FYI: Test #2 will cover:

Topic 5: Radiation Law #6 (absorption curves)
Topic 6 : Atmo Structure & Composition (all)
Topic 7: Thermodynamics (content covered today & next Monday)

A few final review points to emphasize on:

Topic #6 Atmospheric Structure & Composition . . .

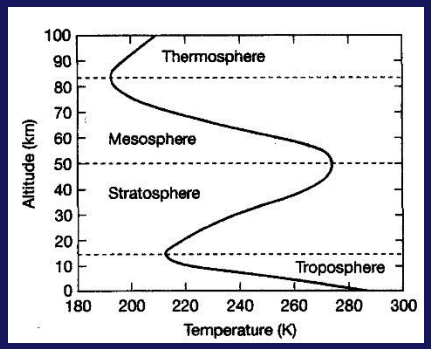
SUMMARY OF KEY CONCEPTS: short version

1. Four gases N_2, O_2, Ar, & CO_2 comprise about 99% of the volume – but "minor" trace Greenhouse Gases are extremely important. **Q. Which of these 4 is a GHG?**

2. Most of the MASS of the atmosphere is in the bottom few kilometers (i.e. the Toposphere!)

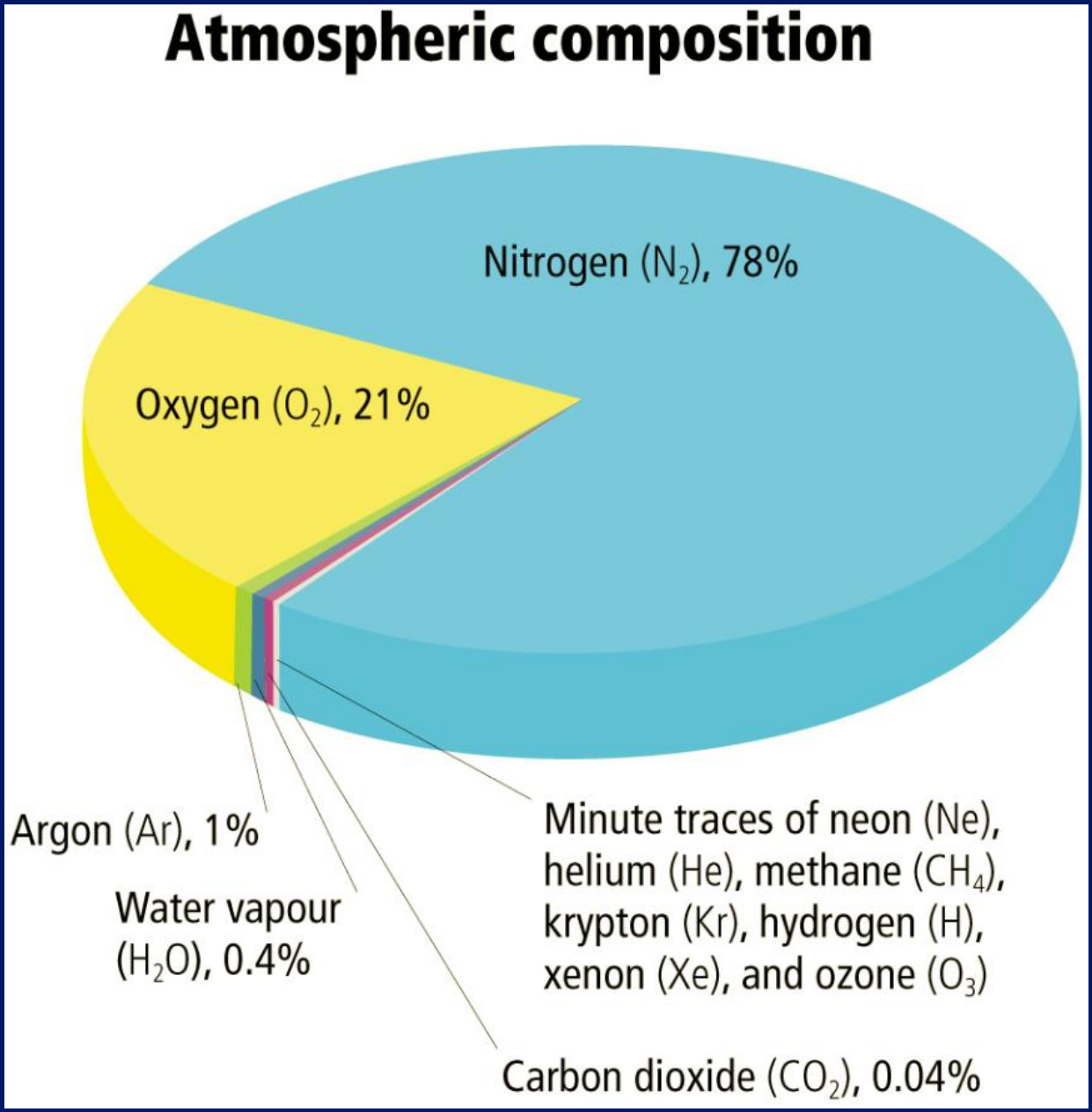
3. Different gases are abundant at certain levels in the atmosphere. The effect of radiation absorbed by these gases is seen in the vertical temperature profile

4. . . . which leads to the vertical structure of the atmosphere➔

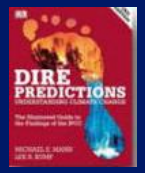


"Visualization" of the info in the table on the top of Class Notes p 33:

