

# Topic # 13 (cont.)

## OZONE DEPLETION IN THE STRATOSPHERE – Part II

A Story of Anthropogenic  
Disruption of a Natural  
Steady State

p 77-79 in Class Notes

# REVIEW . . .

**Q – Is the depletion of STRATOSPHERIC OZONE (in the OZONE HOLE and elsewhere) an important CAUSE of GLOBAL WARMING?**

**1 – YES**

**2 -- NO**

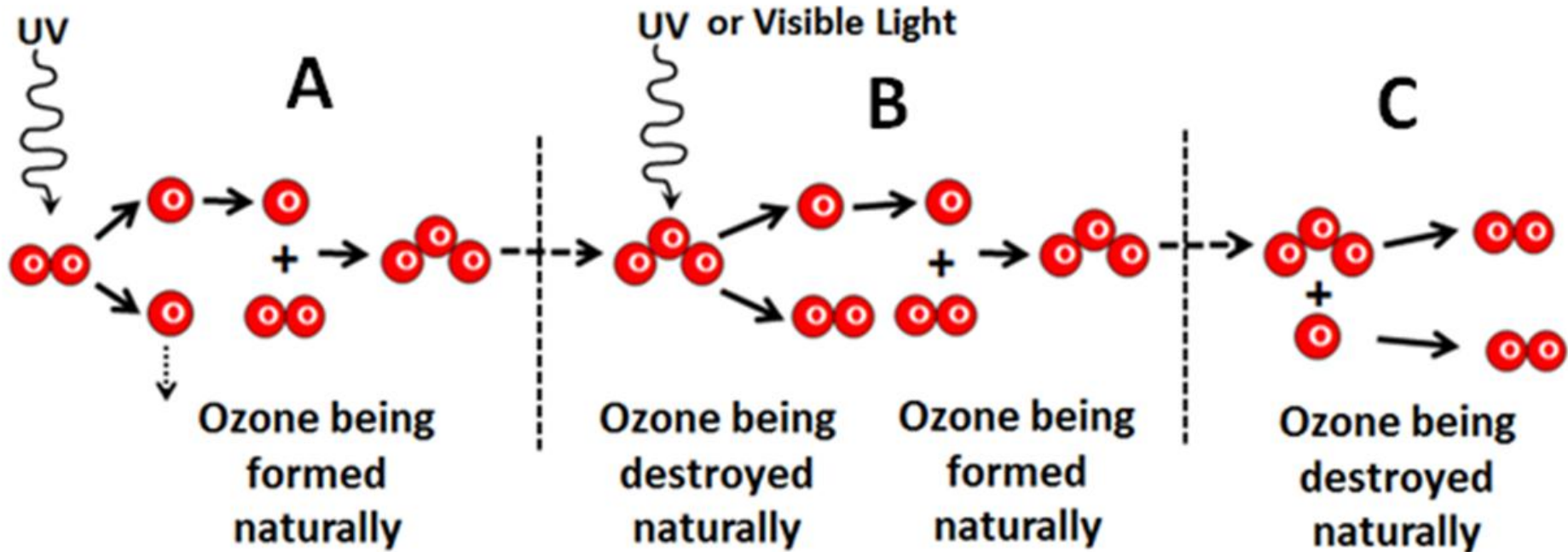
**More on this  
later . . .**

# THE CHAPMAN MECHANISM

(first proposed in 1930s)

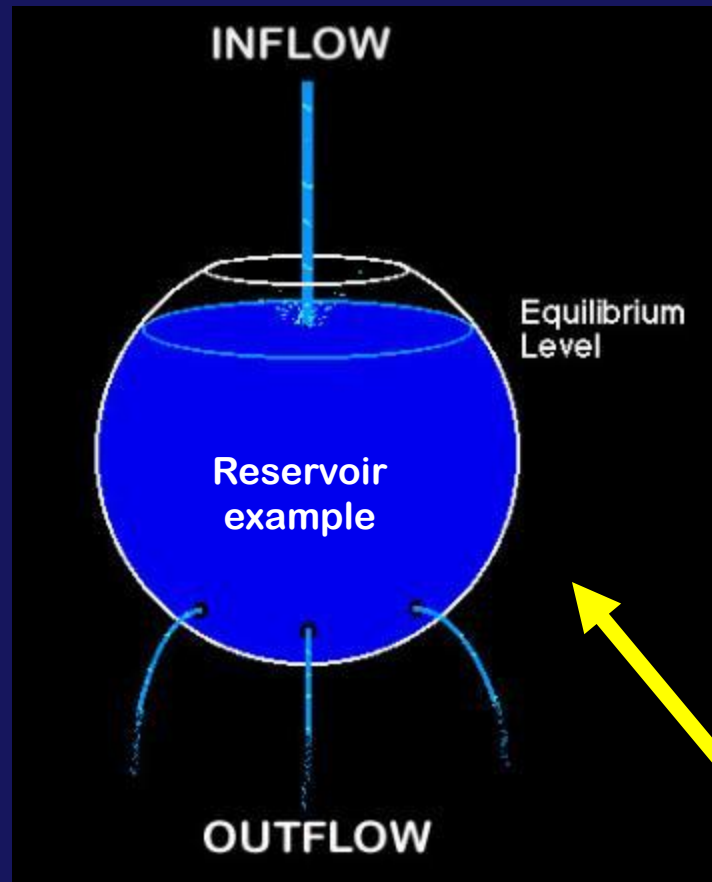
- ozone is continuously produced and destroyed
- through **PHOTOCHEMICAL REACTIONS** in the stratosphere
- involves oxygen ( $O_2$ ), molecular oxygen ( $O$ ), photons of UV radiation, and **OZONE** ( $O_3$ ).

# The Chapman Mechanism



*(See explanation in box on top of p 77)*

[Go to movie clip]



***Steady state can be achieved in a reservoir:***

- a) if there are no inflows or outflows, *or*
- b) if the rate of inflow = the rate of outflow.

