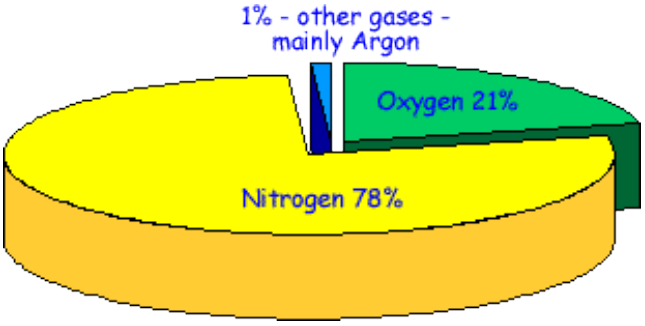
Atmosphere

Essential Questions:

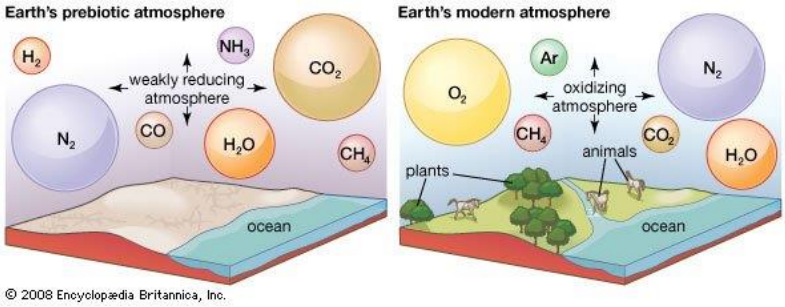
- What is the gas and particle composition of the atmosphere?
- What are the 5 layers of the atmosphere?
- How is energy transferred around the atmosphere?

Composition of the Atmosphere

- Currently:
  - Nitrogen (N_2): 78%
  - Oxygen (O_2): 21%
  - Argon (Ar)
  - Carbon dioxide (CO_2)
  - Water Vapor (H_2O)



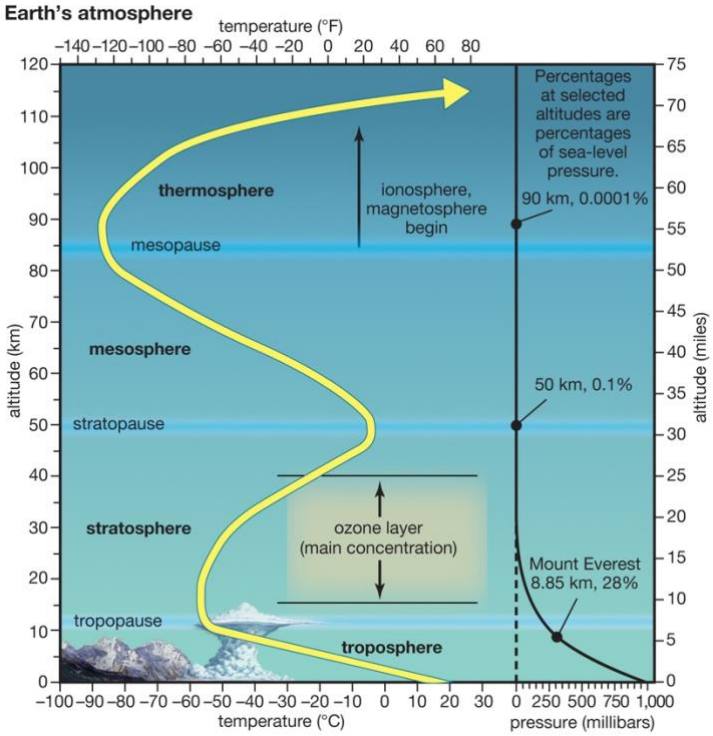
- In the past:
  - Helium, hydrogen, methane, ammonia



Variable Atmospheric Components

- The following gases change over time:
  - Water vapor
  - Carbon dioxide: increase over past 200 years : 0.028% to 0.039%
  - Ozone: O_3
    - In the upper atmosphere: protects from ultraviolet radiation
    - In the lower atmosphere: it is a pollutant
  - Particles:
    - Dust
    - Salt
    - Ice
    - Fungi
    - Bacteria

Atmospheric Layers



- Troposphere:
  - weather occurs here
  - most of the atmospheres mass
  - temp range: 15ºC to -60ºC
- Stratosphere:
  - contains the ozone layer
  - temp range: -60ºC to 0ºC
- Mesosphere:
  - very cold because little solar radiation is absorbed
  - temp range: 0ºC to -90ºC
- Thermosphere:
  - contains ionosphere
  - temp range: up to 2000ºC
- Exosphere:
  - transition between space and Earth's atmosphere
  - temp range: 0ºC to 2000ºC

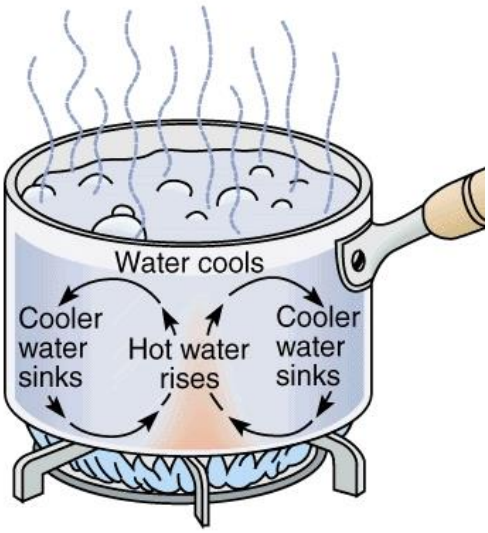
Thermal Energy Transfer (Heat)

