## TOPICS 4.4TO4.5 AND 4.7TO4.8

# EARTHS ATMOSPHERE, GLOBAL WIND PATTERNS, SOLAR RADIATION, AND SEASONS

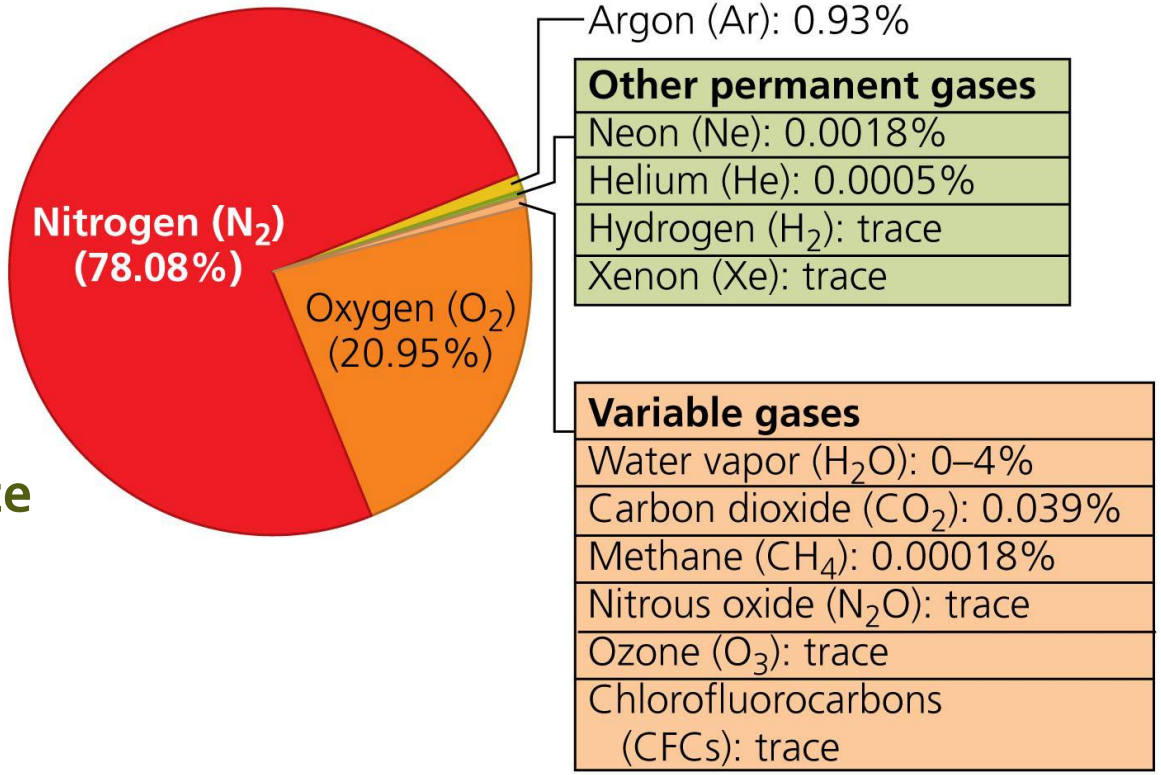
**Enduring Understanding:** Earth's systems interact, resulting in balance over time.

**Learning Objectives:** Describe the structure and composition of earths atmosphere. Explain how environmental factors result in atmospheric circulation. Explain how the sun's energy affects the Earth's surface. Describe how the earths geography affects weather and climate. Describe the environmental changes and effects that result from El Nino / La Nina events (Enso).

**Related Reading:** pg.448 – 456, 99-100, 425-426 "Environment; The Science Behind The Stories" 4th edition, Withgott, Jay and Laposata, Matthew.

