

Air Pollution

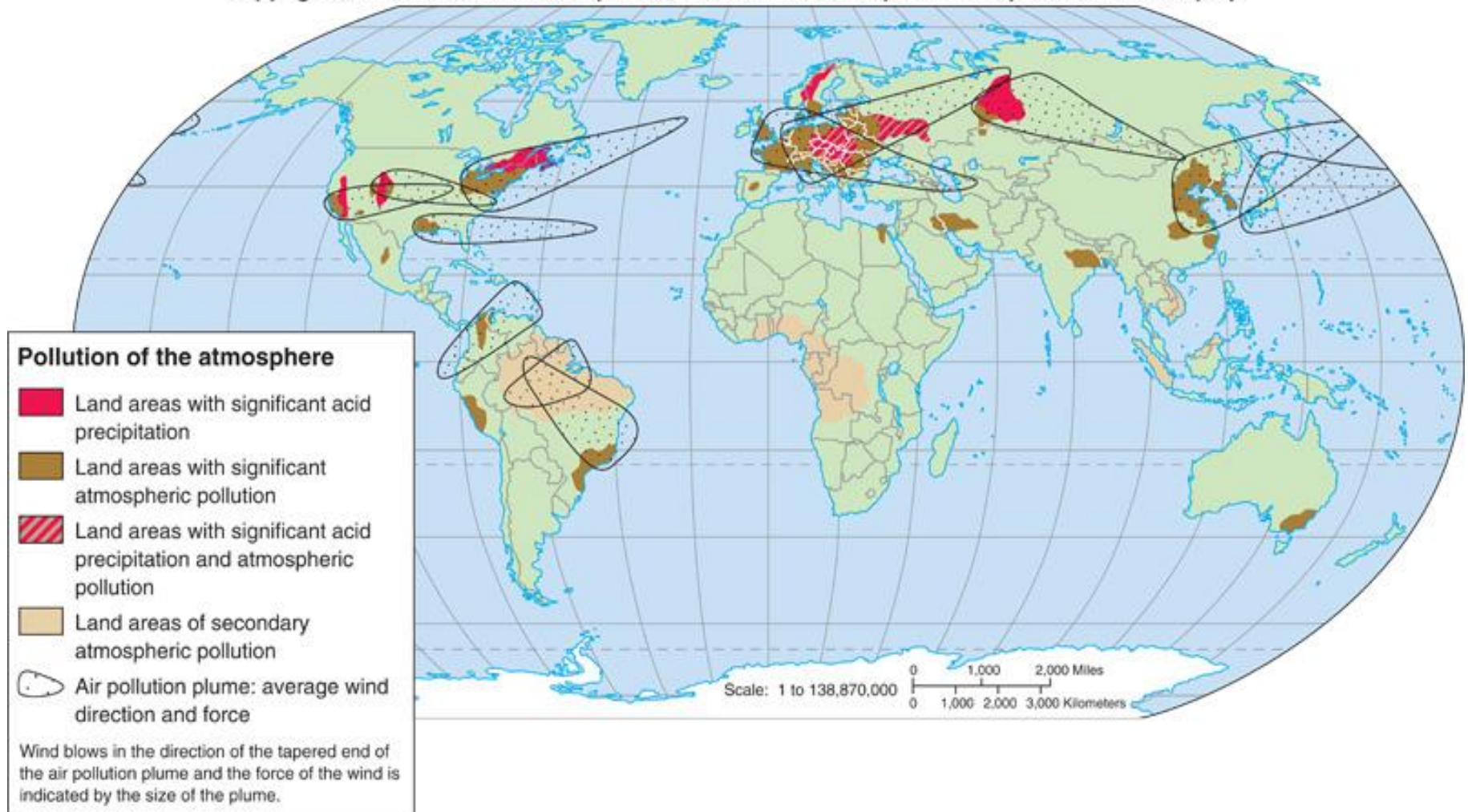


Climate Processes And Air Pollution

- Air pollution is defined as any contaminant added to the air that is harmful to the health of living organisms.
- Due to the nature of air and wind, this pollution can be carried great distances.

