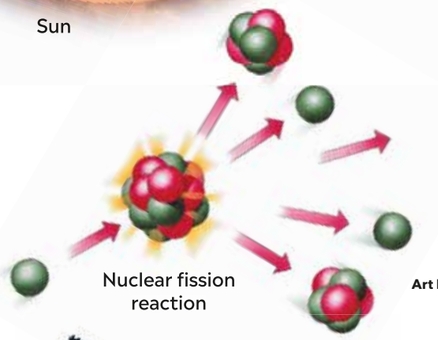
Sun



Nuclear fission reaction

Layers of Earth's atmosphere

DK | Penguin Random House

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Fungi

Petrol pump, USA

Research buoy

Contents

Planting trees

Earth's **climate**

Currents in Earth's atmosphere and oceans carry heat and moisture around the globe, sustaining life. These currents also create the weather. The long-term pattern of weather in a particular place is its climate. Climates vary slowly over time, forcing life to adapt to new conditions, but recently the rate of climate change has speeded up.

Living planet

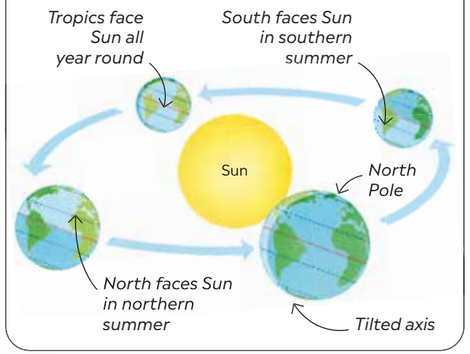
Earth's atmosphere acts like an insulating blanket, keeping temperatures within the limits that allow life to survive.

Changing climate

Scientists are studying Earth's climate across the world, including Antarctica, as seen here. They have shown that for most of human history the climate has been stable, enabling civilizations to rise and prosper. But since 1900, the climate has been changing.

TILTED EARTH

The Sun shines directly on the tropics around the Equator, with a concentrated energy that creates tropical climates. Sunlight strikes the poles at an angle, dispersing its energy and allowing ice sheets to form. The spinning Earth is tilted on its axis, so as Earth orbits the Sun each year, the Sun's rays heat the north more intensely during the northern summer, and the south during the northern winter, creating annual seasons.



