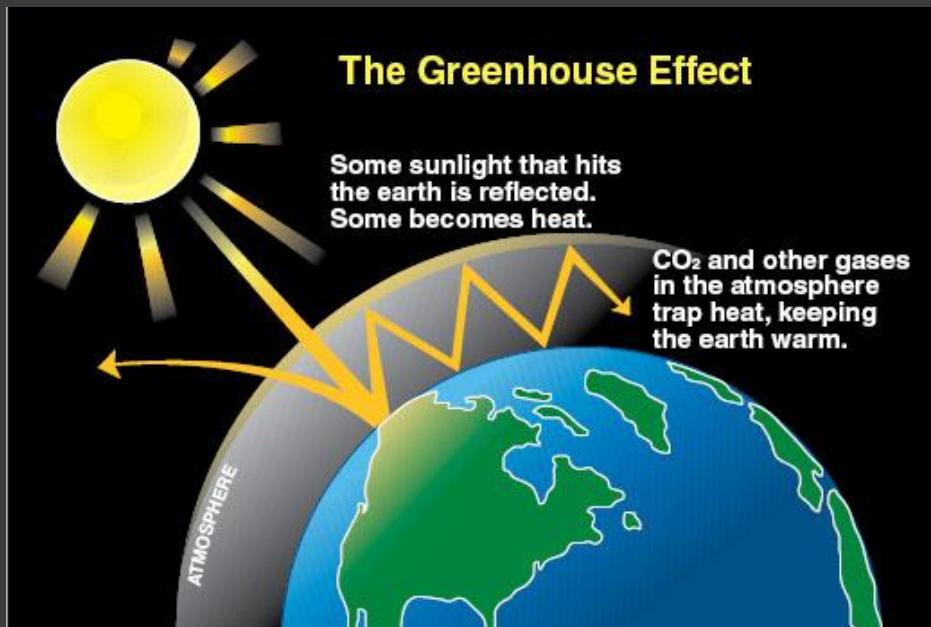


UNIT 3:

GREENHOUSE EFFECT

Greenhouse Effect

- Introduction to climate and climate change
- Greenhouse Effect



The Greenhouse Effect

- It is a natural process that has been happening for millions of years
- Gases and clouds absorb infrared radiation emitted from Earth's surface and radiate it, heating the atmosphere and Earth's surface
- <http://www.youtube.com/watch?v=OqVyRa1iuMc>

Sun

Some energy is reflected.

Some energy is emitted out to space.

Some energy is absorbed by Earth's surface.

Some energy is absorbed by the atmosphere and clouds.

Energy is converted to thermal energy, warming up Earth's surface.

Greenhouse gases in the atmosphere absorb radiation from Earth's surface, then radiate it back in all directions.

Warm Earth emits infrared radiation.

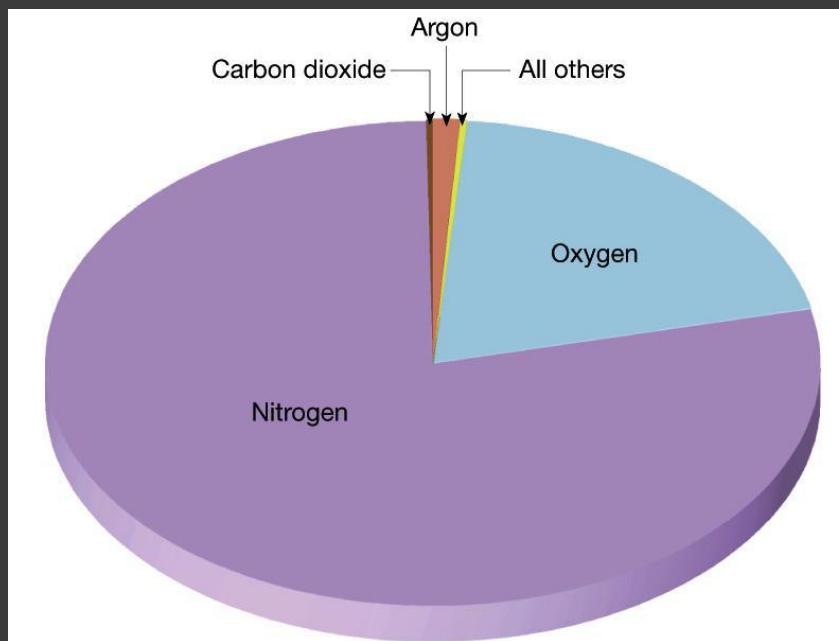
Some energy is radiated back to Earth's surface, warming it even more.

