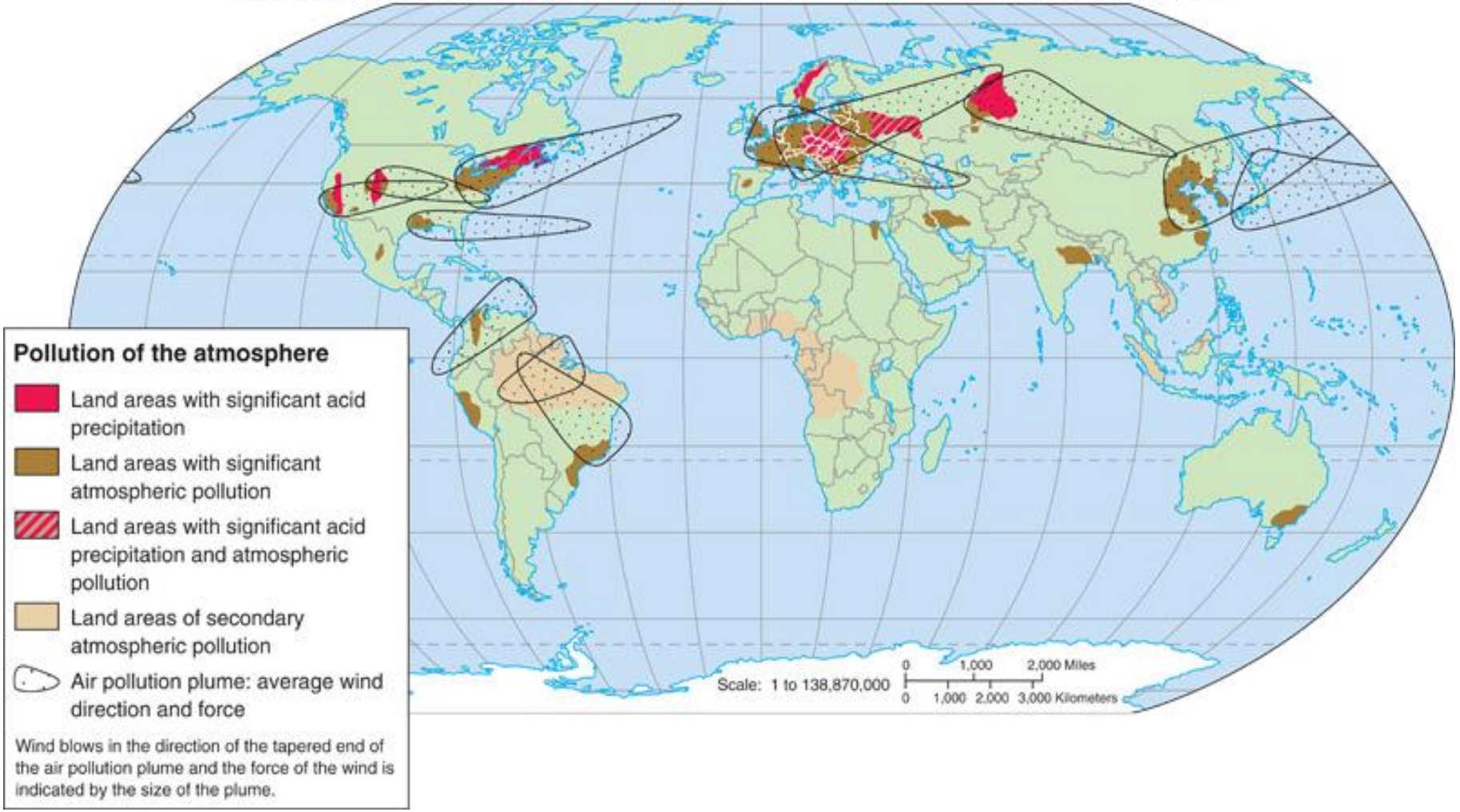
Air Pollution

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



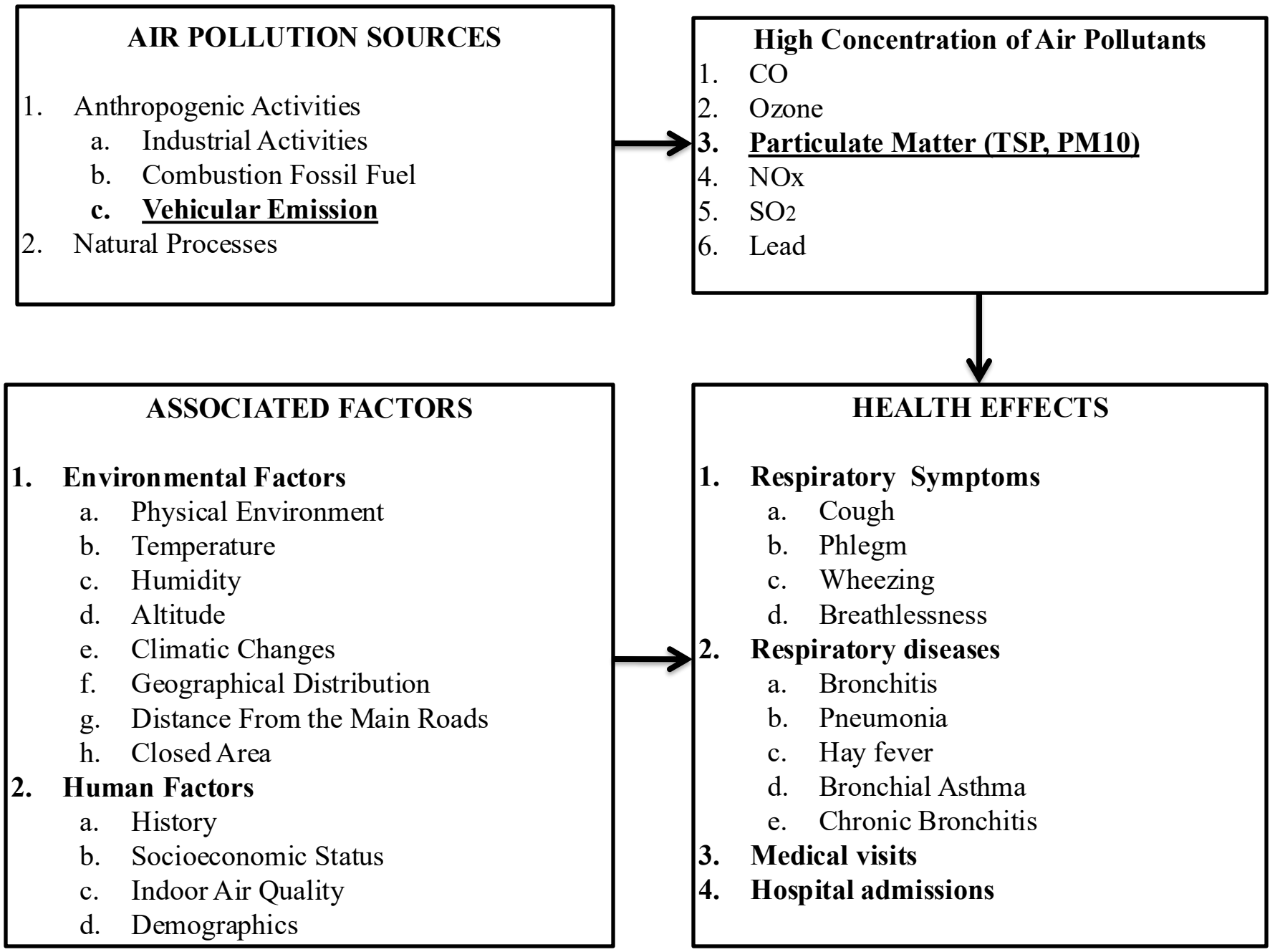
Air Pollution Classification

- **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 (SO_2) 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 (NOx) and volatile organic compounds (VOC).

