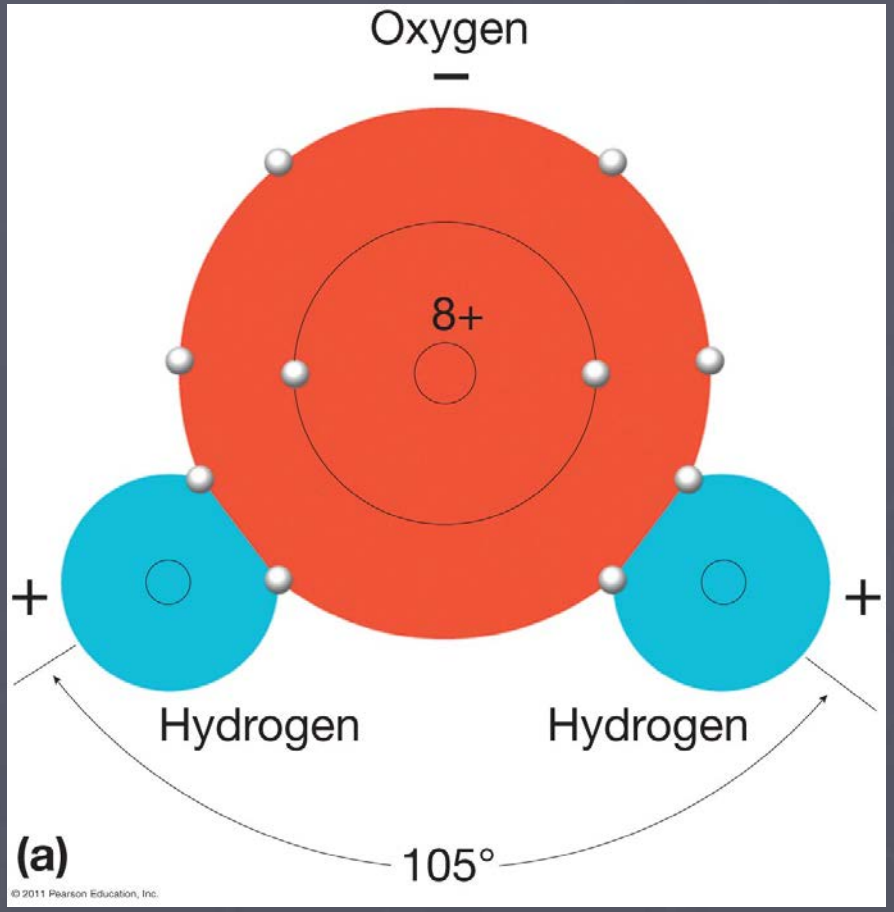
The Hydrological Cycle

Chapter 6: Water and Atmospheric Moisture

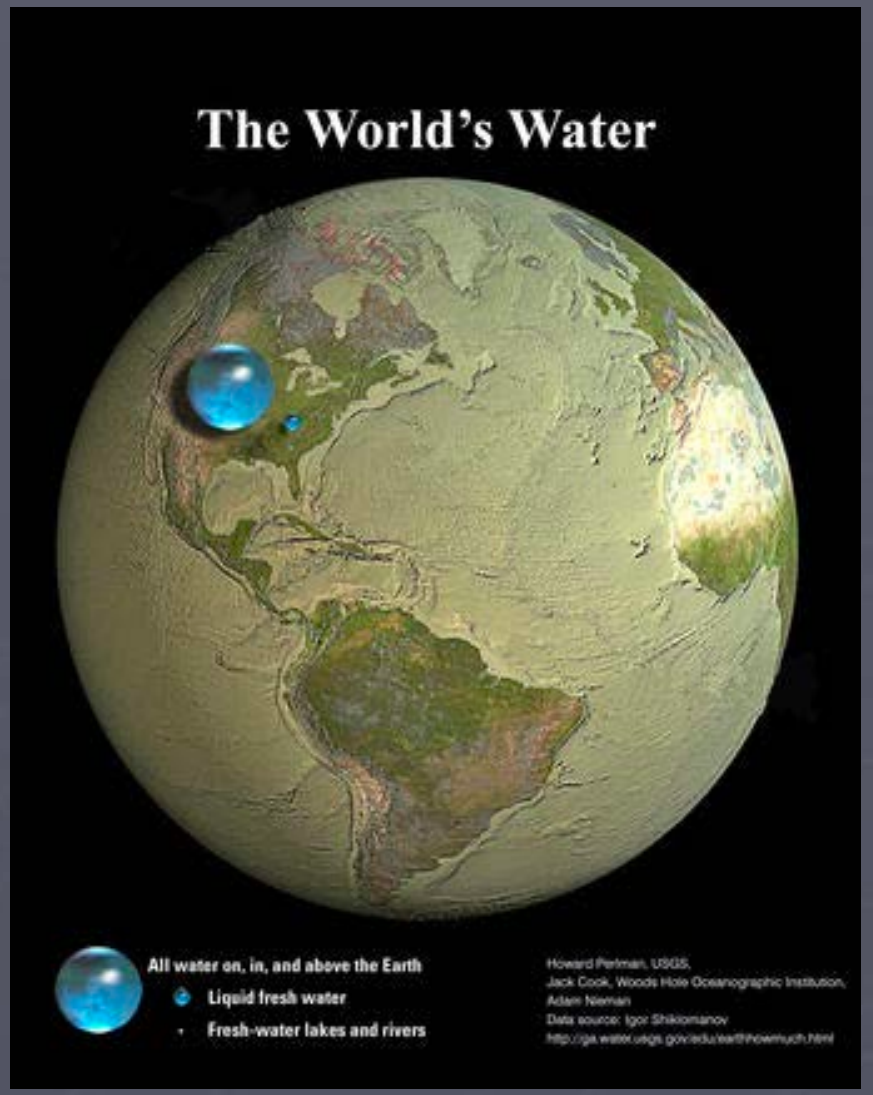
Significance of Water

- Water is the most abundant substance on Earth
  - 70% of Earth's surface covered by water
- Water is the only substance that can be readily found in all three phases
- Universal Solvent



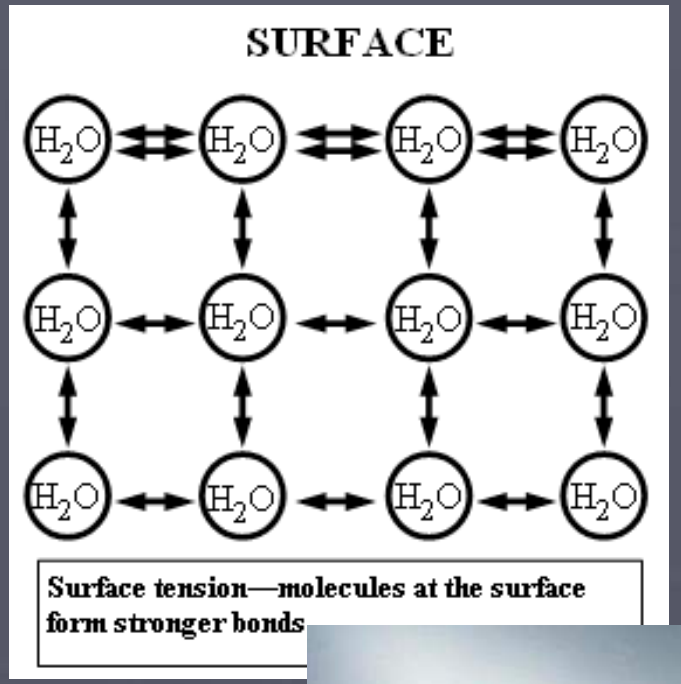
Where is the Earth's water?

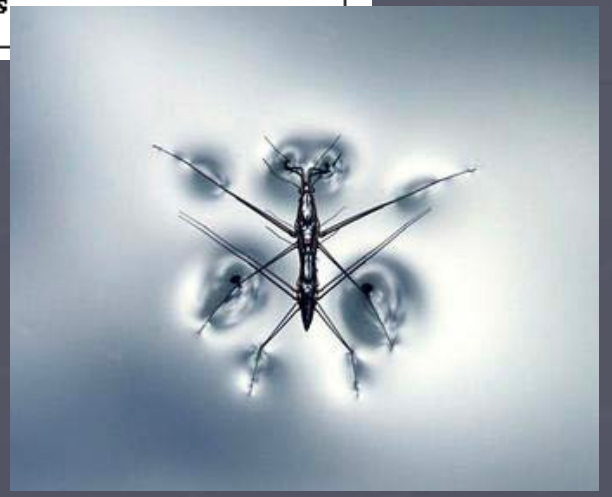
- 1.7% is locked into Icecaps
- Less than .03% is in the atmosphere
- 3% is freshwater
- 1.69% is groundwater
- 96.54% is in Oceans/Seas



