

Access the universe

An initial primer for the novice Amateur Astronomer

By Allen Little ®

I have just completed a very good on line Astronomy course provided free by www.about.com. Much of the material in this booklet is built around my learning in that short course. Full credit is given to the original Authors and Publisher with no literary rights assumed or transferred. www.about.com ©

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Access the universe

To begin with it's important we are clear about the topic we are considering. In the general public's mind there is a degree of confusion between the terms **Astronomy** and **Astrology**.

Astronomy is a natural science that deals with the study of celestial objects (such as stars, planets, comets, nebulae, star clusters and galaxies) and phenomena that originate outside the Earth's atmosphere (such as the cosmic background radiation). It is concerned with the evolution, physics, chemistry, meteorology, and motion of celestial objects, as well as the formation and development of the universe.

Astrology is a group of systems, traditions, and beliefs which hold that the relative positions of celestial bodies and related details can provide information about personality, human affairs, and other terrestrial matters. A practitioner of astrology is called an astrologer. Astrologers believe that the movements and positions of celestial bodies either directly influence life on Earth or correspond to events experienced on a human scale

Astronomy, derived from the Greek words for star law, is the scientific study of all objects beyond our world. It is also the process by which we seek to understand the physical laws and origins of our universe.

Over the centuries there have been countless innovators that have contributed to the development and advancement of astronomy. Some of these key individuals include:

Nicolaus Copernicus (1473 - 1543): He was a Polish physician and lawyer by trade, but is now regarded as the father of the current heliocentric model of the solar system.

Tycho Brahe (1546 - 1601): A Danish nobleman, Tycho designed and built instruments of greater power and resolution than anything that had been developed previously. He used these instruments to chart the positions of planets and other celestial objects with such great precision, that it debunked many of the commonly held notions of planetary and stellar motion.

Johannes Kepler (1571 - 1630): A student of Tycho's, Kepler continued his work, and from that promulgated three laws of planetary motion:

1. Planets move in elliptical orbits with the Sun at one focus of the ellipse.
2. The orbital speed of a planet varies so that a line joining the Sun and the planet will sweep over equal areas in equal time intervals.
3. The amount of time a planet takes to orbit the Sun is related to its orbit's size, such that the period, P , squared is proportional to the semi-major axis, a , cubed.

Access the universe

Galileo Galilei (1564 - 1642): While Galileo is sometimes credited (incorrectly) with being the creator of the telescope, he was the first to use the telescope to make detailed studies of heavenly bodies. He was the first to conclude that the Moon was likely similar in composition to the Earth, and that the Sun's surface changed (i.e., the motion of sunspots on the Sun's surface). He was also the first to see four of Jupiter's moons, and the phases of Venus. Ultimately it was his observations of the Milky Way, specifically the detection of countless stars, that shook the scientific community.

Isaac Newton (1642 - 1727): Considered one of the greatest scientific minds of all time, Newton not only deduced the law of gravity, but realized the need for a new type of mathematics (calculus) to describe it. His discoveries and theories dictated the direction of science for more than 200 years, and truly ushered in the era of modern astronomy.

Albert Einstein (1879 - 1955): Einstein is famous for his development of general relativity, a correction to Newton's law of gravity. But, his relation of energy to mass ($E=mc^2$) is also important to astronomy, as it is the basis for which we understand how the Sun, and other stars, fuse hydrogen into Helium for energy.

Edwin Hubble (1889 - 1953): During his career, Hubble answered two of the biggest questions plaguing astronomers at the time. He determined that so-called spiral nebulae were, in fact, other galaxies, proving that the Universe extends well beyond our own galaxy. Hubble then followed up that discovery by showing that these other galaxies were receding at speeds proportional to their distances away from us.

Stephen Hawking (1942 -): Very few scientists alive today have contributed more to the advancement of their fields than Stephen Hawking. His work has significantly increased our knowledge of black holes and other exotic celestial objects. Also, and perhaps more importantly, Hawking has made significant strides in advancing our understanding of the Universe and its creation.

Branches of Astronomy

There are really two main branches of astronomy: optical astronomy (the study of celestial objects in the visible band) and non-optical astronomy (the use of instruments to study objects in the radio through gamma-ray wavelengths).

Optical Astronomy: Today, when we think about optical astronomy, we most instantly visualize the amazing images from the Hubble Space Telescope (HST), or close up images of the planets taken by various space probes.

What most people don't realize though, is that these images also yield volumes of information about the structure, nature and evolution of objects in our Universe.

Access the universe

Non-optical Astronomy: While optical telescopes are sometimes considered the only pure instruments for doing astronomy research, there are other types of observatories that make significant contributions to our understanding of the Universe. These instruments have allowed us to create a picture of our universe that spans the entire electromagnetic spectrum, from low energy radio signals, to ultra high energy gamma-rays. They give us information about the evolution and physics of some of the Universe's most dynamic treasures, such as neutron stars and black holes. And it is because of these endeavours that we have learned about the structure of galaxies including our Milky Way.

Subfields of Astronomy

There are so many types of objects that astronomers study, that it is convenient to break astronomy up into subfields of study.

Planetary Astronomy: Researchers in this subfield focus their studies on planets, both within and outside our solar system, as well as objects like asteroids and comets.

Solar Astronomy: While the sun has been studied for centuries, there is still a significant amount of active research conducted. Particularly, scientists are interested in learning how the Sun changes, and trying to understand how these changes affect the Earth.

Stellar Astronomy: Simply, stellar astronomy is the study of stars, including their creation, evolution and death. Astronomers use instruments to study different objects across all wavelengths, and use the information to create physical models of the stars.

Galactic Astronomy: The Milky Way Galaxy is a very complex system of stars, nebulae, and dust. Astronomers study the motion and evolution of the Milky Way in order to learn how galaxies are formed.

Extragalactic Astronomy: Astronomers study other galaxies in the Universe to learn how galaxies are grouped and interact on a large scale.

Cosmology: Cosmologists study the structure of the Universe in order to understand its creation. They typically focus on the big picture, and attempt to model what the Universe would have looked like only moments after the Big Bang.

Even though man has studied the heavens for thousands of years, we still know very little about the Universe we live in. And as we continue to learn more, we are consistently amazed, and sometimes confused, by what we learn.

Here is a collection of amazing, interesting, and strange astronomy facts, in no particular order.