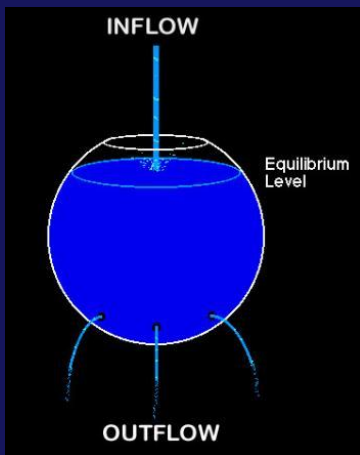
**Any imbalance in these rates leads to a change in the level of the reservoir.**



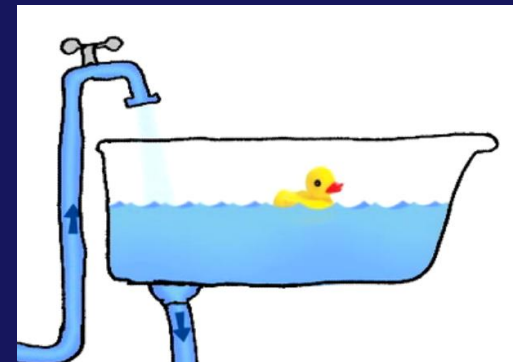
# FLOW DIAGRAM OF A STEADY STATE



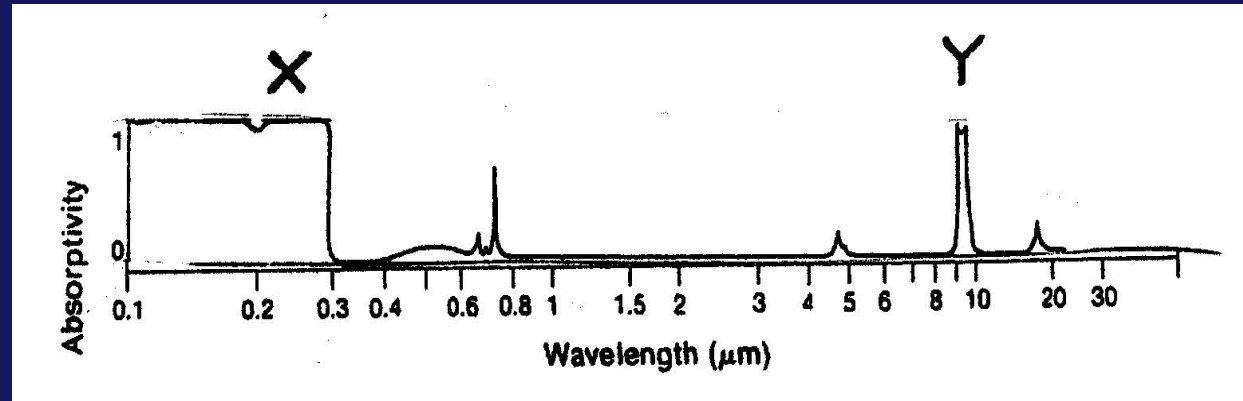
Where have we seen something like this before?



Lesson 1  
Carbon Dioxide in  
the Atmosphere



Q on  
MONDAY:

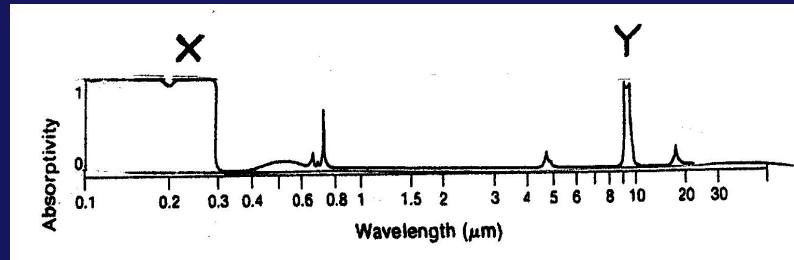


Q – What is the CORRECT completion to this sentence:

The global change issue usually referred to as Stratospheric Ozone Depletion is related to the part of the absorption curve that is labeled \_\_\_\_\_.

(1) **X** or (2) **Y**

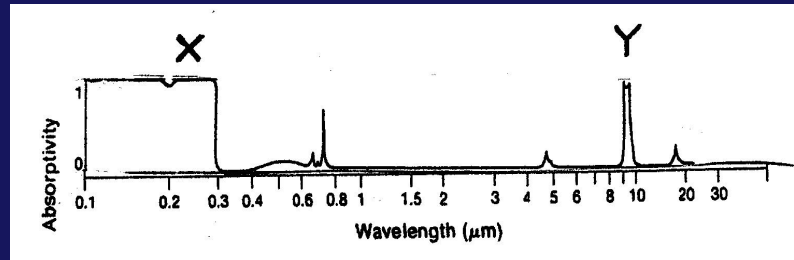
# Q. Ok, X is right, but Why?



1. . . . because X represents **UV** radiation being absorbed -- hence **if ozone is depleted, MORE ultraviolet** radiation will **reach the Earth's surface**.
2. . . . because X represents **terrestrial longwave** radiation being absorbed -- and hence serves as a catalyst in the Chapman mechanism.
3. . . . because X represents **easy transmission of wavelengths of terrestrial longwave radiation out to space** which then disappear through the “atmospheric window” also known as the ozone hole.



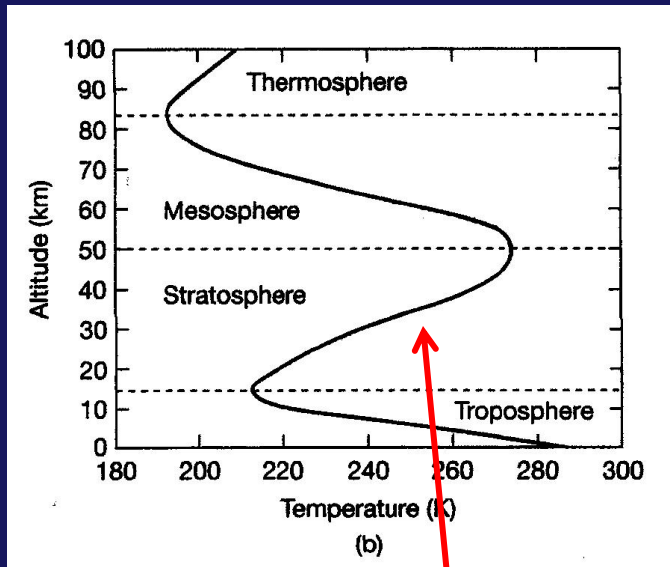
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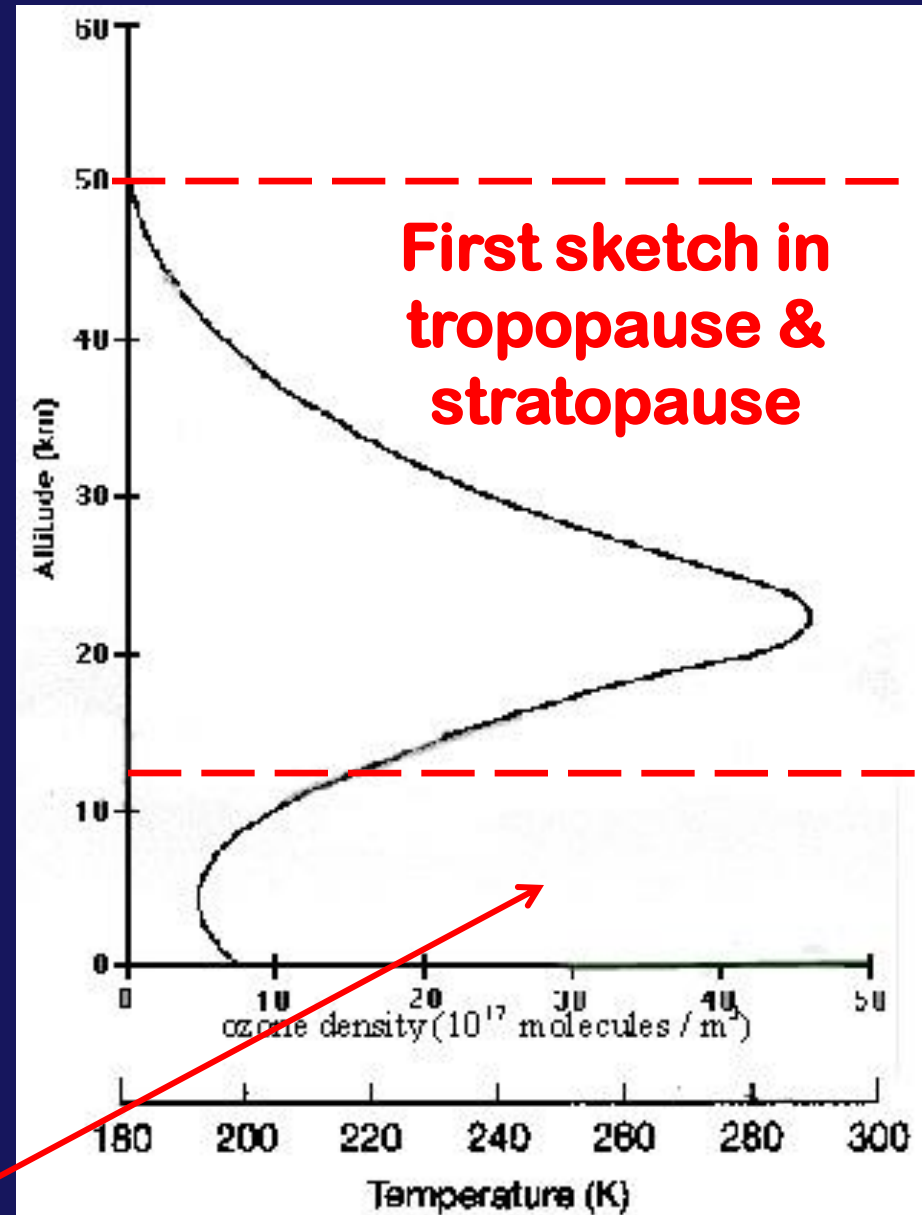
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# Ozone Density graph

