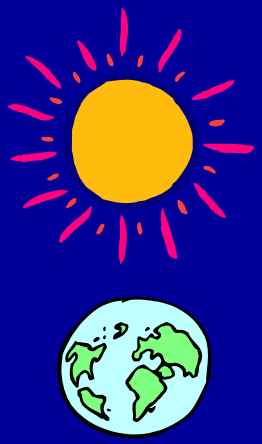
TOPIC # 6
The RADIATION LAWS
PART 2

Class Notes p 31

OBJECTIVES:



To understand more essentials about
Solar radiation
&
Terrestrial radiation

based on the principles of the last 2 **"Radiation Laws."**

THE RADIATION LAWS

Review of Laws # 2 – 4

Fill in Top of p 31

REVIEW: Match each equation with the correct phrase below & fill in the name of the LAW:

(a) $E = \sigma T^4$ (b) $E = hc/\lambda$ (c) $\lambda_m = a/T$

"The hotter the body, the shorter the wavelength"
The cooler the body, the longer the wavelength"

"The hotter the body, the (much) greater the amount of energy flux or radiation"

"SHORTER wavelengths have HIGHER intensity radiation than LONGER wavelengths"

Top of p 31

ANSWERS!

(c) $\lambda_m = a / T$ **Wien's Law**

"The hotter the body, the shorter the wavelength"
The cooler the body, the longer the wavelength"

(a) $E = \sigma T^4$ **Stefan-Boltzmann Law**

"The hotter the body, the (much) greater the amount of energy flux or radiation"

(b) $E = h c / \lambda$ **Planck Function**

"SHORTER wavelengths have HIGHER intensity radiation than LONGER wavelengths"

On to the last two laws . . . .

These last two laws (#5 and #6) will not be on the Friday's test . . .
Laws # 1-4 will

LAW #5: Radiation & distance -- the inverse-square law

The inverse square law describes:

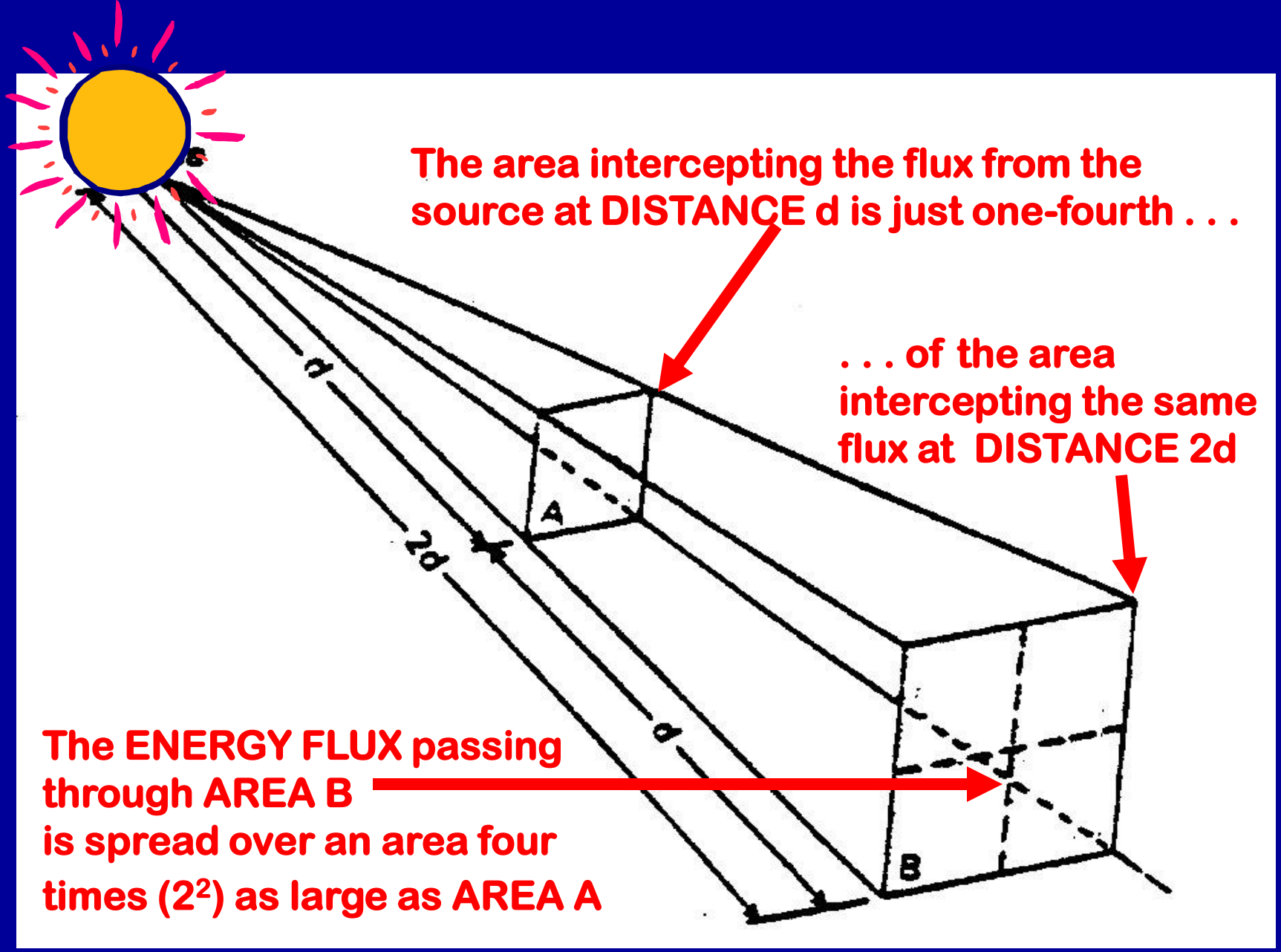
how solar FLUX of ENERGY
decreases
with increasing DISTANCE
from the source of
the radiation flux
i.e., the Sun

