The sun is an ordinary star, one of about 100 billion in our galaxy, the Milky Way. The sun has extremely important influences on our planet: It drives weather, ocean currents, seasons, and climate, and makes plant life possible through photosynthesis. Without the sun’s heat and light, everything that makes life possible on Earth would not exist.

About 4.5 billion years ago, the sun began to take shape from a molecular cloud that was mainly composed of hydrogen and helium. A nearby supernova emitted a shockwave, which came in contact with the molecular cloud and energized it. The molecular cloud began to compress, and some regions of gas collapsed under their own gravitational pull. As one of these regions collapsed, it also began to rotate and heat up from increasing pressure. Much of the hydrogen and helium remained in the center of this hot, rotating mass. Eventually, the gases heated up enough to begin nuclear fusion, and became the sun in our solar system.

Other parts of the molecular cloud cooled into a disc around the brand-new sun and became planets, asteroids, comets, and other bodies in our solar system.

The sun is about 150 million kilometers (93 million miles) from Earth. This distance, called an astronomical unit (AU), is a standard measure of distance for astronomers and astrophysicists.

An AU can be measured at light speed, or the time it takes for a photon of light to travel from the sun to Earth. It takes light on the sun about 8 minutes and 19 seconds to reach Earth.

The radius of the sun, or the distance from the very center to the outer limits, is about 700,000 kilometers (432,000 miles). That distance is about 109 times the size of Earth’s radius. The sun not only has a much larger radius than the Earth—it is also much more massive. The sun’s mass is more than 333,000 times that of the Earth, and contains about 99.8 percent of all of the mass in the entire solar system!

**Composition**
The sun is made up of a blazing combination of gases. These gases are actually in the form of plasma. Plasma is a state of matter similar to gas, but with most of the particles ionized. This means the particles have an increased or reduced number of electrons.

About three quarters of the sun is hydrogen, which is constantly fusing together and creating helium by a process called nuclear fusion. Helium makes up almost the entire remaining quarter. A very small percentage (1.69 percent) of the sun’s mass is made up of other gases and metals: iron, nickel, oxygen, silicon, sulfur, magnesium, carbon, neon, calcium, and chromium. This 1.69 percent may seem insignificant, but its mass is still 5,628 times the mass of Earth.

The sun is not a solid mass. It does not have easily identifiable boundaries like rocky planets such as Earth.
Instead, the sun is composed of layers made up almost entirely of hydrogen and helium. These gases carry out different functions in each layer, and the sun’s layers are measured by their percentage of the sun’s total radius.

The sun is permeated and somewhat controlled by a magnetic field. The magnetic field is produced by a combination of three complex mechanisms: a circular electric current that runs through the sun; layers of the sun that rotate at different speeds; and the sun’s ability to conduct electricity. Near the sun’s equator, magnetic field lines make small loops near the surface. Magnetic field lines that flow through the poles extend much farther, thousands of kilometers, before returning to the opposite pole.

The sun rotates around its own axis, just like Earth. The sun rotates counterclockwise, and takes between 25 and 35 days to complete a single rotation.

The sun orbits clockwise around the center of the Milky Way. Its orbit is between 24,000 and 26,000 light-years away from the galactic center. The sun takes about 225 million to 250 million years to orbit one time around the galactic center.

**Electromagnetic Radiation**

The sun’s energy travels to Earth at the speed of light in the form of electromagnetic radiation (EMR).

The electromagnetic spectrum exists as waves of different frequencies and wavelengths. The frequency of a wave represents how many times the wave repeats itself in a certain unit of time. Waves with very short wavelengths repeat themselves several times in a given unit of time, so they are high-frequency. In contrast, low-frequency waves have much longer wavelengths.

The vast majority of electromagnetic waves that come from the sun are invisible to us. The most high-frequency waves emitted by the sun are gamma rays, X-rays, and ultraviolet radiation (UV rays). The most harmful UV rays are almost completely absorbed by Earth’s atmosphere. Less potent UV rays travel through the atmosphere, and can cause sunburn.

The sun also emits infrared radiation, whose waves are much lower-frequency. Most heat from the sun arrives as infrared energy.