## Temperature graph



Now roughly sketch the temperature line from this graph onto the ozone graph



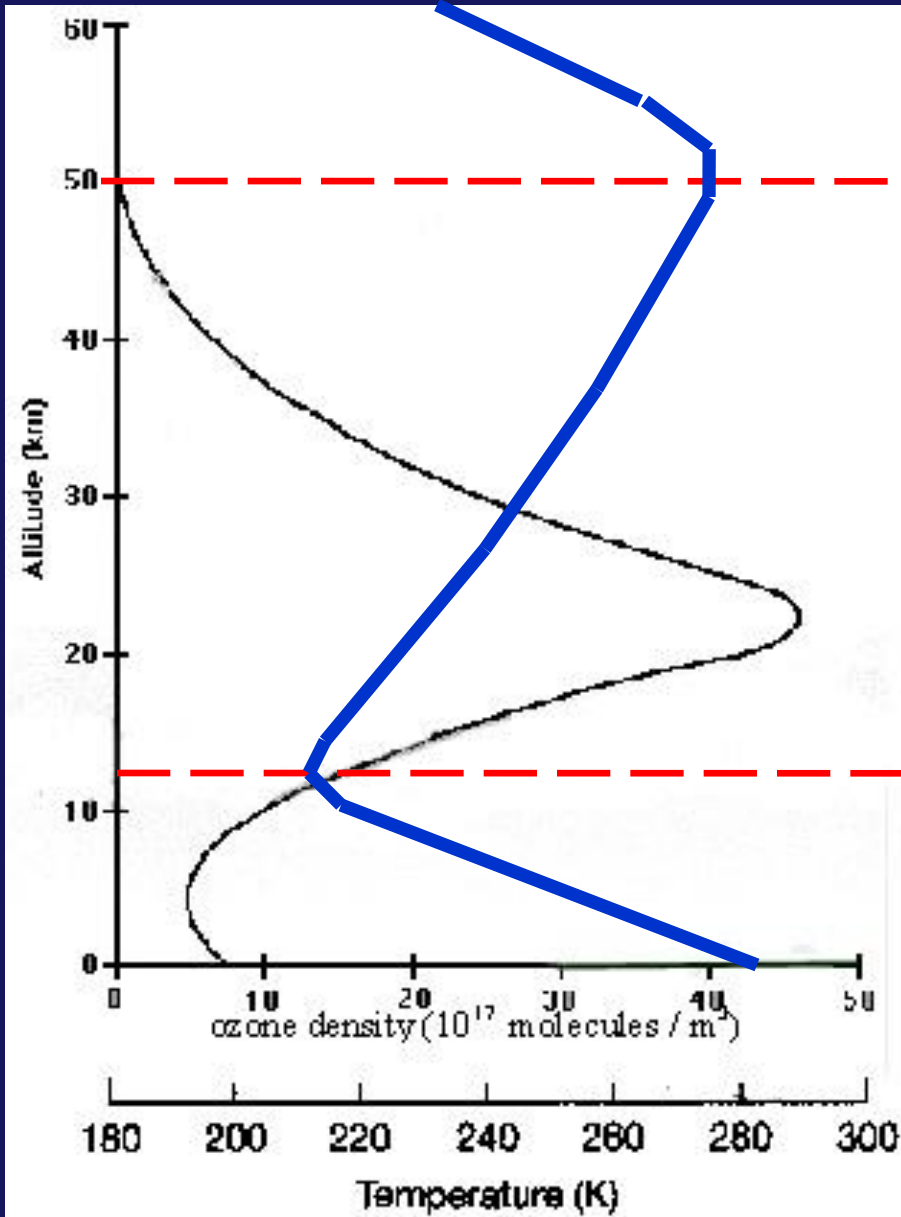
# TEMPERATURE

[ increases / decreases ]

with increasing altitude  
in the stratosphere

← The high concentration  
of ozone at this level  
**WARMES** the stratosphere  
above it