INVERSE SQUARE LAW =

The amount of radiation passing through a particular unit area is:

INVERSELY PROPORTIONAL
to the
SQUARE of the distance
of that unit area from the source

$$(1/d^2)$$


The area intercepting the flux from the source at DISTANCE d is just one-fourth . . .
. . . of the area intercepting the same flux at DISTANCE 2d
d
2d
A
B
The ENERGY FLUX passing through AREA B is spread over an area four times (2^2) as large as AREA A

Inverse-Square Law (easy way):

If we double the distance from the source to the interception point, the intensity of the radiation decreases by a factor of

$(1/2)^2 = ¼$

OR

If we triple the distance from the source to the interception point, the intensity decreases by a factor of

$(1/3)^2 = 1/9$ . . . . etc, etc.

OR

if we reduce the distance from the source to the interception point by a factor of 2 or 3, the intensity of the radiation increases by a factor of

$2^2 = 4$

or

$3^2 = 9$

. . . etc, etc.

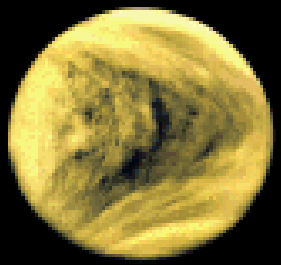
Why is this concept important?

Because it means that relatively SMALL changes in distance from the source of energy (e.g., the Sun)

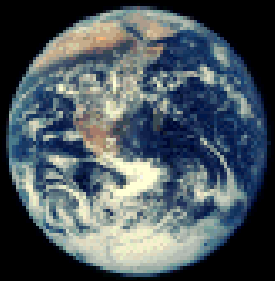
can result in LARGE changes in the amount of energy received by a planet's surface.

GOLDILOCKS & THE 3 PLANETS

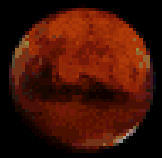
To Sun



VENUS

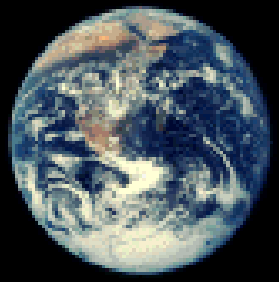


EARTH



MARS

GOLDILOCKS & THE 3 PLANETS

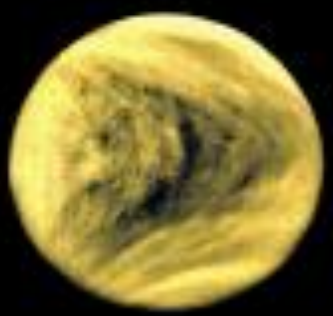


Yikes! Venus is too HOT!

GOLDILOCKS & THE 3 PLANETS

Brrrrrrrrrr, Mars is too COLD!!

GOLDILOCKS & THE 3 PLANETS



Ahhhh! Earth is JUST RIGHT!

But is being at "just the right distance" the primary determinant of Earth's temperature?

IT'S IN 'GOLDILOCKS' AREA, BUT HOT AND INCREDIBLY HUMID

Worse-than-Florida planet is in life zone

The Associated Press The Associated Press | Posted: Tuesday, September 13, 2011 12:00 am

WASHINGTON - Astronomers believe they have found a second planet outside our solar system that seems to be in the right zone for life, just barely. But it would feel like a steam bath - hot, sticky and beyond ur

The most exciting of those planets is only the second to be confirmed as lying in what astronomers call the "Goldi-locks zone." That means it's not too hot and not too cold for liquid water to be present. Water is the key to a planet being able to support Earth-like life, scientists say.

