environmental effects: Reduces visibility; acid deposition of H_2SO_4 droplets can damage trees, soils, and aquatic life in lakes.

Property damage: Corrodes metal; soils and discolors buildings, clothes, fabrics, and paints.

OZONE (O_3)

Description: Highly reactive, irritating gas with an unpleasant odor that forms in the troposphere as a major component of photochemical smog (Figures 12-21).

Major human sources: Chemical reaction with volatile organic compounds (VOCs, emitted mostly by cars and industries) and nitrogen oxides to form photochemical smog (Figure 12-21).

Health effects: Breathing problems; coughing; eye, nose, and throat irritation; aggravates chronic diseases such as asthma, bronchitis, emphysema, and heart disease; reduces resistance to colds and pneumonia; may speed up lung tissue aging.

Environmental effects: Ozone can damage plants and trees; smog can reduce visibility.

Property damage: Damages rubber, fabrics, and paints.

LEAD

Description: Solid toxic metal and its compounds, emitted into the atmosphere as particulate matter.

Major human sources: Paint (old houses), smelters (metal refineries), lead manufacture, storage batteries, leaded gasoline (being phased out in developed countries).

Health effects: Accumulates in the body; brain and other nervous system damage and mental retardation (especially in children); digestive and other health problems; some lead-containing chemicals cause cancer in test animals.

Environmental effects: Can harm wildlife.

*Data from U.S. Environmental Protection Agency.

Miller 2005

28

"Are you saving the industry a billion dollars but taking away $10 billion worth of benefits for the general public?" Amar asked.

Mercury…

Mercury is a toxic metal emitted by industrial sources. U.S. power plants emit 48 tons a year, and the new rule establishes an emissions-trading program that is expected to lower emissions to about 31 tons by 2010 and to about 15 tons by 2026. The Harvard analysis was based on similar targets in President Bush's "Clear Skies" legislative proposal.

In most cases, mercury toxicity results from eating fish: Industrial emissions fall from the air into water and are taken up by fish. Because the metal does not break down, it moves steadily up the food chain to species that people consume. A major reason for the dramatic difference in the health benefit estimates was that the EPA looked only at the effects of reducing mercury levels in freshwater fish, but most of the fish Americans eat comes from oceans.

"Some very large share of mercury exposure comes from tuna," Hammitt said. "And while it's true that our power plants have less effect on tuna than on [freshwater] northern pike, if you ignore the saltwater pathway you'll miss a lot of the benefit."

Even though U.S. power plants contribute only about 1 percent of the mercury in the oceans, reducing even that small amount makes a difference, he said. The EPA has said that ocean species such as tuna, pollock, shrimp and halibut account for two-thirds of the mercury Americans consume, while catfish, the largest source of mercury among freshwater fish, accounts for only 3 percent.

By Shankar Vedantam
Washington Post Staff Writer
Tuesday, March 22, 2005; Page A01

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Illinois

Why is the statewide methylmercury advisory only for predator species?

Mercury stays in the environment for a long time. Small organisms absorb mercury from water and sediment; these organisms then are eaten by smaller fish. Predator fish eat the smaller fish and methylmercury is accumulated up the food chain. Larger fish have the highest amounts of methylmercury stored in their bodies. **Predator species for Illinois include all species of black bass (largemouth, smallmouth and spotted), striped bass, white bass, hybrid bass, walleye, sauger, saugeye, flathead catfish, muskellunge and northern pike.**

How does methylmercury get into bodies of water in Illinois?

Mercury is a metal that occurs naturally in small amounts in the environment. It also comes from burning coal or trash and from industry. Mercury gets into lakes and rivers in several ways, including rain and runoff. When conditions are right in the water, certain kinds of bacteria change metallic mercury into the more toxic methylmercury. Methylmercury is stored in the muscle of fish, the part of the fish people eat.

What are the potential health effects for people who eat fish contaminated with methylmercury?

The developing nervous systems of fetuses and children could be damaged if exposed to even small amounts of methylmercury. At high doses, methylmercury can affect the central nervous system (causing such health problems as memory loss and slurred speech) and can cause kidney damage and failure, and gastrointestinal damage. The possible health effects depend on how much methylmercury is stored in the fish and how much fish is eaten over a period of time. Based on the amounts of methylmercury detected in predator sport fish in Illinois, it is unlikely that people would experience adverse health effects associated with exposure to high doses.

