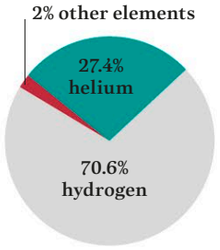
The Sun

It takes up to **100,000 years** for **energy to travel** from the Sun's **core to its surface**

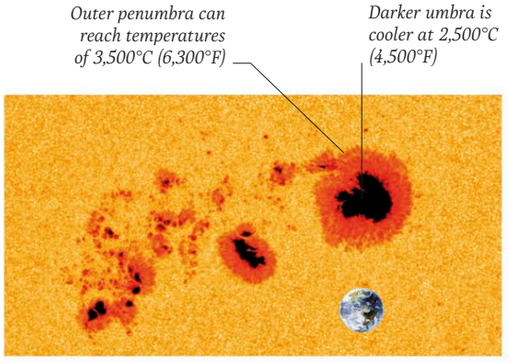
The Sun is our nearest star – a vast ball of mostly hydrogen and helium gas that shines with incandescent light due to nuclear fusion in its core. Cyclical changes alter the Sun's appearance from year to year, while electromagnetic radiation (see p.188) and streams of particles from its surface spread out, influencing the entire Solar System.



Composition by mass
The vast majority of the Sun's mass is accounted for by the two lightest elements.

The solar cycle

The Sun goes through an 11-year cycle of activity that principally affects dark sunspots on its visible surface, and bright solar flares that erupt from its upper atmosphere. This cycle is driven by changes to the solar magnetic field.

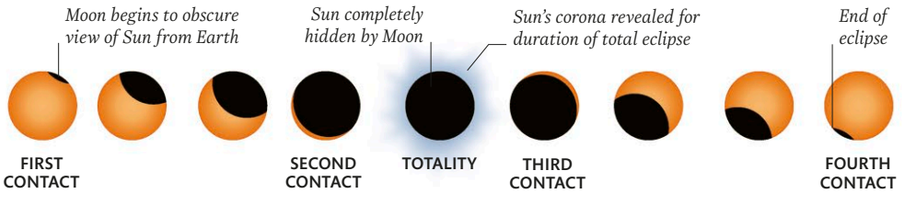


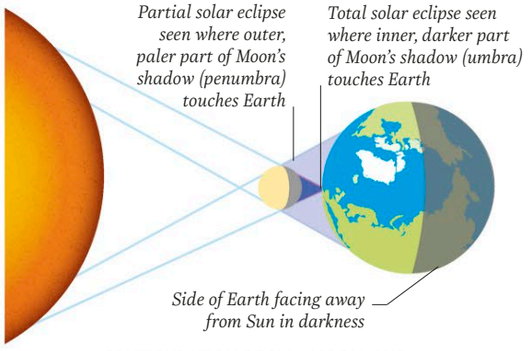
Sunspots
Photographed in January 2014, sunspot AR1944 was one of the largest of the past nine years – Earth is shown to scale.

Solar eclipses

Solar eclipses occur when Earth's Moon passes in front of the Sun. Because the Moon's orbit is tilted relative to Earth's, they do not happen at every new Moon. The precise alignment required means each eclipse is only visible from a very limited part of Earth's surface.

Total eclipse
During a total eclipse, the Moon covers an increasingly large area of the Sun before covering it completely at "totality" for up to 7 minutes.

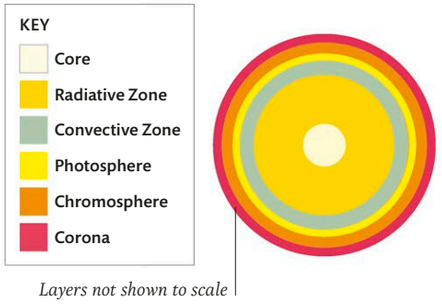




CONFIGURATION OF SUN, MOON, AND EARTH DURING A TOTAL ECLIPSE (NOT TO SCALE)

