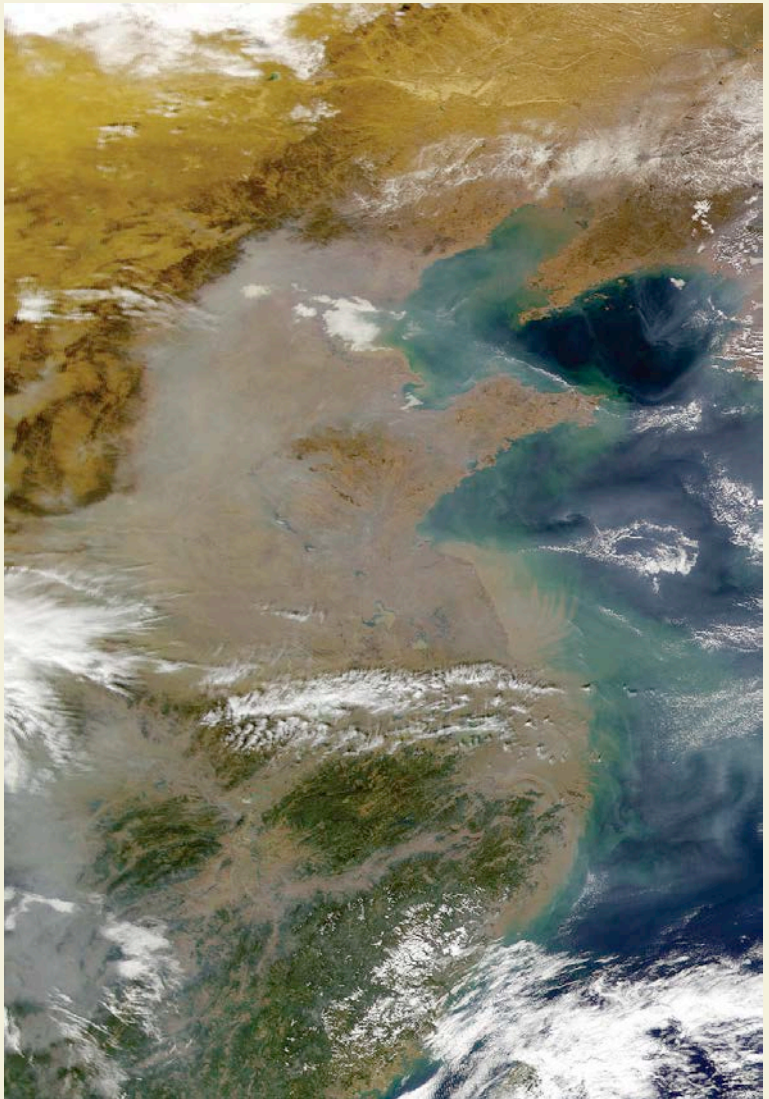
Chapter 18: Air Pollution

Core Case Study: South Asia's Massive Brown Cloud

- South Asian Brown Cloud
  - Causes
  - Chemical composition
  - Areas impacted
- Air pollution connects the world
  - Affects west coast of the United States
- China and India need stricter air pollution standards



Air Pollution in Shanghai, China

Fig. 18-2, p. 465

VIDEO: Beijing Experiences Terrible Air Quality

18-1 What Is the Nature of the Atmosphere?

Concept 18-1 *The two innermost layers of the atmosphere are the troposphere, which supports life, and the stratosphere, which contains the protective ozone layer.*

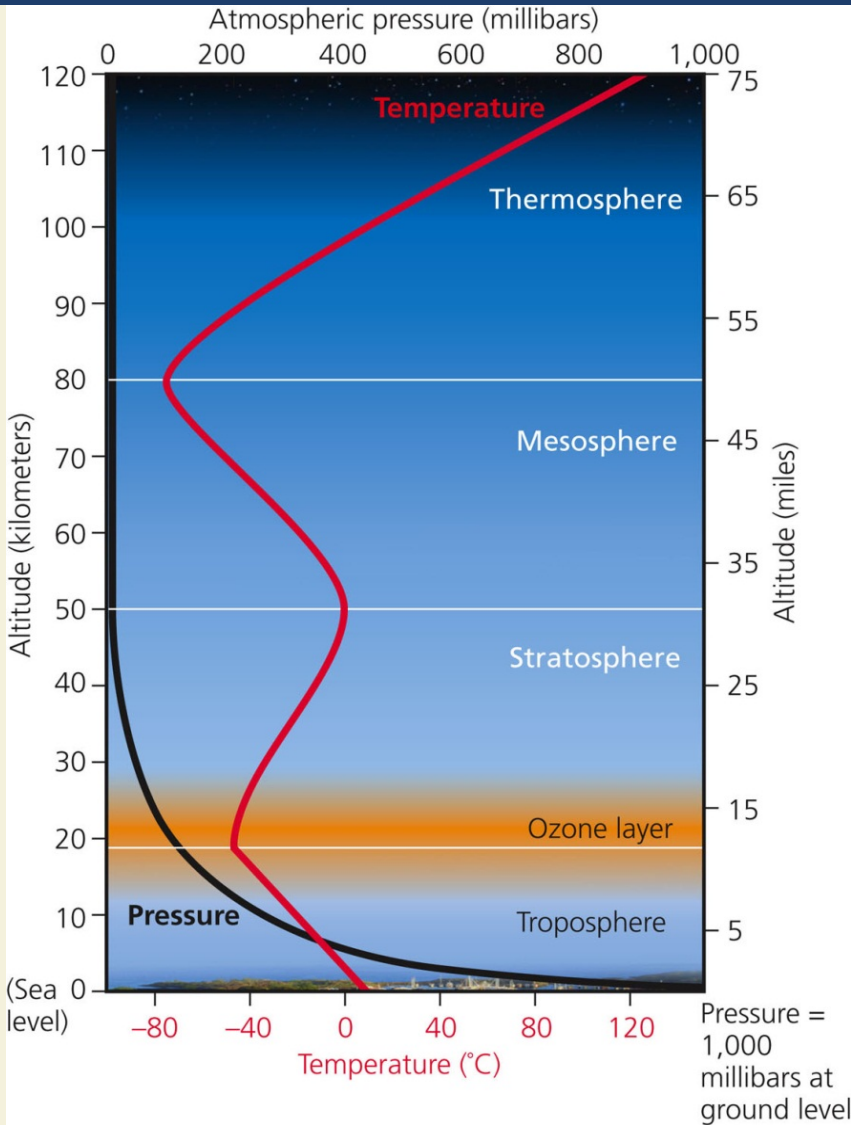
The Atmosphere Consists of Several Layers

Density varies

- Decreases with altitude

Atmospheric pressure

- Decreases with altitude



Air Movements in the Troposphere Play a Key Role in Earth's Weather and Climate

Troposphere

- 75–80% of the earth's air mass
- Closest to the earth's surface
- Chemical composition of air
- Rising and falling air currents: weather and climate
- Involved in chemical cycling

Case Study: The South Asian Brown Clouds, Melting Glaciers, and Atmospheric Cooling

2008 UNEP study on South Asian Brown Clouds

- Causing gradual melting of Himalayan glaciers
- Particles absorb sunlight and warm air above the glaciers
- Reflect some sunlight back to space
- Overall cooling affect on earth's atmosphere

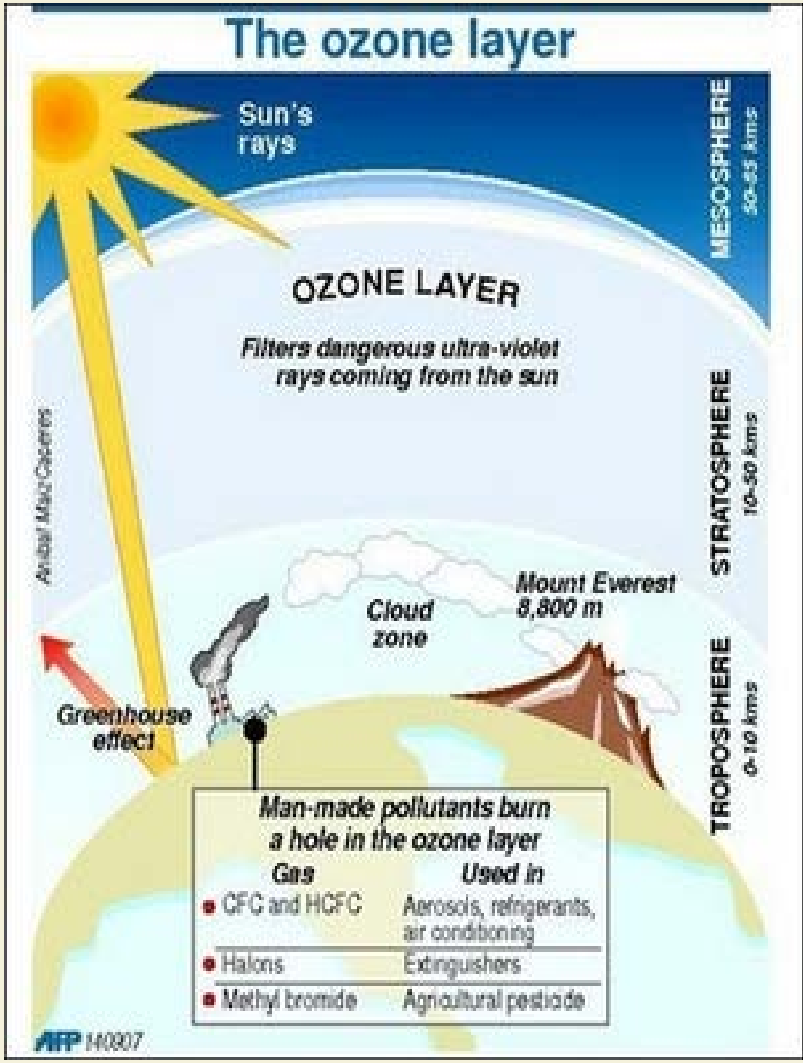
The Stratosphere Is Our Global Sunscreen

Stratosphere

- Similar composition to the troposphere, with 2 exceptions
  - Much less water
  - O_3, **ozone layer**

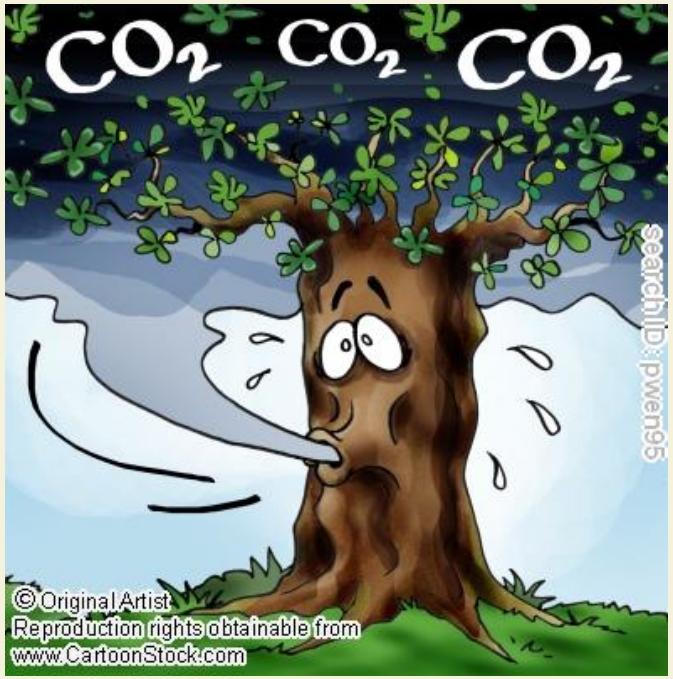
Ozone layer

- Filters 95% of harmful UV radiation
- Allows us and other life to exist on land



18-2 What Are the Major Outdoor Pollution Problems?

Concept 18-2 *Pollutants mix in the air to form industrial smog, primarily as a result of burning coal, and photochemical smog, caused by emissions from motor vehicles, industrial facilities, and power plants.*



What is Air Pollution?

Air pollution

- Concentrations high enough to harm human health or alter climate

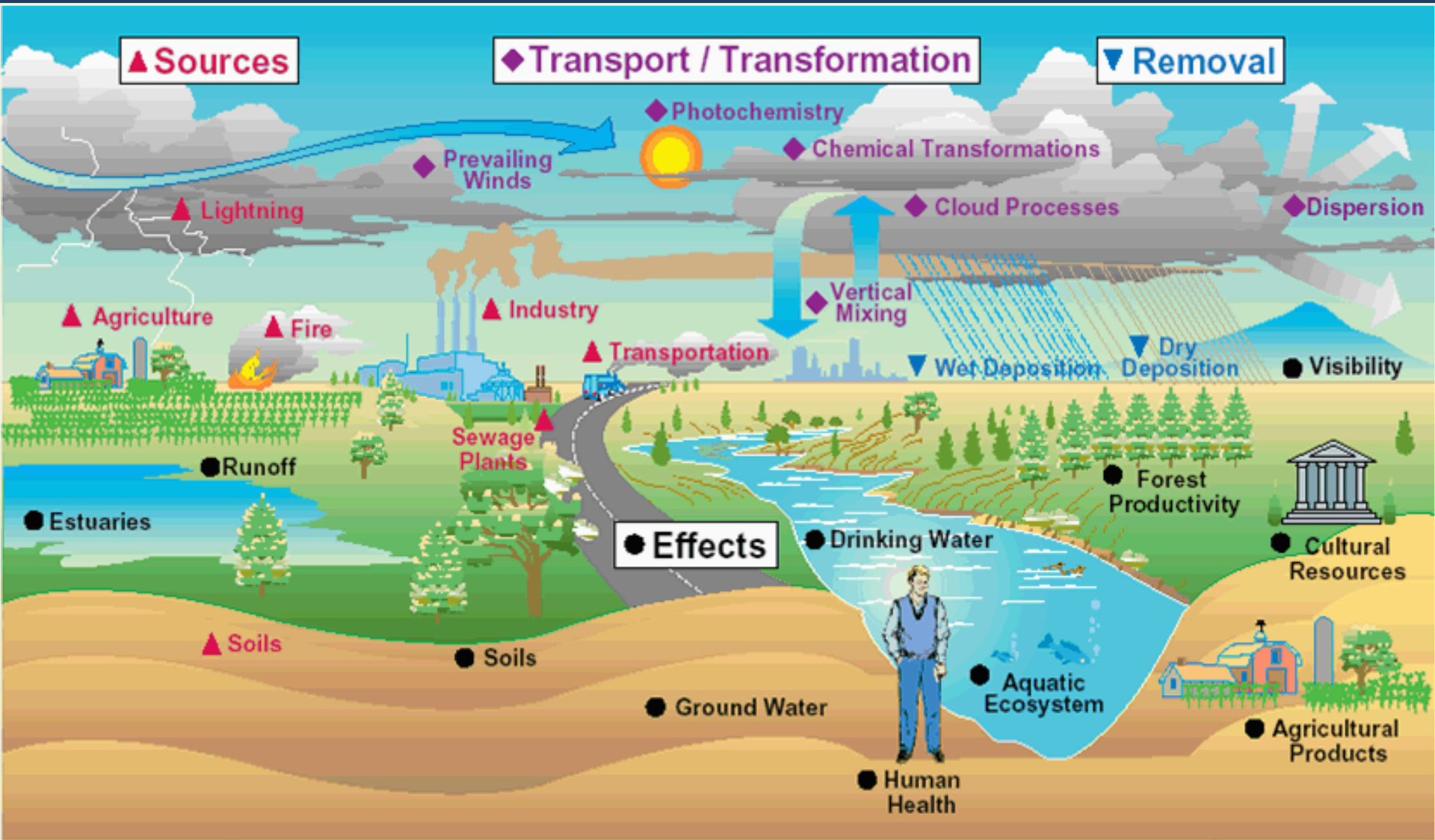
Natural sources

- Dust blown by wind
- Pollutants from wildfires and volcanoes
- Volatile organics released by plants

Burning Fossil Fuels Causes Air Pollution

Fig. 18-4, p. 468

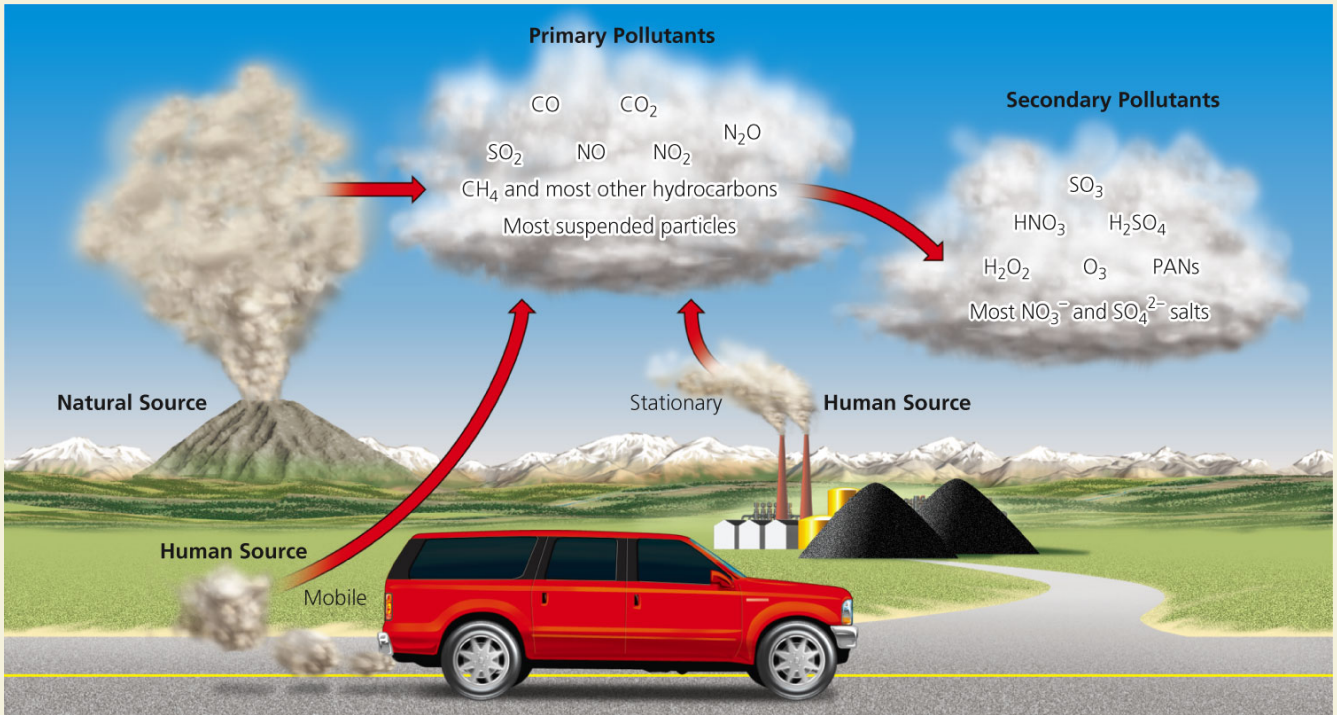
Air Pollution Pathways



Air Pollution Comes from Natural and Human Sources

Human sources: mostly in industrialized and/or urban areas

- Stationary sources: power plants and industrial facilities
- Mobile sources: motor vehicles