Sandwiched between infrared and UV is the visible spectrum, which contains all the colors we see on Earth. The color red has the longest wavelengths (closest to infrared), and violet (closest to UV) the shortest.

The sun itself is white, which means it contains all of the colors in the visible spectrum. The sun appears orangish yellow because the blue light it emits has a shorter wavelength, and is scattered in the atmosphere—the same process that makes the sky appear blue.

Astronomers, however, call the sun a “yellow dwarf” star because its colors fall within the yellow-green section of the electromagnetic spectrum.

**Evolution of the Sun**

The sun, although it has sustained all life on our planet, will not shine forever. The sun has already existed for about 4.5 billion years.

The process of nuclear fusion, which creates the heat and light that make life on our planet possible, is also the process that slowly changes the sun’s composition. Through nuclear fusion, the sun is constantly using up the hydrogen in its core: Every second, the sun fuses around 620 million metric tons of hydrogen into helium.

At this stage in the sun’s life, its core is about 74% hydrogen. Over the next 5 billion years, the sun will burn through most of its hydrogen, and helium will become its major source of fuel.
Over those 5 billion years, the sun will go from “yellow dwarf” to “red giant.” When almost all of the hydrogen in the sun’s core has been consumed, the core will contract and heat up, increasing the amount of nuclear fusion that takes place. The outer layers of the sun will expand from this extra energy.

The sun will expand to about 200 times its current radius, swallowing Mercury and Venus. Astrophysicists debate whether Earth’s orbit would expand beyond the sun’s reach, or if our planet would be engulfed by the sun as well.

As the sun expands, it will spread its energy over a larger surface area, which has an overall cooling effect on the star. This cooling will shift the sun’s visible light to a reddish color—a red giant.

Eventually, the sun’s core reaches a temperature of about 100 million on the Kelvin scale, the common scientific scale for measuring temperature. When it reaches this temperature, helium will begin fusing to create carbon, a much heavier element. This will cause intense solar wind and other solar activity, which will eventually throw off the entire outer layers of the sun. The red giant phase will be over. Only the sun’s carbon core will be left, and as a “white dwarf,” it will not create or emit energy.

Sun’s Structure

The sun is made up of six layers: core; radiative zone; convective zone; photosphere; chromosphere; and corona.

Core

The sun’s core, more than a thousand times the size of Earth and more than 10 times denser than lead, is a huge furnace. Temperatures in the core exceed 15.7 million Kelvin (also 15.7 million degrees Celsius, or 28 million degrees Fahrenheit). The core extends to about 25% of the sun’s radius.

The core is the only place where nuclear fusion reactions can happen. The sun’s other layers are heated from the nuclear energy created there. Protons of hydrogen atoms violently collide and fuse, or join together, to create a helium atom.

This process, known as a PP (proton-proton) chain reaction, emits an enormous amount of energy. The energy released during one second of solar fusion is far greater than that released in the explosion of hundreds of thousands of hydrogen bombs.

During nuclear fusion in the core, two types of energy are released: photons and neutrinos. These particles carry and emit the light, heat, and energy of the sun. Photons are the smallest particle of light and other forms of electromagnetic radiation. Neutrinos are more difficult to detect, and only account for about 2% of the sun’s total energy. The sun emits both photons and neutrinos in all directions, all the time.

Radiative Zone

The radiative zone of the sun starts at about 25% of the radius, and extends to about 70% of the radius. In this broad zone, heat from the core cools dramatically, from between 7 million to 2 million K.

In the radiative zone, energy is transferred by a process called thermal radiation. During this process, photons that were released in the core travel a short distance, are absorbed by a close-by ion, released by that ion, and absorbed again by another. One photon can continue this process for almost 200,000 years!

A neutrino’s trip through the radiative zone and the rest of the sun’s layers is much quicker: In about 2.3 seconds, neutrinos pass through more than 643,738 kilometers (400,000 miles) of the sun’s layers. Neutrinos aimed at Earth easily pass through Earth’s atmosphere, water, land, ice, animals, plants, and humans.
This is possible because neutrinos do not carry an electric charge. They do not interact with most particles that they come in contact with.

Transition Zone: Tachocline
Between the radiative zone and the next layer, the convective zone, there is a transition zone called the tachocline. This region is created as a result of the sun’s differential rotation.

