1903CE032
Global Warming and Climate Change

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Course Objectives

1. To understand the Earth's Climate System and the concept of Global Warming.

2. To analyze the global warming and their effects due to climate change.

3. To comprehend the impact of climate change on society and its mitigation measures.

Course Outcomes

1. Outline the principle involved in the greenhouse gas emission.
2. Explain the carbon emission and its mitigation methods.
3. Illustrate about the climate variability parameters.
4. Describe the climate components and the circulation system.
5. Discuss about the physical processes involved in the climate system.

Syllabus

Unit I Introduction of global warming 9 Hours

Introduction - the gas law - ideal gas equation- the mole concept- sample calculations- ppm - sulphur pollutants-oxides of nitrogen - particulate - Green House Gases.

Unit II Mitigation measure, emission targets and carbon trading 9 Hours

Introduction-reduction of carbon dioxide emissions from power generation- carbon credits-carbon dioxide from vehicle - miscellaneous source of carbon dioxide- uptake of carbon dioxide by vegetation.

Unit III Overview of climate variability and climate science 9 Hours

Climate dynamics, climate change and climate prediction - the chemical and physical climate system and aspects - El Nino and global warming - global change in recent history.

Unit IV Basics of global climate 9 Hours

Components and phenomena in the climate system - basics of radioactive forcing - atmospheric circulation-ocean circulation-land surface processes - the carbon cycle.

Unit V Physical processes in the climate system 9 Hours

Conservation of momentum-equation of state- temperature equation - continuity equation -conservation of mass applied to moisture – saturation - wave processes in the atmosphere and ocean.

What’s the difference?

GLOBAL WARMING

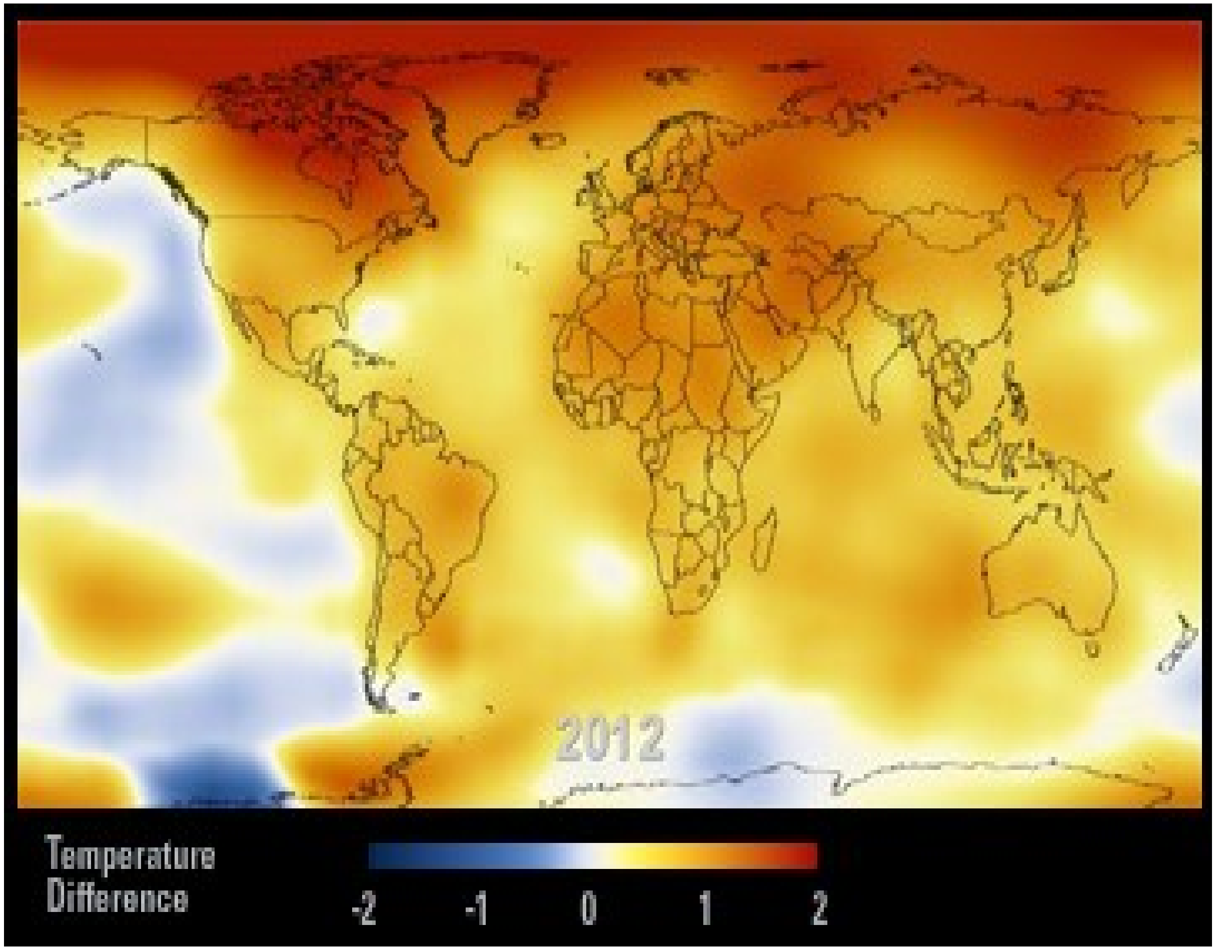
Is the increase of the Earth’s average surface temperature due to a build-up of greenhouse gases in the atmosphere.

CLIMATE CHANGE

Is the long-term changes in climate, including average temperature and precipitation. It recognizes that, although the average surface temperature may increase, the regional or local temperature may decrease or remain constant.

What does “average” mean?

- Climate is the average weather conditions over time.
- Global warming refers to an increase in the Earth’s average temperature.

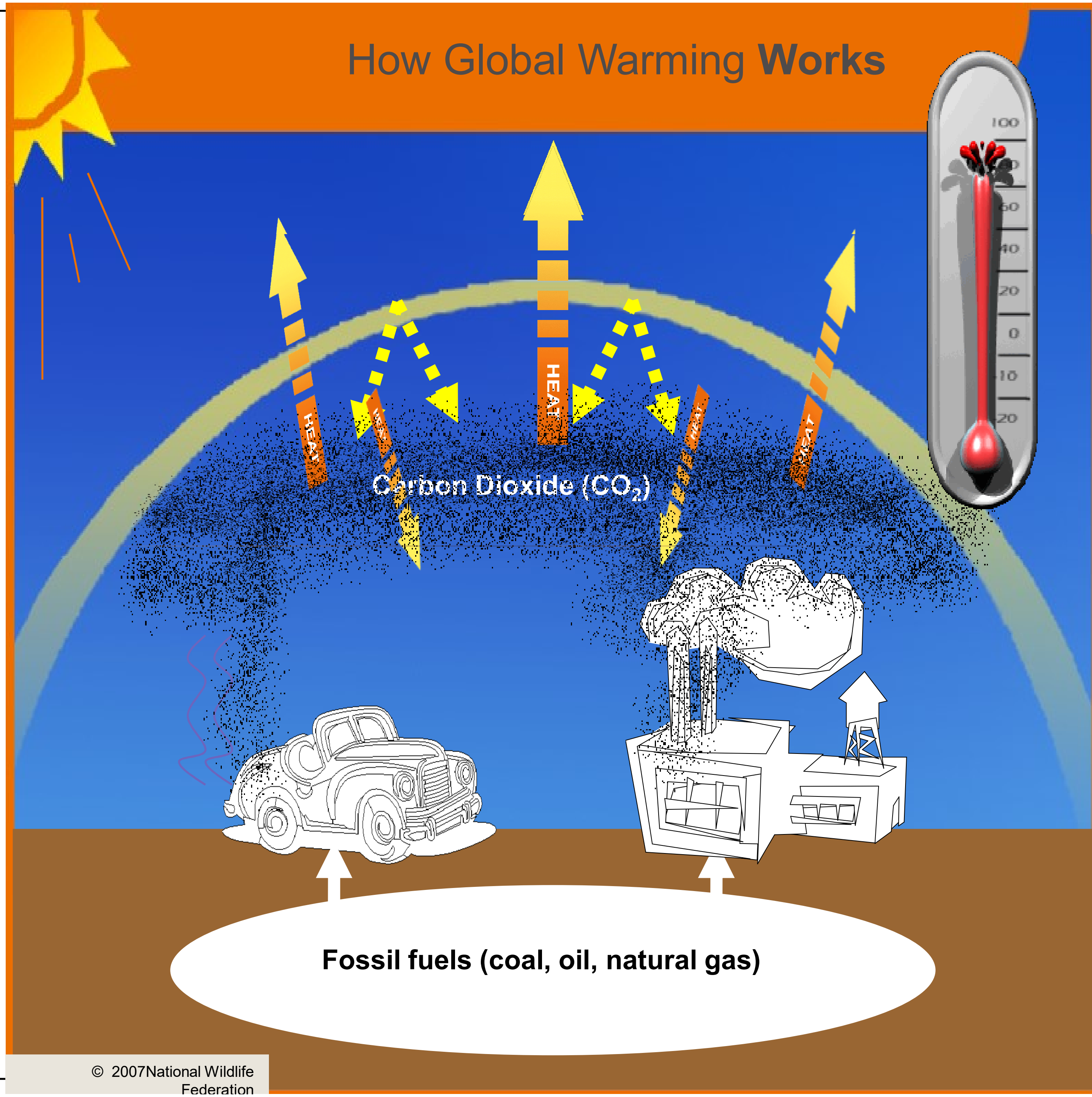


This map shows the five-year average variation of global surface temperatures from 1884 to 2012.

Dark blue indicates areas cooler than average.

Dark red indicates areas warmer than average.

Source: NASA Climate http://climate.nasa.gov/key_indicators#globalTemp


How Global Warming **Works**
HEAT
Carbon Dioxide (CO_2)
Fossil fuels (coal, oil, natural gas)
© 2007National Wildlife Federation

Factors Responsible For Global Warming..

There are many factors responsible for Global Warming.Some of the factors are:-

1)CFC's(Chlorofluorocarbons Carbons).

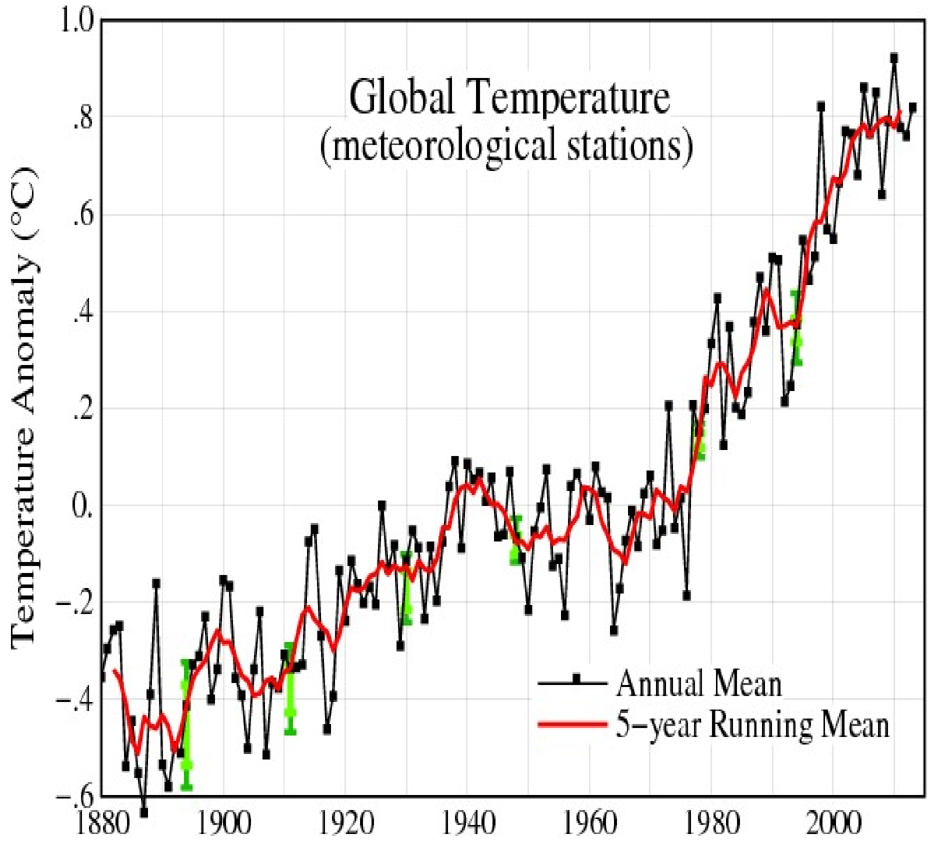
2)Deforestation.

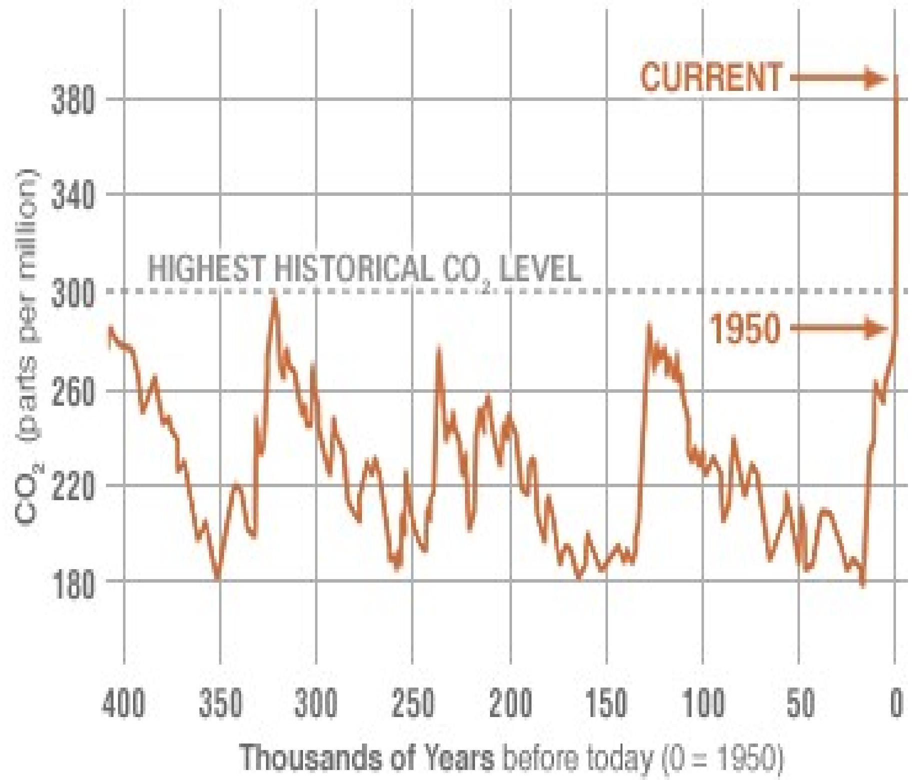
3) Pollution.

4)Over exploitation of resources.

5)Urbanization.

