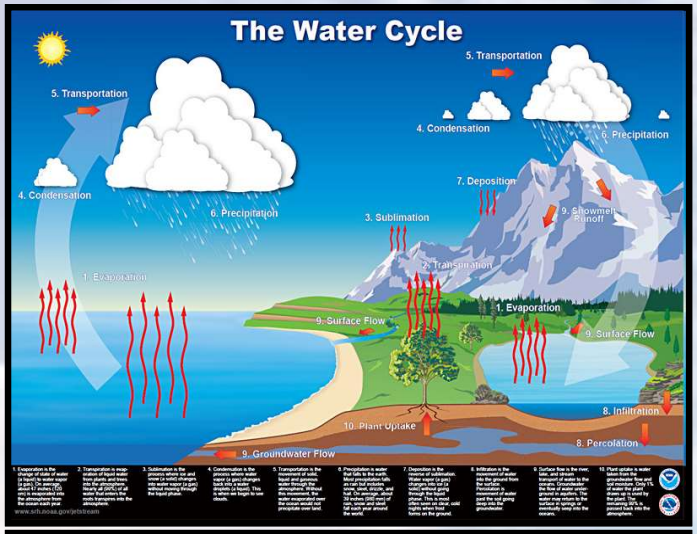
Lecture 7

Water in the Atmosphere & Dew and Frost

Learning Goals for Part 1 of Chapter 4



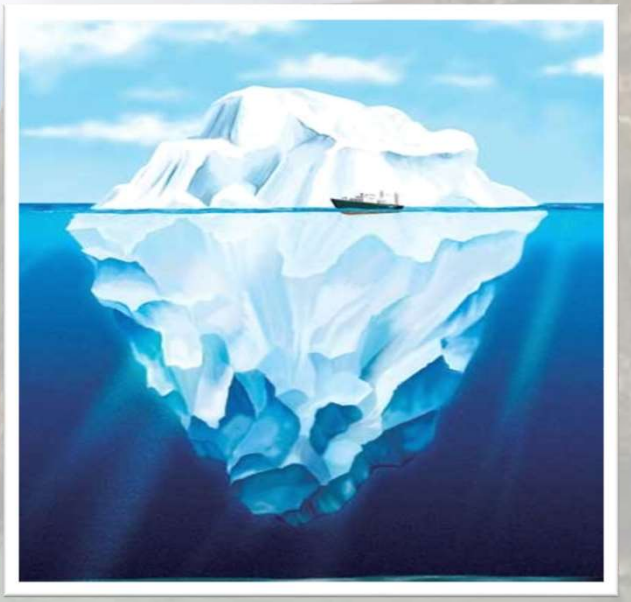
1. Know the different components of the **WATER CYCLE** and if energy is released or required.

2. Be able to tell the difference between the different ways we describe **HUMIDITY**.

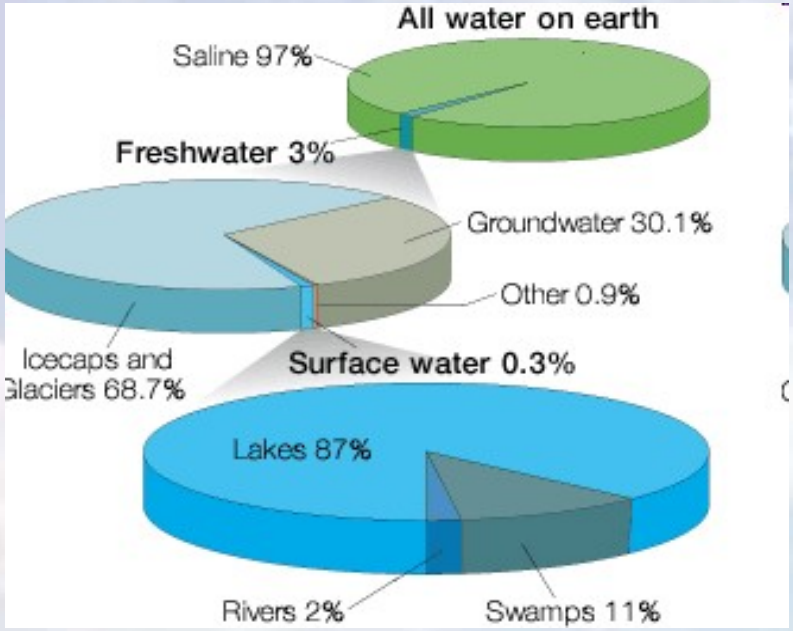
3. Know the difference between **DEW** and **FROST**.

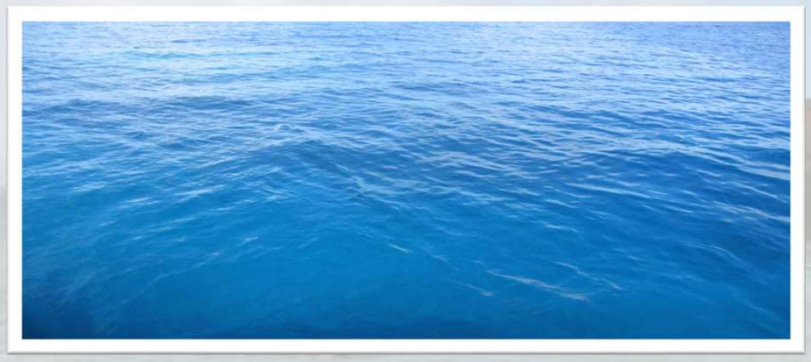
Water – gives life and so much more

- **Special Properties:**
  - Water easily changes from solid (ice) to liquid to gas (water vapor).
  - Ice is **LESS dense** than water so it floats….
    - Ice cubes, ice bergs and ice caps….
  - Has an unusually **high heat capacity**.
    - It has a specific heat is 3 times that of land….



Water, water, everywhere, but not a drop to drink….





