

A Celestial Primer



Jason Carr
WiredCosmos.com

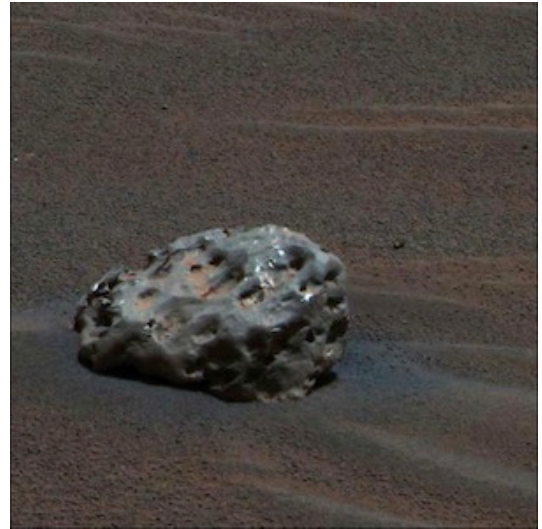
Understanding Space - Celestial Objects

Space is a big, fascinating, and stunningly beautiful place. The universe is full of stars, galaxies, nebulae, planets, moons and much more. Ranging from lifeless rocky worlds such as Mercury to vast galaxies tens of thousands of light-years across, space is home to truly awesome displays of nature. Celestial objects, also known as astronomical objects, comprise the physical entities that make up the universe. The universe has a hierarchal structure. On the smallest scales of astronomical objects, there is the Earth and our moon. The Earth is part of our solar system of eight planets while, in turn, our solar system is one of billions in the Milky Way galaxy. The Milky Way is one of 54 galaxies in the Local Group, a part of one of many superclusters that make up the universe – everything that exists.

The following guide, roughly in order from the smallest to the largest celestial objects, will help you to understand the scale of the universe, its hierarchal structure and some of the many fascinating things that lie beyond the borders of our world.

1 - Meteors

Meteors are small, rocky debris floating around in the vacuum of space ranging in size from grains of sand to massive boulders. When these enter the atmosphere of Earth or any other celestial body, they are called meteoroids. These bombard us constantly, but the vast majority of them burn up as they descend into the Earth's atmosphere. This is precisely what *shooting stars* are – small, burning debris making brief streaks of light in the night sky as they are vaporized. If a meteoroid is either large enough or travelling fast enough to make it through the atmosphere without being annihilated, it will make it to the ground, becoming a meteorite.



Fun Facts about Meteors

- The largest known meteorite is the Hoba meteorite in Namibia weighing about sixty tons. It is the worlds heaviest naturally occurring chunk of iron and it is believed to have hit Earth's surface about 80,000 years ago.
- The best-known meteor showers are the Perseids and Leonids that fall every year in August and November respectively.
- Some meteorites on Earth originated from Mars, such as the famous Allan Hills 84001 meteorite. This one attracted a great deal of attention due to the presence of possible fossilized remains of Martian bacteria.

2 - Comets

Comets are small, icy celestial bodies composed of a nucleus, coma and tail. The nucleus comprises the solid bulk of the comet and ranges in size from a hundred meters to a few dozen kilometers. Comets are characterized by spectacular comas and tails, leaving a long trail of bright matter behind them. There are over 4,000 known comets in the solar system and some have been known since ancient times. Many comets



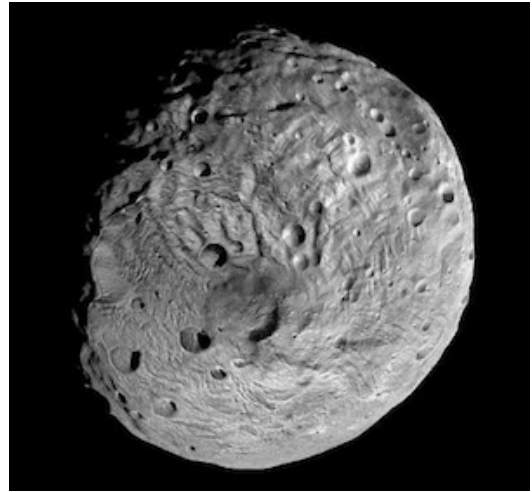
have enormous, elliptical orbits around the sun, many reaching maximum distances far beyond the orbit of Pluto.

