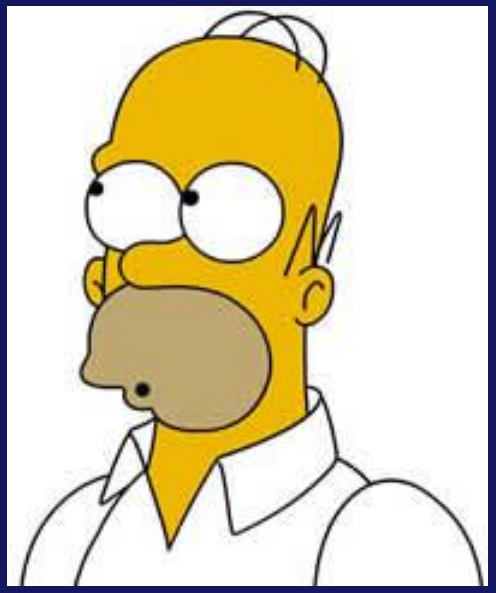
Ready for some more SCIENCE Homer?



(Homer gives his brain a pep talk)

REVIEW:
THE TWO LAWS OF THERMODYNAMICS

#1 First Law

(2 simple ways of understanding it)

- Energy can be transformed (changed from one form to another), but the total amount always remains the same.

  (same as the "Law of Conservation of Energy")

- HEAT added = increase in THERMAL ENERGY
  + external WORK DONE

#2 Second Law

(3 things to remember)

- Thermal energy flows spontaneously ONLY from a higher temperature object to a lower-temperature object (and not the other way).

- Thermal energy input to do the work must also have thermal energy output (exhaust) hence heat engines are never 100% efficient.

- There is an irreversibility about any process that creates thermal energy. Energy of all kinds in our material world disperses or dissipates if it is not hindered from doing so!

(concept of "Increasing Entropy")

MORE ABOUT THERMAL ENERGY:

First, some background is needed . . . . .

- Unit of Measure of Thermal Energy
  (i.e., the joule or calorie)
- Specific Heat
- Heat Capacity
- Change of Phase

(i.e., Latent Energy LE & Sensible Heat (H)

- Heat Transfer

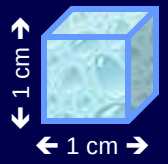
Quick Review: Thermal Energy Units

Unit for Thermal Energy
= the *joule* or *calorie*.

"Low Joule Cola"

A CALORIE is the amount of thermal energy required to change the temperature of 1 gram of water by 1°C (specifically from 14.5°C to 15.5°C) 1 calorie = 4.186 joules

(one gram of water is roughly equivalent to the weight of one cubic centimeter of water



. . . or about the mass of 1 small paper clip!)

REMINDER: 1 calorie is NOT the same as our everyday language use of the term “calorie” in “nutrition” discussions:

“nutrition calorie” = kilocalorie!

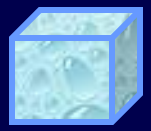
1 “calorie” in nutrition context =
1000 calories
or a kilocalorie (Kcal)

“Munch”

Other Important Terms:

Specific Heat = the amount of thermal energy (in calories) required to raise the temperature of 1 gram of ***any substance*** by 1°C.

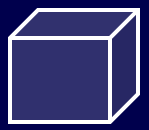
Specific heat =
1.00 calorie



1 g
of water

vs.

Specific heat =
0.24 calorie



1 g
of air

vs.

Specific heat =
0.20 calorie

1 g
of sand

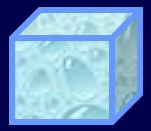
One Other Important Term:

Heat Capacity = **specific heat x mass (density) of a substance for a given volume.**

(Density is measured in grams per cubic centimeter.)

Heat capacity represents the capacity of a substance to absorb heat in relation to its ***volume*** and ***density***.

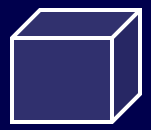
Heat capacity = 1.00 calorie / cubic cm



1 cubic cm of water

vs.

Heat capacity = 0.00024 – .00034 calorie / cubic cm



1 cubic cm of air

vs.

Heat capacity = 0.1 – 0.6 *higher if wet* calorie / cubic cm

1 cubic cm of sand

Specific Heat & Heat Capacity for Different Substances

Substance	Specific Heat		Heat Capacity
	cal	*joules*	
water	1.00	4.186	1.00
air	0.24	1.005	0.00024 - 0.00034
concrete	0.21	.879	0.50
sand	0.20	.837	0.10 - 0.60 (higher if wet)
iron	0.105	.440	0.82
silver	0.056	.234	0.59

Note the HEAT CAPACITY differences between higher density substances (like water, iron) vs. the low density substance of AIR.

CLICKER SELF-TEST TIME!!! . . . .➔

Channel 41

Q1 - Assume you have an equal volume of WATER, AIR & SAND.

Which will HEAT UP THE FASTEST if the same amount of thermal energy is transferred into the substance?

1. AIR
2. WATER
3. SAND

HINT: the greater the heat capacity, the LONGER it will take to heat up the substance.

Q1 - Assume you have an equal volume of WATER, AIR & SAND.

Which will HEAT UP THE FASTEST if the same amount of thermal energy is transferred into the substance?

1. AIR
2. WATER
3. SAND

Explanation:

The lower the heat capacity, the quicker the response to a transfer of heat into the substance!

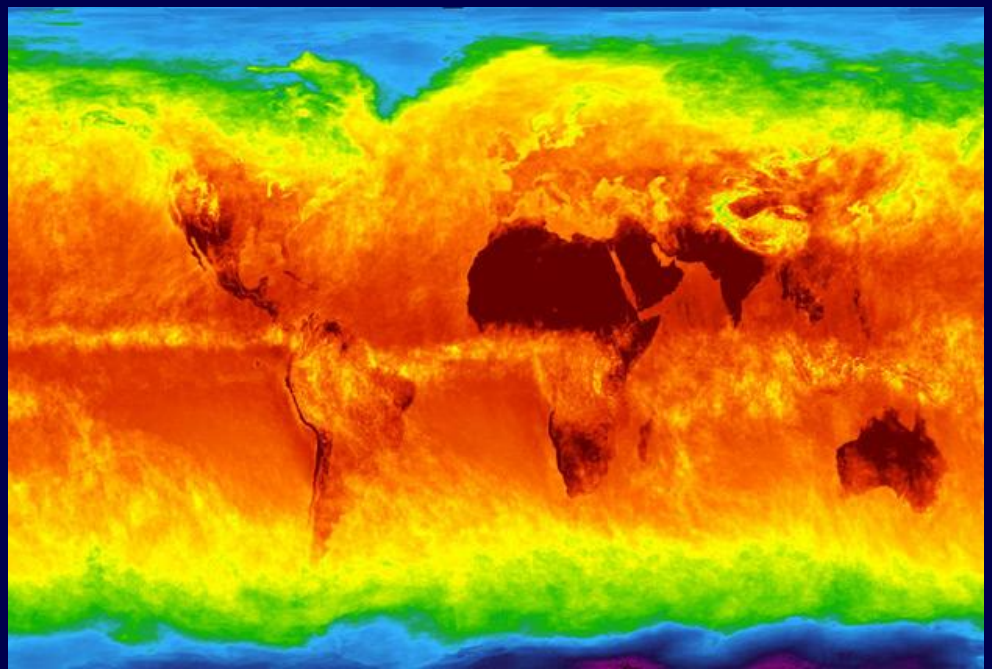
Q2 – As global warming is occurring we will be able to detect it <u>FIRST</u> where?