Temperature & CO_2 Data





Source: NASA Goddard Space Flight Center
http://data.giss.nasa.gov/gistemp/graphs_v3/

Source: NASA Climate, Data from NOA
http://climate.nasa.gov/key_indicators#co2

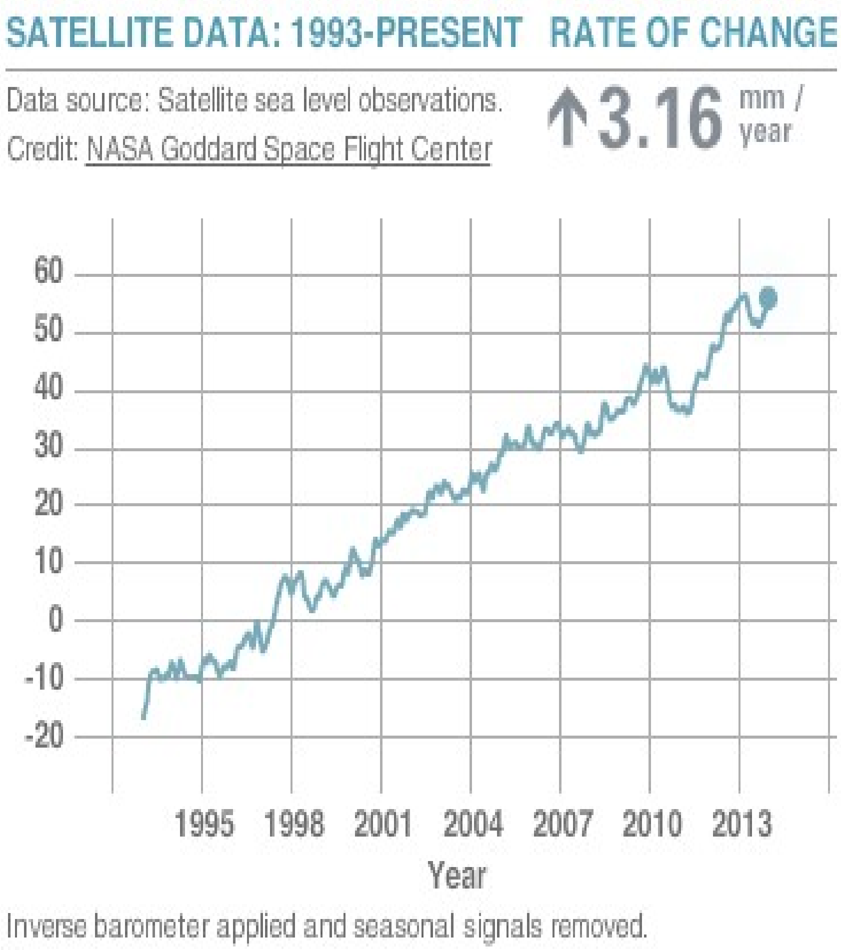
Glaciers are melting

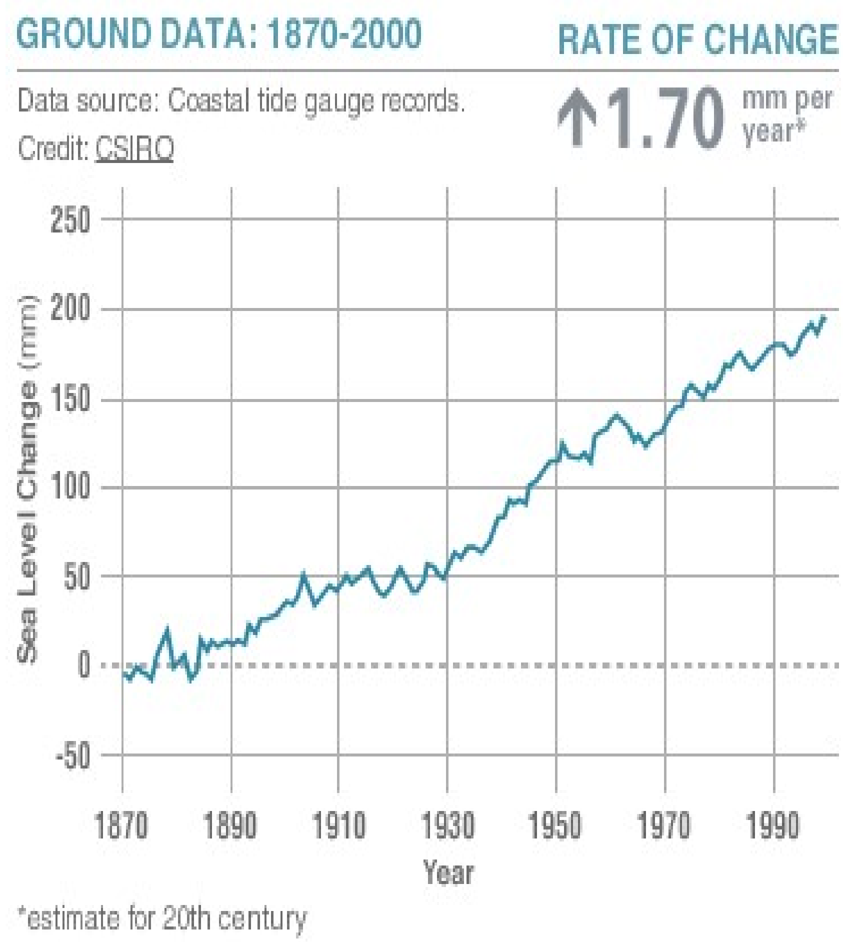
So are ice caps on both North and South poll. Pictured example: Portage Glacier, Alaska

1914

2004

Global Sea Level Rise

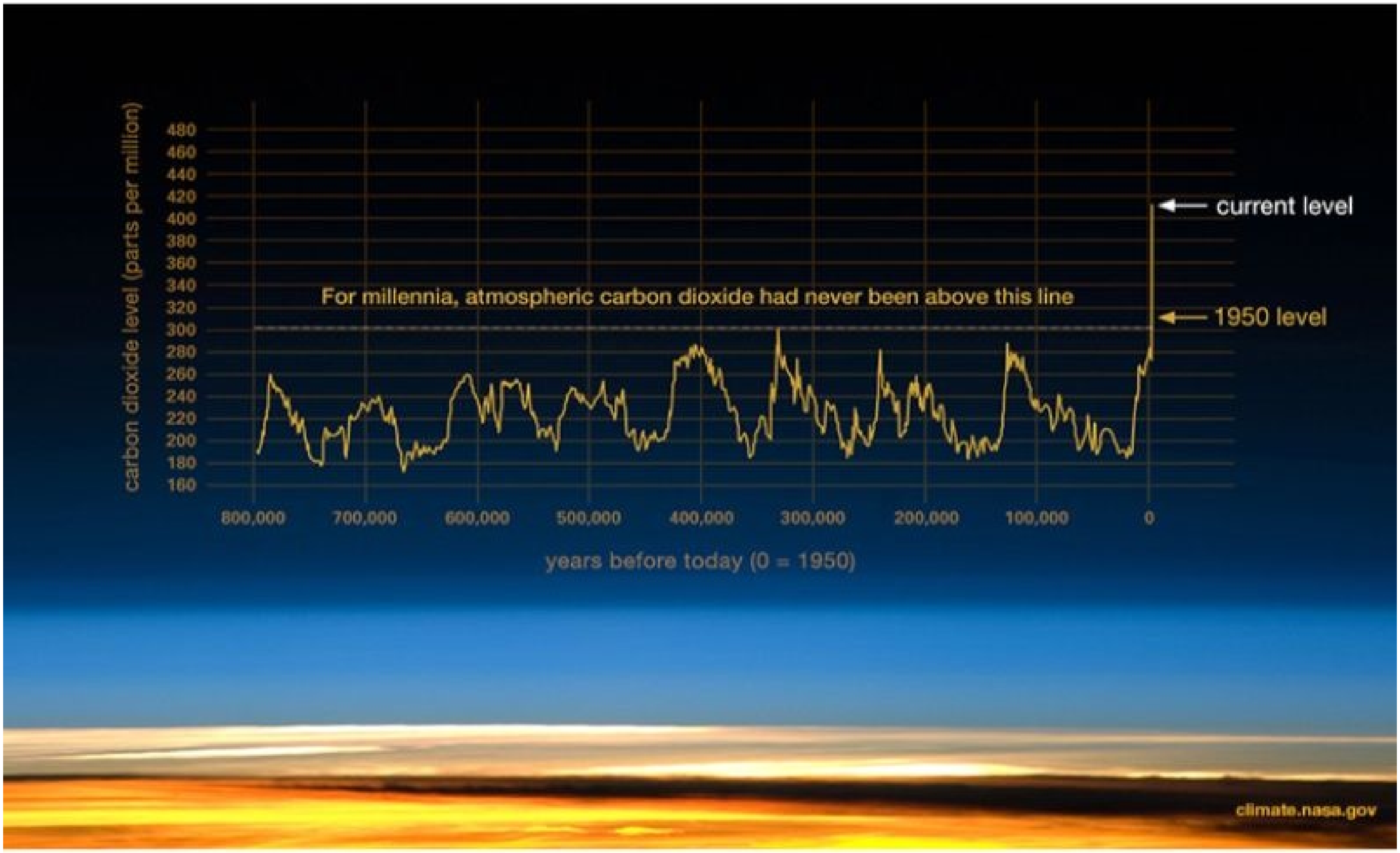


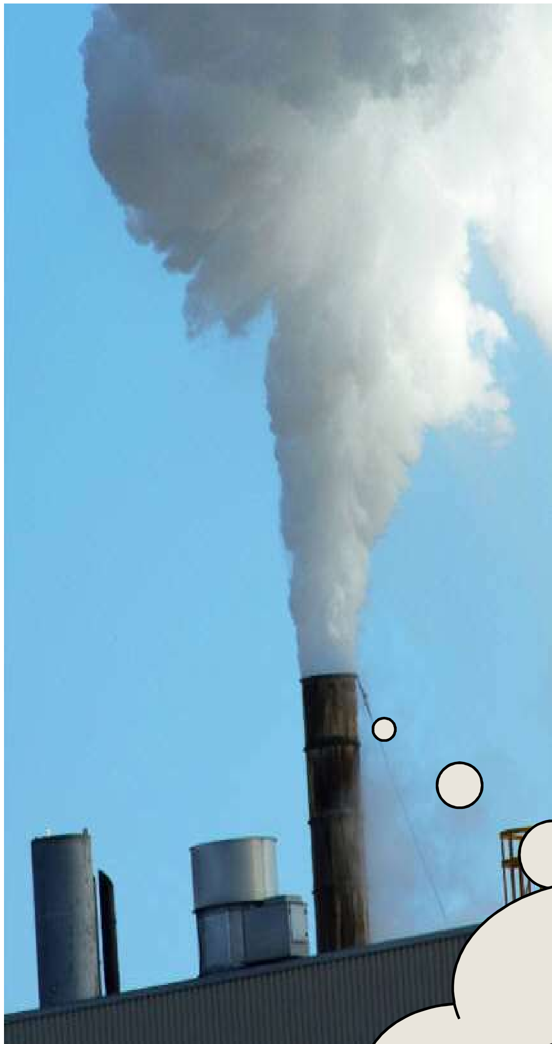


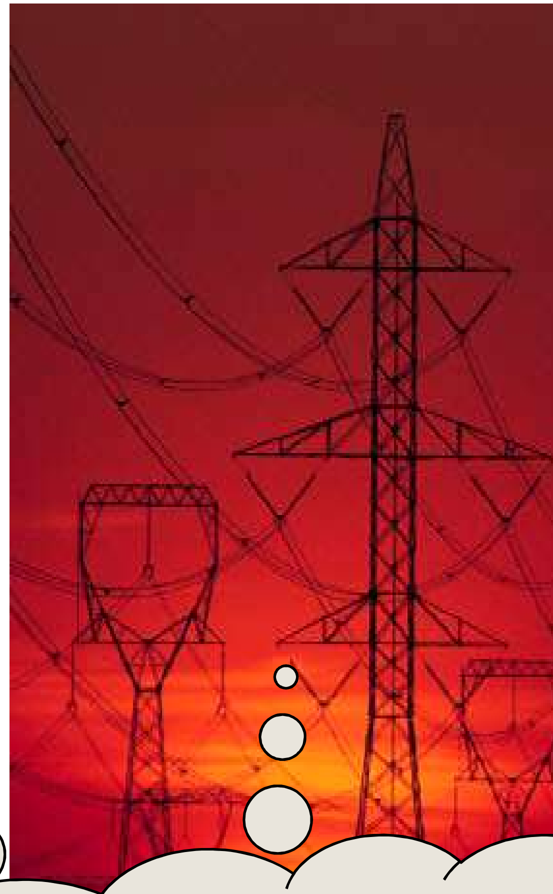
Visit: http://climate.nasa.gov/key_indicators for interactive charts on sea level and other key climate change indicators.

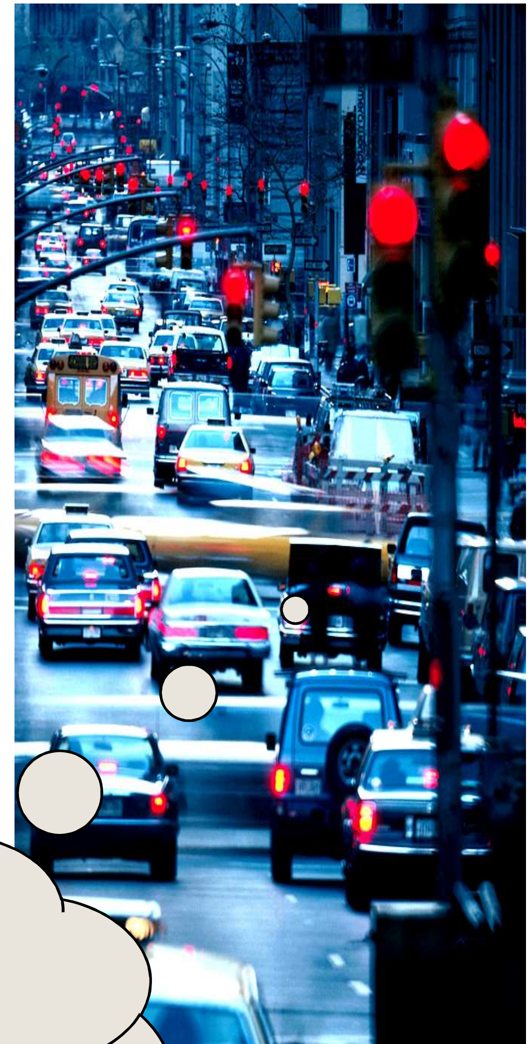
Source: NASA Climate http://climate.nasa.gov/key_indicators#seaLevel

Why is climate change happening?









Pollution from coal, natural gas, and oil

"Warming of the climate system is unequivocal,
human influence on the climate system is clear …"

What causes Earth's climate to change?

- Changes in the atmosphere

- Natural processes
  - Volcanoes
  - Tectonic plate movement
  - Changes in the sun
  - Shifts in Earth's orbit

- Human activities – any activity that releases "greenhouse gases" into the atmosphere

What are greenhouse gases?

Any gases that cause the "greenhouse effect!"

