Topic 9: Chemistry of the Atmosphere

Phase 1 – Volcanoes Gave out Gases

During the first billion years of Earth's history, the surface was covered in volcanoes.

- Eruptions released gases
- This formed the early atmosphere:
- Mainly CO_2 (virtually ZERO O_2) – similar to Mars and Venus today.
- Volcanic activity also released N_2, H_2O and small amounts of CH_4 and NH_3 which built up in the atmosphere over time

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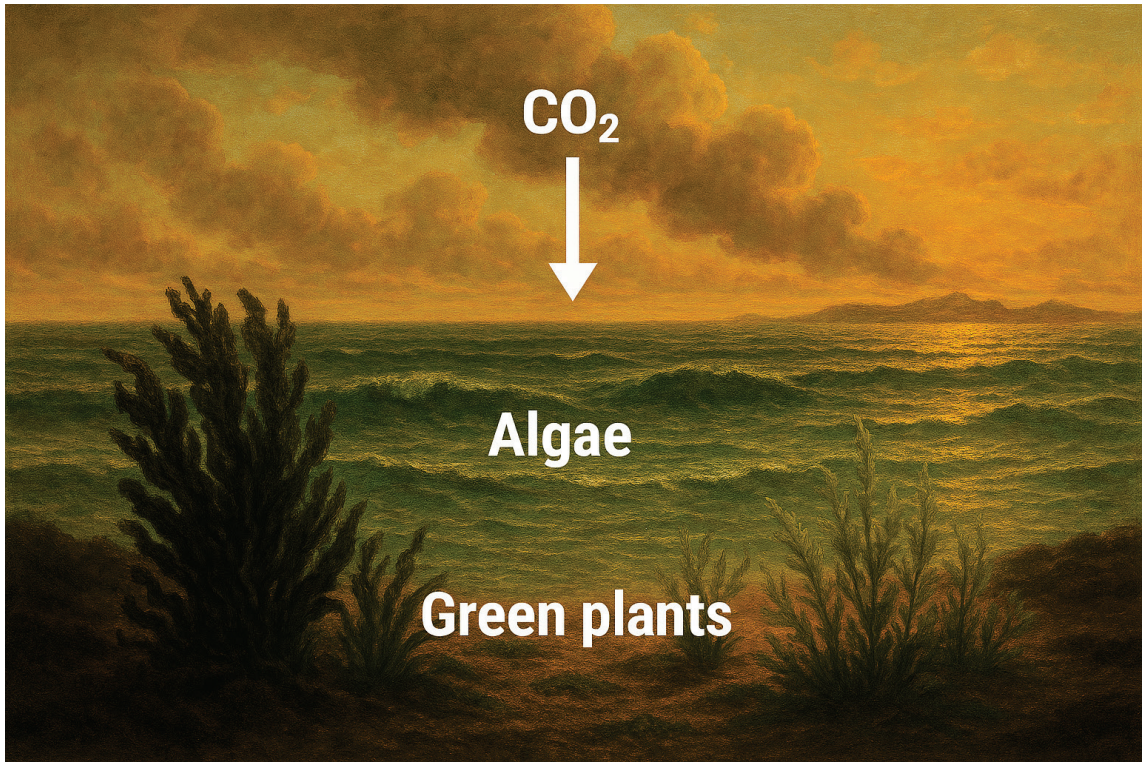
Phase 2 – Oceans, Algae and Green Plants Absorbed CO_2

When the water vapour in the atmosphere condensed, it formed the oceans.



- Much CO_2 removed from early atmosphere as it dissolved in the oceans.
- Dissolved CO_2 formed carbonate precipitates that produced sediments on the seabed
- Marine animals evolved, incorporating carbonates into their shells and skeletons
- Green plants and algae evolved and absorbed some of the CO_2 via Photosynthesis

