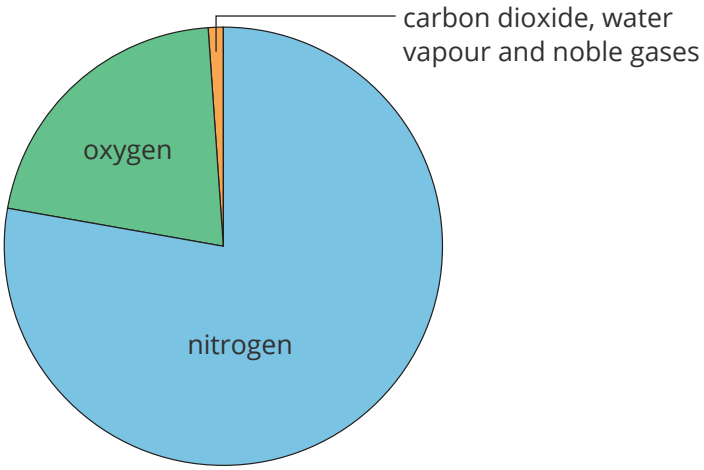
Evolution of the Earth's Atmosphere

Read the text below and then answer the questions on the accompanying sheet.

For the last 200 million years, the proportions of different gases in the Earth's atmosphere have remained relatively stable. Today's atmosphere is around four-fifths nitrogen, about one-fifth oxygen and small proportions of other gases, including carbon dioxide, water vapour and noble gases.



The Early Atmosphere

The composition of the atmosphere has not always been the same. The Earth formed 4.6 billion years ago, so we have limited evidence about the early atmosphere. Scientists have studied gas bubbles trapped in ancient rocks on Earth and also the atmosphere on other planets and moons. Using this limited data, they have developed theories about what they think the atmosphere was like. There are several theories about how the atmosphere was formed and these have changed and developed over time based on new evidence.

One theory suggests that for the first billion years, Earth had no oceans and was covered in volcanoes. The intense volcanic activity released lots of carbon dioxide that made up most of the early atmosphere, along with nitrogen and possibly some methane and ammonia. At this point, the atmosphere may have been like the atmospheres of Mars and Venus today, with little or no oxygen.

Water vapour released from the volcanoes condensed as the Earth gradually cooled down and fell as rain. This rain settled in hollows of the crust to form the oceans. Carbon dioxide dissolved in the water to form soluble carbonate compounds which reduced the carbon dioxide in the atmosphere. These carbonate compounds precipitated as sediments which eventually formed sedimentary rocks.

Oxygen in the Atmosphere

Around 3.4 billion years ago, the simple gases in the atmosphere and oceans formed the compounds needed for life to start. Initially, simple organisms used the breakdown of these chemicals as a source of energy.

Around 2.7 billion years ago, bacteria and algae evolved. Algae used energy from the sun for photosynthesis, which can be represented by the equation:

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

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

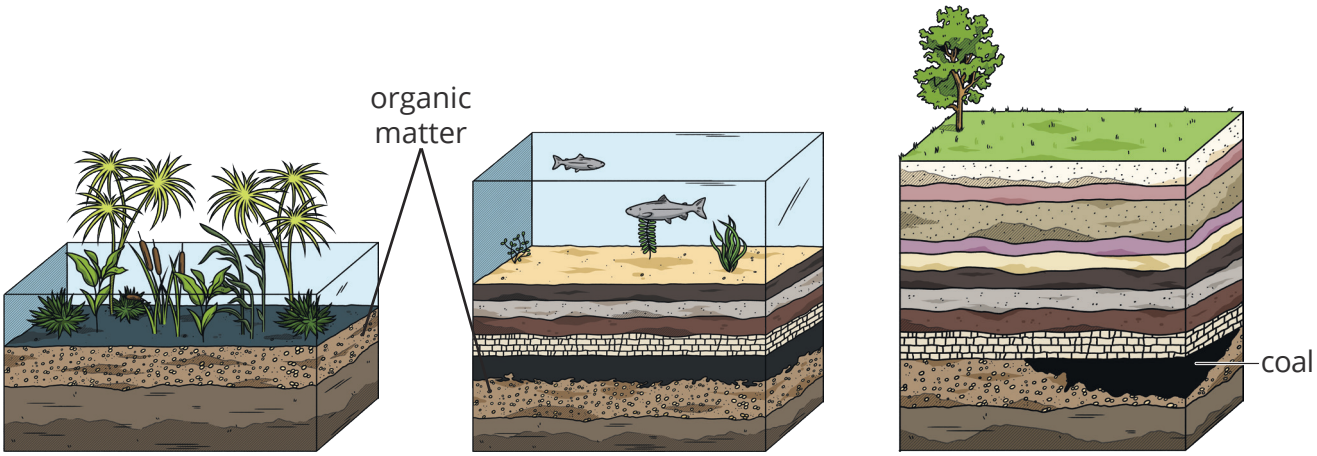
The oxygen gas produced as a waste product meant that oxygen was released into the atmosphere. Over the next billion years, plants evolved and the percentage of oxygen in the atmosphere increased steadily until there was enough to support animal life. Animals cannot make their own food in the way that plants and algae can, so rely on the plants for both food and oxygen to respire.