**WHY???**



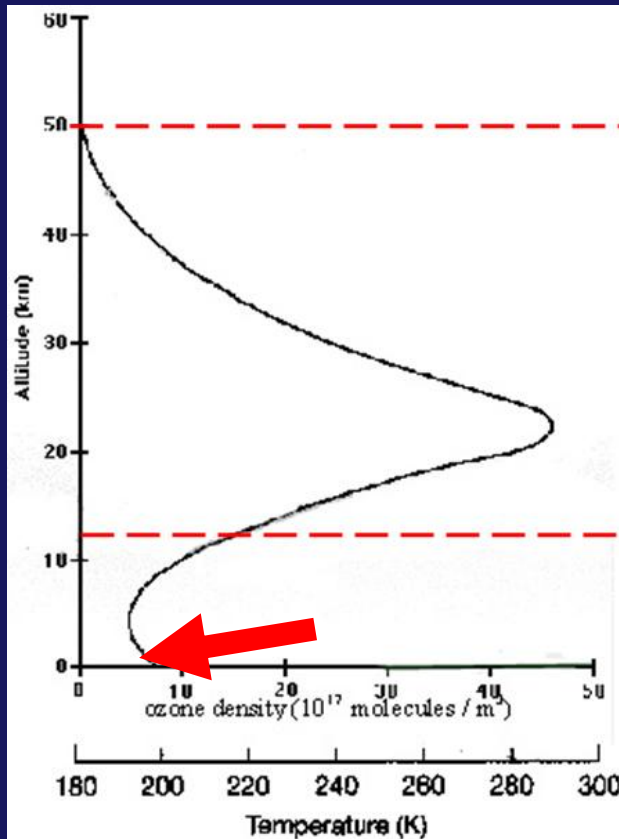
## Q. Why is there an increase in temperature with altitude in the STRATOSPHERE?

1. It is the closest layer to the sun, hence it is closest to the solar “heat source.”
2. It receives **large amounts of UV radiation** from the sun PLUS it has a **high concentration of ozone** which absorbs this UV which excites molecules → warming
3. It is the layer which **contains most of the GH gases** that absorb IR radiation emitted by the Earth’s surface.

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# What about the ozone that is concentrated in the troposphere?



## 2 Consequences:

- 1) Impacts health!
- 2) Contributes to enhanced GH Effect (warming in the troposphere)

← Ozone has increased in the troposphere due to **photochemical smog** reactions = “bad ozone”  
WHY “BAD”?

 +  = tropospheric ozone



# HEALTH AND ENVIRONMENTAL EFFECTS OF GROUND-LEVEL OZONE

Why are We Concerned  
about Ground-Level Ozone?

→ Ozone is the prime ingredient  
of smog in our cities and  
other areas of the country.

Phoenix  
smog →



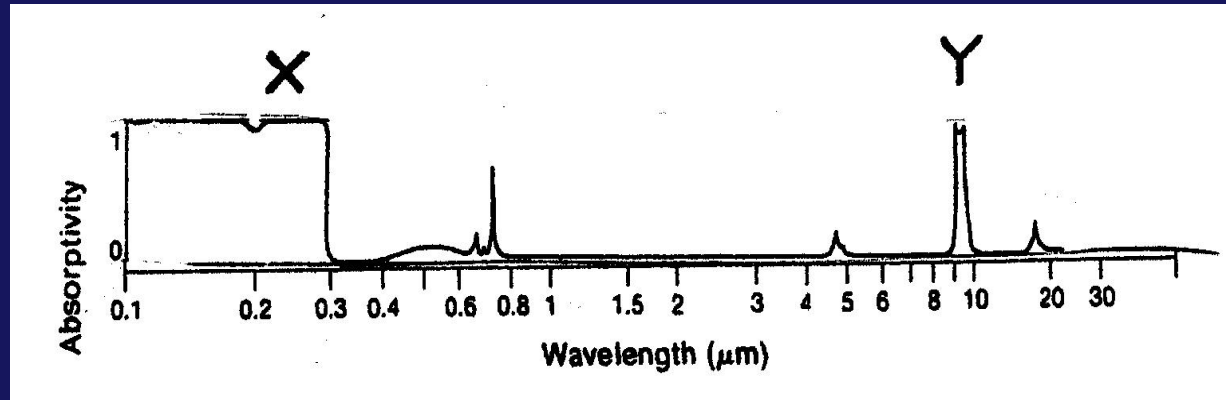
**→ When inhaled, even at very low levels, ozone can:**

- cause acute respiratory problems
- aggravate asthma
- cause significant temporary decreases in lung capacity
- cause inflammation of lung tissue
- lead to hospital admissions & emergency room visits
- impair the body's immune system defenses





