Global Warming & Ozone Loss

tutorial by Paul Rich

Outline

1. Greenhouse Effect
   - What is the greenhouse effect?
   - What problems result from human impacts?
   - What are some solutions?
2. Ozone Shield
   - What is the ozone shield?
   - What problems result from human impacts?
   - What are some solutions?

1. What is the Greenhouse Effect?

Greenhouse Effect: a natural process that traps heat near the Earth's surface.

- short wave radiation in
- long wave radiation out
- re-radiation downward by "greenhouse gases" in atmosphere

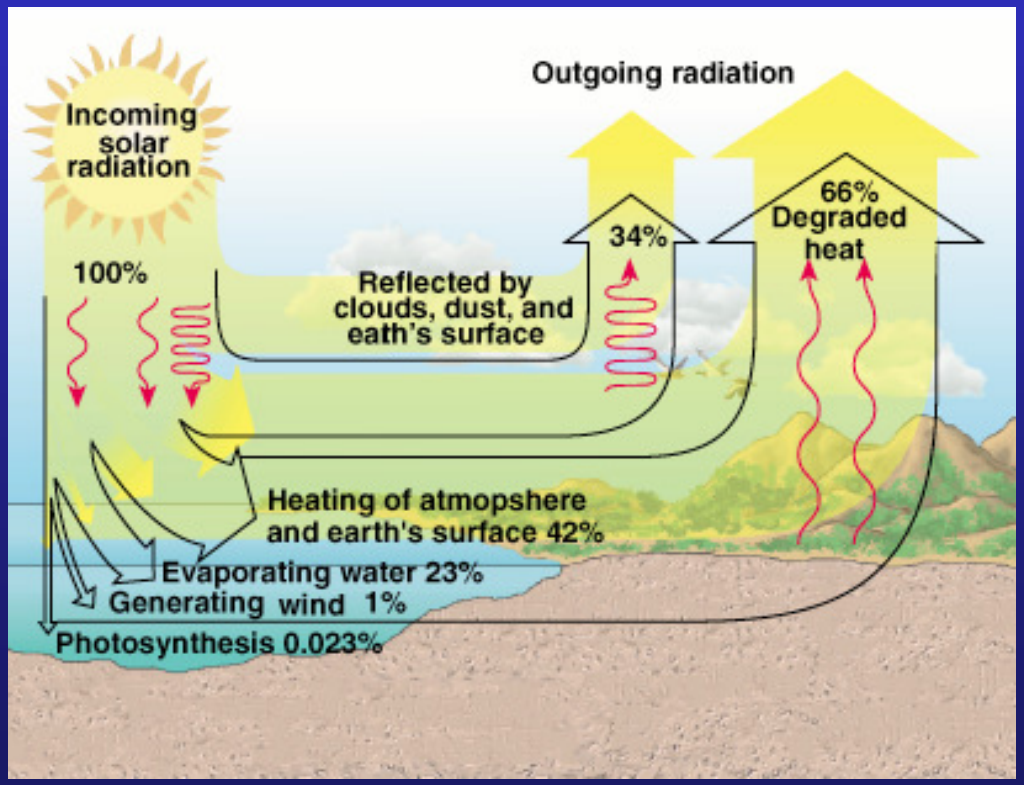
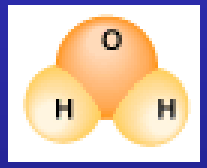


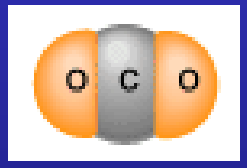
Fig. 4–7

What Natural Gases Are Involved?

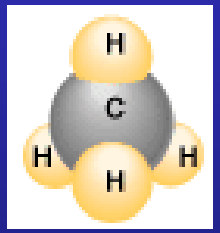
water
H_2O



carbon dioxide
CO_2



methane
CH_4



Human inputs?

Greenhouse Effect:

- carbon dioxide (CO_2)
  - 75% developed countries
  - 22% U.S.
- chlorofluorocarbons (CFCs)

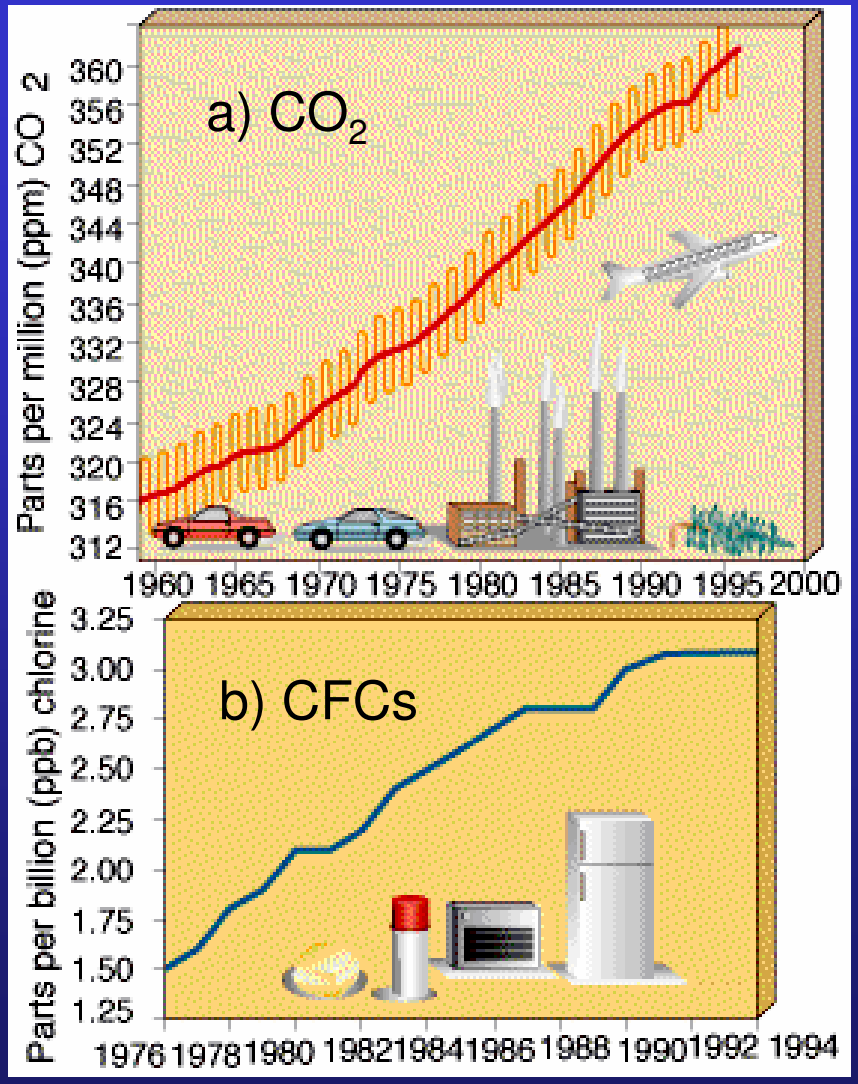


Fig. 19–2 a & b

Human inputs? (continued)

Greenhouse Effect:

- methane (CH_4)
- nitrous oxide (N_2O)