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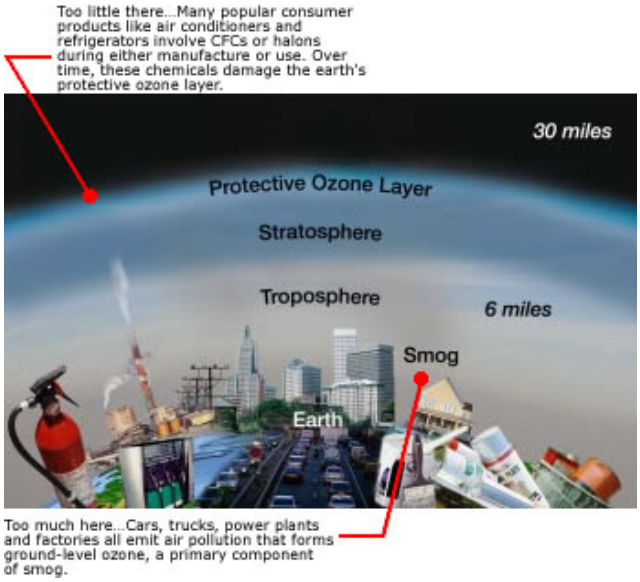
Ozone information from the EPA:

http://www.epa.gov/oar/oaqps/gooduphigh/



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Chapter 12
- Global Climate Change
- Ozone
- Air Pollution

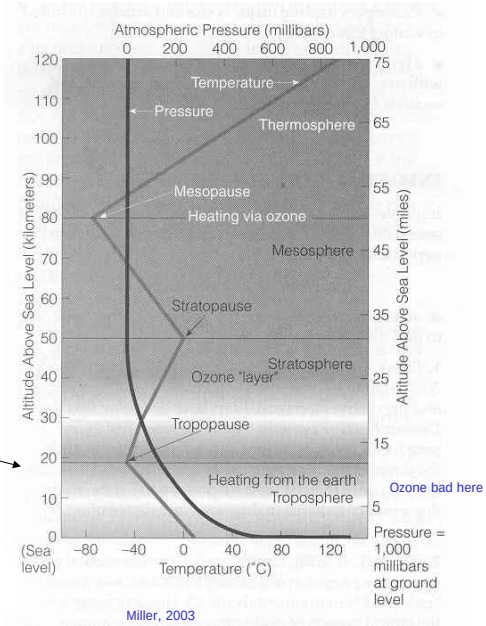
Atmosphere

Stratosphere
(Ozone = Sunscreen)
blocks 95% UV

Troposphere (80% air mass)
(Weather)

N	0.78
O	0.21
H_20	up to 0.04
Ar	0.01
CO_2	0.00037

etc.



Ozone bad here

Miller, 2003

Figure 11-1 The earth's current atmosphere consists of several layers. The average temperature of the atmosphere varies with altitude (lighter line). Most UV radiation from the sun is absorbed by ozone (O_3), which is found primarily in the stratosphere in the *ozone layer* 17–26 kilometers (10–16 miles) above sea level.

Global Warming vs. Ozone Depletion

Table 11-1 Major Characteristics of Global Warming and Ozone Depletion

Characteristic	Global Warming	Ozone Depletion
Region of atmosphere involved	Troposphere.	Stratosphere.
Major substances involved	CO_2, CH_4, N_2O (greenhouse gases).	O_3, O_2, chlorofluorocarbons (CFCs).
Interaction with radiation	Molecules of greenhouse gases absorb infared (IR) radiation from the earth's surface, vibrate, and release longer-wavelength IR radiation (heat) into the lower troposphere. This natural greenhouse effect helps warm the lower troposphere.	About 95% of incoming ultraviolet (UV) radiation from the sun is absorbed by O_3 molecules in the stratosphere and does not reach the earth's surface.
Nature of problem	There is a high probability that increasing concentrations of greenhouse gases in the troposphere from burning fossil fuels, deforestation, and agriculture are enhancing the natural greenhouse effect and raising the earth's average surface temperature (Figure 11-6, bottom, and Figure 11-11, p. 243).	CFCs and other ozone-depleting chemicals released into the troposphere by human activities have made their way to the stratosphere, where they decrease O_3 concentration. This can allow more harmful UV radiation to reach the earth's surface.
Possible consequences	Changes in climate, agricultural productivity, water supplies, and sea level.	Increased incidence of skin cancer, eye cataracts, and immune system suppression and damage to crops and phytoplankton.
Possible responses	Decrease fossil fuel use and deforestation.	Eliminate CFCs and other ozone-depleting chemicals and find acceptable substitutes.

