AIR POLLUTION

CHAPTER EIGHTEEN

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. Indoor Air Pollution
   types, radon
5. Effects of Air Pollution
   human health, plants, aquatic life, property
6. Preventing & Reducing Air Pollution
   laws, technology

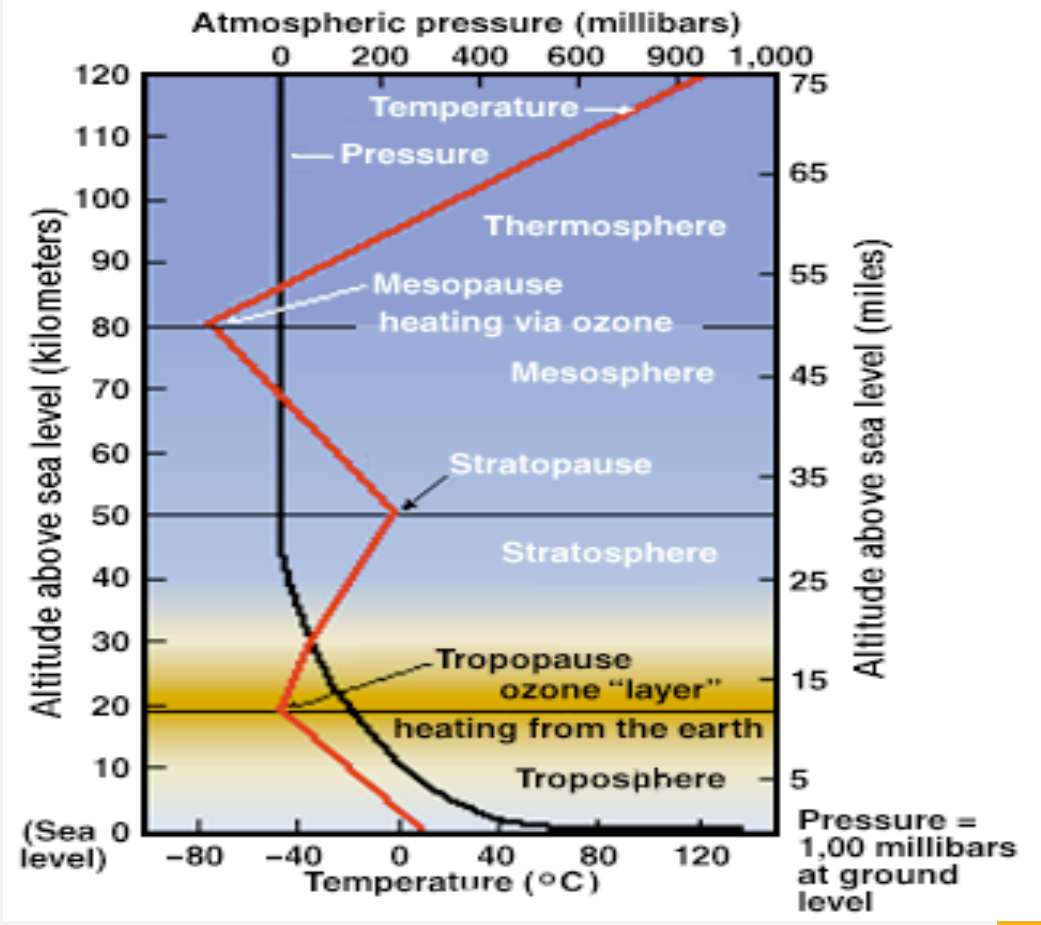
I. The Atmosphere

Troposphere:

- 75% of mass of Earth's air;
- Where greenhouse effect occurs: heat is trapped near Earth's surface;
- Also heated from beneath: solar radiation passes through the atmosphere and heats the Earth's surface

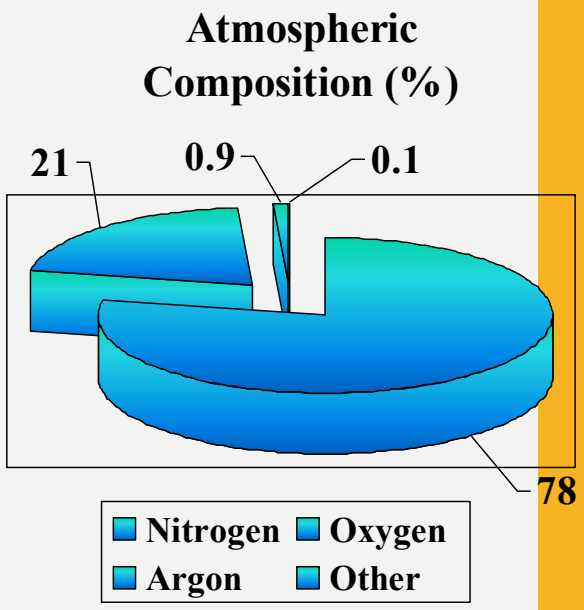
Stratosphere:

- Includes the ozone layer, which filters ultraviolet (UV) radiation



THE ATMOSPHERE

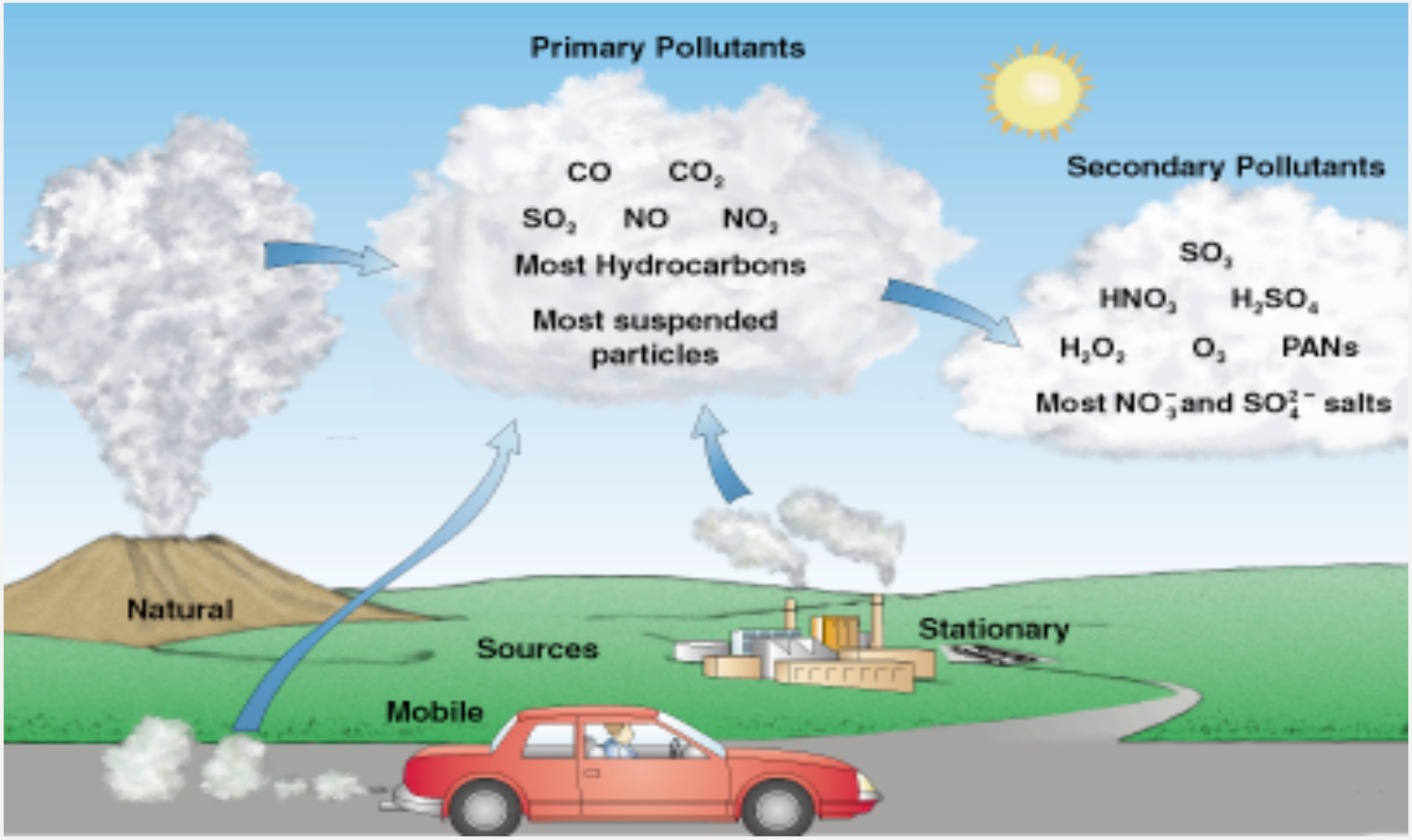
- The atmosphere is the thin layer of gases that surrounds the Earth
  - 78% nitrogen
  - 21% oxygen
  - 0.9% argon
  - 0.1% water vapor, carbon dioxide, neon, helium and other trace gases



- The Mesosphere extends from 50 km to about 80 km above the Earth
  - The coldest layer of the atmosphere, dropping as low as -90% C
- The Thermosphere extends from 80 km into outer space
  - The lower layer of the thermosphere is the ionosphere (80 km to 550 km) that can reflect radio waves back to Earth. It cannot reflect television waves, which have a shorter wavelength
  - The upper layer of the thermosphere is the exosphere, which extends for thousands of kilometers above the Earth, blending into the vacuum of interplanetary space

2. Urban Air Pollution

Pollutants include natural and human sources.
Primary pollutants can form secondary pollutants.



