

Monday Sep 21st

SIT ANYWHERE TODAY!

**Wrap-Up of Topic #5 on the Radiation Laws
and start of Topic # 6**

Atmospheric & Structure & Composition



0 days to

Zero Emissions Day on September 21

The Global 24 hour Moratorium
on the use of **Fossil Fuels**

ZeDay Guidelines are simple:

1. Don't use or burn **oil** or **gas** or **coal**.
2. Minimize (or eliminate) your use of electricity generated by fossil fuels.
3. Don't put anyone in harm's way: All essential and emergency services operate normally.
4. Do your best, have fun, enjoy the day!

Our world is counting on us

It's up to each of us to take care of our planet at this point. When your driving something this large you have to stop every now and then – reflect on what's working and what's not working – and set a new course for where you really want to be. **Zero Emissions Day** provides just that opportunity to benefit everything and everyone on our planet.



National Drive Electric Week 2015

September 12-20, 2015

Going Electric: My LEAF "EV"



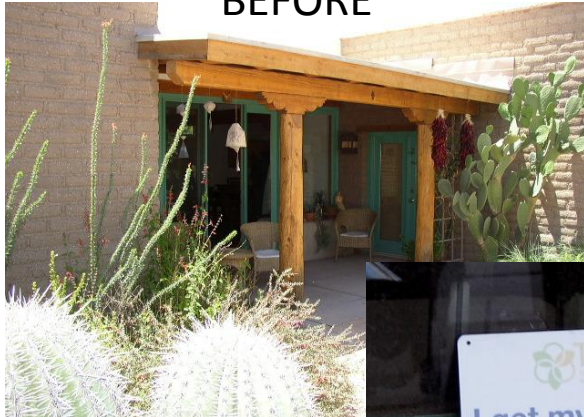
Electric
&
Solar
powered!



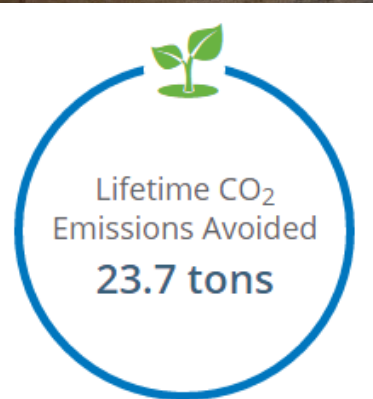
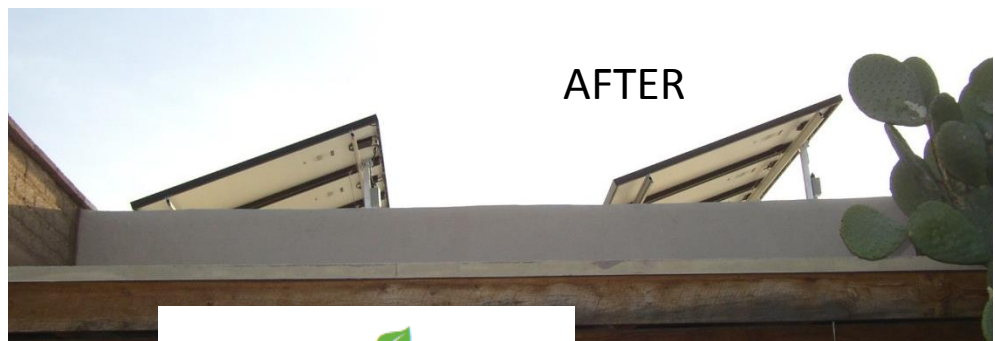
"plugging in"
at home

The Maddox-Hirschboeck Residence

BEFORE



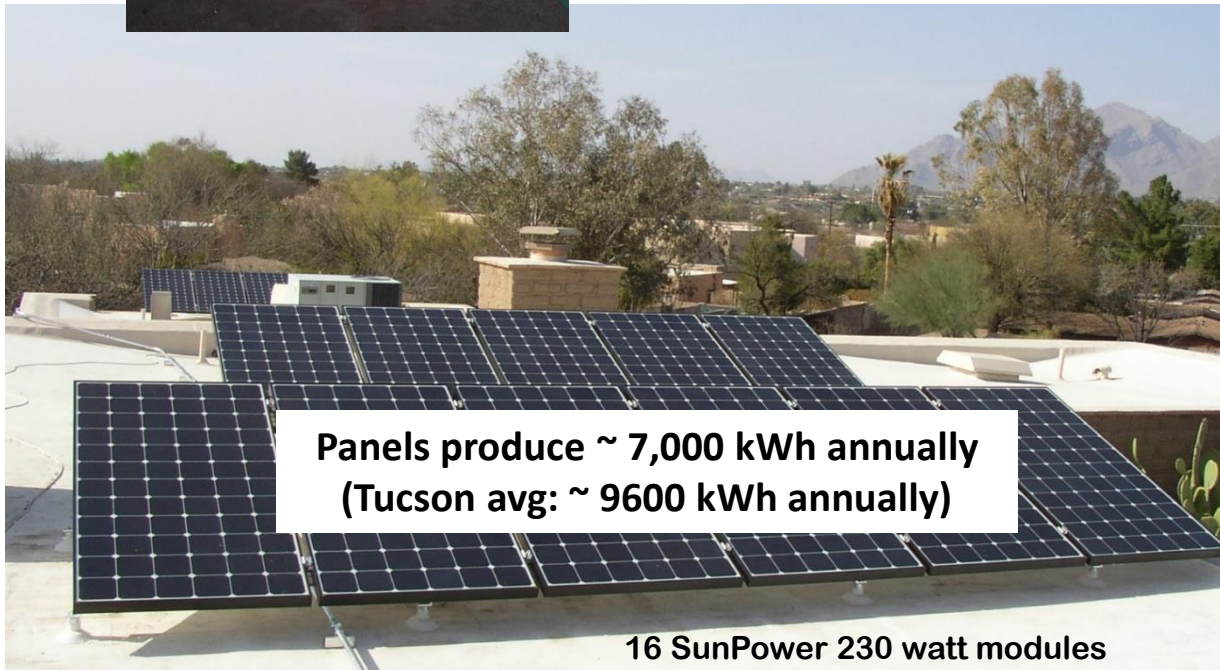
AFTER



Inverter
(DC → AC)
Solar Meter
& AC Disconnect



Net Meter
& Electric
Panel



Panels produce ~ 7,000 kWh annually
(Tucson avg: ~ 9600 kWh annually)

16 SunPower 230 watt modules



Beginning THIS WEEK . . .

Welcome to the United Nations. It's your world!

  **2015**
TIME FOR
GLOBAL ACTION
FOR PEOPLE AND PLANET

HOME ABOUT 2015 SECRETARY-GENERAL GOALS TAKE A

UNITED NATIONS
SUSTAINABLE
DEVELOPMENT
SUMMIT 2015
25-27 SEPTEMBER

< >

UN Sustainable Development Summit 2015 Search

<http://www.un.org/sustainabledevelopment/>

SEPTEMBER 21-28, 2015. NEW YORK CITY

CLIMATE
WEEK
NYC

CLIMATE WEEK NYC 2014 KICKED OFF WITH SECRETARY
JOHN KERRY, BAN KI-MOON AND APPLE CEO TIM COOK

LEARN MORE

C

We hope you are able to join us! The Climate Group is proud to convene our seventh Climate Week NYC in September 2015. Climate Week NYC brings together influential global figures - and new voices - from the worlds of business, government and society who are leading the low carbon transition. We are home to events, activities and high-profile meetings across

**CORPORATIONS AND CLIMATE ADAPTATION:
INNOVATION IN EMERGING ECONOMIES**

9/23 : 8:30am - 10:00am

Baker & McKenzie LLP

424 Fifth Avenue

New York, New York 10018

POPE ECOLOGY / POPE ECONOMICS

9/24 : 6:00pm - 8:00pm

Columbia University, East Gallery, Buell Hall

515 West 116th Street

New York, NY 10027

CLIMATE, DATA AND JOURNALISM

9/23 - 5:30pm

**BUSINESS AND CLIMATE JUSTICE: HUMAN RIGHTS
FROM THE FRONTLINES TO PARIS**

9/23 : 6:00pm - 8:00pm

Roosevelt House Public Policy Institute at Hunter College

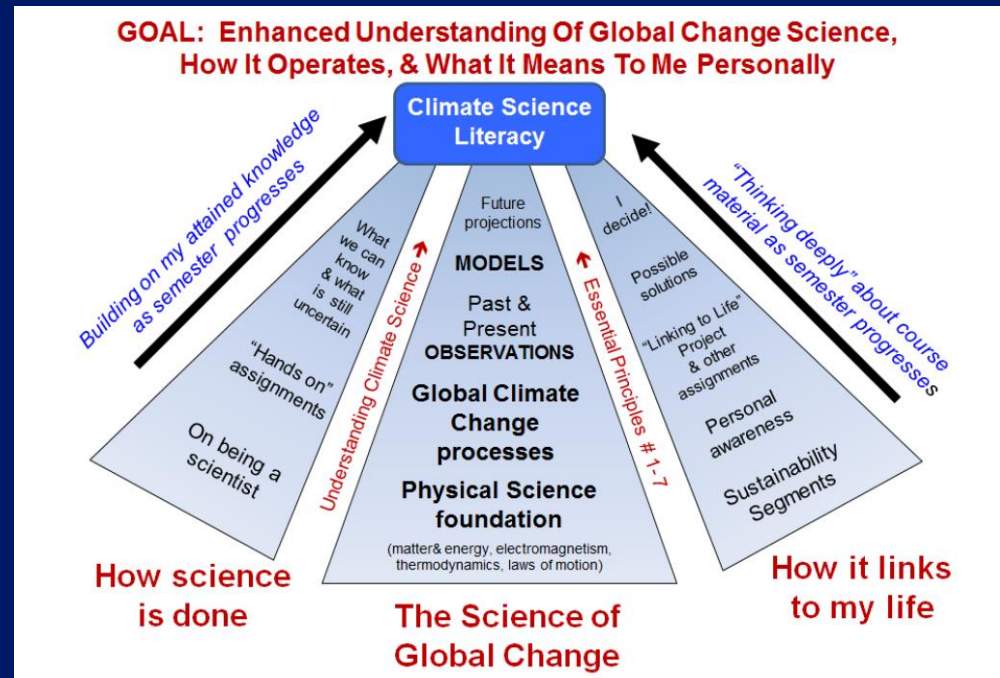
<http://www.climateweeknyc.org/>

Our CLASS:

1. Learn & Understand the **SCIENCE** underlying all this!

2. Decide for yourself

3. LINK this to YOUR LIFE in the way you want to live it **“LTL Project”**

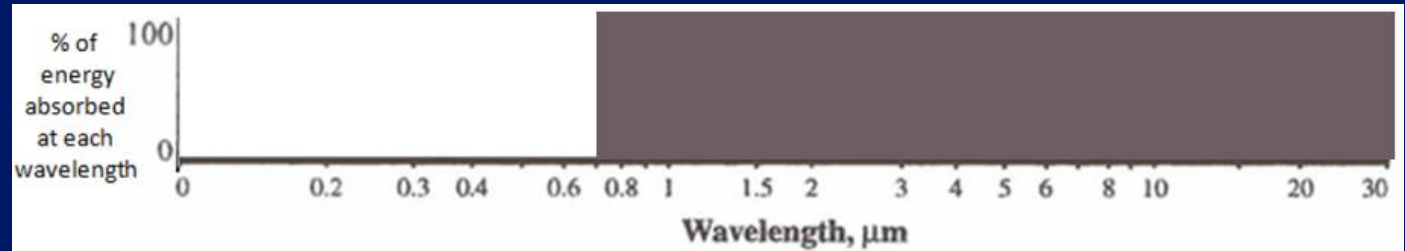


Sooooo. . . On with the SCIENCE!

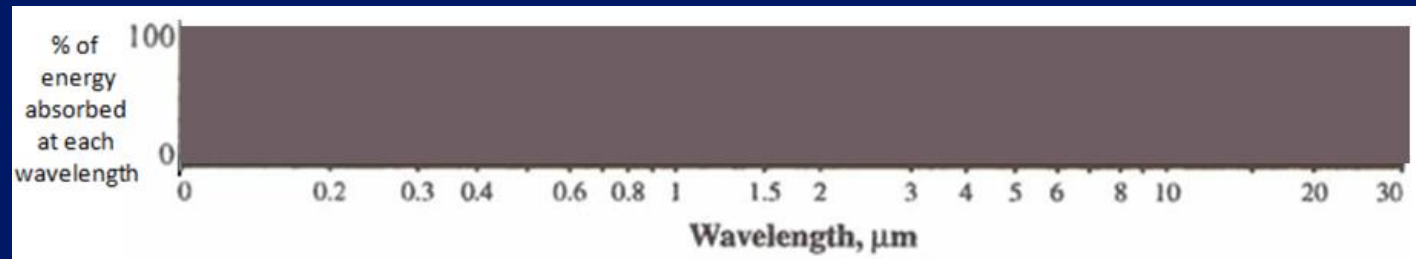
Fire up your CLICKERS for some questions to solidify the concepts from the last few classes

CLICKER Q1 Which of the following absorption curves represents a hypothetical atmosphere that has a “perfect” greenhouse effect ?

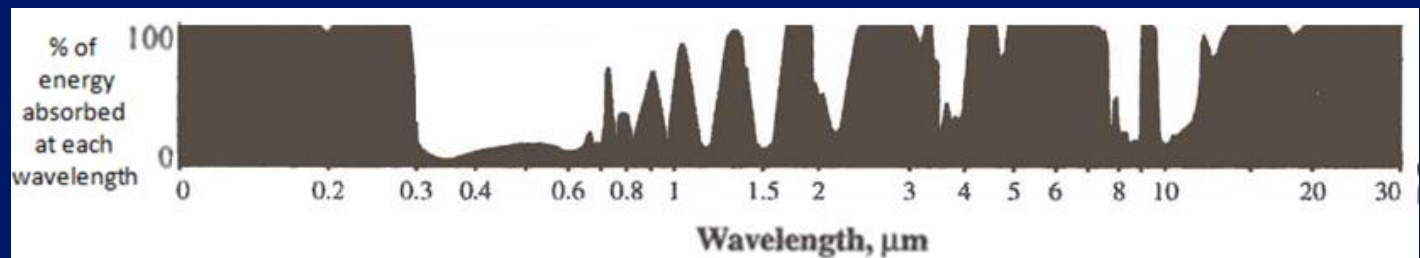
1.



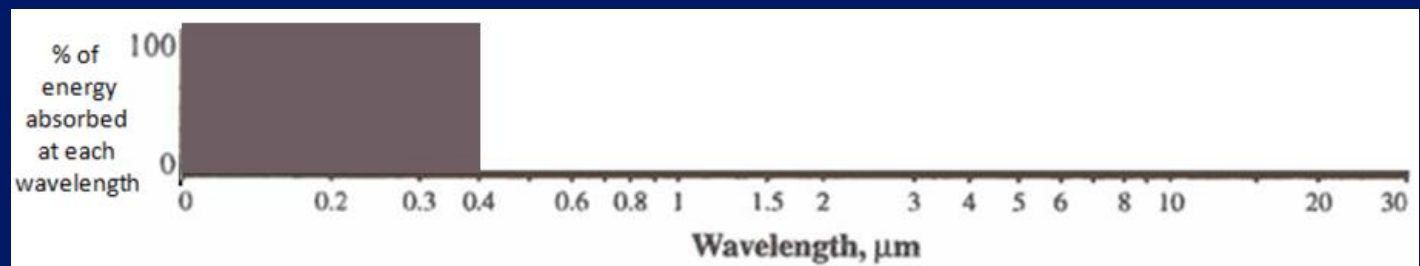
2.