# OZONE'S DUAL PERSONALITY!

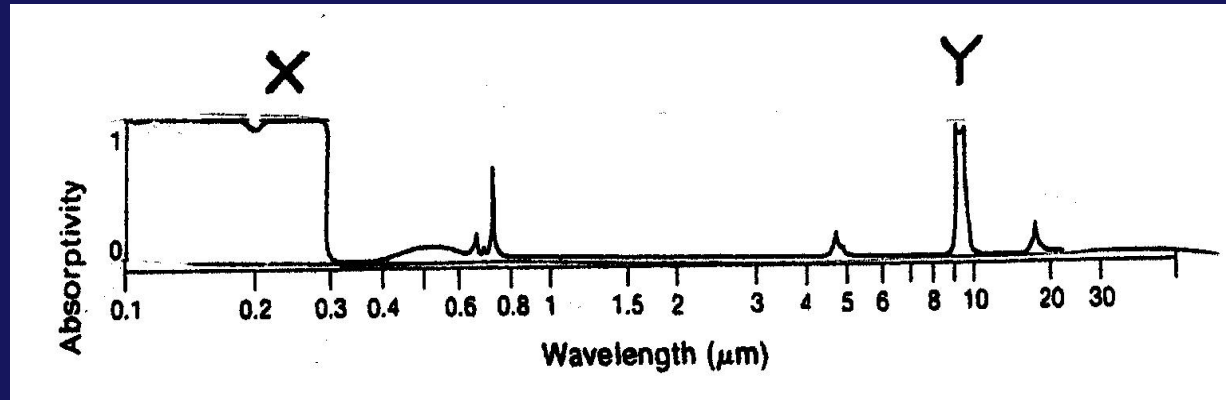


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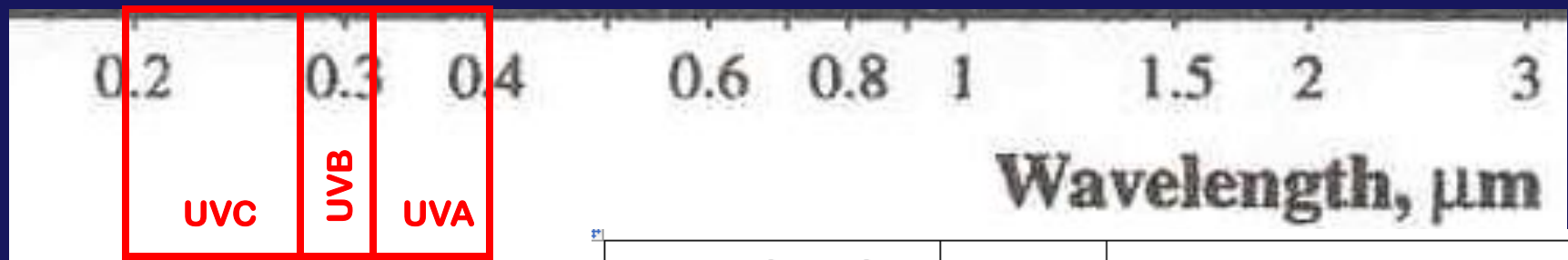
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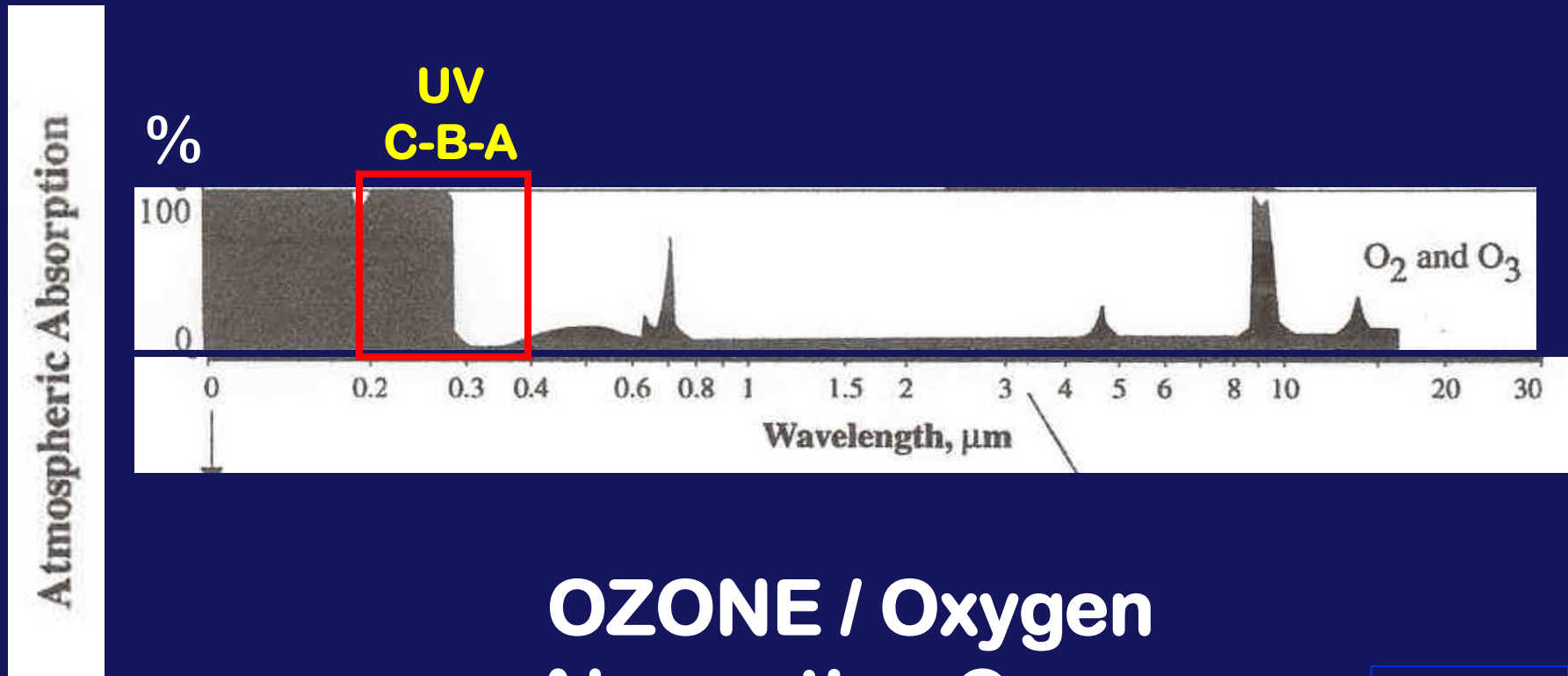
**ANOTHER LINK TO  
EVERYDAY LIFE:**

**SUN SAFETY!**



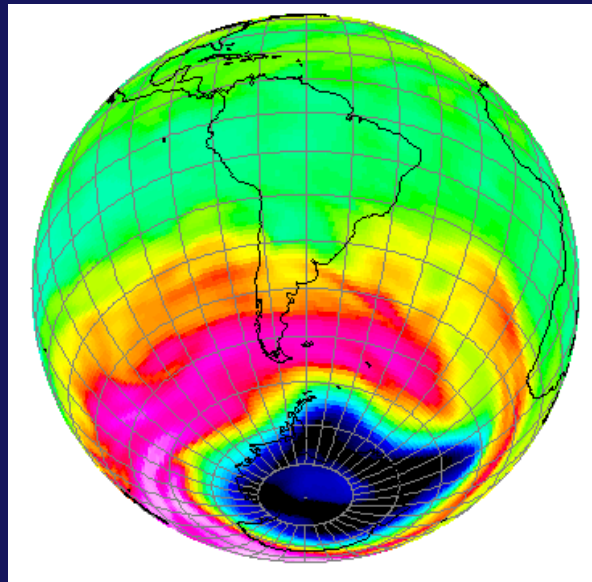
Wavelength Range	Name	Biological Effect
.32 to .4 $\mu\text{m}$ (320-400 nm)	UVA	once thought to be relatively harmless, <b>BUT causes wrinkles, premature aging</b> and associated sun-related skin damage; <b>new research indicates possible skin cancer link</b>
.29 to .32 $\mu\text{m}$ (290-320 nm)	UVB	<b>harmful</b> , causes sunburn, skin cancer, and other disorders
.20 to .29 $\mu\text{m}$ (200 - 290 nm)	UVC	<b>extremely harmful, damages DNA</b> -- but almost completely absorbed by ozone

# WHY FULL SPECTRUM PROTECTION IS NEEDED!!



OZONE / Oxygen  
Absorption Curve

# THE DESTRUCTION OF STRATOSPHERIC OZONE



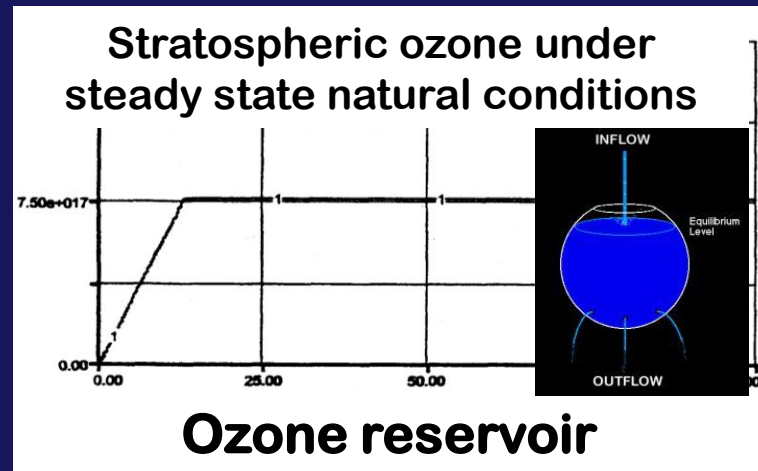
# The ozone hole is:

-- a depletion of ozone in the lower stratosphere

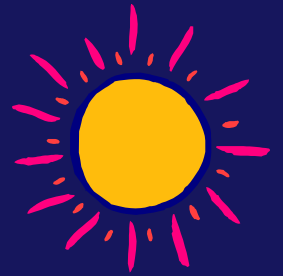
-- that has occurred with increasing severity each spring (since measurements begin in 1970s)

NOTE: this and other “bullet” items from today’s lecture are in the box on p 79

The Chapman Mechanism “balance” is being disrupted by the introduction of CFC's and other similar gases into the stratosphere:



- > CFCs are photo-dissociated into **FREE CHLORINE ATOMS (Cl)** and other molecular fragments by **UV rays**
- > **Chlorine** (and other gases such as Nitric oxide, NO) act as catalysts in ozone loss reactions





# CATALYST =

**A compound that increases the rate of a chemical reaction and is itself unchanged by the reaction**

*Through chemical reactions:*

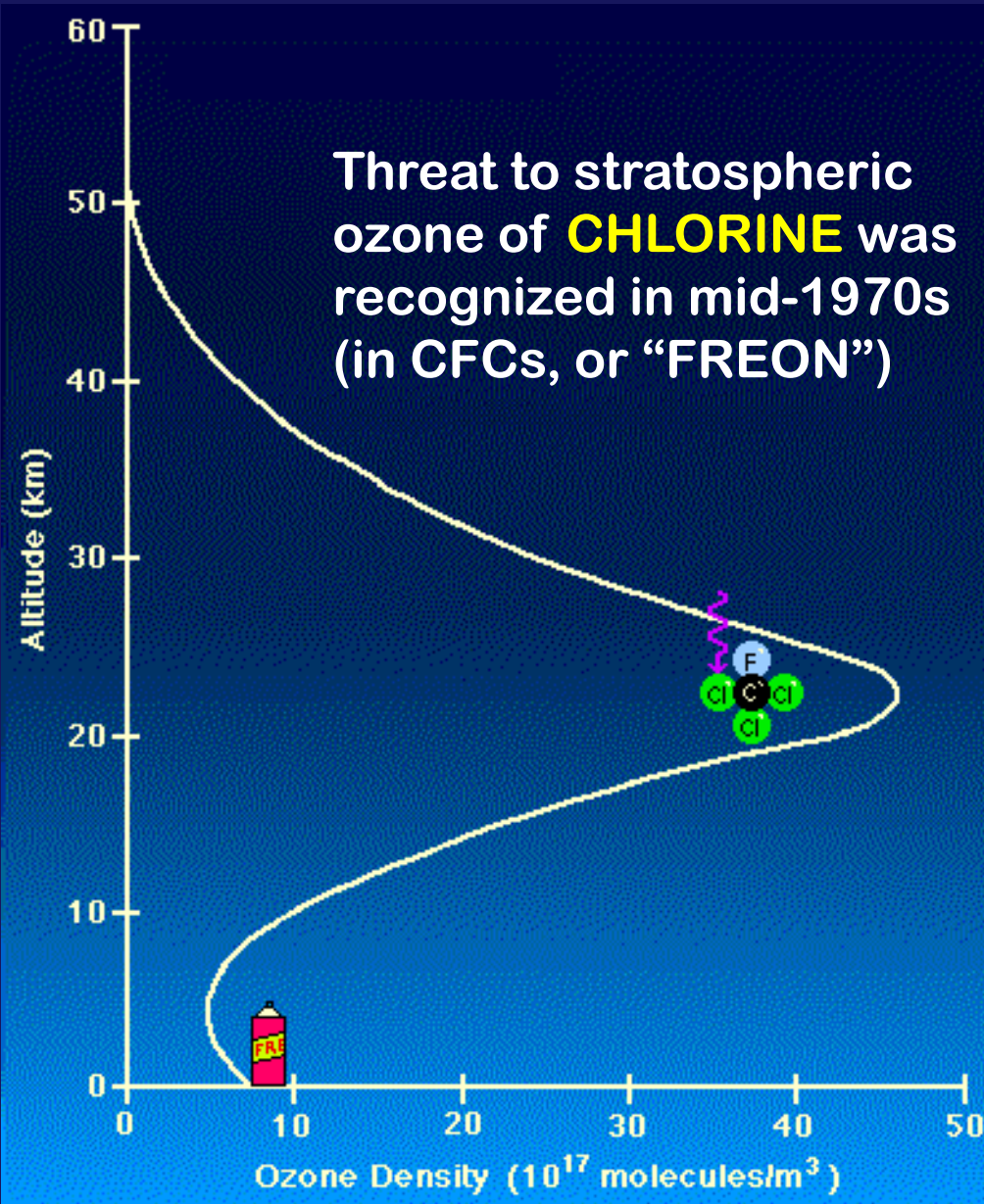
- the chlorine removes ozone from the stratosphere
- and also frees more chlorine atoms to begin the process all over again