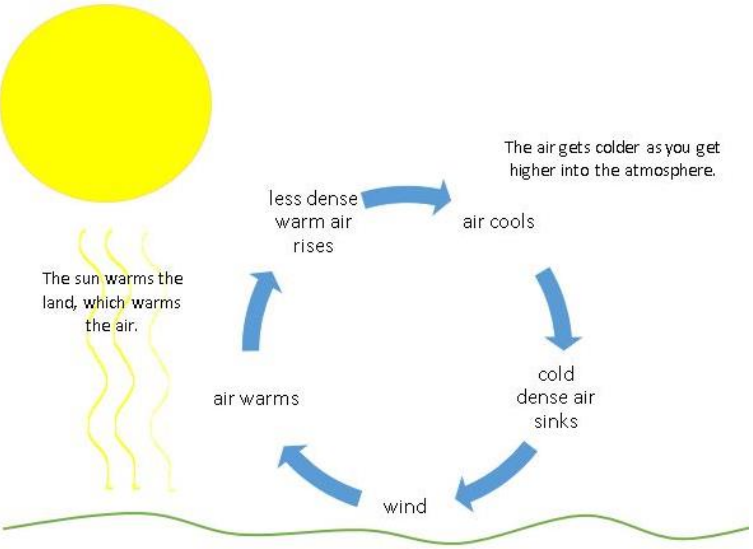
- Heat: transfer of thermal energy from high to lower temperature
  - in the atmosphere this is done by: radiation, conduction & convection

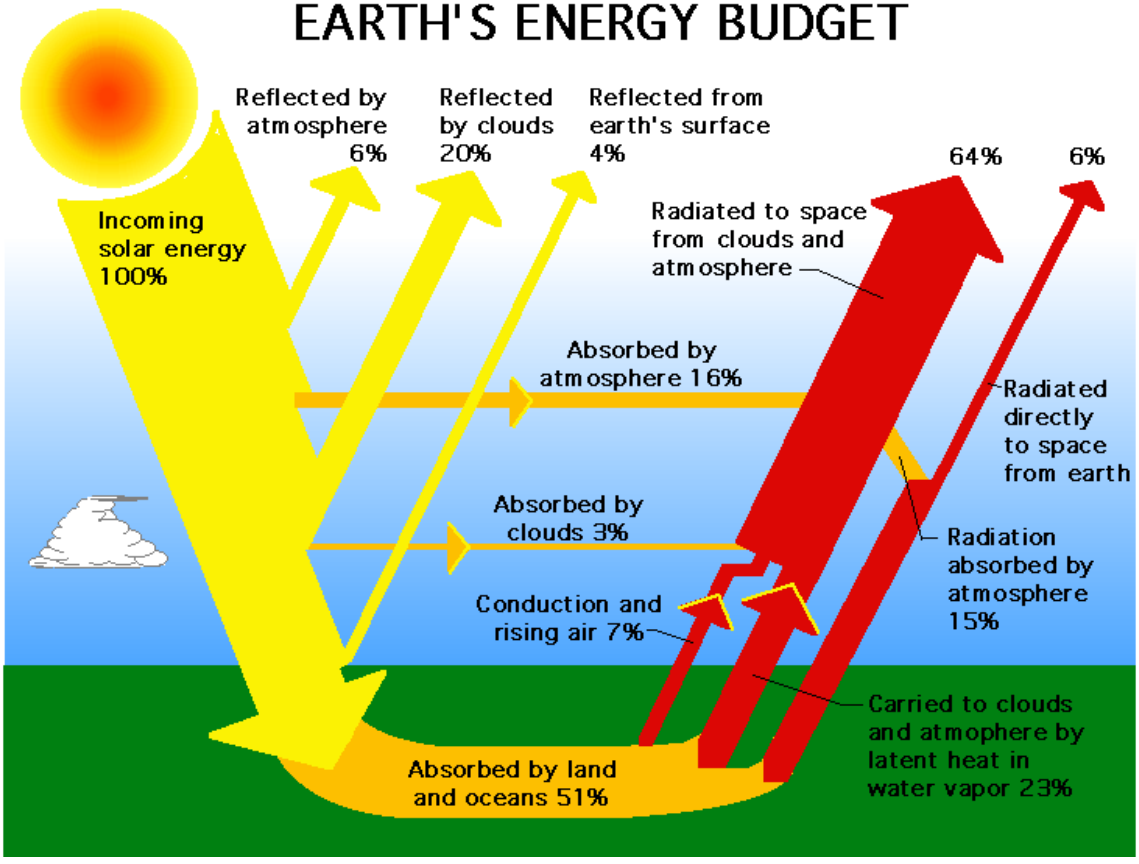
- **Radiation:** transfer of heat by electromagnetic waves (EMR)
  - example: heat lamp: emits visible & infrared light, that energy gets absorbed by the food and heats up
  - Visible and Infrared EMR is absorbed and reflected by clouds, atmosphere & Earth's surface
  - rate of absorption by the Earth varies from place to place and by the season

- **Conduction:** transfer of heat through direct contact
  - occurs most easily in solids because particles are close together