Properties of Water

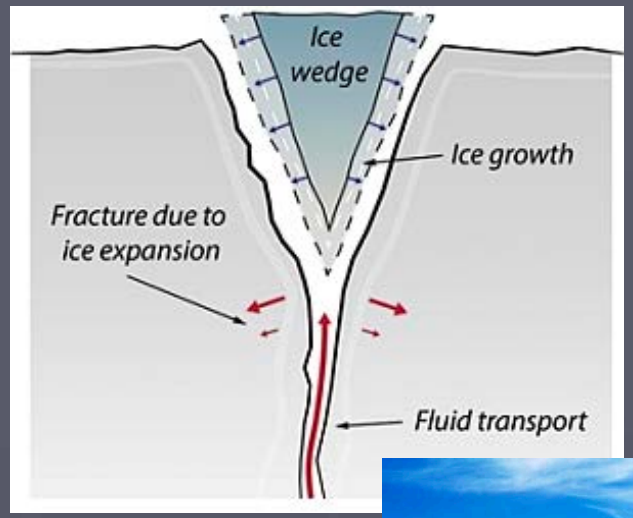
- Cohesion – Attraction to other water molecules
  - Surface Tension – Bonds between water molecules strengthen allowing it to resist other substances
- Adhesion – Attraction to molecules from other substances

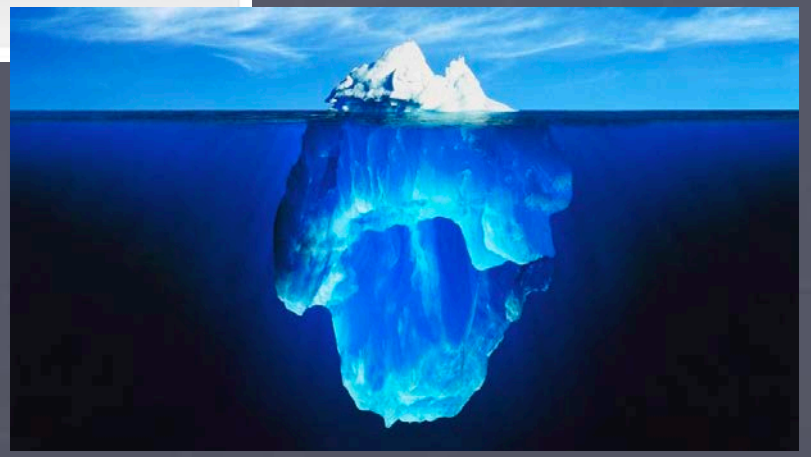


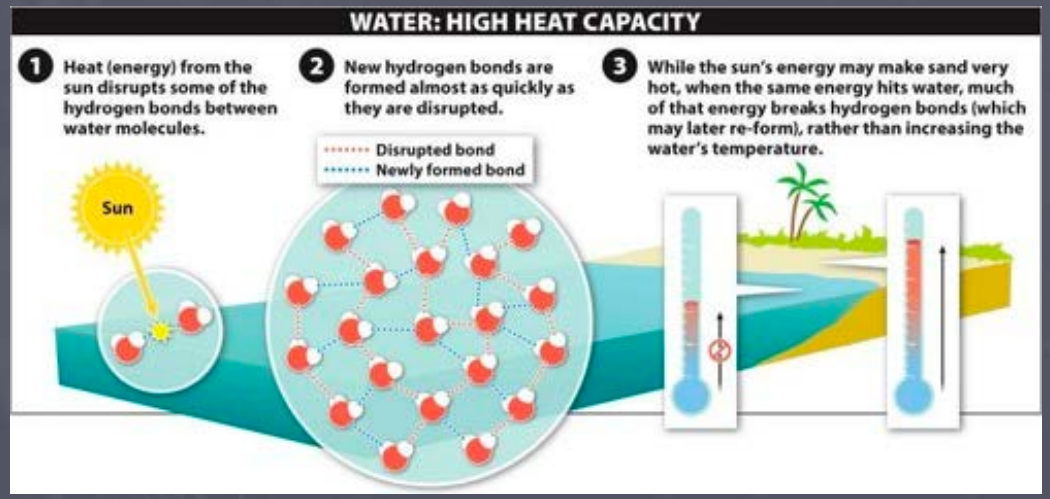


Properties of Water

- Expansion
  - Water expands when it freezes
    - Takes up more area but is less dense
- High Specific Heat
  - Can absorb large amounts of heat
    - Helped by water's transparency

