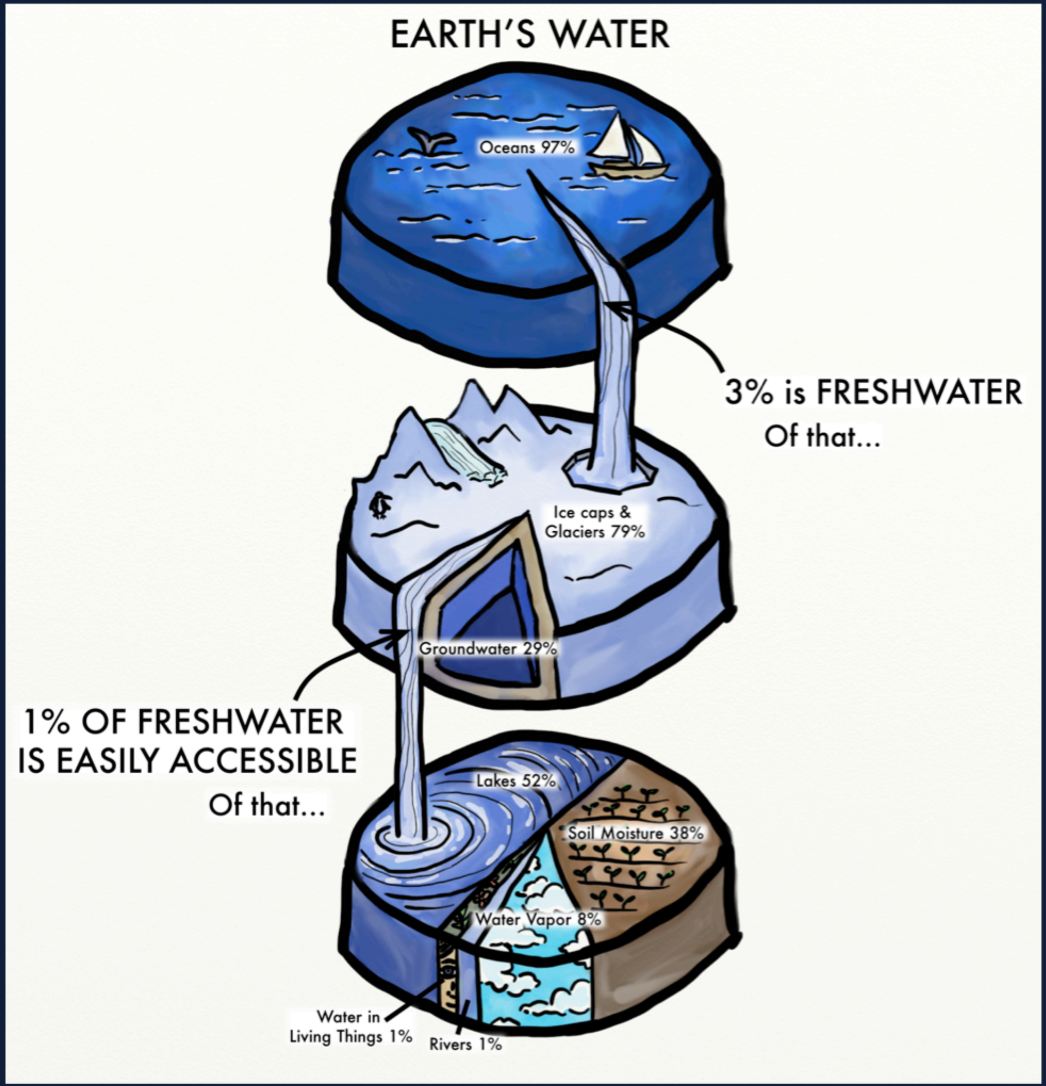
Circulation of water on Earth



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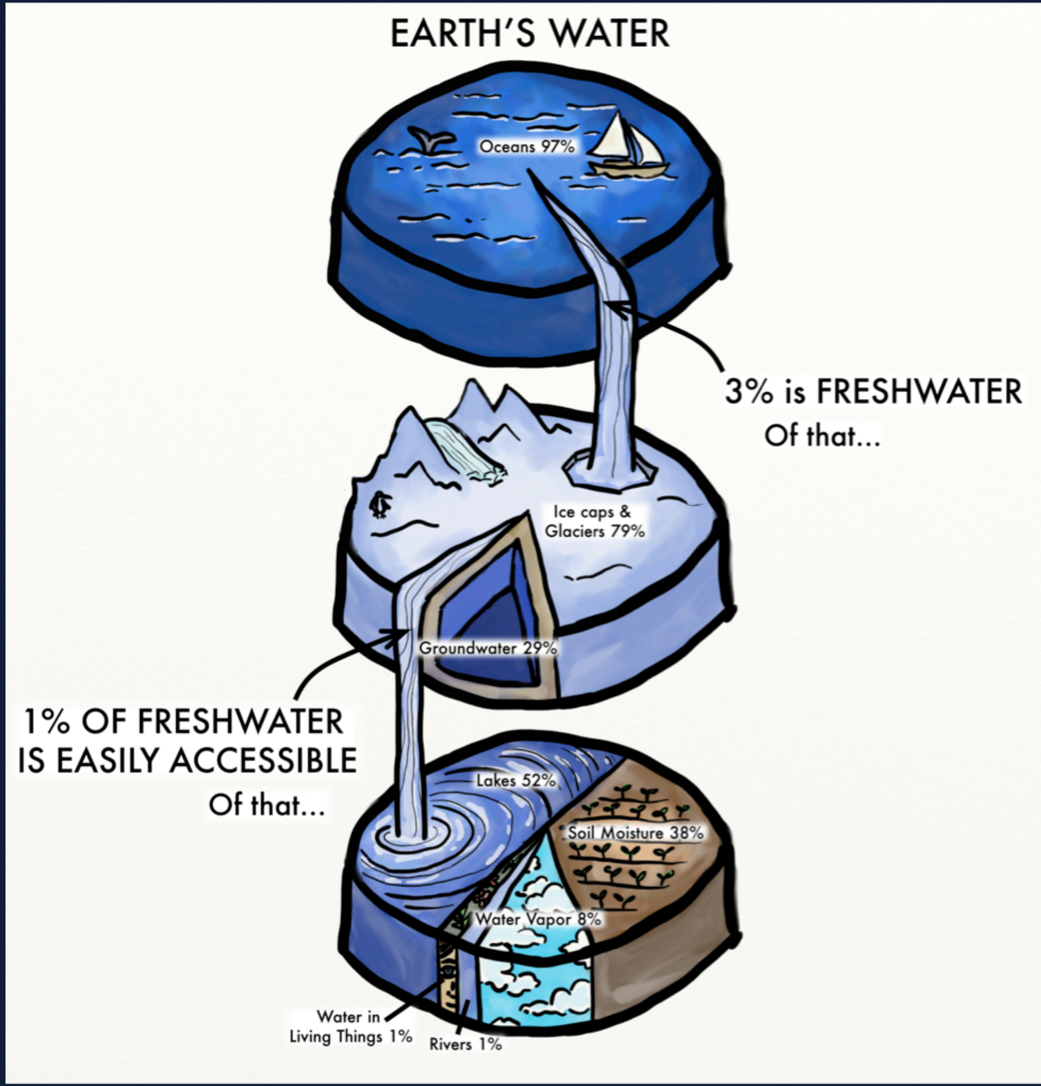
~ ***Most*** (97%) of the ***water*** on Earth is ***oceanic salt water***



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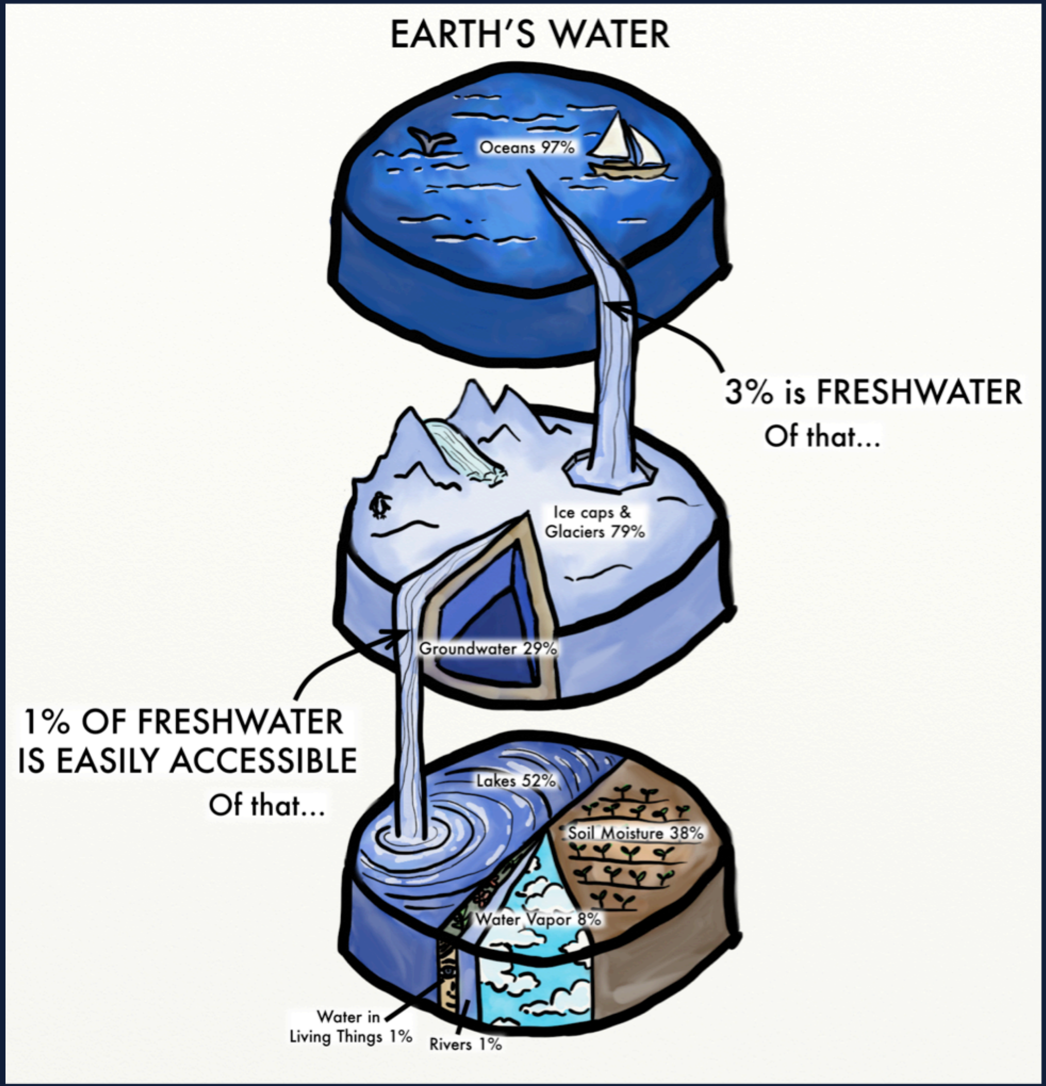

Circulation of water on Earth

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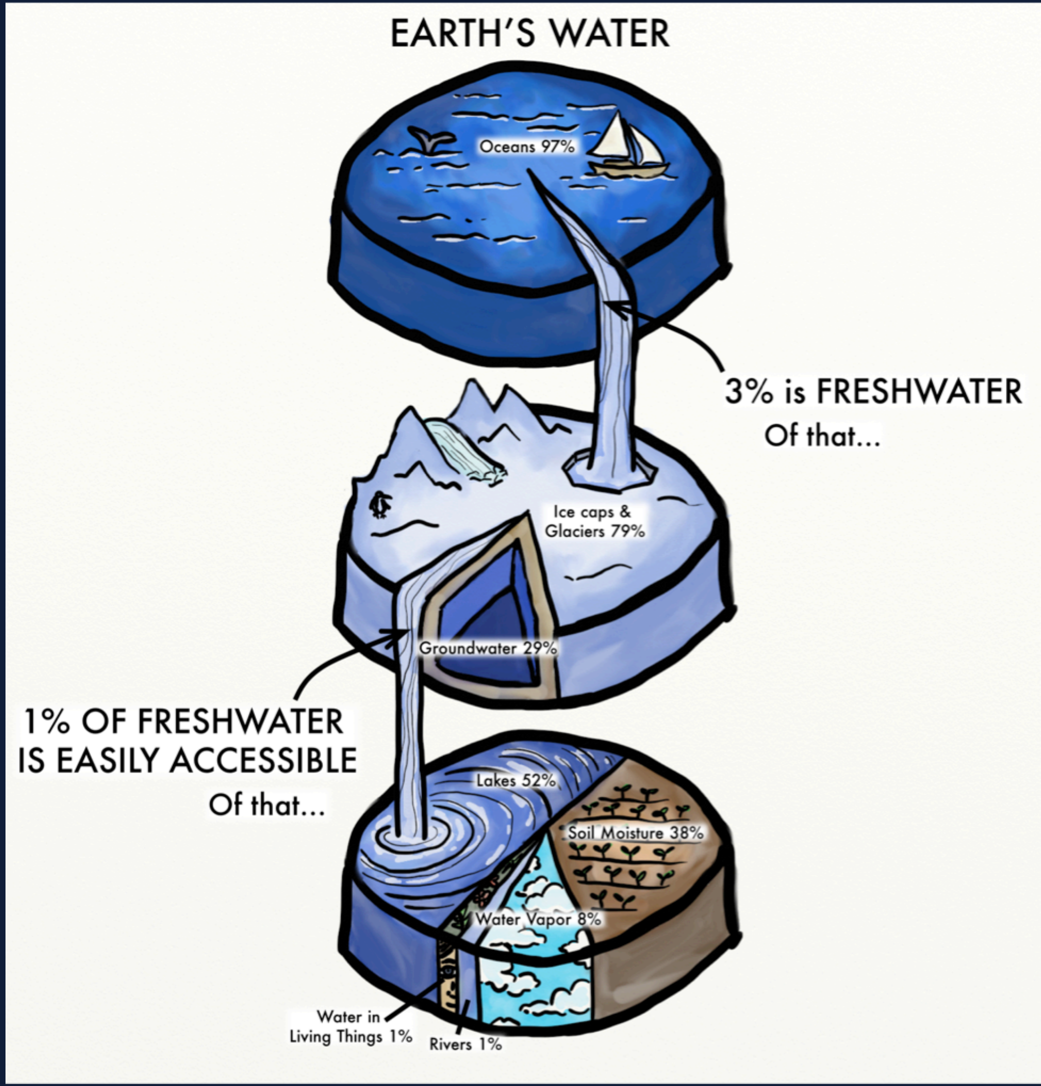
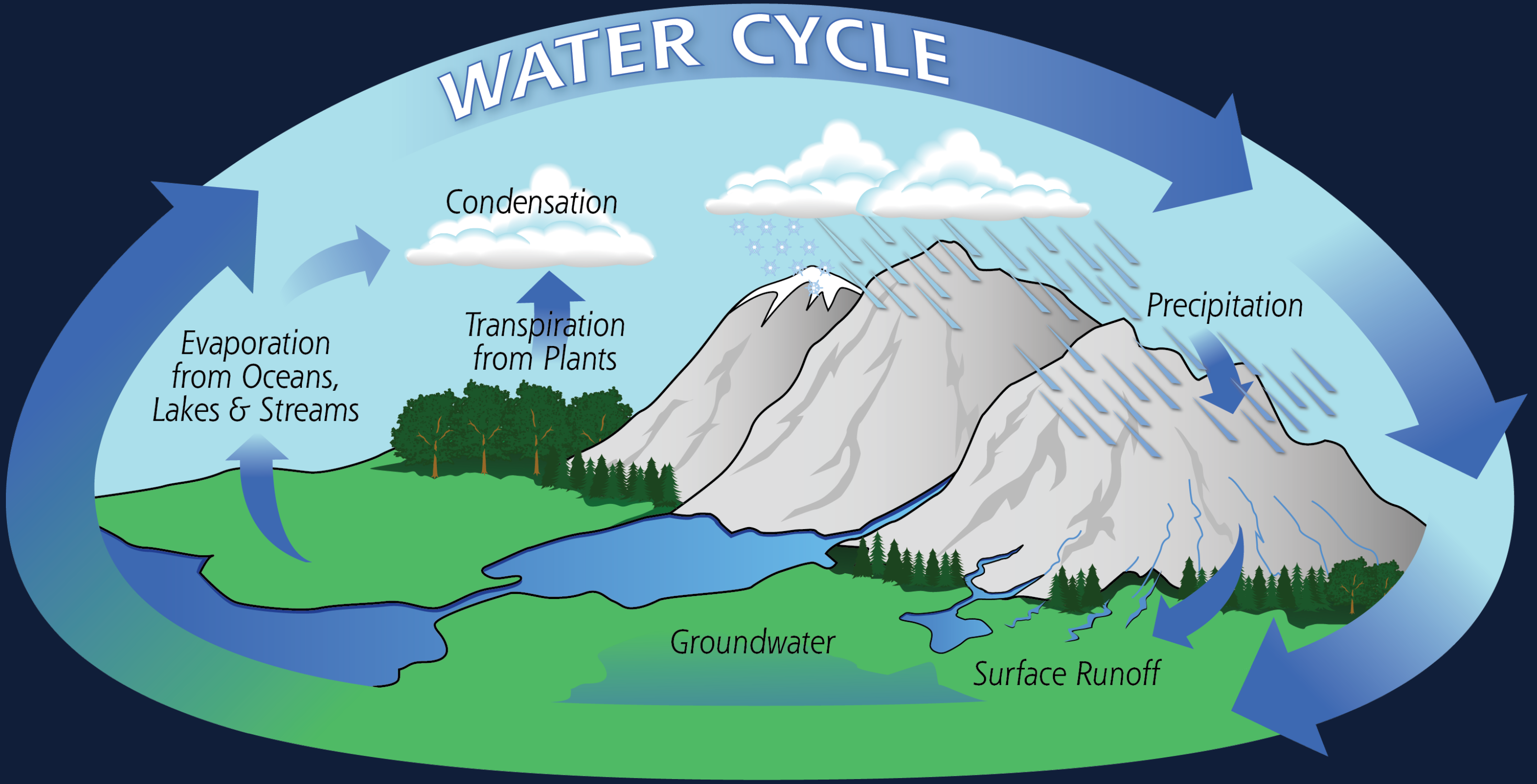
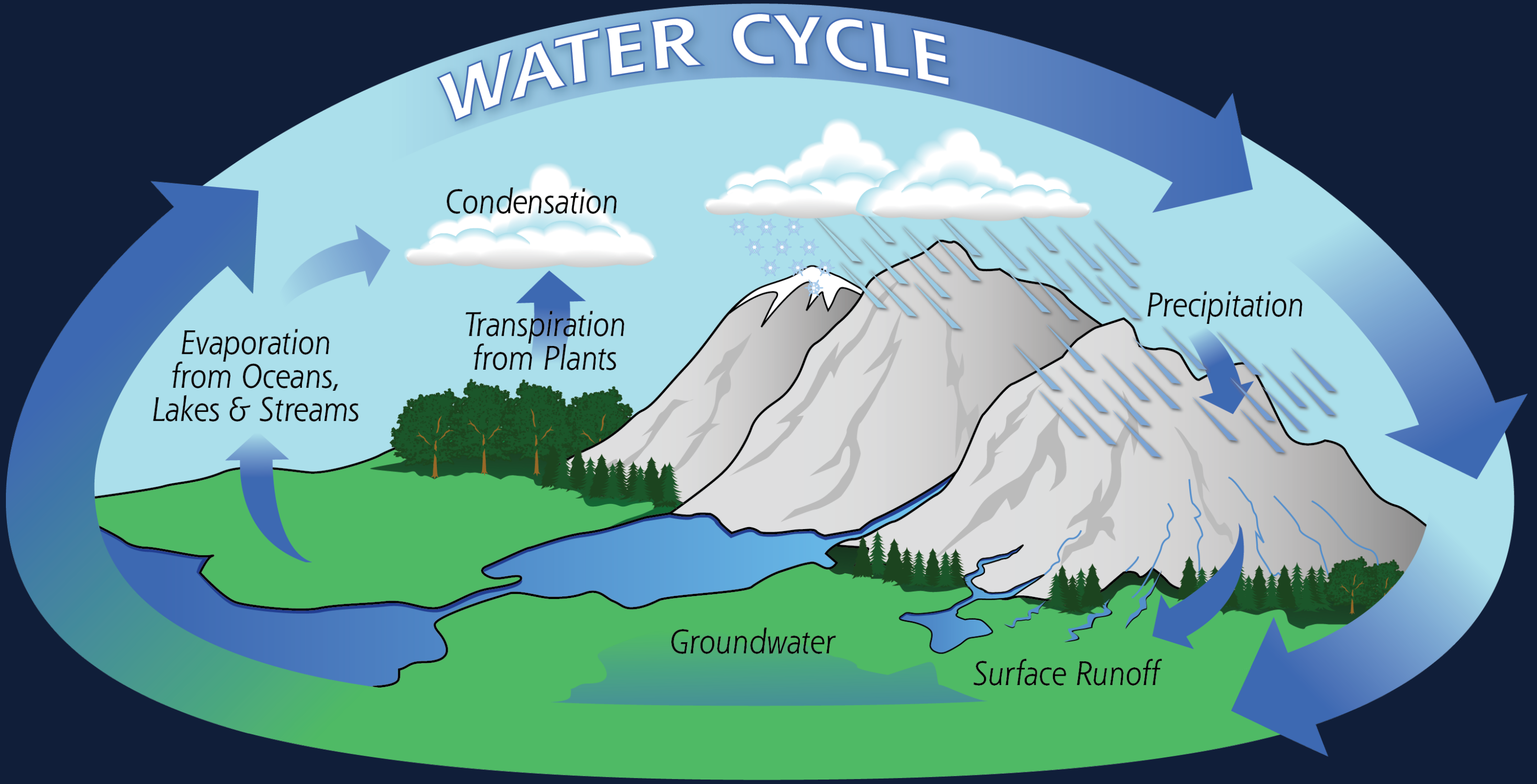
~ The ***majority*** of the ***remaining*** 3% is in ***polar ice sheets***

~ This leaves only ***.001%*** in the ***atmosphere***, most in the ***gaseous (vapor)*** form.




WATER CYCLE
Condensation
Evaporation
from Oceans,
Lakes & Streams
Transpiration
from Plants
Precipitation
Groundwater
Surface Runoff

~ Liquid ***water*** ***evaporates*** from the ***ocean***, ***condenses*** into to ***clouds*** and produces ***rain***.



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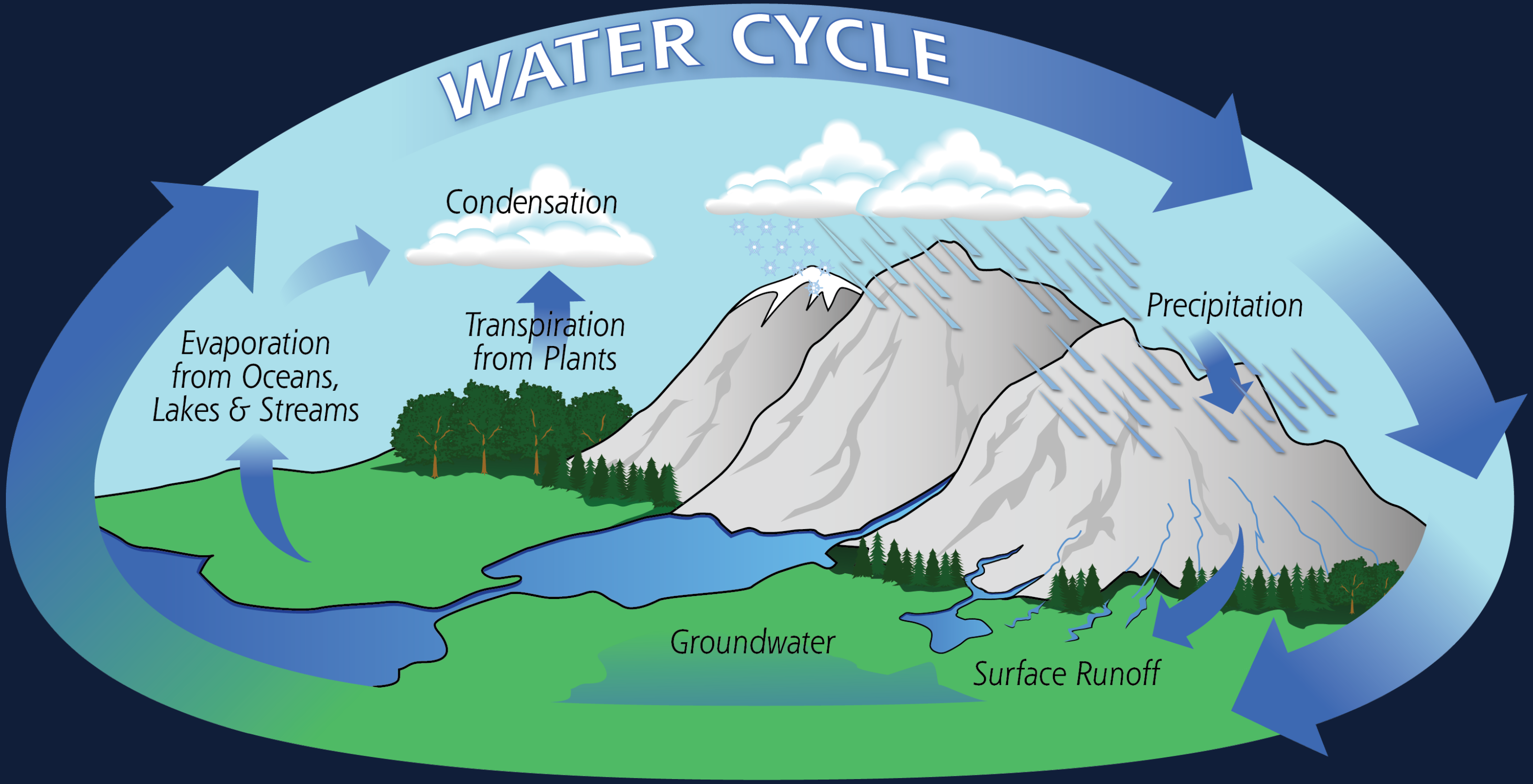
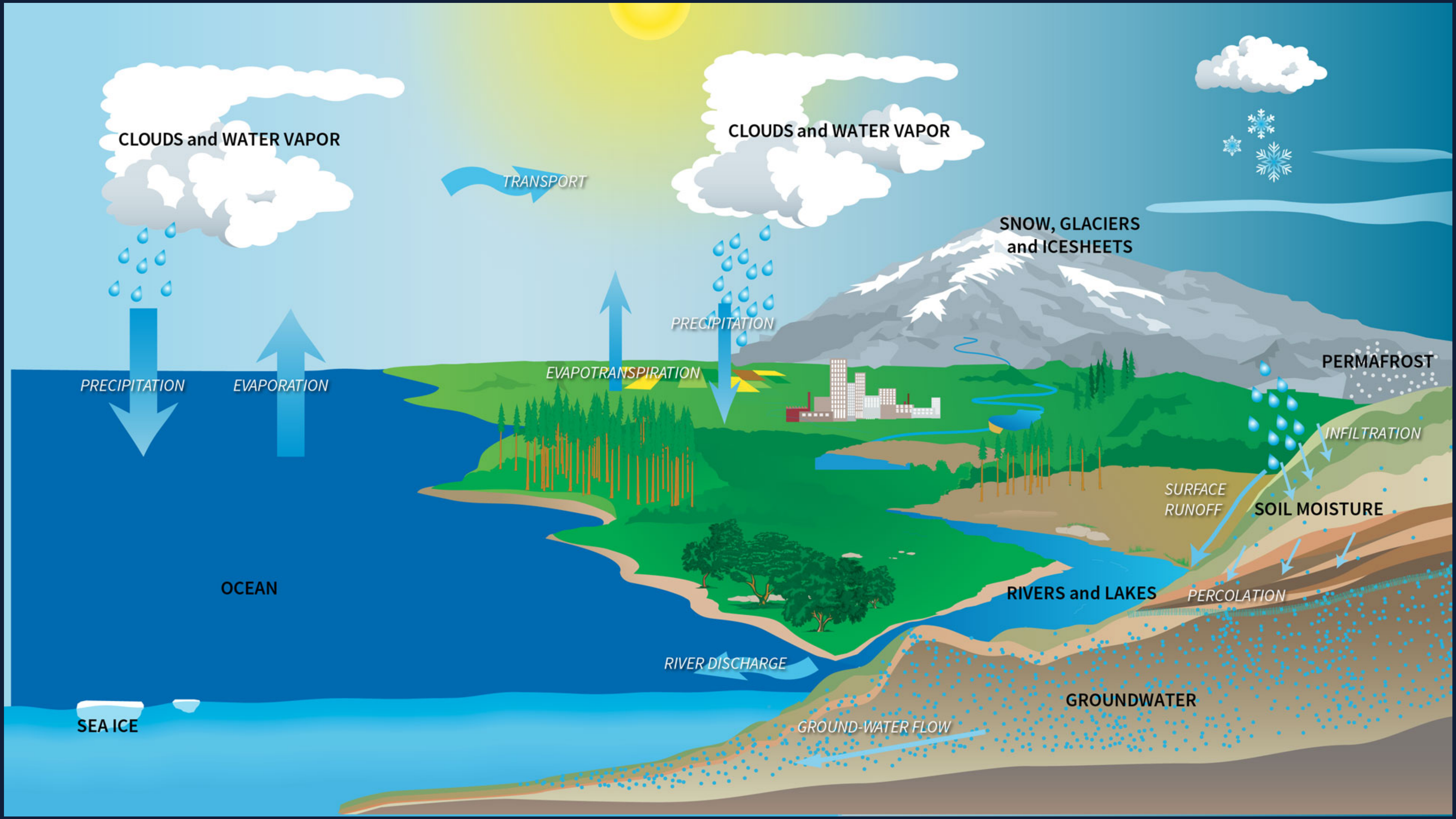


~ The ***rain*** ***falls*** into the ***ocean*** or onto ***land*** where it ***flows back*** to the ***ocean*** or is ***evaporated*** through ***plants***.