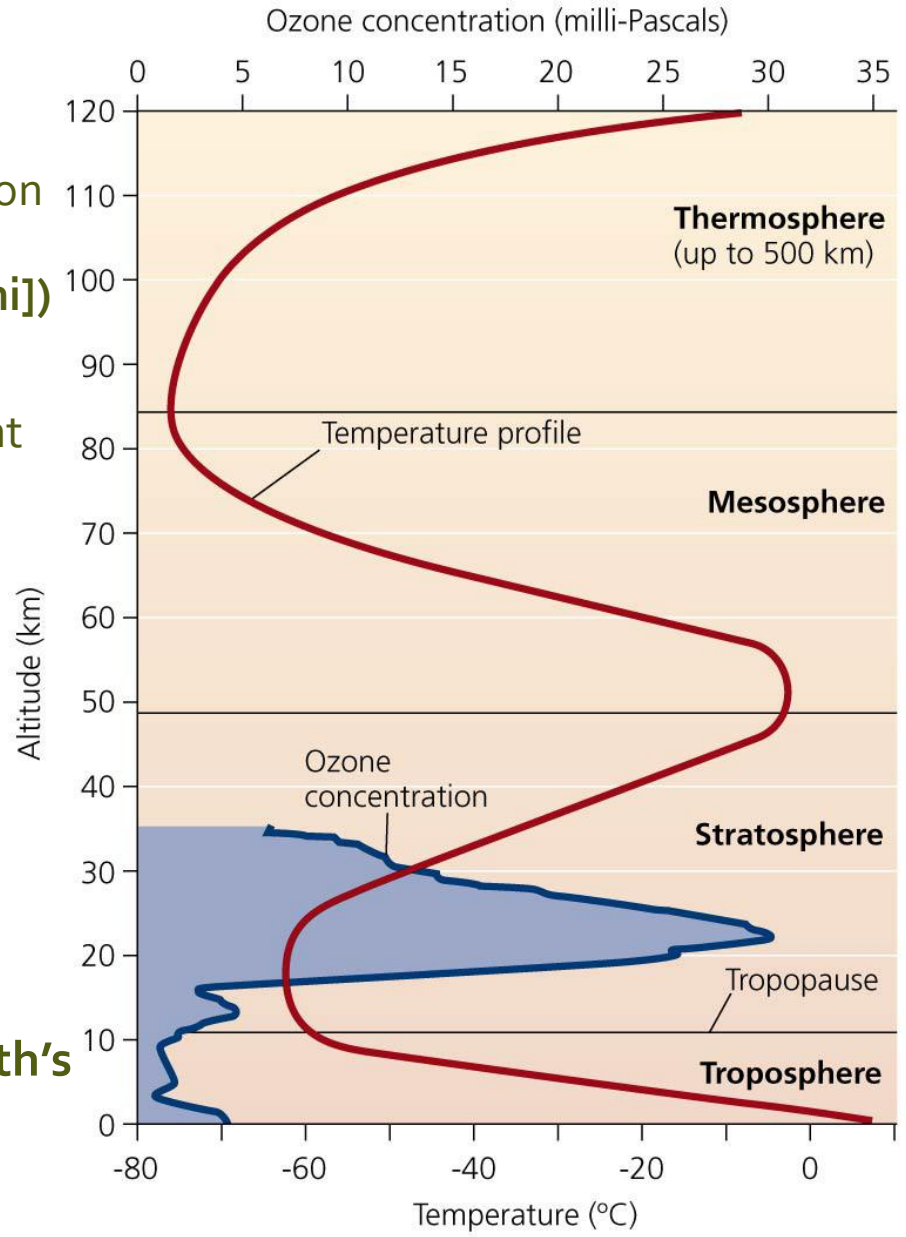
# The Atmosphere

- **The *Atmosphere* is the thin layer of gases around Earth**
  - Moderates Climate
  - Provides oxygen
  - Absorbs radiation
  - Transports and recycles water and nutrients
  - Burns up incoming meteors and alien space ships
- **Composed of 78% $N_2$, 21% $O_2$ The rest is minute concentrations of either:**
  - *Permanent gases* that remain at stable concentrations
  - *Variable gases* with varying concentrations across time and place
- **Human activity is changing the amount of some gases**
  - $CO_2$, methane ($CH_4$), ozone ($O_3$)

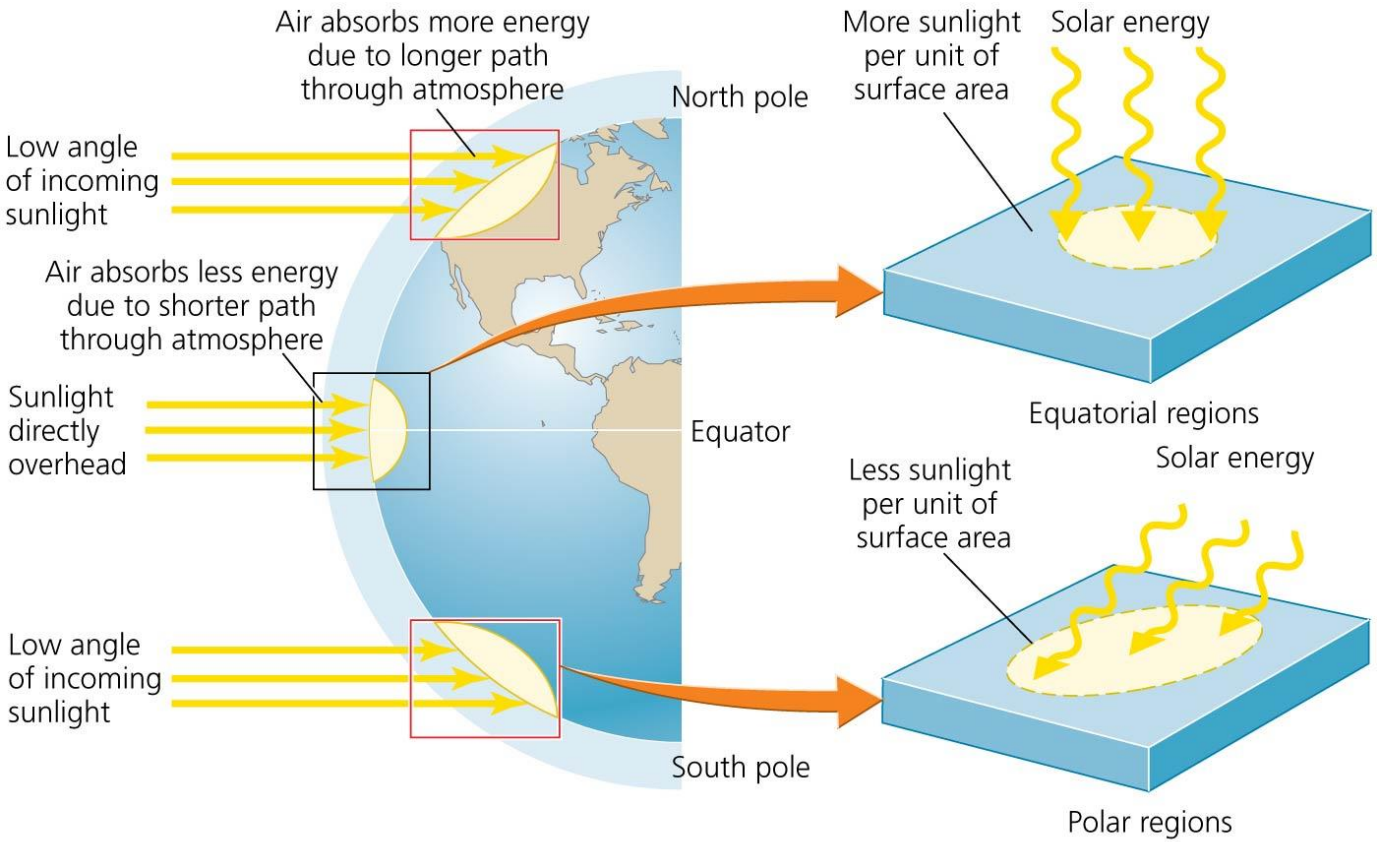


# The Atmosphere is Layered

- **The atmosphere is a thin coating only 1/100 the diameter of the Earth**
  - Consists of four layers that differ in temperature, density, and composition
- **The *Troposphere* is the bottommost layer (from ground up to 11 km [7 mi])**
  - Contains ¾ of the atmosphere's mass, including air for breathing
  - Weather is a phenomena of the troposphere resulting from air movement
  - The air gets colder with altitude in the troposphere.
- **The *Stratosphere* occurs between 11–50 km (7–31 mi) above sea level**
  - Drier and less dense, with little vertical mixing
  - Becomes warmer with altitude
  - Contains UV radiation-blocking *ozone*, 17–30 km (10–19 mi) above sea level
  - Air temperature increases with altitude in the stratosphere.
- **The Mesosphere and Thermosphere are the uppermost layers of earth's atmosphere, which extends to 500km (300 mi) above earth surface.**
  - The boundary between these two layers is also marked by a reversal in temperature trends.