Percent Concentration (by volume) of the major GASES in the Atmosphere



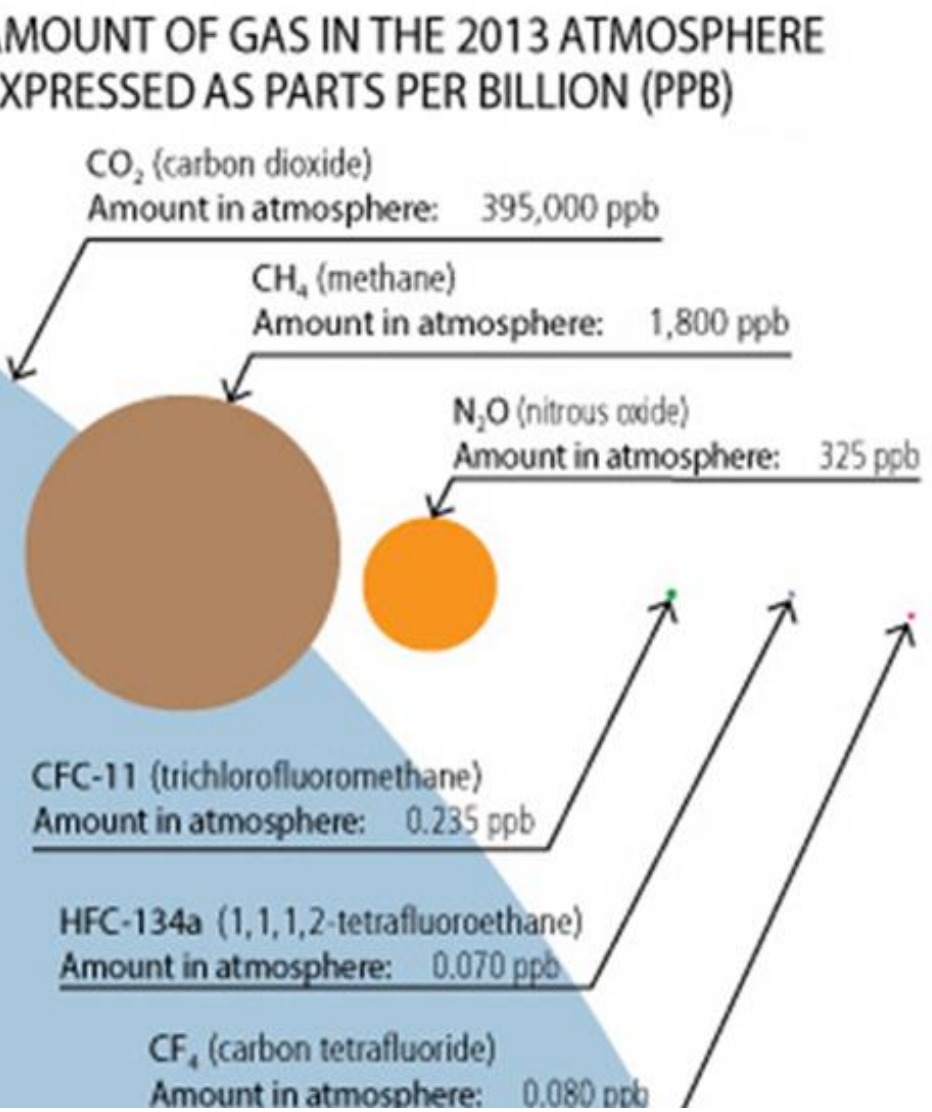
FROM:
Dire Predictions
pp 28-29

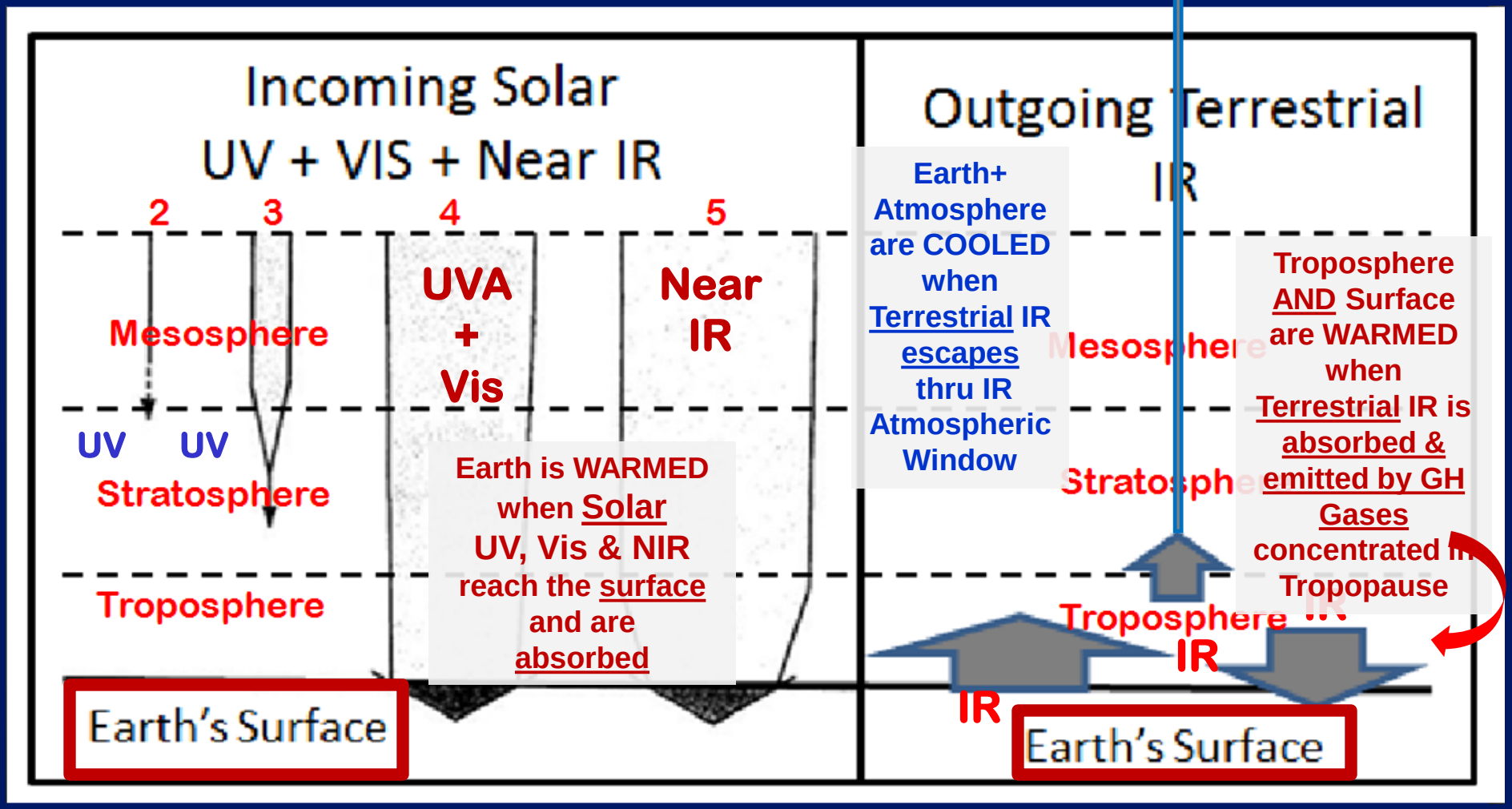


Greenhouse Gas Concentrations in Atmosphere in parts per billion (ppb)

Compare concentrations w/ TABLE on p 33

(“RF” column in Table = an indicator of GH Gas effectiveness)





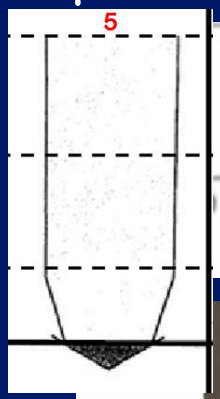
Q: Why do we say:

"The atmosphere is heated from BELOW ” ?