CLOUDS and WATER VAPOR
TRANSPORT
CLOUDS and WATER VAPOR
SNOW, GLACIERS and ICESHEETS
PRECIPITATION
EVAPOTRANSPIRATION
PRECIPITATION
EVAPORATION
PERMAFROST
INFILTRATION
SURFACE RUNOFF
SOIL MOISTURE
OCEAN
RIVERS and LAKES
PERCOLATION
RIVER DISCHARGE
GROUNDWATER
SEA ICE
GROUND-WATER FLOW

Humidity: Water vapor in the air

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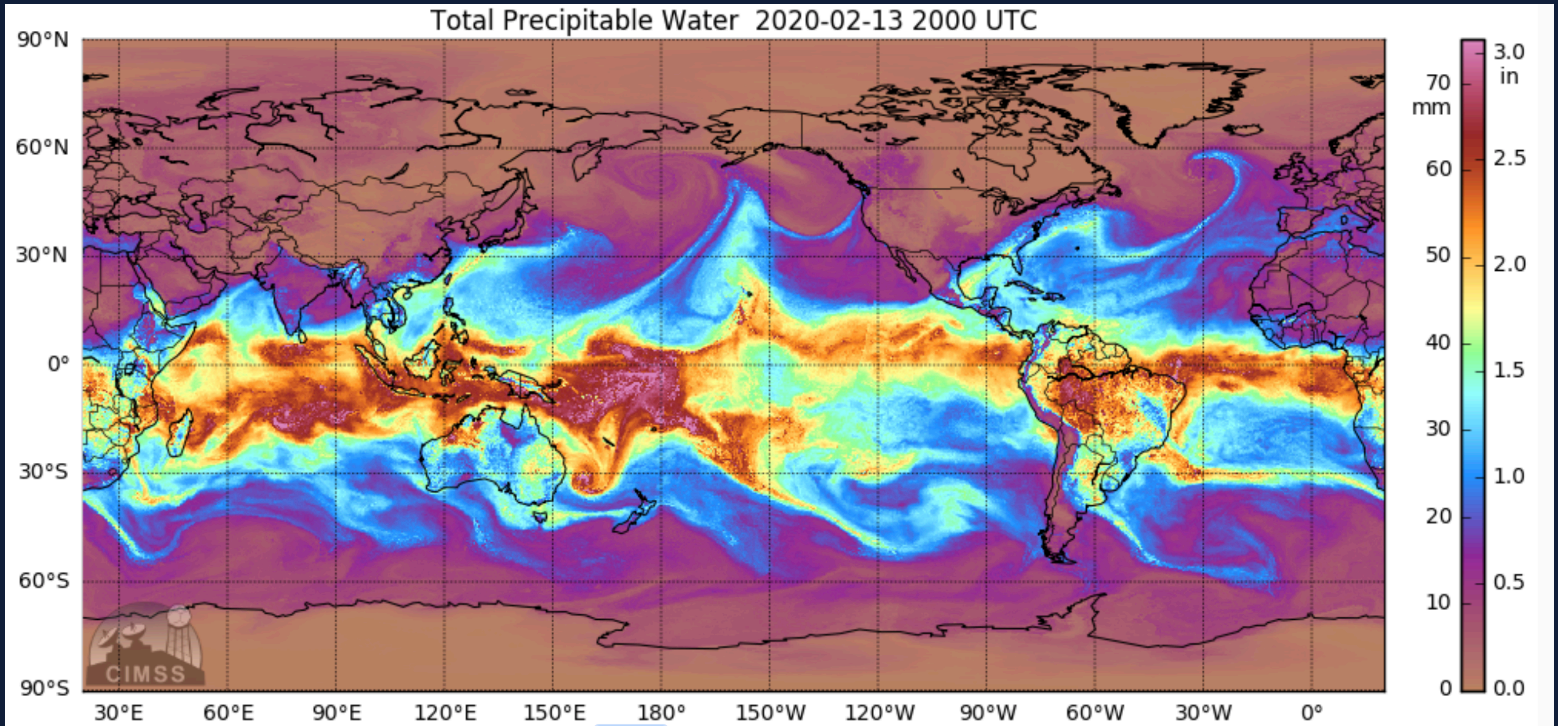

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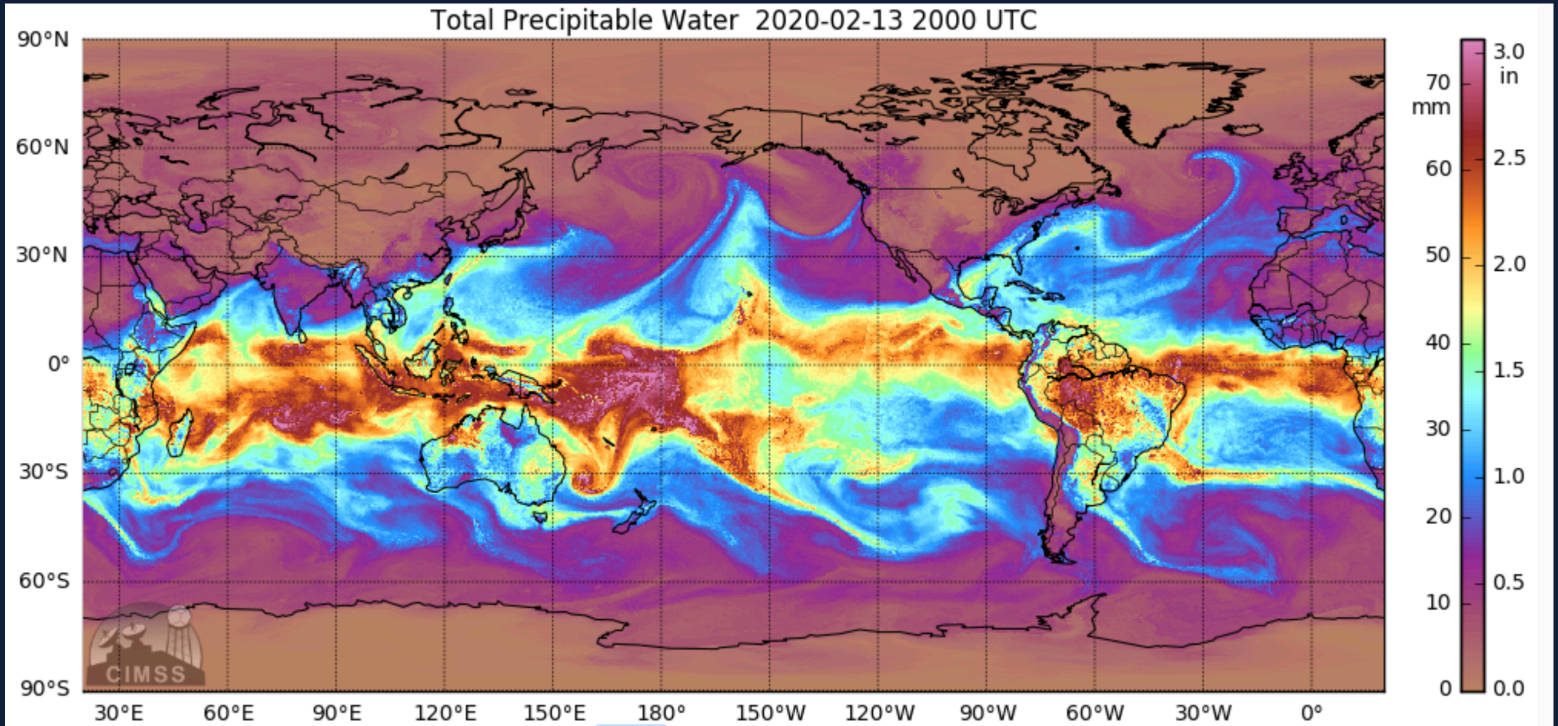

~ Meteorologists have ***many ways*** to ***quantify*** water ***vapor content***, including specific humidity, mixing ratio, vapor pressure, relative humidity, and dew point.

~ The first ***two measures*** are similar: both involve the ***mass*** of ***water vapor*** contained ***in*** some ***amount of air***.

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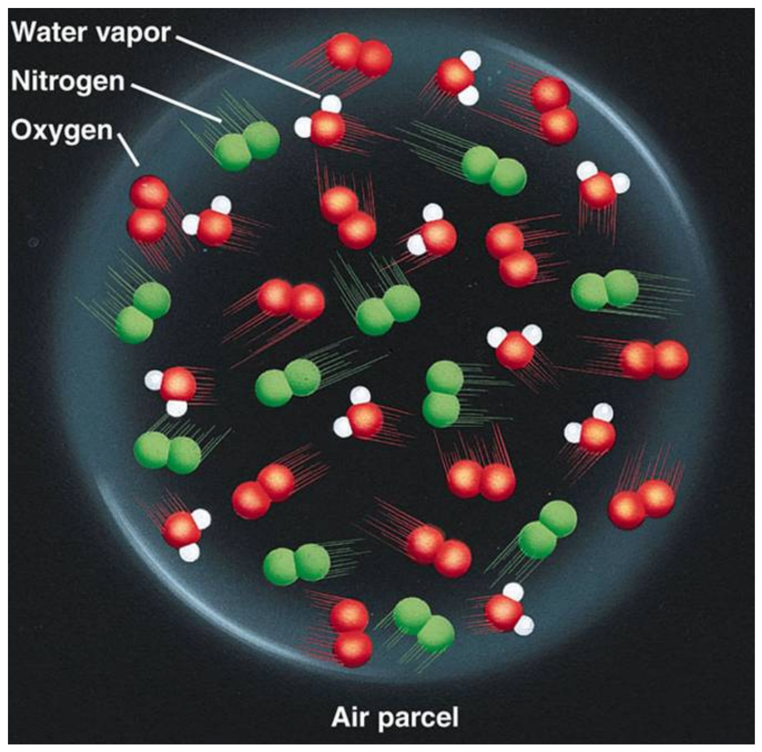

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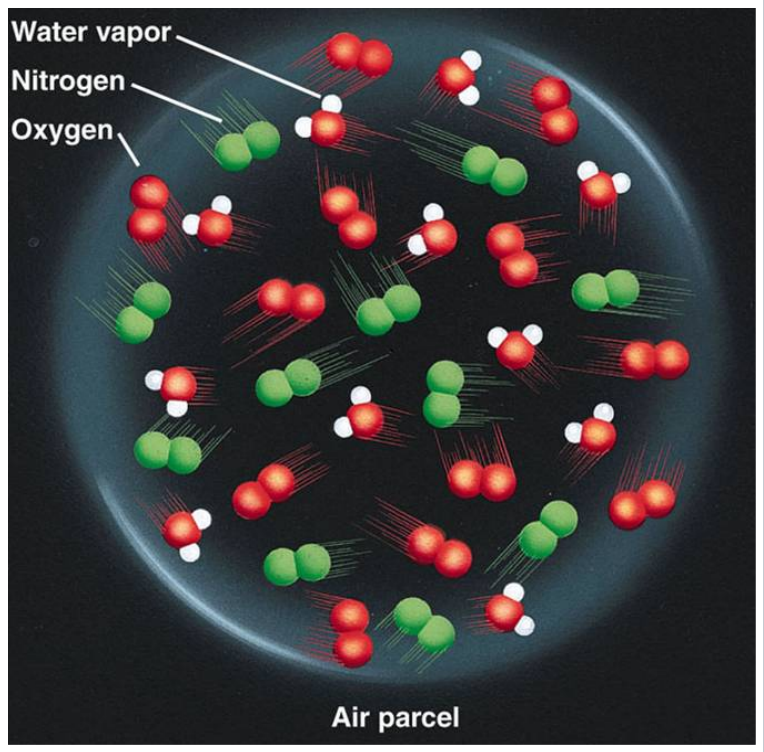

$$\text{specific humidity} = \frac{\text{mass of vapor (grams)}}{\text{mass of air (kilograms)}} = \frac{\text{mass of vapor}}{\text{mass of vapor } + \text{ dry air}}$$

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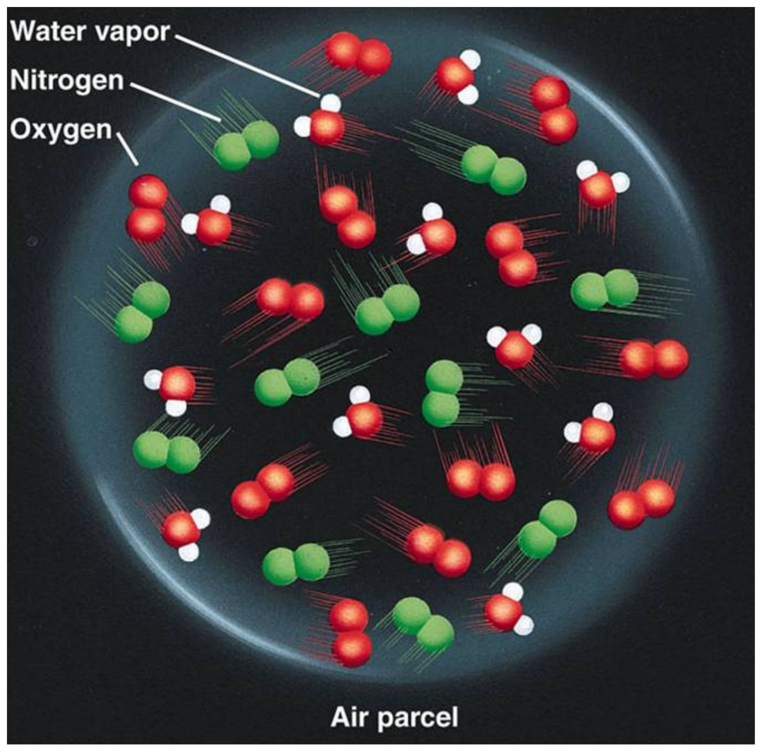

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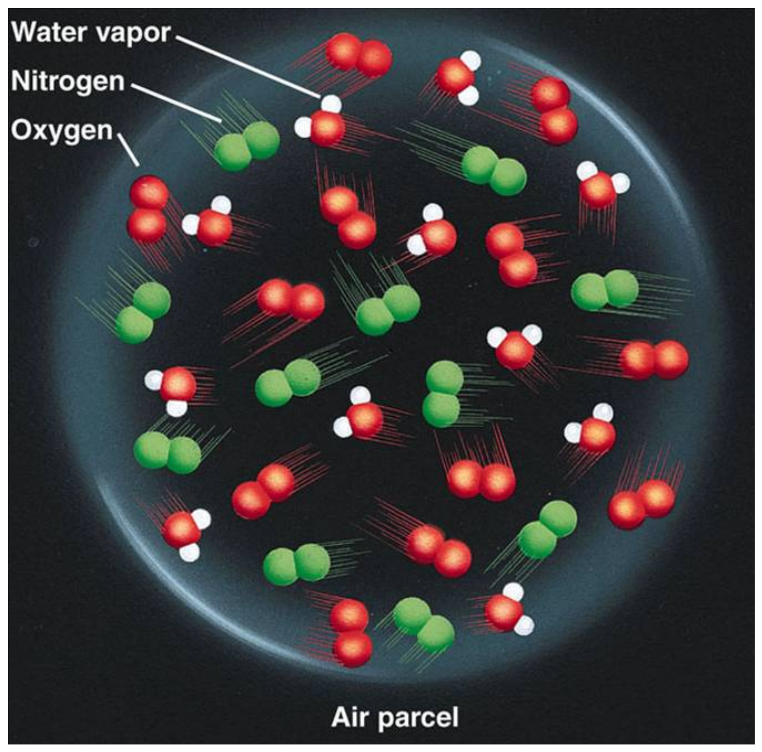

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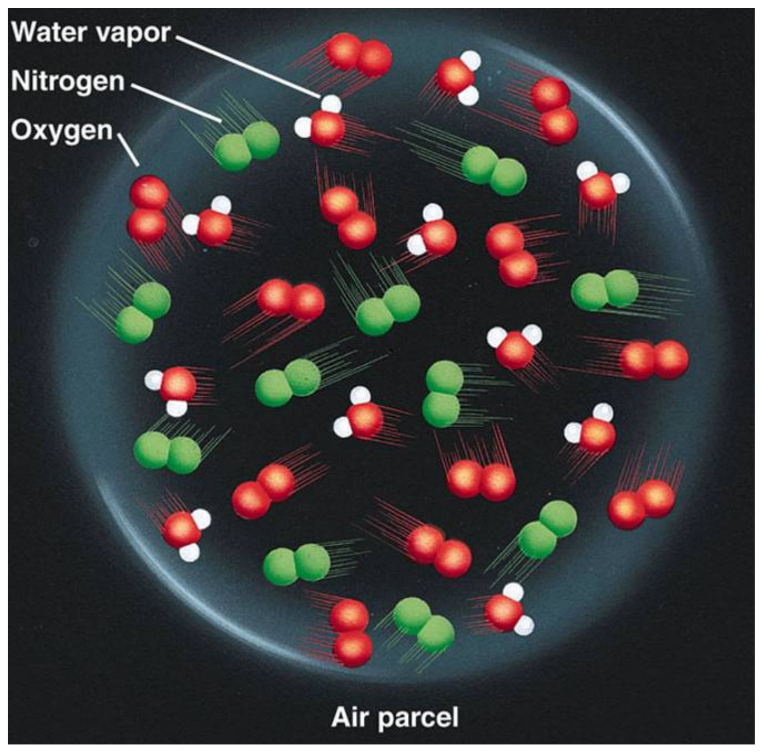

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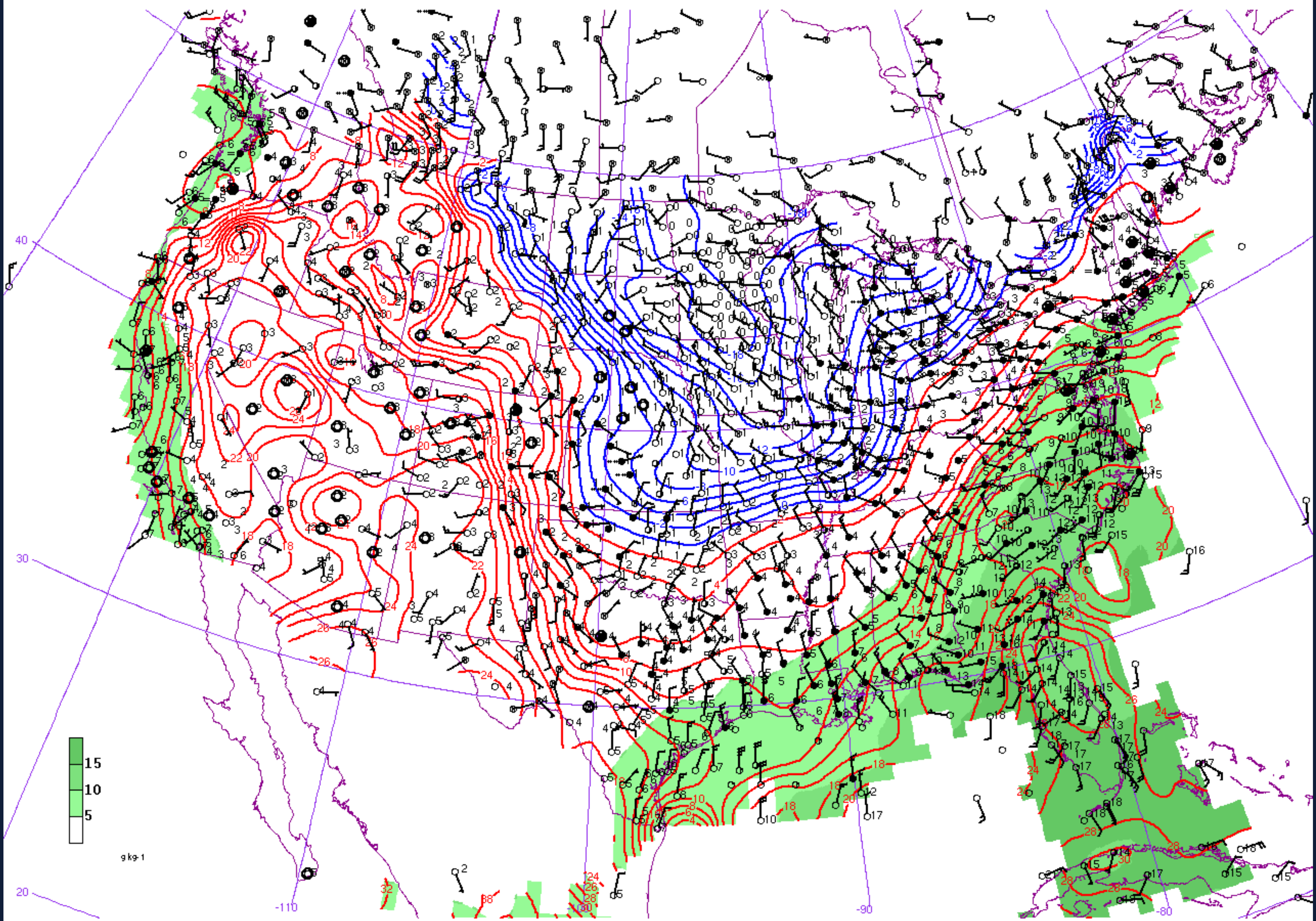
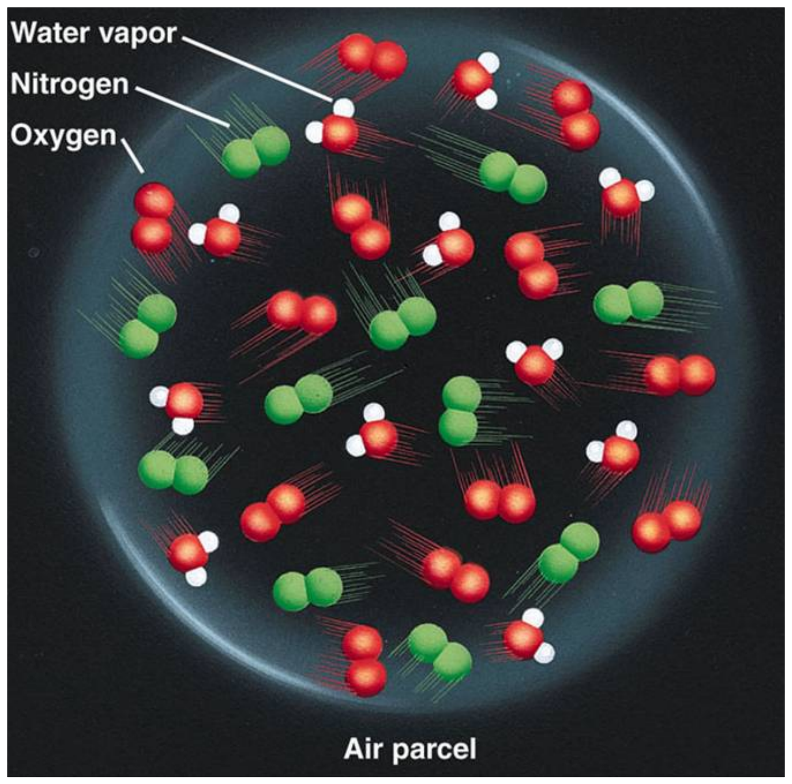


200213/2000 Sfc. Potential Temp. & Mix. Ratio (C; g kg-1)



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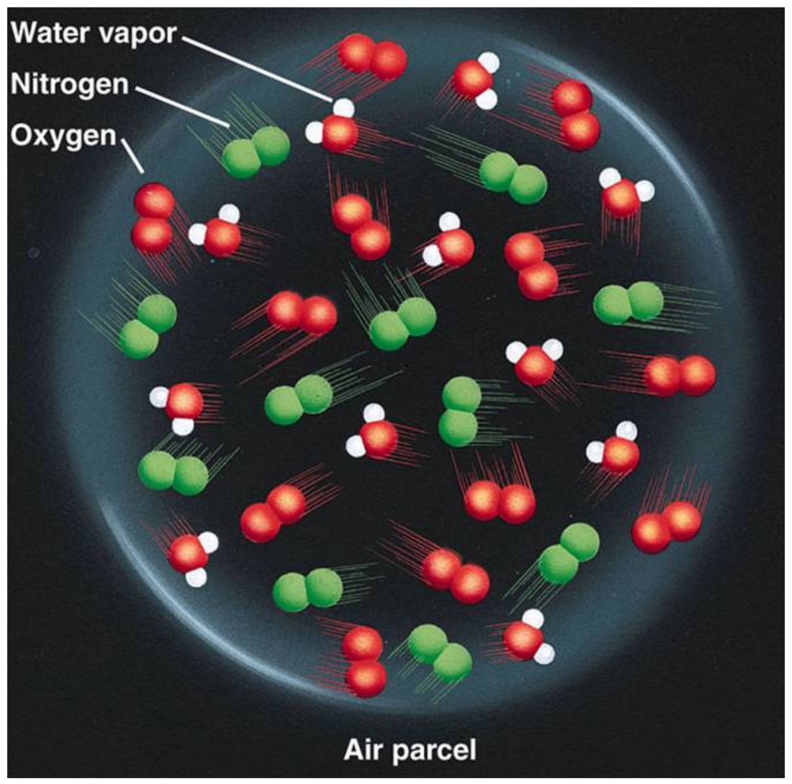

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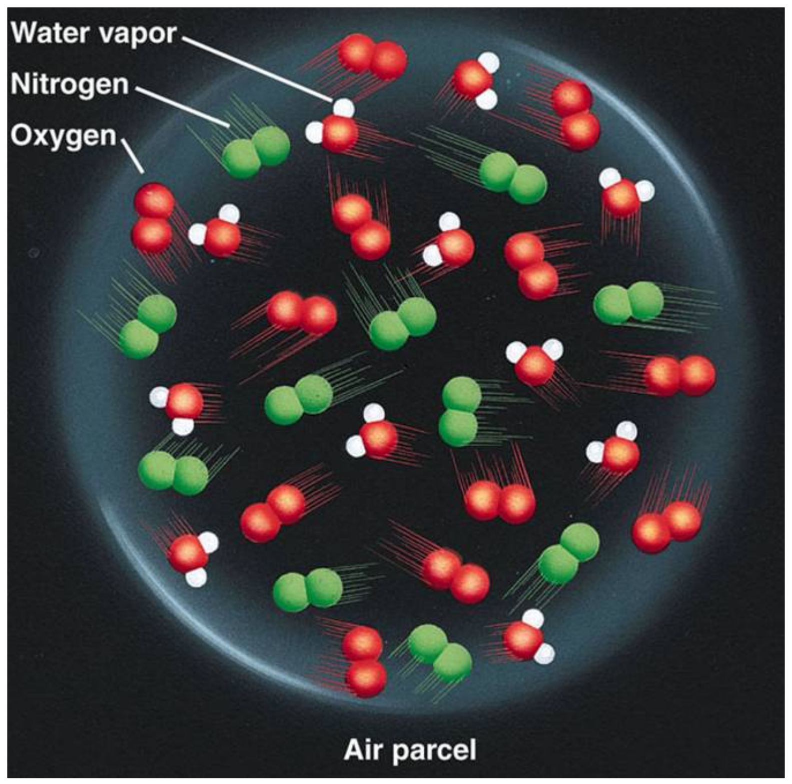

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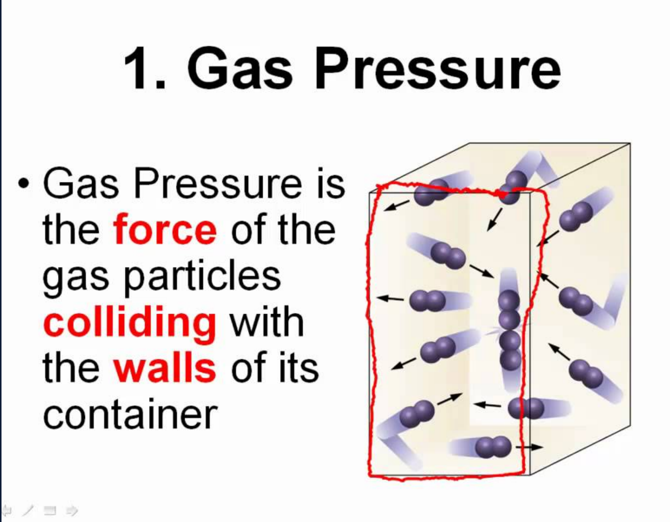

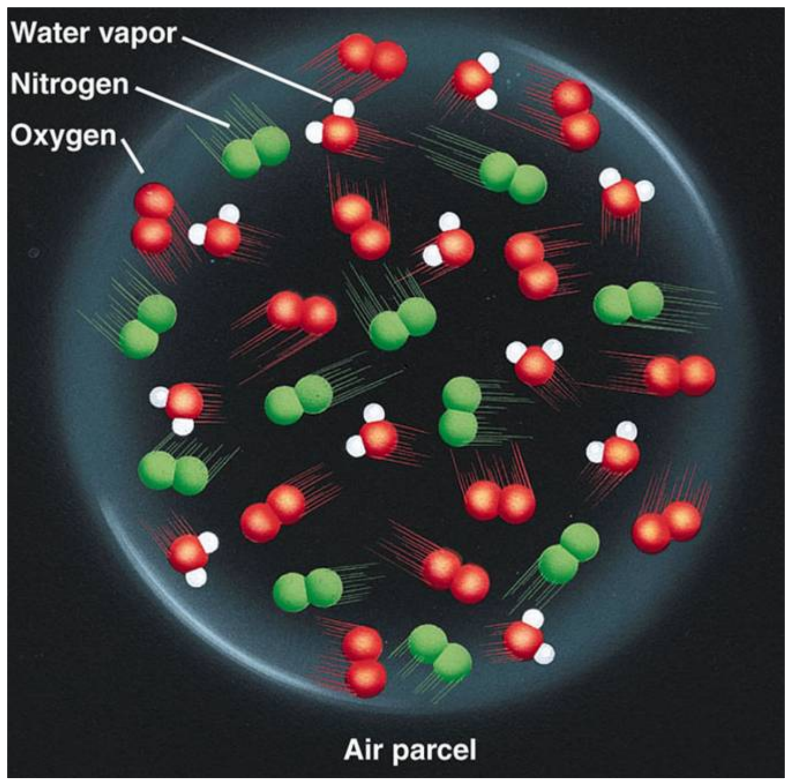

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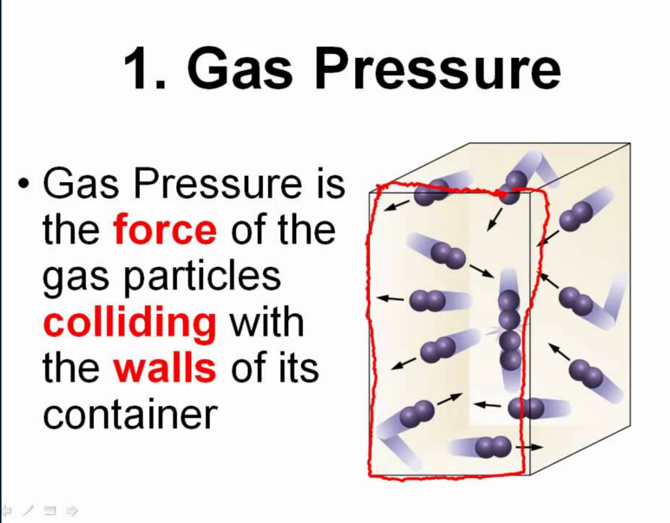
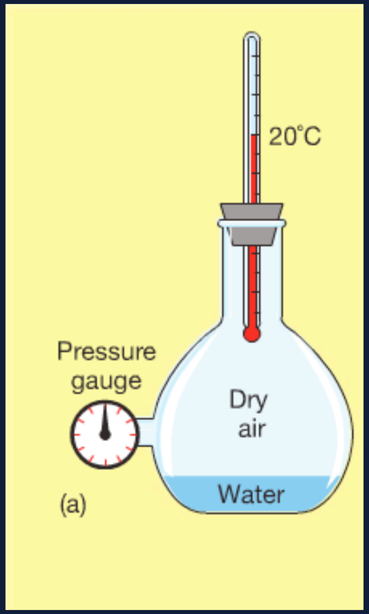
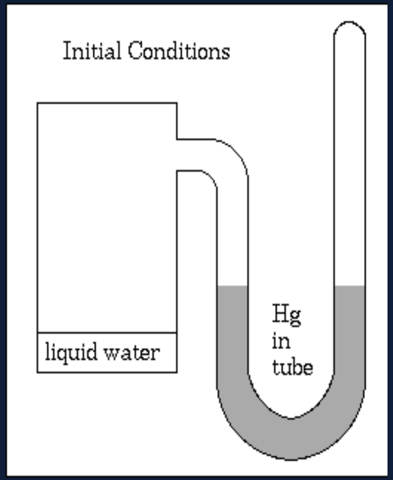


~ ***Vapor*** molecules ***hitting*** the sides of a ***container*** exert a ***force*** (per area) we measure as ***pressure***.

~ Imagine a ***flask*** filled with ***dry air*** and some ***water***, fitted with a ***pressure gauge*** at ***constant temperature***.