Fun Facts about Comets

- Extremely bright comets typically appear no more than once every decade. These are known as the Great Comets and are visible to the naked eye.
- One of the most famous comets, Halley's Comet (shown above) may have been the Star of Bethlehem referred to in the Bible. Halley's Comet makes an appearance every 75 years.
- The Great Comet of 1811 was clearly visible for almost nine months. It had a coma fifty percent longer than the diameter of the sun – up to 1,000,000 miles long!

3 - Asteroids

Asteroids are small celestial bodies of which there are many millions around the Solar System. Asteroids orbit the Sun just like planets do, but they are far smaller. Because of this, they also have negligible gravitational pulls and no atmospheres to speak of. Also, because of their lack of size and gravity, smaller asteroids are irregularly-shaped rather than near-perfect spheres like planets and dwarf planets. The majority of known asteroids are located in the Asteroid Belt between the orbits of Mars and Jupiter. Asteroids are also found in the Kuiper Belt beyond the orbit of Pluto.



Fun Facts about Asteroids

- An asteroid impact may have been what wiped out the dinosaurs in the Cretaceous-Palaeogene extinction event 65.5 million years ago.
- Some asteroids have moons (satellites), such as 243 Ida and its tiny moon, Dactyl. Until its discovery, it was thought that only planets had moons.
- Asteroids may one day be used for mining thanks to their abundance of valuable metals and materials.

4 - Dwarf Planets

Dwarf planets are characterized as small planets that are massive enough to have gravitational forces great enough make them spherical in shape. They also orbit the sun directly. Most notably, Pluto is a dwarf planet that was reclassified as such in 2006, until which point it had, since its discovery in 1930, been described as the Solar System's ninth planet. All of the five known dwarf planets are considerably smaller than the Earth's Moon. Dwarf planets may also have their own moons. Pluto, for example, has at least five. Dwarf planets are too small and do not have a high enough gravitational pull to be able to retain any more than a trace atmosphere.

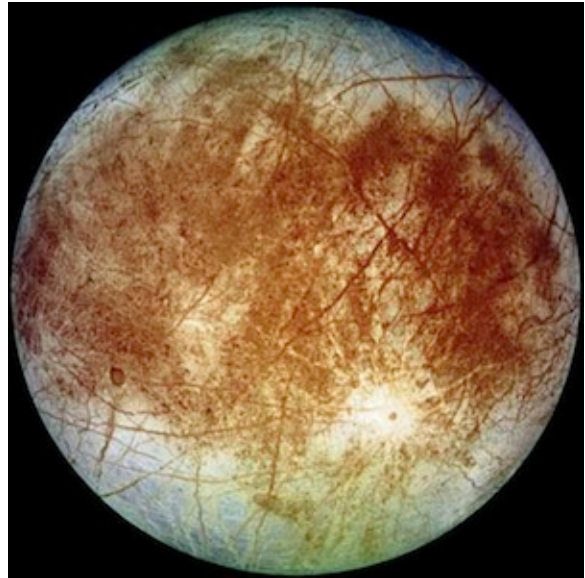


Fun Facts about Dwarf Planets

- Ceres, in spite of being the smallest known dwarf planet, was the first one discovered due to the fact that it is the largest non-planetary body in the inner solar system. It was discovered in 1801.
- All other dwarf planets are found in the Kuiper Belt extending beyond the orbit of Pluto.
- In 2015, NASA's New Horizons space probe will visit the dwarf planet Pluto and take the first ever photos of its surface.

5 - Moons

Moons, known as *natural satellites* in the scientific community, are objects ranging in size from tiny asteroids to bodies larger than the planet Mercury. They are gravitationally bound to their host planets, just as the Moon is to Earth. Earth, of course, has only one moon, but some of the other planets in the Solar System have dozens. In total, there are at least 176 moons in the Solar System. Mercury and Venus have none as far as we know, while Mars has two and the gas giant planets have dozens. The first moons discovered around other planets were the four Galilean moons of Jupiter in 1610 by Galileo.



Fun Facts about Moons

- Many smaller moons are captured asteroids, pulled into the orbit of planets by powerful gravitational pulls. The two Martian moons, Phobos and Deimos are two such moons.
- One of Saturn's moons, Titan, is the only moon in the Solar System known to have a thick atmosphere. Because of this and other factors, it remains one of the first places in the Solar System to search for extraterrestrial life.
- Jupiter has more moons than any other planet in the Solar System with a total of 67! The four largest of these are Io, Europa (shown on right above), Ganymede, and Callisto. Ganymede is actually larger than the planet Mercury. These four moons are known as the Galilean moons.