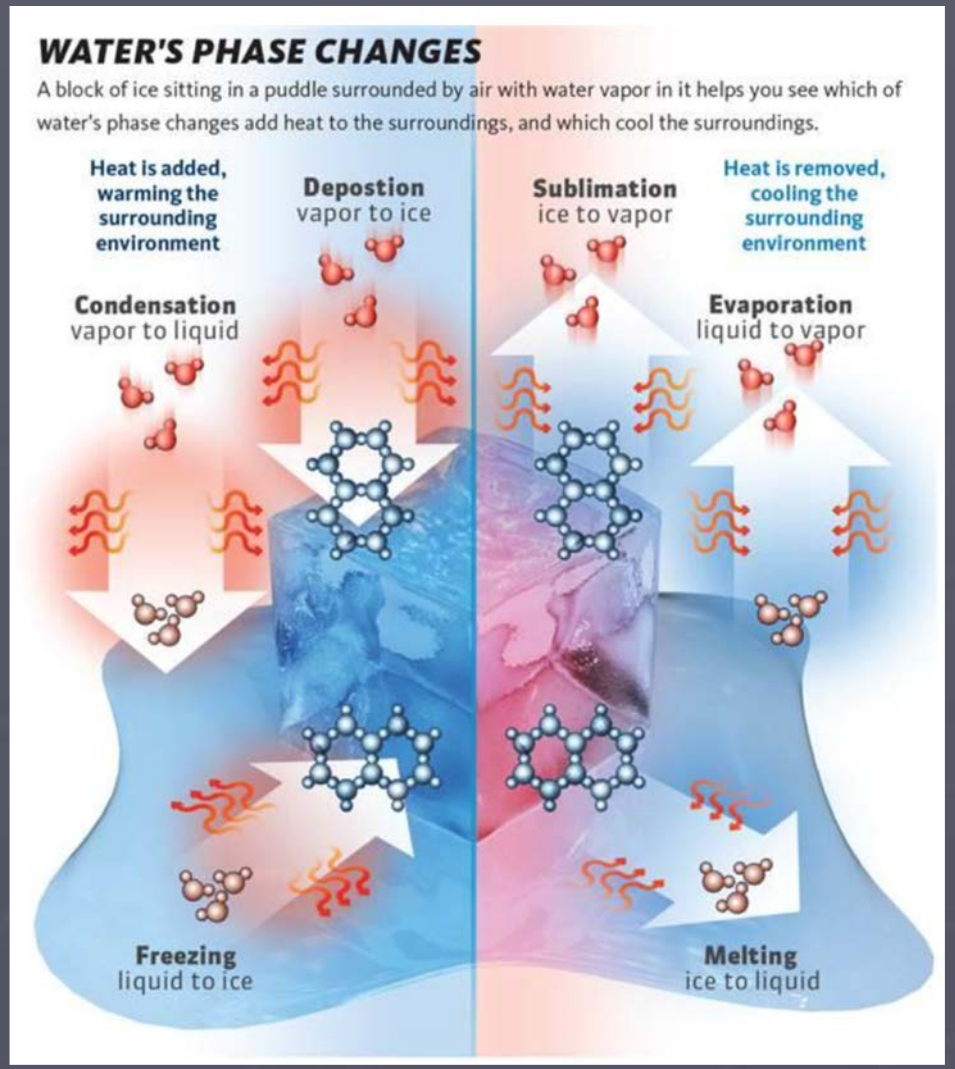




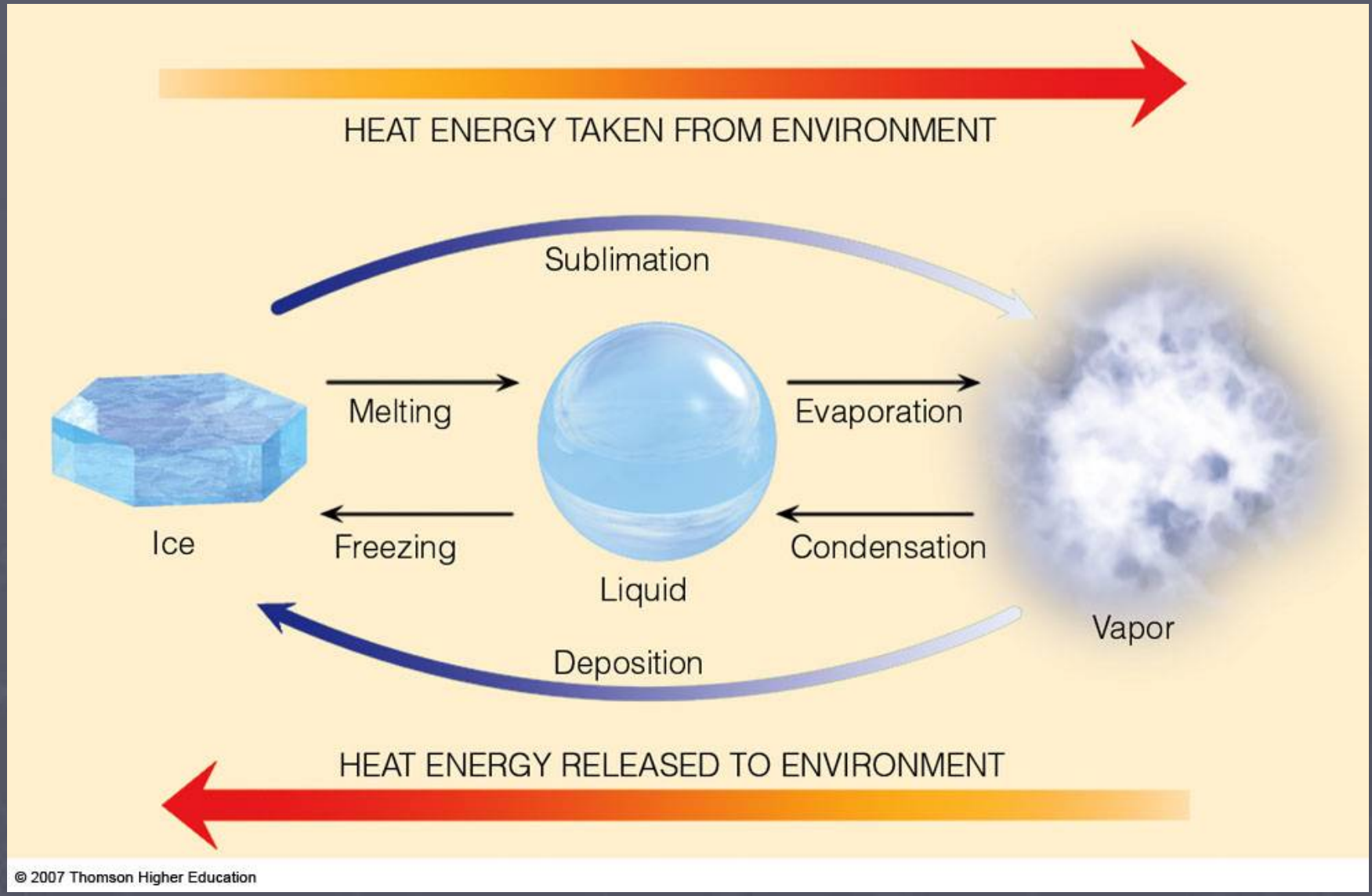


Phases Changes of Water

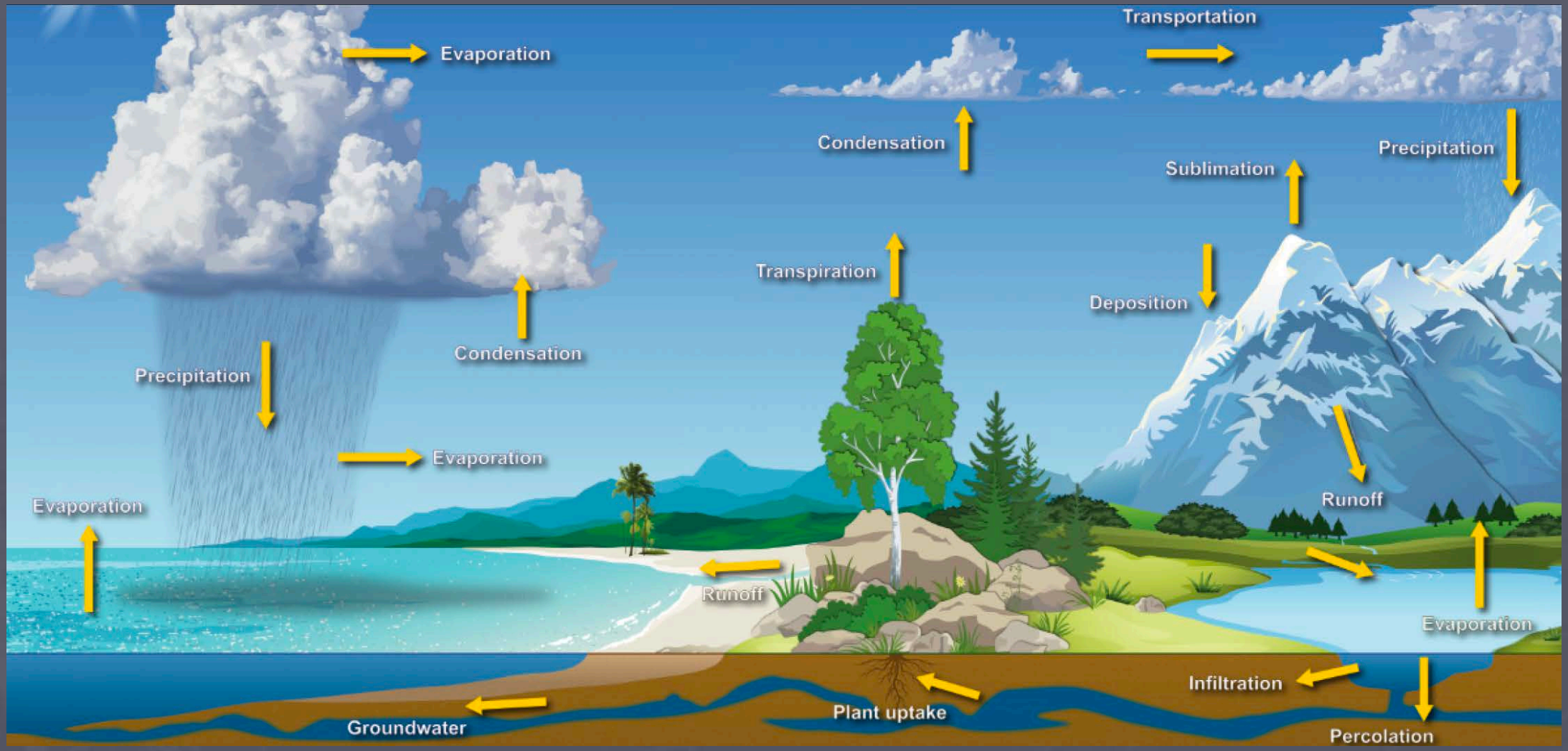
- Freezing –liquid to solid (Ice)
- Melting – Solid to liquid (Water)
- Evaporation – liquid to vapor (Steam)
- Deposition – Vapor to to solid (Frost)
- Sublimation – Solid to Vapor (Dry Ice vapor)
- Condensation – Vapor to liquid (cloud)