What if there was no Greenhouse effect?

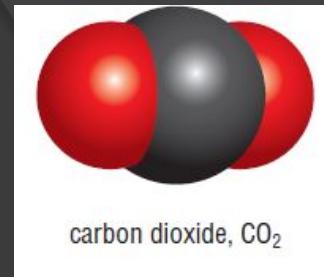
- The Earth's average global temperature would be -18°C instead of 15°C

Greenhouse Gases

- Any gas in the atmosphere (ie: water vapour, carbon dioxide, and methane) that absorbs lower energy infrared radiation



Greenhouse Gas – Carbon Dioxide



- CO₂ makes up only 385 ppm of the Earth's atmosphere which represents only about 0.0385%
- But, CO₂ is estimated to cause up to a quarter (1/4) of the natural greenhouse effect on Earth
- CO₂ molecules have atoms that can vibrate and wiggle in many ways and can absorb different types of energy

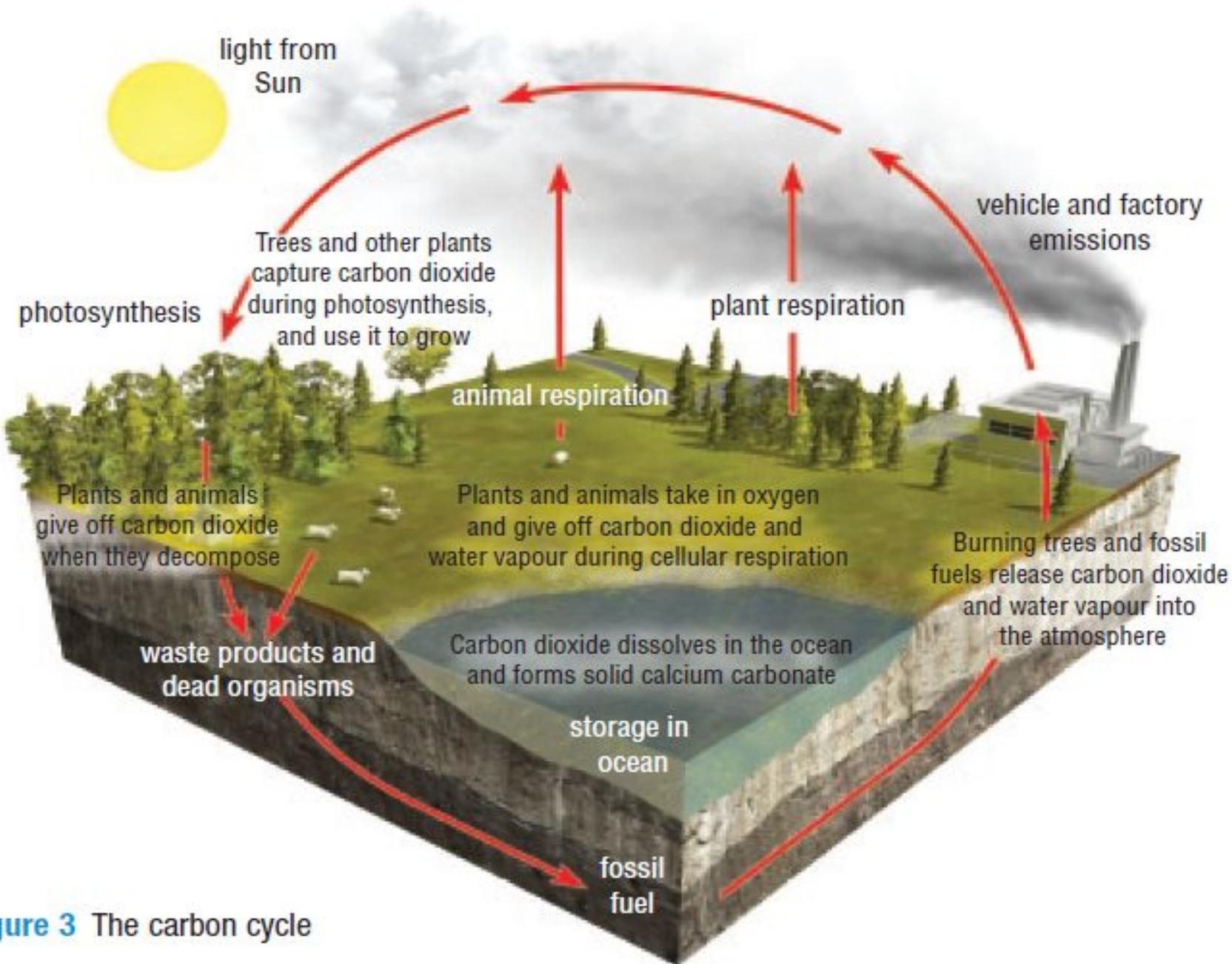
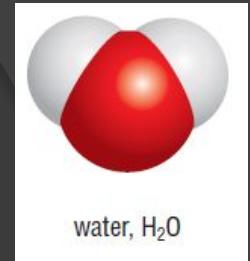


