

Chapter 20

Air Pollution

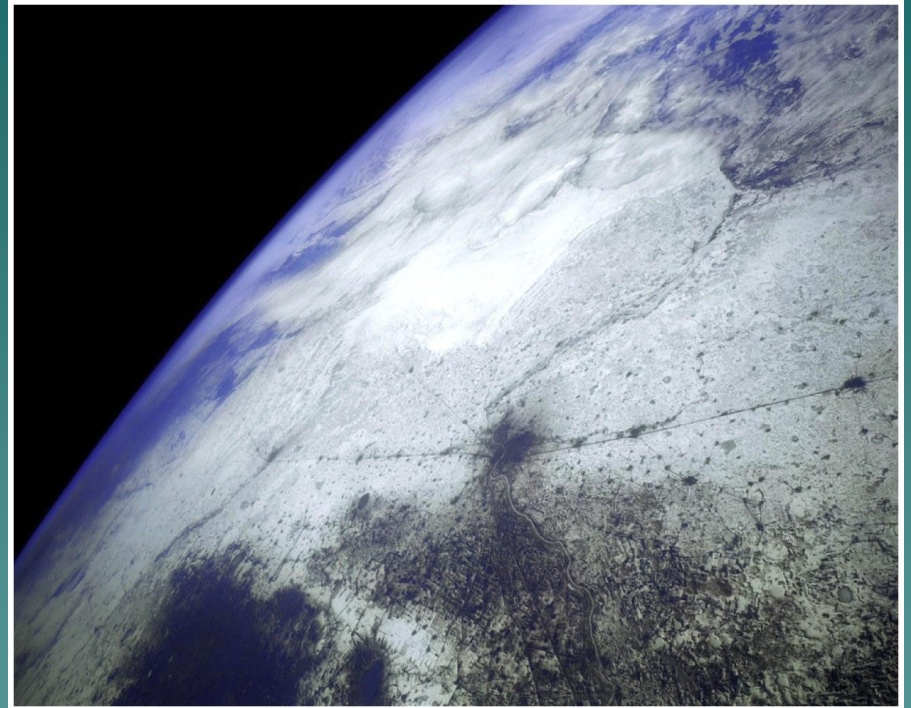


Overview of Chapter 20

- Atmosphere as a Resource
- Types and Sources of Air Pollution
 - Major Classes of Air Pollutants
 - Sources of Outdoor Air Pollutants
 - Urban Air Pollution
- Effects of Air Pollution
- Controlling Air Pollution in the US

Atmosphere as a Resource

- Atmospheric Composition
 - Nitrogen 78.08%
 - Oxygen 20.95%
 - Argon 0.93%
 - Carbon dioxide 0.04%
- Ecosystem services
 - Blocks UV radiation
 - Moderates the climate
 - Redistributes water in the hydrologic cycle



Types and Sources of Air Pollution

o Air Pollution

- Chemicals added to the atmosphere by natural events or human activities in high enough concentrations to be harmful

o Two categories

• Primary Air Pollutant

- Harmful substance that is emitted directly into the atmosphere

• Secondary Air Pollutant

- Harmful substance formed in the atmosphere when a primary air pollutant reacts with substances normally found in the atmosphere or with other air pollutants

Major Air Pollutants

Table 20.1 Major Air Pollutants

<i>Pollutant</i>	<i>Composition</i>	<i>Primary or Secondary</i>	<i>Characteristics</i>
Particulate matter			
Dust	Variable	Primary	Solid particles
Lead	Pb	Primary	Solid particles
Sulfuric acid	H ₂ SO ₄	Secondary	Liquid droplets
Nitrogen oxides			
Nitrogen dioxide	NO ₂	Primary	Reddish-brown gas
Sulfur oxides			
Sulfur dioxide	SO ₂	Primary	Colorless gas with strong odor
Carbon oxides			
Carbon monoxide	CO	Primary	Colorless, odorless gas
Carbon dioxide*	CO ₂	Primary	Colorless, odorless gas
Hydrocarbons			
Methane	CH ₄	Primary	Colorless, odorless gas
Benzene	C ₆ H ₆	Primary	Liquid with sweet smell
Ozone	O ₃	Secondary	Pale blue gas with acrid odor
Air toxics			
Chlorine	Cl ₂	Primary	Yellow-green gas

* Discussed in Chapter 21.

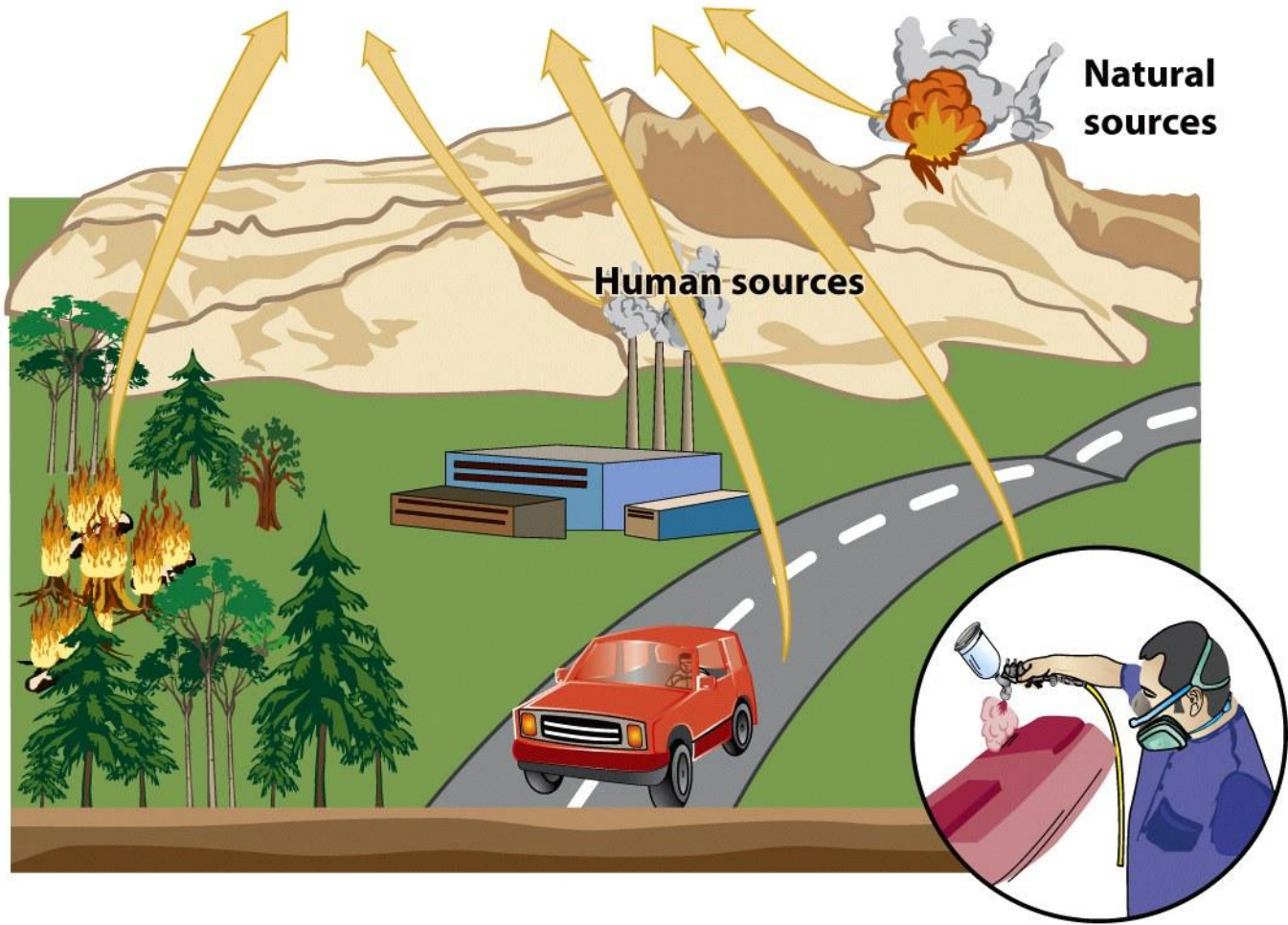
Source: Environmental Protection Agency.