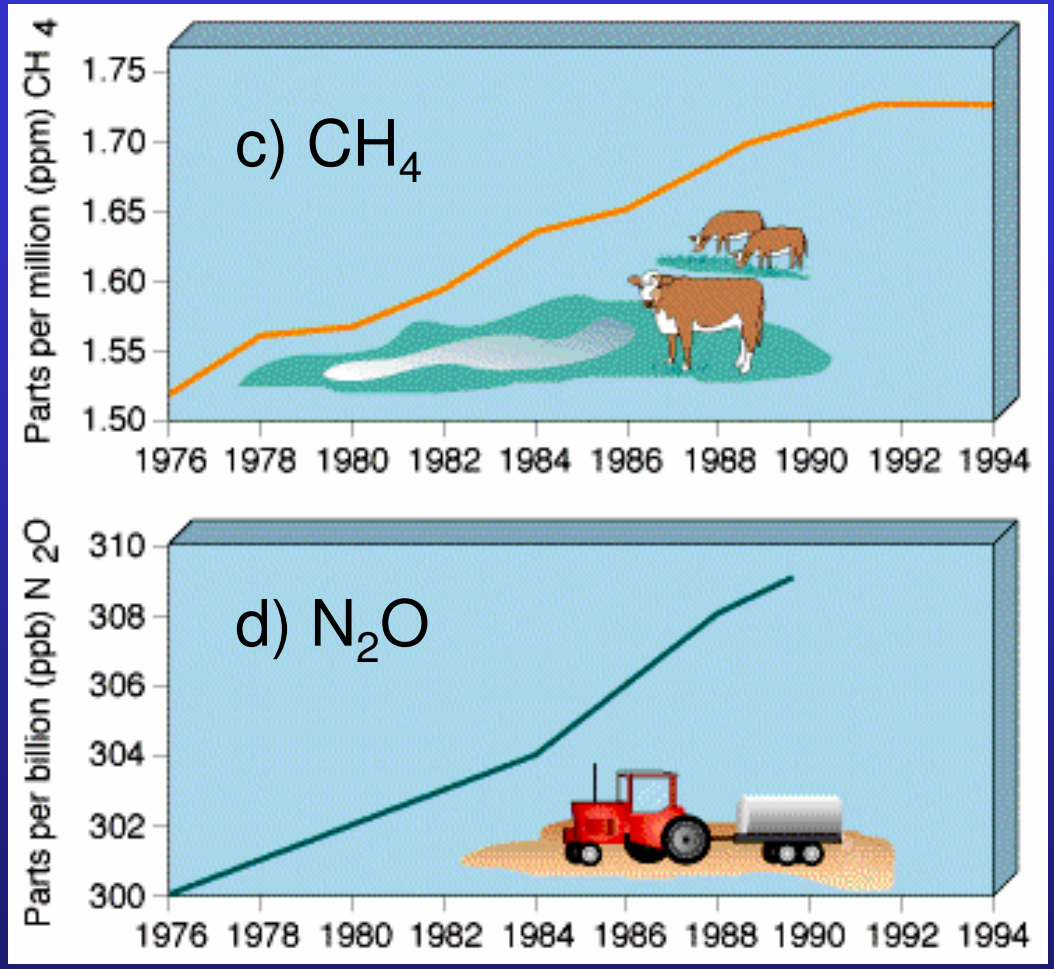


Fig. 19–2 c & d

Proposed Consequences of Increased Greenhouse Gases

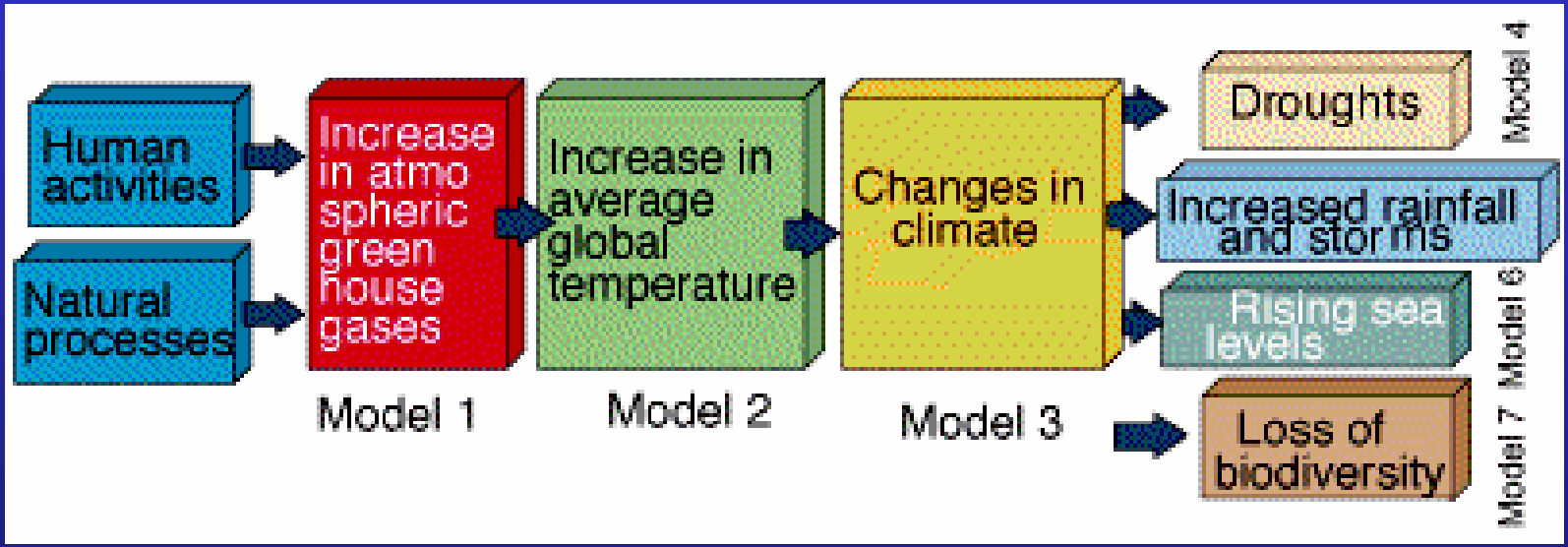


Fig. 19–6

Climate Changes During Past 900,000 Years

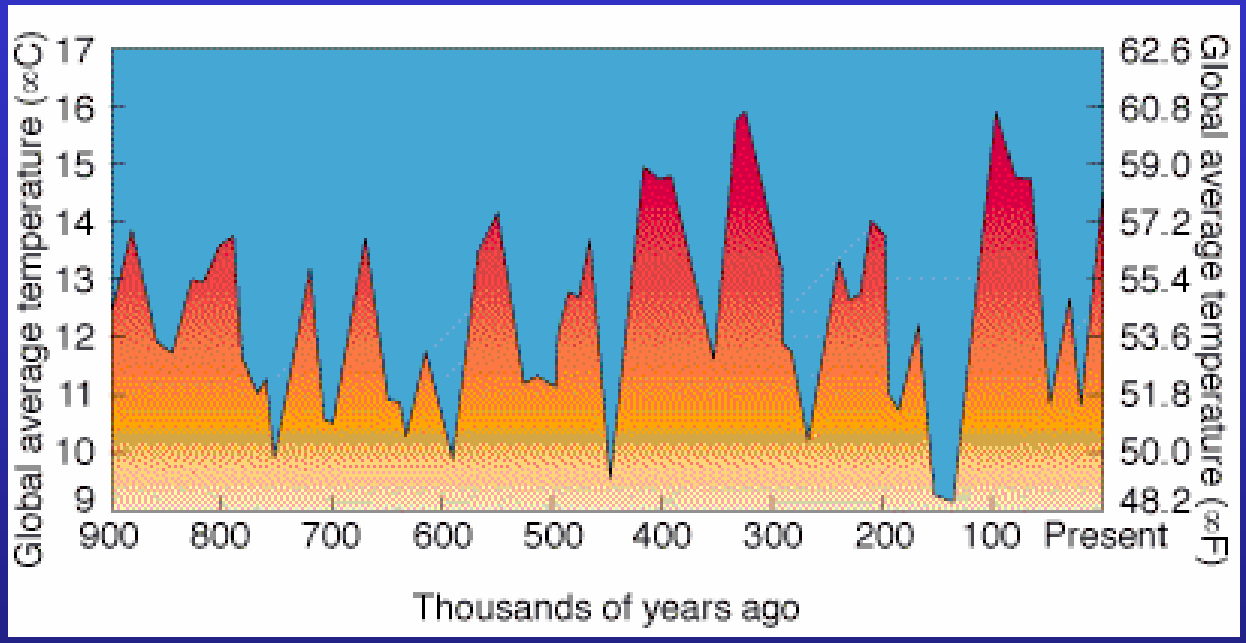


Fig. 19–3

- Past climate based on study of Antarctic glaciers
- Cycles of Ice Ages lasting about 100,000 years
- Interglacial Periods lasting 10,000 to 12,500 yrs