Some Pollutants in the Atmosphere Combine to Form Other Pollutants

- **Primary pollutants**
  - Emitted directly into the air
- **Secondary pollutants**
  - From reactions of primary pollutants
- Air quality improving in developed countries
- Less-developed countries face big problems
  - Indoor pollution: big threat to the poor

Indoor Air Pollution in Bangladesh

Fig. 18-6, p. 469

Human Impact on Atmosphere

- **Burning Fossil Fuels**
  - **Adds CO_2 and O_3 to troposphere**
  - **Global Warming**
  - **Altering Climates**
  - **Produces Acid Rain**
- **Using Nitrogen fertilizers and burning fossil fuels**
  - **Releases NO, NO_2, N_2O, and NH_3 into troposphere**
  - **Produces acid rain**
- **Refining petroleum and burning fossil fuels**
  - **Releases SO_2 into troposphere**
- **Manufacturing**
  - **Releases toxic heavy metals (Pb, Cd, and As) into troposphere**

www.dr4.cnrs.fr/gif-2000/ air/products.html

Criteria Air Pollutants

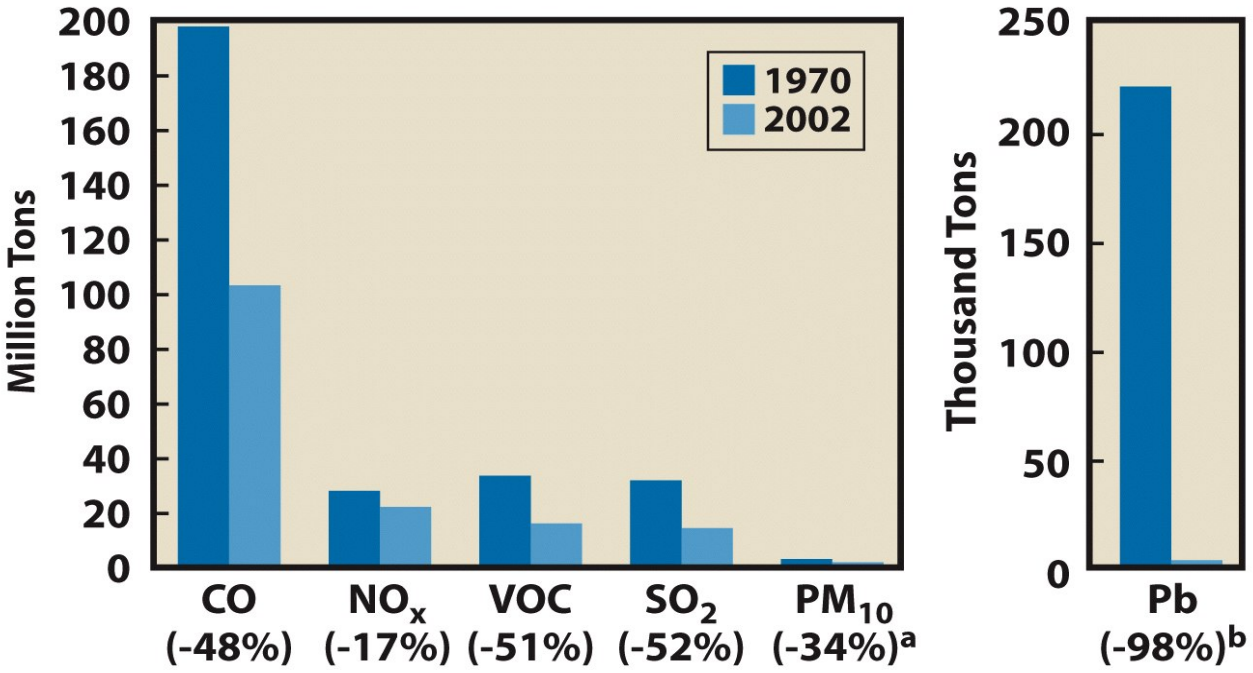
EPA uses six "criteria pollutants" as indicators of air quality

1. Nitrogen Dioxide: NO_2
2. Ozone: ground level O_3
3. Carbon monoxide: CO
4. Lead: Pb
5. Particulate Matter: PM_{10} (PM 2.5)
6. Sulfur Dioxide: SO_2

- Volatile Organic Compounds: (VOCs)

EPA established for each concentrations above which adverse effects on health may occur

US Emissions of Six Major Air Pollutants



Note that there have been significant reductions.

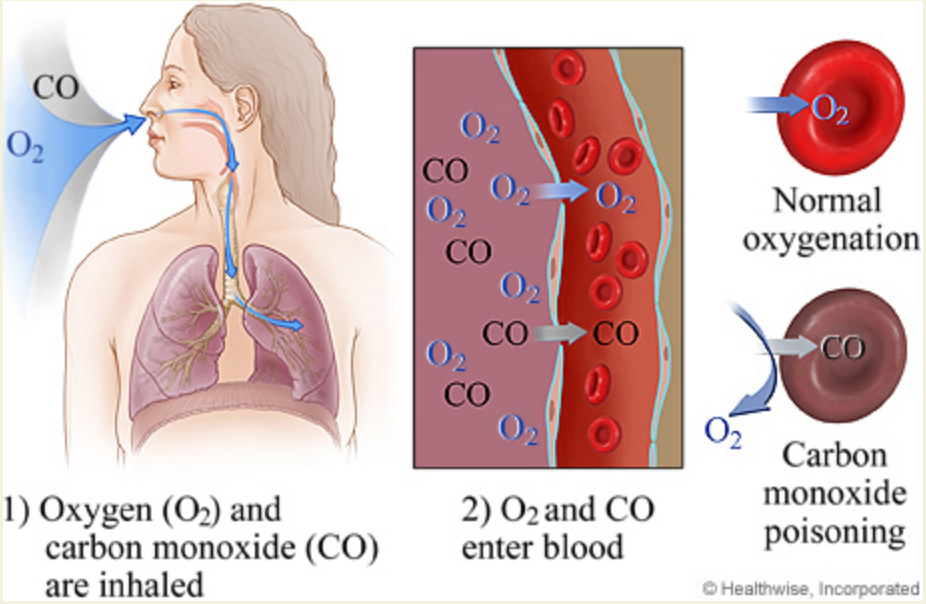
[a] Based on 1985 emission estimates. Emission estimates prior to 1985 are uncertain.

[b] Values for lead are based on 2001 data; 2002 data for lead are not yet available.

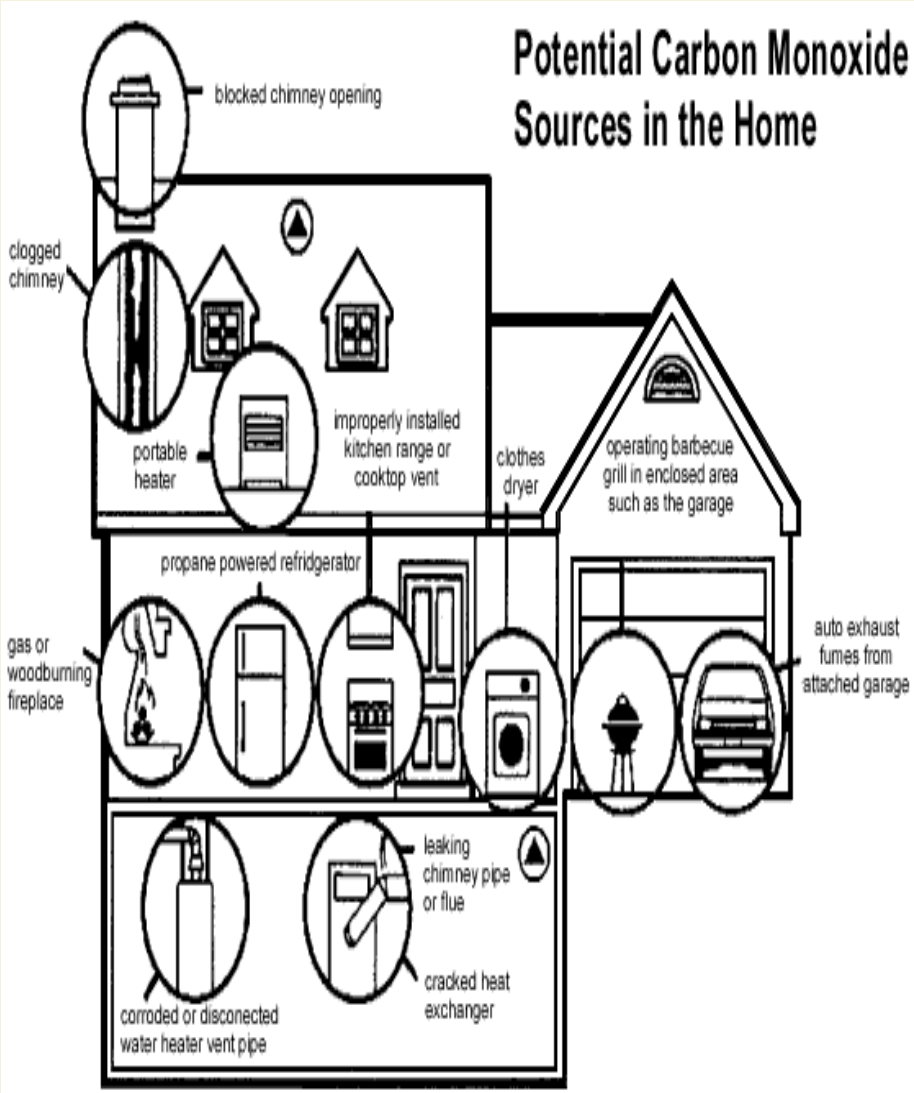
Carbon Monoxide (CO)

- ***Properties***: colorless, odorless, heavier than air, 0.0036% of atmosphere
- ***Effects***: binds tighter to Hb than O_2, mental functions and visual acuity, even at low levels
- ***Sources:*** incomplete combustion of fossil fuels 60 - 95% from auto exhaust
- ***Class***: carbon oxides (CO_2, CO)
- ***EPA Standard***: 9 ppm
- 5.5 billion tons enter atmosphere/year

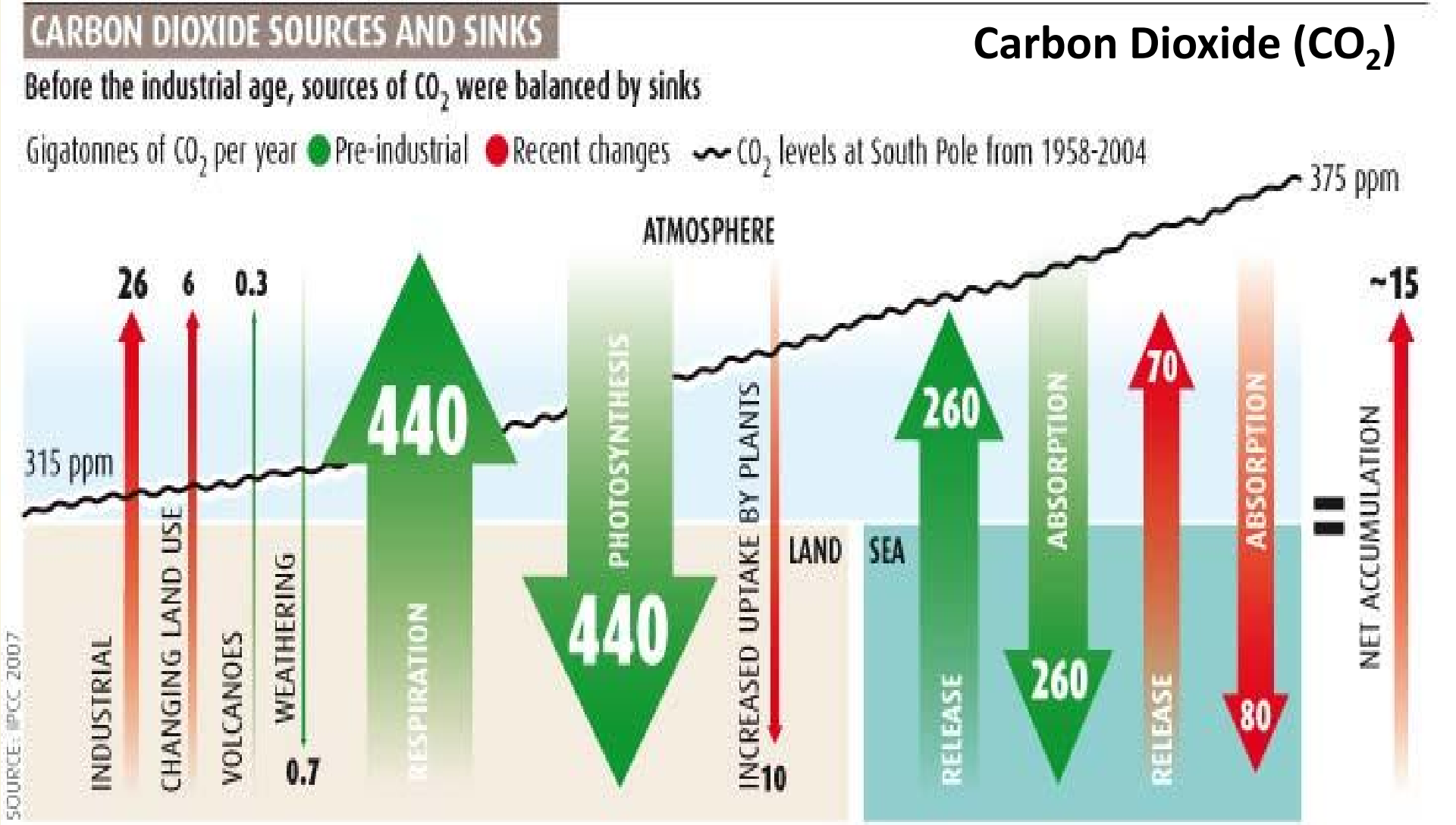
Major Outdoor Air Pollutants
CARBON OXIDES



Carbon Monoxide (CO)



Carbon Dioxide: Sources and Sinks



Carbon Dioxide (CO_2)

Major Outdoor Air Pollutants
NITROGEN OXIDES

Nitrogen oxides (NO) and **nitric acid (HNO_3)**

- Sources
- Acid deposition
- Photochemical smog
- Human health and environmental impact

Nitrogen Dioxide (NO_2)

- ***Properties***: reddish brown gas, formed as fuel burnt in car, strong oxidizing agent, forms Nitric acid in air
- ***Effects***: acid rain, lung and heart problems, decreased visibility (yellow haze), suppresses plant growth
- ***Sources***: fossil fuels combustion @ higher temperatures, power plants, forest fires, volcanoes, bacteria in soil
- ***Class***: Nitrogen oxides (NO_x)
- ***EPA Standard***: 0.053 ppm

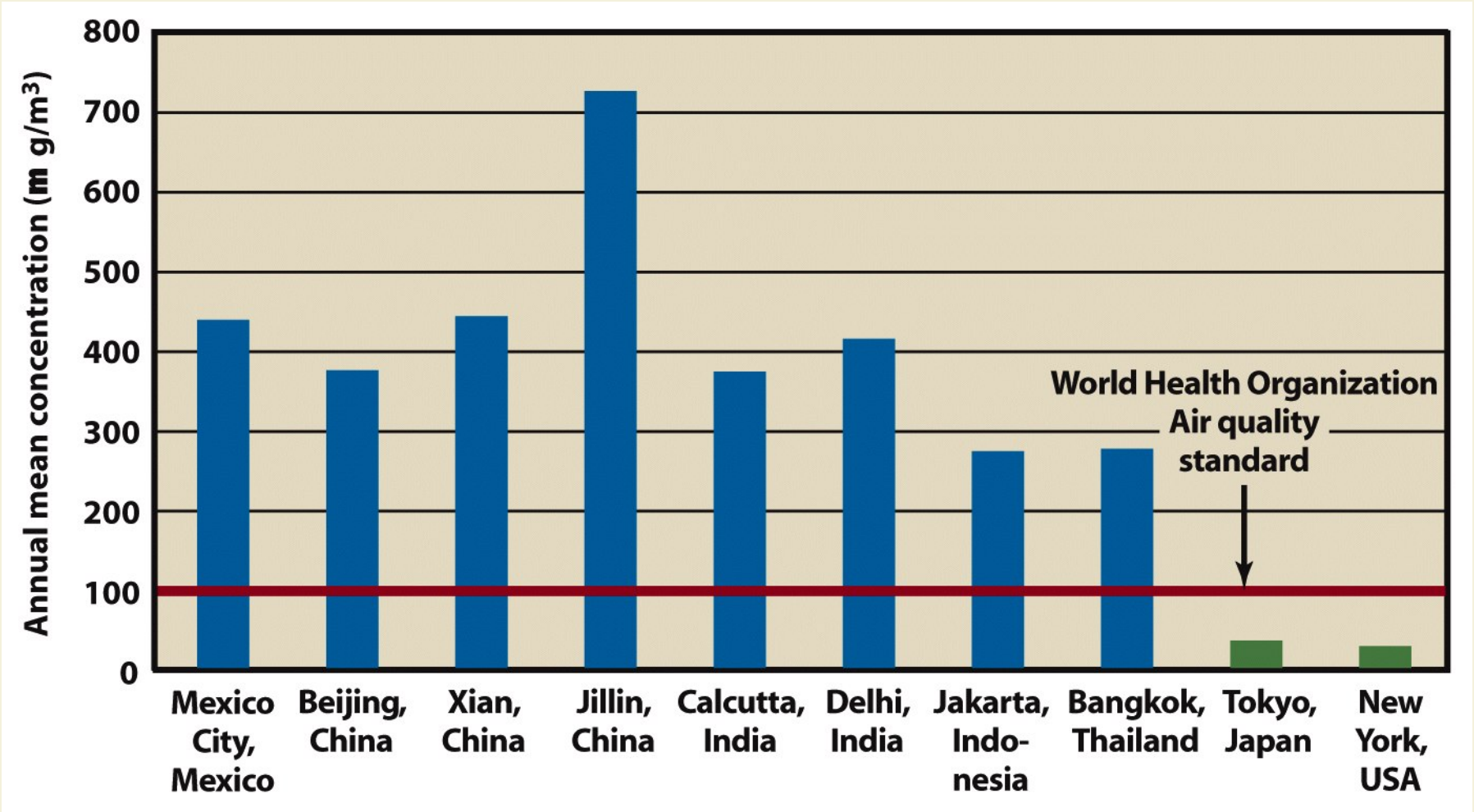
Sulfur Dioxide (SO_2)