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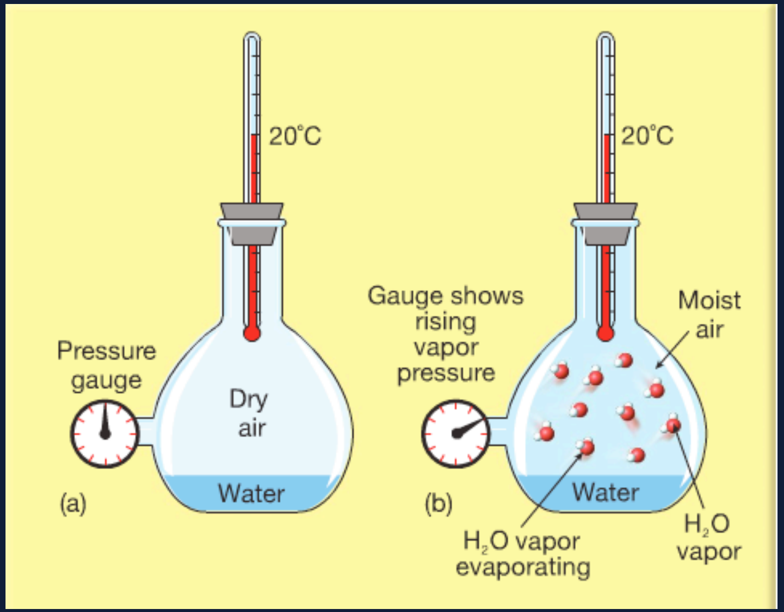

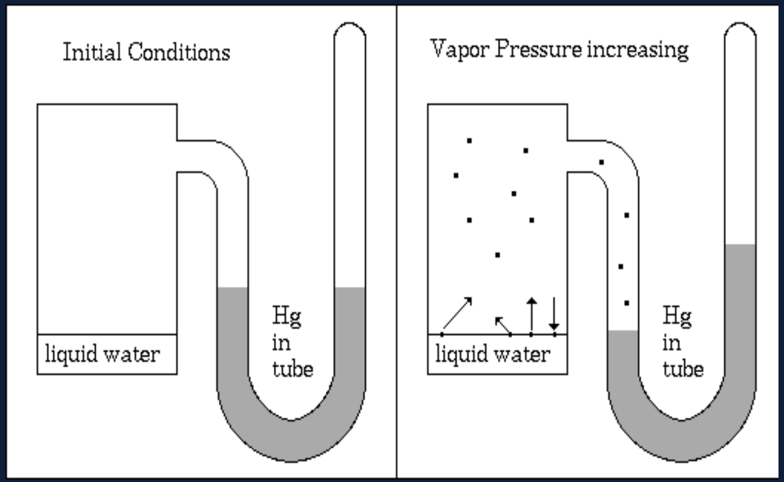

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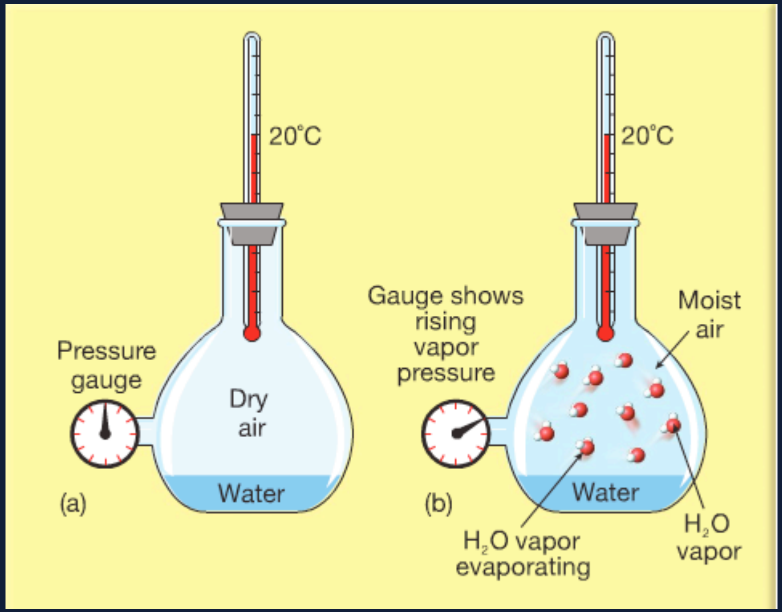

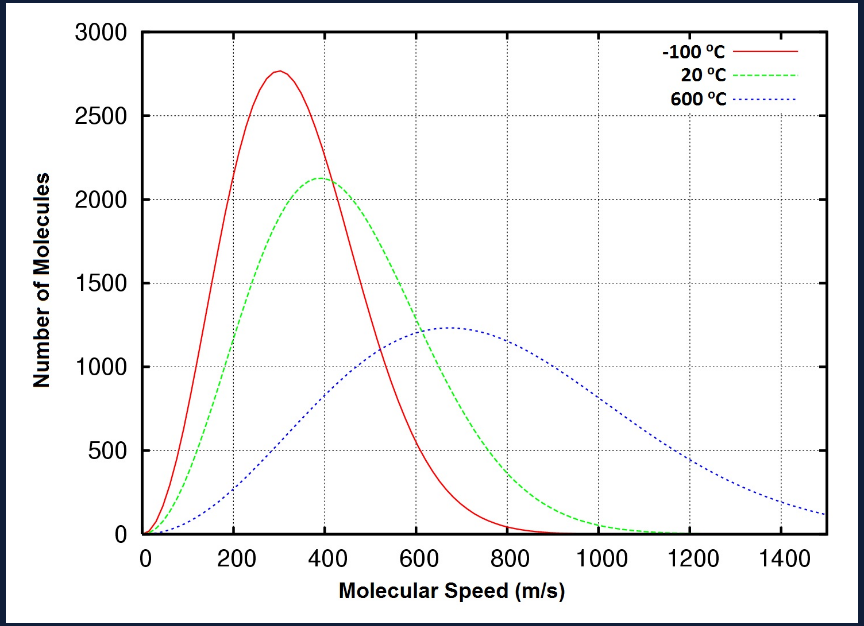

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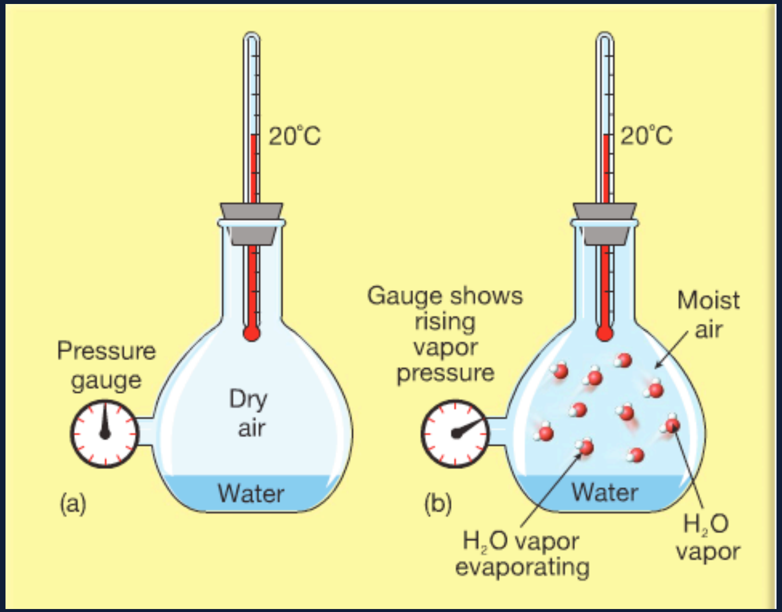
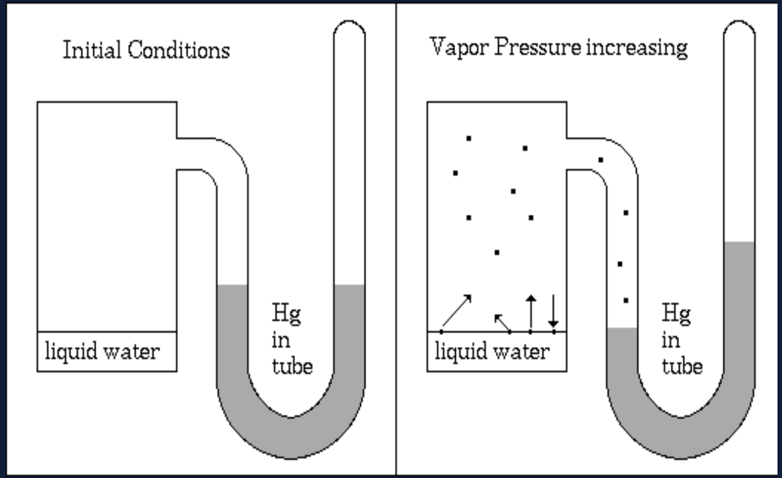
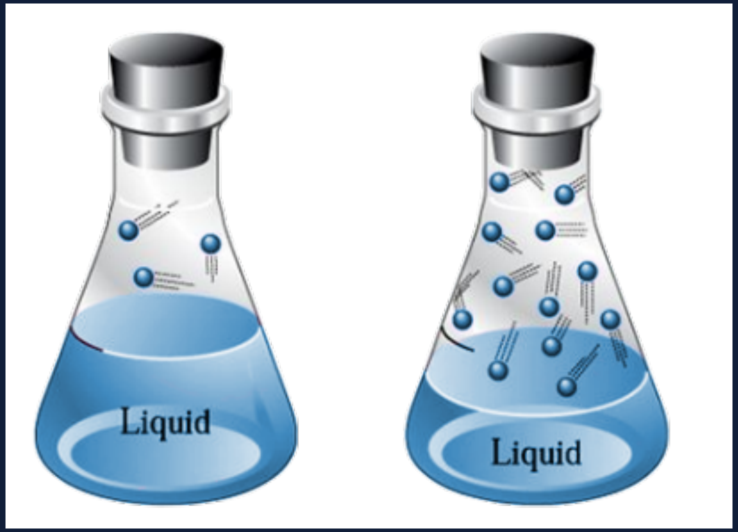
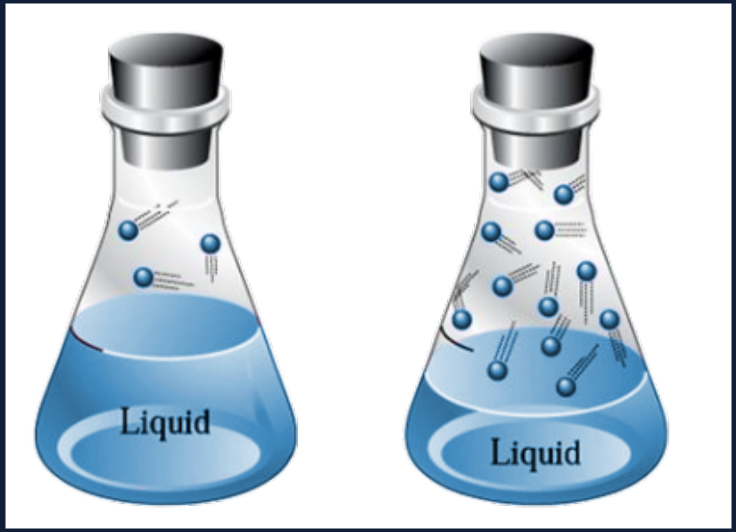
~ These ***vapor molecules*** will ***hit*** the sides of the ***flask***, ***increasing*** the ***pressure***.






Liquid
Liquid



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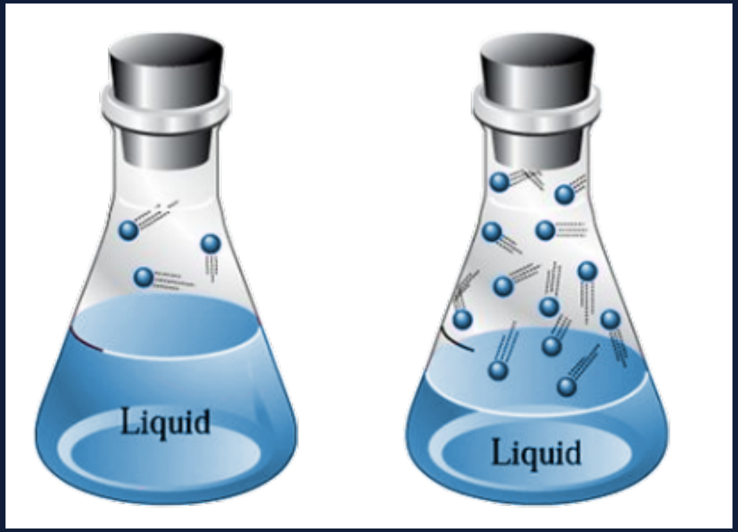

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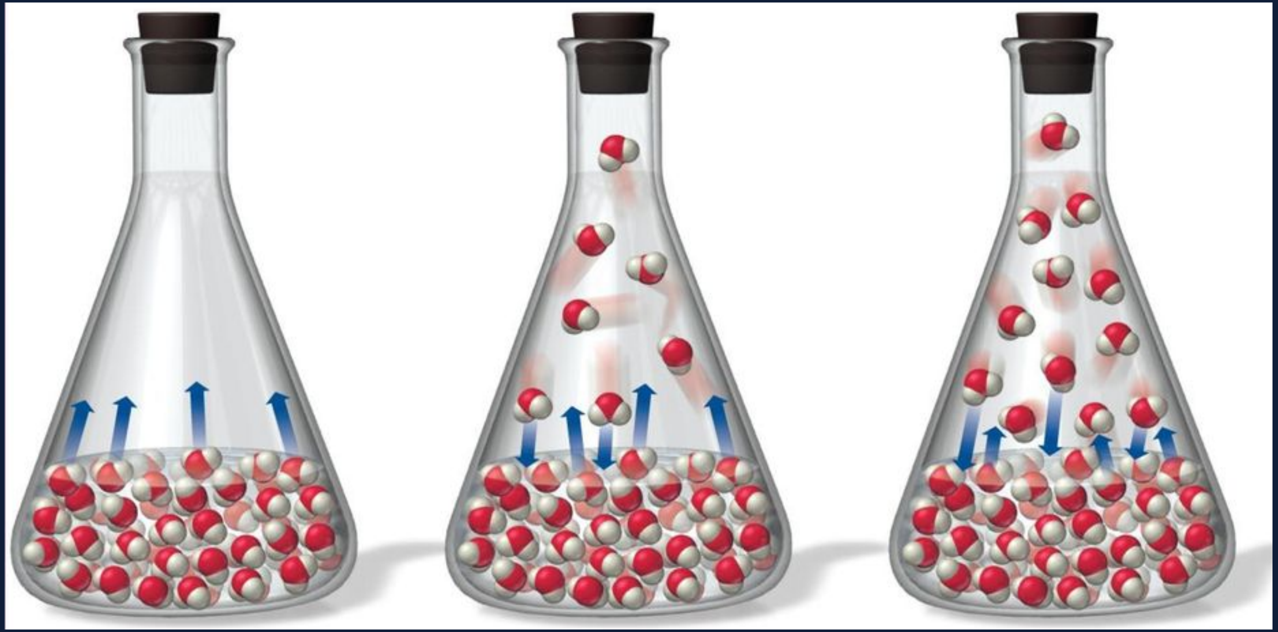

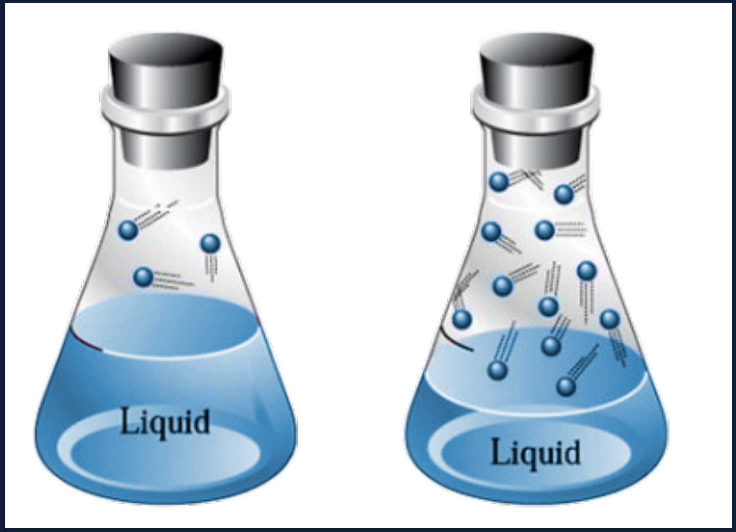

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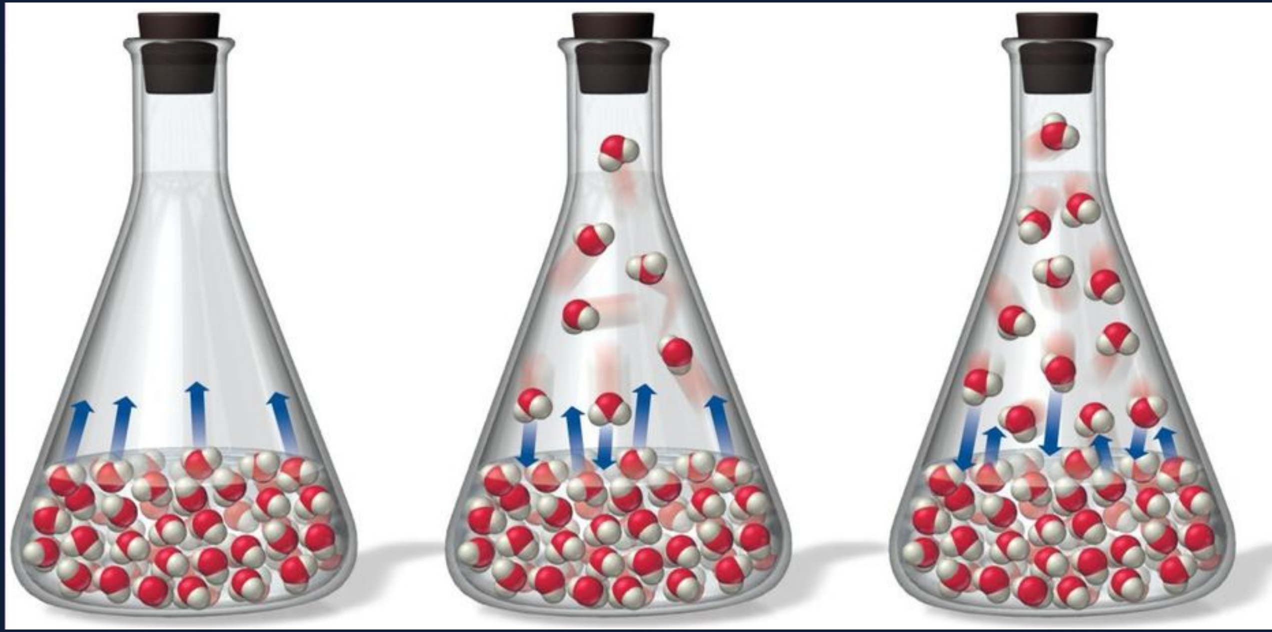
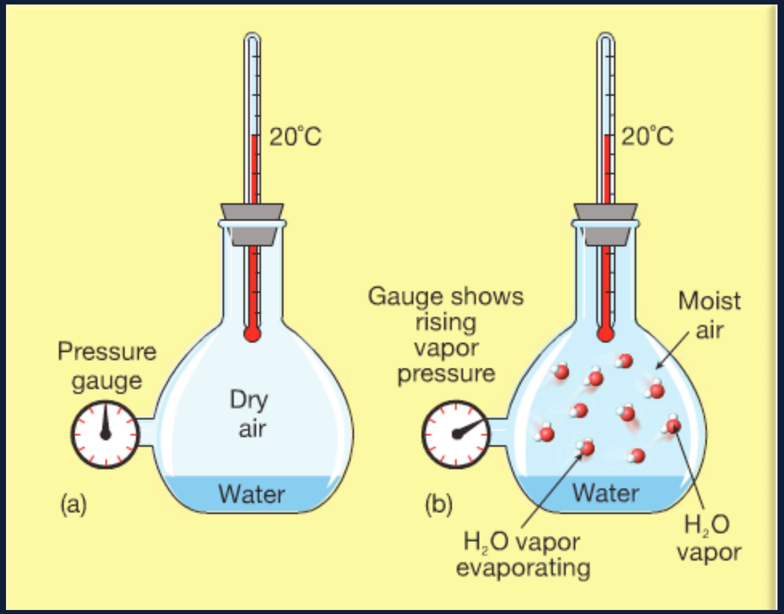
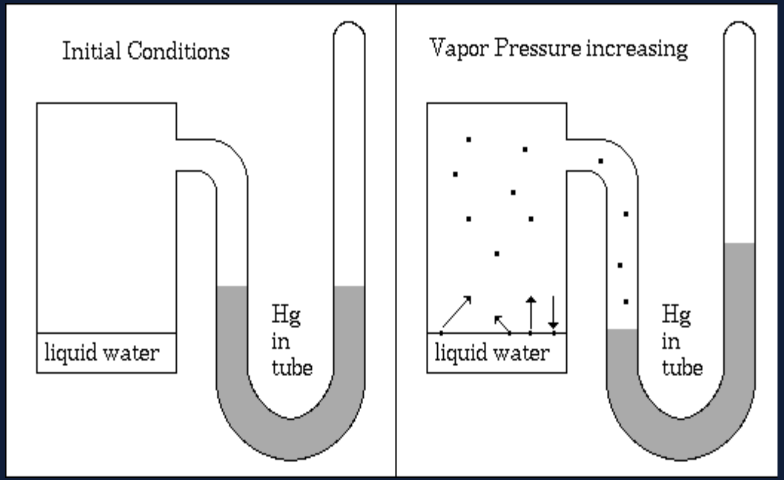
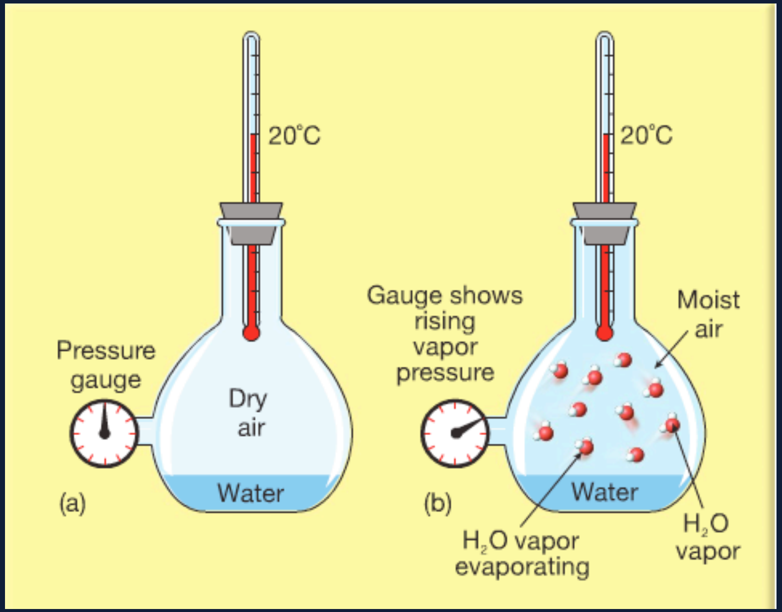
~ Eventually, a ***balance*** is reached where the ***number*** of molecules ***evaporating*** ***equals*** the ***number*** ***condensing***.




20°C
20°C
Pressure gauge
Dry air
Water
(a)
Gauge shows rising vapor pressure
Moist air
Water
(b)
H_2O vapor evaporating
H_2O vapor


Initial Conditions
liquid water
Hg in tube
Vapor Pressure increasing
liquid water
Hg in tube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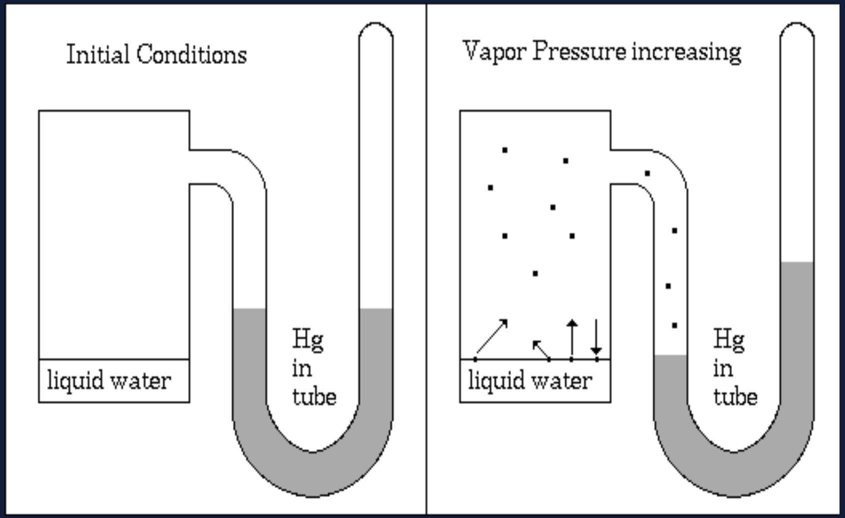
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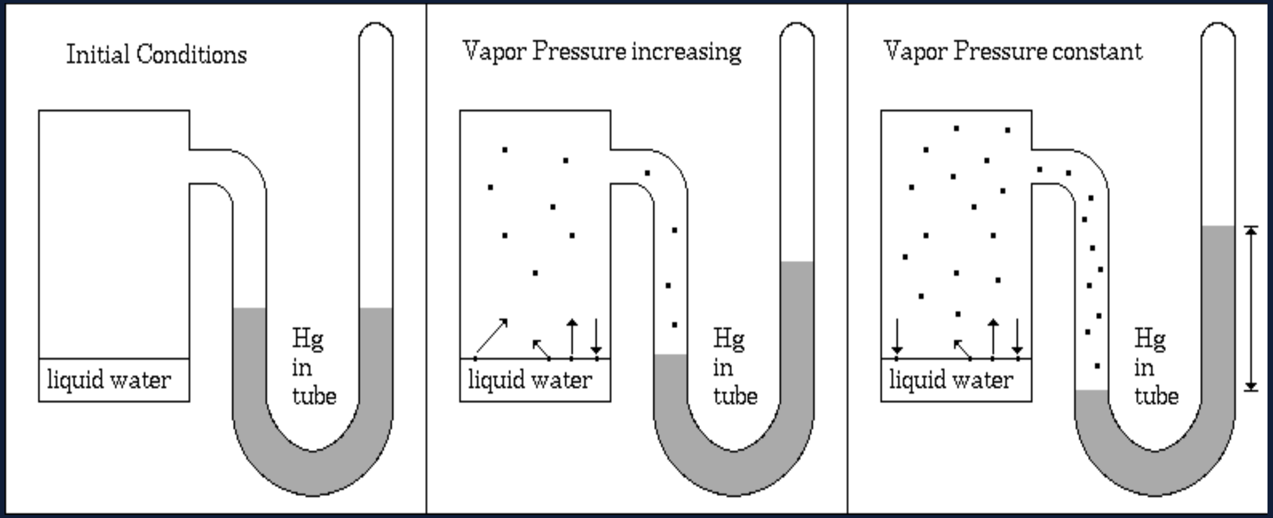
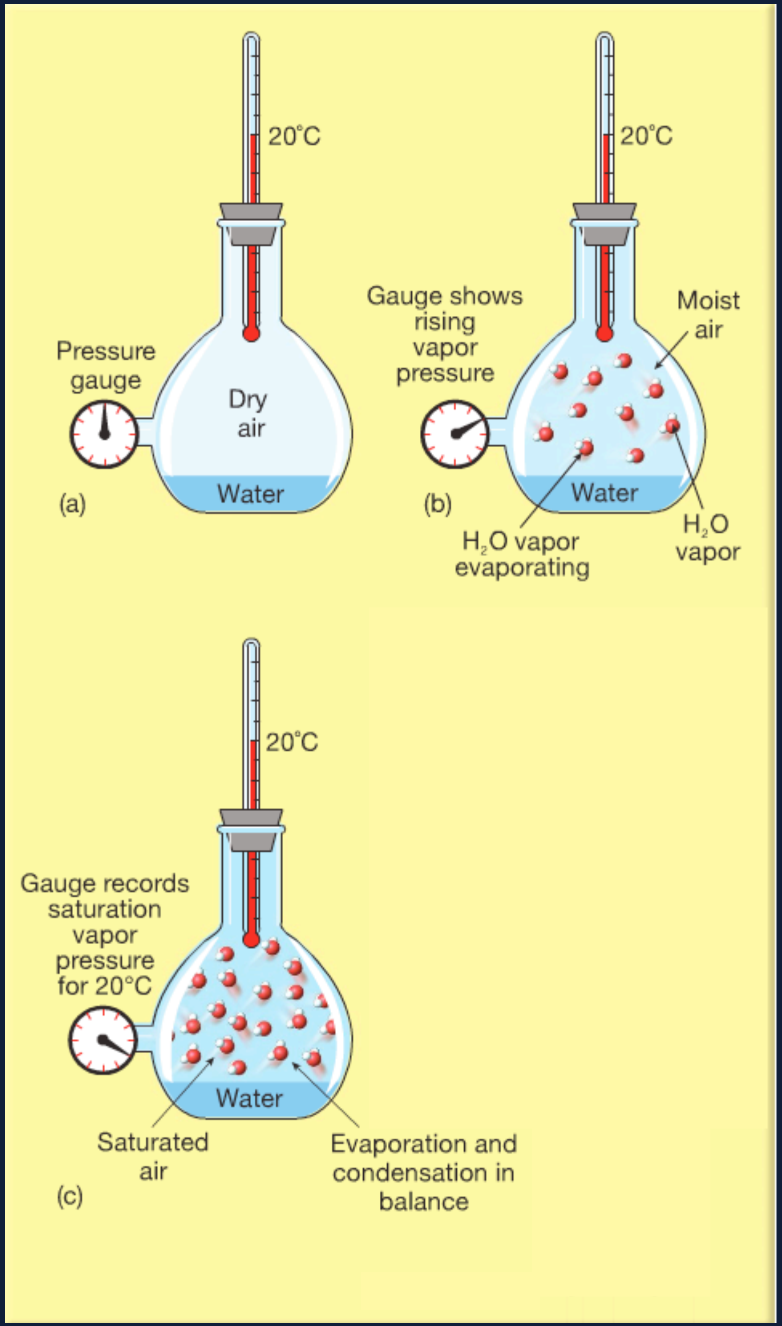
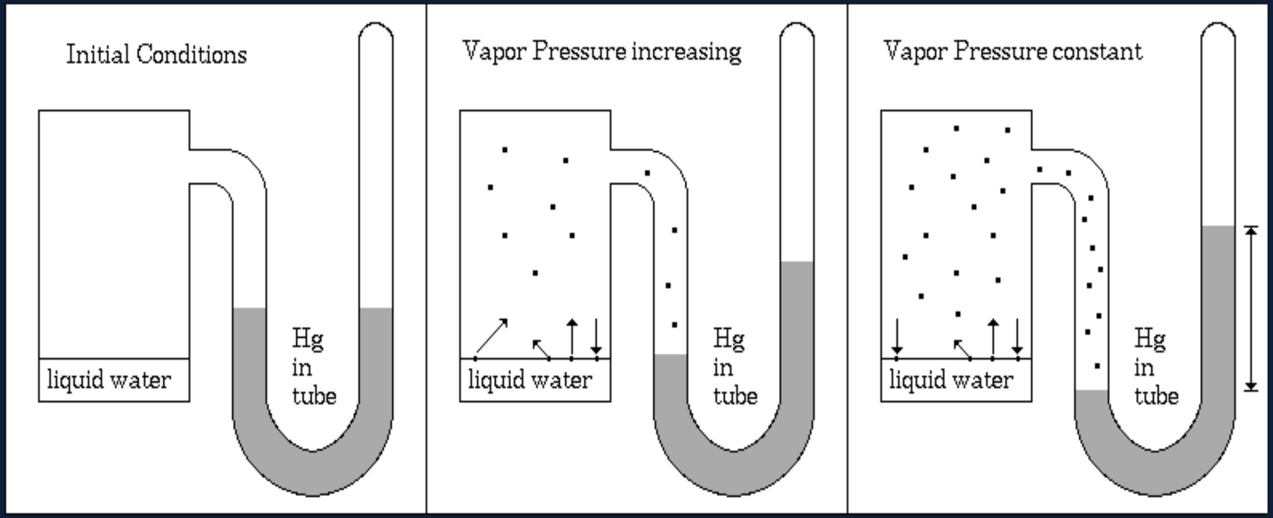


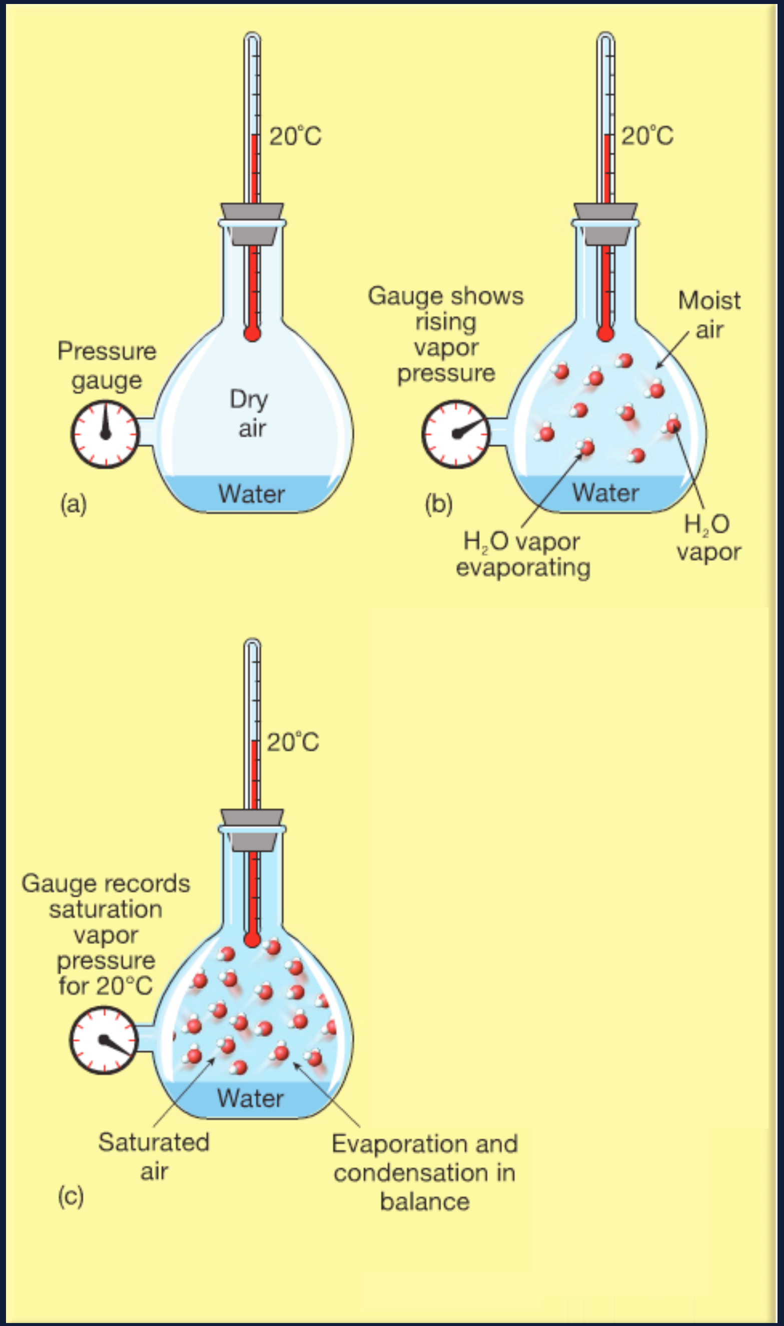
Initial Conditions
liquid water
Hg
in
tube
Vapor Pressure increasing
liquid water
Hg
in
tube
Vapor Pressure constant
liquid water
Hg
in
tube



20°C
Pressure gauge
Dry air
Water
(a)
20°C
Gauge shows rising vapor pressure
Moist air
Water
(b)
H_2O vapor evaporating
H_2O vapor
20°C
Gauge records saturation vapor pressure for 20°C
Water
Saturated air
(c)
Evaporation and condensation in balance

~ This ***balance*** is called ***saturation*** (the air is "holding" as much as water vapor as it can) and the ***vapor pressure*** is called the ***saturation vapor pressure***.