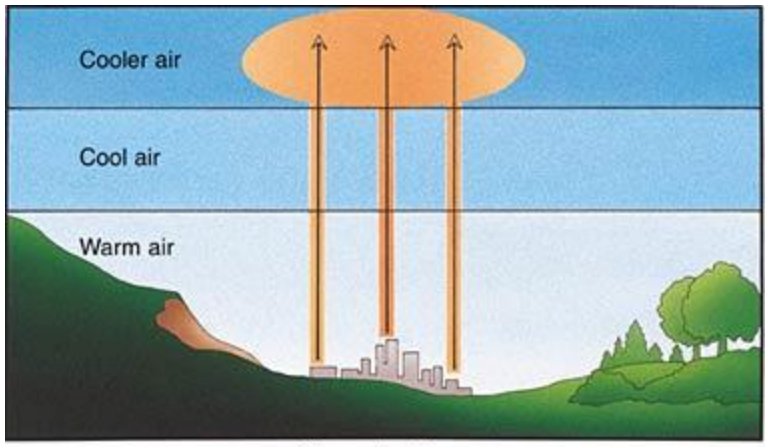

AIR POLLUTION SOURCES
1. Anthropogenic Activities
a. Industrial Activities
b. Combustion Fossil Fuel
c. Vehicular Emission
2. Natural Processes
High Concentration of Air Pollutants
1. CO
2. Ozone
3. Particulate Matter (TSP, PM10)
4. NOx
5. SO2
6. Lead
ASSOCIATED FACTORS
1. Environmental Factors
a. Physical 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.

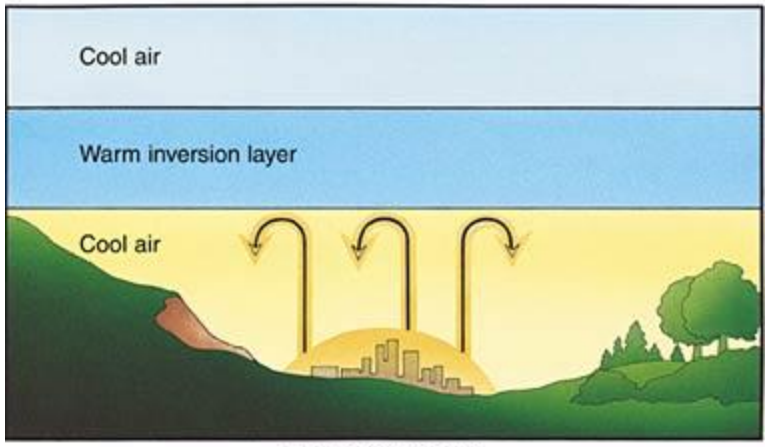
Temperature Inversion

- Temperature inversions trap any air pollution produced, allowing it to accumulate to much higher than normal levels.



Normal pattern

- Two major air pollution events occurred in the 20th century because of this phenomenon.



Thermal inversion

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.

Noon in Donora

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 CO_2.
  - 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