Climate During Past 160,000 Years

- End of last ice age about 10,000 yr ago
- Now in warm interglacial period
- Based on ice core data, analysis of trapped gas
- Correlation between CO_2 & mean temperature

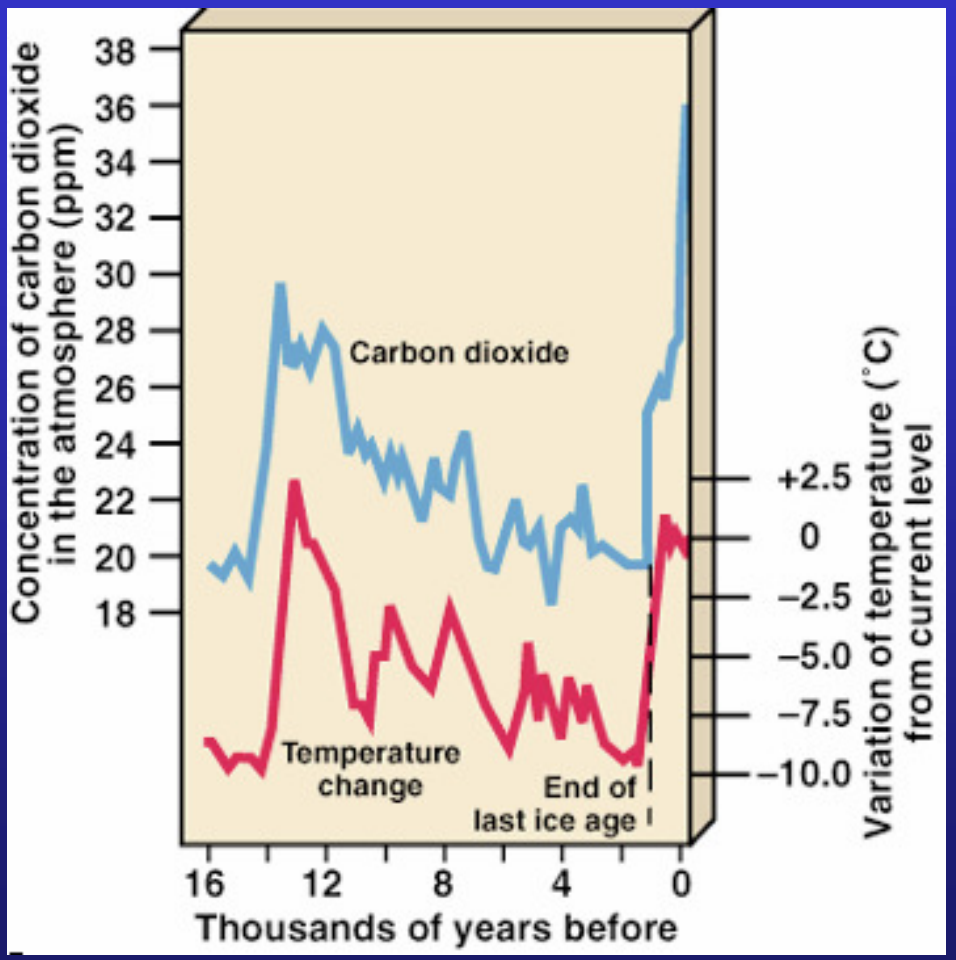


Fig. 19–4

What is the Scientific Consensus?

- Mean global temperature rose about 0.6º C (1º F) in past 100 years
- Increase is real, not explained by natural variation in solar radiation
- Warming greater at poles than equator, greater at night, mostly in troposphere

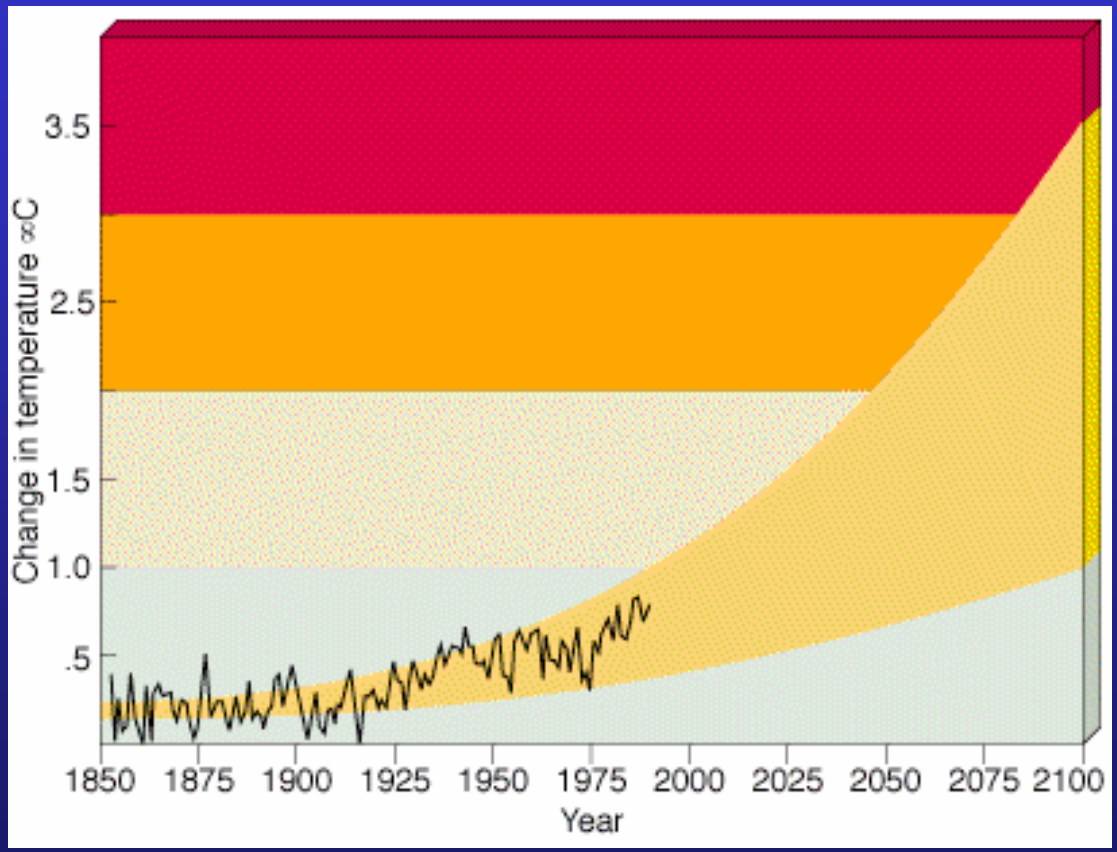


Fig. 19–5

Future Scenarios

General Circulation Models (GMCs) used to predict future climate

- Projected warming of 1 to 3.5 º C between 1990 & 2100
- Likely scenario: doubling of CO_2 (from 280 ppm to 560 ppm) before 2100 leading to warming of 2º C