AIR POLLUTION

- Air pollution is the presence of one or more chemicals in the atmosphere in quantities and duration that cause harm to humans, other forms of life, and materials

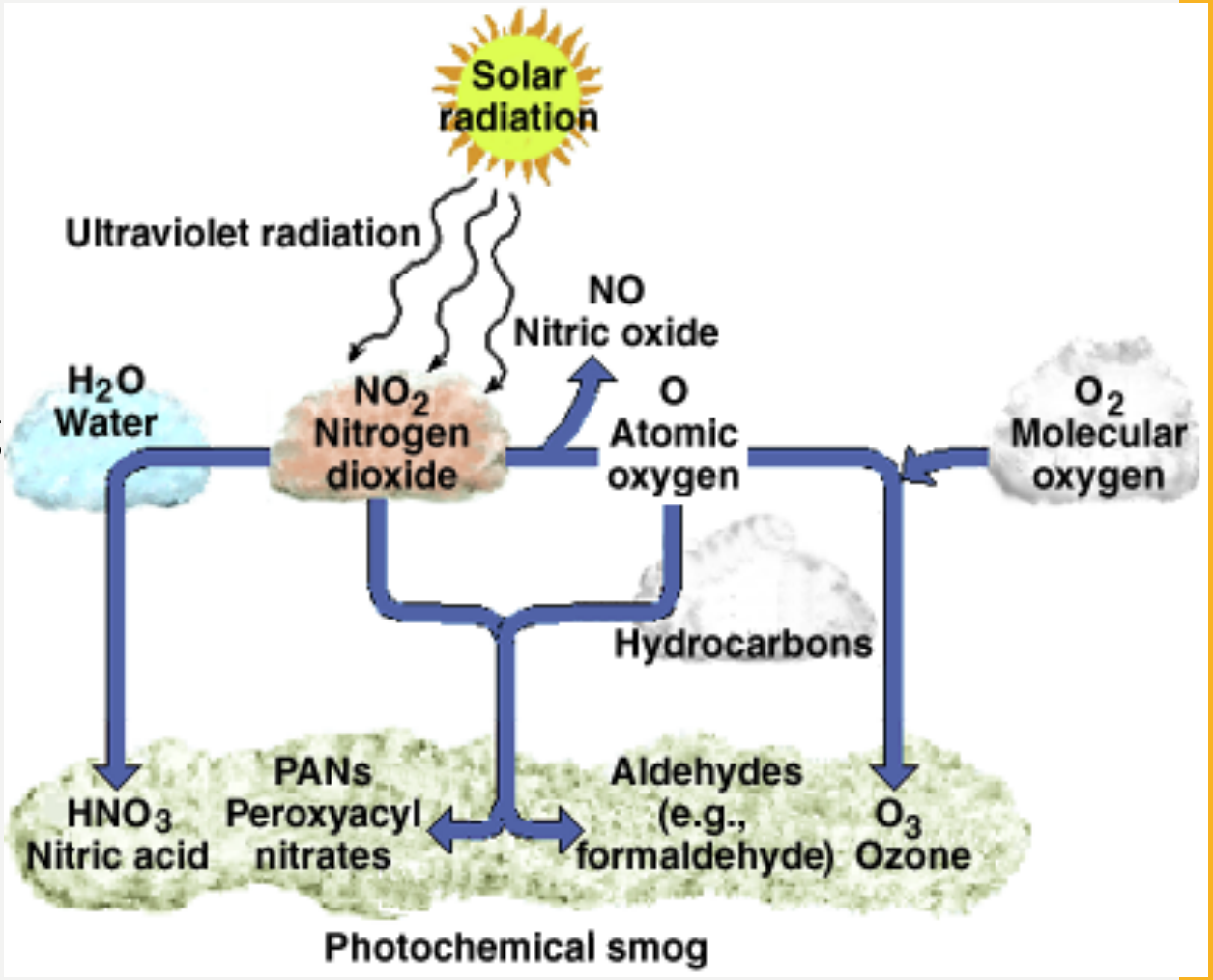
- Primary pollutants: Products of natural events and human activities are called
- Secondary pollutants: Some primary pollutants may react with one another or with the basic components of air to form new pollutants called

MAJOR AIR POLLUTANTS

Carbon oxides	CO, CO_2
Sulfur oxides	SO_2 , SO_3
Nitrogen oxides	NO, NO_2, N_2O
Volatile organic compounds (VOCs)	Methane, propane, chlorofluorocarbons
Suspended particulate matter	Particles (dust, lead, soot) + liquids (PCBs, dioxins, pesticides)
Radioactive Substances	(radon-222, plutonium-239)
Photochemical oxidant	Ozone (O_3), PANs, etc.
Hazardous air pollutants	Formaldehyde, etc.
Toxic Compounds	(mostly carcinogens)

Photochemical Smog

Photochemical smog: secondary pollutants (HNO_3 PANs, O_3) are formed in complex reactions involving input of energy from sun.



Industrial Smog

Industrial Smog: mostly sulfur dioxide, sulfuric acid suspended in droplets, and a variety of particulates (soot).