Eu sy cc cc sc

O A pl

Tl with plenty of humidity.

"It's going to be really muggy - just think about the muggiest day you can think of," said study author Lisa Kaltenegger, an astronomer with the Max Planck Institute in Germany. "We're not saying it's habitable for you and me."

But other types of life - probably shorter and squatter life - could conceivably take root there, she said. They would probably be closer to the ground than humans because gravity on this larger-than-Earth planet is about 1.4 times what we experience, she said.

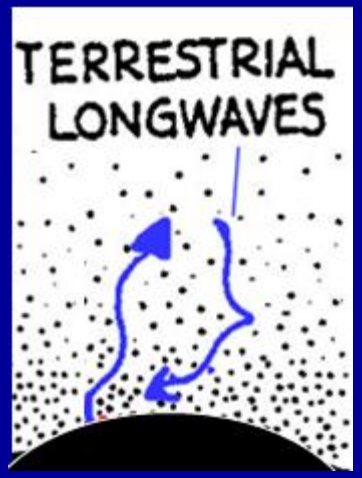
For it to be considered livable by astronomers, at least 60 percent of it would have to be covered in clouds, Kaltenegger said. Earth has about 50 percent cloud cover, so 60 percent seems reasonable, she said.

The new planet, called HD85512b, closely circles a star about 35 light-years from Earth in the constellation Vela. Each light-year is 5.8 trillion miles. The only reason it might not be too hot for life is that its sun is about 1,800 degrees cooler than ours, Kaltenegger said.

Artist's rendition!

The planet HD85512b is in the constellation Vela, about 35 light-years from Earth.

Temperatures there may hit 120 deg F



The absorption of terrestrial Longwave Infrared radiation by Greenhouse Gases in the atmosphere, and the re-radiation of Longwave Infrared energy from the atmosphere to the Earth's surface by GH Gases. . .

. . . is what keeps the Earth in the "just right" temperature range for water to be present in all 3 phases . . . . . . and just right for US too!

Without the "Greenhouse Effect" the Earth would be TOO COLD for life as we know it!


Thanks, Greenhouse Effect!

Q1 The inverse-square law – when applied to the distance between a planet and the Sun -- IS what determines that planet's temperature.

YES or NO?

1. **Yes, this is what the Goldilock's Effect is illustrating.**

2. **No, how much solar energy the planet reflects back must also be taken into account**

3. **No, whether or not the planet has a greenhouse effect must also be taken into account.**

Q1 The inverse-square law – when applied to the distance between a planet and the Sun -- IS what determines that planet's temperature.

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2. **No, how much solar energy the planet reflects back must also be taken into account**
3. **No, whether or not the planet has a greenhouse effect must also be taken into account.**

Both 2 & 3 are correct!

TRICK QUESTION!

LAW #6: Selective emission and absorption

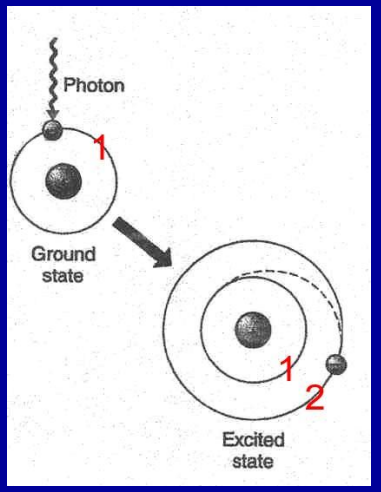
Part (a) of the law:

Some substances emit and absorb radiation at certain wavelengths only.

This is mainly true of gases.

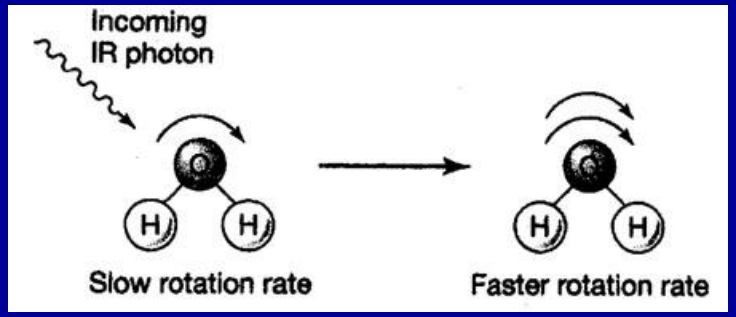
Why?

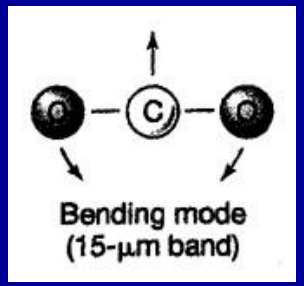
Recall QUANTUM BEHAVIOR!