- **Convection:** movement of heated material from one place to another through currents in a liquid or gas
  - main mechanism for energy trans fer in the atmosphere
  - warm air (less dense) rises
  - cool air (more dense) sinks







Temperature and Air Pressure in the Atmosphere

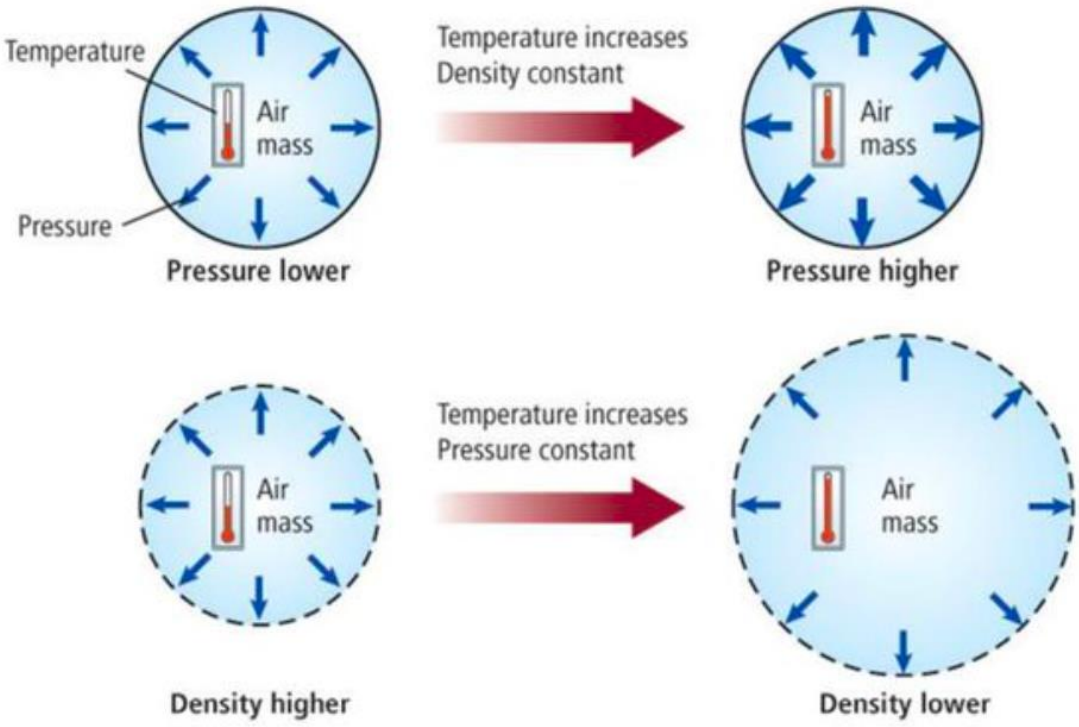
Essential Questions:

- What are the 3 main properties of the atmosphere and how do they interact?
- Why do atmospheric properties change with changes in altitude?

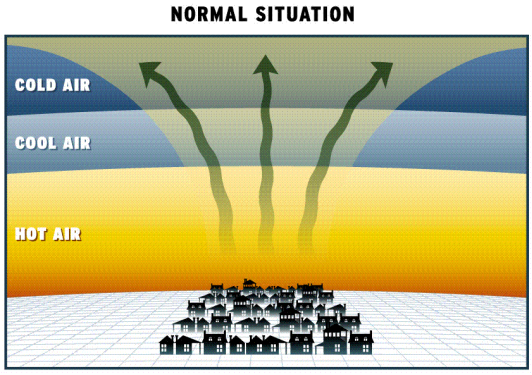
- **Temperature:** average kinetic energy of particles in a material
  - measured in ^oC, ^oF, or K
    - $^oF = 9/5^oC + 32$ $^oC = 5/9(^oF-32)$
  - **Adiabatic:** air changing temp without being heated or cooled, but by changing pressure; ex. can of compressed air
    - Temperature increases if pressure increases: ↑T ↑P
    - Temperature decreases if pressure decreases: ↓T ↓P

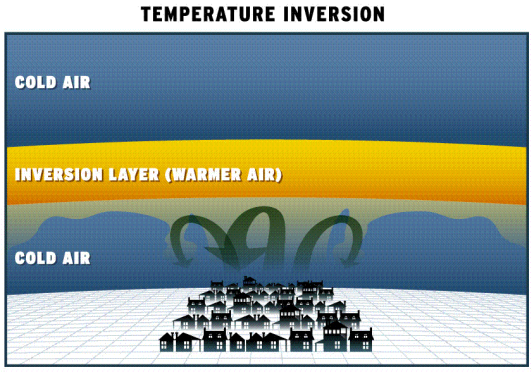
- **Pressure:** force dived by area
  - units: Newtons per square meter: N/m^2
  - often measured in millibars (mb)
    - 100,000 N/ m^2 = 1000 mb ; 14.7 lb/ in^2
- **Density:** mass/volume
  - units: kg/m^3 or g/cm^3
  - Pressure increases if Density increases: ↑P↑ D
  - Pressure decreases if Density decreases: ↓P↓D

Can crushing https://www.youtube.com/watch?v=Yz6vw2u1yRU
Egg in bottle https://www.youtube.com/watch?v=zSXzo_LNhO0



- **Temperature Inversion:** Increase in temperature with height in an atmospheric layer(usually the troposphere/lower layer)