Review p 33

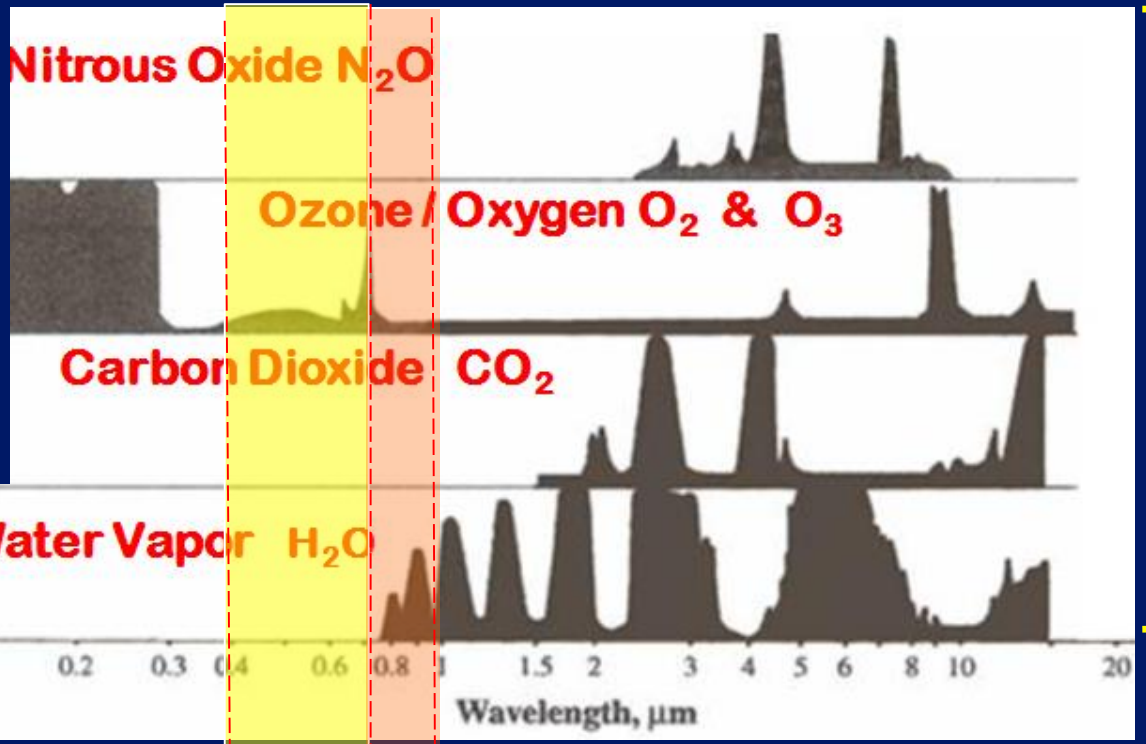
WHERE IS Near IR ?

0.7 - 1.0 μm

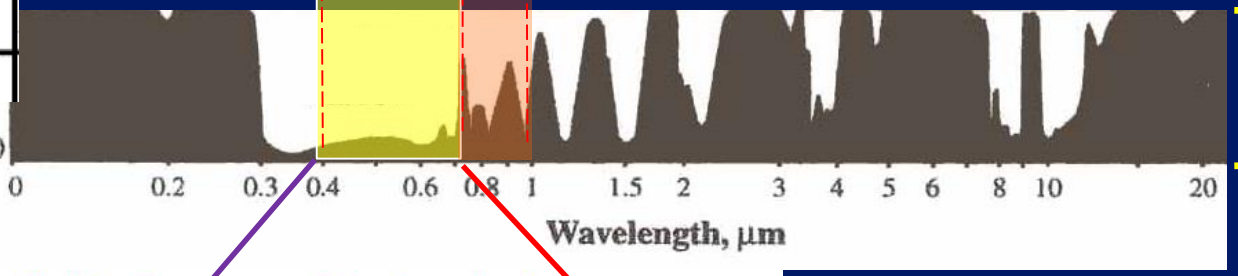


← UV | Visible | Near IR | Far IR →

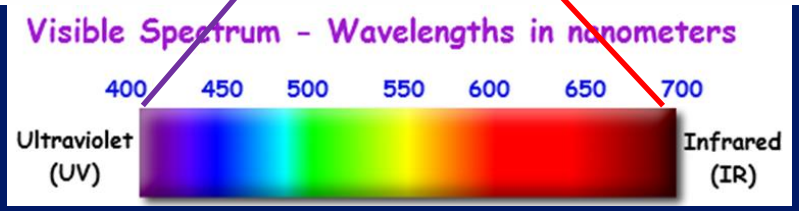
0.4 0.7 1.0

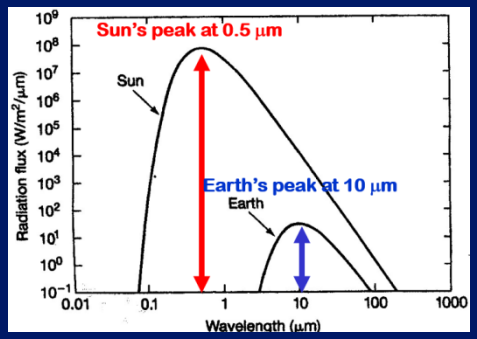


Absorption by Individual Gases



Absorption by Total Atmosphere





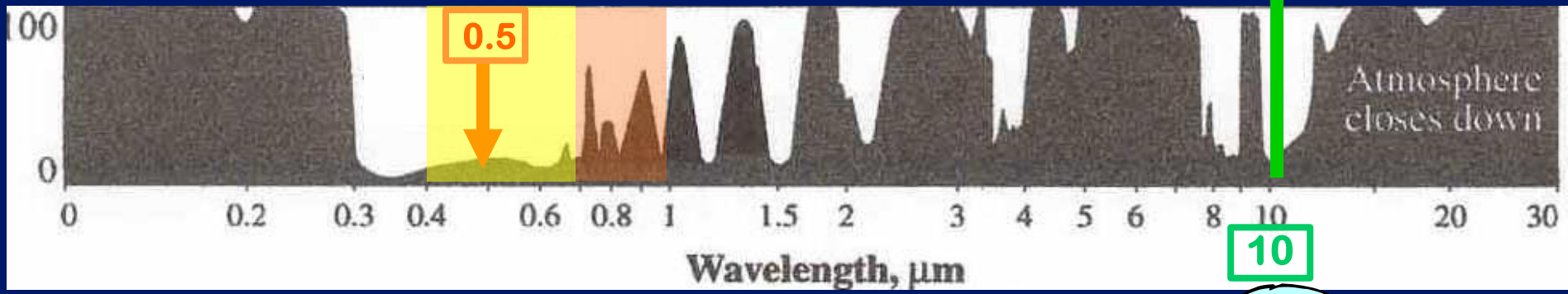
WHOLE ATMOSPHERE:
Absorption + Transmission

thru UV / Vis atmospheric window

TRANSMISSION OF Incoming SW UV+Vis+NIR is how the SUN WARMS the EARTH

thru IR atmospheric window

TRANSMISSION OF Outgoing LW / IR is how the Earth "COOLS ITSELF"



UV VISIBLE NIR

Far IR

Bottom row p 28

CHECKPOINT

THINK . . . then share
What's still fuzzy . . .
what's now perfectly clear
about Topic #6?

TOPIC # 7
LAWS OF THERMODYNAMICS & ENERGY TRANSFORMATIONS

The Next Piece in the Puzzle to Understand Global Changes

Featuring . . . .

OUR QUOTE OF THE DAY . . .

. . . is from HOMER SIMPSON

PART A - Thermal Energy Background

THERMODYNAMICS

(def) = The study of the general properties of ENERGY.

Thermal <u>ENERGY</u> plays a central role, so . . .

the **<u>STUDY OF ENERGY</u>**

can also be called "**THERMODYNAMICS.**"

Forms of Energy - Review

- **Kinetic** (KE) = energy of *motion* *or* the ability of a mass to do work.