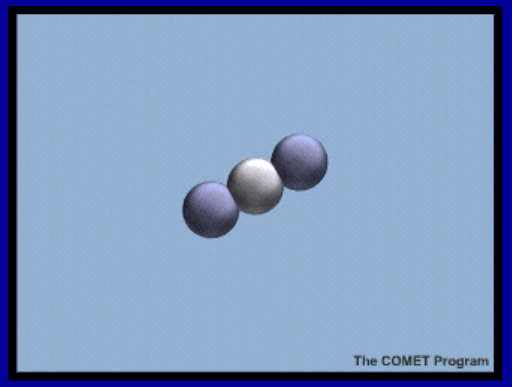


ELECTRON energy states allow absorption of photons/wavelengths of only a specified frequency

Different GAS MOLECULES allow absorption of photons/wavelengths of only specified frequencies (and wavelengths) because of how the gas molecules vibrate, bend, and rotate







Part (b) of the law:

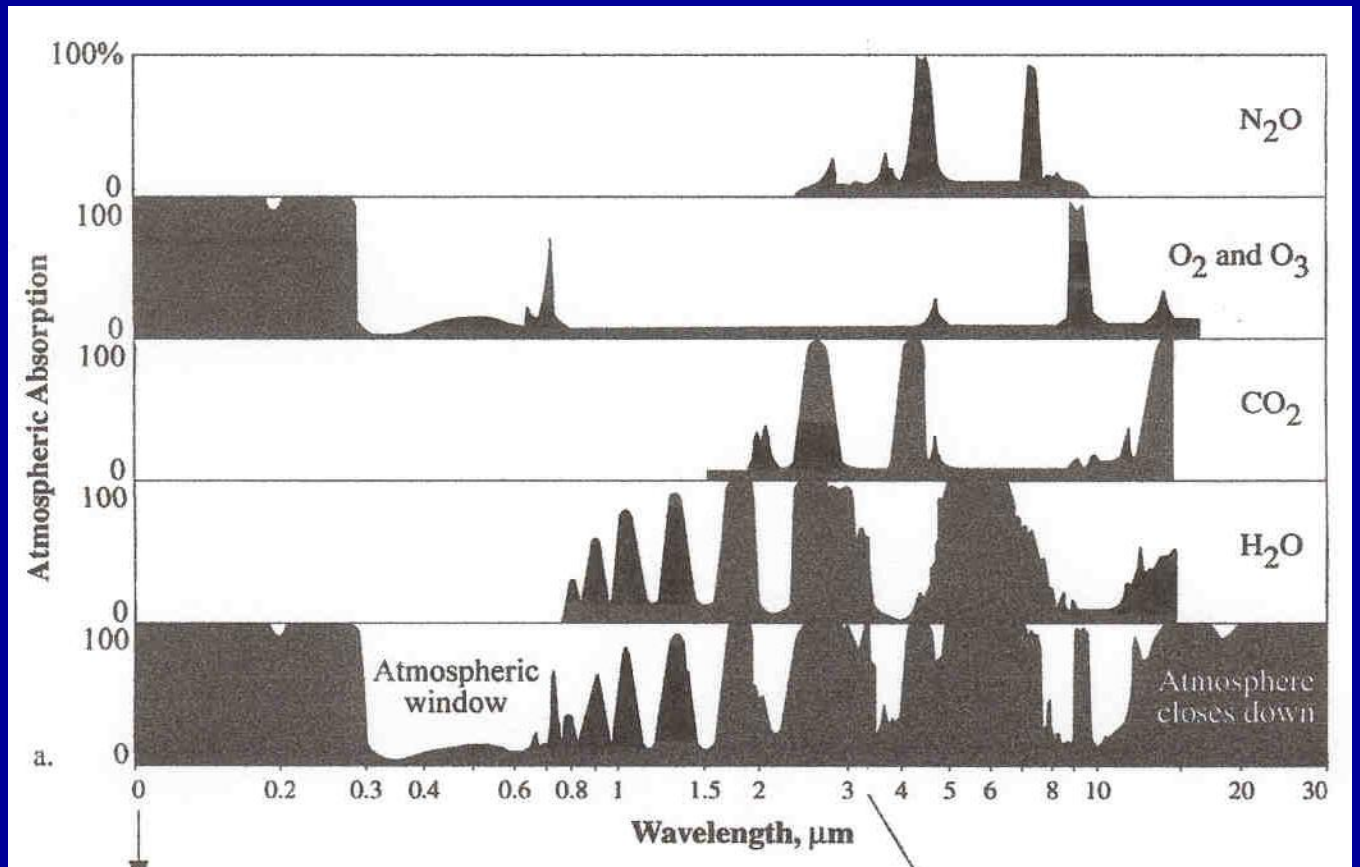
Some substances (like gases) absorb only radiation of wavelengths they can emit.