# Insolation




- ***Insolation*** **= Incoming solar radiation**
  - The amount of solar energy received by Earth
  - Global average 340 W/m$^{2,}$ but insolation varies by location and season.
- **The angle that sunlight strikes a surface determines how much energy is absorbed by the surface.**
  - High angle (close to 90˚) sunlight allows more energy to be absorbed by surfaces than low angle sunlight (close to 0˚ or 180º)
  - Higher latitudes (near poles) receive lower angle sunlight on average
  - Low latitudes (near equator) receive higher angle sunlight
  - The more energy absorbed by the surface, the higher the temperature of the surface will be

# Insolation Climate and Seasons

- **Because the rotational axis of Earth is tilted, each hemisphere tilts toward the sun for half the year**
  - Results in a change of seasons and day length
  - Equatorial regions are less affected by this tilt, so days average 12 hours throughout the year and the climate is relatively stable throughout the year
  - Polar regions receive low angle sun for long periods during their summers, and no sun at all during some period of their winters.
  - Temperate regions experience the greatest variation in temperature through the year, due to insolation angles that are close to 90 in summer and considerably less in the winter.
  - If Earth was a flat-sided cube, on a vertical axis, all areas would receive equal insolation all year.

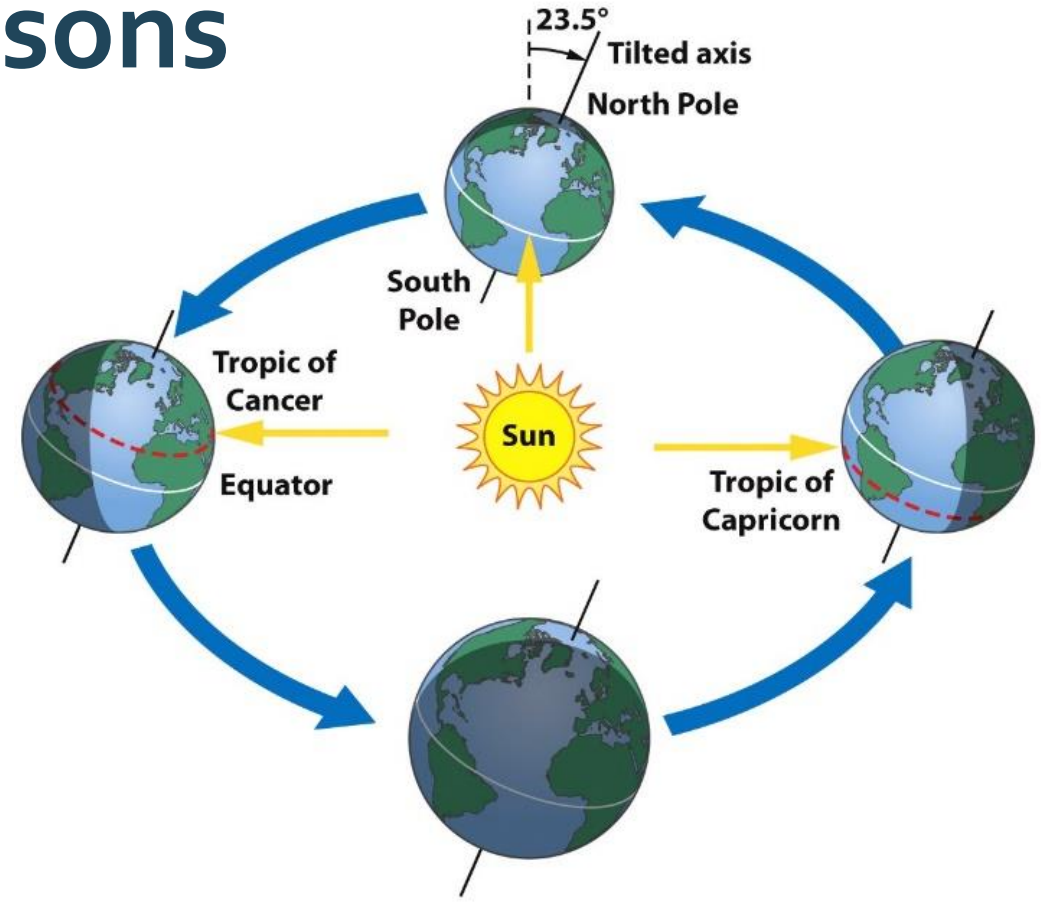



**Figure 4.10 part 1**
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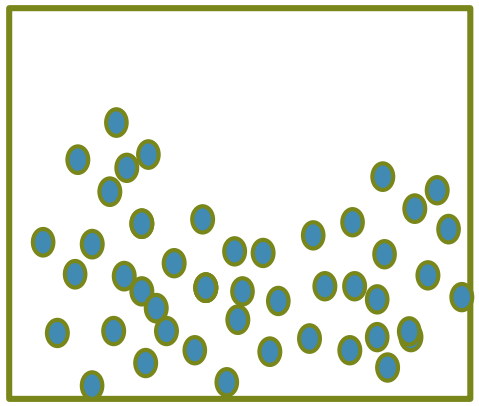
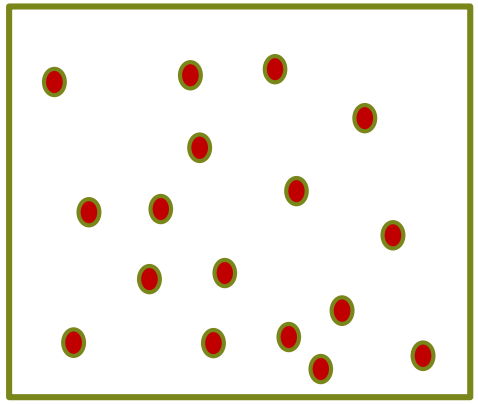
**Why Do We Have Different Seasons?**
https://www.youtube.com/watch?v=WgHmqv_-UbQ

