Very Interesting! In addition to mathematics, physics and astronomy, Newton also had an interest in alchemy, mysticism and theology. Isaac Newton was born in 1643 in Woolsthorpe, England. His father was a wealthy, uneducated farmer who died three months before Newton was born. Newton's mother remarried and he was left in the care of his grandmother. He attended Free Grammar school. Though Newton did not excel in school, he did earn the opportunity to attend Trinity College Cambridge where he wanted to study law. His mother refused to pay for his education so while at college he worked as a servant to pay his way. Newton also kept a journal where he was able to express his ideas on various topics. He became interested in mathematics after buying a book at a fair and not understanding the math concepts it contained. Newton graduated with a bachelors degree in 1665. The further pursuit of an education was interrupted by the plague. Trinity College was closed due to the highly contagious, deadly disease. Newton went home. It was during this time that Newton started to pursue his own ideas on math, physics, optics and astronomy. By 1666 he had completed his early work on his three laws of motion. The university reopened and Newton took a fellowship in order to obtain his masters degree. As the years progressed, Newton completed his work on universal gravitation, diffraction of light, centrifugal force, centripetal force, inverse-square law, bodies in motion and the variations in tides due to gravity. His impressive body of work made him a leader in scientific research. However, in 1679 his work came to standstill after he suffered a nervous breakdown. Upon regaining his health Newton returned to the university. He became a leader against what he saw as an attack on the university by King James II. The king wanted only Roman Catholics to be in positions of power in government and academia. Newton spoke out against the king. When William of Orange drove James out of England, Newton was elected to Parliament. While in London he became more enchanted with the life of politics than the life of research. After suffering a second breakdown in 1693 Newton retired from research. He became Warden of the Royal Mint in 1696. He became Master of the Royal Mint in 1699. Newton was very instrumental in developing techniques to prevent counterfeiting of the English money. Throughout Newton's career he was torn between his desire for fame and his fear of criticism. His overwhelming fear of criticism caused him to resist immediate publication of his work. As a consequence Newton often felt compelled to defend his work against plagiarism. One such dispute arose over calculus. Though Newton had been the first to derive calculus as a mathematical approach, Gottfried Leibniz was the first one to widely disseminate the concept throughout Europe. The dispute with Leibniz dominated the last years of his life. Newton died in 1727. In 1665 Newton's education was interrupted. Why? Did you know? The Answer The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn What is the shape of the universe? Answer: One of the most profound insights of General Relativity was the conclusion that mass caused space to curve, and objects travelling in that curved space have their paths deflected, exactly as if a force had acted on them. If space itself is curved, there are three general possibilities for the geometry of the universe. Each of these possibilites is tied to the amount of mass (and thus to the total strength of gravitation) in the universe, and each implies a different past and future for the universe. First, let's look at shapes and curvatures for a two-dimensional surface. Mathematicians distinguish 3 qualitatively different classes of curvature, as illustrated in the following image: The flat surface at the left is said to have zero curvature, the spherical surface is said to have positive curvature, and the saddle-shaped surface is said to have negative curvature. The preceding is not too difficult to visualize, but General Relativity asserts that space itself (not just an object in space) can be curved, and furthermore, the space of General Relativity has 3 space-like dimensions and one time dimension, not just two as in our example above. This IS difficult to visualize! Nevertheless, it can be described mathematically by the same methods that mathematicians use to describe the 2-dimensional surfaces. So what do the three types of curvature - zero, positive, and negative -mean to the universe? If space has negative curvature, there is insufficient mass to cause the expansion of the universe to stop. In such a case, the universe has no bounds, and will expand forever. This is called an open universe. If space has no curvature (i.e, it is flat), there is exactly enough mass to cause the expansion to stop, but only after an infinite amount of time. Thus, the universe has no bounds and will also expand forever, but with the rate of expansion gradually approaching zero after an infinite amount of time. This is termed a flat universe or a Euclidian universe (because the usual geometry of non-curved surfaces that we learn in high school is called Euclidian geometry). If space has positive curvature, there is more than enough mass to stop the present expansion of the universe. The universe in this case is not infinite, but it has no end (just