Access the universe

- ❖ Scientists believe that we can only see about 5% of the matter in the Universe. The rest is made up of invisible matter (called Dark Matter) and a mysterious form of energy known as Dark Energy.
- ❖ Neutron stars are so dense, that a soup can full of neutron star material would have more mass than the Moon.
- ❖ The Sun produces so much energy, that every second the core releases the equivalent of 100 billion nuclear bombs.
- ❖ Galileo Galilei is often incorrectly credited with the invention of the telescope. Instead, historians now believe the Dutch eyeglass maker Johannes Lippershey as its creator. Galileo was, however, probably the first to use the device to study the heavens.
- ❖ Black Holes are so dense, and produce such intense gravity, that even light can not escape. Theoretical physicists predict that there are situations under which light can escape (which is called Hawking radiation).
- ❖ Light from distant stars and galaxies takes so long to reach us, that we are actually seeing objects as they appeared hundreds, thousands or even millions of years ago. So, as we look up at the sky, we are really looking back in time.
- ❖ The Crab Nebula was produced by a supernova explosion in 1054 A.D. The Chinese and Arab astronomers at the time noted that the explosion was so bright, that it was visible during the day, and lit up the night sky for months.
- ❖ Shooting stars are usually just tiny dust particles falling through our atmosphere. Comets sometimes pass through Earth's orbit, leaving trails of dust behind. Then as Earth plows through the dust in its path, the particles heat up, creating the streaks in the night sky.
- ❖ Even though Mercury is the closest planet to the Sun, temperatures can reach -280 degrees F. Why? Since Mercury has almost no atmosphere, there is nothing to trap heat near the surface. So, the dark side of Mercury (the side facing away from the Sun) is very cold.
- ❖ Venus is considerably hotter than Mercury, even though it is further away from the Sun. The thickness of Venus' atmosphere traps heat near the surface of the planet.

Since the beginning of time human kind have marvelled at nature and what it provides. The things above below and within us have fascinated many.

These notes arise out of my own interest in the wonders of Astronomy. As a new comer I soon came to realise there is much to be learned and understood about the ever expanding panorama which is the Sky.

To create an accurate model, you must first begin with accurate data. Gather and understand information to the best of your ability. If you don't know simply ask. Never fudge it and pretend you know or understand.

Seek clarification and test what you hear against the things which are known and clearly agreed upon. As a new Astronomer listen intently and engage in conversation about what is before you. Many think Astronomy is about seeing the panorama of deep space. I have very real difficulty seeing the stars and appreciate it when people take the time to help my understanding. Astronomy may be about looking and seeing but for me understanding and visualisation in the mind is as important.

Access the universe

I enjoy reading about what others have seen and documented. A good example of what can come out of observation and communication survives today in Kepler's laws of planetary motion:

1. Planets move in elliptical orbits with the Sun at one focus of the ellipse.
2. The orbital speed of a planet varies so that a line joining the Sun and the planet will sweep over equal areas in equal time intervals.
3. The amount of time a planet takes to orbit the Sun is related to its orbit's size, such that the period, P , squared is proportional to the semi-major axis, a , cubed.

When beginning in Astronomy have a simple strategy of inquisition which you can become master of.

- Keep things clear and simple.
- Look at object you can confidently identify.
- Gather information to support your learning and experience.
- Share your observations and experience with others.
- Belong to and be active in a local Astronomy group.

In the beginning:

In order to understand how the larger things fit together we need to explore some of our history. The thinkers and shakers of ancient times eked out livings with the same seasons and skyline many of us take for granted.

From earliest times Astronomy has been of interest to many. The study of our Universe is not new, the history of astronomy shows it to be the oldest science. People have been looking up, trying to explain the universe for as long as there have been people. The earliest Astronomers were priests and holy men, studying the movement of celestial bodies to determine celebrations and planting cycles.

Astronomy is one of the oldest sciences. Prehistoric cultures left behind astronomical artefacts such as the Egyptian monuments and Stonehenge, and early civilizations such as the Babylonians, Greeks, Chinese, and Indians performed methodical observations of the night sky.

Looking back in history, the ancient Greeks were the first to start developing theories about the design of the Universe (early science of astronomy).

Previous observations of the moon had already led to the knowledge that the Earth was round. When coupled with Plato's assertion that the sphere was the perfect geometrical shape, the original Geocentric, or Earth-Centered view of the Universe was formed.

Access the universe

While many earlier observers in history believed the heavens were a giant bowl covering the Earth, this new philosophy, expounded by Astronomer Eudoxus and Philosopher Aristotle in the 4th century BC, said the sun, moon, and planets hung on concentric spheres, all surrounding the Earth. He was the Greek philosopher who made important contributions by systemizing deductive logic and wrote on physical subjects. His philosophy had a long-lasting influence on the development of all Western philosophical theories. Although helpful to ancient people trying to make sense of an unknown universe, this model did not help in properly tracking planets, the moon, or stars. Still, with few refinements, it remained the predominant scientific view of the Universe for another 600 years.

In the 2nd century BC, Claudius Ptolemaeus (Ptolemy), a Roman astronomer working in Egypt added epicycles to the Geocentric model. He said that the planets moved in perfect circles, attached to perfect spheres, that all rotated around the Earth. While it was wrong, this theory could, at least, predict the paths of the planets fairly well. This view remained in use for another 1400 years. Not much is known about the life of the Roman scholar Claudius Ptolemaeus who is more commonly known as Ptolemy. However, he was estimated to have lived from approximately 90 to 170 CE and he worked in the library at Alexandria from 127 to 150. He is known for his three scholarly works: the *Almagest* - which focused on astronomy and geometry, the *Tetrabiblos* which focused on astrology, and, most importantly, *Geography* - which advanced geographic knowledge.

Geography consisted of eight volumes. The first discussed the problems of representing a spherical earth on a flat sheet of paper (remember, ancient Greek and Roman scholars knew the earth was round) and provided information about map projections. The second through seventh volumes of the work were a gazetteer of sorts, as a collection of eight thousand places around the world.

This gazetteer was remarkable for Ptolemy invented latitude and longitude - he was the first to place a grid system on a map and use the same grid system for the entire planet. His collection of place names and their coordinates reveals the geographic knowledge of the Roman empire in the second century.

From where do you observe the universe ?

The final volume of *Geography* was Ptolemy's atlas featuring maps that utilized his grid system and maps that placed north at the top of the map, a cartographic convention that Ptolemy created. Unfortunately, his gazetteer and maps contained a great number of errors due to the simple fact that Ptolemy was forced to rely upon the best estimates of merchant travellers (who were incapable of accurately measuring longitude at the time).

Like much knowledge of the ancient era, the awesome work of Ptolemy was lost for over a thousand years after it was first published. Finally, in the early fifteenth century his work was rediscovered and translated into Latin, the language of the educated populace.

Access the universe

Geography gained rapid popularity and there were more than forty editions printed from the fifteenth through sixteenth centuries. For hundreds of years, unscrupulous cartographers of the middle ages printed a variety of atlases with the name Ptolemy on them, to provide credentials for their books.

Ptolemy erroneously assumed a short circumference of the earth, which ended up influencing Christopher Columbus that he could reach Asia by sailing west from Europe. Additionally, Ptolemy showed the Indian Ocean as a large inland sea, bordered on the south by Terra Incognita (unknown land). The idea of a large southern continent sparked countless expeditions.

Geography had a profound a profound effect on the geographical understanding of the world in the Renaissance and it was fortunate that its knowledge was rediscovered to help establish geographical concepts that we almost take for granted today.

