

Camp Eberhart Astronomy Program

AstroCamp Solar System Award

The Sun

The Sun is different than any of the other bodies in the Solar System. For one thing, it's **HUGE!** For another, the Sun is a star with planets in orbit around it. Since the Latin word for a sun was *sol*, anything that has to do with the *sol* is said to be *solar* in nature. The term *solar system* means those things in the orbital system of a *sol*. In our case that is the Sun and its planets.

The Sun is the star at the center of the Solar System. It formed about 4.6 billion years ago from a huge cloud of gas and dust. The Sun is an average sized, yellow, middle aged star.

This means that the Sun is an 864,000 mile (1.4 million km) diameter glowing ball of very hot gases with a family of planets swirling around it. The Sun rotates (spins) on its axis once every 25 1/3 days, much longer than it takes the tiny Earth, where only 24 hours are required to spin its 7900 mi (12,600km) diameter once around the cycle of day & night.

Looking at the Sun in the sky it seems pretty small in comparison with Klinger Hall, let alone the fact that 109 Earths could fit side by side across it! The reason that it seems so small is because it is really very far away, about 93 million miles (150 million km). A beam of light travelling at 186,000 miles per second (300,000 km/sec) takes over 8 minutes to reach Earth from the Sun. Hey, that is what is called the **speed of light**. At that speed it would take us 4 years and 3 months to reach the next closest star.

The nuclear furnace in the **core**, or center, of the Sun is what creates the heat and the light from the Sun. This heat radiates from the core through the less dense and transparent **radiative zone**. As the gases cool further from the core they become denser and the heat transfer changes from radiation to convection in the opaque **convection zone**. Once through the convection zone it's on to the Sun's surface, the **photosphere**. The Sun's inner atmosphere is called the **chromosphere** outer atmosphere is called the **corona**.

Think of it this way. The photosphere is churning and boiling like a thick pot of chili or oatmeal. Heat deep inside the Sun rises from the transparent radiative zone through the convective zone until it bubbles at the visible surface, the photosphere. At the photosphere, things cool down a bit and the gas begins to sink back down through the convective zone. When the gases reach the radiative zone, things heat up and the whole process starts all over again. If the photosphere is the boiling chili then the chromosphere is the steam right over the top of the pot and the corona is the splatter ring of tomato sauce on the stove.

The Colors of Sunrise and Sunset

The color of the sky here on Earth depends on how sunlight passes through the atmosphere. Ordinary "white" light is really a mixture of all the colors of the spectrum or rainbow: Red, orange, yellow, green, blue, indigo and violet. Just remember ROY G. BIV. We can roughly divide these colors into red and blue. Air molecules in the atmosphere (careful, they are everywhere!) scatter blue light but not red so the sky looks blue and the Sun appears yellow. As the Sun sets, its light must pass through more and more atmosphere, scattering more and more blue until the Sun appears red.

Seasons

Repeat after me: The seasons are NOT caused by any change in the distance of the Earth from the Sun!

The Earth's distance varies by less than 3% during the year. Ironically, the Sun is closer to the Earth during our winter than during the summer. So what does cause the seasons?

Every planet's rotation axis is tilted relative to its orbit. The Earth's is tilted by $23\frac{1}{2}^{\circ}$ while Mercury is 0° , Jupiter 8° , Mars 25° , Uranus 98° (on its side!) and Venus by 177° (almost upside down!). The seasons are determined simply by which hemisphere of the Earth is tipped toward or away from the Sun and receives more or less direct (and more or less concentrated) sunlight. We experience winter when Earth's northern hemisphere is tipped away from the Sun and we get less direct light & heat. When the northern hemisphere is tipped toward the Sun, we experience summer. Note that the southern hemisphere has the opposite seasons as we do at Camp Eberhart. Yes, it is winter in Australia right now and they celebrate the Christmas, Hanukkah and New Year holidays during their summer!

Solar Eclipse

When the Moon's orbit takes it on a path directly between the Sun and the Earth, part of the light from the Sun is blocked, or eclipsed, from hitting the Earth and a shadow falls on the Earth.

The Planets of the Solar System

1. **Mercury:** The closest and fastest moving planet to the Sun is small and ash gray colored. Just like the Earth's moon, it is covered with craters and only slightly larger. It has a large core of iron nickel metal with a thin covering of rock. Temperatures can range from 870°F (465°C) at noon to -300°F (-185°C) at night. A solar day on Mercury is twice and the sidereal (by the stars) day is three times longer than its year of 88 days! Water ice has even been discovered at the bottom of polar craters that never see sunlight! Mercury has no moons.
2. **Venus:** Considered to be Earth's sister planet because of its similar size and mass and because it is the planet that comes closest to us. However, they are also very different. The temperature everywhere on the surface is almost 900°F (482°C), hot enough to melt lead and hotter than Mercury, results from a runaway greenhouse effect from its thick atmosphere of carbon dioxide

which traps the heat of the Sun on the planet's surface, much the same way a lid on a cup of hot chocolate keeps the heat in the cup. Atmospheric pressure at the surface is 90x that of the Earth. It is known as the Morning or Evening Star due to its brilliant white color that comes from its thick atmosphere. Venus is the next brightest object in the sky after the Sun and Moon. It has no moons.