Primary air pollutants


CO
SO₂ NO CO₂
NO₂
Most hydrocarbons
Most particulates

Secondary air pollutants

HNO₂ SO₃
HNO₃ H₂SO₄
H₂O₂ O₃ PANs
Most NO₃⁻ and SO₄²⁻
salts



Major Classes of Air Pollutants

- Particulate Material
 - Nitrogen Oxides
 - Sulfur Oxides
 - Carbon Oxides
 - Hydrocarbons
 - Ozone
- 

Particulate Material


- Thousands of different solid or liquid particles suspended in air
 - Includes: soil particles, soot, lead, asbestos, sea salt, and sulfuric acid droplets
- Dangerous for 2 reasons
 - May contain materials with toxic or carcinogenic effects
 - Extremely small particles can become lodged in lungs

Nitrogen and Sulfur Oxides

o Nitrogen Oxides

- Gases produced by the chemical interactions between atmospheric nitrogen and oxygen at high temperature
- Problems
 - Greenhouse gases
 - Cause difficulty breathing

o Sulfur Oxides

- Gases produced by the chemical interactions between sulfur and oxygen
 - Causes acid precipitation
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Carbon Oxides and Hydrocarbons

o Carbon Oxides

- Gases carbon monoxide (CO) and carbon dioxide (CO₂)
- Greenhouse gases

o Hydrocarbons

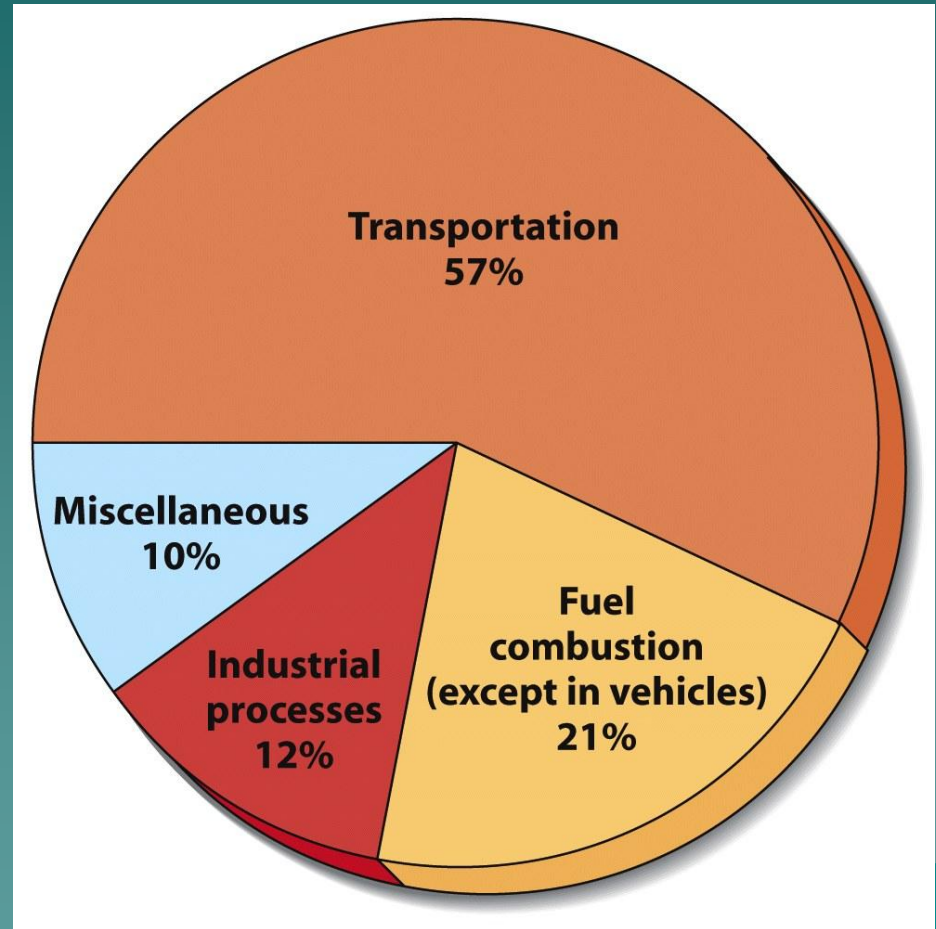
- Diverse group of organic compounds that contain only hydrogen and carbon (ex: CH₄-methane)
- Some are related to photochemical smog and greenhouse gases

Ozone

- Tropospheric Ozone
 - Man-made pollutant in the lower atmosphere
 - Secondary air pollutant
 - Component of photochemical smog
- Stratospheric Ozone
 - Essential component that screens out UV radiation in the upper atmosphere
 - Man-made pollutants (ex: CFCs) can destroy it