In the 16th century, Nicolaus Copernicus, a Polish Astronomer, tiring of the cumbersome and imprecise nature of the Ptolemaic Model, began working on a theory of his own. He theorized that the Sun was at the centre of the Universe, and that the Earth and other planets revolved around it.

The Copernican Model of the Universe, while still incorrect, did three main things. It explained the prograde and retrograde motions of the planets. It took the Earth out of it's spot as the centre of the universe. And, it expanded the size of the Universe. (In a geocentric model, the size of the Universe is limited so that it can revolve once every 24 hours, or else the stars would get slung off due to centrifugal force. While it was a major step in the right direction, Copernicus' theories were still quite cumbersome and imprecise. His book, *On the Revolutions of the Heavenly Bodies*, which was published as he lay on his deathbed, was still a key element in the beginning of the Renaissance and the Age of Enlightenment.

Listen and engage in conversation:

One of the most satisfying aspects of Astronomy for me has been engaging with a variety of knowledgeable Astronomers. Books and magazines are expensive and often beyond the budget of novices.

The early theories of the Universe and astronomy, while very clever, all had the same problem. They were all based on incorrect information and beliefs. To create an accurate model, you must first begin with accurate data.

Thanks to the observations of Tycho Brahe, his assistant, Johannes Kepler was able to determine that the circle was not the correct geometric form to explain planetary motions. As a mathematician, he knew that a circle is just a specialized ellipse. Utilizing non-circular ellipses, he was able to calculate orbits, which correctly predicted planetary positions. He couldn't directly measure a planet's exact orbital sizes, but he was able to measure the ratio by using his equation and Brahe's observations. Tycho Brahe (1546-1601) was born at Knudstrup Sweden.

Access the universe

While attending the universities of Copenhagen and Leipzig to study law and philosophy, he became interested in Astronomy and spent most evenings studying the stars. One of Tycho Brahe's first contributions to astronomy was the detection and correction of several grave errors in the standard astronomical tables. Then, in 1572, he discovered a supernova located in the constellation of Cassiopeia. After Tycho Brahe's death, his assistant, Johannes Kepler used Tycho Brahe's observations to calculate his own three laws of planetary motion. Kepler explained how planets moved, but he still couldn't explain why. Born in 1571, he went on to attend the University of Tübingen, where he studied theology and classics. There, he met mathematics professor, Michael Maestlin, who became his mentor. Maestlin was a proponent of the heliocentric model of the solar system and planets introduced by astronomer Nicolaus Copernicus. Johannes Kepler, too, accepted this theory immediately, seeing the hand of God in its simplicity and becoming interested in astronomy. Giving up his plan of becoming a clergyman, Johannes Kepler departed the University of Tübingen in 1594 to accept a chair in mathematics and astronomy at the university in Graz, Austria. After taking this position, he developed a complex hypothesis to explain the distance between the orbits of planets. (He, like so many before him, mistakenly believed these orbits were circular. Still, his early calculations matched the observational evidence within 5%. In his later work, he altered his thinking to believe that planetary orbits are elliptical.) Johannes Kepler next theorized that the sun emitted a constant force across the planes of a planet's orbit, which diminished with distance. He believed this force pushed the planets around their orbits. In 1596, he published these theories in a treatise called *Mysterium Cosmographicum* (Cosmographic Mystery). This was the first written defense of the Copernican model, which used geometric calculations as evidence.

Up till this time, scientists believed that objects tended to stay at rest. Observation had shown all motion eventually ceases and unmoving objects did not begin to move on their own. So the question, why would planets?

Many of the names from Astronomical history carry on today associated with missions of exploration.

In the early 17th century, Galileo Galilei used surfaces of varying smoothness to slide blocks across. He found that rough tables made objects slow down at a faster rate than smooth ones. Extrapolating from these observations, he theorized that if a surface were completely smooth, objects would continue moving forever.

If you've studied physics, you'll recognize this as the basis for the theory of inertia. Objects in motion tend to stay in motion in a straight line, and objects at rest tend to stay at rest, unless acted upon by an external force.

Now they knew why the planets were moving, but why in a circle? Why not keep traveling in straight lines and fly off into deep space?

This was answered by Sir Isaac Newton when he published *Philosophiæ Naturalis Principia Mathematica*.

Access the universe

He theorized that the external force that kept the planets in orbit was the pull of gravity. According to Newton, the same force that causes an apple falls to the ground also explains why the moon continually "falls" around the Earth.

Meanwhile, our view of the Universe kept evolving. While Tycho Brahe's attempt to compromise with the Copernican theory and the Ptolemaic model led to an awkward mess, his observations helped Johannes Kepler calculate his three laws of planetary motion, which gave a more accurate picture. Galileo's discovery of the moons of Jupiter with the newly invented telescope lent credence to the sun-centered model of the solar system.

Starting with Brahe's years of observation, the work of Kepler, Galileo, and Newton were part of a new era of science, where observation, not philosophy was king. Scientists no longer tried to match data to theory. This would lead to a real renaissance in astronomy and cosmology as well as science in general.

Some people have called Tycho Brahe the Father of Modern Astronomy, but I tend to believe that title belongs to Galileo Galilei. However, Brahe did advance the science more than anyone in the past, simply by using his senses, rather than philosophy to study the sky.

What Brahe began, his assistant, Johannes Kepler expanded upon. His Laws of Planetary Motion were a major building block in the foundation of modern astronomy.

Galileo began the modern age of science, but others continued it. Here, in brief, are some of the other bright lights that helped bring Astronomy to its current place.

- Edmund Halley (1656-1742) was a British Astronomer who was also a big fan of Sir Isaac Newton. After encouraging Newton to write his Principia, Halley then published it at his own expense. Not stopping to rest on the fame of another, he went on to calculate the orbits of comets, including the one named after him.
- Sir William Herschel (1738-1822), though born in Germany, was a British astronomer. He discovered Uranus in 1781 coined the word asteroids. He also catalogued about 2000 nebulae, discovered several satellites of Uranus and Saturn, studied the rotation of planets. Discovered and studied binary stars. He discovered two satellites each orbiting Uranus and Saturn. He studied the rotation period of many planets, the motion of double stars, and nebulae. He cataloged more than 800 double stars and contributed new information on the constitution of nebulae. Herschel was the first to propose that these nebulae were composed of stars. He is considered the founder of sidereal astronomy.
- Albert Einstein (1879-1955) was a German-born American physicist and Nobel laureate. He may be the most well-known scientist of the 20th century. In 1915, he developed his general theory of relativity, which states that the speed of light is constant and that the curvature of space and the passage of time are linked to gravity.