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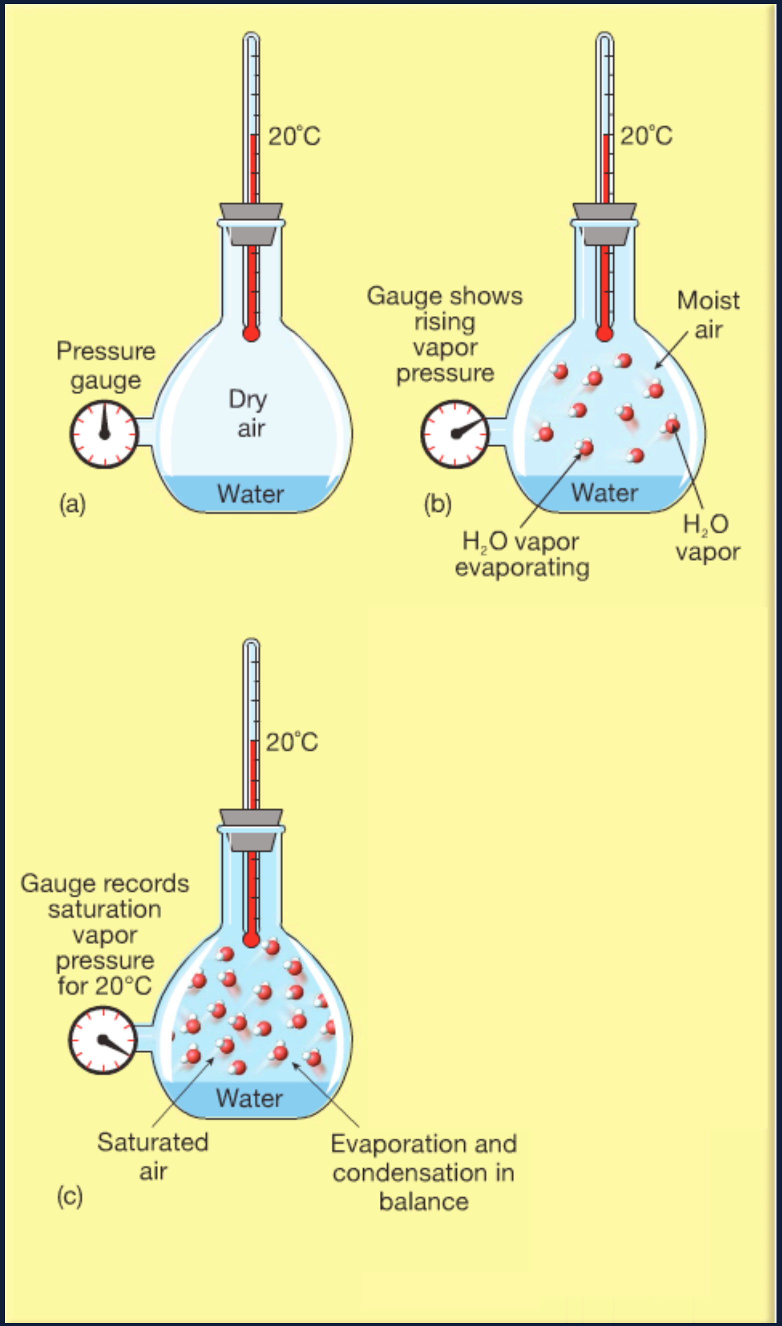

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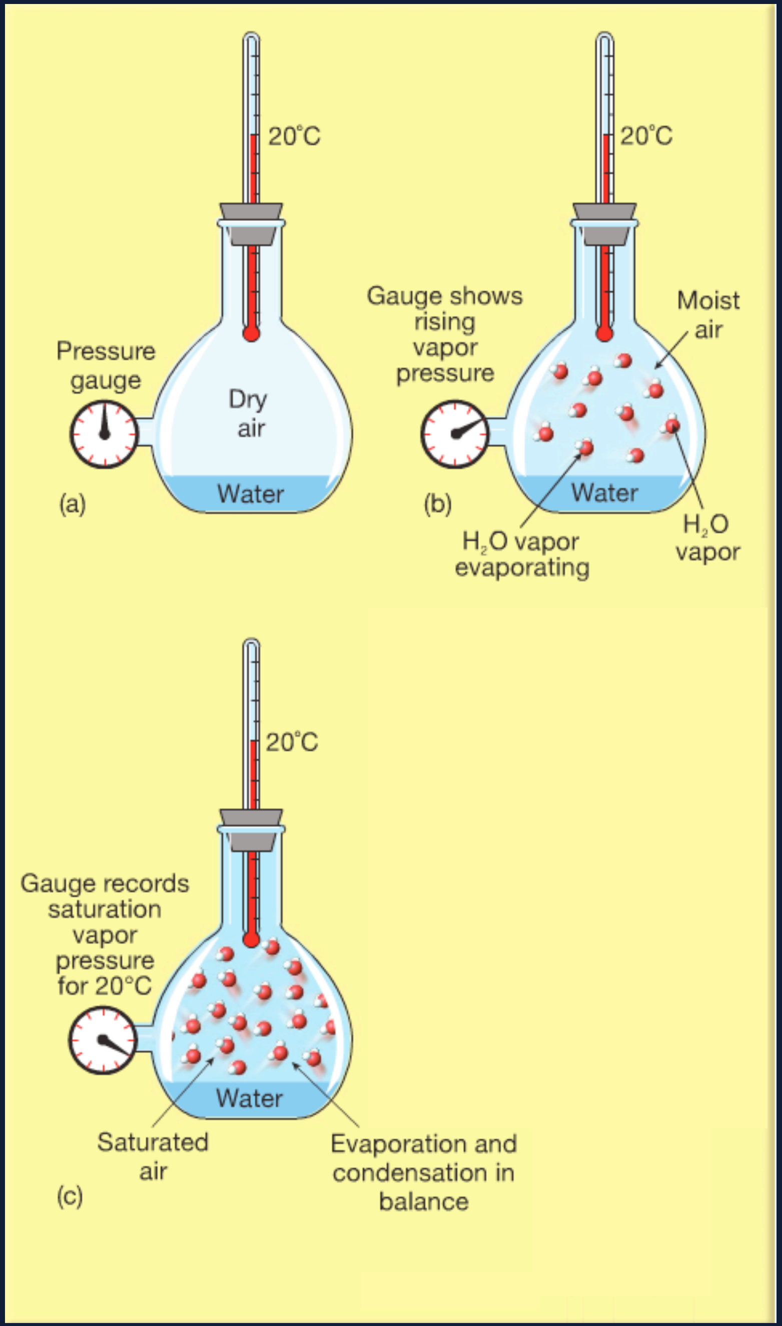
~ If the ***temperature*** of the flask is ***increased*** or ***decreased***, a ***new balance*** will need to be ***achieved***.



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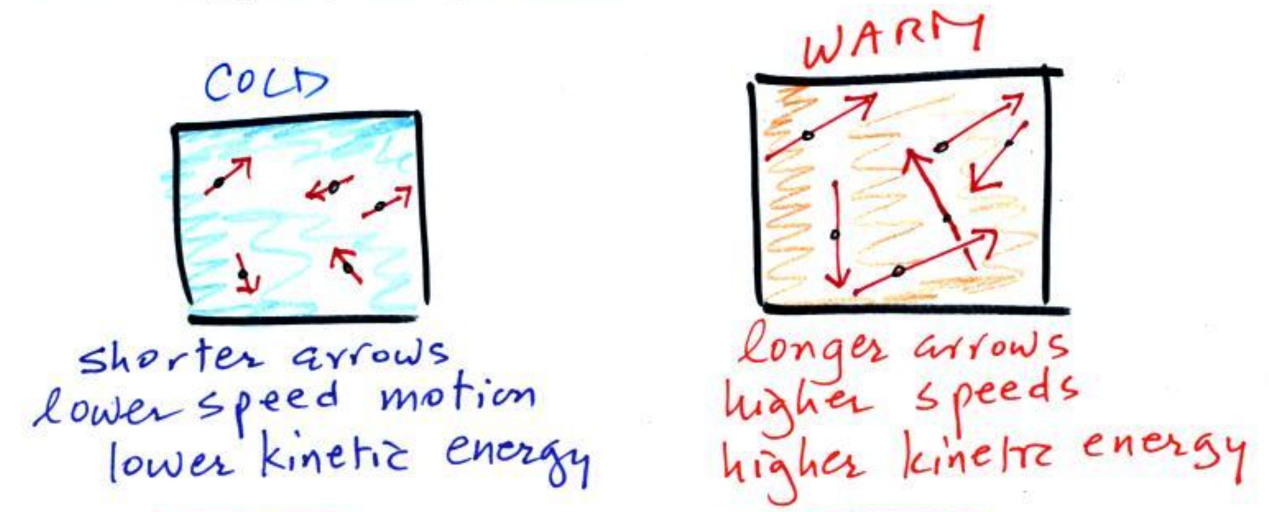

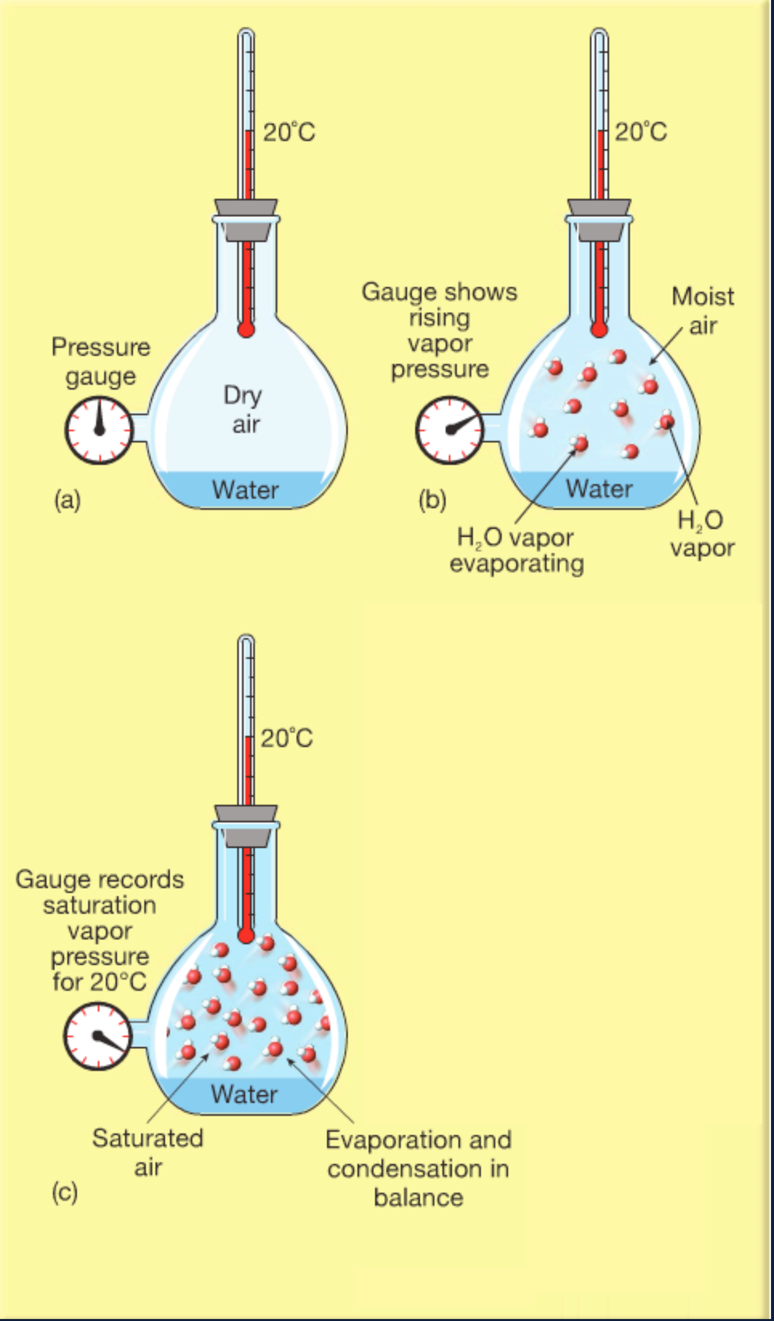

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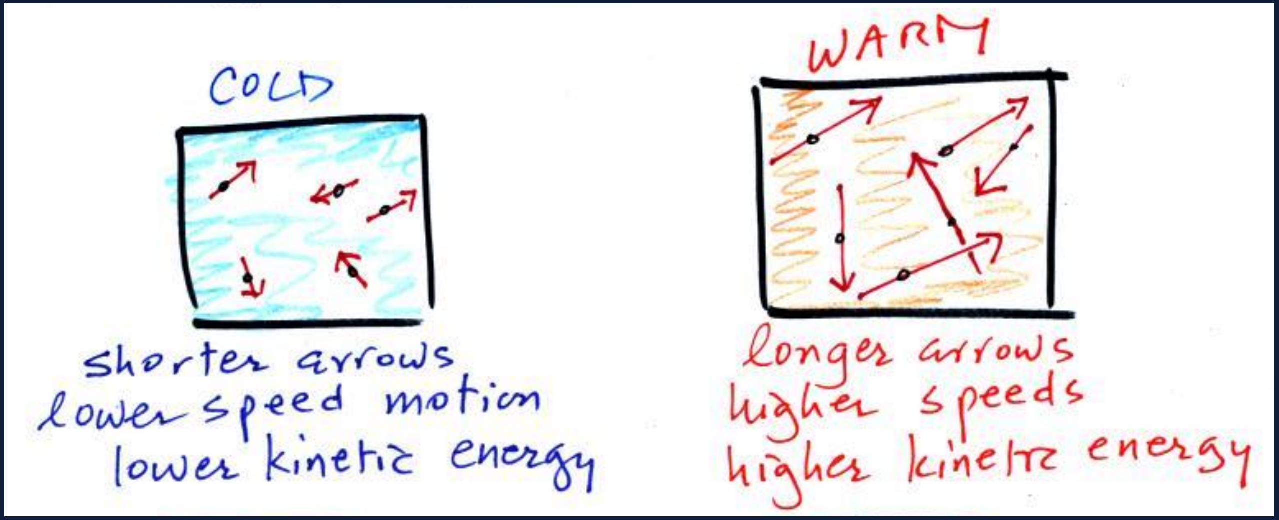

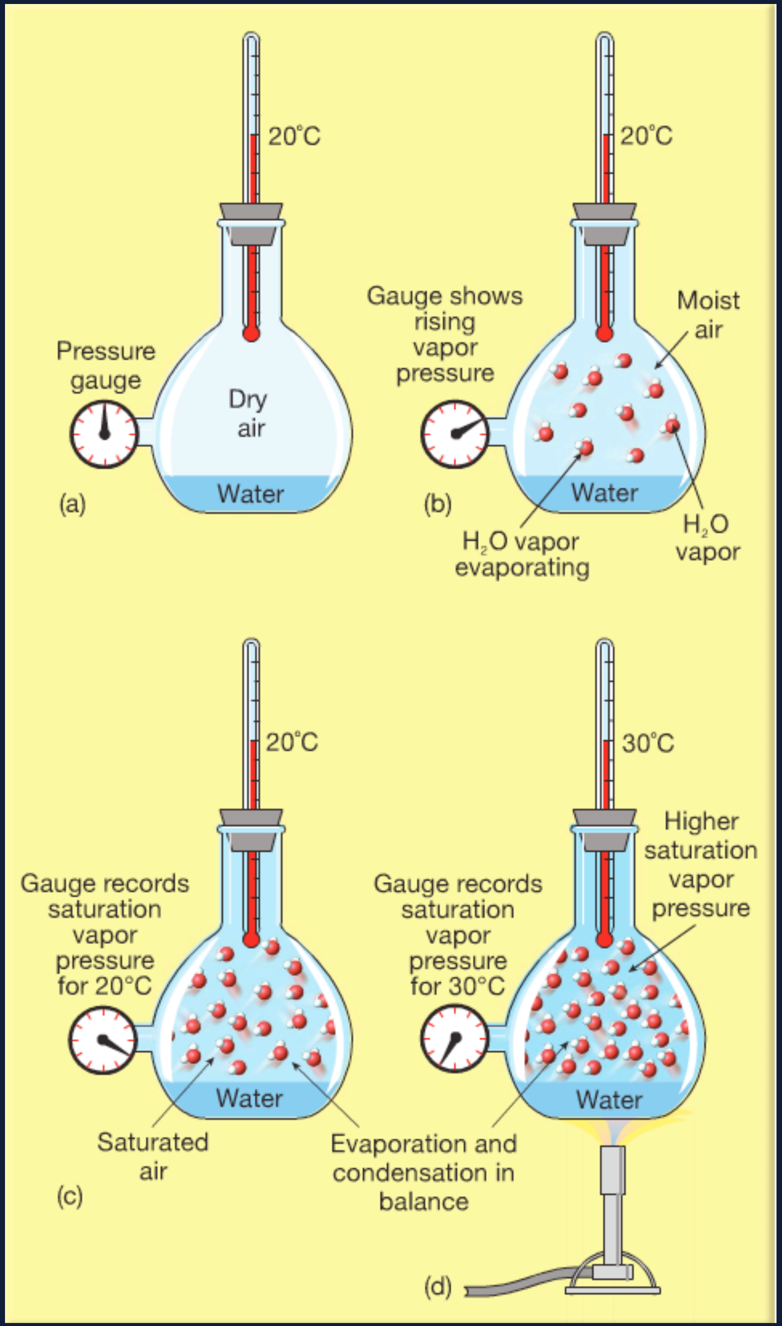

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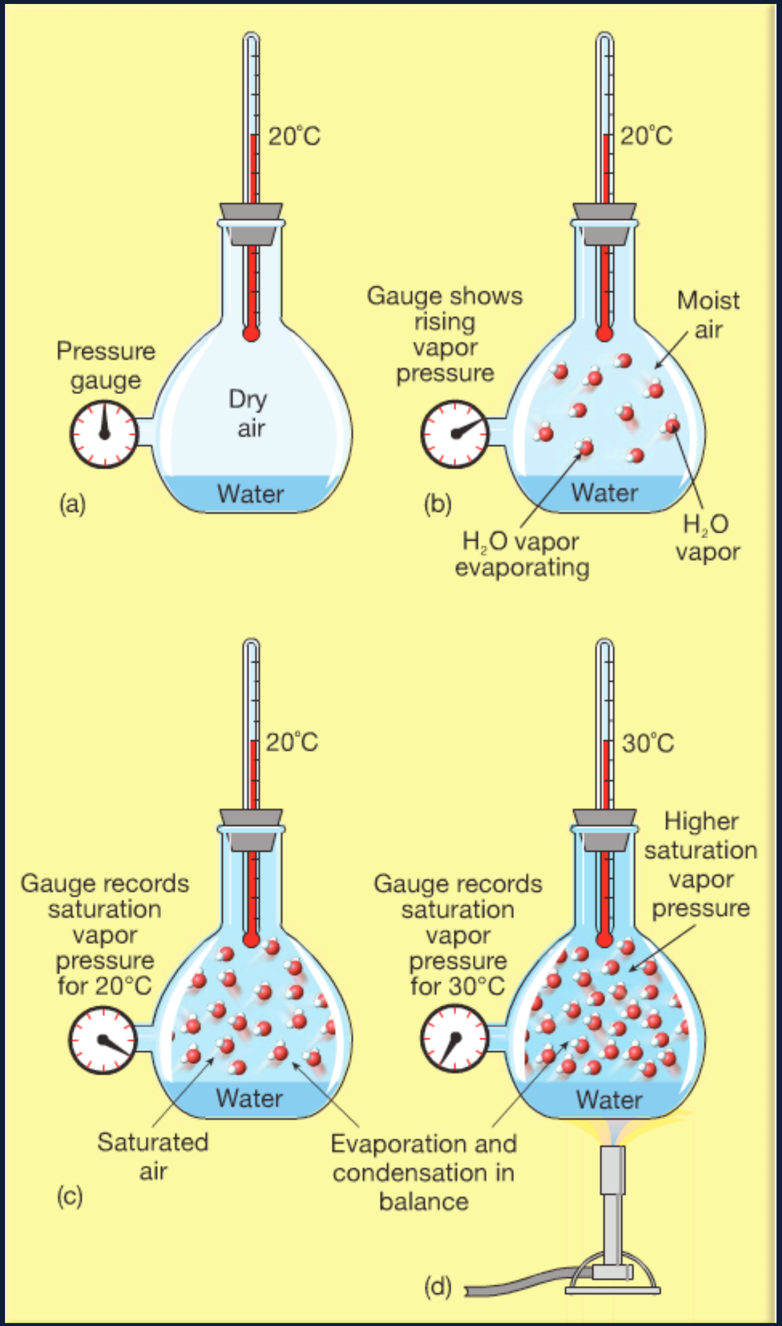

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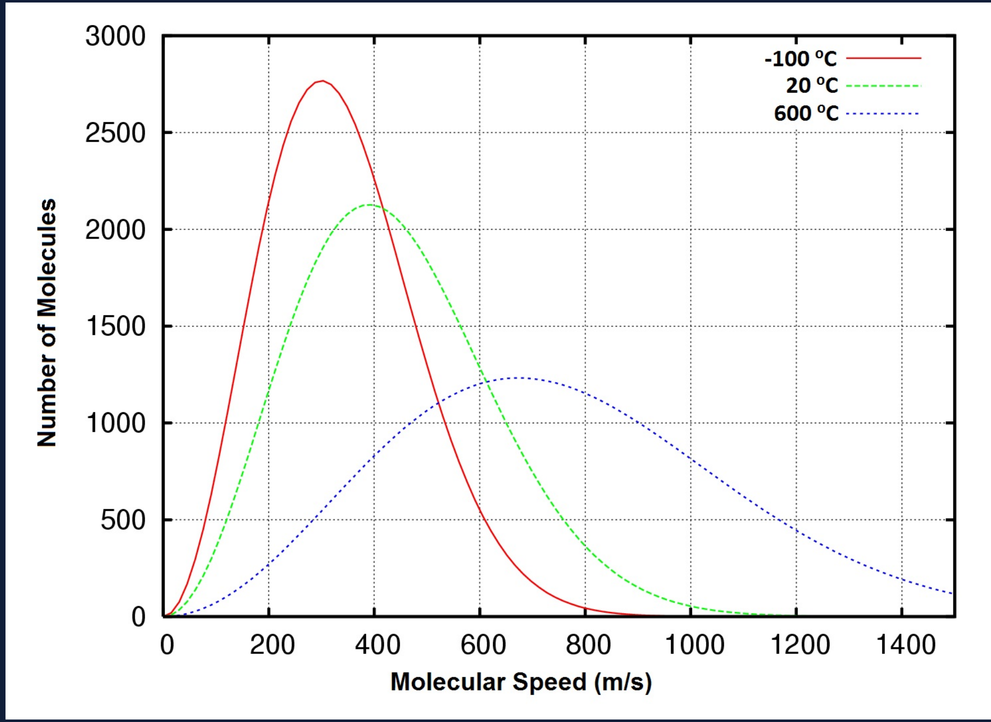

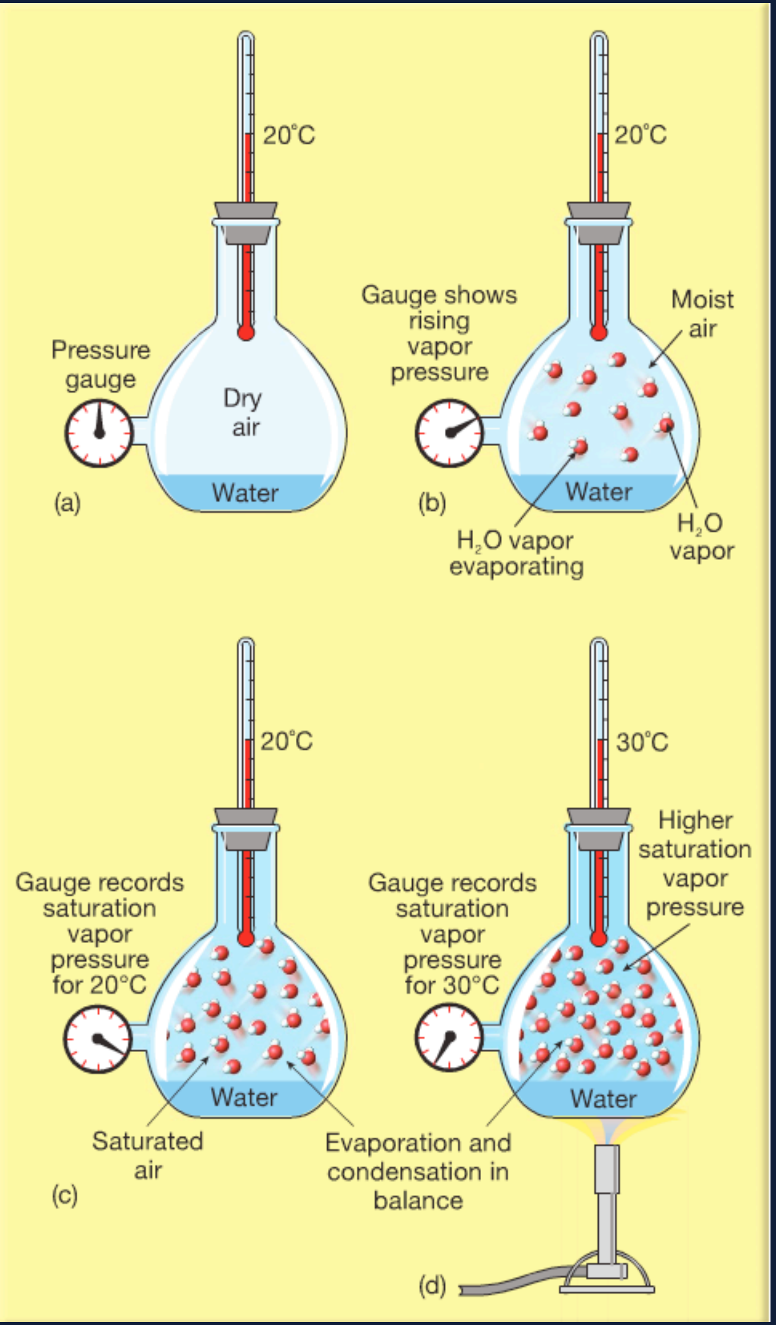

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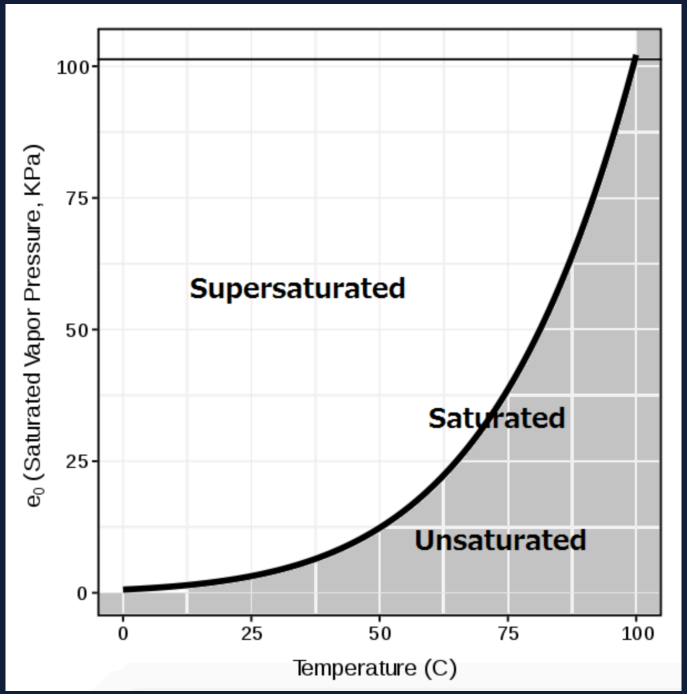