Figure 3 The carbon cycle

Greenhouse Gas – Water Vapour



- 2/3 of Earth's natural greenhouse effect is caused by water vapour in the atmosphere
- Amount of water in atmosphere depends on temperature; about 4%

Positive Feedback Loop

*A produces more of B
which in turn produces more of A*

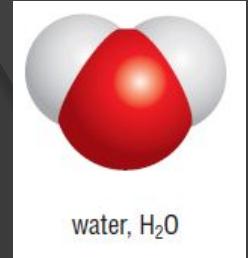
- example:
 - someone starts to take drugs, the drug has effects on the body, the body eventually adjusts to the drug, and the person requires more of the drug for the same effect

Negative Feedback Loop

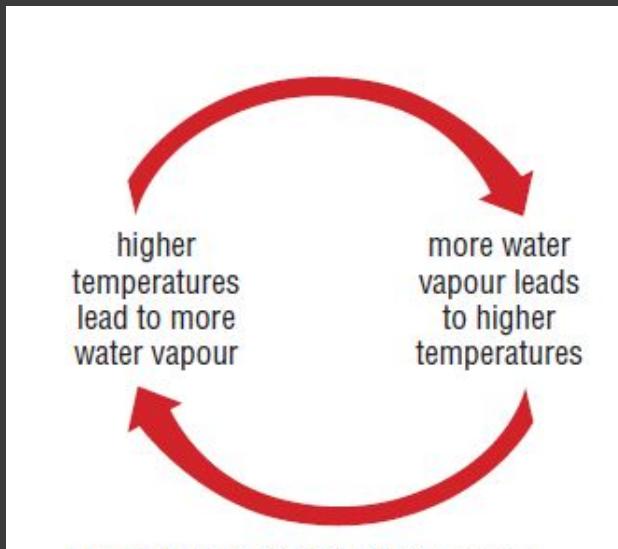
-self-regulating system that works to maintain stability

- example
 - Thermostat -the temperature in a heated room reaches a certain upper limit, the room heating is switched off so that the temperature begins to fall. When the temperature drops to a lower limit, the heating is switched on again