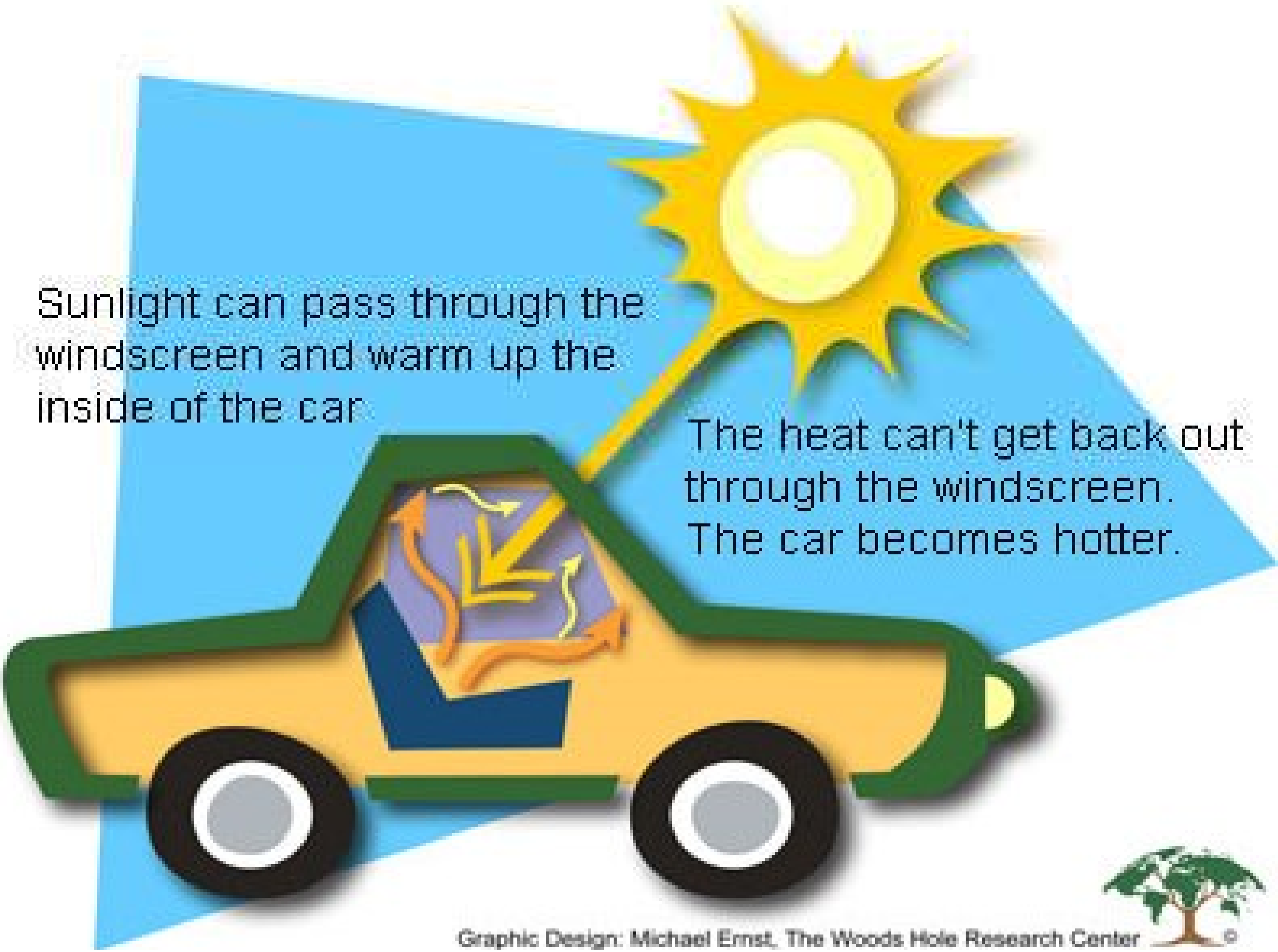
water vapor

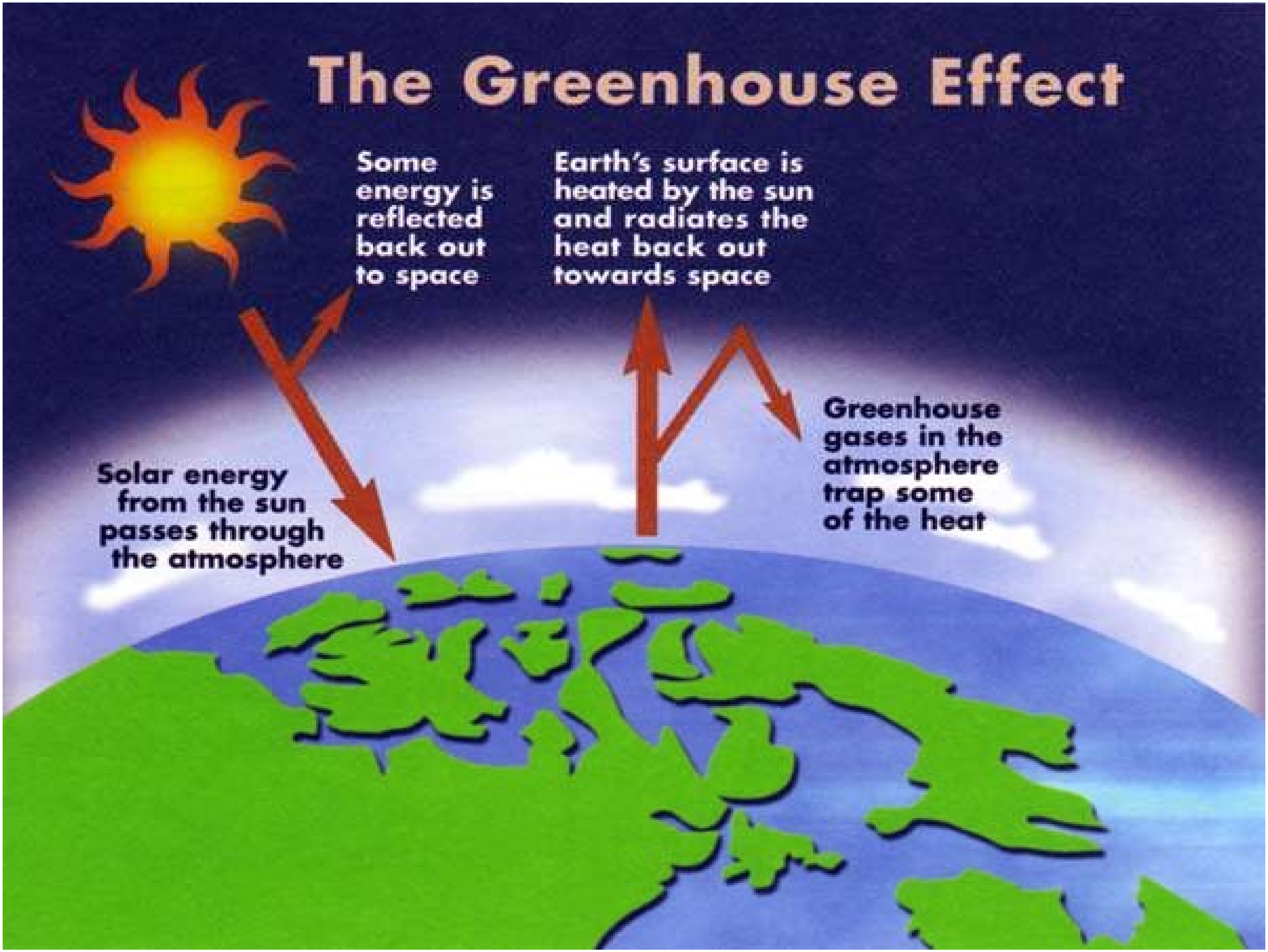
methane

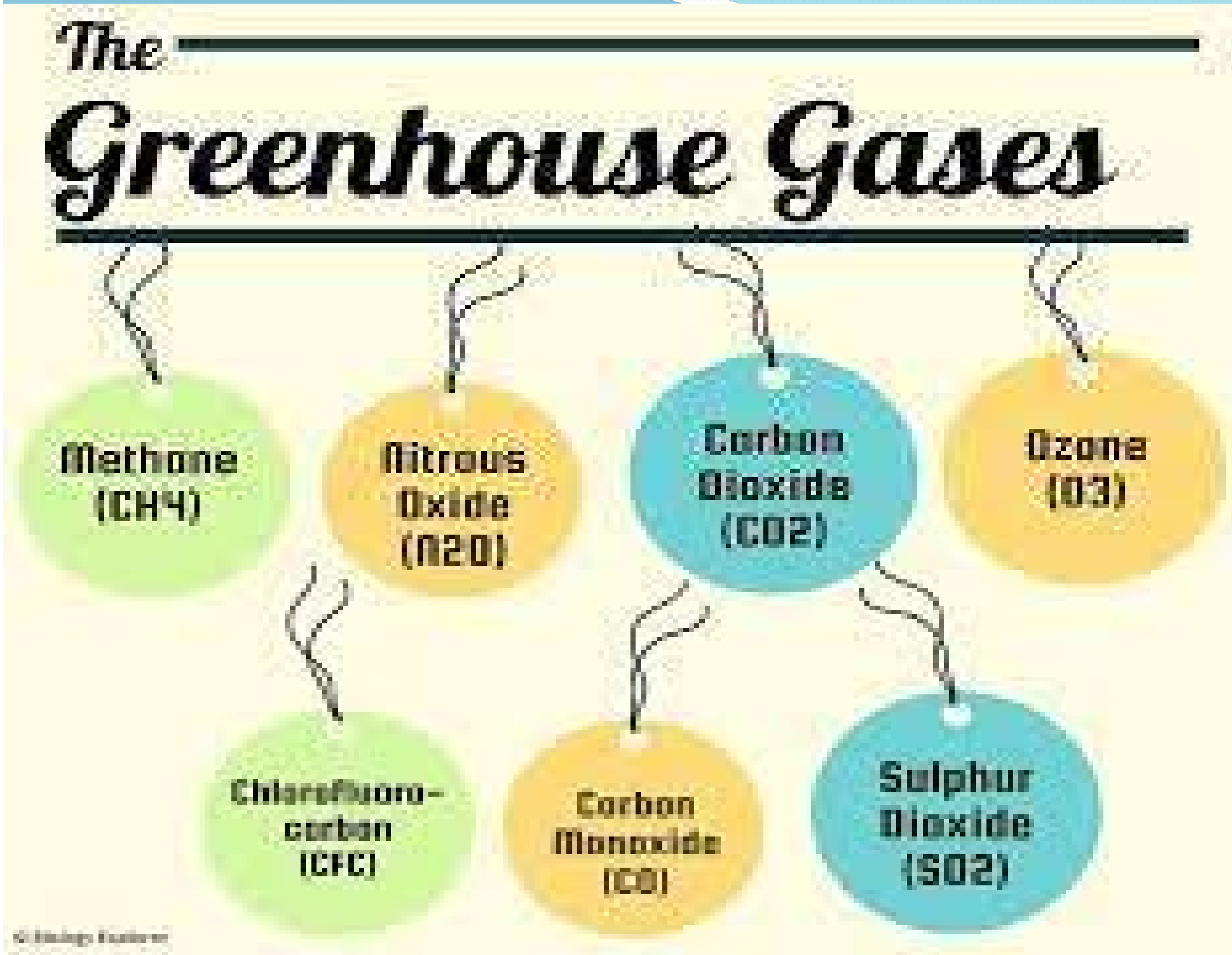
carbon dioxide

nitrous oxide

Imagine… a car on a cool but sunny day…


Sunlight can pass through the windscreen and warm up the inside of the car
The heat can't get back out through the windscreen. The car becomes hotter.
Graphic Design: Michael Ernst, The Woods Hole Research Center


The Greenhouse Effect
Some energy is reflected back out to space
Earth's surface is heated by the sun and radiates the heat back out towards space
Greenhouse gases in the atmosphere trap some of the heat
Solar energy from the sun passes through the atmosphere


The
Greenhouse Gases
Methane (CH4)
Nitrous Oxide (N2O)
Carbon Dioxide (CO2)
Ozone (O3)
Chlorofluoro-carbon (CFC)
Carbon Monoxide (CO)
Sulphur Dioxide (SO2)

Causes and Effects of Climate Change

Causes

- Rapid industrialization
- Energy use
- Agricultural practices
- Deforestation
- Consumer practices
- Livestock
- Transport
- Resource extraction
- Pollution

Effects

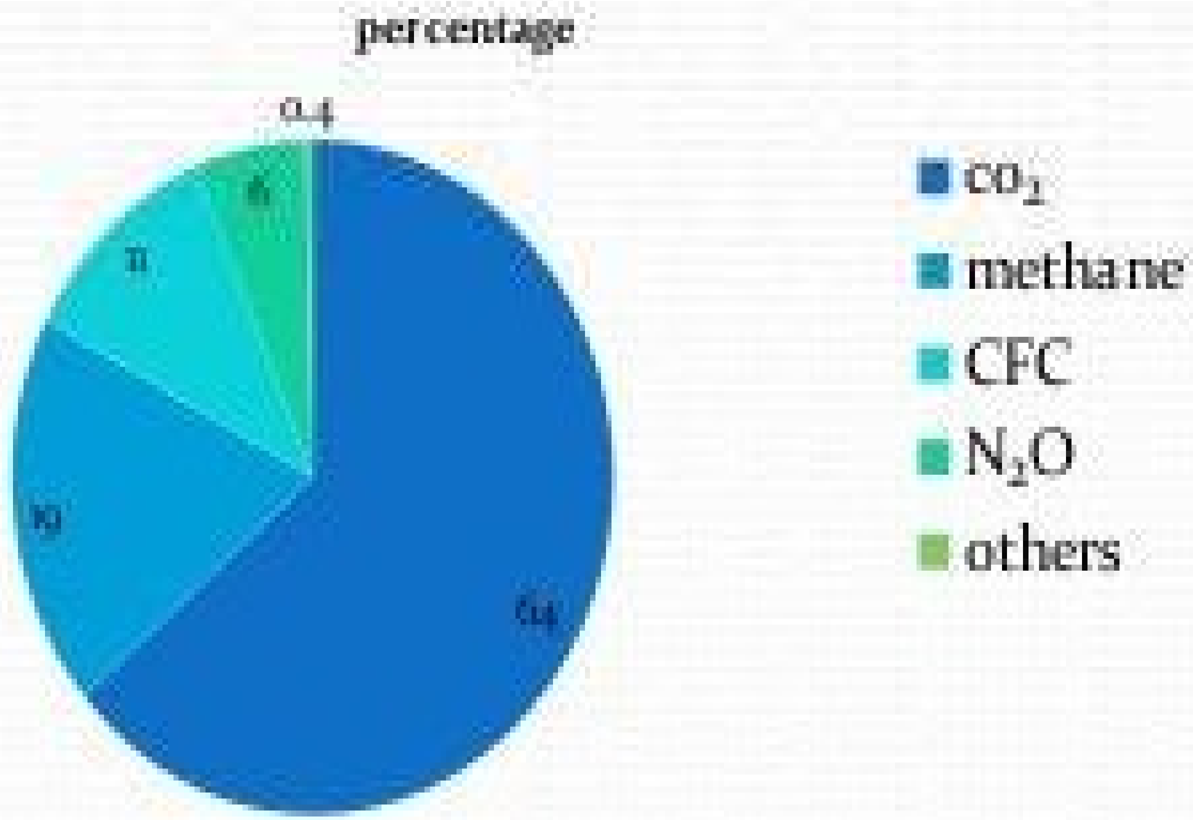
- Rising temperatures
- Rising sea levels
- Unpredictable weather patterns
- Increase in extreme weather events
- Land degradation
- Loss of wildlife and biodiversity

What are the social impacts of climate change?

Displaced people. Poverty. Loss of livelihood. Hunger. Malnutrition. Increased risk of diseases. Global food and water shortages.

GlobalGiving

Gas type responsible



Sources of greenhouse gases

1. Thermal power stations based on fossil fuels, mainly coal and mineral oil emitting huge amount of CO_2.
2. Numerous factories and industrial chimney wastes
3. Automobiles
4. Deforestation and burning of fossil fuels.