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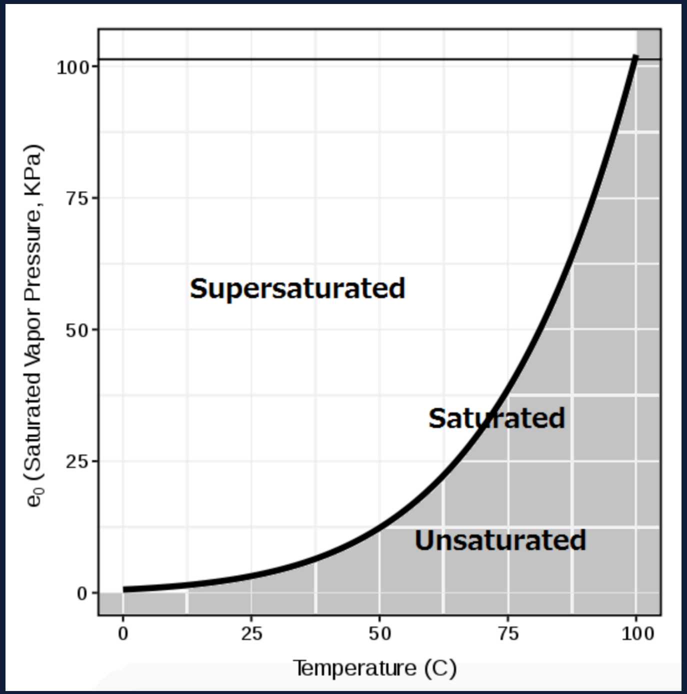

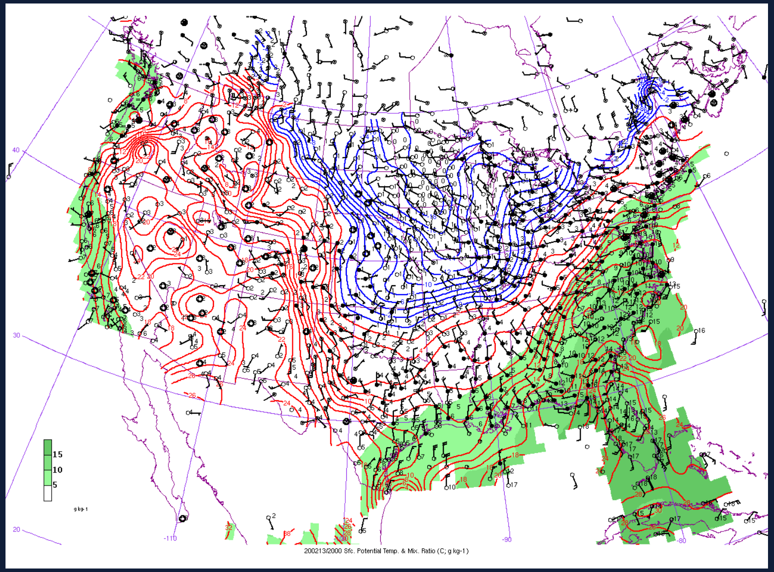

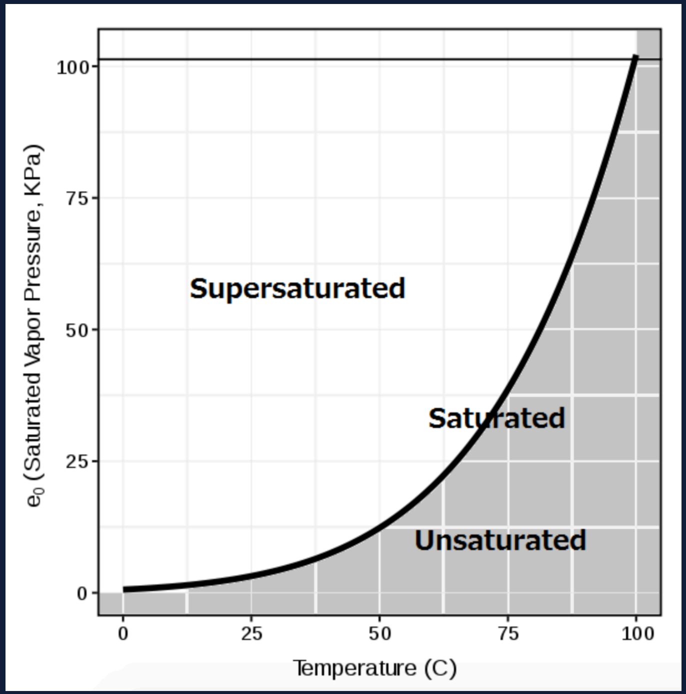

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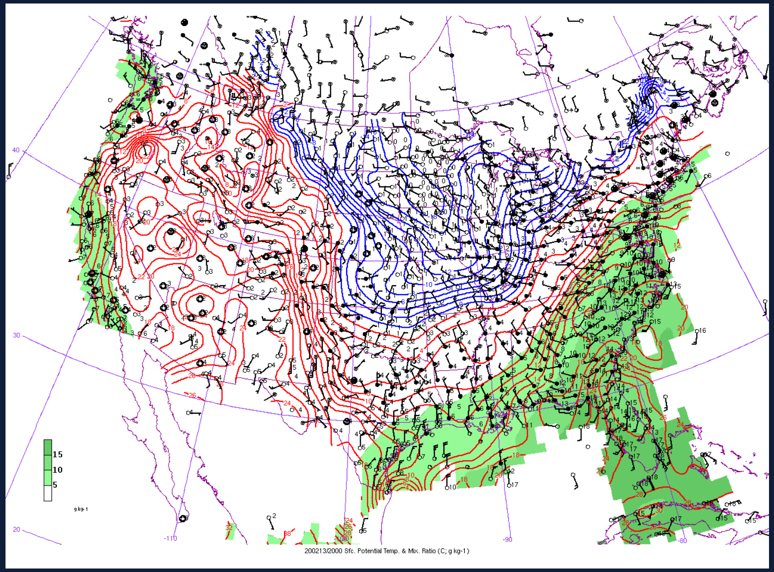

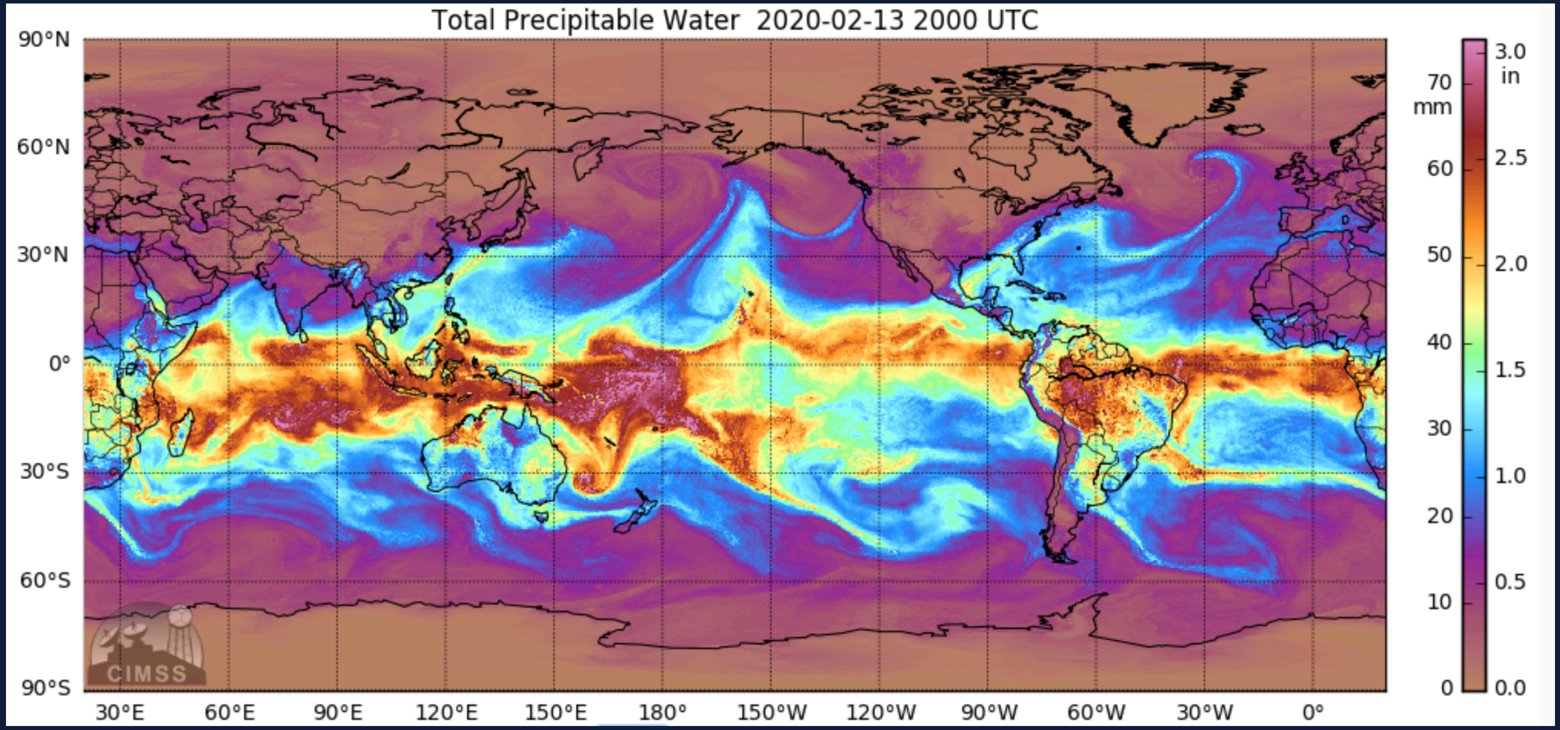

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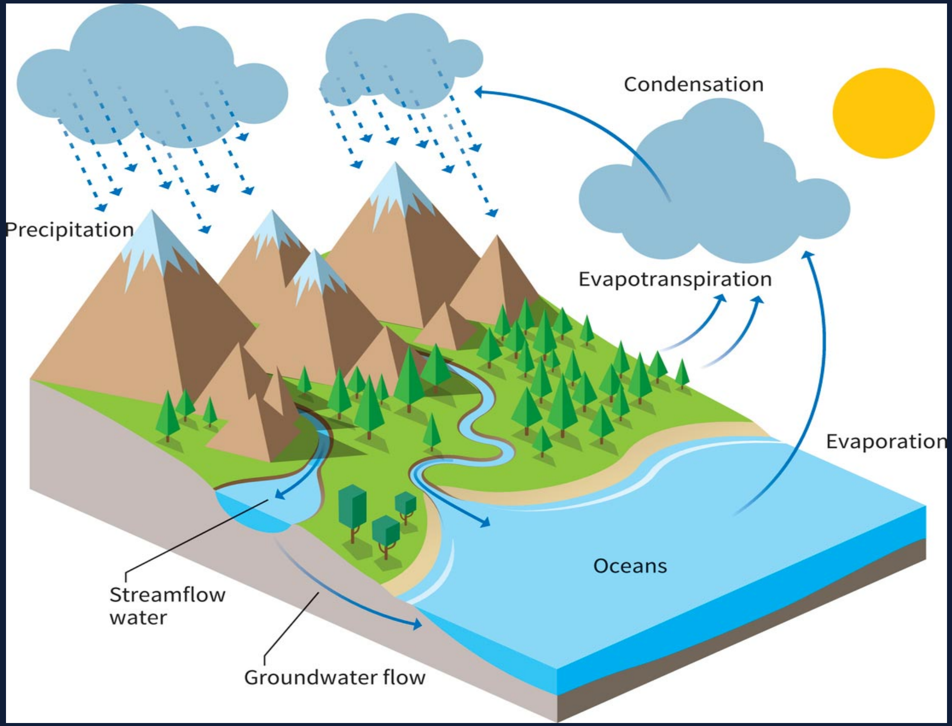

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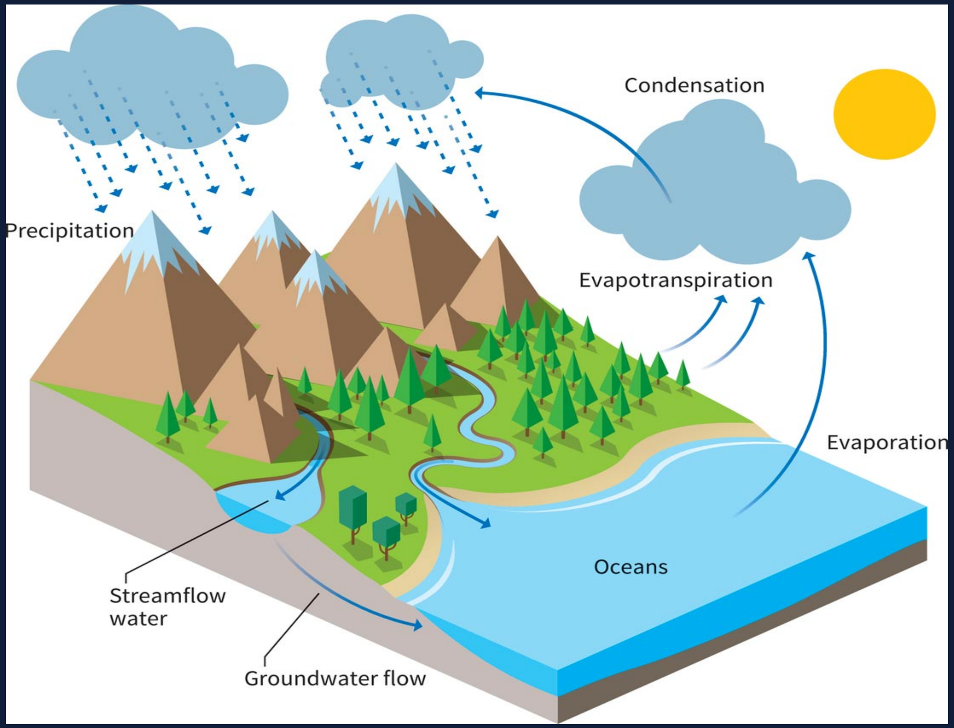

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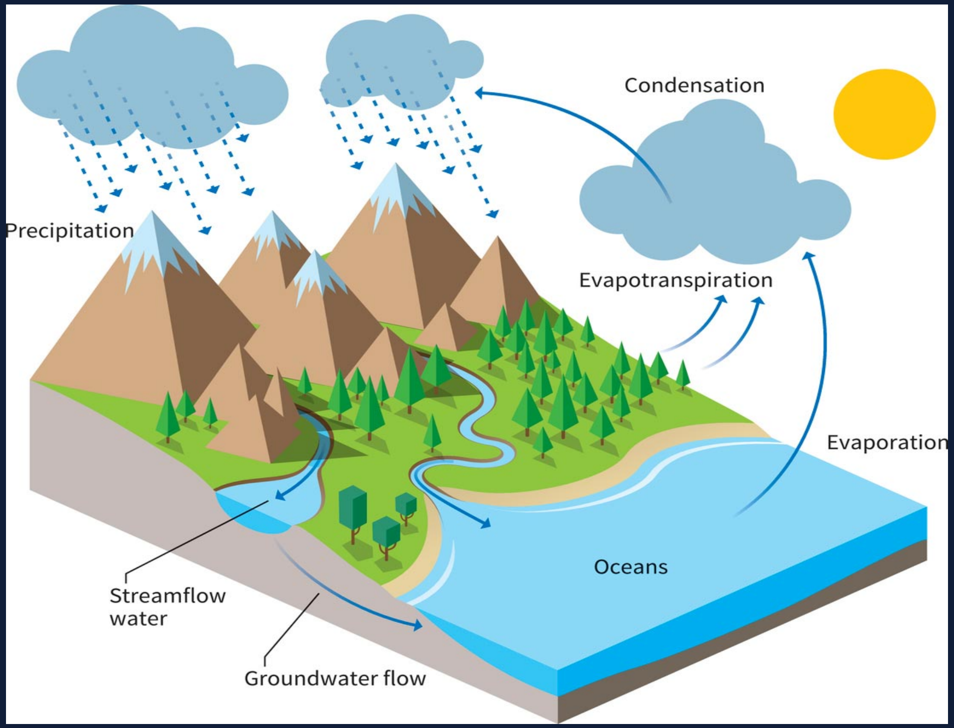

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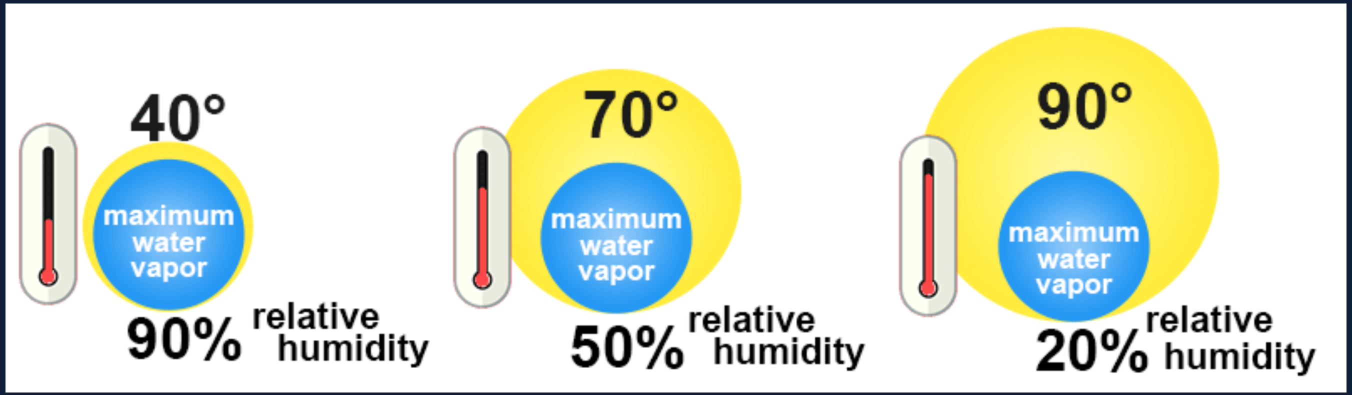

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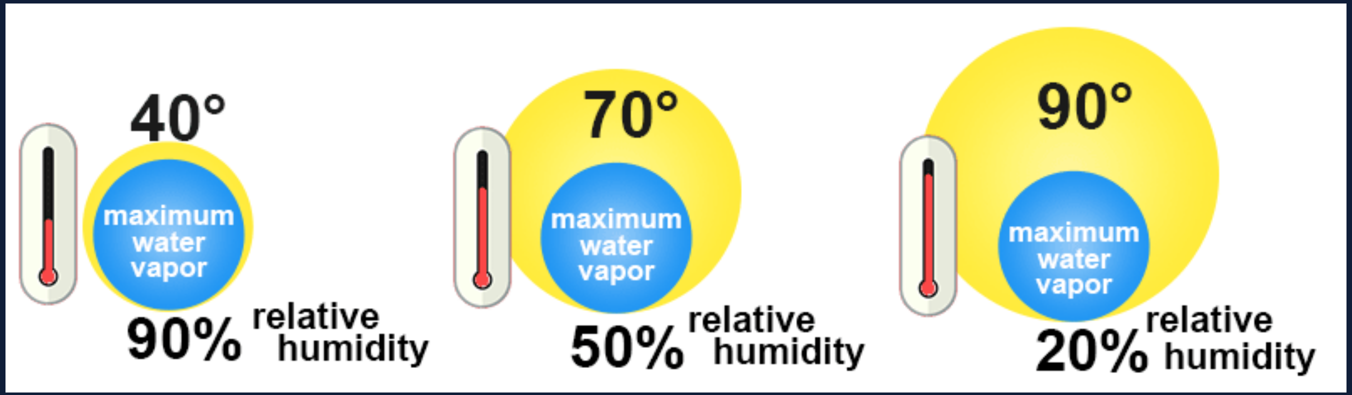
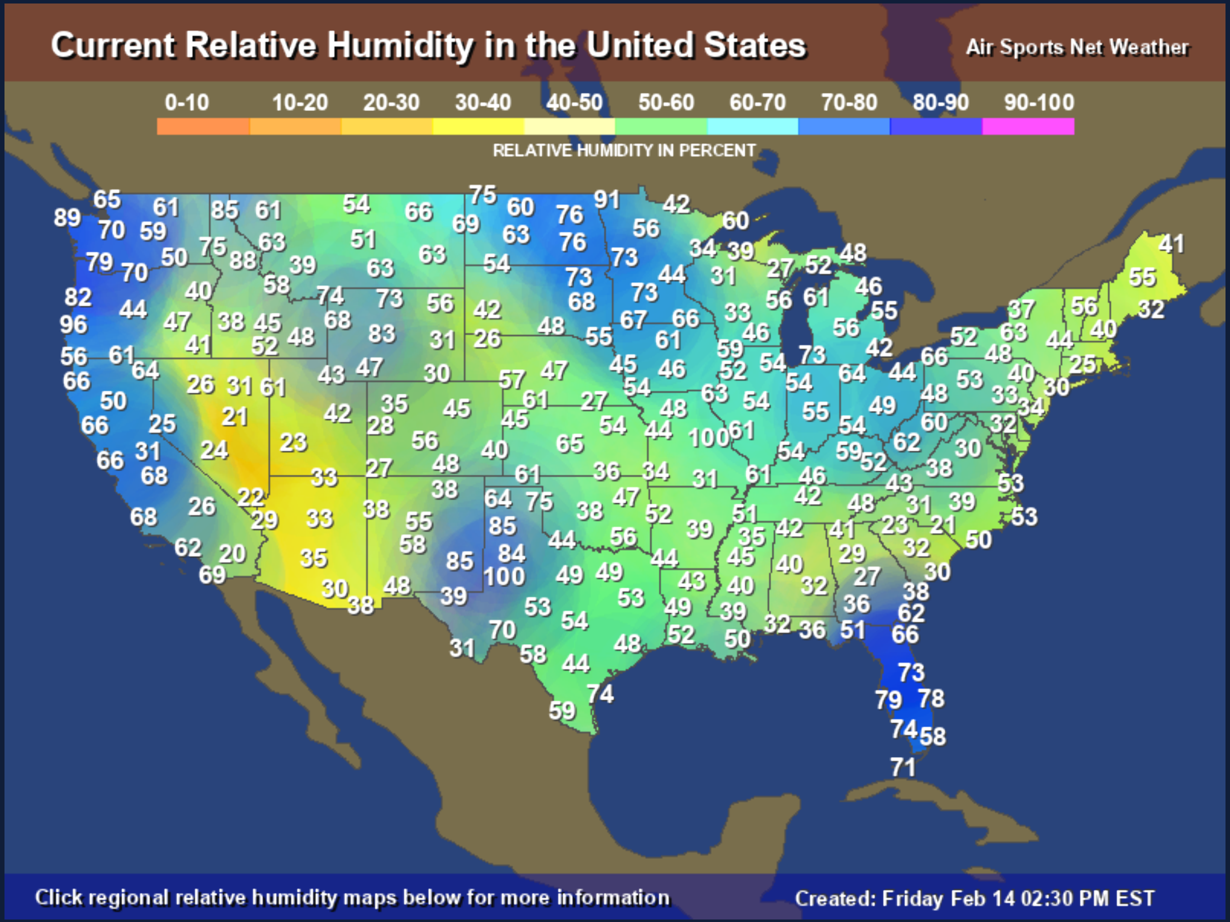
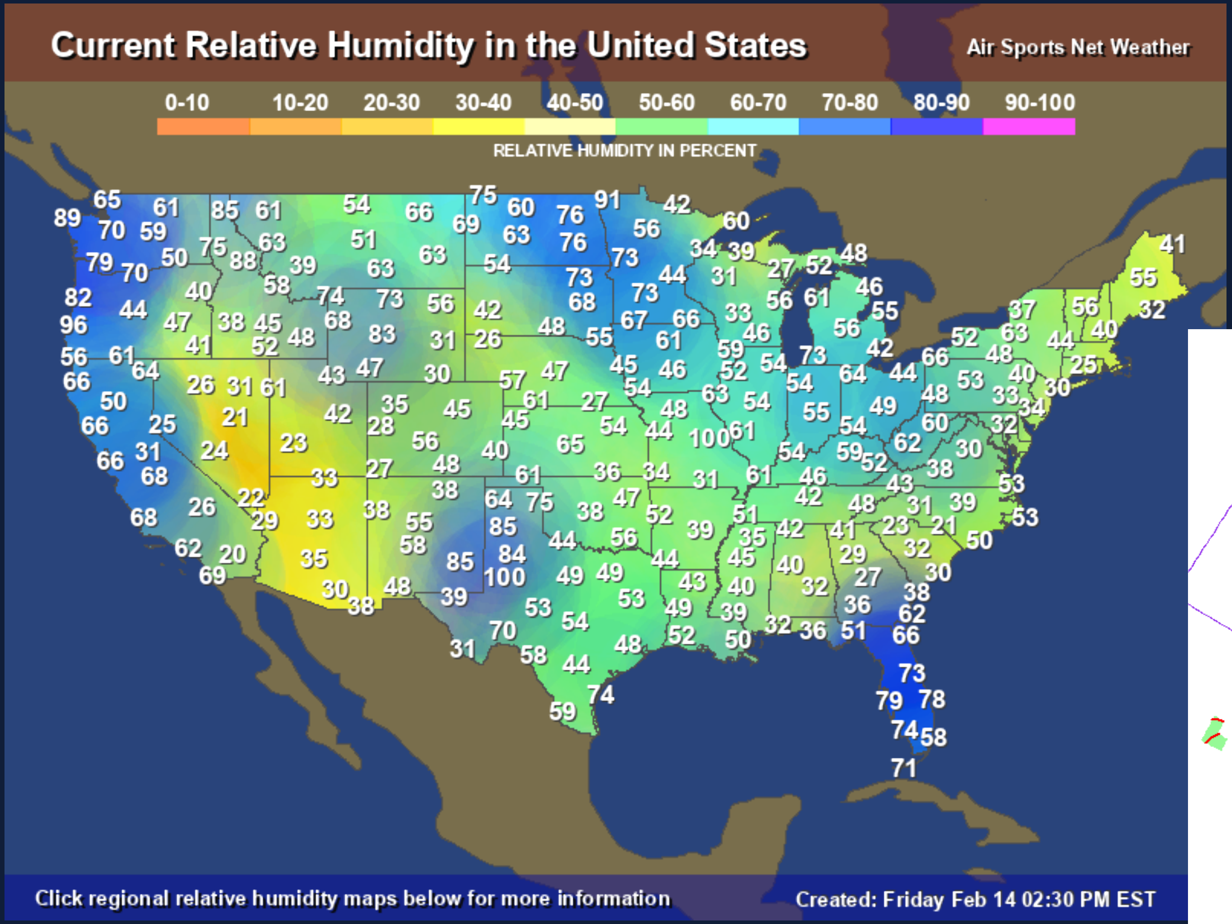


~ ***Relative humidity*** (***RH***) is used frequently by ***TV meteorologists*** to tell us ***how moist*** the air is, BUT this is ***<u>misleading</u>*** and ***<u>misunderstood</u>***!