Barren desert

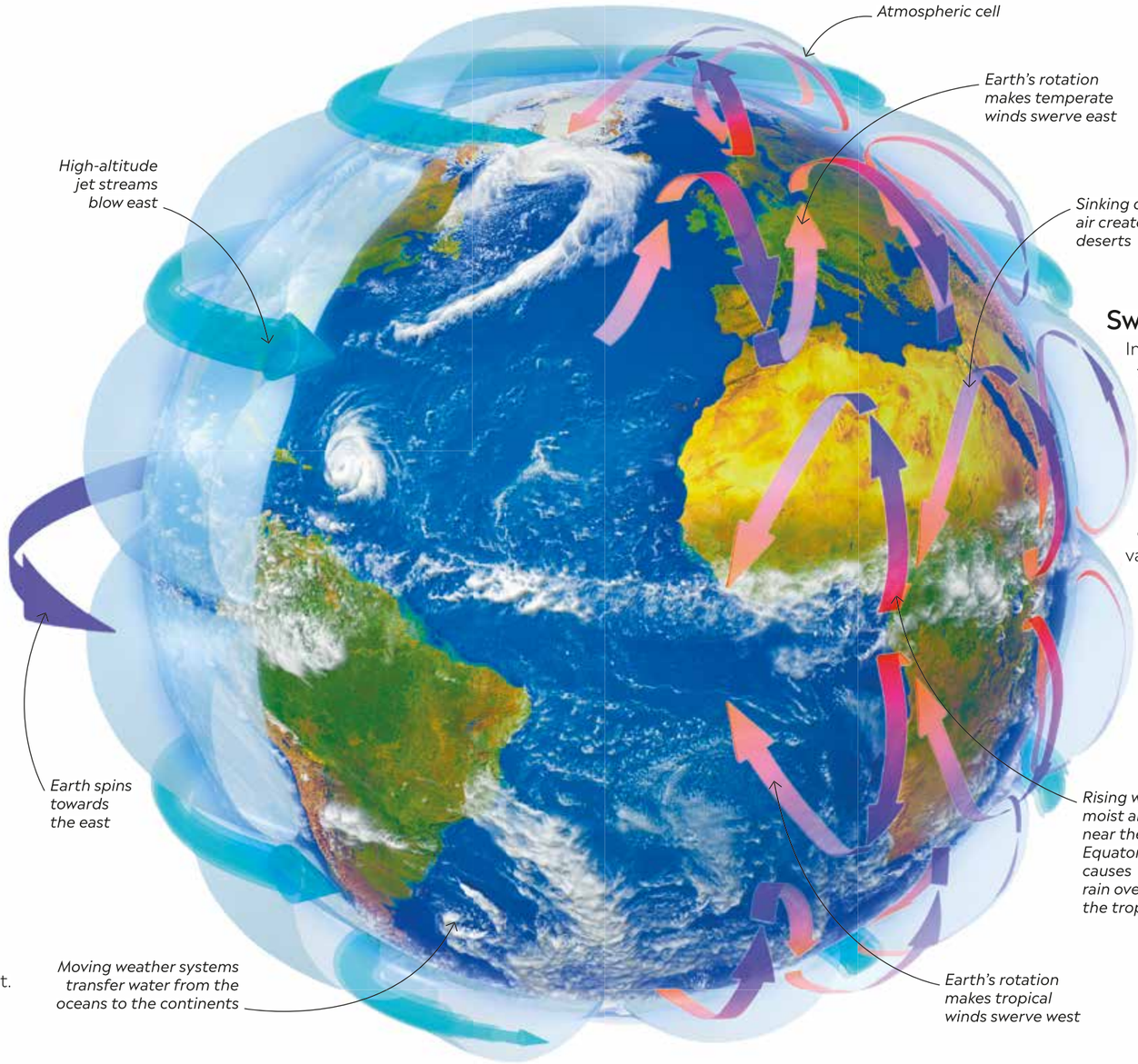
Liquid water is vital to living things, so regions where any water is either permanently frozen or dried up by the Sun are lifeless deserts. In a hot desert like this one in Israel, a slight rise in average temperature could wipe out all traces of life.

Teeming with life

Where the climate is warm and wet, rich ecosystems such as this rainforest provide food for a huge variety of animals. They have all evolved to flourish in the conditions created by a particular type of climate, and many may not be able to survive rapid climate change.

Warming world

Global average temperatures started rising in about 1900. They have risen and fallen many times since then, but the trend has crept upwards. This matches the rise of modern industry, huge cities, and increasing consumption of fuel such as coal and oil to provide energy for heating, electrical power, and transport.



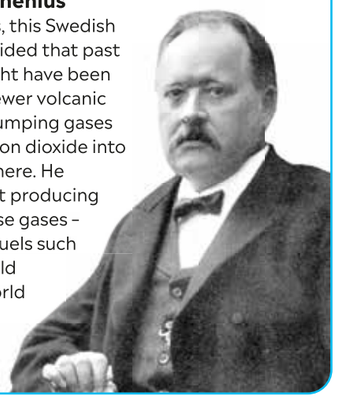
Swirling currents

Intense sunlight in the tropics generates warm air currents that flow towards the poles in a series of rising and sinking "cells". This cools the tropics and warms the temperate and polar regions, giving the planet a more even climate. Winds and weather systems driven by high-altitude air currents also carry moisture from the oceans over the continents, where it falls as rain or snow. This provides the vital water that allows life to flourish on land. Variations in temperature and rainfall create a variety of climate zones, such as deserts and rainforests.

