**The Sun**
The Sun is our nearest star. It provides the Earth, which orbits at a distance of 150 million kilometres, the right amount of light and heat to support life.

**HOW THE SUN WAS BORN**
The cloud of dust and gas that would become our solar system started to collapse about 4.6 billion years ago. It took about 100,000 years for the protostar to become hot and dense enough for nuclear fusion to begin. It took another 10 million years for the gas giants, like Jupiter, to form and 180 million years for the inner rocky planets to form.

**Core**
The core is the engine room of the Sun. Here, the extreme temperature and pressure is sufficient to sustain nuclear fusion. The Sun converts four million tonnes of hydrogen into helium every second via a process called the proton-proton chain.

1. Two hydrogen nuclei (protons) are forced together. One of the protons detaches as a neutron (via the weak force), emitting a positron and a high-energy neutrino – creating a deuterium nucleus.
2. Another proton fuses with the deuterium nucleus, emitting a high-energy gamma-ray photon – creating a helium-3 nucleus.
3. Finally, two helium-3 nuclei fuse to create a helium-4 nucleus. Two protons are ejected along the way of energy.

**Convection Zone**
The turbulent region carries energy to the Sun's surface in thermal plumes. The material cools at the surface and plunges back to the bottom of the convection zone. It is reheated by the radiation zone where it travels back to the surface once more.

**Radiation Zone**
Energy from the core travels through the radiation zone in the form of electromagnetic radiation (photons). The region is so dense that photons are continually absorbed and re-emitted by atoms. It takes an average 170,000 years for energy to leave it.

**Photosphere**
The photosphere is the visible surface of the Sun. Sunspots are dark, planet-sized regions on the photosphere. They are dark because they are cooler than their surroundings. Sunspots are caused by strong magnetic disturbances. They evolve over several days and may last for months. They are active regions and are associated with solar flares and Coronal Mass Ejections.

**Chromosphere**
In the chromosphere, hydrogen atoms absorb energy from the photosphere and re-emit it in reddish light (chromo means colour). It is here that spectacular and violent events, such as prominences and solar flares occur.

**Corona**
The corona is the Sun's extended atmosphere – larger in volume than the entire Sun. More than 1 million°C. Why the corona is so much hotter than the Sun's surface is one of science's biggest mysteries.

**How prominences and flares form**
1. The Sun rotates faster at its equator than it does near its poles. The difference causes the magnetic field to become distorted.
2. It becomes twisted into loops that break through the surface. In some regions, the loops merge into complex active regions, which can generate explosive solar flares or expel plasma into space in a coronal mass ejections. In some cases, the loops evolve into solar prominences where matter dark material is trapped in loop structures in the solar atmosphere.
STUDYING THE SUN

The Sun emits light across the electromagnetic spectrum. Different wavelengths reveal different features.

- 6,700°C: The photosphere (revealing sunspots)
- 9,700°C: The upper photosphere - emitted by carbon-4
- 49,700°C: The lower chromosphere - emitted by helium-2
- 600,000°C: The corona (revealing sun prominences) - emitted by iron-9
- 1 million°C: Hotter region of the corona and solar flares - emitted by iron-10
- 10 million°C: The hottest material in a solar flare - emitted by iron-20

Each wavelength shows features of the Sun's surface and atmosphere shining at different temperatures.

SOLAR MISSIONS

- SOHO (Solar Dynamics Observatory): NASA's SOHO has been observing the Sun since 1995. It is studying how the Sun's magnetic field is generated and how it is altered during its life cycle. The SOHO spacecraft was launched in 1995.

- STEREO (Solar Terrestrial Relations Observatory): STEREO consists of two nearly identical spacecraft. They were launched by NASA in 2006 to slowly separating orbits around the Sun. This gives them a stereoscopic view of the Sun and of events like solar flares and coronal mass ejections.

- Hinode (Sunrise): Hinode was launched in 2006 to explore the Sun's magnetic fields. This joint Japanese/UK mission uses optical, extreme ultraviolet (EUV), and x-ray instruments to investigate the interaction between the Sun's magnetic fields and coronal mass ejections.

- SOHO (Solar and Heliospheric Observatory): This joint ESA/NASA mission has revolutionized our understanding of solar physics. Launched in 1996, it has twelve instruments that monitor the Sun's internal structure, its outer atmosphere, and the solar wind.

SPACE WEATHER

High-energy solar events, such as Solar Flares and Coronal Mass Ejections (CMEs), can produce magnetic storms on Earth that may damage satellites, disrupt communications, and sometimes produce electric blackouts.

The solar wind is a stream of plasma - electrons, protons, and alpha particles (helium nuclei) - released from the upper atmosphere of the Sun. The solar wind is the Sun's magnetic field. This pressure generally pushes the field outwards, but when it interacts with the Earth's magnetic field, it can produce magnetic storms on Earth.

Coronal Mass Ejections (CMEs) are the most powerful events in the solar system. A single CME can throw more than ten billion tonnes of charged particles into space - covering an area as wide as 150 million miles.

Although the main CMEs may take several days to reach Earth, shockwaves can accelerate some of its particles to close to the speed of light at this speed they can cover the 93 million miles to Earth in as little as 50 minutes.

THE SEASONS

The Earth's axis is tilted at an angle of 23.45°, so as it orbits the Sun through the year, it wobbles from side to side.

- Summer: Sun's rays hit the Earth at a more direct angle - meaning more sunlight can fall on a smaller area than it does during winter.

- Winter: In the summer, the northern hemisphere faces towards the Sun. The Sun's rays hit the Earth at a more direct angle - meaning more sunlight can fall on a smaller area than it does during winter.

ECLIPSES

- Solar eclipse: A solar eclipse occurs when the Moon passes directly between the Sun and the Earth.

- Lunar eclipse: A lunar eclipse occurs when the Moon passes directly behind the Earth into its shadow.

PHASES OF THE MOON

Only one half of the Moon is illuminated by the Sun. During its orbit, different areas of illumination are visible from Earth.

- First quarter: The Moon's illumination begins to increase.
- Waxing crescent: The Moon is partially illuminated, with the illuminated part facing Earth.
- Waxing gibbous: The Moon is almost fully illuminated.
- Full Moon: The entire face of the Moon is illuminated.
- New Moon: The Moon is not illuminated.
- Waning gibbous: The Moon is partially illuminated again, with the illuminated part facing away from Earth.
- Waning crescent: The Moon's illumination begins to decrease.

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