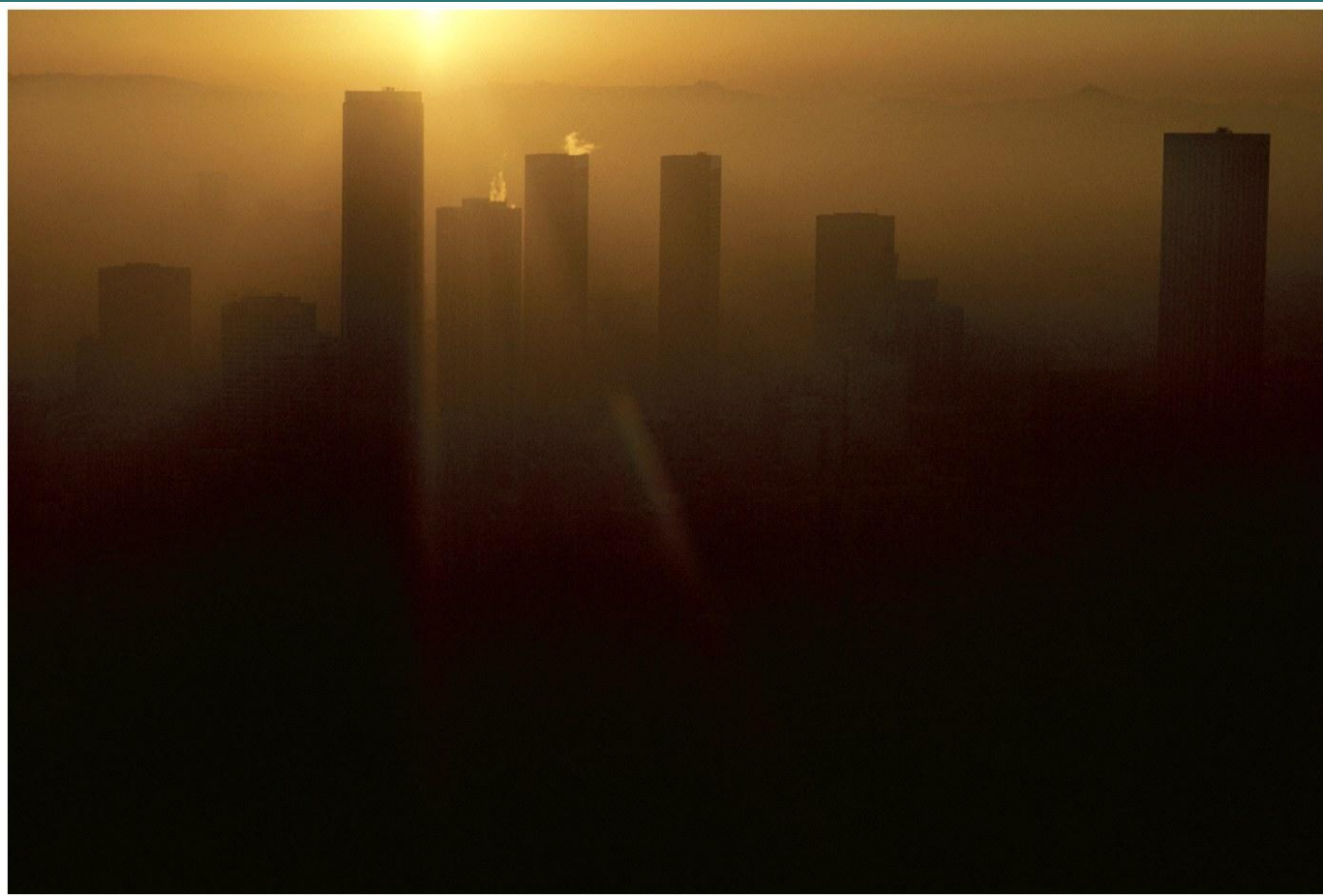
Sources of Outdoor Air Pollution

- Two main sources
 - Transportation
 - Industry
- Intentional forest fires is also high

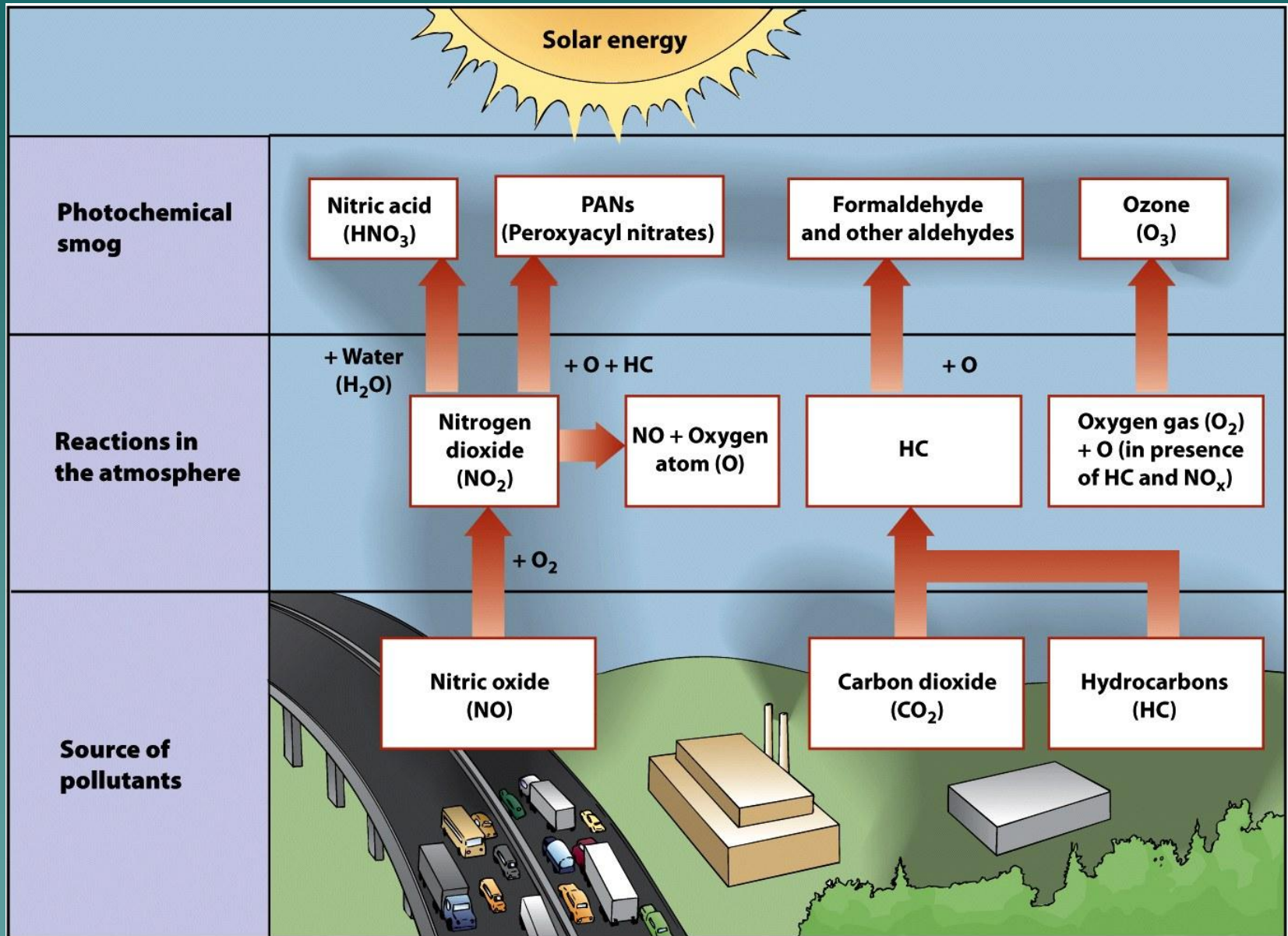


Urban Air Pollution

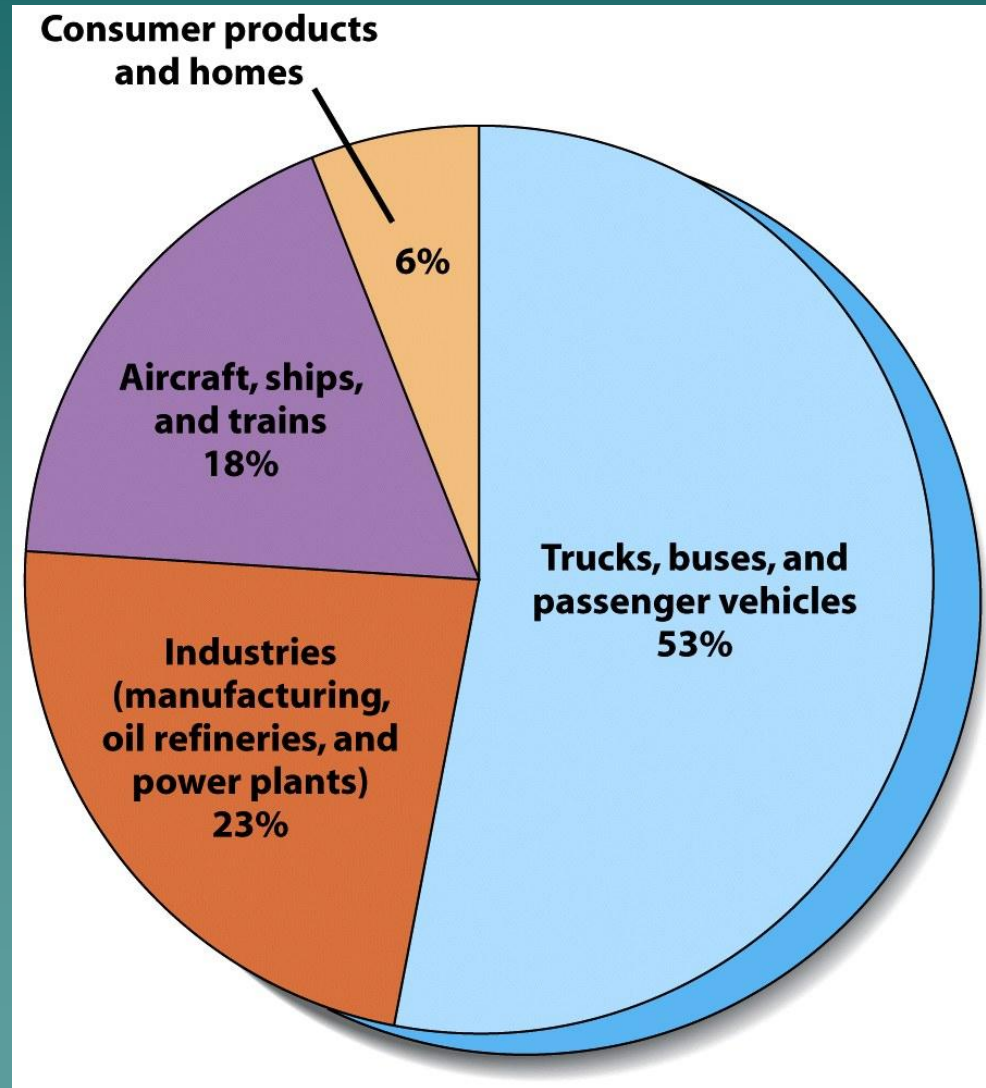
- Photochemical Smog (ex: Los Angeles below)
 - Brownish-orange haze formed by chemical reactions involving sunlight, nitrogen oxide, and hydrocarbons



