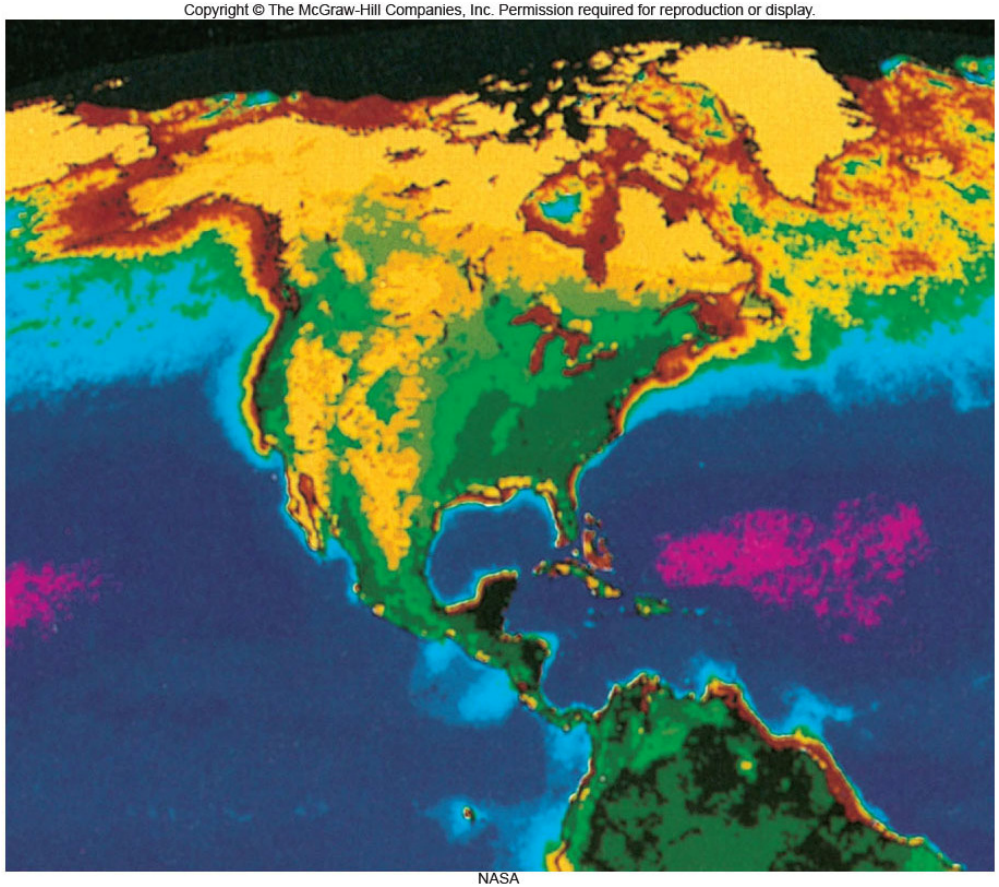
The Biosphere

Chapter 58



NASA

Effects of Sun, Wind, Water

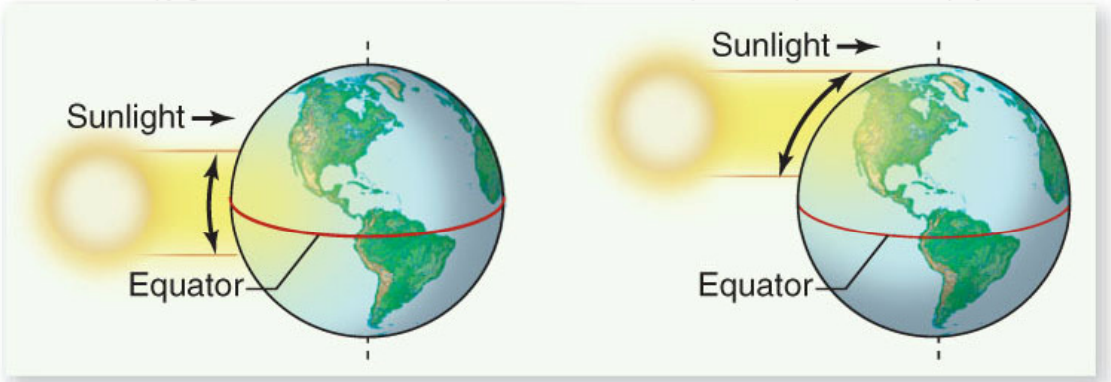
- **Biosphere:** includes all living communities on Earth
- Global patterns of life on Earth are influenced by
  1. The amount of solar radiation that reaches different areas
  2. Patterns of global atmospheric circulation which influence oceanic circulation

Effects of Sun, Wind, Water

- Earth receives energy from the Sun
- Solar radiant energy passes through the atmosphere and its intensity and wavelength composition are modified
- About 1/2 of the energy is absorbed within the atmosphere
  - UV-B is strongly absorbed by the ozone

Effects of Sun, Wind, Water

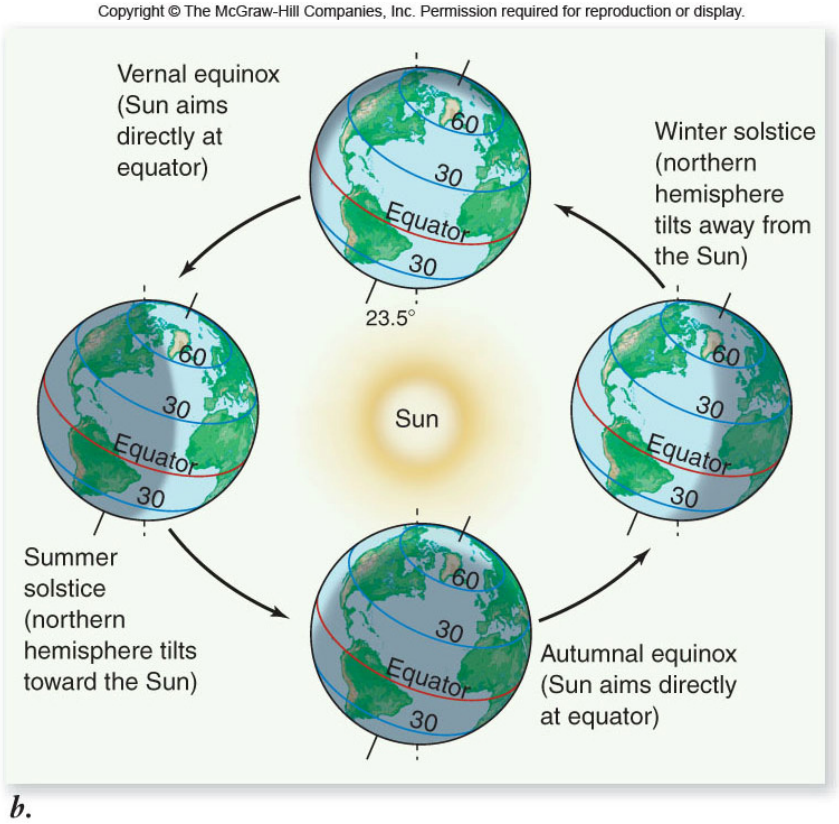
- Some parts of the Earth's surface receive more energy from the Sun than others
- This has a great effect on climate



a.

Effects of Sun, Wind, Water

- **Angle of incidence:** how the Sun's rays strike the spherical Earth
- Earth's orbit around the Sun and its daily rotation on its own axis affect climate



b.

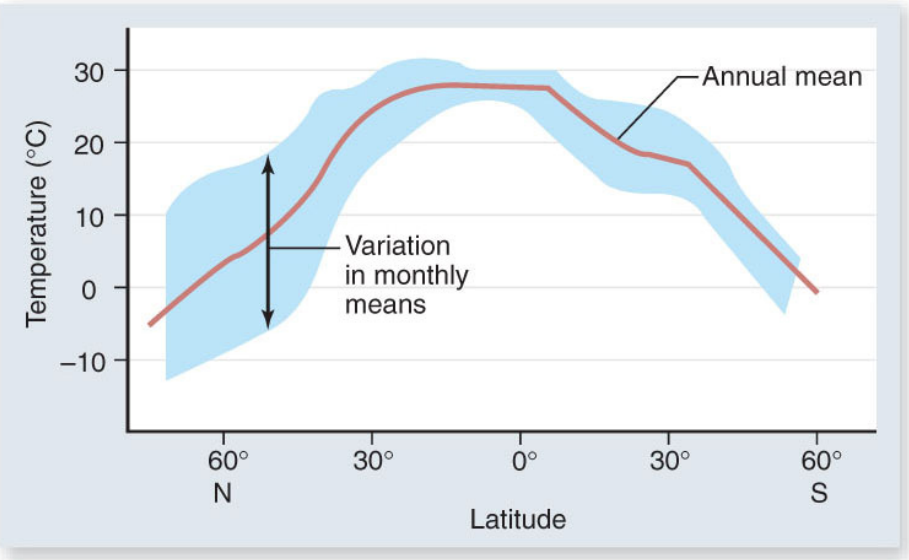
Effects of Sun, Wind, Water

- Global circulation patterns
  - Hot air rises relative to cooler air
  - Heating at the equator causes air to rise from the surface to high in the atmosphere
  - Rising air is rich in water vapor
    - Warm air holds more water than cold
    - Intense solar radiation at the equator provides the heat needed for water to evaporate