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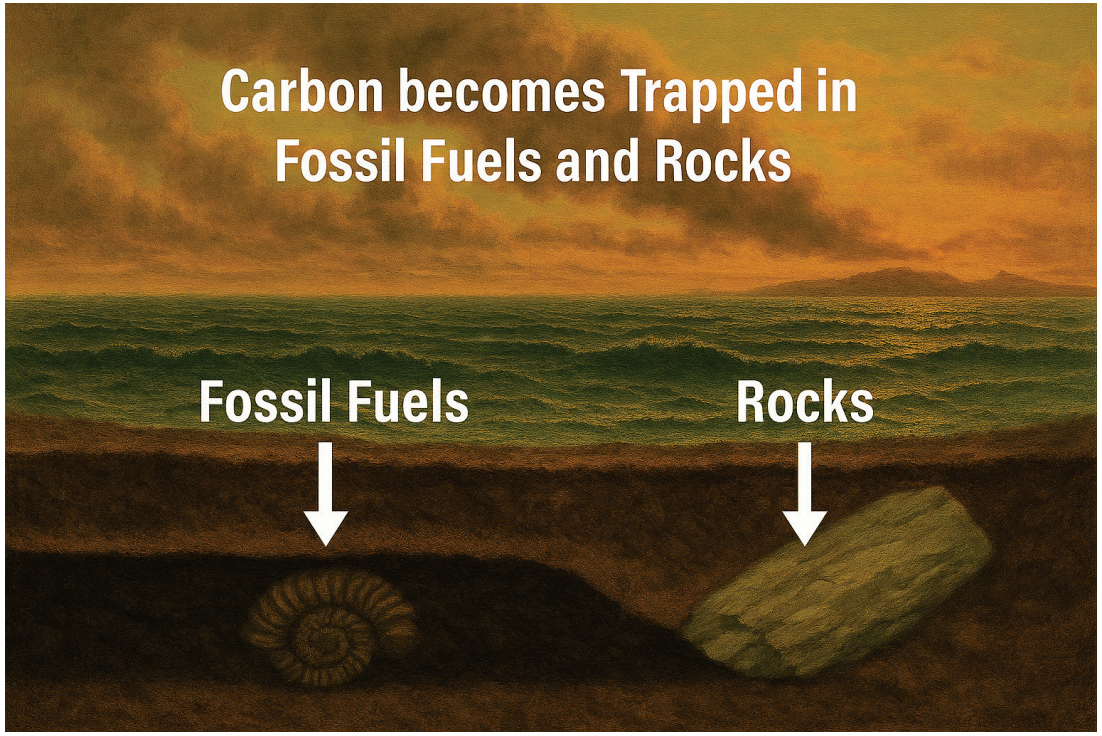
Phase 2 (cont.) – Carbon becomes Trapped in Fossil Fuels and Rocks

Some of the C incorporated into organisms from the atmosphere and oceans became locked up in rocks and fossil fuels after the organisms died.



- Plants, plankton and marine animals die, fall to the seabed and get buried by layers of sediment.
- Compressed over millions of years to form sedimentary rocks, oil and gas (trapping C)
- Coal, crude oil and natural gas made by this process are called ‘fossil fuels’
- Crude oil and natural gas formed from plankton deposits. These fossil fuels form reservoirs under the seabed trapped in rock.
- Coal is a sedimentary rock made from thick plant deposits.
- Limestone is a sedimentary rock – $CaCO_3$ deposits from shells and skeletons of marine organisms.

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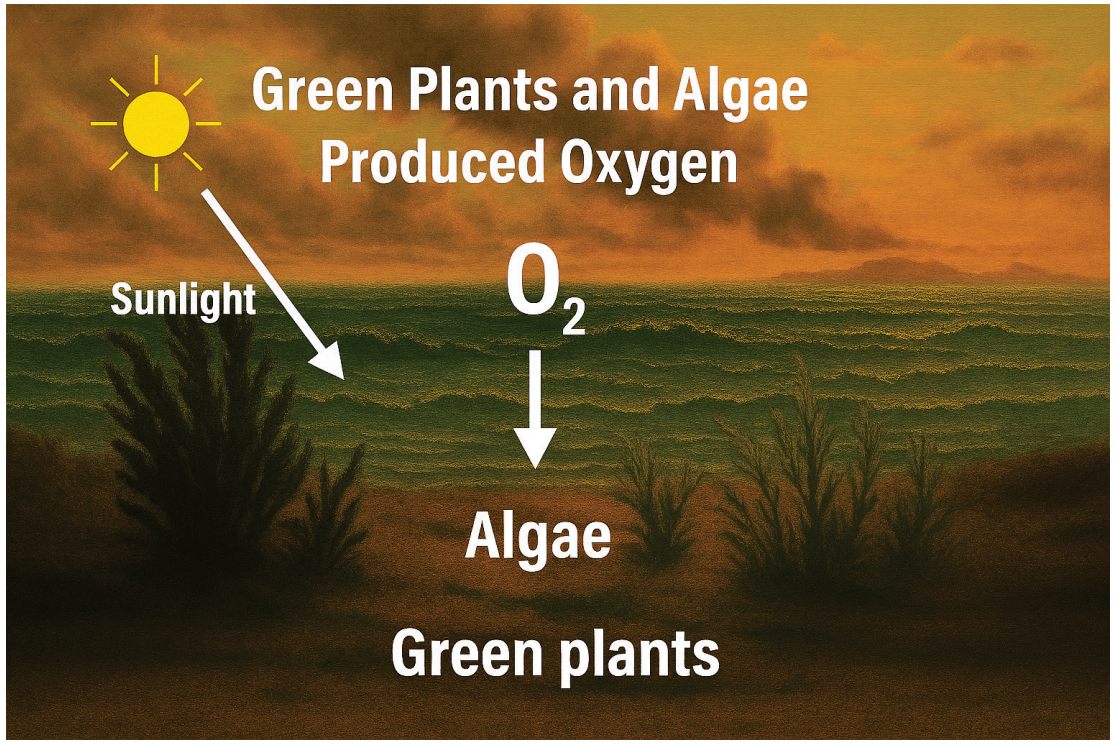
Phase 3 – Green Plants and Algae Produced Oxygen