Formation of Photochemical Smog



Sources of Smog in Los Angeles



Case-In-Point Air Pollution in Beijing and Mexico City



- Beijing (left)
- Mexico City (above)

Effects of Air Pollution

- o Low level exposure
 - Irritates eyes
 - Causes inflammation of respiratory tract
- o Can develop into chronic respiratory diseases

Table 20.2 Health Effects of Several Major Air Pollutants

<i>Pollutant</i>	<i>Source</i>	<i>Effects</i>
Particulate	Industries, electric power plants, motor vehicles, construction, agriculture	Aggravates respiratory illnesses; long-term exposure may cause increased incidence of chronic conditions such as bronchitis; linked to heart disease; suppresses immune system; some particles, such as heavy metals and organic chemicals, may cause cancer or other tissue damage
Nitrogen oxides	Motor vehicles, industries, heavily fertilized farmland	Irritate respiratory tract; aggravate respiratory conditions such as asthma and chronic bronchitis
Sulfur oxides	Electric power plants and other industries	Irritate respiratory tract; same effects as particulates
Carbon monoxide	Motor vehicles, industries, fireplaces	Reduces blood's ability to transport oxygen; headache and fatigue at lower levels; mental impairment or death at high levels
Ozone	Formed in atmosphere (secondary air pollutant)	Irritates eyes; irritates respiratory tract; produces chest discomfort; aggravates respiratory conditions such as asthma and chronic bronchitis

Health Effects of Air Pollution

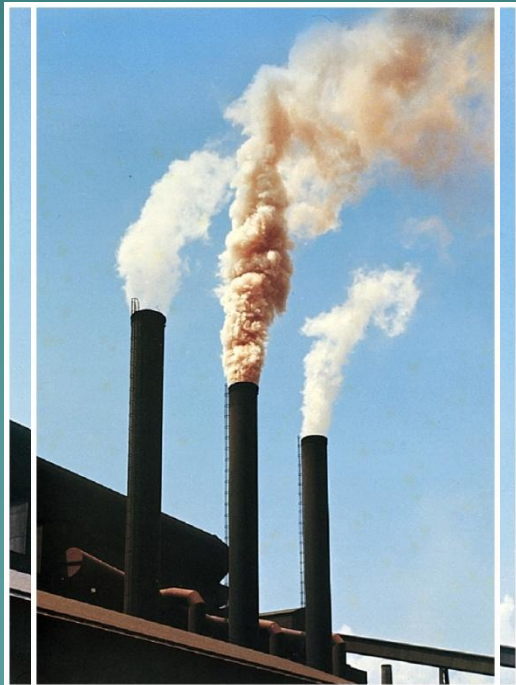
- Sulfur Dioxide and Particulate material
 - Irritate respiratory tract and impair ability of lungs to exchange gases
- Nitrogen Dioxides
 - Causes airway restriction
- Carbon monoxide
 - Binds with iron in blood hemoglobin
 - Causes headache, fatigue, drowsiness, death
- Ozone
 - Causes burning eyes, coughing, and chest discomfort

Children and Air Pollution

- Greater health threat to children than adults
 - Air pollution can restrict lung development
 - Children breath more often than adults
- Children who live in high ozone areas are more likely to develop asthma

Controlling Air Pollution in US

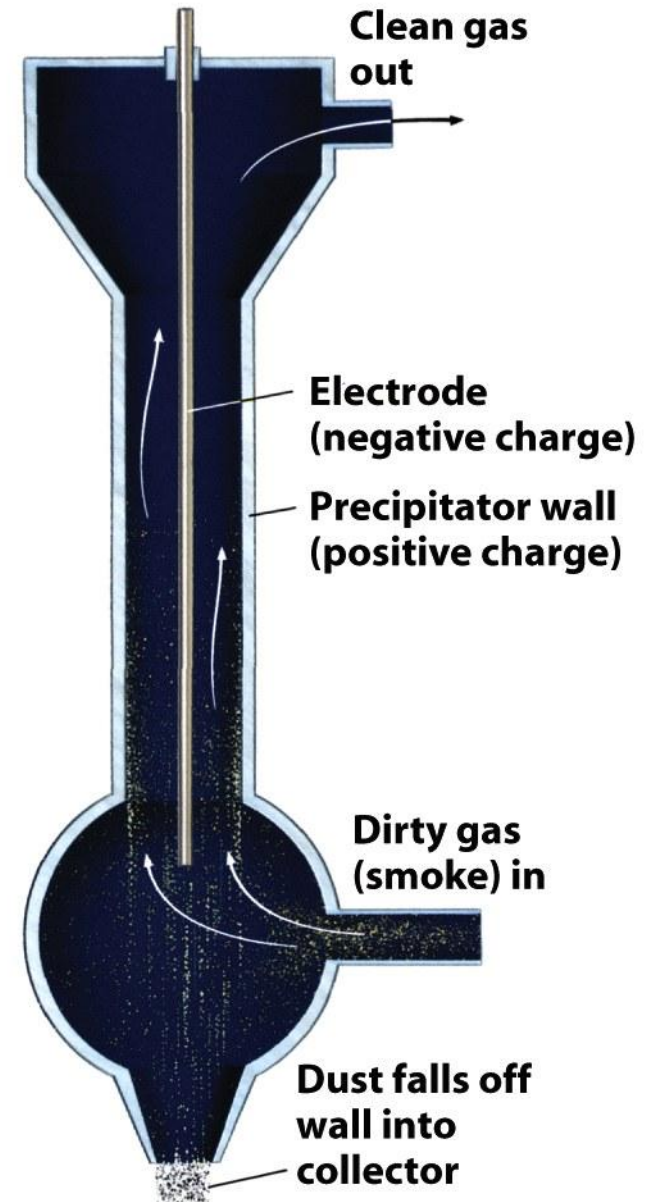
- o Smokestacks with electrostatic precipitator (right)