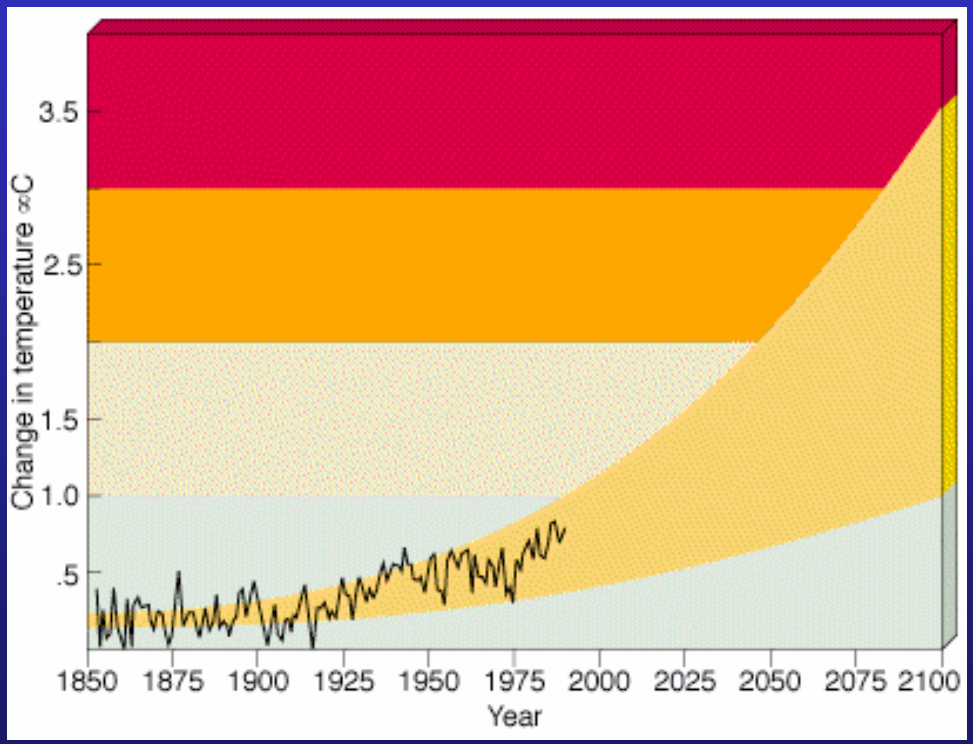


Fig. 19–5

Ecological Implications

- Shift of habitat to higher latitudes
- Shift of habitat to higher elevations
- Potential large loss of biodiversity

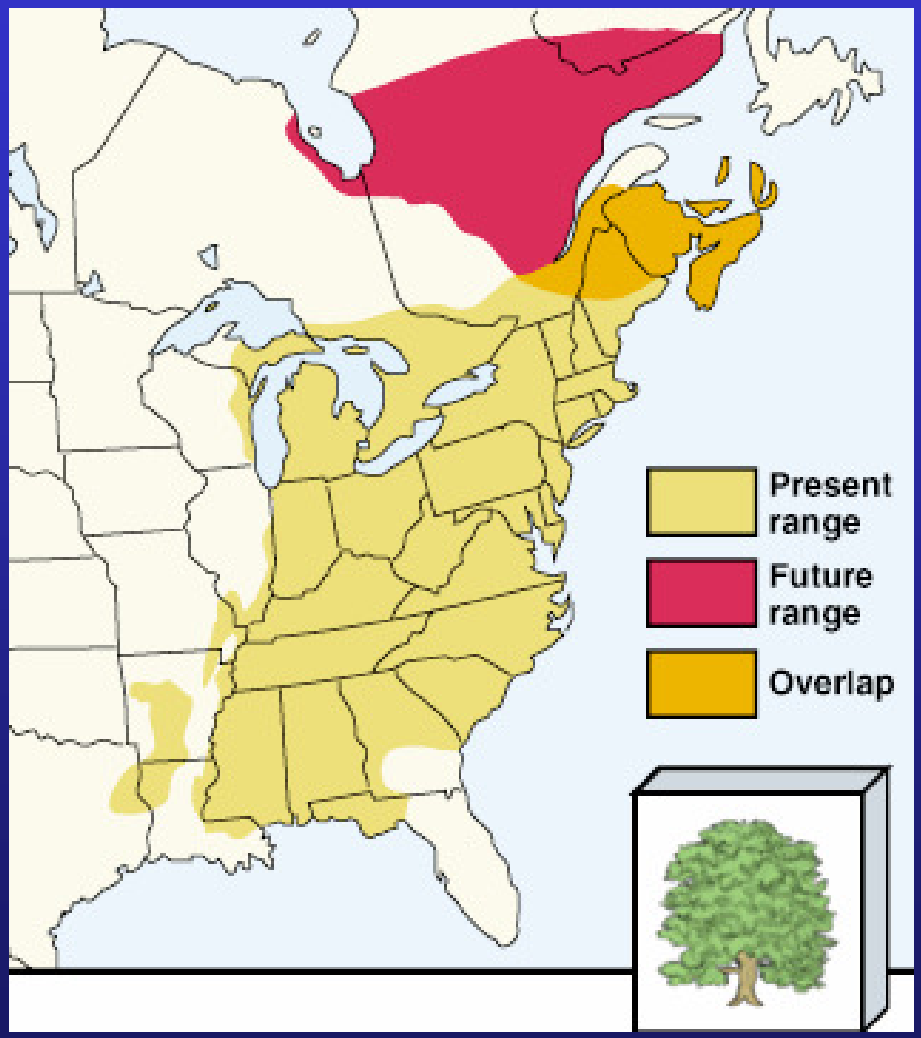
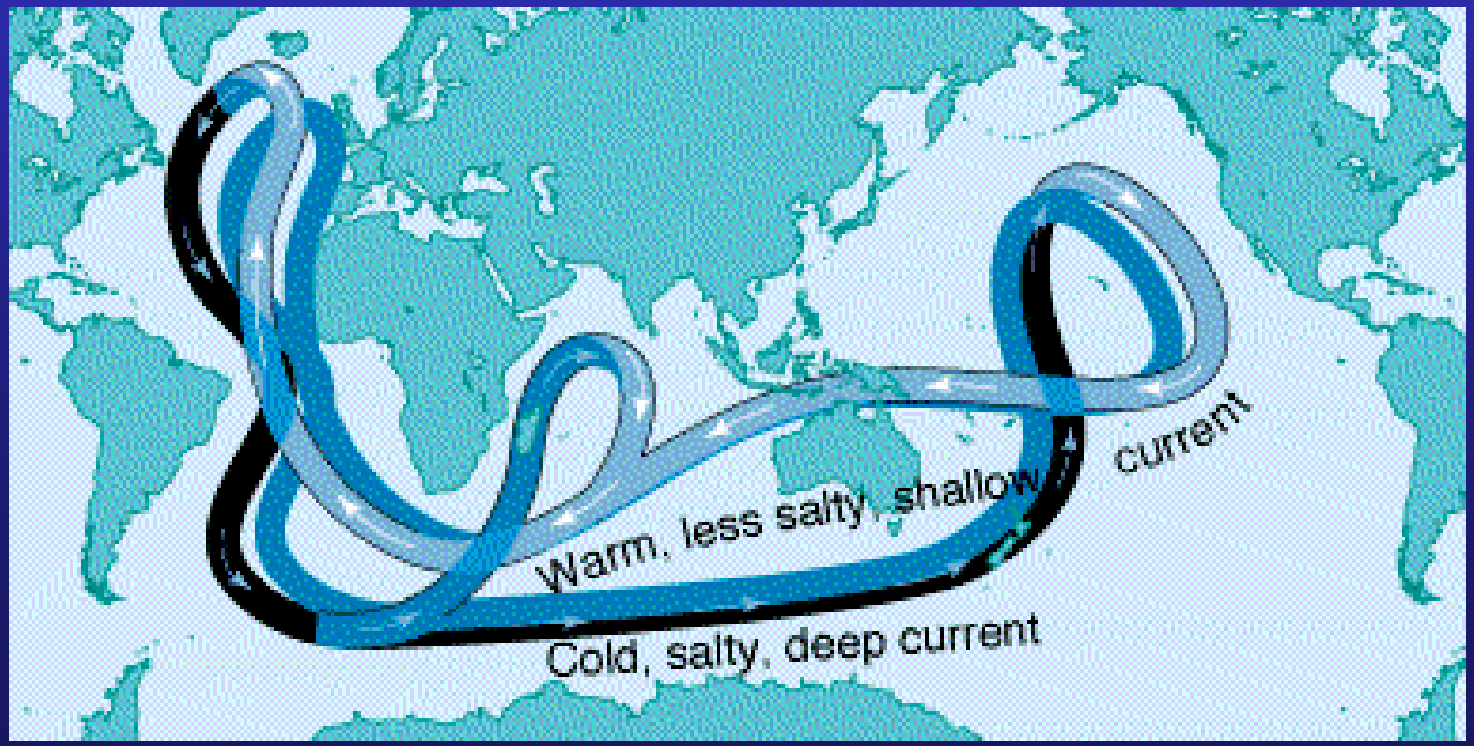