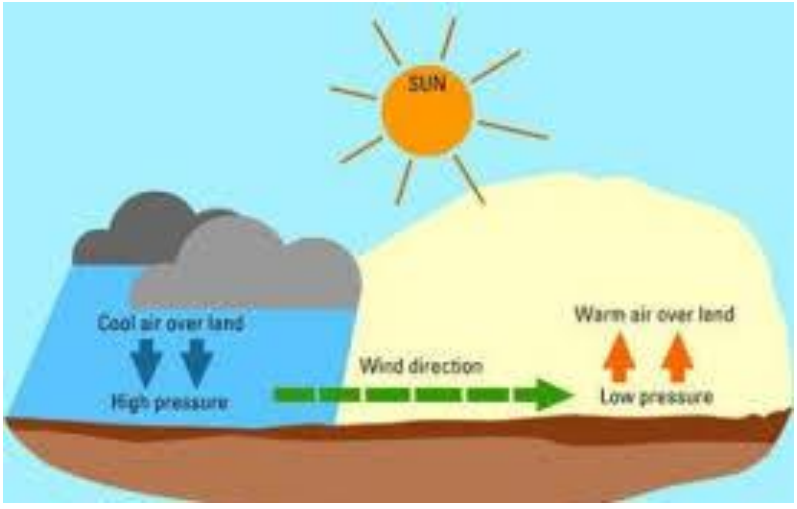
- Rapid cooling of land on a cold, clear night can cause a temp inversion
- Temperature inversions can cause fog, haze, and smog
- Air pollution is trapped under the inversion layer

https://www.youtube.com/watch?v=iBP1CJMlLJM

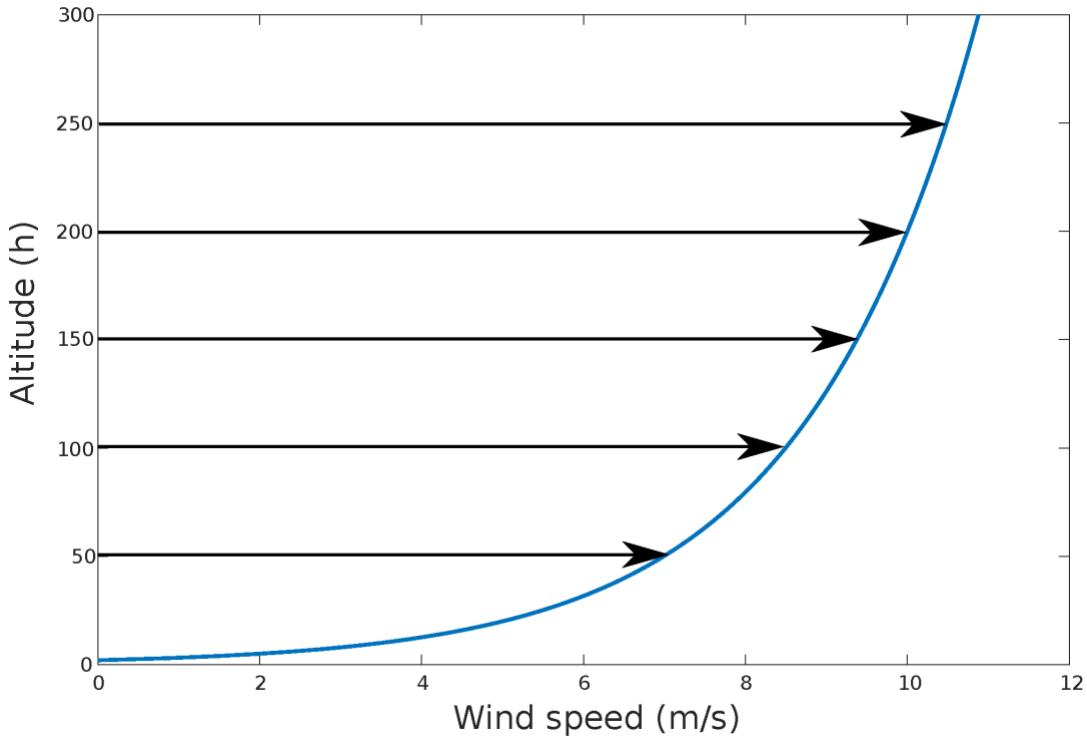
- **Wind:** movement of air; caused by cold, dense air rushing towards warm, less dense air
  - air moves from regions of higher density to areas of lower density

    high density ⟶ low density
  - air pressure increases as density increases; so air moves from areas of high pressure to low pressure

    high pressure ⟶ low pressure



- **Wind speed and Altitude**
    - wind moves slower near the Earth's surface due to friction
    - wind speed is measured in:
        - miles per hour (mph)
        - kilometers per hour (km/h)
        - at sea: knots
            1 knot = 1.85 km/h or 1.15 mph
    - wind speeds increase at higher altitudes



- **Humidity:** amount of water vapor in the atmosphere at a given location
    - water molecules are constantly evaporating into the atmosphere and then condensing to form clouds and precipitation
        - if rate of evaporation > rate of condensation, then the amount of water vapor increases
    - two ways to express: relative humidity and dew point

- **Relative Humidity:** amount of water vapor needed for a volume of air to reach saturation
    - Saturation: amount of water vapor in the air is at its max
    - Relative humidity is expressed as a percentage of saturation
        100% humidity = 100% saturation