  (related to mass and velocity)

- **Potential** (PE) = energy a system possesses if it is capable of doing work, but is NOT doing work now

[*Includes: gravitational, elastic, chemical, electrical, magnetic . . . and* ELECTROMAGNETIC]

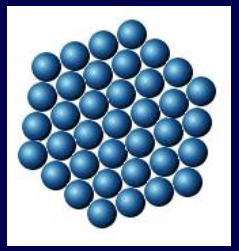
review

Thermal Energy (def)

= the grand TOTAL of all energies inside a substance

. . . specifically:

a measure of the quantity of *atomic kinetic & potential energy* contained in every object

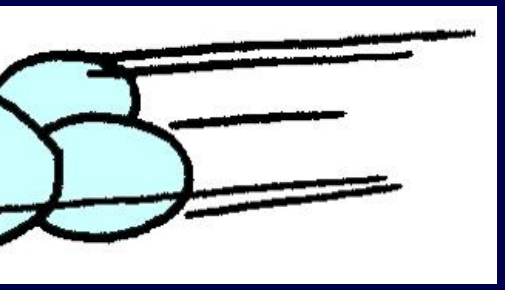


Thermal Energy vs Temperature:

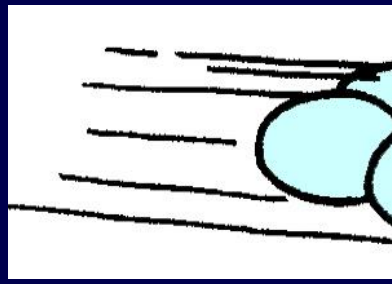
- **Temperature is a "measure" of the AVERAGE kinetic energy of each molecule in a body.**

Temperature = tells how warm or cold a body is with respect to some standard scale:

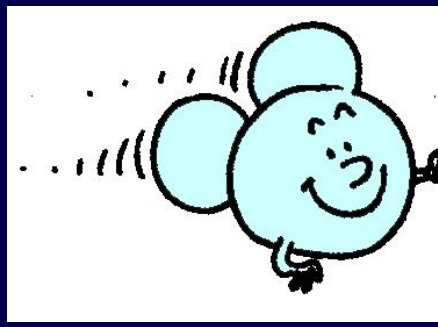
	K	°C	°F
Absolute Zero	0	- 273.15°C	- 459.15°F
Freezing Point of H_2O:	273.15	0°C	32°F
Boiling Point of H_2O:	373.15	100°C	212°F



If a body has a high temperature, each of its molecules has, on the average, a large amount of kinetic energy.



if a body has a low temperature, each molecule on the average has a small amount of kinetic energy.



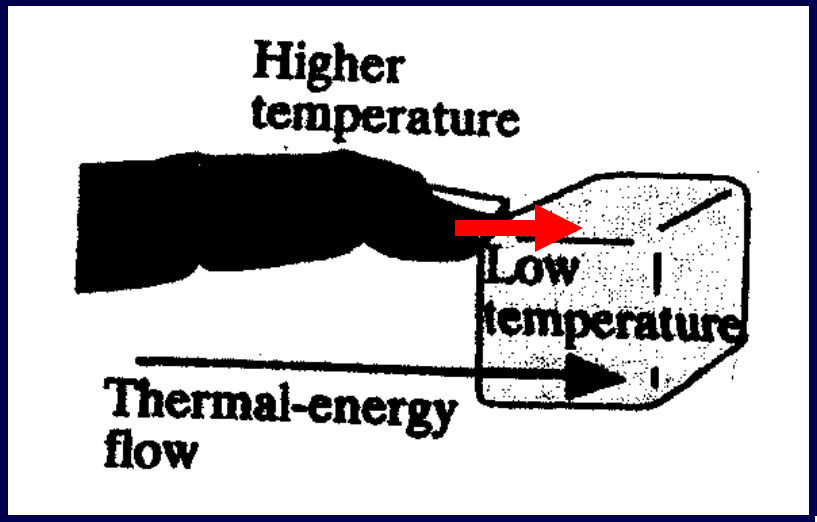
(and if atoms lose all their kinetic energy, they reach the **"ABSOLUTE ZERO“** of temperature)

Thermal Energy vs. Heat:

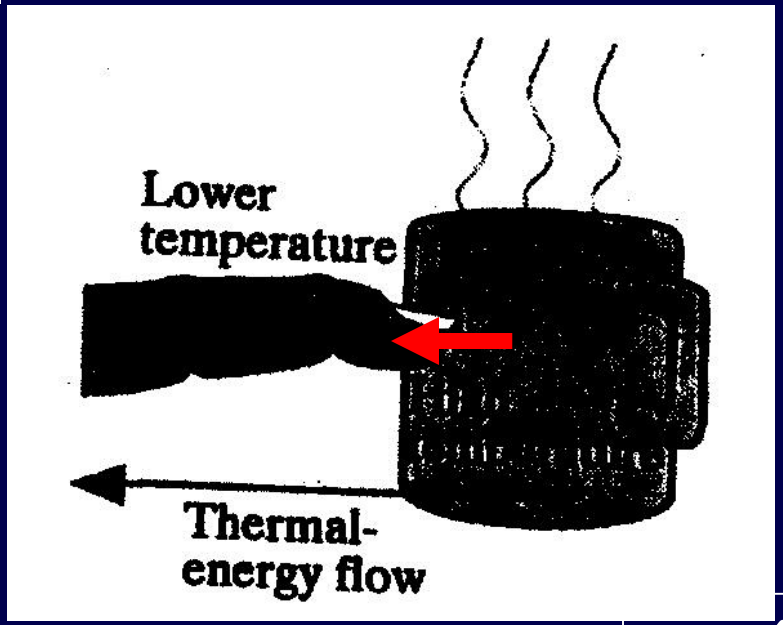
HEAT = Thermal Energy Transfer (or Flow)

Heat = the thermal energy that is *transferred* from one body to another because of a temperature difference.

PART A - Thermal Energy Background



Heat will always flow from a substance of higher temperature to a substance of lower temperature, until both come to a common temperature.



CLICKER Q➔

Clicker Q1 - Which way is heat being transferred?

1. From the cold beer can into Homer's warmer beer belly

2. From Homer's beer belly to the colder beer can

3. From BOTH the beer can to Homer and Homer to the beer can

Clicker Q 1- Which way is heat being transferred?

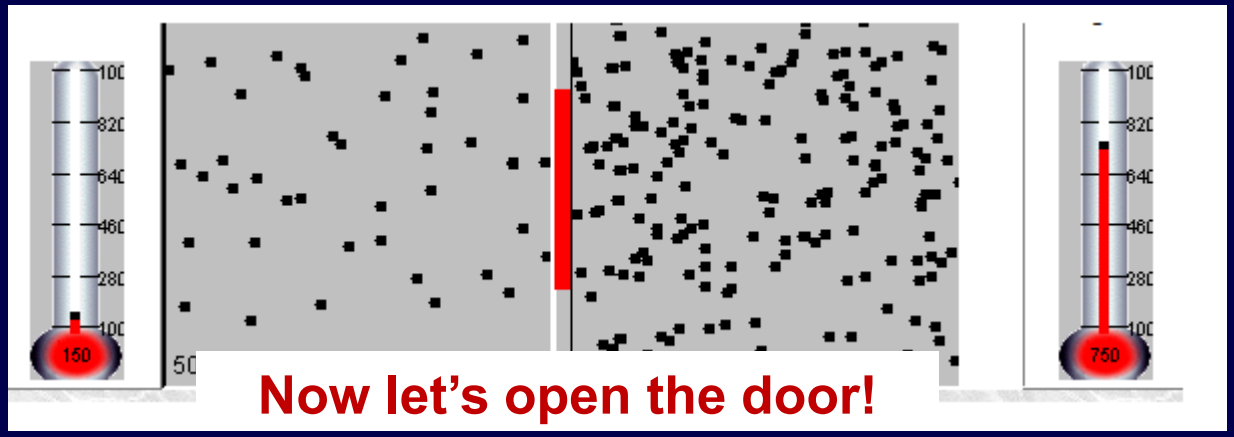
1. From the cold beer can into Homer's warmer beer belly
2. From Homer's beer belly to the colder beer can
3. From BOTH the beer can to Homer and Homer to the beer can

PART A - Thermal Energy Background

DOOR CLOSED

Cold chamber

Warm chamber



What will happen?