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

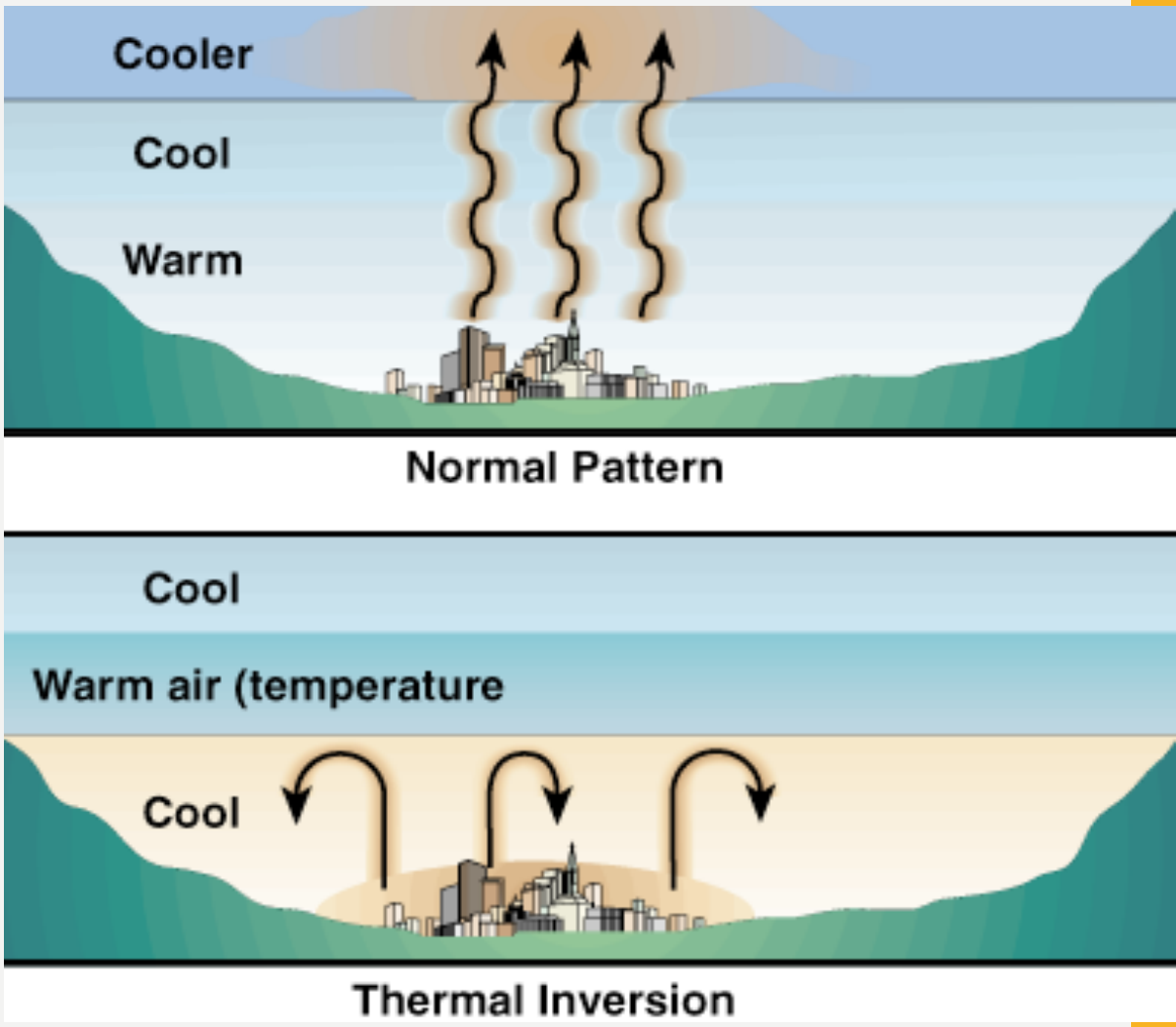
  $S + O_2 \rightarrow SO_2$

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

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

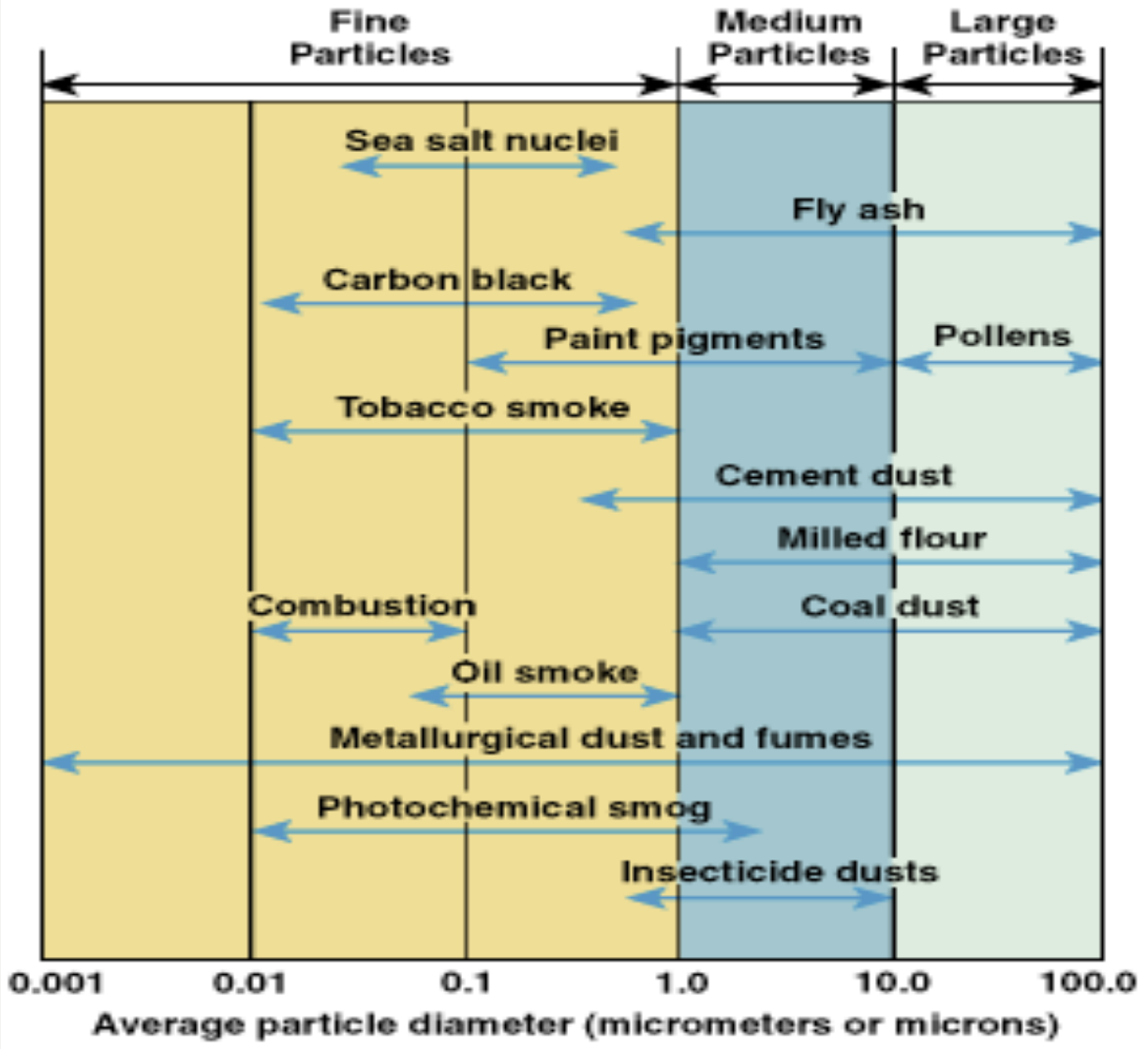
Thermal Inversions

Thermal inversions:
Cool air trapped beneath warm air. Leads to accumulation of dangerous levels of air pollution (photochemical smog, industrial smog) near the ground.