as the area on the surface of a sphere is not infinite but there is no point on the sphere that could be called the "end"). The expansion will eventually stop and turn into a contraction. Thus, at some point in the future the galaxies will stop receding from each other and begin approaching each other as the universe collapses on itself. This is called a closed universe. The geometry of the universe is often expressed in terms of the "density parameter", which is defined as the ratio of the actual density of the universe to the critical density that would be required to cause the expansion to stop. Thus, if the universe is flat (contains just the amount of mass to close it) the density parameter is exactly 1, if the universe is open with negative curvature the density parameter lies between 0 and 1, and if the universe is closed with positive curvature the density parameter is greater than 1. The density parameter determined from various methods such as calculating the number of baryons created in the big bang, counting stars in galaxies, and observing the dynamics of galaxies both near and far. With some rather large uncertainties, all methods point to the universe being open (i.e. the density parameter is less than one). But we need to remember that it is unlikely that we have detected all of the matter in the universe yet. The current theoretical belief (because it is predicted by the theory of cosmic inflation) is that the universe is flat, with exactly the amount of mass required to stop the expansion (the corresponding average critical density that would just stop the is called the closure density). Recent observations (such as the BOOMERANG and MAXIMA cosmic microwave background radiation results, and various supernova observations) imply that the expansion of the universe is accelerating. If so, this strongly suggests that the universe is geometrically "flat". In reality, determining the value of the density parameter and thus the ultimate fate of the universe remains one of the major unsolved problems in modern cosmology. The recently (June 30, 2001) launched MAP mission will be able to measure the value definitively within the next 5 years. The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn For very far objects (beyond about 1 billion light-years) none of the above methods work. Scientists must move from direct observation to using observations in conjunction with a theory. The theory used to determine these very great distances in the universe is based on the discovery by Edwin Hubble that the universe is expanding. In 1929, Edwin Hubble announced that almost all galaxies appeared to be moving away from us. In fact, he found that the universe was expanding - with all of the galaxies moving away from each other. This phenomenon was observed as a redshift of a galaxy's spectrum. This redshift appeared to be larger for faint, presumably further, galaxies. Hence, the farther a galaxy, the faster it is receding from Earth. You can see this trend in Hubble's data shown in the images above. The velocity of a galaxy could be expressed mathematically as v = H x d where v is the galaxy's radial outward velocity, d is the galaxy's distance from Earth, and H is the constant of proportionality called the Hubble constant. The exact value of the Hubble constant is still somewhat uncertain, but is generally believed to be around 65 kilometers per second for every megaparsec in distance. (A megaparsec is given by 1 Mpc = 3 x 106 light-years). This means that a galaxy 1 megaparsec away will be moving away from us at a speed of 65 km/sec, while another galaxy 100 megaparsecs away will be receding at 100 times this speed. So essentially, the Hubble constant reflects the rate at which the universe is expanding. So to determine an object's distance, we only need to know its velocity. Velocity is measurable thanks to the Doppler shift. By taking the spectrum of a distant object, such as a galaxy, astronomers can see a shift in the lines of its spectrum and from this shift determine its velocity. Putting this velocity into the Hubble equation, they determine the distance. Note that this method of determining distances is based on observation (the shift in the spectrum) and on a theory (Hubble's Law). If the theory is not correct, the distances determined in this way are all nonsense. Most astronomers believe that Hubble's Law does, however, hold true for a large range of distances in the universe. It should be noted that, on very large scales, Einstein's theory predicts departures from a strictly linear Hubble law. The amount of departure, and the type, depends on the value of the total mass of the universe. In this way a plot of recession velocity (or redshift) vs. distance, which is a straight line at small distances, can tell us about the total amount of matter in the universe and may provide crucial information about the mysterious dark matter. The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn Where did the Moon come from? Answer: Any theory which explains the existence of the Moon must naturally explain the following facts: The Moon's low density (3.3 g/cc) shows that it does not have a substantial iron core like the Earth does. Moon rocks contain few volatile substances (e.g. water), which implies extra baking of the lunar surface relative to that of Earth. The relative abundance of oxygen