Implications of Part (b):

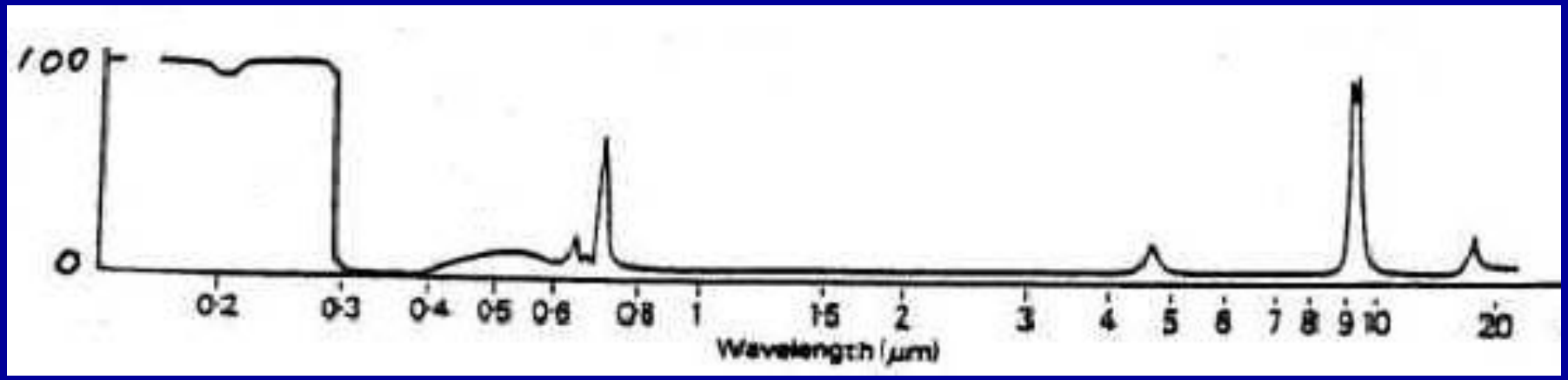
The **frequency & wavelength** of a photon absorbed by a given electron, atom, molecule **will be the same as** the frequency / wavelength with which it is emitted.

The pattern of electromagnetic wavelengths that are absorbed & emitted by a particular atom (or combination of atoms)

is called its ABSORPTION SPECTRUM or its ABSORPTION CURVE

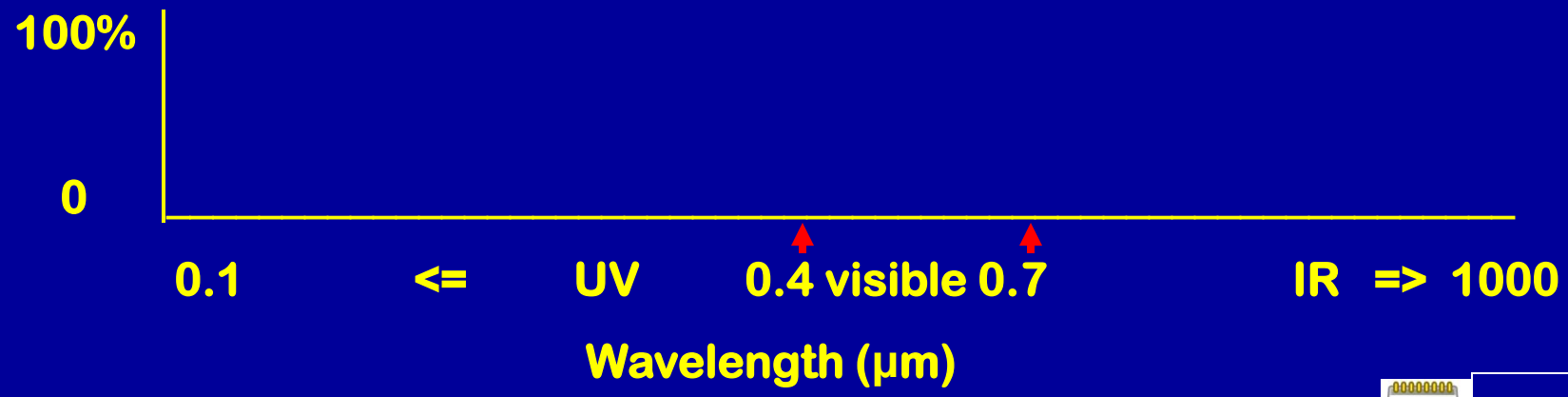


An absorption curve: another view (without shading under the curve)