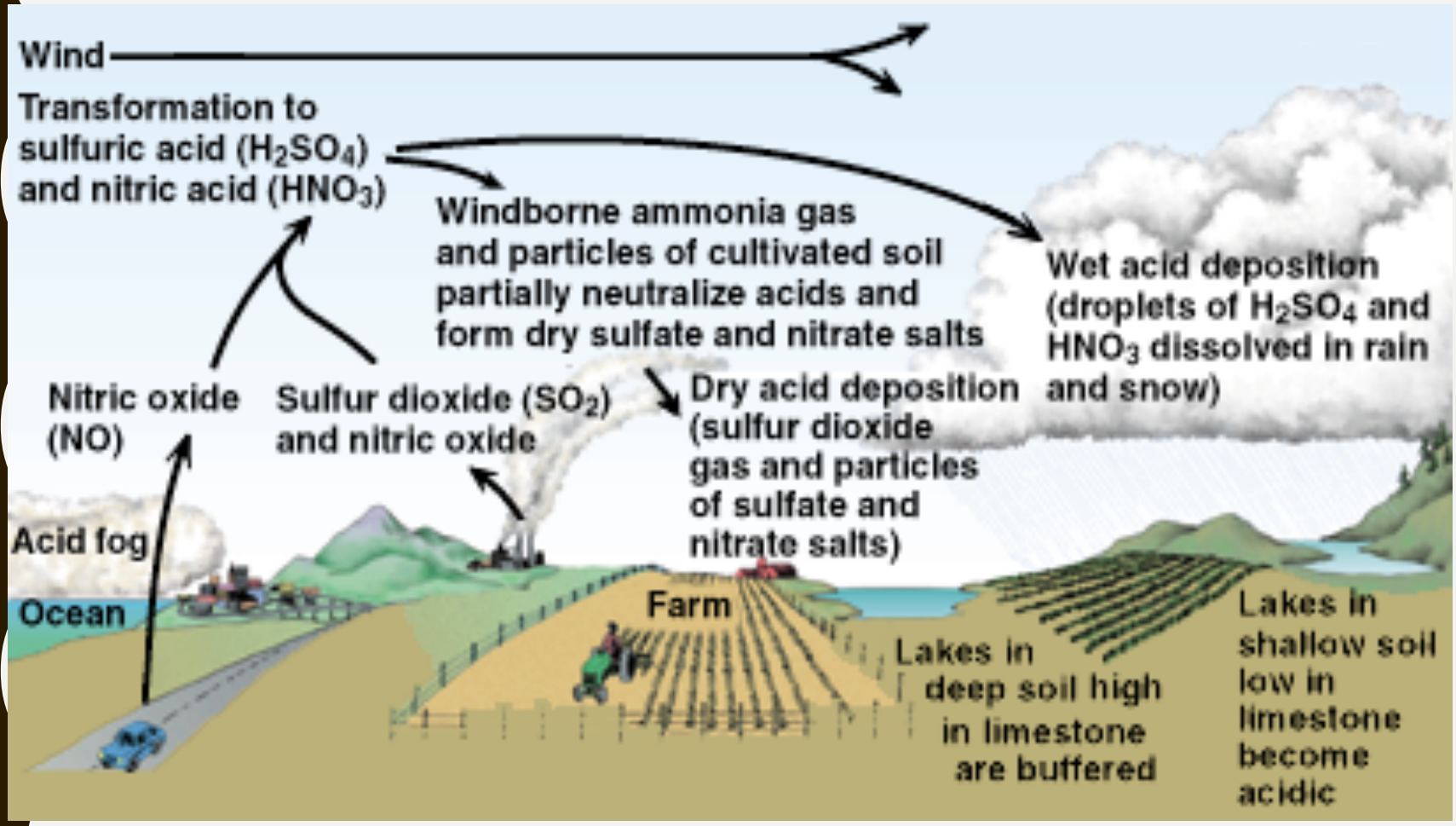
Air Pollution

Suspended particulate matter: particles of solid matter and droplets of liquid released into the atmosphere by burning fossil fuels and other human activities.



3.Acid Deposition

Acid deposition: Secondary pollutants (acids) transported by winds descend to the Earth



ACID DEPOSITION

- Acid Deposition is the mixture of acidic rain, snow, fog, cloud vapor, and particles that reach the earth's surface.

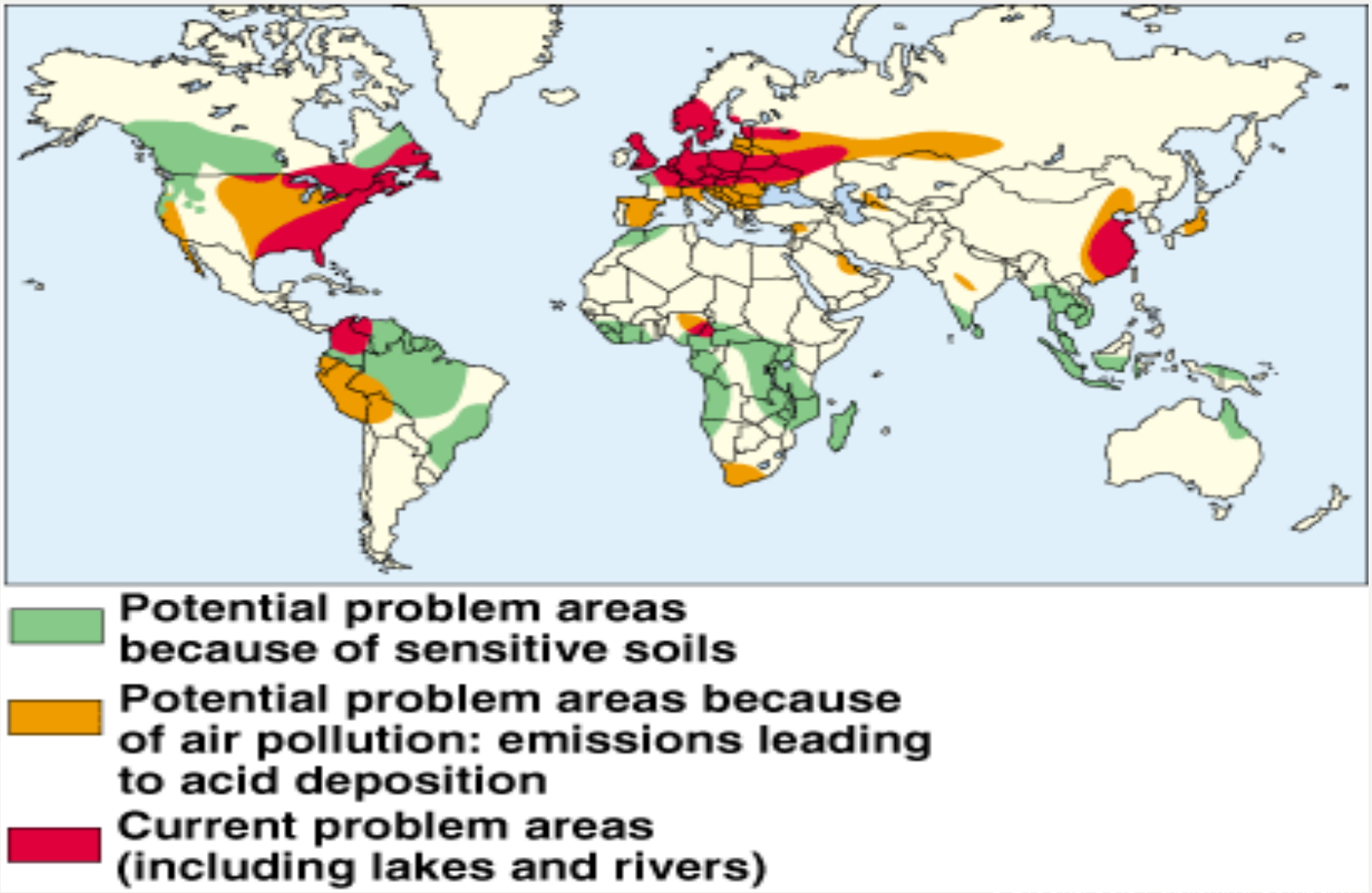
Effects of acid deposition include

- Direct damage to plant foliage, bark and roots
- Soil acidification and death of microorganisms
- Lake acidification and stress of aquatic life

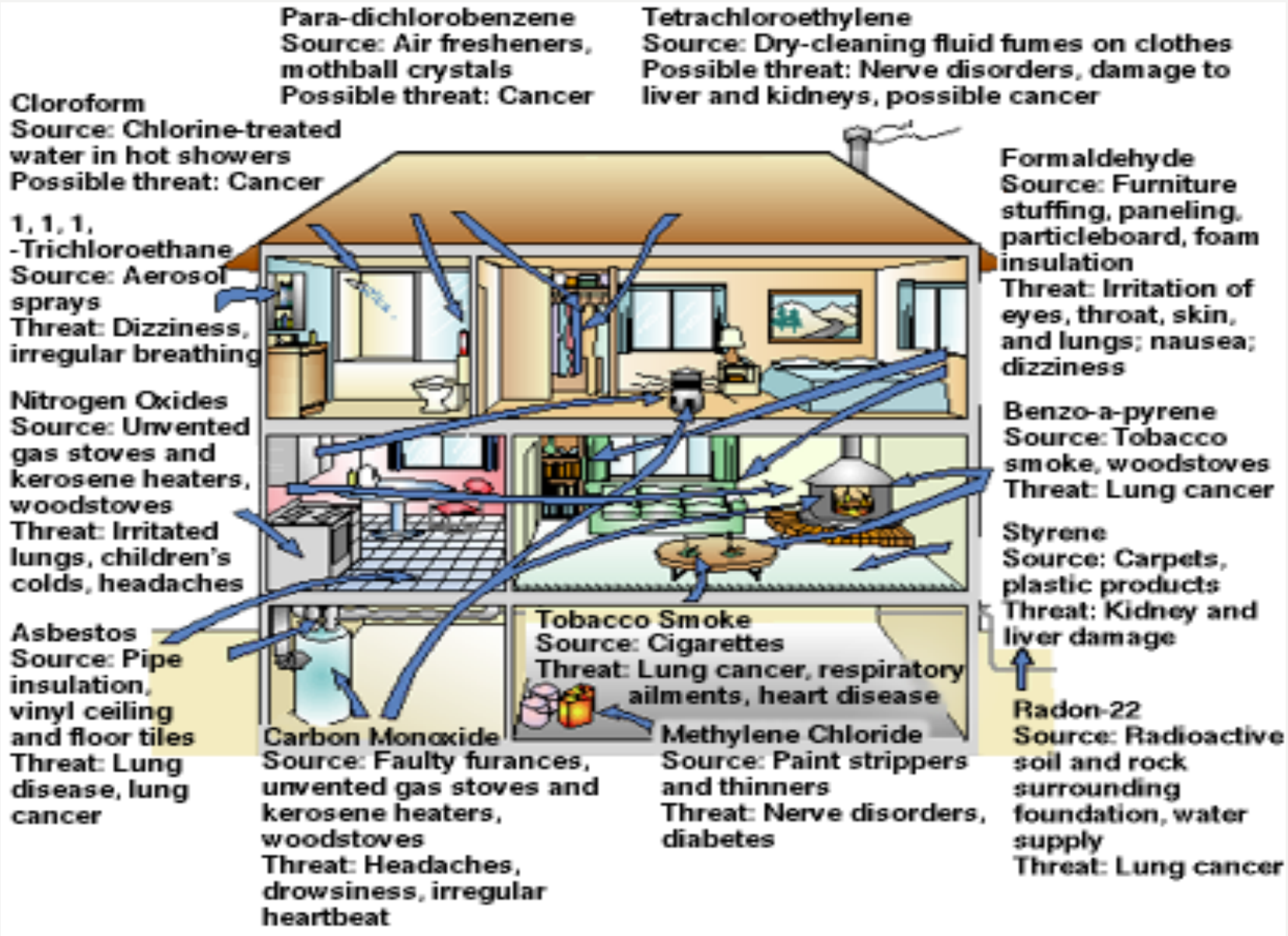
Sulfur dioxide dissolves in water vapor to form acidic solutions