Long-Range Transport

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



Air Pollution Classification

- **Primary Pollutants**

Released directly into the air

- **Secondary Pollutants**

Formed as a result of a chemical reaction in the air.

1. **Smog**: Reaction of sunlight with nitrogen oxide (NO_x), the words smoke and fog
2. **Acid Rain**: Reaction of sulfur dioxide (SO₂) with water to form sulfuric acid.
3. **Ozone**: Tropospheric, or ground level ozone, is not emitted directly into the air, but is created by **chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC)**.

AIR POLLUTION SOURCES

1. Anthropogenic Activities
 - a. Industrial Activities
 - b. Combustion Fossil Fuel
 - c. **Vehicular Emission**
2. Natural Processes

High Concentration of Air Pollutants

1. CO
2. Ozone
3. **Particulate Matter (TSP, PM10)**
4. NO_x
5. SO₂
6. Lead

ASSOCIATED FACTORS

1. **Environmental Factors**
 - a. Physical Environment
 - b. Temperature
 - c. Humidity
 - d. Altitude
 - e. Climatic Changes
 - f. Geographical Distribution
 - g. Distance From the Main Roads
 - h. Closed Area
2. **Human Factors**
 - a. History
 - b. Socioeconomic Status
 - c. Indoor Air Quality
 - d. Demographics

HEALTH EFFECTS

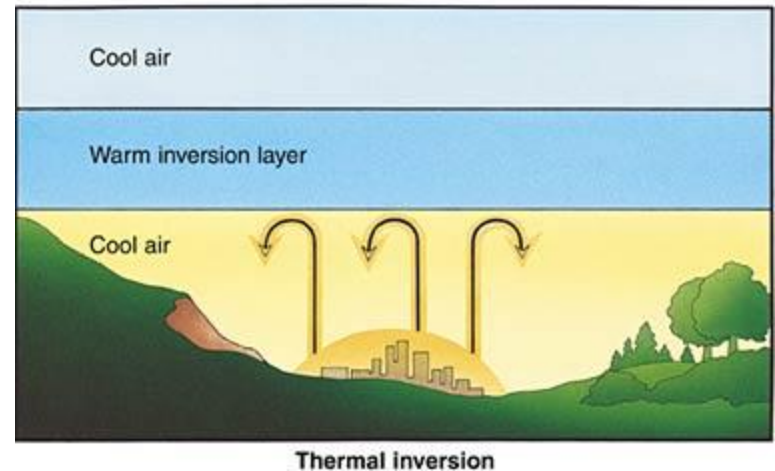
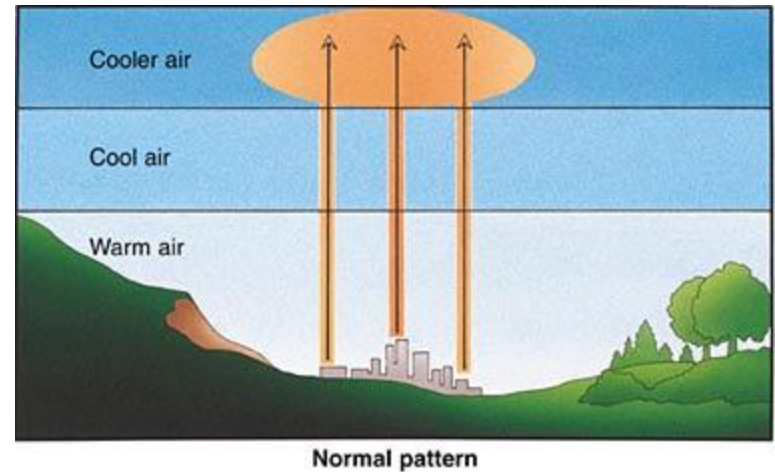
1. **Respiratory Symptoms**
 - a. Cough
 - b. Phlegm
 - c. Wheezing
 - d. Breathlessness
2. **Respiratory diseases**
 - a. Bronchitis
 - b. Pneumonia
 - c. Hay fever
 - d. Bronchial Asthma
 - e. Chronic Bronchitis
3. **Medical visits**
4. **Hospital admissions**