EYEWITNESS

Svante Arrhenius

In the 1890s, this Swedish chemist decided that past ice ages might have been caused by fewer volcanic eruptions pumping gases such as carbon dioxide into the atmosphere. He thought that producing more of these gases – by burning fuels such as coal – would make the world warm up.



The greenhouse **effect**

The atmosphere that surrounds our planet acts as both sunscreen and insulation, shielding life from the fiercest of the Sun's rays while retaining heat that would otherwise escape back into space at night. This feature of the atmosphere is known as the greenhouse effect. Life on Earth would be impossible without it, but its increasing power is also causing global warming.

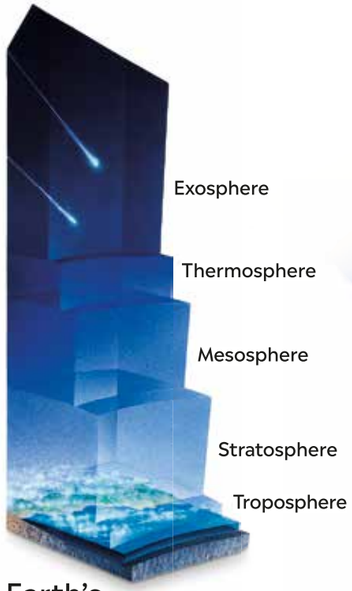
Life support

Without Earth's atmosphere, temperatures would be scorching by day, and plunge to far below freezing at night. The average global temperature would sink from 14°C (57°F) to about –18°C (0°F). Without the greenhouse effect, life on Earth could not have evolved.

Like any living being, the rose plant will die if temperatures remain freezing.

