DOWNLOAD PDF EXPLORING THE OUTER SOLAR SYSTEM

Chapter 1 : Outer Solar System | Science Mission Directorate

Periodically, gravitational forces cause comets, such as Lovejoy seen here, to shoot from the outer solar system toward the sun where they pose a danger to Earth-bound life.

Its radiation would deliver about 3, rems per day to unshielded colonists on Io and about rems per day to unshielded colonists on Europa. Io[edit] Io is not ideal for colonization, due to its hostile environment. The moon is under influence of high tidal forces, causing high volcanic activity on the moon. The moon is also extremely dry. Io is the least ideal place for colonization of the four Galilean moons. Despite this, its volcanoes could be energy resources for the other moons, better to colonize. Colonization of Europa The magnetic field of Jupiter and coâ€"rotation enforcing currents The Artemis Project proposed a plan to colonize Europa. The report also discusses use of air pockets for human habitation. Ganymede[edit] Ganymede is the largest moon in the Solar System. Ganymede receives about 8 rem of radiation per day. It might be possible to build a surface base that would produce fuel for further exploration of the Solar System. Jupiter trojans[edit] The Keck Observatory announced in that the binary Jupiter trojan Patroclus , and possibly many other Jupiter trojans, are likely composed of water ice, with a layer of dust. This suggests that mining water and other volatiles in this region and transporting them elsewhere in the Solar System, perhaps via the proposed Interplanetary Transport Network , may be feasible in the not-so-distant future. This could make colonization of the Moon , Mercury and main-belt asteroids more practical. The Saturnian System[edit] Robert Zubrin identified Saturn , Uranus and Neptune as "the Persian Gulf of the Solar System", as the largest sources of deuterium and helium-3 to drive a fusion economy, with Saturn the most important and most valuable of the three, because of its relative proximity, low radiation, and excellent[clarification needed] system of moons. Colonization of Titan Zubrin identified Titan as possessing an abundance of all the elements necessary to support life, making Titan perhaps the most advantageous locale in the outer Solar System for colonization. He said, "In certain ways, Titan is the most hospitable extraterrestrial world within the Solar System for human colonization. The thick atmosphere and the weather, such as potential flash floods, are also factors to consider. This means liquid water could be collected much more easily and safely on Enceladus than, for instance, on Europa see above. Discovery of water, especially liquid water, generally makes a celestial body a much more likely candidate for colonization. The higher density of Enceladus indicates a larger than Saturnian average silicate core that could provide materials for base operations. Uranus[edit] Because Uranus has the lowest escape velocity of the four gas giants, it has been proposed as a mining site for helium Kuiper belt and Oort cloud[edit].

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Chapter 2 : Astronomy for Kids - calendrierdelascience.com

Our final lesson in this part of Astronomy will concentrate primarily on the outer solar system, including two gas giants; Jupiter, Saturn and the two ice giant planets Uranus, and Neptune. There's also Pluto, which is a dwarf planet, as well as other distant small worlds that remain unexplored.