6 - Planets

There are a total of eight planets in our solar system. Our solar system is comprised of the inner planets and the outer planets. The inner planets, in order of distance from the Sun, are Mercury, Venus, Earth, and Mars. Far beyond the orbit of Mars lie the outer planets, Jupiter, Saturn, Neptune and Uranus. These four planets are gas giants and, thanks to their size and gravitational influence, they each have numerous moons. Gas giants have no known solid surface. The planets of the Solar System vary dramatically. Mercury is a lifeless rock, Venus is a hellish inferno, Earth is home to the only forms of life that we know of and Mars still remains our first candidate in the search for extraterrestrial life either long dead or still present. Since 1995, many hundreds of planets have been discovered orbiting other stars as well. These are known as extrasolar planets.

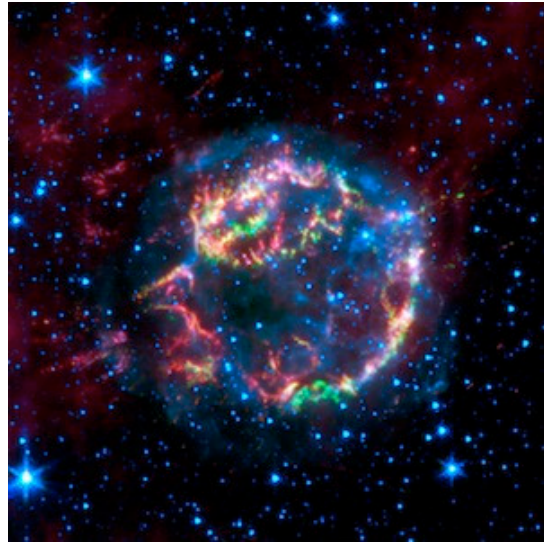


Fun Facts about Planets

- There are more than 850 planets orbiting stars other than our own (the Sun), and more are being discovered every week in large part due to the work of the Kepler Space Telescope.
- Venus is the hottest planet in the Solar System with surface temperatures high enough to melt lead and air pressures as high as those one kilometer under the sea.
- Water, a key ingredient for life as we know it, is common throughout the Solar System. Water ice is widely distributed on Mars and exists on the Moon, many comets and asteroids, and on various other astronomical bodies.

7 - Stars

Stars form the center of solar systems, just like our own star, the Sun, is the center of our own Solar System. When you look up at the sky on a clear night, you can start to grasp the vastness of space and the countless trillions of stars in the universe. The vast majority of stars are far more massive than even the largest planets, with the smallest ones being considerably larger than Jupiter and the largest ones being hundreds of times bigger than the Sun. The Sun is



nothing special as far as stars go and, in fact, there are billions of other stars just like it in our galaxy alone. Just like the Sun, many other stars host planetary systems, some of which may be very much like our own (and possibly home to extraterrestrial life). Stars are classified by spectrum types and are designated by letters. Our sun is a *class G* star.

Fun Facts about Stars

- The largest known star is the red hypergiant called VY Canis Majoris. 3 billion kilometers (about 1.86 billion miles) in diameter, the star would extend further than Saturn's orbit if placed in our Solar System.
- Our own star, the Sun, is approximately 1.4 million kilometers (nearly 870,000 miles) in diameter.
- The nearest star to Earth other than the Sun is the triple-star system, Alpha Centauri, 4.3 light-years away. 4.3 light-years equates to approximately 40,000,000,000,000 kilometers. Travelling at 252,800 km/h, the speed of the fastest man-made object, the Helios 2 space probe, would take around 18,000 years to reach it.

8 - Galaxies

Stars make up galaxies such as our own galaxy, the Milky Way. The Milky Way is one of many billions of galaxies in the known universe. The Milky Way alone contains between 100 and 400 billion stars. Galaxies are vast, gravitationally bound systems containing not only stars, but also nebulae, rogue planets (planets without a host star) and various other celestial bodies.