Differential rotation happens when different parts of an object rotate at different velocities. The sun is made up of gases undergoing different processes at different layers and different latitudes. The sun’s equator rotates much faster than its poles, for instance.

The rotation rate of the sun changes rapidly in the tachocline.

Convective Zone
At around 70% of the sun’s radius, the convective zone begins. In this zone, the sun’s temperature is not hot enough to transfer energy by thermal radiation. Instead, it transfers heat by thermal convection through thermal columns.

Similar to water boiling in a pot, or hot wax in a lava lamp, gases deep in the sun's convective zone are heated and “boil” outward, away from the sun’s core, through thermal columns. When the gases reach the outer limits of the convective zone, they cool down, and plunge back to the base of the convective zone, to be heated again.

Photosphere
The photosphere is the bright yellow, visible "surface" of the sun. The photosphere is about 400 kilometers (250 miles) thick, and temperatures there reach about 6,000 K (5,700° C, 10,300° F).

The thermal columns of the convection zone are visible in the photosphere, bubbling like boiling oatmeal. Through powerful telescopes, the tops of the columns appear as granules crowded across the sun. Each granule has a bright center, which is the hot gas rising through a thermal column. The granules’ dark edges are the cool gas descending back down the column to the bottom of the convective zone.

Although the tops of the thermal columns look like small granules, they are usually more than 1,000 kilometers (621 miles) across. Most thermal columns exist for about 8 to 20 minutes before they dissolve and form new columns. There are also “supergranules” that can be up to 30,000 kilometers (18,641 miles) across, and last for up to 24 hours.

The sun is constantly covered by about 4,000 granules.

Sunspots, solar flares, and solar prominences take form in the photosphere, although they are the result of processes and disruptions in other layers of the sun.

Photosphere: Sunspots
A sunspot is just what it sounds like—a dark spot on the sun. A sunspot forms when intense magnetic activity in the convective zone ruptures a thermal column.

At the top of the ruptured column (visible in the photosphere), temperature is temporarily decreased because hot gases are not reaching it. This cooler temperature (still 6,000 K, or 2,727° C, or 4,940° F) causes the top of the column to appear much darker than the surrounding area.

Photosphere: Solar Flares
The process of creating sunspots opens a connection between the corona (the very outer layer of the sun) and the sun’s interior. Solar matter surges out of this opening in formations called solar flares. These explosions are
massive: In the period of a few minutes, solar flares release the equivalent of about 160 billion megatons of TNT, or about a sixth of the total energy the sun releases in one second.

Clouds of ions, atoms, and electrons erupt from solar flares, and reach Earth in about two days. Solar flares and solar prominences contribute to space weather, which can cause disturbances to Earth’s atmosphere and magnetic field, as well as disrupt satellite and telecommunications systems.

*Photosphere: Coronal Mass Ejections*
Coronal mass ejections (CMEs) are another type of solar activity caused by the constant movement and disturbances within the sun’s magnetic field. Eruptions from CMEs travel from 20 to 3,200 kilometers (12 to 2,000 miles) per second.

Although CMEs typically form near the active regions of sunspots, the correlation between the two has not been proven. The cause of CMEs is still being studied, and it is hypothesized that disruptions in either the photosphere or corona lead to these violent solar explosions.

*Photosphere: Solar Prominence*
Solar prominences are bright loops of solar matter. They can burst far into the coronal layer of the sun, expanding hundreds of kilometers per second. These curved and twisted features can reach hundreds of thousands of kilometers in height and width, and last anywhere from a few days to a few months.

Solar prominences are cooler than the corona, and they appear as darker strands against the sun. For this reason, they are also known as filaments.

*Photosphere: Solar Cycle*
The sun does not constantly emit sunspots and solar ejecta; it goes through a cycle of about 11 years. During this solar cycle, the frequency of solar flares changes. During solar maximums, there can be several flares per day. During solar minimums, there may be fewer than one a week.

The solar cycle is defined by the sun’s magnetic fields, which loop around the sun and connect at the two poles. Every 11 years, the magnetic fields reverse, causing a disruption that leads to solar activity and sunspots.