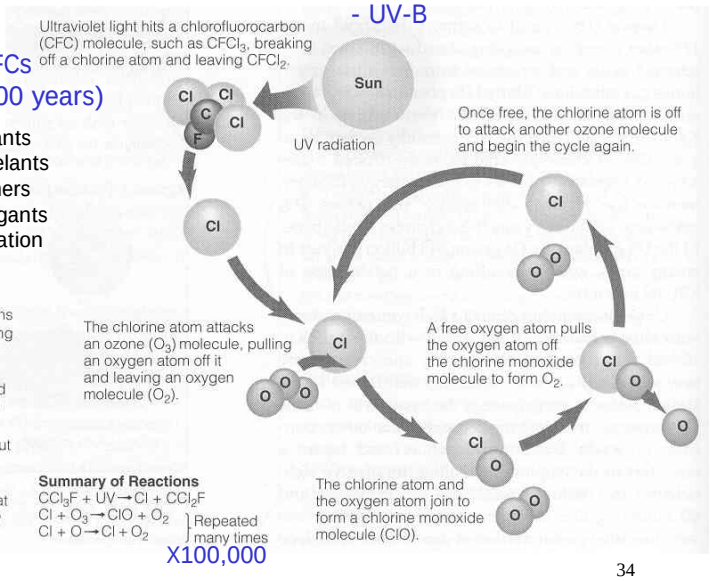
Miller, 2003, see Miller 2005 Table 12-1

Ozone depletion in the stratosphere

- Ozone thinning at the poles
- Seasonal
- UV-B

CFCs
(last ~100 years)

-Coolants
-Propelants
-Cleaners
-Fumigants
-Insulation



Miller, 2003

Figure 11-19 A simplified summary of how chlorofluorocarbons (CFCs) and other chlorine-containing compounds destroy ozone in the stratosphere. Note that chlorine atoms are continuously regenerated as they react with ozone. Thus they act as *catalysts*, chemicals that speed up chemical reactions without being used up by the reaction. Bromine atoms released from bromine-containing compounds that reach the stratosphere also destroy ozone by a similar mechanism.

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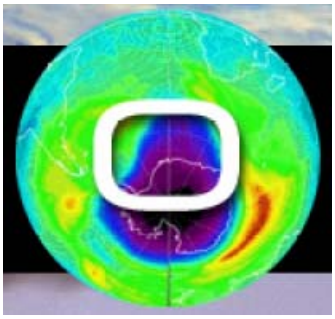
van der Leun (UNEP) 1995

Environmental Effects of Ozone Depletion

Some reductions in ODCs, but continued thinning - why?

UV-B (290-315 nm) effects - ouch.

- -Human and Animal Health
- -Terrestrial Plants
- -Aquatic Ecosystems
  - Phytoplankton as CO_2 sink
  - Base of food web
- -Biogeochemical Cycles
  - alter decomposition rates etc.
- -Air Quality



http://www.epa.gov/oar/oaqps/gooduphigh/ozone.pdf

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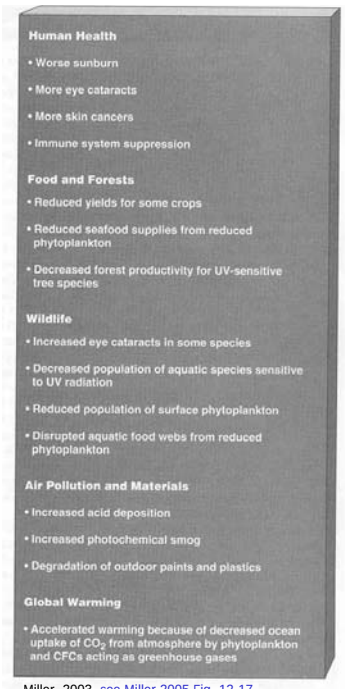
Effects of Ozone Thinning

Cataracts
Cancer
Immune system

Crops
Phytoplankton
Aquatic ecosystems
Forests

Air Pollution

(Global Warming
-indirectly)



Miller, 2003, see Miller 2005 Fig. 12-17

Figure 11-20 Expected effects of decreased levels of ozone in the stratosphere.