Effects of Greenhouse effect

1. global warming and climate change.
2. Rise of sea level
3. Worsening health effects
4. Disruption of the water cycle
5. Changing forest and natural areas
6. Challenges to agriculture and the food supply
7. Effect on the ozone layer
8. Effect on oceanic climate

Country specific carbon emission

Control of Greenhouse Effect

- Alternate sources of energy are to be used
- Advanced and efficient technologies for reducing emissions from fossil fuels.
- Afforestation and reforestation on a large scale
- Water logging should be avoided
- Reduction of the use of CFC
- Carbon market

Option for reducing CO_2

Carbon Management

- Dr. Klaus and his synthetic trees
- John H Martins theory of phytoplankton growth in ocean
- Injection of CO_2 into underground strata or deep ocean water

Consequences

- As a result change of climate has occurred which threats the sustainability of life. The consequences are as follows -:
- Melting of polar ice caps and glaciers along with thermal expansion of water.
- More droughts and floods.
- More terrible storms.
- Many more hot days.
- More diseases like malaria and dengue
- Impacts of ecosystem would change the crop production potential of a region specially Asia, Africa, South and Central America.

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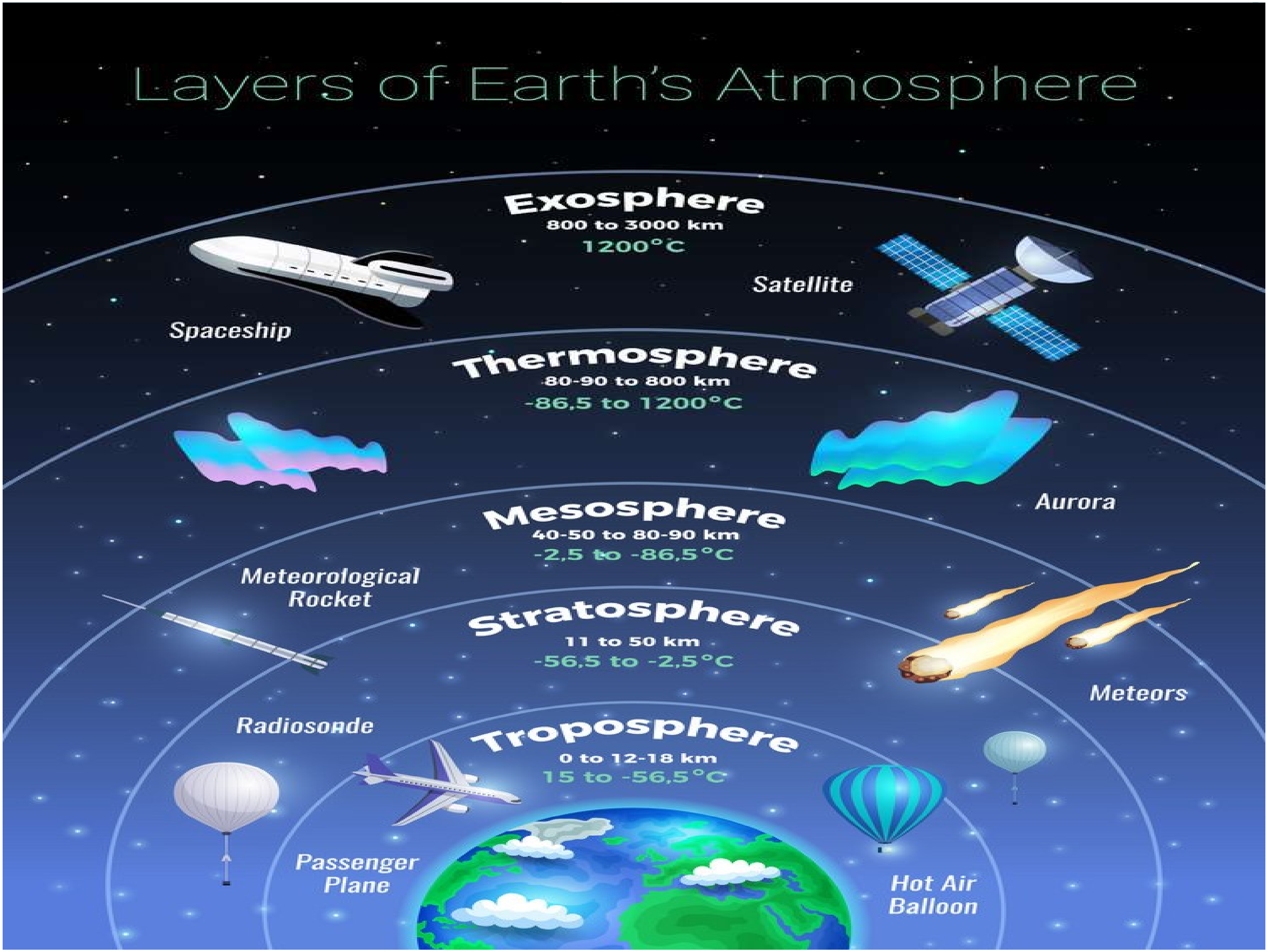
Who is responsible ?

- Affluent and rich countries are responsible for changes of climate.
- Global energy consumption and CO_2 emissions have increased 3 times between 1950 – 85.
- In 1990 out of 21 billion tons of global emissions, 14 billion tons are emitted by rich countries.
- US alone emitted 5 billion tons of carbon.
- India emits 159 million tons.

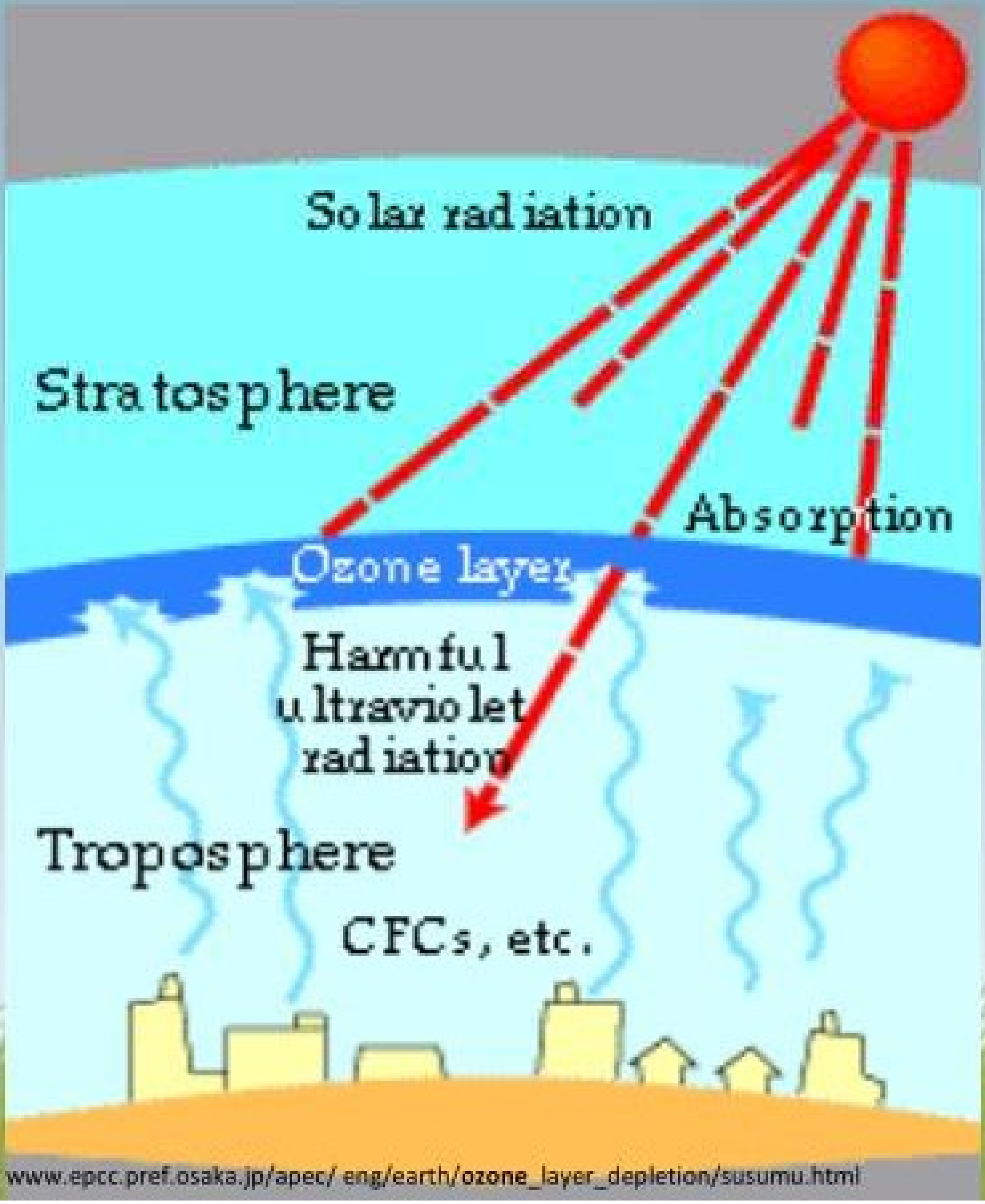

Layers of Earth's Atmosphere
Exosphere
800 to 3000 km
1200°C
Spaceship
Satellite
Thermosphere
80-90 to 800 km
-86,5 to 1200°C
Aurora
Mesosphere
40-50 to 80-90 km
-2,5 to -86,5°C
Meteorological
Rocket
Stratosphere
11 to 50 km
-56,5 to -2,5°C
Meteors
Radiosonde
Troposphere
0 to 12-18 km
15 to -56,5°C
Passenger
Plane
Hot Air
Balloon

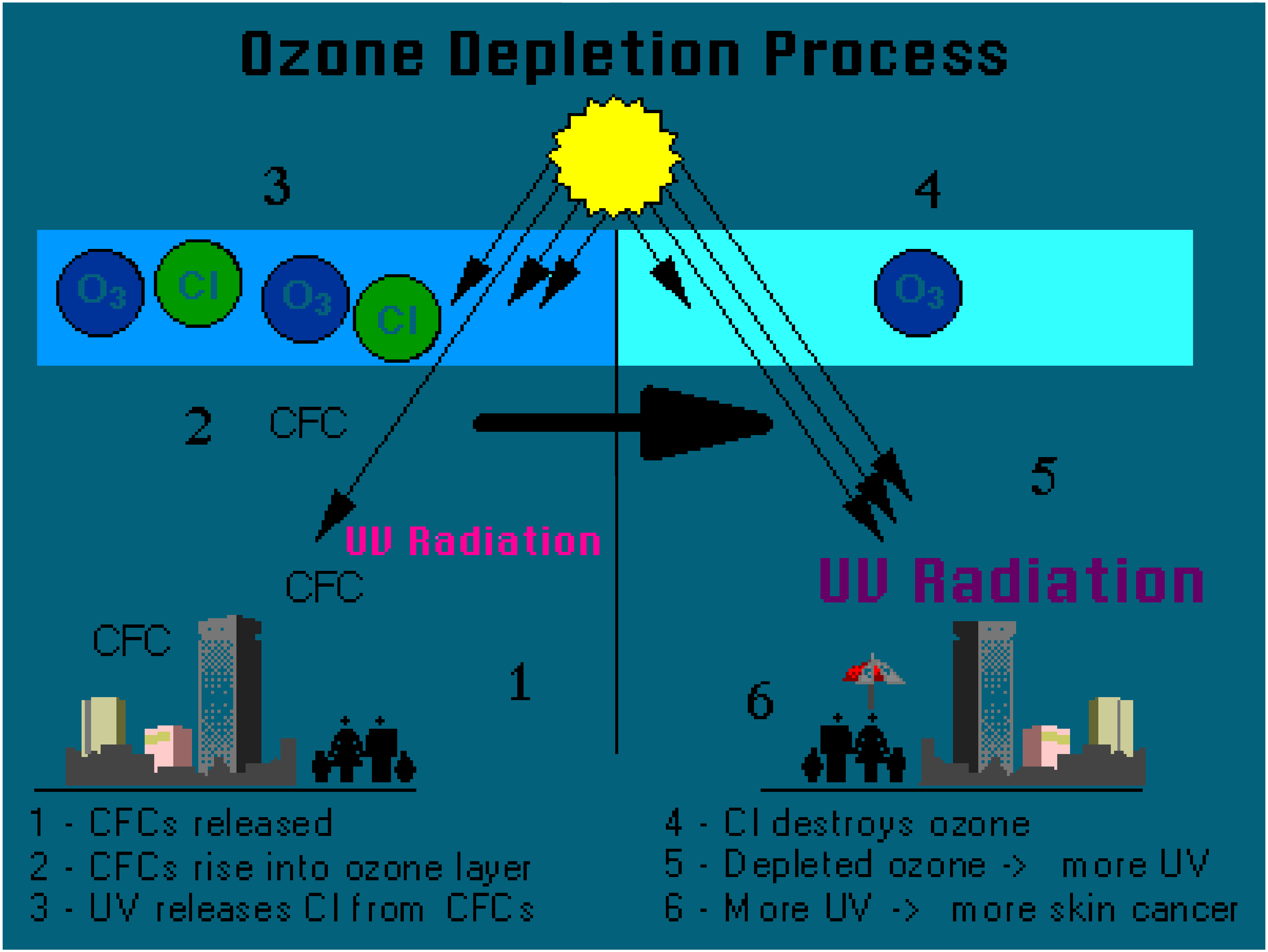
What is Ozone? Ozone Layer?

- Ozone (O3) is a highly-reactive from of oxygen.
- Unlike oxygen (O2), ozone has a strong scent and is blue in color.
- Ozone exists within both the tropospheric and stratospheric zones of the Earth's atmosphere
- In the troposphere, ground level ozone is a major air pollutant and primary constituent of photochemical smog
- In the stratosphere, the ozone layer is an essential protector of life on earth as it absorbs harmful UV radiation before it reaches the earth.