- ***Properties***: colorless gas with irritating odor
- ***Effects***: produces acid rain (H_2SO_4), breathing difficulties, eutrophication due to sulfate formation, lichen and moss are indicators
- ***Sources***: burning high sulfur coal or oil, smelting or metals, paper manufacture
- ***Class***: sulfur oxides
- ***EPA Standard***: 0.3 ppm (annual mean)
- Combines with water and NH_4 to increase soil fertility

Suspended Particulate Matter (PM_{10})

- ***Properties*: particles suspended in air (<10 um)**
- ***Effects*: lung damage, mutagenic, carcinogenic, teratogenic**
- ***Sources*: burning coal or diesel, volcanoes, factories, unpaved roads, plowing, lint, pollen, spores, burning fields**
- ***Class*: SPM: dust, soot, asbestos, lead, PCBs, dioxins, pesticides**
- ***EPA Standard*: 50 ug/m^3 (annual mean)**

Total Suspended Particulates (TSP) for several large countries



Ozone

- ***Properties***: colorless, unpleasant odor, major part of photochemical smog
- ***Effects***: lung irritant, damages plants, rubber, fabric, eyes, 0.1 ppm can lower PSN by 50%,
- ***Sources***: Created by sunlight acting on NO_x and VOC , photocopiers, cars, industry, gas vapors, chemical solvents, incomplete fuel combustion products
- ***Class***: photochemical oxidants

Volatile Organic Compounds (VOC)

- ***Properties***: organic compounds (hydrocarbons) that evaporate easily, usually aromatic
- ***Effects***: eye and respiratory irritants; carcinogenic; liver, CNS, or kidney damage; damages plants; lowered visibility due to brown haze; global warming
- ***Sources:*** vehicles (largest source), evaporation of solvents or fossil fuels, aerosols, paint thinners, dry cleaning
- ***Class***: HAPs (Hazardous Air Pollutants)
  - Methane
  - Benzene
  - Chlorofluorocarbons (CFCs), etc.
- Concentrations indoors up to 1000x outdoors
- 600 million tons of CFCs

Lead (Pb)

- ***Properties*: grayish metal**
- ***Effects*: accumulates in tissue; affects kidneys, liver and nervous system (children most susceptible); mental retardation; possible carcinogen; 20% of inner city kids have [high]**
- ***Sources*: particulates, smelters, batteries**
- ***Class*: toxic or heavy metals**
- ***EPA Standard*: 1.5 ug/m^3**
- **2 million tons enter atmosphere/year**

	MAJOR SOURCES	HEALTH EFFECTS	ENVIRONMENTAL EFFECTS
SO_2	Industry	Respiratory and cardiovascular illness	Precursor to acid rain, which damages lakes, rivers, and trees; damage to cultural relics
NO_x	Vehicles; industry	Respiratory and cardiovascular illness	Nitrogen deposition leading to over-fertilization and eutrophication
PM	Vehicles; industry	Particles penetrate deep into lungs and can enter bloodstream	Visibility
CO	Vehicles	Headaches and fatigue, especially in people with weak cardiovascular health	
Lead	Vehicles (burning leaded gasoline)	Accumulates in bloodstream over time; damages nervous system	Fish/animal kills
Ozone	Formed from reaction of NO_x and VOCs	Respiratory illness	Reduced crop production and forest growth; smog precursor
VOCs	Vehicles; industrial processes	Eye and skin irritation; nausea; headaches; carcinogenic	Smog precursor

Chemical Reactions That Form Major Outdoor Air Pollutants

Table 18-1 Chemical Reactions That Form Major Air Pollutants

Pollutant	Chemical Reaction
Carbon monoxide (CO)	$2C + O_2 \rightarrow 2CO$
Carbon dioxide (CO_2)	$C + O_2 \rightarrow CO_2$
Nitric oxide (NO)	$N_2 + O_2 \rightarrow 2NO$
Nitrogen dioxide (NO_2)	$2NO + O_2 \rightarrow 2NO_2$
Sulfur dioxide (SO_2)	$S + O_2 \rightarrow SO_2$

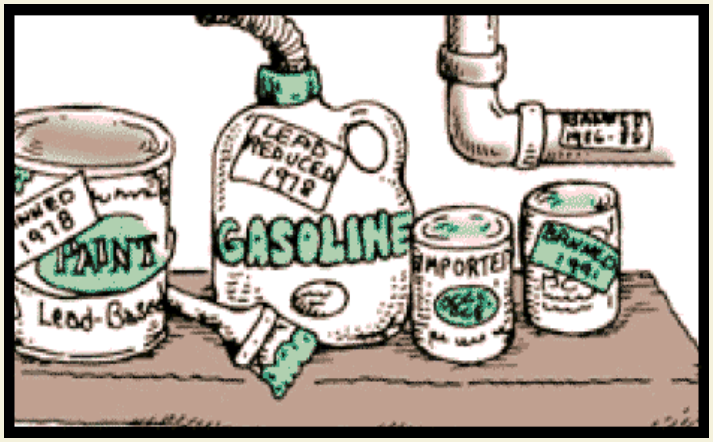
Table 18-1, p. 470

Statue Corroded by Acid Deposition and Other Forms of Air Pollution, RI, U.S.

Fig. 18-7, p. 471

Case Study: Lead Is a Highly Toxic Pollutant

- In air, water, soil, plants, animals
- Does not break down in the environment
- Human health and environmental impact
  - Children most vulnerable
  - Can cause death, mental retardation, paralysis



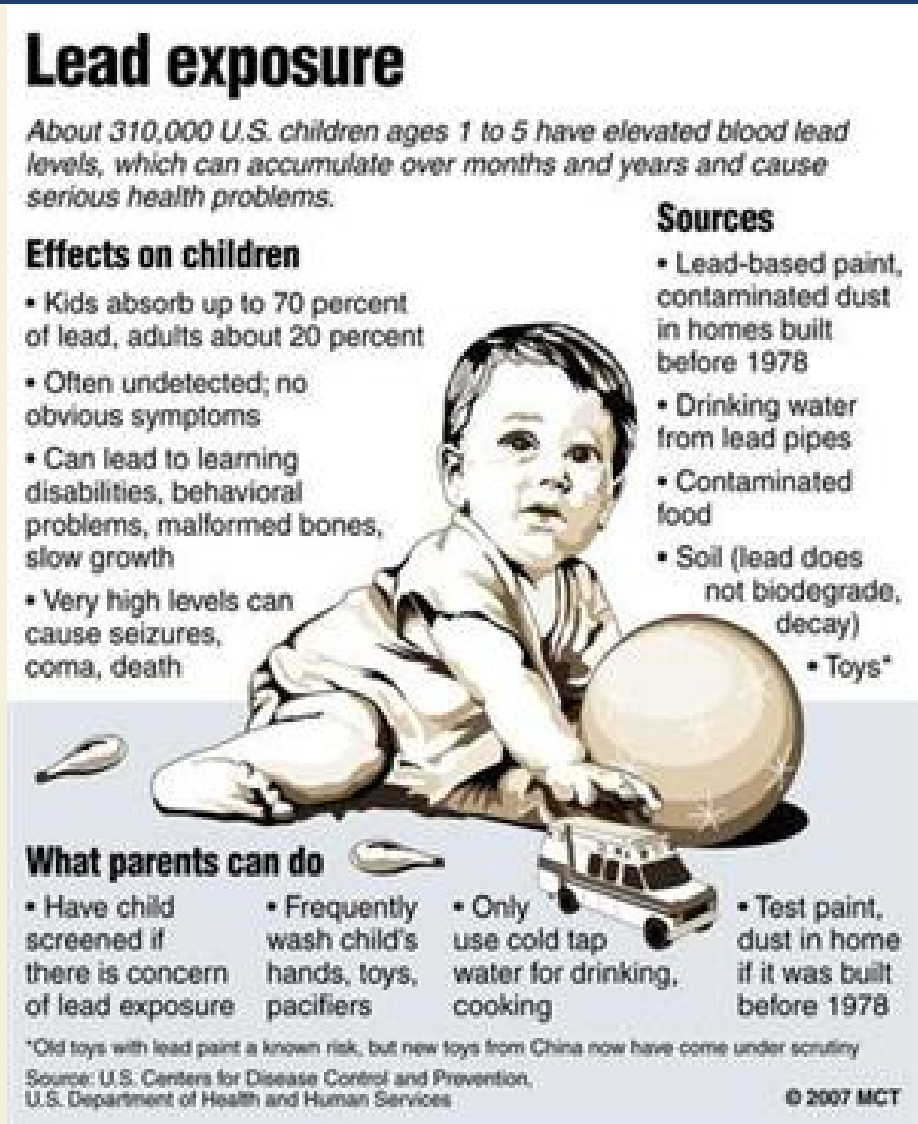
Case Study: Lead Is a Highly Toxic Pollutant

Reduction of lead (Pb)

- Unleaded gasoline
- Unleaded paint

Still problems

- 15-18 million children have brain damage
- Need global ban on lead in gasoline and paint



Solutions: Lead Poisoning, Prevention and Control

Solutions

Lead Poisoning

Prevention

Phase out leaded gasoline worldwide

Phase out waste incineration

Ban use of lead solder

Ban use of lead in computer and TV monitors

Ban lead glazing for ceramicware used to serve food

Ban candles with lead cores

Test blood for lead by age 1

Control

Replace lead pipes and plumbing fixtures containing lead solder

Remove leaded paint and lead dust from older houses and apartments

Sharply reduce lead emissions from incinerators

Remove lead from TV sets and computer monitors before incineration or land disposal

Test for lead in existing ceramicware used to serve food

Test existing candles for lead

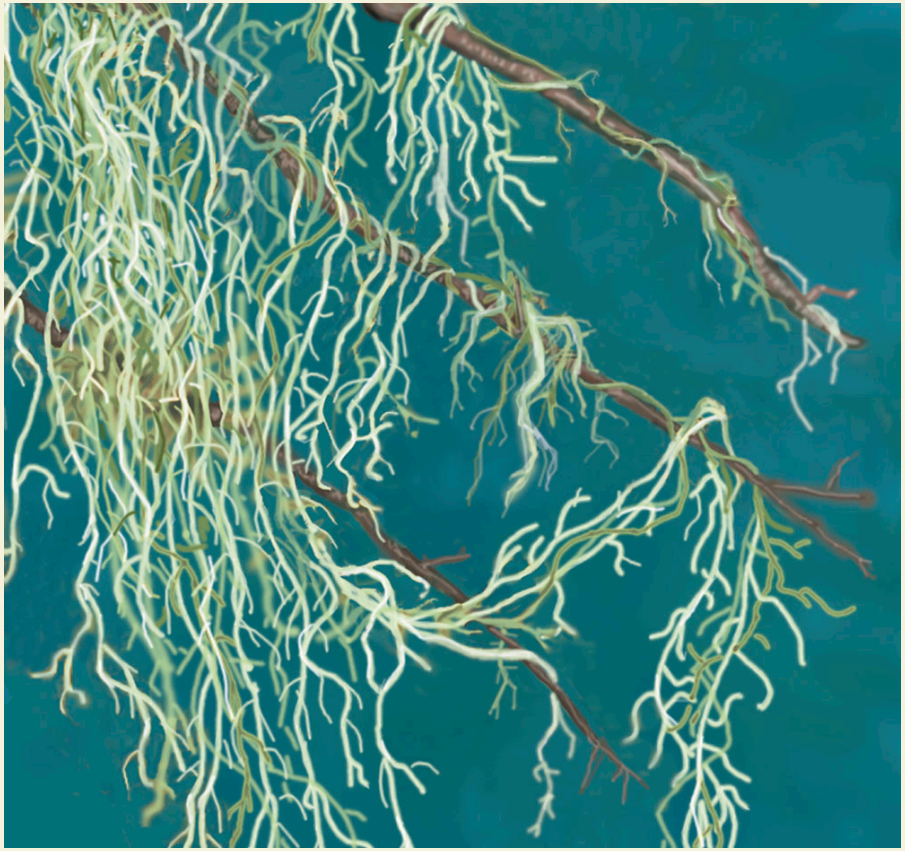
Wash fresh fruits and vegetables

Fig. 18-8, p. 472

Science Focus: Detecting Air Pollutants

- Chemical instruments
- Satellites
- Lasers and remote sensors
- Biological indicators
  - Lichens

Natural Capital: Lichen Species, Vulnerability to Air Pollutants



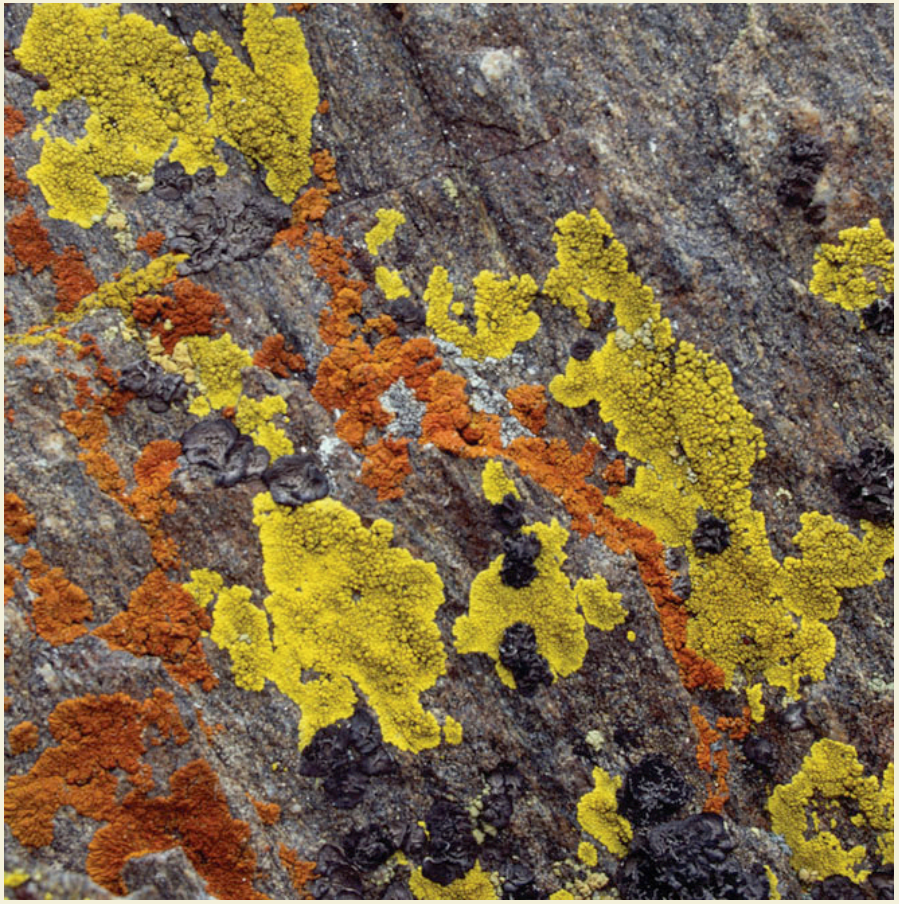
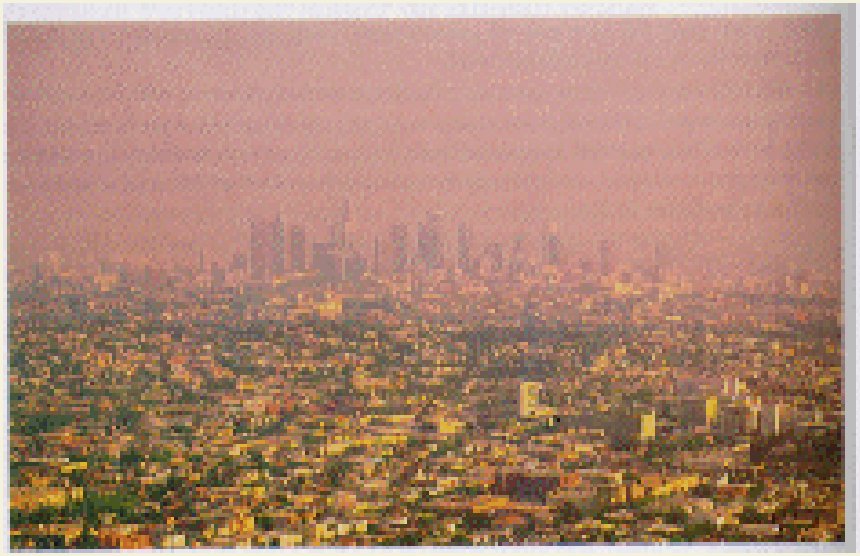


Fig. 18-A, p. 473

Smog Forms

...when polluted air is stagnant

(weather conditions, geographic location)



Los Angeles, CA

Types of Smog

Smog

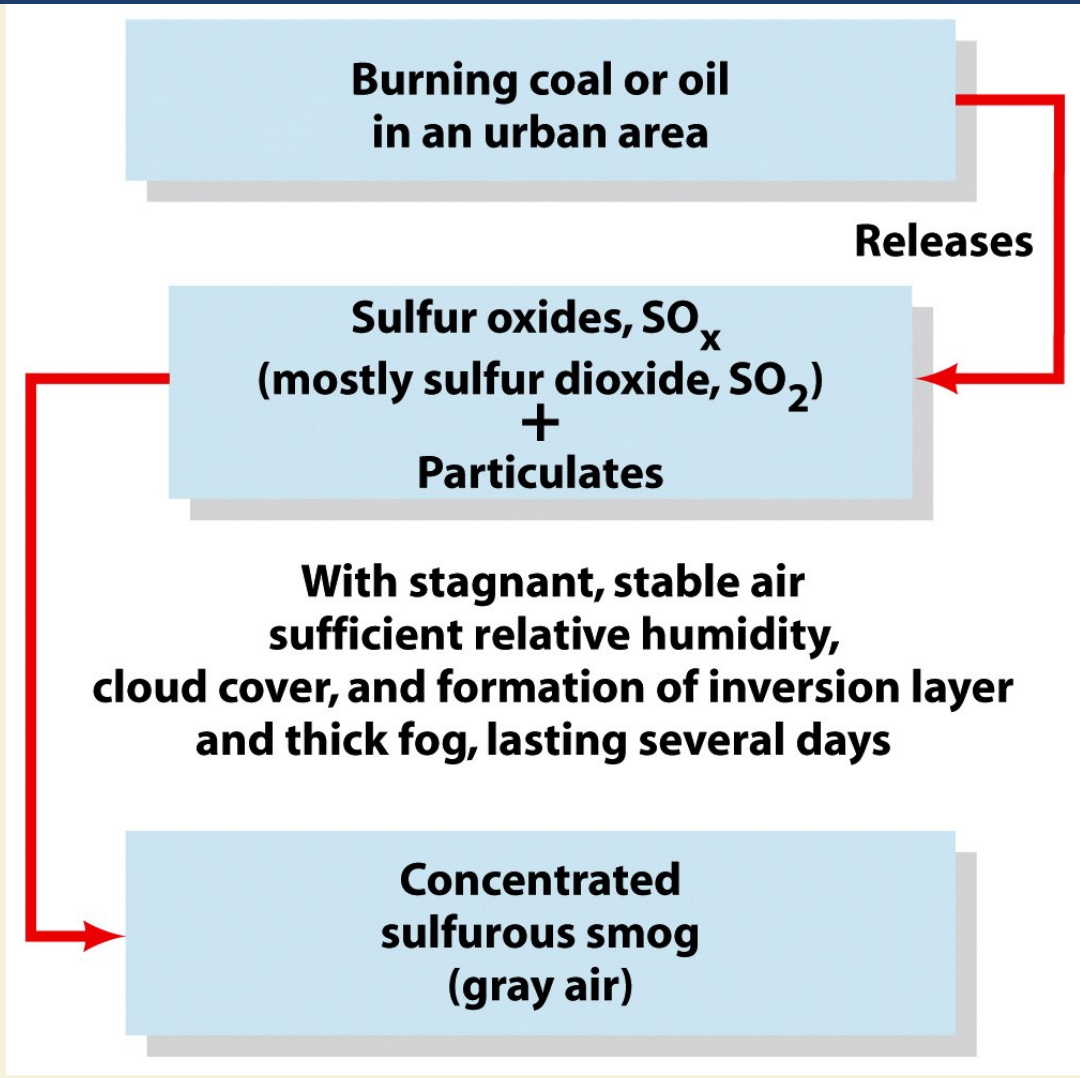
- A mixture between smoke and fog that produces unhealthy urban air