Relative Humidity (%)

Dew point depression: difference between Wet-bulb and Dry-bulb

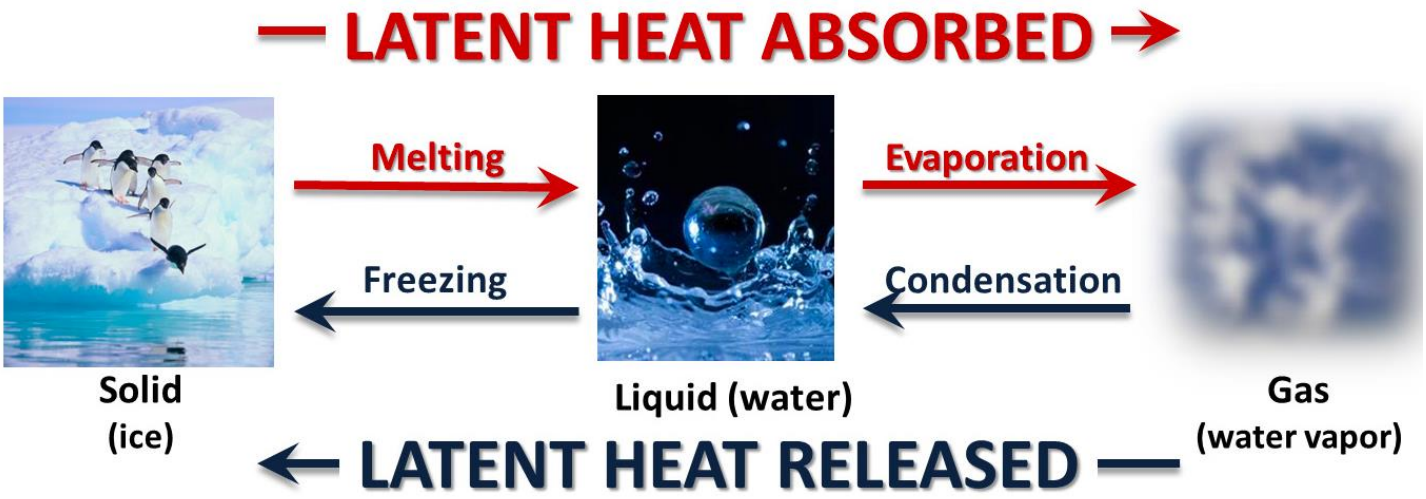
Dry-Bulb Temperature (°F)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
32	90	79	69	60	50	41	31	22	13	4					
36	91	82	73	65	56	48	39	31	23	14	6				
40	92	84	76	68	61	53	46	38	31	23	16	9			
44	93	85	78	71	64	57	51	44	37	31	24	18	12		
48	93	87	80	73	67	60	54	48	42	36	31	25	19	14	8
52	94	88	81	75	69	63	58	52	46	41	36	30	25	20	15
56	94	88	82	77	71	66	61	55	50	45	40	35	31	26	21
60	94	89	84	78	73	66	63	58	53	49	44	40	35	31	27
64	95	90	85	79	75	70	66	61	56	52	48	43	39	35	31
68	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35
72	95	91	86	82	78	73	69	65	61	57	53	49	46	42	39
76	96	91	87	83	78	74	70	67	63	59	55	52	48	45	42
80	96	91	87	83	79	76	72	68	64	61	57	54	51	47	44
84	96	92	88	84	80	77	73	70	66	63	59	56	53	50	47
88	96	92	88	85	81	78	74	71	67	64	61	58	55	52	49
92	96	92	89	85	82	78	75	72	69	65	62	59	57	54	51
96	96	93	89	86	82	79	76	73	70	67	64	61	58	55	53
100	96	93	90	86	83	80	77	74	71	68	65	62	59	57	54

Dry Relative Humidity < 25%
Comfortable Relative Humidity 25-64%
Uncomfortable Relative Humidity ≥ 65%

- **Dew Point:** temperature to which air must be cooled at a constant pressure to reach saturation

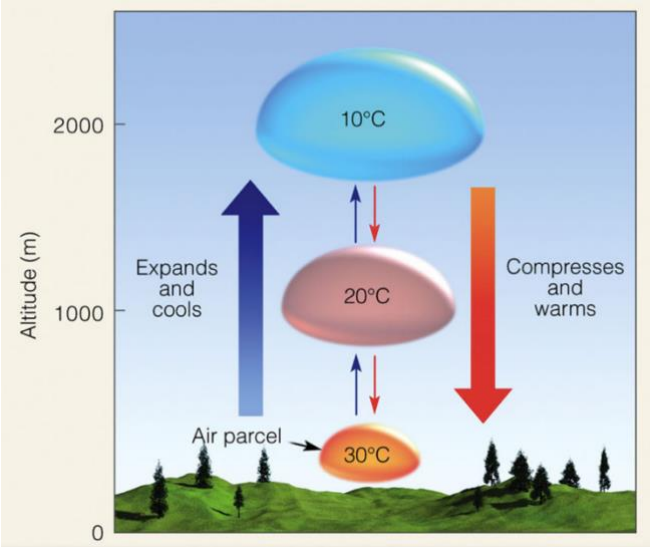
Dewpoint	How it Feels	Emojification
50 – 60°F	Comfortable	
60 – 65°F	Getting Sticky	
65 – 70°F	Unpleasant	
70°F or more	Downright Gross	