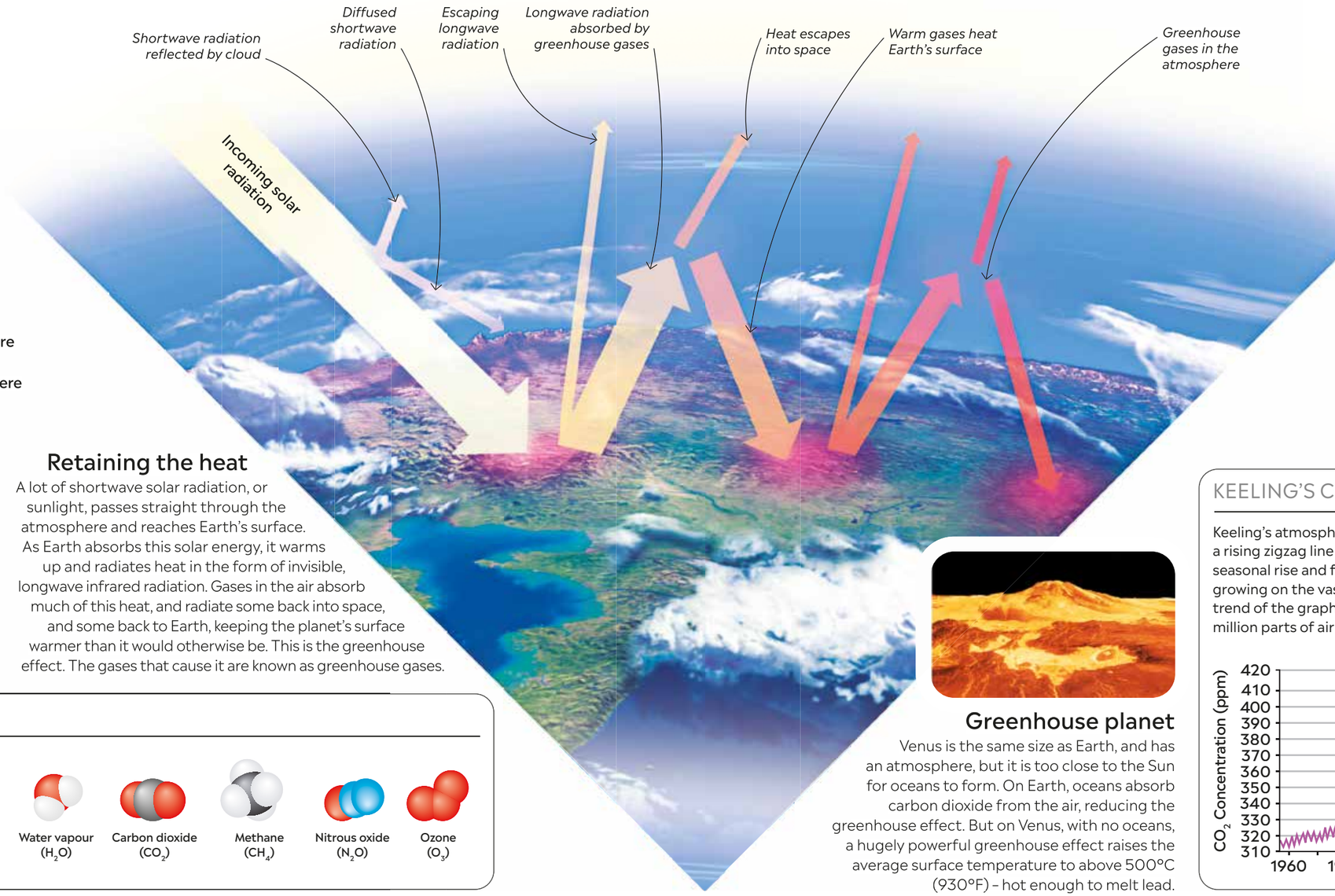
Cold neighbour

The Moon is a lot smaller than Earth, and has lower gravity, so any gas seeping from its interior drifts into space instead of forming an atmosphere. With no greenhouse effect, the surface temperature is far lower – one reason why there is no life on the Moon.



Earth's atmosphere

The multi-layered atmosphere is mainly made up of nitrogen and oxygen gas, plus far smaller amounts of carbon dioxide, water vapour, and other gases. Most of the gases are concentrated in the lowest layer – the troposphere.



Retaining the heat

A lot of shortwave solar radiation, or sunlight, passes straight through the atmosphere and reaches Earth's surface. As Earth absorbs this solar energy, it warms up and radiates heat in the form of invisible, longwave infrared radiation. Gases in the air absorb much of this heat, and radiate some back into space, and some back to Earth, keeping the planet's surface warmer than it would otherwise be. This is the greenhouse effect. The gases that cause it are known as greenhouse gases.

GREENHOUSE GASES

The main greenhouse gases are water vapour, carbon dioxide, methane, nitrous oxide, and ozone. Gases are clusters of atoms called molecules. Carbon dioxide has one carbon and two oxygen atoms.

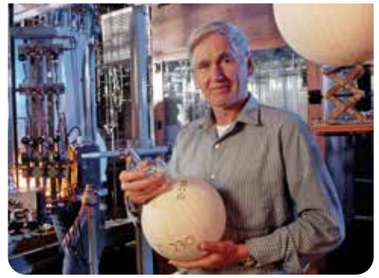
Greenhouse planet

Venus is the same size as Earth, and has an atmosphere, but it is too close to the Sun for oceans to form. On Earth, oceans absorb carbon dioxide from the air, reducing the greenhouse effect. But on Venus, with no oceans, a hugely powerful greenhouse effect raises the average surface temperature to above 500°C (930°F) – hot enough to melt lead.

EYEWITNESS

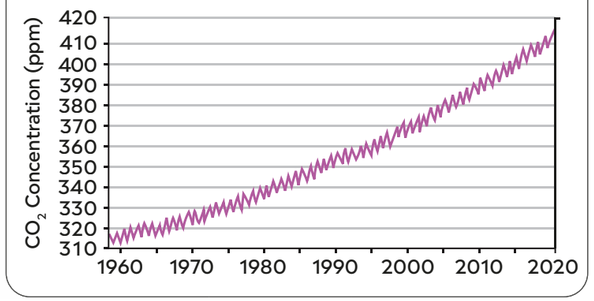
Charles Keeling

Measurements of carbon dioxide (CO_2) in the air by American scientist Charles Keeling show its concentration has been increasing every year since 1958. CO_2 absorbs a lot less energy per molecule than the other greenhouse gases, but there is much more of it.



