Air Pollution

tutorial by Paul Rich

Outline

1. The Atmosphere
   layers, some major processes
2. Urban Air Pollution
   photochemical & industrial smog
3. Regional Air Pollution from Acid Deposition
   acid deposition, consequences, solutions
4. Effects of Air Pollution
   human health, plants, aquatic life, property
5. Indoor Air Pollution
   types, radon
6. Preventing & Reducing Air Pollution
   laws, technology

1. The Atmosphere

***troposphere**, the innermost layer:*

- where weather occurs;
- contains 75% of mass of Earth's air;
- location of greenhouse effect, whereby heat is trapped near Earth's surface;
- heated from beneath because solar radiation passes through atmosphere & heats Earth's surface.

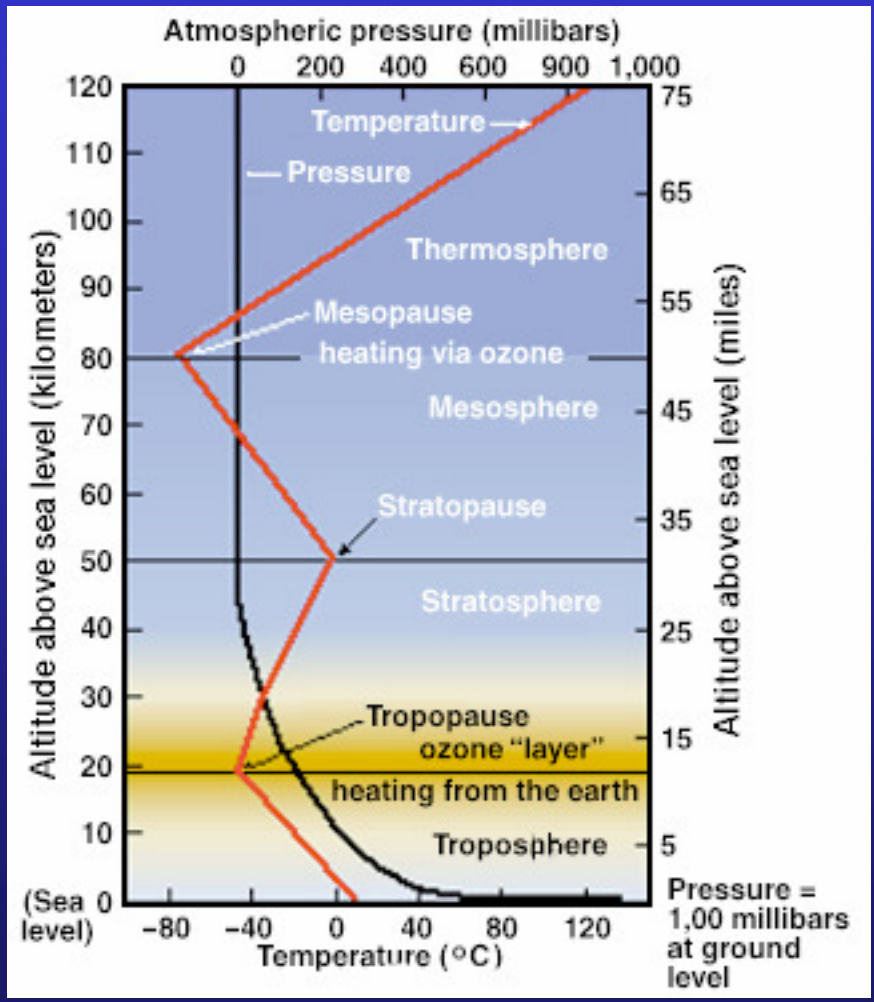


Fig. 18–2

The Atmosphere

***stratosphere**, the second innermost layer:*

- includes ozone layer, which filters ultraviolet radiation;
- increasing temperature with altitude makes layer stable & limits mixing with troposphere.

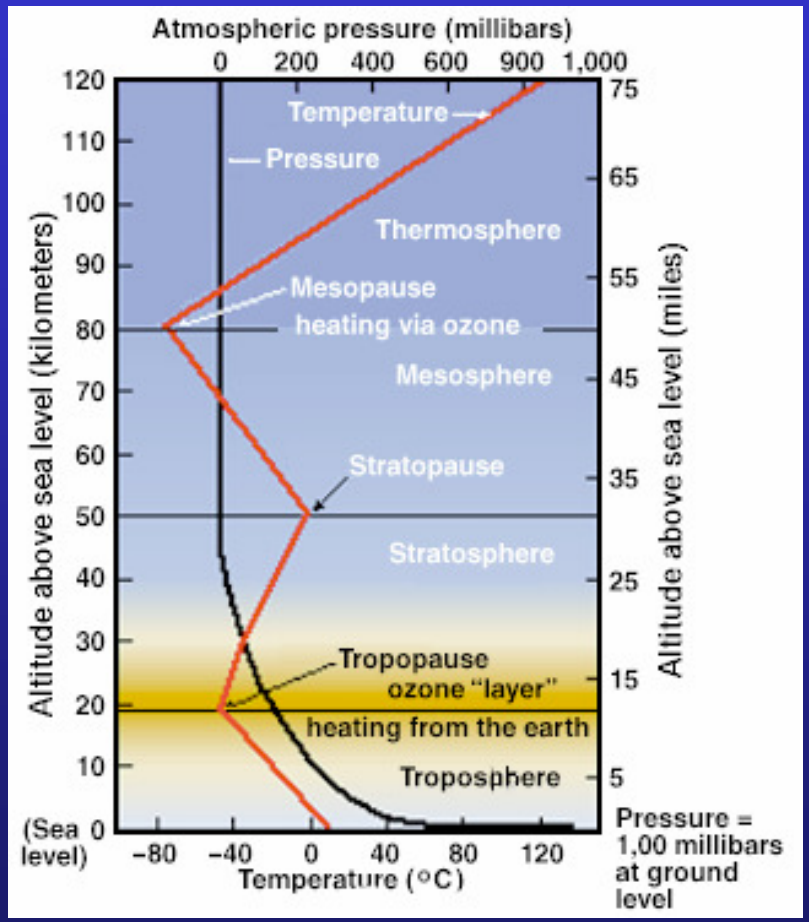


Fig. 18–2

The Atmosphere

Human inputs to the troposphere modify Earth's gaseous nutrient cycles.

- nitrogen & sulfur compounds are among the substances released by burning fossil fuels;
- humans add carbon dioxide (CO_2) & other greenhouse gases by burning fossil fuels & clearing forests.