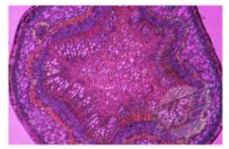
- Oceans account for most of water **(>97%)**
  - Not readily useable by humans or plants
- Ice sheets in Antarctica and Greenland **(~3%)**
- Atmosphere has only a little **(0.001%)**

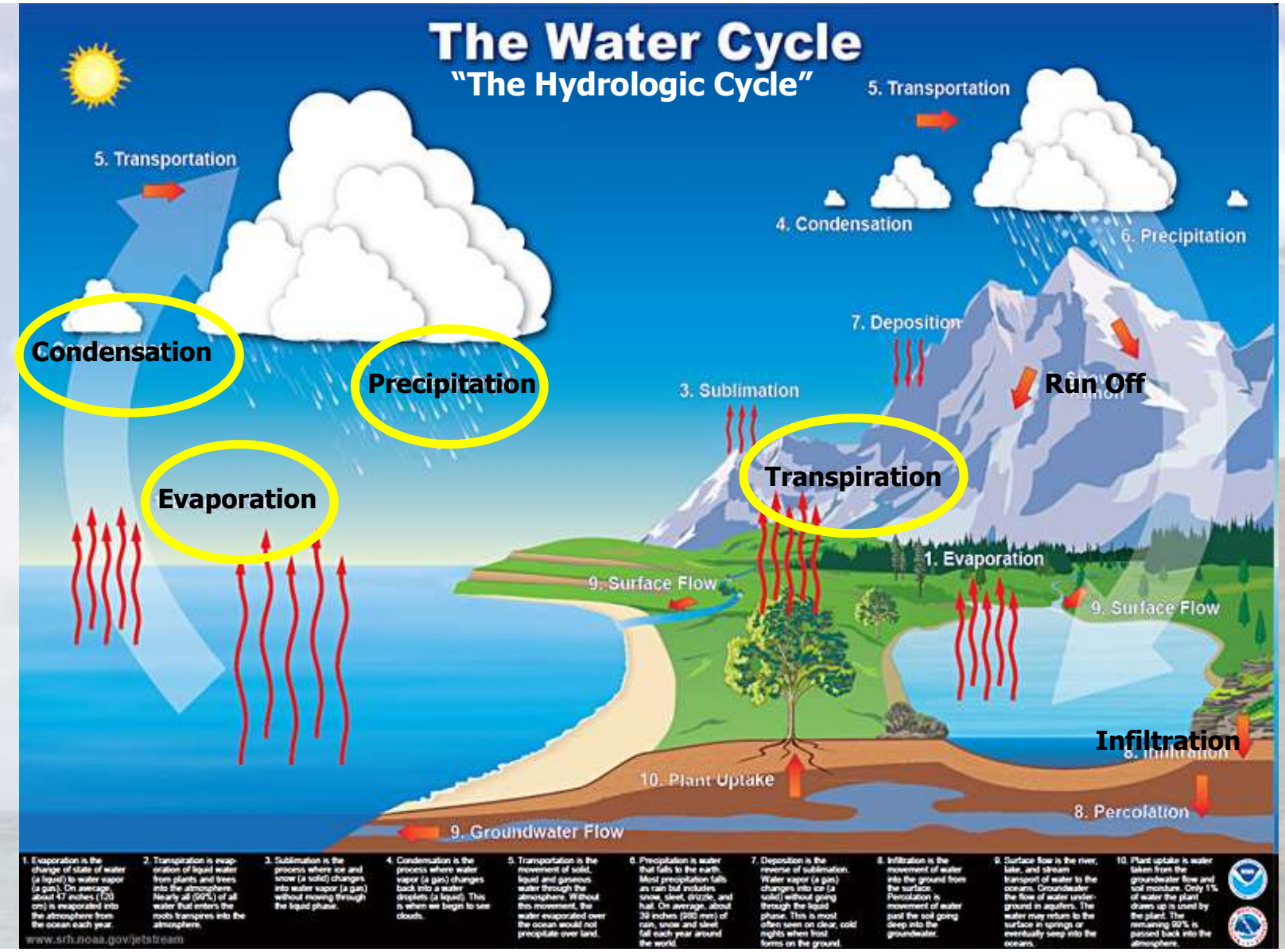
Water is Everywhere!!!

- Oceans
- Glaciers
- Rivers
- Lakes
- Air
- Soil
- Living tissue (body is made up of 70% water)



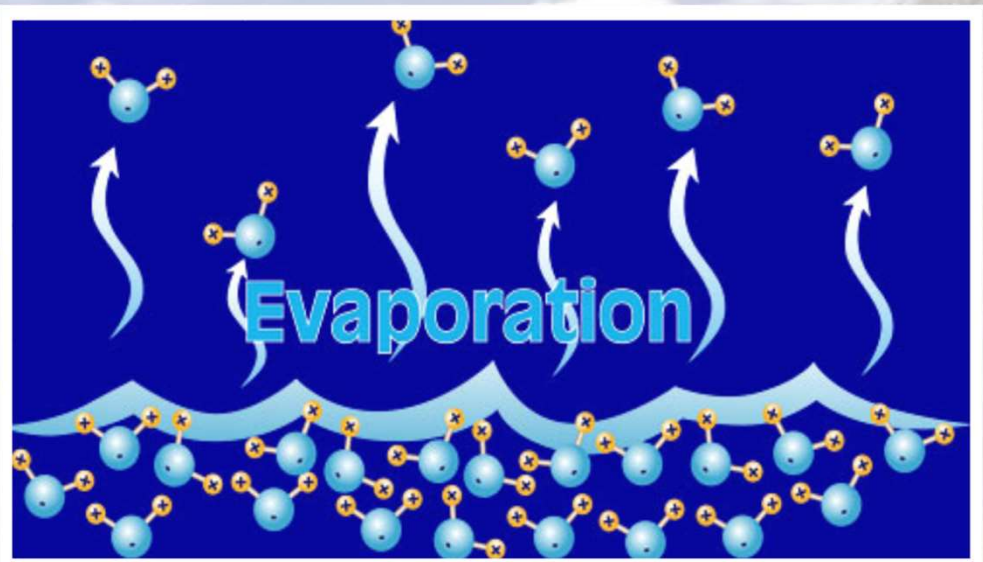





The Water Cycle
"The Hydrologic Cycle"
5. Transportation
5. Transportation
4. Condensation
6. Precipitation
7. Deposition
Run Off
Condensation
Precipitation
3. Sublimation
Transpiration
Evaporation
1. Evaporation
9. Surface Flow
9. Surface Flow
Infiltration
10. Plant Uptake
8. Percolation
9. Groundwater Flow
1. Evaporation is the change of state of water (a liquid) to water vapor (a gas). On average, about 47 inches (120 cm) is evaporated into the atmosphere from the ocean each year.
2. Transpiration is evaporation of liquid water from plants and trees into the atmosphere. Nearly all (99%) of all water that enters the roots transpires into the atmosphere.
3. Sublimation is the process where ice and snow (a solid) changes into water vapor (a gas) without moving through the liquid phase.
4. Condensation is the process where water vapor (a gas) changes back into a water droplets (a liquid). This is when we begin to see clouds.
5. Transportation is the movement of solid, liquid and gaseous water through the atmosphere. Without this movement, the water evaporated over the ocean would not precipitate over land.
6. Precipitation is water that falls to the earth. Most precipitation falls as rain but includes snow, sleet, drizzle, and hail. On average, about 39 inches (995 mm) of rain, snow and sleet fall each year around the world.
7. Deposition is the reverse of sublimation. Water vapor (a gas) changes into ice (a solid) without going through the liquid phase. This is most often seen on clear, cold nights when frost forms on the ground.
8. Infiltration is the movement of water into the ground from the surface. Percolation is movement of water past the soil going deep into the groundwater.
9. Surface flow is the river, lake, and stream transport of water to the oceans. Groundwater is the flow of water underground in aquifers. The water may return to the surface in springs or eventually seep into the oceans.
10. Plant uptake is water taken from the groundwater flow and soil moisture. Only 1% of water the plant draws up is used by the plant. The remaining 99% is passed back into the atmosphere.
www.srh.noaa.gov/jetstream