The solar cycle can have effects on Earth’s climate. For example, the sun’s ultraviolet light splits oxygen in the stratosphere and strengthens Earth’s protective ozone layer. During the solar minimum, there are low amounts of UV rays, which means that Earth’s ozone layer is temporarily thinned. This allows more UV rays to enter and heat the Earth’s atmosphere.

*Solar Atmosphere*
The solar atmosphere is the hottest region of the sun. It is made up of the chromosphere, the corona, and a transition zone called the solar transition region that connects the two.

The solar atmosphere is obscured by the bright light emitted by the photosphere, and it can rarely be seen without special instruments. Only during solar eclipses, when the moon moves between the Earth and the sun and hides the photosphere, can these layers be seen with the unaided eye.

*Chromosphere*
The pinkish-red chromosphere is about 2,000 kilometers (1,250 miles) thick and riddled with jets of hot gas.

At the bottom of the chromosphere, where it meets the photosphere, the sun is at its coolest, at about 4,400 K (4,100° C, 7,500° F). This low temperature gives the chromosphere its pink color. The temperature in the chromosphere increases with altitude, and reaches 25,000 K (25,000° C, 45,000° F) at the outer edge of the
The chromosphere gives off jets of burning gases called spicules, similar to solar flares. These fiery wisps of gas reach out from the chromosphere like long, flaming fingers; they are usually about 500 kilometers (310 miles) in diameter, and move outward from the sun at about 20 kilometers (12 miles) per second. Spicules only last for about 15 minutes, but can reach thousands of kilometers in height before collapsing and dissolving.

**Solar Transition Region**
The solar transition region (STR) separates the chromosphere from the corona.

Below the STR, the layers of the sun are controlled and stay separate because of gravity, gas pressure, and the different processes of exchanging energy. Above the STR, the motion and shape of the layers are much more dynamic. They are dominated by magnetic forces. These magnetic forces can put into action solar events such as coronal loops and the solar wind.

The state of helium in these two regions has differences as well. Below the STR, helium is partially ionized. This means it still has one electron. Around the STR, helium absorbs a bit more heat and loses its last electron. Its temperature soars to almost 1 million K (1 million° C, 1.8 million° F).

**Corona**
The corona is the wispy outermost layer of the solar atmosphere, and can extend millions of kilometers into space. Gases in the corona burn at about 1 million K (1 million° C, 1.8 million° F), and move about 145 kilometers (90 miles) per second.

Some of the particles reach an escape velocity of 400 kilometers per second (249 miles per second). They escape the sun’s gravitational pull and become the solar wind. The solar wind blasts from the sun to the edge of the solar system.

Other particles form coronal loops. Coronal loops are bursts of particles that curve back around to a nearby sunspot.

Near the sun’s poles are coronal holes. These areas are colder and darker than other regions of the sun, and allow some of the fastest-moving parts of the solar wind to pass through.

Electromagnetic radiation that escapes from the corona is classified into three types: K-corona, F-corona, and E-corona.

The light from the K-corona comes from sunlight scattering free electrons. Light from the F-corona is caused by sunlight bouncing off of cosmic dust particles. Light from the E-corona results from changes in the quantity of photons in an otherwise uniform area. The E-corona supplies information about the corona’s composition.

**Solar Wind**
The solar wind is a stream of extremely hot, charged particles that are thrown out from the upper atmosphere of the sun. Enormous amounts of material are released from the sun: about 4-6 billion metric tons every hour. This means that every 150 million years, the sun loses a mass equal to that of the Earth. However, even at this rate of loss, the sun has only lost about 0.01% of its total mass from solar wind.

The solar wind blows in all directions, at about 1 million kph (620,000 mph). It continues moving at that speed for about 10 billion kilometers (6 billion miles).

Some of the particles in the solar wind slip through Earth’s magnetic field and into its upper atmosphere near the
poles. As they collide with atmosphere, these charged particles set the atmosphere aglow with color, creating auroras, colorful light displays known as the Northern and Southern Lights. Solar winds can also cause solar storms. These storms can interfere with satellites and knock out power grids on Earth.

The solar wind fills the heliosphere, the massive bubble of charged particles that encompasses the solar system.

The solar wind eventually slows down near the border of the heliosphere, at a theoretical boundary called the heliopause. This boundary separates the matter and energy of our solar system from the matter in neighboring star systems and the interstellar medium.