Without Electrostatic precipitator

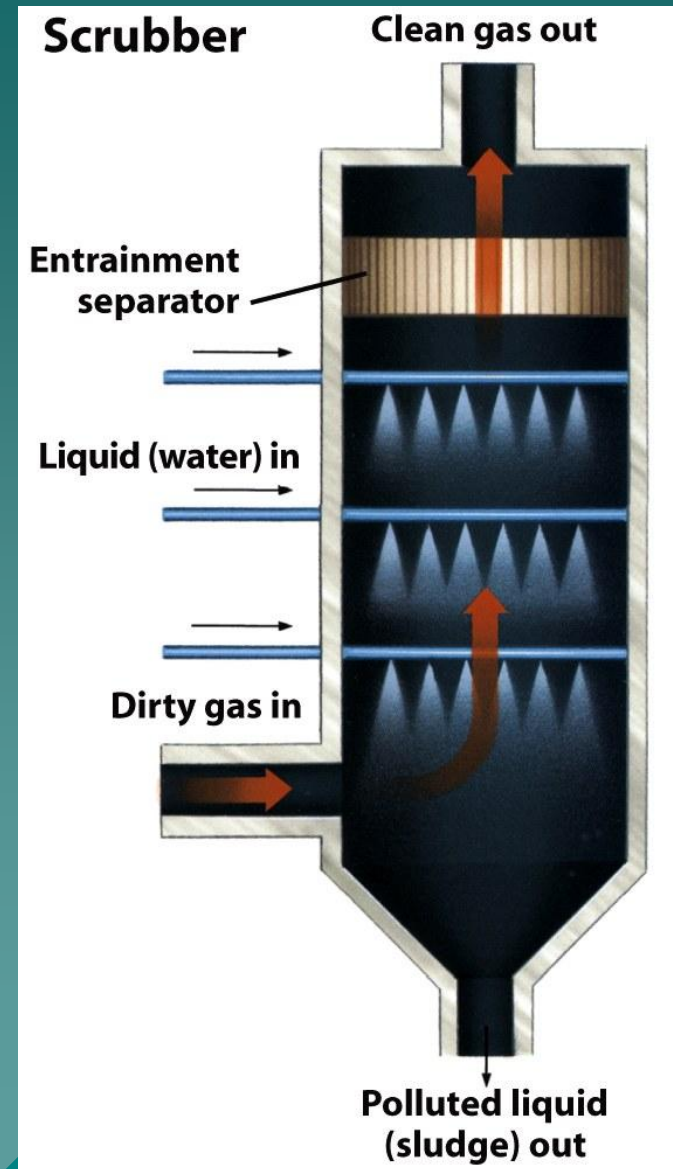
With Electrostatic precipitator

Electrostatic precipitator



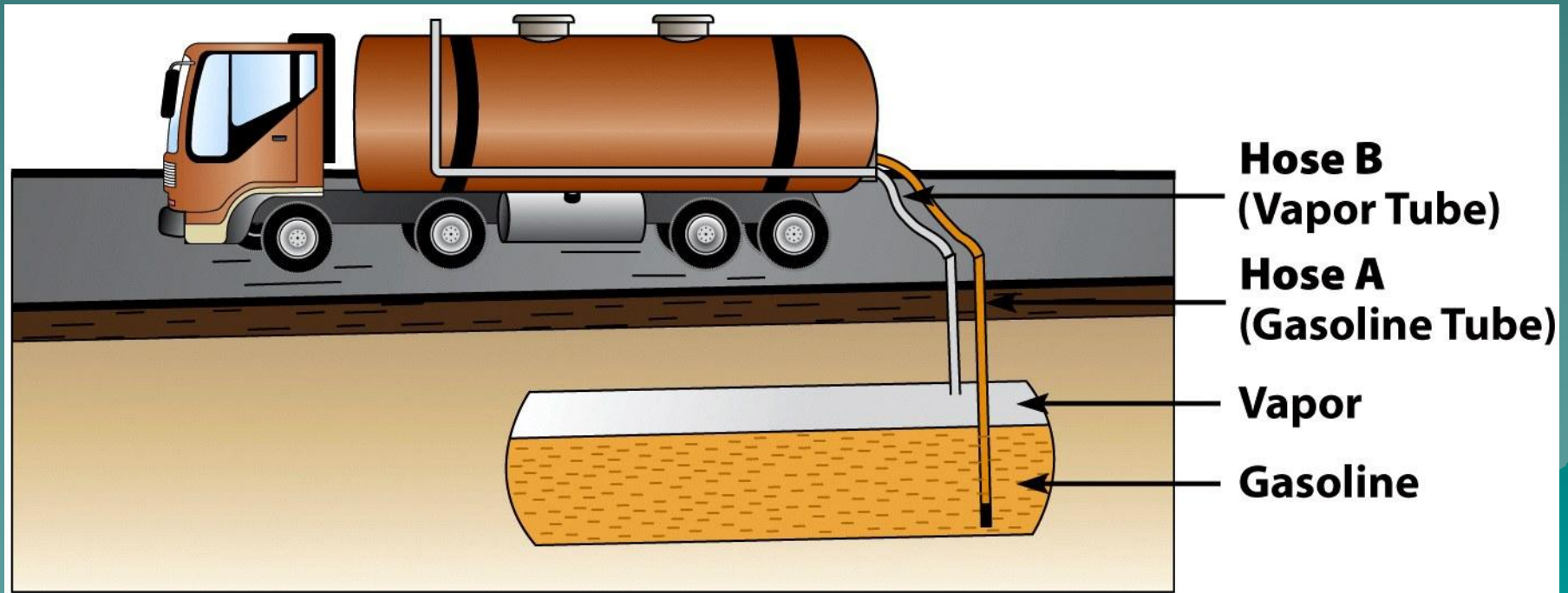
Controlling Air Pollution in the US

- o Smokestacks with scrubbers (right)
- o Particulate material can also be controlled by proper excavating techniques



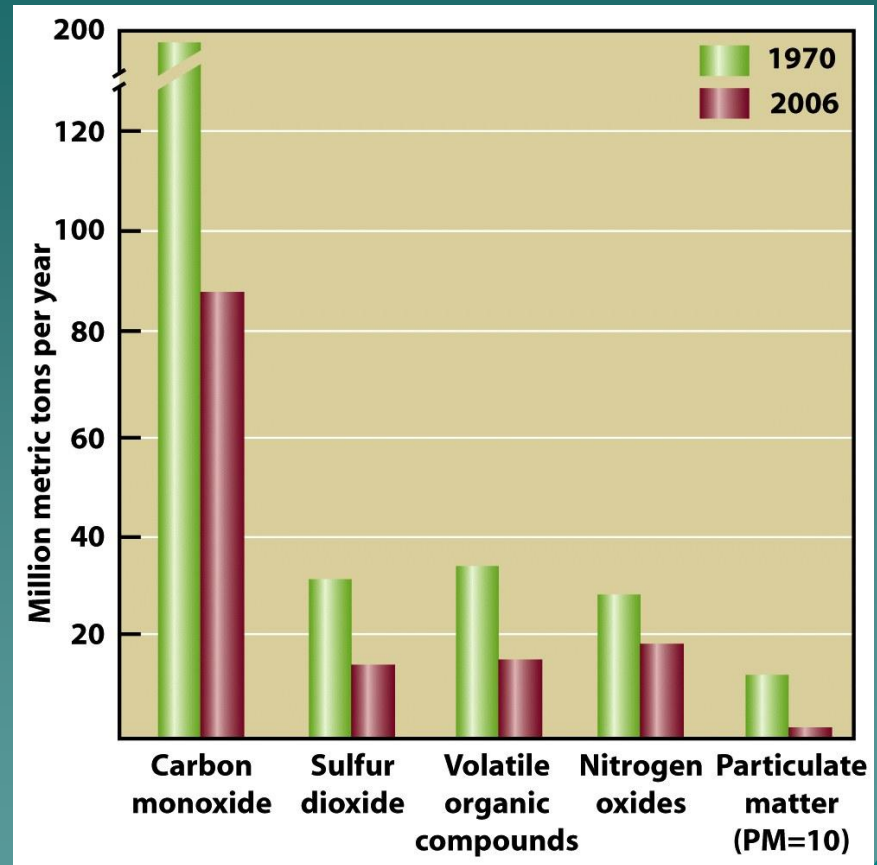
Controlling Air Pollution in the US

- o Phase I Vapor Recovery System for gasoline



The Clean Air Act

- o Authorizes EPA to set limits on amount of specific air pollutants permitted
- o Focuses on 6 pollutants:
 - lead, particulate matter, sulfur dioxide, carbon monoxide, nitrogen oxides, and ozone
- o Act has led to decreases!