isotopes on Earth and on the Moon are identical, which suggests that the Earth and Moon formed at the same distance from the Sun. Various theories had been proposed for the formation of the Moon. Below these theories are listed along with the reasons they have since been discounted. The Fission Theory: This theory proposes that the Moon was once part of the Earth and somehow separated from the Earth early in the history of the solar system. The present Pacific Ocean basin is the most popular site for the part of the Earth from which the Moon came. This theory was thought possible since the Moon's composition resembles that of the Earth's mantle and a rapidly spinning Earth could have cast off the Moon from its outer layers. However, the present-day Earth-Moon system should contain "fossil evidence" of this rapid spin and it does not. Also, this hypothesis does not have a natural explanation for the extra baking the lunar material has received. The Capture Theory: This theory proposes that the Moon was formed somewhere else in the solar system, and was later captured by the gravitational field of the Earth. The Moon's different chemical composition could be explained if it formed elsewhere in the solar system, however, capture into the Moon's present orbit is very improbable. Something would have to slow it down by just the right amount at just the right time, and scientists are reluctant to believe in such "fine tuning". Also, this hypothesis does not have a natural explanation for the extra baking the lunar material has received. The Condensation Theory: This theory proposes that the Moon and the Earth condensed individually from the nebula that formed the solar system, with the Moon formed in orbit around the Earth. However, if the Moon formed in the vicinity of the Earth it should have nearly the same composition. Specifically, it should possess a significant iron core, and it does not. Also, this hypothesis does not have a natural explanation for the extra baking the lunar material has received. There is one theory which remains to be discussed, and it is widely accepted today. The Giant Impactor Theory (sometimes called The Ejected Ring Theory): This theory proposes that a planetesimal (or small planet) the size of Mars struck the Earth just after the formation of the solar system, ejecting large volumes of heated material from the outer layers of both objects. A disk of orbiting material was formed, and this matter eventually stuck together to form the Moon in orbit around the Earth. This theory can explain why the Moon is made mostly of rock and how the rock was excessively heated. Furthermore, we see evidence in many places in the solar system that such collisions were common late in the formative stages of the solar system. This theory is discussed further below. More About The Giant Impactor Theory In the mid-1970s, scientists proposed the giant impact scenario for the formation of the Moon. The idea was that an off-center impact of a roughly Mars-sized body with a young Earth could provide Earth with its fast initial spin, and eject enough debris into orbit to form the Moon. If the ejected material came primarily from the mantles of the Earth and the impactor, the lack of a sizeable lunar core was easily understood, and the energy of the impact could account for the extra heating of lunar material required by analysis of lunar rock samples obtained by the Apollo astronauts. For nearly a decade, the giant impact theory was not believed by most scientists. However, in 1984, a conference devoted to lunar origin prompted a critical comparison of the existing theories. The giant impact theory emerged from this conference with nearly consensus support by scientists, enhanced by new models of planet formation that suggested large impacts were actually quite common events in the late stages of terrestrial planet formation. The basic idea is this: about 4.45 billion years ago, a young planet Earth -- a mere 50 million years old at the time and not the solid object we know today-- experienced the largest impact event of its history. Another planetary body with roughly the mass of Mars had formed nearby with an orbit that placed it on a collision course with Earth. When young Earth and this rogue body collided, the energy involved was 100 million times larger than the much later event believed to have wiped out the dinosaurs. The early giant collision destroyed the rogue body, likely vaporized the upper layers of Earth's mantle, and ejected large amounts of debris into Earth orbit. Our Moon formed from this debris. Image Credit: Joe Tucciarone The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn What is gravity? Answer: We don't really know. We can define what it is as a field of influence, because we know how it operates in the universe. And some scientists think that it is made up of particles called gravitons which travel at the speed of light. However, if we are to be honest, we do not know what gravity "is" in any fundamental way - we only know how it behaves. Here is what we do know... Gravity is a force of attraction that exists between any two masses, any two bodies, any two particles. Gravity is not just the attraction between objects and the Earth. It is an attraction that exists between all objects, everywhere in the universe. Sir Isaac Newton (1642 -- 1727) discovered that a force is required