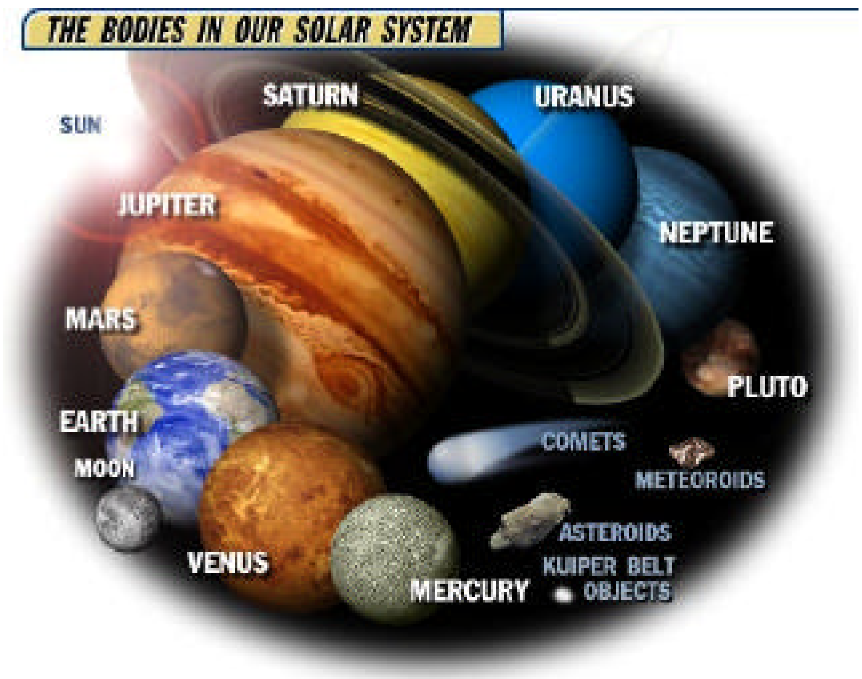
Solar System

Science Information Background



Courtesy NASA

All Grades

The Sky Is Our Cosmic Home

For most of history, we have looked up to the sky and known that we humans are but a small part of a much larger cosmos. Yet the untouchable domain of the sky remained a mystery to nearly all our ancestors. The only clues to our place in the cosmic scheme of things were provided by the small points of light arranged in patterns that reappeared night after night and year after year, the constant orb of the Sun, and the changing orb of the Moon. It is no surprise that early peoples were avid sky watchers and that fear was struck into their hearts by the occasional cataclysmic event, such as a solar eclipse or the passage of a comet.

We now know that what we see in the sky is just our nearby cosmic neighborhood, the local stellar neighborhood, and of course, our solar system. As the name suggests, the solar system is comprised of all the celestial objects in orbit around the Sun and the overall environment which the Sun influences.

The Sun – Giver of Light and Life

At the center of it all is the Sun, our nearest star and the brightest object in the sky. There is little wonder that cultures all over the world and throughout history built temples and even constructed cities based on its rising and setting: It provides the light of day and the warmth that makes our very survival possible. In fact, the Sun, conveniently located 150 million kilometers (93 million miles) away, provides energy to fuel all of life on Earth.

All of the apparent motions of the Sun are actually caused by motions or aspects of Earth. The apparent movement of the Sun (and the stars by night) through the course of a single day is caused by the spin of Earth on its axis; the apparent northward and southward migration of the sunrise and sunset points is due to the tilt of Earth's axis and Earth's motion around the Sun once every year. In the summer, the nearest pole (the north pole for Colorado) points toward the Sun; in the winter, the nearest pole points away from the Sun.

The Sun is a ball of gas, held together and heated by its own self-gravity. At its center, the heat and pressure are so high that nuclear fusion reactions are ignited, releasing even more heat. The energy liberated at the core takes hundreds of thousands of years to filter out to the Sun's surface, or photosphere, where it is released into space; it takes only eight minutes for light from the Sun's surface to reach Earth.

The Sun was born about 4.6 billion years ago, at the same time that Earth and other planets were also formed. The Sun is about halfway through its life. In another 5 billion years or so, the Sun will run out of nuclear fuel in its core, and it will become unstable, evolving to a red giant and eventually puffing off its outer layers as a planetary nebula, leaving only a white-dwarf core behind.

The Moon and Its Phases

Second in prominence to the life-giving Sun is our planet's lone satellite, which we naturally call *the* Moon. In contrast to the Sun, whose glowing disk never changes in its overwhelming brightness, the Moon passes through a repeated cycle of phases. Night after night, we see that the face of the Moon stays the same but its illumination changes. An intimate link exists between the Moon's phases and its times of rising and setting. The Moon rises and sets a little later each day, and like the cycle of phases, it takes a month for the moonrise to occur at the same time of day.

Both the phases of the Moon's illumination and the changes in the Moon's rising time are explained by the way the Moon moves in orbit around Earth. Its orbit carries the Moon from west to east, in the same direction that Earth spins on its axis. If you look for the Moon on successive nights, you will see that from one day to the next, the Moon has moved about 13 degrees eastward, and so it appears over the eastern horizon just a little later—about 50 minutes—each day.

The Moon keeps the same face to Earth for the same reason we have tides on Earth. Just as gravity's pull causes the ocean to rise and fall, it also pulls on the solid body of the Moon. The Moon is not perfectly spherical, but instead bulges in one direction, more like a football. Tidal forces of gravity keep the oblong Moon always pointed toward us, in a so-called "tidal lock."