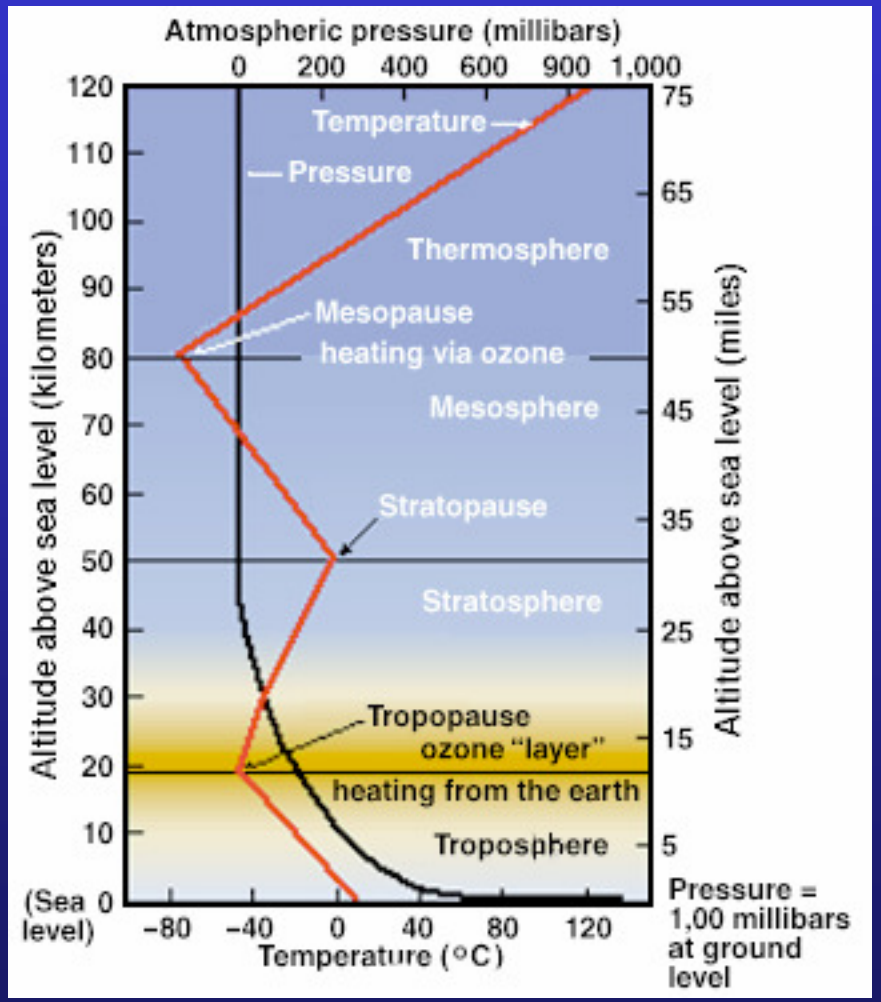


Fig. 18–2

2. Urban Air Pollution

Pollutants include both natural & human sources. Sources can be mobile or stationary. Within the atmosphere chemical reactions can form secondary pollutants from primary pollutants.

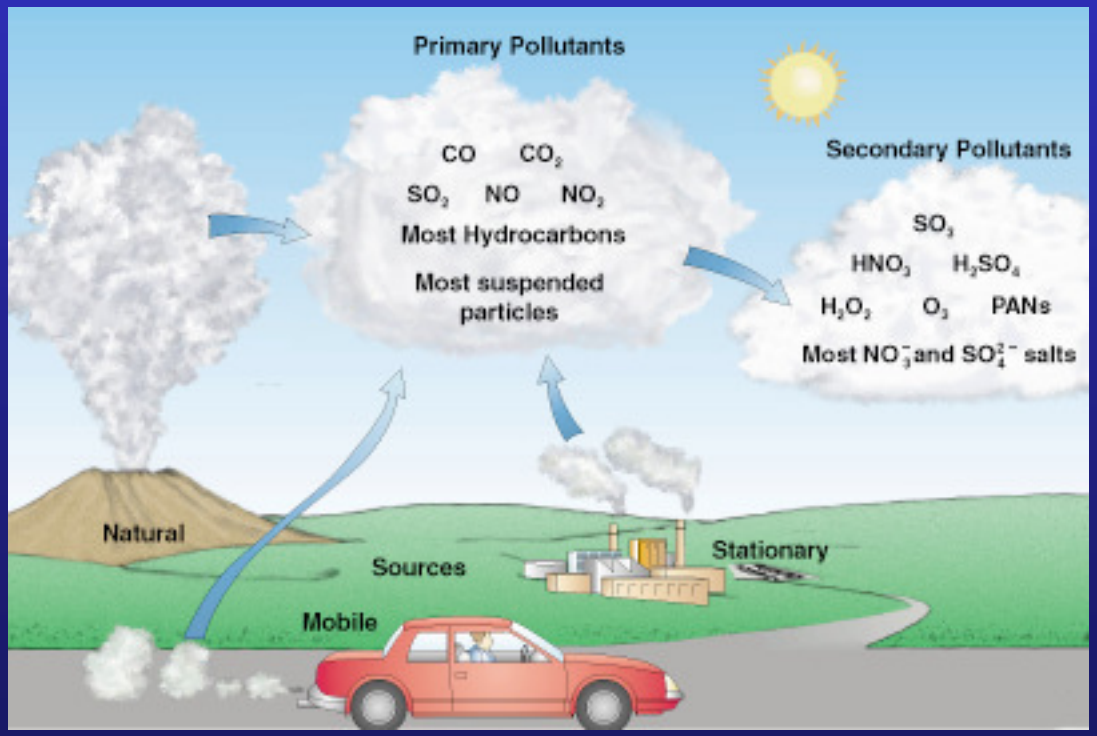


Fig. 18–3

Air Pollution

In addition to gaseous pollutants, ***suspended particulate matter****, consisting of particles of solid matter & droplets of liquid, is released into the atmosphere by burning fossil fuels & by other human activities.*

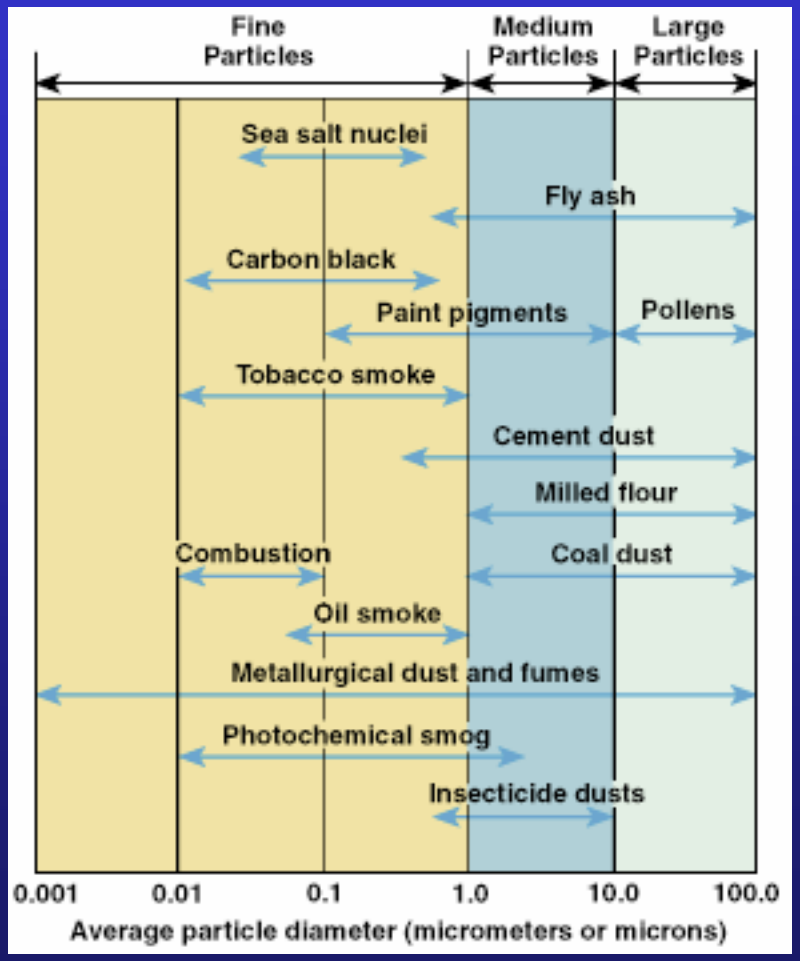


Fig. 18–4

Photochemical Smog

Photochemical smog *consists of secondary pollutants (HNO_3 PANs, O_3…) that are formed in a complex series of reactions involving input of energy from solar radiation.*