1) EVAPORATION

REQUIRES ENERGY



- **The process by which a liquid is transformed into a gas**

- Happens over Oceans, Lakes, Rivers and other “standing” bodies of water

- **Powered by the sun!**
  - Solar radiation heats up the water molecules until they are “freed” from the liquid state.
  - **Heat is absorbed during evaporation**

2) CONDENSATION

RELEASES ENERGY

- **The change from a gas to a liquid**
- Responsible for the formation of **clouds**
- **Heat is released during condensation**

3) PRECIPITATION

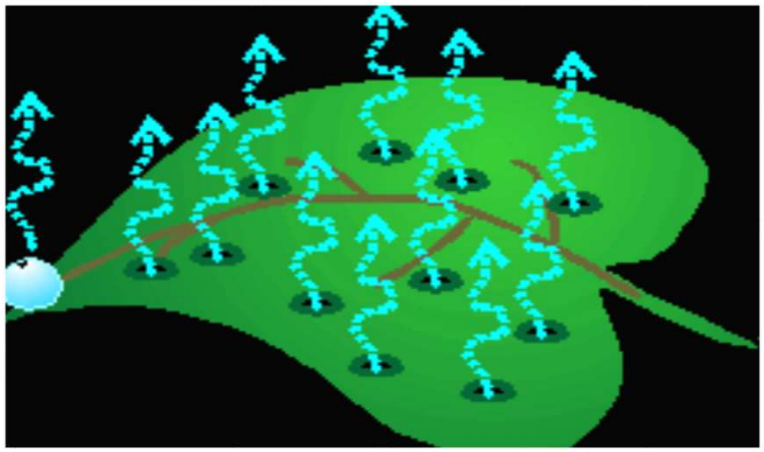
- Falling liquid or solid in the atmosphere.
- Balances Evaporation
  - Average annual precipitation equals evaporation.
- Happens over Land or Oceans
- Returns the water to the ocean or soaks into the ground.

4) TRANSPIRATION

- **The release of water vapor to the atmosphere by plants**

- Plants uptake water through their roots that fell as precipitation

- Not as important as evaporation



Credit: Ming kei College, Hong Kong

Over Land and Ocean?

- Evaporation **exceeds** Precipitation over **Water**
  - No plants, so no transpiration
- Precipitation **exceeds** Evaporation over **Land**
- Condensation happens everywhere.

SUBLIMATION

REQUIRES ENERGY

- **Conversion of a solid directly to a gas**

- EX: Gradual shrinking of unused ice cubes, the rapid conversion of dry ice into gas.

- How piles of snow tend to disappear even if the air temperature never reaches above 32F (when air is dry)

DEPOSITION

RELEASES ENERGY

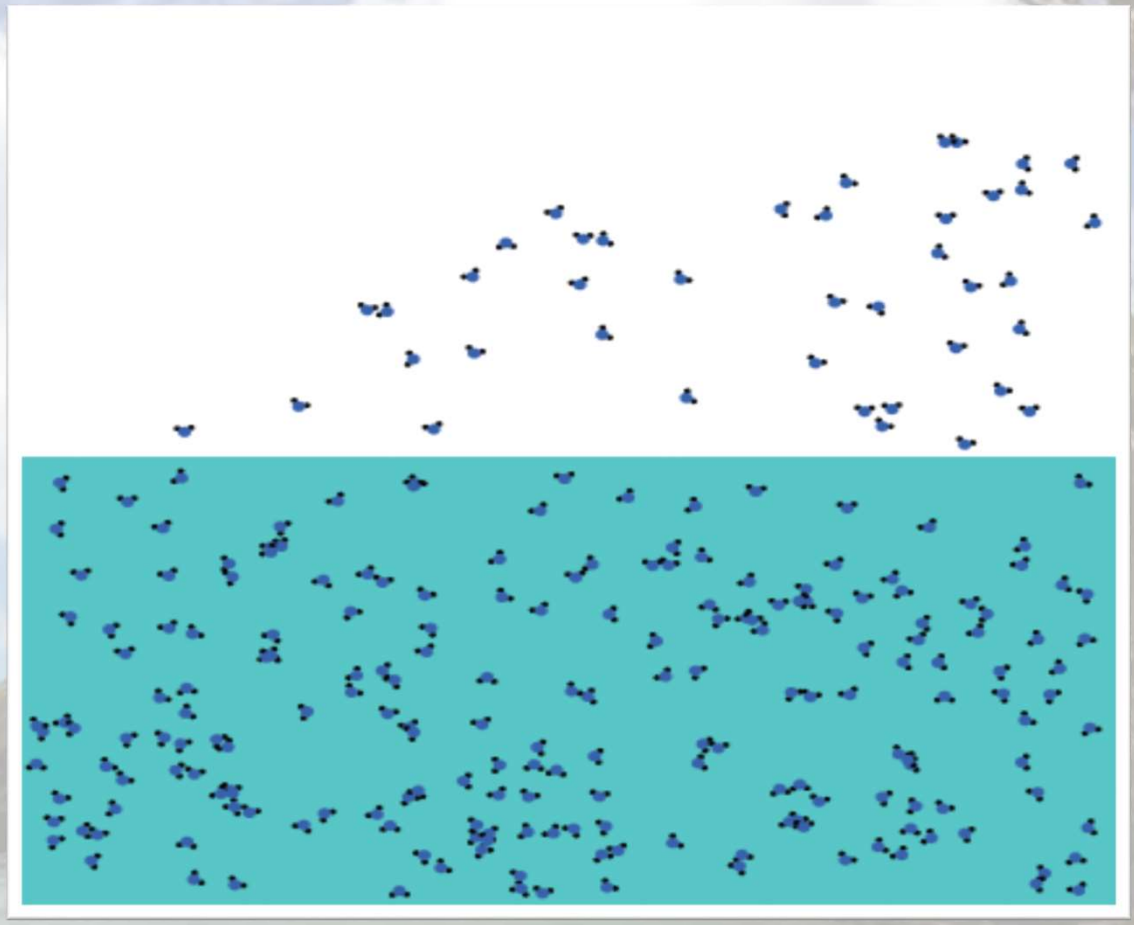
- **Conversion of a gas directly to a solid**
- EX: Frost on a window pane (white frost, hoar frost… FROST).
- EX: Frost the builds up in the freezer.. Was once part of your ice cube!
- Happens without passing through an intermediate liquid phase