Greenhouse Gas – Water Vapour

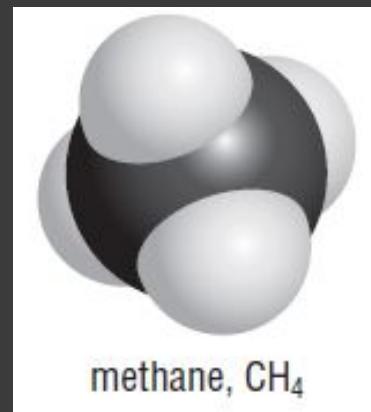


- Water vapour and temperature are related by a positive feedback loop



Greenhouse Gases – Methane (CH_4)

- There is less methane in the atmosphere than carbon dioxide
- Methane can absorb more thermal energy than carbon dioxide (23 more times)



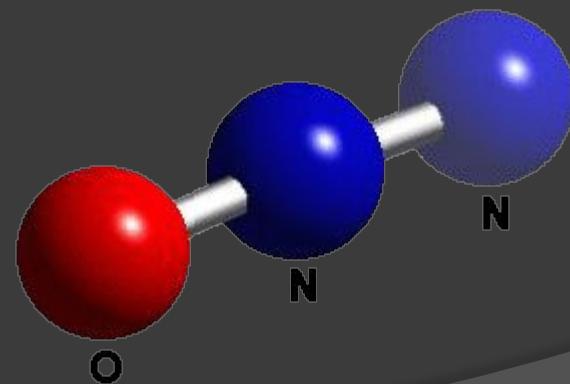
Greenhouse Gases – Ozone (O_3)

- Forms a layer protecting the Earth's surface from the Sun's higher-energy UV radiation
- Ozone also acts as a greenhouse gas