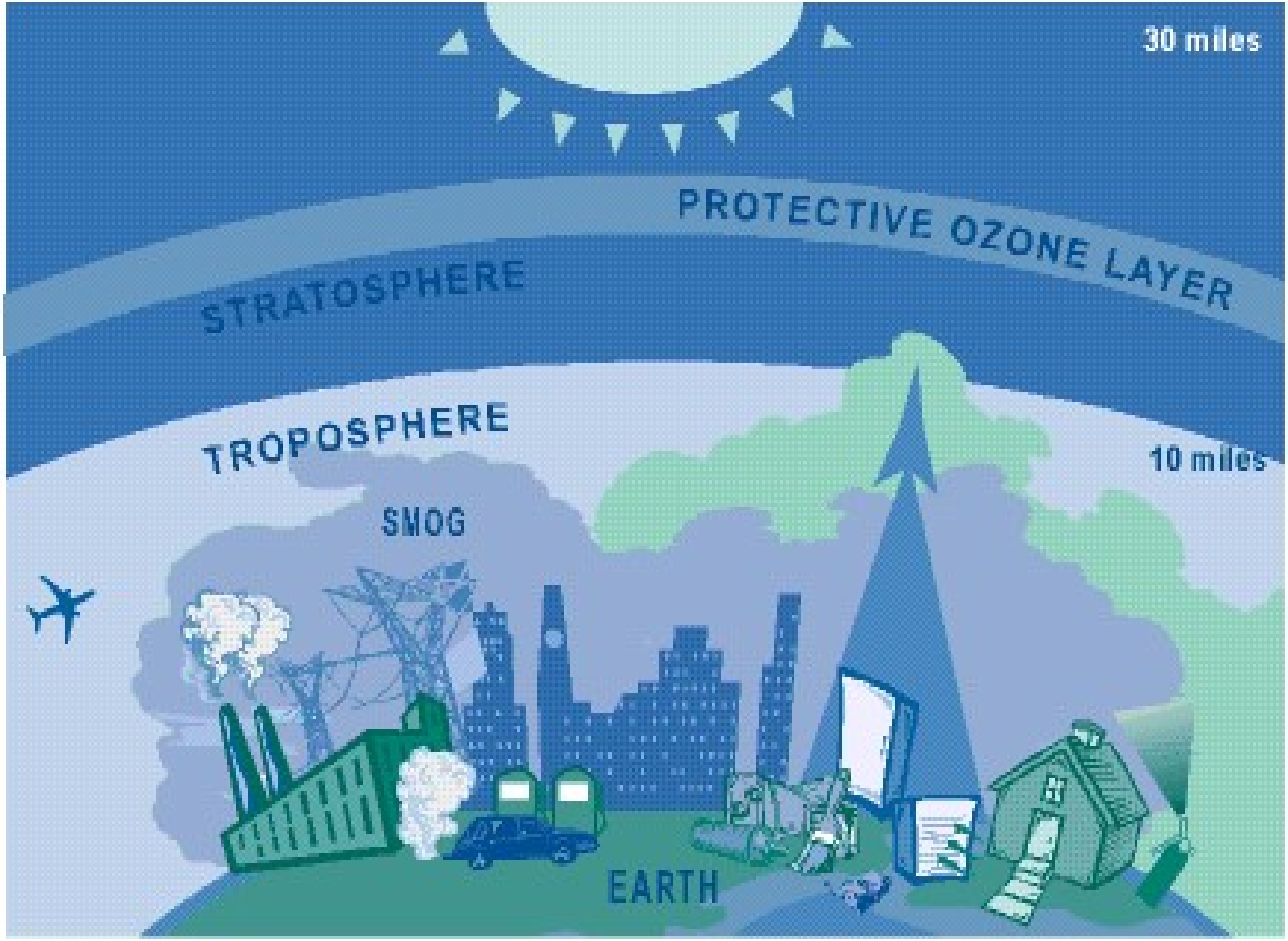
What is Ozone layer

- Ozone is a triatomic form of oxygen (O3) found in Earth's upper and lower atmosphere.
- The ozone layer, situated in the stratosphere about 15 to 30 km above the earth's surface.
- Ozone protects living organisms by absorbing harmful ultraviolet radiation (UVB) from the sun.
- The ozone layer is being destroyed by CFCs and other substances.
- Ozone depletion progressing globally except in the tropical zone.





Ozone Depletion Process
3
4
O_3
Cl
O_3
Cl
O_3
2
CFC
5
UV Radiation
CFC
UV Radiation
CFC
1
6
1 - CFCs released
2 - CFCs rise into ozone layer
3 - UV releases Cl from CFCs
4 - Cl destroys ozone
5 - Depleted ozone -> more UV
6 - More UV -> more skin cancer


30 miles
PROTECTIVE OZONE LAYER
STRATOSPHERE
TROPOSPHERE
10 miles
SMOG
EARTH

Effects

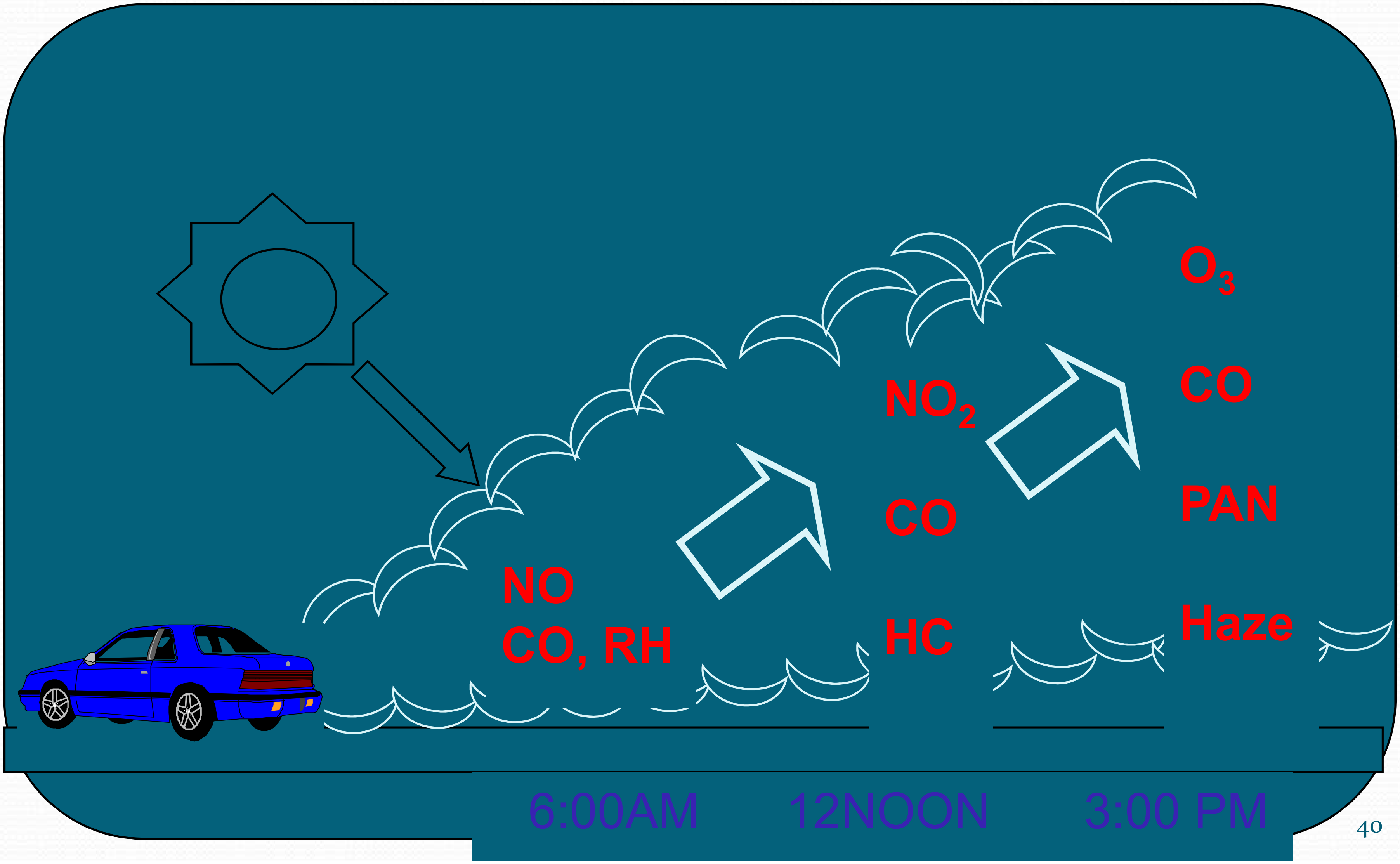
- -- Skin Cancer (melanoma and nonmelanoma)
  -- Premature aging of the skin and other skin problems
  -- Cataracts and other eye damage
  -- Immune system suppression

Ground Level Ozone Formation

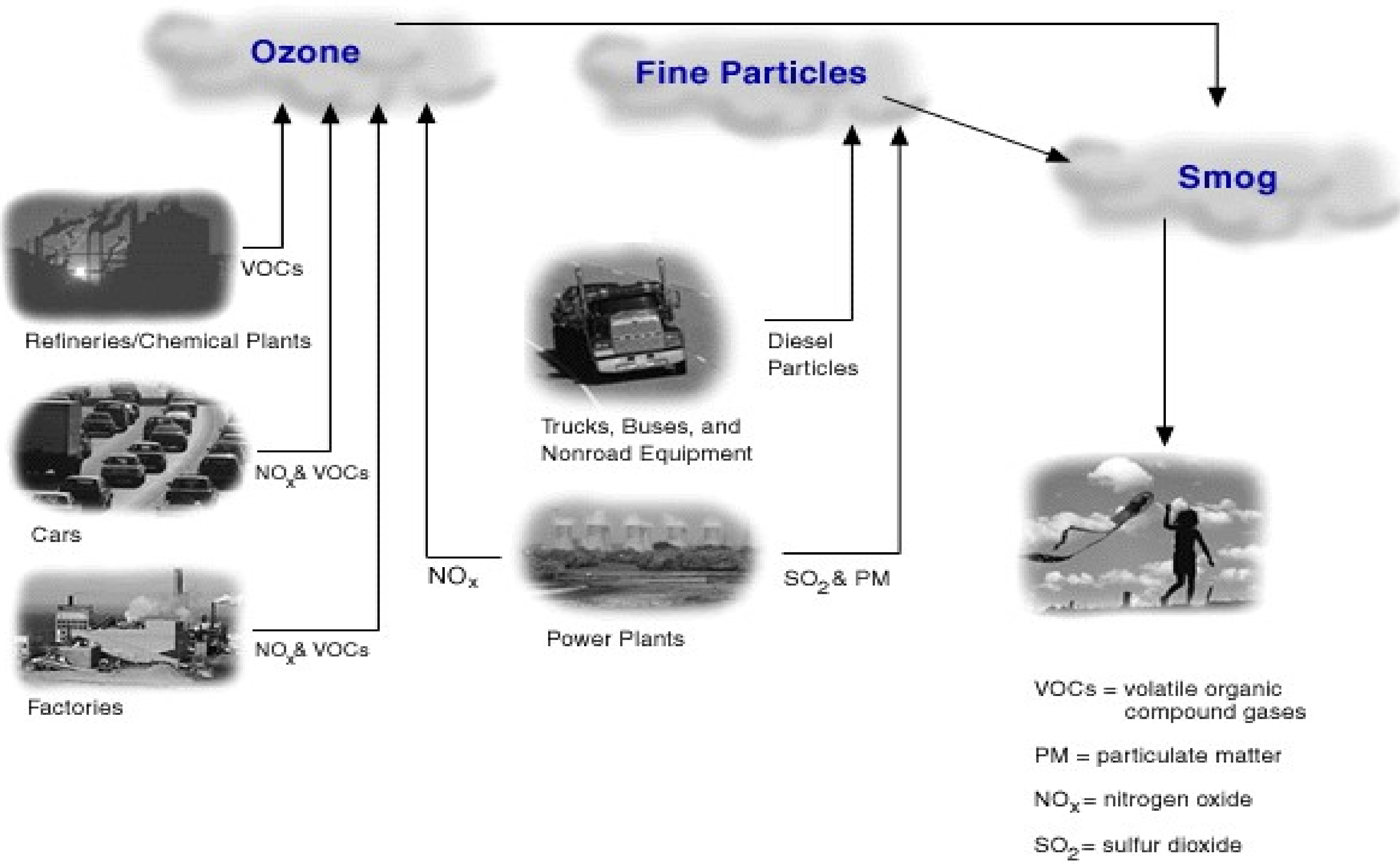
Ground level Ozone Formation

- Secondary Pollutant
- VOCs+ NO_x → Ozone
- In presence of sunlight
- Ozone + NO_X + HCs → Smog (haze)

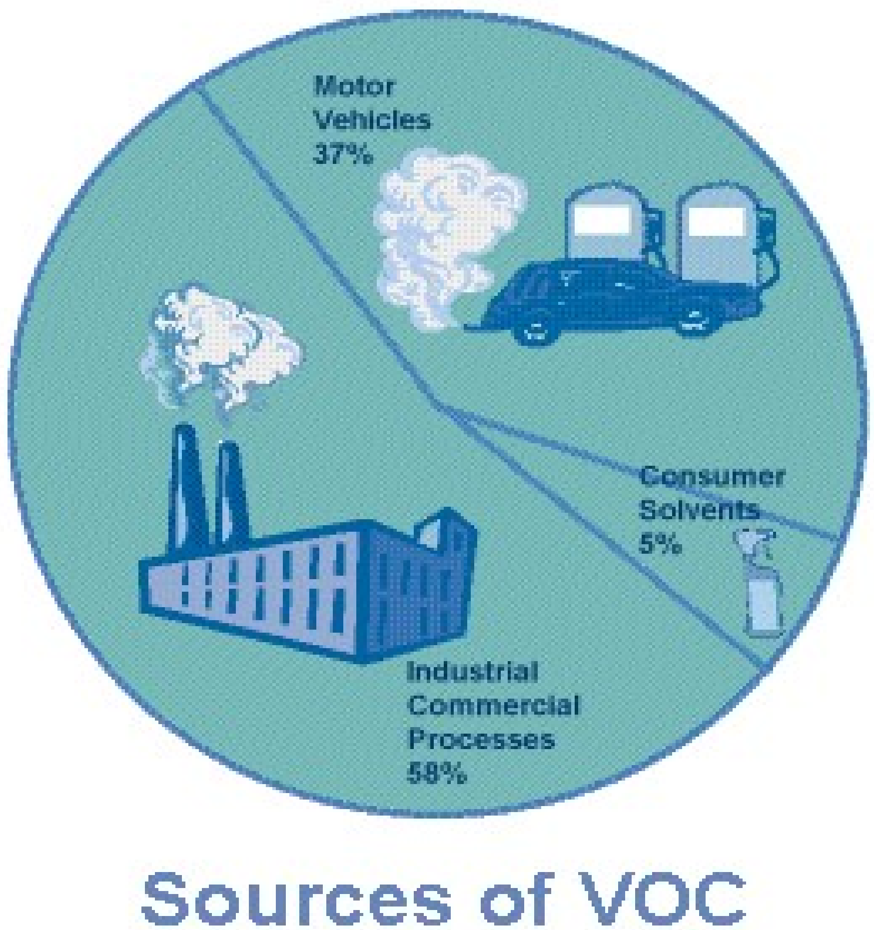
Photochemical Smog



Smog Sources

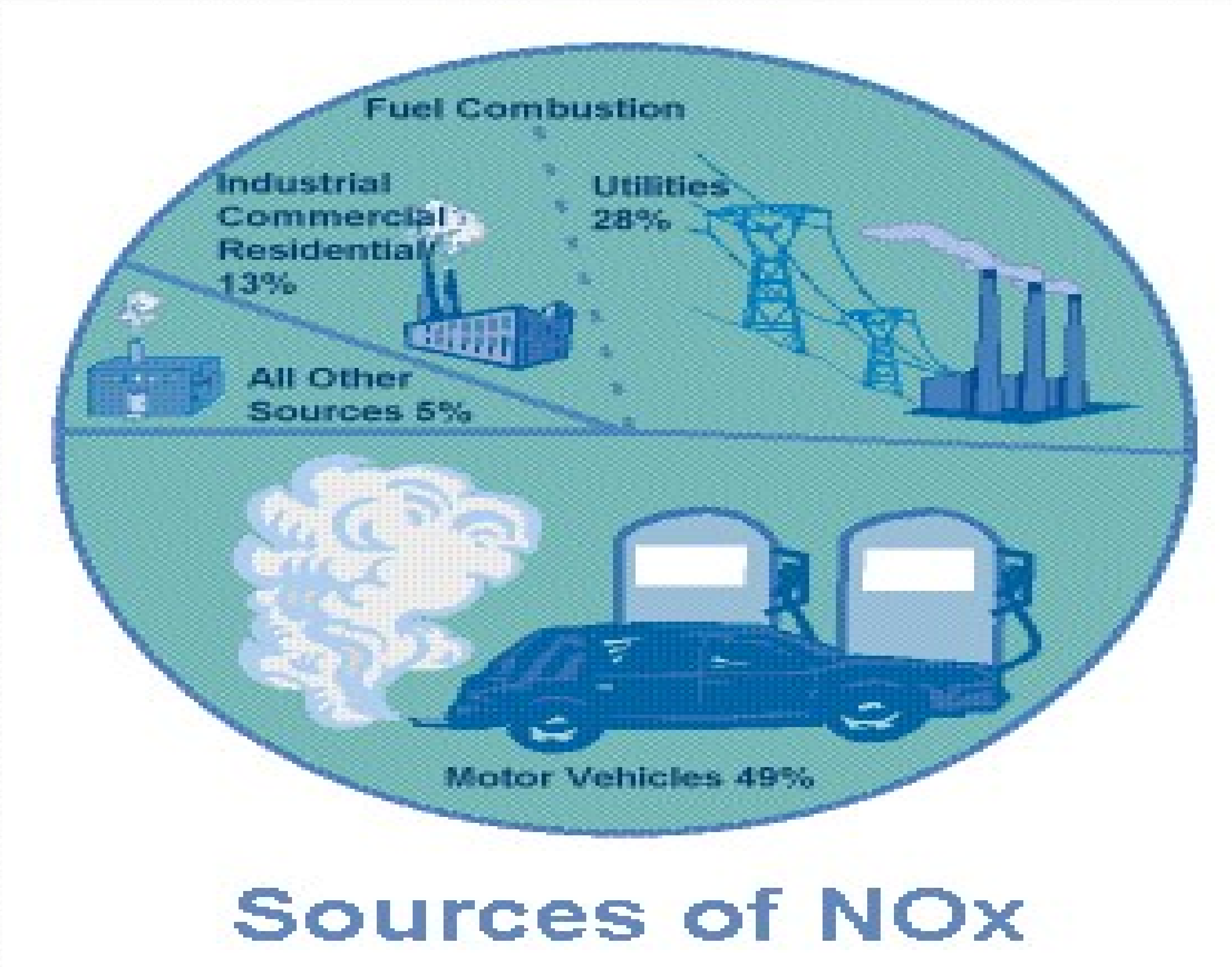


Sources of Volatile Organic Carbons



Volatile organic compounds (VOC) means any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions.