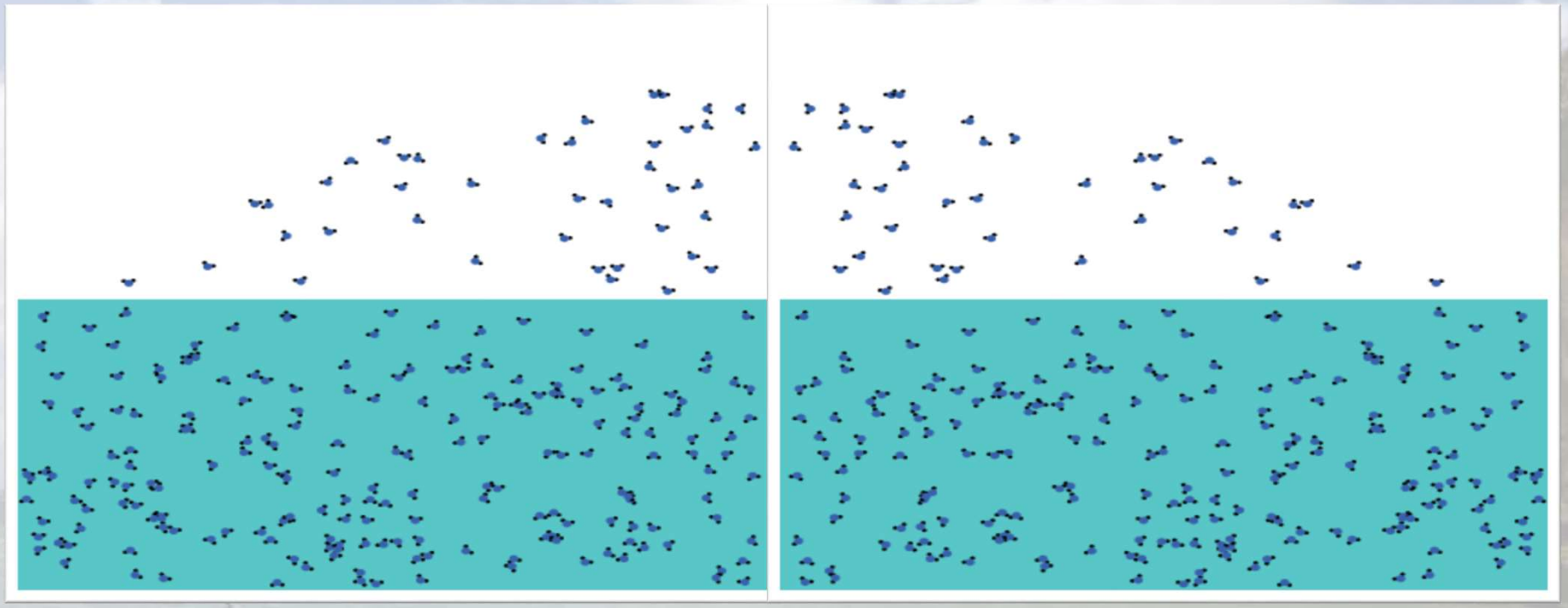

Water Vapor Content of Air

- Humidity
- Vapor Pressure
- Relative Humidity
- Dew Point

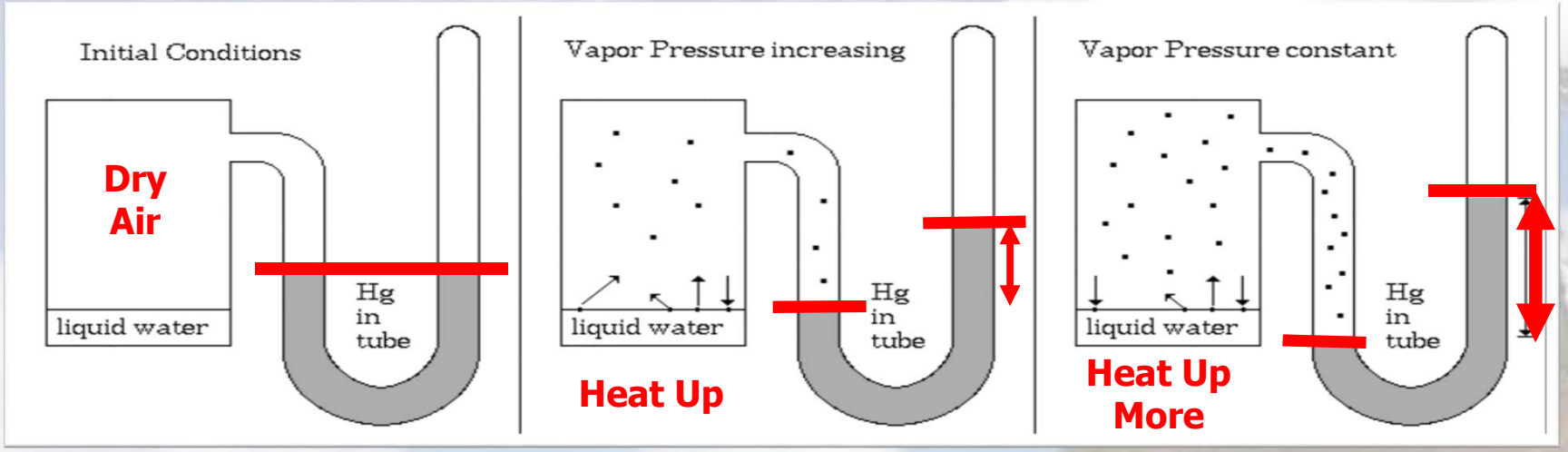


Humidity

- The general term used to describe the **amount** of **water vapor** in the air



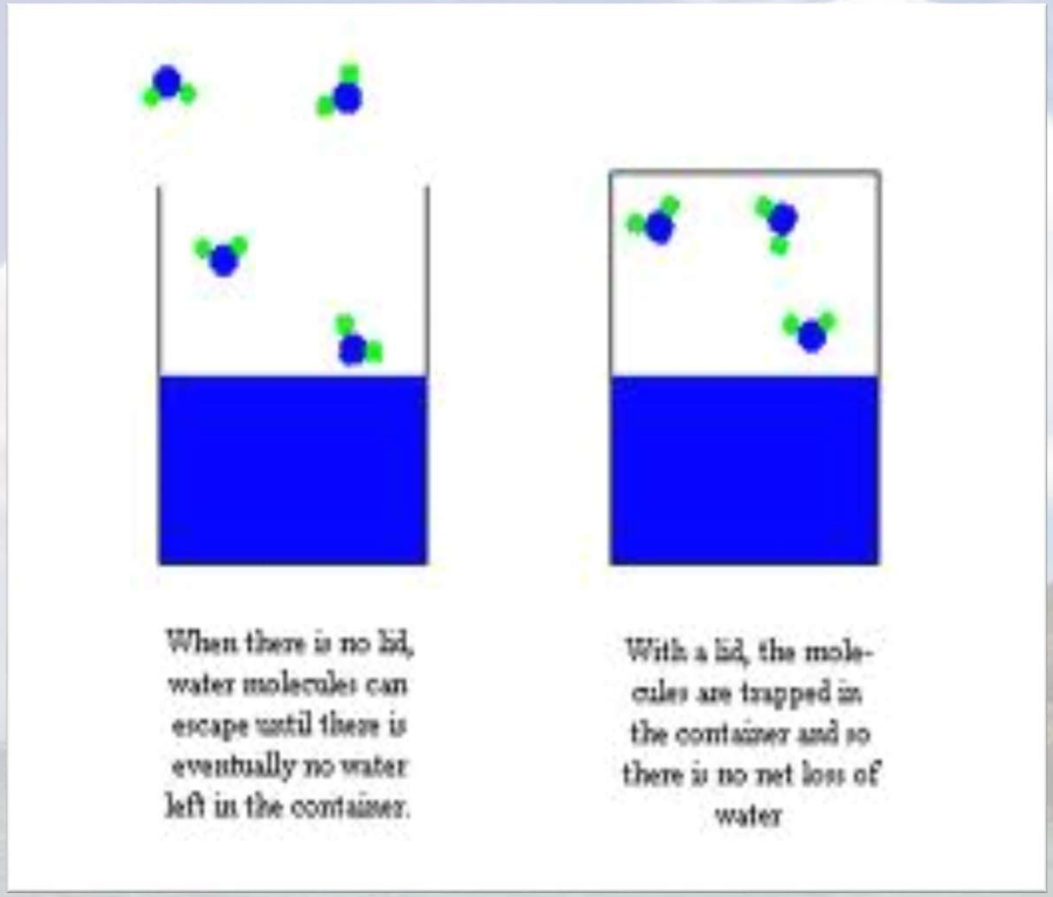
Vapor Pressure



- That part of the **total atmospheric pressure** attributable to its water-vapor content.

- As **more water vapor** is added to dry air the vapor **pressure increases**.