3.

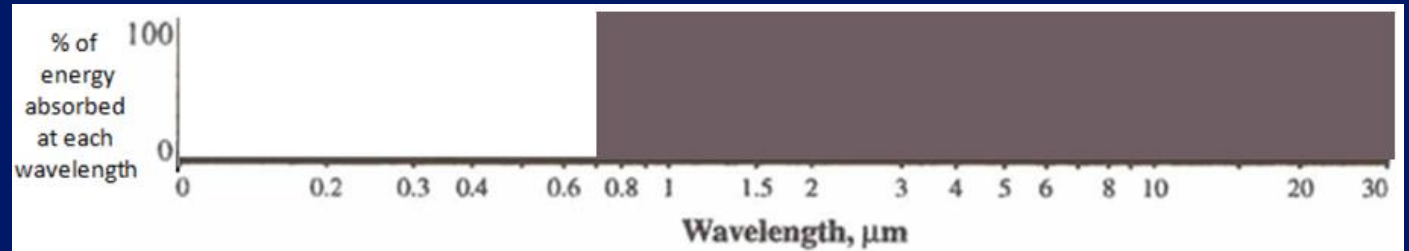


4.

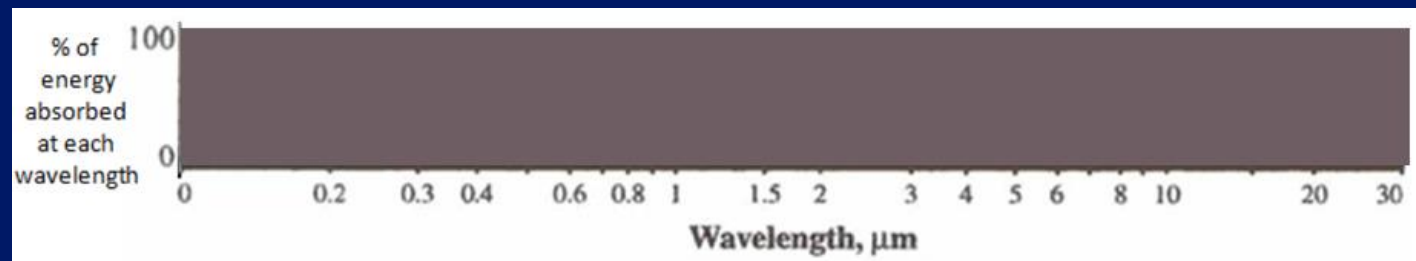


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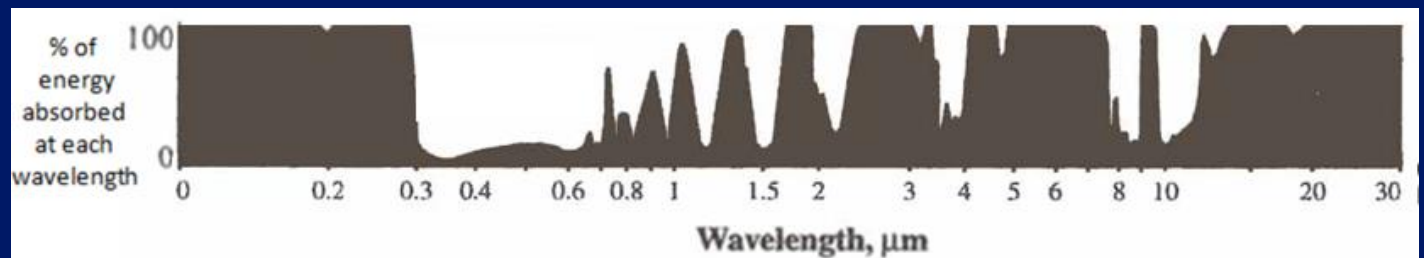
1.



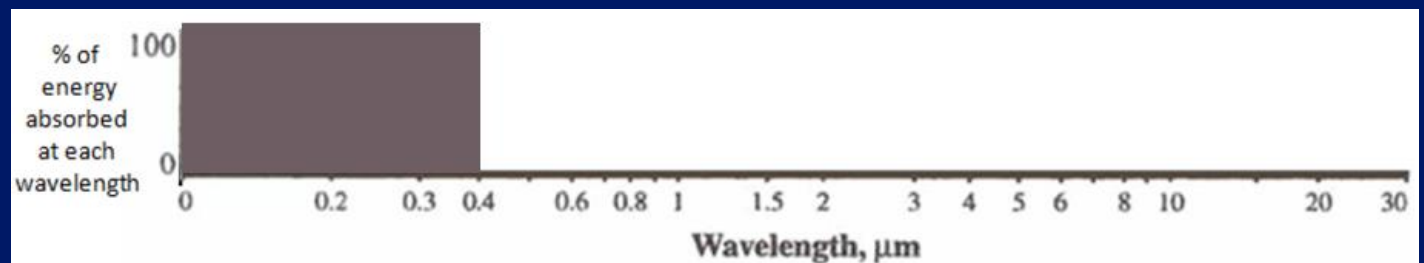
2.



3.

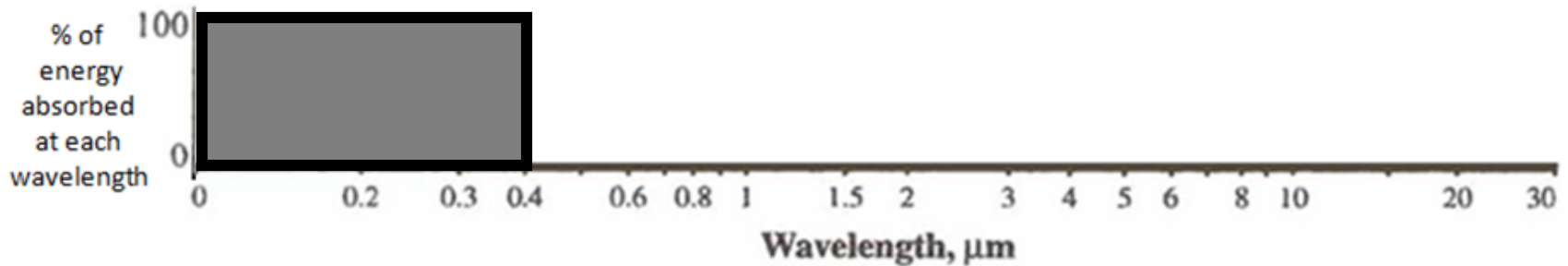


4.

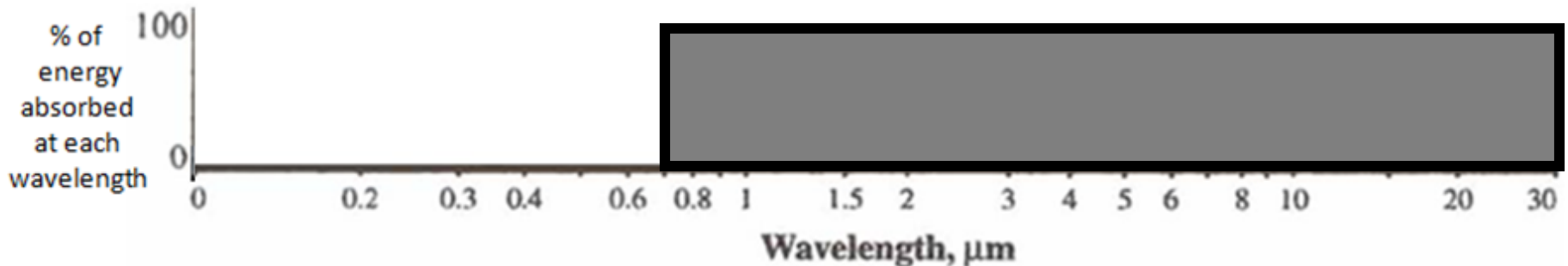


Next: The ANSWERS to the first part of G-1:

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.

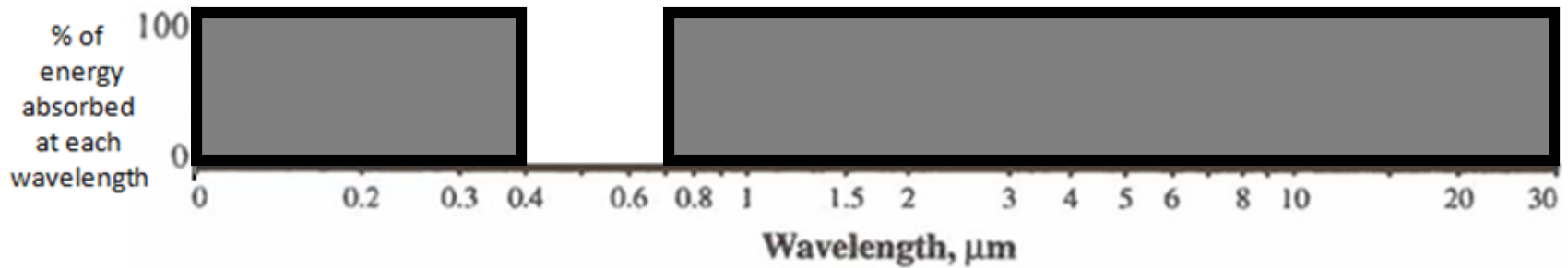


Q2. Draw an absorption curve for a "perfect" greenhouse gas that absorbs ALL IR radiation, but no visible or UV:

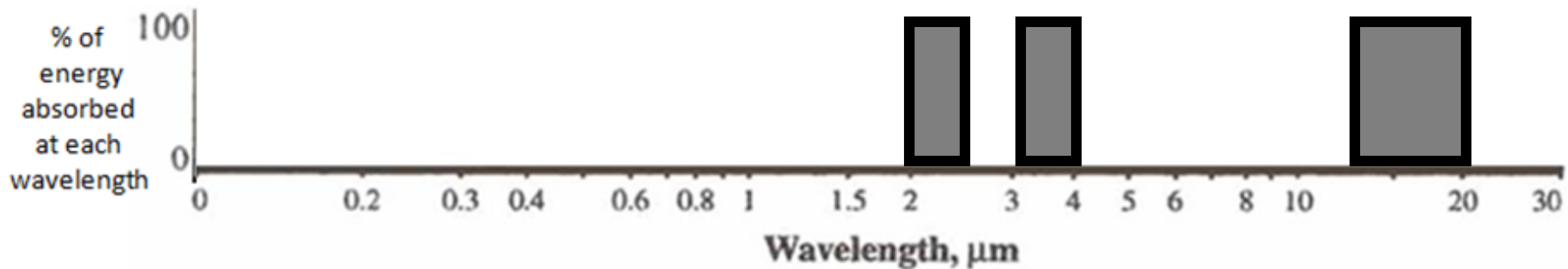


The ANSWERS to the first part of G-1:

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 without 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



The ANSWERS to the first part of G-1:

Q5. Is the hypothetical gas in Q4 likely to be a GREENHOUSE GAS? **YES** No

Briefly explain WHY you answered YES or NO, including the definition of a greenhouse gas in your answer:

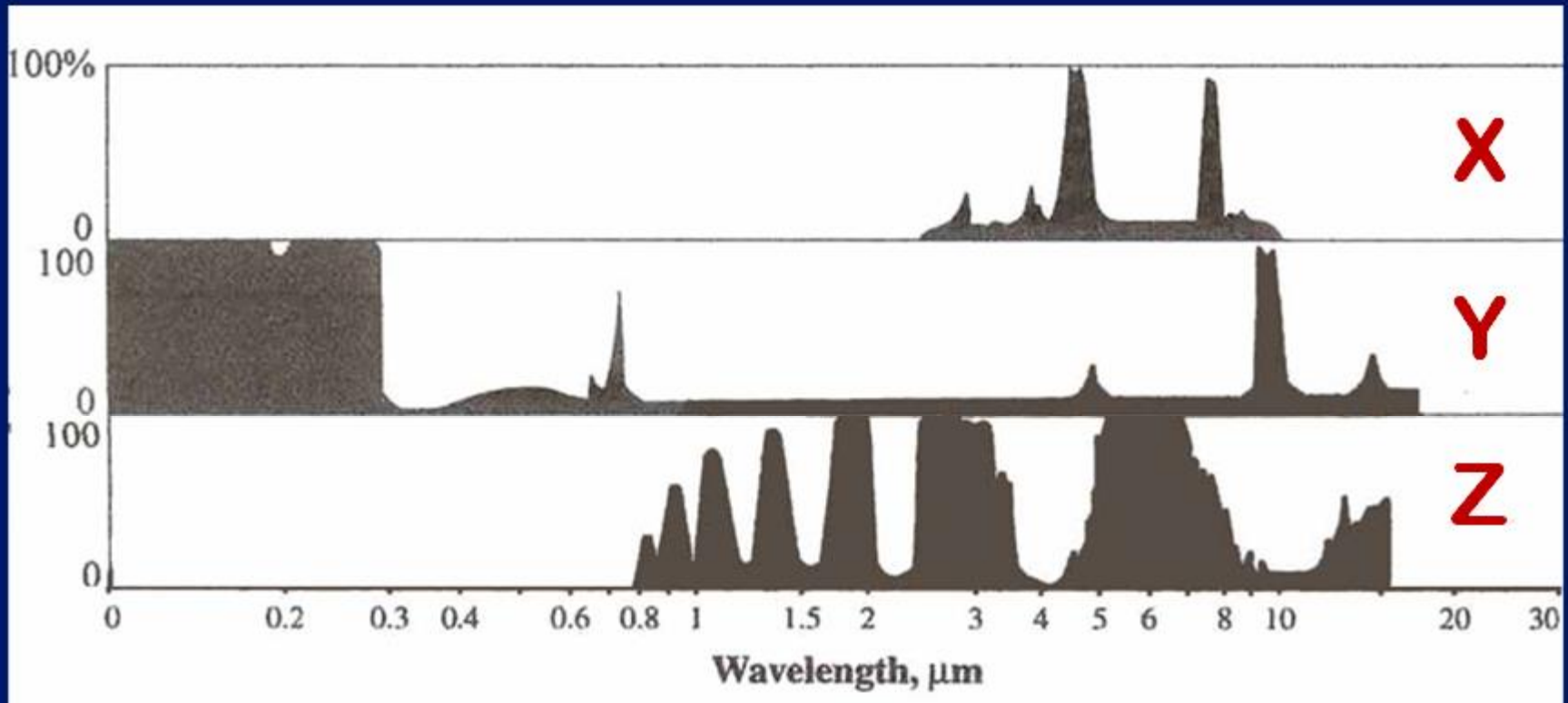
SIMPLEST ANSWER (but other wording may be correct)

A greenhouse gas is a gas than can absorb and emit infrared radiation.

The absorption curve in Q4 shows that the gas is absorbing wavelengths of energy in the INFRARED part of the spectrum, therefore it is a greenhouse gas.

CLICKER Q2 – Which of the following absorption curves is for a GAS that is **NOT** a greenhouse gas!