# CFC compounds

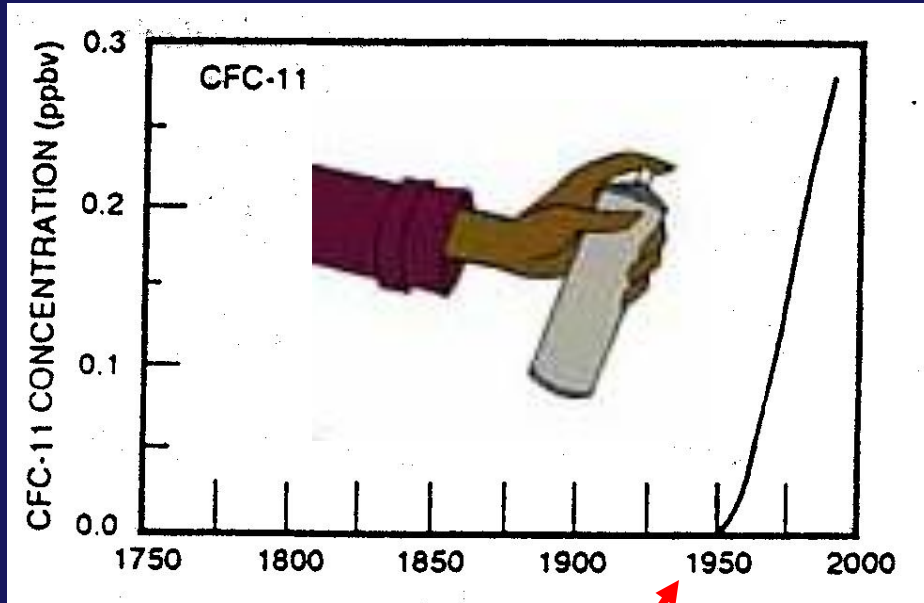
## Chlorofluorocarbons

are unreactive at Earth's surface,

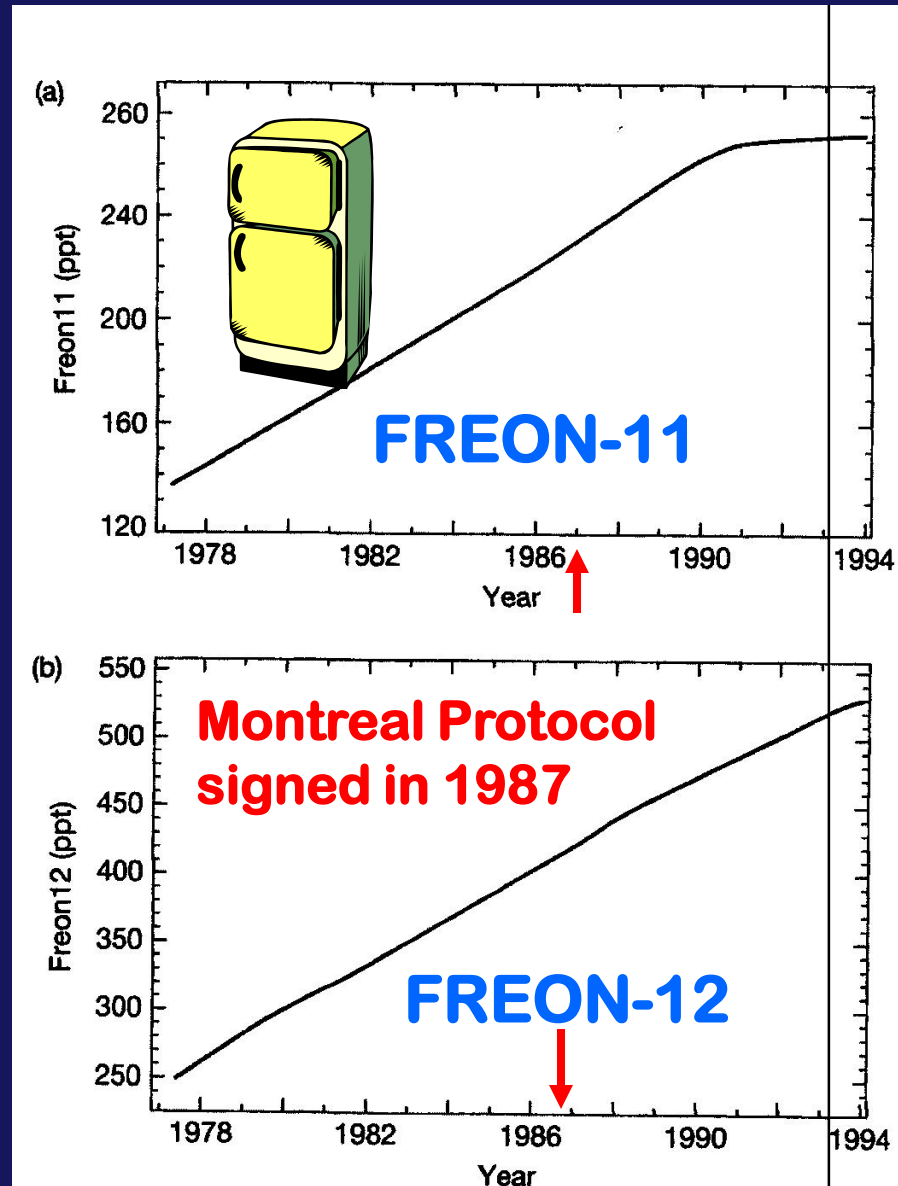
but if they get into the stratosphere, they can be broken down by high energy UV radiation → leads to release of highly reactive **CHLORINE atoms (Cl)**



# CFCs: Trends



Human-made --  
didn't exist  
before 1950!



# **CFC's & the CHLORINE CATALYST**

**A single chlorine atom may  
destroy hundreds of thousands of  
ozone molecules during its  
residence in the stratosphere!**