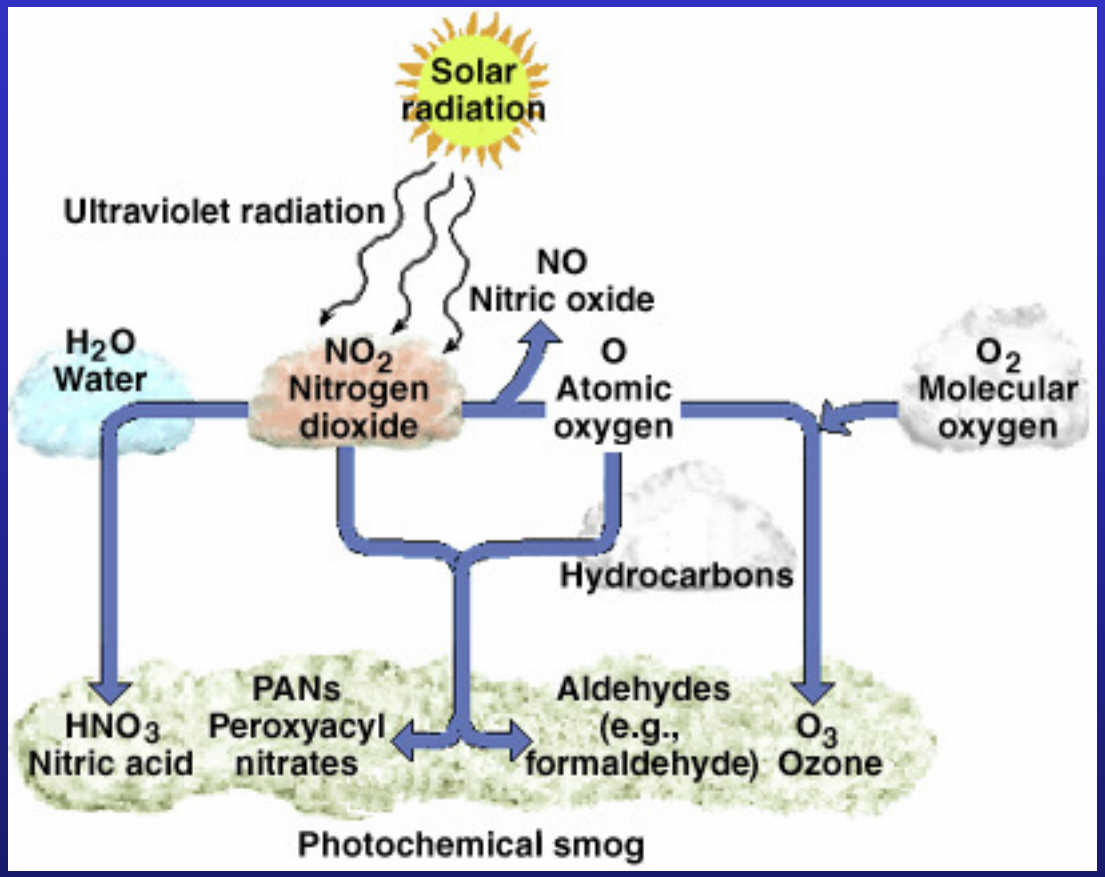


Fig. 18–5

Industrial Smog

Industrial Smog *consists mostly of sulfur dioxide, sulfuric acid suspended in droplets, & a variety of particulates (soot).*

- sulfur compounds in coal & oil react with oxygen to form sulfur dioxide (SO_2), a colorless suffocating gas;

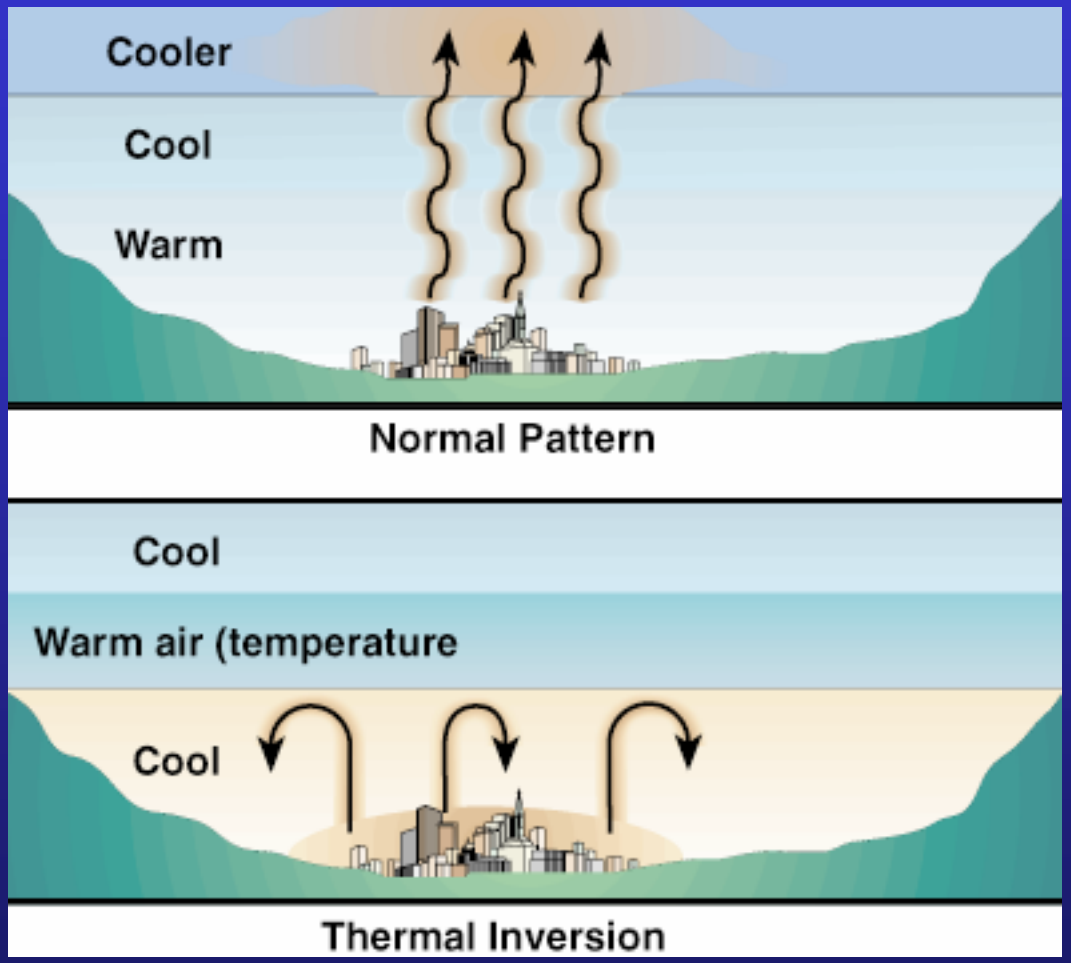
  $S + O_2 \rightarrow SO_2$

- in the troposphere some of the sulfur dioxide reacts with oxygen to from sulfur trioxide (SO_3), which then reacts with water vapor to form sulfuric acid (H_2SO_4).