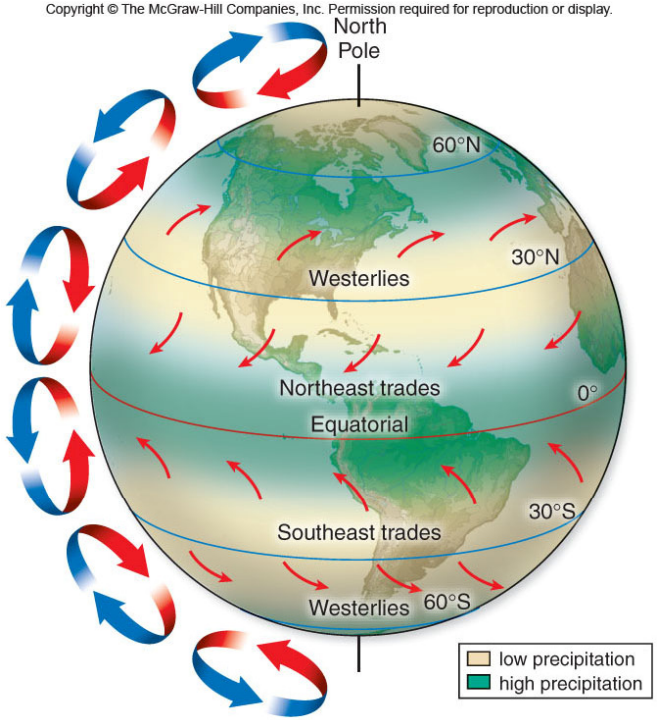
Effects of Sun, Wind, Water

- After the warm moist air moves from the surface at the equator
  - Warm air moves north and south
  - Cooler air flows toward the equator from both hemispheres
  - Air descends at 30˚ latitude-desert regions of the earth
  - At 60˚ latitude air begins to rise again

Effects of Sun, Wind, Water



Annual mean temperature varies with latitude

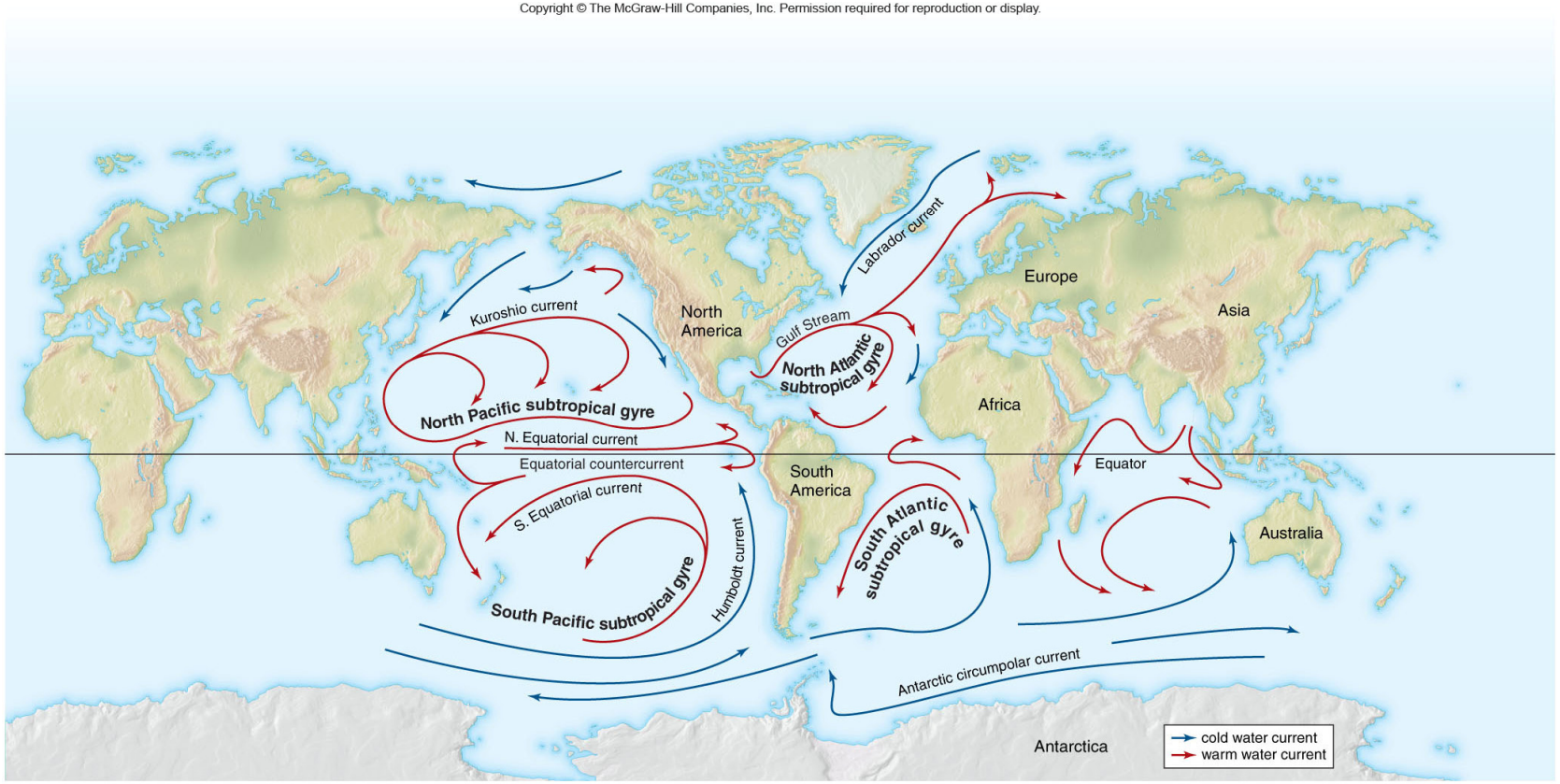


Global patterns of atmospheric circulation

Effects of Sun, Wind, Water

- **The Coriolis effect:** the curvature of the paths of the winds due to Earth's rotation
  - Northern hemisphere: counterclockwise--winds curve to the right of their direction of motion
  - Southern hemisphere: clockwise -- winds curve to the left; blow westward as well as toward the equator

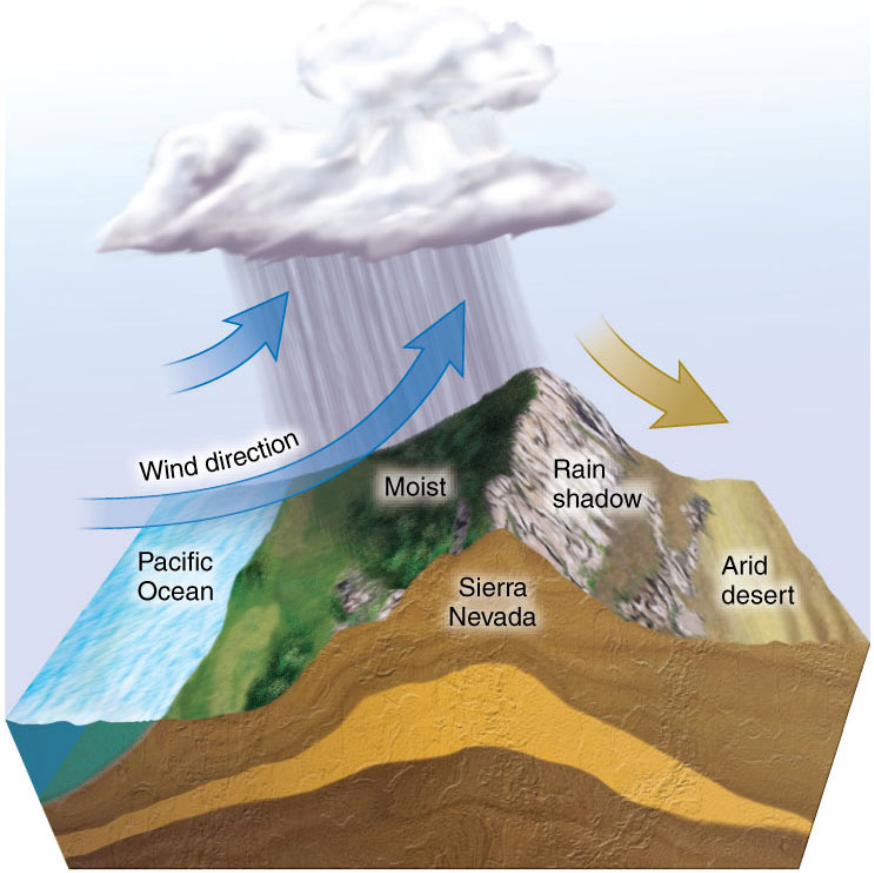
Effects of Sun, Wind, Water



Ocean currents are largely driven by winds

Effects of Sun, Wind, Water

- Regional and local differences affect terrestrial ecosystems
- Rain shadows:
  - Rain falls as air rises
  - Remains dry on the leeward side of the mountain