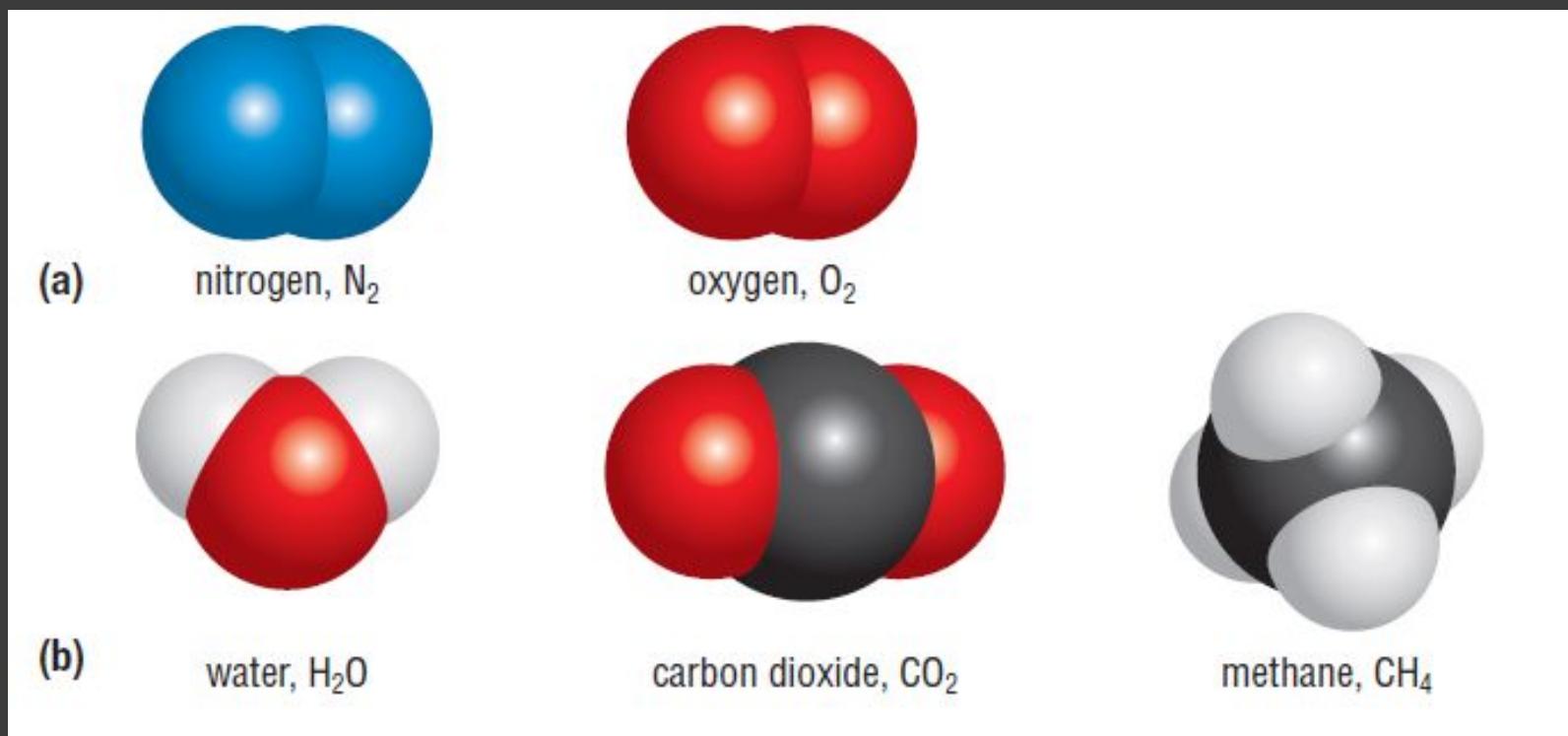


Greenhouse Gases – Nitrous Oxide (N_2O)

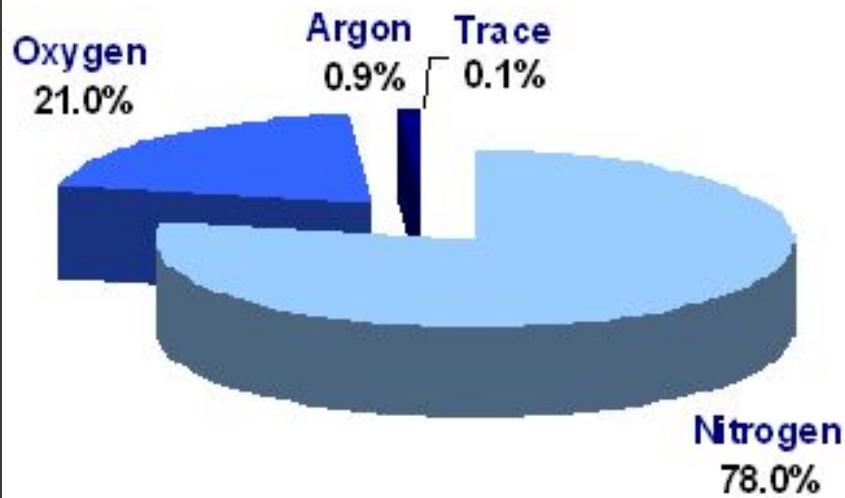
- 300 times more effective than a molecule of CO_2 as a greenhouse gas
- Lower levels of nitrous oxide can be found in the atmosphere than carbon dioxide



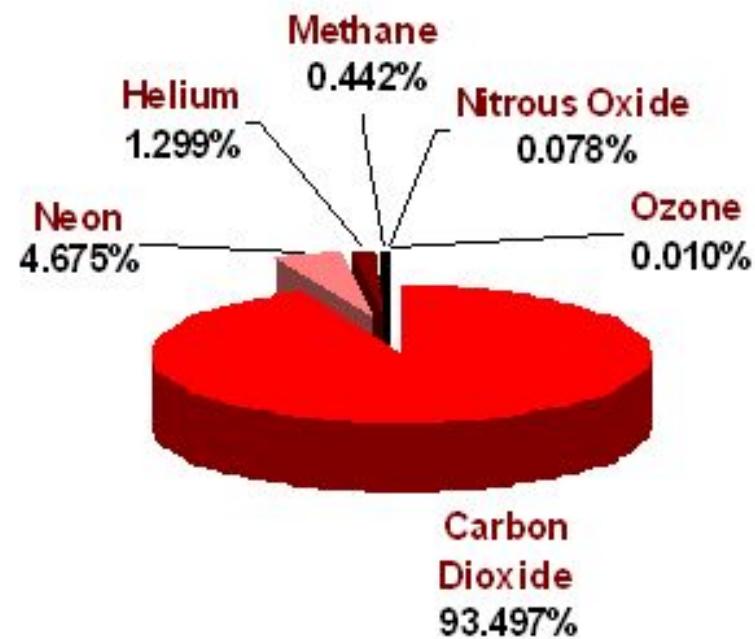
- The molecule's increased ability to vibrate will allow for greater absorption of energy