ABSORPTION CURVES

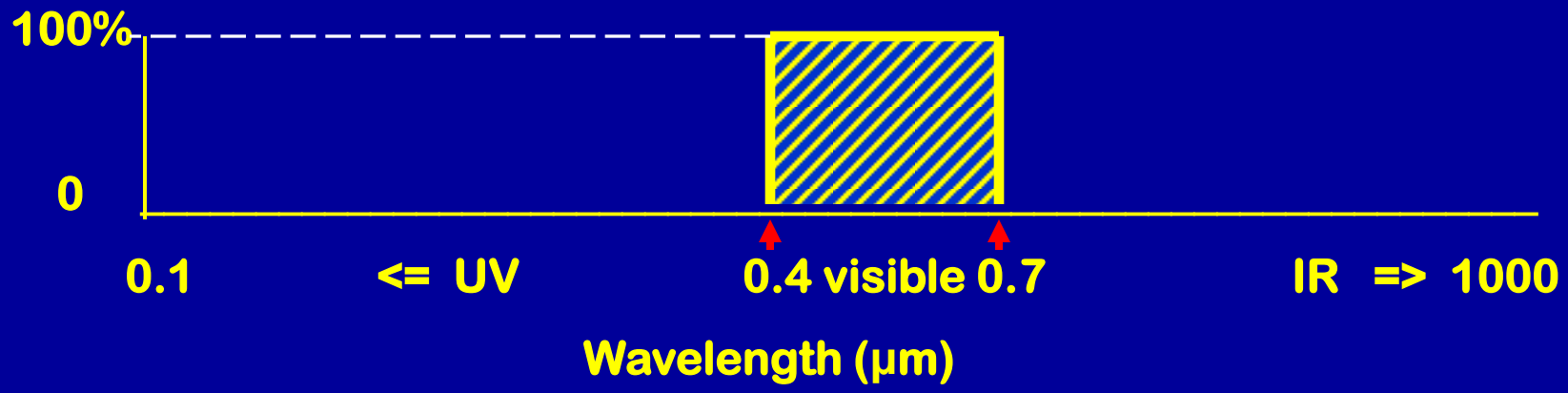
We use an absorption curve to show the relationship between **wavelength** (along the horizontal axis)
and
% of energy at a given wavelength that is **absorbed** (vertical axis):



Top p 32

What would a curve for a hypothetical gas that absorbs ALL VISIBLE LIGHT but NO UV or IR

LOOK LIKE ??



GROUP ASSIGNMENT G-1
Understanding Absorption Curves

☼ **GROUP ASSIGNMENT G-1: UNDERSTANDING ABSORPTION CURVES** (worth 5 pts)

GROUP # _____

	Each Group Participant's SIGNATURE:	*PRINT NAME legibly next to the signature:*
GROUP LEADER:	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____
	_____	_____

TODAY's GROUP LEADER = 1st in the ALPHABET on your Group List

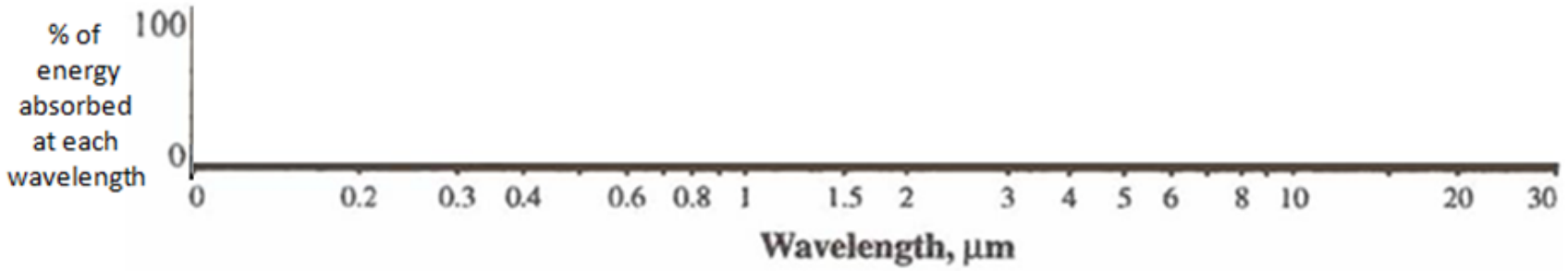
Pass the GROUP form around so each member of the group SIGNS IT & PRINTS THEIR NAME

BACKGROUND:

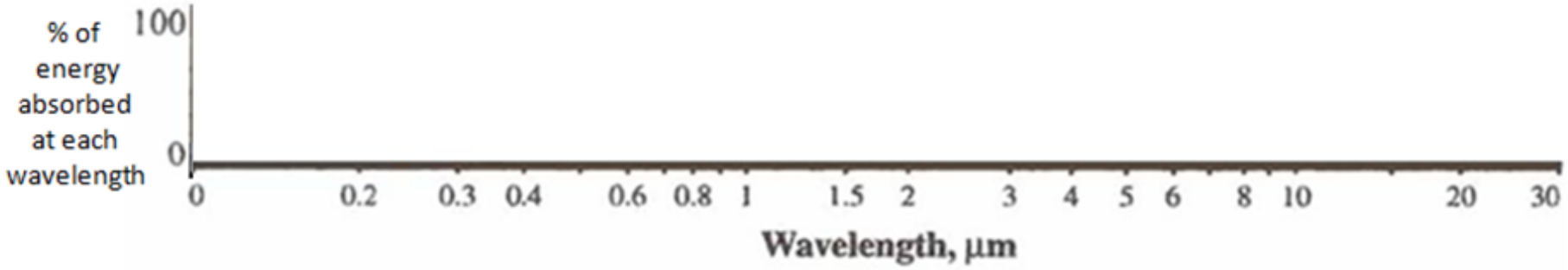
ABSORPTION CURVES (diagrams that show *which* wavelengths of energy different gases selectively absorb)

We use an **absorption curve** (graph) to show the relationship between **wavelengths** of the electromagnetic spectrum (along the horizontal axis) and the **% of energy at each wavelength** that is absorbed by a particular gas (vertical axis)

Q1. *Draw an absorption curve for a hypothetical gas that can absorb ALL UV radiation but zero visible light and IR radiation. Then* ***shade in the area under your curve*** *in this and subsequent questions.*



Q2. *Draw an absorption curve for a "perfect" greenhouse gas that absorbs ALL IR radiation, but no visible or UV:*

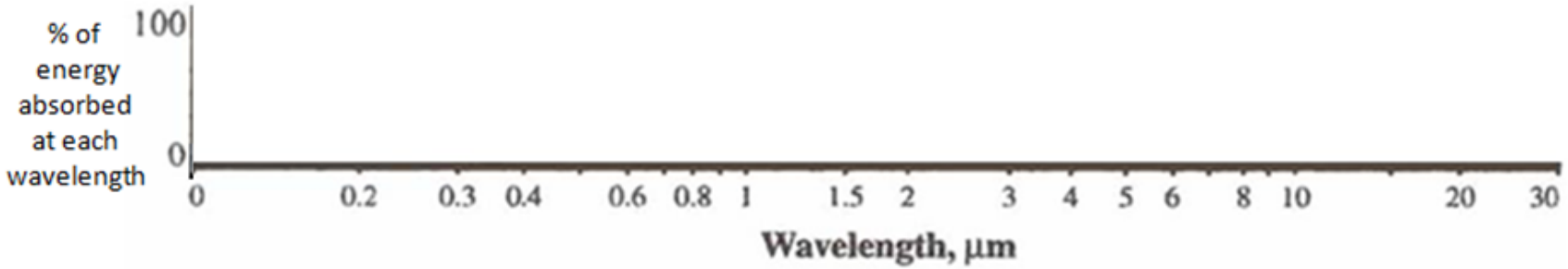


Review for Q2:

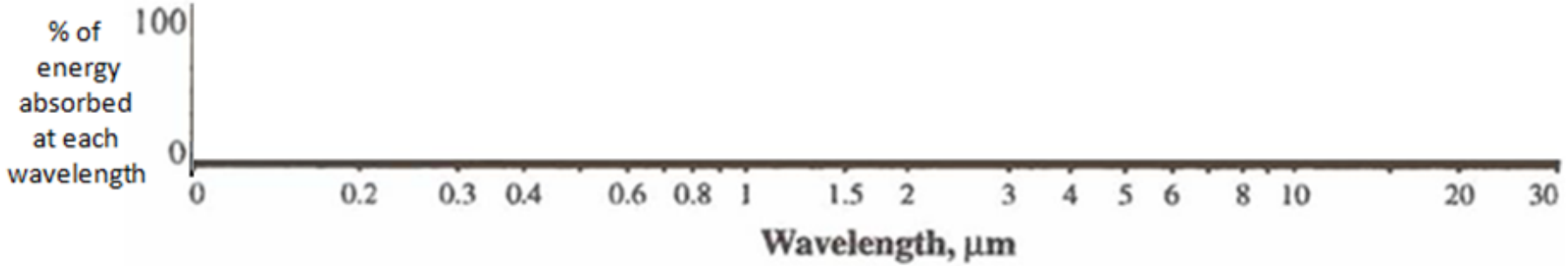
DEFINITION OF GREENHOUSE GASES

(def): **Greenhouse gases are gases which both absorb and emit electromagnetic radiation in the infrared (IR) part of the spectrum.**

Q3. *Draw an absorption curve for a hypothetical gas that absorbs ALL UV radiation and ALL IR radiation, but leaves a "WINDOW" open for visible light, allowing the visible light wavelengths to pass through the gas unimpeded <u>without</u> being absorbed:*



Q4. *Draw an absorption curve for a hypothetical gas that can absorb 100% of the IR radiation in these three wavelength bands*: **band from 2 to 2.5 µm** **band from 3 to 4 µm** **band from 13 to 20 µm**



Q5. Is the hypothetical gas in Q4 likely to be a GREENHOUSE GAS?