1: X **2: Y** **3: Z** **4: NONE of THEM**



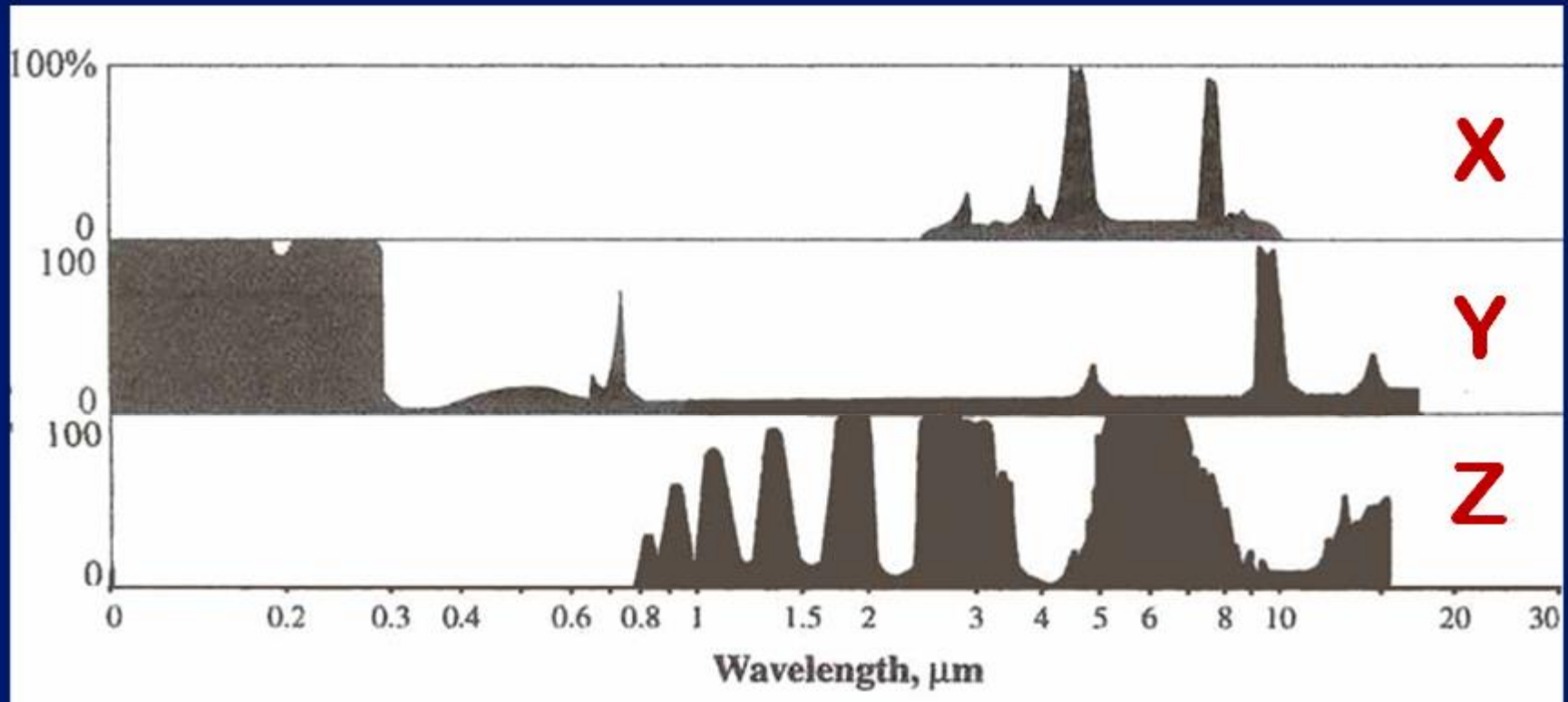
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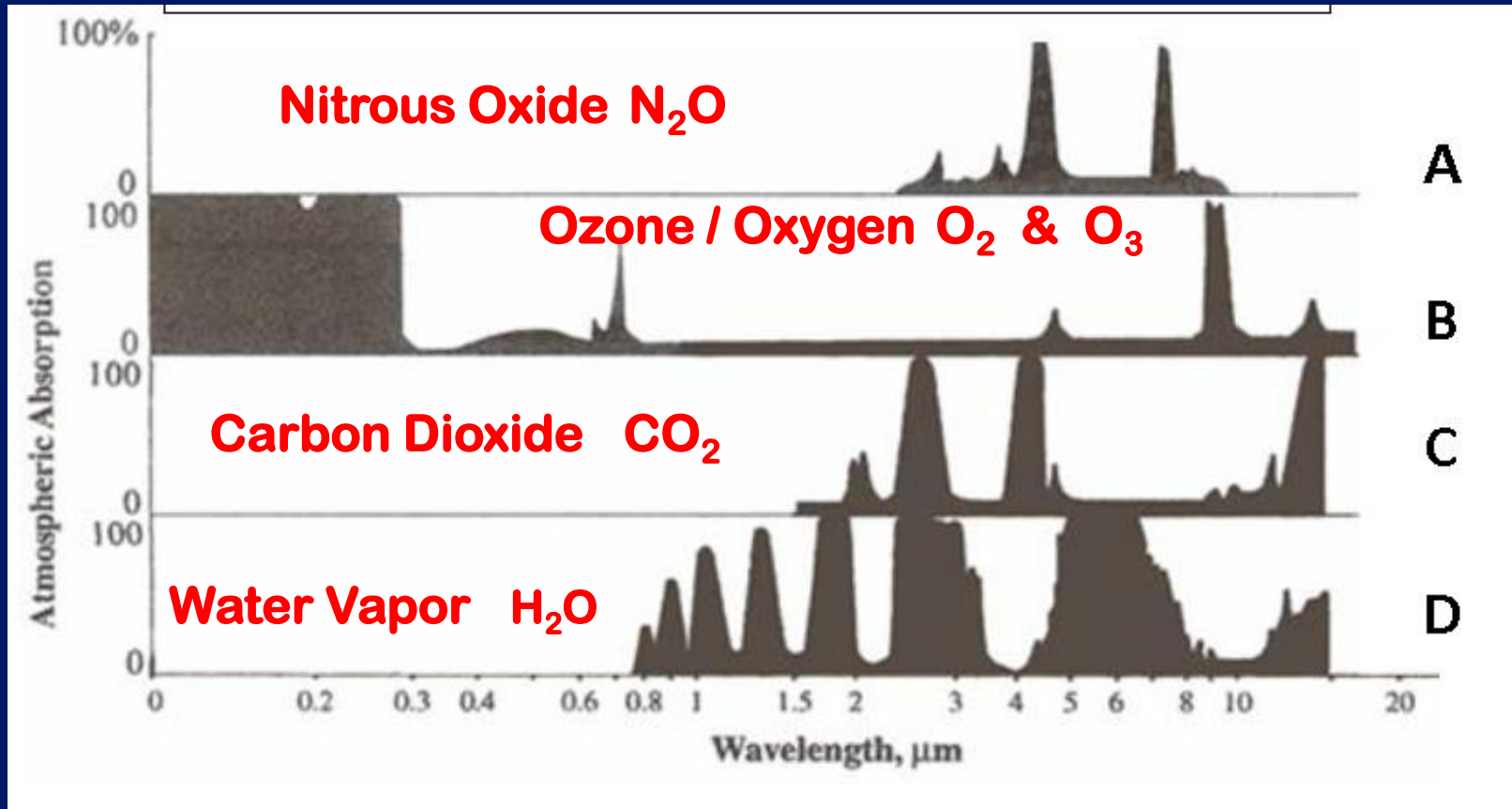
2: Y

3: Z

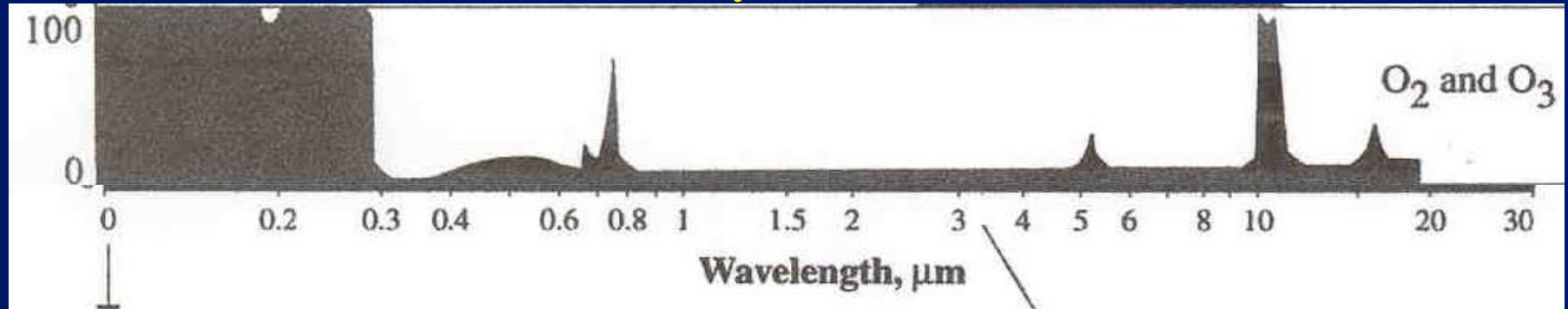
4: NONE of THEM



The ANSWERS to the first part of G-1:



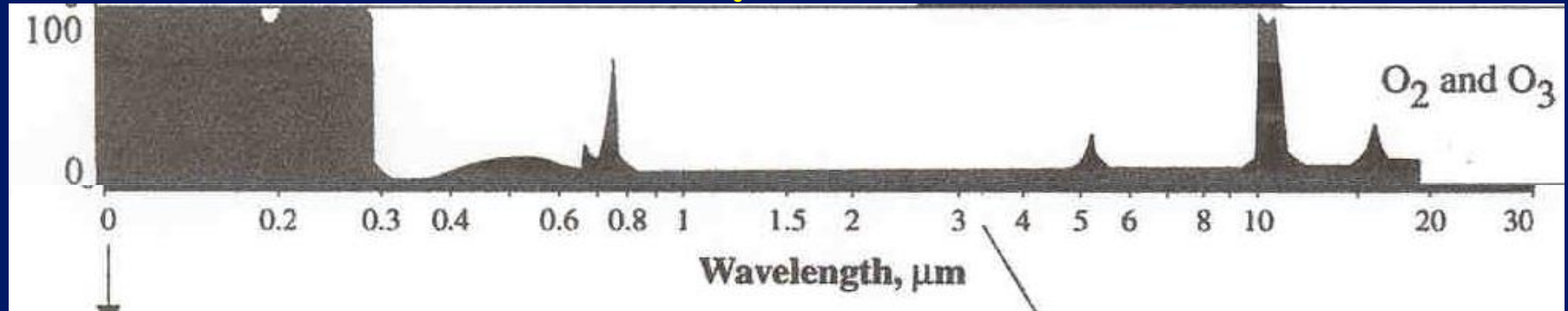
CLICKER Q3 HOW IS OZONE (actually O_3 & O_2) unique???



- 1) It absorbs **only UV** – hence it's **NOT** a GHG
- 2) It absorbs **almost ALL visible** wavelengths
- 3) It absorbs **BOTH UV** and **IR** so **IS** a GHG
- 4) It absorbs **BOTH UV** and **IR** so is **NOT** GHG



CLICKER Q3 HOW IS OZONE (actually O_3 & O_2) unique???

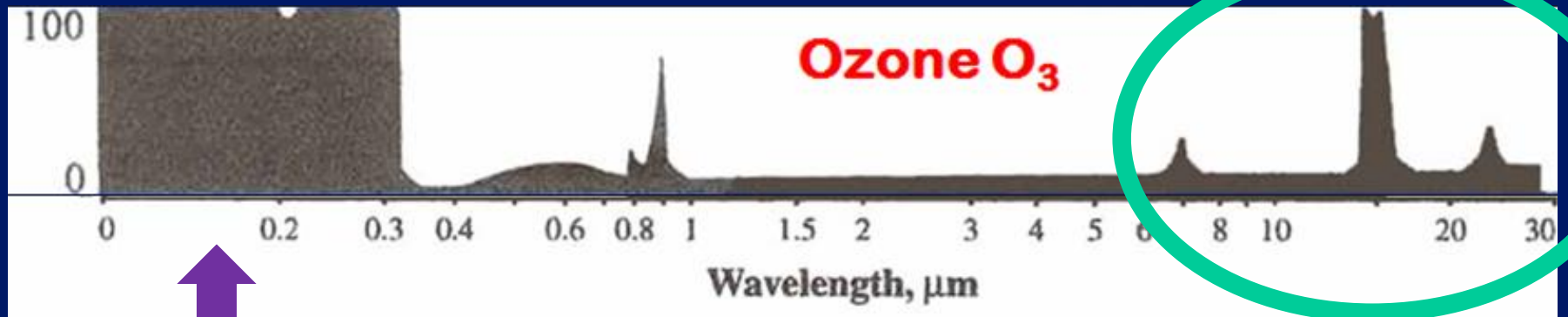


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- 4) It absorbs **BOTH UV** and **IR** so is **NOT** GHG

But **only** the IR absorption makes it a GHG!!

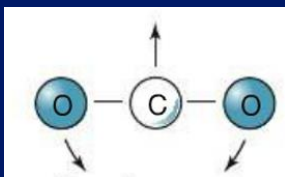
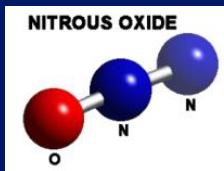
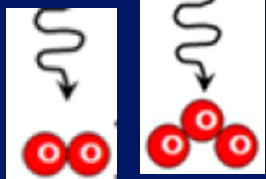
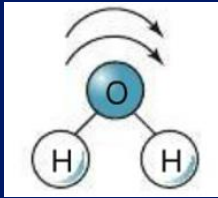


Absorption in this part of the absorption curve (IR wavelengths) indicates that OZONE is a greenhouse gas



. . . even though OZONE also absorbs radiation in the UV part of the spectrum!