CHECKPOINT

Got all that Homer?

OK, LET'S MOVE ON TO PART B . . . . .

on p 38 ➔

PART B – Temperature Responses & Thermal Energy Storage (in Different Substances)

Background needed . . . . .

- Units of Measure of Thermal Energy
  (i.e., the joule or calorie)

- Specific Heat & Heat Capacity

Thermal Energy Units Review:

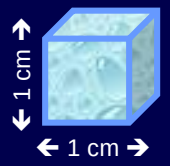
Units for Thermal Energy
= the *joule* or *calorie*.

A CALORIE is the amount of **THERMAL ENERGY** required to change the temperature of 1 gram of water by 1°C *

1 calorie = 4.186 joules

1 joule = 0.239005736 calories

Simple ways to "envision" one gram =



tiny cube of water

Mass of a paperclip

* specifically from 14.5°C to 15.5°C

STUDY THE TABLE ON TOP of p 38 and pick out 3 substances we could use to make estimates about the

Temperature Response & Thermal Energy Storage

of different parts of our Earth's environment

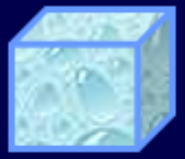
Specific Heat & Heat Capacity for Different Substances

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.

Key Term #1

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



1 g
of water

Specific heat =
1.00 calorie

vs.

1 g
of air

Specific heat =
0.24 calorie

vs.

1 g
of sand

Specific heat =
0.20 calorie

Key Term #2

Heat Capacity = **Specific Heat x Mass (density)**

MASS of a substance for a given VOLUME

GRAMS / CUBIC CENTIMETER

1 cubic cm
of water

Heat capacity =
1.00
calorie / cubic cm

vs.

1 cubic cm
of air

Heat capacity =
0.00024 – .00034
calorie / cubic cm

vs.

1 cubic cm
of sand

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

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

Clicker Q2 - 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

Clicker Q2 - Why will he burn his tongue, even if the pie crust is cool enough to hold?

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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


whiteboard

QUESTION: 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 . . . WHY?

AIR

WATER

SAND

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

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

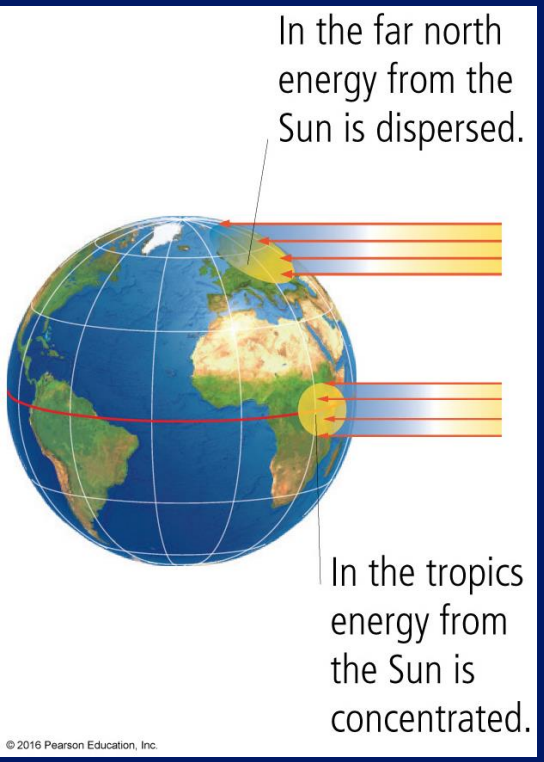
Which will HEAT UP THE FASTEST if the same amount of thermal energy is transferred into the substance?

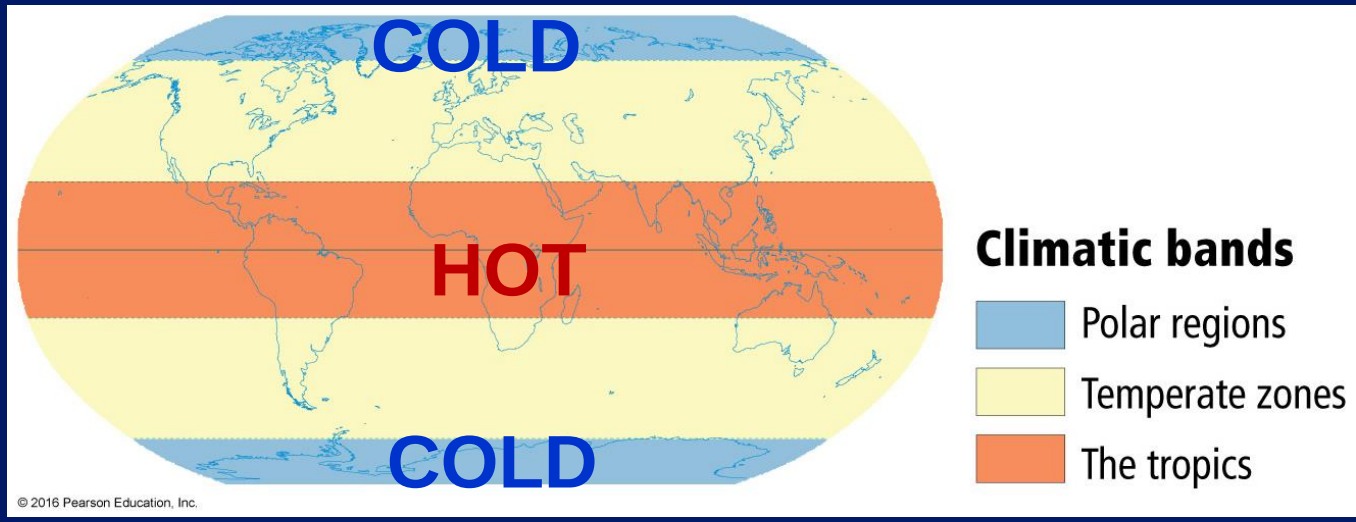
1. AIR
2. WATER
3. SAND

Explanation:

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

QUESITON: What's wrong with this TEMPERATURE MAP?





Answer: The map shows NO DIFFERENCE in the way that continents and oceans heat up when solar energy is absorbed in tropical low latitudes

Source: Dire Predictions pp 10-15

QUESTION:

– As global warming is occurring WHERE will we be able to detect a temperature change FIRST ?

OCEAN or CONTINENT

NEITHER: They will both heat up at the same rate!