Air Pollution and Topography

- The effects of air pollution are also influenced by the shape of the land.
- Temperature inversions occur when a layer of dense, cool air is trapped below a layer of lighter, warmer air. ظاهرة الانقلاب الحراري
 - Most likely to occur in valleys and canyons.

Temperature Inversion

- Temperature inversions trap any air pollution produced, allowing it to accumulate to much higher than normal levels.
- Two major air pollution events occurred in the 20th century because of this phenomenon.



Air Pollution History

The Donora Fluoride Fog of 1948

- In late October, the town of Donora experienced a temperature inversion.
- The town is located along the Monongahela River south of Pittsburgh, within a small valley.
- The main employer of the town was a US Steel Zinc smelting plant.



Donora Fluoride Fog

- Emissions of sulfur dioxide, nitrogen dioxide, and fluoride from the zinc smelting plant began to accumulate.
- The smog became so thick that driving was impossible.
- The plant itself did not cease operations until 4 days later.
- The smog finally broke up as a rainstorm entered the area after 5 days.

Donora Fluoride Fog

- A total of 20 residents died; About a 1/3 to a 1/2 of the town's entire population of 14,000 became sickened.
- Donora experienced higher than normal mortality rates for 10 years afterwards.



Air Pollution History

The London Smog of 1952

- London naturally has very calm air, and regularly experiences thick sea fog.
- The weather turned unusually cold, causing the residents to burn greater amounts of coal to heat their homes.
- This combined with a temperature inversion to create a thick smog of sulfur dioxide over the city.
- The number of fatalities is unknown, but estimated to be around 12,000.

The London Smog of 1952

- As a result of this disaster, London passed its own Clean Air Act.
- One of the specific changes made was to make chimneys taller to reach above a temperature inversion.



Clean Air Act

- Initially, the law (in USA) required the EPA to **set and enforce limits** for 6 different air pollutants.
- These are called criteria pollutants.
 1. Sulfur Dioxide
 2. Carbon Monoxide
 3. Particulates
 4. Ozone
 5. Nitrogen Oxides
 6. Lead



Criteria Pollutants

1. Sulfur dioxide

- Colorless gas often associated with “rotten eggs” smell
- Forms sulfuric acid in clouds.
- Biggest source: coal burning power plants

2. Nitrogen oxides

- Reddish brown gas
- Reacts with water vapor to form nitric acid (HNO_3)
- Reacts with sunlight to form smog
- Biggest source: car exhaust (traffic)

3. Carbon Monoxide

- Colorless, odorless, highly toxic gas
- Binds to hemoglobin in red blood cells, interfering with oxygen transport
- Biggest source: car exhaust

4. Particulate Matter

- Dust, ash, soot, lint, smoke, pollen, spores, and all other suspended matter.
- Cause the most visibility problems
- Biggest source: unpaved road dust and construction

Criteria Pollutants

5. Ozone

- Molecule made of three oxygen atoms → O_3
- Pale blue gas, odor resembling chlorine bleach
- Secondary pollutant; not released directly

6. Lead

- Enters the air as particles or part of dust.
- The biggest source used to be exhaust from cars using leaded gas

Clean Air Act

- The Clean Air Act was amended in 1990 and included additional provisions and controls for:
 1. Acid Rain
 2. Urban Smog
 3. Toxic and Hazardous Air Pollutants
 4. Protection of the Ozone Layer
 5. Leakage of volatile organic compounds