Green Plants and Algae absorbed CO_2 from the atmosphere and produced O_2 by Photosynthesis: Light used to convert CO_2 and H_2O into Sugars



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

Carbon dioxide + water → glucose + oxygen

- Algae evolved first ~ 2.7 billion yrs ago
- Green plants evolved over the next billion years
- As O_2 levels built up, more complex life (animals) evolved
- Eventually, ~ 200 million years ago, the atmosphere reached similar composition to today:
  80% N_2, 20% O_2
  Trace amounts of CO_2, Noble gases and H_2O

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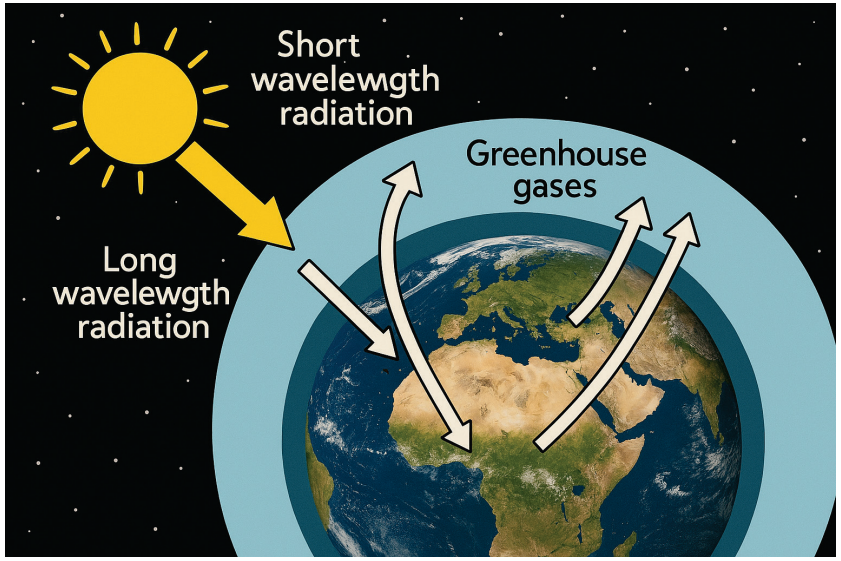
Climate Change and Greenhouse Gases

Greenhouse gases (e.g. CO_2, CH_4 and H_2O) act as insulating layer in Earth's atmosphere allowing Earth to be warm enough to support life!



- All particles absorb certain frequencies of radiation
- Greenhouse gases DO NOT absorb incoming short wavelengths from the Sun but Do absorb long wavelengths from the Earth's surface.
- They re-radiate it in all directions – including back to Earth
- Longwave radiation is thermal radiation, resulting in warming of the Earth surface – Greenhouse Effect

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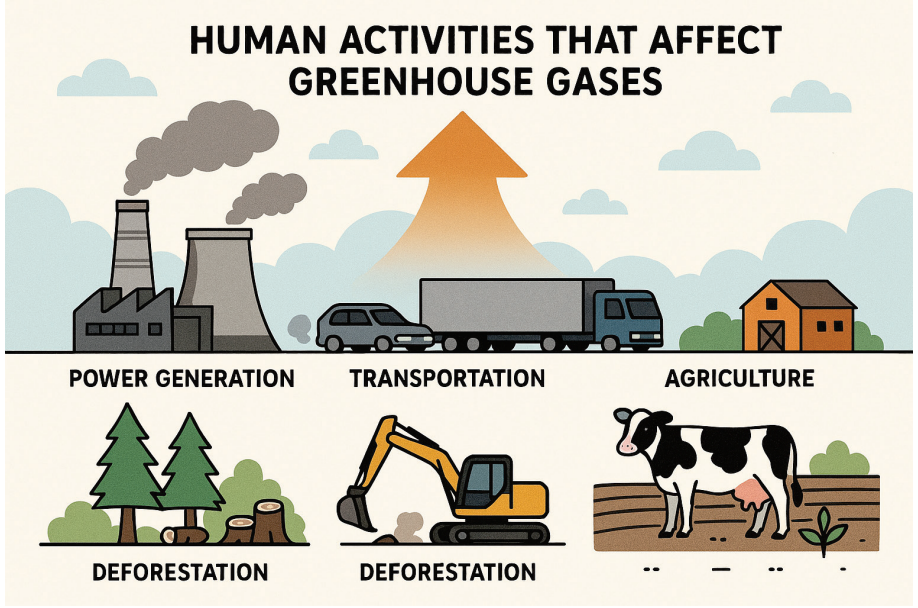
Climate Change and Greenhouse Gases

Some forms of human activity affect the amount of greenhouse gases in the atmosphere:



- Deforestation – fewer trees mean less CO_2 absorbed by photosynthesis
- Burning Fossil Fuels – Releases CO_2 from previously locked up Carbon
- Agriculture – More farm animals produce more CH_4 through digestive processes
- Creating Waste – more landfill sites and more agricultural waster means more CO_2 and CH_4 released by decomposition of waste