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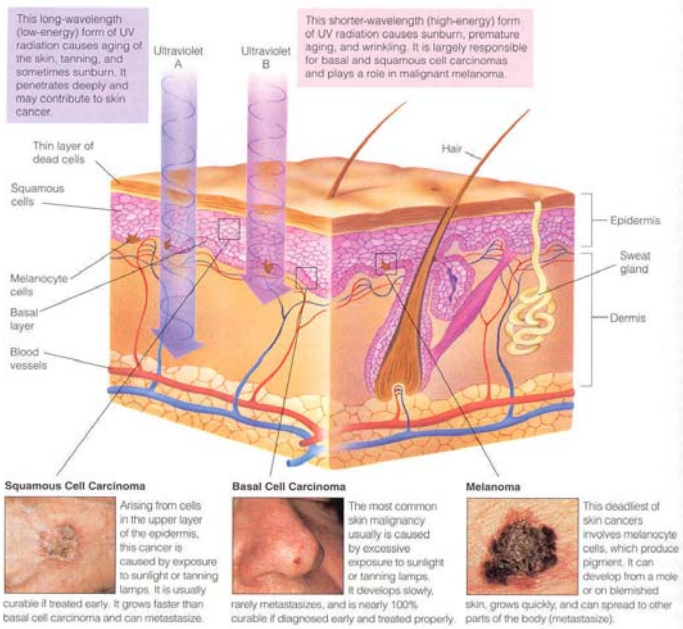

Figure 13-20 Structure of the human skin and the relationships between ultraviolet (UV-A and UV-B) radiation and the three types of skin cancer. The incidence of these types of cancer is rising, mostly because more fair-skinned people have increased their exposure to sunlight by moving to areas with sunnier climates and spending more of their leisure time exposed to sunlight. If ozone-destroying chemicals continue to reduce stratospheric ozone levels, incidence of these types of cancers is expected to rise. (The Skin Cancer Foundation)

Miller, 2003 (other)

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Effective International Agreements regarding ODCs

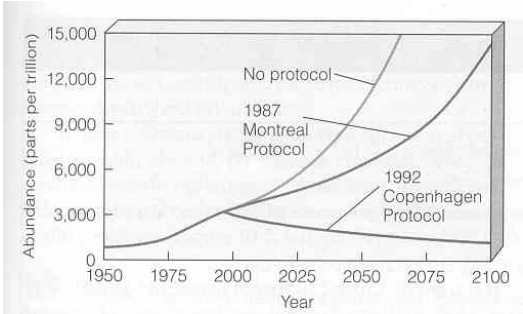

Figure 11-21 Projected concentrations of ozone-depleting chemicals (ODCs) in the stratosphere under three scenarios: **(1)** no action, **(2)** the 1987 Montreal Protocol, and **(3)** the 1992 Copenhagen Protocol. Miller, 2003, see Miller 2005 Fig. 12-19

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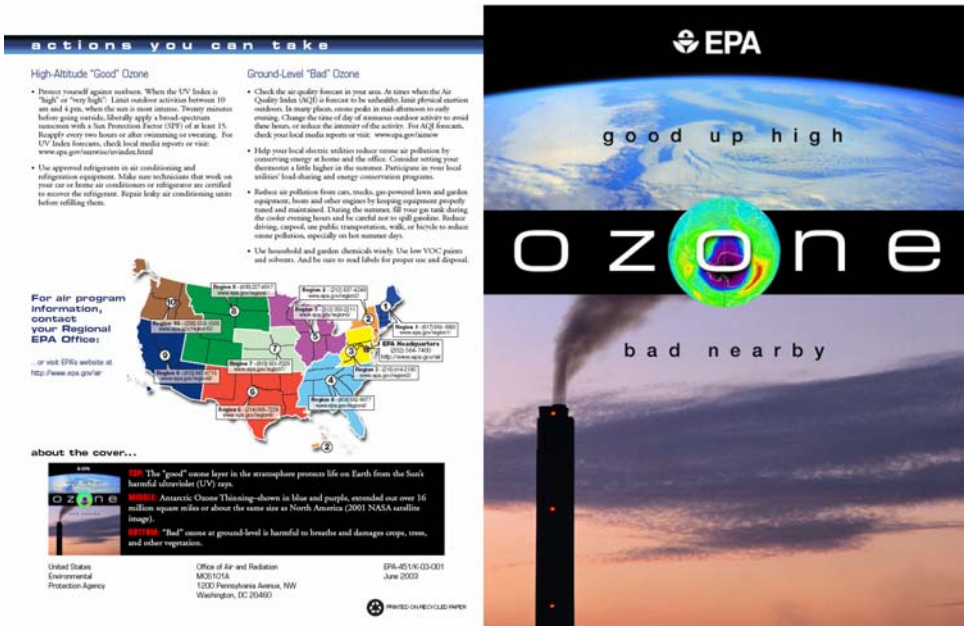