The interstellar medium is the space between star systems. The solar wind, having traveled billions of kilometers, cannot extend beyond the interstellar medium.

**Studying the Sun**

The sun has not always been a subject of scientific discovery and inquiry. For thousands of years, the sun was known in cultures all over the world as a god, a goddess, and a symbol of life.

To the ancient Aztecs, the sun was a powerful deity known as Tonatiuh, who required human sacrifice to travel across the sky. In Baltic mythology, the sun was a goddess named Saule, who brought fertility and health. Chinese mythology held that the sun is the only remaining of 10 sun gods.

In 150 CE, Greek scholar Claudius Ptolemy created a geocentric model of the solar system in which the moon, planets, and sun revolved around the Earth. This was the model for almost 1,200 years, reaching people in Western Europe, North Africa, and the Middle East.

It was not until the 16th century that Polish astronomer Nicolaus Copernicus used mathematical and scientific reasoning to prove that planets rotated around the sun. This heliocentric model is the one we use today.

In the 17th century, the telescope allowed people to examine the sun in detail. The sun is much too bright to allow us to study it with our eyes unprotected. With a telescope, it was possible for the first time to project a clear image of the sun onto a screen for examination.

English scientist Sir Isaac Newton used a telescope and prism to scatter the light of the sun, and proved that sunlight was actually made of a spectrum of colors.

In 1800, infrared and ultraviolet light were discovered to exist just outside of the visible spectrum. An optical instrument called a spectroscope made it possible to separate visible light and other electromagnetic radiation into its various wavelengths. Spectroscopy also helped scientists identify gases in the sun's atmosphere—each element has its own wavelength pattern.

However, the method by which the sun generated its energy remained a mystery. Many scientists hypothesized that the sun was contracting, and emitting heat from that process.

In 1868, English astronomer Joseph Norman Lockyer was studying the sun's electromagnetic spectrum. He observed bright lines in the photosphere that did not have a wavelength of any known element on Earth. He guessed that there was an element isolated on the sun, and named it helium after the Greek sun god, Helios.

Lockyer’s discovery revolutionized solar science. Over the next 30 years, astronomers concluded that the sun had a hot, pressurized core that was capable of producing massive amounts of energy through nuclear fusion.

Technology continued to improve and allowed scientists to uncover new features of the sun. Infrared telescopes...
were invented in the 1960s, and scientists observed energy outside of the visible spectrum. Twentieth-century astronomers used balloons and rockets to send specialized telescopes high above the Earth, and examined the sun without any interference from the Earth’s atmosphere.

_Solrad 1_ was the first spacecraft designed to study the sun, and was launched by the United States in 1960. That decade, NASA sent five _Pioneer_ satellites to orbit the sun and collect information about the star.

In 1980, NASA launched a mission during the solar maximum to gather information about the high-frequency gamma rays, UV rays, and X-rays that are emitted during solar flares.

The Solar and Heliospheric Observatory (SOHO) was developed in Europe and put into orbit in 1996 to collect information. SOHO has been successfully collecting data and forecasting space weather for 12 years.

_Voyager 1_ and _2_ are spacecraft traveling to the edge of the heliosphere to discover what the atmosphere is made of where solar wind meets the interstellar medium. Both spacecraft are scheduled to reach this boundary in 2014!

Another development in the study of the sun is helioseismology, the study of solar waves. The turbulence of the convective zone is hypothesized to contribute to solar waves that continuously transmit solar material to the outer layers of the sun. By studying these waves, scientists understand more about the sun’s interior and the cause of solar activity.

**Energy from the Sun**

_Photosynthesis_

Sunlight provides necessary light and energy to plants and other producers in the food web. These producers absorb the sun’s radiation and convert it into energy through a process called photosynthesis.

Producers are mostly plants (on land) and algae (in aquatic regions). They are the foundation of the food web, and their energy and nutrients are passed on to every other living organism.

_Fossil Fuels_

Photosynthesis is also responsible for all of the fossil fuels on Earth. Scientists estimate that about 3,000 million years ago, the first producers evolved in aquatic settings. Sunlight allowed plant life to thrive and adapt. After the plants died, they decomposed and shifted deeper into the Earth, sometimes thousands of meters. This process continued for millions of years.