Acid Deposition

A widespread problem, especially in areas downwind from major industrial sites.



4. Indoor Air Pollution



INDOOR AIR POLLUTION

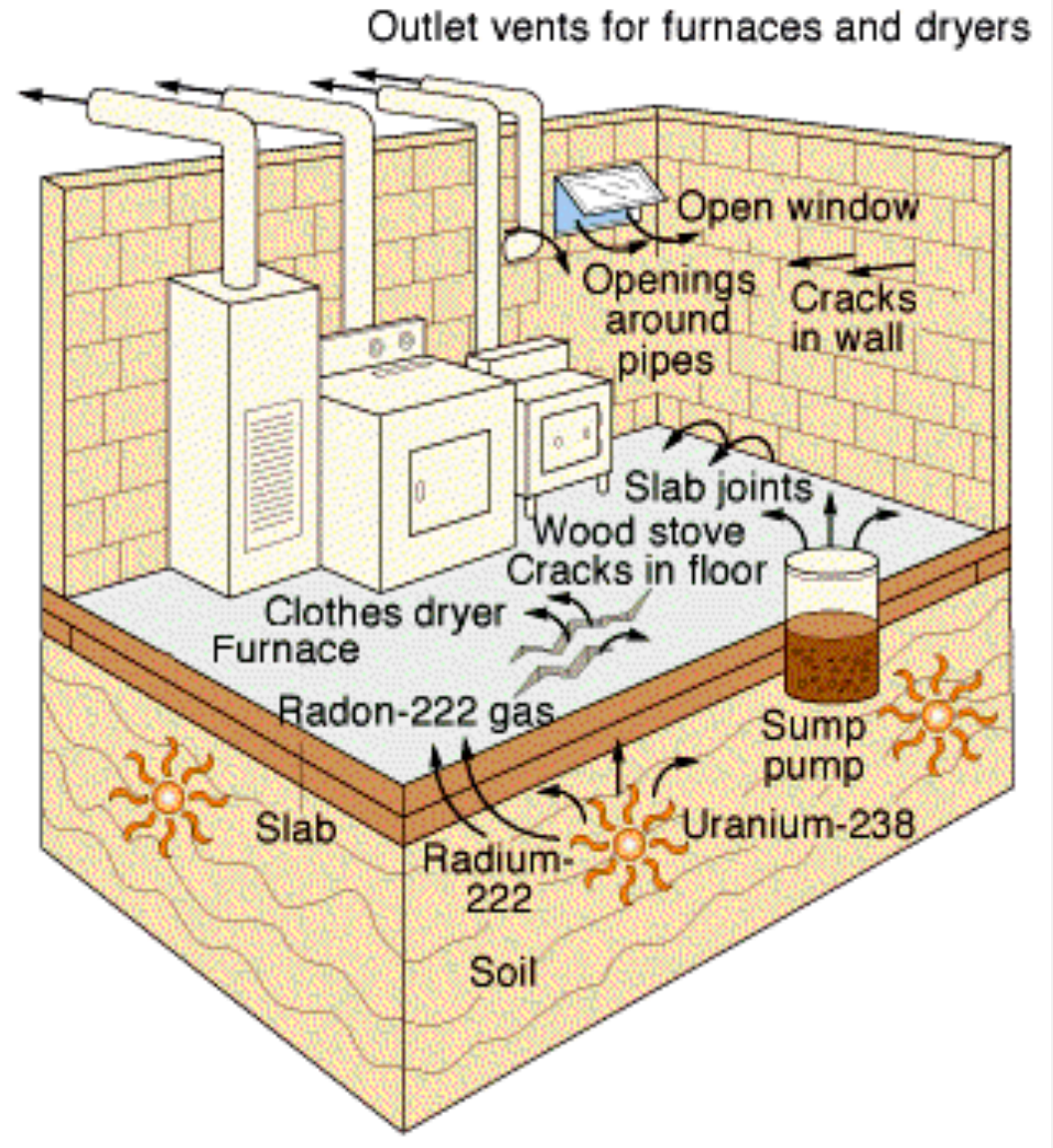
•Indoor air pollution can be an even greater health threat than outdoor air pollution.

•Air pollution is not limited to the outdoors. Buildings with particularly poor air quality are said to have sick-building syndrome.

•Causes of sick-building syndrome may include the presence of tobacco smoke, formaldehyde, gasoline, radon gas, asbestos, carbon monoxide, and some species of fungi and bacteria.

Indoor Air Pollution

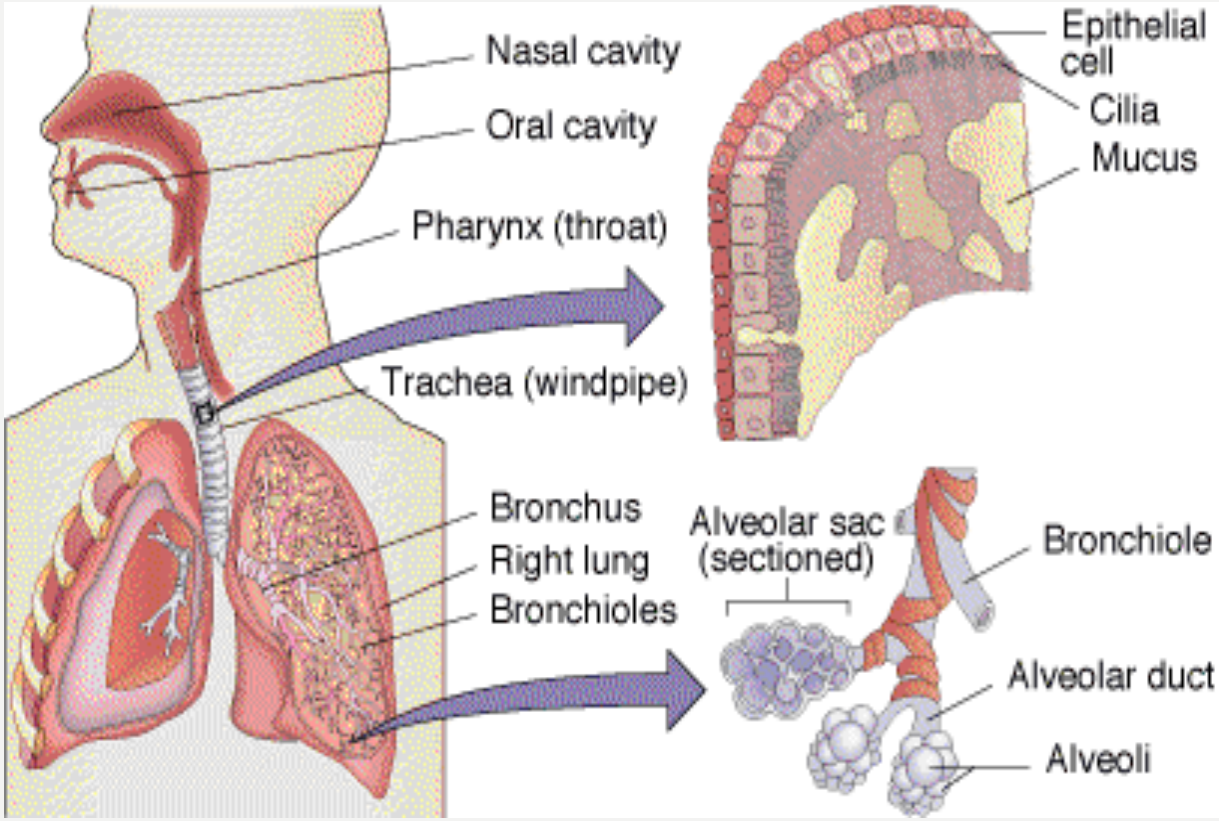
Radon–222: A colorless, odorless, naturally occurring gas that is a breakdown product of uranium–238 found in small amounts in most soil. Radon gas causes lung cancer & other health problems. Ventilation & proper building can prevent accumulation of this dangerous gas.