- **Latent Heat:** as water vapor in the air condenses, thermal energy is released as latent heat.
  - this latent heat can add energy to fuel storms such as hurricanes



- **Condensation:** when water goes from gas to liquid
  - when this occurs, the temperature doesn't change, only the amount of latent heat energy changes!
- Condensation level: height at which condensation occurs
  - cloud formation
- Adiabatic: air changing temp without being heated or cooled, but by changing pressure; ex. can of compressed air

- adiabatic heating: occurs when air is compressed
- adiabatic cooling: occurs when air expands

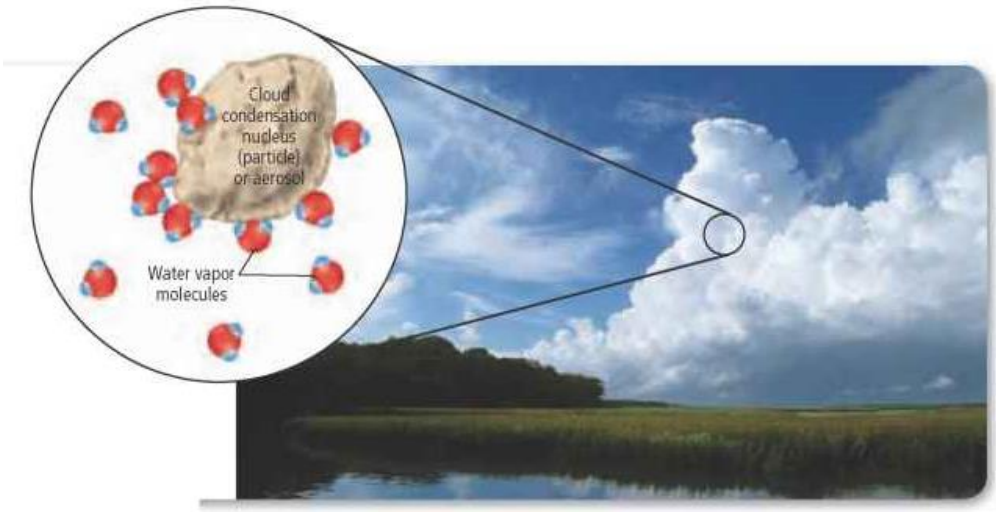


Clouds and Precipitation

Essential Questions:

- What is the difference between stable and unstable air?
- How do low, middle, high, and vertical development clouds differ?
- How does precipitation occur?

- **Cloud Formation:** Clouds form when rising air masses cools, causes water vapor to condense.
  - Condensation Nucleus: a particle in the atmosphere around which water droplets can form. When there are a lot of droplets, clouds form
    - Ice
    - Salt
    - Dust
    - Or any other solid particles, such as pollen