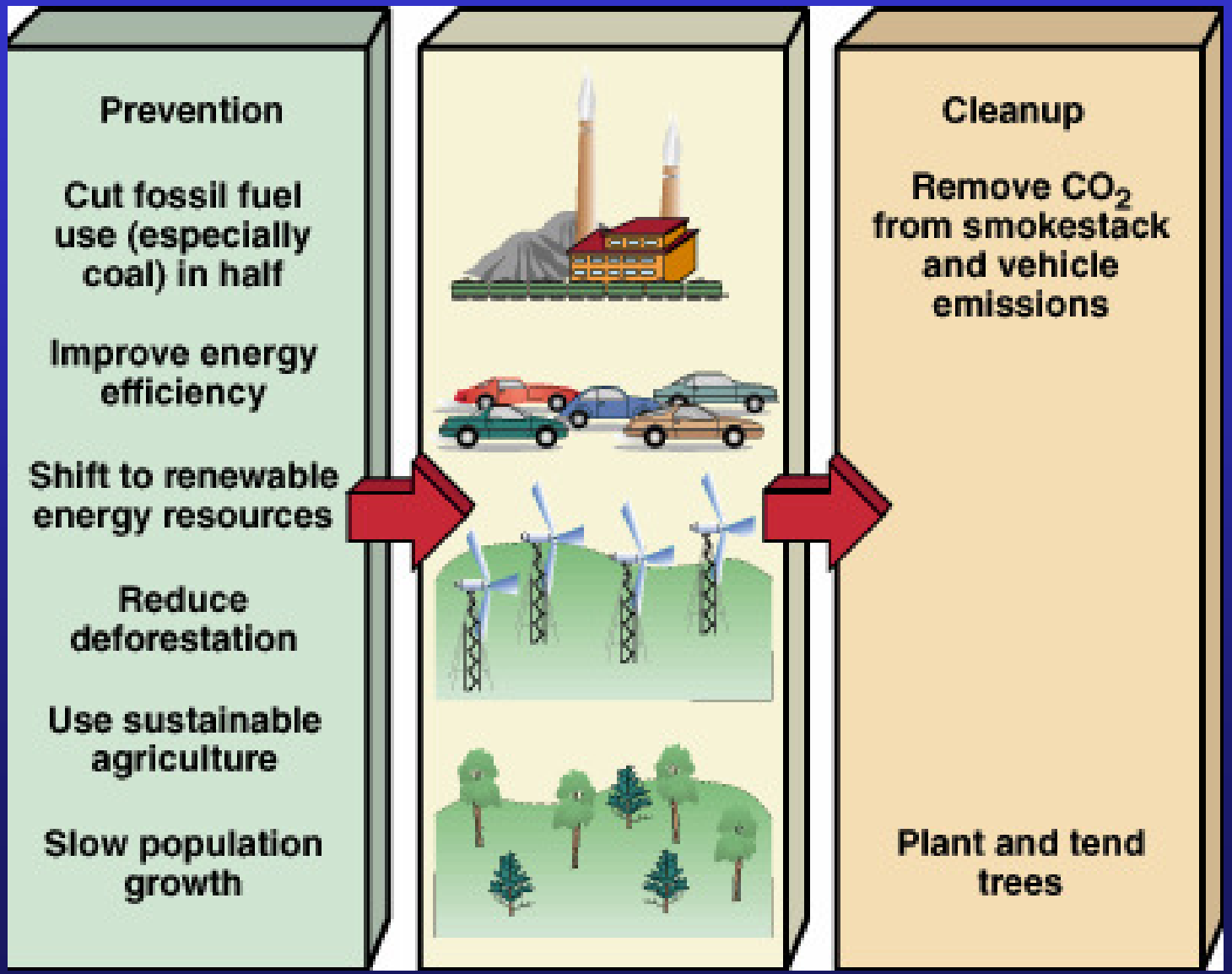
Fig. 19–8

Impact on Oceans

- Warming could decrease ability of ocean to absorb CO_2 & serve as “sink” for carbon
- Increases in CO_2 can lower pH of seawater impacting marine organisms & production of O_2



Solutions to Global Warming



2. What is the Ozone Shield?

Ozone Shield: a natural process that filters ultraviolet (UV) radiation before it reaches the lower atmosphere.