Phase Changes of Water

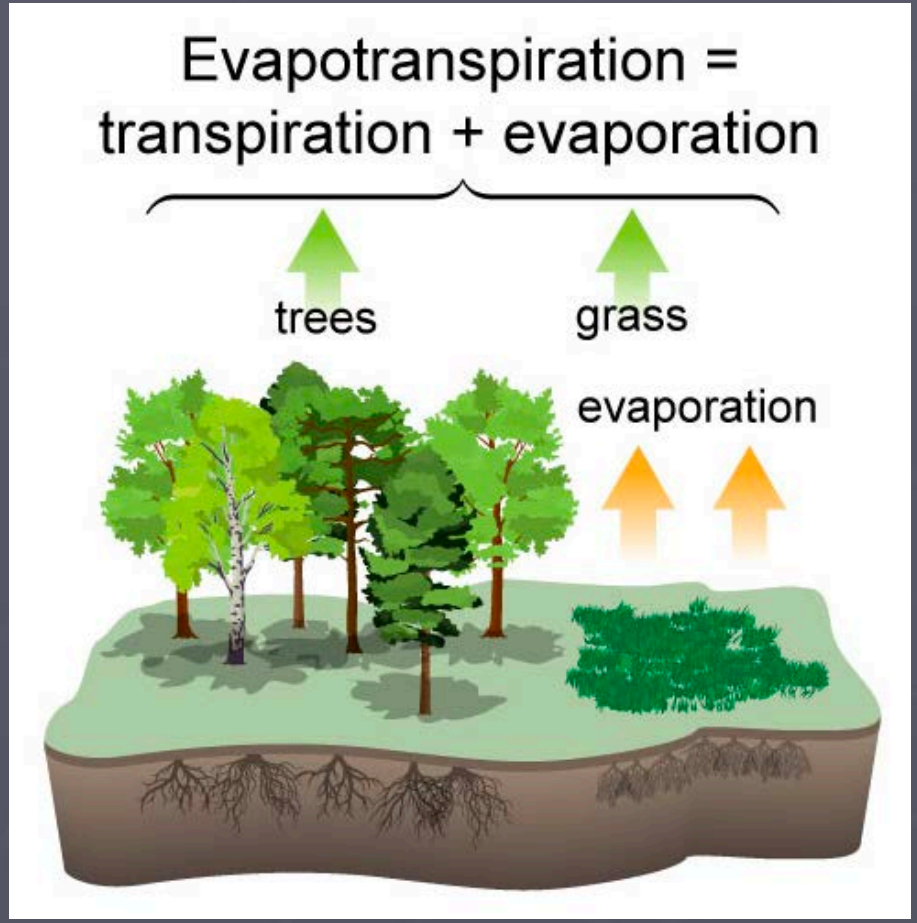


The Water Cycle



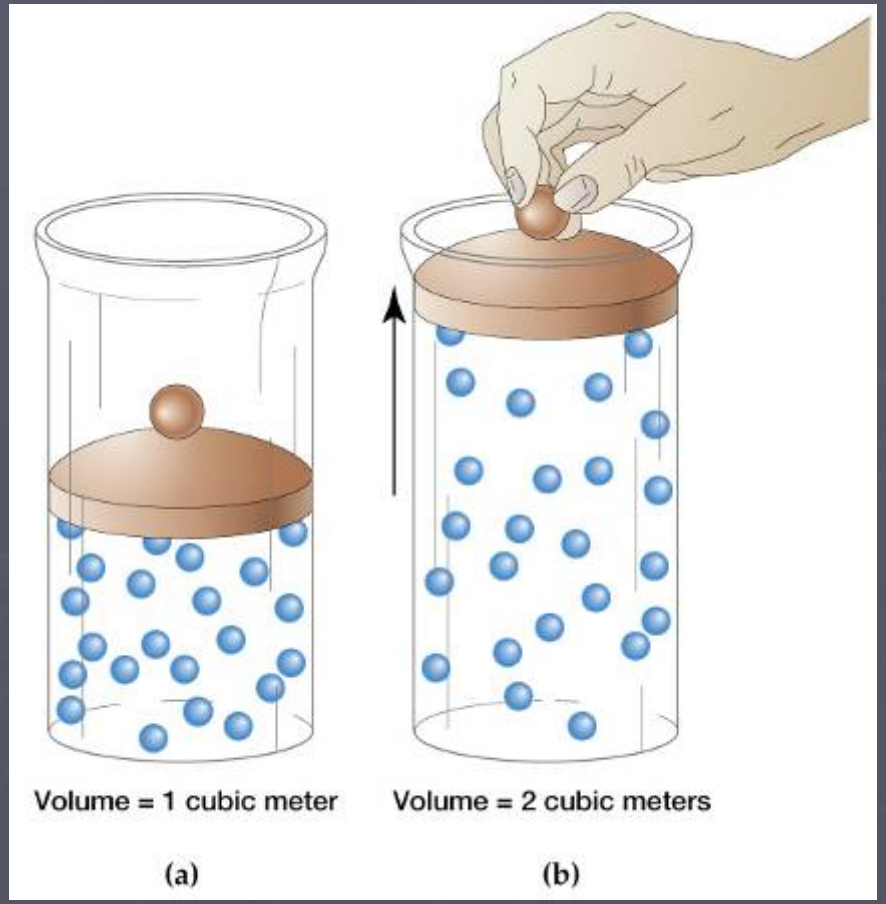
Evapotranspiration

- The loss of water to the atmosphere from the planet's surface (evaporation) and from living things (transpiration)
- Affected by a number of factors
  - Temperature of air and water
  - Humidity
  - Wind
  - Vapor pressure



Humidity

- Humidity is measure of water vapor in the air
  - Not the same as relative humidity
- Ways to measure humidity
  - Absolute Humidity
    - Direct measure of water vapor content of air (mass to volume)
      - grams of vapor per m3 of air
  - Specific Humidity
    - Direct measure of water vapor content (mass to mass)
      - grams of vapor per kg of air
  - Vapor Pressure
    - Pressure exerted by water vapor in air



Relative Humidity and Dew Point

- Both are good measures how comfortable it is outside
- **Relative humidity** is the percent the air is saturated with water vapor at a given temperature
  - Measures moisture and temperature
  - Warmer air can hold more vapor
- **Dew Point** is the temperature at which the air will become fully saturated
  - Literally when dew will start forming
  - Measures only moisture

Dew Point and Relative Humidity

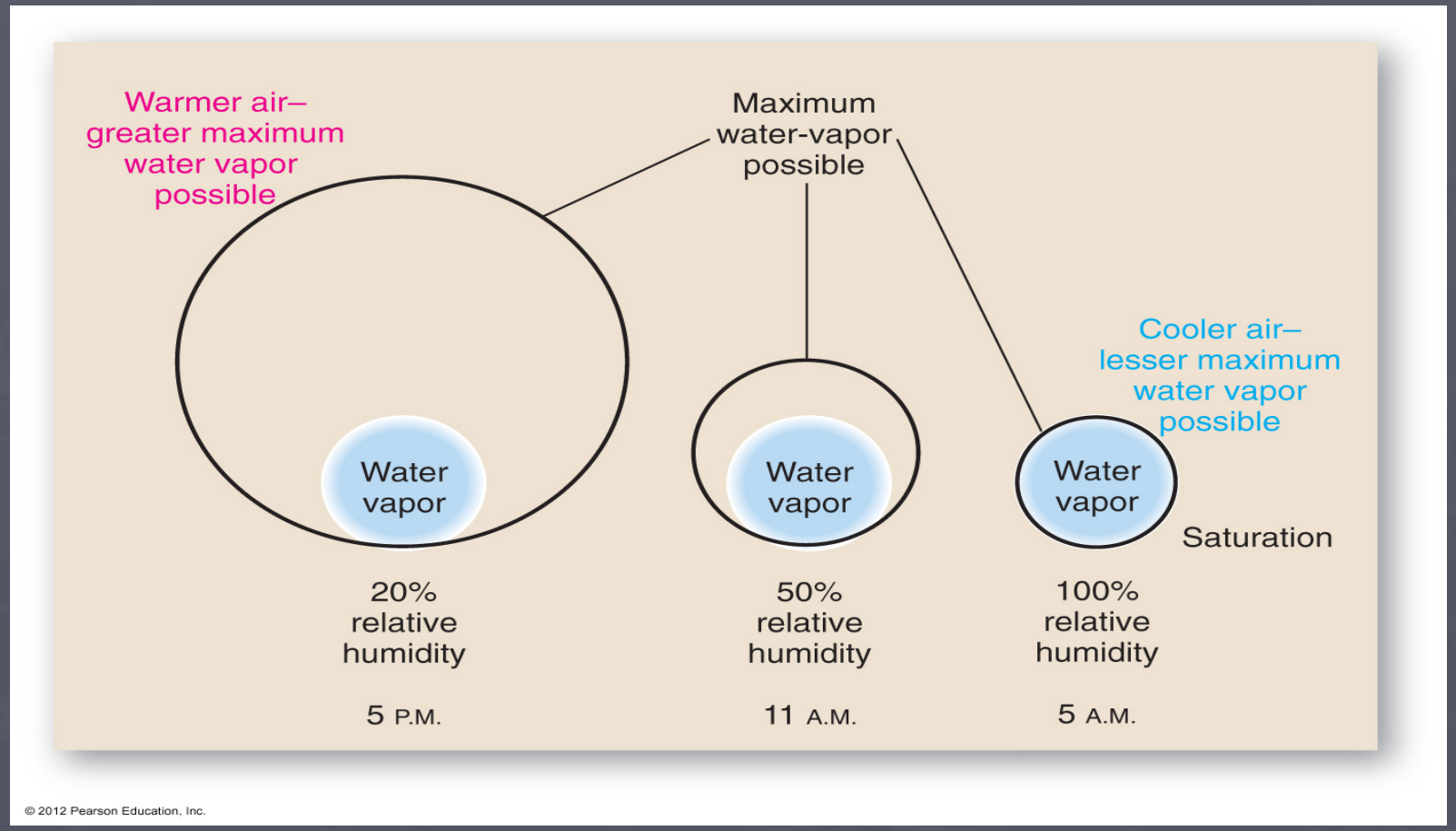
Dew point		Human perception[1]	Relative humidity at 32 °C (90 °F)
Over 26 °C	Over 80 °F	Severely high. Even deadly for asthma related illnesses	65% and higher
24–26 °C	75–80 °F	Extremely uncomfortable, fairly oppressive	62%
21–24 °C	70–74 °F	Very humid, quite uncomfortable	52–60%
18–21 °C	65–69 °F	Somewhat uncomfortable for most people at upper edge	44–52%
16–18 °C	60–64 °F	OK for most, but all perceive the humidity at upper edge	37–46%
13–16 °C	55–59 °F	Comfortable	38–41%
10–12 °C	50–54 °F	Very comfortable	31–37%
Under 10 °C	Under 50 °F	A bit dry for some	30%

Relative Humidity

- Humidity that changes how the air feels
  - High relative humidity – Air is more saturated, feels hotter than it actually is
    - Sweat does not evaporate as much – making air feel muggy
  - Low relative humidity – Air has less vapor, allowing more moisture to evaporate
    - Sweat evaporates quicker - making air feel cooler
- Humans generally most comfortable with RH of 30 to 50