Vapor Pressure - SATURATION



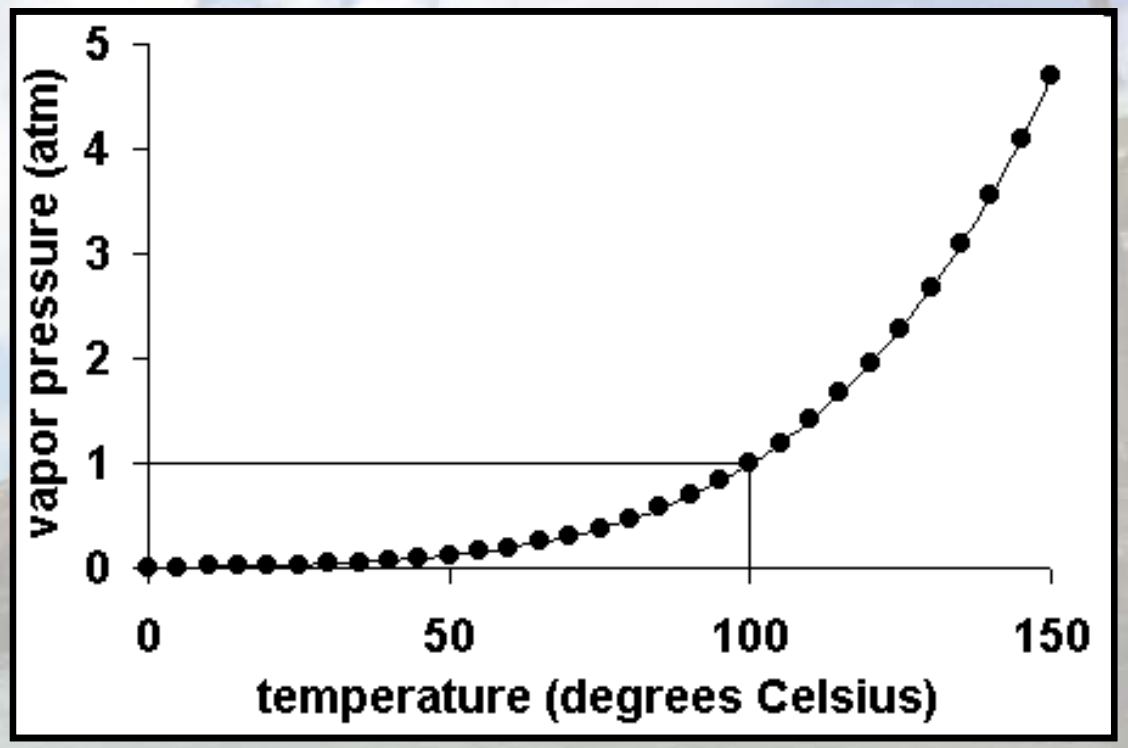
- Initially more molecules leave the surface of the water than return.
- Over time:
  - **number of molecules leaving = the number molecules returning**
- This is **SATURATION**

Saturation Vapor Pressure

- When air is saturated the pressure exerted by the motion of the water vapor molecules is called the **Saturation Vapor Pressure.**

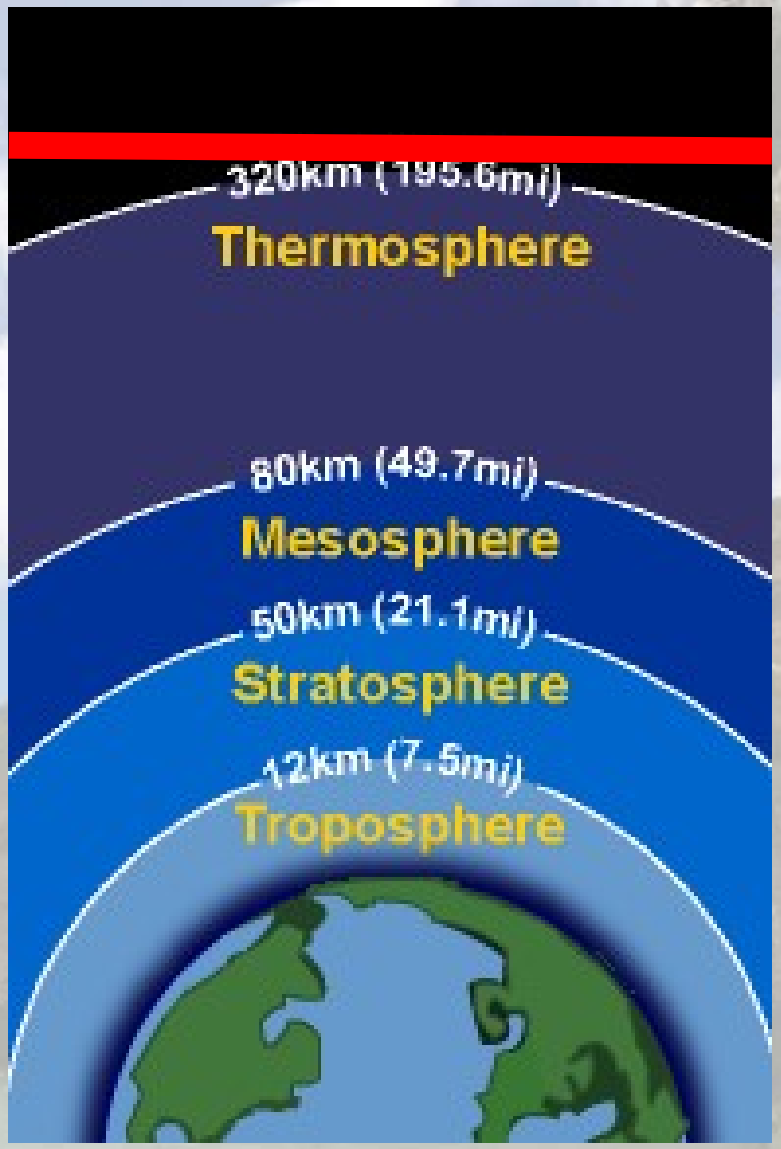
- Varies as a function of **temperature**