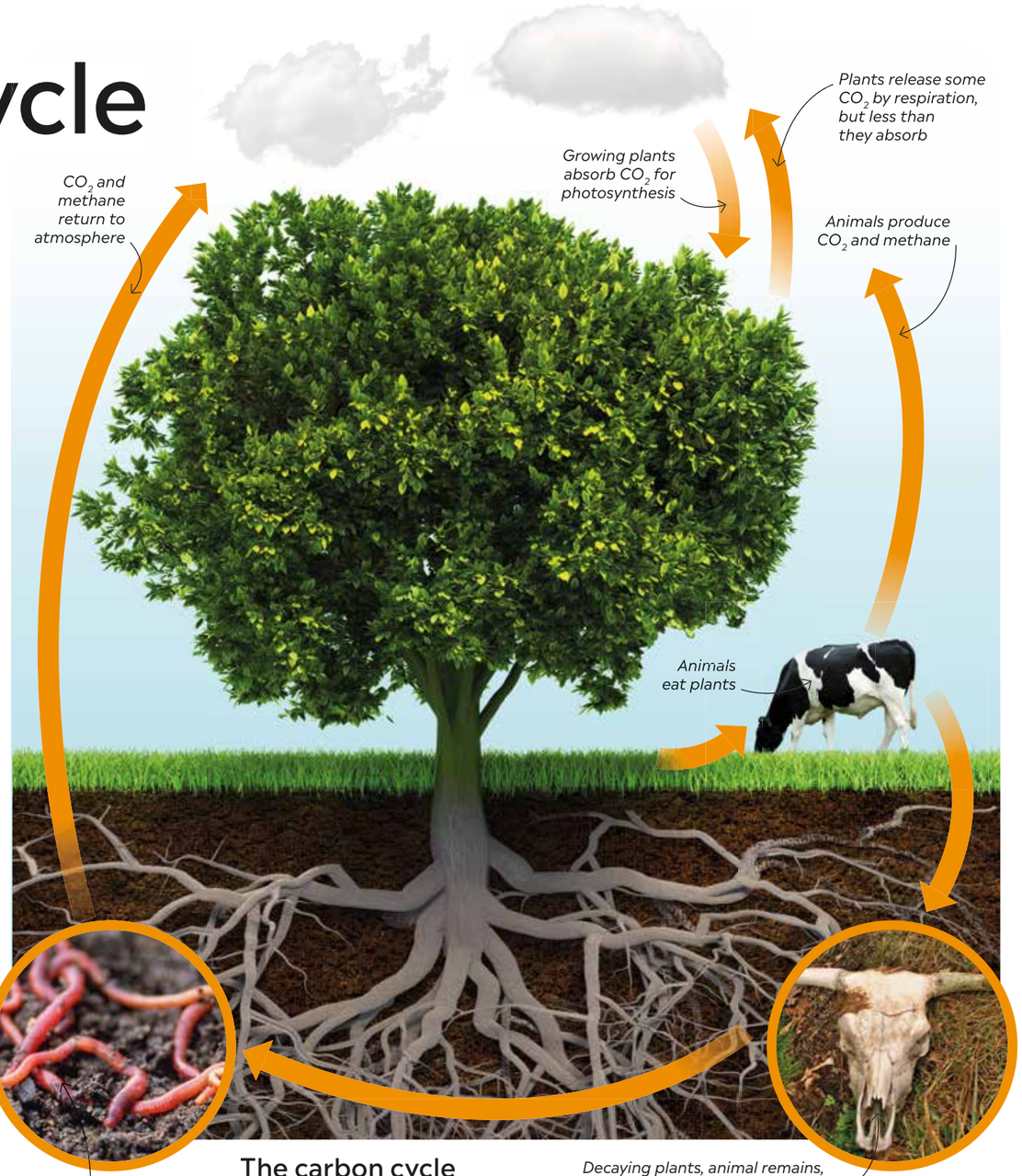
KEELING'S CURVE

Keeling's atmospheric carbon dioxide measurements create a rising zigzag line on a graph. The zigzag effect indicates the seasonal rise and fall due to the absorption of CO_2 by plants growing on the vast northern continents in summer. But the trend of the graph keeps rising, from 315 parts of CO_2 per million parts of air in 1958 to 411 in 2019.



The carbon **cycle**

When carbon combines with oxygen, it forms carbon dioxide (CO_2). Green plants absorb CO_2 from the air during photosynthesis, fuelling life processes. During respiration, plants release CO_2 back into the air. CO_2 is also released through burning and decay, absorbed and released by the oceans, and erupted from volcanoes. So carbon is continually passing between living things, the atmosphere, oceans, and rocks – an exchange called the carbon cycle.



Photosynthesis

Green plants and marine plankton use solar energy to turn CO_2 and water into sugar. This process, called photosynthesis, also releases oxygen. Sugar stores the energy of the Sun in chemical form, and nearly all living things on Earth rely on this energy to build their tissues and fuel their activities. Life is built on carbon.

Respiration

Plants and animals use oxygen to release the energy stored in sugar and other carbohydrates. Known as respiration, this turns the sugar back into CO_2 and water. Animals breathe in the oxygen, and breathe out to lose CO_2 and water vapour.

The carbon cycle

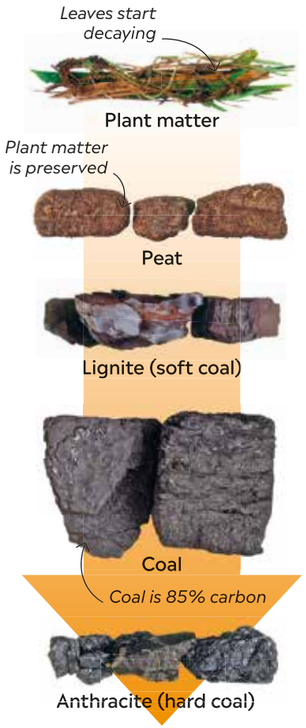