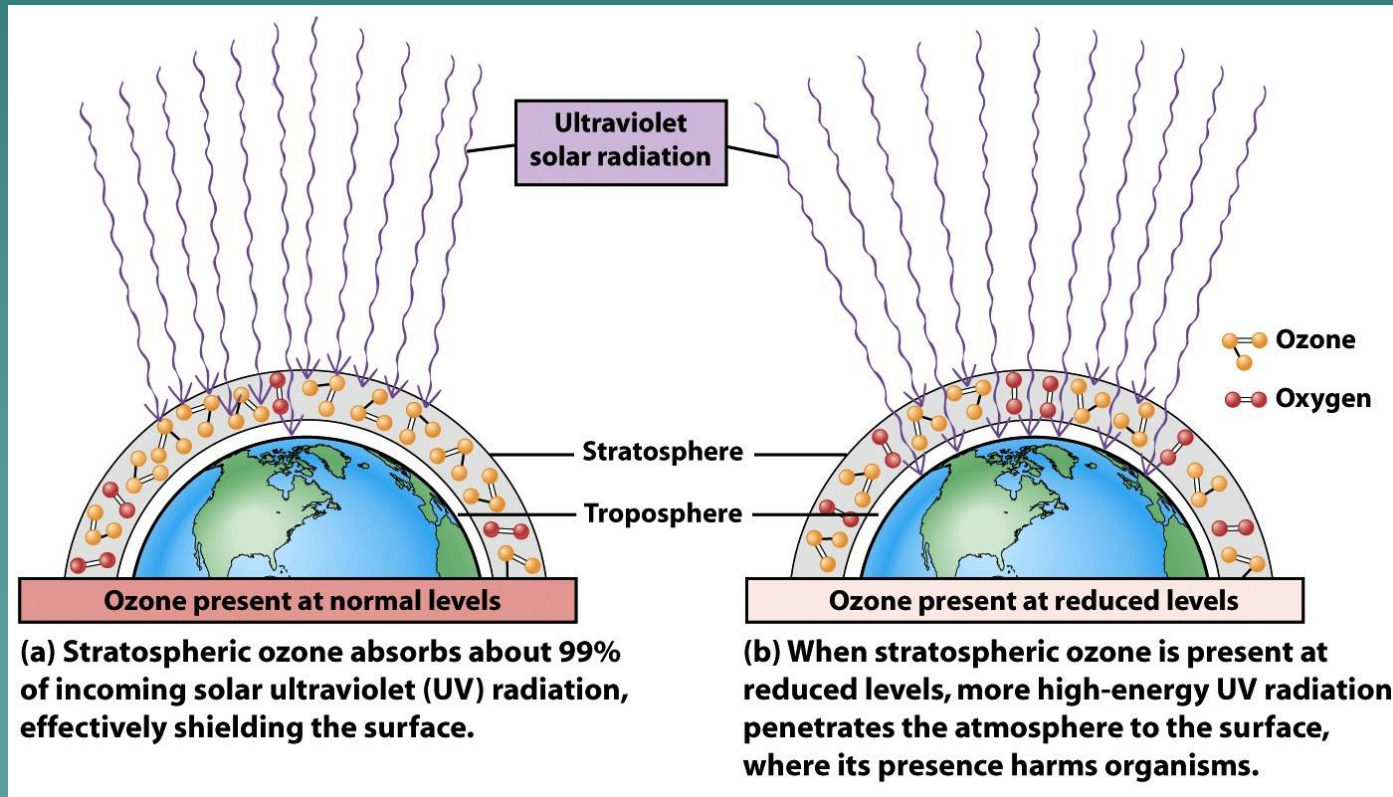


Other Ways to Improve Air Quality

- Reduce sulfur content in gasoline from its current average of 330 ppm to 30 ppm
 - Sulfur clogs catalytic converters
- Require federal emission standards for all passenger vehicles
 - Including SUVs, trucks and minivans
- Require emission testing for all vehicles
 - Including diesel

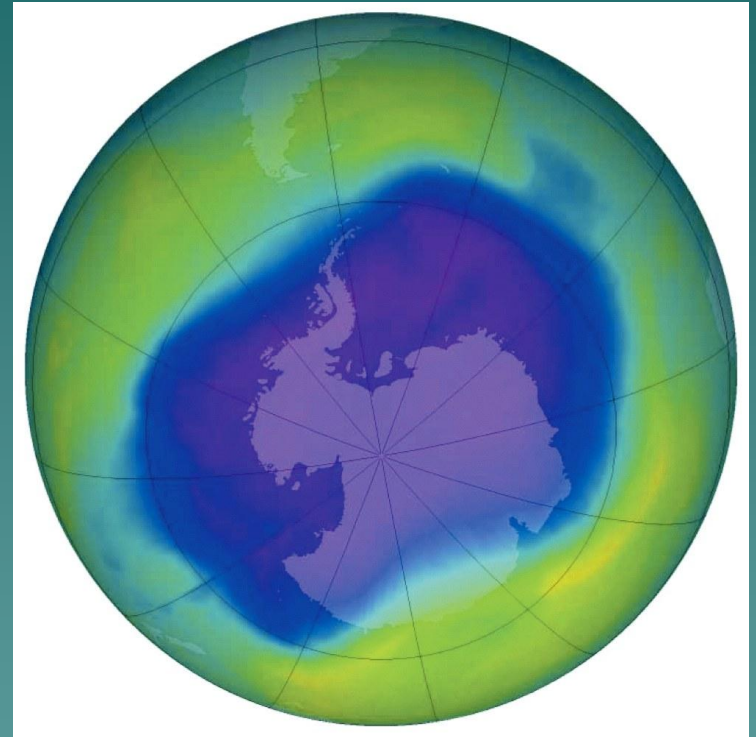
Ozone Depletion in Stratosphere

- Ozone Protects earth from UV radiation
 - Part of the electromagnetic spectrum with wavelengths just shorter than visible light



Ozone Depletion in Stratosphere

- Ozone thinning/hole
 - First identified in 1985 over Antarctica
- Caused by
 - human-produced bromine and chlorine containing chemicals
 - Ex: CFCs



Ozone Depletion in Stratosphere

- Hole over Antarctica requires two conditions:
 - Sunlight just returning to polar region
 - Circumpolar vortex- a mass of cold air that circulates around the southern polar region
 - Isolates it from the warmer air in the rest of the planet
- Polar stratospheric clouds form
 - Enables Cl and Br to destroy ozone

Effects of Ozone Depletion

- Higher levels of UV-radiation hitting the earth
 - Eye cataracts
 - Skin cancer (right)
 - Weakened immunity
- May disrupt ecosystems
- May damage crops and forests