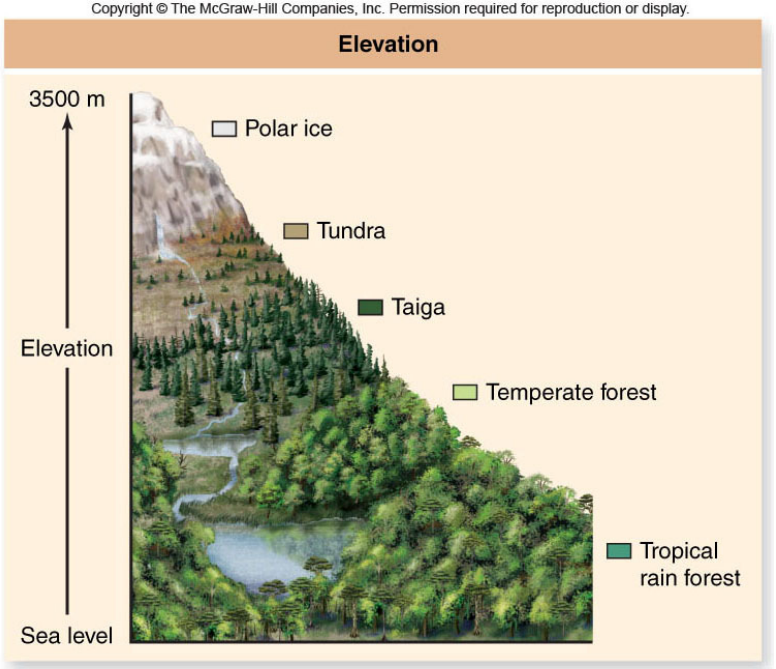


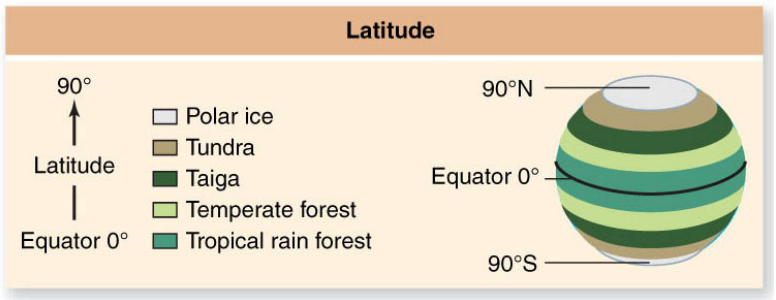
Effects of Sun, Wind, Water

- Monsoon winds
  - Heating and cooling of continent
  - Winds blow off the water into the interior in the summer
  - Winds blow off land onto the water in the winter
  - Winds affect rainfall patterns
    - Duration
    - Strength

Effects of Sun, Wind, Water

- Elevation: temperature and other conditions change with elevation
- Air temperature falls about 6˚C for every 1000m increase in elevation



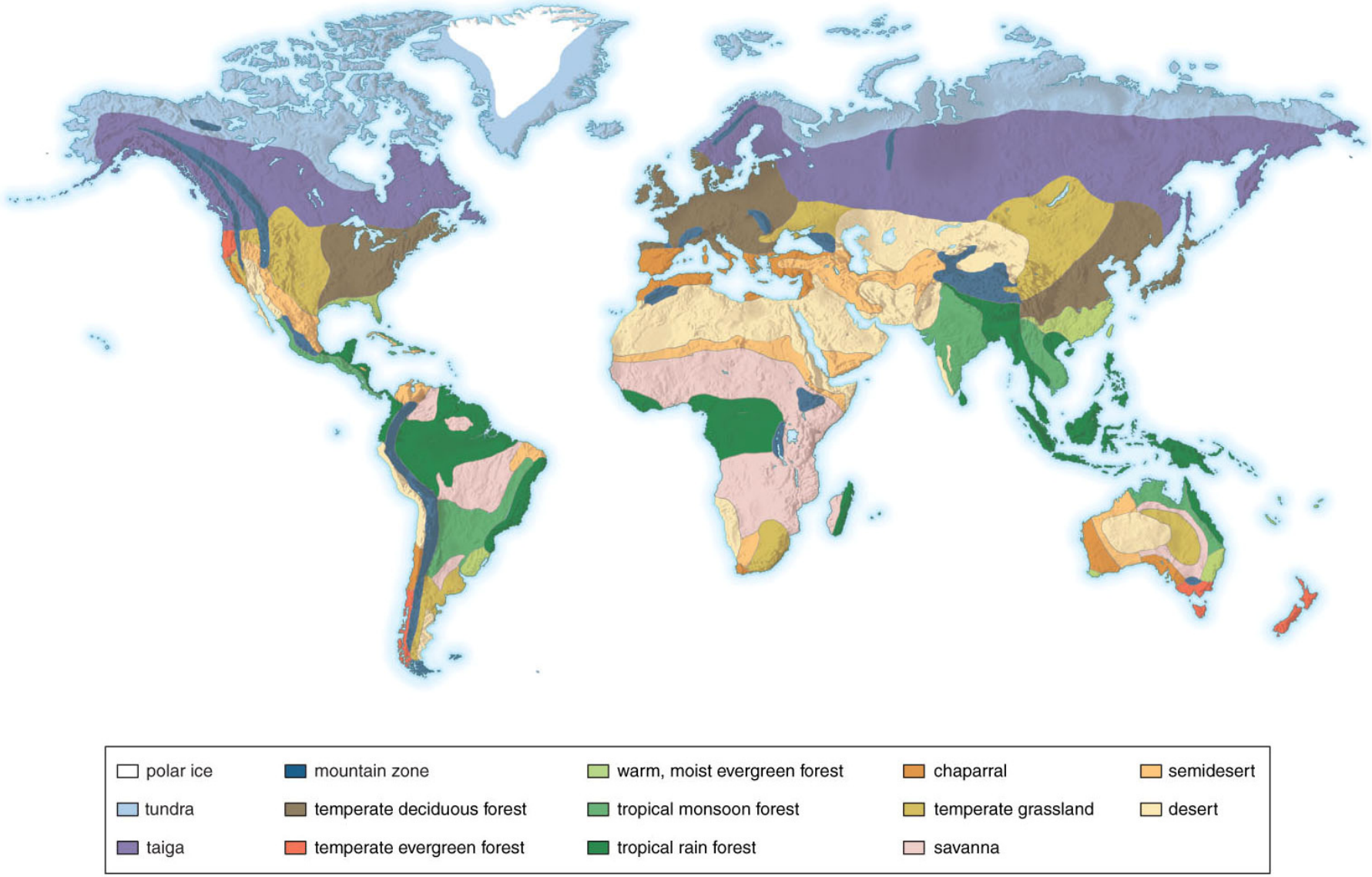


Effects of Sun, Wind, Water

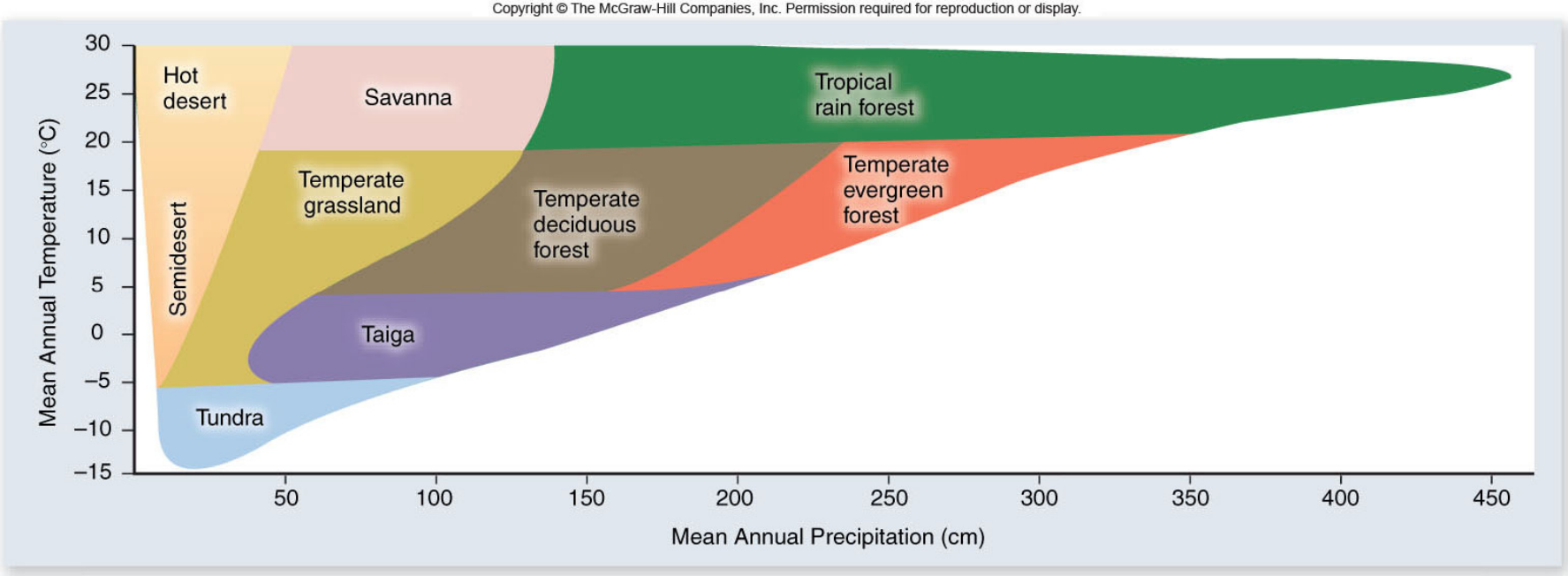
- Presence of microclimate factors
- **Microclimates:** highly localized sets of climatic conditions
  - Gaps in forest canopy
    - High air temperature and low humidity
  - Under a log in the forest
    - Low air temperature and high humidity