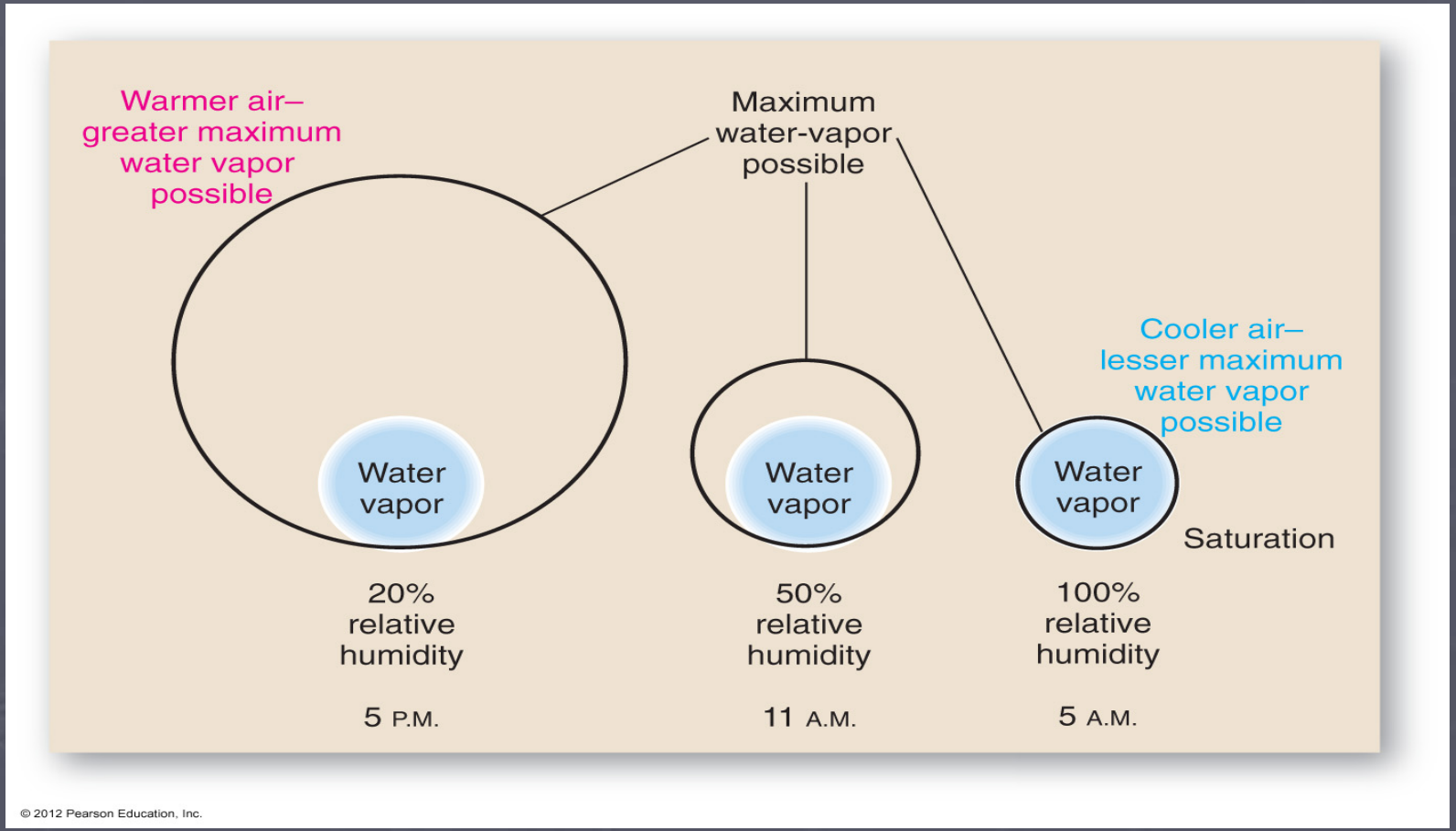
Changes in Relative Humidity

- An increase in air temperature allows more room for water vapor



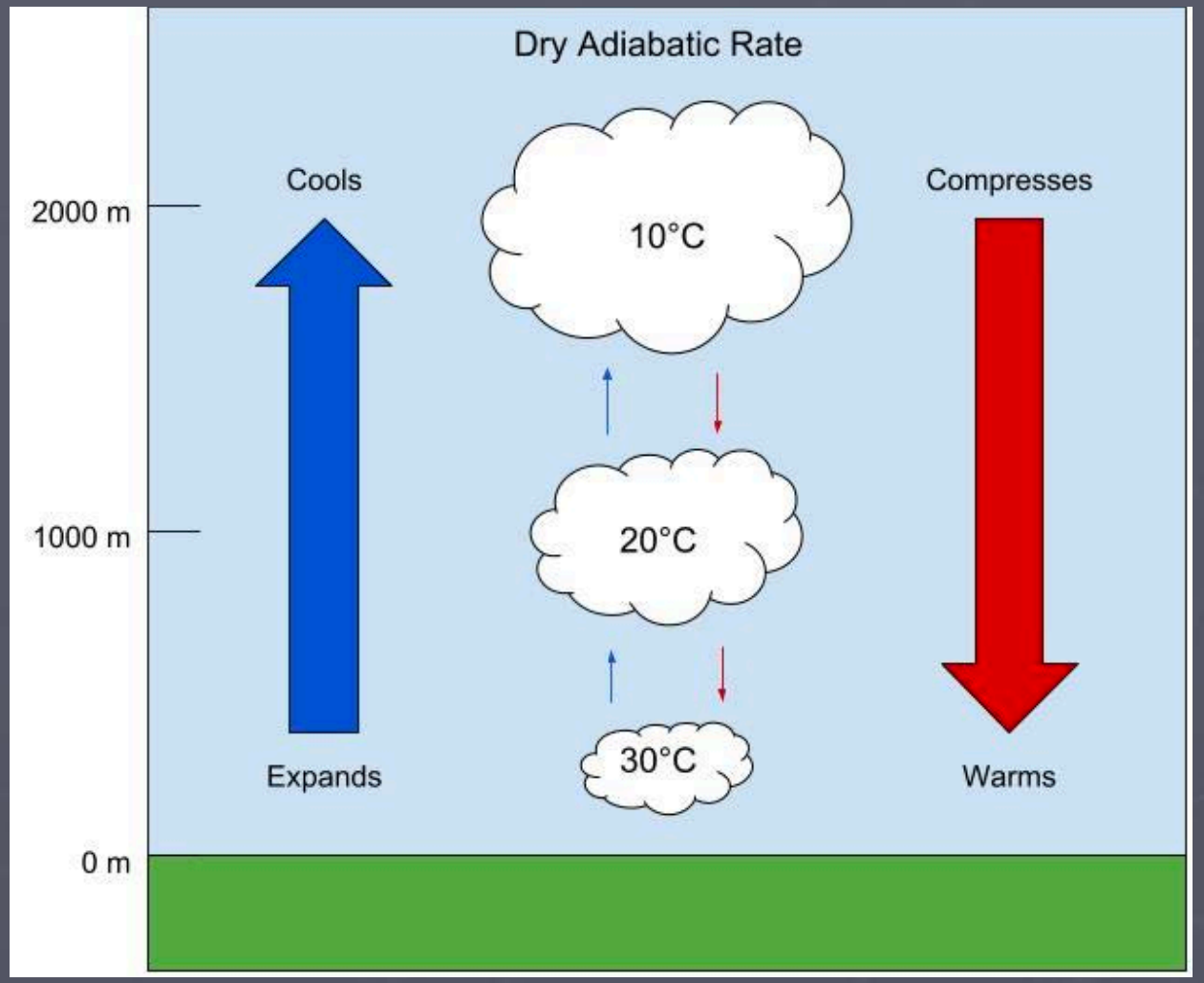
Changes in Relative Humidity

- Temperature staying the same but amount of moisture increasing

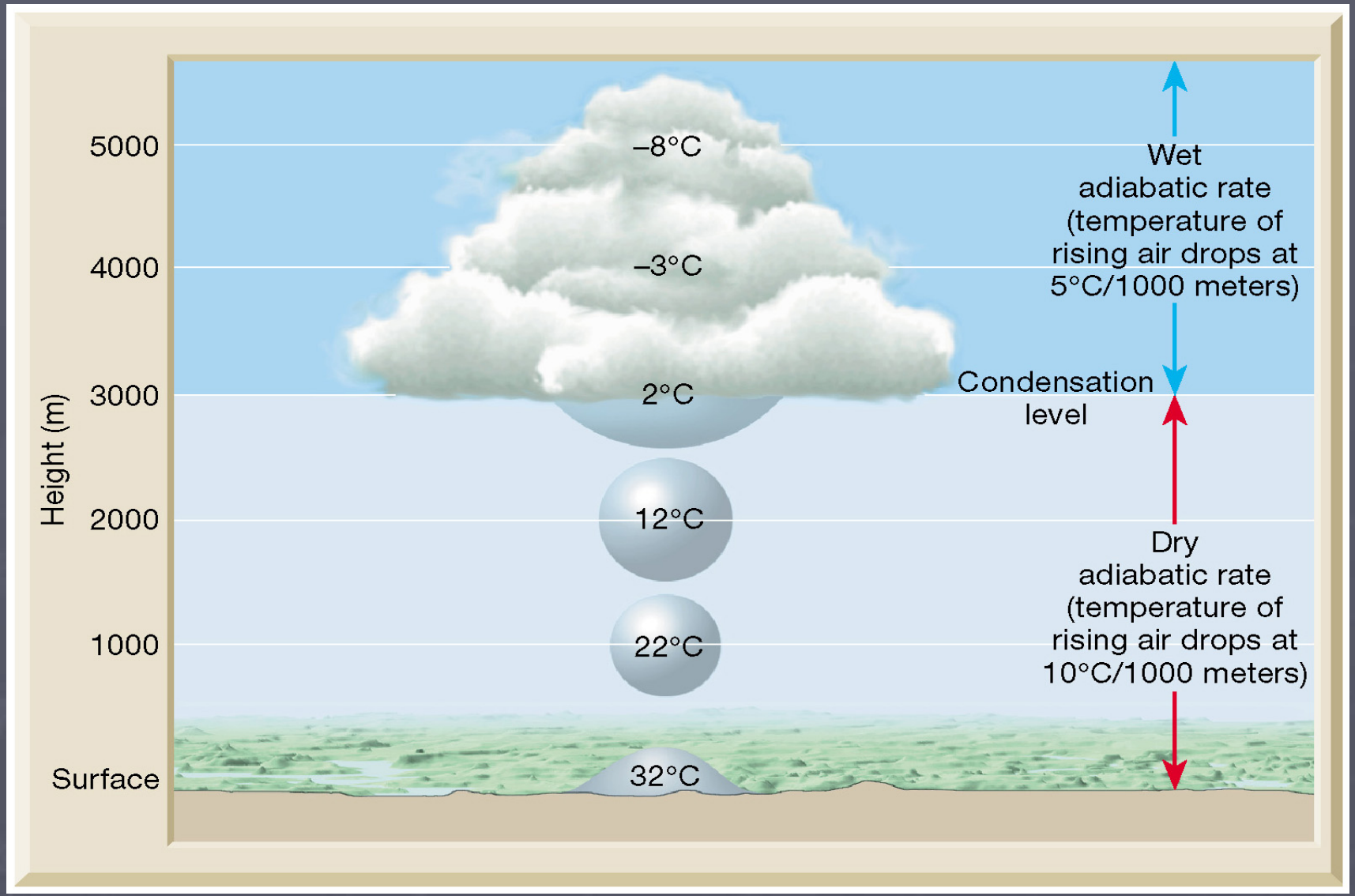


Adiabatic Heating and Cooling

- Happens when a parcel of air moves altitude until it reaches its dew point and causes cloud formation