Atmospheric Composition



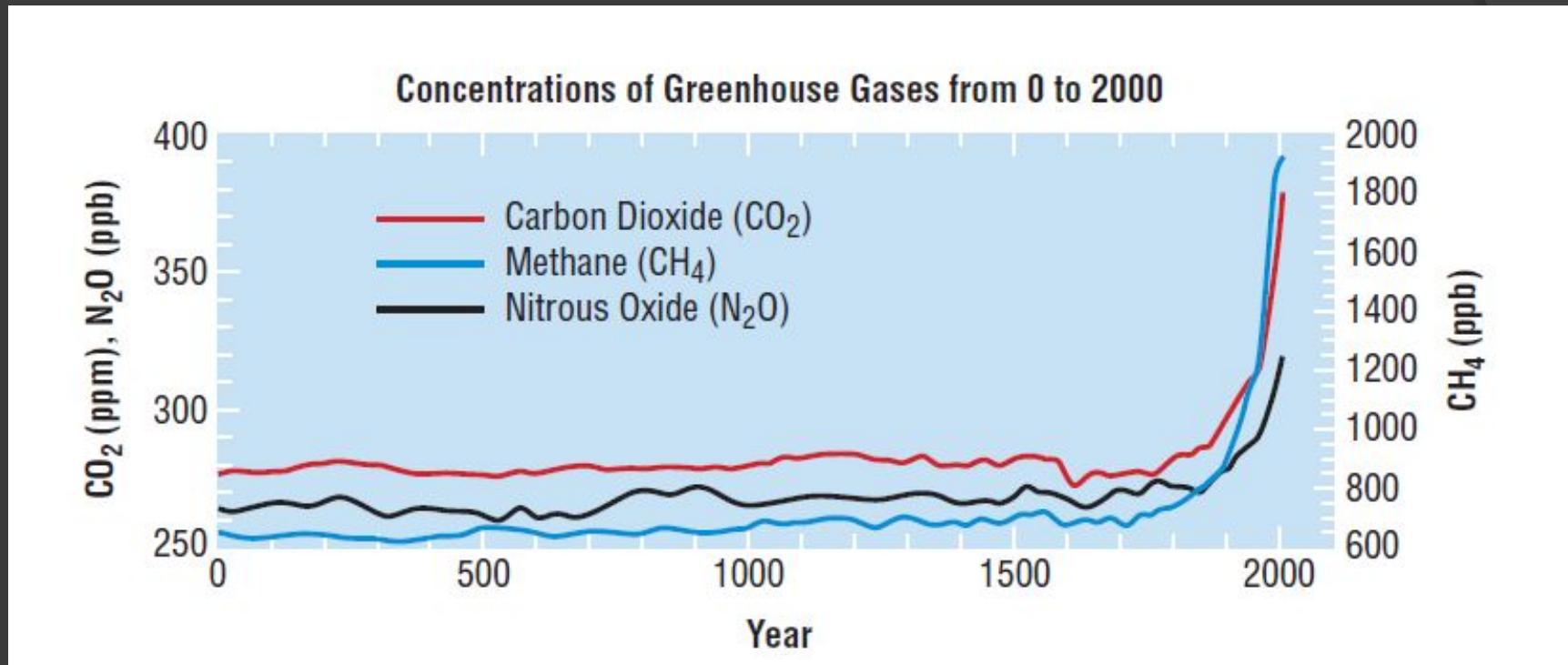
Trace Gases



Greenhouse Gases – Changing the Climate

- Greenhouse gases have been a part of our atmosphere for hundreds of thousands of years and have contributed to the naturally occurring greenhouse effect

But, what's happening now?