Under intense pressure and high temperatures, these remains became what we know as fossil fuels. These microorganisms became petroleum, natural gas, and coal.

People have developed processes for extracting these fossil fuels and using them for energy. However, fossil fuels are a nonrenewable resource. They take millions of years to form.

**Solar Energy Technology**

Solar energy technology harnesses the sun’s radiation and converts it into heat, light, or electricity.

Solar energy is a renewable resource, and many technologies can harvest it directly for use in homes, businesses, schools, and hospitals. Some solar energy technologies include solar voltaic cells and panels, solar thermal collectors, solar thermal electricity, and solar architecture.

Photovoltaics use the sun’s energy to speed up electrons in solar cells and generate electricity. This form of technology has been used widely, and can provide electricity for rural areas, large power stations, buildings, and
smaller devices such as parking meters and trash compactors.

The sun’s energy can also be harnessed by a method called “concentrated solar power,” in which the sun’s rays are reflected and magnified by mirrors and lenses. The intensified ray of sunlight heats a fluid, which creates steam and powers an electric generator.

Solar power can also be collected and distributed without machinery or electronics. For example, roofs can be covered with vegetation or painted white to decrease the amount of heat absorbed into the building, thereby decreasing the amount of electricity needed for air conditioning. This is solar architecture.

Sunlight is abundant: In one hour, the Earth’s atmosphere receives enough sunlight to power the electricity needs of all people for a year. However, solar technology is expensive, and depends on sunny and cloudless local weather to be effective. Methods of harnessing the sun’s energy are still being developed and improved.

VOCABULARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Part of Speech</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>astronomer</td>
<td>noun</td>
<td>person who studies space and the universe beyond Earth's atmosphere.</td>
</tr>
<tr>
<td>astronomical unit</td>
<td>noun</td>
<td>(AU) (150 million kilometers/93 million miles) unit of distance equal to</td>
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<tr>
<td></td>
<td></td>
<td>the average distance between the Earth and the sun.</td>
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<tr>
<td>aurora</td>
<td>noun</td>
<td>brightly colored bands of light, visible around Earth’s geomagnetic</td>
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<td></td>
<td></td>
<td>poles, caused by solar wind interacting with particles in Earth's</td>
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<td></td>
<td></td>
<td>magnetic field.</td>
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<tr>
<td>chromosphere</td>
<td>noun</td>
<td>transparent layer of gas surrounding the photosphere (visible disc) of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a star.</td>
</tr>
<tr>
<td>climate</td>
<td>noun</td>
<td>all weather conditions for a given location over a period of time.</td>
</tr>
<tr>
<td>compress</td>
<td>verb</td>
<td>to press together in a small space.</td>
</tr>
<tr>
<td>convection</td>
<td>noun</td>
<td>transfer of heat by the movement of the heated parts of a liquid or gas.</td>
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<tr>
<td>core</td>
<td>noun</td>
<td>the extremely hot center of Earth, another planet, or a star.</td>
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<tr>
<td>corona</td>
<td>noun</td>
<td>outermost part of the sun or another star's atmosphere.</td>
</tr>
<tr>
<td>coronal mass ejection</td>
<td>noun</td>
<td>huge burst of solar wind and other charged particles.</td>
</tr>
<tr>
<td>dense</td>
<td>adjective</td>
<td>having parts or molecules that are packed closely together.</td>
</tr>
<tr>
<td>differential rotation</td>
<td>noun</td>
<td>pattern where different parts of an object rotate at different speeds or</td>
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<tr>
<td></td>
<td></td>
<td>velocities.</td>
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<tr>
<td>dust</td>
<td>noun</td>
<td>microscopic particles of rocks or minerals drifting in space. Also called</td>
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<tr>
<td></td>
<td></td>
<td>cosmic dust or space dust.</td>
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<tr>
<td>electricity</td>
<td>noun</td>
<td>set of physical phenomena associated with the presence and flow of</td>
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<td></td>
<td></td>
<td>electric charge.</td>
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<tr>
<td>electromagnetic spectrum</td>
<td>noun</td>
<td>continuous band of all kinds of radiation (heat and light).</td>
</tr>
<tr>
<td>Equator</td>
<td>noun</td>
<td>imaginary line around the Earth, another planet, or star running east-</td>
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<tr>
<td></td>
<td></td>
<td>west, 0 degrees latitude.</td>
</tr>
<tr>
<td>escape velocity</td>
<td>noun</td>
<td>speed and force that an object must have to escape the gravity of a</td>
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<tr>
<td></td>
<td></td>
<td>larger body, instead of orbiting around it.</td>
</tr>
<tr>
<td><strong>food web</strong></td>
<td>noun</td>
<td>all related food chains in an ecosystem. Also called a food cycle.</td>
</tr>
<tr>
<td><strong>fossil fuel</strong></td>
<td>noun</td>
<td>coal, oil, or natural gas. Fossil fuels formed from the remains of ancient plants and animals.</td>
</tr>
<tr>
<td><strong>frequency</strong></td>
<td>noun</td>
<td>number of waves made in a specific area over specific time period.</td>
</tr>
<tr>
<td><strong>galaxy</strong></td>
<td>noun</td>
<td>collection of stars, planets, gases, and other celestial bodies bound together by gravity.</td>
</tr>
<tr>
<td><strong>generator</strong></td>
<td>noun</td>
<td>machine that converts one type of energy to another, such as mechanical energy to electricity.</td>
</tr>
<tr>
<td><strong>granule</strong></td>
<td>noun</td>
<td>top of a convective cell on the sun's photosphere, where hot gases rise and quickly dissipate.</td>
</tr>
<tr>
<td><strong>gravitational pull</strong></td>
<td>noun</td>
<td>the physical attraction between two objects.</td>
</tr>
<tr>
<td><strong>heliopause</strong></td>
<td>noun</td>
<td>outer boundary of the solar system, where the solar wind is stopped by the interstellar medium.</td>
</tr>
<tr>
<td><strong>helioseismology</strong></td>
<td>noun</td>
<td>study of the sun's interior by analysis of the (mostly acoustic) waves it emits.</td>
</tr>
<tr>
<td><strong>infrared radiation</strong></td>
<td>noun</td>
<td>part of the electromagnetic spectrum with wavelengths longer than visible light but shorter than microwaves.</td>
</tr>
<tr>
<td><strong>interstellar medium</strong></td>
<td>noun</td>
<td>material in the space between star systems, mostly hydrogen plasma and cosmic dust.</td>
</tr>
<tr>
<td><strong>ionize</strong></td>
<td>verb</td>
<td>to add or remove an electron to an atom or group of atoms, giving them an electric charge.</td>
</tr>
<tr>
<td><strong>Isaac Newton</strong></td>
<td>noun</td>
<td>(1642-1727) English physicist, mathematician, and philosopher.</td>
</tr>
<tr>
<td><strong>Kelvin scale</strong></td>
<td>noun</td>
<td>scale for measuring temperature where zero Kelvin is absolute zero, the absence of all energy.</td>
</tr>
<tr>
<td><strong>magnetic field</strong></td>
<td>noun</td>
<td>area around and affected by a magnet or charged particle.</td>
</tr>
<tr>
<td><strong>molecular cloud</strong></td>
<td>noun</td>
<td>region of gas, plasma, and cosmic dust where molecules (usually molecular hydrogen) form.</td>
</tr>
<tr>
<td><strong>neutrino</strong></td>
<td>noun</td>
<td>subatomic particle that carries no electrical charge and interacts weakly with all other matter.</td>
</tr>
<tr>
<td><strong>nonrenewable resource</strong></td>
<td>noun</td>
<td>natural resource that exists in a limited supply.</td>
</tr>
<tr>
<td><strong>nuclear fusion</strong></td>
<td>noun</td>
<td>process where the nuclei of one element, usually hydrogen, fuse with each other to form the nuclei of another element, usually helium.</td>
</tr>
<tr>
<td><strong>nutrient</strong></td>
<td>noun</td>
<td>substance an organism needs for energy, growth, and life.</td>
</tr>
<tr>
<td><strong>orbit</strong></td>
<td>noun</td>
<td>path of one object around a more massive object.</td>
</tr>
<tr>
<td><strong>ozone layer</strong></td>
<td>noun</td>
<td>layer in the atmosphere containing the gas ozone, which absorbs most of the sun's ultraviolet radiation.</td>
</tr>
<tr>
<td><strong>photon</strong></td>
<td>noun</td>
<td>smallest unit of light, or electromagnetic radiation.</td>
</tr>
<tr>
<td><strong>photosphere</strong></td>
<td>noun</td>
<td>lowest visible layer of a star and the boundary from which the star's diameter is measured.</td>
</tr>
</tbody>
</table>
photosynthesis  
**noun**

process by which plants turn water, sunlight, and carbon dioxide into water, oxygen, and simple sugars.