  - As air descends and is compressed air will warm
  - As air ascends and expands air cools

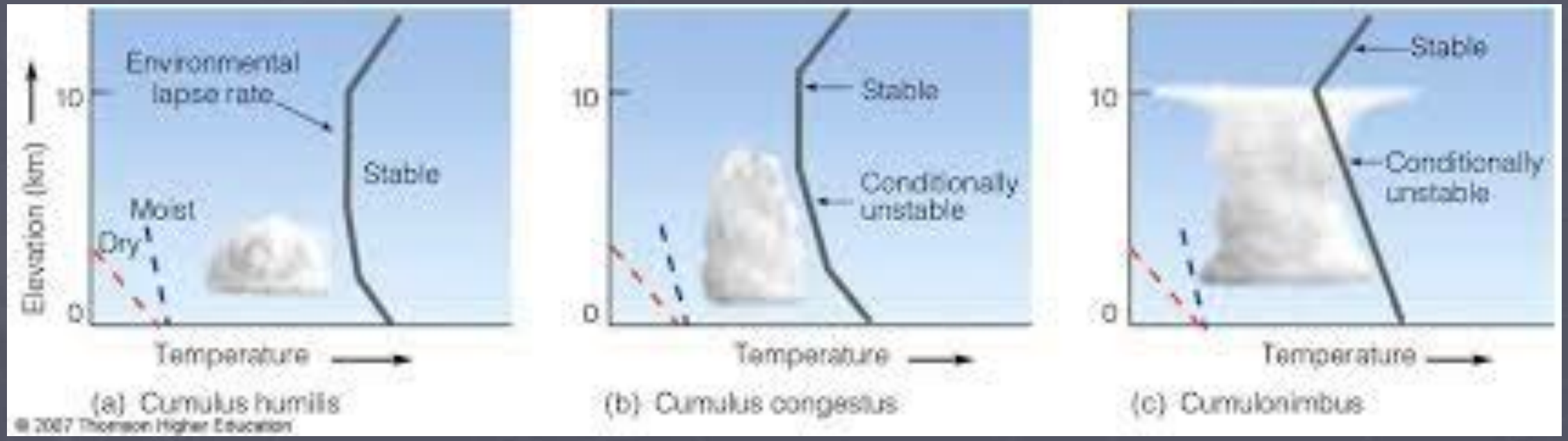


Adiabatic Cloud Formation



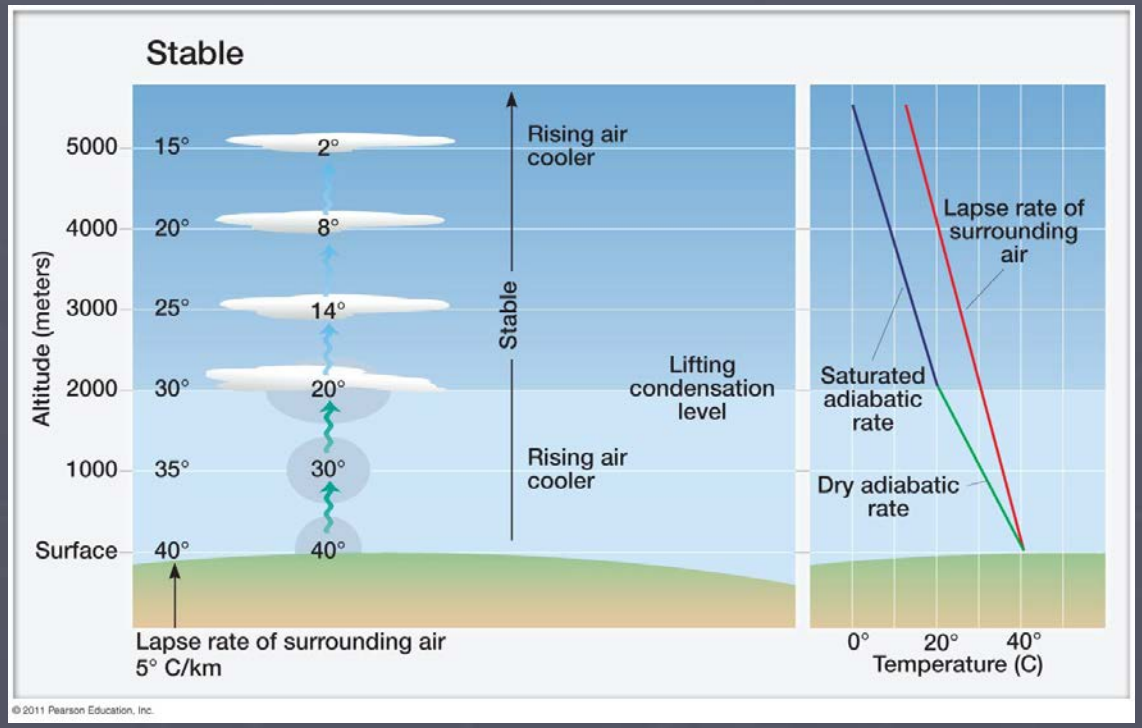
Stable and Unstable Air

- Air stability dependent upon differences in temperature at altitude
  - **Environmental Lapse Rate** – The rate at which air temperatures change at different altitudes
  - Determines types of clouds and precipitation