1 = the ocean temperature

2 = the land surface temperature (i.e., soil)

3 = actually, they will both heat up at the same rate

Map of global surface temperatures



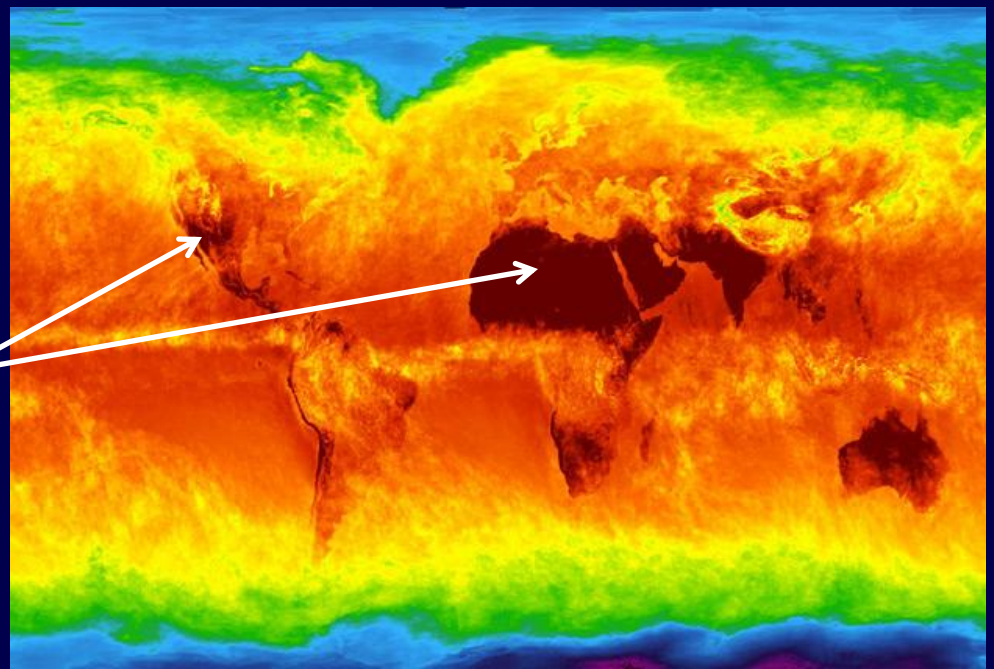
Q2 – As global warming is occurring we will be able to detect it FIRST where?

1 = the ocean temperature

2 = the land surface temperature (i.e., soil)

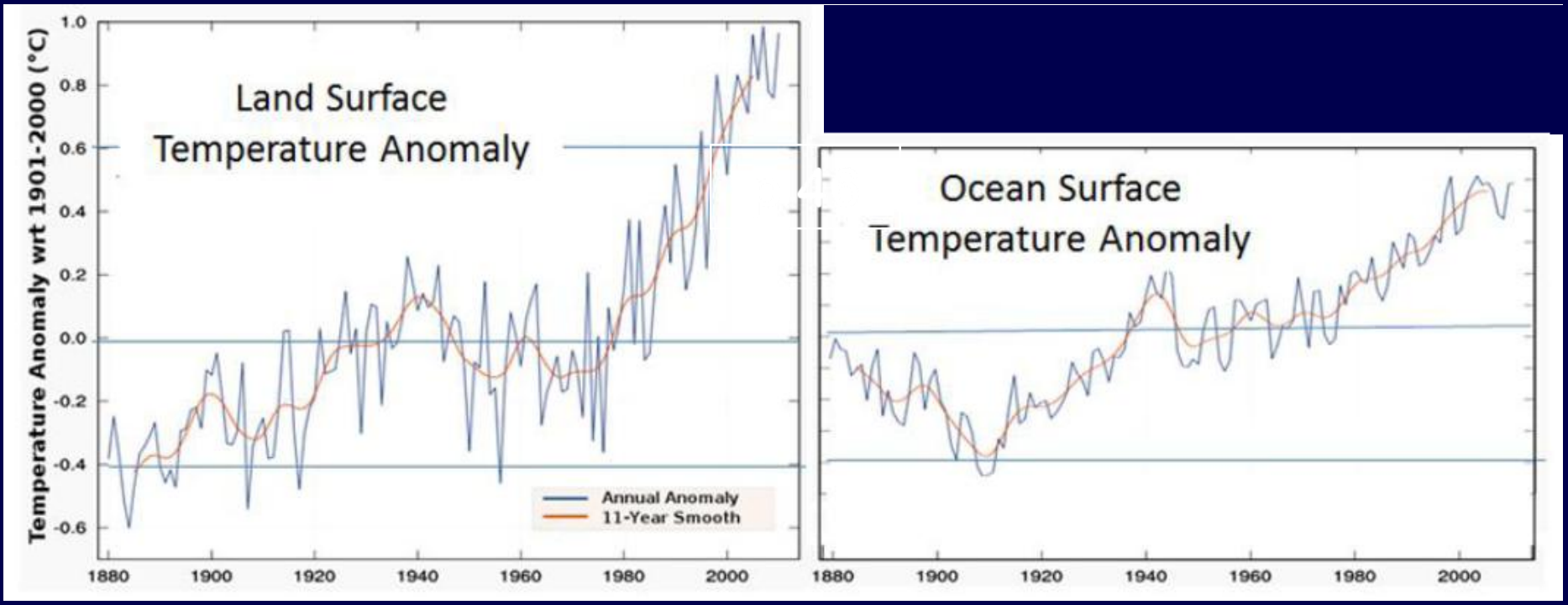
3 = actually, they will both heat up at the same rate

Note where the hottest temperatures occur



INDICATOR INTERLUDE . . .

Q. Why does the ocean surface warm more slowly than the land surface?



http://www.ncdc.noaa.gov/cmb-faq/anomalies.php

Q3 - Why will he burn his tongue, even if the pie crust is cool enough to hold?

1 - Because due to the high specific heat of the water in the apple pie filling, the filling will heat up faster and to a much higher temperature than the crust can achieve

2 – Because, due to the high specific heat and heat capacity of the water in the apple pie filling, the filling will hold the thermal energy longer than the crust will after the pie is taken out of the oven.

3 - BOTH

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Q4 - Which component of the EARTH SYSTEM has the ability to store thermal energy the longest -- once it heats up?

1. The ATMOSPHERE
2. The CONTINENTS
3. The OCEAN

Q4 - Which component of the EARTH SYSTEM has the ability to store thermal energy the longest -- once it heats up?

1. The ATMOSPHERE
2. The CONTINENTS
3. The OCEAN

INDICATOR INTERLUDE . . .