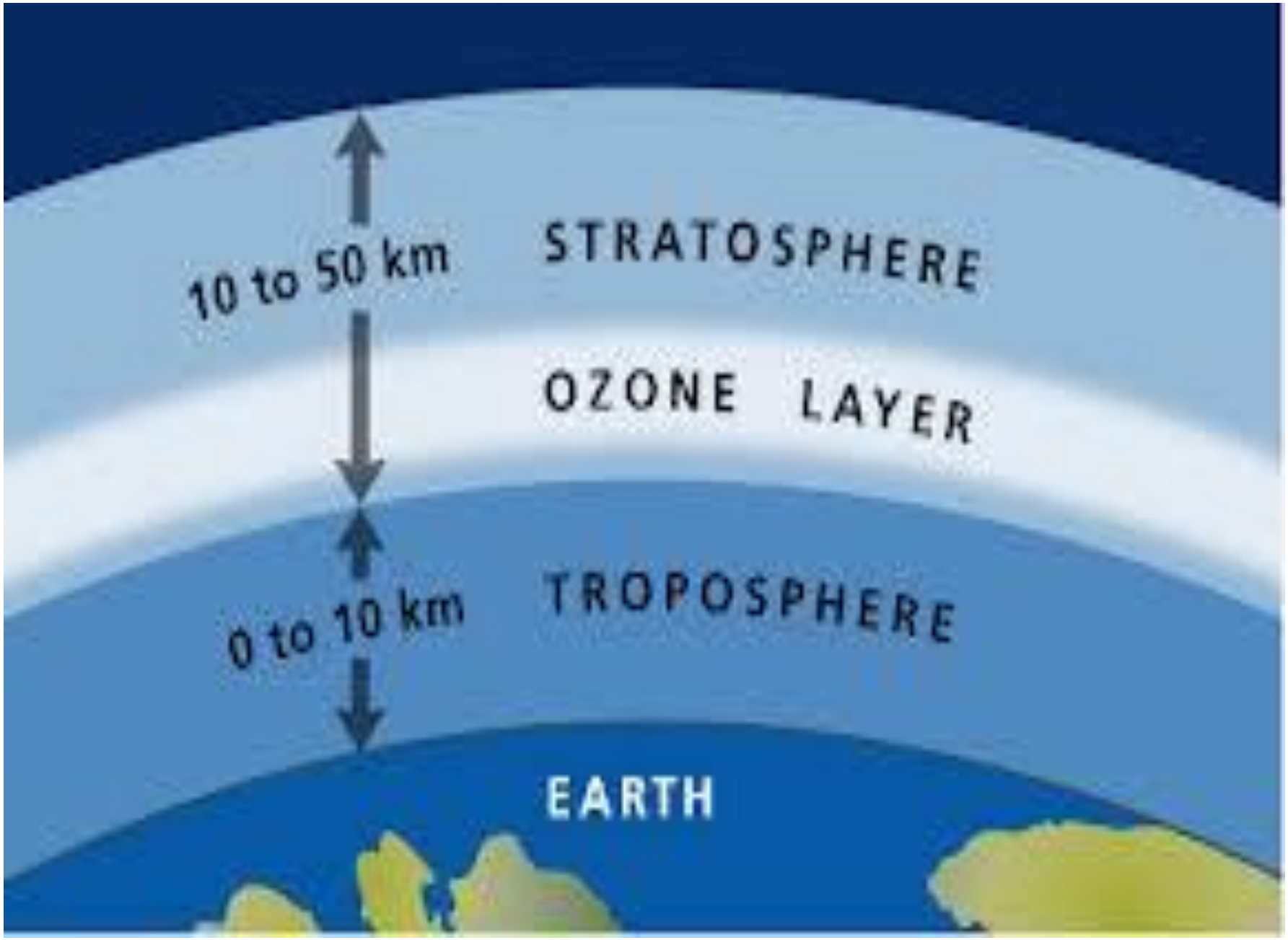
- Indoor air pollution can have more significant effects on human health than outdoor pollution.
  - People generally spend more time indoors.
  - Cigarette smoke is the most common indoor air pollutant in the U.S.