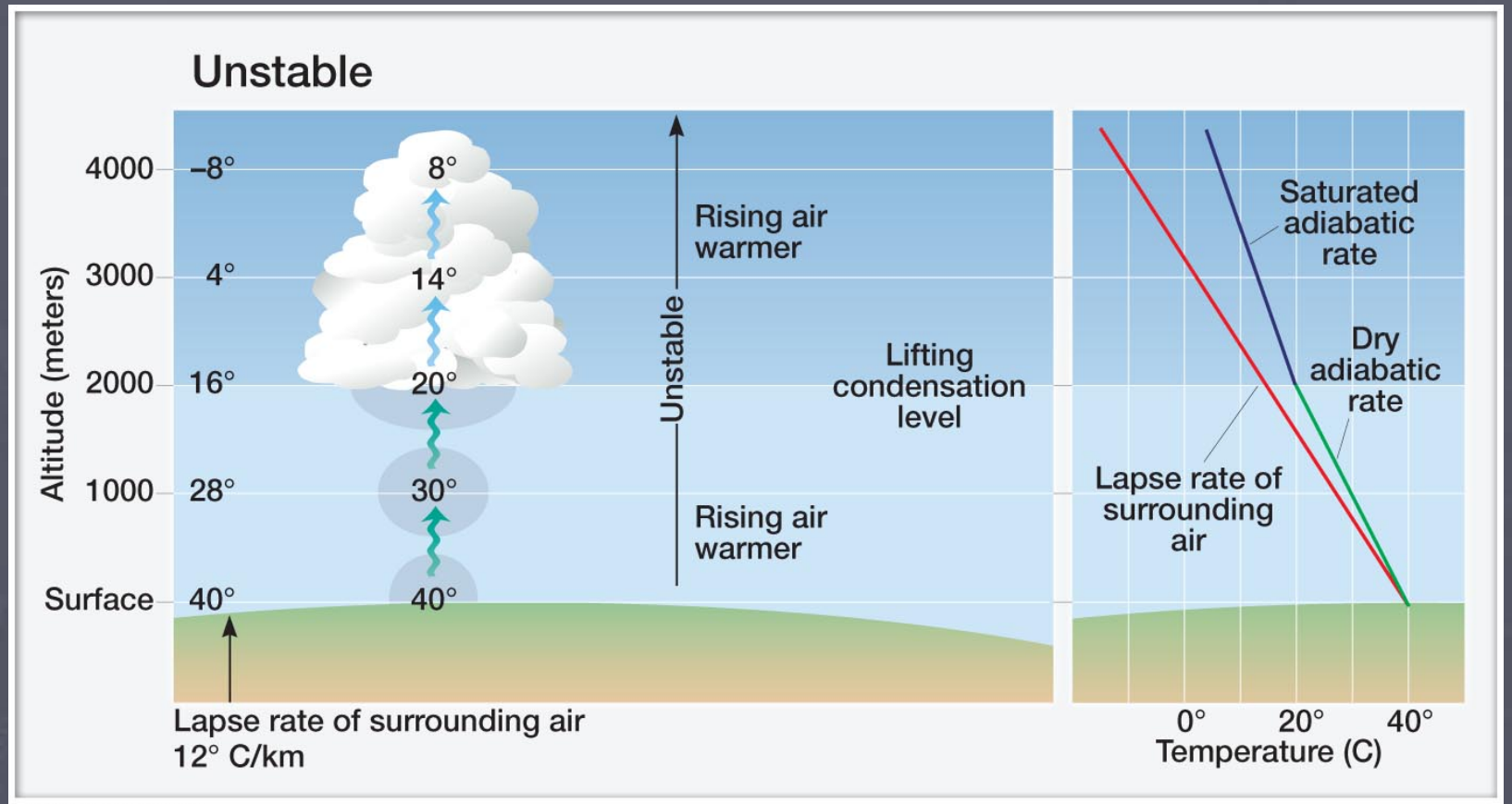
Stable Air

- Cooler and denser than surrounding air, wants to sink
- Often results in widespread clouds with little vertical thickness (or sunny!)
- Precipitation, if any, is light to moderate



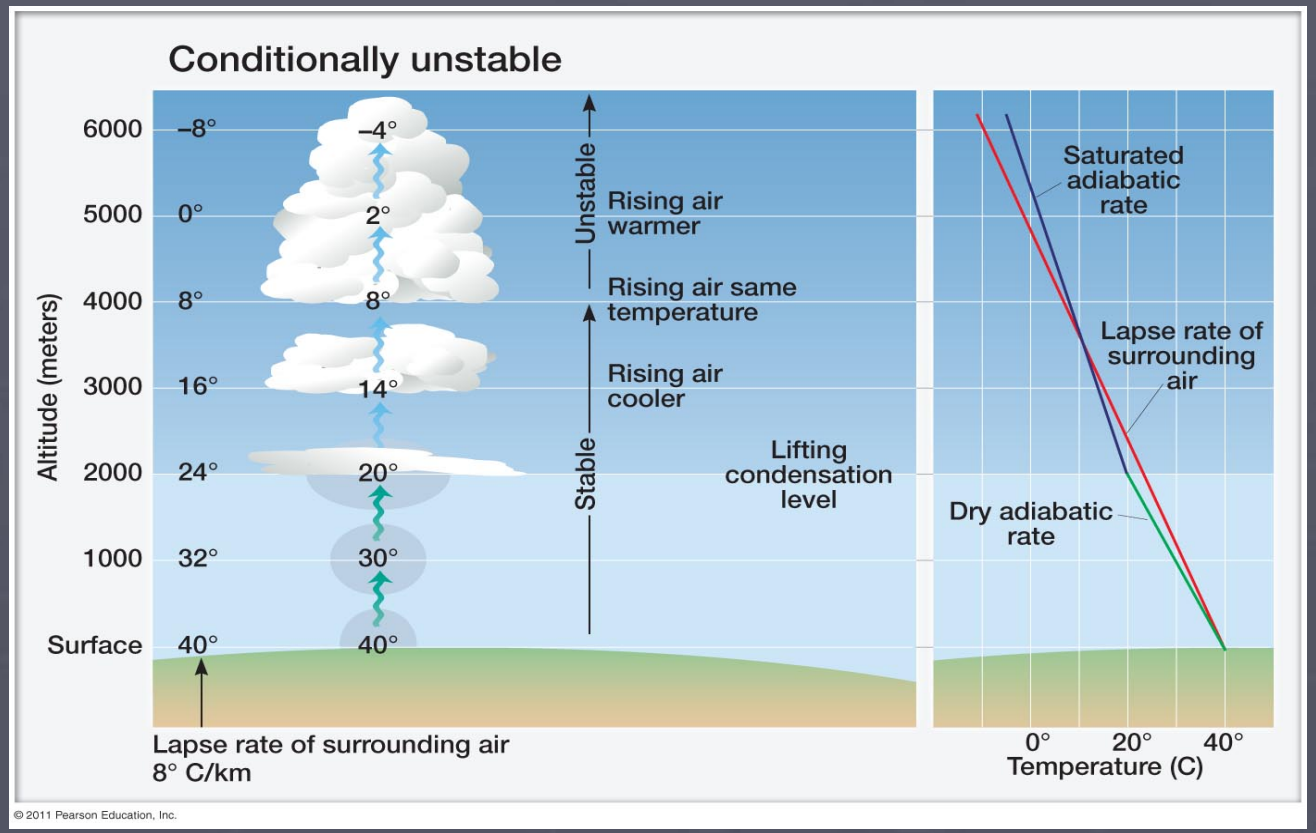
Unstable Air

- Environmental lapse rate is greater than the dry adiabatic rate
- Clouds are often towering



Conditionally Unstable

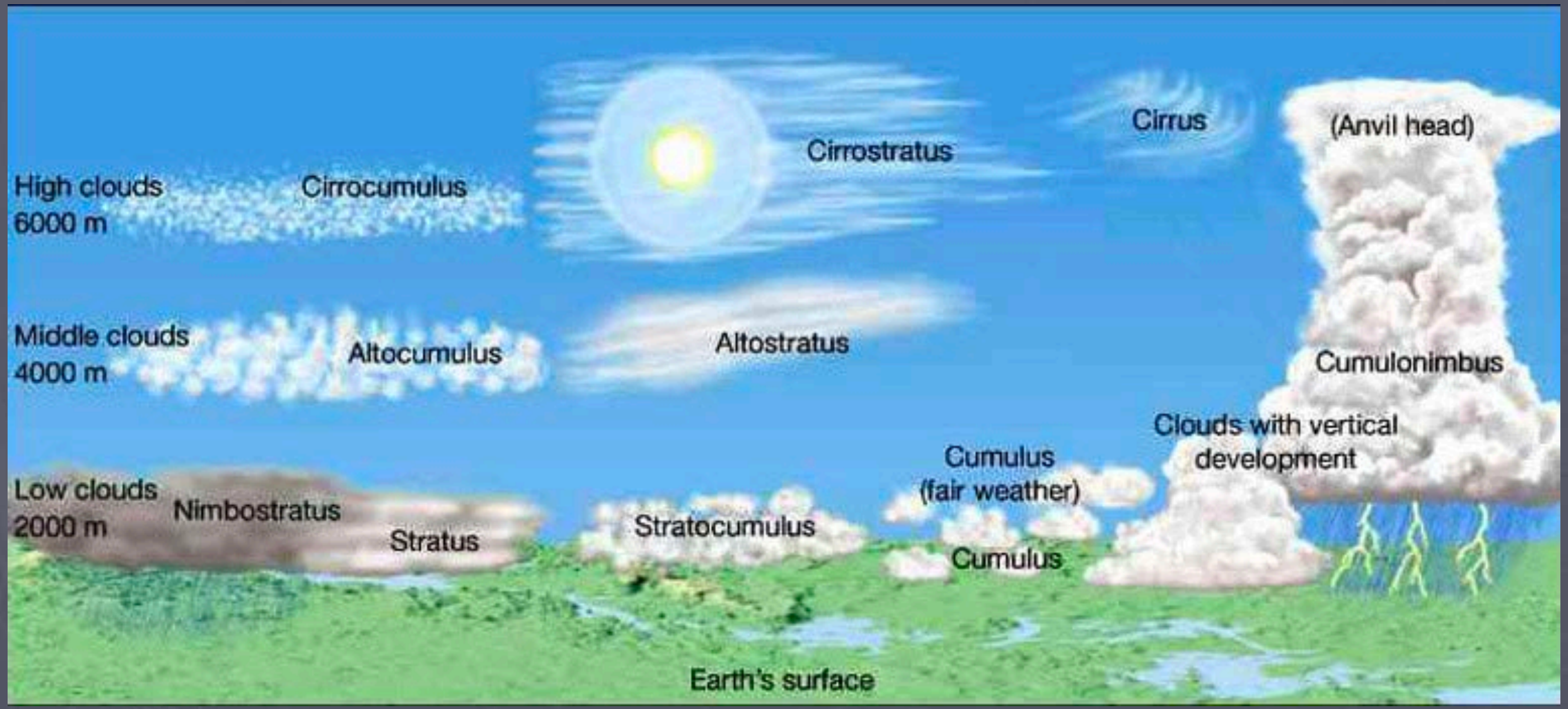
- Environmental lapse rate is less than the dry adiabatic rate
  - but greater than saturated Adiabatic Rate