  $2\ SO_2 + O_2 \rightarrow SO_3$ $\quad$ $SO_3 + H_2O \rightarrow H_2SO_4$

Thermal Inversions

Thermal inversions *involve trapping cool air beneath warm air. This prevents mixing and leads to accumulation of dangerous levels of air pollution (photochemical smog, industrial smog…) near the ground.*



Air Pollution Video:
http://video.nationalgeographic.com/video/player/environment/environmental-threats-environment/state-of-the-earth/air.html

3. Regional Air Pollution from Acid Deposition

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

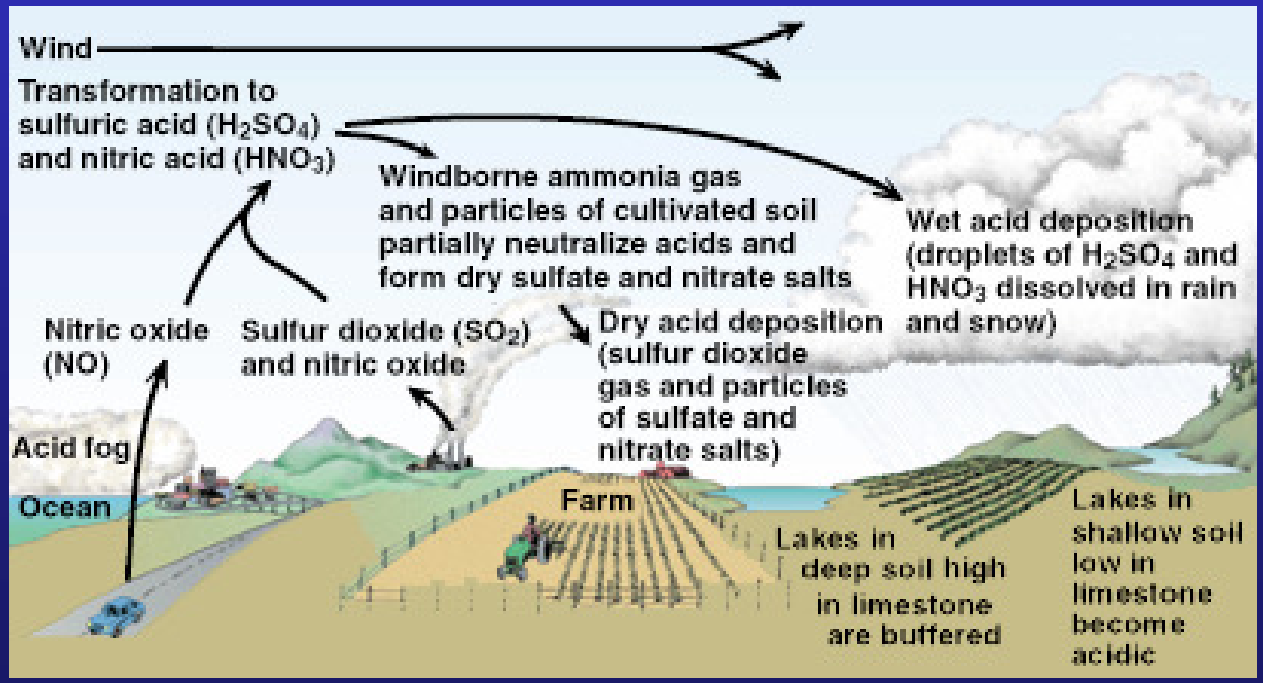


Fig. 18–7

Acid Deposition

Acid deposition is now a problem in widespread regions, especially in expansive areas downwind from major industrial areas.

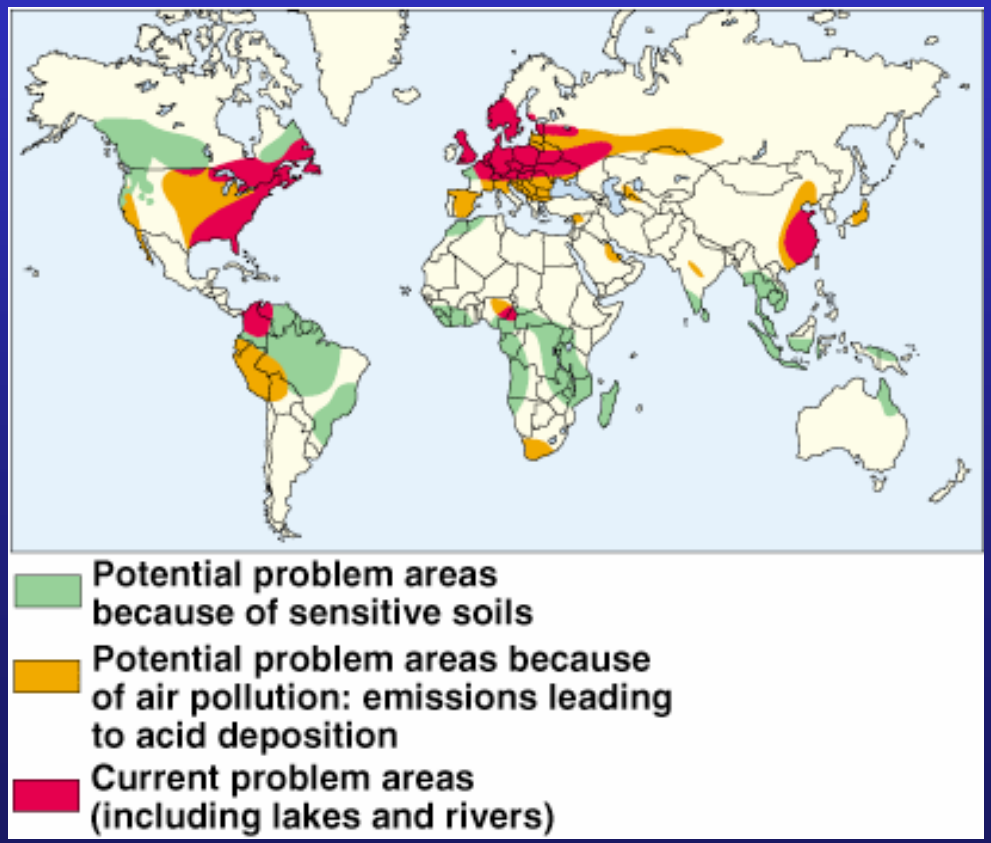
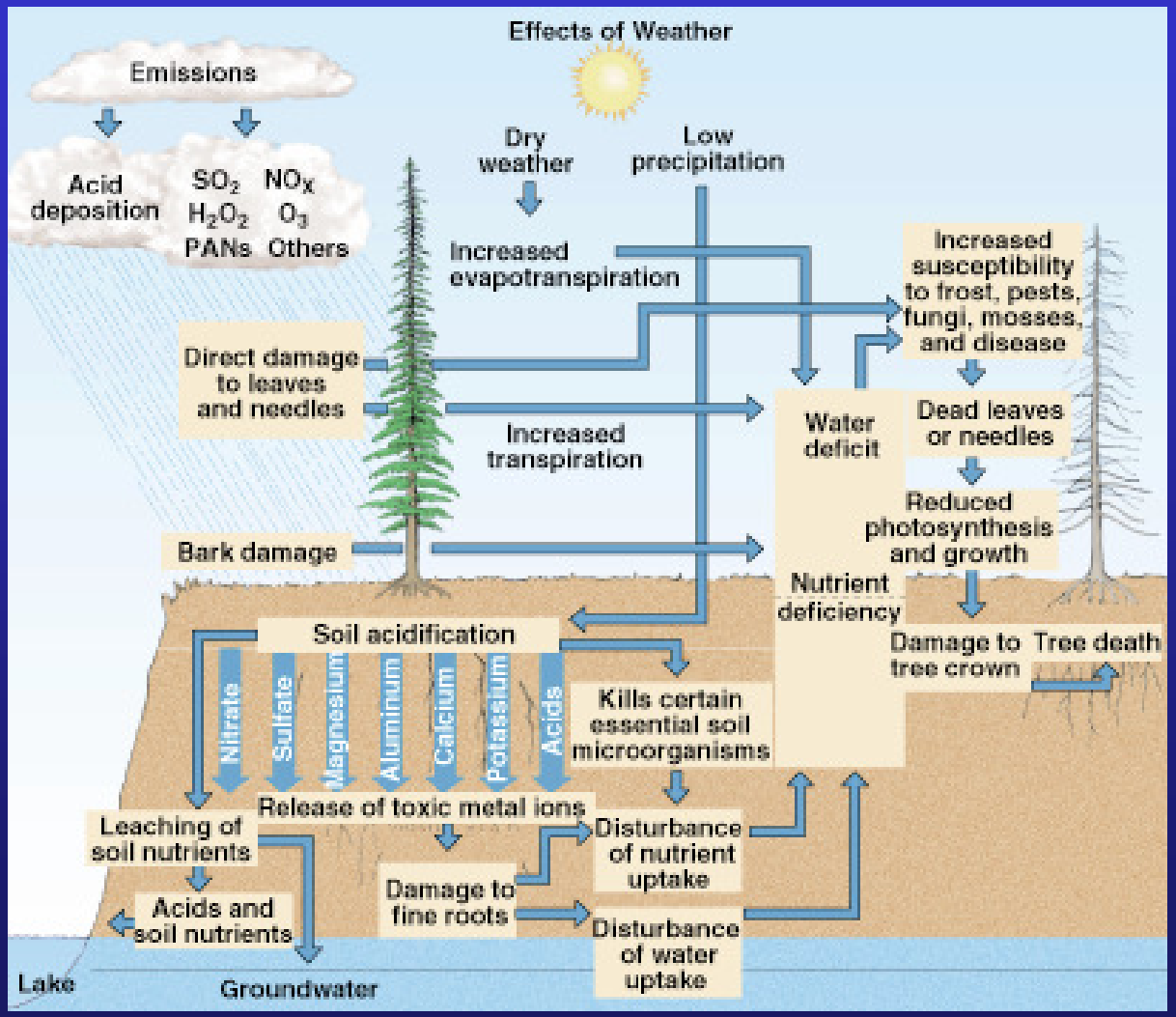