Sources of NO_x

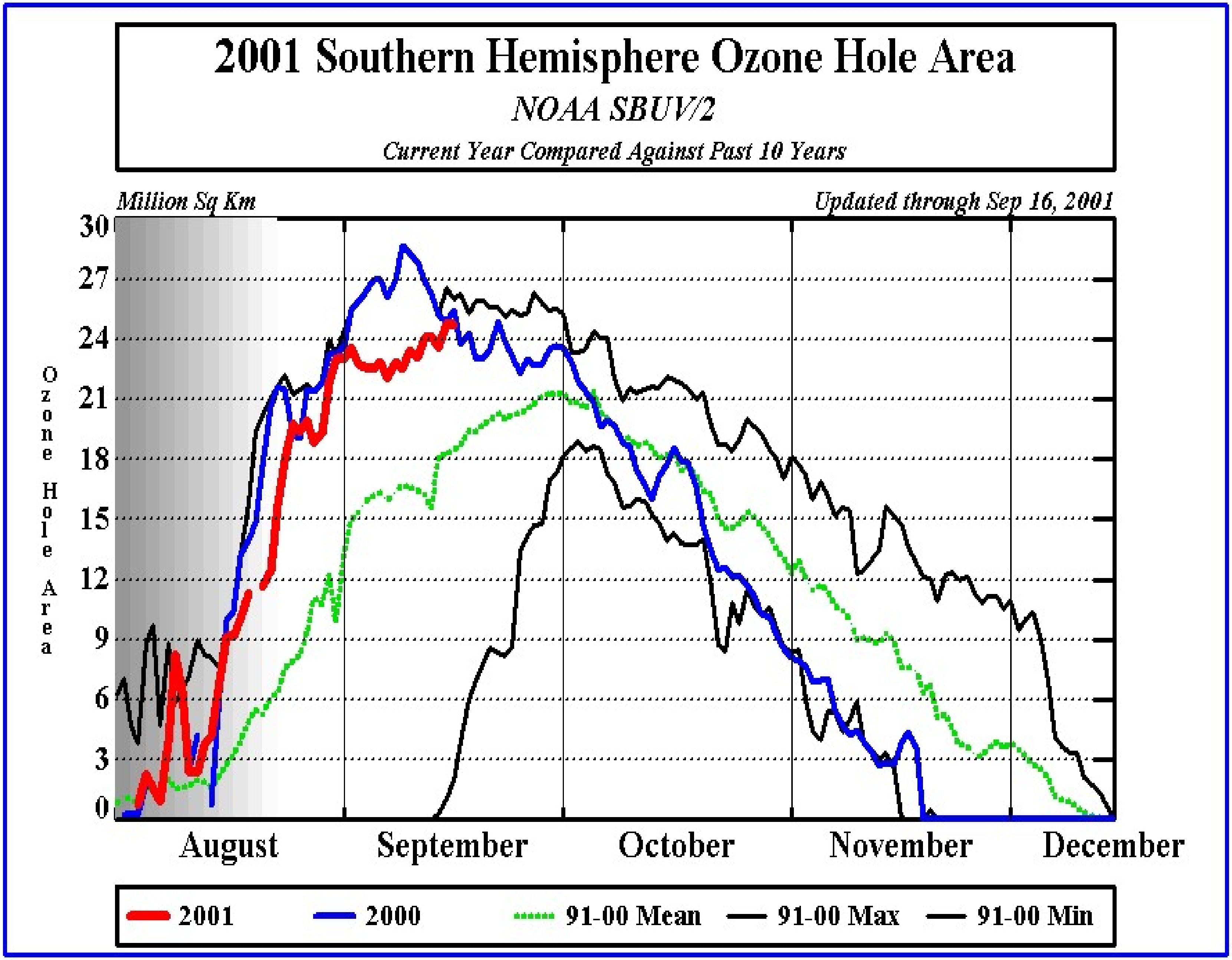


What can We do?

- Keep your automobile well tuned and maintained.
- Carpool, use mass transit, walk, bicycle, and/or reduce driving, especially on hot summer days.
- Be careful not to spill gasoline when filling up your car or gasoline-powered lawn and garden equipment. During the summer, fill your gas tank during the cooler evening hours.

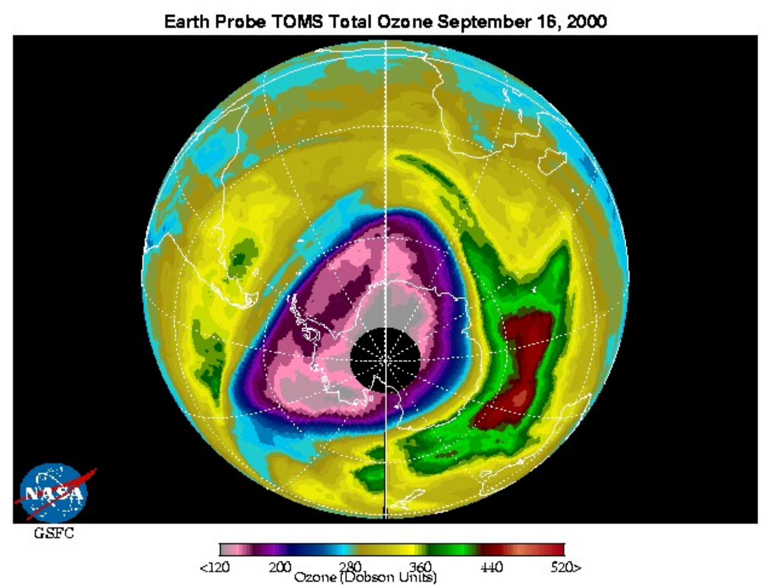
What can we do?

- Make sure your car's tires are properly inflated and your wheels are aligned.
- Participate in your local utility's energy conservation programs.
- Seal containers of household cleaners, workshop chemicals and solvents, and garden chemicals to prevent VOC from evaporating into the air. Dispose of them properly.



http://www.cpc.ncep.noaa.gov/products/stratosphere/sbuv2to/ozone_hole_plot.gif

The Antarctic Ozone Hole

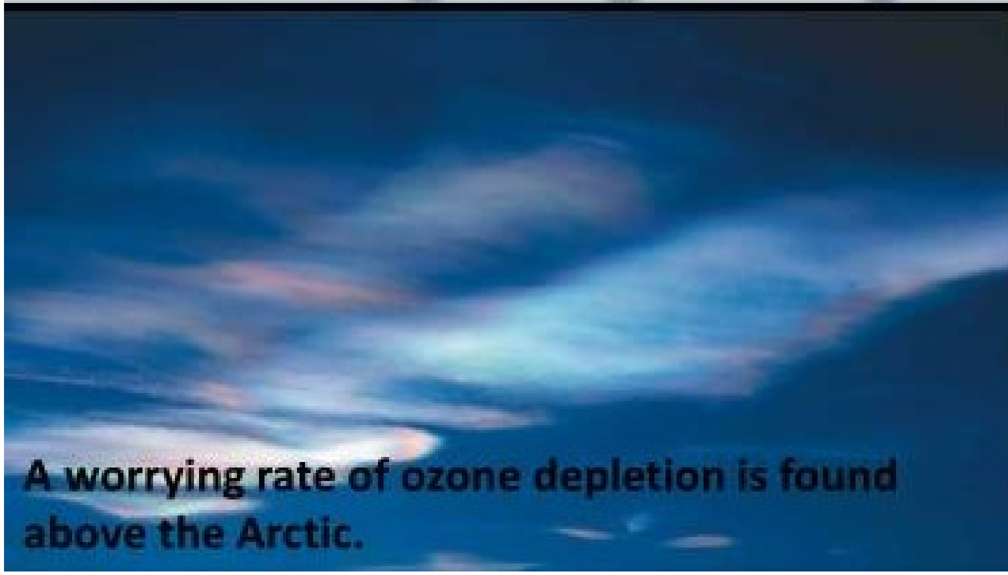


- The ozone hole is defined as the area having less than 220 dobson units (DU) of ozone in the overhead column (i.e., between the ground and space).

Source: http://jwocky.gsfc.nasa.gov/multi/recent_ozone91200.gif

Ozone Depletion

- **Ozone Depletion;** Destruction of the stratospheric ozone layer. This destruction of ozone is caused by the breakdown of certain chlorine and/or bromine containing compounds (chlorofluorocarbons or halons), which break down when they reach the stratosphere and then catalytically destroy ozone molecules.



Causes of Ozone Depletion

- Increase in the level of free radicals such as hydroxyl radicals, nitric oxide radicals and atomic chlorine and bromine.
- The most important compound, which accounts for almost 80% of the total depletion of ozone in the stratosphere are chlorofluorocarbons (CFC).

refrigerants & propellants

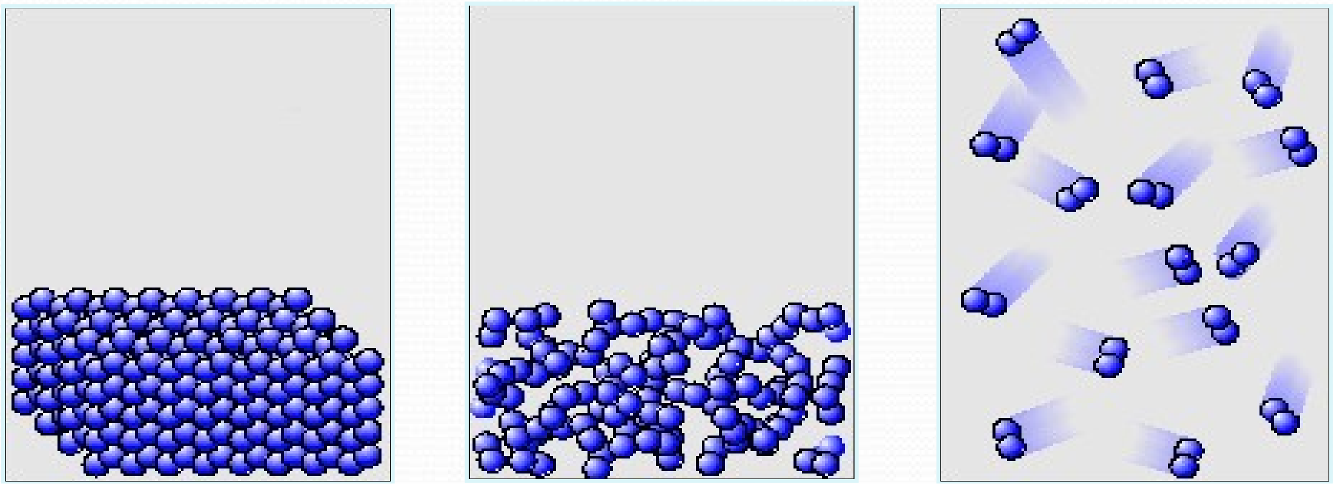
Introduction to Gases

EQ:
How do we use the Kinetic Molecular Theory to explain the behavior of gases?

States of Matter

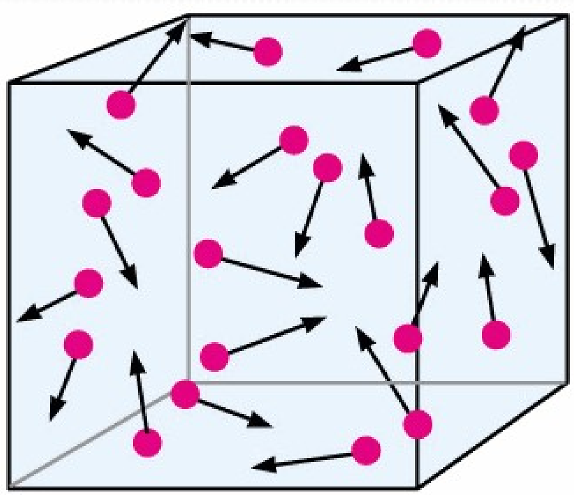
2 main factors determine state:

- The forces (inter/intra molecular) holding particles together
- The kinetic energy present (the energy an object possesses due to its motion of the particles)
- KE tends to 'pull' particles apart



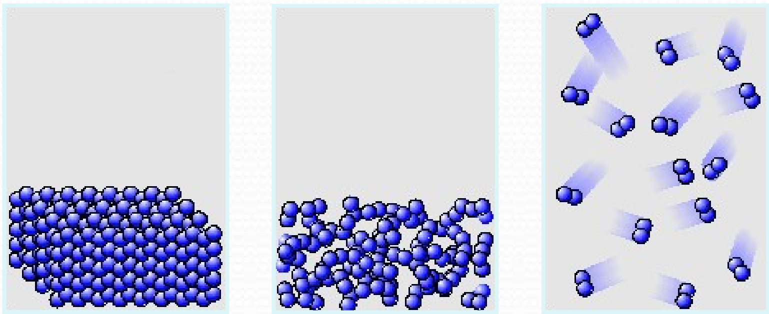
Kinetic Energy , States of Matter & Temperature

- Gases have a higher kinetic energy because their particles move a lot more than in a solid or a liquid
- As the temperature increases, there gas particles move faster, and thus kinetic energy increases.