**[Go to movie clip]**

**This chemical theory of ozone destruction by  
CFC's was first proposed in 1974 – but no  
observations existed!**

**(Atmospheric chemists Crutzen, Molina, Rowland  
were later given Nobel prize for this theory)**

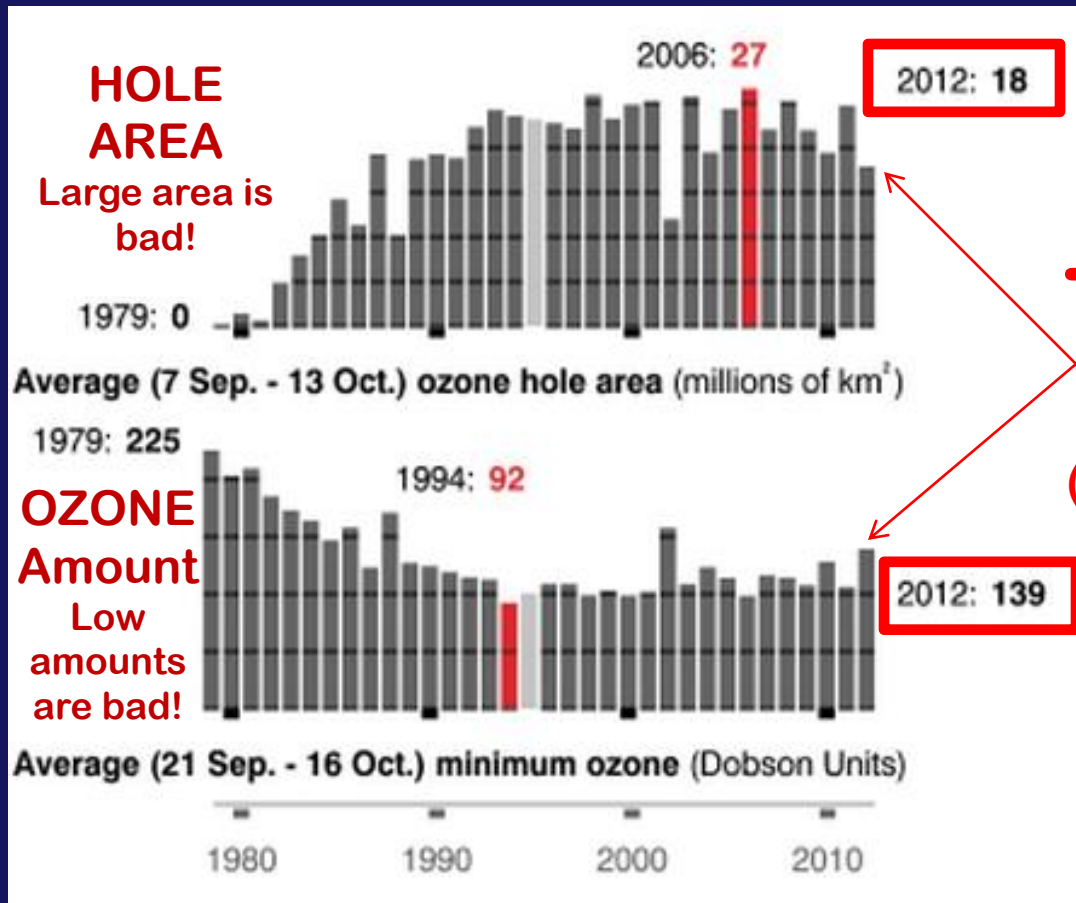
# RECIPE FOR THE OZONE HOLE

<http://www.youtube.com/watch?v=qUfVMogldr8>



**OZONE HOLE WATCH**  
images, data, and information; updated daily

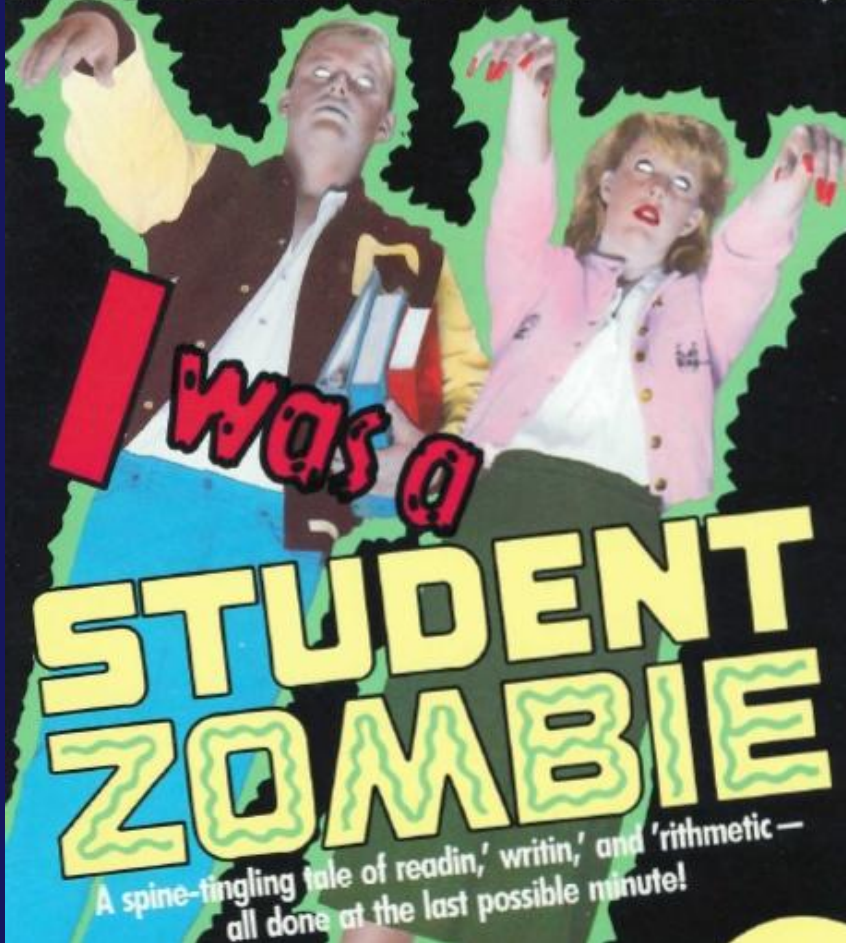
## Annual Ozone Hole Variations (since 1979)



**This year:**  
**2012**  
(better than last!)

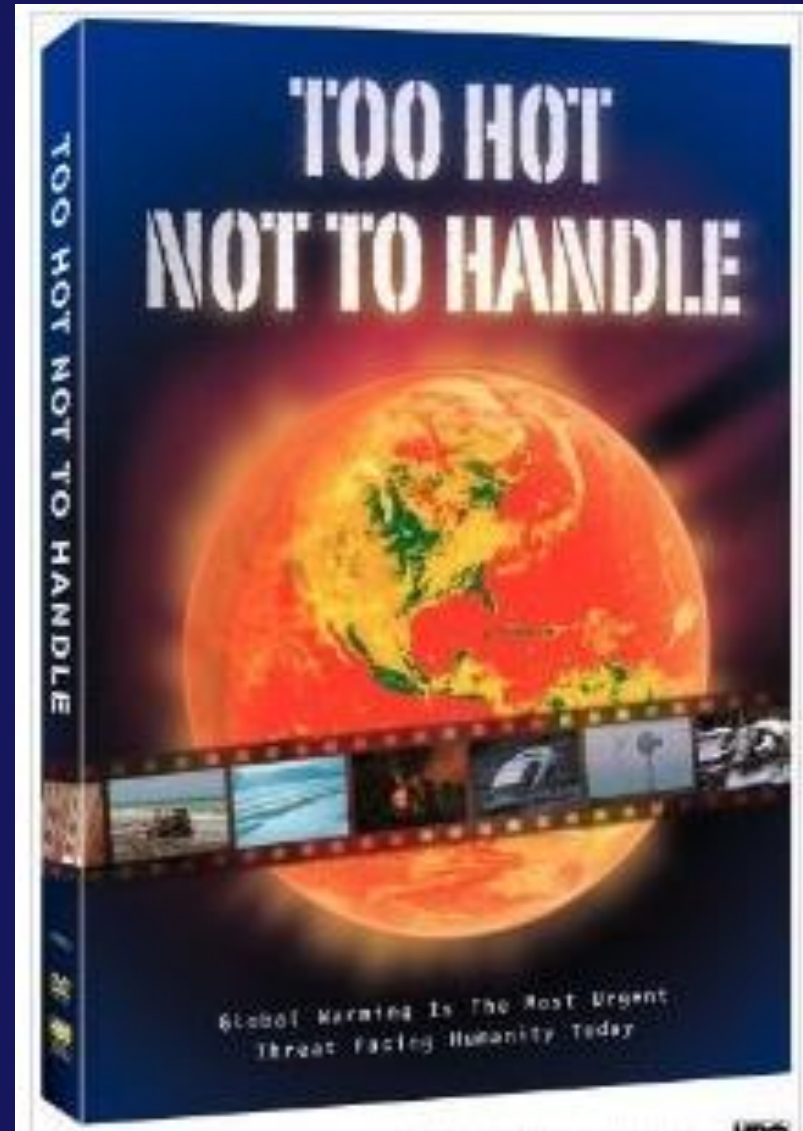


It's happening right now...in YOUR town...  
in YOUR school...in YOUR class...in YOUR BRAIN!



**ZOMBIE  
BREAK !**

Let's start  
looking at  
**SOLUTIONS!!!!**





**On FRIDAY:**  
**The STORY OF THE DISCOVERY**  
**OF**  
**THE OZONE HOLE:**

**“A Misadventure of Science?”**