to change the speed or direction of movement of an object. He also realized that the force called "gravity" must make an apple fall from a tree, or humans and animals live on the surface of our spinning planet without being flung off. Furthermore, he deduced that gravity forces exist between all objects. Newton's "law" of gravity is a mathematical description of the way bodies are observed to attract one another, based on many scientific experiments and observations. The gravitational equation says that the force of gravity is proportional to the product of the two masses (m1 and m2), and inversely proportional to the square of the distance (r) between their centers of mass. Mathematically speaking, F=Gm1m2 / r2, where G is called the Gravitational Constant. It has a value of 6.6726 x 10-11 m3 kg-1 s-2. The effect of gravity extends from each object out into space in all directions, and for an infinite distance. However, the strength of the gravitational force reduces quickly with distance. Humans are never aware of the Sun's gravity pulling them, because the pull is so small at the distance between the Earth and Sun. Yet, it is the Sun's gravity that keeps the Earth in its orbit! Neither are we aware of the pull of lunar gravity on our bodies, but the Moon's gravity is responsible for the ocean tides on Earth. The story of Isaac Newton discovering the laws of gravity by watching apples falling from a tree is probably just a myth. He did do his work on gravity while at a farm, but that is about as much as can be proven. The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn How do we know that dark matter exists? Answer: Dark matter is the name scientists have given to the particles which we believe exist in the universe, but which we cannot directly see! Dark matter was initially called "missing matter" because astronomers could not find it by observing the universe in any part of the electromagnetic spectrum. This material appears to have mass (and therefore generates gravity), but it does not appear to absorb or emit any electromagnetic radiation. Given the fact that it does not send us any light (which is how we have learned most of what we know about the universe), it is not difficult to understand that it has been hard to discover anything about the nature of these mysterious particles. But do not despair, scientists are coming up with clever new ways to probe the dark parts of the cosmos! Scientists study dark matter by looking at the effects it has on visible objects. Scientists believe that dark matter may account for the unexplained motions of stars within galaxies. Computers play an important role in the search for dark matter information. They allow scientists to create models which predict galaxy behavior. Satellites are also being used to gather dark matterinformation. In 1997, a Hubble Space Telescope image revealed light from a distant galaxy cluster being bent by another cluster in the foreground of the image. Based on the way the light was bent, scientists estimated the mass of the foreground cluster to be 250 times greater than the visible matter in the cluster. Scientists believe that dark matter in the cluster accounts for the unexplained mass. More recently, astronomers have used NASA's Chandra X-ray Observatory to make the most detaile measurement yet of the distribution of dark matter in a massive cluster of galaxies. Chandra observed a cluster of galaxies called Abell 2029 located about a billion light-years from Earth. The cluster is composed of thousands of galaxies enveloped in a gigantic cloud of hot gas, and an amount of dark matter equivalent to more than a hundred trillion Suns! The hot gas in the cluster is held in the cluster primarily by the gravity of the dark matter, so the distribution of the hot gas is determined by that of the dark matter. By precisely measuring the distribution of X-rays from the hot gas, the astronomers were able to make the best measurement yet of the distribution of dark matter near the center of a galaxy cluster. Extrapolating from their results, their results indicate that about 80 percent of the total amount of matter in the universe consists of a form of dark matter called "cold dark matter" - to distinguish it from "hot dark matter". Cold? Hot? These terms do to refer to the temperature of the particles, but to the speed at which the dark matter particles were moving when the galaxies began to form billions of years ago. According to computer models, there are two possibilities for how dark matter would have been behaving at that time depending on exactly how and when it formed. Cold dark matter would have been moving slowly by the time of galaxy formation; hot dark matter would still have been moving quickly. This composite image (Chandra X-ray image on the left and DSS optical image on the right) of the galaxy cluster Abell 2029 shows a huge hot gas cloud (as seen in X-rays) envelopes the galaxies in the cluster (the bright spots in the visible image). The cluster does not behave as scientists would expect it to if only the visible matter is generating the gravity present in the cluster. 