Increases since about 1750 are attributed to human activities in the industrial era.

Table 1 Concentrations and Lifetimes of Atmospheric Greenhouse Gases

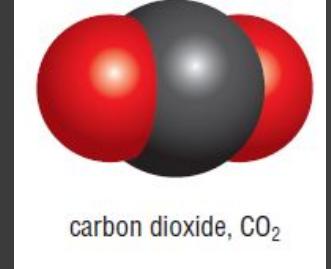
Greenhouse gas	Concentration in the atmosphere		
	Pre-industrial level	2008 level	Approximate atmospheric lifetime
carbon dioxide	280 ppm	384 ppm	100 to 1 000 years
methane	0.700 ppm (700 ppb)	1.785 ppm (1785 ppb)	12 years
nitrous oxide	0.270 ppm (270 ppb)	0.321 ppm (321 ppb)	114 years
CFC-11	trace amounts	0.000251 ppm (251 ppt)	45 years
CFC-12	trace amounts	0.000525 ppm (525 ppt)	100 years

Data from *IPCC Climate Change 2007: The Physical Science Basis* and *The NOAA Annual Greenhouse Gas Index*

Anthropogenic (Human Influenced) Sources of Greenhouse Gases

◎ Carbon Dioxide:

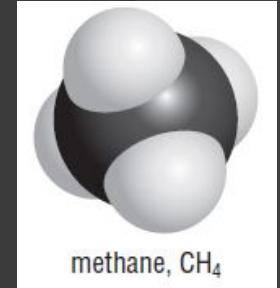
- Burning fossil fuels (coal, gasoline, natural gas) releases CO₂
- Deforestation – inhibits photosynthesis which would remove CO₂ from the atmosphere; also as left over forest waste decomposes, it produces greenhouse gases



Anthropogenic (Human Influenced) Sources of Greenhouse Gases

○ Methane

- Agricultural activities – rice farming, cattle ranching
- Landfills and sewage treatment plants – methane is released as organic material decays
- Coal mining and natural gas extraction releases methane



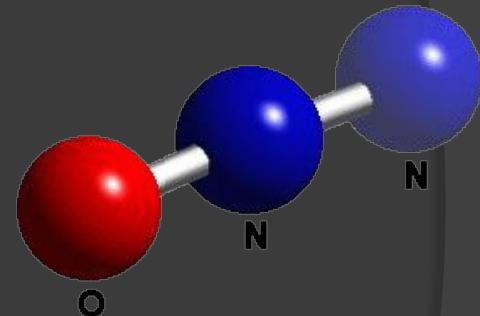
Anthropogenic (Human Influenced) Sources of Greenhouse Gases

● Nitrous Oxide

- Management of livestock feed and waste
- Use of nitrogen fertilizers

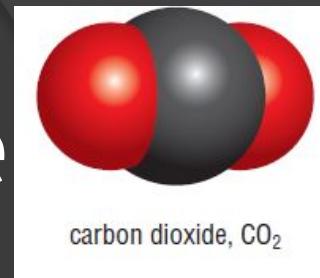
Chlorofluorocarbons (CFCs)