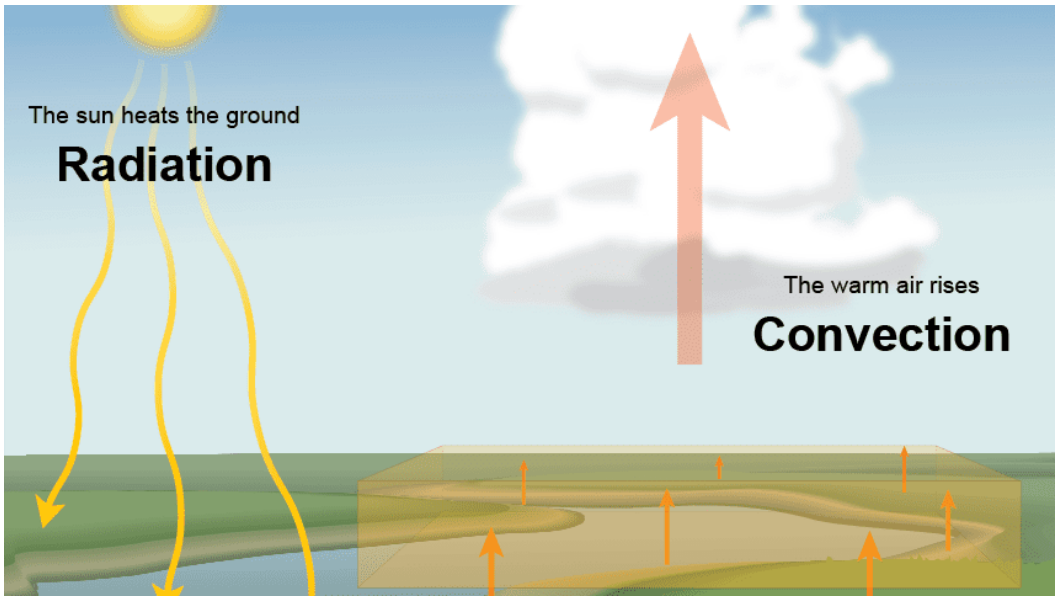


- **Atmospheric Stability:**

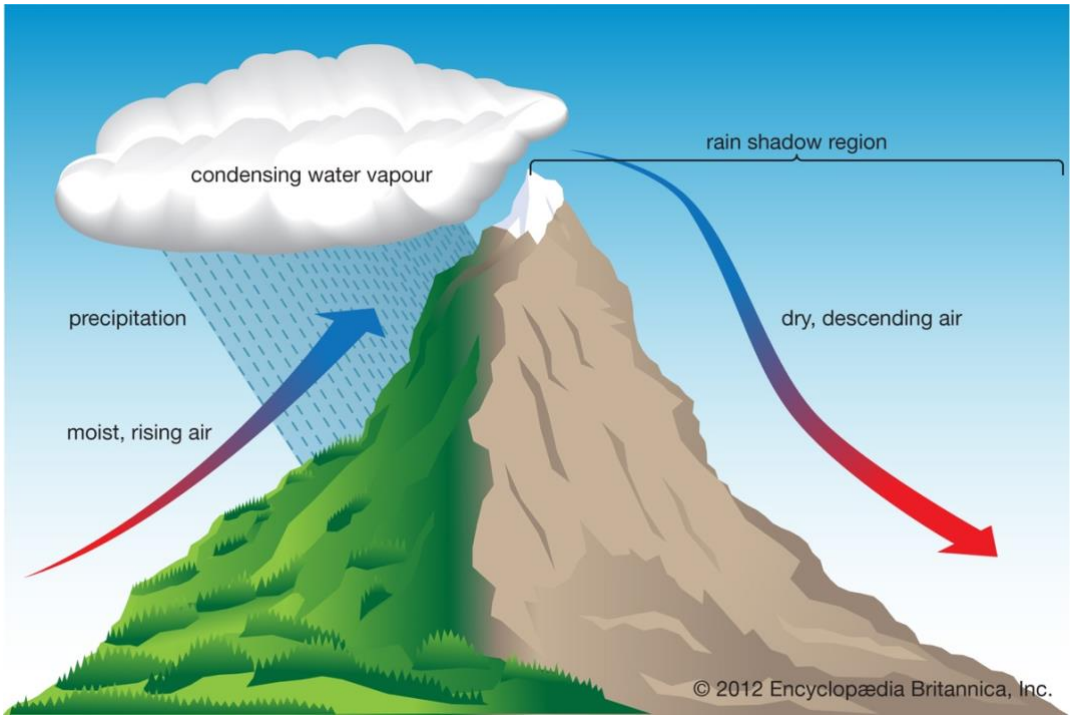
- As an air mass rises it cools.
  - Stable Air: air that stops rising because it has cooled.
    - Produces fair weather clouds.
  - Unstable Air: air that continues to rise because it is always less dense than the surrounding atmosphere.
    - Produces thunderstorm clouds.

- **Atmospheric Lifting:** Clouds form when moist air rises and cools.

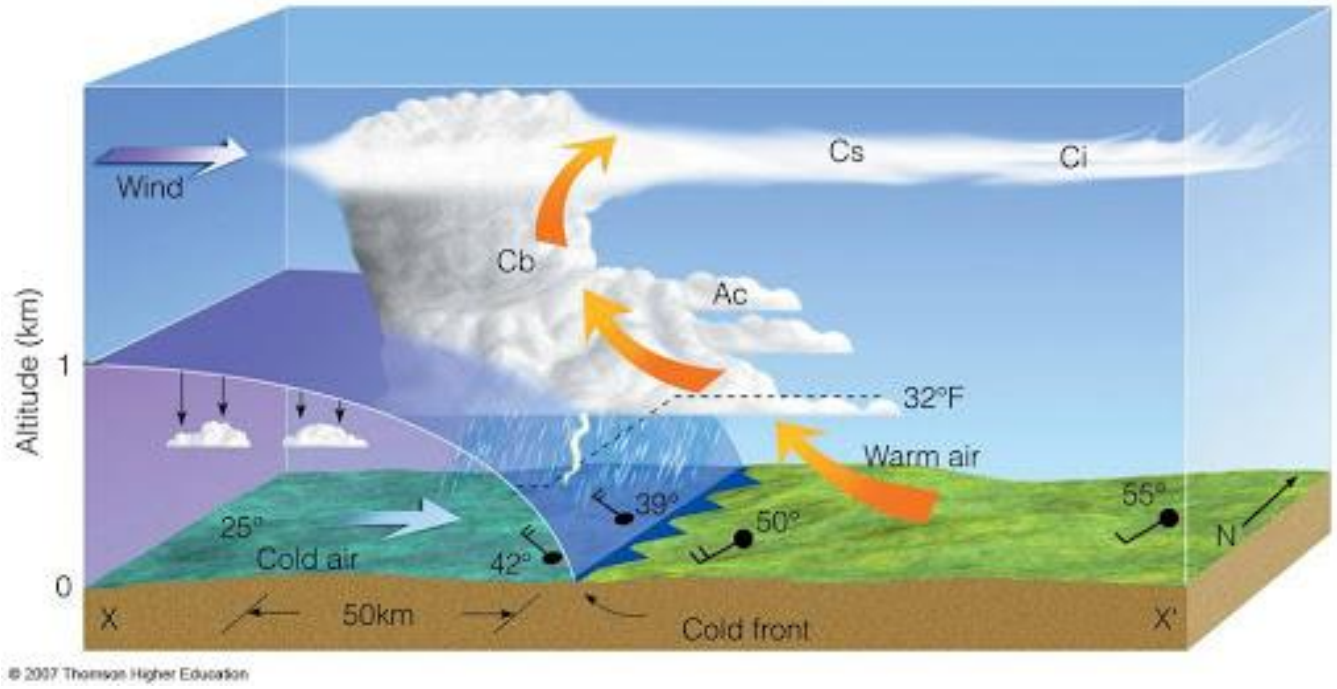
  - Convective Lifting: warm, less dense air will rise.