Biomes

- **Biomes:** a major type of ecosystem on land
- Each biome has a characteristic appearance
  - Defined largely by sets of regional climatic conditions
- Biomes are named according to their vegetational structures
- Eight principle biomes



Biomes



Predictors of biome distribution
Temperature and precipitation

Biomes

- Tropical rain forests
  - 140-450 cm rain/yr
  - Richest ecosystems on land
  - High temperature and high rainfall
  - Very high diversity: 1200 species of butterflies in a single square mile

Biome	Climate	Example Location	Characteristic Flora	Characteristic Fauna	
Tropical Rain Forest	High temperatures year round	 Brazilian rain forest	 Plant Species	 Animal Species	

Biomes

- Savanna
  - 50-120 cm rainfall/yr
  - Tropical or subtropical grasslands
  - Occur as a transition ecosystem between tropical rainforests and deserts
  - Serengeti of East Africa

Biome	Climate	Example Location	Characteristic Flora	Characteristic Fauna	
Savanna	Warm temperatures year round	 Serengeti	 Plant Species	 Animal Species	

Biomes

- Deserts
  - 25-40cm rainfall/yr; unpredictable
    - Plants and animals cannot depend on any rainfall
  - 30˚N and S latitudes, rainshadows
  - Vegetation sparse, animals adapted to little water availability

Biome	Climate	Example Location	Characteristic Flora	Characteristic Fauna	
Desert	Warm and cool temperatures	 Mojave	 Plant Species	 Animal Species	

(left to right): © Adam Jones/Getty Images; © age fotostock/SuperStock

Biomes

- Temperate grasslands: prairies
  - Rich soils
  - Grasses with roots that penetrate deep into the soil
  - In North America converted to agricultural use
  - Adapted to periodic fire

Biome	Climate	Example Location	Characteristic Flora	Characteristic Fauna	
Temperate Grasslands	Warm summers cool winters	 South Dakota prairie	 Plant Species	 Animal Species	

	Biome	Climate	Example Location	Characteristic Flora	Characteristic Fauna
	Temperate Deciduous Forest	Warm summers cool winters	 Acadia National Park	 Plant Species	 Animal Species
	Temperate Evergreen Forest	Temperate climates	 Mount Hood	 Plant Species	 Animal Species
	Taiga	Cold temperatures	 Northwest Territory, Canada	 Plant Species	 Animal Species
	Tundra	Cold temperatures	 Alaska	 Plant Species	 Animal Species

Freshwater Habitats

- Fresh water covers only 2% of Earth's surface
- Formation of fresh water
  - Evaporation of water into atmosphere
  - Falls back to Earth's surface as precipitation
- Wetlands: marshes, swamps, bogs
- Rivers, lakes, streams

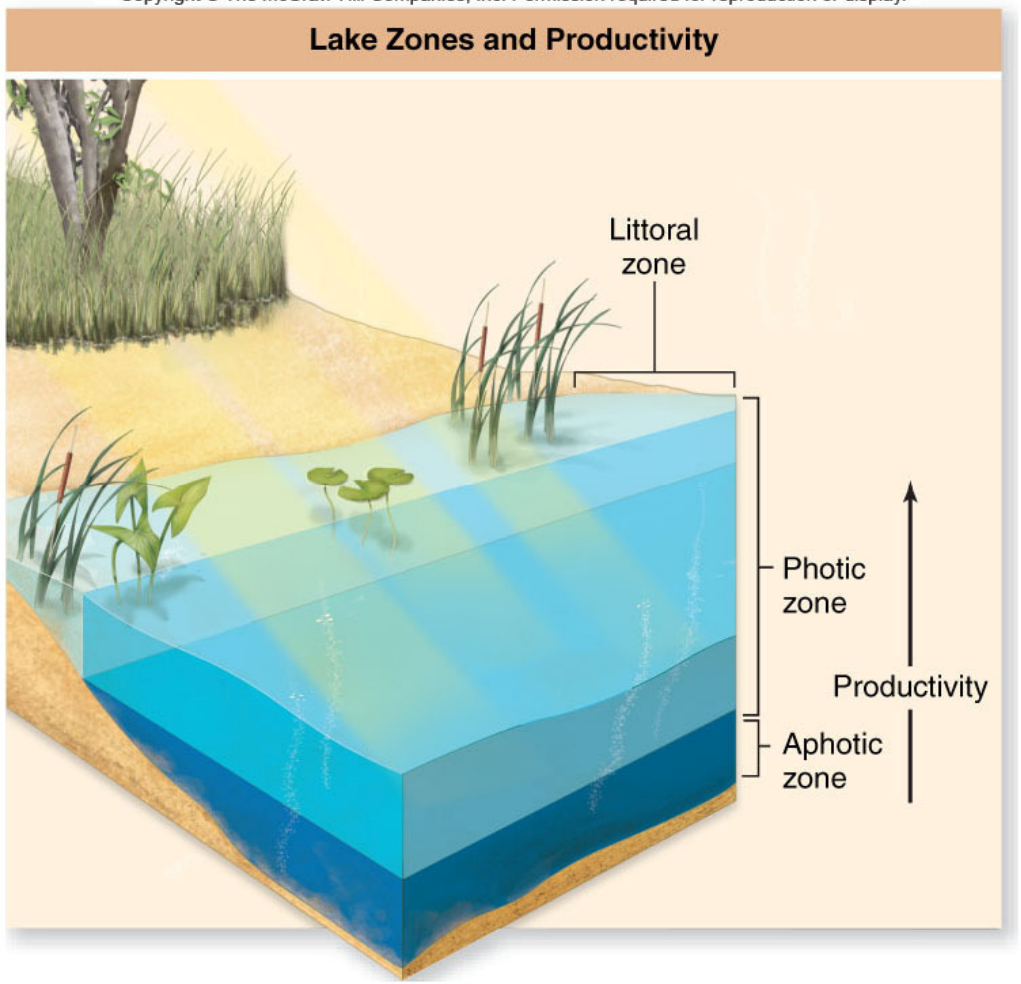
Freshwater Habitats

- Life depends on oxygen availability
  - Oxygen per liter is only 5% of that in the atmosphere
- Oxygen added by photosynthesis and aeration from the atmosphere
- Oxygen is removed by animal and detritivores respiration, and through decaying organic matter
- Warm water holds less O_2 than cooler water

Freshwater Habitats

- Lake and pond habitats change with water depth
  - Intensity of light decreases with water depth
  - **Photic zone:** area where light penetrates and photosynthesis is possible
  - **Littoral zone:** shallows at edge of lake
  - **Aphotic** (benthic) **zone**: below light penetration level

Freshwater Habitats



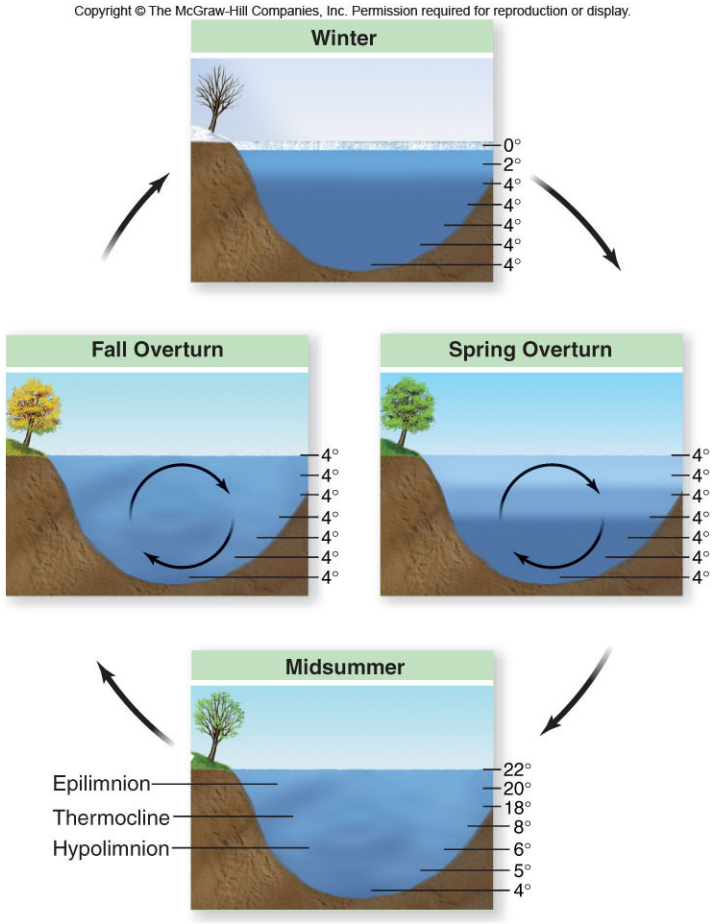
Lake Zones and Productivity

Freshwater Habitats

- **Thermal stratification:** warm water is less dense than cold water and tends to float on top. Layering is stratification.
- **Thermocline:** a transition layer between warm and cold waters
- Water is most dense at 4˚C and least dense at 0˚C
- Thermal stratification tends to cut off the oxygen supply to bottom waters
- Anoxia: oxygen depleted waters

Freshwater Habitats

- Wind can force the layers to mix



Annual cycle of thermal stratification in a temperate-zone lake

Freshwater Habitats

- Oligotrophic water: low in nutrients, usually high in oxygen
- Crystal clear conditions because of the low amount of organic matter
- Light penetrates deep in the water column

Oligotrophic Lake

a.