5. Effects of Air Pollution

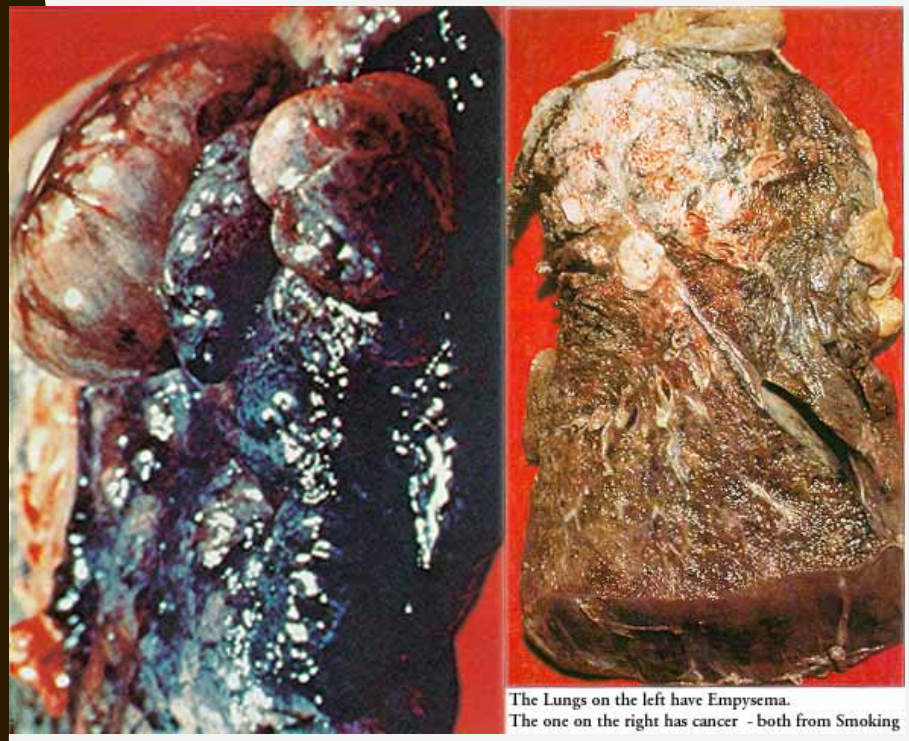
Air pollution damages the health of humans and other living organisms, and also damages property.

Causes respiratory diseases in humans: lung cancer, asthma, chronic bronchitis, and emphysema



HUMAN HEALTH

Exposure to air pollutants, particularly cigarette smoke may lead to several human health issues



The Lungs on the left have Empysema.
The one on the right has cancer - both from Smoking

- Lung cancer
- Asthma – muscle spasms in the bronchial walls
- Chronic bronchitis – inflammation of cells lining the bronchi and bronchioles
- Emphysema – damage to air sacs in lungs

Health Effects of Air Pollution

- **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 and asthma;
- **Sulfur dioxide (SO_2)**: causes constriction of airways and can cause bronchitis;
- **Nitrogen oxides (especially NO_2)**: irritate lungs, cause conditions similar to bronchitis and emphysema;
- **Volatile organics** (& toxic particulates): cause mutations, reproductive problems, and cancer;
- **Ozone**: causes coughing, chest pain, shortness of breath, & eye, nose, and throat irritation.

More Effects of Air Pollution

Aquatic Life:

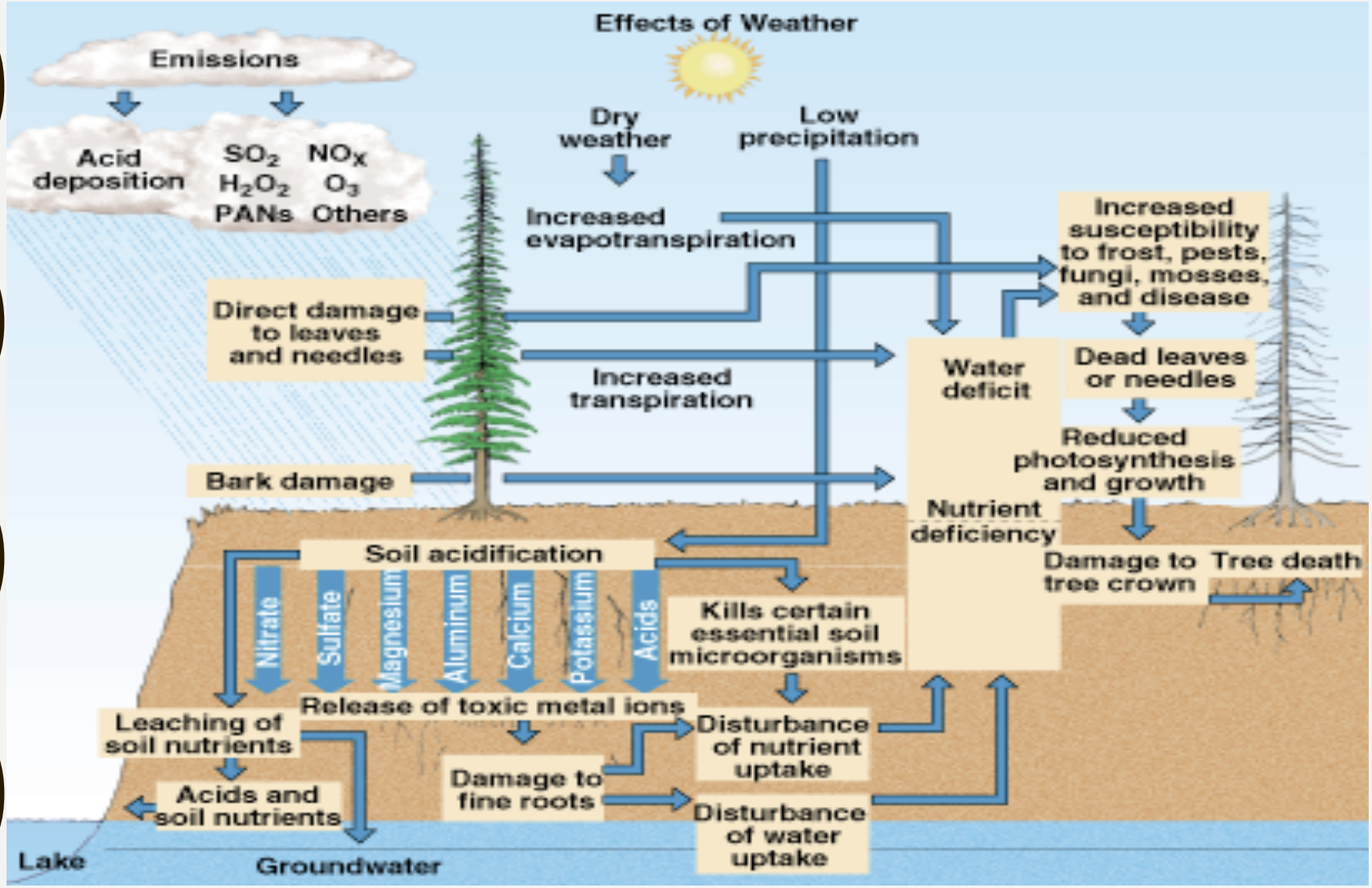
- high acidity (low pH) can leach harmful minerals such as aluminum into the environment, kill fish and other organisms, inhibit reproduction, disrupt food chains, & decrease productivity;

Property:

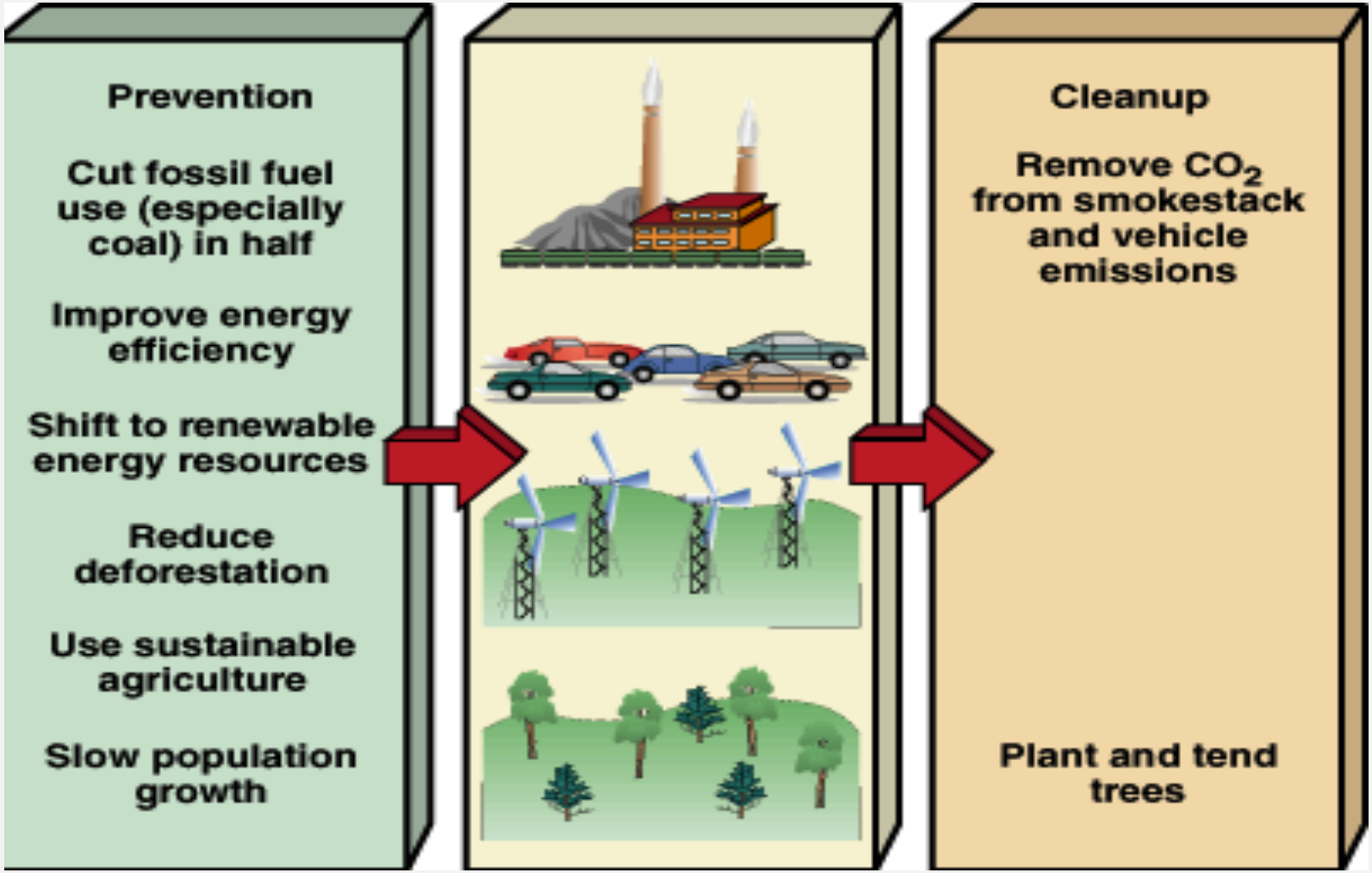
- air pollutants cause billions of dollars of damage to various materials (buildings estimated at $5 billion annually);
- breaks down paints on cars and buildings, deteriorates roofing, etches stained glass windows, dissolves and discolors marble (see Table 10–3).

Effects of Air Pollution

Effects of prolonged exposure to atmospheric pollutants on trees and soils.



6. Preventing & Reducing Air Pollution



CARS, GAS, AND AIR

- More than half of the ozone-forming pollutants come from mobile sources (i.e., cars and trucks)
- Other sources include:
  - Lawn mowers
  - House paint
  - Charcoal lighter fluid

- Monthly commuting costs

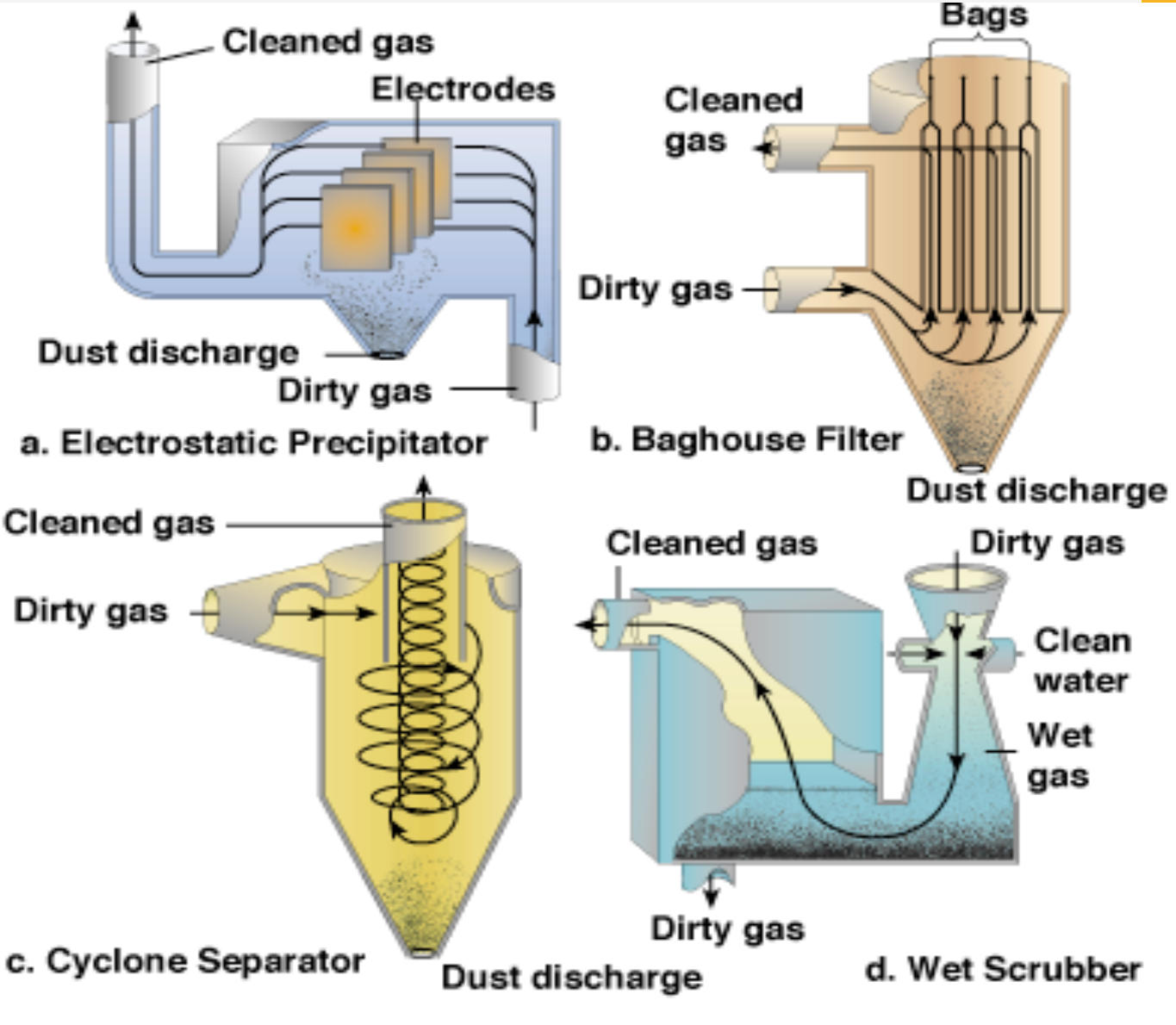
Car (single occupant)	$141
Sport Utility Vehicle	$153
Carpool (2 persons)	$ 71
Vanpool (15 seater)	$ 9

Pollution from Vehicles (per year):

	Passenger Cars	SUVs
CO_2	15,200 lbs.	21,200
CO	420 lbs.	547
HC	55 lbs.	74
NO	50 lbs.	-
Particulates	2.7 lbs.	3.3