Q. Why is the heat CONTENT of the ocean so much greater than the land?

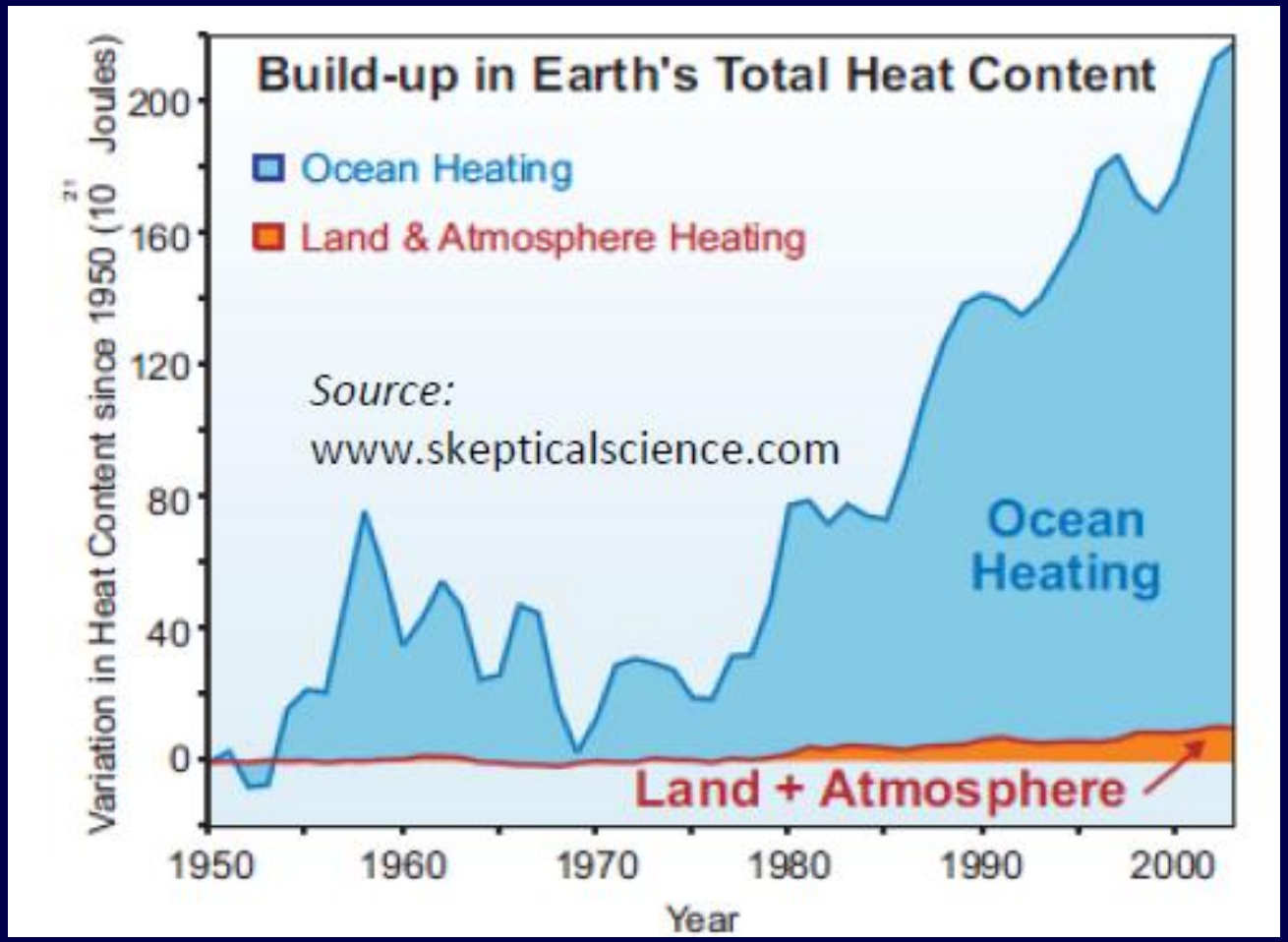


Figure: Total Earth Heat Content from 1950 (Murphy 2009). Ocean data from Domingues et al 2008.
http://www.skepticalscience.com/How-do-we-know-global-warming-is-still-happening.html

One last quick review point . . . .

Heat generally causes *EXPANSION* of a substance.

WHY?

When the temperature of the substance increases:

-- the molecules jiggle faster
-- more energetic collisions occur between the molecules
-- molecules are forced to move farther apart
-- thereby expanding the substance and making it LESS DENSE.

Top of p 47

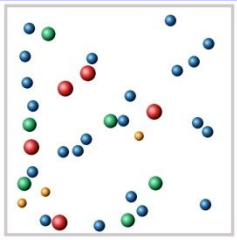
As air heats up, it expands, hence hot air is less dense than cold air & tends to RISE.

Likewise, cold air is more dense than hot air & tends to SINK

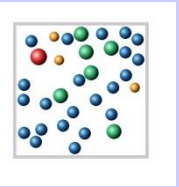
We call this process **CONVECTION** & it is a form of HEAT TRANSFER

These thermal differences play an important role in driving ATMOSPHERIC CIRCULATION, WEATHER & GLOBAL CLIMATE PATTERNS . . . . .

HOT



COLD

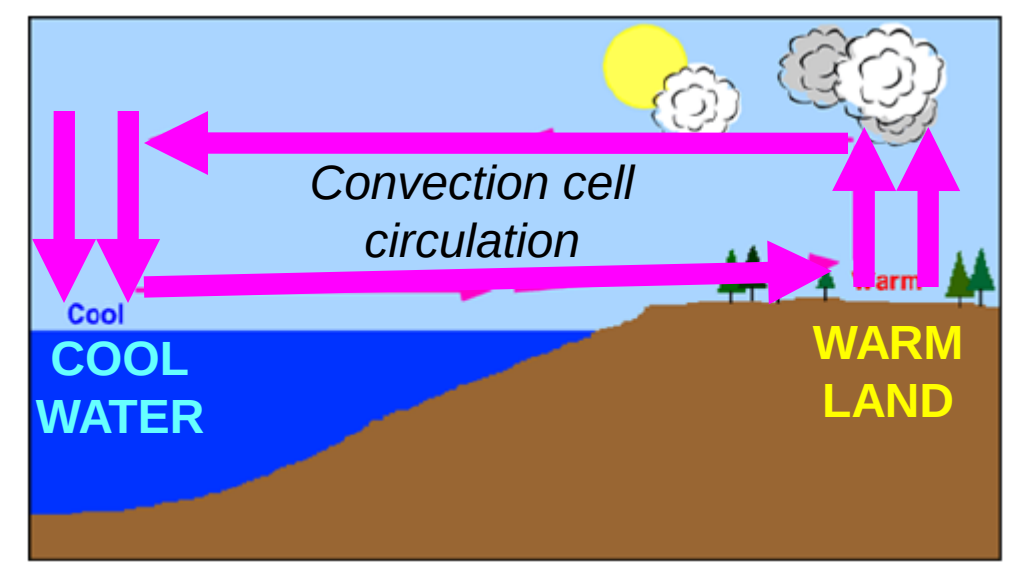


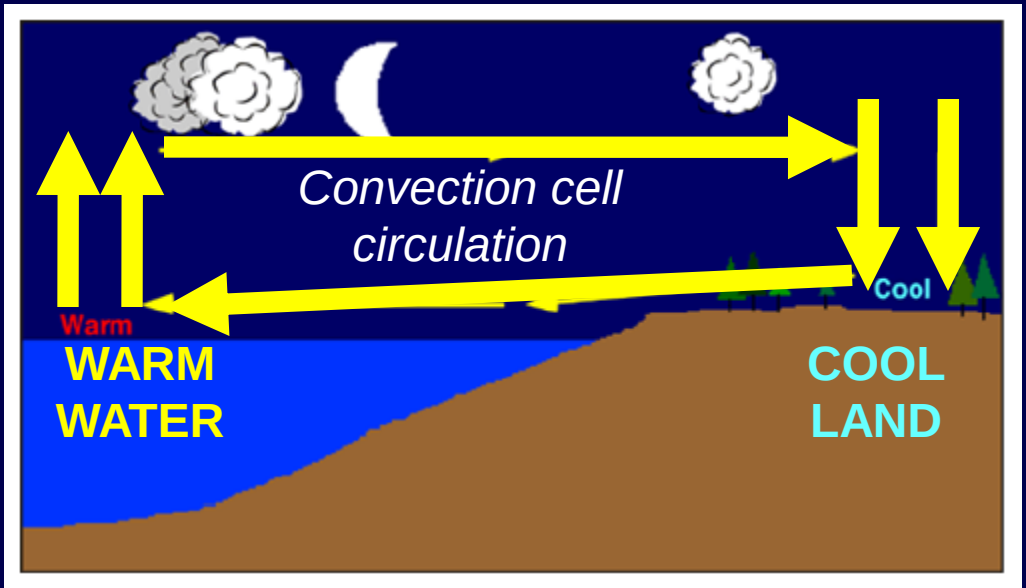
Example: **Sea Breeze & Land Breeze**

Thermally driven density differences of air

+ differences in the specific heat / heat capacity of LAND vs. WATER

➔ atmospheric circulation





On large continental scale
= MONSOON CIRCULATION!