Listen to this story via streaming audio, a downloadable file, or get help. Billions of kilometers from Earth, beyond the orbit of Neptune, lies perhaps the most forbidding part of our solar system, a vast realm so cold and dark it sparks a frisson of dread among thoughtful astronauts. The Sun, so cheerful and warming here on Earth, is merely the brightest star in the night sky there. A spaceship exploring the outer reaches of our solar system could go a long time without seeing much. And, indeed, for most of the past century astronomers figured there was little enough to see: Better perhaps to pass them by and head for a far-away star. Reproduced courtesy of Dave Jewitt. Lately astronomers have found that the frontier beyond Neptune, far from empty, is swarming with thousands of dark and mysterious objects -- enough to make a star-bound explorer pause for a second look. Indeed, say astronomers, it may be only a matter of time before observers spot one as big as Pluto itself. Beginning in they had doggedly scanned the heavens in search of dim objects beyond Neptune. The bright streak in this CCD image is an asteroid, faster-moving that QB1 because it lies much closer to the Sun. It was the only way, he figured, to solve a baffling mystery about comets: Some comets loop through the solar system on periodic orbits of a half-dozen years or so. They encounter the Sun so often that they quickly evaporate -- vanishing in only a few hundred thousand years. Astronomers call them "short-period comets," although "short-lived" is more to the point. It was a real puzzle. The ones beyond Neptune, Kuiper speculated, never stuck together, remaining instead primitive and individual. Nowadays they occasionally fall toward the Sun and become short-period comets. Planetesimals -- the building-blocks of planets -- were plentiful during the early days of our solar system. Are they still lurking unseen beyond the orbits of Neptune and Pluto? This painting of the early solar system appears courtesy of scientist and artist William K. Hartmann copyright , all rights reserved. It was a neat solution to the mystery, but with the arguable exception of Pluto, no one could find any members of the Kuiper Belt -- that is, until Jewitt and Luu did it in Since then astronomers have been discovering KBOs at a dizzying pace. The International Astronomical Union now catalogues of them. If you added all of them together they would form a planet about one-tenth the mass of Earth. The Kuiper Belt is about times more massive than the asteroid belt between Mars and Jupiter, he added. Finding even or so KBOs among the tens of thousands beyond Neptune is impressive. These faraway objects are surprisingly dark. The organic goop makes good camouflage against the black of space. The penetration depth of the cosmic rays into the ice could be as large as one meter. The time difference T3-T0 is approximately hundred million years. Pluto has enough mass and gravity to retain a tenuous atmosphere from which bright surface frosts may be deposited on the surface. Varuna is km wide and nearly as large as the behemoth asteroid Ceres km. But no matter, KX76 is still big, perhaps or more km across. Only the diameters of Pluto, Charon, and Varuna have been very accurately measured. Lately the technology for finding KBOs, both big and small, has become a lot more powerful. It pulls in 24 objects for the price of one. How big is KX76? To calculate the size of a Kuiper Belt Object or any heavenly body that shines by reflected sunlight three measurements are needed: The approximate distance and brightness of KX76 are known. But no one knows its reflectivity. Careful infra-red measurements of the object, as yet undone, are required for that. Classical, Scattered, and Plutinos. Click on the image to see how they are distributed. Join our growing list of subscribers - sign up for our express news delivery and you will receive a mail message every time we post a new story!!!

Chapter 3 : How Do Scientists Explore the Solar System? | Wonderopolis

Exploring Our Solar System: Planets and Space for Kids - FreeSchool Here is an in-depth introduction to the Solar System and the planets that are in it. From the sun to why poor Pluto is no.