Current Relative Humidity in the United States
Air Sports Net Weather
0-10
10-20
20-30
30-40
40-50
50-60
60-70
70-80
80-90
90-100
RELATIVE HUMIDITY IN PERCENT
Click regional relative humidity maps below for more information
Created: Friday Feb 14 02:30 PM EST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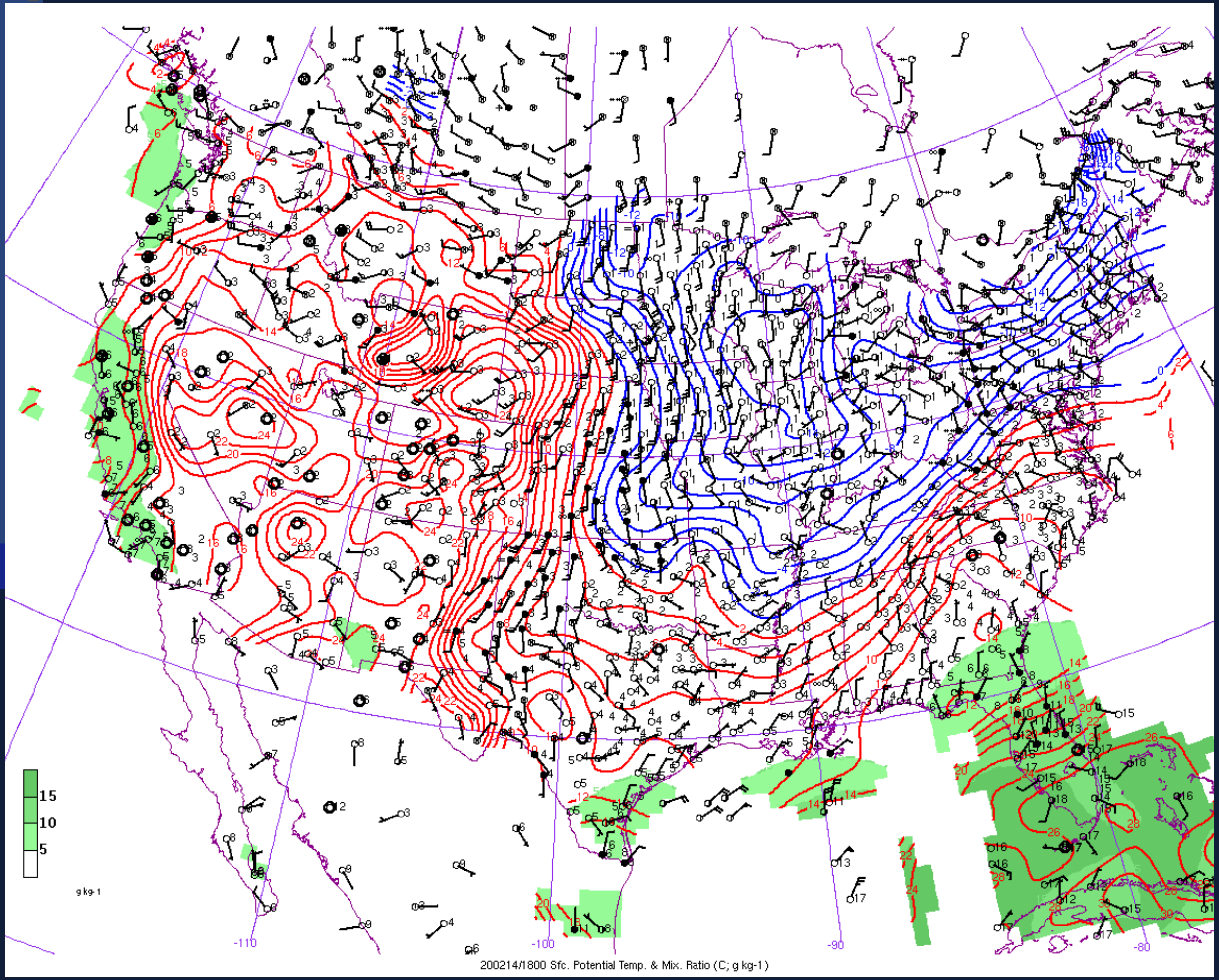
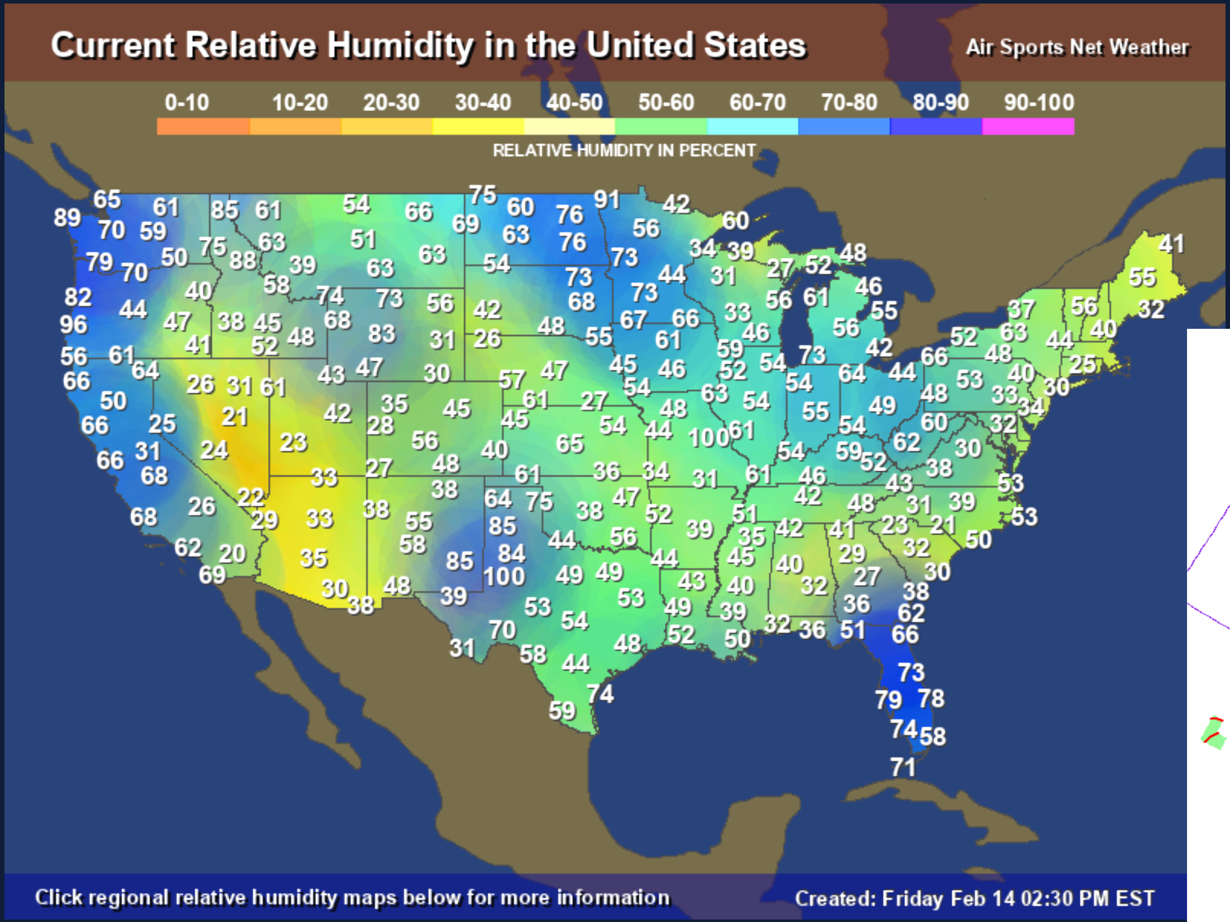

15
10
5
g kg-1
200214/1800 Sfc. Potential Temp. & Mix. Ratio (C; g kg-1)


Current Relative Humidity in the United States
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0-10 10-20 20-30 30-40 40-50 50-60 60-70 70-80 80-90 90-100
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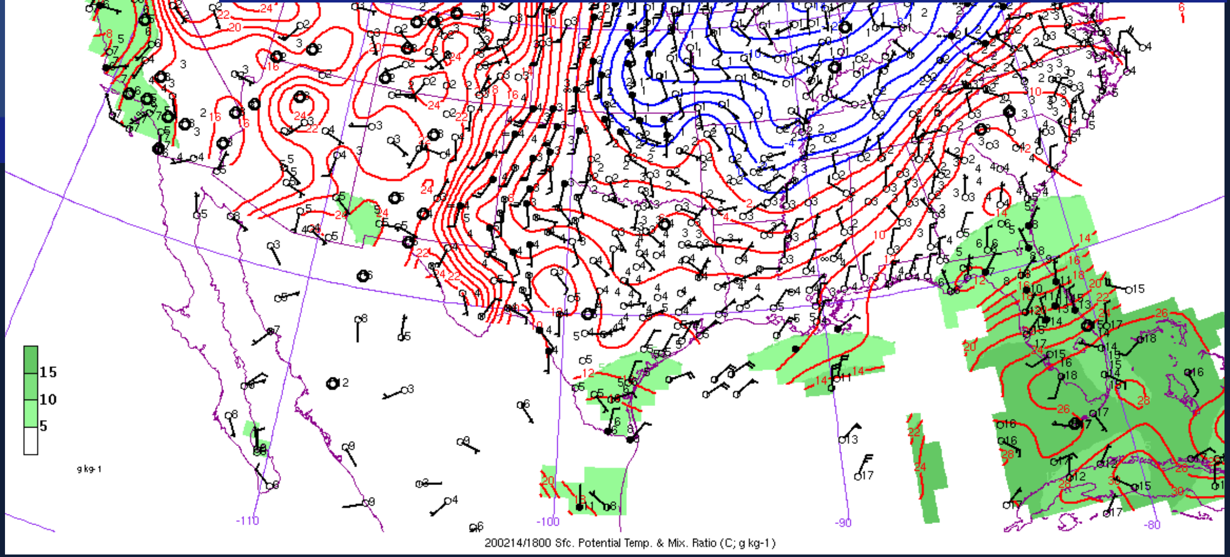
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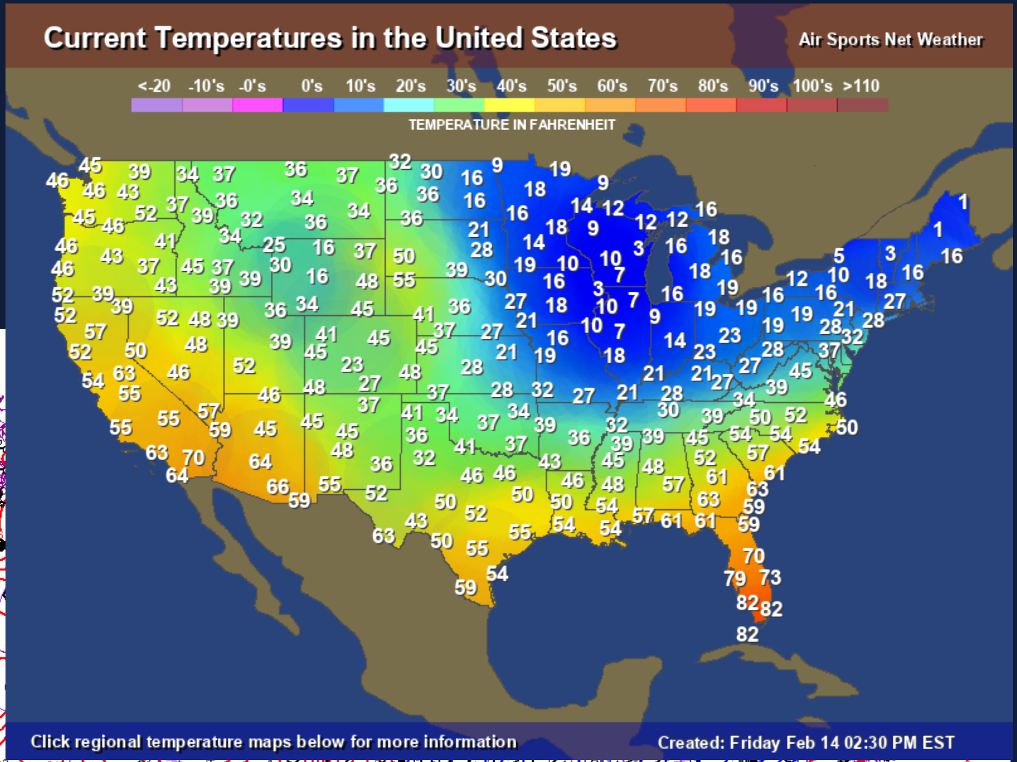
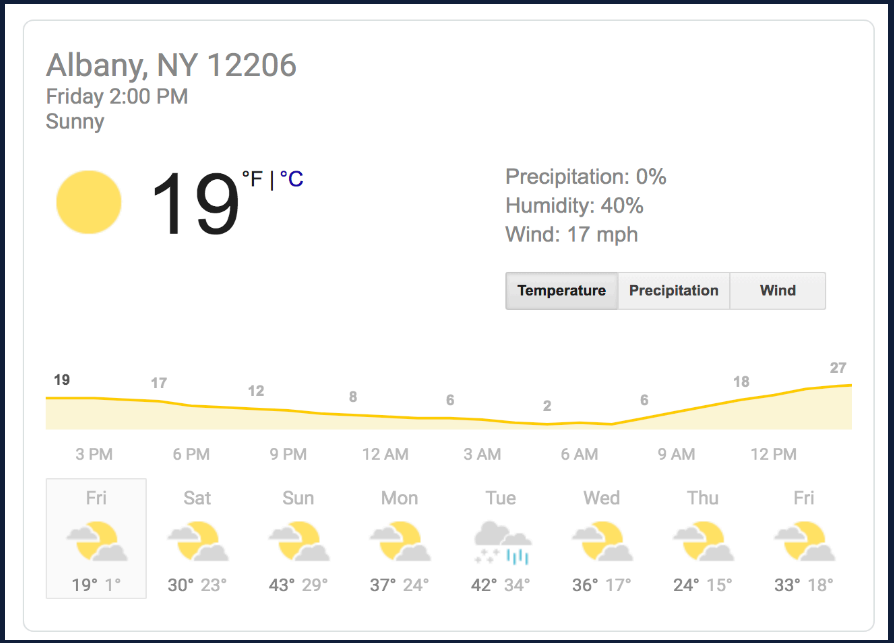

Current Temperatures in the United States
Air Sports Net Weather
<-20 -10's -0's 0's 10's 20's 30's 40's 50's 60's 70's 80's 90's 100's >110
TEMPERATURE IN FAHRENHEIT
Click regional temperature maps below for more information
Created: Friday Feb 14 02:30 PM EST



Albany, NY 12206
Friday 2:00 PM
Sunny
19 °F | °C
Precipitation: 0%
Humidity: 40%
Wind: 17 mph
Temperature
Precipitation
Wind
19
17
12
8
6
2
6
18
27
3 PM
6 PM
9 PM
12 AM
3 AM
6 AM
9 AM
12 PM
Fri
Sat
Sun
Mon
Tue
Wed
Thu
Fri
19° 1°
30° 23°
43° 29°
37° 24°
42° 34°
36° 17°
24° 15°
33° 18°

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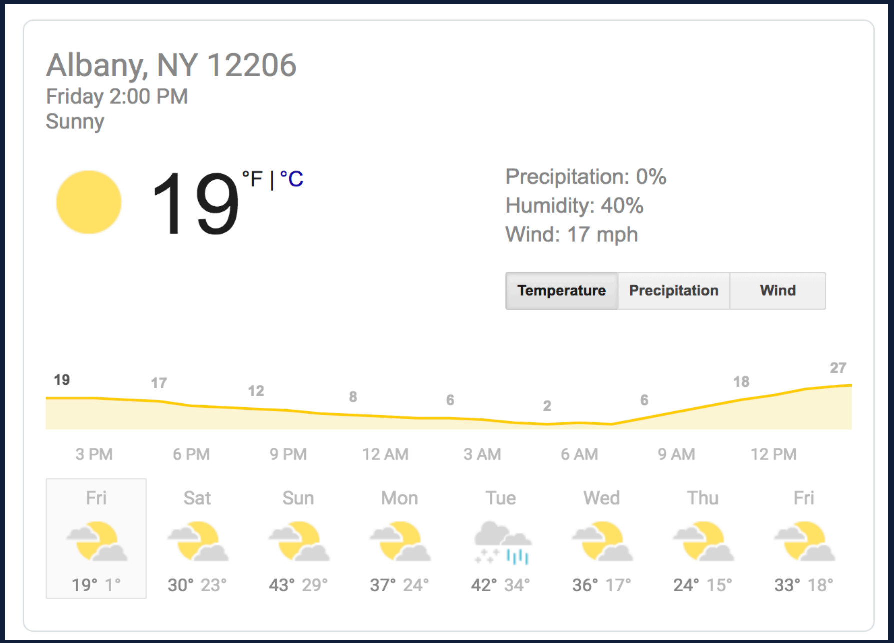

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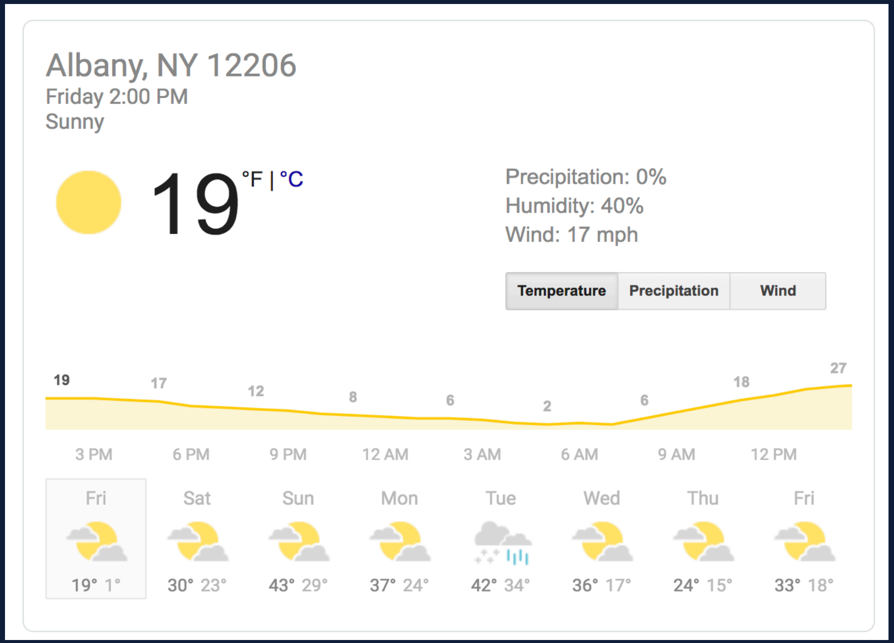

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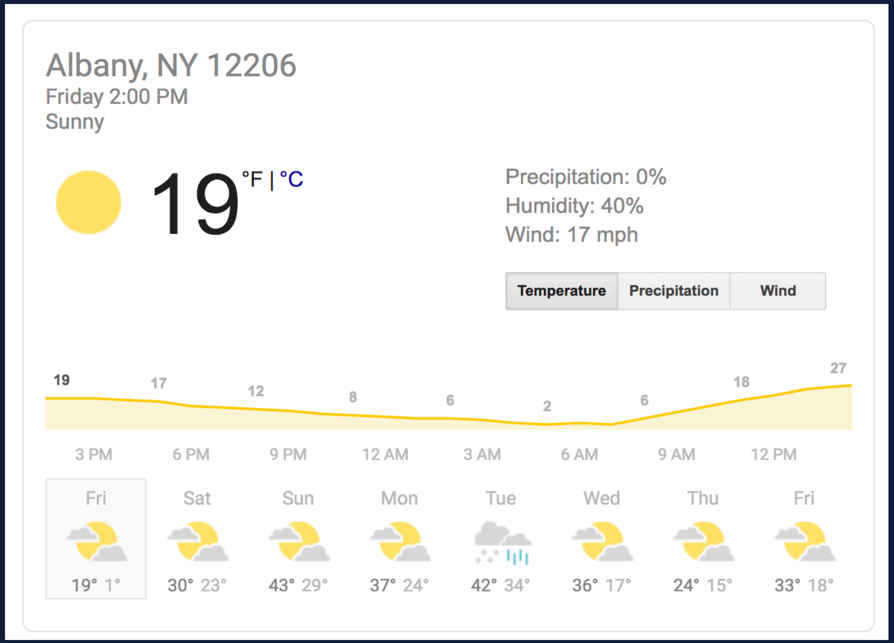

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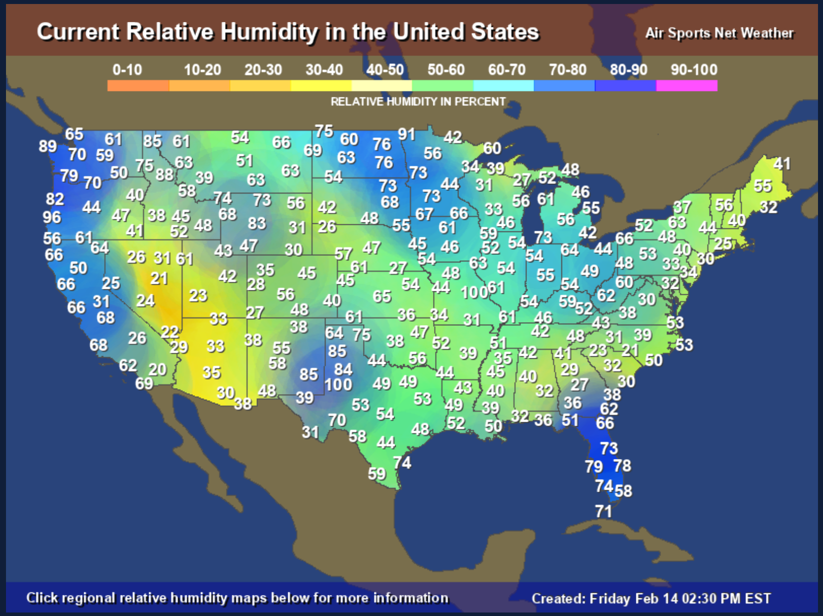

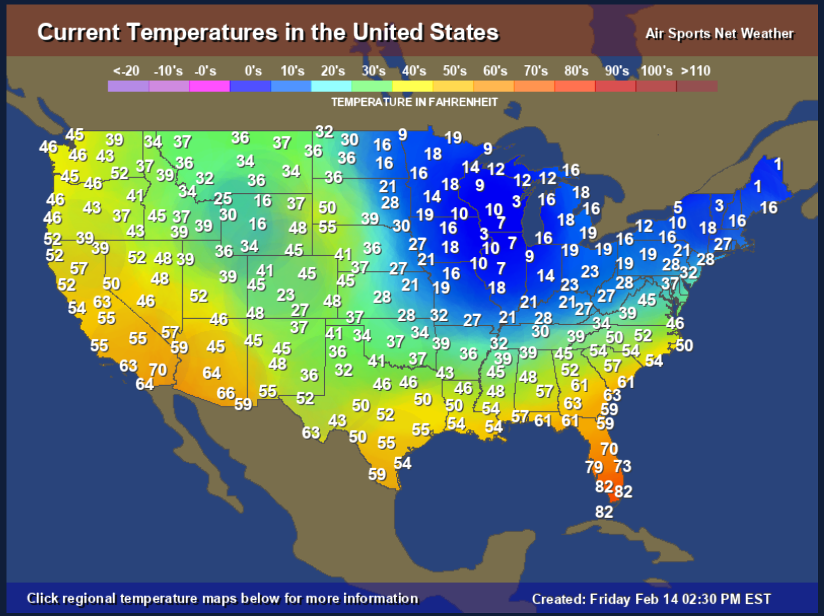

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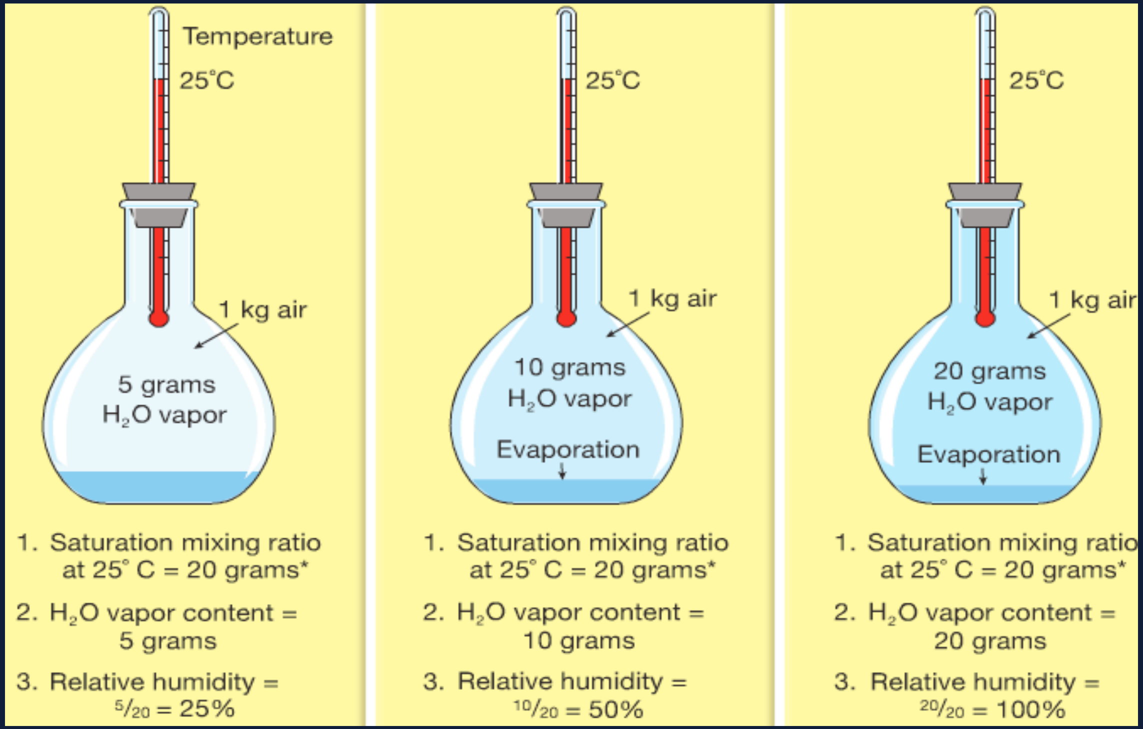

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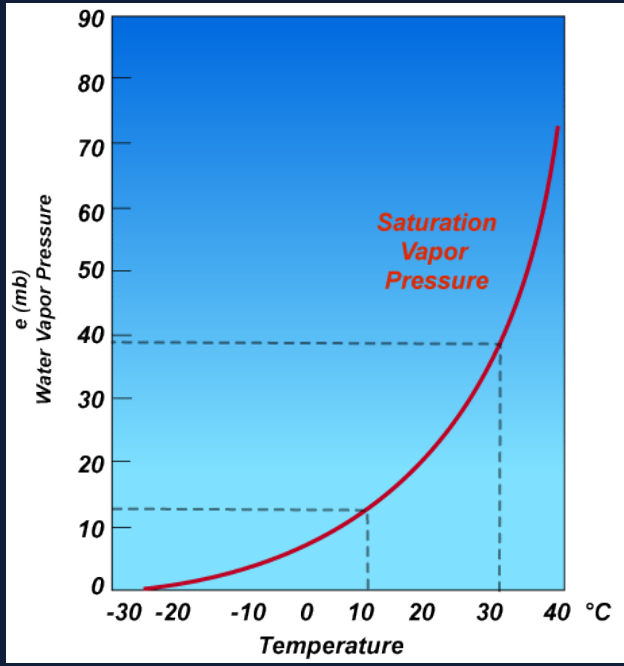
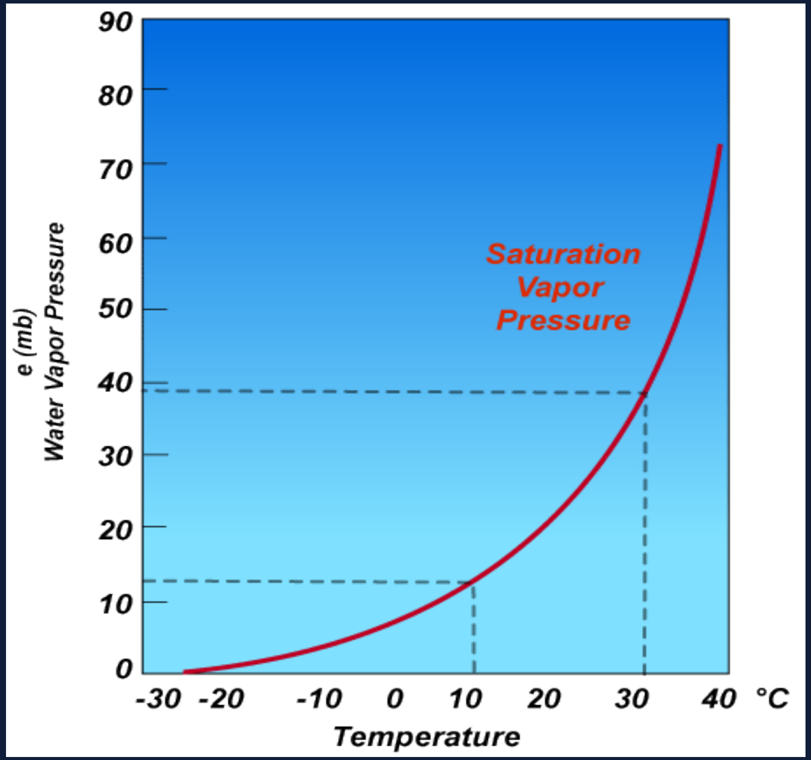
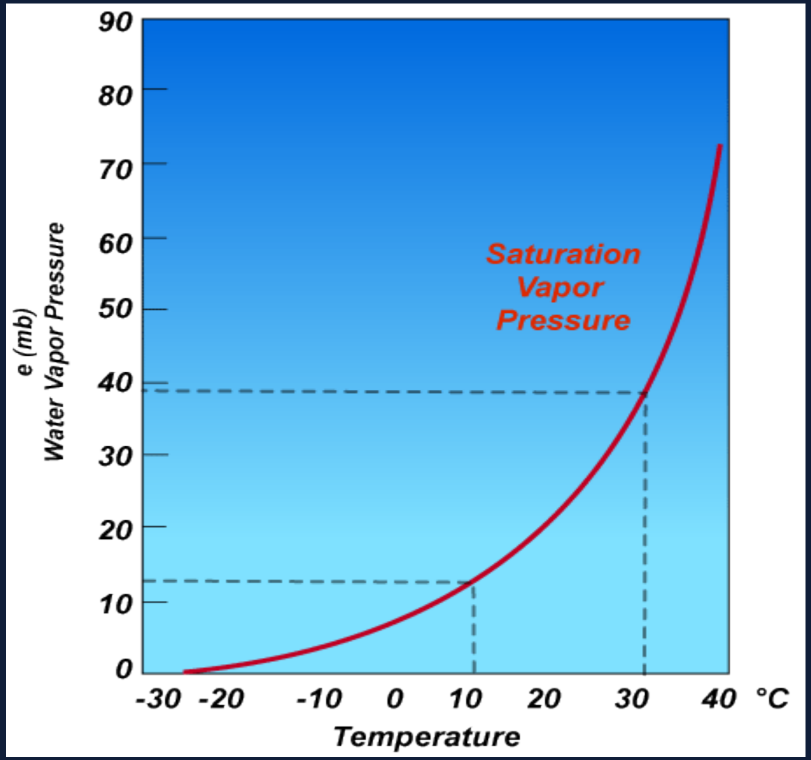




90
80
70
60
50
40
30
20
10
0
e (mb)
Water Vapor Pressure
Saturation Vapor Pressure
-30 -20 -10 0 10 20 30 40 °C
Temperature

~ As ***temperature decreases***, so does the ***amount*** of water ***vapor required to saturate*** the air.