- You can "**FIT**" more water vapor in warmer air.



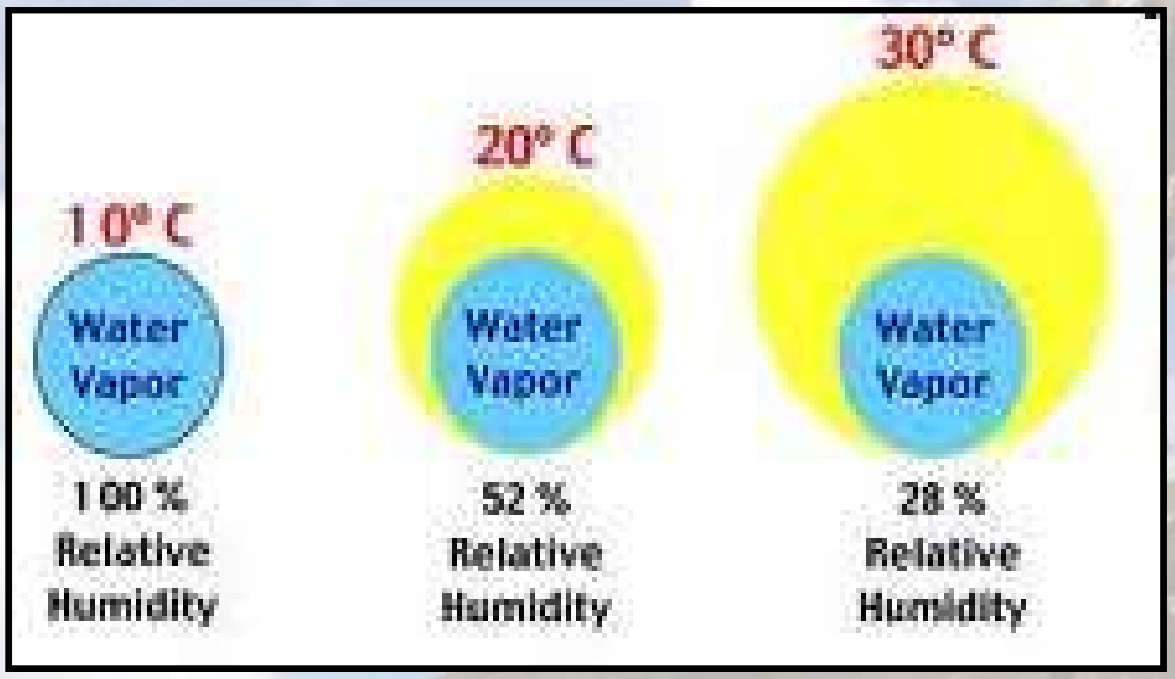
In the real atmosphere

- In nature Gravity is the "**LID**" keeping the water vapor in (like in our jar and test-tube examples)
- Atmosphere isn't always in balance at every second
- **Net evaporation**: When more water is leaving a surface
- **Net condensation**: When more water is returning to a surface
- At **saturation** net evaporation = net condensation



Relative Humidity

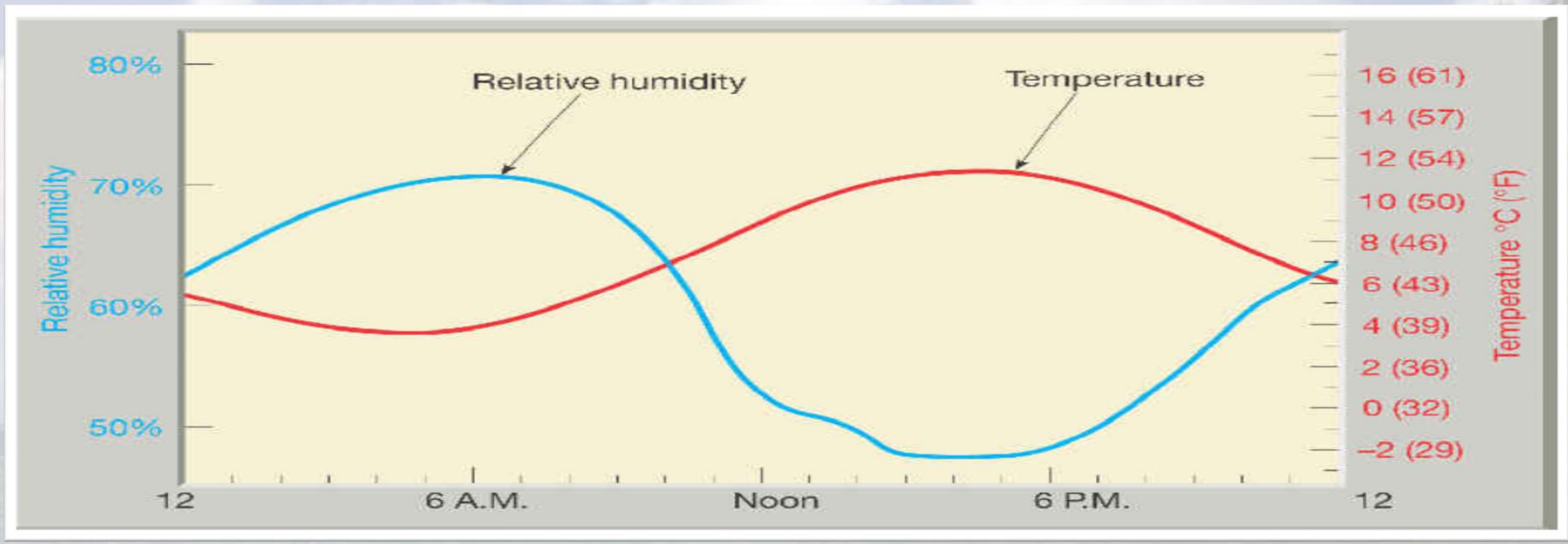
- The ratio of the air's **actual water vapor content** compared with the **amount of water vapor required for saturation** at that **temperature** and **pressure**