# Convection Helps Explain Patterns of Global Air Circulation and Precipitation

- **Land and water absorb solar energy then radiate heat**
  - Heat radiating from Earth's surface causes air near the surface to warm, expand and become less dense, leading it to rise.
  - Solar energy absorbed by water, increases the molecular speed of water molecules causing them to change phase from liquid to gas, leading to evaporation.
  - As gases in the air (including water vapor) rise away from the warm surface of Earth, gas molecules lose energy and condense, causing them to sink, and in the case of water vapor to undergo another phase change from gas to liquid.
  - This explains patterns of precipitation and global air circulation.





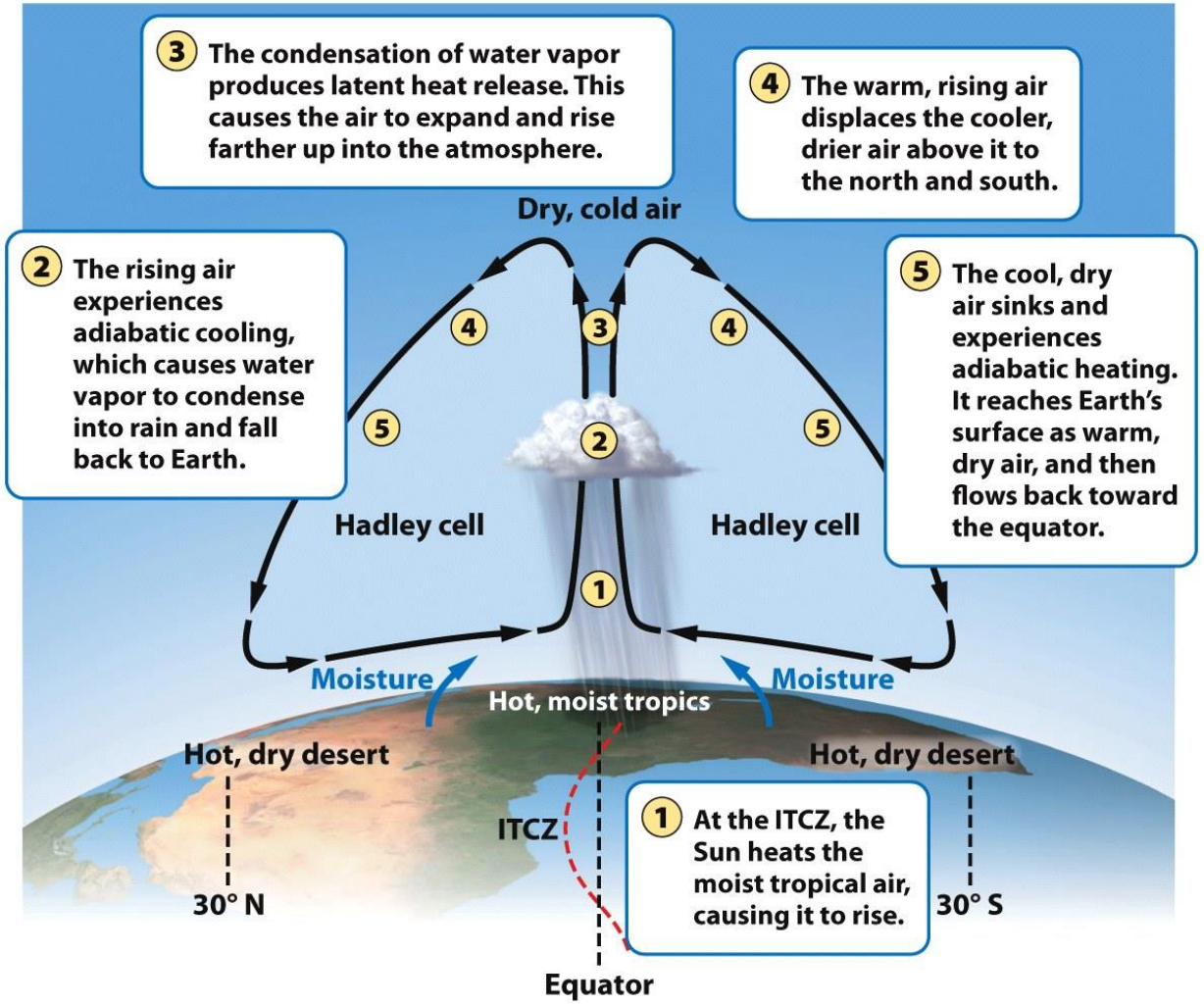



**Figure 4.6**
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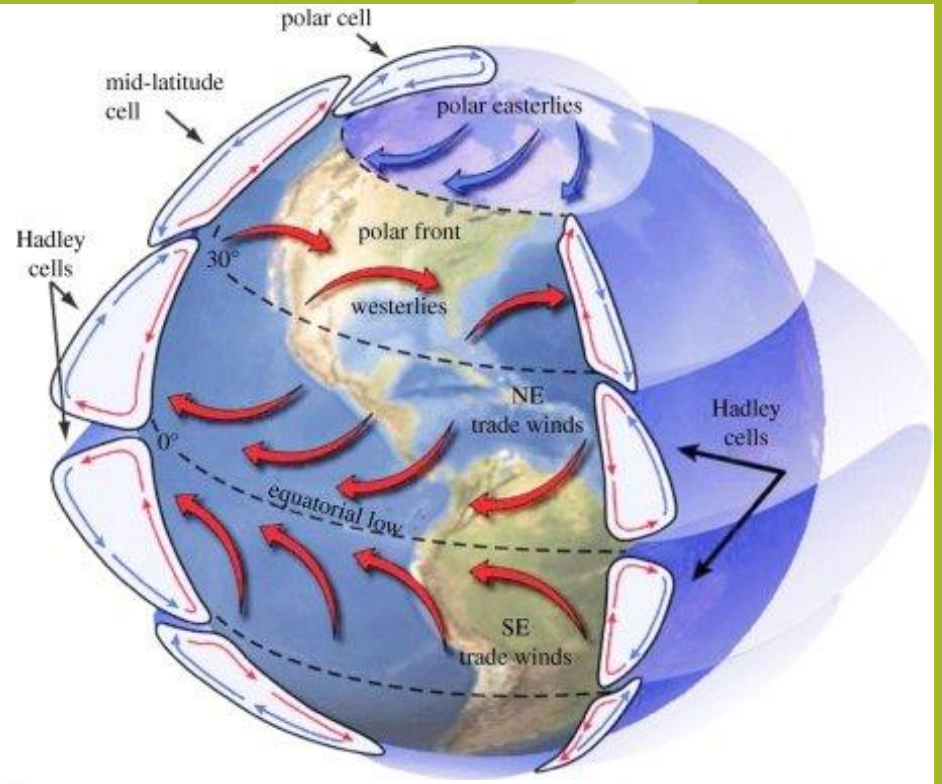
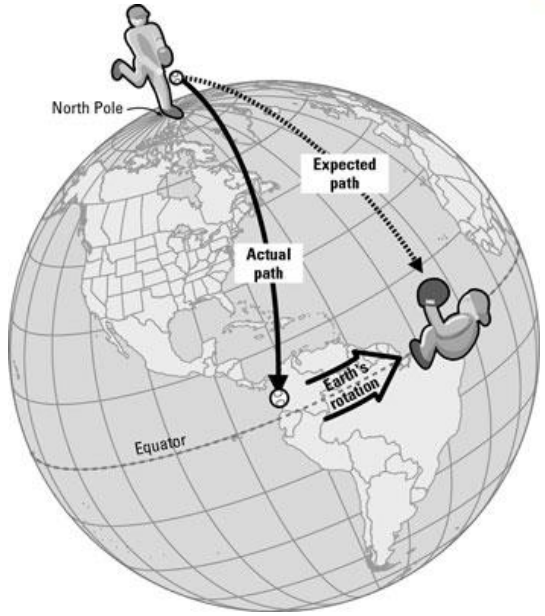
# Variations in Solar Radiation affect air circulation and precipitation

- **The differential heating of earths surface causes:**
- **Variations in Evaporation**
  - Areas that absorb more solar radiation experience greater rates of evaporation
- **Global air circulation patterns (wind)**
  - Areas that absorb more solar radiation heat faster and lead to rising air masses
  - Air masses spread along earth expanding into voids created by rising air masses
  - Results in convective cells of air movement (***Hadley cells, Ferrel Cells, Polar cells***)

# Coriolis Effect alters wind patterns

- Based on just the convection cells we just looked at, prevailing winds should blow on a north / south axis
- Prevailing winds actually blow primarily along an east / west axis
- The ***Coriolis effect*** deflects winds from north/south to east/west due to drag along the surface of earth as it rotates in space
  - The Coriolis effect creates wind (and water) patterns that move to the west toward the equator and to the east toward the poles.
  - Fluids (air and water) have an apparent motion to the right in the northern hemisphere, and to the left in the southern hemisphere.