Access the universe

- Thinking the universe was unchanging, he inserted his "cosmological constant" into his calculations to make them fit his belief.
- Willem de Sitter: (1872 - 1934), a Dutch astronomer, removed Einstein's cosmological constant and used the theory of relativity to show that the universe may always be expanding.
 - Georges-Henri Lemaitre: (1894 - 1966) was not only a Belgian astronomer, he was also a Jesuit priest. Discovering the writings of Russian mathematician, Alexander Friedmann, Lemaitre took his solution for an expanding universe and theorized that if the universe is expanding, if we follow it back to the starting point, then our universe began as a great "cosmic egg" which exploded and expanded outward. Lemaitre is called by some, the father of the Big Bang Theory.
 - Edwin P. Hubble (1889-1953), American Astronomer. In the 1920s, Albert Einstein stated, "I have made my greatest blunder." This pronouncement came when Edwin Hubble demonstrated that the universe was not static and Einstein's cosmological constant was not necessary. Utilizing improved telescopic devices, he was also able to confirm that those "fuzzy" objects astronomers had seen for years were in fact other galaxies.
 - Thomas Gold (1920 - 2004) is an American astronomer. Though it is generally believed that Gold's "Steady State" theory of the universe is incorrect, he has made many major contributions to our knowledge of the universe, including the nature of pulsars as rotating neutron stars, and the origin of planetary hydrocarbons.

That brings us into the twentieth century. There have been and are many other great brains in the field of astronomy, but it's time to get away from history for now.

We need to hold all this information in context from ground zero in our Solar System, the neighbourhood in our home Galaxy of the Milky Way...

I am fascinated with time and distance. Because of eyesight challenges its difficult to ascertain the relative position of objects we are observing. Our universe is huge, larger than most of us can even imagine. In fact, our solar system is beyond the grasp of many. Our standard system of measurement just doesn't do astronomy justice, so let's look at a better way to get a grip on astronomy distances for the solar system, galaxy and universe during this lesson on the universe.

In perhaps a nod to the old belief of Earth as the centre of the universe, our first unit of measurement is based on the distance of our home to the sun. We are 93 million miles from the sun, but it's much simpler to say we're one astronomical unit (AU) from the sun. An Astronomical Unit is a unit of length used for distances within the solar system; equal to the mean distance between the Earth and the Sun. An astronomical unit (abbreviated as AU, au, a.u., or sometimes ua) is a unit of length equal to approximately 149.60 million kilometres. The mean distance from the Earth to the Sun (the semi-major axis of Earth's orbit), approximately 149,600,000 kilometres (symbol AU).

Access the universe

In our solar system, the distance from the sun to the other planets can be measured in astronomical units as well: Mercury .38 AUs, Venus .72 AUs, Mars 1.52 AUs, Jupiter 5.2 AUs, Saturn 9.54 AUs, Uranus 19.218 AUs, Neptune 30.06 AUs, and Pluto 39.5 AUs.

This works great within our own solar system, but as we move through our galaxy, distances grow ever farther apart. That's why we created a unit of measure based on the distance that light travels in a year. We call these units "light years," of course. A light year is 6 trillion miles. (6,000,000,000,000 miles)

The closest star to our solar system is actually a system of three stars called the Alpha Centauri System, consisting of Alpha Centauri, Rigil Kentaurus, and Proxima Centauri, which is actually slightly closer than her sisters. Alpha Centauri is 4.3 light years from Earth.

If we want to move beyond our "neighborhood," our nearest neighboring galaxy is Andromeda. At 2.2 million light years, it's the most distant object that we can see without a telescope, and the only object outside our own galaxy in the universe.

2.2 million light years is a huge distance, but merely a drop in the bucket to the size of our universe. In order to measure larger distances, the parsec (Paralax Second) was invented. A parsec is approximately 3.258 light years. Along with the parsec, larger distances are measured in kiloparsecs (thousand parsecs) and megaparsecs (million parsecs).

One other way to denote very large numbers is something called scientific notation. This system is based on the number ten and is written like this 1×10^1 . This number equals 10. The small 1 located to the right of the 10 indicates how many times 10 is used as a multiplier. In this case once, so the number equals 10. So, 1×10^2 would be the same as $1 \times (10 \times 10)$ or 100. An easy way to figure a scientific notation number out is to add the same number of zeros at the end as the small number to the right of 10. So, 1×10^5 would be 100,000. Small numbers can be written this way as well by using a negative power (the number to the right of 10). In that case, the number will tell you how many places to move the decimal point to the left. An example: 2×10^{-2} eqAs.

- ❖ **Dr. Carl Sagan (1934 - 1996): Perhaps no one has done as much to bring the wonders of astronomy and our universe to the lay public as Dr. Sagan. It is appropriate to mention him here during a discussion of how large the universe is, since the phrase for which he will always be remembered is "Billions and billions." This was his way of expressing the incredibly large number of stars, planets, and galaxies, during the production of his famous PBS TV series, "Cosmos." He was an astronomer, educator, author, pioneer in exobiology, Director for Planetary Studies, and David Duncan Professor of Cornell University. As someone once said, perhaps his greatest contribution to the world was his commitment to truth. He died of pneumonia on December 20, 1996 after a two year battle with bone marrow disease.**

Access the universe

- ❖ **Prof. Stephen Hawking (1942 - Still Alive):** If anyone were to rival Dr. Sagan in popularity among lay persons, it would have to be Dr. Stephen Hawking. Born in Oxford, England, he attended University College there, earning a degree in physics despite his desire to study mathematics and his father's request that he study chemistry. Despite being diagnosed with ALS (amyotrophic lateral sclerosis or Lou Gehrig's disease) in 1963 (at which time, doctors didn't believe he would live to complete his degree), he earned his PhD in 1966. In 1988, he published his famous "A Brief History of Time." By mid 1995 it had been on The Sunday Times best-sellers list for 237 weeks. This broke the previous record of 184 weeks, a feat which is recorded in the 1998 Guinness Book of Records. Despite dire predictions by doctors over the years, Hawking is and married with three children. He uses a wheelchair for locomotion. In 1985, he completely lost the use of his vocal chords in an operation to assist his breathing. Today, he communicates through a computerized speech synthesizer. He is also the editor of Stephen Hawking's *A Brief History of Time: A Reader's Companion* and has written a number of other excellent books on astronomy. He presently holds Sir Issac Newton's chair as Lucasian Professor of Mathematics at Cambridge University. Now that we've been amazed by the size of the universe and met some great thinkers.

Stars are massive shining spheres of hot gas*, the closest of which is our Sun. Those stars which you see with your naked eye in the night sky all belong to the Milky Way Galaxy, the huge system of stars that contains our solar system. There are around 5,000 stars which can be seen with the naked eye, though not all stars are visible at all times and places. With a small telescope, hundreds of thousands of stars can be seen.

Larger telescopes can show millions of galaxies, many of which may each contain over 200 billion stars. Today, scientists believe there are more than 1×10^{22} stars in the universe (10,000,000,000,000,000,000,000). Many of these stars are so large that if they took our Sun's place, they would engulf Earth, Mars, Jupiter, and Saturn. Others, called white dwarf stars, are around the size of Earth, and neutron stars are less than about 10 miles in diameter.

Our Sun, one of the stars in the universe, is about 93 million miles from Earth, 1 Astronomical Unit (AU). The difference in its appearance from the stars visible in the night sky is due to its close proximity. The next closest star is Proxima Centauri, which is more than 20 trillion miles from Earth.