Review



| Gas | Primary absorption wavelengths (in micrometers) | |
|-----|--|--|
|-----|--|--|

Water vapor
(H₂O)



| | |
|----------|----------|
| 0.8 | 4 to 7 |
| 1 | 9 to 10 |
| 1.5 | 11 to 20 |
| 2 to 3.5 | |

Molecular
oxygen (O₂) and
Ozone (O₃)

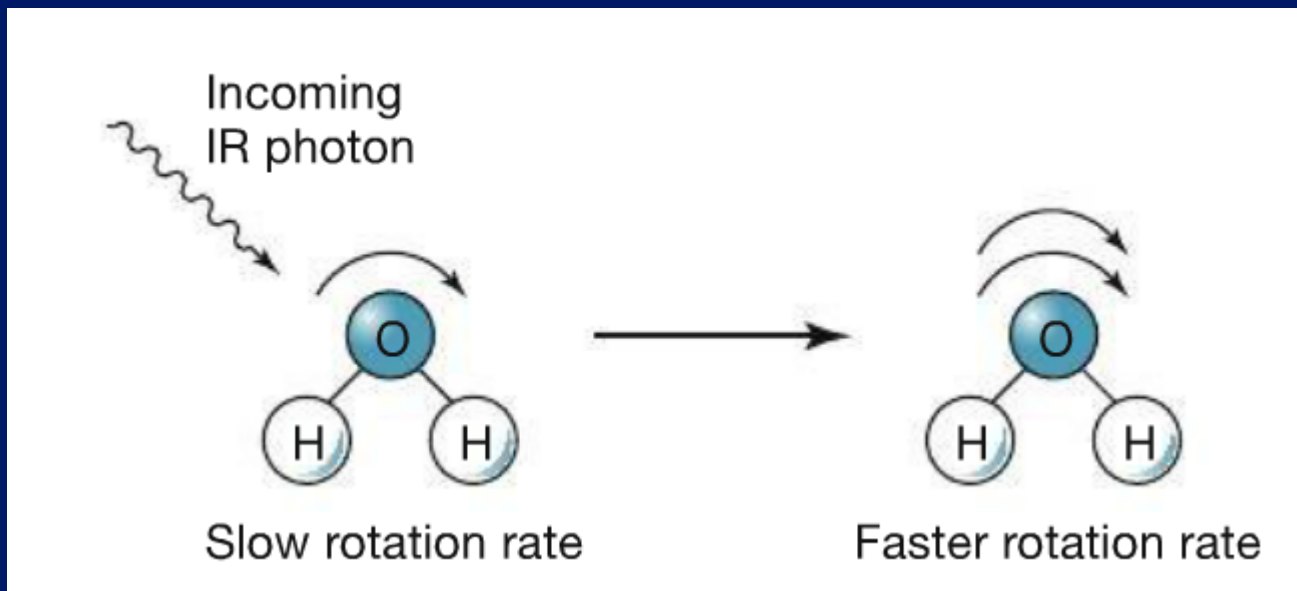
| |
|-----------------|
| 0.0001 to 0.280 |
| 8.5 to 10 |

Nitrous oxide
(N₂O)

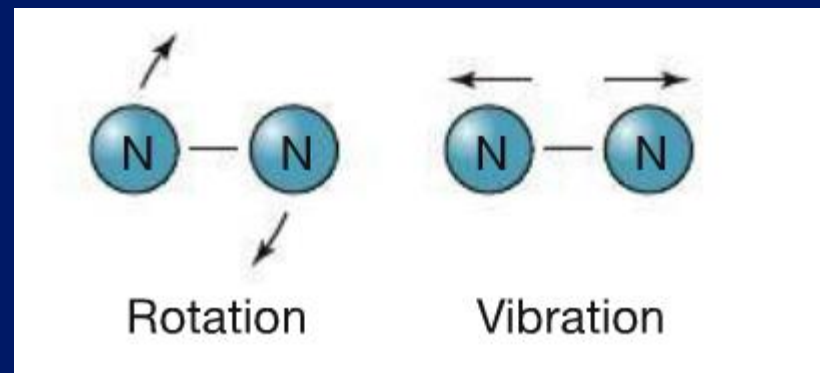
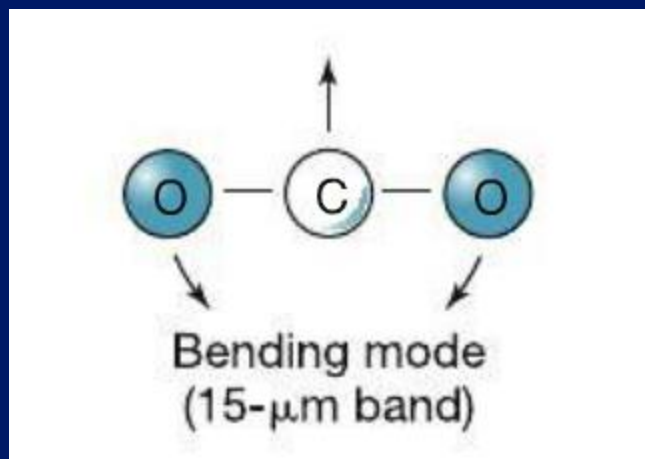
| |
|----------|
| 4 to 5 |
| 7 to 7.5 |

Carbon dioxide
(CO₂)

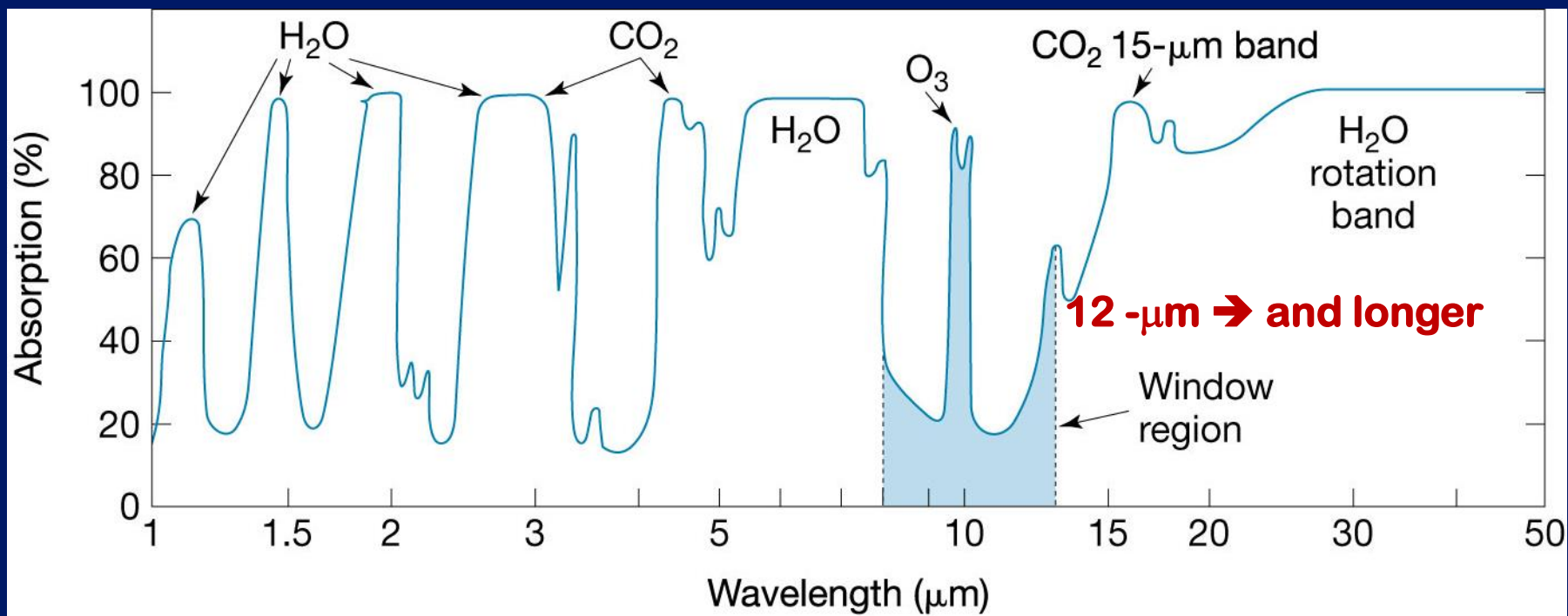
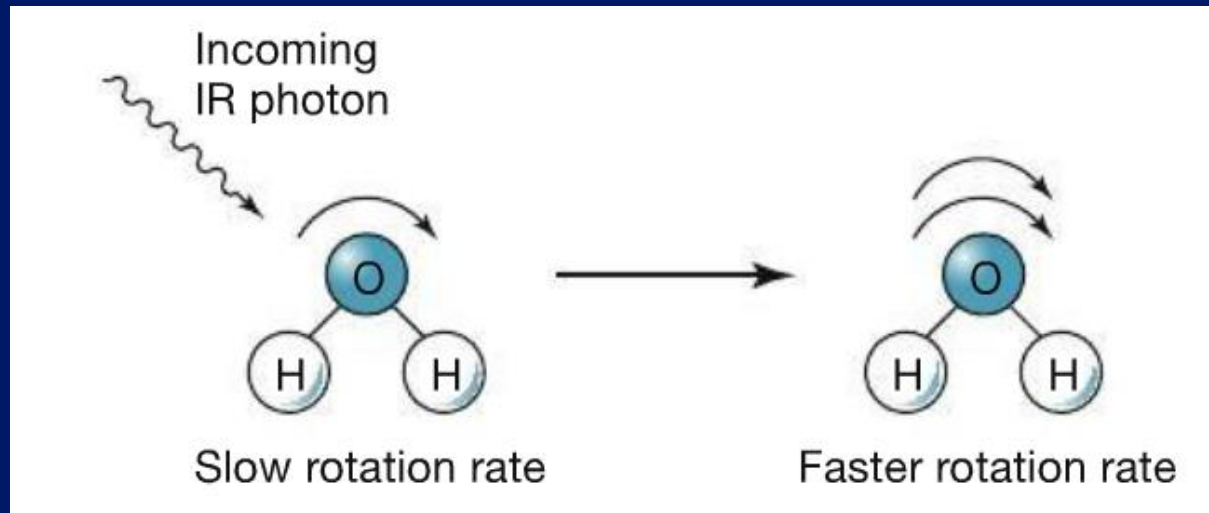
| |
|----------|
| 2 to 2.5 |
| 3 to 4 |
| 13 to 20 |



N₂ (not N₂O)

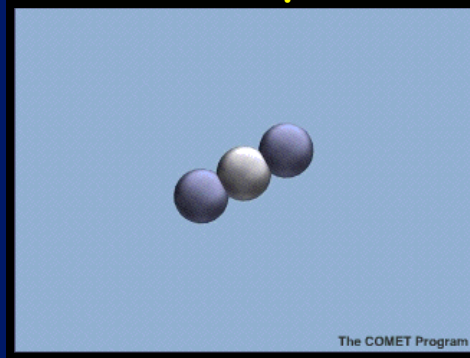


WATER VAPOR



CARBON DIOXIDE

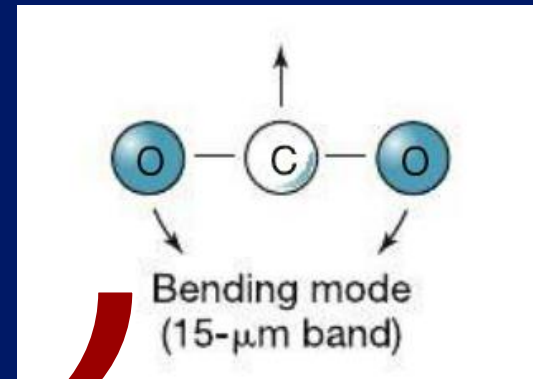
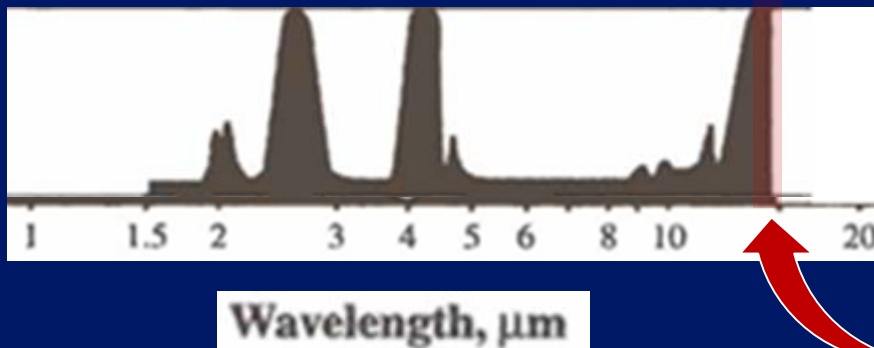
IR radiation photons



As a triatomic molecule, one way that CO_2 vibrates is in a “bending mode”

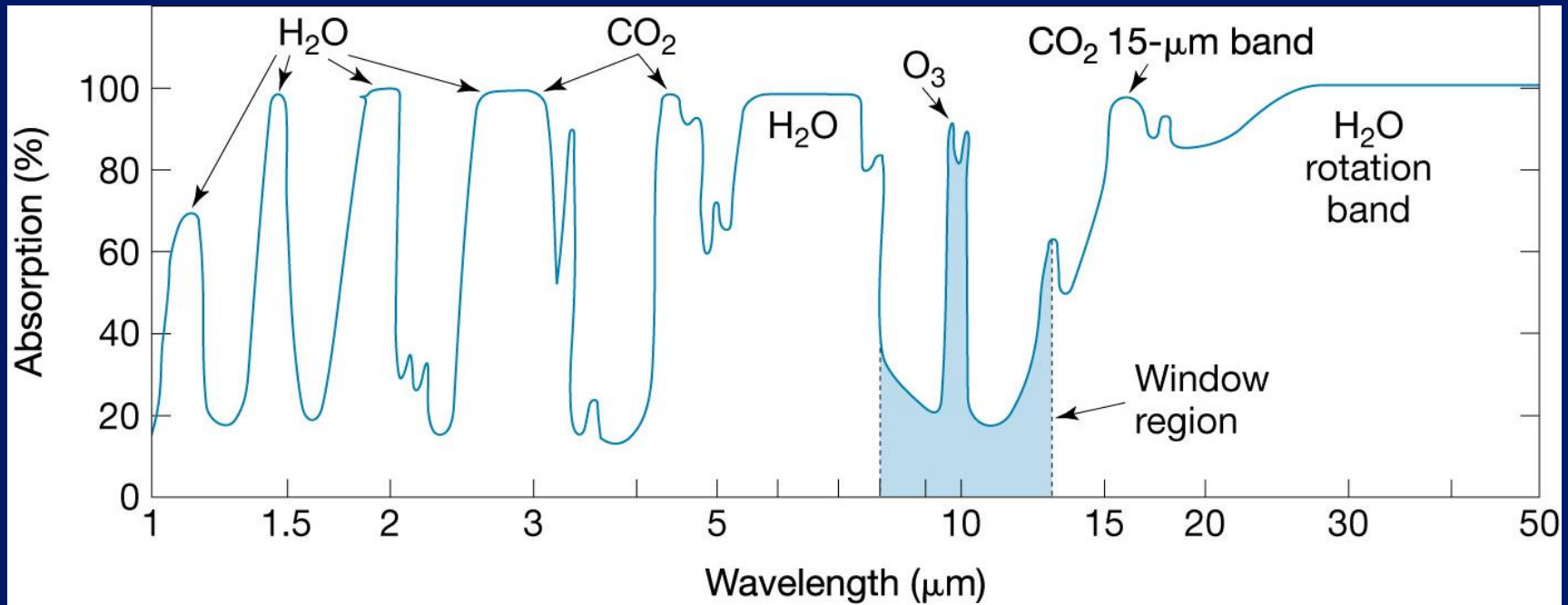
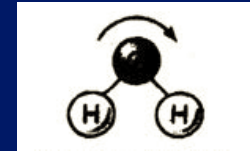
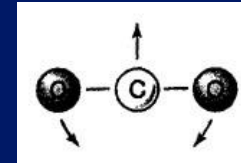
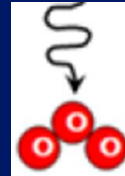
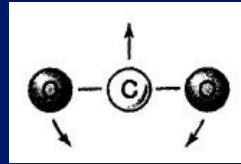
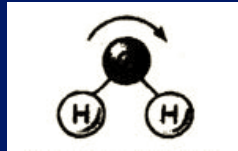
Carbon Dioxide CO_2

15- μm band



This vibration mode has a frequency that allows CO_2 to absorb IR radiation at a wavelength of about 15 micrometers

Close up view of combined absorption of IR wavelengths by GHG's: H_2O , CO_2 , O_3



Explore
Absorption
Curves
yourself:

http://apollo.lsc.vsc.edu/classes/met130/notes/chapter2/42_Selective_Absorption/42.html