Got all that Homer?

A
Short Break
on HEAT TRANSFER

http://fp.arizona.edu/kkh/nats101gc/Heat-transfer.html

THERMAL ENERGY TRANSFER

(aka “Heat Transfer”)

CONDUCTION = passage of thermal energy through a body **without large-scale movement** of matter within the body. Most effective in SOLIDS.

CONVECTION = passage of thermal energy through a fluid (liquid or gas) **by means of large-scale movements** of material within the fluid, as in a convection cell. Most effective in GASES & LIQUIDS.

RADIATION = the transfer of thermal energy by ***electromagnetic radiation*.** The only one of the three mechanisms of heat transfer that does not require atoms or molecules to facilitate the transfer process, i.e., **does not even need MATTER as a medium to transfer energy!**

Skip to p 48

HEAT TRANSFER = the process by which thermal energy moves from one place to another

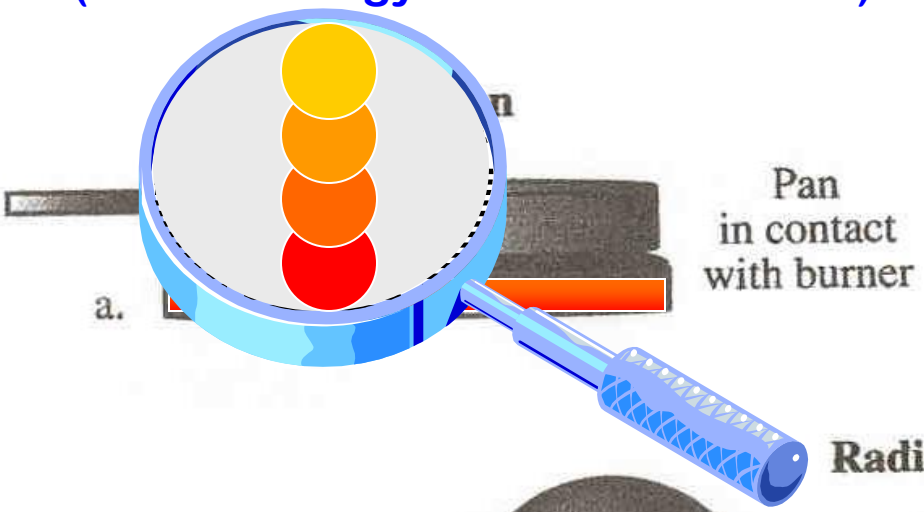
HEAT TRANSFER

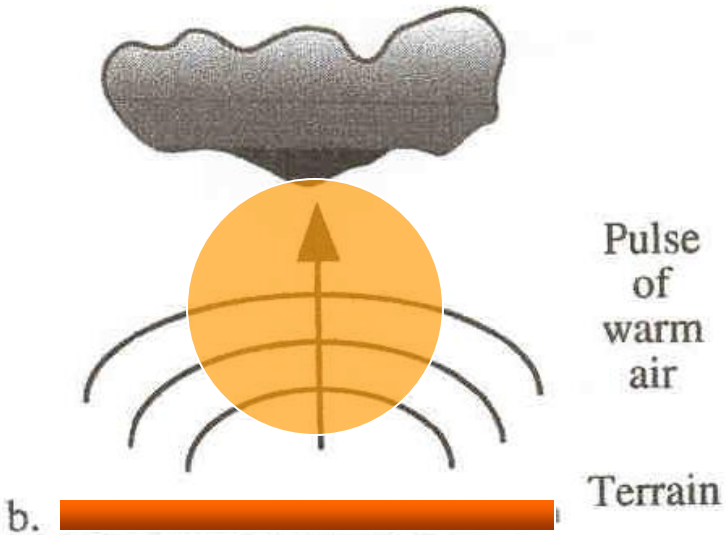
CONVECTION

Mass of warm air or liquid heats, expands, rises

CONDUCTION

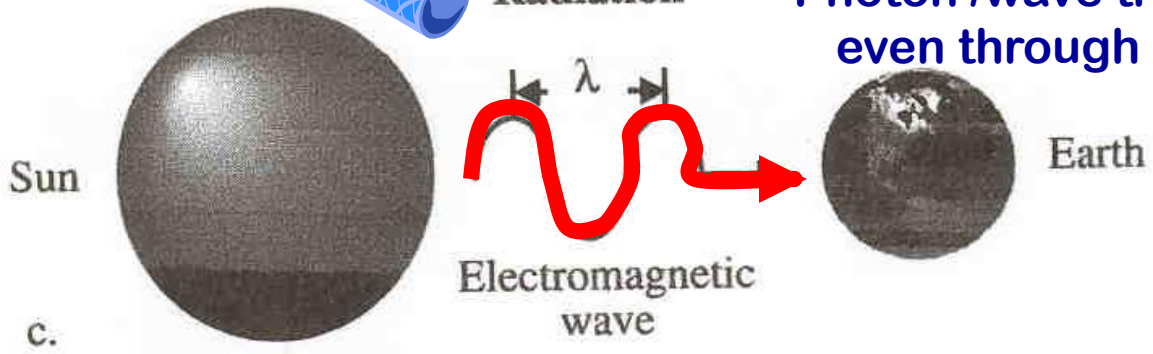
Jiggling molecule ➔ jiggling molecule
transfer of heat
(kinetic energy at molecular scale)





RADIATION

Photon /wave transport: even through a void!



Electromagnetic Radiation

(a KEY POINT about it!)

Electromagnetic energy (radiation) is not heat energy.

It does not become heat (jiggling molecules) until it strikes an object, is absorbed by the object and sets the molecules in the object in motion, thereby heating up the object.