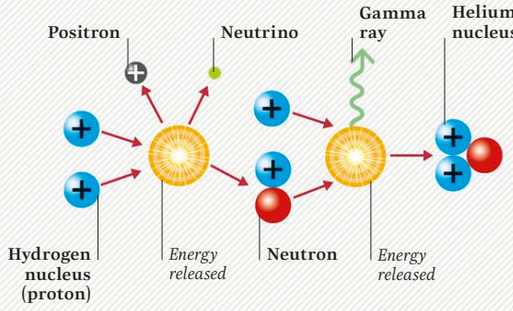
The Sun's layers

The Sun's structure is divided into layers, where different processes dominate. Energy is produced in the core and makes its way out through the radiative and convective zones. The photosphere is the visible surface – a layer where the Sun's gas becomes transparent. Above this lie the thin chromosphere and a vast outer atmosphere or corona.



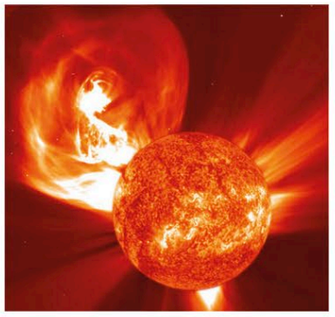
THE SUN'S SOURCE OF ENERGY

Temperatures and pressures in the Sun's core are so high that a process called nuclear fusion is triggered. This involves the forcing-together of lightweight hydrogen nuclei (single particles called protons) in a series of reactions that eventually create nuclei of helium. Along the way, smaller particles (positrons and neutrinos) are released, along with energy in the form of gamma rays.

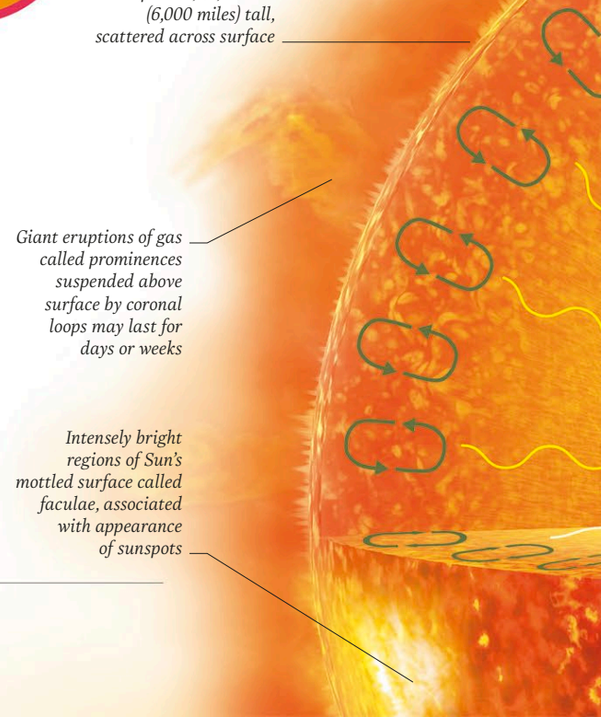


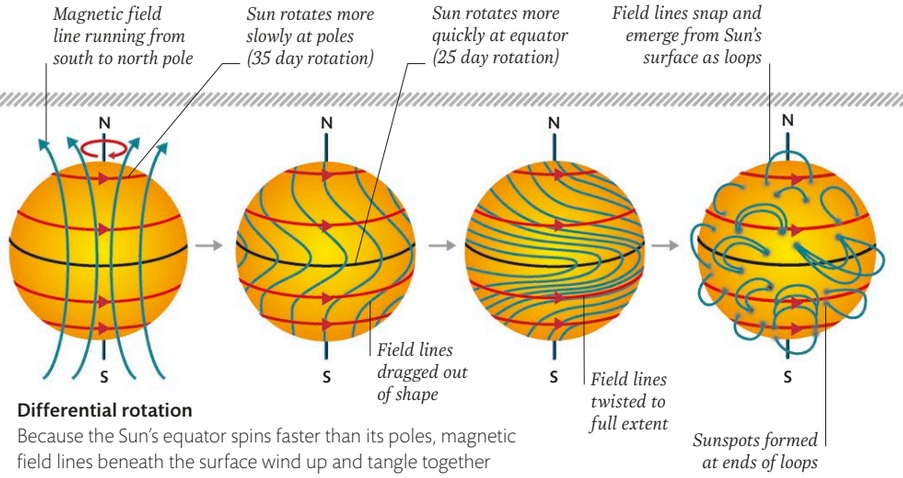
NUCLEAR FUSION IN THE SUN

Features of the Sun
By using special filters and cameras that can detect radiations beyond visible light, details on and above the Sun's incandescent surface are revealed, which offer clues to the complex structure hidden below the photosphere.