[Coriolis Effect on Wind](https://www.nationalgeographic.org/encyclopedia/coriolis-effect/7th-grade/)
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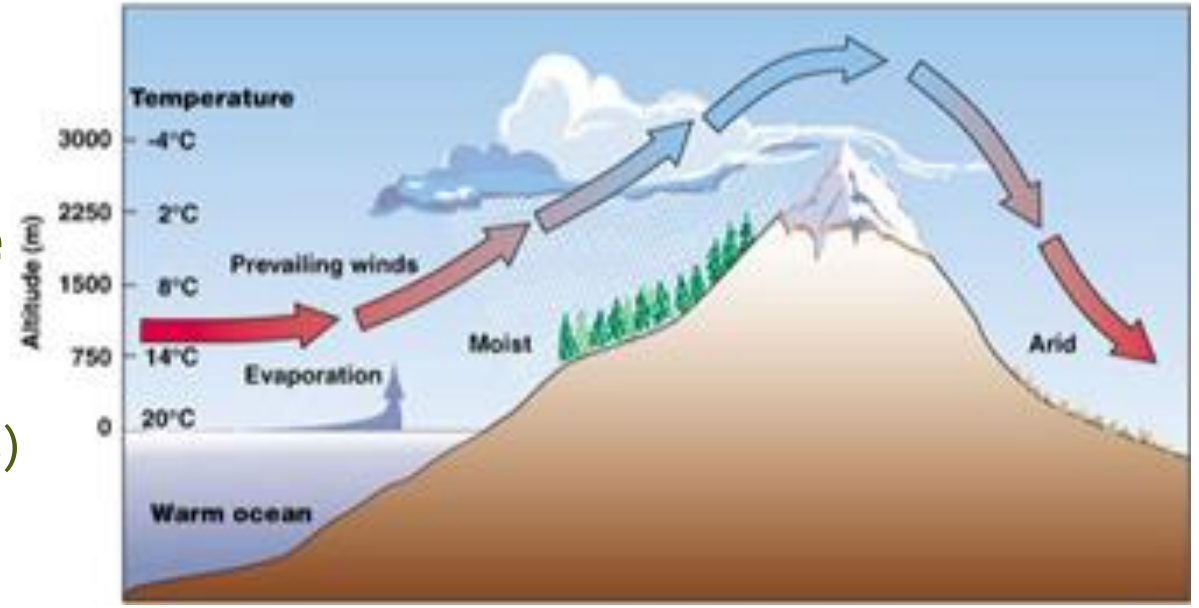
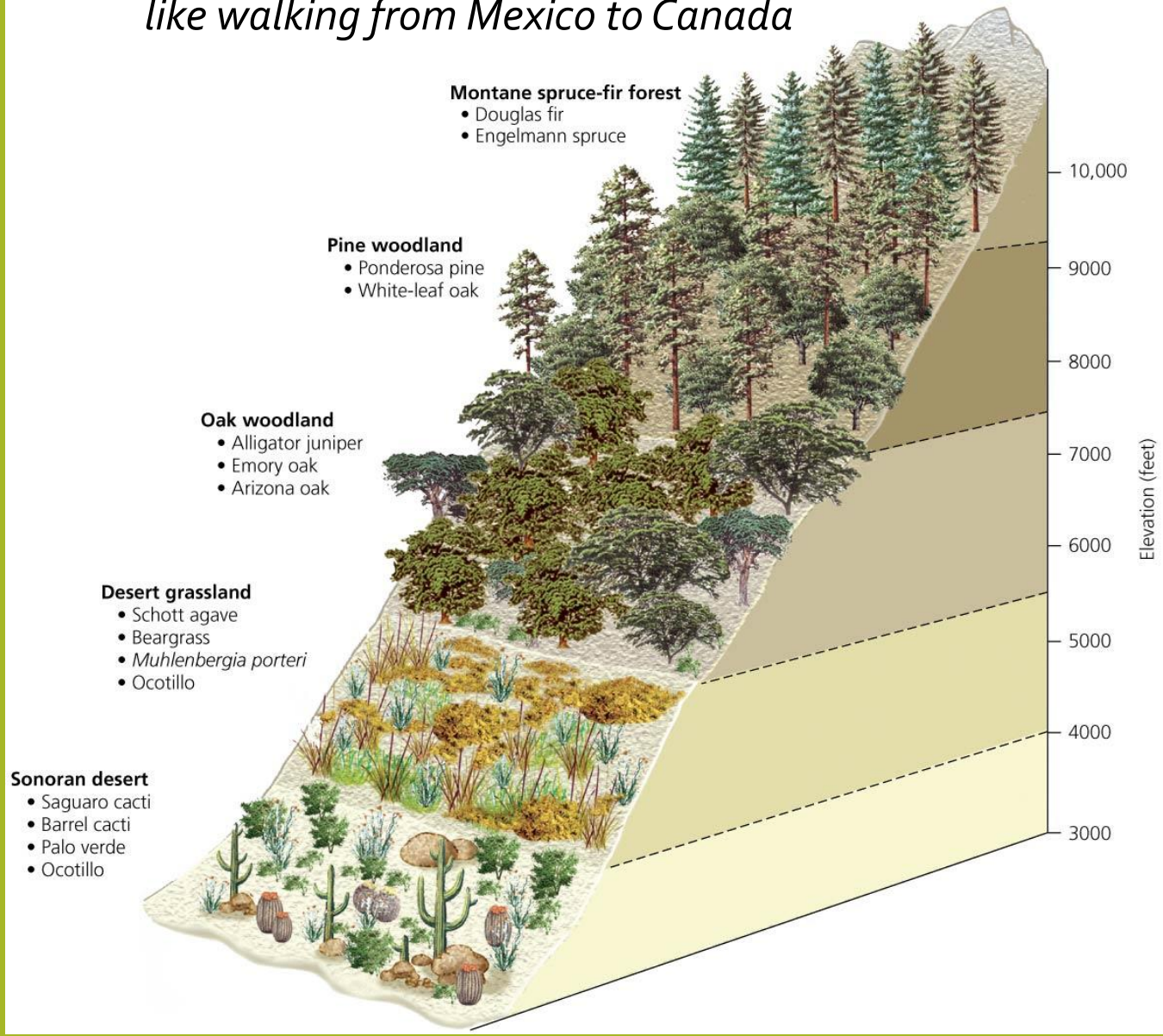
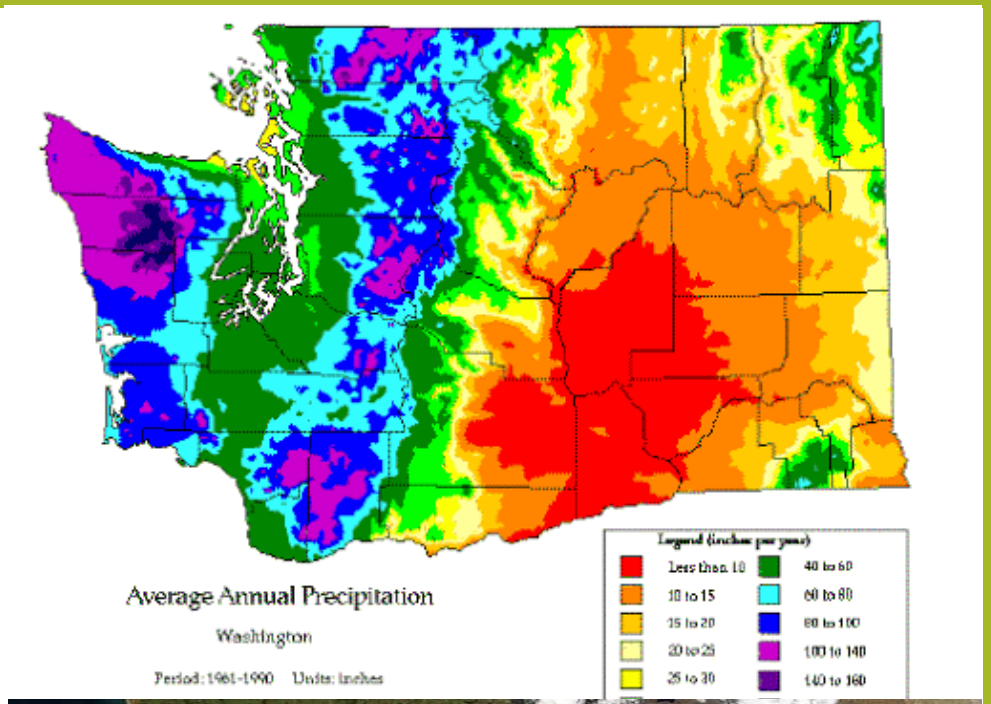
# Mountain Ranges Create Their Own Climates