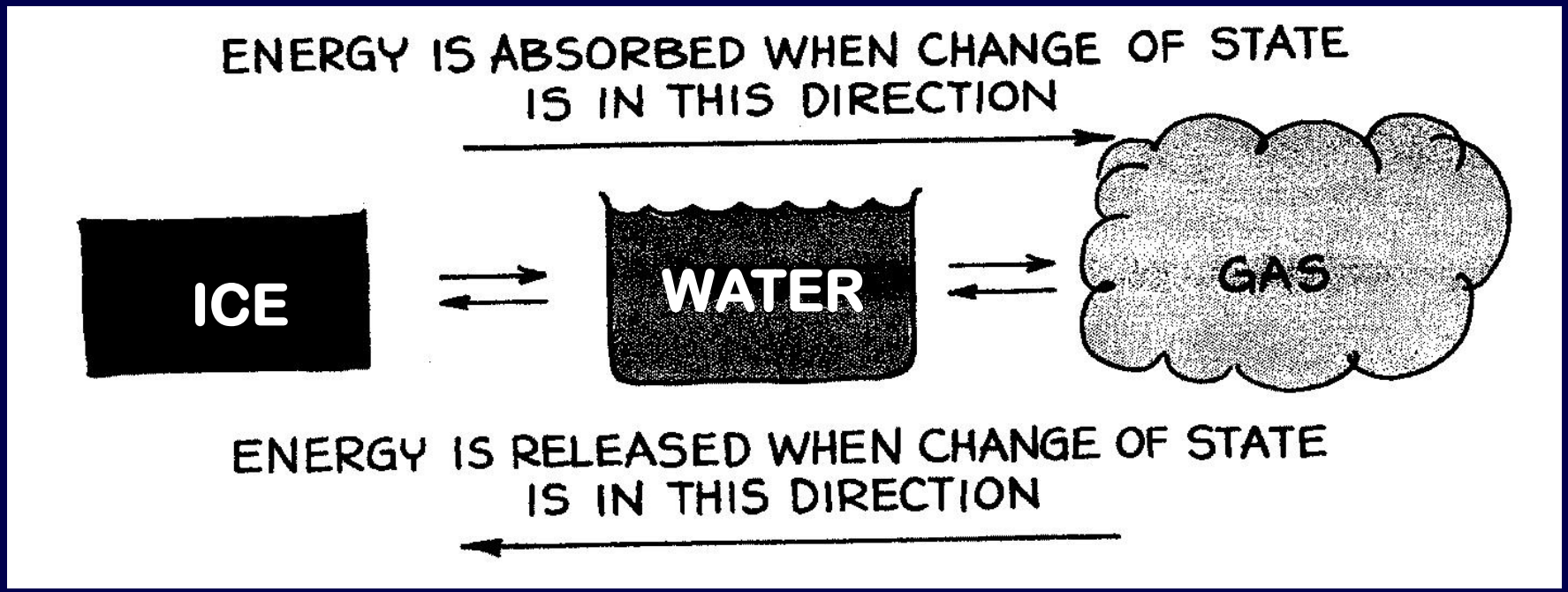
KEY CONCEPT:

The sun's energy comes in as radiant (electromagnetic) energy, and is converted to measurable heat only after it is absorbed (e.g., by the surface of the earth, a gas in the atmosphere, etc.).

THERMAL ENERGY & PHASE CHANGES IN H_2O

Energy stored as LATENT ENERGY

(energy is "hidden" & not sensed)



Energy released as SENSIBLE HEAT

(i.e. the warmth can be "sensed")

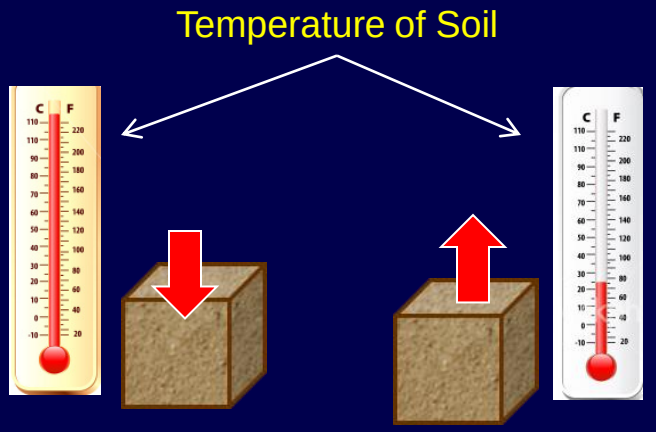
Now back to p 47

DEFINITIONS:

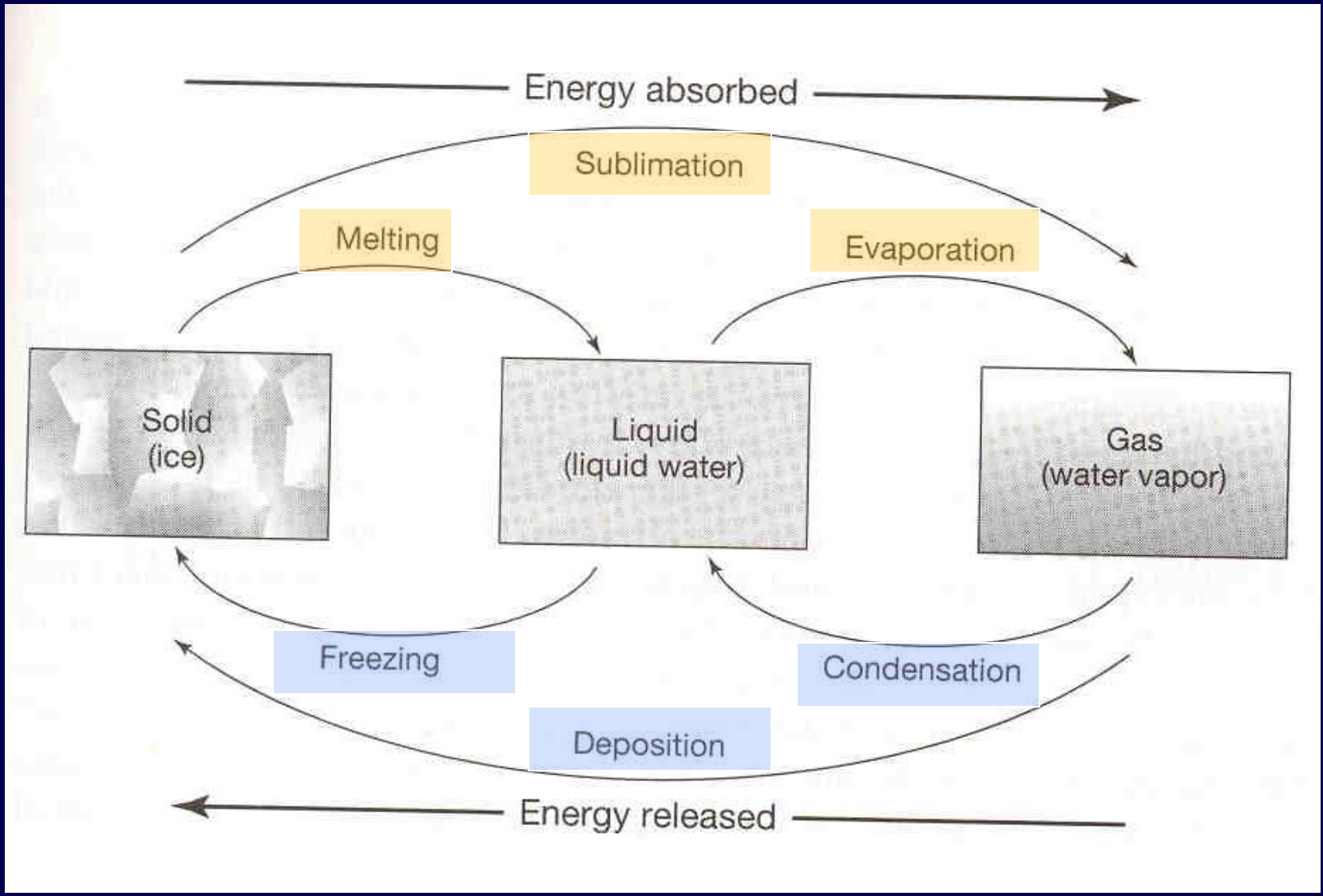
LATENT ENERGY (LE) & SENSIBLE HEAT (H)

LATENT ENERGY (LE) = the amount of energy released or absorbed by a substance during a **change of phase**, such as when water evaporates.