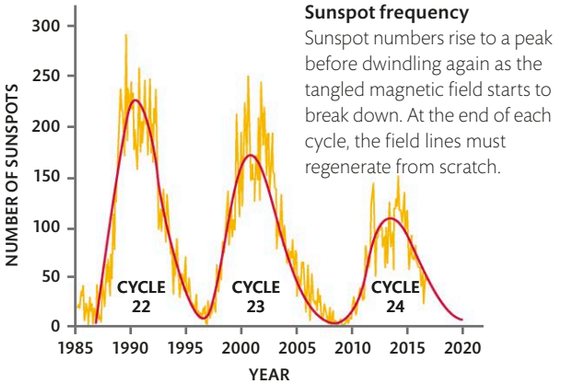


Coronal mass ejection
When loops of magnetic field short-circuit high in the Sun's outer corona, huge amounts of energy are released, spitting vast clouds of gas into space at speeds of millions of kilometres per hour.





Differential rotation
Because the Sun's equator spins faster than its poles, magnetic field lines beneath the surface wind up and tangle together over many rotations, driving activity on the Sun's surface.

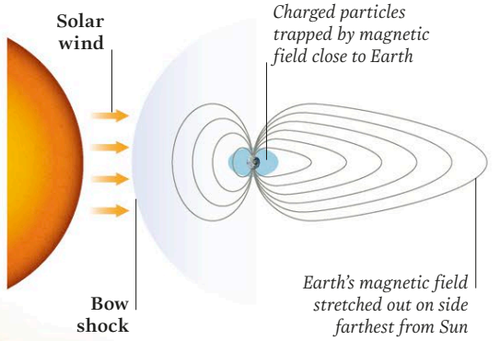


Sunspot frequency
Sunspot numbers rise to a peak before dwindling again as the tangled magnetic field starts to break down. At the end of each cycle, the field lines must regenerate from scratch.

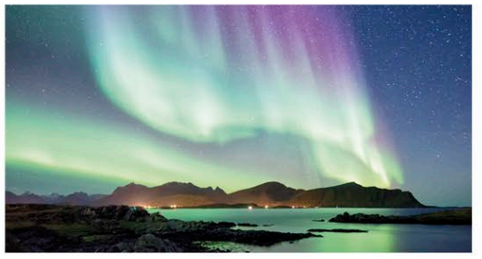
Solar wind

At its outer edges, the Sun's corona merges with the solar wind, a stream of stray particles driven out from the Sun by the pressure of radiation behind. As the solar wind streams past Earth, it distorts our planet's magnetic field, before continuing out through the Solar System until it eventually slows beyond the orbit of Neptune.