Stars come in a wide variety of colours, ranging from deep red, through orange and yellow to an intense white-blue. The colour of a star depends on its temperature. Cooler stars tend to be red, while the hottest ones are blue.

Hipparchus, an astronomer we haven't met yet lived in the second century BC. He divided stars into six brightness groups, which are called magnitudes. First magnitude is the brightest and sixth magnitude is the faintest. This system, though a bit modified, is still in use. The difference in magnitude is measured mathematically. Each star magnitude is 2.5 times brighter than the next lower star.

Access the universe

This has expanded our system into more than six levels, with the brightest stars now represented by negative numbers.

Stars - Stars – Stars

Stars are primarily made of hydrogen, smaller amounts of helium, and trace amounts of other elements. Even the most abundant of the other elements present in stars (oxygen, carbon, neon, and nitrogen) are only present in very small quantities

Despite the wide spread use of phrases like "the emptiness of space," space is definitely not empty. It is full of gasses and dust. This can even be see as clouds of dust obscure the view of many stars. This matter can become compressed by any number of celestial events, including collisions and blast waves from exploding stars, causing lumps of matter to form.

If the gravity of these lumps of matter is strong enough, they can pull in other matter for fuels and as they continue to compress, their internal temperatures are raised to such a point that the hydrogen ignites in thermonuclear fusion. While the gravity continues pulling, trying to collapse the star into the smallest possible size, the fusion stabilizes it, preventing further contraction. Thus, a great struggle ensues for the life of the star, as each force continues to push or pull.

There are a number of different processes (thermonuclear fusion) which make stars produce light, heat and energy. The most common happens when 4 hydrogen atoms combine into a helium atom. This releases energy, which is converted to light and heat.

Eventually, most of the fuel, hydrogen, is exhausted. As the fuel begins to run out, the strength of the thermonuclear fusion reaction declines. Soon (relatively speaking), gravity will win and the star will collapse under its own weight. At that time, it becomes what is known as a white dwarf.

As the fuel further depletes and reaction stops all together, it will collapse further, into a black dwarf. This process can take billions and billions of years to complete. Towards the end of the twentieth century, astronomers began to discover planets orbiting other stars. Because planets are so much smaller and fainter than stars, they are difficult to detect and impossible to see, so how do scientists find them? They measure tiny wobbles in a star's motion caused by the gravitational pull of the planets. Although no Earth-like planets have been discovered yet, scientists are hopeful. let's take a look at some of these balls of gas.

Finding your way around the sky:

Any traveller needs to know where they are going and so planning is important. Some basic knowledge will tell you about common things visible in the sky where you are located. Knowing your street address or viewing location is useful. There is an excellent **Free** tool available to assist and give enhanced Star Gazing pleasure its called **Stellarium 0.10.2** Full information about this free and very worthwhile down load can be had at their web site **[www.stellarium.org/wiki/index.php/Main Page](http://www.stellarium.org/wiki/index.php/Main_Page)**

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Your position in terms of latitude, longitude, and altitude together with seasonal variations will determine what is viewable at any given time. The Sky map will show different views at different times and locations.

A GPS will tell where you are located. A GPS Global Positioning System is a space-based radio navigation system which provides reliable positioning, navigation, and timing services to civilian users on a continuous worldwide basis. The GPS is made up of three parts: satellites orbiting the Earth; control and monitoring stations on Earth; and the GPS receivers. GPS satellites broadcast signals from space that are picked up and identified by GPS receivers. Each GPS receiver then provides three-dimensional location (latitude, longitude, and altitude) plus the time.

With your position known it will be possible to see features of the sky for the time you are viewing. Obviously this will be influenced by atmospheric conditions such as cloud cover and penetrating illumination. As with land travel, a clear map is required to assist in identification of objects. There are many very good maps for sale but good advice is to check out the free maps you can create at **About Astronomy & Space**. These are fine for novice Astronomers. You must be aware of the variations in viewing and reporting in various parts of the world. Here in the Southern Hemisphere we have some of the best viewing positions in the world but sadly much of the produced to intends to satisfy Northern Hemisphere readers.

In order to enjoy the best views of the sky, you should try to find a nice size field, preferably with as little light around as possible to minimize the light pollution. Light pollution is any light around you which prevents your eyes from adjusting to the dark, thereby making star gazing more difficult. Your back yard may work just fine.

The skies above us are home to stars, satellites, planets, galaxies and a wealth of amazing insights into the world we live in. Throughout New Zealand there are many local Astronomical groups dedicated to sharing knowledge about the universal wonders of space.

The Southern Cross

Perhaps the best known constellation seen in New Zealand is the Southern Cross. Once you locate this constellation, use it to orient yourself on the sky map.

Many stars names indicate their brightness and location in a particular constellation. Astronomers call the Southern Cross the Crux and attach a letter of the Greek alphabet to the main stars in their order of brightness. The brightest star is at the bottom and, moving clockwise, the main stars are progressively dimmer.

The brightest star is Alpha Crucis, also known as Acrux. It is the 14th brightest star in the sky and is really a triple star. When viewed through binoculars it appears as two blue-white stars

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With a good telescope it is possible to discern that the brighter of the two is really another pair. They are located 321 light years from earth.

Beta Crucis, also known as Mimosa, forms the eastern tip of the upright cross. It is the second brightest star in the Southern Cross, and the 20th brightest star in the sky. Lying some 353 light years away, it is a blue-white giant star.

Gamma Crucis or Gacrux, at the top of the cross, is a distinct red-orange star, and stands out in contrast to the other, blue-white stars of the cross. It lies 88 light years from earth.

Delta Crucis is the faintest of the four stars making up the cross. Like Beta Crucis, it is a blue-white giant star. It lies some 364 light years from earth.

The faint fifth star, Epsilon Crucis, shows up as a dusty orange colour below and just to the left of Delta Crucis. Its not represented on the New Zealand flag, and is barely visible from light-polluted cities and suburbs. This star is an orange giant, located about 570 light years away.

Matariki

The Pleiades star cluster, also known as the Seven Sisters and Messier 45, is a conspicuous object in the night sky with a prominent place in ancient mythology. The cluster contains hundreds of stars, of which only a handful are commonly visible to the unaided eye. The stars in the Pleiades are thought to have formed together around 100 million years ago, making them 1/50th the age of our sun, and they lie some 130 parsecs (425 light years) away.

From our perspective they appear in the constellation of Taurus, with approximate celestial coordinates of 3 hours 47 minutes right ascension and +24 degrees declination. To Maori the Pleiades star cluster is known as the Matariki and its considered important for establishing the correct time to plant crops. This constellation is also believed to have been used by navigators on long sea journeys.

The Matariki star cluster contains more than 1000 stars, but only seven to nine can be seen by naked eye in the night sky.

The first rising of the Pleiades and of Rigel occurs just prior to sunrise in late May or early June, and it indicates the old year has ended and new one year has begun.