E-Text
Fig 3-13



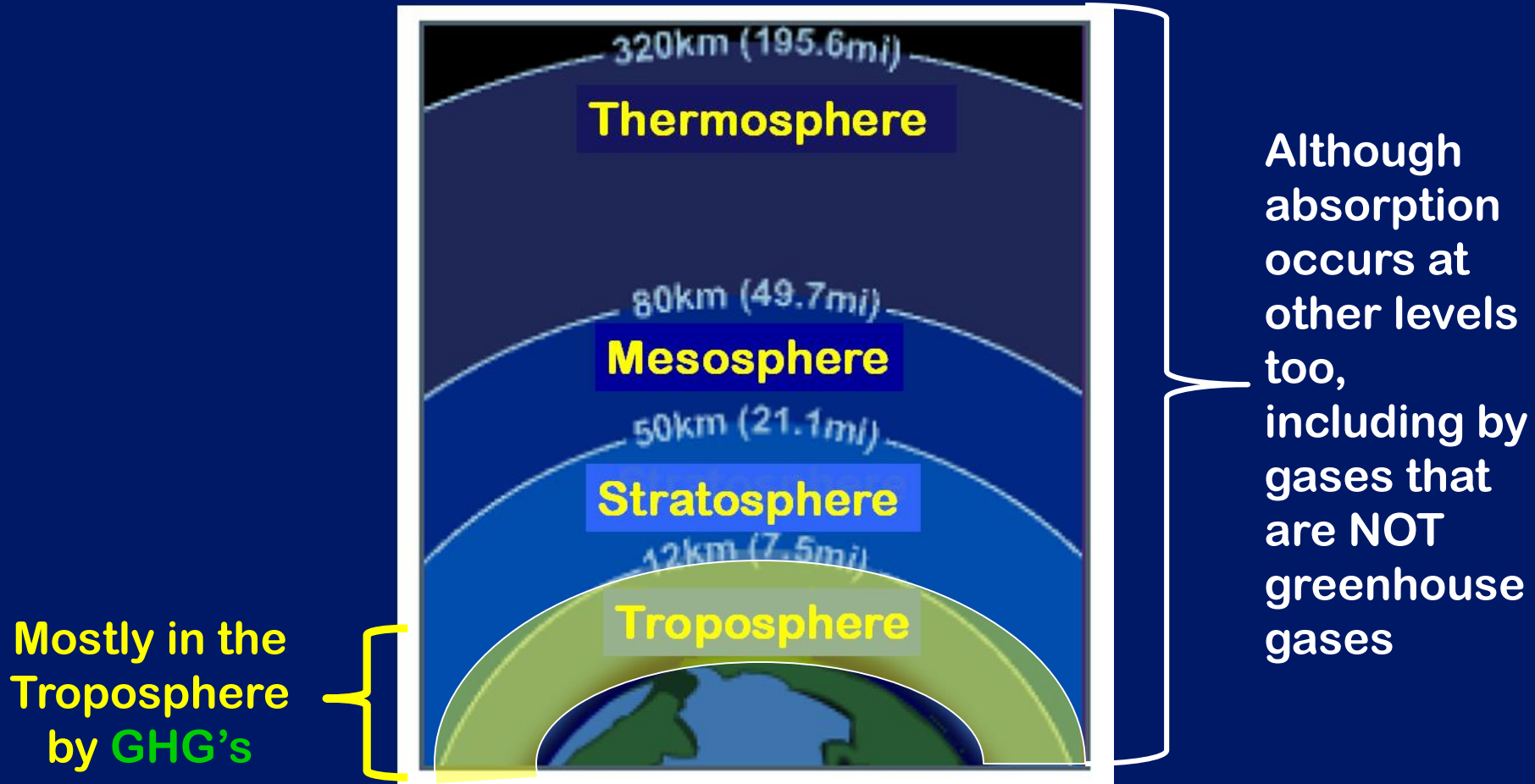
CHECKPOINT

THINK for 15 seconds

TABLE CHAT for 15 seconds

What's your most burning question?

WHERE IS ALL THIS ABSORPTION HAPPENING?

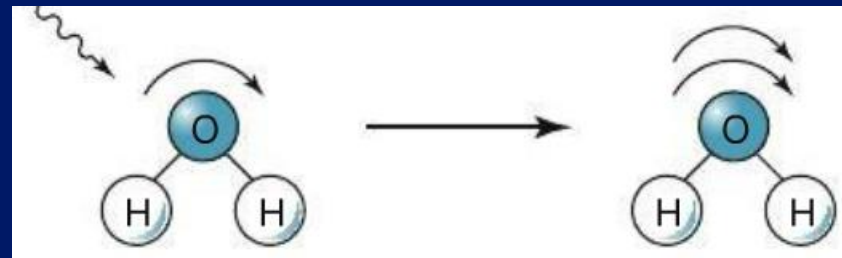
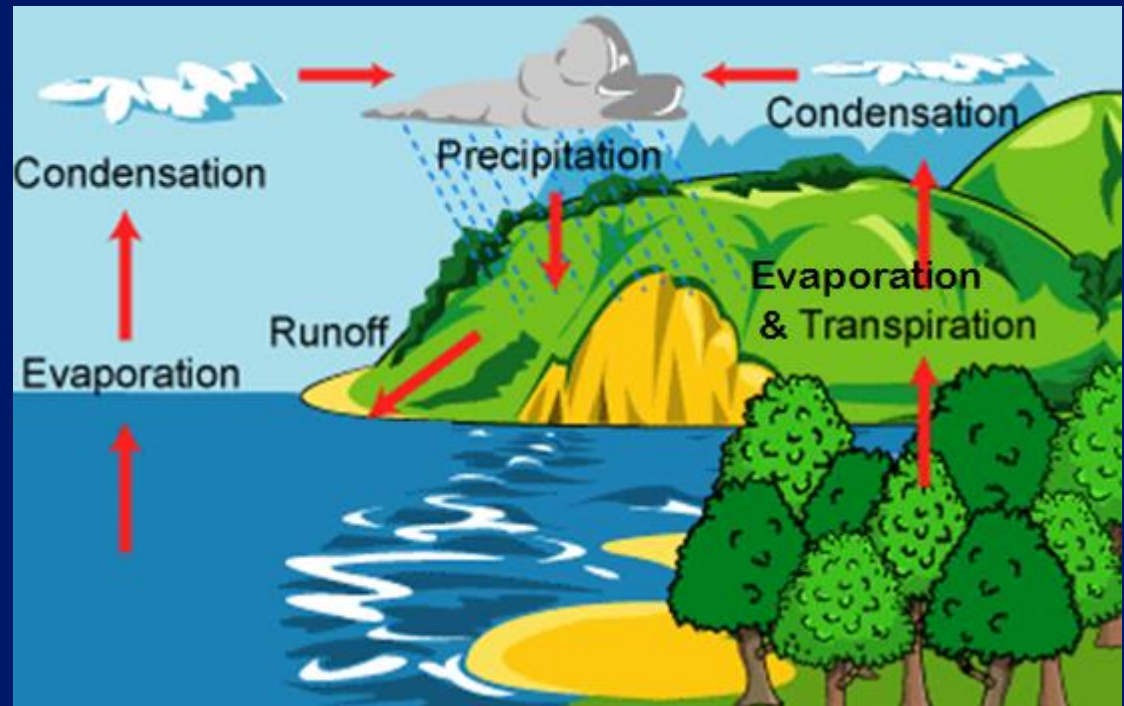


more in Topic #6 on **Wednesday** . . .

WATER VAPOR

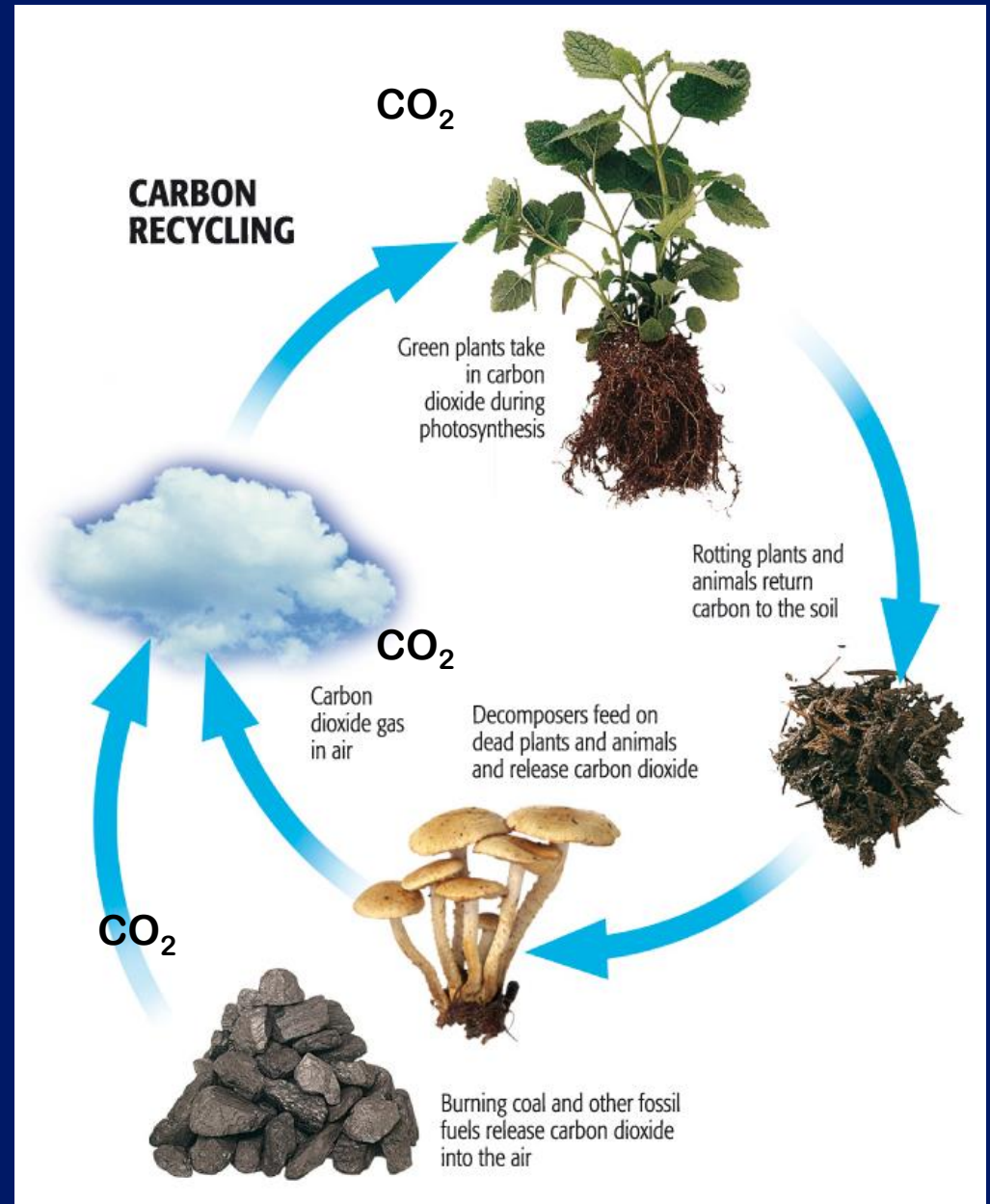
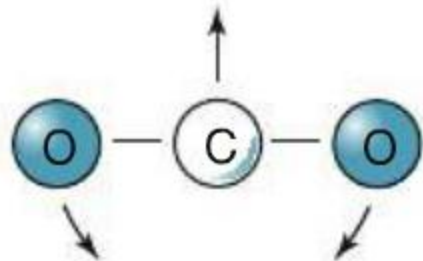
H_2O moves in
and out of the
atmosphere
as part of the
Water Cycle

The Hydrologic Cycle



CARBON DIOXIDE

CO₂ moves in and out of the atmosphere as part of the Carbon Cycle:

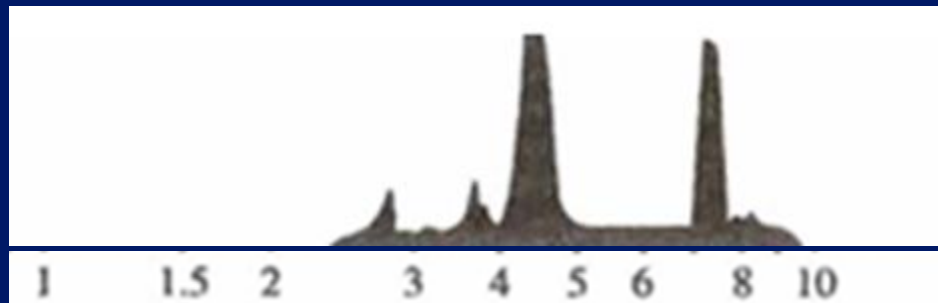


NITROUS OXIDE

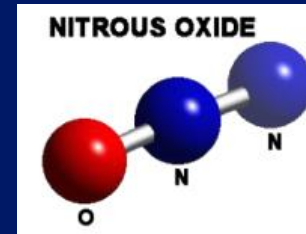
What about another triatomic
molecule?

N_2O (Nitrous oxide)

Nitrous Oxide N_2O

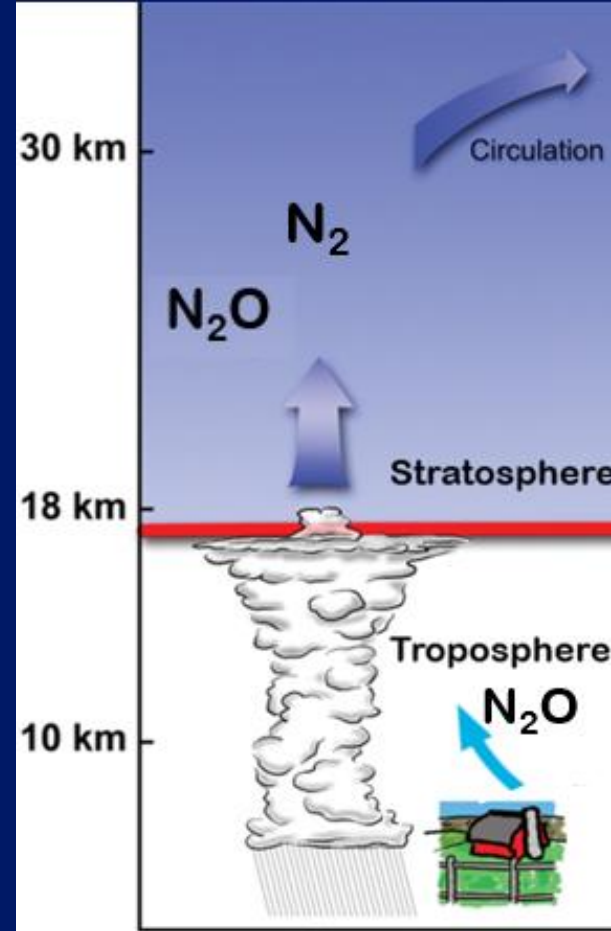
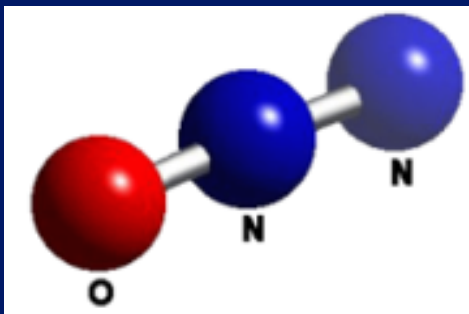


Wavelength, μm



NITROUS OXIDE

N_2O moves in and out of the atmosphere as part of the Nitrogen Cycle



N_2O is produced naturally in soil



also comes from fossil fuel combustion, burning forests, use of nitrogen fertilizers

OK, take a **MEDIA MINUTE** !