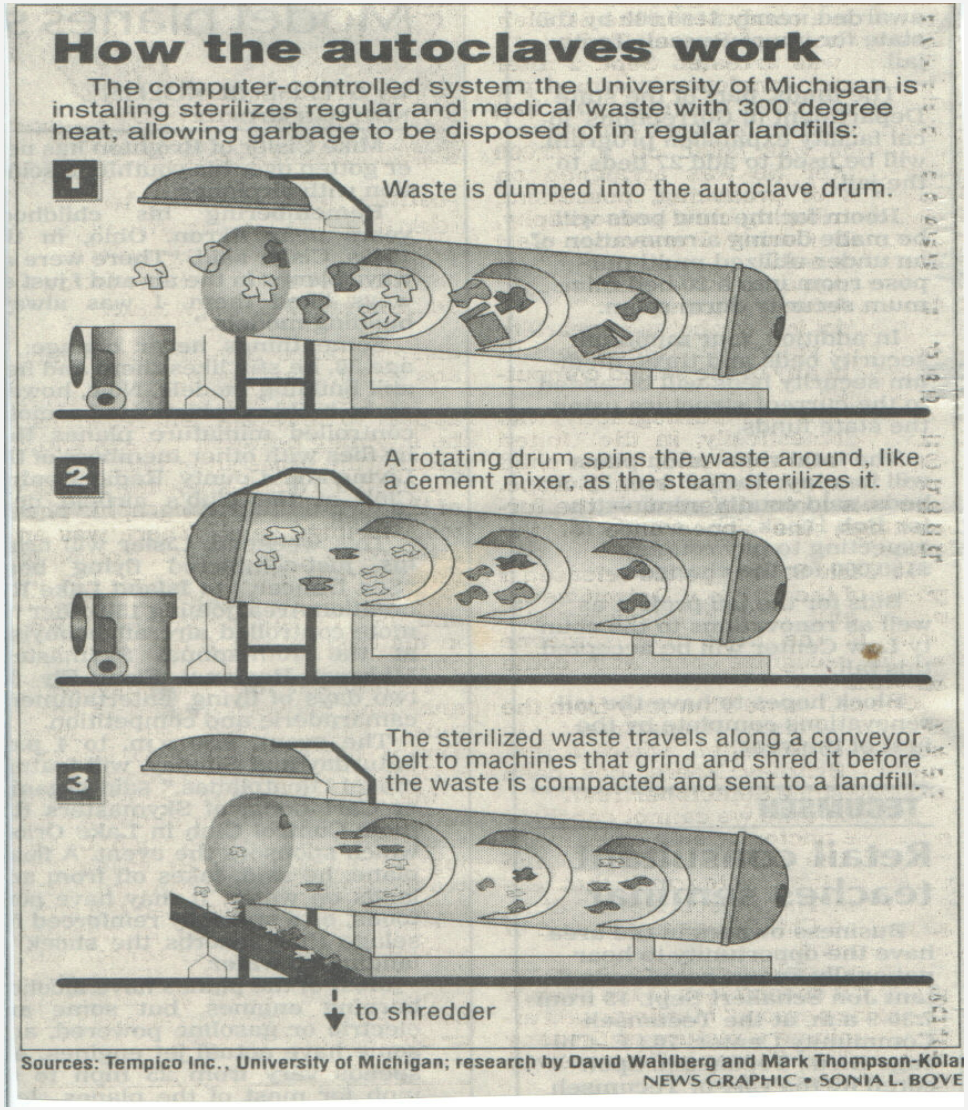
Technologies for Preventing & Reducing Air Pollution

Technologies to remove particulates from the exhaust of electric power and industrial plants. All **produce hazardous waste** that must be disposed of.



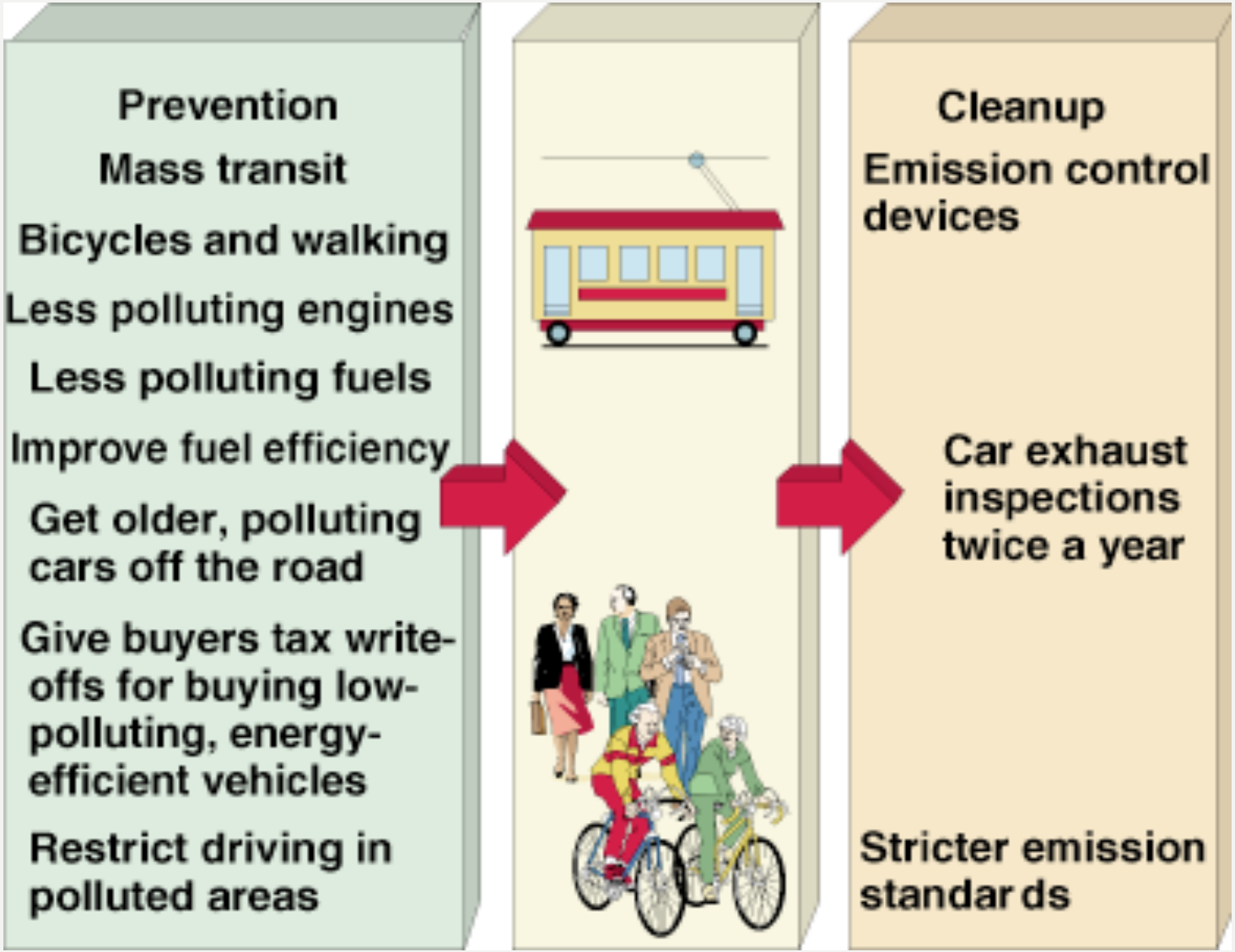
AUTOCLAVES VS. INCINERATION

- Waste heated by steam to sterilize
- Sterilized waste ground and shredded
- Compacted waste sent to a landfill



Preventing & Reducing Air Pollution

Methods for reducing emissions from motor vehicles.



Preventing & Reducing Air Pollution

- Emphasize pollution prevention
- Improve energy efficiency
- Reduce use of fossil fuels (especially coal and oil)
- Increase use of renewable energy
- Slow population growth
- Regulate air quality for entire regions
- Tax the production of air pollution
- Transfer appropriate technologies to developing countries

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.

CLEAN AIR ACTS – DEFICIENCIES

- Continued reliance on pollution cleanup rather than prevention
- Failure to sharply increase fuel efficiency standards for cars and light trucks
- No requirement for stricter emission standards for fine particulates
- Giving municipal trash incinerators 30-year permits
- Weak standards for incinerators
- Weak standards for emissions of CO_2 and other greenhouse gases