When starting out in Astronomy don't expect to see everything at once, You need to learn how to focus your eyes and look at what is before you. it's a very large universe. When you've had a little experience with star gazing, you can consider buying a telescope but first talk to someone with more experience about the best telescope for your purposes.

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When beginning don't worry too much about identifying the objects you are viewing, just enjoy the splendours of the night sky. If curiosity does get the better of you, simply glance at your map and you should be able to recognize many of the stars and/or planets that are visible. Remember that the Earth is constantly moving, so allow for that movement as you look at the map.

Stars are massive shining spheres of hot gas, the closest of which is our Sun. Stars are primarily made of hydrogen, smaller amounts of helium, and trace amounts of other elements. Even the most abundant of the other elements present in stars are only present in very small quantities. Those stars which you see with your naked eye in the night sky all belong to the Milky Way Galaxy, the huge system of stars that contains our solar system. Here are the Top 10 Brightest stars as seen from Earth.

1: Sirius - also known as the Dog Star, is the brightest star in the sky.
Distance: 8.6 LY

2: Canopus - the second brightest star in the sky.
Distance: 74 LY

3: Rigel Kentaurus - also known as Alpha Centauri, is the third brightest star in the sky. Distance: 4.3 LY

4: Arcturus is the 4th-brightest star in the entire sky.
Distance: 34 LY

5: Vega - is the fifth brightest star in the sky.
Distance: 25 LY

6: Capella - is the sixth brightest star in the sky.
Distance: 41 LY

7: Rigel - is the seventh brightest star in the sky.
Distance: 1400 LY

8: Procyon - is the eighth brightest star night sky.
Distance: 11.4 LY

9: Achernar - is the ninth brightest star night sky.
Distance: 69 LY

10: Betelgeuse - is the tenth brightest star in the sky.
Distance: ~1400 LY

Constellations:

In ancient times long before the birth of what we know as Astronomy , people looked to the sky and the stars, wondering about what they saw.

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Besides star gazing, they played a version of the modern kids game, connect the dots, and named patterns of stars after what they reminded them of. Then they created stories about these constellations. There are some 88 recognised Constellations in the sky.

What Is A Constellation?

When you go outside on a dark clear night, look up into the night sky and see hundreds if not thousands of stars randomly spread across the sky - how do you tell one from another? The answer is you learn the constellations.

1. The constellations are totally imaginary things that poets, farmers and astronomers have made up over the past 6,000 years (and probably even more!). The real purpose for the constellations is to help us tell which stars are which, nothing more. On a really dark night, you can see about 1000 to 1500 stars. Trying to tell which is which is hard.
2. If you were shown a map of the world then you would easily recognise the continents and countries and would be able to pick out cities and towns. Well let's split the sky into continents, countries and cities.
3. The constellations help by breaking up the sky into more manageable bits. For example, if you spot three bright stars in a row in the winter evening, you might realize, "That's part of Orion!"
4. Suddenly, the rest of the constellation falls into place and you can declare: "There's Betelgeuse in Orion's left shoulder and Rigel is his foot." And once you recognize Orion, you can remember that Orion's Hunting Dogs are always nearby. Then you might recognize the two bright stars in the upper and lower left of the photograph as Procyon in Canis Minor and Sirius in Canis Major.
5. The constellations change throughout the year. In winter and early spring we have Orion dominating the sky.
6. His arch enemy Scorpio is high in the southern sky during the summer months.
7. From the northern hemisphere Ursa Major or the great bear never disappears beneath the horizon. We have now broken it down into 'the plough', 'the chariot' or in the USA 'the big dipper'.
8. Follow the two stars at the end of the plough, known as the pointers and they point to the North Star.
9. Follow them downwards and they point to Leo the lion.
10. Using one constellation helps us find many more constellations.
11. Let's go back to Orion. Follow the stars in the belt up past the star Betelgeuse in his left shoulder and we come across Castor and Pollux the two bright stars in Gemini the twins.
12. Follow his belt in a line upwards and we find Aldebran, the eye of Taurus the Bull.
13. There are 88 recognisable constellations in the sky. Some take a little more imagination than others to see them.
14. The W shape of Cassiopeia, a beautiful lady sitting in a chair needs a lot of imagination.
15. What about Pegasus, the winged horse, and Perseus, the prince, all once famous

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16.names from mythology. Perhaps we spend too much time in front of a television to really let our minds run astray!

To assist the novice Astronomers there is a very good educational video available free on the internet at <http://www.videojug.com/film/what-is-a-constellation>

Most of the constellations we discuss today are over 2000 years old. As a matter of fact, the constellations Ursa Major and Ursa Minor, the Big Bear and the Little Bear, have been constellations since the Ice Ages. Most names, however, come from ancient Greece.

Although the Greek versions are mostly what we use today to describe the constellations, many other cultures throughout the world created their own patterns and stories for the stars.

Although most people can recognize the Big Dipper, it is not really a constellation. It is what is known as an asterism, or a group of stars. It is actually part of a larger constellation called Ursa Major. Likewise, the Little Dipper is a part of Ursa Minor. On the other hand, our "landmark" for the south, the Southern Cross is an actual constellation called Crux.

To find the constellations when they appear in the night sky, download a sky map from About Astronomy & Space <http://space.about.com/> or simply get more information about the various constellations. A telescope is not necessary to view constellations.

<http://space.about.com/>

The Sun

While some stars in our galaxy are nearly as old as the universe, about 15 billion years, our sun is a second-generation star. It is only 4.6 billion years old. Some of its material came from former stars.

Stars are designated by a letter and a number combination roughly according to their surface temperature. The classes from hottest to coolest are: W, O, B, A, F, G, K, M, R, N, and S. The number is a subcategory of each designation. Our Sun is designated as a G2 star. Astronomers describe Sol as a very ordinary star. It acts just as would be expected from a star of similar size.

Star masses typically range from 0.3 to 3.0 times the mass of the Sun with most stars having masses similar to that of the Sun.

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Our solar system is part of a larger system known as a galaxy. The name of our galaxy is the Milky Way. The Milky Way contains about 100 million stars, all revolving around a point known as the galactic centre.

We are located in the outer part of the galaxy, approximately 1.6×10^{17} miles from the Galactic centre. At our current orbital speed of 140 miles/second, our solar system takes about 250 million years for one orbit around the Galactic centre.

Since its creation, our star has used up about half of the hydrogen in its core. Over the next 5 billion years or so, it will grow steadily brighter as more helium accumulates in its core. As the supply of hydrogen dwindles, the Sun's core must keep producing enough pressure to keep the Sun from collapsing in on itself. The only way it can do this is to increase its temperature. Eventually it will run out of hydrogen fuel. At that point, it will go through a radical change which will most likely result in the complete destruction of the planet Earth.

WARNING DANGER

The sun must never be viewed directly, either with or without a magnifying device. Permanent damage will be caused to the eyes in a fraction of a second unless proper care and precaution is taken. There are filters which can be utilized with many telescopes. (SUNGLASSES ARE NOT ADEQUATE!) Consult someone with recognised experience and seniority before attempting Solar viewing.