actions you can take

High-Altitude "Good" Ozone

- Protect yourself against sunburn. When the UV Index is "high" or "very high". Limit outdoor activities between 10 am and 4 pm, when the sun is most intense. Twenty minutes before going outside, liberally apply a broad-spectrum sunscreen with a Sun Protection Factor (SPF) of at least 15. Reapply every two hours or after swimming or sweating. For UV Index forecasts, check local media reports or visit: www.epa.gov/sunwise/uvindex.html
- Use approved refrigerants in air conditioning and refrigeration equipment. Make sure technicians that work on your car or home air conditioners or refrigerator are certified to recover the refrigerant. Repair leaky air conditioning units before refilling them.

Ground-Level "Bad" Ozone

- Check the air-quality forecast in your area. At times when the Air Quality Index (AQI) is forecast to be unhealthy, limit physical exertion outdoors. In many places, ozone peaks in mid-afternoon to early evening. Change the time of day of strenuous outdoor activity to avoid these hours, or reduce the intensity of the activity. For AQI forecasts, check your local media reports or visit: www.epa.gov/airnow
- Help your local electric utilities reduce ozone air pollution by conserving energy at home and the office. Consider setting your thermostat a little higher in the summer. Participate in your local utilities' load-sharing and energy conservation programs.
- Reduce air pollution from cars, trucks, gas-powered lawn and garden equipment, boats and other engines by keeping equipment properly tuned and maintained. During the summer, fill your gas tank during the cooler evening hours and be careful not to spill gasoline. Reduce driving, carpool, use public transportation, walk, or bicycle to reduce ozone pollution, especially on hot summer days.
- Use household and garden chemicals wisely. Use low VOC paints and solvents. And be sure to read labels for proper use and disposal.

For air program information, contact your Regional EPA Office:

...or visit EPA's website at http://www.epa.gov/air

about the cover...

TOP: The "good" ozone layer in the stratosphere protects life on Earth from the Sun's harmful ultraviolet (UV) rays.

MIDDLE: Antarctic Ozone Thinning–shown in blue and purple, extended out over 16 million square miles or about the same size as North America (2001 NASA satellite image).

BOTTOM: "Bad" ozone at ground-level is harmful to breathe and damages crops, trees, and other vegetation.

United States Environmental Protection Agency

Office of Air and Radiation
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Washington, DC 20460

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EPA

good up high

ozone

bad nearby

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http://www.epa.gov/oar/oaqps/gooduphigh/ozone.pdf

good up high

bad nearby

What is Ozone?

Ozone is a gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone can be "good" or "bad" for your health and the environment, depending on its location in the atmosphere.

How Can Ozone Be Both Good and Bad?

Ozone occurs in two layers of the atmosphere. The layer closest to the Earth's surface is the troposphere. Here, ground-level or "bad" ozone is an air pollutant that is harmful to breathe and it damages crops, trees and other vegetation. It is a main ingredient of urban smog. The troposphere generally extends to a level about 6 miles up, where it meets the second layer, the stratosphere. The stratosphere or "good" ozone layer extends upward from about 6 to 30 miles and protects life on Earth from the sun's harmful ultraviolet (UV) rays.

Too little there... Many popular consumer products like air conditioners and refrigerators evolve CFCs or halons during either manufacture or use. Over time, these chemicals damage the earth's protective ozone layer.

Too much here... Cars, trucks, power plants and factories all emit air pollution that forms ground-level ozone, a primary component of smog.

What is Happening to the "Good" Ozone Layer?