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.**


10 to 50 km
STRATOSPHERE
OZONE LAYER
0 to 10 km
TROPOSPHERE
EARTH

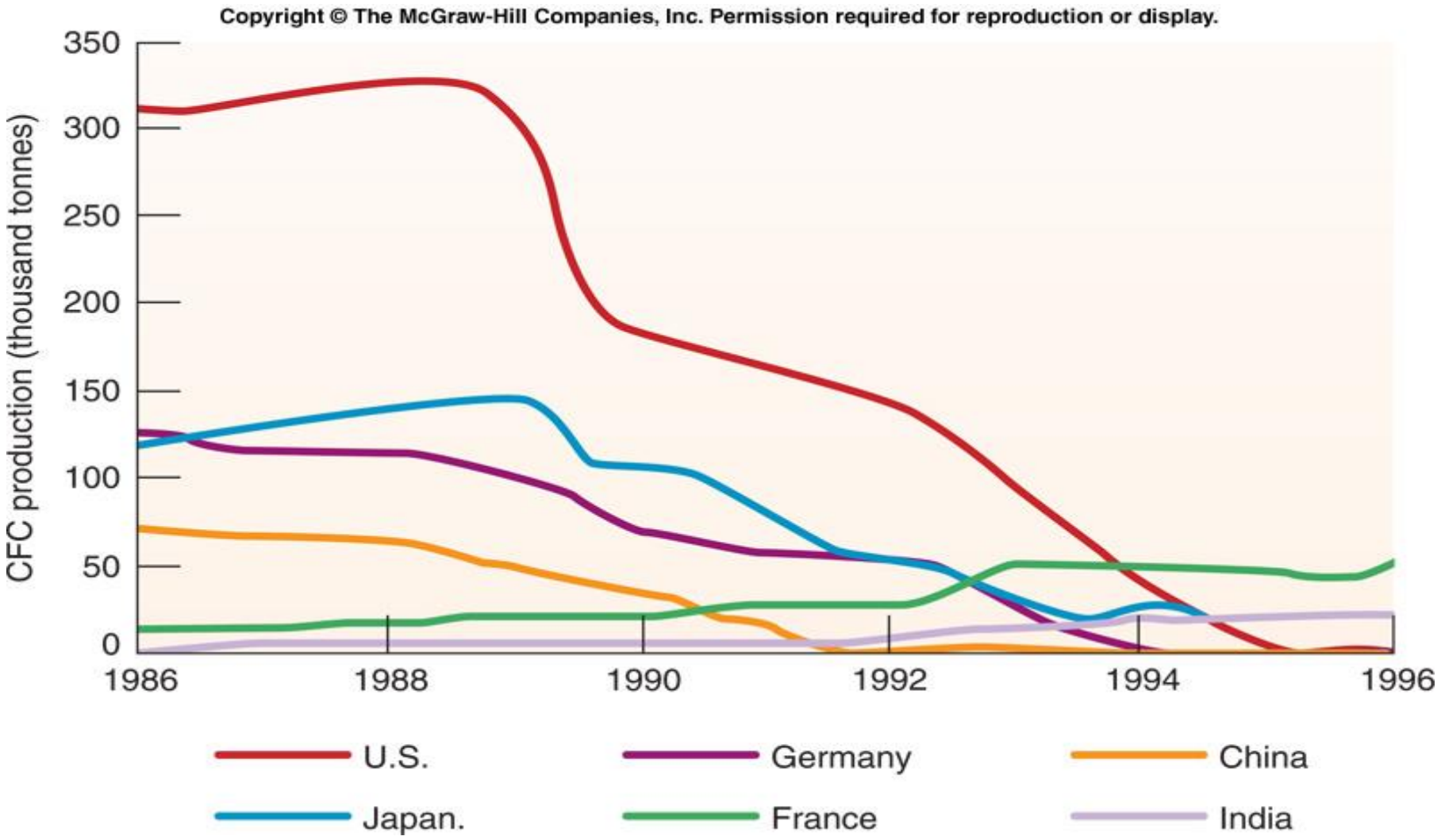
Stratospheric Ozone Cont'd

- 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 **Chloroflurocarbons (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