Sun Statistics:

- diameter: 1,390,000 km.
- mass: 1.989×10^{30} kg
- temperature: 5800 K (surface) 15,600,000 K (core)

A very interesting phenomenon associated with the Sun is called an eclipse. It happens when our own moon passes between the Earth and the Sun, blocking out all or part of the sun from view. Even though a portion of the sun is blocked, it is even more dangerous to view the sun during an eclipse than during a normal day.

The Inner Solar System

Before the late 1700s, people were aware of only five other planets besides the Earth; Mercury, Venus, Mars, Jupiter, and Saturn. In 1781, Sir William Herschel, a German-born British musician and astronomer, discovered Uranus using a telescope. Citing wobbles in the orbit of Uranus, two astronomers John Couch Adams of Great Britain and Urbain Jean Joseph Leverrier of France, each independently calculated the existence and position of a new planet in 1845 and 1846, respectively. Using Leverrier's calculations, Johann Gottfried Galle of Germany first observed Neptune in 1846.

Access the universe

The final planet, Pluto was discovered by a massive telescopic search started in 1905 by American astronomer Percival Lowell. He theorized the existence of a distant planet beyond Neptune because of slight anomalies in the orbit of Uranus. The Lowell Observatory staff, continued the search started by the man it was named for until the search ended successfully in 1930. An American astronomer, Clyde William Tombaugh, found Pluto near the position Lowell had predicted.

We'll now concentrate on the Inner Solar System, the so-called Terrestrial Planets; Mercury, Venus, Earth, and Mars as well as the asteroid belt. Next lesson, we'll look at the other planets of our solar system.

Mercury, the second smallest planet, is the closest planet to the Sun. Its average distance is approximately 36 million miles. Mercury's diameter is 3,032 miles, and its volume and mass are about one-eighteenth that of Earth. Mercury is approximately as dense as Earth and denser than of any of the other planets. Its gravity on the surface is about one-third of the Earth's and about twice that of the Moon.

Mercury's orbit takes it around the Sun approximately every 88 Earth days. One Mercury day, the time it takes to revolve around its axis, is equal to just under 59 Earth days. Its low temperature is because of its extremely long night. It takes 58 days to turn once but because it goes around the sun every 88 days the night time is effectively 176 earth days long. Hence the chill factor. Mercury can be viewed with binoculars or even the naked eye, but it is always close to the Sun and hard to see in the twilight sky.

Venus, the sixth largest planet, is the second in distance from the sun. It's average distance from the sun is around 67 million miles. It has a diameter of around 7,500 miles. Conditions on the surface of Venus are fairly stable, but would be very unpleasant for humans. The temperature is about 864° F and the surface pressure is 96 bars (Compare that to 1 bar for Earth). Venus's atmosphere is nearly all carbon dioxide (CO₂). It has a cloud base at about 31 miles, made mostly of sulphuric acid.

Besides the sun and the moon, Venus is the brightest object in the sky. It is known as the morning star when it appears in the east at sunrise, and the evening star when it is in the west at sunset. It is easily visible with the unaided eye, and when viewed through a telescope, exhibits phases like the moon.

We're not used to thinking of **Earth** as a planet, though we all know it is. This "third rock from the sun" is also the fifth in size.

The diameter of the earth at the equator is about 7926 miles, but that's not the whole story.

Because the earth is not a perfect sphere but is slightly flattened at the poles, the diameter of the earth measured around the North Pole and the South Pole is about 7899 miles. Seventy-one percent of the Earth's surface is covered with water, the only planet where it exists in its liquid form on the surface. This may account for the fact that the Earth is the only planet known to contain life.

Access the universe

While it's fairly easy to see portions of the Earth with the unaided eye, our close proximity prevents us from seeing it in its entirety. One needs to travel into space for that view, and I hear it's spectacular.

The Earth has a satellite, moon, called Luna. It's 238,000 miles from the Earth and has a diameter of 2155 miles. Because of its size and rocky composition, the moon has also been called a terrestrial planet along with Mercury, Venus, Earth, and Mars. It has no atmosphere, but there is water ice in some deep craters. The moon is the only extra-planetary body that a human has visited.

Besides the sun, the moon is the brightest object in the sky and very easily seen with the naked eye. Using a telescope, you can easily map out many of the Lunar features.

The Red Planet, **Mars**, the seventh largest, is the fourth planet from the sun at an average distance of 141 million miles. Named for the Roman god of war, Mars is about half the diameter of Earth (about 4212 miles), with one tenth Earth's mass. It's gravity is about one third that of Earth. Although Mars's surface is closest to that of Earth of any of the planets, it would still be a very harsh place to live, with temperature extremes between -225 and +60 degrees Fahrenheit, with an average of -67 degrees. Mars has a very thin atmosphere made up mostly of a tiny amount of carbon dioxide (95.3%) plus nitrogen (2.7%), argon (1.6%) and traces of oxygen (0.15%) and water (0.03%).

When it is in the night sky, Mars is easily visible with the naked eye. A good telescope will allow the viewer to make out details, such as the famous canals.

Mars has two moons, Phobos and Deimos. Compared to our moon, these satellites are quite small. It is believed they may have been asteroids, captured into Mars orbit. Neither satellite is visible to the unaided eye, but can be viewed with a fairly decent telescope. The majority of asteroids fill a space between Mars and Jupiter known as the Asteroid Belt. The largest of these asteroids is 1 Ceres, at a whopping 578 miles across. The smallest are mere pebbles. The total mass of all the asteroids is less than that of the moon.

Although they are not visible to the naked eye, many asteroids can be viewed with binoculars or telescopes.

Our final lesson will concentrate primarily on the Outer Solar System, including the four Jovian gas giants; Jupiter, Saturn, Uranus, and Neptune as well as an unusual smaller planet called Pluto. We'll wrap up with some final information, comments, and sources for further study.

Jupiter, the fifth planet from the sun, is also the largest in our solar system. Its average distance is approximately 480 million miles, which is about five times the distance from Earth to the Sun. Unlike the terrestrial planets,

Access the universe

Jupiter is a large ball of gas, tightly condensed. It has no surface, though it may have a core composed of comet-like rock-forming minerals, but the core makes up less than 5 percent of the planet's mass, which is approximately 318 times the mass of Earth. Gravity at the top of the clouds in Jupiter's atmosphere is about 2.5 times Earth's gravity. Jupiter takes about 11.9 Earth years on its journey around the sun, and its day is only about 9.9 hours. It is the fourth brightest object in Earth's sky, after the Sun, the Moon, and Venus. It is more than three times brighter than Sirius, the brightest star, and can be seen easily with the naked eye, though binoculars or a telescope may show details, like the giant red spot, or Jupiter's rings.