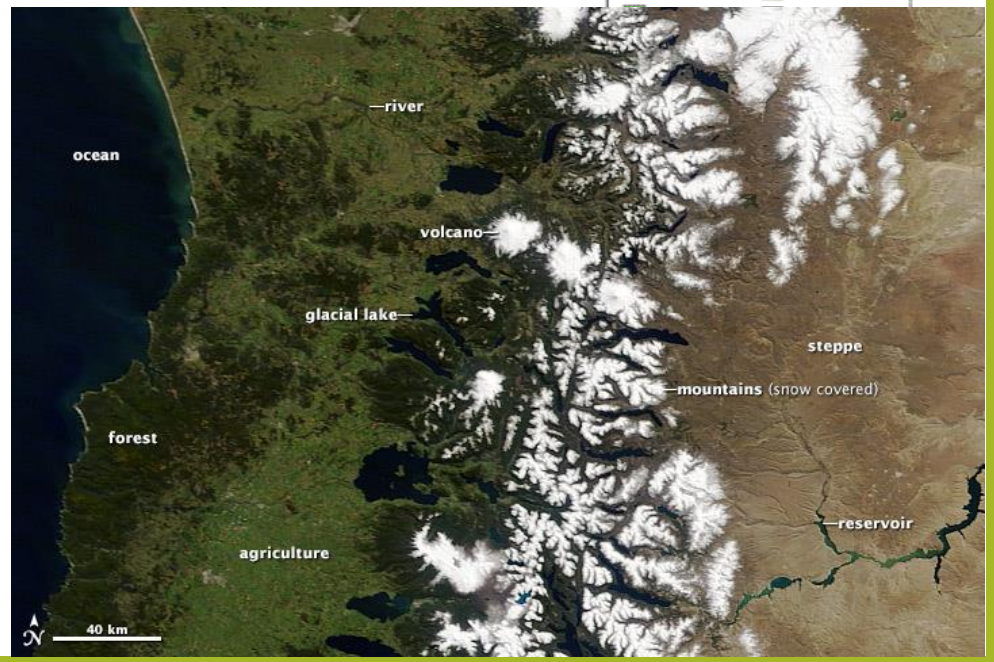



- **The climate varies with altitude in the same way it varies with latitude**
  - Temperature changes approximately 3.5˚F per thousand feet of altitude (≈ 6℃ per 1000 meters)
  - A mountain climber in the Andes begins in the tropics and ends on a glacier
- **Mountain ranges can create a *Rainshadow* effect**
  - Prevailing winds carry water vapor.
  - Mountain ranges deflect winds and water vapor upwards.
  - As air masses rise, they cool, and the water vapor condenses into precipitation on the windward side of mountain ranges.
  - After cresting the mountain, cold, dry, high-elevation air begins to sink and become warmer.
  - Warm, dry air leads to increased evaporation on the leeward side of the mountain range.
  - Vegetation communities on leeward and windward sides of mountain ranges can be very different

*Hiking up a mountain in the southwest U.S. is like walking from Mexico to Canada*