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

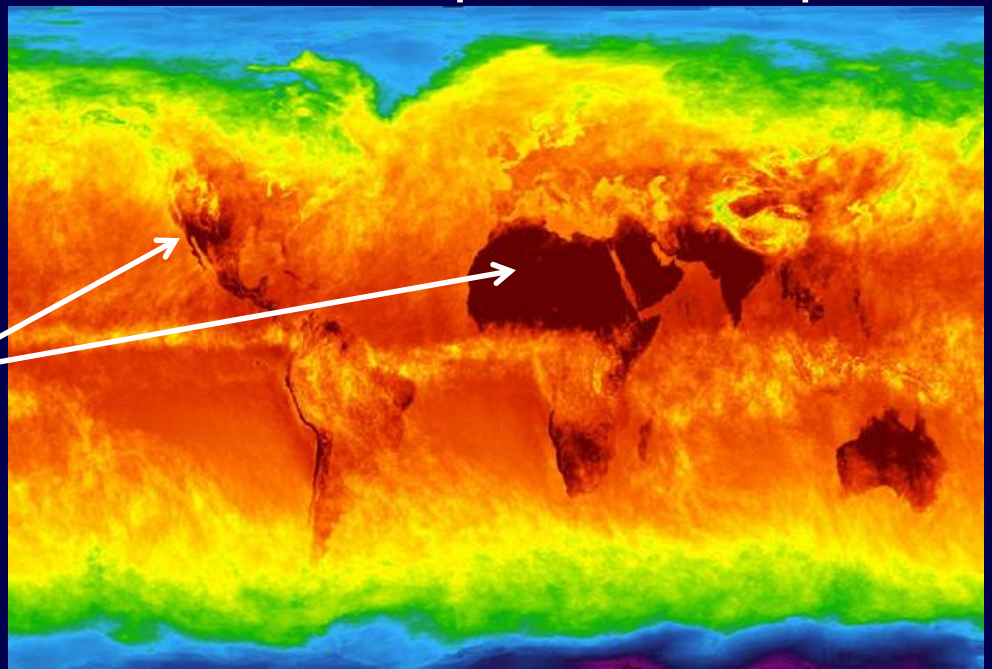
1 = the ocean temperature

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

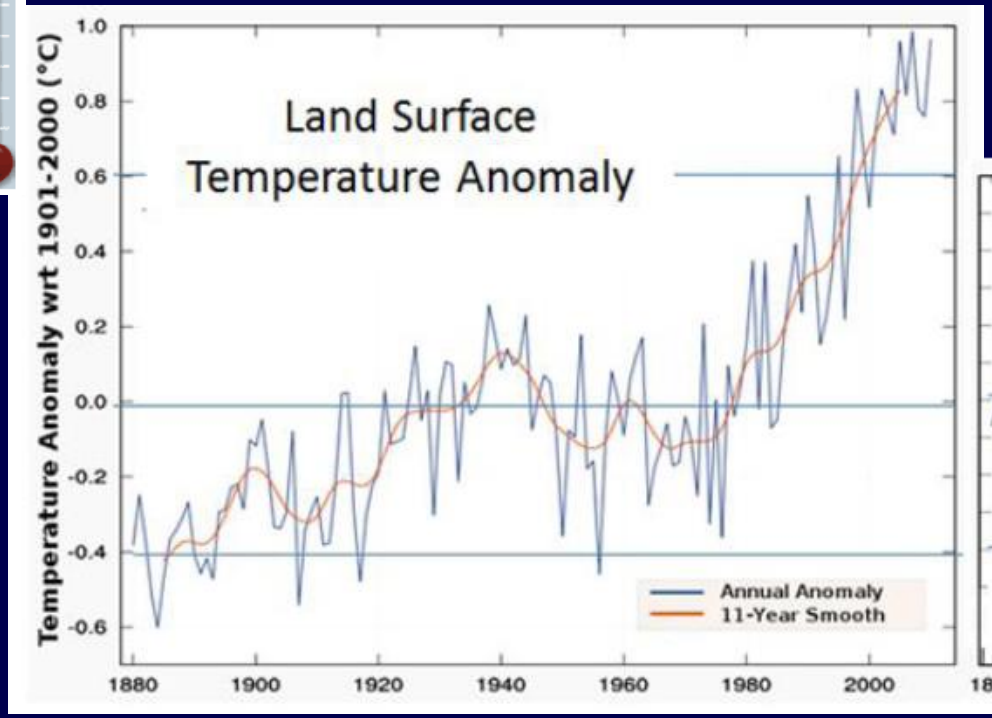
3 = actually, they will both heat up at the same rate

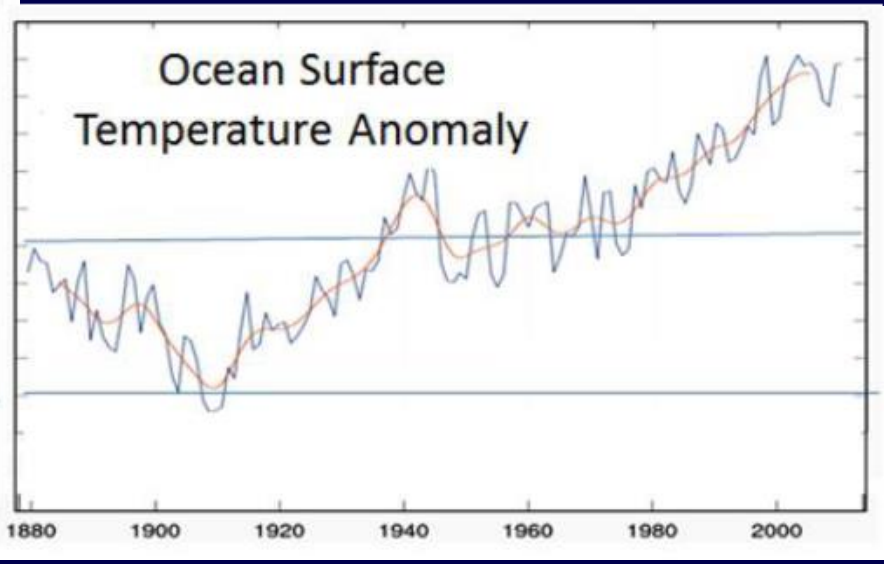
A better temperature map!

Note where the hottest temperatures occur



EXPLORING THE EVIDENCE . . .





Thought Q1. Why does the ocean surface warm more slowly than the land surface?

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

Clicker Q3 - 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

Clicker Q3 - 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

EXPLORING
THE EVIDENCE . . .

Thought Q2.