photovoltaic  
**adjective**

able to convert solar radiation to electrical energy.

plasma  
**noun**

state of matter with no fixed shape and molecules separated into ions and electrons.

power grid  
**noun**

network of cables or other devices through which electricity is delivered to consumers. Also called an electrical grid.

radiative zone  
**noun**

area of a star's interior where energy is transferred through thermal radiation.

radius  
**noun**

ray extending from the center of a circle or sphere to its surface or circumference.

red giant  
**noun**

"main sequence" star with huge surface area, low surface temperature, and reddish color.

renewable resource  
**noun**

resource that can replenish itself at a similar rate to its use by people.

rotate  
**verb**

to turn around a center point or axis.

rupture  
**verb**

to break or tear.

satellite  
**noun**

object that orbits around something else. Satellites can be natural, like moons, or made by people.

solar architecture  
**noun**

the planning and design of buildings to make the most use of the sun's heat and light.

solar cycle  
**noun**

fairly predictable changes in solar activity (such as sunspots and solar flares) over an 11-year period.

solar eclipse  
**noun**

event when the sun is blocked by the moon passing between it and the Earth.

solar energy  
**noun**

radiation from the sun.

solar flare  
**noun**

explosion in the sun's atmosphere, which releases a burst of energy and charged particles into the solar system.

solar prominence  
**noun**

huge eruption of cool gases from the surface of the sun, often shaped like a giant loop.

solar storm  
**noun**

sudden change in the Earth's magnetosphere, caused by the solar wind interacting with the Earth's magnetic field. Also called a geomagnetic storm.

solar system  
**noun**

the sun and the planets, asteroids, comets, and other bodies that orbit around it.

solar wind  
**noun**

flow of charged particles, mainly protons and electrons, from the sun to the edge of the solar system.

space weather  
**noun**

changes in the environment outside the Earth's atmosphere, usually influenced by the sun.

spectroscopy  
**noun**

science of the measurement of light that is reflected, absorbed, or emitted by different materials.

spicule  
**noun**

thin, dynamic jet of solar material ejected from the chromosphere (upper atmosphere) of the sun.

star  
**noun**

large ball of gas and plasma that radiates energy through nuclear fusion, such as the sun.
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>sunspot</td>
<td>noun, dark, cooler area on the surface of the sun that can move, change, and disappear over time.</td>
</tr>
<tr>
<td>supernova</td>
<td>noun, sudden, violent explosion of a massive star.</td>
</tr>
<tr>
<td>tachocline</td>
<td>noun, transition zone in the sun, between inner, radiative zone and the outer, convective zone.</td>
</tr>
<tr>
<td>transition zone</td>
<td>noun, area between two natural or artificial regions.</td>
</tr>
<tr>
<td>ultraviolet radiation</td>
<td>noun, powerful light waves that are too short for humans to see, but can penetrate Earth's atmosphere. Ultraviolet is often shortened to UV.</td>
</tr>
<tr>
<td>wavelength</td>
<td>noun, the distance between the crests of two waves.</td>
</tr>
<tr>
<td>white dwarf</td>
<td>noun, small, dense &quot;main sequence&quot; star that has used up most of its nuclear fuel.</td>
</tr>
</tbody>
</table>

FOR FURTHER EXPLORATION

Articles & Profiles
- National Geographic News: Sun is Roundest Natural Object Known

Images
- National Geographic Science: Sun Photos

Video
- National Geographic Video: Sun 101

Websites
- NASA: Solar System Exploration—Sun
- NASA: Solar and Heliospheric Observatory (SOHO)
- NASA: Heliophysics