  - Orographic Lifting: when an air mass is forced to rise over a topographic barrier (mountains.)
    - Wind forces warm air up mountain side.
    - When air reaches dew point, clouds form and precipitation occurs.



- Convergence: warm air collides with cold air.
    - less dense warm air is forced up.
    - when rising air reaches dew point clouds form.



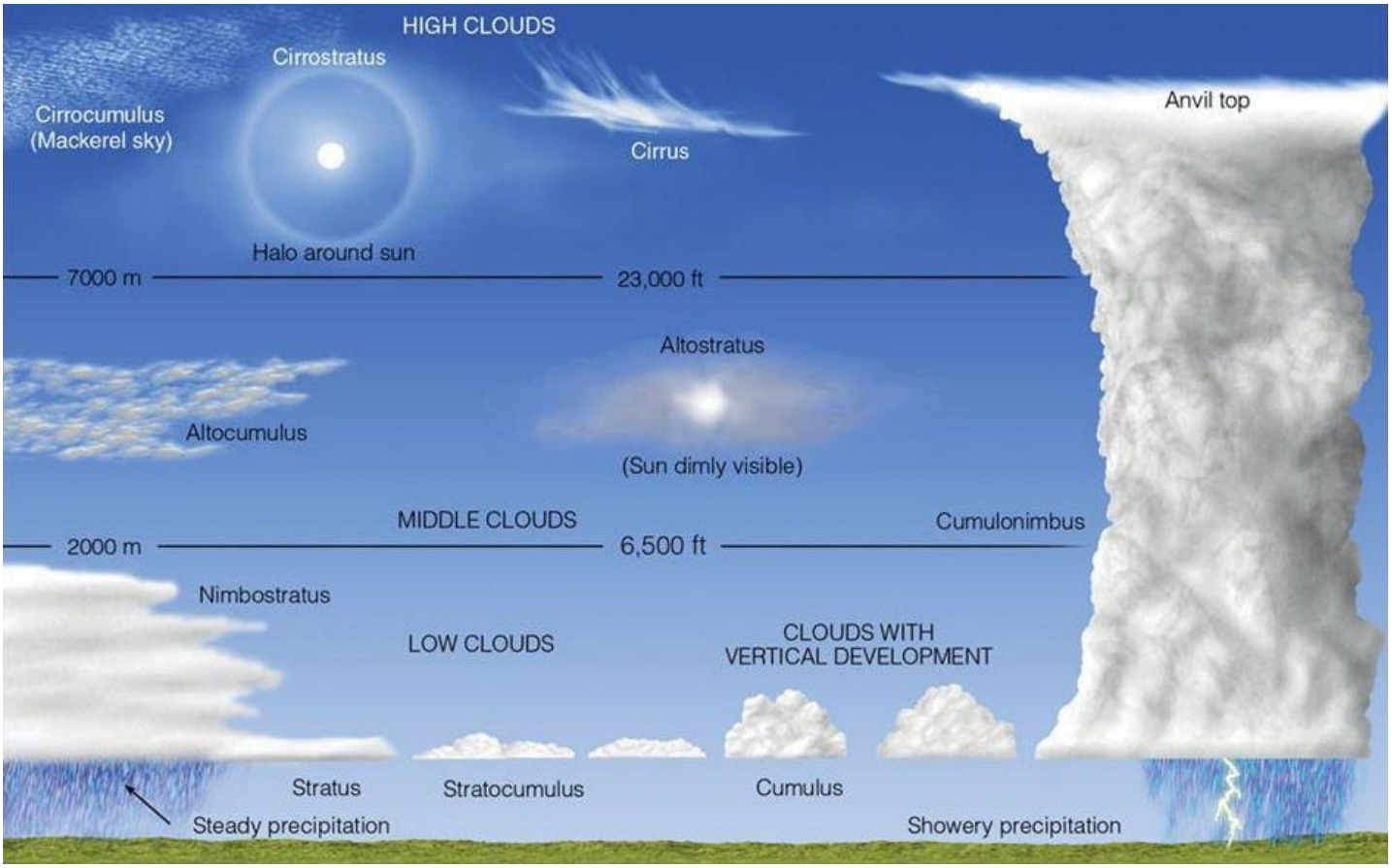
- **Cloud Types:** Clouds are classified based on altitude, and then further subdivided based on shape

Latin words that represent some of our basic clouds
Stratus (Latin for "layer"), **Cumulus** ("heap"), **and Cirrus** ("curl of hair").

- Low
    - Cumulous: puffy and lumpy looking
        - cumulonimbus: heavy rain/thunderstorms
    - Stratus: layered, overcast days, mist/fog, steady rain
        - nimbostratus: block whole sky; precipitation

- Middle: Ice and water droplets
    - Altocumulus: white or gray; large round or wavy
    - Altostratus: gray - thin sheets

- High: Ice crystals
    - Cirrus: wispy horse tails and indistinct
    - Cirrostratus: continuous layer that covers the sky
    - Cirrocumulus: rippled or granulated, fish scale look (mackerel sky)



- **Types of Precipitation:** droplets in clouds grow through coalescence; when droplets stick together forming rain drops

  - Four types
    - Rain: liquid water
    - Snow: solid ice crystals
    - Sleet: mixture of rain and snow
    - Hail: forms when drops of water freeze together when droplets move up and down through freezing and non-freezing air