Freshwater Habitats

- Eutrophic water: high in nutrients, densely populated with algae and plant material
- Low in dissolved oxygen in summer
- Light does not penetrate the water column

Eutrophic Lake

b.

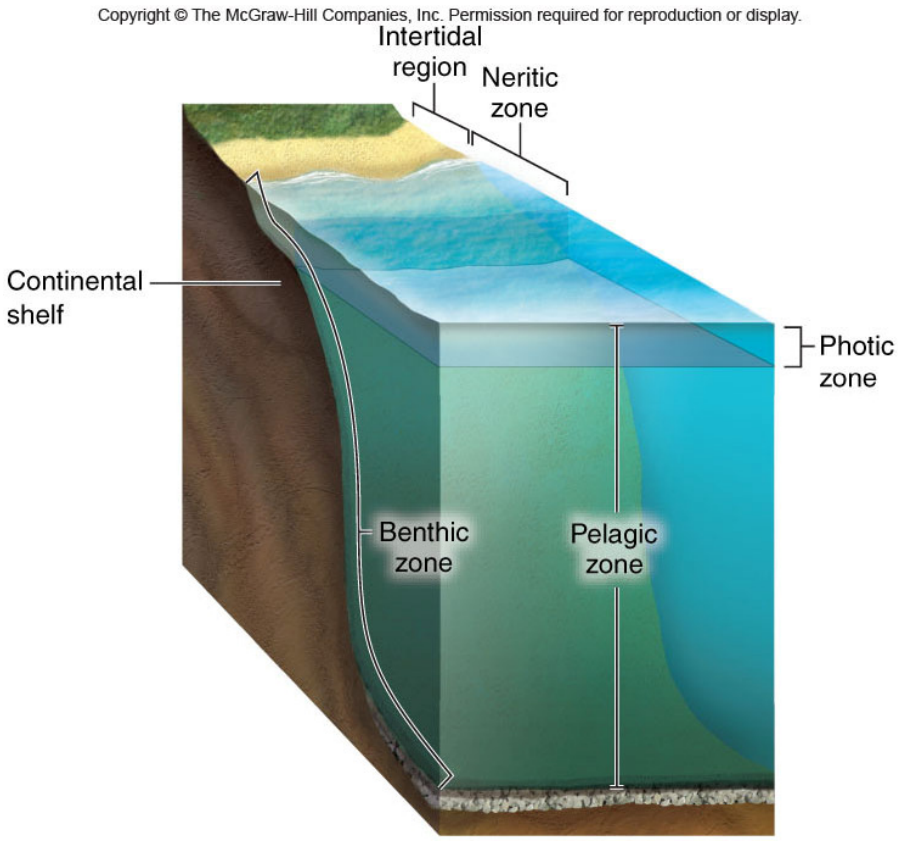
Marine Habitats

- 71% of the Earth's surface is covered by ocean
- Continental shelves: near coastlines, water is not especially deep
  - ~ 80km wide and 1m to 130m deep
- Average depth of the open ocean is 4,000 - 5,000m deep
  - Trenches: 11,000m deep
- Principle primary producers are phytoplankton (single cell or colonial)

Marine Habitats

- Oceanic Zones

- Open oceans have low primary productivity
- Oligotrophic ocean: Low nutrient levels "biological deserts"



Marine Habitats

- Continental shelf ecosystems provide abundant resources
- **Neritic waters:** waters over the shelves
  - High concentrations of nitrates and other nutrient
  - Shallow, up welling occurs here
- 99% of ocean food supply comes from neritic waters
- Petroleum comes almost exclusively from shelves

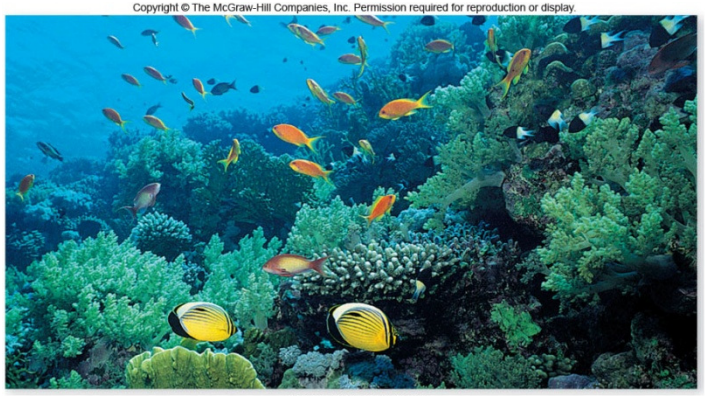
Marine Habitats

- **Estuaries:** shelf ecosystem where fresh water from streams or rivers mix with ocean water
  - **Intertidal habitat:** area that is exposed to air at low tide but under water at high tide
  - **Salt marshes:** in the intertidal zone
  - **Mangrove swamps:** occur in tropical and subtropical intertidal zones

Marine Habitats

Mangrove Swamp

Louisiana Marsh



Coral Reef

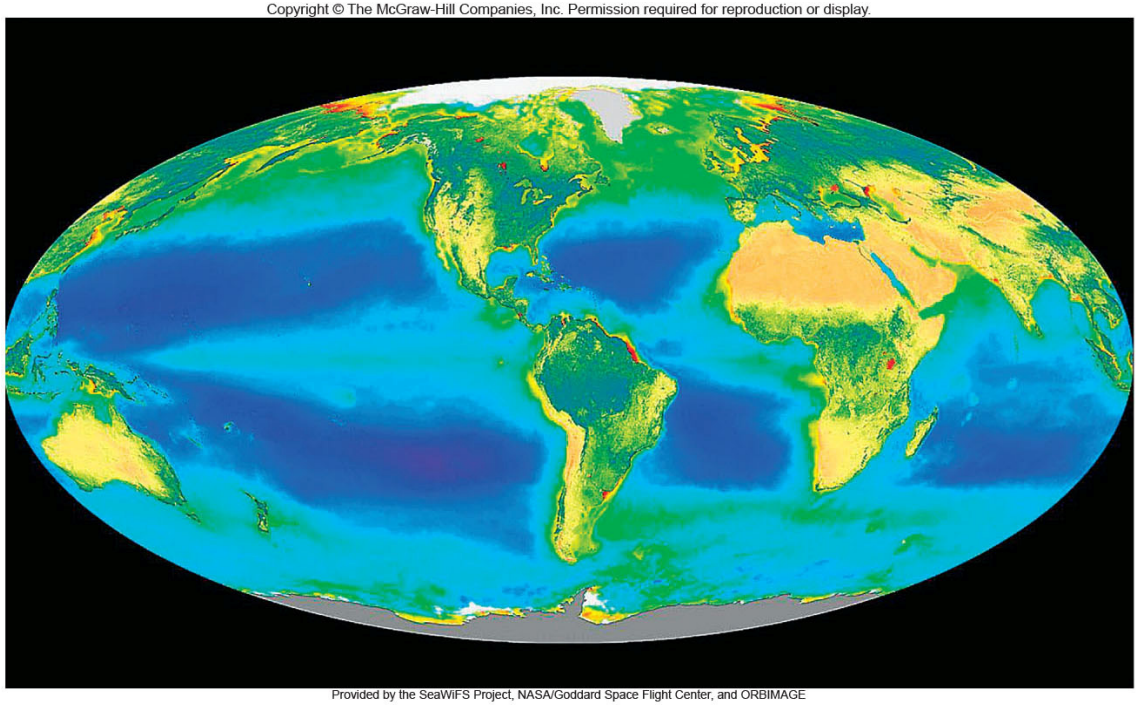
Marine Habitats

- Banks and coral reefs
  - Banks are local shallow areas on the shelves
    - Fishing grounds
  - Coral reefs occur in subtropical and tropical latitudes
  - Defining feature is stony corals
    - Algal symbioses: cnidarians and dinoflagellates

Marine Habitats

Green areas are upwelling regions

Dark blue are oligotrophic



Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE

Upwelling regions: localized places where deep water is drawn consistently to the surface