Decrease of Carbon Dioxide

Photosynthesis removes carbon dioxide from the atmosphere and locks it in the plants as they use it to make new plant material as they grow. As more algae and plants evolved, the percentage of carbon dioxide in the atmosphere decreased.

When animals eat plants, this carbon can be transferred to the animal tissues. Over millions of years, the shells and skeletons of animals with locked in carbon became covered with layers of sediment. The pressure from these layers formed sedimentary rocks such as limestone ($CaCO_3$). The carbon dioxide from the atmosphere became locked in these rocks within the Earth's crust.

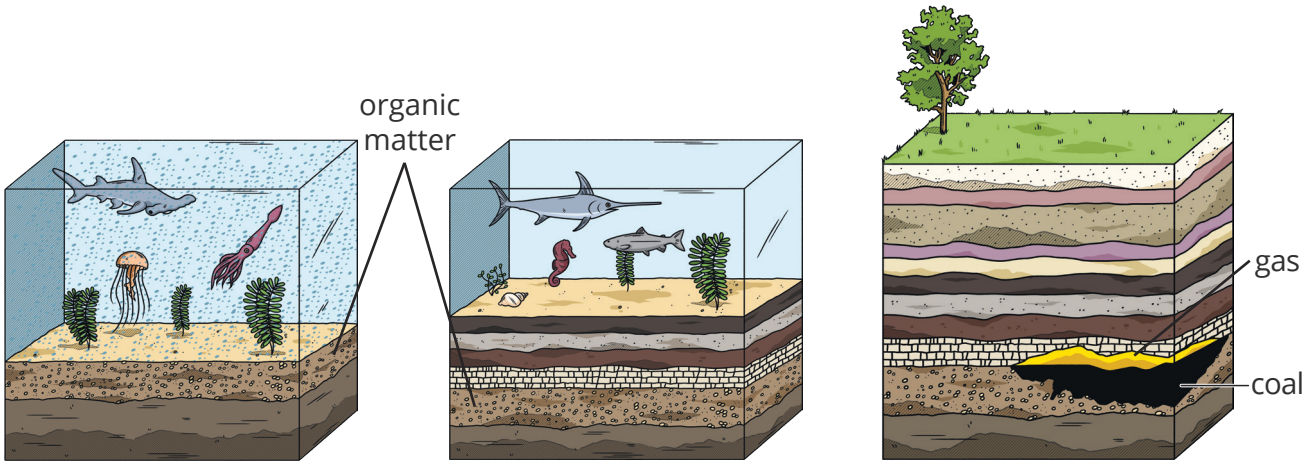
Carbon dioxide levels in the atmosphere were also decreased by the formation of fossil fuels. Coal, oil and natural gas formed in different conditions, but all involved a lack of oxygen, pressure from layers of sediments and heat from the Earth's crust.



Coal was formed from trees and ferns which were buried in swamps.

Layers of sediment built up on top of the dead organic matter and a lack of oxygen prevented oxidation from occurring.

Pressure from the layers of sediment and heat from the Earth's crust turned the remains into coal over millions of years.



Crude oil and natural gas were formed from simple plants and animals living in oceans and lakes.

Layers of sediment built up on top of the dead organic matter and a lack of oxygen prevented oxidation from occurring.

Pressure from the layers of sediment and heat from the Earth's crust turned the remains into crude oil and natural gas over at least a million years.

Carbon is locked in the fossil fuels and is released back into the atmosphere when they are burnt.