Unit 9: Chemistry of the Atmosphere

The modern atmosphere

For 200 million years, the proportions of gases in the atmosphere have been the same as they are today:

- about four-fifths (approximately 80 %) nitrogen
- about one-fifth (approximately 20 %) oxygen
- small proportions of various other gases, including carbon dioxide, water vapour and noble gases.

The Earth's early atmosphere

It is hard to say exactly how the atmosphere has developed because it has taken 4.6 billion years.

One theory suggests that the first **billion years** of the Earth's existence included **intense volcanic activity**. This released large amounts of **carbon dioxide**, and **nitrogen** and a little **methane** (CH_4) and **ammonia** (NH_3). It may also have released the **water vapour** that later formed the oceans. There was little or no oxygen.

This would make Earth's early atmosphere similar to **Venus** or **Mars** today.

Changes to the early atmosphere

As the earth cooled the water vapour **condensed** and formed **oceans**.

Carbon dioxide dissolved in the oceans. It formed hard solid **precipitates**. Some of it was used by sea creatures to make shells, and these later formed rocks like **limestone**.

2.7 billion years ago, algae and plants began producing oxygen by **photosynthesis**, which also reduced the carbon dioxide in the atmosphere

$$6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + 6O_2$$

carbon dioxide + water $\xrightarrow{\text{light}}$ glucose + oxygen

Greenhouse gases

Greenhouse gases include:

- Water
- Carbon dioxide
- Methane

Without them, the Earth would be too cold to sustain life, but too much of them can lead the Earth to heat up, and lead to extreme weather events.

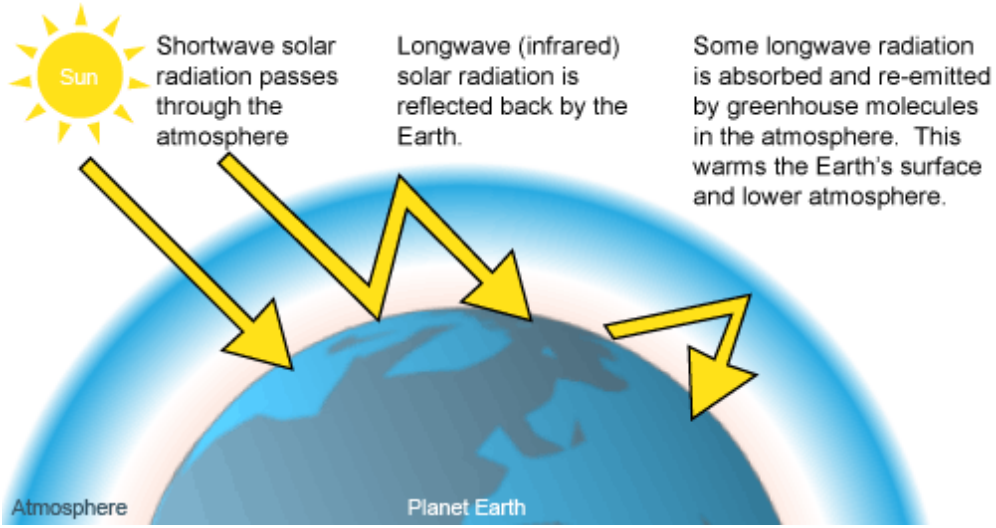

Image from: http://lagoscleanbeach.wix.com

Greenhouse gases like **carbon dioxide** allow **shortwave** radiation to easily pass through the atmosphere

They reach the ground, where they begin to **heat the Earth's surface**.

The carbon dioxide then absorbs the outgoing **longwave** radiation, causing the atmosphere to warm up, and the radiation not to escape.

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Global Climate Change

An increase in average global temperature is a major cause of **climate change.** This may lead to:

- Global weather patterns changing (leading to flooding in some areas and drought in others)
- Extreme weather events (e.g. hurricanes)
- Ice caps and glaciers melting
- Sea-levels rising, causing flooding in coastal regions
- Desertification
- Reduced yields of crops

Human Activities

Carbon dioxide levels are increased by:

- Burning fossil fuels
- Deforestation
- Destroying peat bogs

Methane levels are increase by:

- Farming cattle
- Growing rice
- Use of landfill

Scientists say…

Based on **peer-reviewed evidence**, many scientists believe human activities will cause the temperature of the atmosphere to increase, and that this will result in **global climate change**.
However, it is difficult to model such **complex systems** as global climate change. This leads to **simplified models**, **speculation** and opinions presented in the media that may be based on only parts of the evidence and which may be **biased**.

Atmospheric pollutants from fuels

When fuels are combusted (burned in oxygen) they may release different types of pollution

Pollutant	**Problem it causes**
Carbon dioxide (CO_2)	Global warming, and dissolves in clouds to form acid rain
Carbon monoxide (CO)	Toxic, and can cause health problems or even kill
Sulfur dioxide (SO_2)	Dissolves in clouds to form acid rain. Causes respiratory problems.
Oxides of nitrogen (e.g. NO, NO_2, N_2O and N_3O_2)	Dissolves in clouds to form acid rain. Causes respiratory problems.
Carbon particulates (soot)	Reflect sunlight, causing global dimming

Carbon footprint

This is the total amount of carbon dioxide and other greenhouse gases emitted over the full life cycle of a product, service or event.

It can be reduced by reducing emission of carbon dioxide and methane.

E.g. Directly, by using "green" energy sources that don't emit carbon dioxide such as solar power and wind power, instead of burning fossil fuels.

E.g. Indirectly, by insulating a building so it requires less heating. This will then require fewer fossil fuels to be burned for electricity.