Other Major Pollutants

– Volatile organic compounds

- Organic (carbon-based) gases like methane (CH_4) that can decompose or react easily, forming carbon dioxide or carbon monoxide in the air.
- Biggest sources:
- Spilled/leaking gasoline that evaporates
- Paint and paint cleaners

Acid Deposition

- Acid Precipitation – Rainfall or snowfall that contains an lower than normal pH.
 - pH scale ranges from 0-14.
 - 7 = Neutral; <7 = Acidic; >7 = Basic
 - Unpolluted rain generally has pH of 5.6.
 - Carbonic acid from atmospheric CO₂.
 - In industrialized areas, the pH level can reach as low as 4.3
 - Rain of pH 2.1 was recorded in the 1970s and 1980s

Acid Deposition Cont'd

- Aquatic Effects
 - Fish and other aquatic organisms are extremely sensitive to pH changes.
 - pH below 5 = eggs will not hatch
 - pH below 4 = kills adult fish

Acid Deposition Cont'd

- Forest Damage
 - Acid rain can cause the pH of soil to decrease.
 - This interferes with trees' ability to absorb nutrients properly.
- Buildings and Monuments
 - Limestone and marble are slowly dissolved as they are exposed to acid rain.
 - Acid rain can also corrode steel, weakening structures like bridges.



Tombstone in Hamilton, NY

Indoor Air Pollution

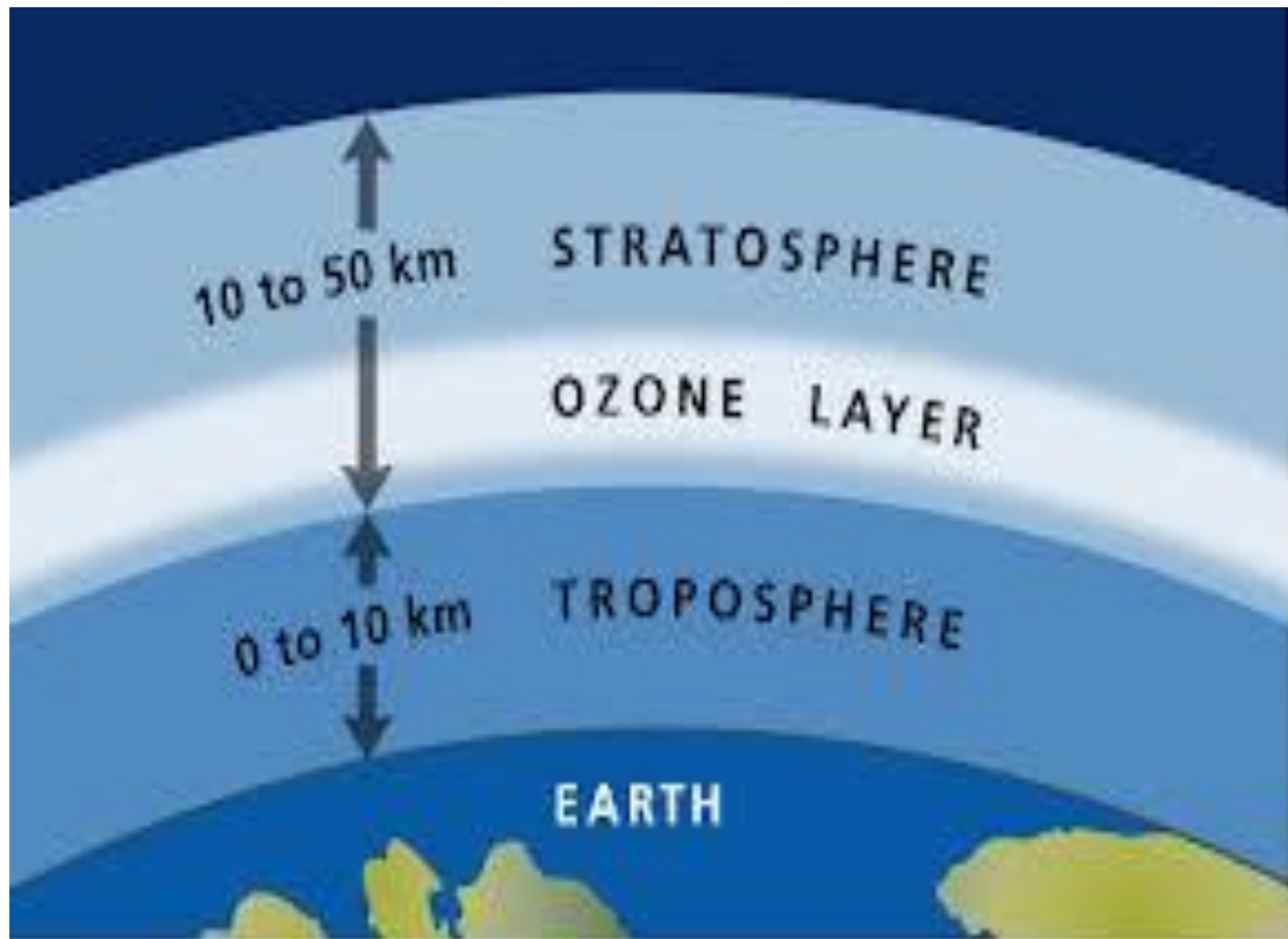
- Indoor air pollution can have more significant effects on human health than outdoor pollution.
 - People generally spend more time indoors.
 - Cigarette smoke is the most common indoor air pollutant in the U.S.