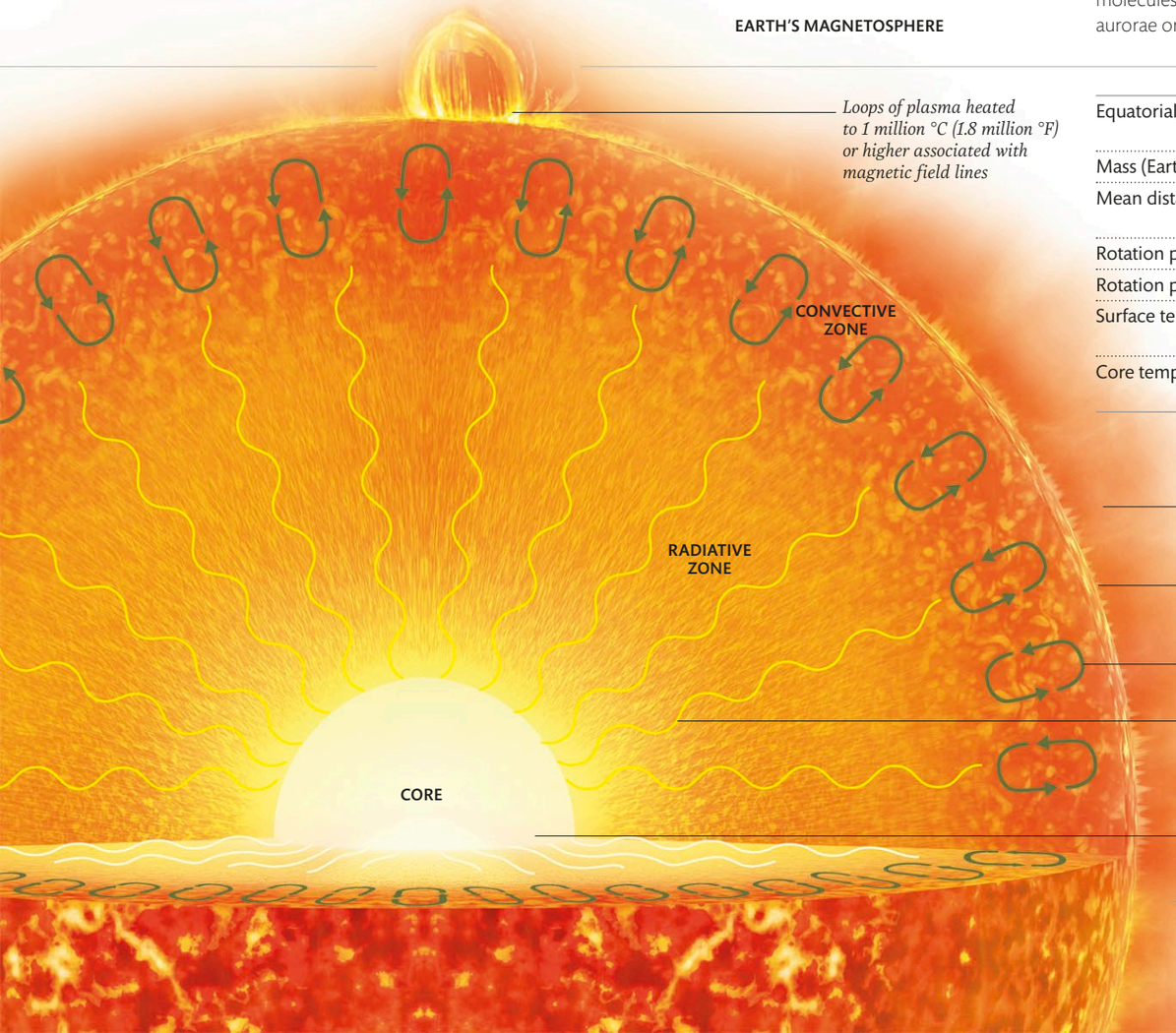
1.3 million Earths would fit **inside the Sun**



EARTH'S MAGNETOSPHERE



Aurora borealis (northern lights)
Particles from the solar wind are drawn down by Earth's magnetosphere above Earth's poles. They energize gas molecules in the upper atmosphere, creating glowing aurorae or northern and southern lights.



Equatorial diameter	1.4 million km (865,000 miles)
Mass (Earth = 1)	333,000
Mean distance from Earth	149.6 million km (93 million miles)
Rotation period (polar)	35 Earth days
Rotation period (equatorial)	25 Earth days
Surface temperature	5,500°C (9,900°F)
Core temperature	15 million °C (27 million °F)

Corona extends outwards into space for millions of kilometres from chromosphere

Irregular layer of atmosphere above photosphere called the chromosphere

Heat and light escape into space at Sun's visible surface called the photosphere

Energy carried by convection cells in convective zone generates magnetic field

Energy travels in form of photons of electromagnetic radiation in radiative zone

Nuclear reactions occur in Sun's core

Light and matter pp.188–89 ▶