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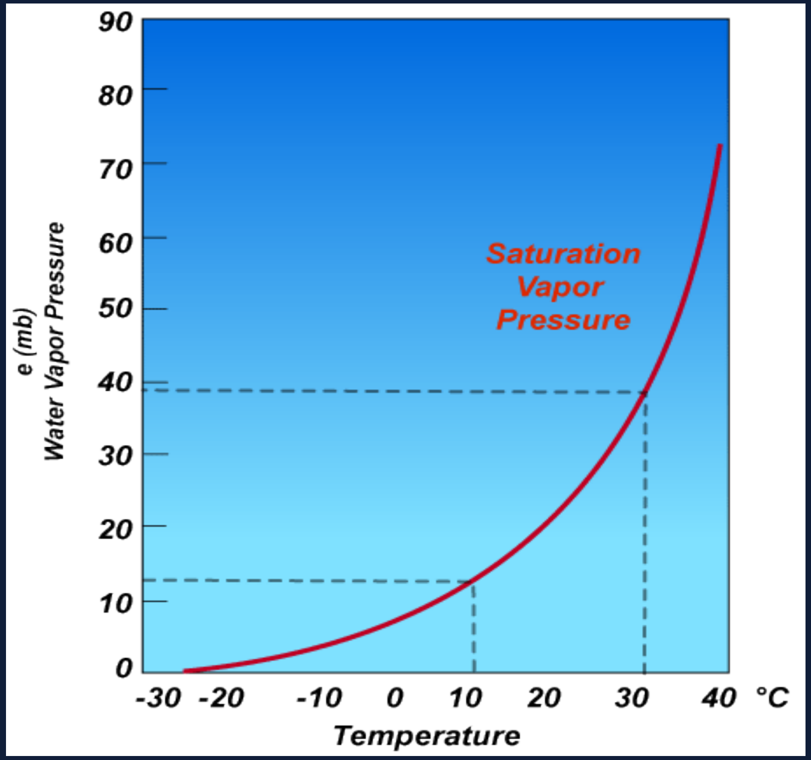

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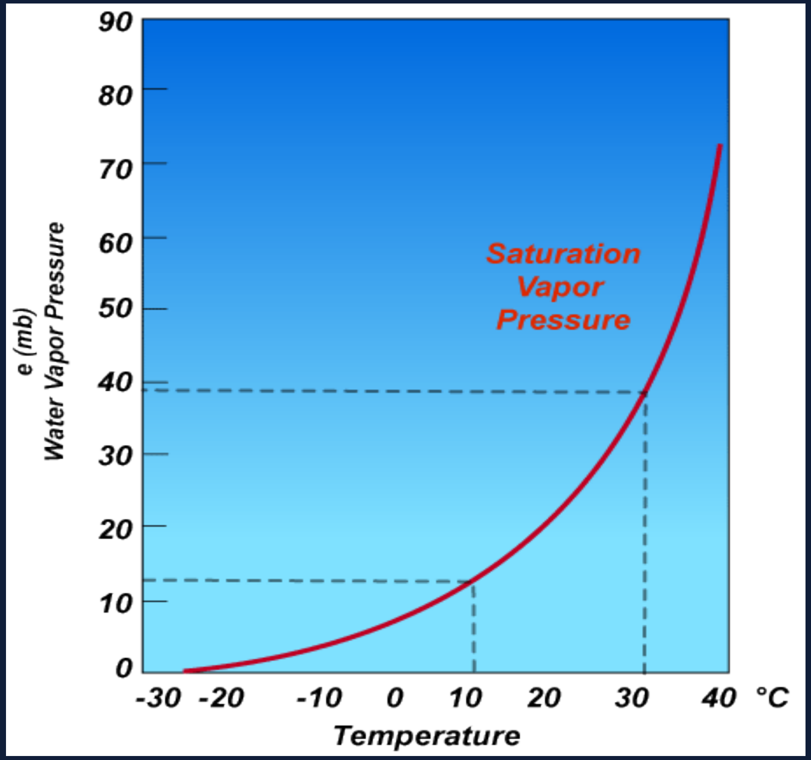

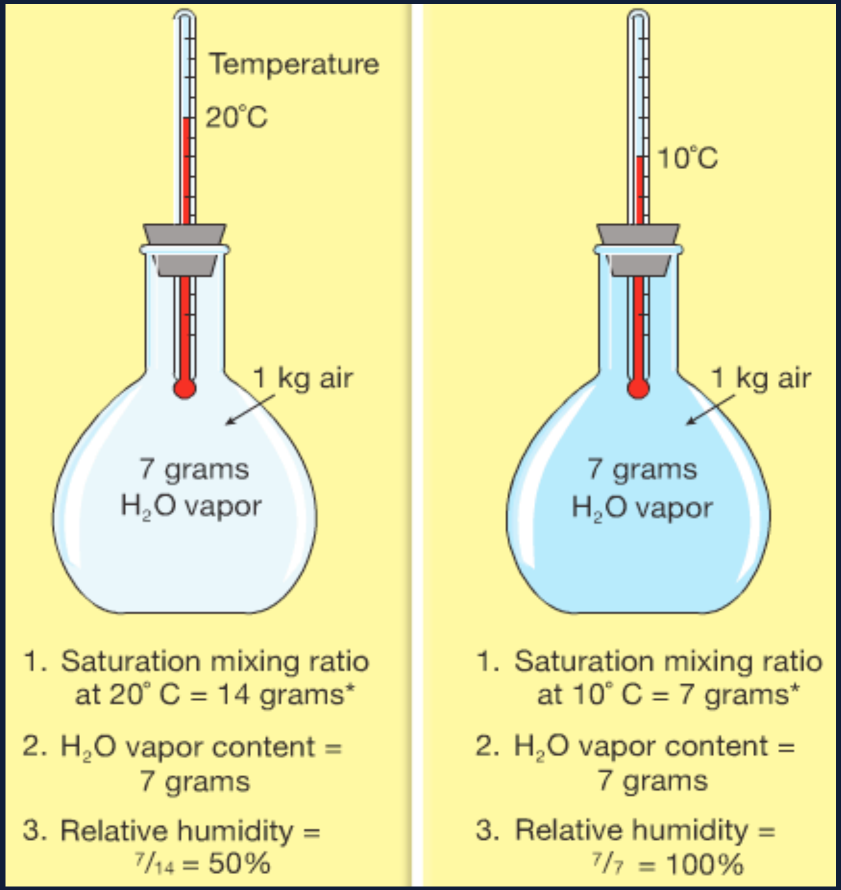

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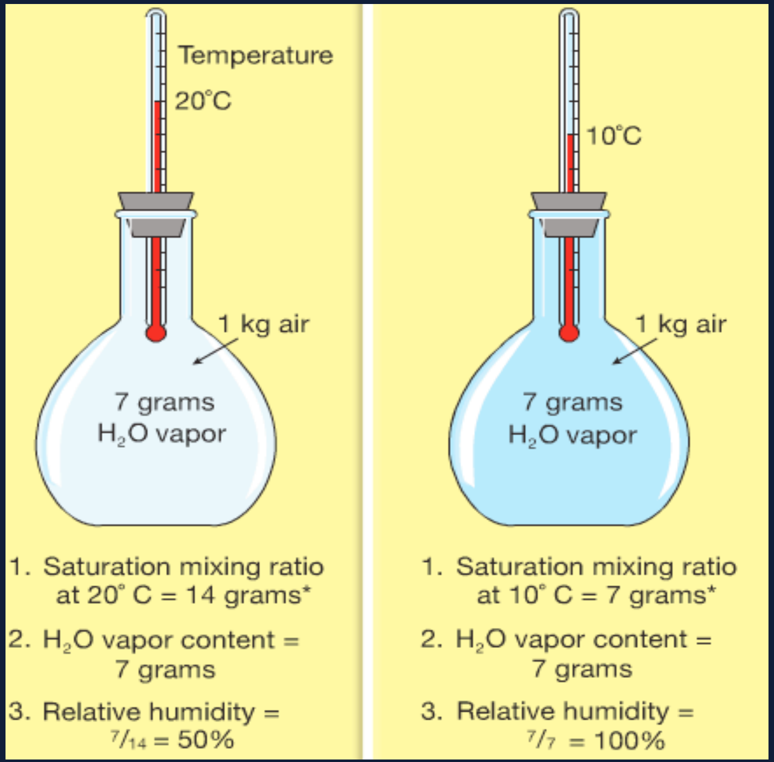

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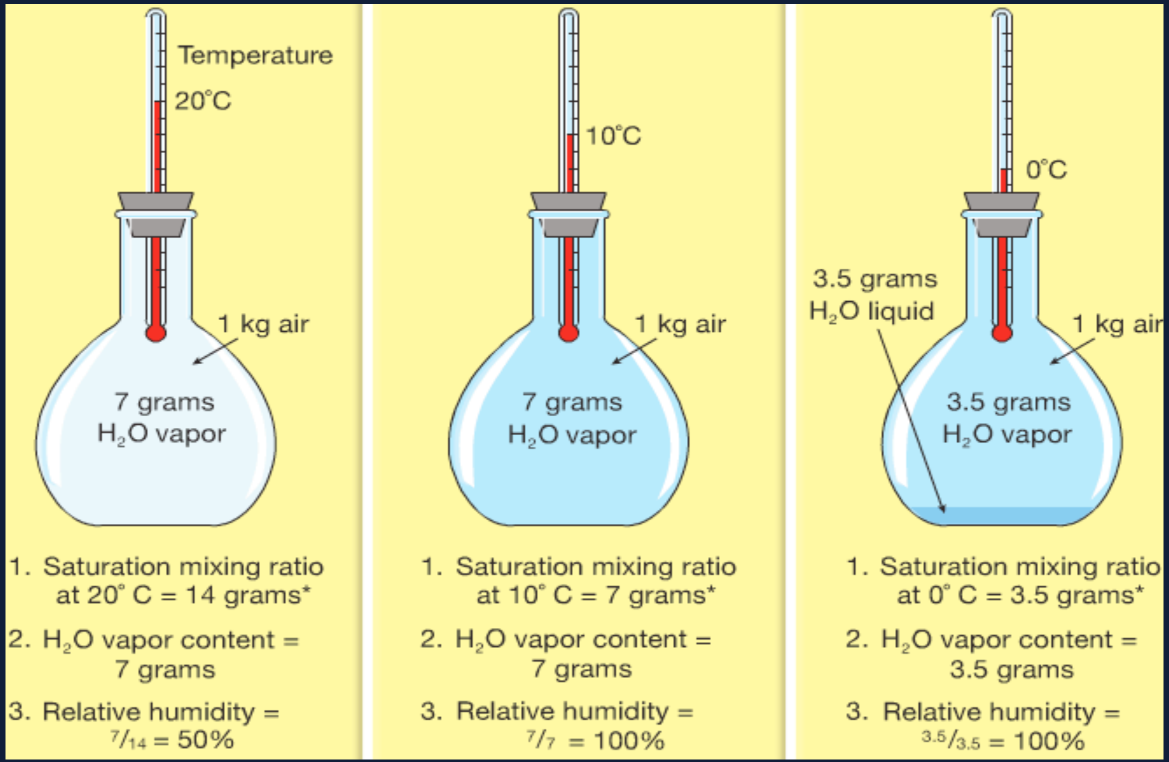

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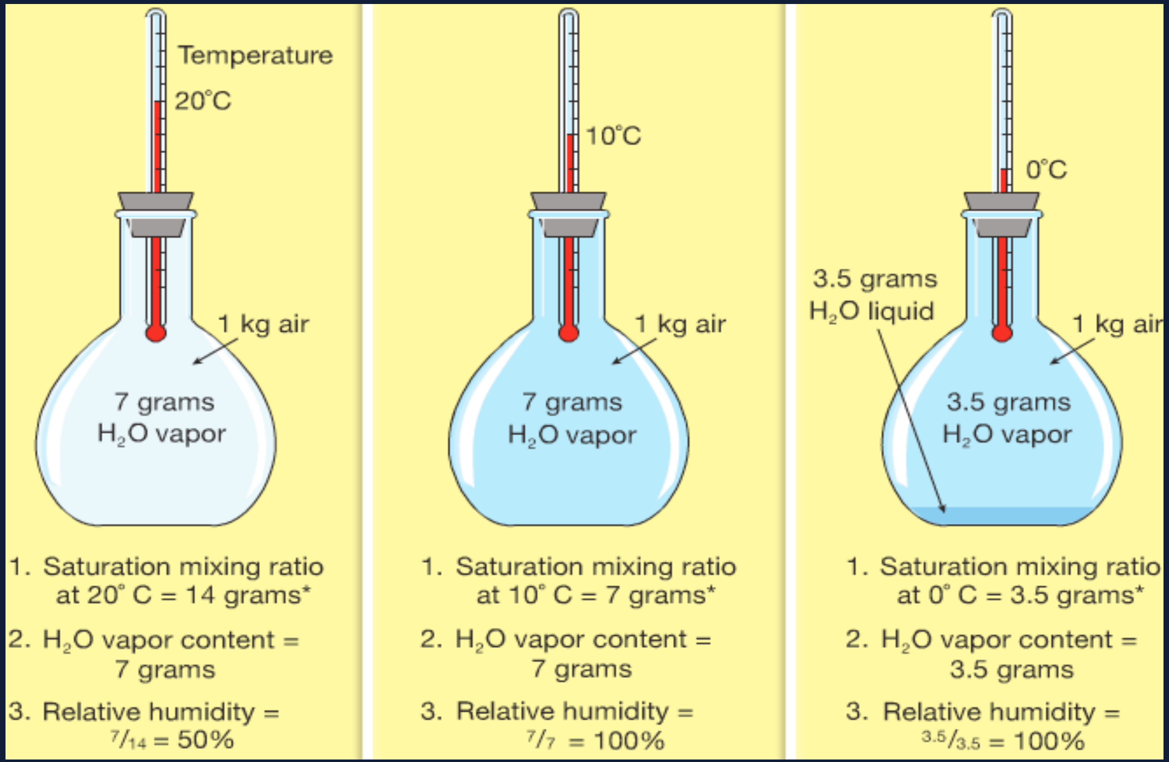

~ The air will be ***supersaturated*** (***RH > 100%***) and ***vapor*** will ***condense out***, in an ***amount equal*** to that needed to ***return*** the system to ***100% RH***.

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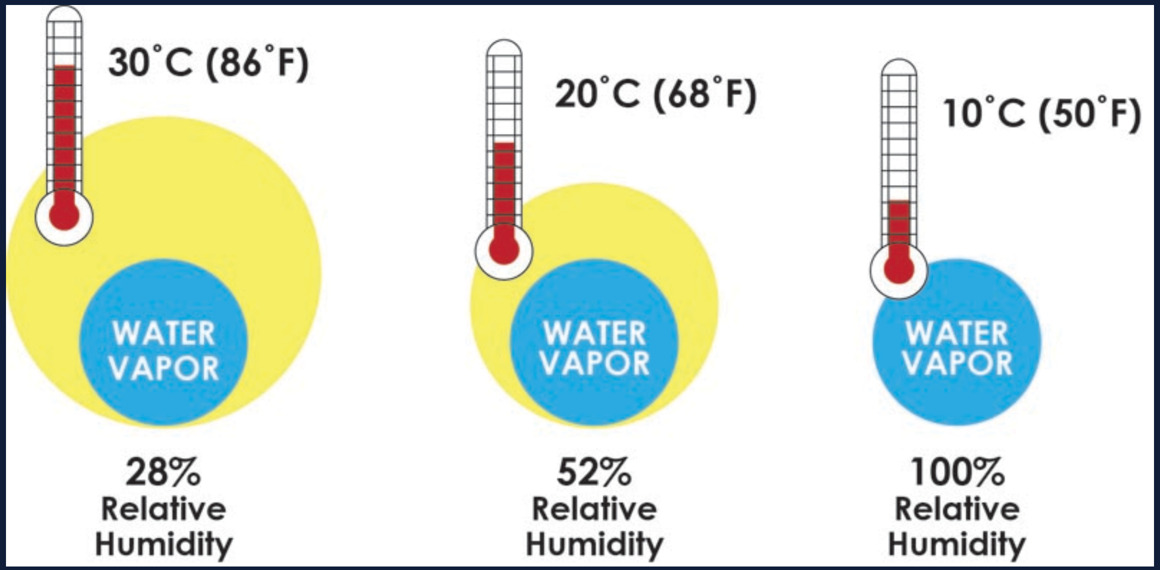

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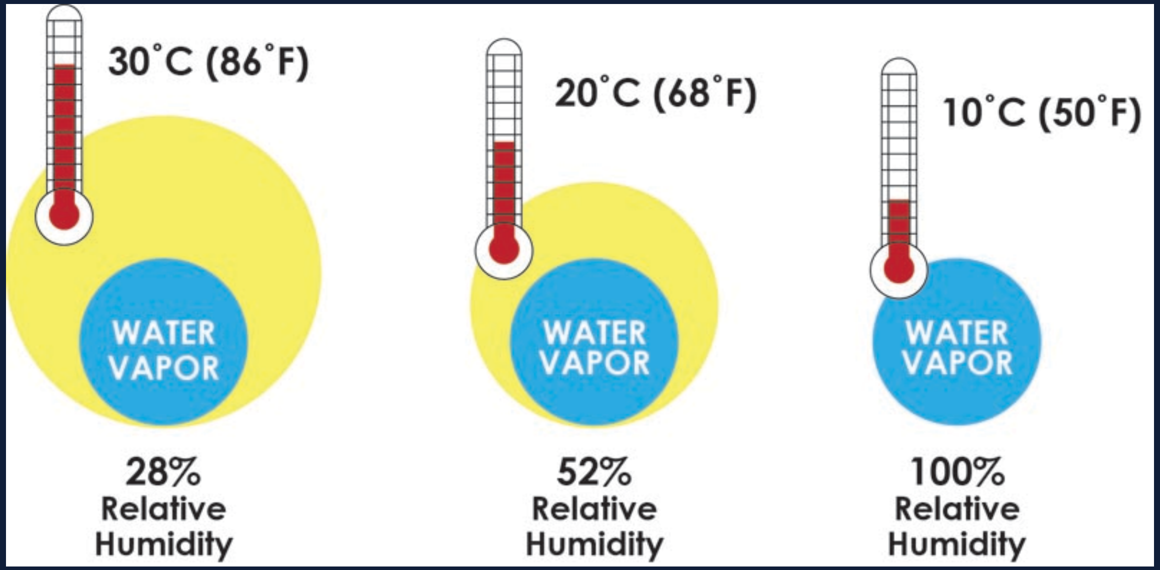

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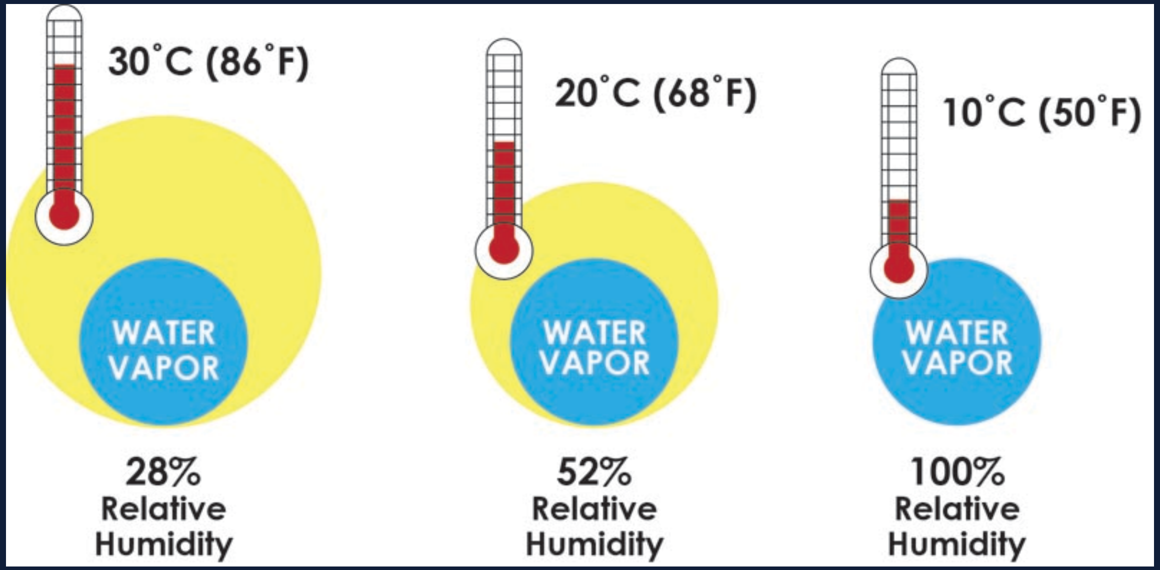

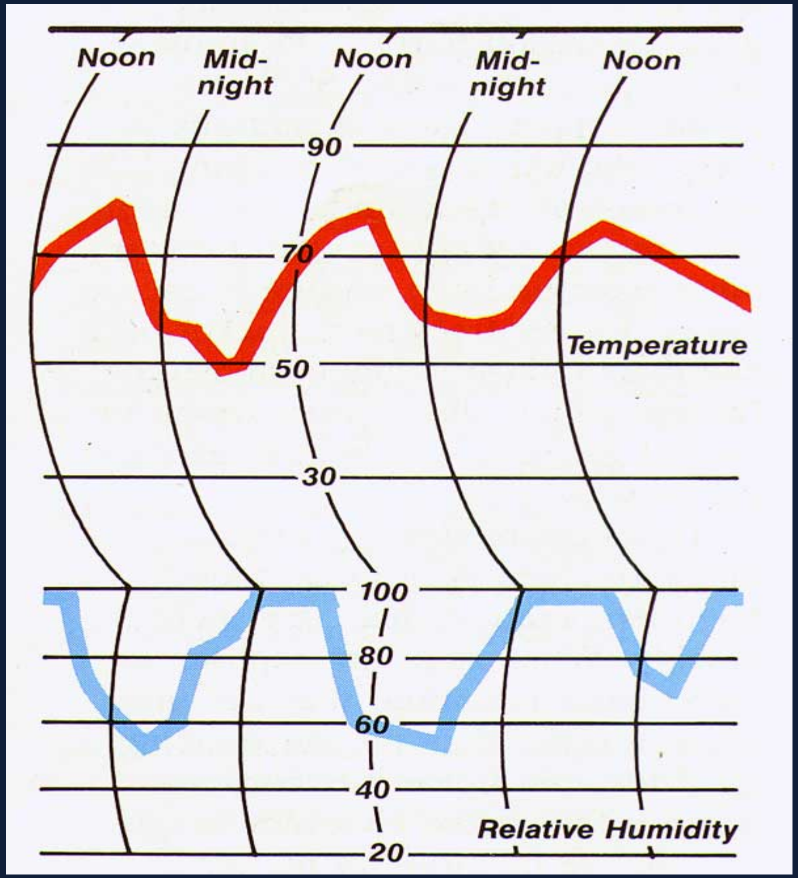

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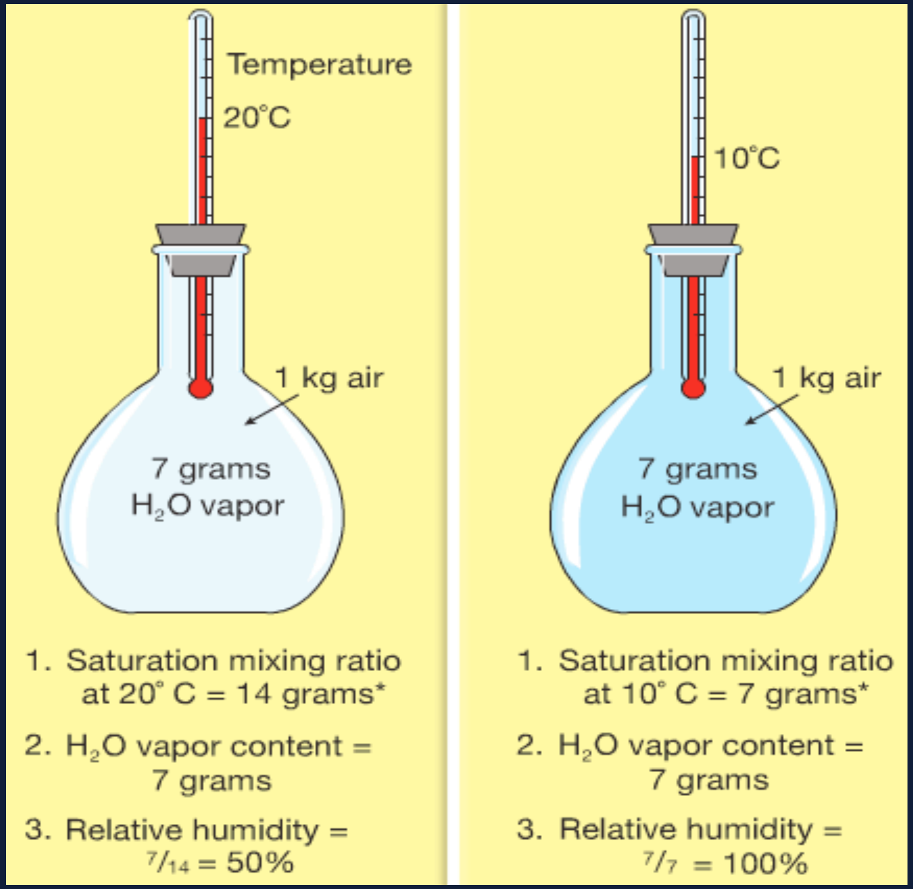

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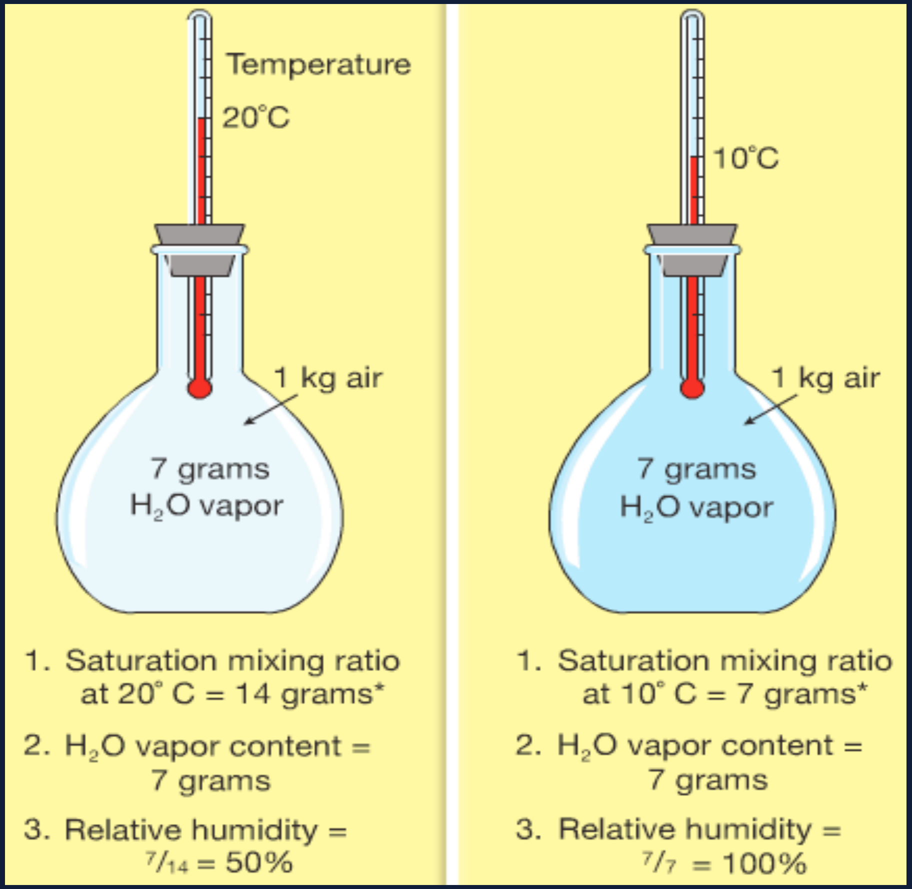