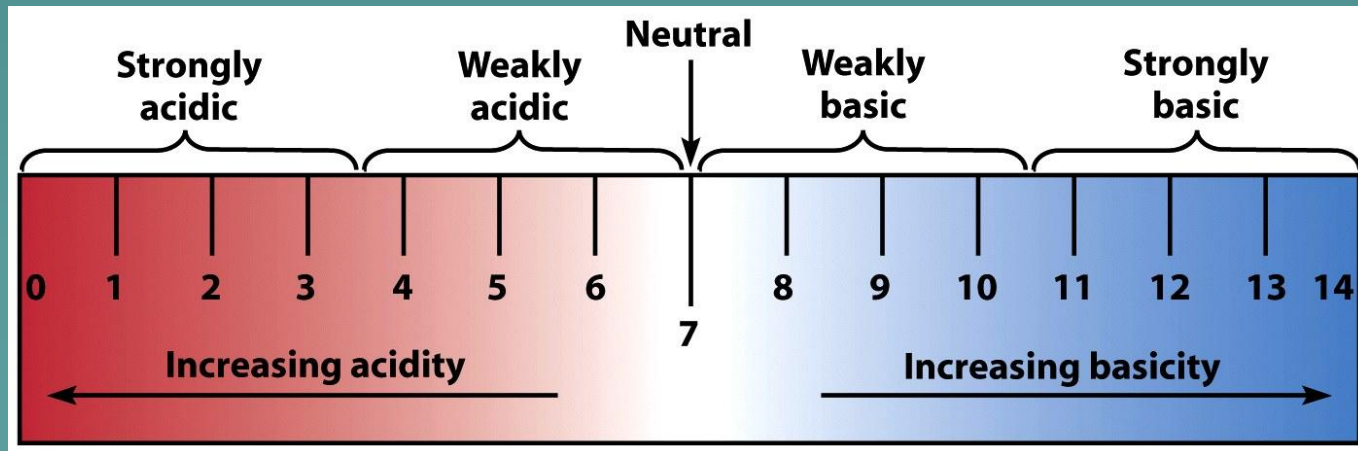


Recovery of Ozone Layer

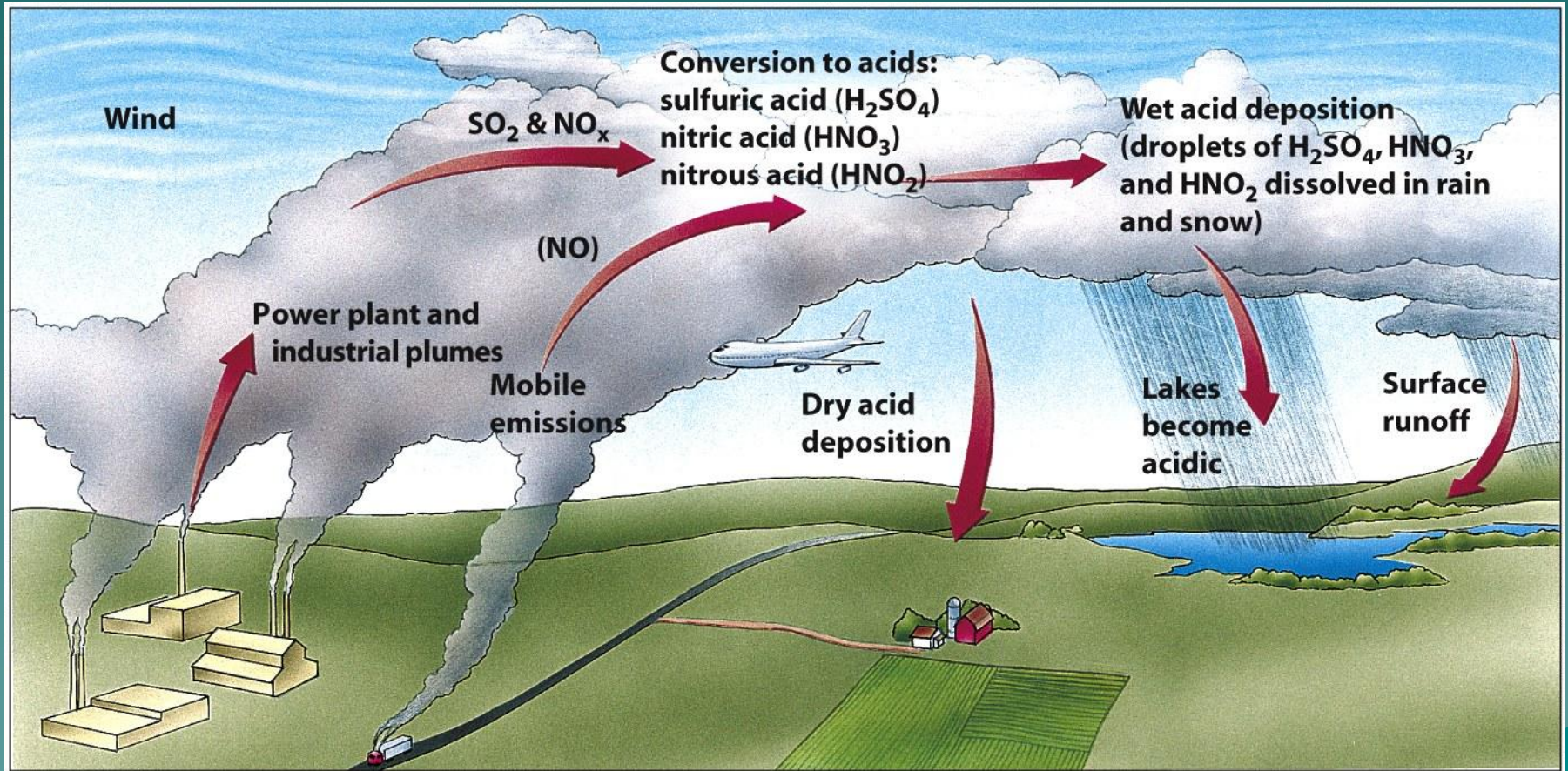
- Montreal Protocol (1987)
 - Reduction of CFCs
 - Started using HCFCs (greenhouse gas)
- Phase out of all ozone destroying chemicals is underway globally
- Satellite pictures in 2000 indicated that ozone layer was recovering
- Full recovery will not occur until 2050

Acid Deposition

- Sulfur dioxide and nitrogen dioxide emissions react with water vapor in the atmosphere and form acids that return to the surface as either dry or wet deposition
- pH scale