Marine Habitats

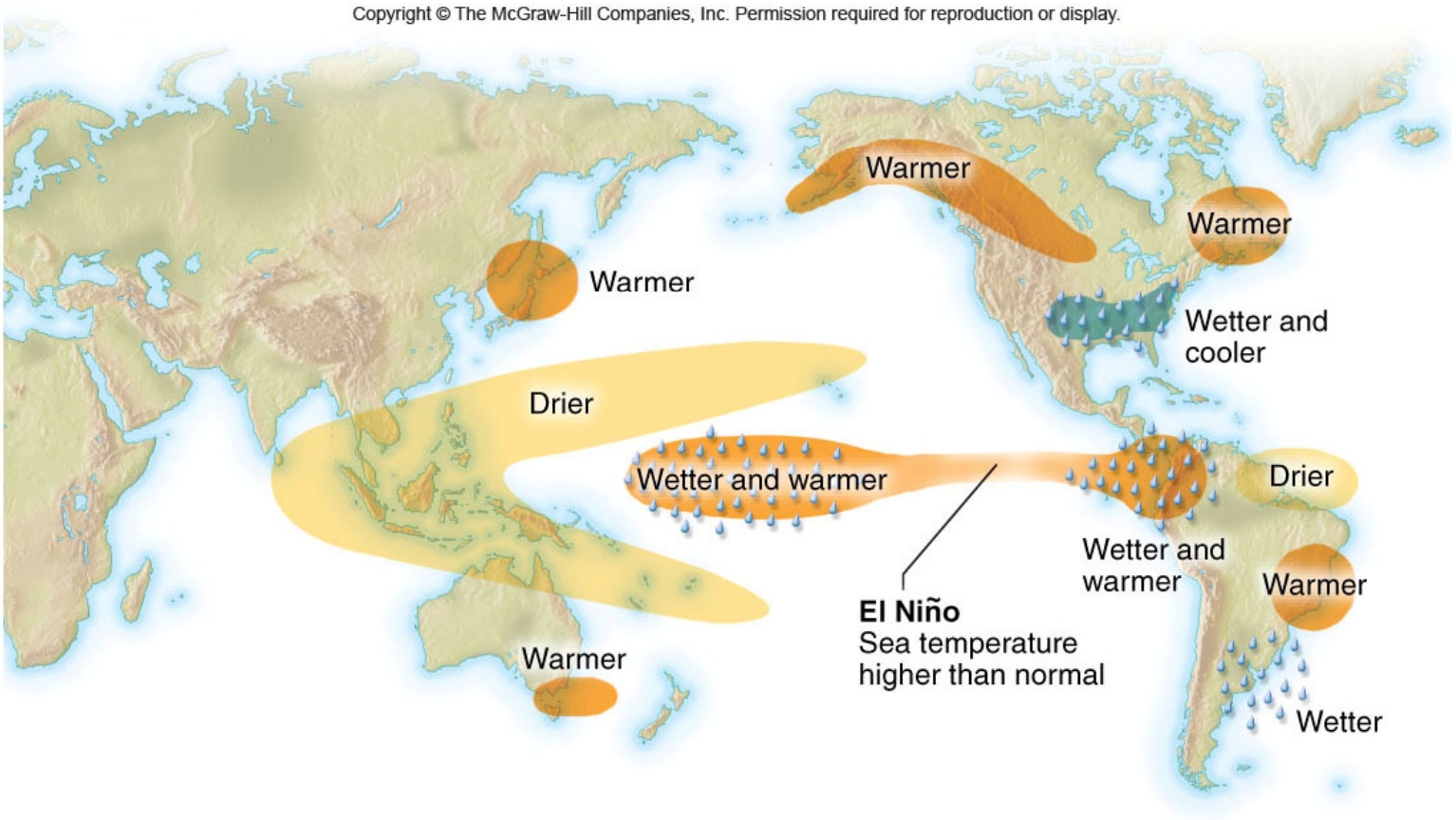
- *El Niño Southern Oscillation*
  - 2-7 years on an irregular and unpredictable basis
  - Coastline waters become waters become profoundly warm
  - Primary productivity unusually low
  - Weakening of the east-to-west Trade Winds
  - Upwelling continues, but only recirculates the thick warm surface layer

Marine Habitats

- El Niño can wreak havoc on ecosystems
  - Plankton abundance can drop to 1/20th normal levels
  - Fish stocks disappear
  - Seabirds and sea lion populations crash
- On land:
  - Heavy rains produce abundant seeds and land birds flourish
  - Increase rodent population
  - Increase predator population

Marine Habitats

El Niño winter



Marine Habitats

- Deep sea: cold, dark place with fascinating communities
  - Seasonless, 2-5˚C, pressure: 400-500 atms
- Food originates from photosynthesis in the sunlit waters
- 99% eaten as it drifts down through the water column
- Animals: small-bodied, thinly distributed

Marine Habitats

Hydrothermal vent communities: thick with life

- Large bodied animals
- Do not depend on the Sun's energy for primary production
- Depend on sulfur-oxidizing bacteria
- Water temperature up to 350˚C

a.

© Jim Church

b.

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Marine Habitats

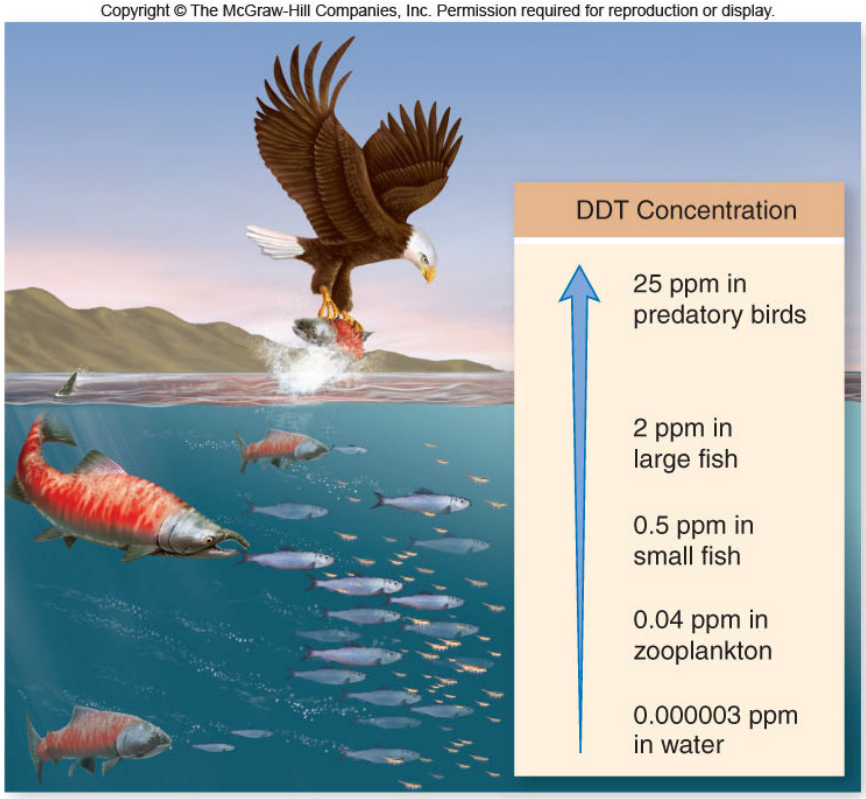
- Once Trade Winds weaken a bit, the pressure difference that makes them blow is lessened, weakening the Trade Winds even more
  - Shift the weather systems of the western Pacific Ocean 6,000km eastward
  - Tropical rainstorms fall on Peru and Ecuador

Human Impacts: Pollution

- Human impacts can cause adverse changes in ecosystems
- DDT: highly effective insecticide, sprayed in United States after WWII
- DDT is oil soluble and biomagnifies in the food chain
- Result of use:
  - Populations of ospreys, bald eagles, and brown pelicans plummeted

Human Impacts: Pollution

- Biomagnification of DDT concentrations in the food chain. Predatory bird species were affected because it made their eggshells so thin that the shells broke during incubation



Human Impacts: Pollution

- Freshwater habitats are threatened by pollution and resource use
- **Point source pollution:** comes from an identifiable location
  - Factories
  - Sewage-treatment plants
- Laws and technologies can be applied because the source is known

Human Impacts: Pollution

- **Diffuse pollution:** is exemplified by eutrophication caused by excessive run-off of nitrates and phosphates
  - Dissolved oxygen declines
  - Fish species change, carp take the place of more desirable species
- Can originate from thousands of lawns, farms, golf clubs…
- Solutions depend on public education and political action

Human Impacts: Pollution

- Pollution from coal burning: acid precipitation
  - When coal is burned sulfur oxide is released
  - Sulfur oxide combines with water in the atmosphere to create sulfuric acid
- Mercury emitted in stack smoke is a second potential problem
  - Mercury biomagnifies: causes brain damage in humans

Human Impacts: Pollution

- Acid precipitation and mercury pollution affect freshwater ecosystems
  - pH levels below 5.0, many fish species and other aquatic animals die or are unable to reproduce
  - Mercury accumulates in the tissues of food fish: dangerous to public health