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

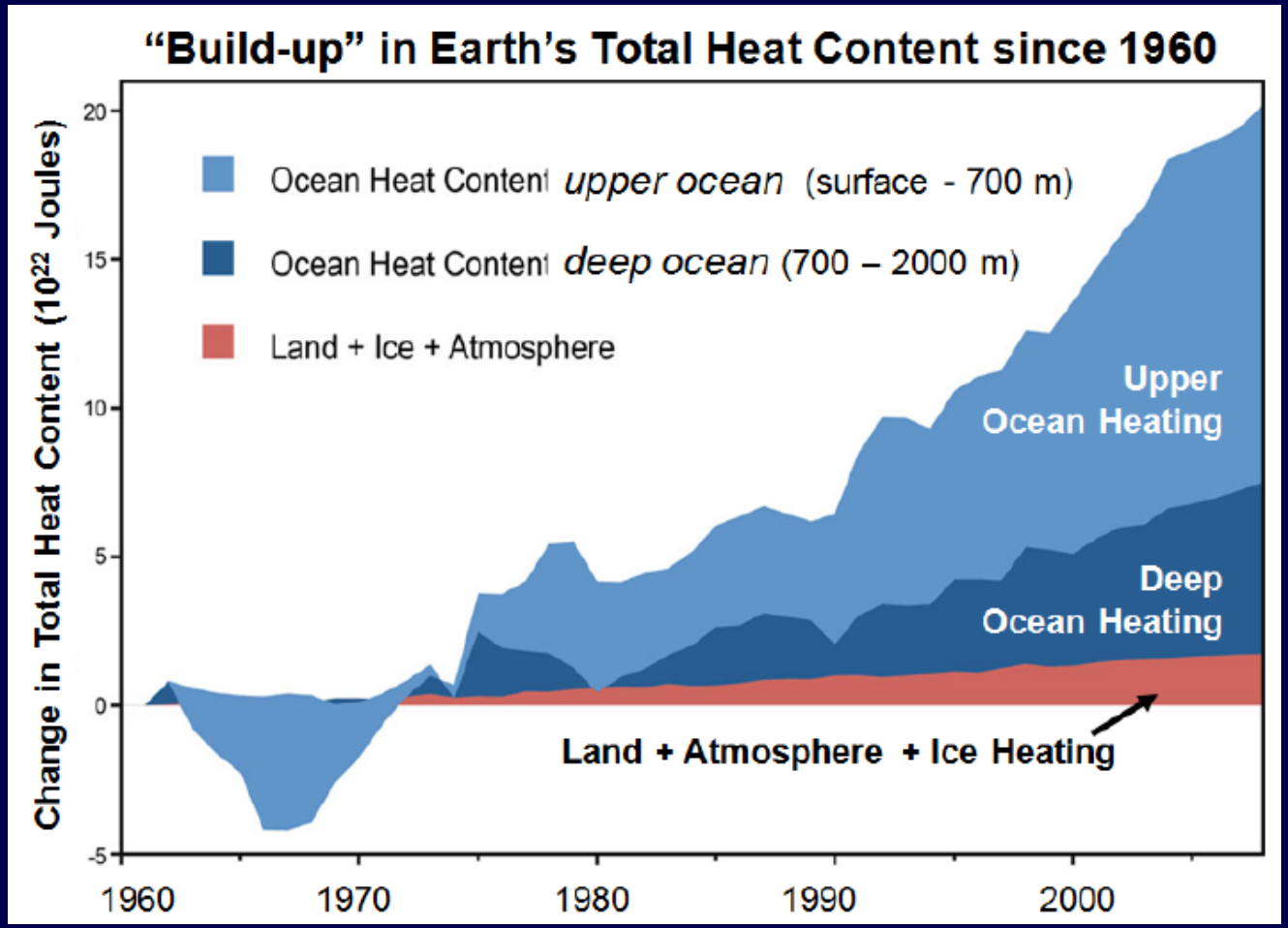


Figure: http://www.skepticalscience.com/earths-climate-system.html updated Dec 2013

CHECKPOINT

Got all that Homer?

OK, LET'S MOVE ON TO PART C . . . . .

on p 39 ➔

THERMAL ENERGY TRANSFER
(aka "Heat Transfer")

Heat Transfer

the process by which thermal energy moves from one place to another . . .

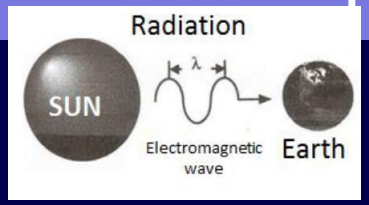
CONDUCTION = passage of thermal energy through a body **without large-scale movement of matter** within the body. Occurs through the transfer of **vibrational energy from one molecule to the next** through the substance. In general, solids (esp. metals) are good conductors & liquids and gases (esp. air) are poor conductors.

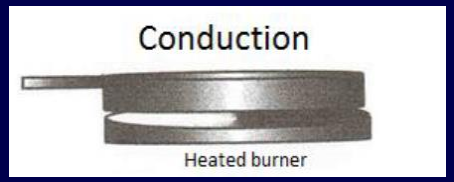
CONVECTION = passage of thermal energy through a fluid (liquid or gas) **by means of large-scale movements of material within the fluid,** as in a ***convection cell.***

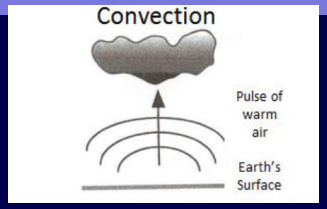
RADIATION = the transfer of thermal **energy in a wave or pulse of *electromagnetic radiation*** (as in a photon) or IR wavelength. The only one of the three mechanisms of heat transfer that **does *not* require atoms or molecules (matter)** to facilitate the transfer process.

READ IT!
3 ways of heat transfer

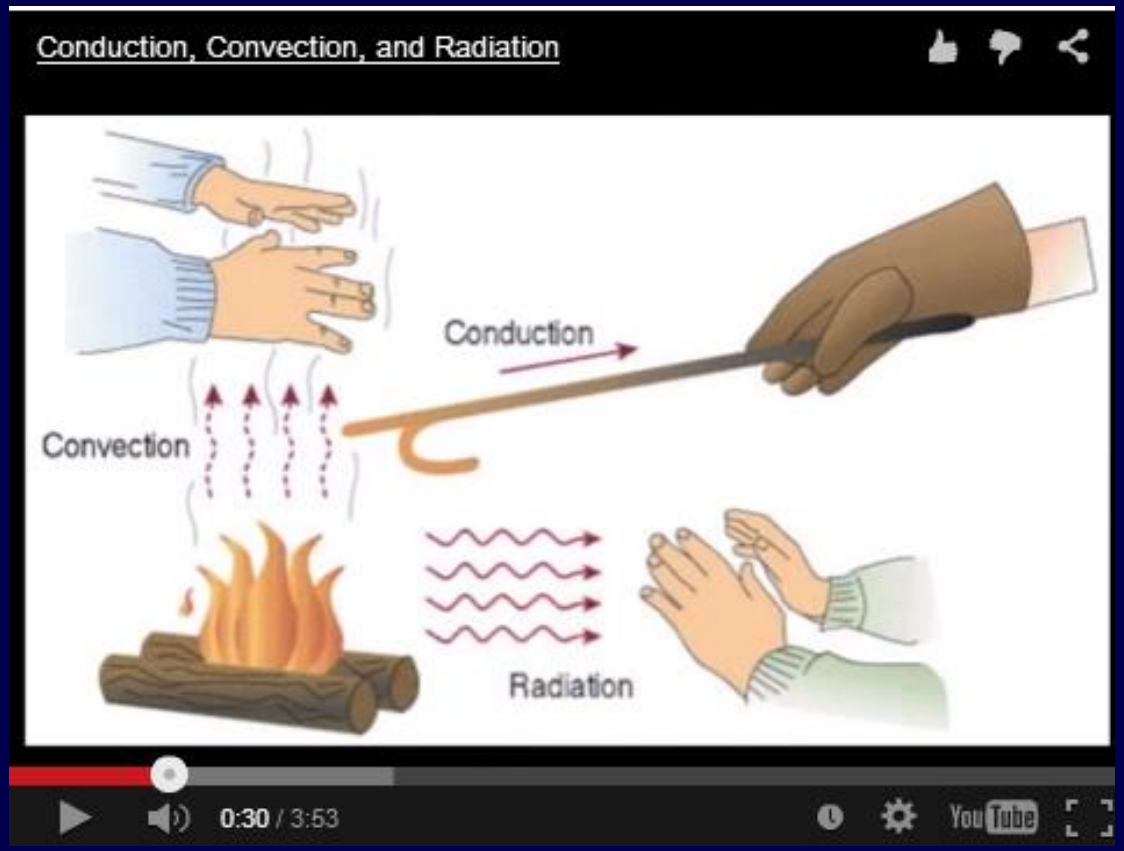
PART C – Thermal Energy Transfer







VIDEO:
"There are three ways that HEAT can travel"