Two Types

- Sulfurous Smog / Industrial Smog / Fossil Fuels
- Photochemical Smog / Sunlight & Pollutants

Burning Coal Produces Industrial Smog

- Chemical composition of **industrial smog**
- Reduction of this smog in urban cities of the United States
- China and smog
  - Human deaths
  - Need strong standards, especially for coal burning



How Pollutants Are Formed from Burning Coal and Oil, Leading to Industrial Smog

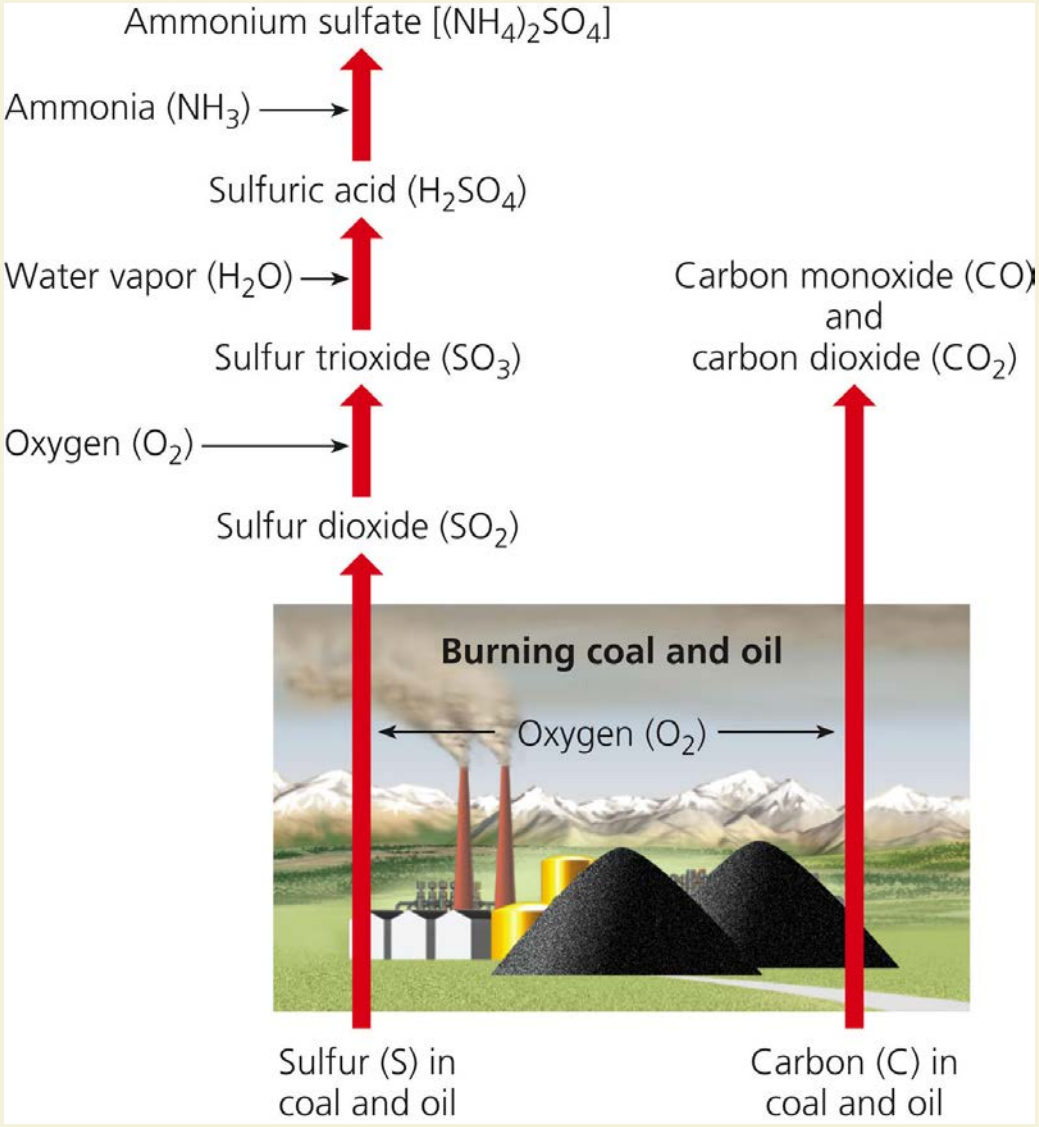


Fig. 18-9, p. 474

Industrial Smog in India

Fig. 18-10, p. 474

Sunlight Plus Cars Equals Photochemical Smog

Photochemical Smog

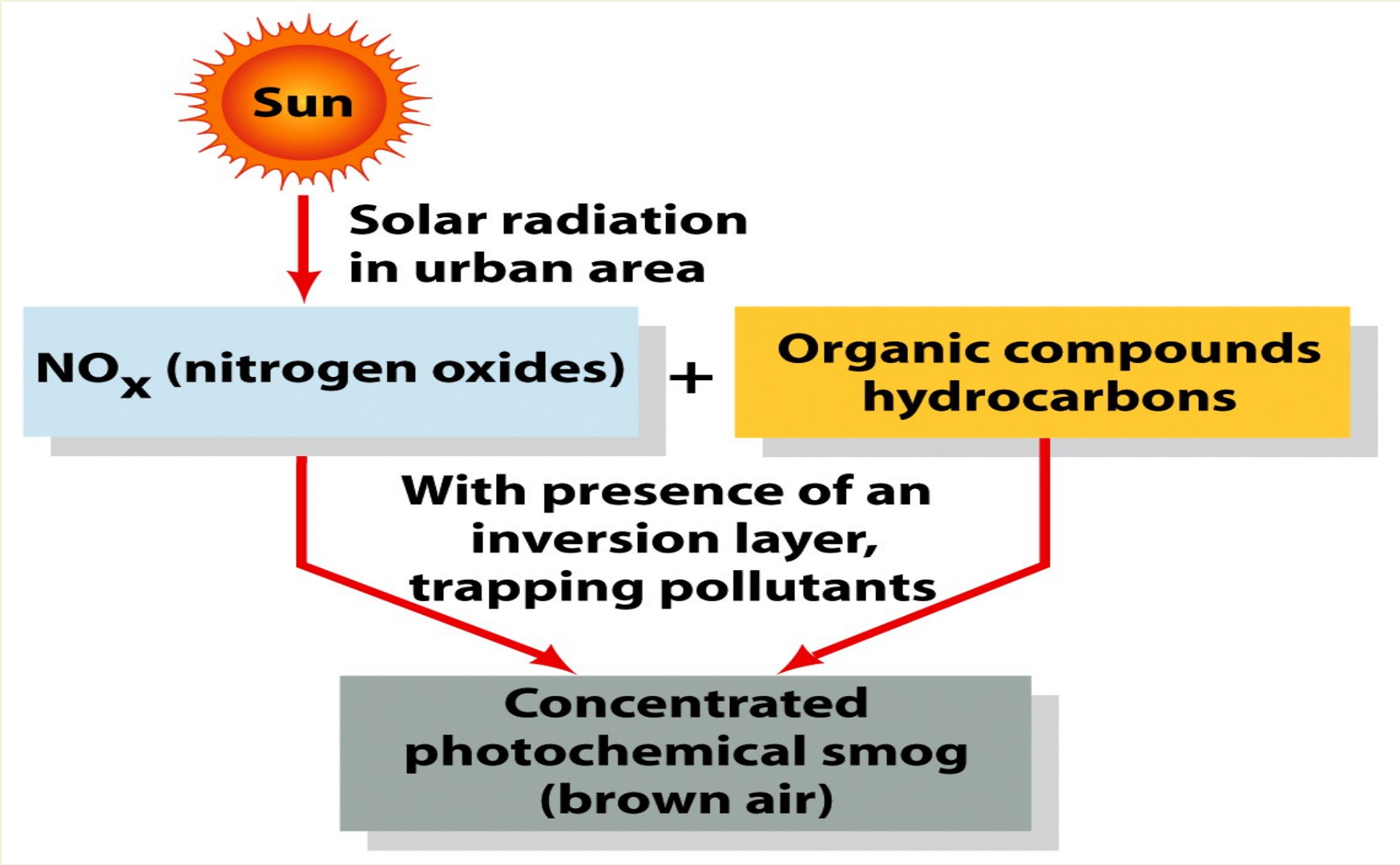
- Chemical composition
- Sources

VOCs + NO_x + Heat + Sunlight yields

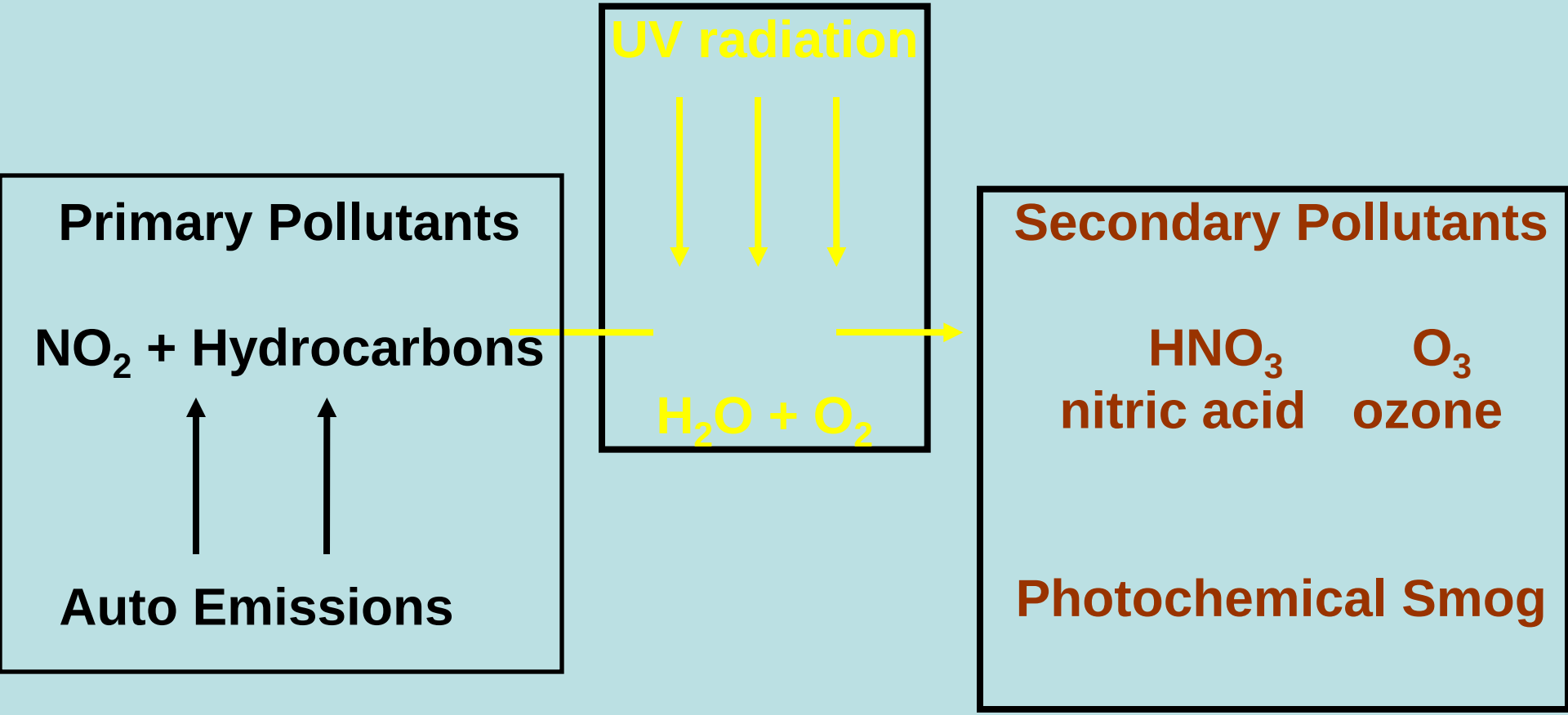
- Ground level O_3 and other photochemical oxidants
- Aldehydes
- Other secondary pollutants

Human health and environmental impact

Formation of Photochemical Smog



Photochemical Smog



A Model of How Pollutants That Make Up Photochemicals Are Formed

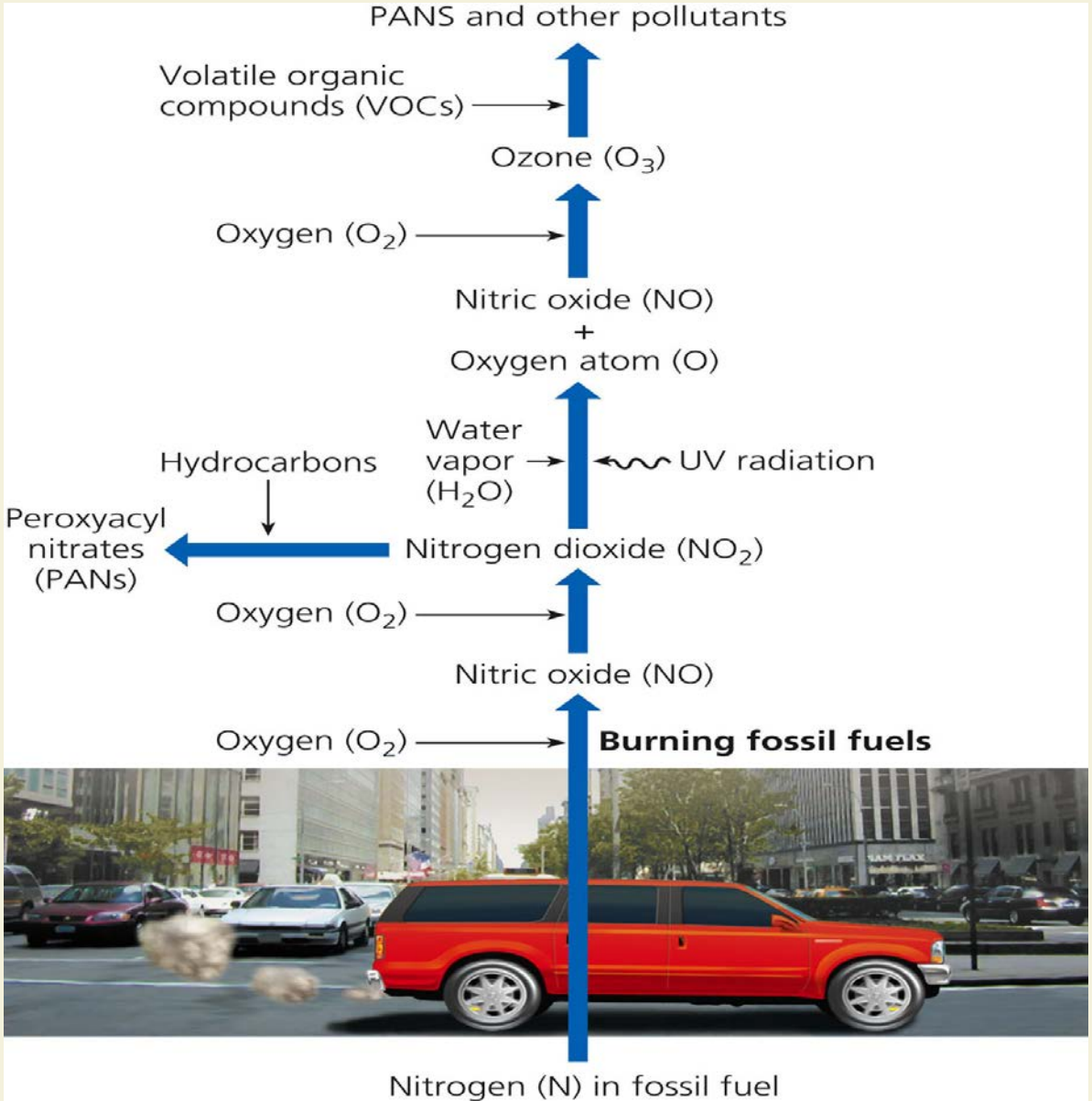


Fig. 18-11, p. 475

Formation of Photochemical Smog

Time	Description
6 - 9 A.M.	Morning commute increases NO_x and VOCs $N_2 + O_2 \rightarrow 2\ NO$ $NO + VOC \rightarrow NO_2$ $NO_2 \xrightarrow{UV} NO + O$
9 - 11 A.M	As traffic decreases NO_x and VOCs react $2NO + O_2 \rightarrow 2NO_2$

Time	Description
11 A.M. – 4 P.M.	**As sunlight becomes intense, NO_2 breaks down and Ozone increases** $NO_2 \xrightarrow{UV} NO + O$ $\quad\quad$ $O_2 + O \rightarrow O_3$ **Nitrogen dioxide also forms nitric acid** $3NO_2 + H_2O \rightarrow 2\,H_2NO_3 + NO$
11 A.M. – 4 P.M.	**Nitrogen dioxide also reacts with VOCs released by autos, industry, etc.** NO_2 + **VOCs** $\rightarrow$ 2 **PANs** **Peroyacyl nitrates (toxic)**
4 P.M. - sunset	As sun goes down the production of ozone halts Net Result: NO + VOC + O_2 + UV $\rightarrow$ O_3 + PAN

Global Outlook: Photochemical Smog in Santiago, Chile

Fig. 18-12, p. 475

Several Factors Can Decrease or Increase Outdoor Air Pollution (1)

- Outdoor air pollution may be decreased by
  1. Settling of particles due to gravity
  2. Rain and snow
  3. Salty sea spray from the ocean
  4. Winds
  5. Chemical reactions

Several Factors Can Decrease or Increase Outdoor Air Pollution (2)

- Outdoor air pollution may be increased by
  1. Urban buildings
  2. Hills and mountains
  3. High temperatures
  4. Emissions of VOCs from certain trees and plants
  5. Grasshopper effect
  6. **Temperature inversions**
     - Warm air above cool air prevents mixing

A Temperature Inversion

Fig. 18-13, p. 476

Calm winds and the inversion result in poor air quality.