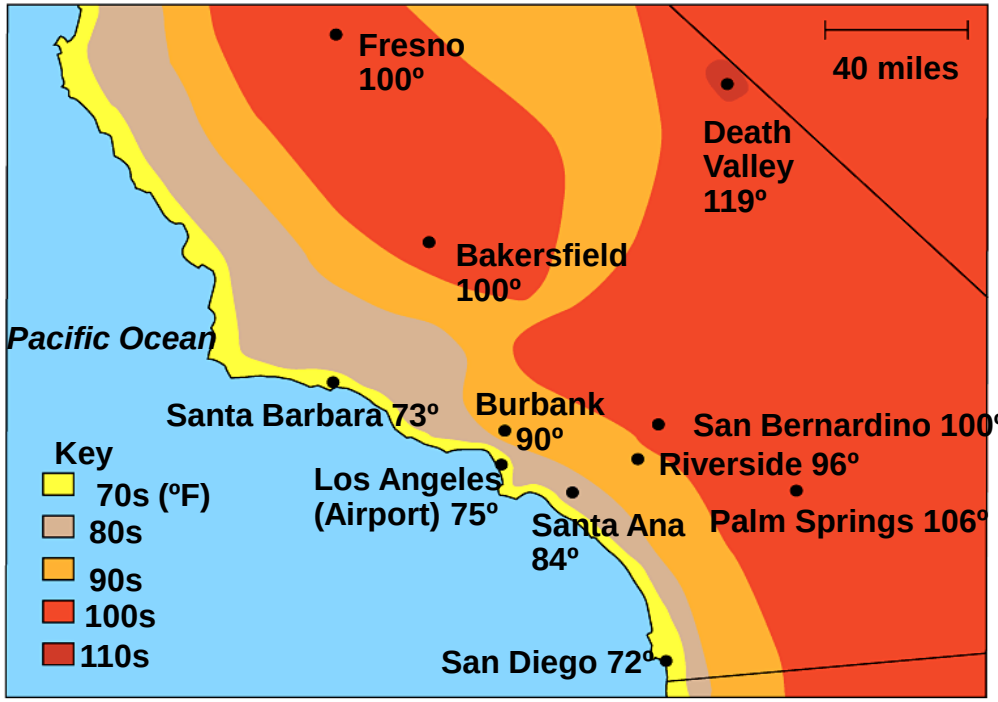



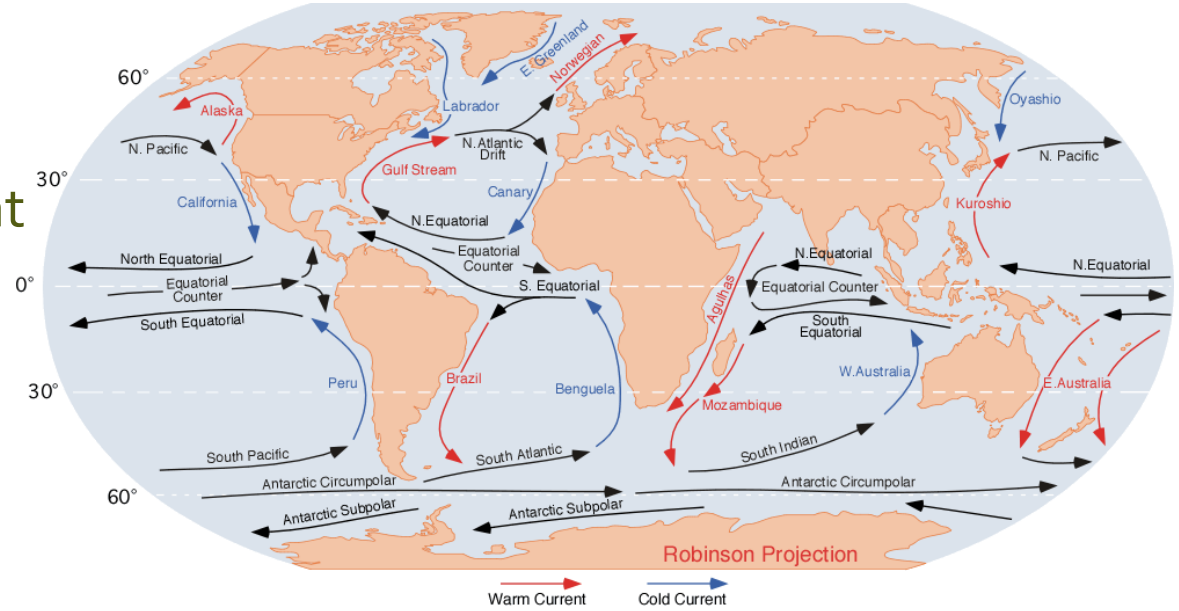
# Oceans Influence Climate and Biome Type

- **Water moderates temperature**
  - Water is polar and therefore has extensive hydrogen bonding between its molecules
  - Hydrogen bonds allow water to absorb a lot of heat with little change in temperature
  - Coastal areas have a more moderate temperature than interiors of continents.

- **Ocean currents transport energy and can influence climate.**