SENSIBLE HEAT (H) = the amount of energy released or absorbed by a substance during a change of temperature (which is not accompanied by a change of state)



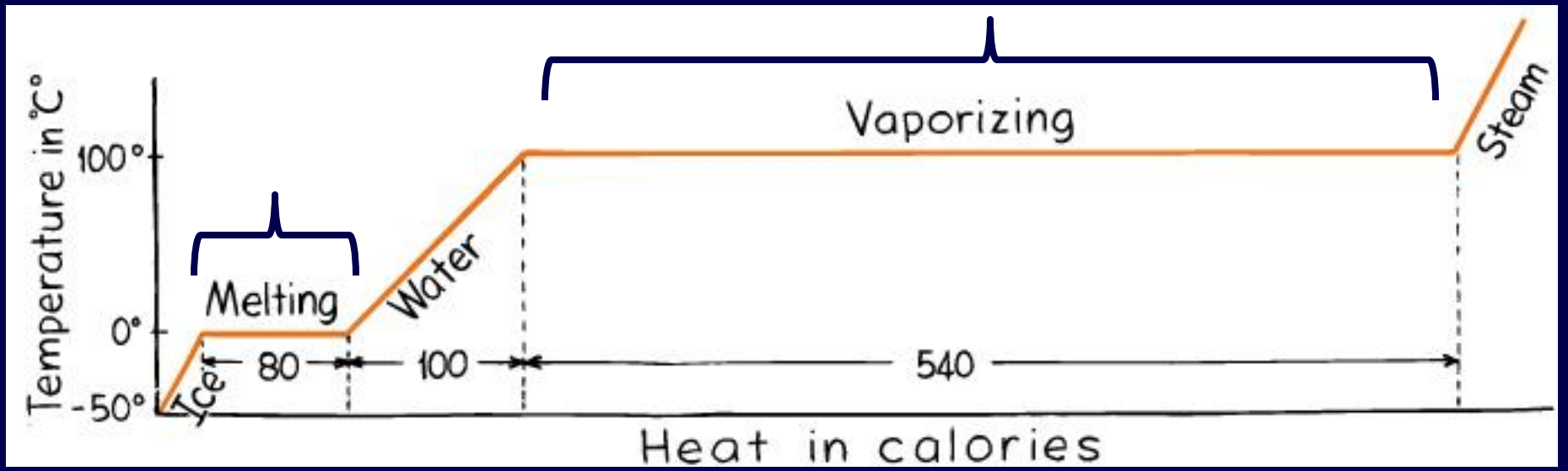
PHASE CHANGES (another view)



This is in your textbook: Fig 4-23 p 77 in SGC E-text

THOUGHT QUESTION:

In this graph, what's happening to the energy in the portions where the graph is <u>horizontal</u>?



HINT: it has to do with

SENSIBLE HEAT (H)

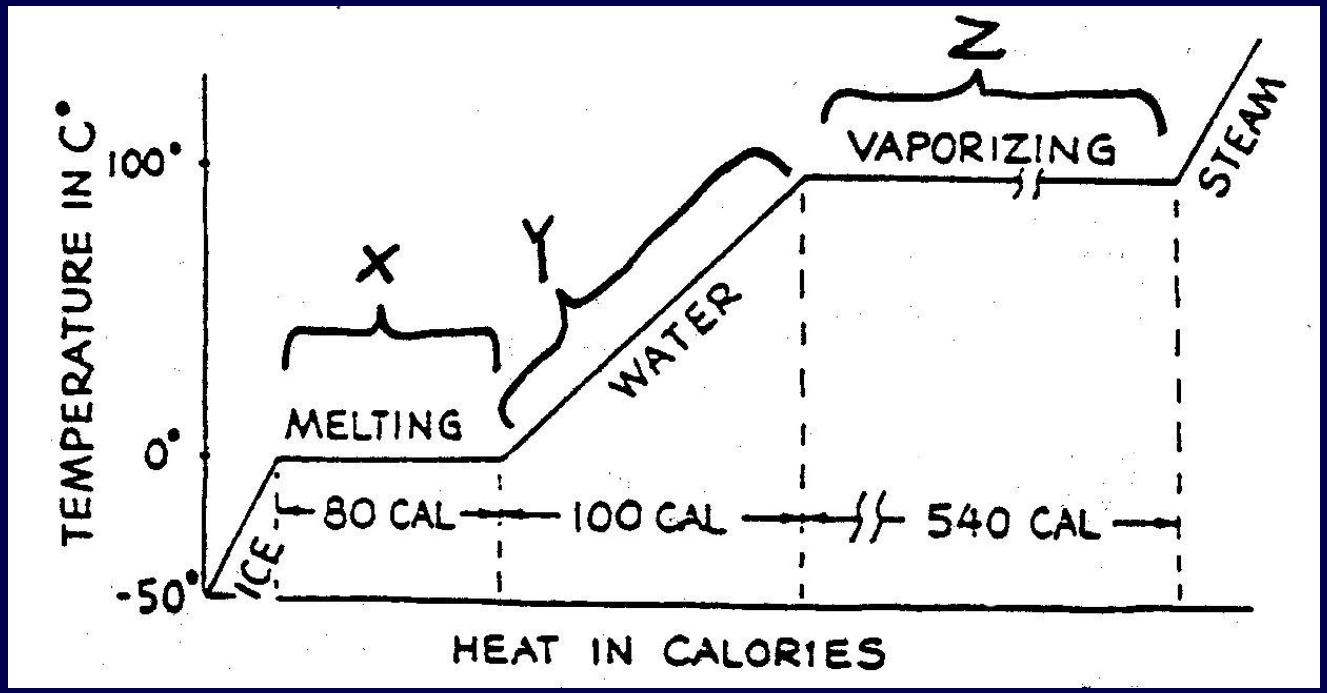
&

LATENT HEAT (LATENT ENERGY) LE

REVIEW / BACKGROUND:

SENSIBLE = the energy can be SENSED (e.g., with a thermometer, by the environment, etc.)

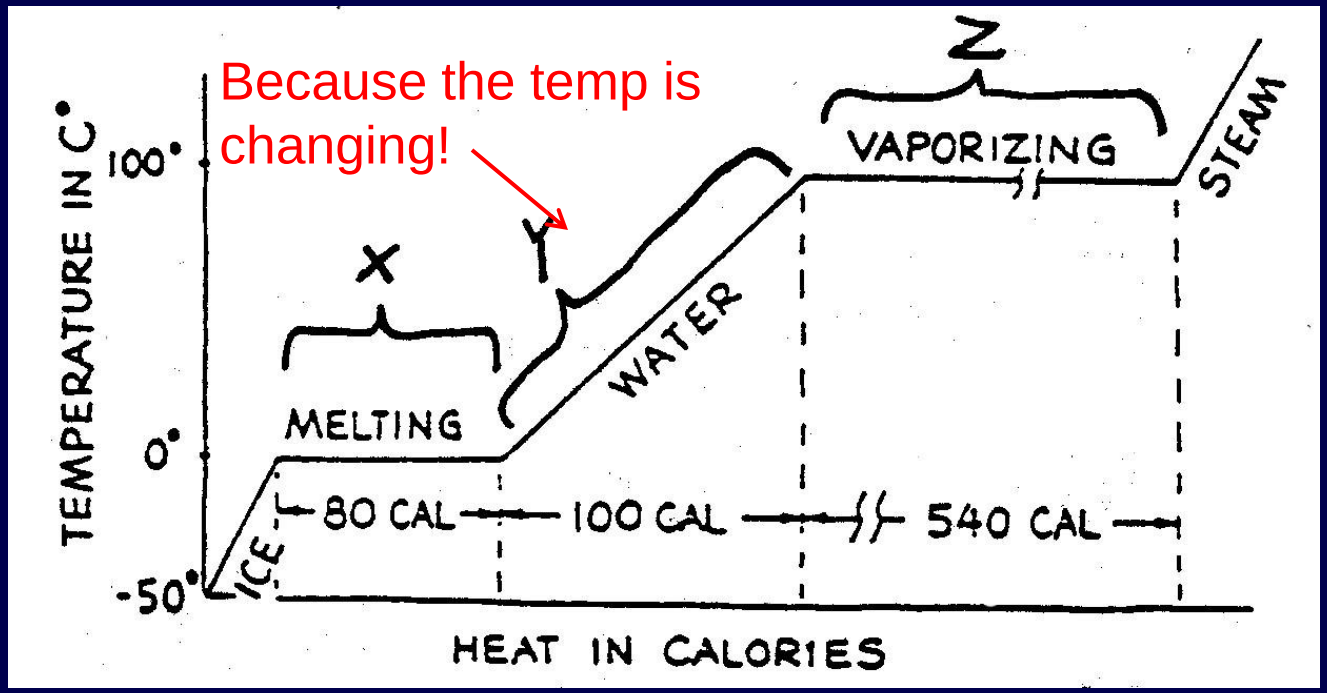
LATENT (means “HIDDEN”) = the energy is there, but it is NOT SENSED by the environment, a thermometer . . . or YOU!