❶ The winter sun, low in the sky, supplies less warmth to the Earth's surface.

❷ Warmer air aloft acts as a lid and holds cold air near the ground.

❸ Pollution from wood fires and cars are trapped by the inversion.

❹ Mountains can increase the strength of valley inversions

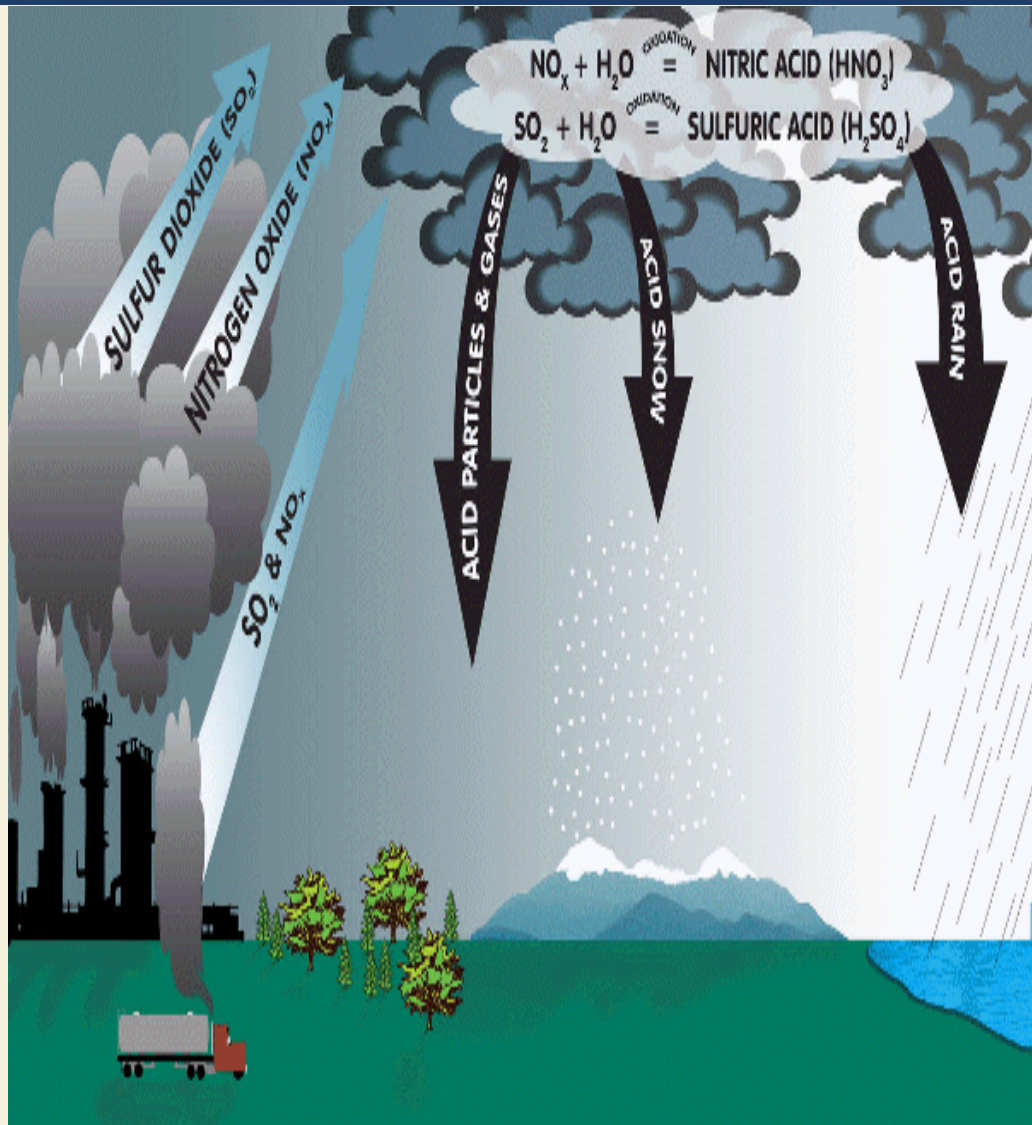
18-3 What Is Acid Deposition and Why Is It a Problem?

Concept 18-3 *Acid deposition is caused mainly by coal-burning power plants and motor vehicle emissions, and in some regions it threatens human health, aquatic life and ecosystems, forests, and human-built structures.*

Acid Disposition Is a Serious Regional Air Pollution Problem

Acid deposition, acid rain

- Chemical sources
- Formation
- Local versus regional problems
- Effects of prevailing winds
- Buffers
- Where is the worst acid deposition?



Natural Capital Degradation: Acid Deposition

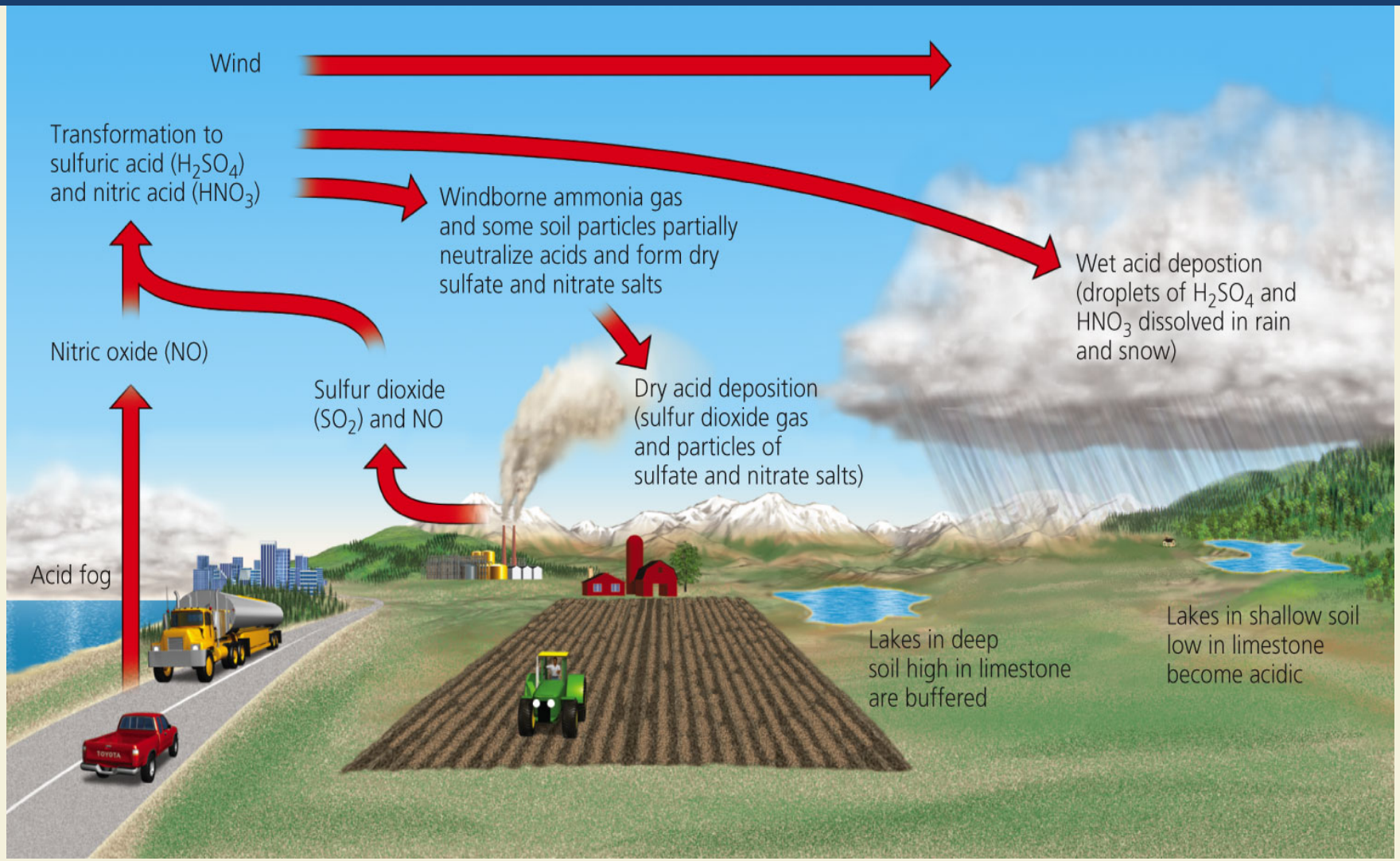


Fig. 18-14, p. 477

Current and Possible Future Acid Rain Problem Areas

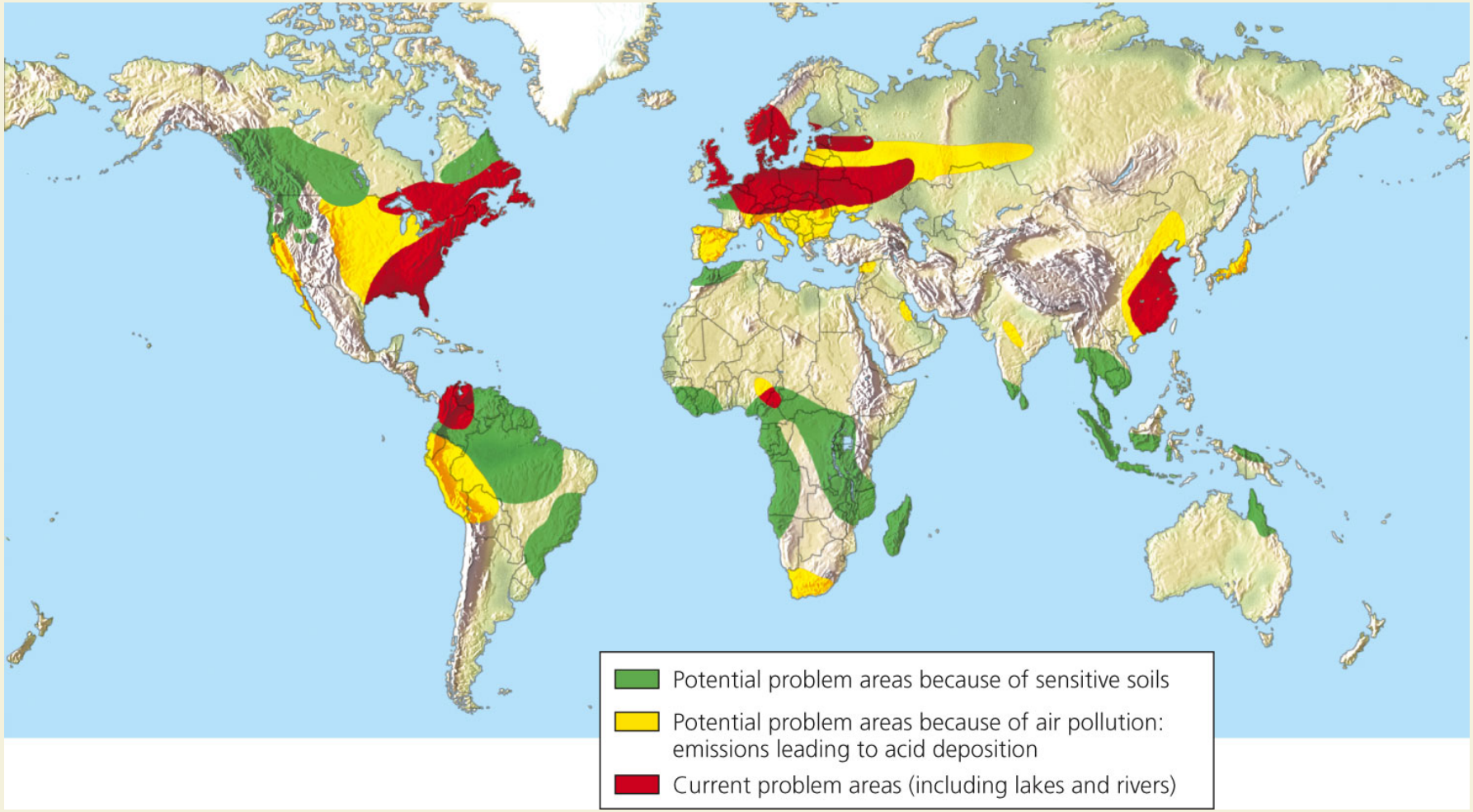
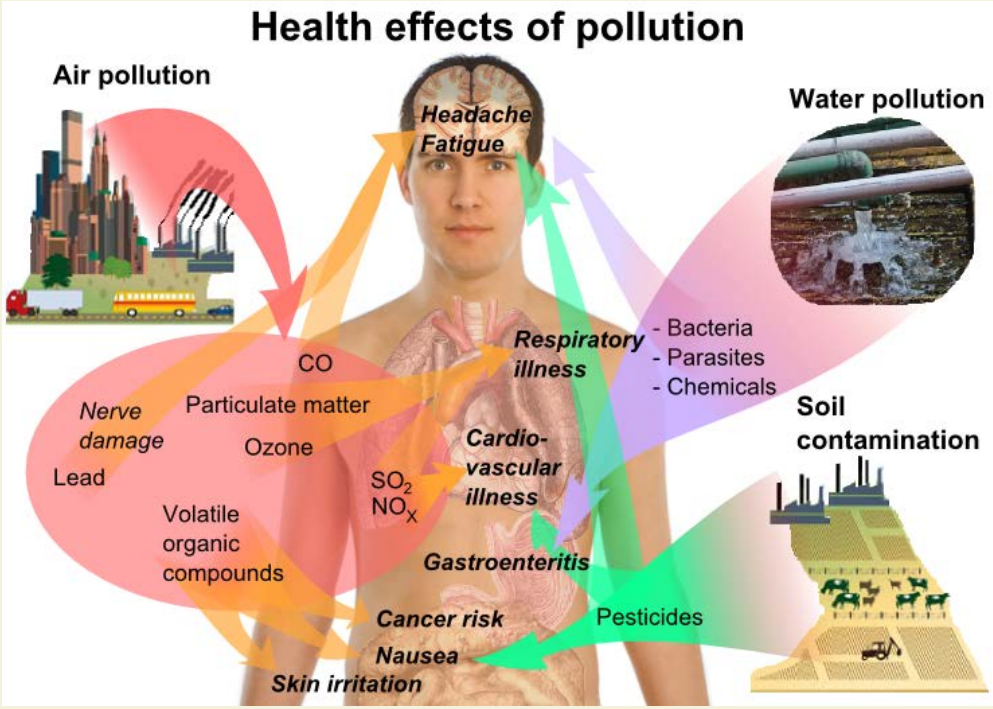


Fig. 18-15, p. 478

Acid Deposition Has a Number of Harmful Effects (1)

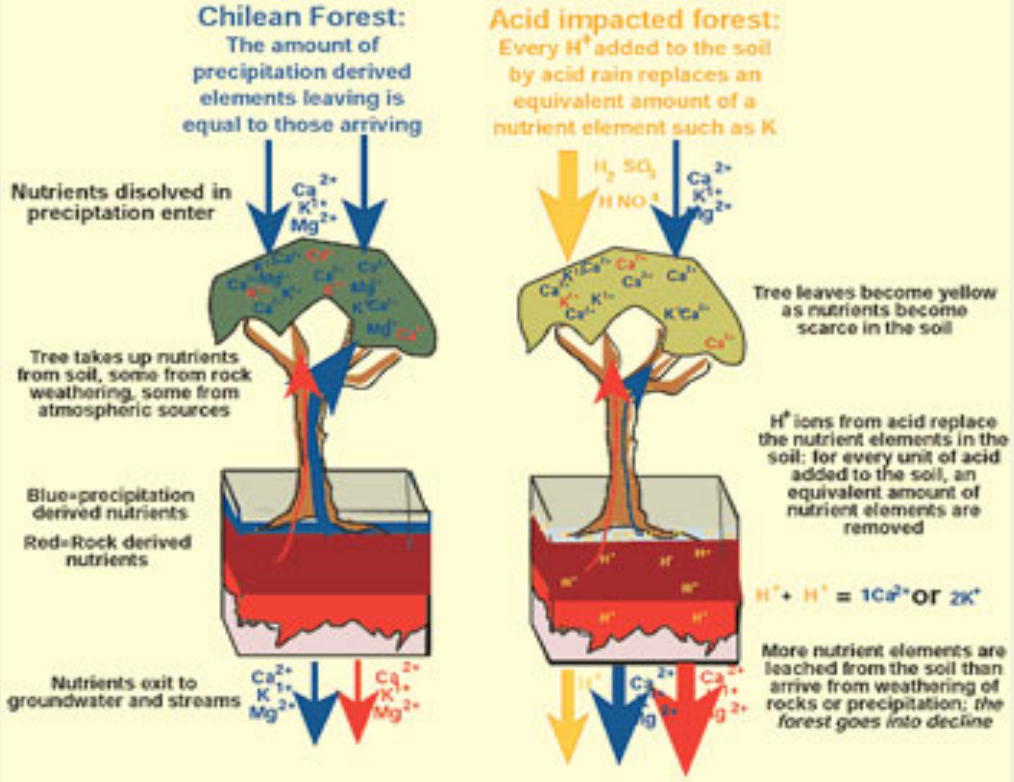
- Human health
  - Respiratory disorders
  - Toxins in fish
- Release of toxic metals
- Aquatic ecosystems affected
  - Lowers pH and kills organisms



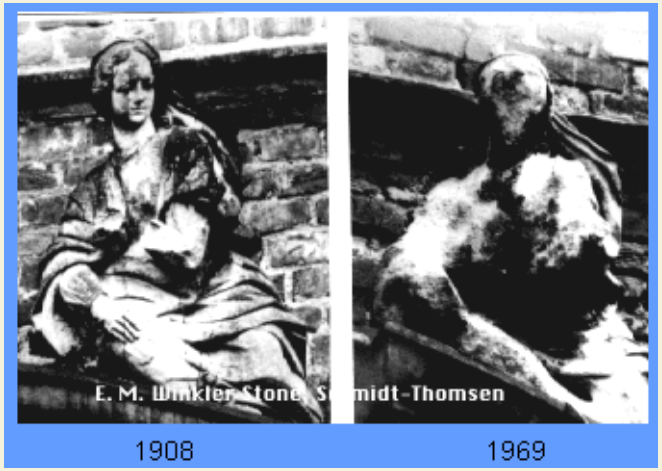
Video: Effects of Air Pollution

Effects of Acid Deposition

- Leaching of soil nutrients
- Lower crop yields
- Forest damage



- Damage to buildings, statues, and monuments



Natural Capital Degradation: Air Pollution Damage to Trees in North Carolina, U.S.