  - San Diego and Savannah, GA are coastal cities at the same latitude, yet the average high temperature for June in San Diego is 72°F and Savannah is 90°F

- **Coastal areas generally experience more precipitation than inland areas**



# Biome Distribution Reflects Climate

- Revisit the map the map of biomes from earlier in the year (topic 1.2) and some of those small variations in biome distribution should make more sense now.
  - Ice on the equator?
  - Deserts so far north in Asia?
  - Different biomes in on each coast of the US despite the same latitude?

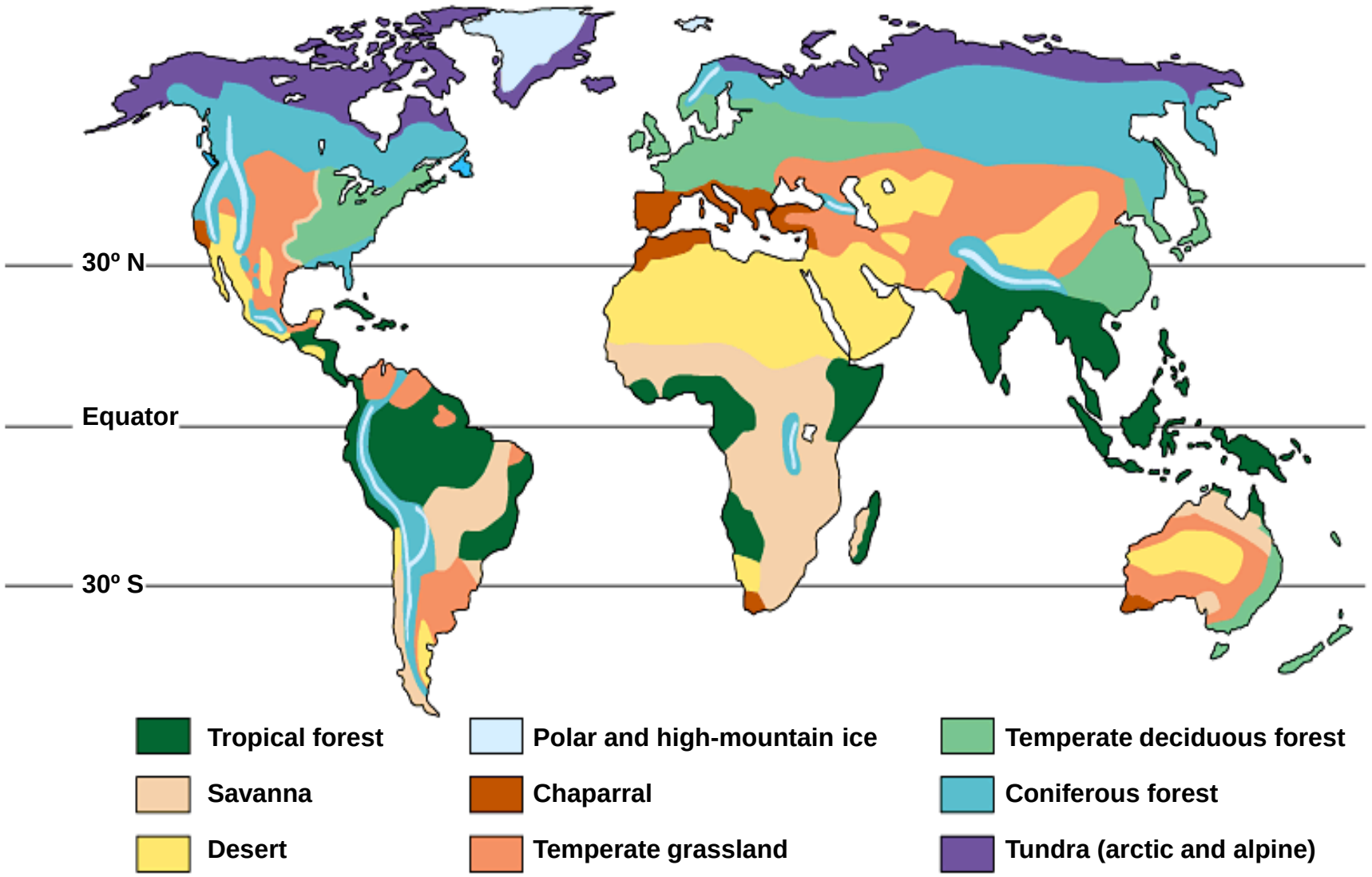



Figure 34.9