Types of Clouds

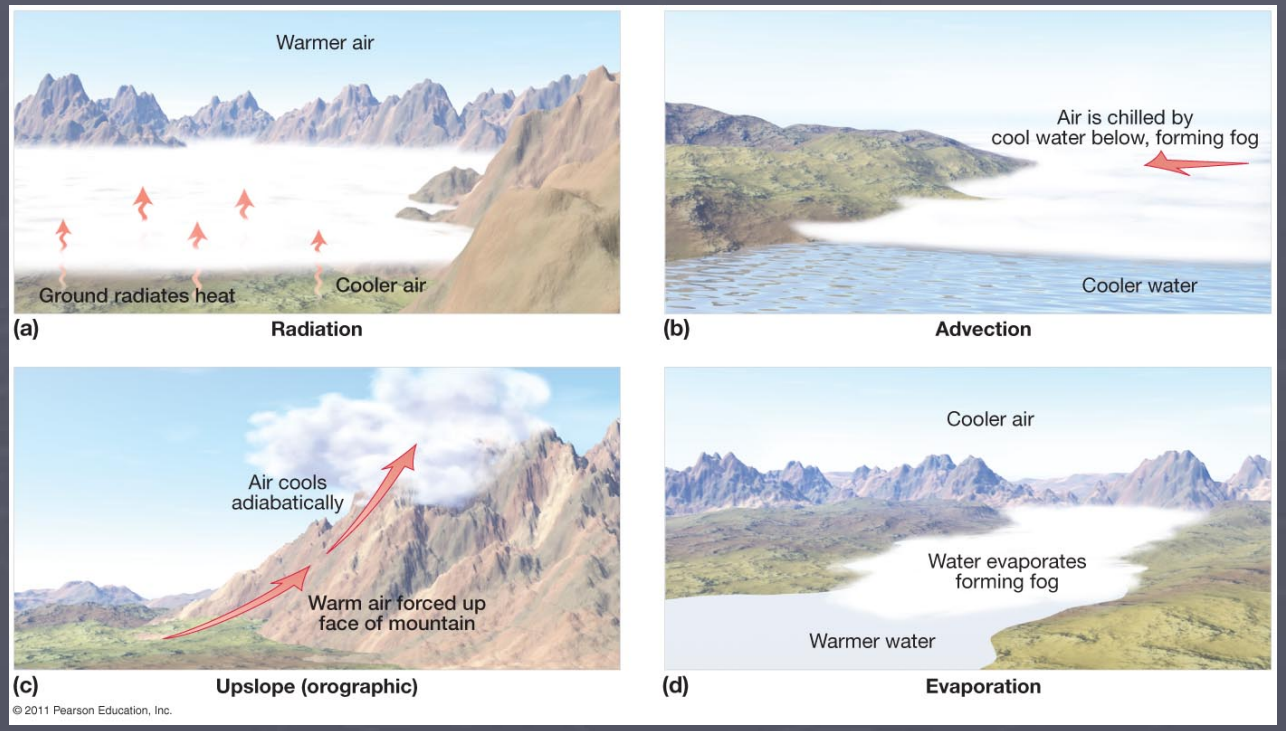
- Clouds are collections of millions of water (or ice) molecules that condense in the atmosphere
  - Classified by form and height
    - **Cirrus** – high, white, thin
    - **Cumulus** - globular cloud masses often associated with fair weather
    - **Stratus** – sheets or layers that cover much of the sky

Types of Clouds



Fog

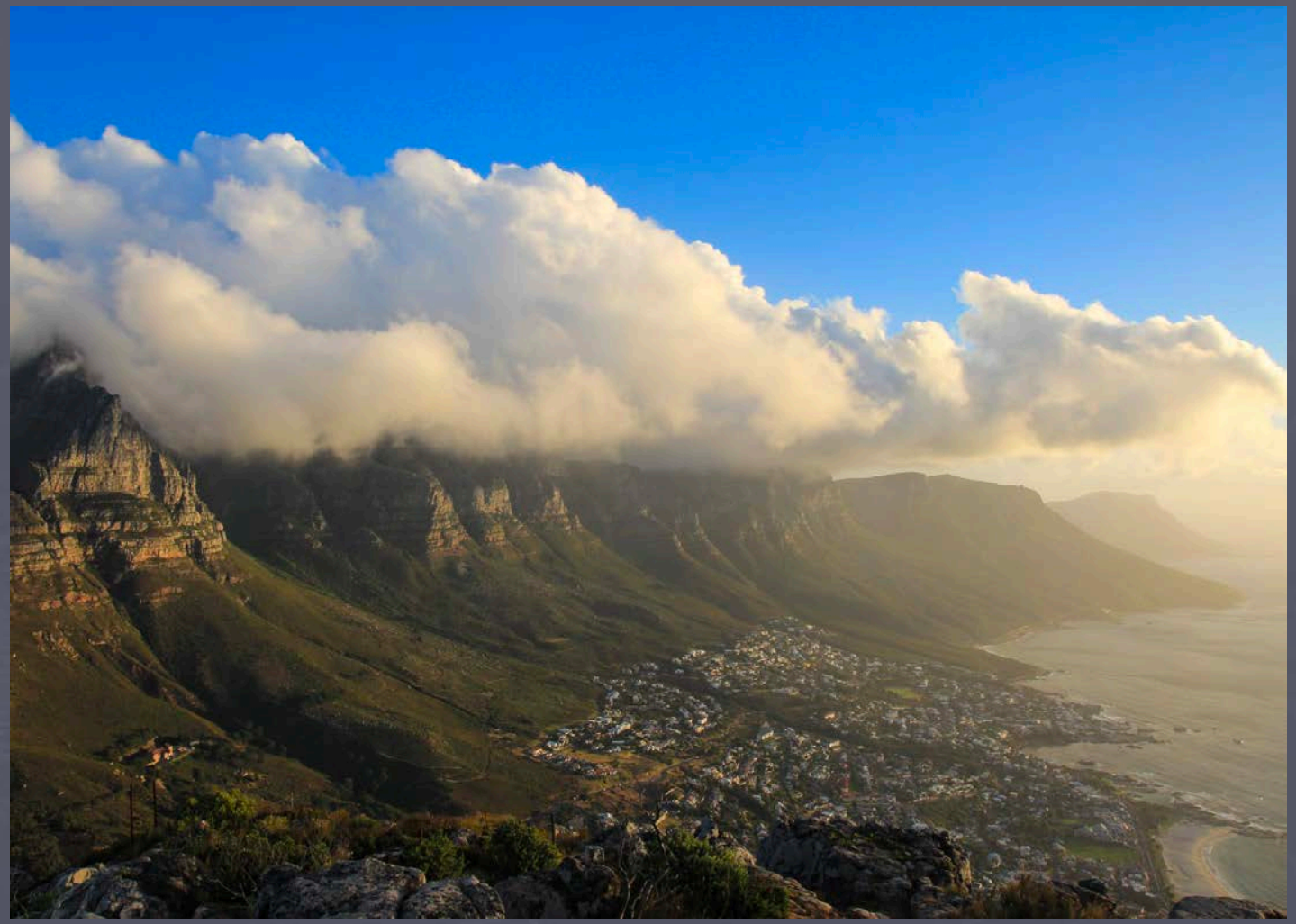
- Fog and clouds are structurally the same
  - Only difference is the altitude they form at and how



Radiation (Ground Fog)

Advection (Sea Fog)

Upslope (Mountain Fog)



Evaporation (Lake/River Fog)