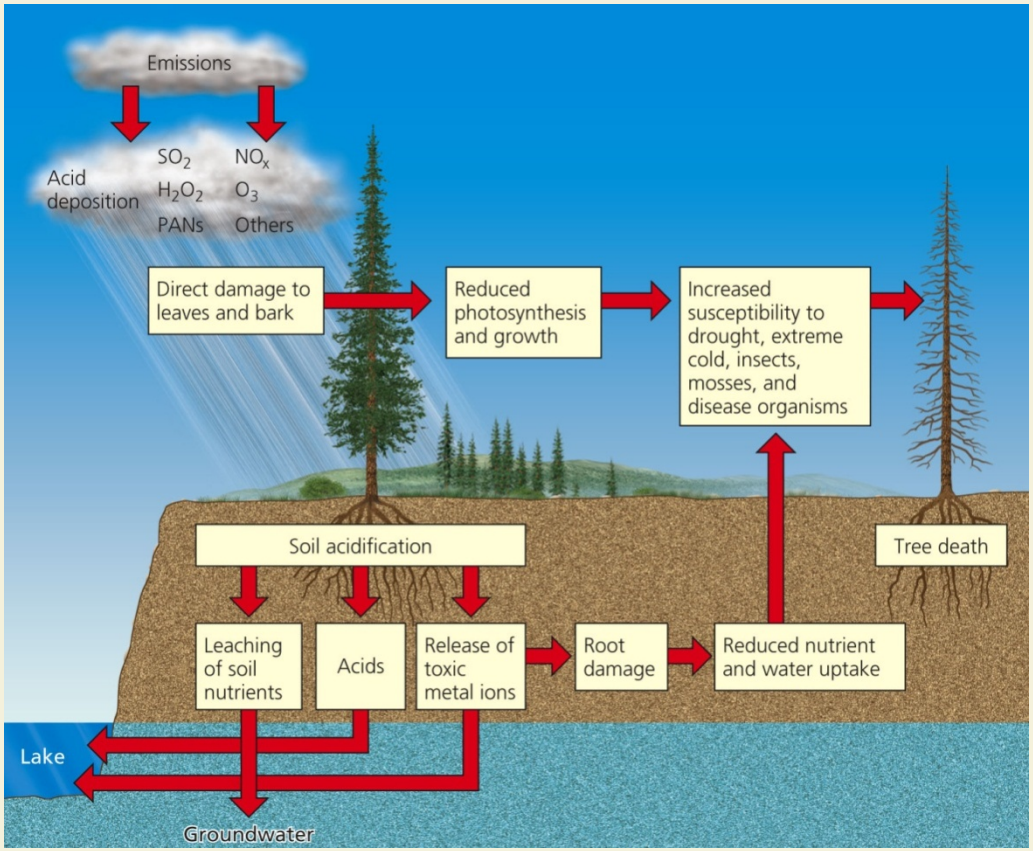


Fig. 18-16, p. 479

We Know How to Reduce Acid Deposition

- Prevention approaches

- Cleanup approaches

Solutions: Acid Deposition

Solutions

Acid Deposition

Prevention

Reduce coal use

Burn low-sulfur coal

Increase use of natural gas and renewable energy resources

Remove SO_2 particulates and NO_X from smokestack gases and remove NO_X from motor vehicular exhaust

Tax emissions of SO_2

Cleanup

Add lime to neutralize acidified lakes

Add phosphate fertilizer to neutralize acidified lakes

Fig. 18-17, p. 480

18-4 What Are the Major Indoor Air Pollution Problems?

Concept 18-4 *The most threatening indoor air pollutants are smoke and soot from the burning of wood and coal in cooking fires (mostly in less-developed countries), cigarette smoke, and chemicals used in building materials and cleaning products.*

Indoor Air Pollution
Developing Countries

Developing countries

- Indoor burning of wood, charcoal, dung, crop residues, coal
- Poor suffer the greatest risk

Burning Wood Indoors in India

Indoor Air Pollution Developed Countries

Developed countries

- Indoor air pollution is greater than outdoor air pollution

Why?

- 11 of the common air pollutants higher inside than outside
- Greater in vehicles than outside
- Health risks magnified: people spend 70–98% of their time is indoors or in cars

Indoor Air Pollution
Who's at Risk?

Who is at greatest risk from indoor air pollution?

- Children under 5 and the elderly
- Sick
- Pregnant women
- People with respiratory disorders or heart problems
- Smokers
- Factory workers

VIDEO: Indoor Air Pollution from Biomass

Indoor Air Pollution
Most Dangerous Pollutants

Four most dangerous indoor air pollutants

- Tobacco smoke
- Formaldehyde
- Radioactive radon-222 gas
- Very small particles

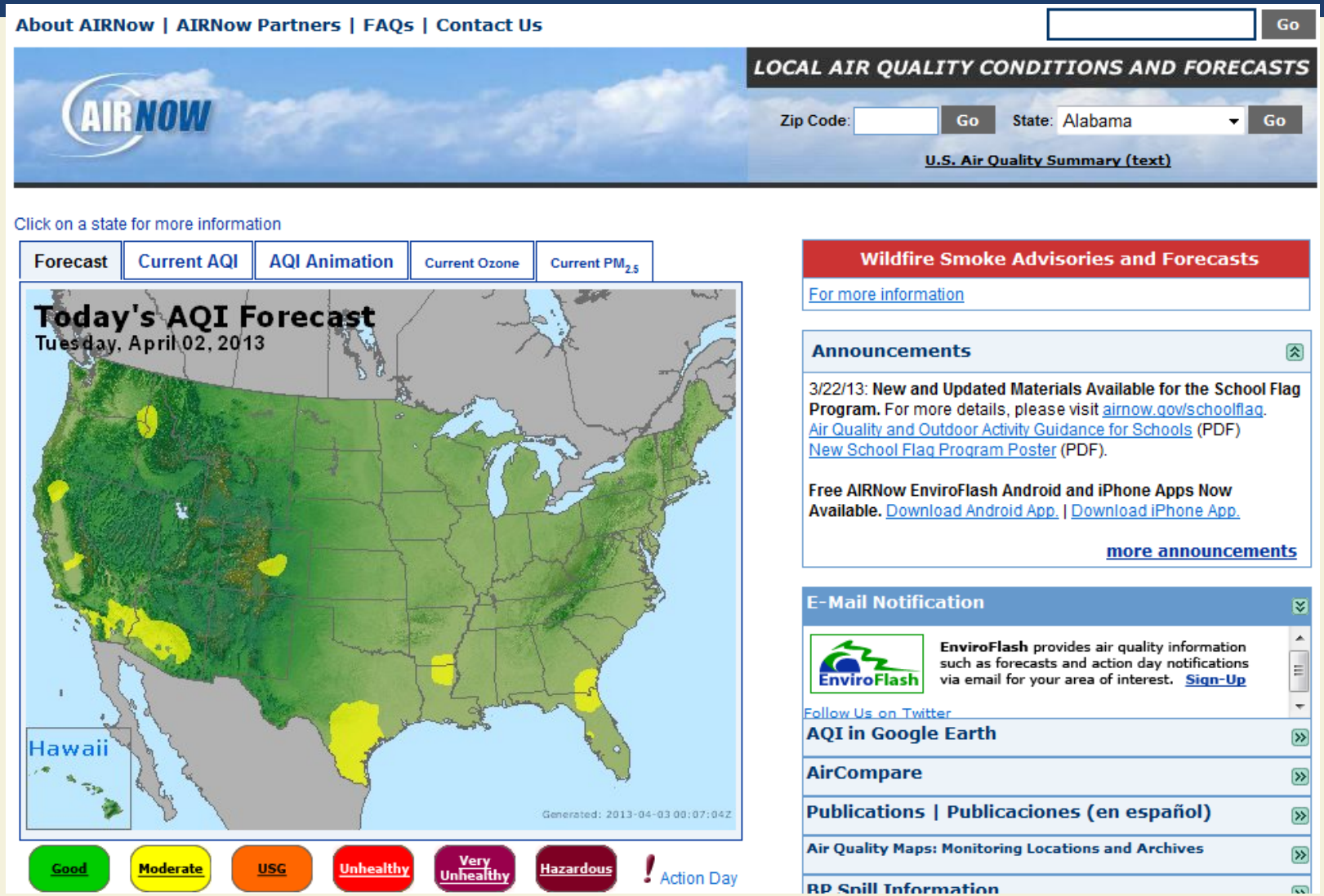
Indoor Air Pollution Is a Serious Problem

Other possible indoor air pollutants

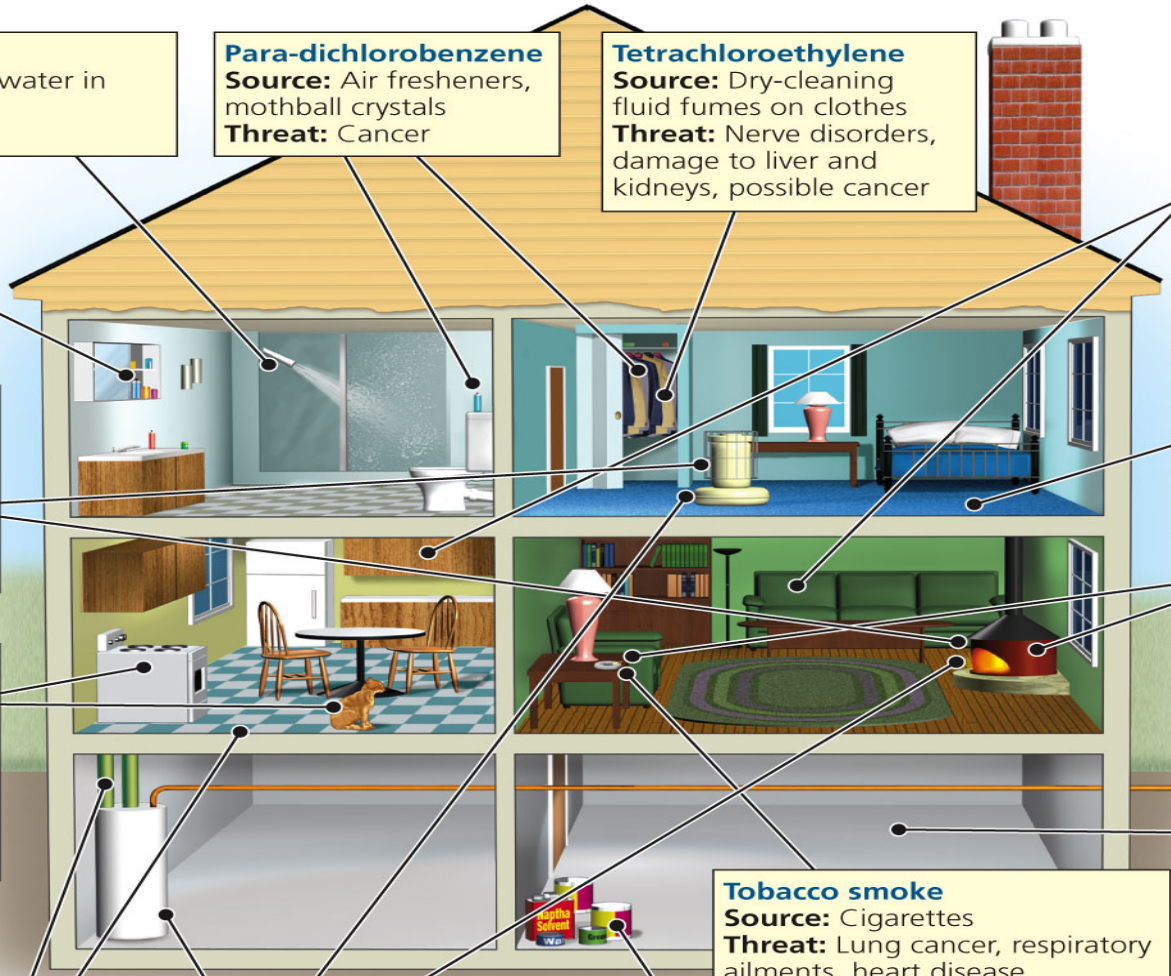
- Pesticide residue
- Pb particles
- Living organisms and their excrements
  - E.g., Dust mites and cockroach droppings
- Airborne spores of molds and mildews

VIDEO: Air Pollutants Inside the Home

WEBSITE: www.Airnow.gov



Some Important Indoor Air Pollutants



Chloroform
Source: Chlorine-treated water in hot showers
Possible threat: Cancer

Para-dichlorobenzene
Source: Air fresheners, mothball crystals
Threat: Cancer

Tetrachloroethylene
Source: Dry-cleaning fluid fumes on clothes
Threat: Nerve disorders, damage to liver and kidneys, possible cancer

Formaldehyde
Source: Furniture stuffing, paneling, particleboard, foam insulation
Threat: Irritation of eyes, throat, skin, and lungs; nausea; dizziness

1,1,1-Trichloroethane
Source: Aerosol sprays
Threat: Dizziness, irregular breathing

Nitrogen oxides
Source: Unvented gas stoves and kerosene heaters, woodstoves
Threat: Irritated lungs, children's colds, headaches

Styrene
Source: Carpets, plastic products
Threat: Kidney and liver damage

Benzo-α-pyrene
Source: Tobacco smoke, woodstoves
Threat: Lung cancer

Particulates
Source: Pollen, pet dander, dust mites, cooking smoke particles
Threat: Irritated lungs, asthma attacks, itchy eyes, runny nose, lung disease

Radon-222
Source: Radioactive soil and rock surrounding foundation, water supply
Threat: Lung cancer

Tobacco smoke
Source: Cigarettes
Threat: Lung cancer, respiratory ailments, heart disease

Asbestos
Source: Pipe insulation, vinyl ceiling and floor tiles
Threat: Lung disease, lung cancer

Carbon monoxide
Source: Faulty furnaces, unvented gas stoves and kerosene heaters, woodstoves
Threat: Headaches, drowsiness, irregular heartbeat, death

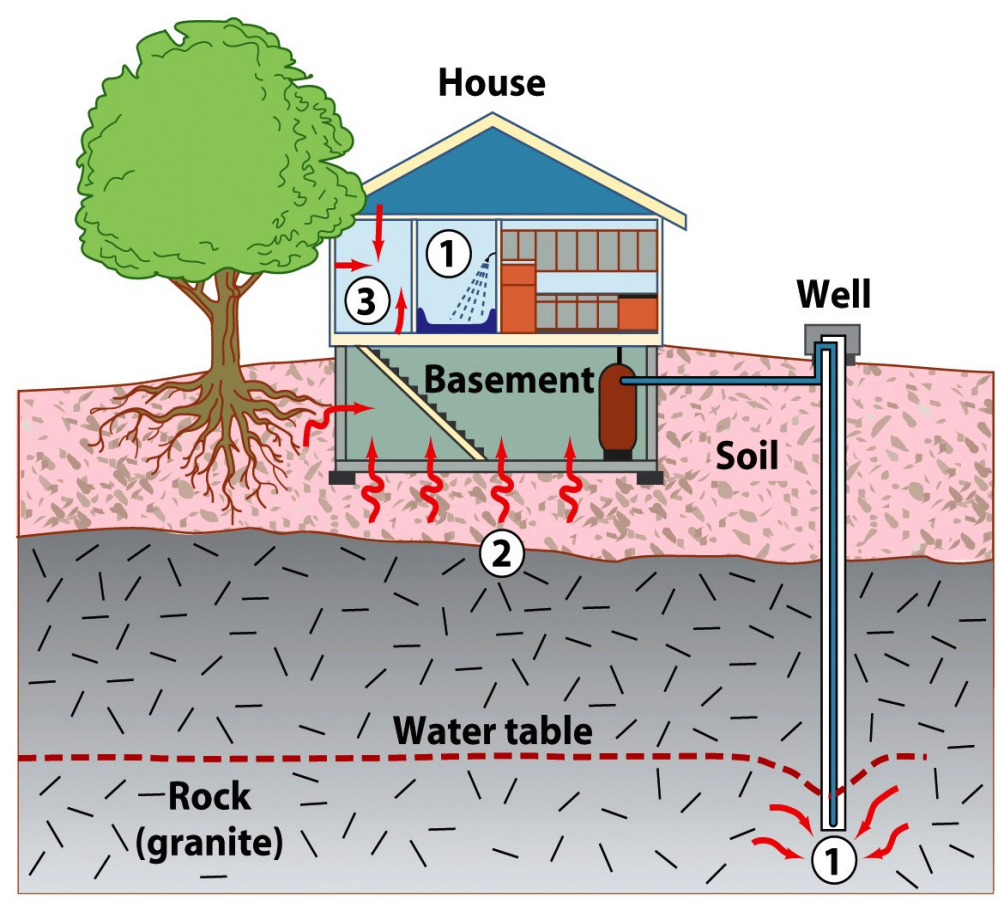
Methylene chloride
Source: Paint strippers and thinners
Threat: Nerve disorders, diabetes