'Dark matter' theory suggests that a huge amount of dark (invisible to direct observation) matter, interacting gravitationally with the normal, visible matter in the universe, exists. So while we still do not know the exact nature of these particles, we have at least learned that they were moving slowly at the time galaxies formed in the early universe. This is new data for the theorists to use in continuing to develop their models. The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn What is a light-year and how is it used? Answer: A light-year is a unit of distance. It is the distance that light can travel in one year. Light moves at a velocity of about 300,000 kilometers (km) each second. So in one year, it can travel about 10 trillion km. More p recisely, one light-year is equal to 9,500,000,000,000 kilometers. Why would you want such a big unit of distance? Well, on Earth, a kilometer may be just fine. It is a few hundred kilometers from New York City to Washington, DC; it is a few thousand kilometers from California to Maine. In the universe, the kilometer is just too small to be useful. For example, the distance to the next nearest big galaxy, the Andromeda Galaxy, is 21 quintillion km. That's 21,000,000,000,000,000,000 km. This is a number so large that it becomes hard to write and hard to interpret. So astronomers use other units of distance. In our solar system, we tend to describe distances in terms of the Astronomical Unit (AU). The AU is defined as the average distance between the Earth and the Sun. It is approximately 150 million km (93 million miles). Mercury can be said to be about 1/3 of an AU from the Sun and Pluto averages about 40 AU from the Sun. The AU, however, is not big enough of a unit when we start talking about distances to objects outside our solar system. For distances to other parts of the Milky Way Galaxy (or even further), astronomers use units of the light-year or the parsec . The light-year we have already defined. The parsec is equal to 3.3 light-years. Using the light-year, we can say that : The Crab supernova remnant is about 4,000 light-years away. The Milky Way Galaxy is about 150,000 light-years across. The Andromeda Galaxy is 2.3 million light-years away. The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn Listen to an audio version of this page. Sorry, your browser does not support the audio element, please consider updating. Stars Stars change over time. It may take millions to billions of years for a star to live out its life. That is a very, very long time! A star is a big ball of gas which gives off both heat and light. So where do stars come from? What happens to them as they grow older? A galaxy contains clouds of dust and gas, as well as stars. It is in the clouds of dust and gas that stars are born. As more and more of the gas (which is mostly hydrogen) is pulled together by gravity into a cloud, the cloud starts to spin. The gas atoms start to bump into each other faster and faster. This creates heat energy. The cloud gets hotter and hotter. Finally, it gets so hot within the cloud that something called "nuclear fusion" happens. The cloud begins to glow. The glowing cloud of gas is now known as a protostar. The protostar continues to grow. Once it stops growing, it is known as a main sequence star. A main sequence star can shine for millions of years or more. The amount of time it lives is determined by how big it is. Medium stars In medium size stars, after the nuclear fusion has used up all the fuel it has, gravity will pull the remaining material closer together. The star will shrink. In fact, it may get to be only a few hundred kilometers wide! The star is then called a "white dwarf". It can stay like this for a long time. Eventually, it will stop producing any light at all. It is then called a "black dwarf" and it will stay that way forever.Massive stars In large size stars, nuclear fusion will continue until iron is formed. In stars, iron acts like an energy sponge. It soaks up the star's energy. This energy is eventually released in a big explosion called a supernova. The little bit of matter that used to be at the center of the star before the supernova will then be either a neutron star or a black hole. Which object it becomes depends on the size of the original star. A star that is 1.5 to 4 times larger than our Sun will become a neutron star. Stars that are even bigger than that will become black holes. Sing me part of a song about a star! Sorry, your browser does not support the audio element, please consider updating. (Words) A Question What type of stars will become neutron stars as they are dying out? 1) Stars smaller than our Sun. 2) Stars more than 10 times larger than our Sun. 3) Stars the same size as our Sun. 4) Stars 1.5 to 4 times larger than our Sun. Show me the Level 2 version of this page. [A B C D E F G H I J K L M N O P Q R S T U V W X Y Z] A ACCREDITED An educational institution which has been recognized as maintaining standards that qualify graduates for admission to higher, or more specialized, institutions or professional practice. ASTEROID A rocky space object which can be from a few hundred feet to several hundred km wide. Most asteroids in our solar system orbit the Sun in a belt between Mars and Jupiter. ASTRONOMER An expert in the study of the Sun, Moon, stars, planets, and other space bodies. ASTRONOMICAL UNIT The approximate distance from the Sun to the Earth which is equal to 150,000,000 kilometers. ASTROPHYSICS The branch of astronomy that deals with the physics of stellar phenomena. ATMOSPHERE The layers of gases which surround a star, like our