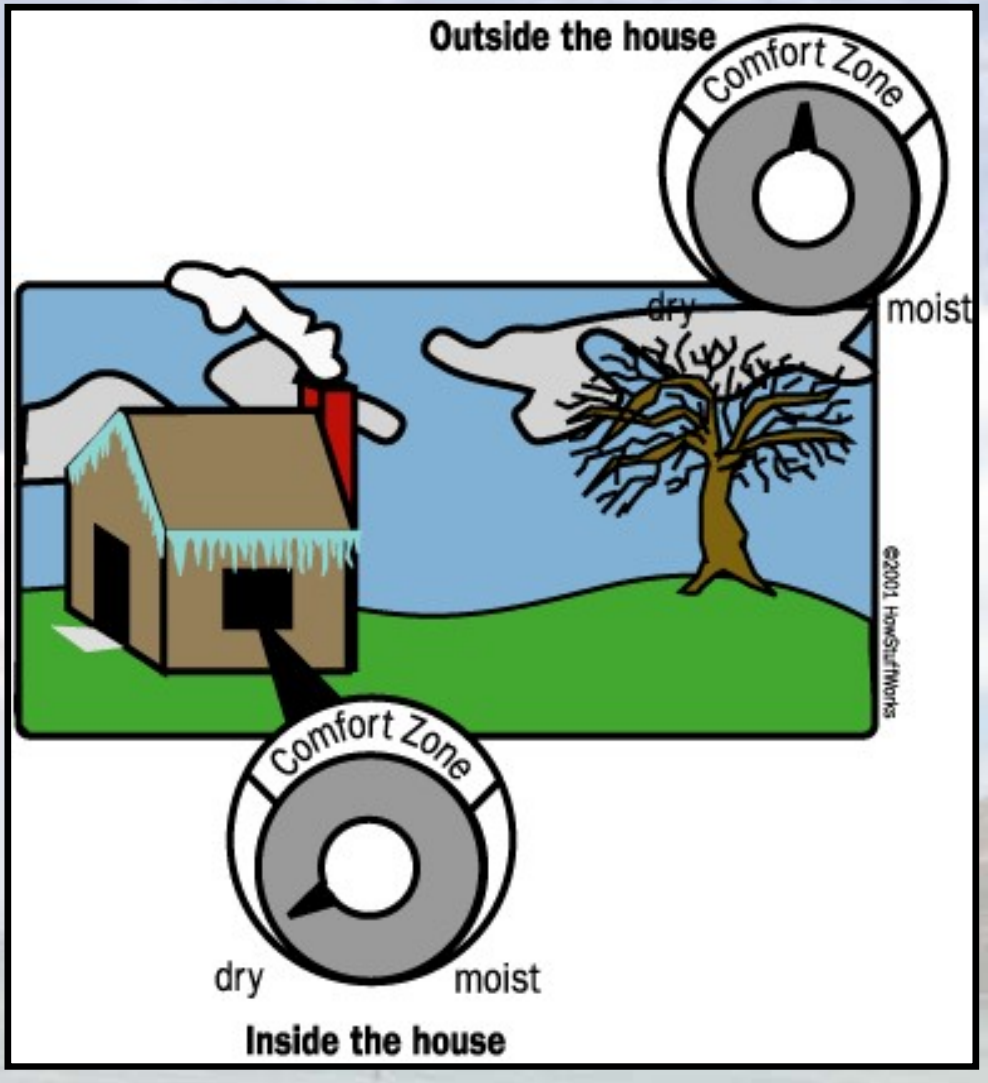


$$\text{Relative Humidity} = \frac{\text{(Actual Vapor Pressure) Water vapor content}}{\text{Water vapor capacity (Saturation Vapor Pressure)}} \times 100 \text{ percent}$$

Natural Changes in Relative Humidity

1. Daily changes in temperatures (daylight verses nighttime temperatures)





Natural Changes in Relative Humidity

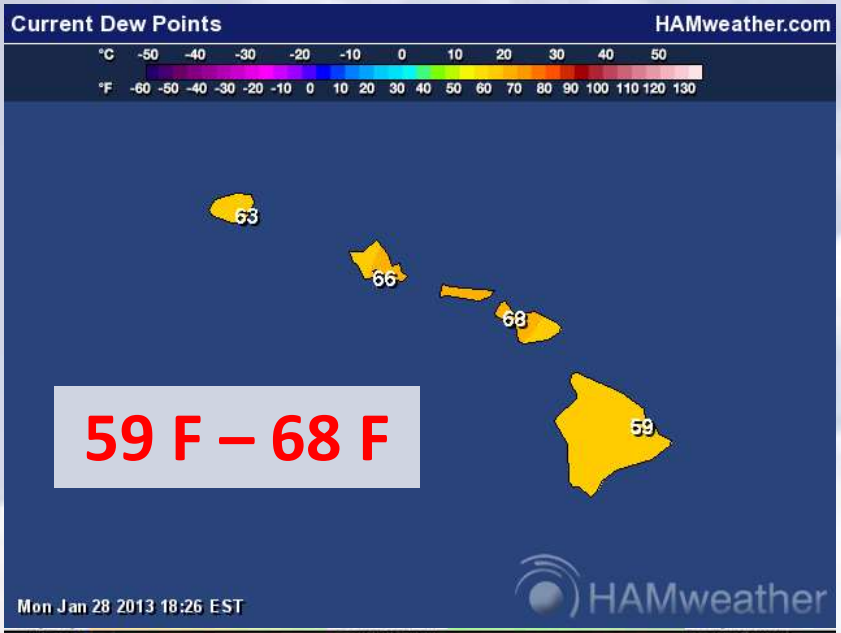
2. Temperature changes that result as air moves **horizontally** from one location to another