Human Impacts: Pollution

- Terrestrial ecosystems are threatened by deforestation
  - Single greatest problem is deforestation by cutting or burning

a. © Peter May/Peter Arnold Inc

b. © Frans Lanting/Minden Pictures

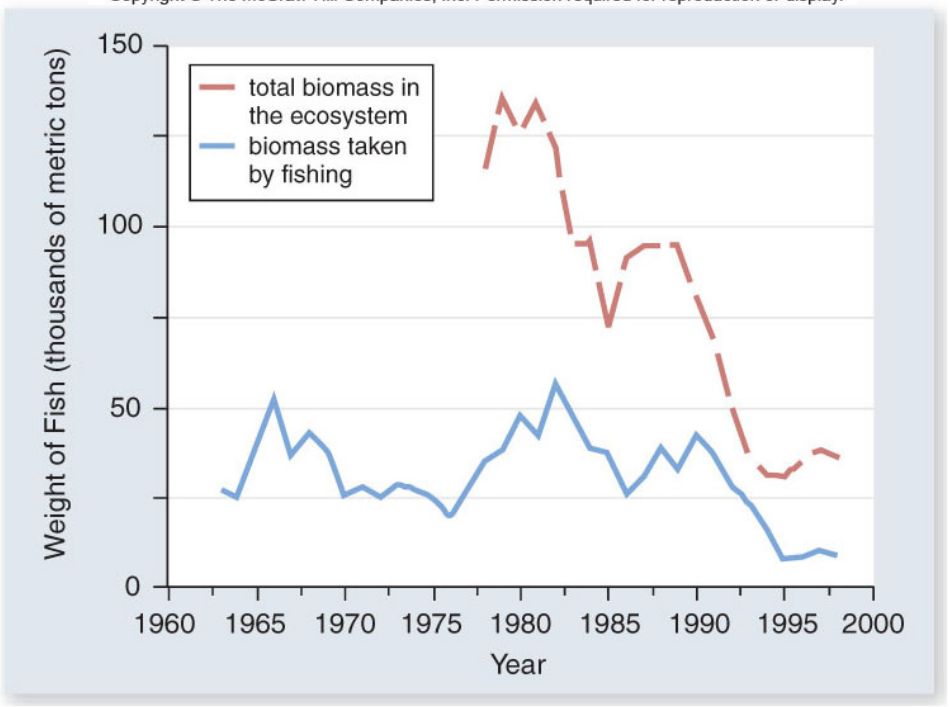
Human Impacts: Pollution

- Deforestation consequences
  - Loss of habitat
  - Major contributing factor in increased desertification
  - Loss of nutrients from soils
  - Eutrophication of lakes, streams, and rivers
  - Disruption of the water cycle
  - Loss of topsoil

Human Impacts: Pollution

- Overfishing of the ocean
  - Crisis proportions -- single greatest problem in the ocean realm

Poaching on terrestrial animals increases when fish populations decline



Human Impacts: Pollution

- Aquaculture is only a quick fix
  - Dietary protein needs of many aquacultured fish are met with wild-caught fish
  - Often damage natural ocean ecosystems: clearing of mangrove swamps for aquaculture area

Human Impacts: Pollution

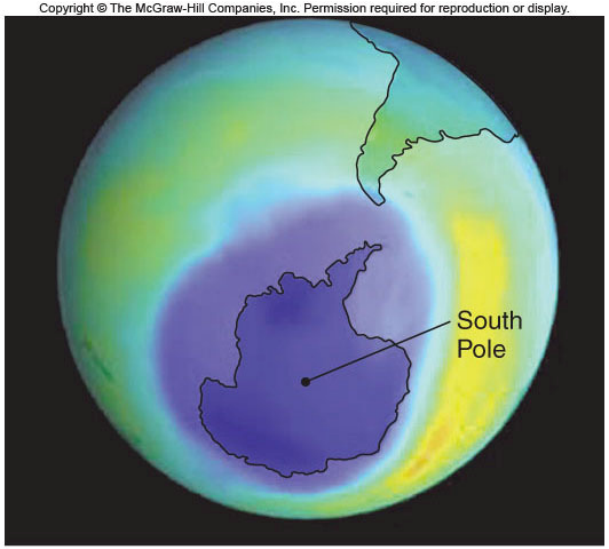
- Pollution effects in the ocean
  - Plastic found washed up on beaches in remote areas
  - Waters are laced with toxic chemicals
  - Biopsy of tissue from Arctic killer whales reveal high levels of pesticides and flame-retardant chemicals

Human Impacts: Pollution

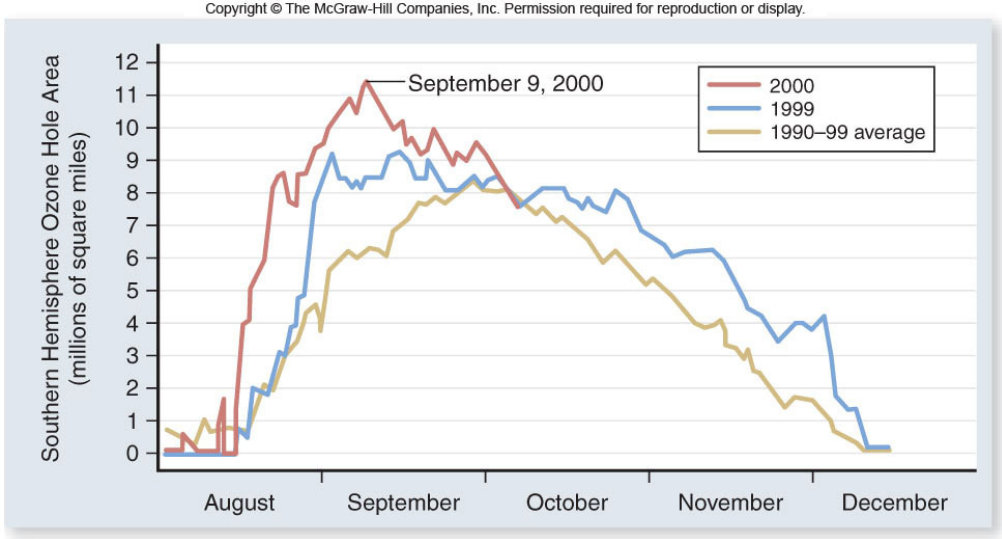
- Destruction of coastal ecosystems
  - Estuaries subjected to severe eutrophication
  - Destruction of salt marshes
    - Major contributing factor to hurricane destruction along the coast of Louisiana
    - Had marshes been present, Katrina might not have caused so much damage

Human Impacts: Pollution

- Stratospheric ozone depletion
  - Ozone hole: over Antarctica between 1/2 to 1/3 of original ozone concentrations are present



a. NASA



b.

Human Impacts: Pollution

- Over United States
  - Ozone concentration has been reduced by about 4%
- Stratospheric ozone is important because it absorbs UV radiation (UV-B)
- UV-B damages tissue increases risks for
  - Cataracts
  - Skin cancer: 1% drop in ozone leads to a 6% increase in skin cancer