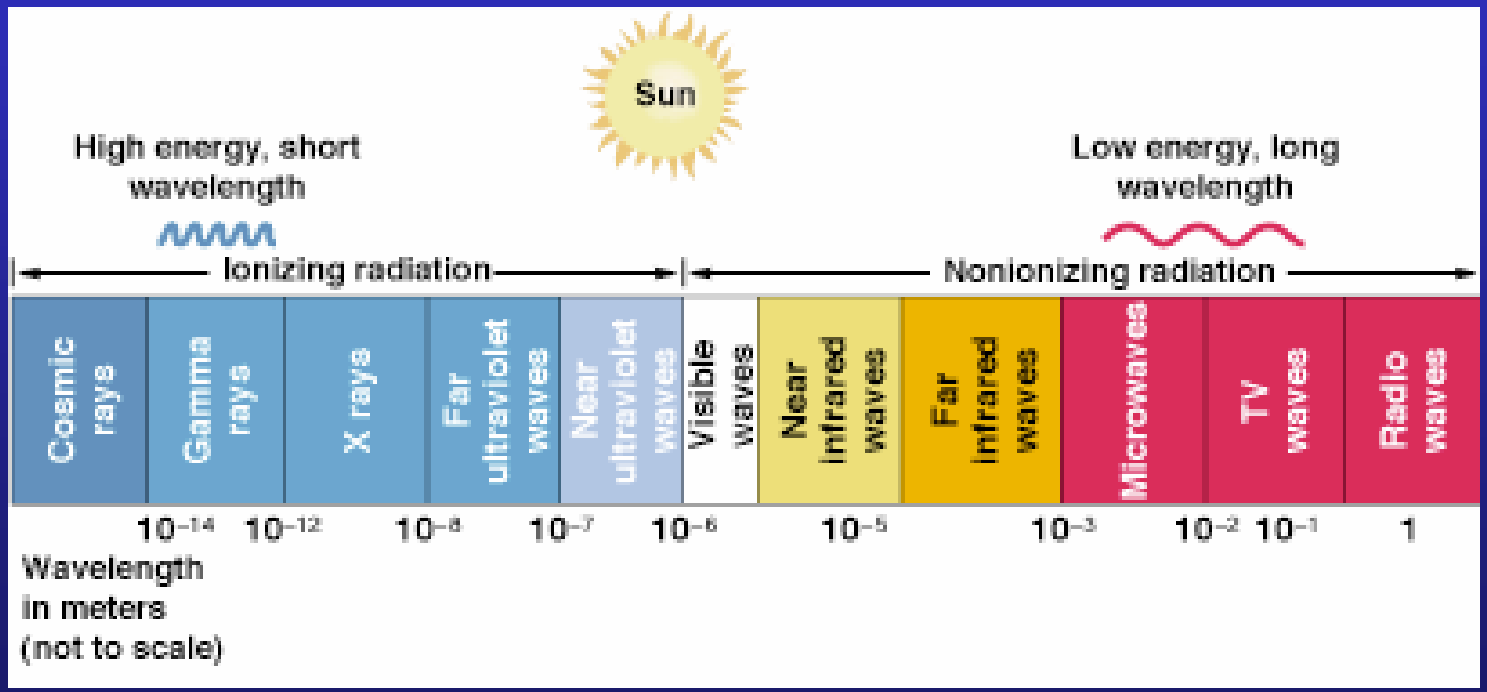


Fig. 3–13

Where does it occur?

- Ozone Shield: in stratosphere

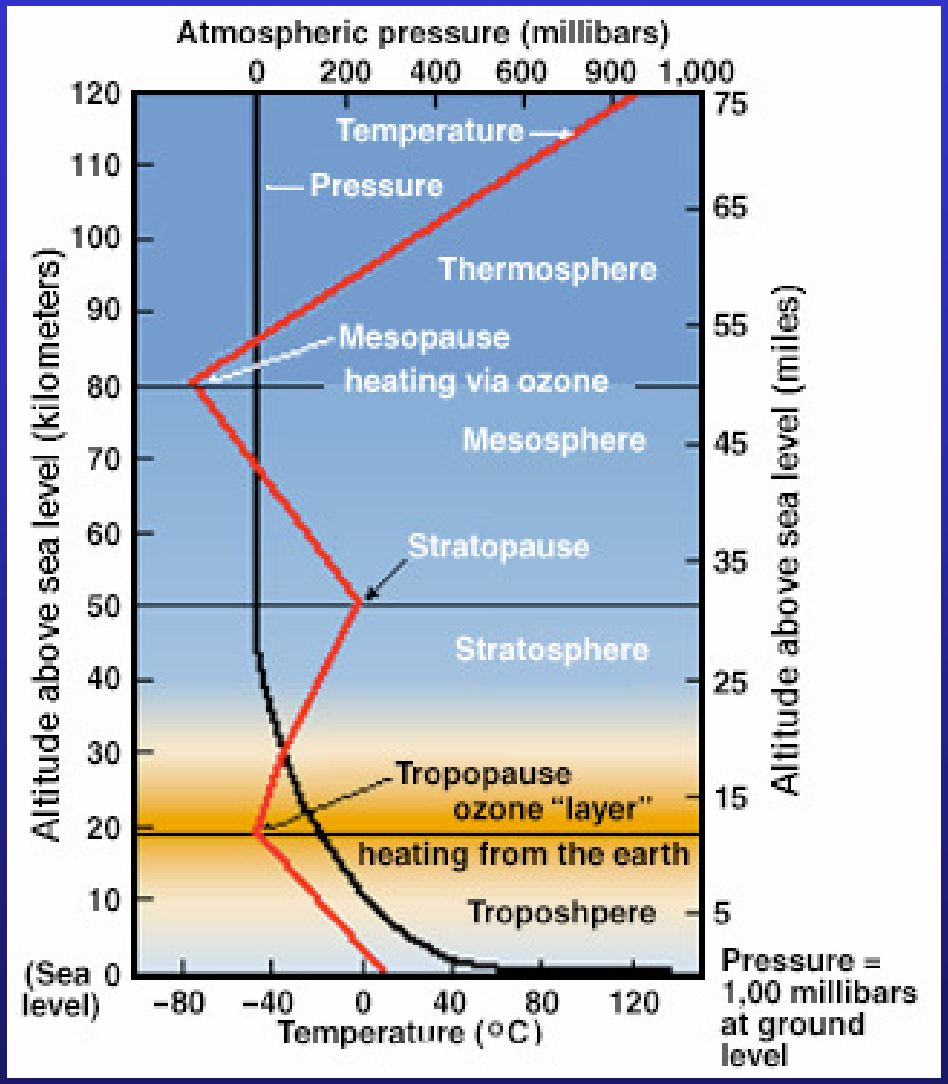
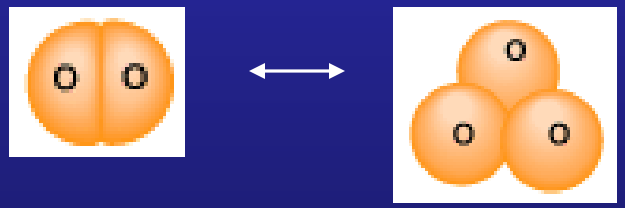


Fig. 18–2

What Natural Gases Are Involved?

oxygen O_2 ozone O_3



Human inputs?

Ozone Shield:

- chlorofluorocarbons (CFCs)
- other stable halogen–containing gases (halogens = chlorine, fluorine, & bromine)

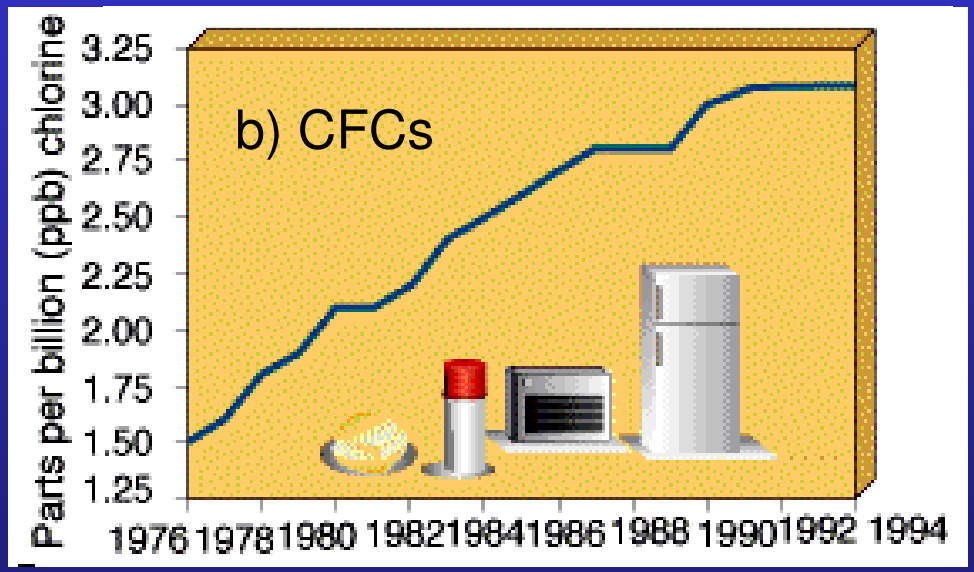
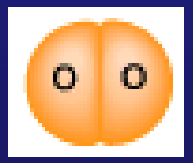


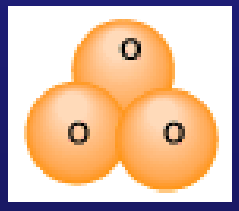
Fig. 19–2b

How Does Ozone Depletion Occur?