The Wandering Planets

Most of the points of light on the celestial sphere are stars that remained fixed in constellations and don't change their positions with respect to one another. But our ancestors recognized that five points of light appeared to change their positions relative to the fixed constellations and each other throughout the year. Named for the gods Mercury, Venus, Mars, Jupiter, and Saturn, these points of light were identified as *planets* (Greek for "wanderers").

The planets change their positions against the stars for two main reasons: First, they are, relatively speaking, very nearby, while the stars are much farther away. Second, they are in orbit around the Sun, just as Earth is, leading to a complicated but decipherable dance. Understanding the regular, mathematical patterns that describe the movements of the planets was a great achievement of the new empirical science of the Renaissance and the Enlightenment, and led to important developments in mathematics and physics. It also confirmed what Copernicus had so boldly proposed and what Galileo had spent the later years of his life under house arrest for defending: Earth was not the center of the universe.

With the advent of telescopes, three more planets were found: Uranus, Neptune, and Pluto in 1781, 1846, and 1930 respectively. They were too faint to see with the unaided eye, but their motions could be observed and their trajectories were calculated, confirming they too were in orbit around the Sun. The naked-eye planets, together with Uranus, Neptune, and Pluto, make up the full complement of planets that are known to reside in our solar system.

The objects in the solar system differ widely from one another but can be sorted into the following types:

Terrestrial	**Asteroid Belt**	**Jovian**	**Kuiper Belt**	**Oort Cloud**
Mercury, Venus, Earth, Mars	Asteroids	Jupiter, Saturn, Neptune, Uranus	Pluto, comets	Comets
Rocky Small Few or no moons No rings	Rocky	Gas and ice Big Lots of moons Rings	Ice and rock	Ice and rock

The trends in the nature of the planets compared to their distance from the Sun give us clues to their origins. We now believe the planets were formed at the same time the Sun was. Closer to the newly formed Sun there was less material available to make new planets, and a strong solar wind from the young Sun blew away extra material that might have made up the inner planets. In addition, the temperature was hotter, driving off any ice that might have been present in the presolar nebula. The planets in our solar system are round, as are most of the moons, but there are moons that are oddly shaped, which are probably captured asteroids.

Asteroids and comets orbit the Sun but are small like moons. They are simply chunks of rock (asteroids) or ice (comets) that never quite pulled it together to become planets and are probably left over from the time of the solar system's formation. By studying asteroids and comets, we learn about the material from which the solar system was made before geological evolution altered its original composition. Asteroids reside throughout the solar system, but a great number of them are concentrated in a ring just past the orbit of Mars called the Asteroid Belt. Similarly, comets spend most of their time in the outermost regions of the solar system in the Kuiper Belt. The most distant comets live in a spherical shell called the Oort cloud nearly 40 times farther away than Pluto.

	Mercury	**Venus**	**Earth**	**Mars**	**Jupiter**	**Saturn**	**Uranus**	**Neptune**	**Pluto**
Distance from Sun (in miles)	36 million	67 million	93 million	142 million	483 million	888 million	1,784 million	2,794 million	3,647 million
Distance from Sun (in km)	58 million	108 million	150 million	228 million	778.4 million	1,426 million	2,871 million	4,498 million	5,906 million
Diameter (miles)	3,030	7,523	7,926	4,222	88,846	74,898	31,763	30,775	1,485
Diameter (km)	4,876	12,107	12,755	6,794	142,983	120,536	51,117	49,527	2,390
Number of Moons	0	0	1	2	61	31	21	11	1
Ring System Present	No	No	No	No	Yes	Yes	Yes	Yes	No
Length of Orbit	88 days	224.7 days	365 days	687 days	4332.6 days	10,759 days	30,684 days	60,190 days	90,465 days
Length of Rotation	59 days	243 days	24 hours	24.5 hours	10 hours	10.2 hours	17.2 hours	16.3 hours	6.4 days

A very popular debate in recent years has arisen around whether or not Pluto should be considered a planet. It is round and orbits the Sun, but it is made of the same kind of material as comets (not at all like a Jovian planet) and has a peculiar, tilted, and elongated orbit more typical of a Kuiper Belt comet. At the time of writing, officially Pluto still holds on to its planet status. But our understanding of what constitutes a planet is growing with each new discovery and Pluto's designation may some day change. For now, the debate over Pluto provides a good illustration of the limitations of a rigid classification system. Pluto is what it is, and it doesn't care what we humans call it!

Life in the Neighborhood

The constituents of the solar system do not live in isolation: As is true of all cosmic systems, they can and do interact with their environment. The heavily cratered surfaces of the terrestrial planets show that the planets have survived a lifetime of impacts from smaller bodies such as asteroids and comets. Most biologists agree that these interactions have had significant influence on the evolution of life on Earth. Just think what might have happened if the dinosaurs had not been extinguished by an asteroid impact. Would mammalian and therefore human life have flourished?

Other, perhaps more subtle examples of the importance of impacts to the evolution of life can be seen in other aspects of Earth's evolution. For example, most researchers agree that the Moon was the result of an enormous impact to Earth shortly after it was formed. While the impact may have been deadly to any life that might have been trying to take hold on Earth at the time, the resulting Moon has been beneficial to the present-day inhabitants of our planet. Without the stabilizing influence of the Moon on Earth's rotation, the environment here on Earth may have been too precarious for life to evolve. In another example, some scientists contend that there is evidence to suggest that the water in Earth's oceans was delivered to our planet by comets from the outer solar system. Life needs liquid water to thrive; without its interplanetary transport, life may never have been able to take root here on Earth.

Finally, life itself may have enjoyed interplanetary travel, buried deep inside rocks that traveled from one planet to another. Early Martian life, if it existed, may have been brought to Earth via this process; we may all be transplanted Martians!