Sun, or a planet, like our Earth. AXIS An imaginary straight line around which an object rotates.B BACTERIA Living things that have only one cell and are so small they can only be seen with a microscope. BASALT A dark, fine-grained volcanic rock. BIG BANG THEORY A theory which states that the Universe began to expand after a super powerful explosion of concentrated matter and energy. BLACK HOLE The leftover core of a super massive star after a supernova. Black holes exert a tremendous gravitational pull.C CELSIUS A scale on a thermometer where the interval between the boiling point and the freezing point of water is divided into 100 degrees. Freezing point is represented by 0 degrees and boiling point is represented by 100 degrees. The same scale is also utilized in Centigrade. CENTIGRADE See CELSIUS. CHARGED PARTICLES electrons, protons, ions. COMA A hazy cloud which surrounds the nucleus of a comet. COMET Frozen masses of gas and dust which have a definite orbit through the solar system. CORONA The very hot outermost layer of a star's atmosphere. Our Sun's corona can only be seen during a total solar eclipse. COSMONAUT An astronaut from the former Soviet Union or the current republic of Russia. COSMOLOGICAL Having to do with the study of the history, structure, and changes in the universe.D DECAYING ORBIT A path around an object which decreases in size with time. For example, when a satellite enters a decaying orbit above Earth, its orbit size decreases to the point that it enters Earth's atmosphere where it burns up. DENSITY The mass per unit of volume of a substance. DOPPLER SHIFT A shift in an object's spectrum due to a change in the wavelength of light that occurs when an object is moving toward or away from Earth.E ELECTROMAGNETIC SPECTRUM The entire range of the different types of electromagnetic radiation, or waves. It goes from the very long wave, low frequency, radio waves through infrared waves and visible light waves to the very high frequency and short waves of the gamma-rays and X-rays. Those wavelengths in the visible light range have a specific color associated with them when they pass through a prism. The lower frequency, longer wavelengths produce a red while those with higher frequency, shorter wavelengths produce a violet. Those wavelengths which fall somewhere in between these two points produce the orange, yellow, green, and blue also found in a spectrum. ELECTROMAGNETIC WAVE A wave of electric and magnetic energy that is generated when an electric charge is accelerated. ELLIPTICAL Shaped like an elongated closed curve. ENERGY Usable heat or power; in physics, it is the capacity of a physical system to perform work.F FAHRENHEIT A scale on a thermometer where the freezing point of water is represented by 32 degrees and the boiling point is represented by 212 degrees. FUSION A nuclear reaction in which an element with small atoms fuses to form an element with larger atoms, releasing large amounts of energy.G GALAXY A cluster of stars, dust, and gas held together by gravity. GAMMA-RAYS Penetrating short wave electromagnetic radiation of very high frequency. GEOSYNCHRONOUS An orbit in which a satellite's rate of revolution matches the Earth's rate of rotation. This allows the satellite to stay over the same site on the Earth's surface at all times. GRAVITATIONAL FIELD The volume over which an object exerts a gravitational pull. GRAVITATIONAL FORCE See Gravity GRAVITATIONAL PULL See Gravity GRAVITY The force of attraction between two objects which is influenced by the mass of the two objects and the distance between the two objects. GYROSCOPE A heavy wheel or disk mounted so that its axis can turn freely in one or more directions. A spinning gyroscope tends to resist change in the direction of its axis.H HABITAT The place in which an organism lives and obtains the materials it needs in order to survive. HELIOCENTRIC Having the Sun as a center, such as a heliocentric solar system.I IMPACT CRATERS Craters which are the result of a collision between a large body, such as a planet or satellite, and a smaller body such as an asteroid or meteorite. INFRARED WAVES Electromagnetic radiation with long wavelengths which is found in the invisible part of the spectrum. Human beings experience infrared waves as heat. ION An electrically charged particle. Ions may be negatively or positively charged.J K KELVIN A scale for measuring temperature where 0 Kelvin is equal to -273.16 degrees Celsius. Zero Kelvin is referred to as absolute zero, the point at which all motion within molecules comes to a stop. KILOGRAM 1000grams. A kilogram equals 2.2 pounds. KILOMETER 1000 meters. A kilometer equals 0.6214 miles. KILOPARSEC 1000 parsecs. A parsec equals 3.26 light years.L LIGHT YEAR The distance light can travel in one year, which is 9,500,000,000,000 kilometers.M MAGNETIC FIELD The area in which an attractive or repelling force exists between two magnets or in association with the element iron. The Earth's magnetic field is thought to be due to the liquid iron-nickel which is in its core. This magnetic field protects Earth from constant bombardment by high-energy charged particles. MANTLE The middle layer of a planet located between the crust, or surface, and the core. MASS The measure of the amount of matter in an object. MATTER Anything which has mass and occupies space. METEOR Meteoroids which burn up