- CFCs stable in the troposphere, but drift into the stratosphere
- UV breaks off chlorine molecule (Cl) from CFC
- Cl acts as a catalyst to break down ozone (O_3)
  - catalyst – promotes a chemical reaction without itself being used up in the reaction
  - shifts equilibrium of oxygen / ozone reaction:

$$O_2 \longleftrightarrow O_3$$





How Does Ozone Depletion Occur?

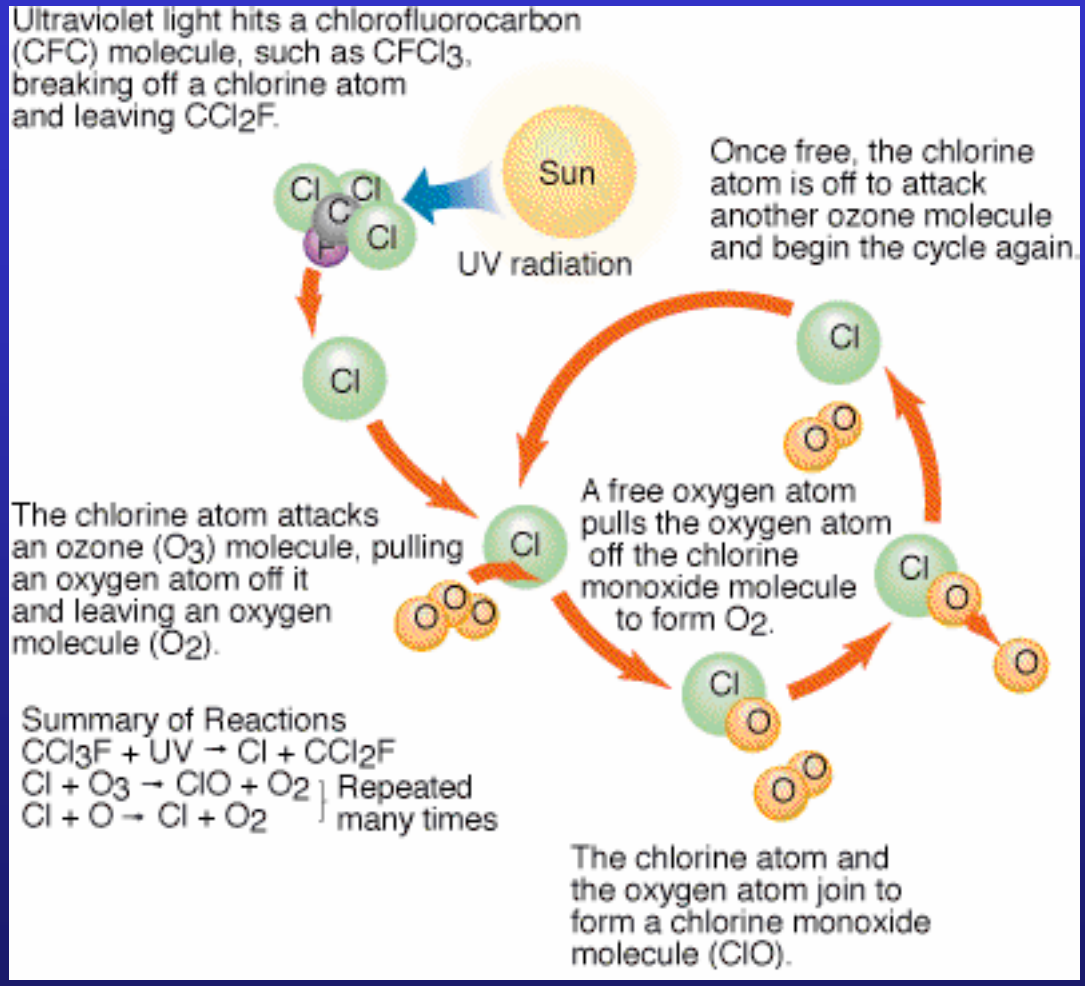


Fig. 19–12

Consequences of Increased Ozone Depleting Gases

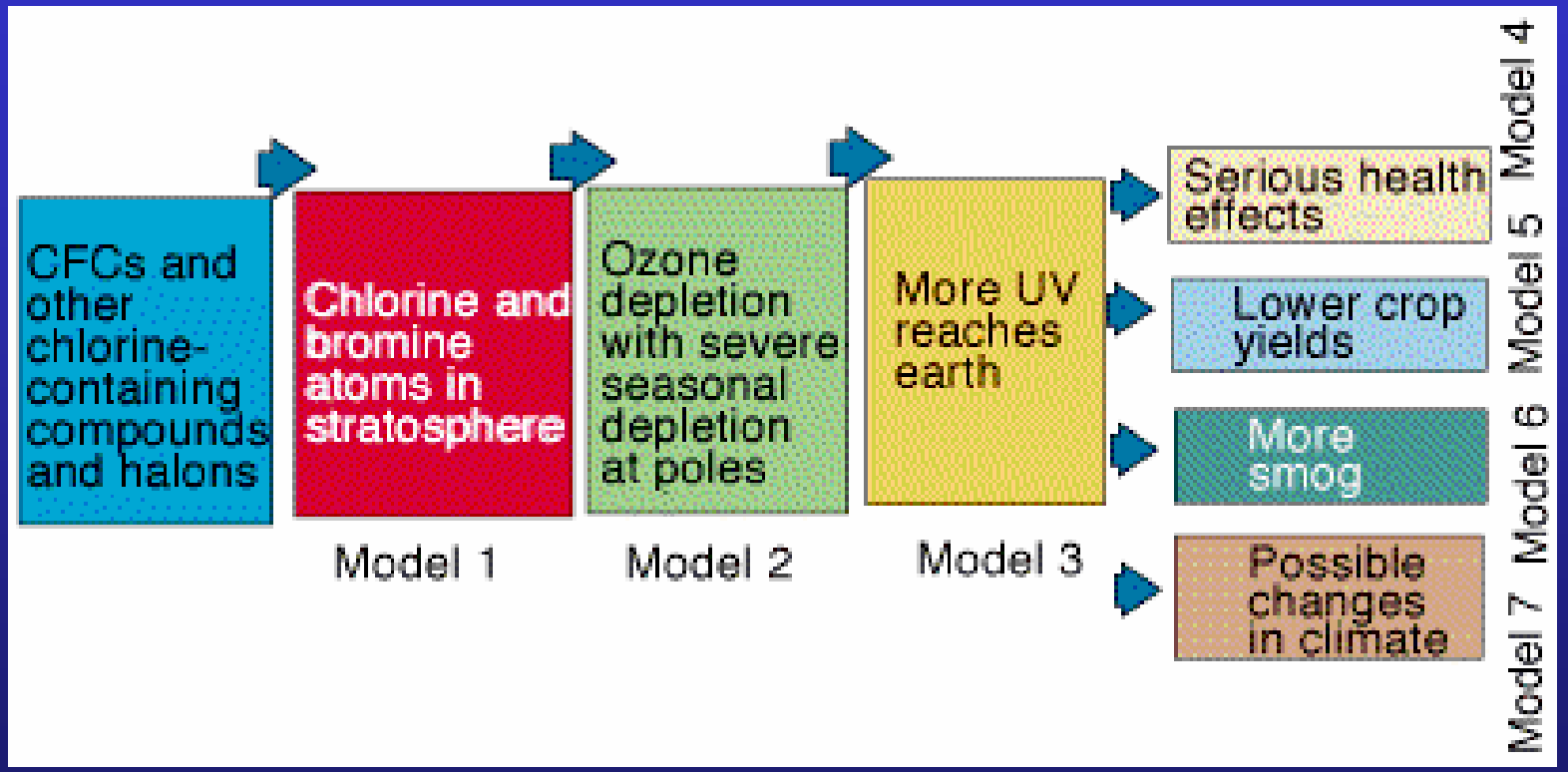


Fig. 19–11

Ozone Hole

- Seasonal thinning of the ozone layer has resulted at the poles, especially in the southern hemisphere.
- Recent models suggest the hole may not get larger.

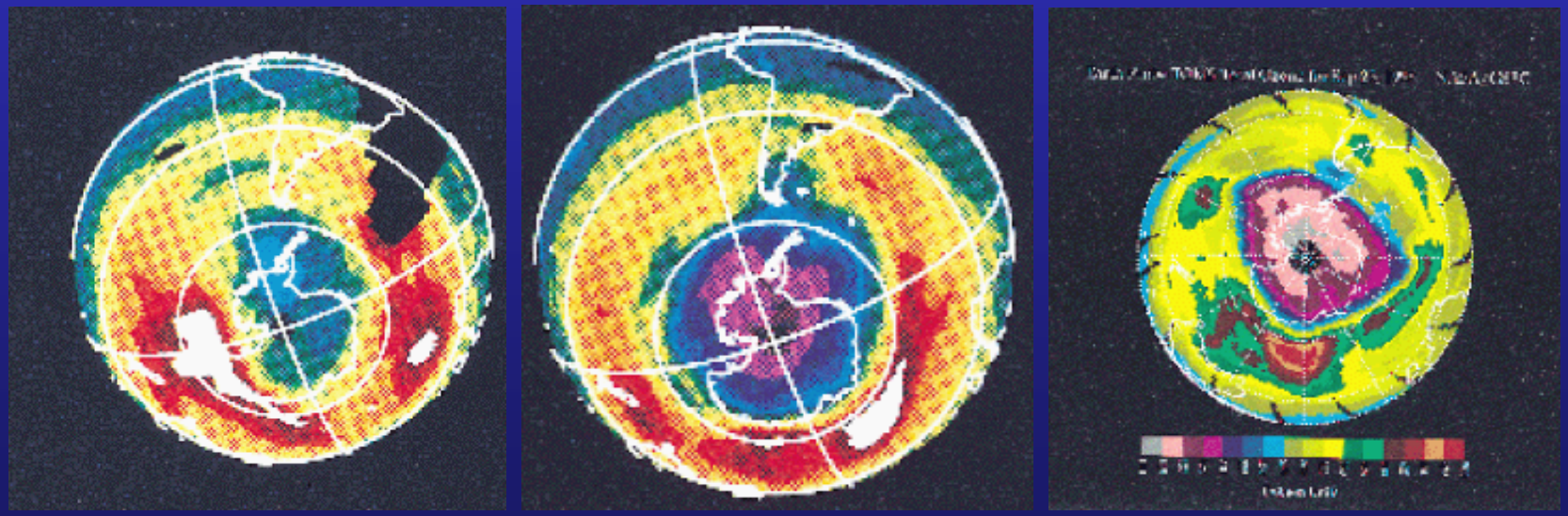


Fig. 19–13

Consequences of Ozone Depletion

- Serious Health Effects - increase in skin cancer & cataracts, especially in southern hemisphere