NITROUS OXIDE
← **Another View**

**DANCE YOUR
PhD !!**



DANCE YOUR PhD:



This graduate student is demonstrating the quantum behavior of a molecule of N_2O :

- one hand = a nitrogen atom
- torso = central nitrogen
- other hand = an oxygen atom

Nitrous Oxide (N_2O) acts as a greenhouse gas through the **absorption of radiation** in **3 vibrational modes**.

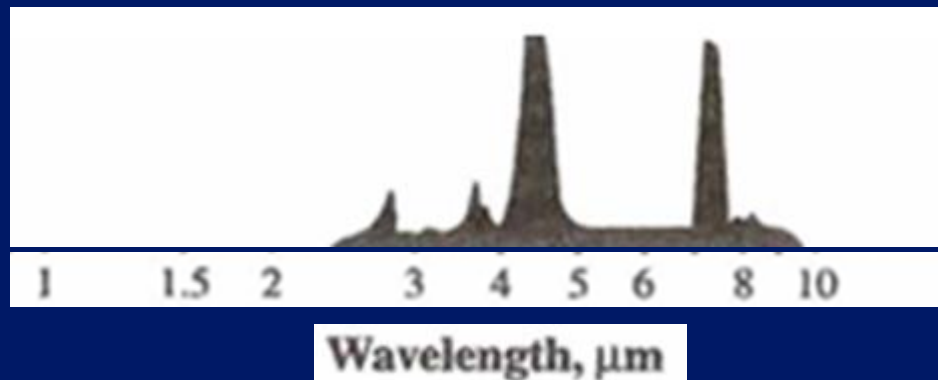
Now, 3 dancers will exhibit the **3 specific movements** of N_2O 's vibrational modes



The N_2O starts in the **soil** where it is produced by microbial activity and **“moves on up”** into the atmosphere.

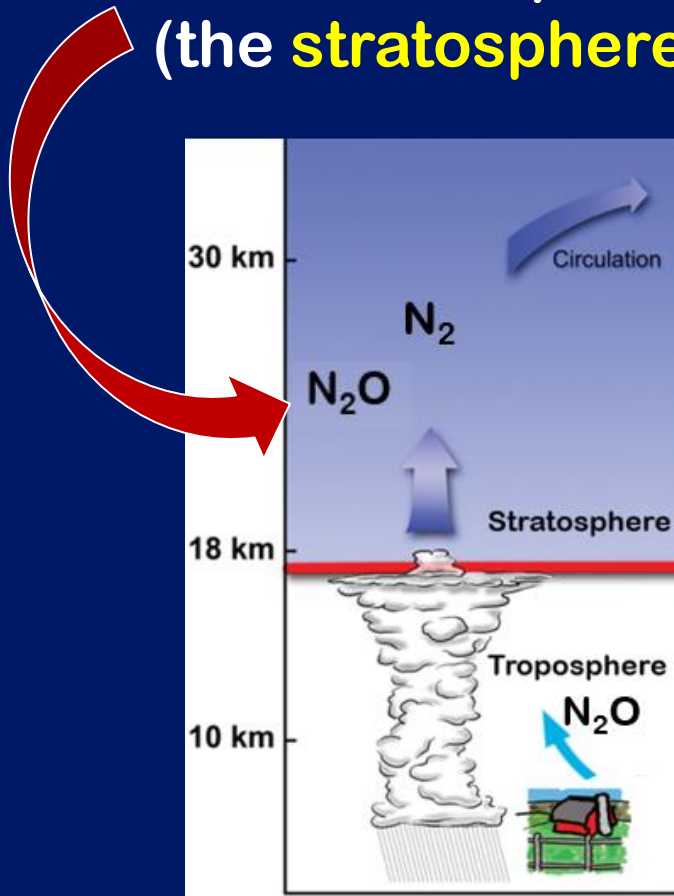


They grads will “dance” the 3 BENDING MODES of N_2O that are due to **Infrared IR absorption at 3 different wavelength bands**





Stepping onto chairs represents the circulation of the N_2O to higher levels in the atmosphere (the **stratosphere**)



... where it is then subject to intense **Ultraviolet (UV) radiation** from the sun.



With the **high energy** from the **UV radiation** bombarding the N_2O the dancers go crazy with high energy dancing.

Eventually the high intensity **UV radiation** leads to the **destruction of one of the N_2O molecules** (called “photolysis”) Shown by jumping from the chair at the end →





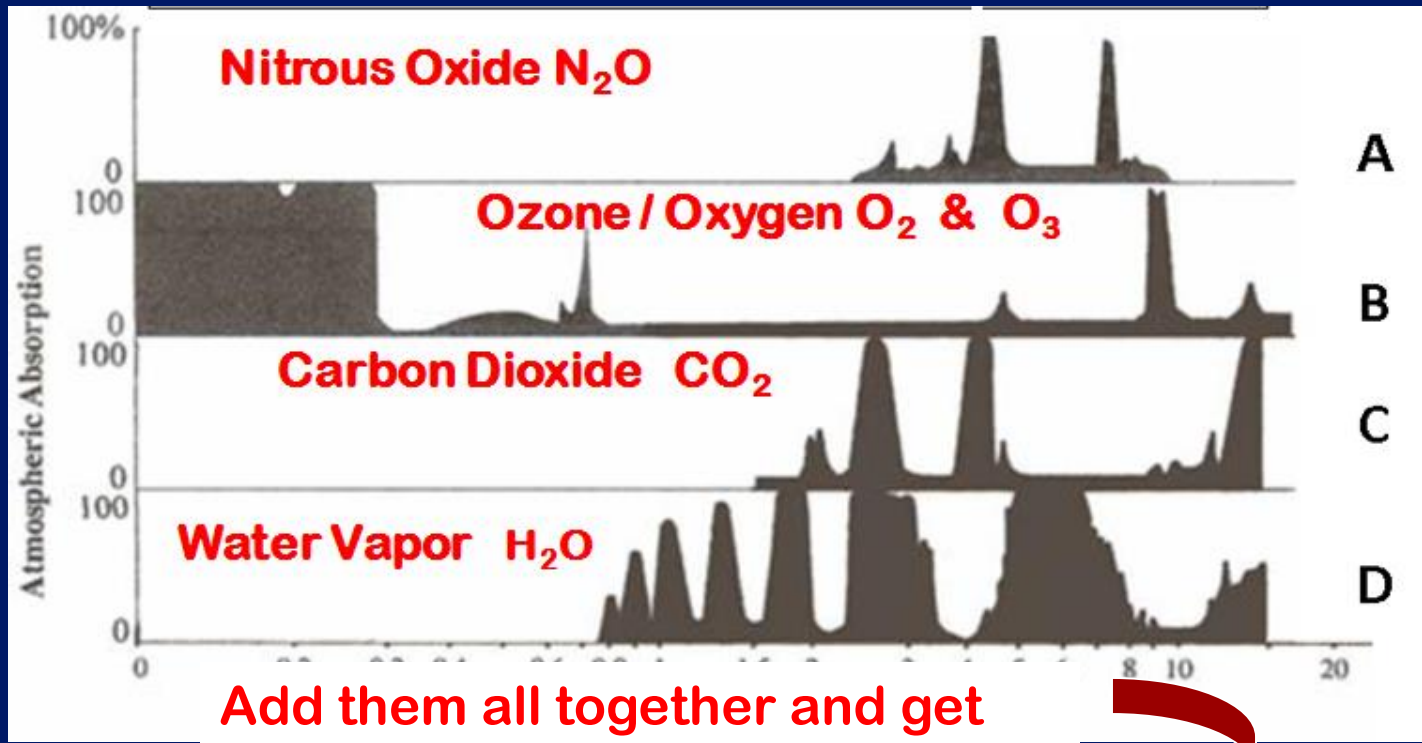
**DANCE YOUR
PhD !!**

<http://www.youtube.com/watch?v=L5j6BS3XoLc>





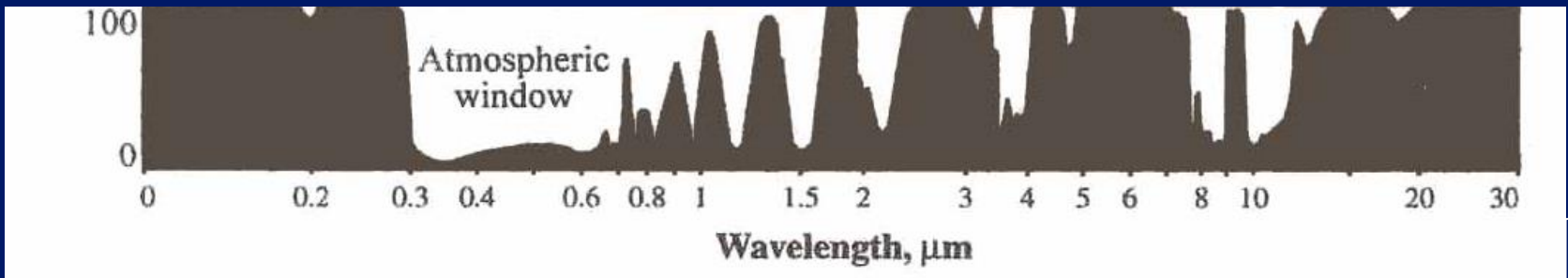
“THINKING MORE DEEPLY” last Part of G-1



Add them all together and get

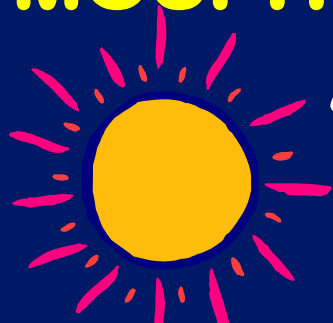


One graph showing absorption by ALL the atmospheric gases !



WHOLE ATMOSPHERE:

Absorption + Transmission

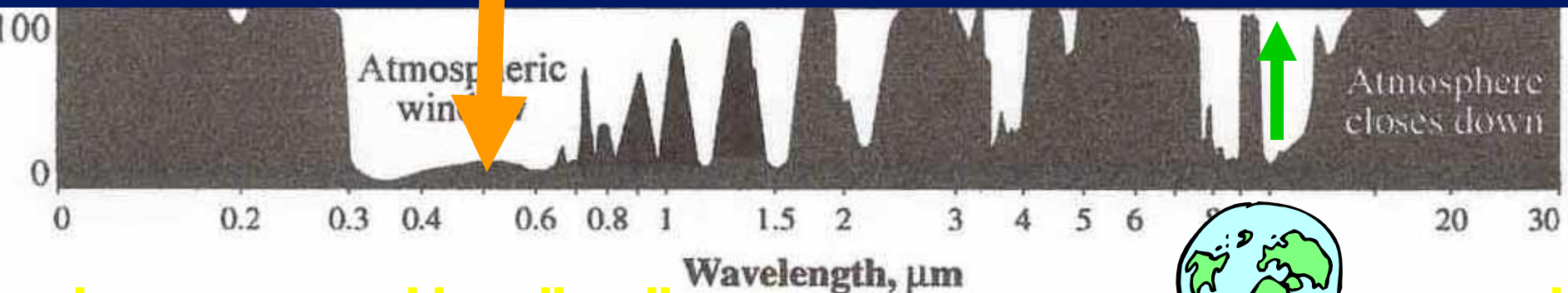


Window #1 with very little UV + Vis + NIR absorption!

Transmission of Incoming SW

Transmission of Outgoing LW

Window #2 with very little IR absorption!



UV

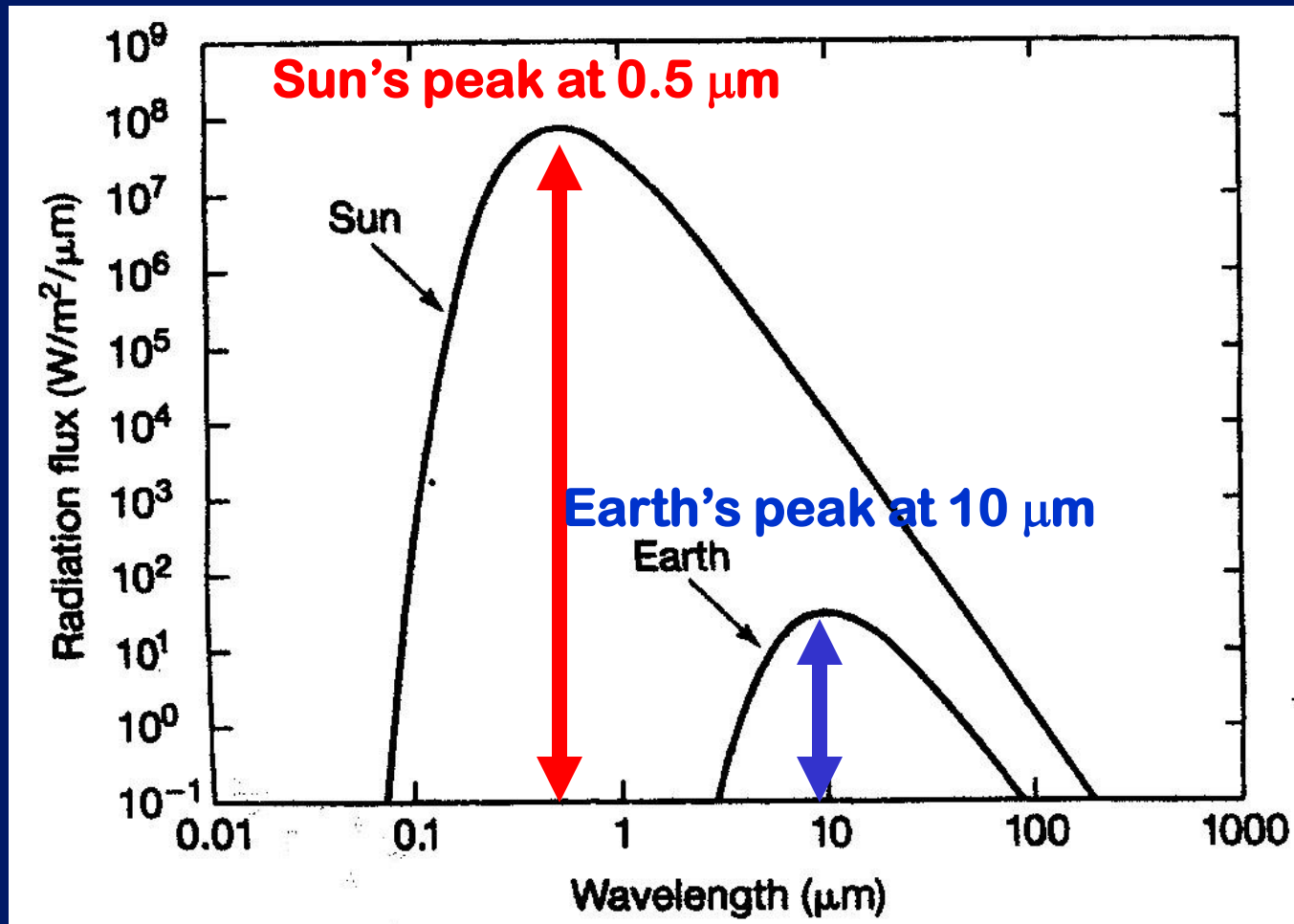
Visible

NIR

Far IR

**Incoming
SW SOLAR (UV + Vis)
window**

**Outgoing
LW TERRESTRIAL (IR)
window**



REMEMBER THIS???