Indoor Air Pollution Cont'd

- Less-developed countries also suffer from indoor air pollution.
 - Organic fuels make up majority of household energy.
 - These fuels are often burned in smoky, poorly ventilated heating and cooking fires.

Atmospheric Ozone

- Ozone is a gas found in the upper atmosphere that blocks some UV radiation.
- Scientists discovered that atmospheric ozone levels were dropping rapidly every year, during September and October.
 - Occurring since at least 1960.
 - A 1% decrease in ozone results in a 2% increase in UV rays reaching the earth.
 - The ozone was being depleted by pollutants containing chlorine.



Stratospheric Ozone Cont'd

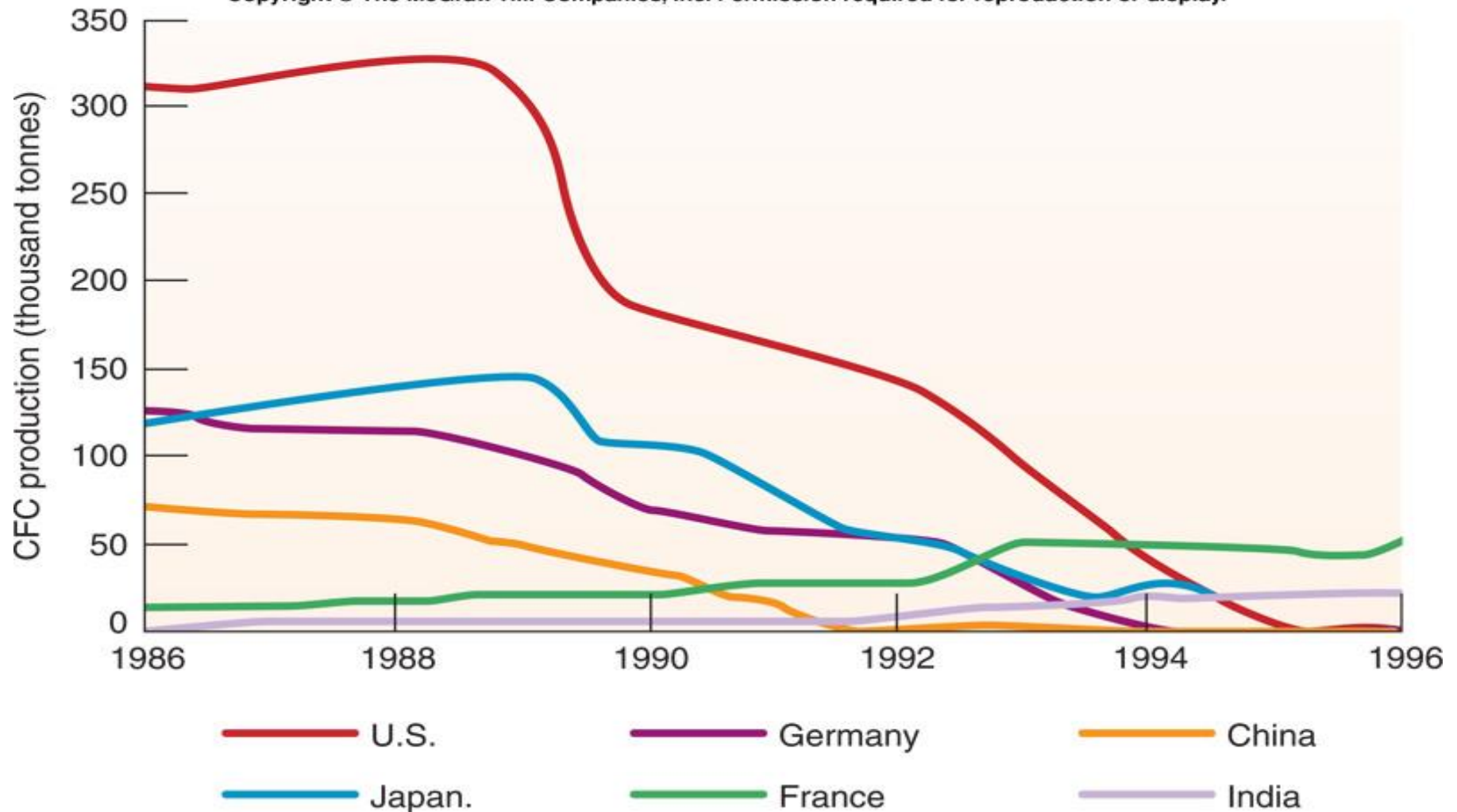
- A concentration of pollution at the poles and other factors caused chlorine pollution to be concentrated in Antarctica.
 - **When the sun returns in the spring, the energy liberates the chlorine from ice.**
 - **Chlorine causes ozone (O_3) to be broken down into oxygen (O_2).**

Montreal Protocol

- The main pollutant behind ozone depletion was **Chlorofluorocarbons (CFCs)**.
 - Used in coolants (refrigerators, air conditioners) and aerosols (hair spray, spray paint).
- The Montreal Protocol was passed in 1989.
 - Countries agreed to phase out CFC use by the year 2000.
 - CFC levels in the atmosphere decreased and the ozone layer is beginning to recover.

CFC Production

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



EFFECTS OF AIR POLLUTION

- Human Health

- EPA estimates each year 50,000 people die prematurely from illnesses related to air pollution.

- Likelihood of suffering ill health is related to intensity and duration of exposure.

- Inhalation is the most common route, but absorption through the skin and consumption via food can also occur.

Plant Pathology

- Chemical pollutants can directly damage plants, or can cause indirect damage by disrupting normal growth and development patterns.