Carbon is constantly being absorbed and released by living things. Plants and other photosynthesizers absorb CO_2 and use some of the carbon to build their tissues. The carbon is released as CO_2 or methane when plants die and decay. If animals eat the plants, they use some of the carbon to build their own tissues, but eventually die too. Meanwhile, both plants and animals release CO_2 when they turn sugar into energy by respiration.

Organic decay

When living things die, other organisms such as bacteria and these fungi start recycling their basic ingredients. This process of decay often combines the carbon in the dead tissues with oxygen, so it returns to the atmosphere as CO_2. Another type of decay combines the carbon with hydrogen to form methane.

CARBON STORAGE

When a plant or animal dies, it usually starts decaying straight away, and its carbon content soon returns to the air. But sometimes it is buried in such a way that it does not decay properly. Dead plants that sink into a waterlogged bog often do not rot away, but turn into deep layers of peat. Eventually, the peat may be compressed into coal, a process that stores the carbon for millions of years.



Volcanic carbon

Carbon stored in the rocks of Earth's crust is returned to the atmosphere by volcanoes. They erupt both molten rock and gases, which include CO_2 released by carbonate rocks, such as limestones, as they melt. Small amounts of CO_2 erupt from volcanoes every year, and are gradually absorbed by the formation of more carbonate rocks.

Temperature control

During Earth's early history, 3.5 billion years ago, CO_2 erupting from volcanoes created an intense greenhouse effect that stopped Earth freezing. Over time, the Sun grew hotter, but most of the erupted CO_2 was soaked up by the oceans (below), reducing the greenhouse effect at roughly the same rate – evidence that Earth may be a self-regulating system.