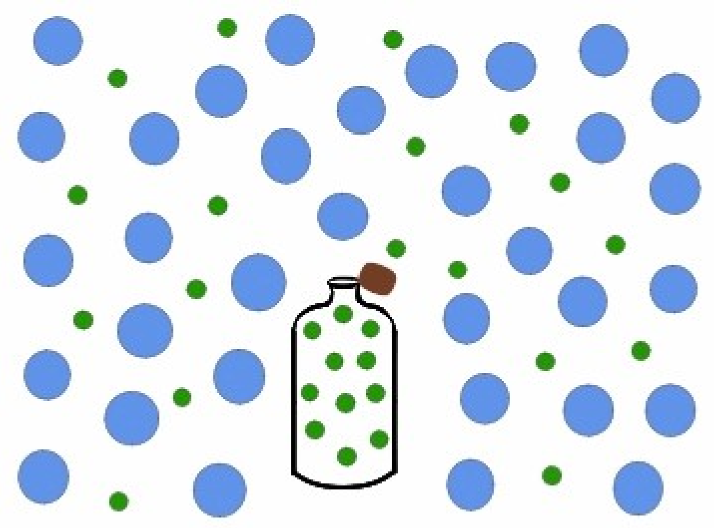
Characteristics of Gases

- Gases expand to fill any container.
  - random motion, no attraction
- Gases are fluids (like liquids).
  - no attraction
- Gases have very low densities.
  - no volume = lots of empty space



Characteristics of Gases

- Gases can be compressed.
  - no volume = lots of empty space
- Gases undergo diffusion & effusion (across a barrier with small holes).
  - random motion



Kinetic Molecular Theory of ‘Ideal’ Gases

- Particles in an ideal gas…
  - have no volume.
  - have elastic collisions (ie. billiard ball→ particles exchange energy with eachother, but total KE is conserved
  - are in constant, random, straight-line motion.
  - don’t attract or repel each other.
  - have an avg. KE directly related to temperature (↑ temp=↑ motion= ↑ KE)

Real Gases

- Particles in a REAL gas…
  - have their own volume
  - attract each other (intermolecular forces)

- Gas behavior is most ideal…
  - at low pressures
  - at high temperatures

Why???

Real Gases

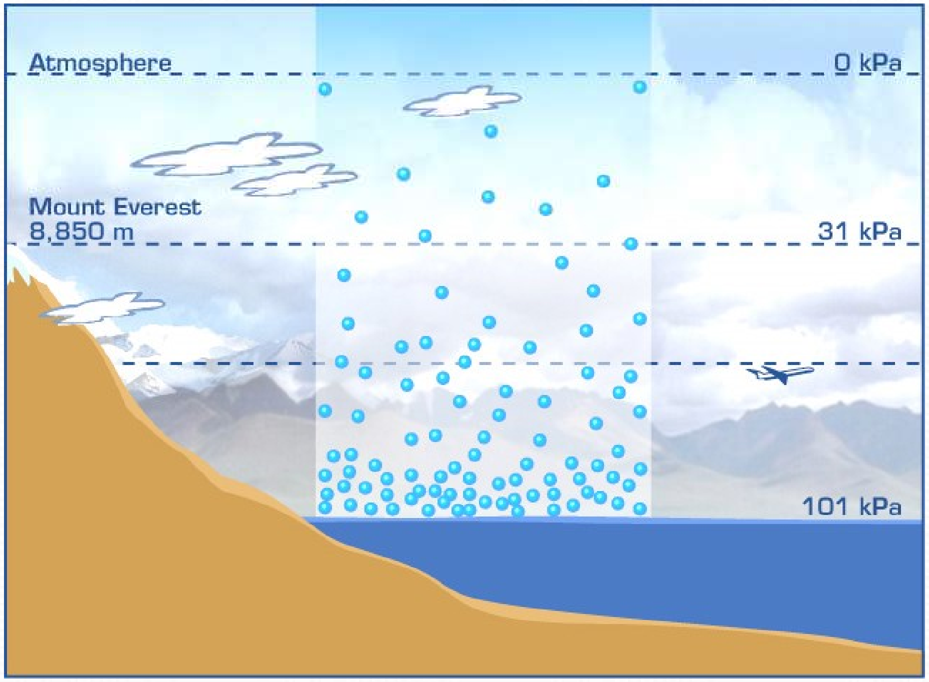
- At STP, molecules of gas are moving fast and are very far apart, making their intermolecular forces and volumes insignificant, so assumptions of an ideal gas are valid under normal temp/pressure conditions. BUT…
  - at <u>high pressures</u>: gas molecules are pushed closer together, and their interactions with each other become more significant due to ***volume***
  - at <u>low temperatures</u>: gas molecules move slower due to KE and ***intermolecular forces*** are no longer negligible

Pressure

$$pressure = \frac{force}{area}$$

Atmospheric Pressure

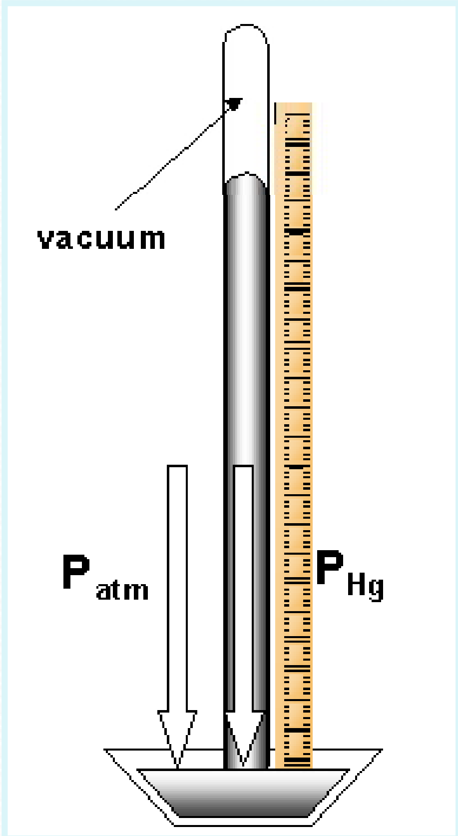
- **The gas molecules in the atmosphere are pulled toward Earth due to gravity, exerting pressure**



- **Why do your ears 'pop' in an airplane?**

Pressure

- **Barometer**
  - measures atmospheric pressure



Mercury Barometer

Units of Pressure

- **<u>At Standard Atmospheric Pressure (SAP)</u>**

  101.325 kPa (kilopascal)

  1 atm (atmosphere)

  760 mm Hg

  (millimeter Hg)

  760 torr

  14.7 psi (pounds per square inch)

$$kPa = \frac{N}{m^2}$$

Standard Temperature & Pressure

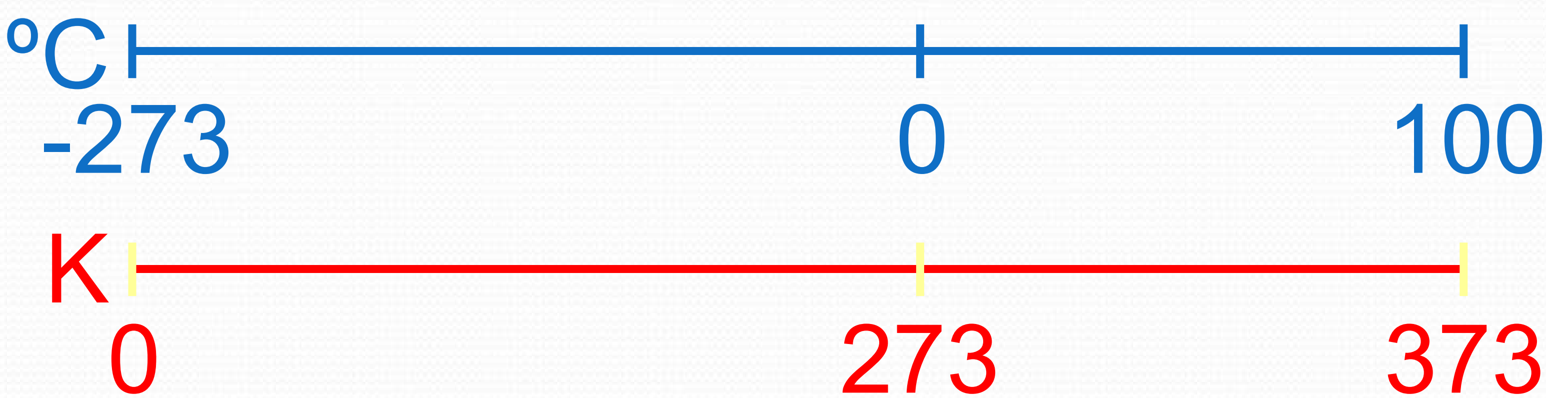
STP

<u>Standard Temperature & Pressure</u>

0°C		273 K
	-OR-	
1 atm		101.325 kPa

Temperature: The Kelvin Scale

- Always use absolute temperature (Kelvin) when working with gases.



$$°C = K - 273 \qquad K = °C + 273$$

Kelvin and Absolute Zero

- Scottish physicist Lord Kelvin suggested that -273°C (0K) was the temperature at which the motion particles within a gas approaches zero.. And thus, so does volume)

- Absolute Zero:

http://www.youtube.com/watch?v=JHXxPnmyDbk

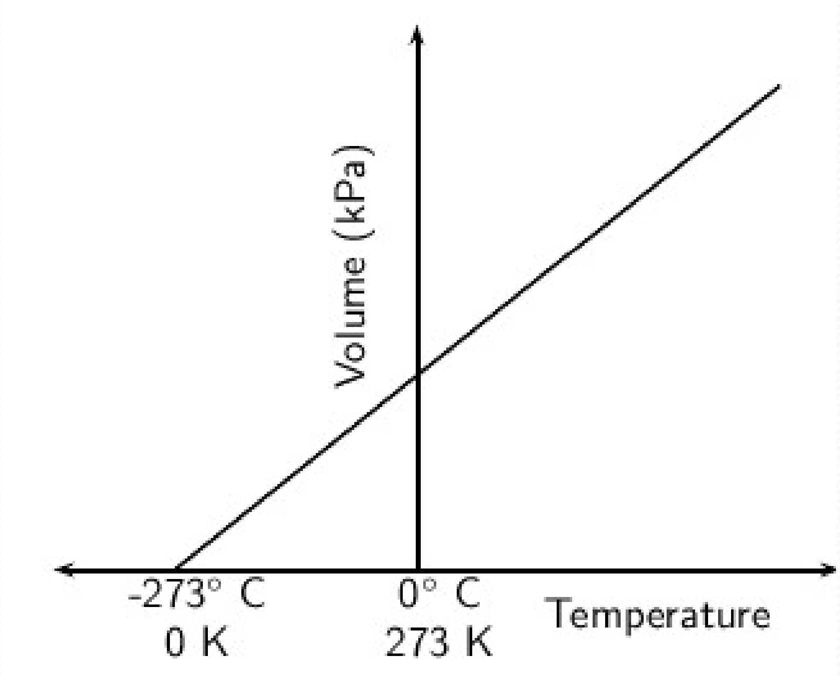
- Comparing the Celsius and Kelvin Scale:

http://www.youtube.com/watch?v=-G9FdNqUVBQ

Why Use the Kelvin Scale?

- Not everything freezes at 0°C, but for ALL substances, motion stops at 0K.
- It eliminates the use of negative values for temperature! Makes mathematic calculations possible (to calculate the temp. twice warmer than -5°C we can't use 2x(-5°C) because we would get -10°C!)

Kelvin Scale vs Celsius Scale



Converting between Kelvin and Celsius

$$°C = K - 273$$

$$K = °C + 273$$

a) $0°C$ = ______K

b) $100°C$ = ______K

c) $25°C$ = _______K

d) $-12°C$ = _______K

e) $-273K$ = _______°C

f) $23.5K$ = _______°C

g) $373.2K$ = _______°C

The Gas Laws

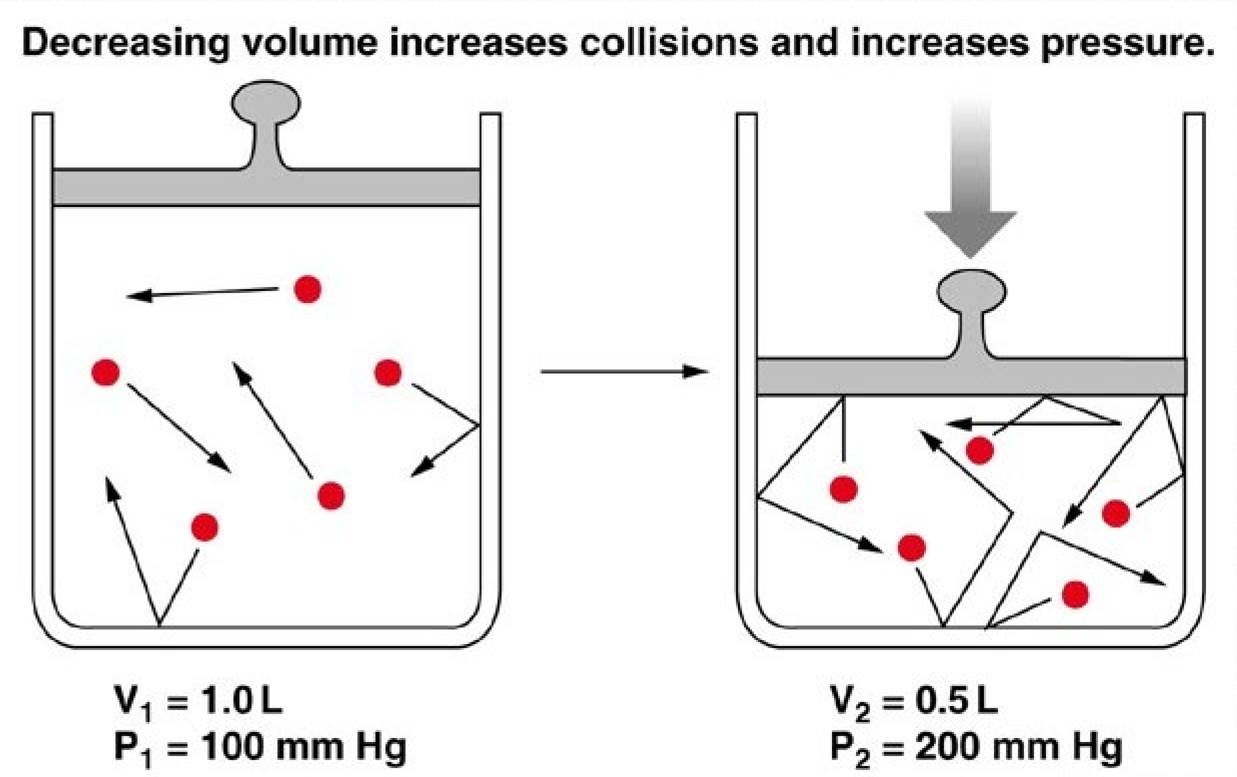
1. Intro to Boyle's Law

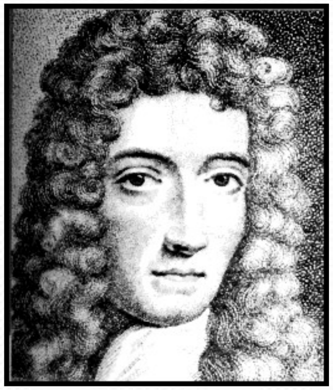
- Imagine that you hold the tip of a syringe on the tip of your finger so no gas can escape. Now push down on the plunger of the syringe.

  What happens to the volume in the syringe?

  What happens to the pressure the gas is exerting in the syringe?