Ozone is produced naturally in the stratosphere. But this "good" ozone is gradually being destroyed by man-made chemicals referred to as ozone-depleting substances (ODS), including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide, carbon tetrachloride, and methyl chloroform. These substances were formerly used and sometimes still are used in coolants, foaming agents, fire extinguishers, solvents, pesticides, and aerosol propellants. Once released into the air these ozone-depleting substances degrade very slowly. In fact, they can remain intact for years as they move through the troposphere until they reach the stratosphere. There they are broken down by the intensity of the sun's UV rays and release chlorine and bromine molecules, which destroy the "good" ozone. Scientists estimate that one chlorine atom can destroy 100,000 "good" ozone molecules.

Even though we have reduced or eliminated the use of many ODSs, their use in the past can still affect the protective ozone layer. Research indicates that depletion of the "good" ozone layer is being reduced worldwide. Thinning of the protective ozone layer can be observed using satellite measurements, particularly over the Polar Regions.

How Does the Depletion of "Good" Ozone Affect Human Health and the Environment?

Ozone depletion can cause increased amounts of UV radiation to reach the Earth which can lead to more cases of skin cancer, cataracts, and impaired immune systems. Overexposure to UV is believed to be contributing to the increase in melanoma, the most fatal of all skin cancers. Since 1990, the risk of developing melanoma has more than doubled.

UV can also damage sensitive crops, such as soybeans, and reduce crop yields. Some scientists suggest that marine phytoplankton, which are the base of the ocean food chain, are already under stress from UV radiation. This stress could have adverse consequences for human food supplies from the oceans.

What is Being Done About the Depletion of "Good" Ozone?

The United States, along with over 180 other countries, recognized the threats posed by ozone depletion and in 1987 adopted a treaty called the Montreal Protocol to phase out the production and use of ozone-depleting substances.

EPA has established regulations to phase out ozone-depleting chemicals in the United States. Warning labels must be placed on all products containing CFCs or similar substances and nonessential uses of ozone-depleting products are prohibited. Releases into the air of refrigerants used in car and home air conditioning units and appliances are also prohibited. Some substitutes to ozone-depleting products have been produced and others are being developed. If the United States and other countries stop producing ozone-depleting substances, natural ozone production should return the ozone layer to normal levels by about 2050.

What Causes "Bad" Ozone?

Ground-level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents are some of the major sources of NOx and VOC.

At ground-level, ozone is a harmful pollutant. Ozone pollution is a concern during the summer months because strong sunlight and hot weather result in harmful ozone concentrations in the air we breathe. Many urban and suburban areas throughout the United States have high levels of "bad" ozone. But many rural areas of the country are also subject to high ozone levels as winds carry emissions hundreds of miles away from their original sources.

How Does "Bad" Ozone Affect Human Health and the Environment?

Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. "Bad" ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.

Healthy people also experience difficulty breathing when exposed to ozone pollution. Because ozone forms in hot weather, anyone who spends time outdoors in the summer may be affected, particularly children, outdoor workers and people exercising. Millions of Americans live in areas where the national ozone health standards are exceeded.

Ground-level or "bad" ozone also damages vegetation and ecosystems. It leads to reduced agricultural crop and commercial forest yields, reduced growth and survivability of tree seedlings, and increased susceptibility to diseases, pests and other stresses such as harsh weather. In the United States alone, ground-level ozone is responsible for an estimated $500 million in reduced crop production each year. Ground-level ozone also damages the foliage of trees and other plants, affecting the landscape of cities, national parks and forests, and recreation areas.

What is Being Done About "Bad" Ozone?

Under the Clean Air Act, EPA has set protective health-based standards for ozone in the air we breathe. EPA, states, and cities have instituted a variety of multi-faceted programs to meet these health-based standards. Throughout the country, additional programs are being put into place to cut NOx and VOC emissions from vehicles, industrial facilities, and electric utilities. Programs are also aimed at reducing pollution by reformulating fuels and consumer/commercial products, such as paints and chemical solvents, that contain VOC. Voluntary programs also encourage communities to adopt practices, such as carpooling, to reduce harmful emissions.

We live with ozone every day. It can protect life on earth or harm it, but we have the power to influence ozone's impact by the way we live.

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http://www.epa.gov/oar/oaqps/gooduphigh/ozone.pdf