Q5 -- Which segment or segments of the graph represent(s) **SENSIBLE HEAT (H)** ?

1 = X & Z **3 = Y only**

2 = X only **4 = Z only**



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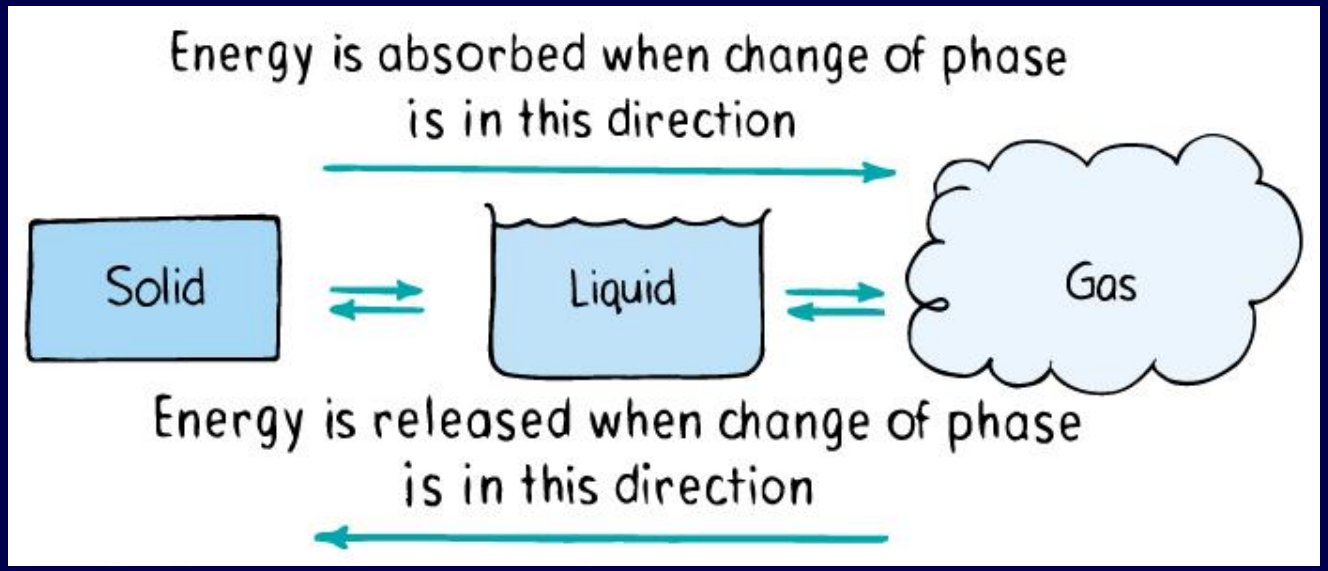
Q6 - In a phase change from ice to water or water to water vapor, WHAT is absorbing the energy?

1 = the surrounding environment

2 = the H_2O molecules

3 = both the environment & the H_2O



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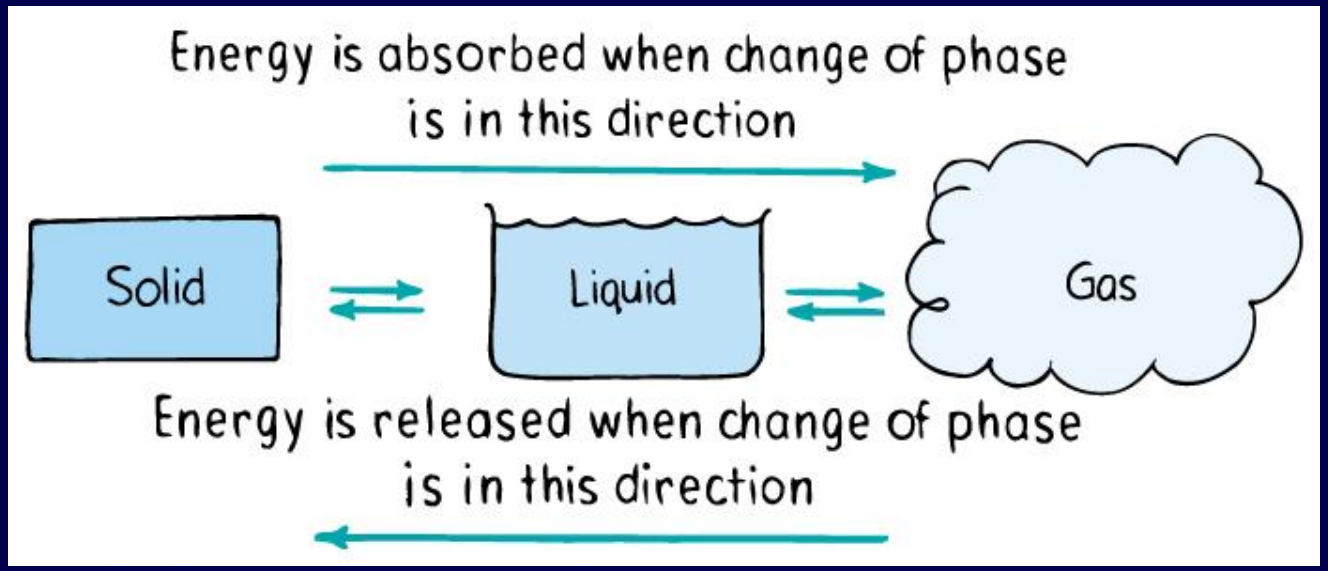
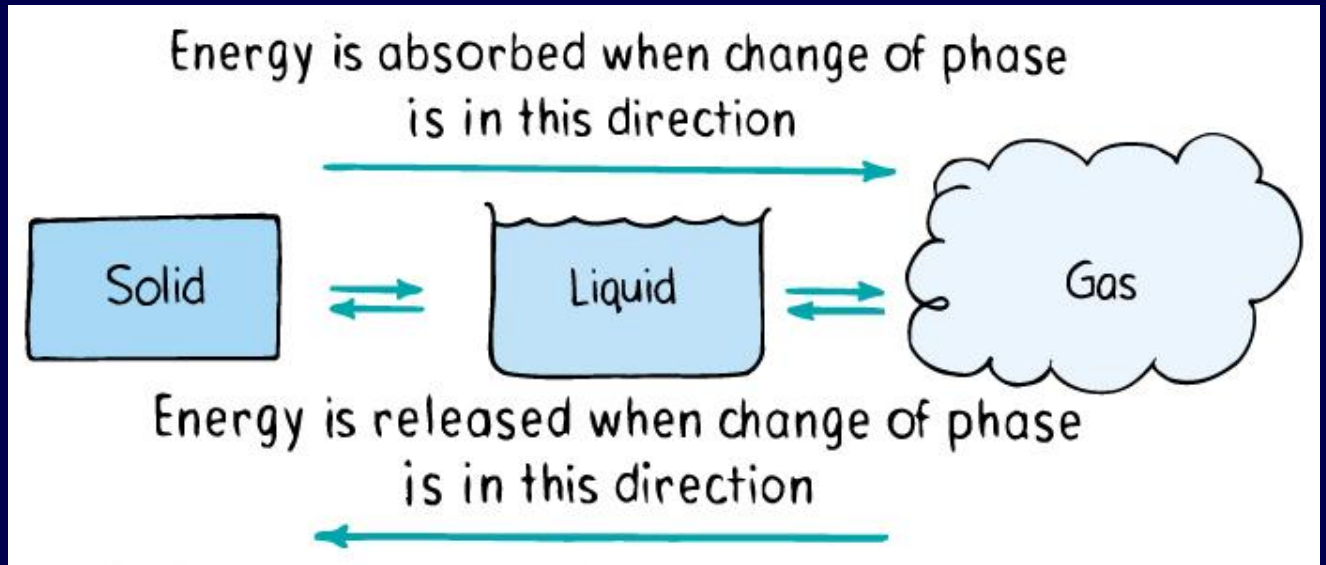