- More Smog - more ozone near earth's surface, produced in photochemical smog – lung problems, suppressed immune response, cancer

Ozone Loss

Projected total ozone loss, averaged over 2010-2019, during September for the Antarctic (left) and during March for the Arctic (right). According to the model used to make these projections, during this period the severity of ozone loss over the Arctic may approach that over the Antarctic. Dark red represents ozone depletion of 54% or more; light blue, 18-30%; dark blue, 6-12%.

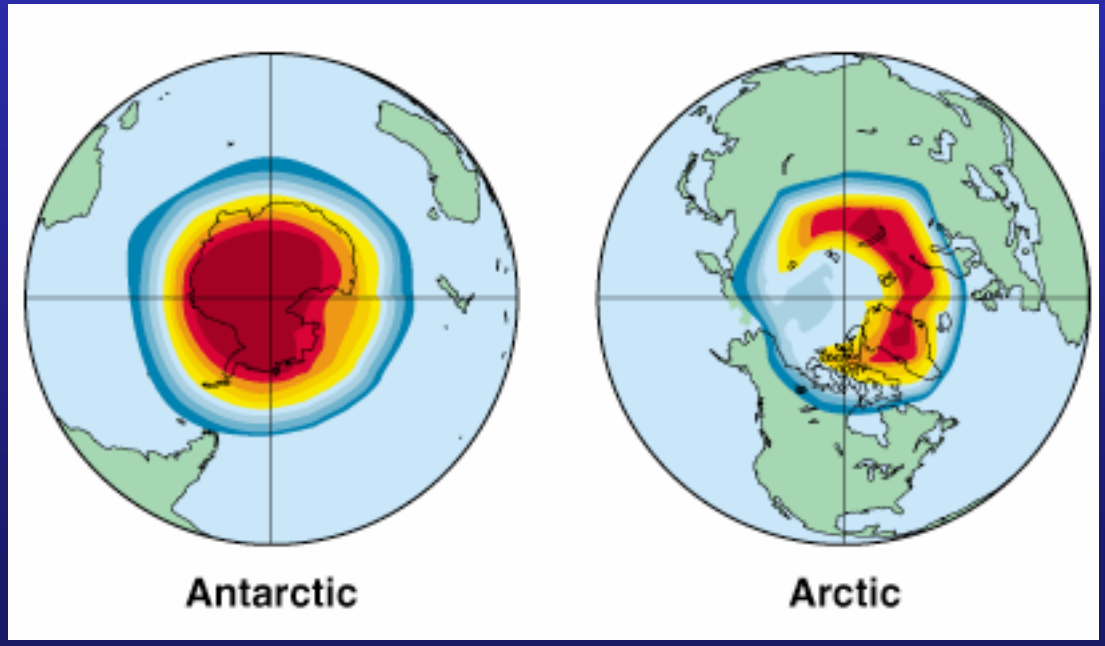


Fig. 19–14

Solutions to Ozone Depletion

- phase out use of ozone–depleting chemicals

  halons, CFCs, methyl chloroform, methyl bromide

- phase in use of CFC substitutes

  non–halogen aerosol propellants, hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), hydrocarbons (HCs), ammonia, water & steam, terpenes, helium