in the atmosphere of a space body, such as the Earth, prior to impacting on the surface. METEORITE Fragments of material that fall from space and impact on other larger space bodies. METEOROID Fragments of material which vaporize when they have a close encounter with a space body which has an atmosphere. METRIC TON 1000 kilograms. A metric ton equals 2,204 pounds. MICROMETEOROID Very small pieces of matter which are encountered in space. MICROWAVE Electromagnetic radiation which has a long wavelength (between 1 mm and 30 cm). Microwaves can be used to study the universe, communicate with satellites in orbit around Earth, and cook popcorn. MYLAR A tough polyester material used as an insulator.N NASA The National Aeronautics and Space Administration which oversees the space program in the United States. NEBULA A low density cloud of gas and dust in which a star is born.O OORT CLOUD A huge cloud which is thought to surround our solar system and reach over halfway to the nearest star. Comets originate in the Oort Cloud. ORBIT A specific path followed by a planet, satellite, etc.P PARSEC One parsec equals 3.26 light-years. PAYLOAD BAY The main body of the Space Shuttle where the payload, or cargo, is stored. PHOTOSYNTHESIS The process by which plants use carbon dioxide, nutrients, and sunlight to produce food. PHYSICIST A person who studies physics. PHYSICS The science of matter and energy, and of interactions between the two. A person who studies physics is called a physicist. PLAINS Vast, flat areas with low elevation. PROBES Unmanned spacecraft which are launched into space in order to collect data about the solar system and beyond. Space probes are not necessarily designed to return to Earth.Q QUANTUM MECHANICS A theory in physics which is based on 2 ideas: (1) light can be emitted or absorbed only in discrete quantities called quanta, whose energy is proportional to their wavelength; and (2) you can never be exactly sure of the position and velocity of a particle, the more accurately you know the one, the less accurately you can know the other. QUASAR A distant energy source which gives off vast amounts of radiation, including radio waves and X-rays.R RADIO WAVES A type of electromagnetic radiation which has the lowest frequency, the longest wavelength, and is produced by charged particles moving back and forth. Radio waves are not blocked by clouds in the Earth's atmosphere. RETROGRADE Having a direction which is opposite that of similar bodies. REVOLUTION The circling of a smaller object around a larger object. ROTATION The spinning of an object on its axis.S SATELLITE An object that revolves around a larger primary body. Satellites may be naturally occurring, such as the Moon, or they may be man-made, such as the Hubble Space Telescope and the Compton Gamma-Ray Observatory. SILICON A non-metallic chemical element. SOLAR ECLIPSE A shadow which falls on an area of Earth when the Moon moves between the Sun and Earth. SOLAR FLARES A magnetic storm on the Sun's surface which shows up as a sudden increase in brightness. SOLAR PROMINENCES Gases trapped at the edge of the Sun which appear to shoot outward from the Sun's surface. SOLAR SYSTEM The Sun and all of the planets, comets, etc. which revolve around it. SOLAR WIND A continuous stream of charged particles which are released from the Sun and hurled outward into space at speeds up to 800 kilometers per second. Solar winds are very prominent after solar flare activity. SOLAR WINGS A panel of solar cells which converts sunlight into electrical energy. SPECTROGRAPH The image of the electromagnetic spectrum produced by a spectroscope. SPECTROSCOPE An instrument which separates visible light into its various wavelengths. Each wavelength corresponds to a specific color in the spectrum. SPECTRUM A band of colors which forms when visible light passes through a prism. The band ranges in color from violet (shorter wavelength) to red (longer wavelength). SUNSPOT A magnetic storm on the Sun's surface which appears as a dark area. A sunspot is approximately 1500 degrees Celsius cooler than it's surrounding material. The number of sunspots we see on the Sun at any given time appears to cycle every 11 years.T TECTONIC ACTIVITY A shifting of an object's surface due to changes in the material underlying the surface. TELESCOPE Any of various devices, sometimes made with an arrangement of lenses, mirrors, or both, used to detect and observe distant objects by their emission, transmission, reflection, or other interaction with invisible radiation. THERMOMETER An instrument for measuring temperature.U ULTRAVIOLET RAYS Invisible electromagnetic radiation which is comprised of very short wavelengths. Human beings get a sunburn from the ultraviolet rays emitted by the Sun. UNIVERSE The vast expanse of space which contains all of the matter and energy in existence.V VOLCANISM Volcanic activity.W X X-RAYS Penetrating electromagnetic radiation which has an extremely short wavelength.Y Z Show me the Level 1 version of this page. The StarChild site is a service of the High Energy Astrophysics Science Archive Research Center (HEASARC), within the Astrophysics Science Division (ASD) at NASA/ GSFC. StarChild Authors: The StarChild Team StarChild Graphics & Music: Acknowledgments StarChild Project Leader: Dr. Laura A. Whitlock Curator: J.D. Myers Responsible NASA Official: Amber Straughn