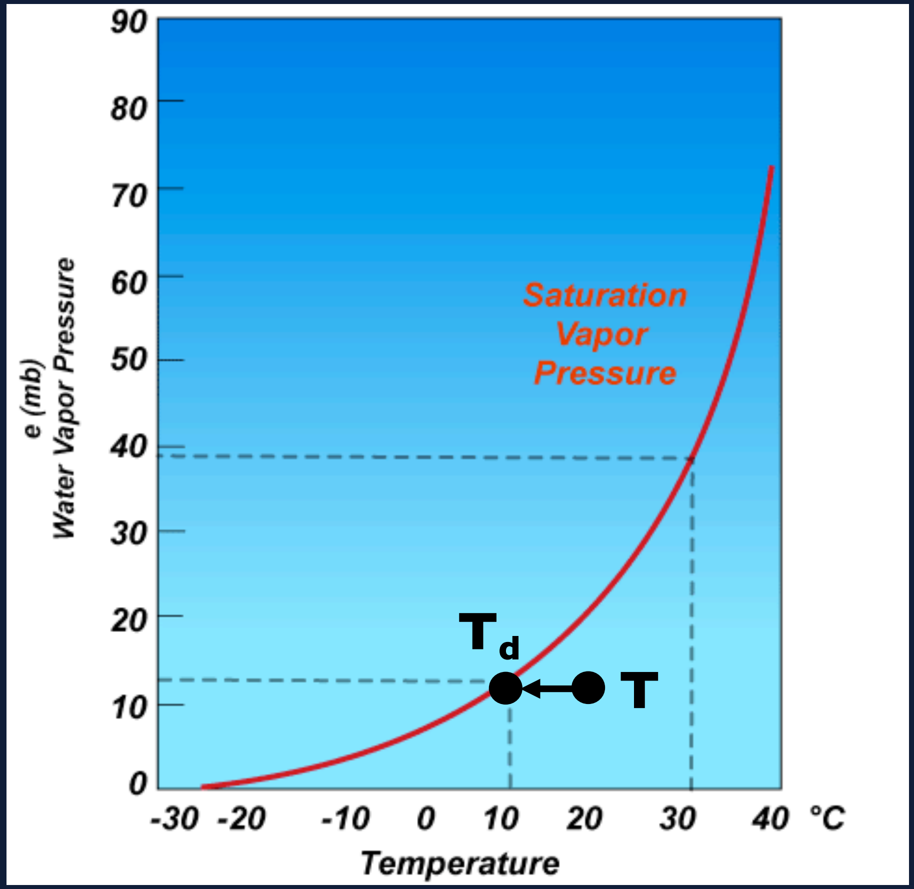

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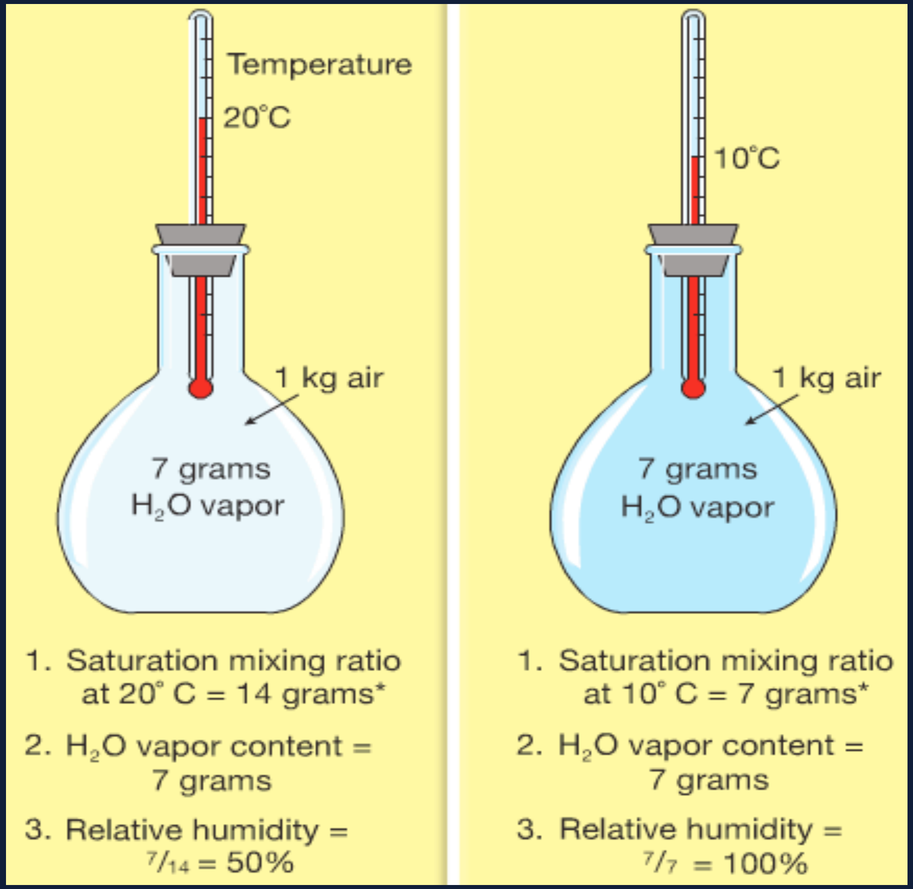
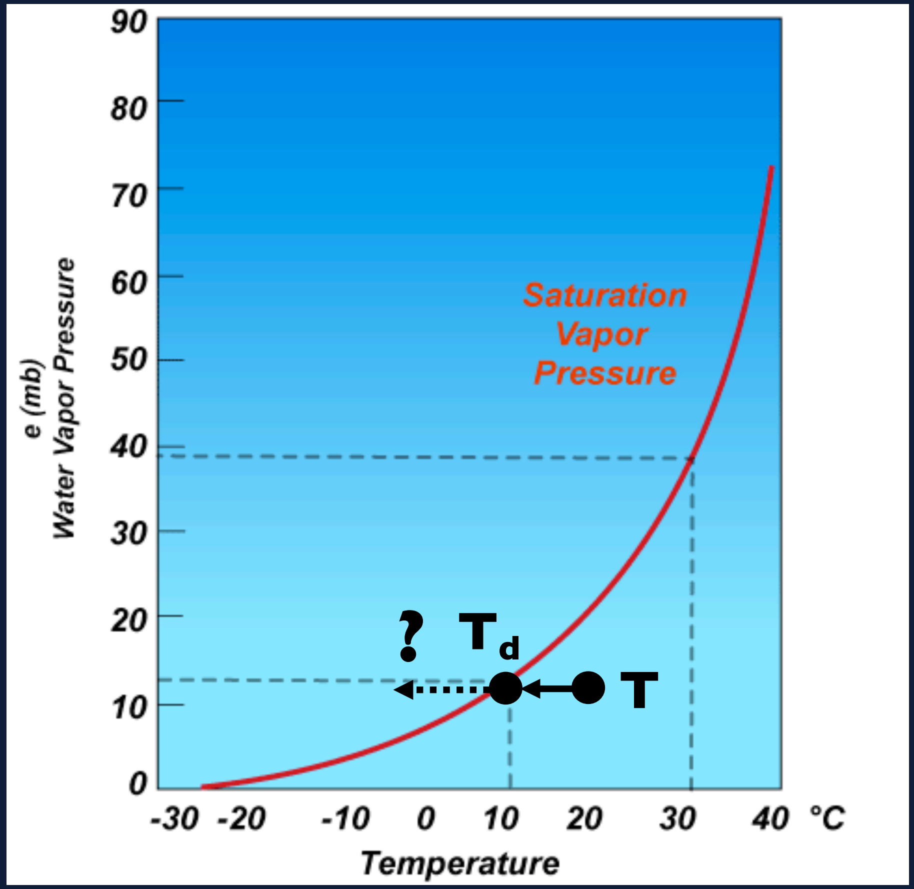
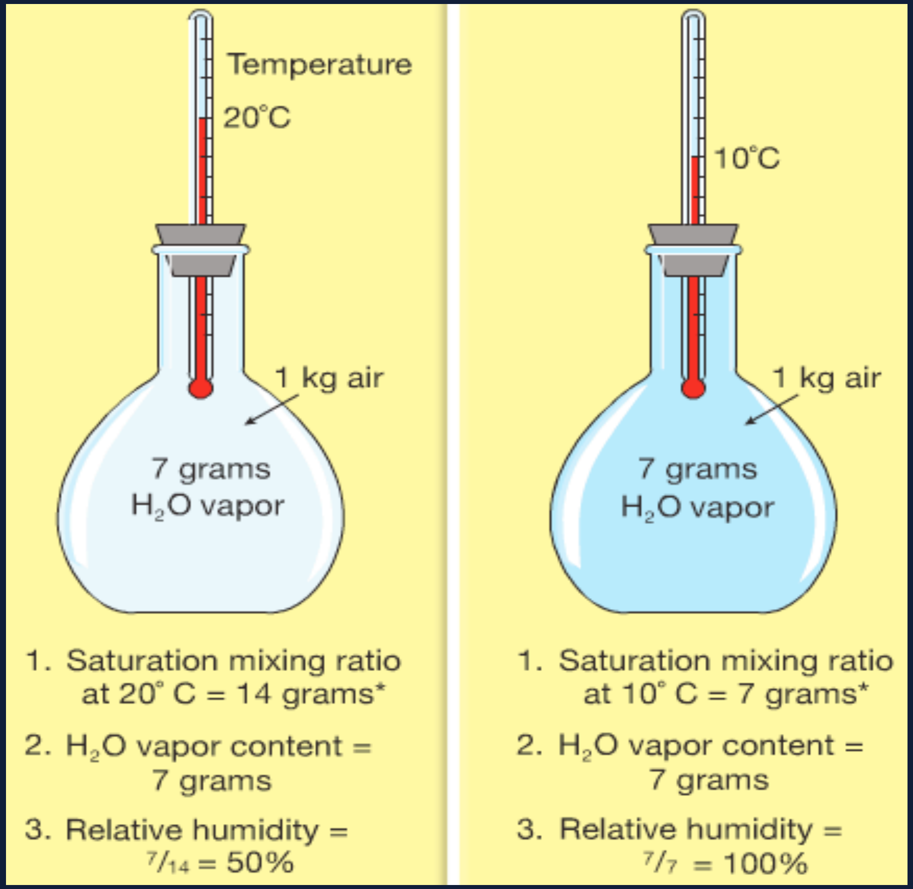
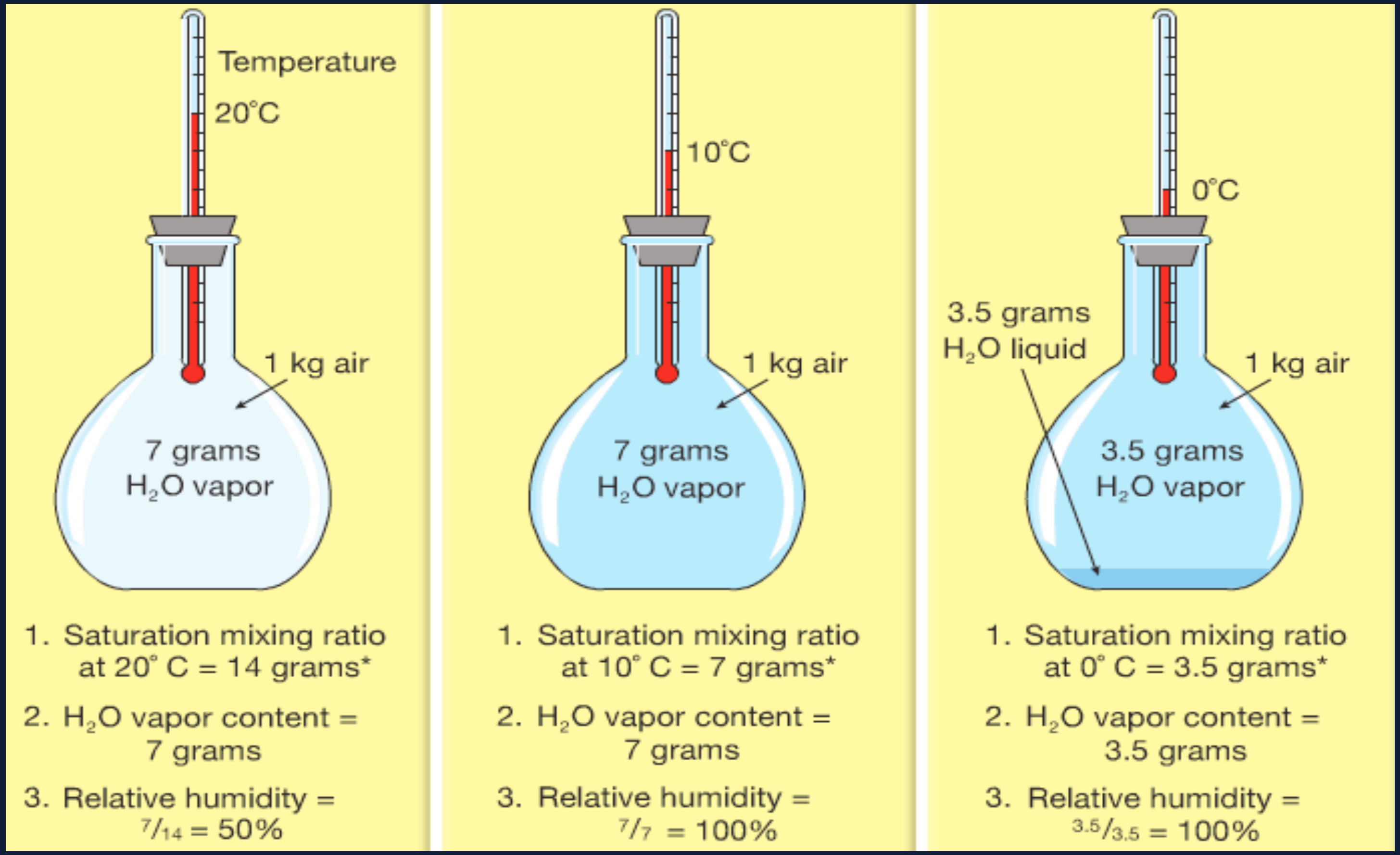


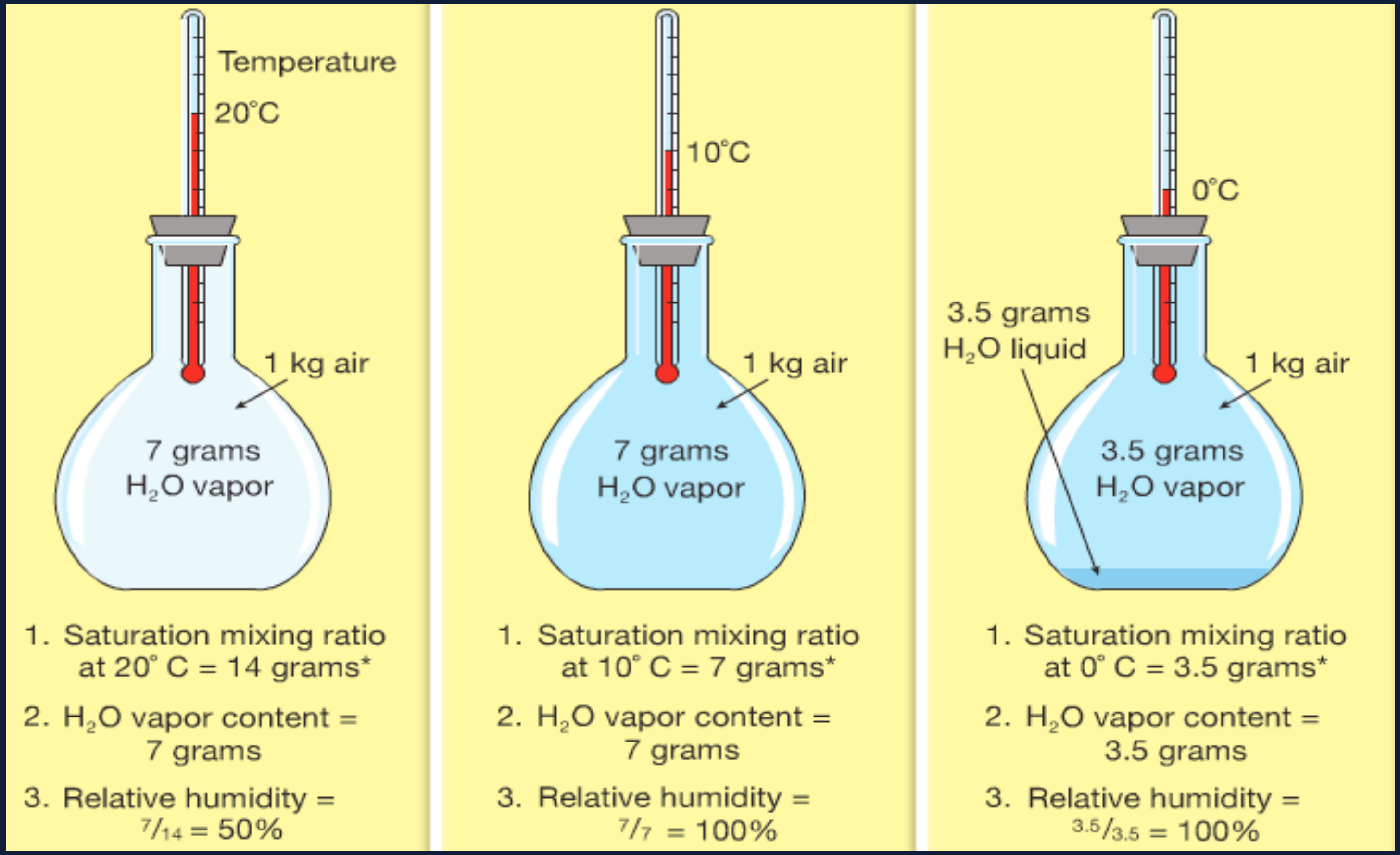




Temperature
20°C
1 kg air
7 grams
H_2O vapor
1. Saturation mixing ratio at 20° C = 14 grams*
2. H_2O vapor content = 7 grams
3. Relative humidity = $^{7}/_{14}$ = 50%
10°C
1 kg air
7 grams
H_2O vapor
1. Saturation mixing ratio at 10° C = 7 grams*
2. H_2O vapor content = 7 grams
3. Relative humidity = $^{7}/_{7}$ = 100%


Temperature
20°C
1 kg air
7 grams
H₂O vapor
1. Saturation mixing ratio at 20° C = 14 grams*
2. H₂O vapor content = 7 grams
3. Relative humidity = 7/14 = 50%
10°C
1 kg air
7 grams
H₂O vapor
1. Saturation mixing ratio at 10° C = 7 grams*
2. H₂O vapor content = 7 grams
3. Relative humidity = 7/7 = 100%
0°C
3.5 grams
H₂O liquid
1 kg air
3.5 grams
H₂O vapor
1. Saturation mixing ratio at 0° C = 3.5 grams*
2. H₂O vapor content = 3.5 grams
3. Relative humidity = 3.5/3.5 = 100%

~ ***Cooling past*** the point of ***saturation*** will cause ***supersaturation*** and ***condensation*** in the form of ***clouds***, ***fog***, or ***dew*** (thus, the name dew point!).



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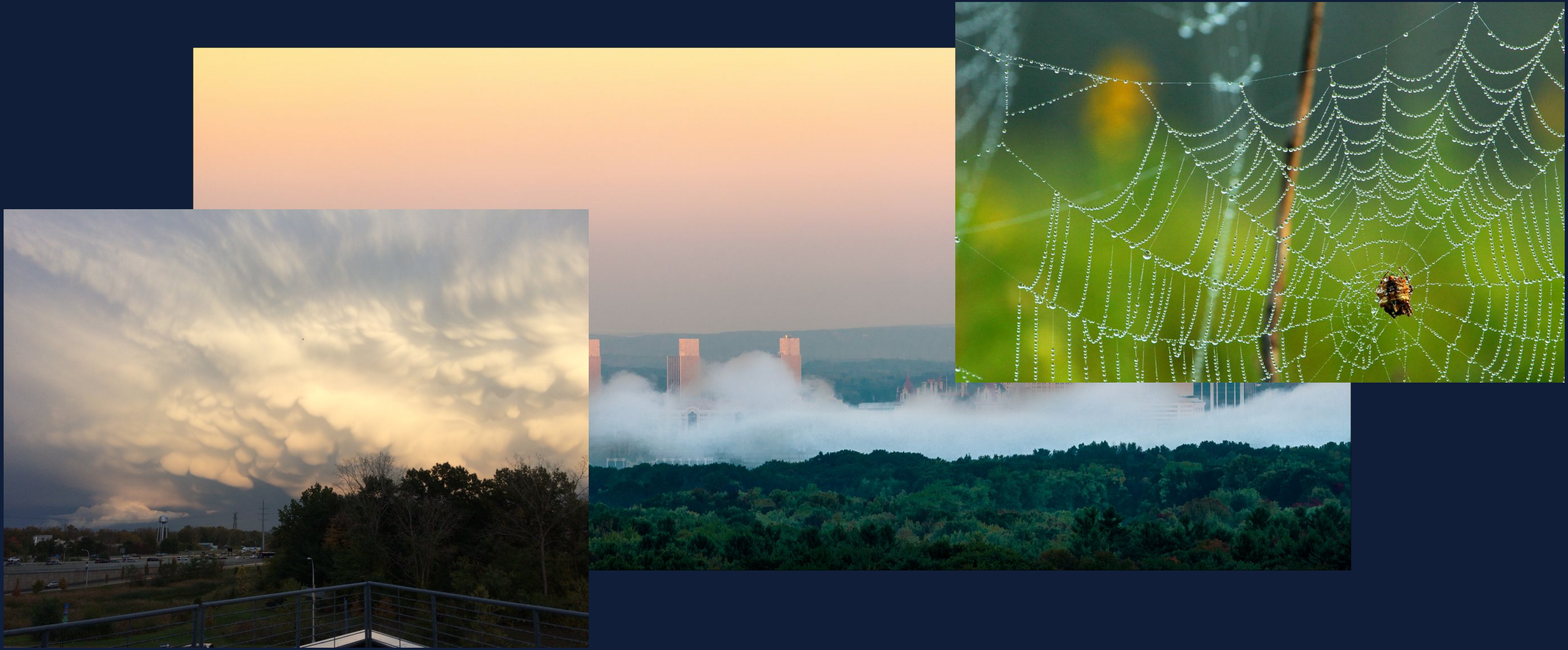

~ The ***difference*** between the ***temperature*** and ***dew point*** tells us ***how close*** the air is to being ***saturated.***

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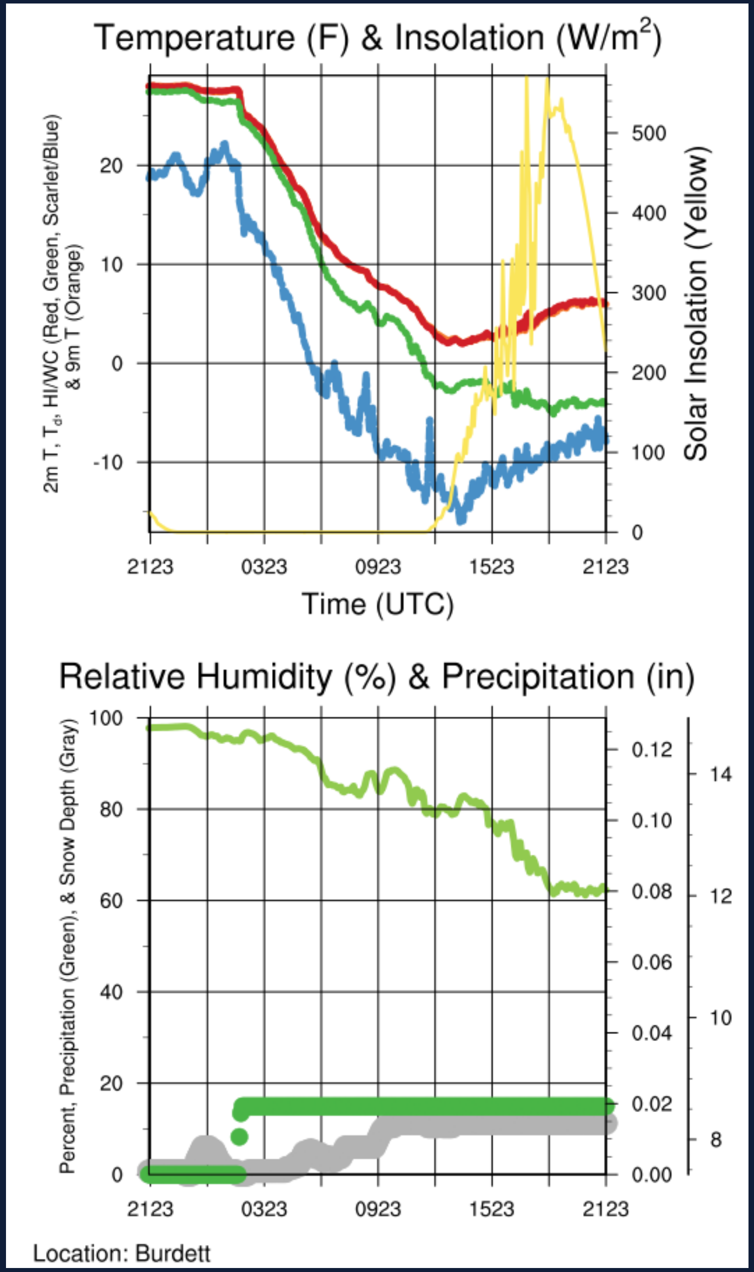
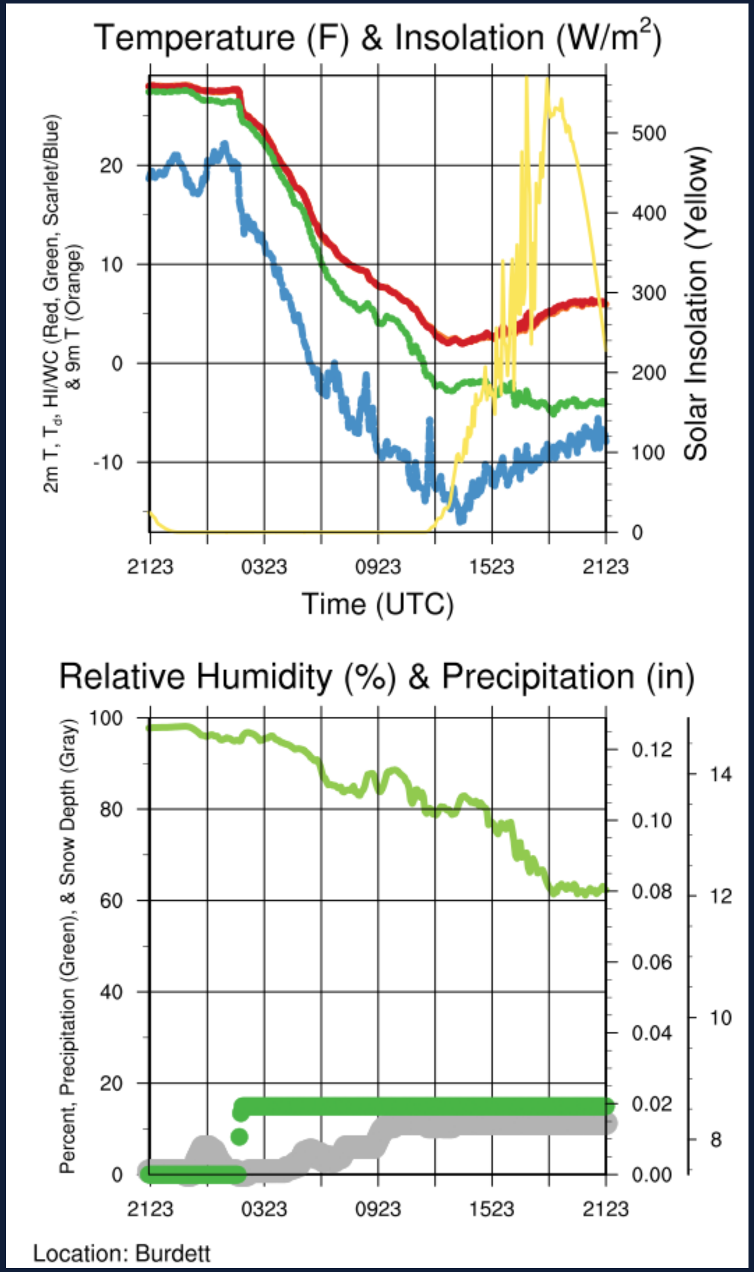


~ The ***difference*** between the ***temperature*** and ***dew point*** tells us ***how close*** the air is to being ***saturated.***

~ Since the ***dew point*** is a ***measure*** of the ***amount of vapor*** in the air, it is the ***quantity*** the ***TV folks should*** be using to ***express*** how ***humid*** the air is!



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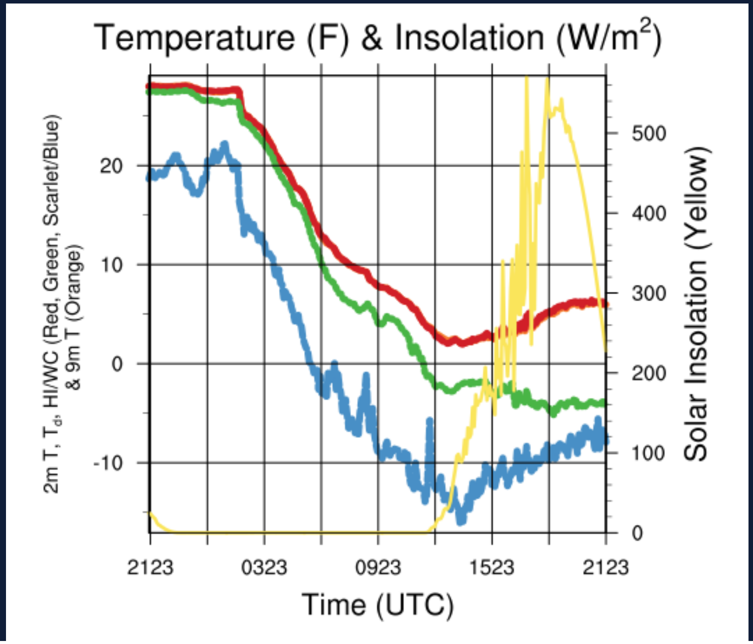

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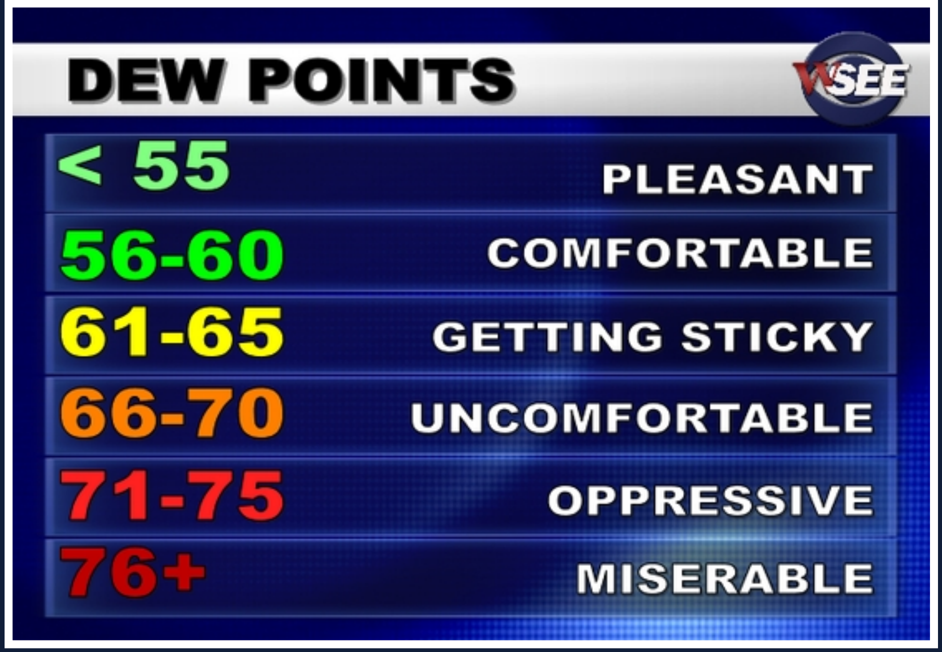
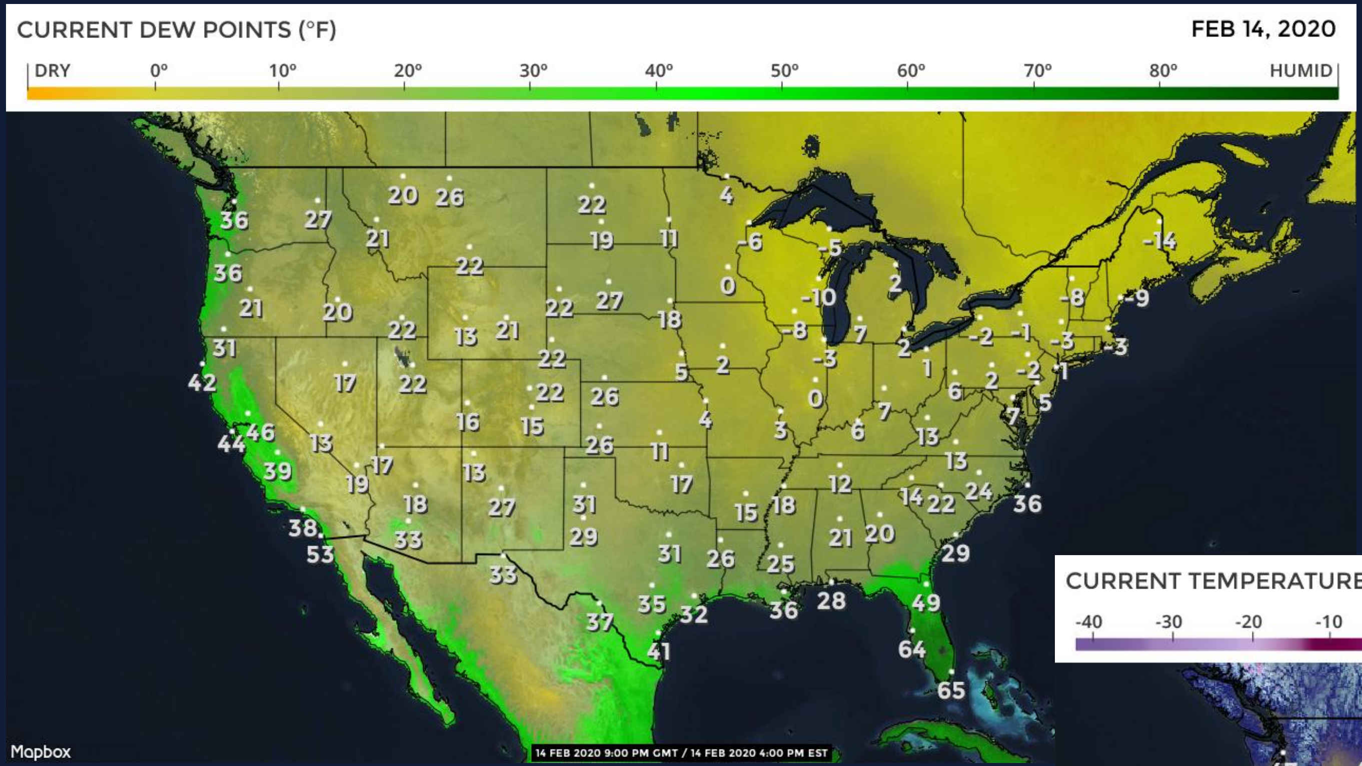
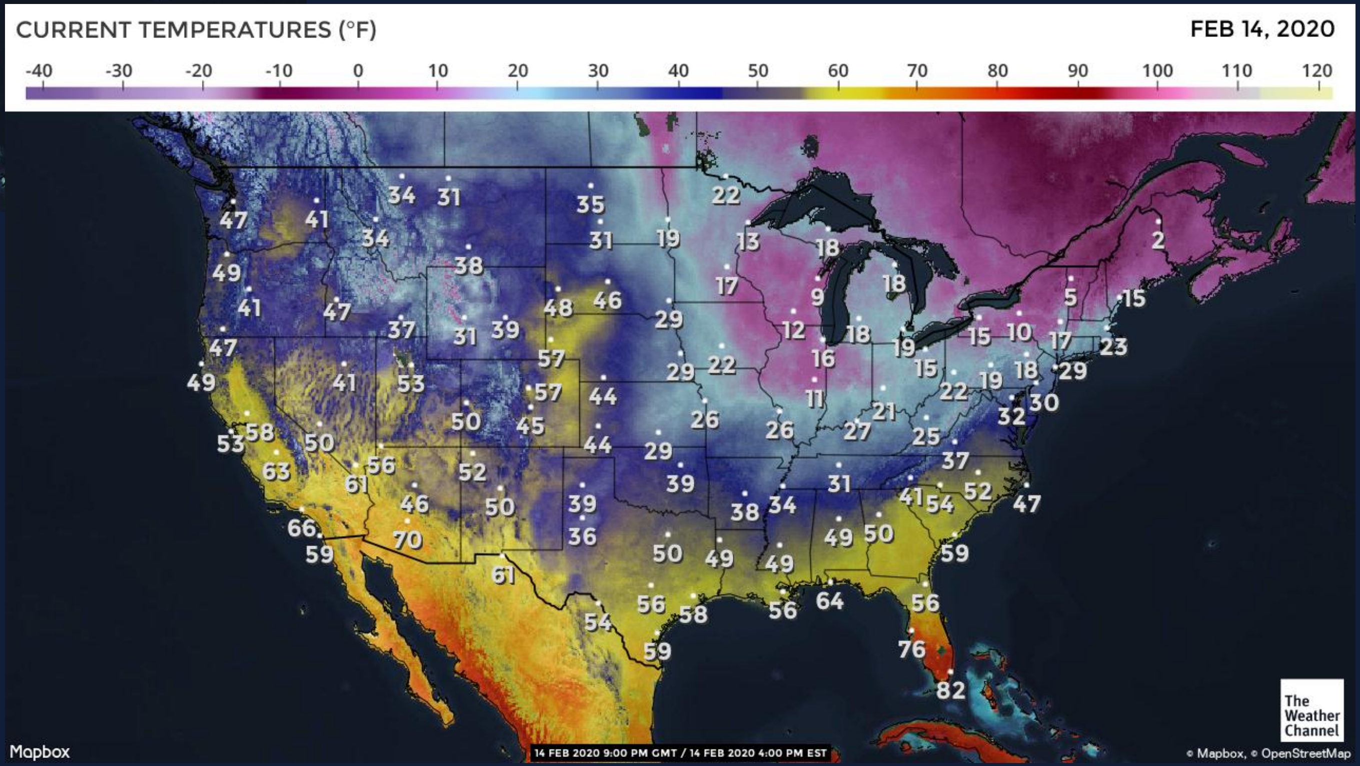



CURRENT DEW POINTS (°F)
FEB 14, 2020
DRY
0°
10°
20°
30°
40°
50°
60°
70°
80°
HUMID
Mapbox
14 FEB 2020 9:00 PM GMT / 14 FEB 2020 4:00 PM EST


CURRENT TEMPERATURES (°F)
FEB 14, 2020
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
Mapbox
14 FEB 2020 9:00 PM GMT / 14 FEB 2020 4:00 PM EST
The Weather Channel
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