Fig. 18–8

Effects on Soil & Plants

Known & suspected effects of prolonged exposure to atmospheric pollutants on trees & soils.



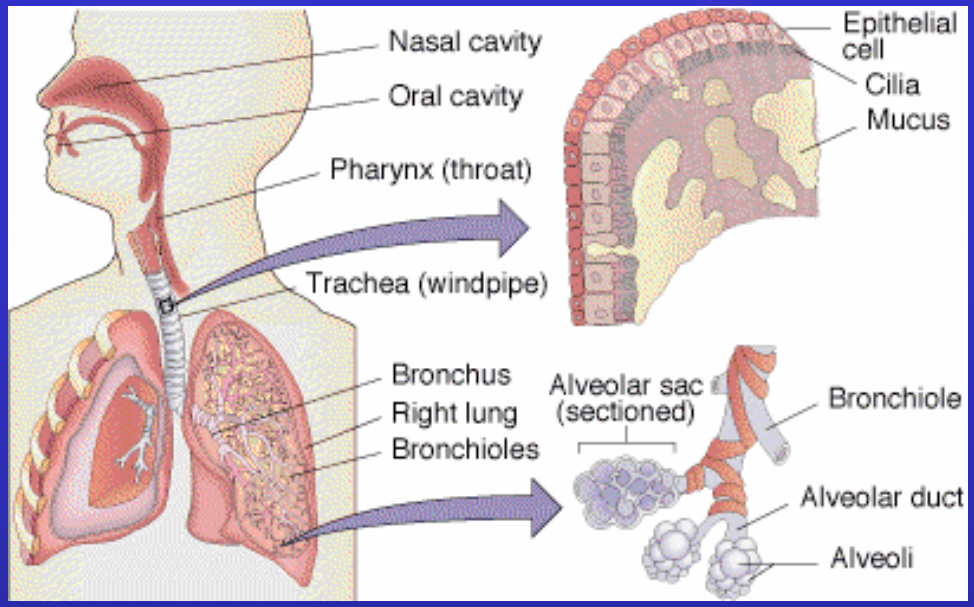
Effects on Aquatic Life

- aquatic ecosystems are the ultimate repository for various air pollutants;
- in particular high acidity (low pH) can leach harmful minerals such as aluminum into the environment, kill fish & other organisms, inhibit reproduction, disrupt food chains, & decrease productivity

Effects on Property

- air pollutants cause billions of dollars of damage to various materials (e.g., damage to buildings in U.S. estimated at $5 billion annually);
- breaks down paints on cars and buildings, deteriorates roofing, etches stained glass windows, dissolves & discolors marble (see Fig. 18–3).

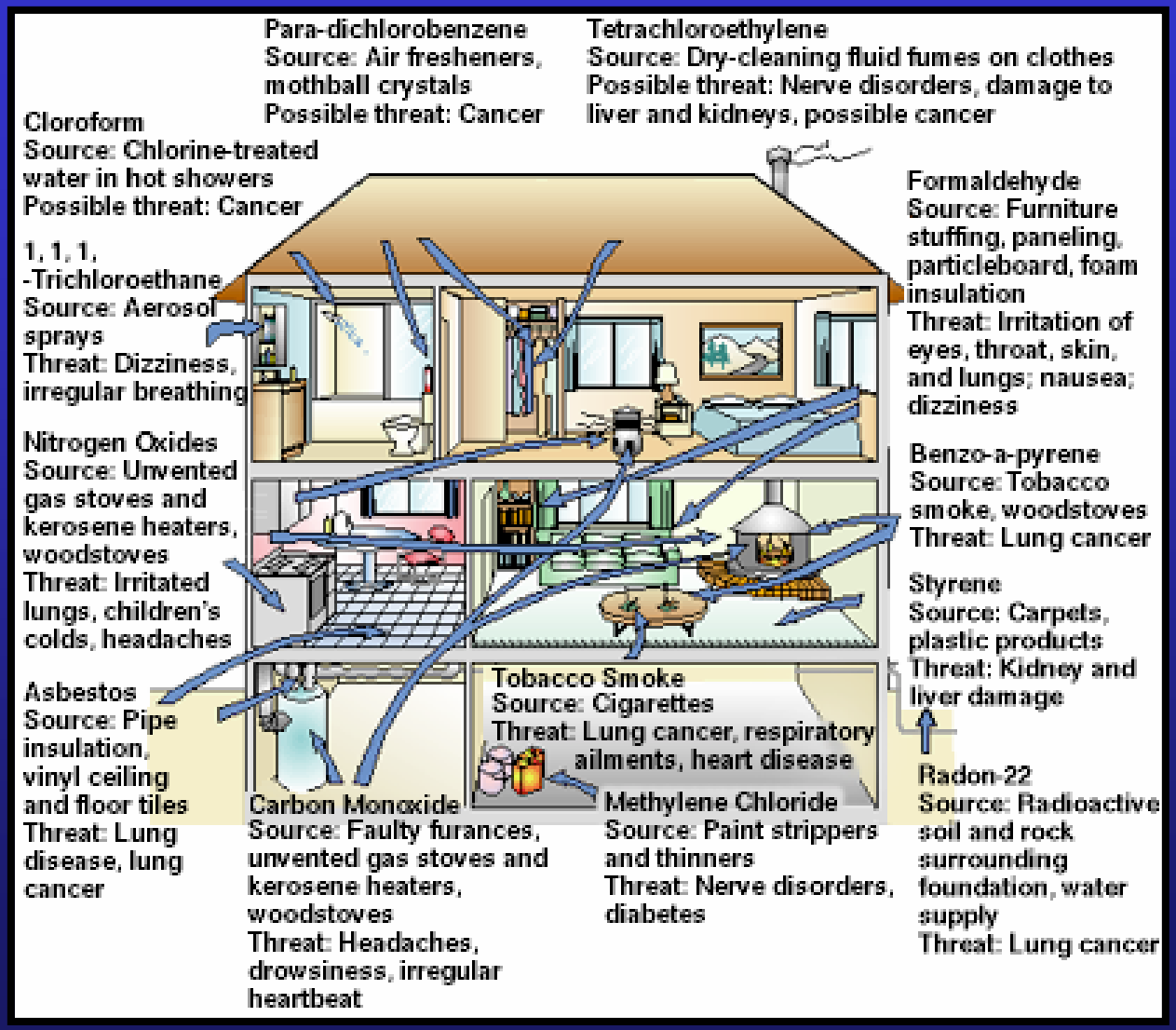
4. Health Effects of Some Major Air Pollutants



- **carbon monoxide (CO)**: reacts with hemoglobin in red blood cells & reduces ability of blood to carry oxygen;
- **particulates**: long–term exposure contributes to lung disease & cancer, aggravates bronchitis & asthma;
- **sulfur dioxide (SO_2)**: causes constriction of airways & can cause bronchitis;
- **nitrogen oxides (especially NO_2)**: irritate lungs, cause conditions similar to bronchitis & emphysema;
- **volatile organics** (& toxic particulates): cause mutations, reproductive problems, & cancer;
- **ozone**: causes coughing, chest pain, shortness of breath, & eye, nose, & throat irritation.