3. **Earth:** Home to the only known life in the Solar System, this planet is 70% covered by water. Only 3% of this water is fresh and 97% is salty. The highest point is 29,035 feet (8850m) (over 5 miles) is Mount Everest on the border of Nepal and China. It has one moon call Moon that orbits the third rock from the Sun where the average temperature is 46°F (8°C).
4. **Mars:** An easy planet to spot because of its reddish color due to an abundance of iron oxide (rust) on the surface. Known as the Red Planet, Mars is similar to Earth because it spins on its axis in 24 hours and 37 minutes, just more than an Earth day. It also has a axial tilt of 25.5°, similar to Earths 23.5°. It has two moons, Phobos (fear) & Deimos (terror). It has the tallest mountain in the Solar System, Olympus Mons, which is 3 times taller than Mt. Everest on Earth.
5. **Jupiter:** Over 65 known moons orbit the largest planet in the Solar System! You can see the 4 largest ones with the telescopes at AstroCamp. They are known as the Galilean Moons because Galileo discovered them on 1609. Their names are Io, Europa, Ganymede and Callisto. Two parallel bands and a big reddish spot can also be seen with a telescope. The Great Red Spot is a 300 year old storm in the atmosphere that is over twice the size of Earth! Jupiter has a thin ring and is so large that 11 Earths would be needed to span its diameter. Its atmosphere is similar in composition to the Sun's, hydrogen (86%) and helium (14%). Deep down, pressure causes the hydrogen gas to become a liquid and eventually a solid. In the center is a small rocky core.
6. **Saturn:** Oh, those majestic rings! Although Jupiter, Uranus and Neptune also have rings, Saturn's are the biggest and brightest by far. They are 170,000 miles (273,600 km) across but only a few yards (meters) thick and are made of ice and rock ranging in size from the size of a house down to dust. Saturn is a ball of hydrogen & helium that, on average, is less dense than water so that it would float in a large enough bathtub, if you could find one. There are 62 known natural satellites orbiting the second largest planet (9.5 Earth diameters across).
7. **Uranus:** The seventh planet from the Sun, it orbits at a distance of 1.8 billion miles (2.9 billion km), more than 19 times farther than Earth. It is the 3rd largest planet at 4 Earth diameters. Its atmosphere is hydrogen and helium with 2% methane. Methane is what gives Uranus its pale blue-green color. It has 11 dark, narrow rings that encircle it and has 27 known satellites. The largest are called Ariel, Umbriel, Titania, Oberon and Miranda. Because of its large amount of frozen ammonia, methane and water ices, it is known as an Ice Giant planet.
8. **Neptune:** Slightly smaller than Uranus, it is encircled by a collection of 6 dark, narrow rings. Some of the rings are incomplete, forming partial ring arcs. The atmosphere is hydrogen, helium & methane giving it a bluish color. Neptune once had a dark spot similar to Jupiter's Great Red Spot and has 13 satellites the largest of which are called Triton & Nereid. Because of its large amount of frozen ammonia, methane and water ices, it is known as an Ice Giant planet.

Dwarf Planets

Dwarf planets are a new class of objects orbiting the Sun that are round but share their orbit with other objects. They are thought to be leftover material from the formation of the Solar System that did not form planets. The following is a partial list that will surely grow in the future.

1. **Ceres**: The first asteroid was discovered by accident in 1801, it is 300mi (483 km) in diameter (1/7 diameter of Moon) and 2.8 times farther from the Sun as the Earth.
2. **Pluto**: Discovered in 1930 by American astronomer Clyde Tombaugh at Lowell Observatory and originally thought to be larger than the Earth, is actually only 1,400 mi (2300 km) diameter which is only 2/3 the size of the Moon. It orbits the Sun in 247 years ranging from 29x to 50x farther from the Sun as Earth. However, it has 5 moons, Charon, Styx, Nix, Hydra and Kerberos. It has a thin atmosphere possibly made of methane and nitrogen.
3. **Haumea** (How-MAY-a): Discovered in 2004, it is 1/3 the size of the Moon, takes 283 years to orbit and is, on average 43x farther from the Sun as Earth.
4. **Makemake**(Mahk-ee-mahk-ee): Discovered in 2005, it is 41% the size of the Moon, takes 310 years to orbit and is, on average 46x farther from the Sun as Earth.
5. **Eris**(AIR-is): Discovered in 2005, it is 2/3 the size of the Moon (similar to Pluto), takes 310 years to orbit and is, on average 68x farther from the Sun as Earth.