Q7 - In a phase change from water vapor to liquid water or liquid water to ice, TO WHERE is the energy being released?

1 = into the surrounding environment

2 = into the H_2O molecules

3 = into both the environment & the H_2O



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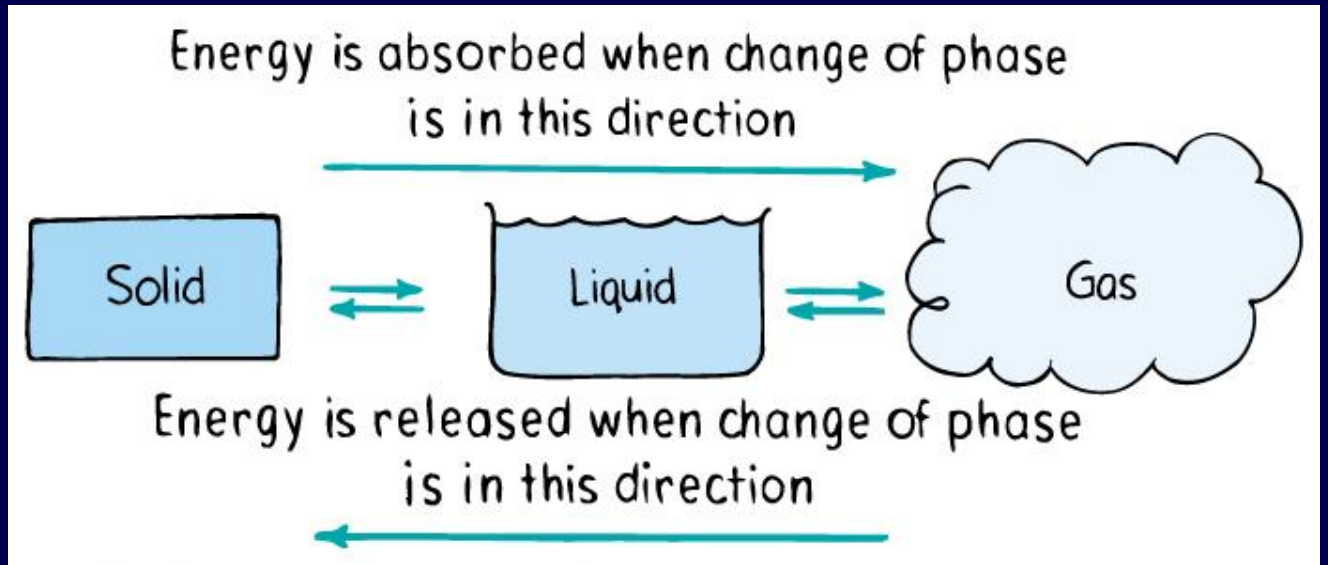
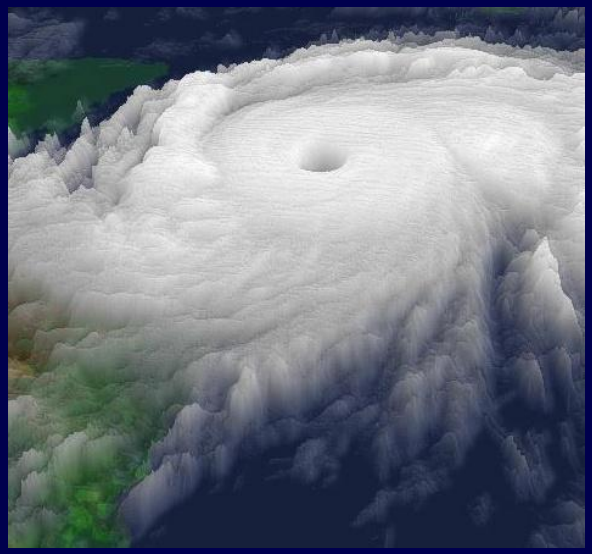
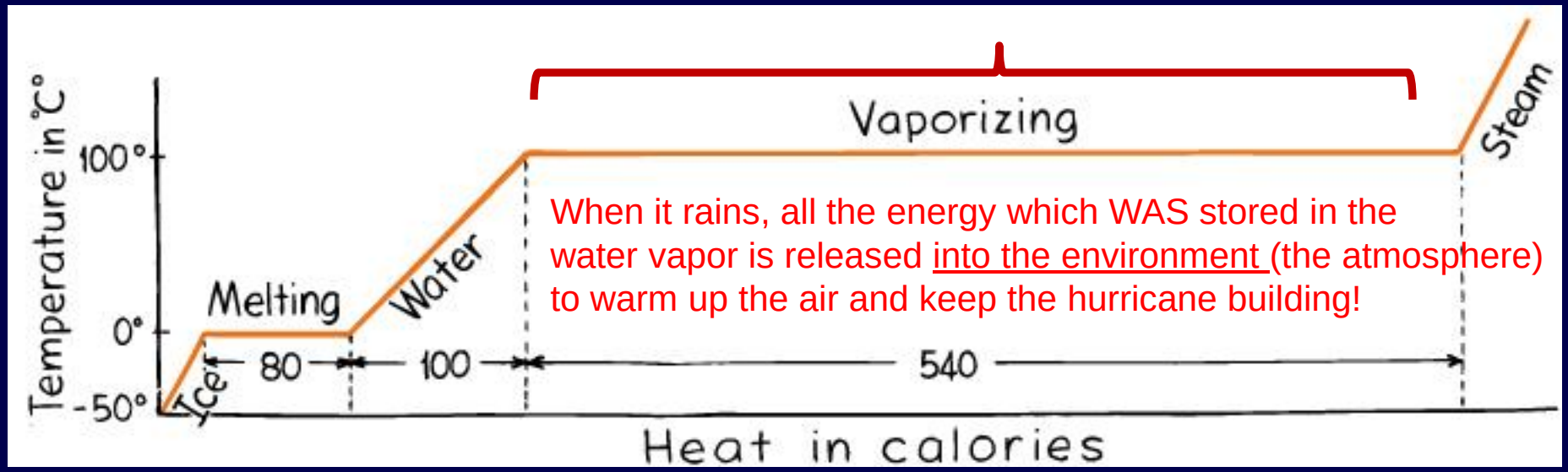


This is what drives tropical storms & HURRICANES!!





See you on Friday for a Group Activity and some practice questions for TEST #2, Homer!