YES NO ***(circle one)***

Briefly explain WHY you answered YES or NO:

(discuss in your group first!)

CHECK YOUR ANSWERS:

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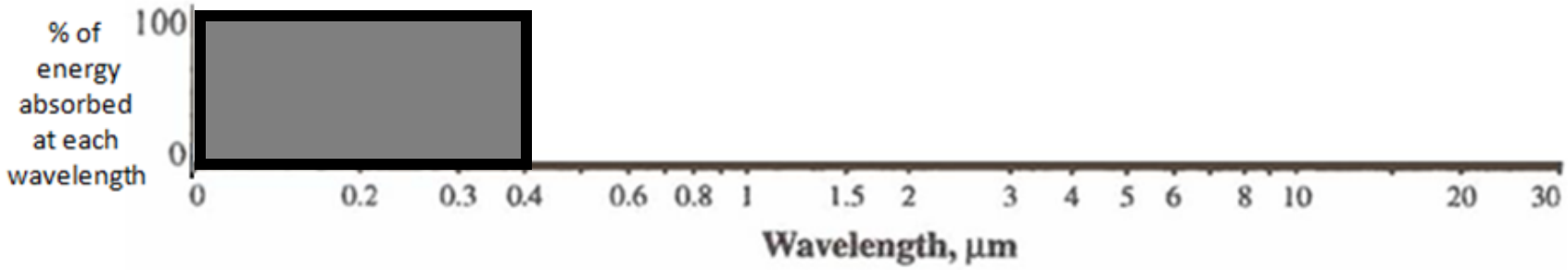

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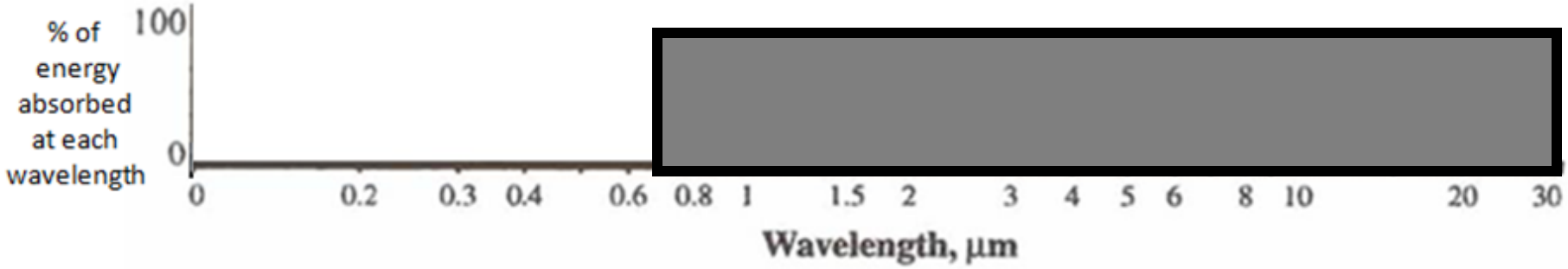

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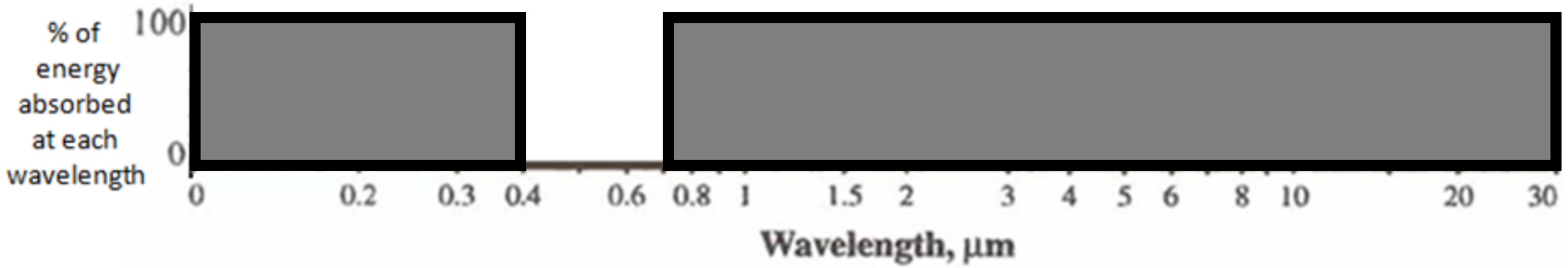

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