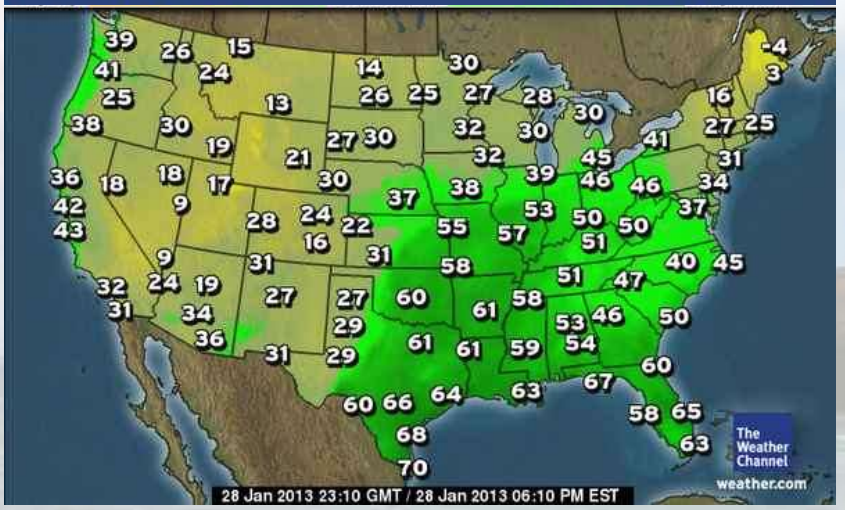
3. Temperature changes caused as air moves **vertically** in the atmosphere

REMEMBER: RH Tells us how close to Saturation the Air is… Not how much water vapor is in the air.

Dew Point Temperature

- The **temperature** at which air needs to be **cooled** to reach **saturation**
- It is a measure of the **actual moisture content** of a parcel of air.
- The term **dew point** stems from the fact that during the night objects at the surface often cool below the dew-point are a coated with dew.





Dew Point Temperature

- When the dew point exceeds **~65F** it is considered humid by most people
- A dew point above **75F** is considered unbearable.

Dew

- **The condensation of water vapor on objects that have cooled to the dew-point.**
  - They radiated away some of their heat.
  - A car will get dew before the cement since they cool at different rates.
  - More frequent on grass since plants **TRANSPIRE** and release water vapor right near the blade!

Frost

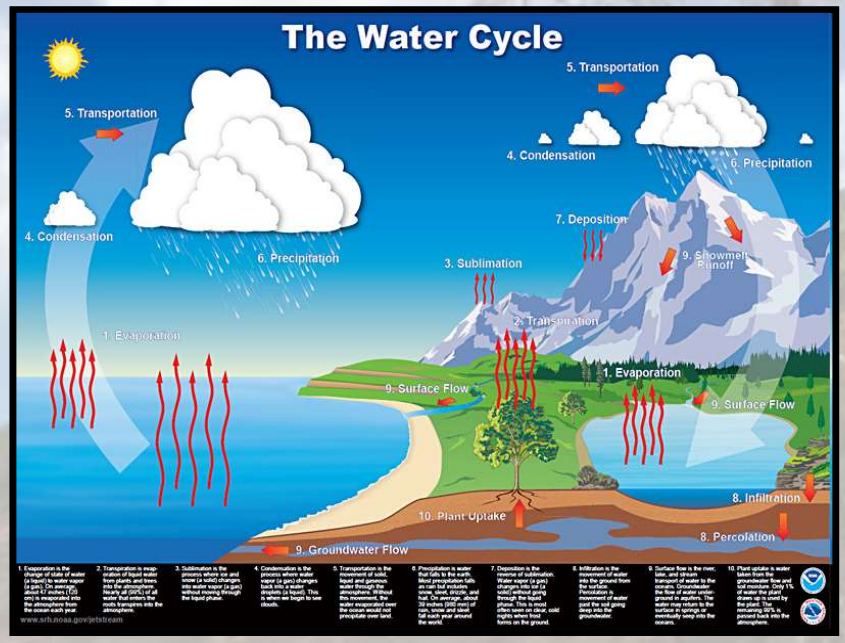
- Frost is **NOT** frozen dew.

- **FROST forms from DEPOSITION**
  - Gas to solid phase
  - Called white frost or hoar frost

Key Information 1

1. Know the different components of the **WATER CYCLE** and if energy is released or required.

- **Evaporation**
  - Liquid → Gas
  - Energy is ABSORBED (Required)
- **Condensation**
  - Gas → Liquid
  - Energy is RELEASED
- **Sublimation**
  - Solid → Gas
  - Energy is ABSORBED (Required)
- **Deposition**
  - Gas → Solid
  - Energy is RELEASED
- **Precipitation**
  - NO PHASE CHANGE
  - Rain falls
  - Snow falls
- **Transpiration**
  - Liquid → Gas
  - Energy is ABSORBED
  - Just like Evaporation but from plants



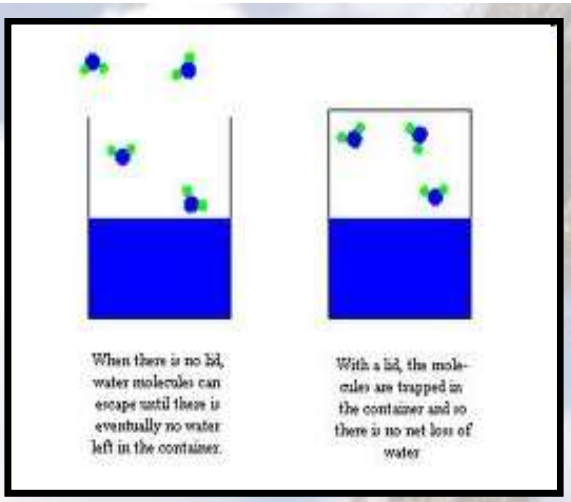
Key Information 2

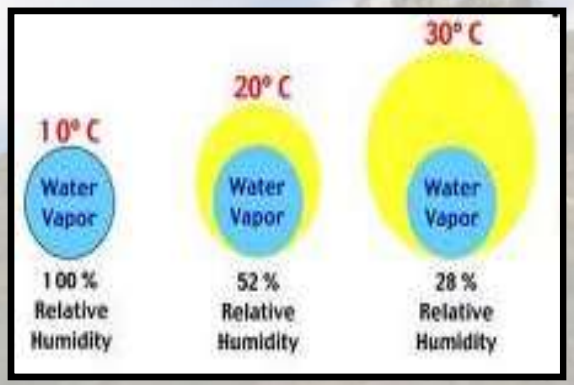
2. Be able to tell the difference between the different ways we describe **HUMIDITY**.

- **Vapor Pressure**
  - That part of the total atmospheric pressure attributable to its water-vapor content.
  - As more water vapor is added to dry air the vapor pressure increases.

- **Relative Humidity**
  - The ratio of the air's actual water vapor content compared with the amount of water vapor required for saturation at that temperature and pressure

- **Dew Point**
  - The temperature at which air needs to be cooled to reach saturation
  - It is a measure of the actual moisture content of a parcel of air.





Key Information 3

3. Know the difference between **DEW** and **FROST**.

- **Dew**
  - The condensation of water vapor on objects that have cooled to the dew-point.
  - Surfaces cool by radiating heat away.

- **Frost**
  - Not frozen dew
  - Frost forms from deposition.
  - Water goes from the gas to the solid phase