- no natural sources of CFCs
- Leak out of refrigerators and air conditioners



Anthropogenic Greenhouse Effect

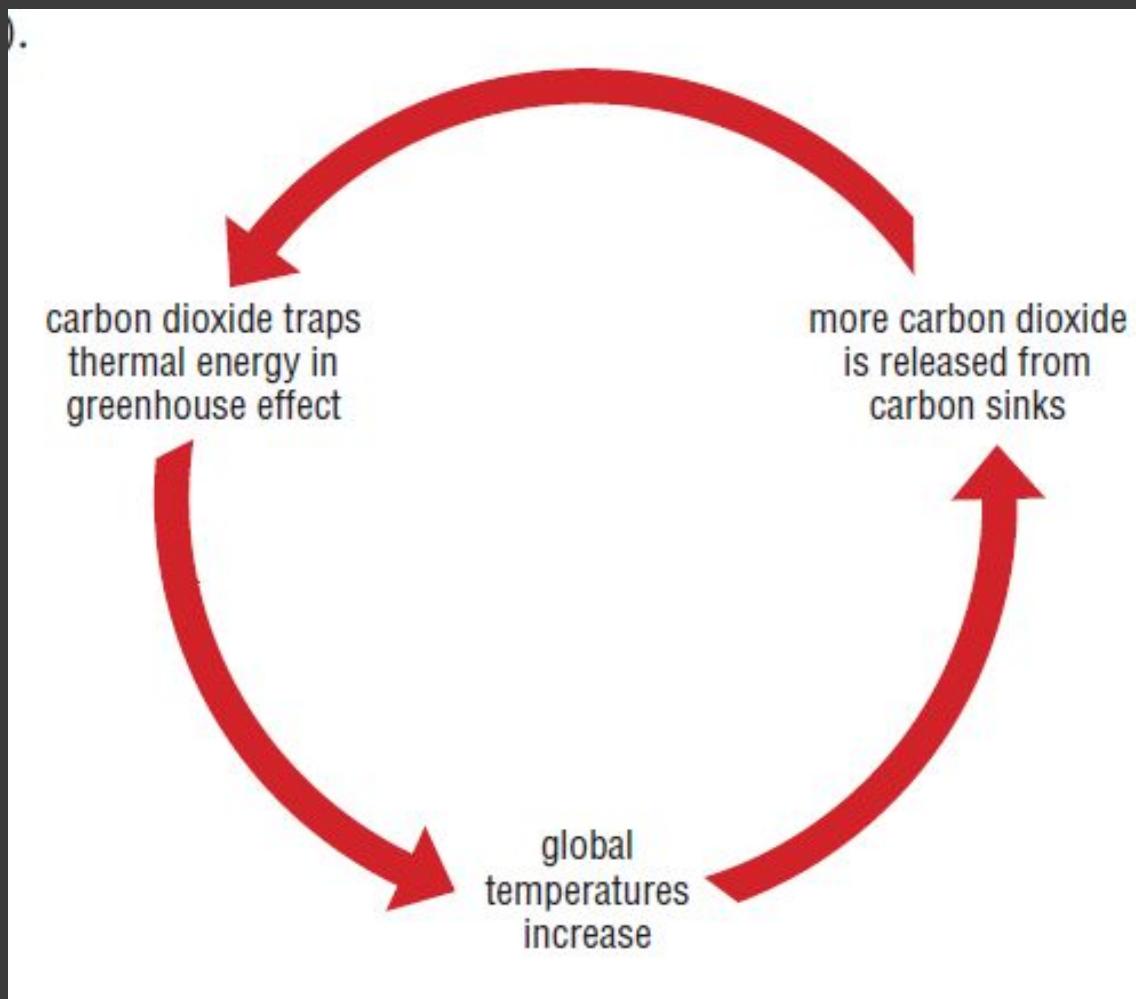
- The increase in the amount of lower-energy infrared radiation trapped by the atmosphere as a result of higher levels of greenhouse gases in the atmosphere due to human activities, which is leading to an increase in Earth's average global temperature



Carbon Dioxide & Global Temperature

- Increases in carbon dioxide levels result in increases in global temperature due to the greenhouse effect; however, increases in temperature can also cause increases in carbon dioxide levels
- As the temperature increases, carbon dioxide stored in plants and oceans (carbon sinks) get released

Positive Feedback Loop



[http://www.youtube.com/watch?v=ZzCA60W
noMk](http://www.youtube.com/watch?v=ZzCA60WnoMk)