How Acid Deposition Develops

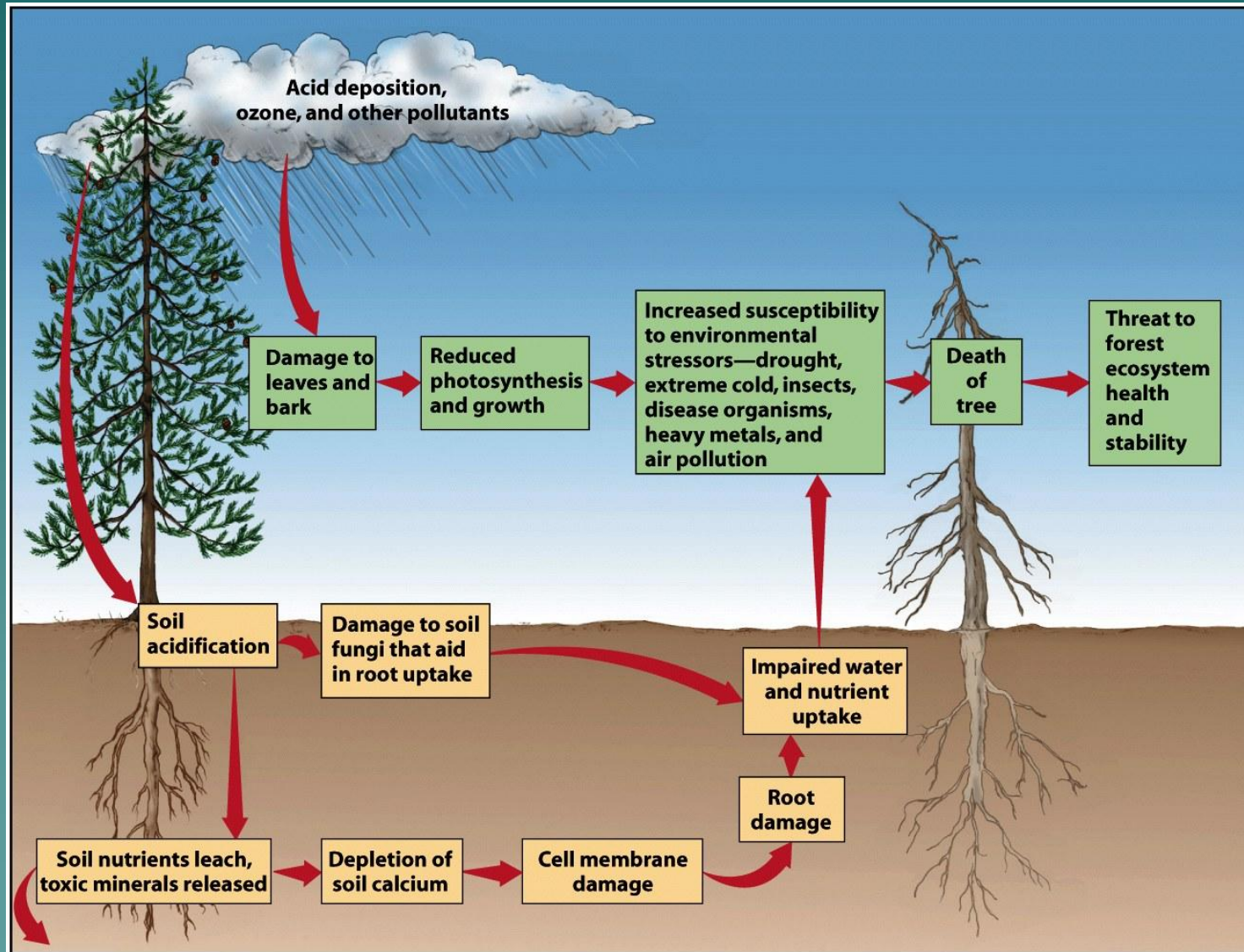


Effects of Acid Deposition

- Declining Aquatic Animal Populations
- Thin-shelled eggs prevent bird reproduction
 - Because calcium is unavailable in acidic soil
- Forest decline
 - Ex: Black forest in Germany (50% is destroyed)



Acid Deposition and Forest Decline

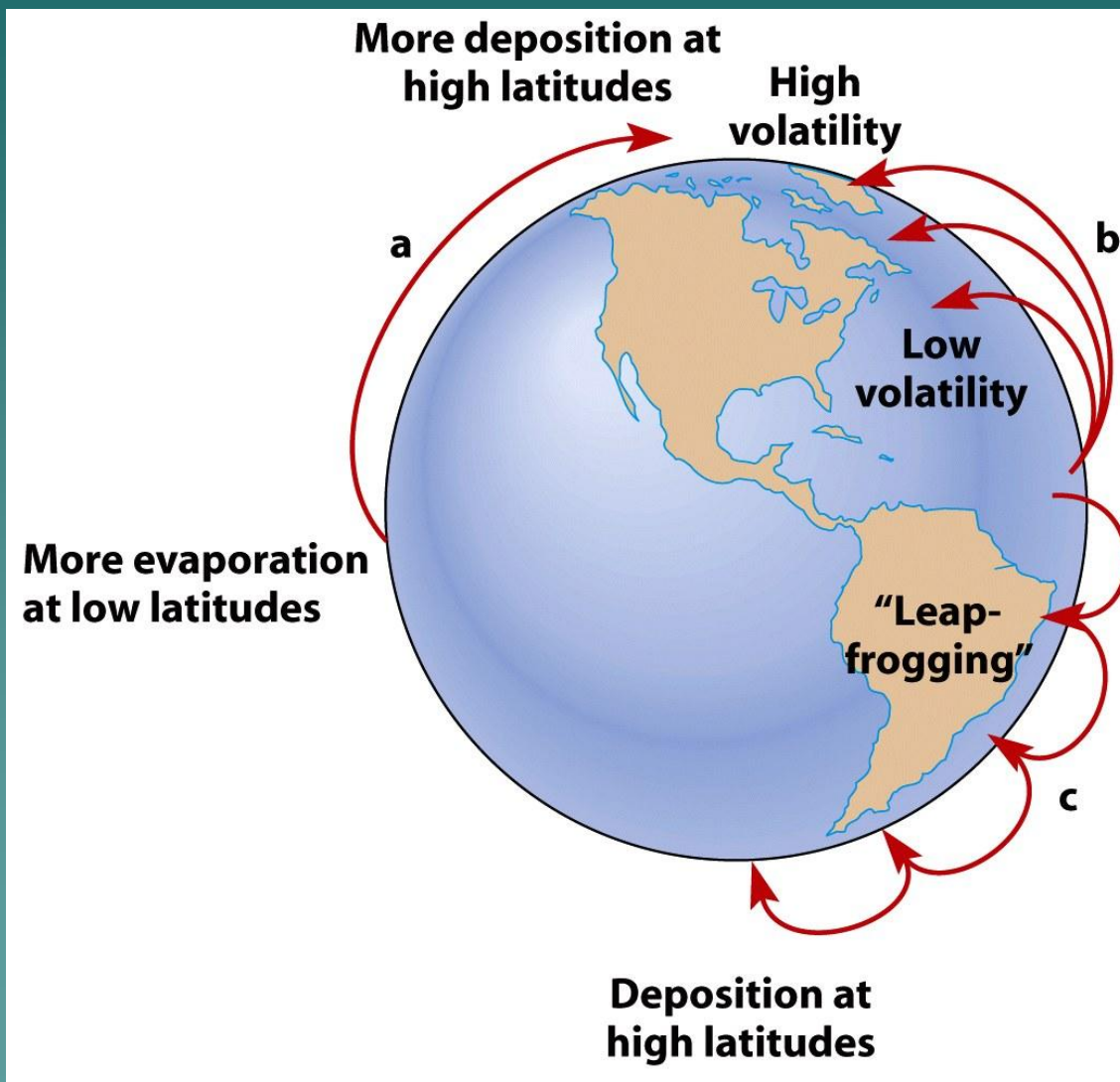


Air Pollution Around the World



- Air quality is deteriorating rapidly in developing countries
- Shenyang, China
 - Residents only see sunlight a few weeks each year
- Developing countries have older cars
 - Still use leaded gasoline
- 5 worst cities in world
 - Beijing, China; Mexico City, Mexico; Shanghai, China; Tehran, Iran; and Calcutta, India

Long Distance Transport of Air Pollutants



Indoor Air Pollution

- Pollutants can be 5-100X greater than outdoors
- Most common:
 - Radon, cigarette smoke, carbon monoxide, nitrogen dioxide, formaldehyde, pesticides, lead, cleaning solvents, ozone, and asbestos