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

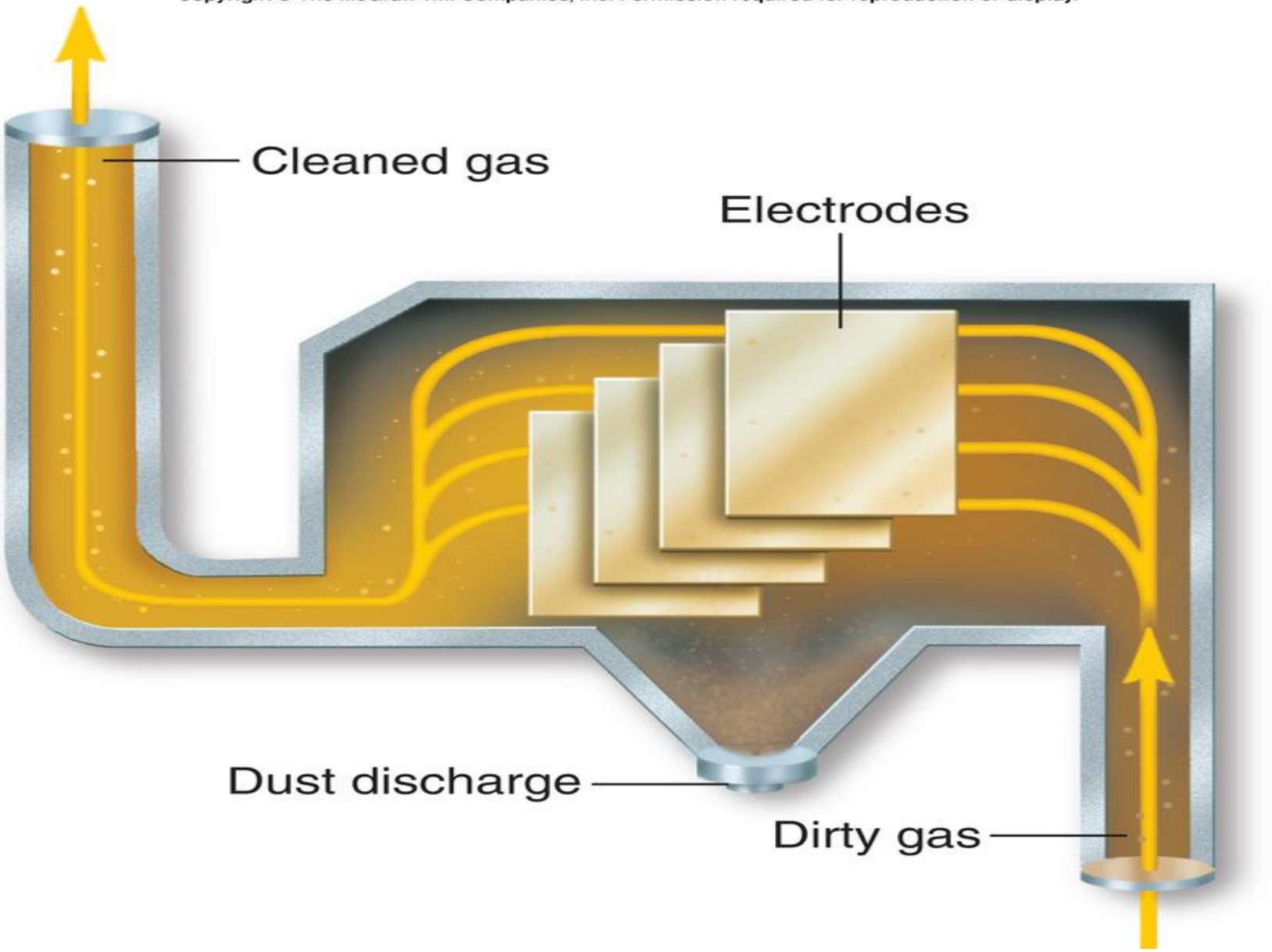
- The production of pollution haze or smog can reduce visibility by as much as 80 percent.

AIR POLLUTION CONTROL

– Most effective strategy for controlling pollution is

<u>to not produce it in the first place.</u>

- *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.