The second largest planet in our solar system, **Saturn**, is the sixth from the sun. Another Jovian planet, Saturn is also primarily condensed gas, with a minute rocky core. The contraction of the planet caused the enormous pressure of Saturn's atmosphere causes so much heat, that it radiates as much into space as it receives from the sun. Saturn is perhaps best known for its rings, which are known by their letter designation, indicating when they were discovered. From the planet outward, they are D, C, B, A, F, G, and E rings, which are comprised of hundreds of thousands of ringlets.

Viewed from earth, Saturn appears as a yellowish object and can be easily viewed by the naked eye. With a telescope, the A and B rings are easily visible, and under very good conditions the D and E rings can be seen. Very strong telescopes can distinguish more rings, as well as the nine satellites of Saturn.

Uranus is the seventh most distant planet from the sun, with an average distance of 1.78 billion miles. It has a mass 14.5 times greater than Earth, with a volume that is 67 times greater. Uranus has a rocky core, completely covered with water, mixed with rocky particles. It has an atmosphere of hydrogen, helium, and methane. Despite its size, Uranus's gravity is only about 1.17 times that of Earth. A Uranus day is about 17.25 Earth hours, while its year is 84 Earth years.

Uranus was the first planet to be discovered using a telescope. Under ideal conditions, it can barely be seen with the unaided eye, but should be clearly visible with binoculars or a telescope.

Like the other "Jovian" planets, Uranus has rings, 11 that are known. It also has 15 moons discovered to date. Ten of these were discovered when Voyager 2 passed the planet in 1986.

The last of the gas giant planets in our solar system is **Neptune**, fourth largest, and usually eighth in distance from the sun. (Read about Pluto below to find out more about that.) Its composition is similar to Uranus, with a rocky core and huge ocean of water. With a mass 17 times that of Earth, it's volume is 72 times Earth's volume. Its atmosphere is composed primarily of hydrogen, helium, and minute amounts of methane. A day on Neptune lasts about 16 Earth hours, while its long journey around the sun makes its year nearly 165 Earth years.

Access the universe

Neptune is occasionally barely visible to the naked eye, and is so faint, that even with binoculars looks like a pale star. With a powerful telescope, it looks like a green disk. It has four known rings and 8 known moons. Voyager 2 also passed by Neptune in 1989, nearly ten years after it was launched. Most of what we know was learned during this pass.

Next, we come to the Kuiper Belt. Often called our Solar System's "final frontier," the Kuiper (pronounced Ki-Per) Belt is a disk-shaped region of icy debris is about 12 to 15 billion kilometers (7.5 billion to 9.3 billion miles) from our Sun.

More than 1,000 Kuiper Belt Objects (KBOs) have been identified since 1992. (They are sometimes called Edgeworth Kuiper Belt objects, acknowledging another astronomer who also is credited with the idea, or they are simply called transneptunian objects (TNOs).)

Probably the most famous of the Kuiper Belt Objects (KBOs) is Pluto, once considered a planet. Pluto was discovered by American astronomer Clyde Tombaugh in 1930, while working at Lowell Observatory in Flagstaff, AZ. The founder of the observatory, Percival Lowell had theorized that a planet beyond Neptune was affecting its orbit as well as that of Uranus. Tombaugh spent months studying images of the sky, looking for that needle in a haystack. Although Lowell was wrong about a planet affecting Uranus and Neptune's orbit, Tombaugh discovered Pluto, anyway.

After many other suggestions and much debate, the planet was named Pluto partly due to its distance from the sun, which keeps it perpetually in the dark, and partly because "PL" are the initials of Percival Lowell.

Pluto takes 248 years to orbit the Sun. Pluto's most recent close approach to the Sun was in 1989.

Between 1979 and 1999, Pluto's highly elliptical orbit brought it closer to the Sun than Neptune, providing rare opportunities to study this small, cold, distant world and its companion moon, Charon.

On August 24, 2006, the International Astronomical Union (IAU) formally downgraded Pluto from an official planet to a dwarf planet. According to the new rules a planet meets three criteria: it must orbit the Sun, it must be big enough for gravity to squash it into a round ball, and it must have cleared other things out of the way in its orbital neighborhood. The latter measure knocks out Pluto. Pluto can only be seen through large telescopes. Even the Hubble Space Telescope can only make out the largest features on Pluto. It's the only planet not yet visited by a spacecraft.

In January of 2006, the New Horizons Mission launched. It swung past Jupiter for a gravity boost and scientific studies, and reach Pluto and its moons, Charon, Nix and Hydra, in July 2015.

Access the universe

Then, as part of an extended mission, the spacecraft would head deeper into the Kuiper Belt to study one or more of the icy mini-worlds in that vast region beyond Neptune's orbit. Sending a spacecraft on this long journey will help us answer basic questions about the surface properties, geology, interior makeup and atmospheres on these bodies.

Comets and Meteors:

Comets have been known to man since we first began looking to the skies; however, it took some time to recognize patterns in these visits. Sometimes called dirty snowballs, they are a mixture of ice and dust, which have highly elliptical orbits about the sun. As a comet nears the Sun, some of the ice turns into gas, which along with the freed loose dust make up the famous tail that streams behind the comet. Comets are only visible as they near the sun. Each pass by the sun wears away more of the comet substance, which may eventually leave a rocky object similar to an asteroid. In fact, some of the asteroids in our part of the galaxy may have been comets at one time. Perhaps the most famous comet is Halley's, which returns approximately every 75 - 79 years. Meteors are basically space debris, often left behind by comets, that enters the atmosphere of the earth. The friction of the atmosphere creates tremendous heat, causing the objects to glow and appear as what is often called a shooting or falling star. Generally these objects burn up before they reach the ground, but if they make it, they are called meteorites. Those that don't get caught in the earth's gravity and pulled into the atmosphere are often called meteoroids. If you watch the sky, generally you can spot one or two meteors an hour. Occasionally, during certain peak times, like the Leonid, Lyrid, Geminid, and Perseid meteor showers, you may be able to see up to 100 per hour.

Other Help:

Another excellent **FREE** resources I use is "**One Minute Astronomy**" published by Brian Ventrudo, Ph.D. Check it out at <http://www.oneminuteastronomer.com/>

Brian says... " Many have an interest in astronomy. But few cultivate their passion for the stars. Some think astronomy is too hard. Others are swept up by day-to-day commitments and can't find time pursue their interest, always waiting for the "right time" to learn more about the night sky. But the basics of astronomy are not difficult. And it doesn't take much time to learn about the lives and deaths of stars, how to use a telescope, and the place of astronomy in our history and culture.

The philosophy behind *One-Minute Astronomer* is simple: to help you build your knowledge and appreciation of astronomy, one small step at a time. That's a worthwhile thing to do. Because when you look into the sky on a clear dark night, you challenge your intellect and imagination. You get to appreciate nature in its ultimate form. You tap into a source of peace, contemplation, and endless wonder. And you gain perspective on your own life and free yourself for a time from its day-to-day worries and constraints. So why not give *One-Minute Astronomer* a try? Because as Carl Sagan once said, "**Somewhere, something incredible is waiting to be known**" ::