Visibility Reduction

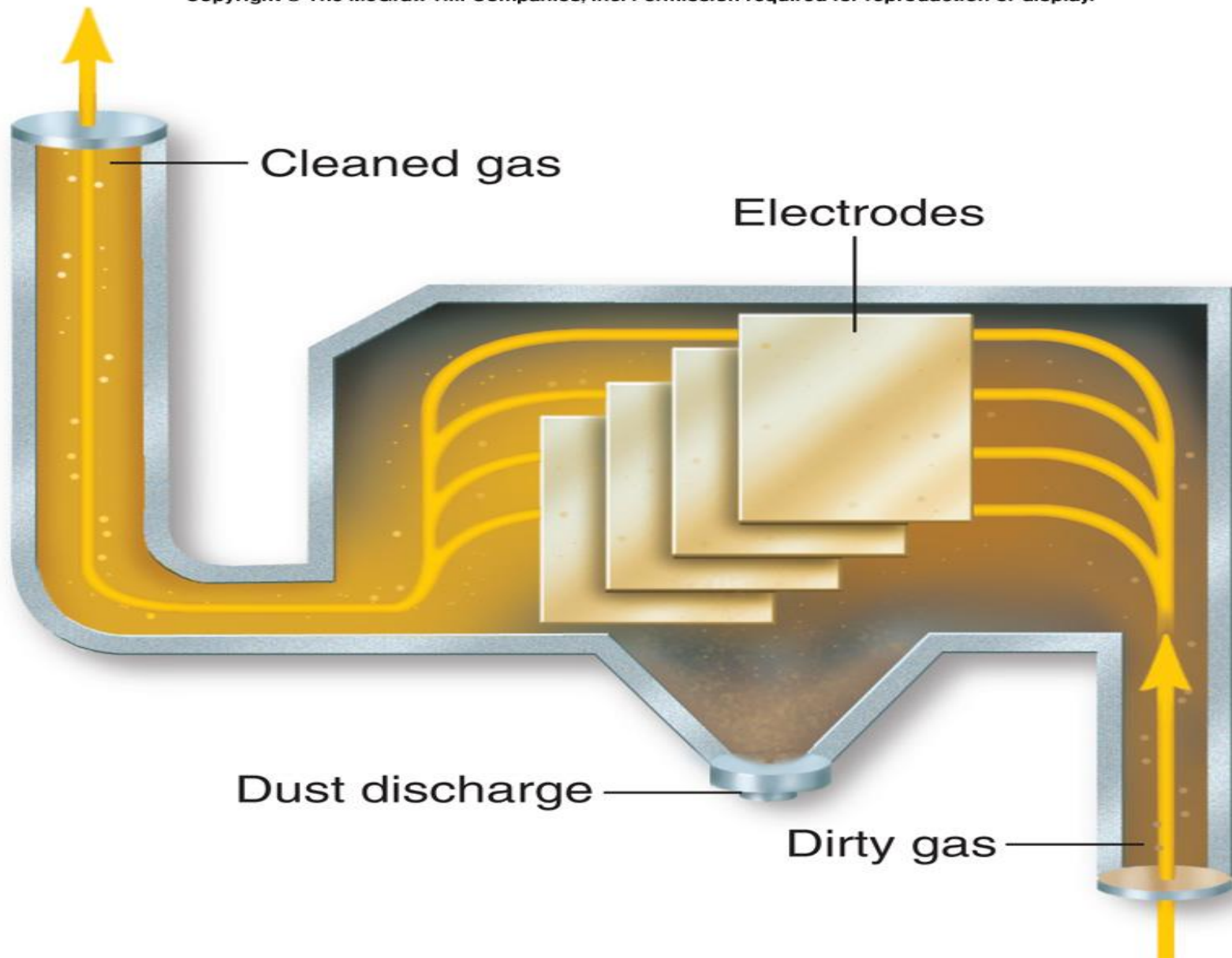
- The production of pollution haze or smog can reduce visibility by as much as 80 percent.



AIR POLLUTION CONTROL

– Most effective strategy for controlling pollution is **to not produce it in the first place.**

- *Particulate Removal - Remove particles physically by trapping them in a porous mesh which allows air to pass through but holds back solids.*
- *Electrostatic Precipitators – Pass air across electrically charged plates that attract the particles of pollution.*



Reducing Pollution

- **Sulfur Dioxide Reduction**

- 1. **Heating Fuel Switching**

- a. Switch from soft coal with a high sulfur content (like was used in London in 1952) to low sulfur coal.
 - b. Change to another fuel (natural gas).

- 2. **Limestone Injection**

- Can reduce sulfur emissions by 90% by mixing crushed limestone with coal before it is fed into a boiler.