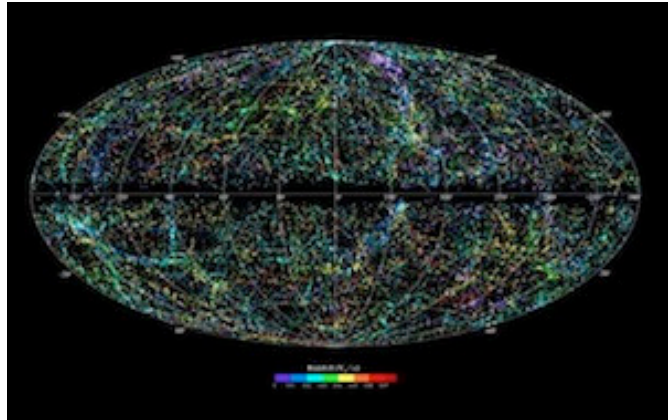
They fall into three broad classes described as elliptical, spiral and lenticular galaxies. Our own galaxy is a barred spiral galaxy characterized by an extremely bright and dense center of stars surrounded by swirling arms. Our own star system lies in one of the arms of the Milky Way orbiting the galactic center at a distance of 26,000 light-years (each light-year is roughly 6 trillion miles). The nearest proper galaxy beyond the Milky Way is Andromeda, about 2.5 million light-years away across a virtually empty void.

Fun Facts about Galaxies

- The most distant galaxies tell us about the history of the universe. This is because we see them as they were when the light left them – effectively, we are looking back in time.
- There are only three galaxies visible to the naked eye from Earth. These are the dwarf galaxies known as the Small and Large Magellanic Clouds and the Andromeda Galaxy.
- There are at least 100 billion galaxies in the known universe, but there may be dozens times more than that.

9 - The Universe

The observable universe comprises absolutely everything that we can see from Earth. Anything that is further away than the edge of the observable universe is invisible to us due to the fact that the light has not yet completed the long journey to Earth. The furthest we can see is approximately 13.75 billion light-years.



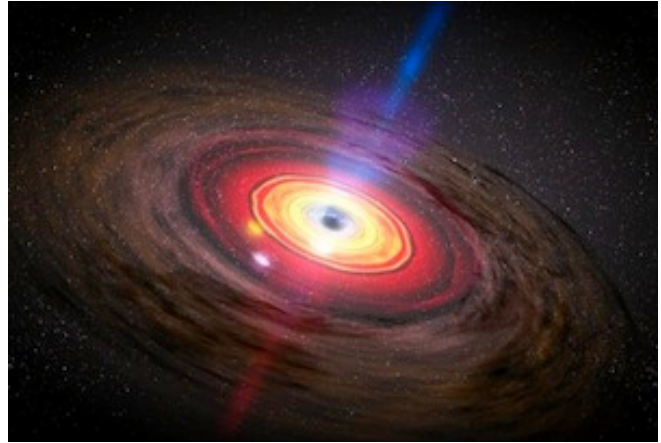
The universe is made up of superclusters containing clusters of galaxies such as the Local Cluster where our own Milky Way galaxy is located. What lies beyond the observable universe is not known, although the universe is still generally thought to be finite. The universe is believed to have been created by the Big Bang and has been rapidly expanding ever since.

Fun Facts about the Universe

- The universe is approximately 93 billion light-years in diameter, but due to the fact that the universe is expanding, we can still see things that are too far away, because we are seeing them as they were when they were closer to us.
- The largest known object in the universe is the Sloan Great Wall, an enormous wall of galaxies about 1.38 billion light-years in length.
- The size of the universe and the number of galaxies and stars in them suggest that life-supporting worlds, although clearly rare, could easily number in the billions.

Honorable Mention - Black Holes

Black holes are perhaps the most fascinating and bizarre of all the objects in space. Sometimes, when a star dies, it starts to collapse, the matter of which it is composed becoming more and more densely packed. Eventually, the star is so massive that its gravitational pull becomes so great that the escape velocity reaches the speed of light.



When not even light is able to escape the surface, the star becomes invisible and only detectable by its influence on the surrounding area. The black hole is composed of an event horizon that marks the point of no return. Additionally, black holes have a gravitational singularity in the center that is infinitely dense, yet has no volume. At this point, the laws of physics simply break down, making black holes the most enigmatic objects in existence. Black holes are thought to exist in the center of many galaxies, including the Milky Way.

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