Review p 24

CLICKER Q4 - Here's the absorption curve for ALL the gases in the atmosphere put together, i.e. curve for the "Whole Atmosphere"

We just talked about two "windows" in the curve that indicate at what wavelengths radiation easily comes **IN** to the surface of the Earth or escapes **OUT** to Space.

Q. Where are these two windows?

1: A + B

2: B + E

3: C & D

4: D + E

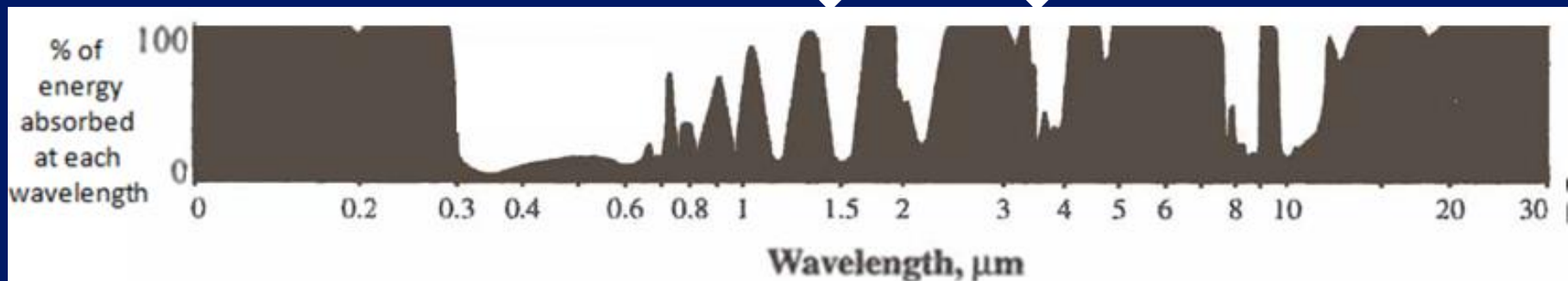
A
↓

B
↓

C
↓

D
↓

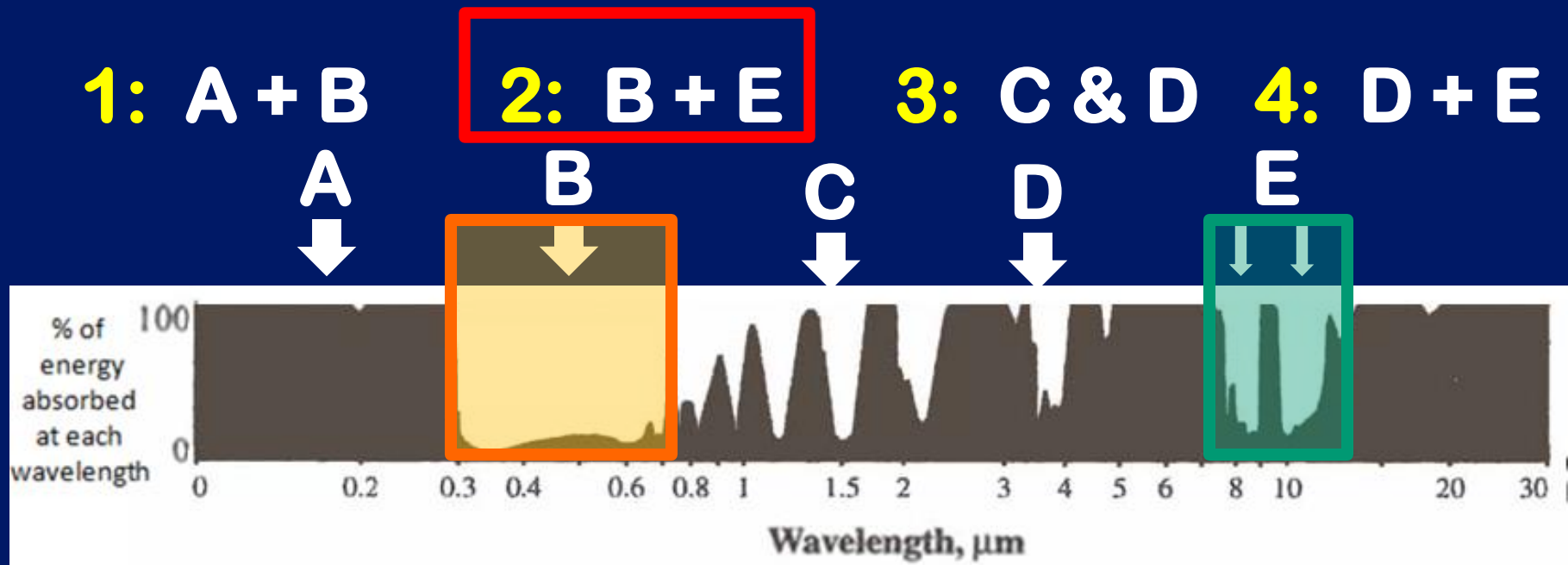
E
↓ ↓



CLICKER Q4 - Here's the absorption curve for ALL the gases in the atmosphere put together, i.e. curve for the "Whole Atmosphere"

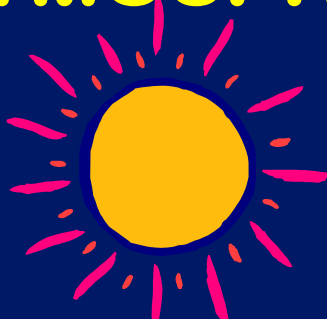
We just talked about two "windows" in the curve that indicate at what wavelengths radiation easily comes **IN** to the surface of the Earth or escapes **OUT** to Space.

Q. Where are these two windows?



WHOLE ATMOSPHERE:

Absorption + Transmission

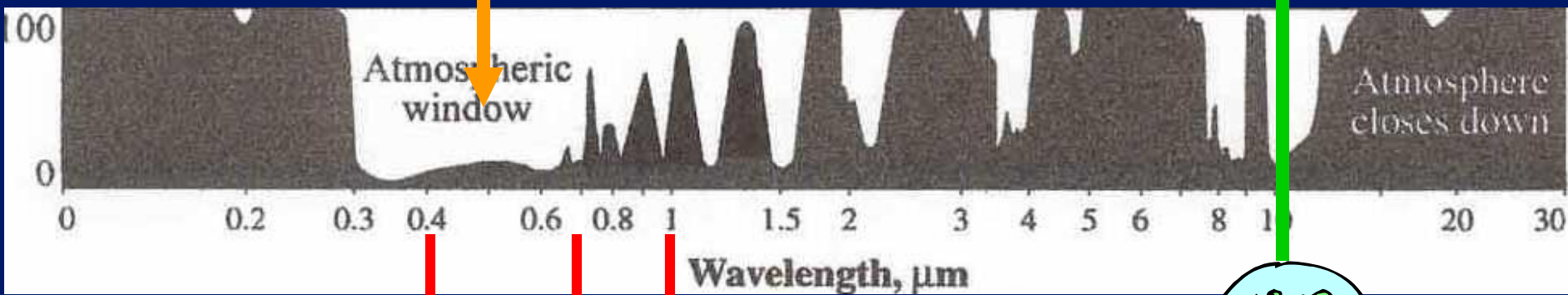


thru UV / Vis atmospheric window

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





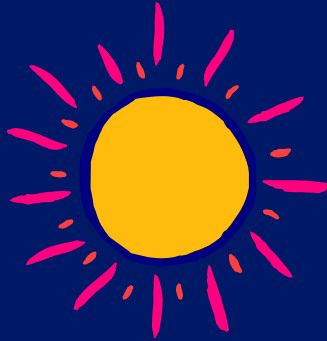
CHECKPOINT

THINK for 15 seconds

TABLE CHAT for 15 seconds

What's your most burning question?

SO WHAT'S THE PROBLEM??



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



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



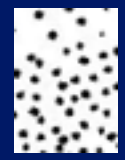
**WHY ARE WE WORRIED ABOUT
GLOBAL WARMING???**



Using the following symbols:



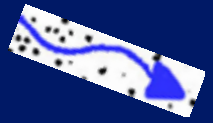
SOLAR
SHORTWAVES



(GH gases in
atmosphere)



(Earth's surface)



TERRESTRIAL
LONGWAVES

(IR radiation)

Make a sketch of how
THE GREENHOUSE EFFECT
works & write out a
DEFINITION OF THE "GHE"

No peeking at:



- CLASS NOTES
- phones or laptops

BRAINSTORMING THE DEFINITION . . .

Natural mechanism or process

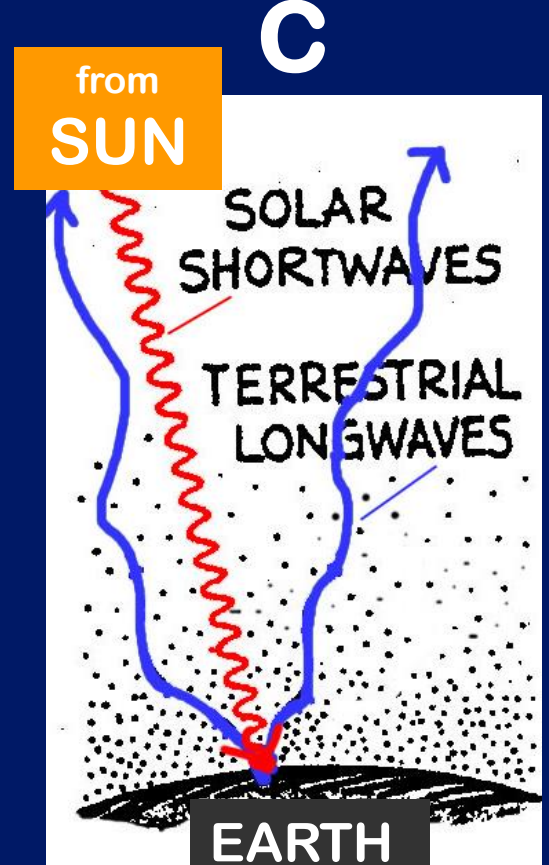
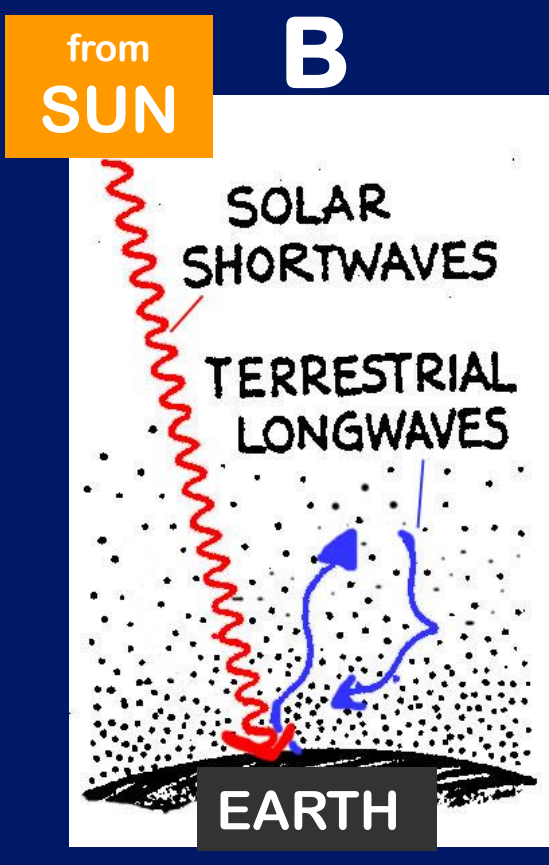
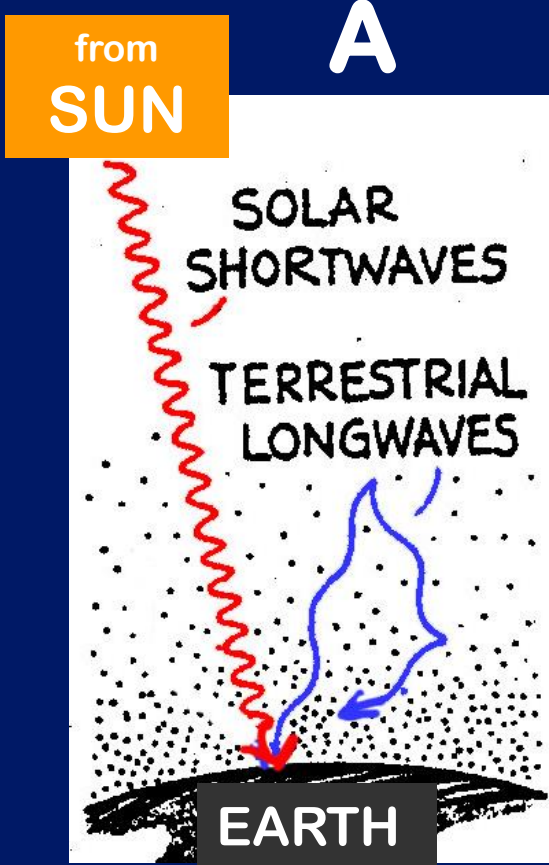
IR-Radiation – from where?


Gases absorb IR (from where?)


Gases emit IR radiation (to where?)


What happens due to the above?

Q 5 - Which one do you think is the most accurate depiction of the Greenhouse Effect??