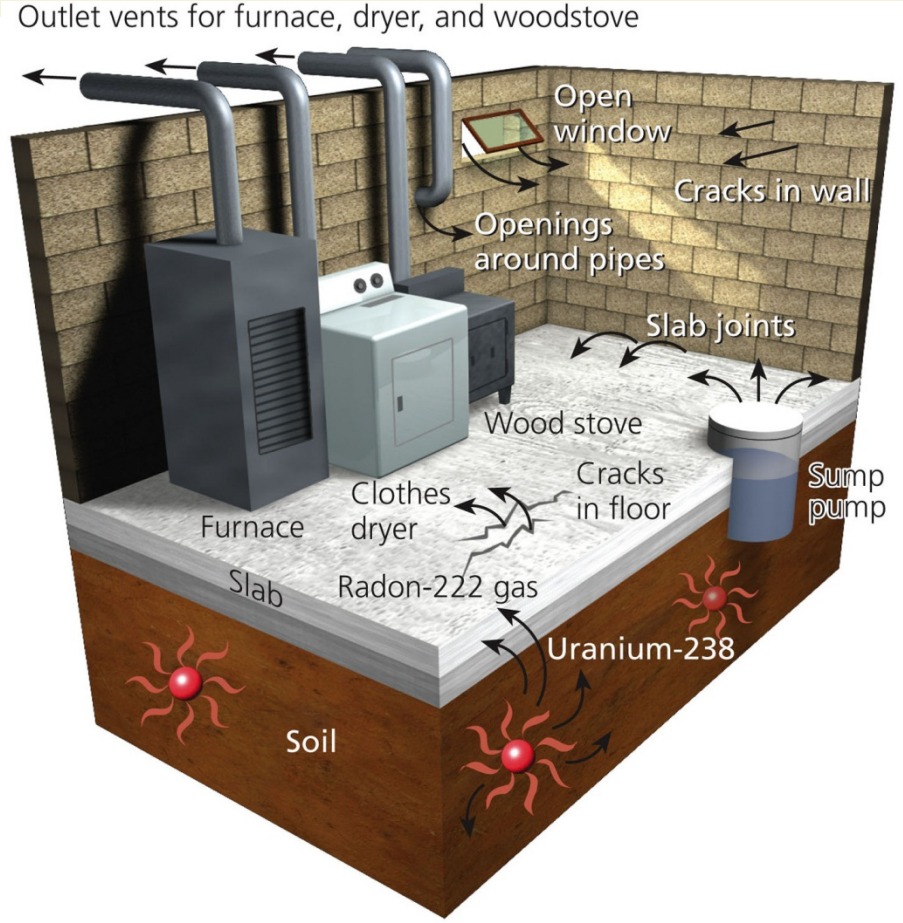
Fig. 18-19, p. 482

Case Study: Radioactive Radon Gas

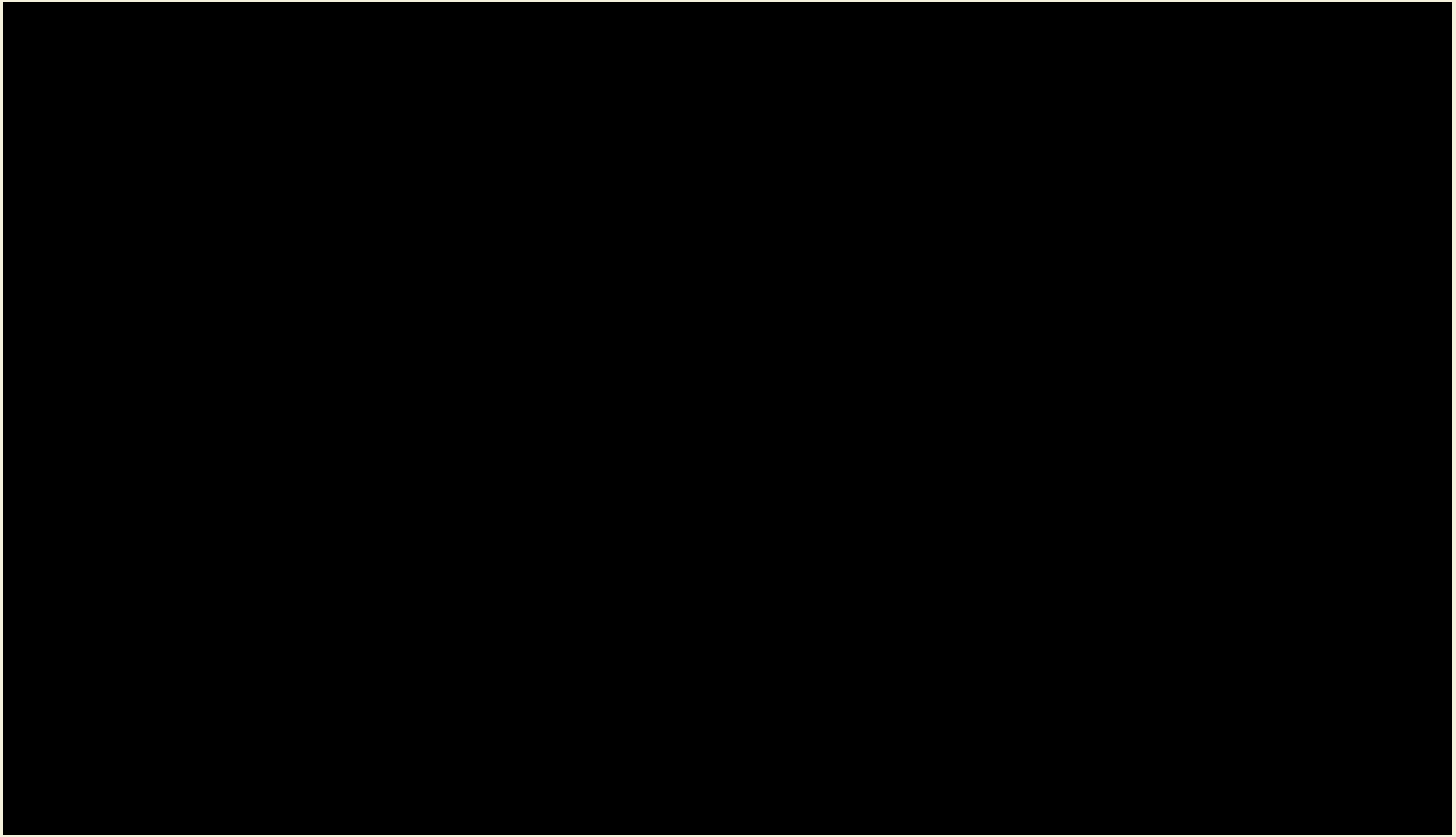
- Can cause lung cancer
- Estimated that 7,000 to 30,000 Americans die each year from radon-induced lung cancer
- Only smoking causes more lung cancer deaths
- Smokers more at risk than non-smokers

How Radon Enters Houses



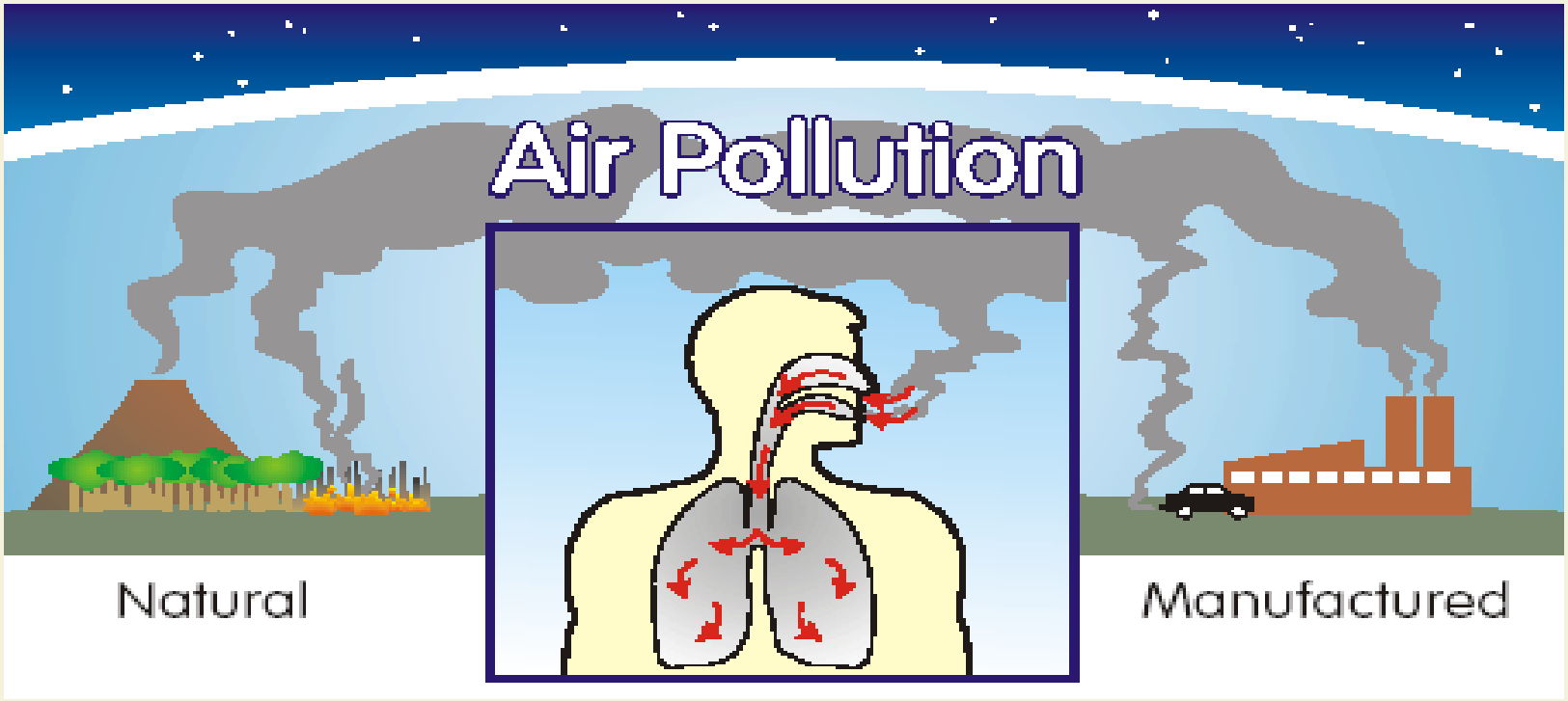


VIDEO: Sick Building Syndrome



18-5 What Are the Health Effects of Air Pollution?

Concept 18-5 *Air pollution can contribute to asthma, chronic bronchitis, emphysema, lung cancer, heart attack, and stroke.*



Your Body's Natural Defenses against Air Pollution Can Be Overwhelmed

- Respiratory system protection from air pollutants
  - Role of cilia, mucus, sneezing, and coughing

- Effect of smoking and prolonged air pollution exposure
  - Chronic bronchitis
  - Emphysema

Major Components of the Human Respiratory System

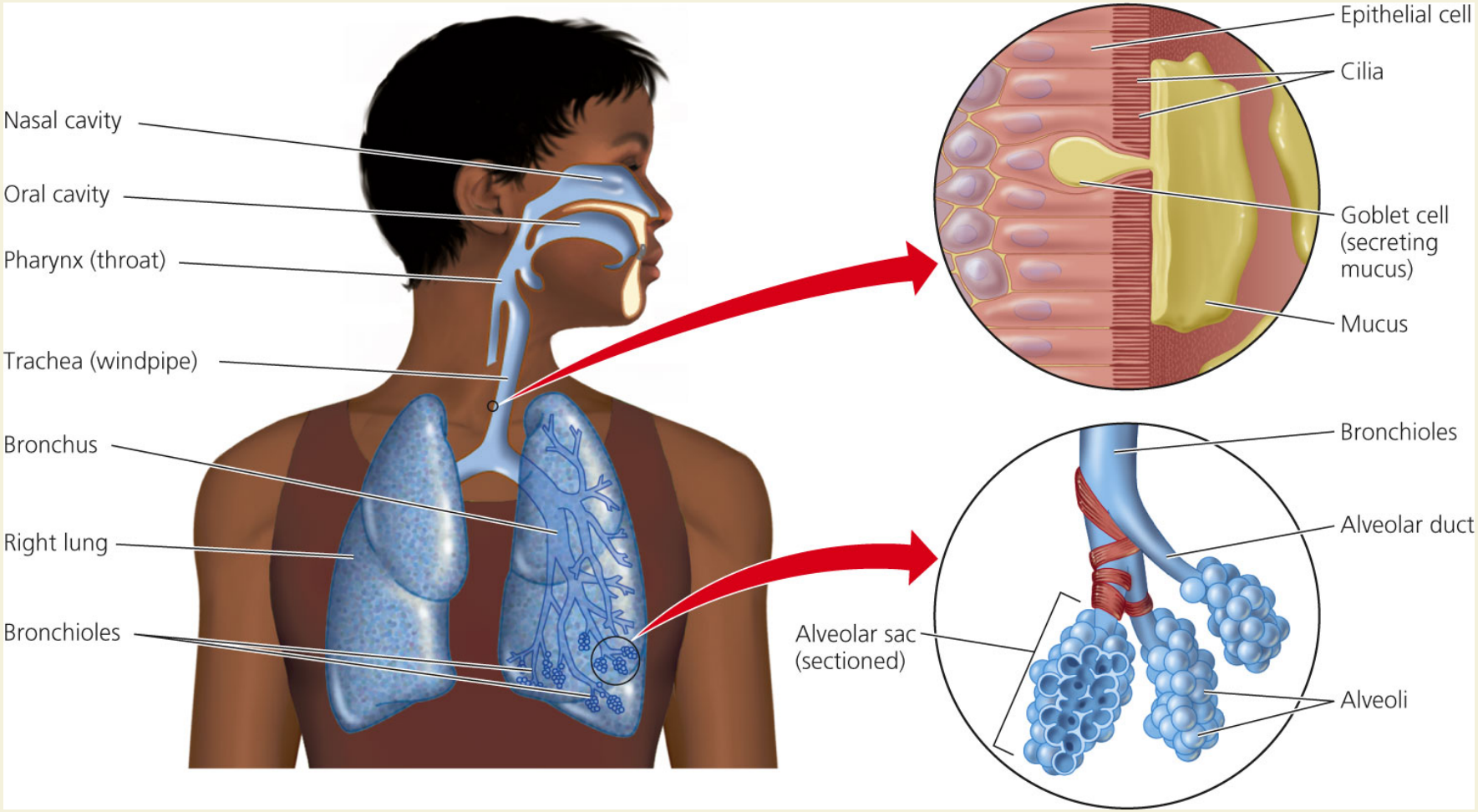


Fig. 18-21, p. 484

Air Pollution Is a Big Killer

- 2.4 million deaths per year world-wide
  - Mostly in Asia; 750,000 in China
  - 150,000 to 350,000 in the United States
  - Role of coal-burning power plants

- EPA: proposed stricter emission standards for diesel-powered vehicles
  - 125,000 die in U.S. each year from diesel fumes
  - Emissions from one truck = 150 cars

Premature Deaths from Air Pollution in the U.S.

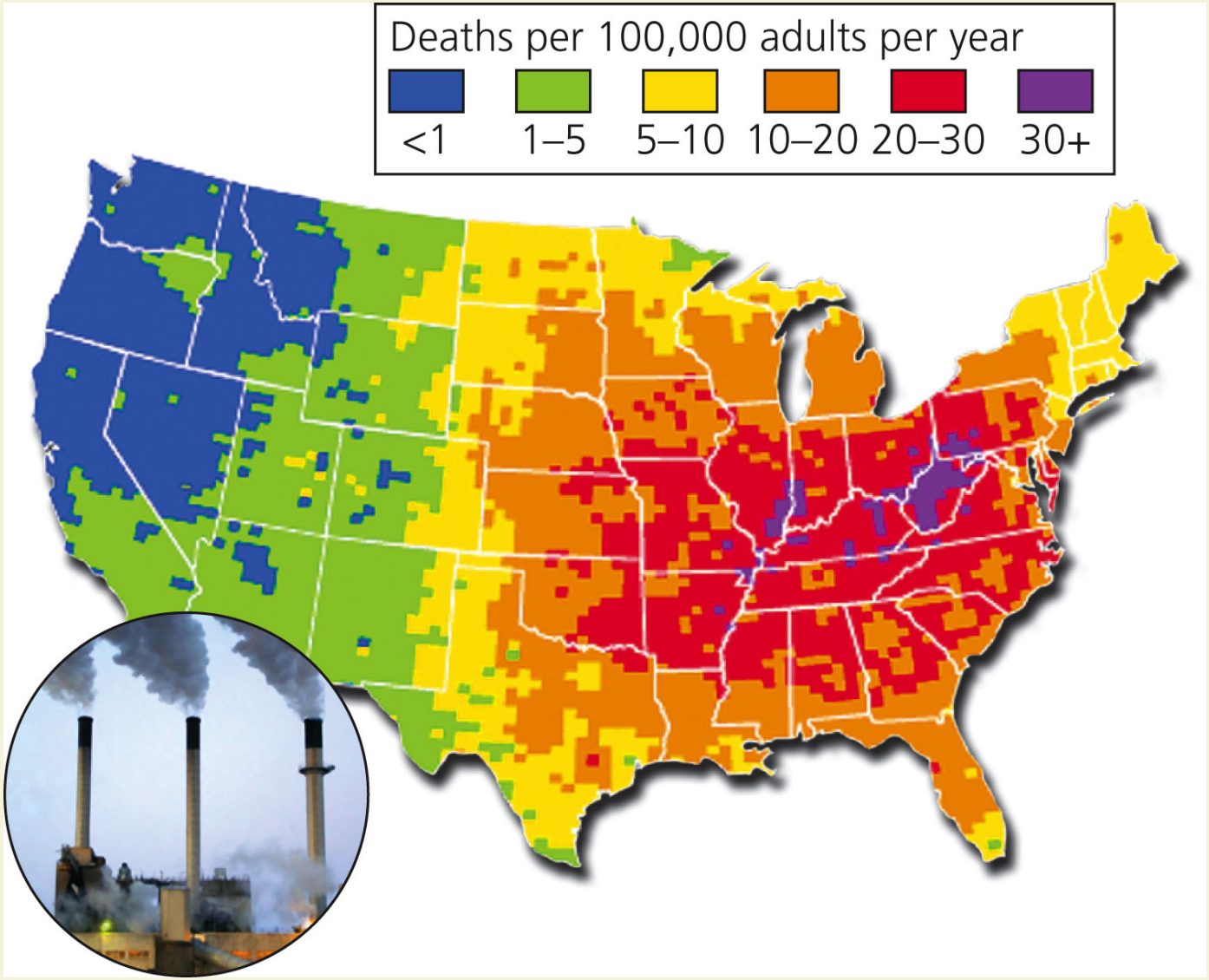


Fig. 18-22, p. 485

18-6 How Should We Deal with Air Pollution?