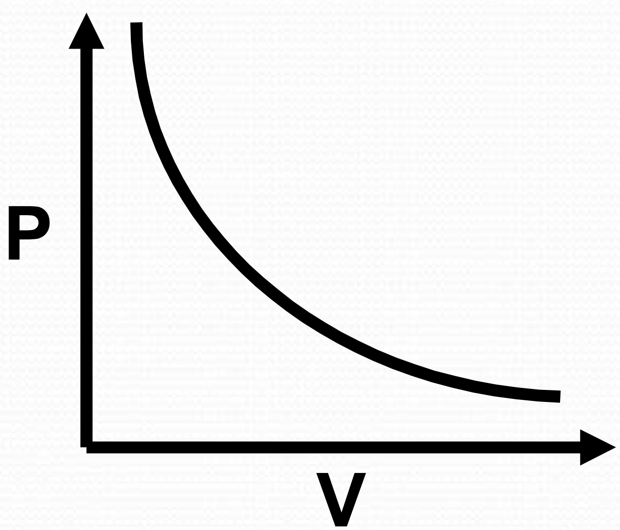
1. Boyle's Law

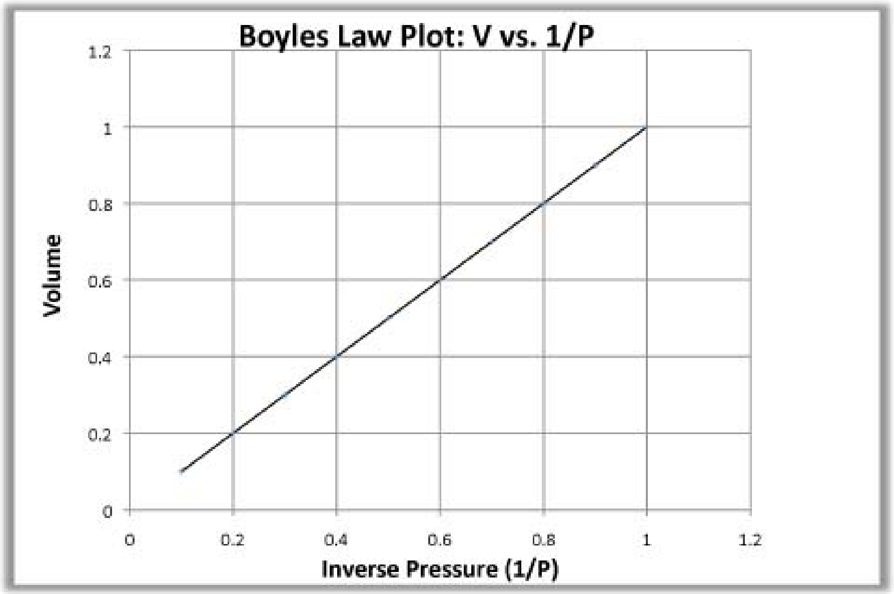

Decreasing volume increases collisions and increases pressure.
$V_1 = 1.0\,L$
$P_1 = 100$ mm Hg
$V_2 = 0.5\,L$
$P_2 = 200$ mm Hg



1. Boyle's Law

- The pressure and volume of a gas are inversely proportional (as one increases, the other decreases, and vice versa
  - at constant mass & temp





1. Boyle's Law

Boyle's Law leads to the mathematical expression: *Assuming temp is constant

$$P_1V_1=P_2V_2$$

Where P_1 represents the initial pressure

V_1 represents the initial volume,

And P_2 represents the final pressure

V_2 represents the final volume

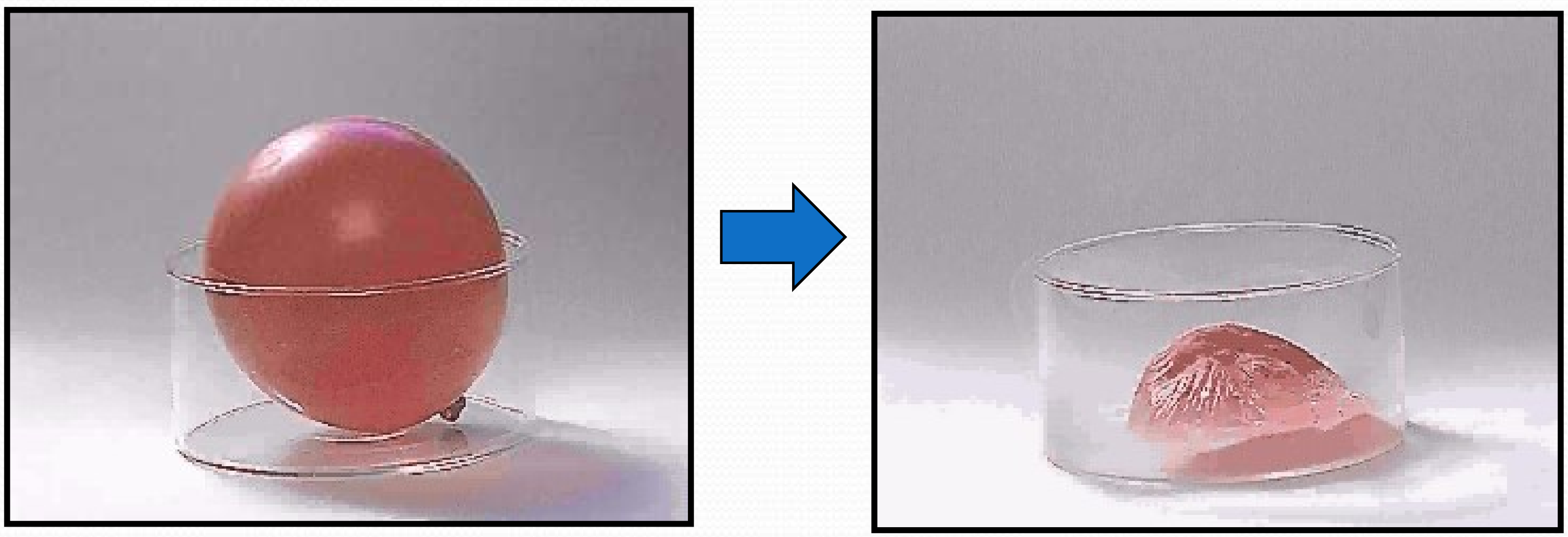
2. Intro to Charles' Law

- Imagine that you put a balloon filled with gas in liquid nitrogen

  What is happening to the temperature of the gas in the balloon?

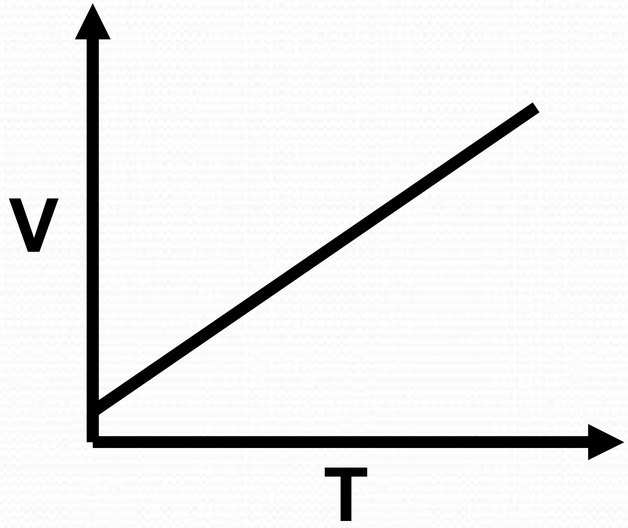
  What will happen to the volume of the balloon?

2. Charles' Law

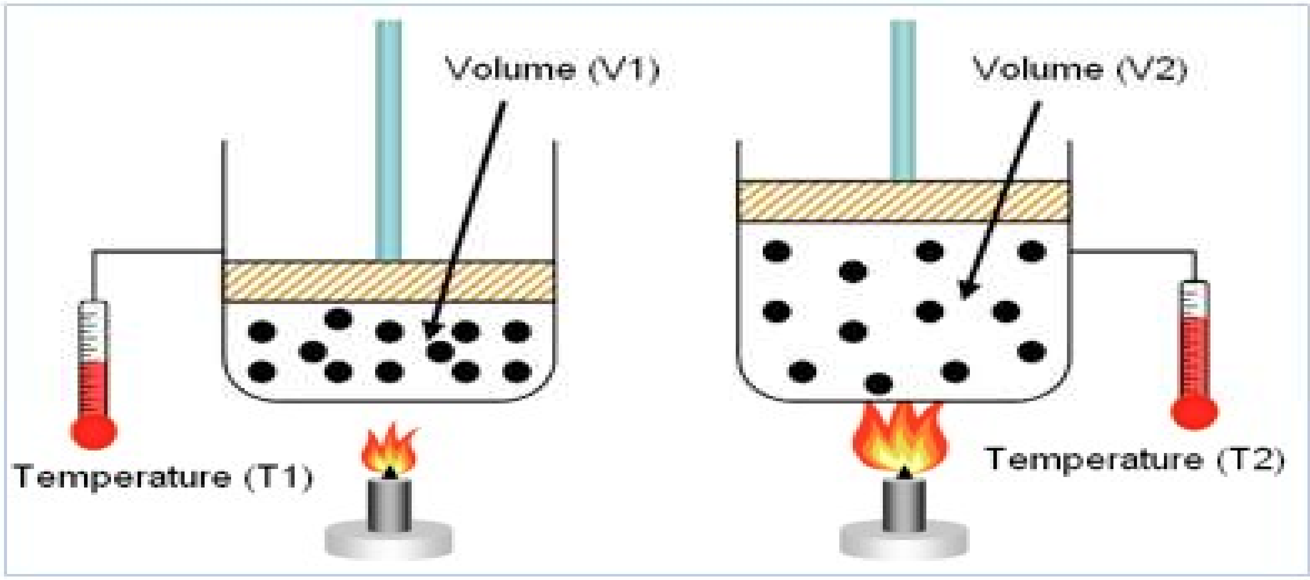


2. Charles' Law

- The volume and absolute temperature (K) of a gas are directly proportional (an increase in temp leads to an increase in volume)
  - at constant mass & pressure



2. Charles' Law



1) Explain how the picture above shows Charles' Law:

2) What are some other examples of Charles' Law that you can think of?
(think of some things that hold gases, and how do they change on a hot/cold day or the amount of heat they are exposed to (tires, balloons, basketballs, footballs, volleyballs, etc.).

2. Charles' Law

- Charles' Law leads to the mathematical expression:

*Assuming pressure remains constant

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

3. Intro to Gay-Lussac's Law

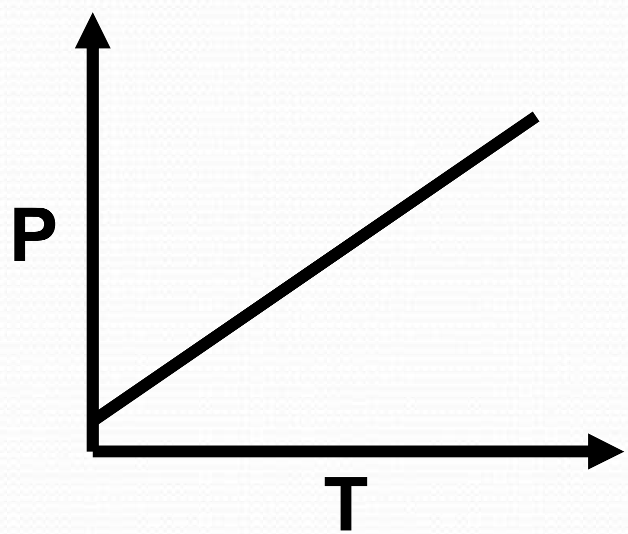
- Imagine you have a balloon inside a container that ensures it has a fixed volume. You heat the balloon.

What is happening to the temp of the gas inside the balloon?

What will happen to the pressure the gas is exerting on the balloon?

3. Gay-Lussac's Law

- The pressure and absolute temperature (K) of a gas are directly proportional (as temperature rises, so does pressure)
  - at constant mass & volume



2. Gay-Lussac's Law

- Gay-Lussac's Law leads to the mathematical expression:

*Assuming volume remains constant

4. Combined Gas Law

By combining Boyle's, Charles' and Gay Lussac's Laws, the following equation is derived:

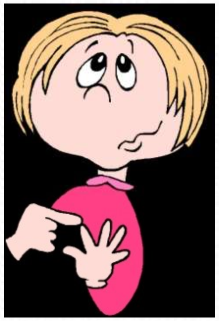
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

The Mole Concept

Avogadro's Number = 6.022×10^{23}

Counting Atoms

- Chemistry is a *quantitative* science - we need a "counting unit."
- The **MOLE**



- 1 mole is the amount of substance that contains as many particles (atoms or molecules) as there are in 12.0 g of C-12.

The Mole is Developed

Avogadro Paper

Carbon Atoms		Hydrogen Atoms		Mass Ratio
Number	**Mass (amu)**	**Number**	**Mass (amu)**	**Mass carbon / Mass hydrogen**
	12		1	$\frac{12 \text{ amu}}{1 \text{ amu}} = \frac{12}{1}$
	24 [2 x 12]		2 [2 x 1]	$\frac{24 \text{ amu}}{2 \text{ amu}} = \frac{12}{1}$
	120 [10 x 12]		10 [10 x 1]	$\frac{120 \text{ amu}}{10 \text{ amu}} = \frac{12}{1}$
	600 [50 x 12]		50 [50 x 1]	$\frac{600 \text{ amu}}{50 \text{ amu}} = \frac{12}{1}$
Avogadro's number	$(6.02 \times 10^{23}) \times (12)$	**Avogadro's number**	$(6.02 \times 10^{23}) \times (1)$	$\frac{(6.02 \times 10^{23}) \times (12)}{(6.02 \times 10^{23}) \times (1)} = \frac{12}{1}$

Particles in a Mole

Amadeo Avogadro

(1776 – 1856)

Amedeo Avogadro (1766-1856) never knew his own number; it was named in his honor by a French scientist in 1909.
its value was first estimated by Josef Loschmidt, an Austrian chemistry teacher, in 1895.

? quadrillions trillions billions millions thousands

1 mole = 602213673600000000000000

or 6.022×10^{23}

There is Avogadro's number of particles in a mole of any substance.

Careers in Chemistry - Philosopher

Q: *How much is a mole?*

A: *A mole is a quantity used by chemists to count atoms and molecules. A mole of something is equal to 6.02 x 10^{23} "somethings."*

1 mole = 602 200 000 000 000 000 000 000

Q: *Can you give me an example to put that number in perspective?*

A: *A computer that can count 10,000,000 atoms per second would take 2,000,000,000 years to count 1 mole of a substance.*

Counting to 1 Mole

Is that right? *A computer counting 10 million atoms every second would need to count for 2 billion years to count just a single mole.*

Lets look at the mathematics.

$$x \text{ sec} = 1 \cancel{\text{year}} \left(\frac{365 \cancel{\text{days}}}{1 \cancel{\text{year}}}\right)\left(\frac{24 \cancel{\text{hours}}}{1 \cancel{\text{day}}}\right)\left(\frac{60 \cancel{\text{min}}}{1 \cancel{\text{hour}}}\right)\left(\frac{60 \text{ sec}}{1 \cancel{\text{min}}}\right) = 31{,}536{,}000 \text{ sec}$$

Therefore 1 year has 31,536,000 seconds or 3.1536×10^7 sec.
A computer counting 10,000,000 atoms every second could count 3.153×10^{14} atoms every year.

Finally, 6.02×10^{23} atoms divided by 3.1536×10^{14} atoms every year equals 1,908,929,477 years or approximately 2 billion years!

How Big is a Mole?

One mole of marbles would cover the entire Earth (oceans included) for a depth of three miles.

One mole of $100 bills stacked one on top of another would reach from the Sun to Pluto and back 7.5 million times.

It would take light 9500 years to travel from the bottom to the top of a stack of 1 mole of $1 bills.

Avogadro's Number

- A MOLE of any substance contains as many elementary units (atoms and molecules) as the number of atoms in 12 g of the isotope of carbon-12.
- This number is called AVOGADRO's number $N_A = 6.02 \times 10^{23}$ particles/mol
- The mass of one mole of a substance is called MOLAR MASS symbolized by MM
- Units of MM are g/mol
- Examples

H_2	hydrogen	2.02	g/mol
He	helium	4.0	g/mol
N_2	nitrogen	28.0	g/mol
O_2	oxygen	32.0	g/mol
CO_2	carbon dioxide	44.0	g/mol

1 Mole of Particles