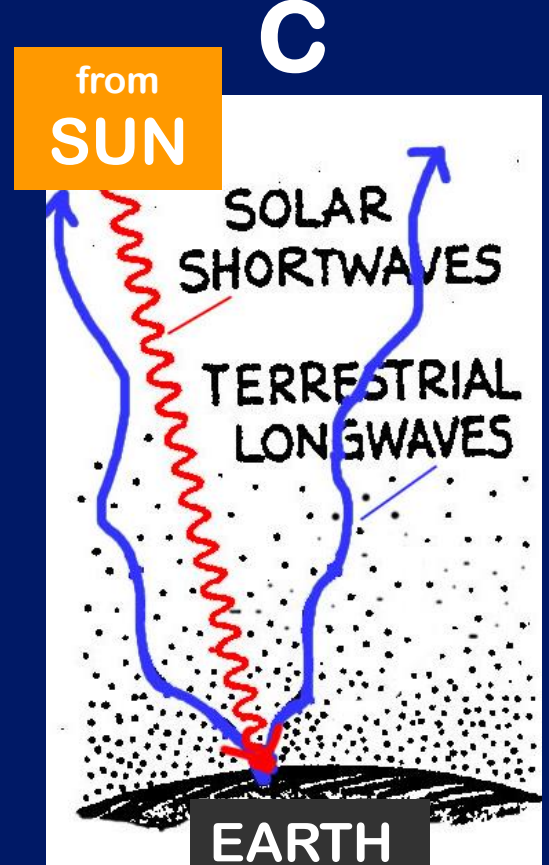
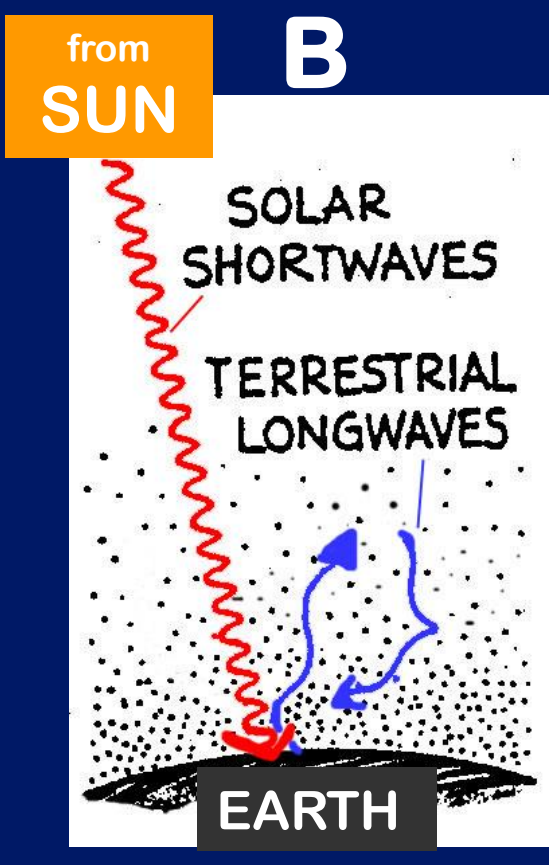
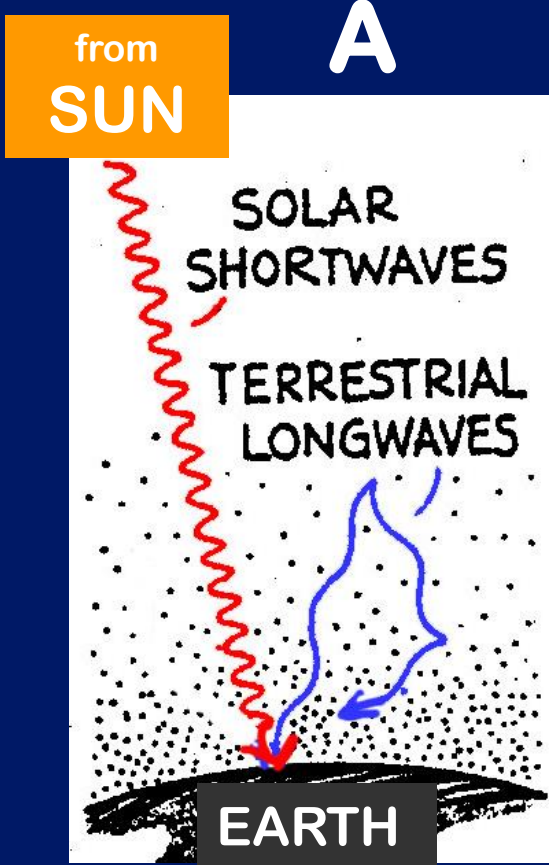
 = gases in the atmosphere


 = solar (shortwave) radiation (High Energy)


 = terrestrial (longwave) radiation (Lower Energy)




Q 5 - Which one do you think is the most accurate depiction of the Greenhouse Effect??

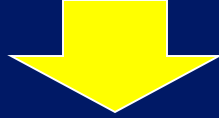
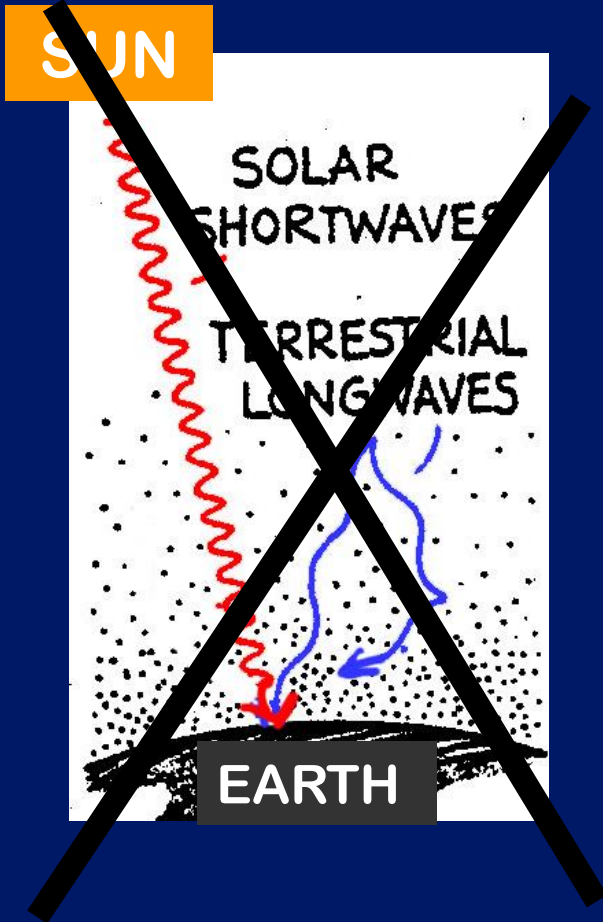


 = gases in the atmosphere

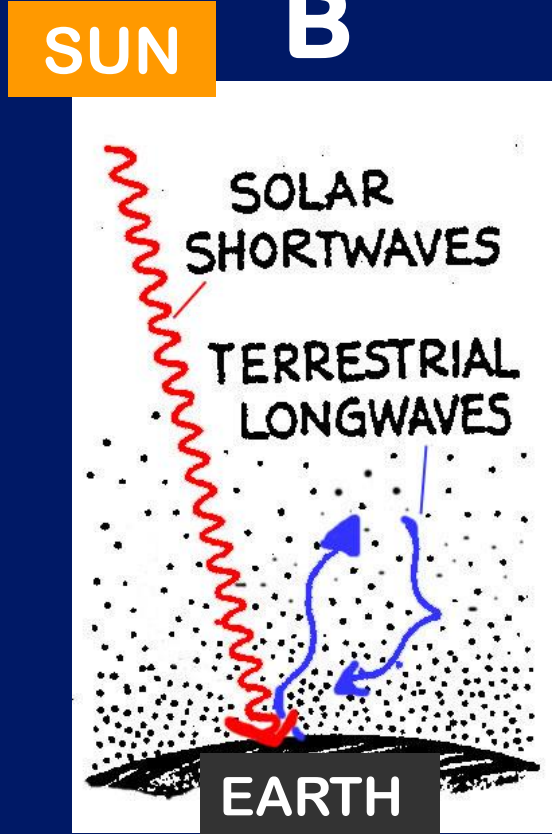
 = solar (shortwave) radiation (High Energy)

 = terrestrial (longwave) radiation (Lower Energy)

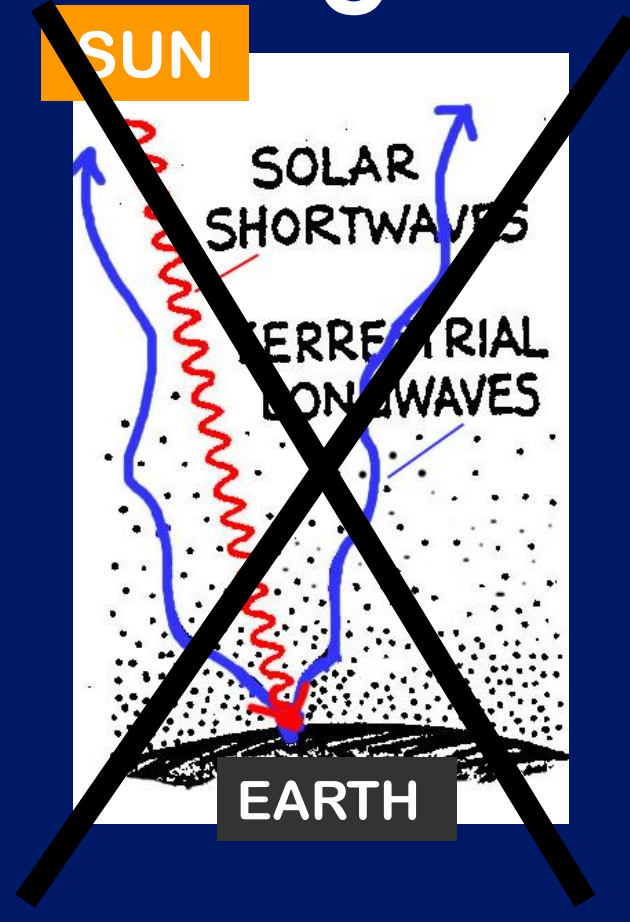
A



B



C



Actually, NONE of these is exactly correct, and we will learn why in a future lecture. . . . but for now, B is the preferred answer see the image on bottom of p 31 in Class Notes.



GREENHOUSE EFFECT (def)

“bare bones” version:

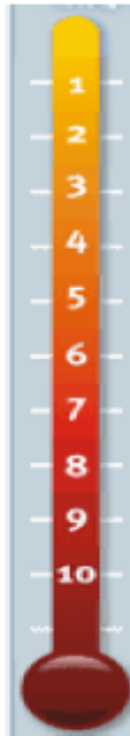
"The greenhouse effect is the natural mechanism by which the Earth's surface is warmed by infrared-absorbing gases in its atmosphere."

HOW COULD THIS DEFINITION
BE IMPROVED?



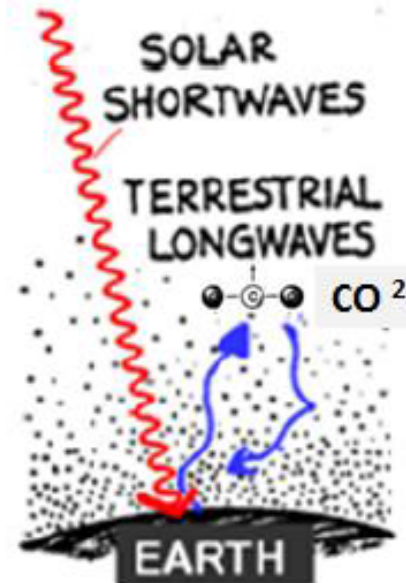
WHY BE CONCERNED ABOUT INCREASING CO₂ ?

EXPLORING
ANOTHER MYTH . . .



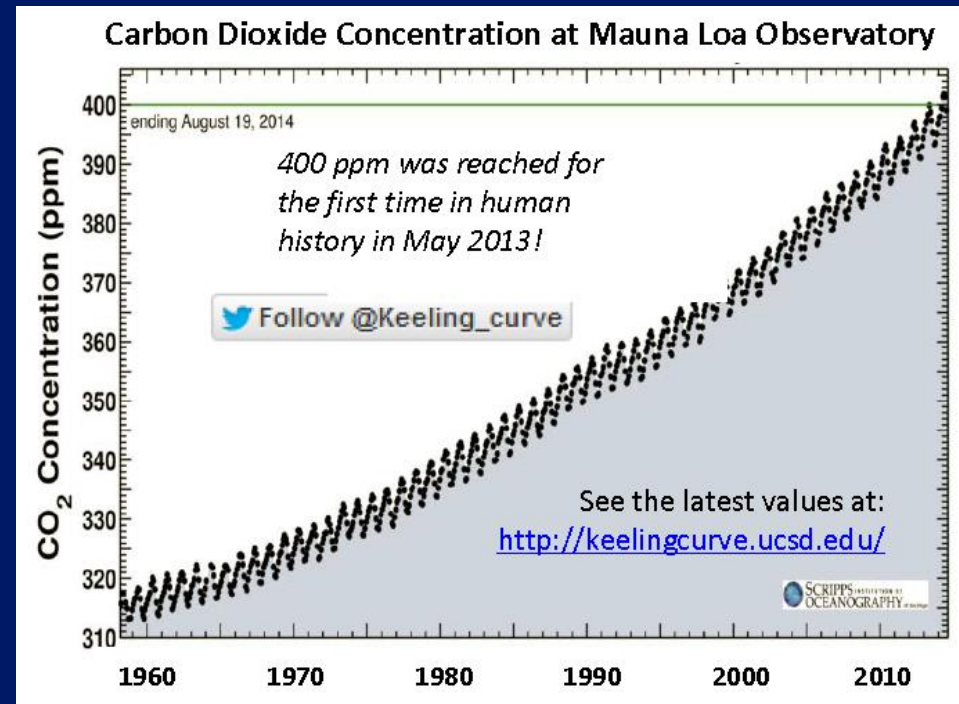
**CLIMATE
MYTH #30:**

*"Increasing CO₂
has little to
no effect"*



If the Earth can “COOL itself” by transmitting IR through the IR Window, WHY SHOULD WE BE SO CONCERNED ABOUT INCREASING CO₂ ?

Even with the increases seen on the Keeling Curve, CO₂'s concentration in the atmosphere is **really low** compared to N₂ and O₂



← “Thinking more deeply” symbol

How do we know more CO₂ is causing warming?



The skeptic argument...

“Increasing CO₂ has little to no effect on enhancing the GREENHOUSE EFFECT because the amount is so small compared to the amount of other gases in the atmosphere.

Therefore the increase in human-produced CO₂ (as seen in the Keeling Curve) is NOT the cause of recent global warming!!

<http://www.skepticalscience.com/empirical-evidence-for-co2-enhanced-greenhouse-effect.htm>

How would you respond?

“Thinking more deeply” symbol →

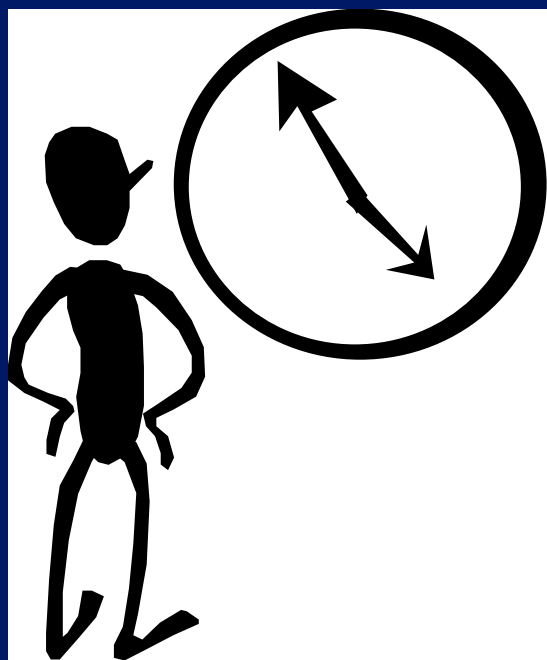


NOW DISCUSS AT YOUR TABLE!!!

& pick someone to respond back
for your group

A **KEY POINT** to help your response
is embedded in the box on
**“IMPLICATIONS OF LAW #6
FOR GLOBAL CLIMATE CHANGE”** on p 27

Read the box . . . then think a bit . . .
WHICH ITEMS (a - g) have relevant info for
responding to this skeptic’s argument?



**IT'S TIME TO
WRAP IT UP
AND QUIET DOWN
&
REPORT BACK!!!**

What we did today . . .

- 1) Reviewed Absorption Curves & WHAT they tell us about different gases
- 2) Learned WHY certain gases behave as GHG's & HOW this relates to the Spectrum
- 3) Learned about 2 Atmospheric Windows, WHAT happens in them & WHY this is important
- 4) Sketched the GH Effect & wrote its definition
- 5) Assessed a “skeptic” comment based on class learning

What to do: on a piece of paper w/ name + Group #

Pick one of the above, **reflect on what you learned today about it**, & explain this in a short paragraph

THINKING DEEPLY WRAP-UP



Participation Point Activity:

Get a piece of paper, put Name & Group # on it

Pick one of the following,
reflect on what you learned today about it,
& explain this in a short paragraph →

GRADED TEST #1
is in your GROUP FOLDER

We will discuss the Test next class!

SEE YOU
WEDNESDAY!!!