4. Indoor Air Pollution

Indoor air pollution can be an even greater health threat than outdoor air pollution.



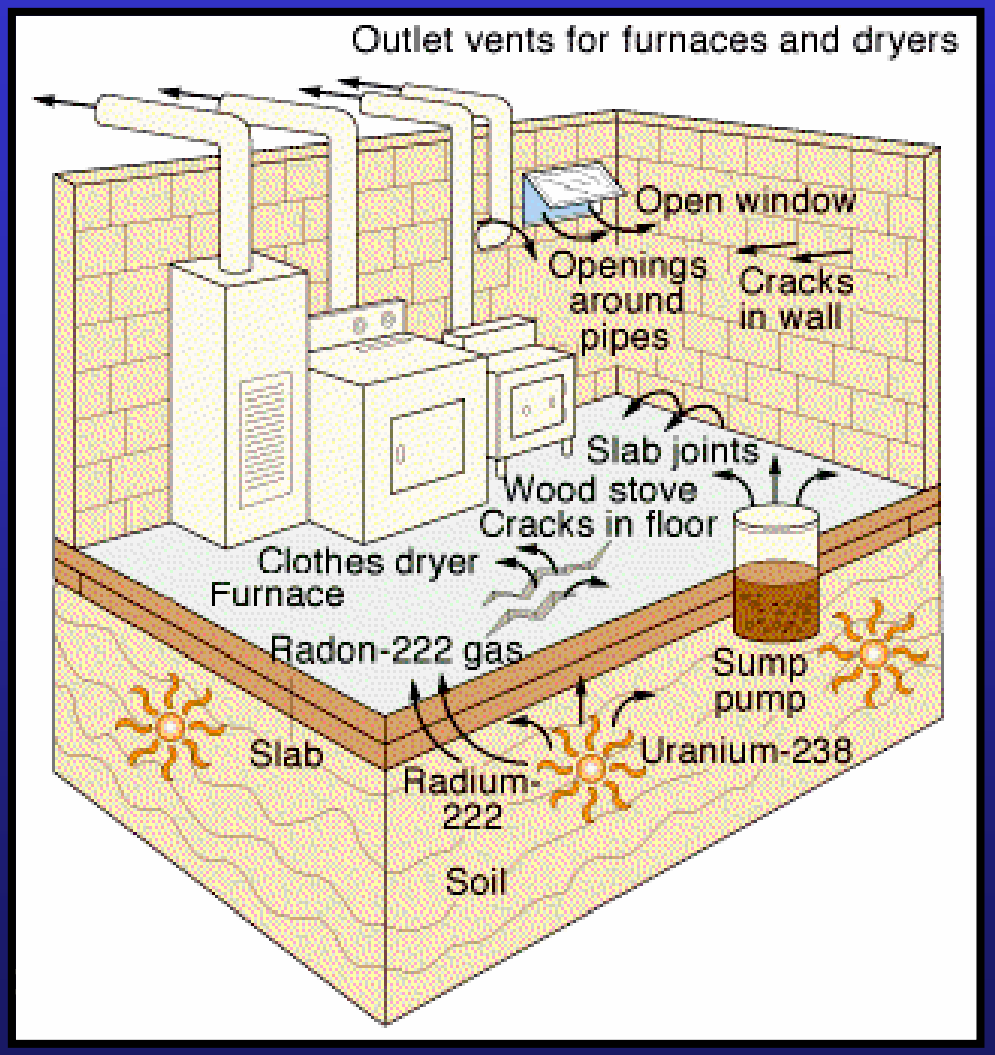
*Visit Tox Town at http://toxtown.nlm.nih.gov/

“Sick Building Syndrome”

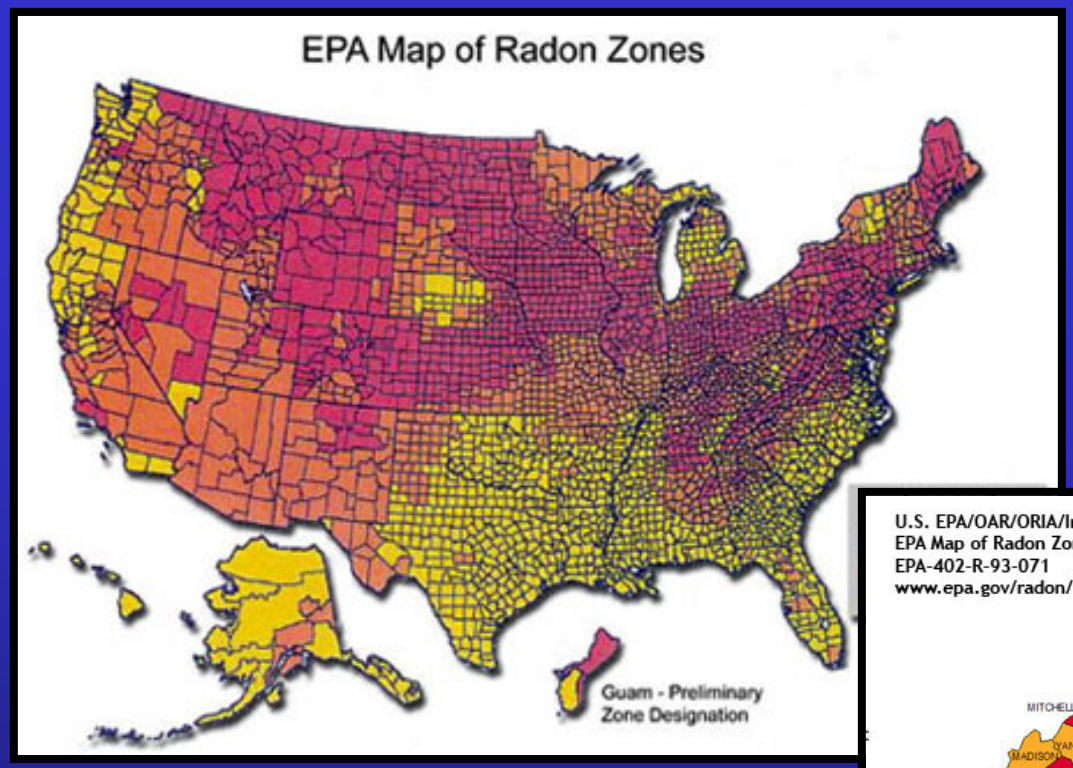
- EPA studies show that 11 common pollutants are generally 2-5 times higher inside homes & commercial buildings than outdoors.
- Health risks are magnified because people spend 70-98% of their time indoors.
- Indoor pollutants linked to dizziness, headaches, coughing, sneezing, nausea, burning eyes, fatigue, & flu-like symptoms
- At greatest are smokers, children under 5, old, sick, pregnant women, etc.
- Building is considered “sick” when at least 20% of its occupants suffer persistent symptoms that disappear when they go outside.
- New buildings are more commonly “sick” than old ones because of reduced air exchange (to save energy) and chemicals from new carpeting and furniture.