https://www.youtube.com/watch?feature=player_embedded&v=7Y3mfAGVn1c

HEAT TRANSFER

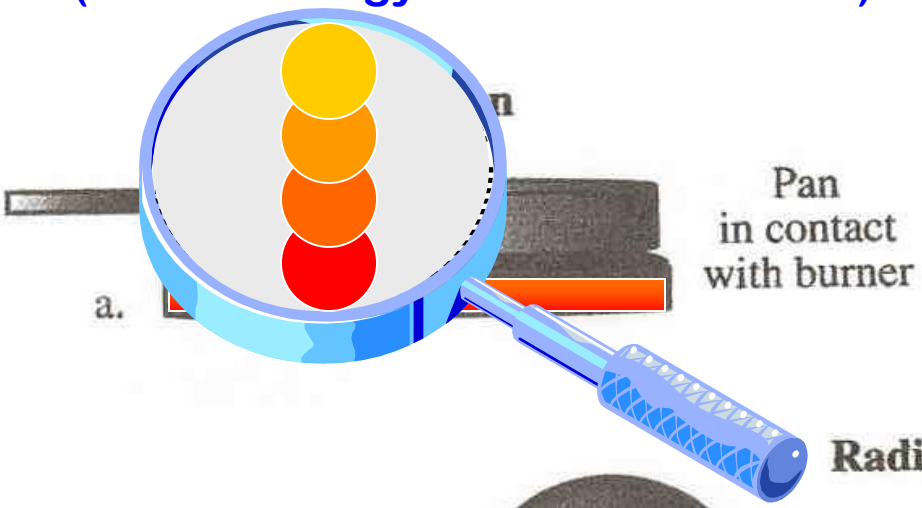
CONVECTION

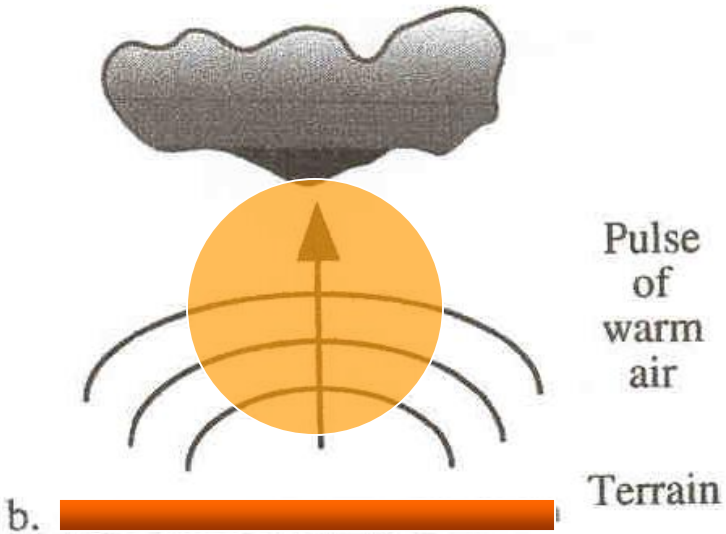
Mass of warm air or liquid heats, expands, rises

CONDUCTION

Jiggling molecule ➔ jiggling molecule transfer of heat

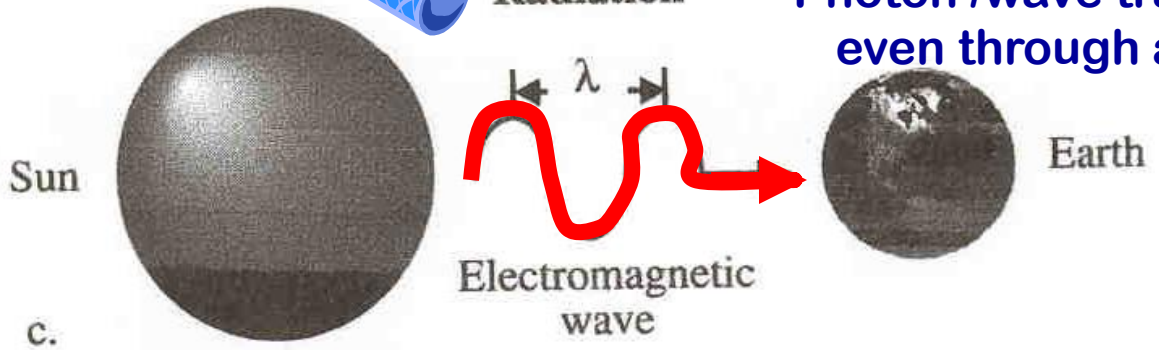
(kinetic energy at molecular scale)





RADIATION

Photon /wave transport: even through a void!



Electromagnetic Radiation

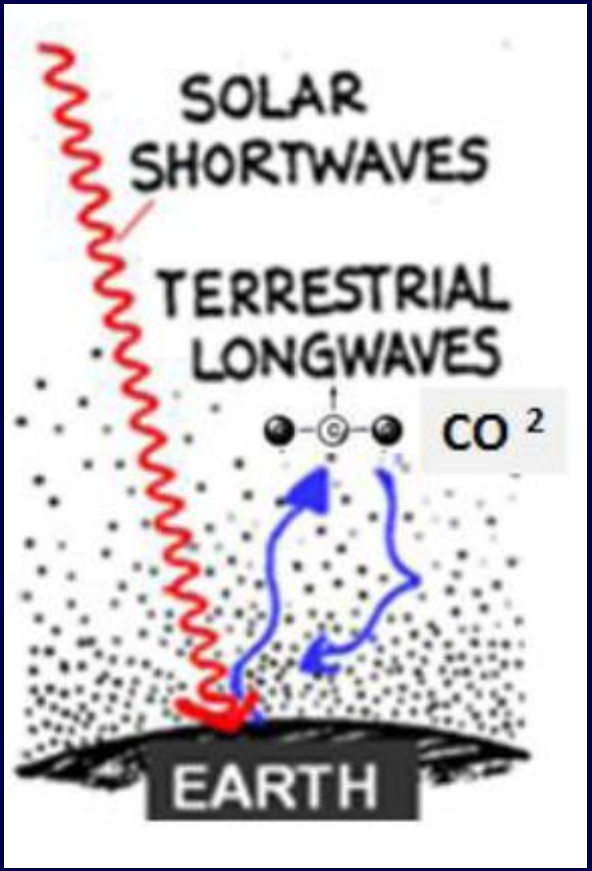
(a KEY POINT about it!)

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.

How does this concept relate to & this FIGURE?

Electromagnetic energy is <u>not</u> HEAT energy.



Electromagnetic Radiation

WHAT IS THE LINK TO GLOBAL CHANGE?

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, by certain gases in the atmosphere -- by the GREENHOUSE GASES

Got all that Homer?

THINKING DEEPLY
WRAP-UP

Participation Point Activity: BONUS POINTS FOR THOSE WHO WERE PRESENT IN CLASS TODAY!

Get a blank index card from you group folder,
put Name & Group # on it &
all present sign your names!

As a Group, pick one NEW thing you learned today about THERMODYNAMICS
& reflect on what it has to do with
GLOBAL CLIMATE CHANGE.
Then explain this in a short paragraph

Can I go now????

YES!!