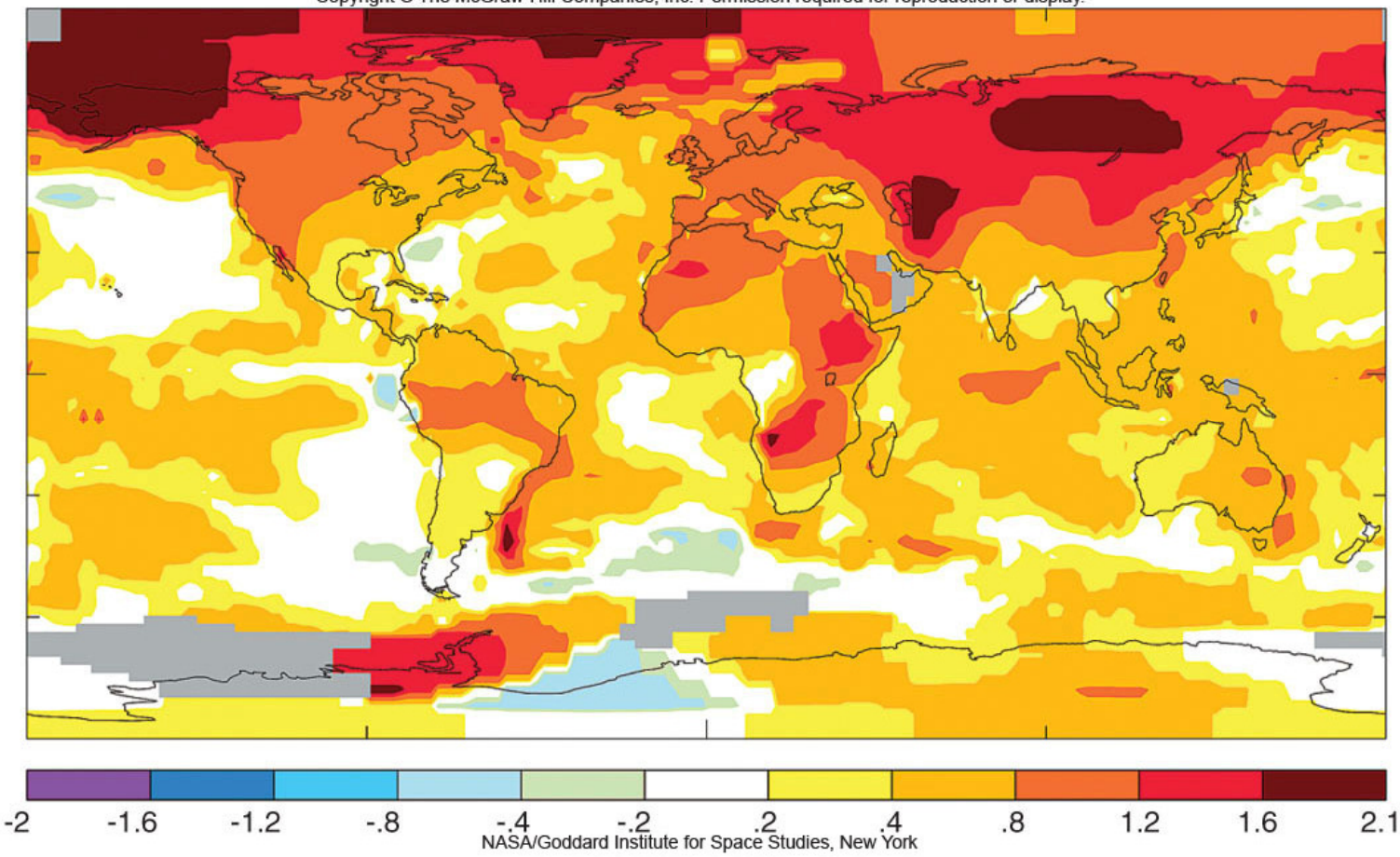
Human Impacts: Pollution

- Ozone depletion and CFCs: Major cause of ozone depletion are chlorine and bromine containing compounds in the atmosphere
- Use of CFCs are being phased out in many countries
- CFC are chemically stable in the atmosphere for many years
- Ozone depletion will continue to occur until all of the CFCs are broken down

Global Warming

- CO_2 and other gases in the atmosphere maintain the Earth's average temperature at 25˚C
- Human activities are now changing the composition of the atmosphere; increasing the CO_2 and other gas levels
- Because of the increase, global temperatures are increasing, causing global warming

Global Warming

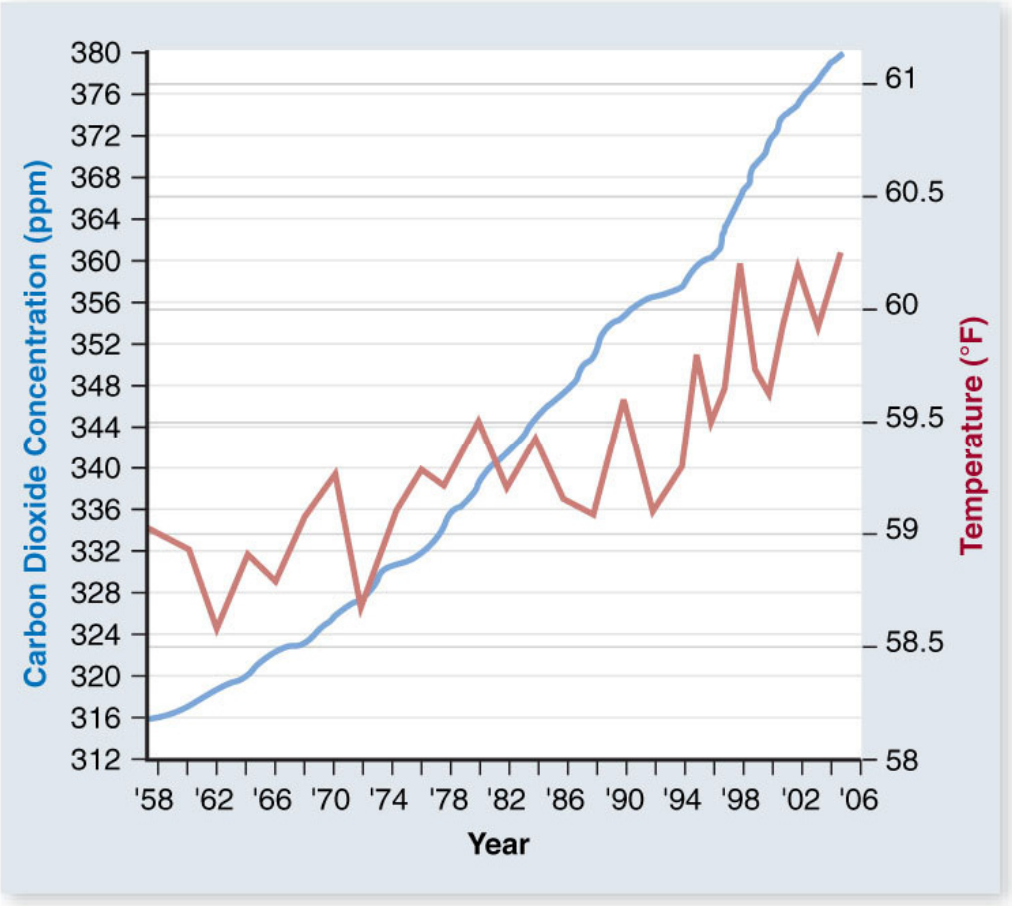


2005 was the warmest year on record

Global Warming

- Based on the outputs of all four models
  - Temperature in Europe is predicted to increase by 2˚C-4˚C by 2080
  - Increases in temperature will be disruptive
    - Snow cover in the Swiss Alps: 300 m higher than today
    - Parts of southern Europe will receive 20% less precipitation
- Cause major economic upheavals

Global Warming



Concentrations of CO_2 since 1958

Global Warming

- Cause of global warming?
  - Greenhouse effect: which is good in that it keeps the Earth warm enough for life
  - But increase in CO_2 emissions through burning of fossil fuels will continue to increase temperatures on Earth

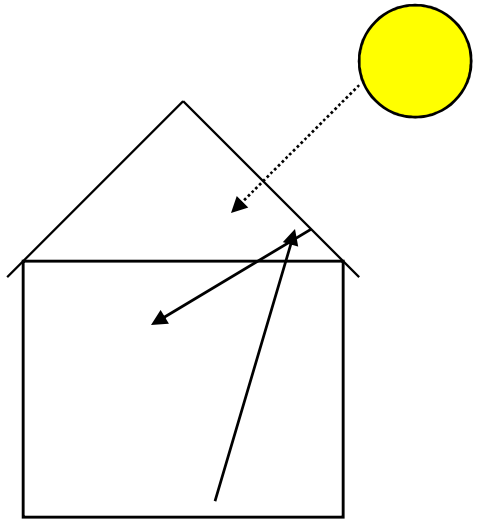
Global Warming

- How CO_2 affects temperature
  - CO_2 absorbs electromagnetic radiant energy
  - Earth receives radiant energy from the Sun
  - Earth also emits radiant energy
  - The Earth's temperature will be constant only if the rates of these two processes are equal

Global Warming

- The atmosphere allows in short wave radiant energy from the Sun, but does not allow the long wave radiant energy from the Earth to escape
- This is the same principle as a Greenhouse

Short wave- in, long wave - cannot get out, increase in temperature in the greenhouse



Global Warming

- Other greenhouse gases
  - **Methane:** 20 xs the heat trapping properties of CO_2, less concentration in the atmosphere, less long-lived
  - Methane is produced globally in anaerobic soils and fermentation reactions of ruminant mammals
  - Methane is locked up in permafrost
    - Sudden release will cause large perturbation in global temperature

Global Warming

- Other greenhouse gases
  - **Nitrous oxide:** agricultural use of fertilizers is the largest source
  - Energy consumption
  - Industrial use
- **Evidence confirms global warming**
  - Ice free seasons 2.5 wks longer
  - Ice at the North Pole decreased
  - Glaciers decreasing in size

Global Warming

© Lonnie G. Thompson, The Ohio State University

Disappearing glaciers

Global Warming

- Global temperature change has affected ecosystems in the past and is doing so now
  - Shift in species geographic ranges
  - Migratory birds arrive earlier at their summer breeding grounds
  - Insects and amphibians breed earlier
  - Wild fruit fly populations-changes in gene frequency
  - “bleaching” of reef building corals

Global Warming

- Problems
  - Rate of warming today is rapid
  - Evolutionary adaptations for species survival may not have time to occur
  - Natural areas no longer cover the whole landscape
  - Species that shift to higher altitudes may have reached the peak of the mountain
  - Species' habitat disappears entirely

Global Warming

- Possible effects on human species
  - Rising sea levels: 200 million people would be affected by increased flooding
    - Coastal cities and entire islands could be submerged
  - Frequency or severity of extreme events will increase (hurricanes, El Niño)

Global Warming

- Effects on agriculture
  - Positive: more CO_2 tends to increase growth of some crops
  - Increase pollen production causing more severe allergies
  - More droughts in some regions
  - Decrease in crop production in tropical areas

Global Warming

- Human health
  - Frequent flooding = loss of safe drinking water
    - Cholera and other epidemics may occur more often
  - Tropical diseases may invade nontropical countries
    - Malaria
    - Dengue fever