Indoor Air Pollution

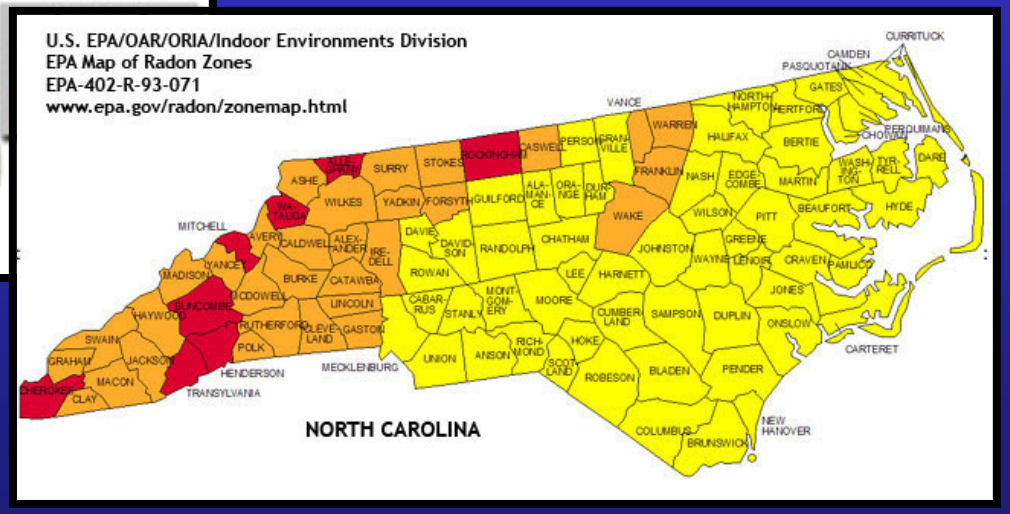
Radon–222 gas is a colorless, odorless, naturally occurring gas that is a breakdown product of uranium–238 found in small amounts in most soil. Radon gas causes lung cancer & other health problems. Ventilation & proper building can prevent accumulation of this dangerous gas.



*See http://www.atsdr.cdc.gov/tfacts145.html



Which states are most at risk?



- **Zone 1** Highest Potential (greater than 4 pCi/L)
- **Zone 2** Moderate Potential (from 2 to 4 pCi/L)
- **Zone 3** Low Potential (less than 2 pCi/L)

6. Preventing & Reducing Air Pollution

A combination of laws, technologies, & responsible practices can be used to prevent & clean up air pollution.

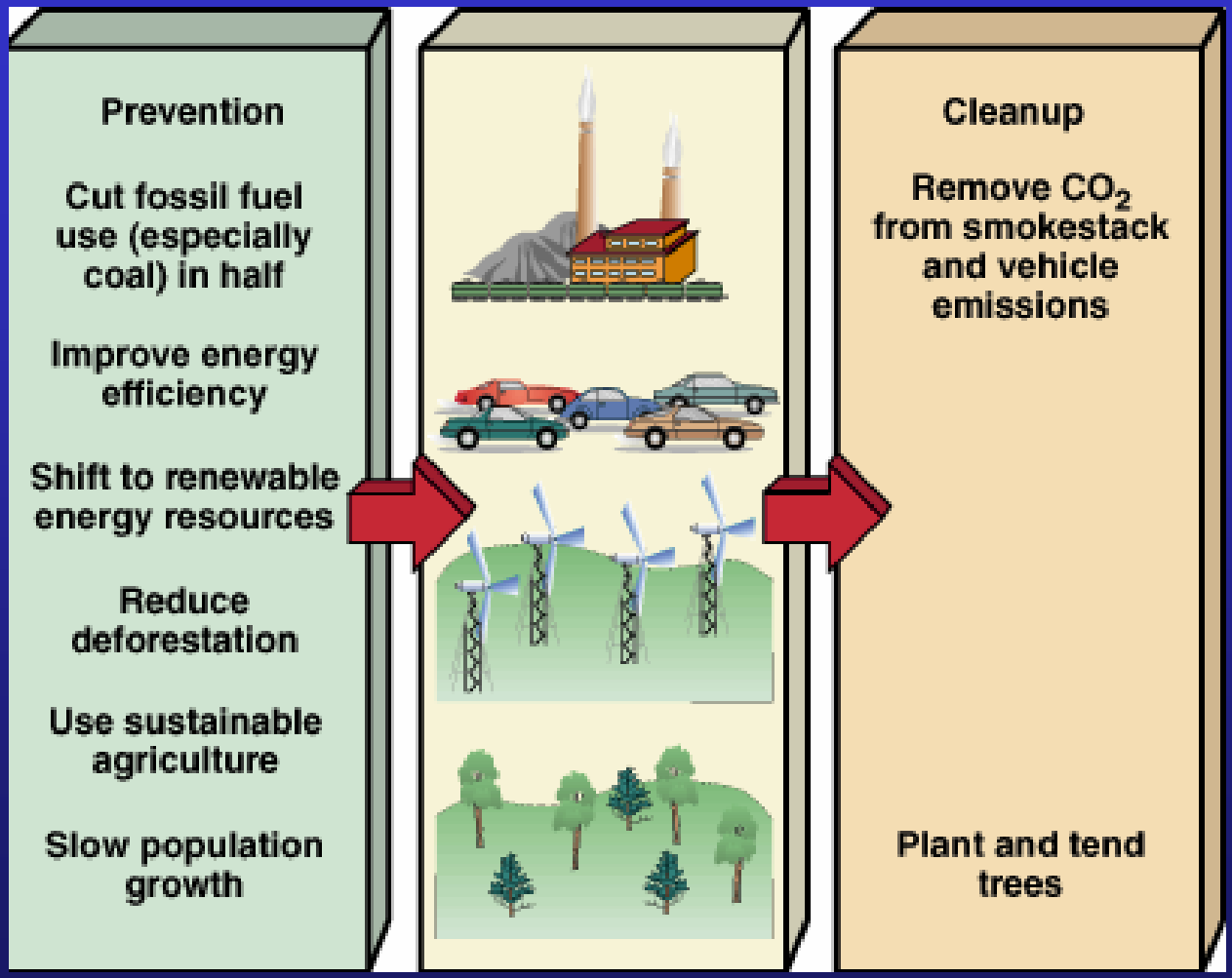


Fig. 18–14

Laws for Preventing & Reducing Air Pollution

The Clean Air Acts of 1970, 1977, & 1990 provide federal air pollution regulations & require the Environmental Protection Agency (EPA) to establish ***national ambient air quality standards*** *(NAAQS).*

- NAAQS apply to seven outdoor pollutants: suspended particulate matter, sulfur oxides, carbon monoxide, nitrogen oxides, ozone, volatile organic compounds, & lead;
- **prevention of significant deterioration** is a policy of the Clean Air Act, under which regions with air quality cleaner than that required by NAAQS are not allowed to deteriorate;
- **national emission standards for toxic air pollutants** require the EPA to regulate many toxic air pollutants.

Effectiveness of Laws

The Clean Air Act has worked.

- between 1970 & 1997 levels of six major air pollutants decreased by 31%;
- nitrogen dioxide levels have increased slightly, primarily from automobiles;
- a 1996 study by the EPA shows that benefits of the Clean Air Act greatly exceed costs: 1970–90 $436 billion spent, health benefits of $2.7 to $14.6 trillion;
- still EPA estimates that 107 million Americans live in areas that exceed at least one outdoor air pollution standard.

Technologies for Preventing & Reducing Air Pollution

Four commonly used methods for removing particulates from the exhaust gases of electric power & industrial plants. All produce hazardous waste that must be disposed of.