- ***Concept 18-6*** *Legal, economic, and technological tools can help us to clean up air pollution, but the best solution is to prevent it.*

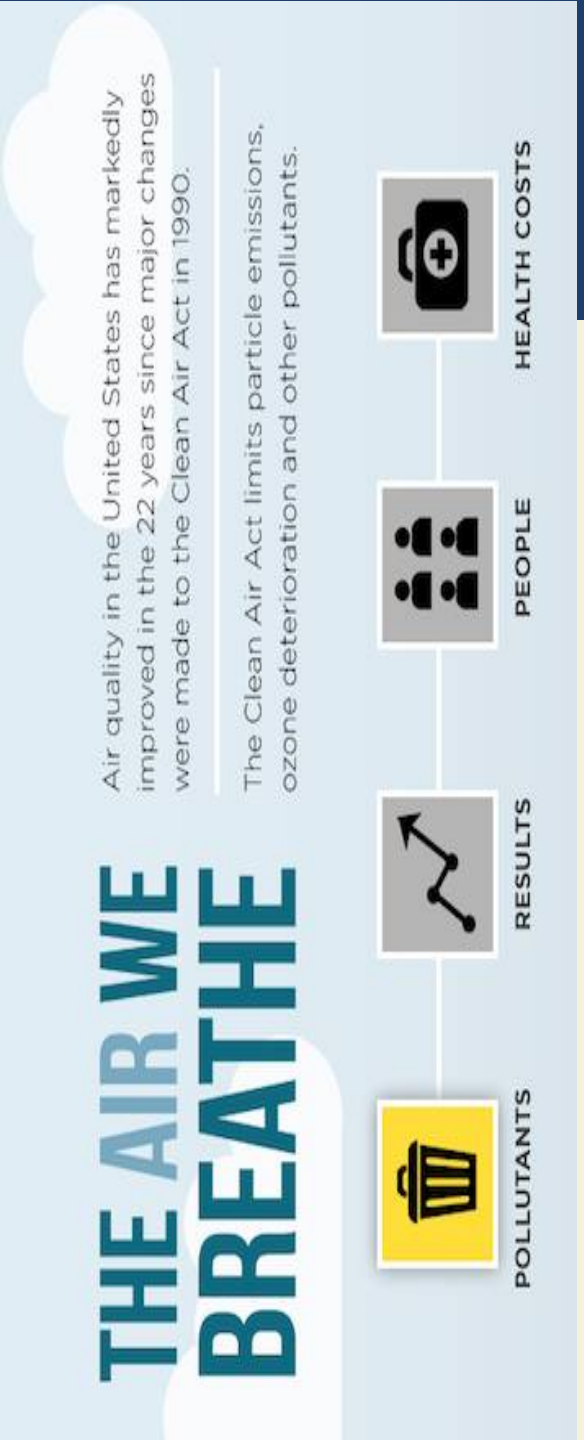
Laws and Regulations Can Reduce Outdoor Air Pollution

United States

- Clean Air Acts: 1970, 1977, and 1990 created regulations enforced by states and cities

EPA

- National ambient air quality standards for 6 outdoor pollutants
- National emission standards for 188 hazardous air pollutants (HAPs)
  - Toxic Release Inventory (TRI)



The Clean Air Act

Congress found:

- Most people now live in urban areas
- Growth results in air pollution
- Air pollution endangers living things

It decided:

- Prevention and control at the source was appropriate
- Such efforts are the responsibility of states and local authorities
- Federal funds and leadership are essential for the development of effective programs

Clean Air Act

- Originally signed 1963
  - States controlled standards
- 1970 – Uniform Standards by Federal Govt.
  - Criteria Pollutants
    - Primary – Human health risk
    - Secondary – Protect materials, crops, climate, visibility, personal comfort

Clean Air Act

- 1990 version
  - Acid rain, urban smog, toxic air pollutants, ozone depletion, marketing pollution rights, VOC's
- 1997 version
  - Reduced ambient ozone levels
  - Cost $15 billion/year -> save 15,000 lives
  - Reduce bronchitis cases by 60,000 per year
  - Reduce hospital respiratory admission 9000/year

WHAT THE CLEAN AIR ACT HAS DONE FOR AMERICA

A RICHER, CLEANER, HEALTHIER NATION

The Clean Air Act is the best argument for sensible environmental regulation. America's public health and its economy have thrived, and pollution has fallen, since the Act's inception.

GDP
207%

ECONOMIC PRODUCTIVITY
100%

ENERGY CONSUMPTION
40%

160,000
LIVES SAVED IN 2010 ALONE

PARTICULATES
22%

NITROGEN OXIDES
39%

SULFUR DIOXIDE
63%

LEAD
98%

EDF
ENVIRONMENTAL DEFENSE FUND
Finding the ways that work
www.edf.org/cleartheair

WHAT MIGHT HAVE BEEN America without the Act

In 1970, President Richard Nixon created the EPA and Congress passed the Clean Air Act. Imagine what the United States would be like without those landmark achievements...

LEADED GAS

Cars would still run on leaded gas, leading to dangerous lead levels in nearly nine out of ten American children.

DYING FORESTS

Vast forests would be destroyed by acid rain. Thousands of lakes that have returned to health would remain lifeless.

HAZARDOUS WASTE

We'd still have raw sewage flowing into rivers, and higher doses of airborne mercury contaminating lakes and affecting the food chain.

FILTHY AIR

Coal plants would emit 50% more pollution than they do now, and nearby office workers would still be changing their shirts at lunchtime because of soot.

VIDEO: Clean Air Act

Laws and Regulations Can Reduce Outdoor Air Pollution (2)

Good news in U.S.

- Decrease in emissions
- Use of low-sulfur diesel fuel
  - Cuts pollution

Less-developed countries

- More air pollution

Case Study: U.S. Air Pollution Can Be Improved

- Rely on prevention of pollution, not cleanup
- Sharply reduce emissions from power plants, industrial plants, and other industry
- Raise fuel-efficiency for cars, SUVs, and light trucks
- Better regulation of emissions of motorcycles and two-cycle gasoline engines

Case Study: U.S. Air Pollution Can Be Improved (2)

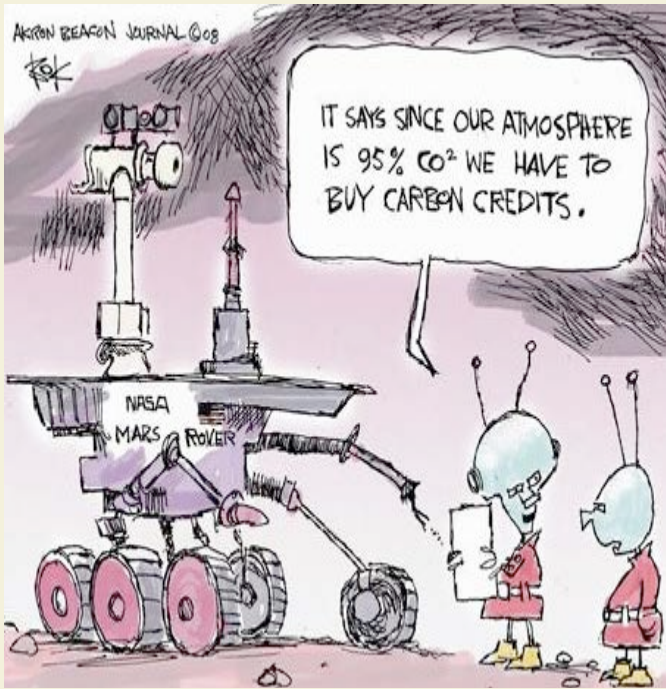
- Regulate air pollution for oceangoing ships in American ports
- Regulate emissions at U.S. airports
- Sharply reduce indoor pollution
- Increased and more accurate monitoring of air pollutants

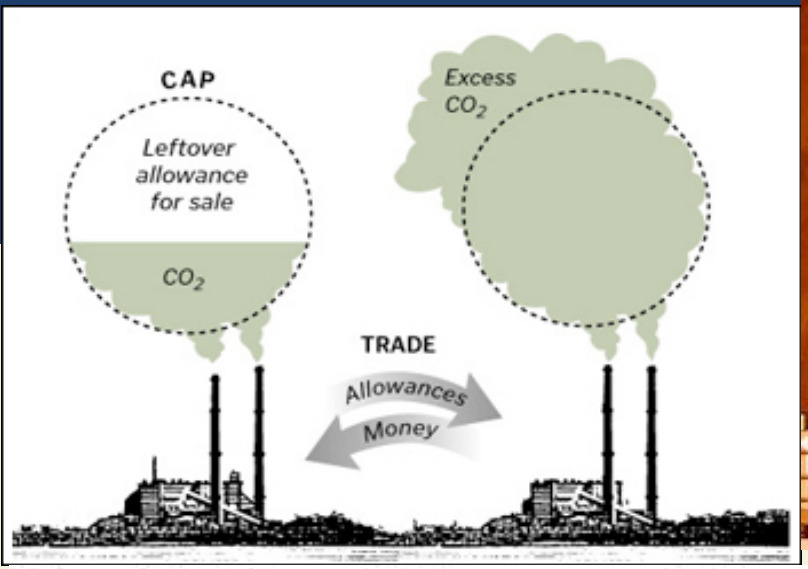
We Can Use the Marketplace to Reduce Outdoor Air Pollution

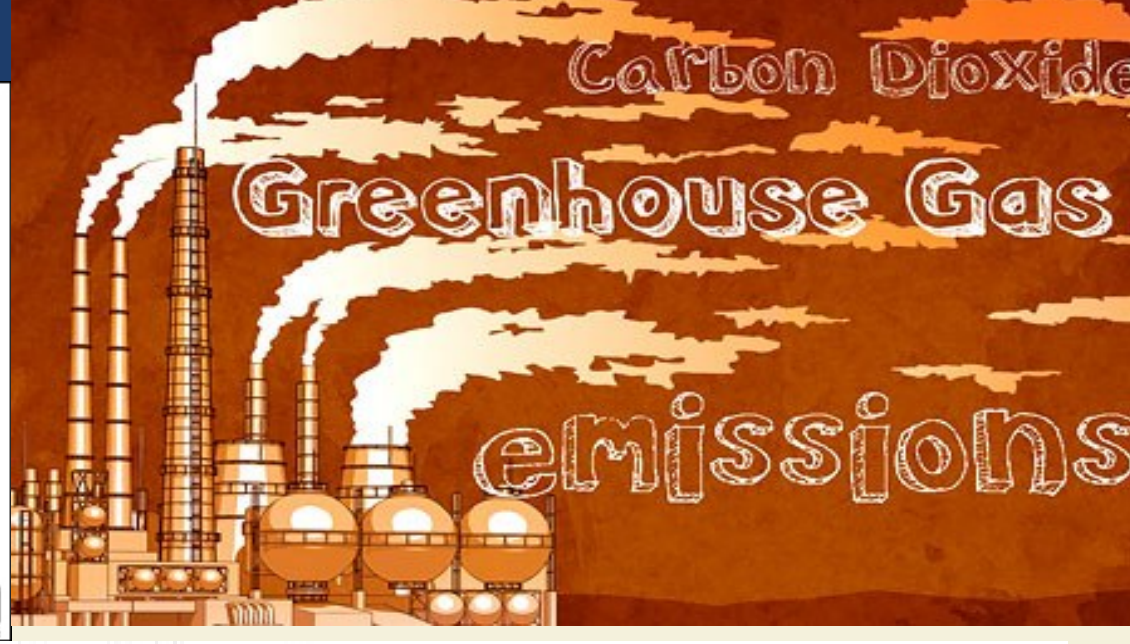
Emission trading or cap-and-trade program

- Mixed reactions to program
- SO_2 emissions down significantly
- NO_x now in effect
- Mercury plan strongly opposed for creating toxic hotspots

Many problems with making cap-and-trade effective

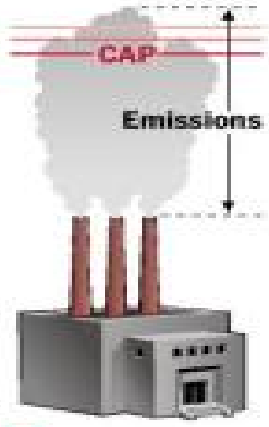




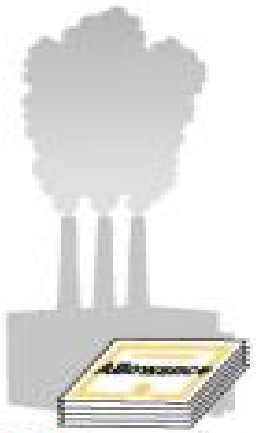


How California's cap-and-trade will work

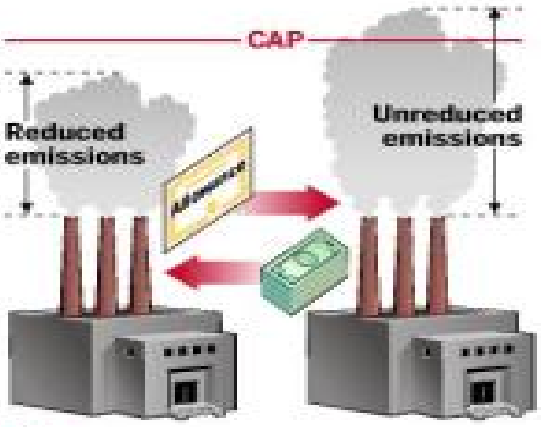
Rather than having a strict government mandate, like a carbon tax, to reduce pollution, a cap-and-trade system uses market mechanisms to reward companies that figure out ways to reduce pollution below the level the government sets. California's cap-and-trade rules, which will affect oil refineries, power plants and large factories, take effect Jan. 1.



1 Starting in 2013, a statewide cap on greenhouse gases will be put in place. Through 2020, it will drop each year by 2 to 3 percent.



2 Industries must obtain a permit, known as an "allowance," for every ton of carbon dioxide and other greenhouse gases they emit.



3 As the cap goes down, companies must decide each year how they will get enough allowances to cover their emissions. Their choices: Operate more efficiently, burn less fossil fuel, or buy allowances from another company.

4 Sacramento makes money by holding an electronic auction four times a year to distribute the pollution allowances. At first, 90 percent will be given away free and 10 percent auctioned for sale. By 2020, 50 percent will be auctioned. The first auction is scheduled for Wednesday.

Source: Mercury News reporting

BAY AREA NEWS GROUP

There Are Many Ways to Reduce Outdoor Air Pollution

- There are ways to deal with
  - Stationary source air pollution
  - Motor vehicle air pollution
    - New cars have lower emissions
- Less-developed countries far behind developed countries in implementing solutions

Solutions: Stationary Source Air Pollution

Solutions

Stationary Source Air Pollution

Prevention

Burn low-sulfur coal or remove sulfur from coal

Convert coal to a liquid or gaseous fuel

Phase out coal use

Reduction or Disposal

Disperse emissions (which can increase downwind pollution) with tall smokestacks

Remove pollutants from smokestack gases

Tax each unit of pollution produced

Fig. 18-23, p. 487

Solutions: Motor Vehicle Air Pollution

Solutions

Motor Vehicle Air Pollution

Prevention

Walk, bike, or use mass transit

Improve fuel efficiency

Get older, polluting cars off the road

Cleanup

Require emission control devices

Inspect car exhaust systems twice a year

Set strict emission standards

Fig. 18-24, p. 487

Reducing Indoor Air Pollution Should Be a Priority

- Greater threat to human health than outdoor pollution

- What can be done?
  - Prevention
  - Cleanup

Solutions: Indoor Pollution

Solutions

Indoor Air Pollution

Prevention

Ban indoor smoking

Set stricter formaldehyde emissions standards for carpet, furniture, and building materials

Prevent radon infiltration

Use less polluting cleaning agents, paints, and other products

Cleanup or Dilution

Use adjustable fresh air vents for work spaces

Circulate air more frequently

Circulate a building's air through rooftop greenhouses

Use efficient venting systems for wood-burning stoves

Fig. 18-25, p. 488

Turbo Stove in India

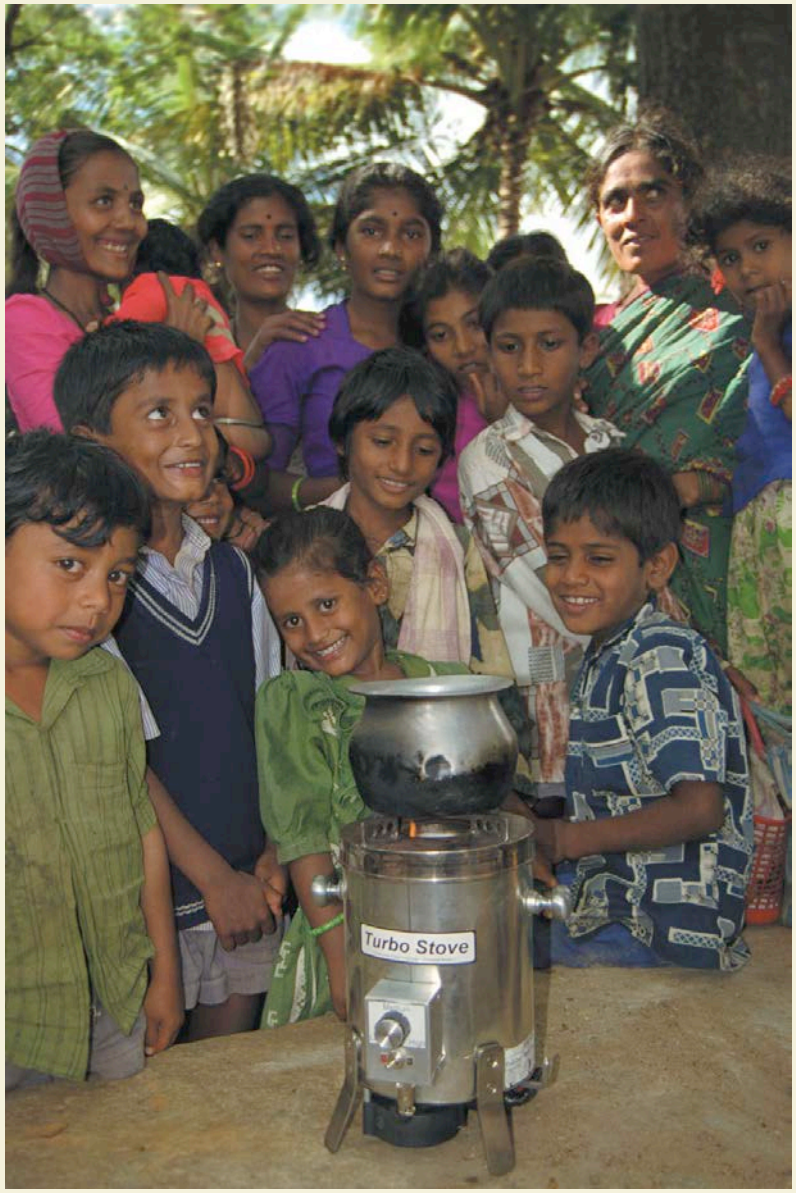


Fig. 18-26, p. 488

What Can You Do? Indoor Air Pollution

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
- Switch to phthalate-free detergents
- Use baked lemons as natural fragrance
- Test your house or workplace for asbestos fiber levels, and check for any crumbling asbestos materials if it was built before 1980
- 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

Fig. 18-27, p. 489

We Need to Put More Emphasis on Pollution Prevention

- Output approaches
- New shift to preventing outdoor and indoor pollution
  - Pressure from citizens

Three Big Ideas

1. Outdoor air pollution, in the forms of industrial smog, photochemical smog, and acid deposition, and indoor air pollution are serious global problems.

2. Each year, at least 2.4 million people die prematurely from the effects of air pollution; indoor air pollution, primarily in less-developed countries, causes about two-thirds of those deaths.

3. We need to put our primary emphasis on preventing outdoor and indoor air pollution throughout the world.