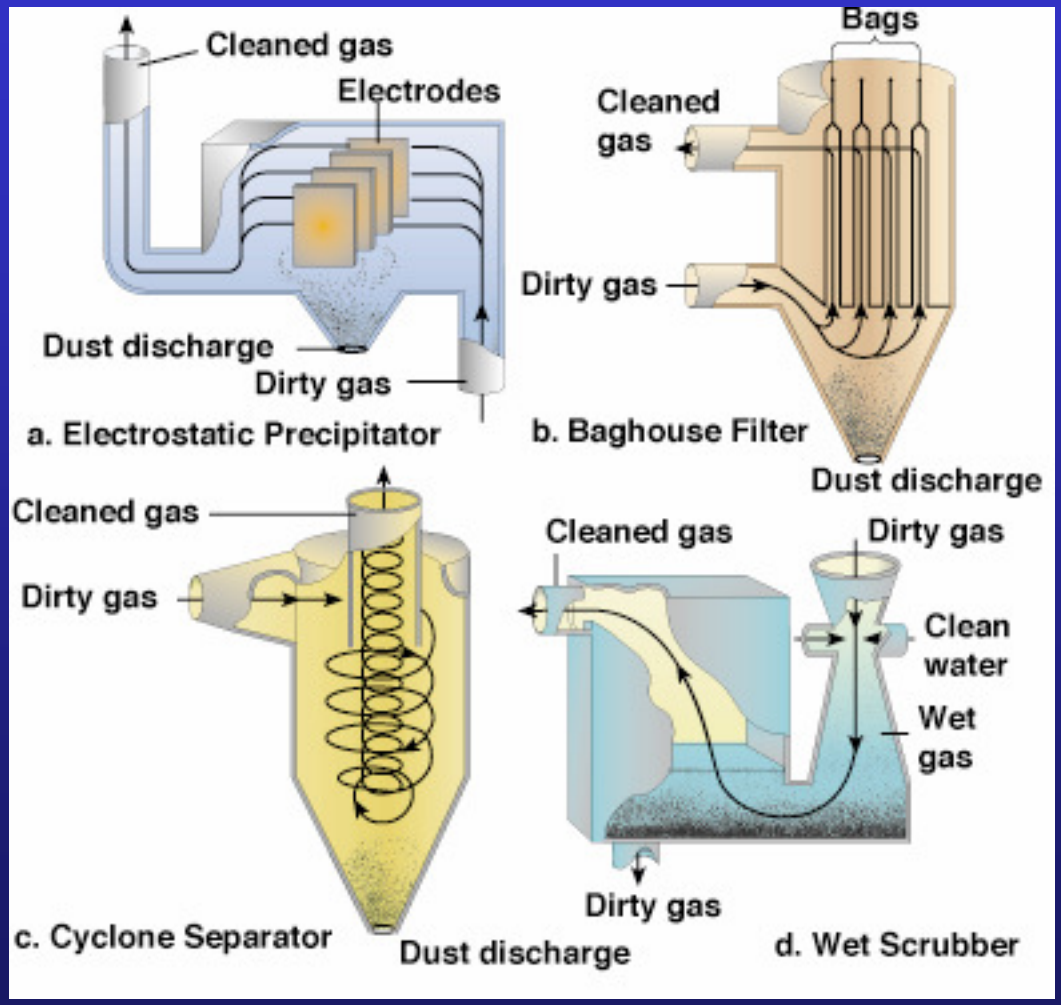


Fig. 18–15

Preventing & Reducing Air Pollution

Methods for reducing emissions from motor vehicles.

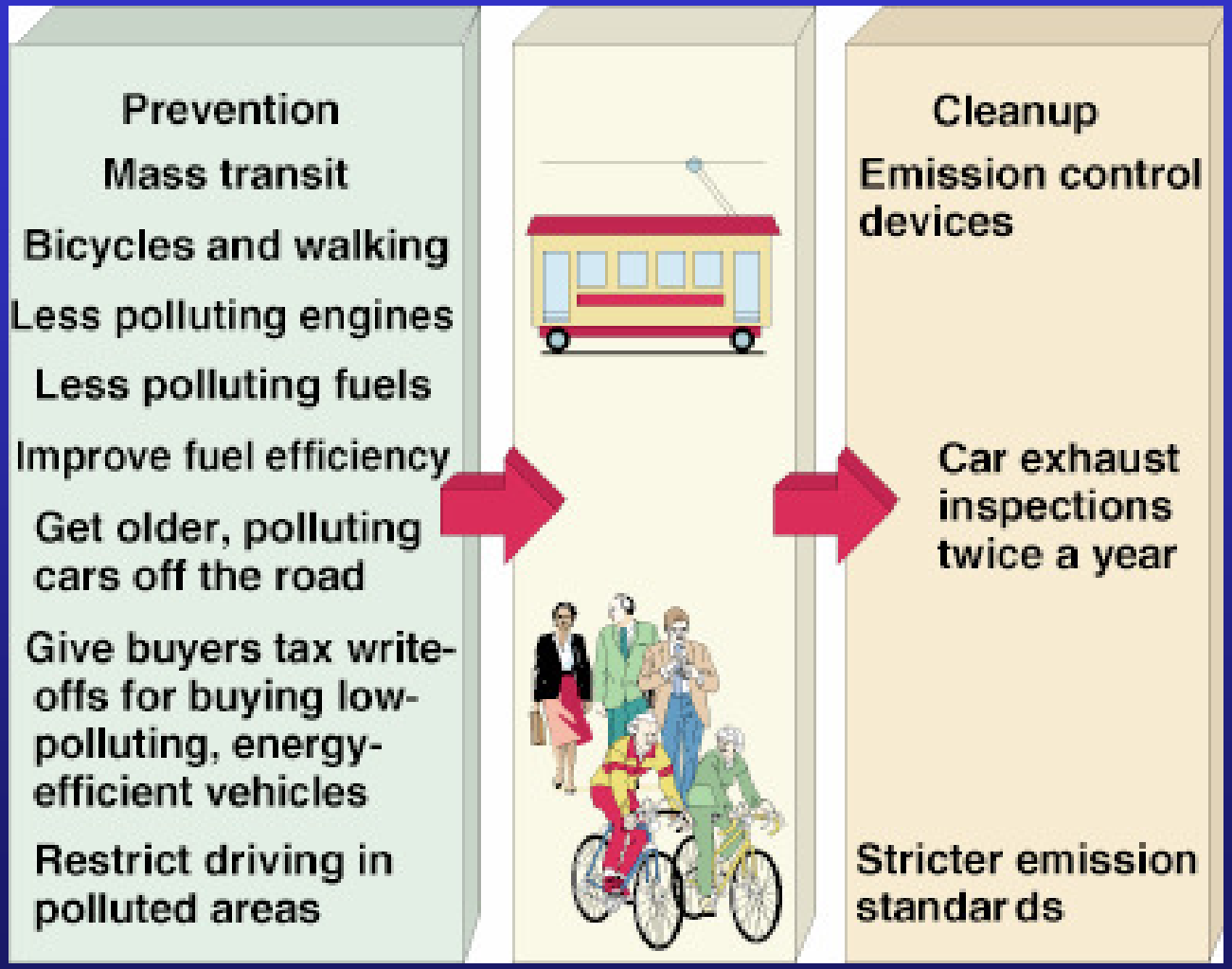


Fig. 18–16

Preventing & Reducing Air Pollution

How can we protect the atmosphere?

- Put more emphasis on pollution prevention;
- improve energy efficiency;
- reduce use of fossil fuels (especially coal & oil);
- increase use of renewable energy
- slow population growth;
- integrate air pollution prevention with other policies;
- regulate air quality for entire regions;
- tax the production of air pollution;
- transfer appropriate technologies to developing countries.