Page 24 Share Cite Suggested Citation: A Program for Exploration, Report of a Study. The National Academies Press. The total plane- tary program should be designed to provide for progress in our understanding of: We believe that these goals remain valid with regard to the study of the outer solar system, and that all three should be recognized in the development of the program for the study of the outer solar system. The major emphasis of the program should be the study of the planets and their near en- vironments. However, spacecraft will spend many years in interplanetary space en route to the planets, and there will be the opportunity for the observation of particles and fields of the interplanetary medium during these times. We wish to emphasize that a study of the interplanetary medium contributes both to an understanding of the origin and evolution of the solar system and to the processes that shape the space environ- ment near the earth. Furthermore, flyby missions offer the possibility of out-of-the-ecliptic and even interstellar tra- jectories, and such flights will greatly enhance the under- standing of how our solar system interacts with the rest of the galaxy. The program for investigation of the outer parts of the solar system should not, in our view, be concentrated on a single goal or a single mission. Rather there should be an emphasis on those experiments and missions that contribute to the understanding of the solar system, the origin of life, and terrestrial processes. The rare opportunities for planetary voyages, the length of these voyages, their cost, and the long times required for preparing spacecraft and experiments all imply that planning for exploration of the outer solar system must take place years in advance of the actual missions. It is imperative that a decision be arrived at determining the character and scope of the program for the exploration of the solar system. We recommend that NASA in its l97l congressional budgetary presentation bring to the Congress a long-term plan for the exploration of the outer parts of the solar system. In addition, NASA should ask Congress for initial funding for a major Jupiter mission, to be discussed in greater detail below, with a target date of l It is our judgment that the current funding for planetary exploration is totally inadequate to take advantage of the opportunities available to us. Technology to place scientifically meaningful payloads near or on the planets is at hand, and the technology required for the long lifetimes and communication can be developed. We believe that we must take ad- vantage of this situation. Therefore, we fully endorse the statements with regard to funding of the previous studies and recommend that a substantially increased fraction of the total NASA budget be devoted to planetary exploration. These objectives should guide the choice of missions and experiments. In presenting the scientific objectives we recognize that missions to the outer planets provide major values other than scientific. The requirements of the missions on technology will undoubtedly stimulate advances with far-reaching consequences. We are not competent to discuss in detail either the technological consequences of voyages to the distant planets or the problems of national prestige but do note that it is important to take these considerations into account in any over-all decision. We recommend that the prime scientific objectives of the exploration of the outer solar system be: Chemical and Isotopic Composition A major problem facing all theories of the origin of the solar system is the determination of chemical composition of the material out of which the sun and the planets formed. Today the evidence is derived from spectroscopic observations of the composition of the sun, from observations of the rocks on the surface of the earth, and from the determination of the composition of meteorites. The compositions do not agree. Further, it is known that the inner planets have lost their lighter elements during their formation and subsequent evo- lution. Presently available evidence suggests that Jupiter and perhaps Saturn may have retained all elements in the same relative abundance and be much more like the primitive solar system in composition. It would appear that Uranus and Neptune differ since they are deficient in hydrogen with respect to the sun and may be deficient in helium as well. In order to identify the variations in chemical abundance, which must ob- viously be intimately related to the processes involved in I0 the origin and evolution of the solar system, it is essential to have more quantitative data on the abundances of the ele- ments of those planets that dominate by mass the planetary system. It is important to emphasize that the ratio of hydrogen to helium in Jupiter and possibly Saturn has significance that goes beyond the problems associated with understanding the origin of the solar system. Rival theories for the origin of the universe have suggested that different amounts of helium will be produced. In the "big bang" model, hydrogen and helium are produced almost immediately as part of the initial expan- sion, whereas in other cosmologies, the helium is produced by later nuclear synthesis. There is some question about whether the amount of helium observed in the sun is accurate. The val- ues currently quoted have a large uncertainty but appear to be distinctly higher than the values obtained from the observa- tions of old stars, a result that would be unacceptable to the big bang cosmology. Thus the determination of the hydrogen and helium concentration within the atmosphere of Jupiter would be of great significance to cosmology. Abundance ratios of isotopes are of great value for an understanding of the problem of element formation, a key ques- tion in cosmology. The carbon-l2 to carbon-l3 ratio is one of great interest; but other isotopic ratios less subject to change by neutron capture would be even more revealing in view of the probability that solar surface electromagnetic effects may have modified materials exterior to the sun during the early stages of solar system development. In view of these considerations, we identify as a prime objective for missions to the outer planets the determination of the relative abundance and isotopic ratios of hydrogen, he- lium, carbon, and heavy elements up to mass 40 in the atmos- pheres of all the outer planets. Origin and Evolution of Life It is commonly assumed that conditions on the primitive earth were very different from those presently obtained. There is some disagreement over the details, but it is generally suppos- ed that during this early period the terrestrial atmosphere was highly reducing, consisting primarily of methane and ammonia. Chemical reactions in this atmosphere were stimulated by solar ultraviolet radiation, electrical discharges, and local sources of planetary thermal energy. The initial result of these re- actions is assumed to be complex organic molecules such as amino acids that are necessary precursors to life itself. Under con- ditions that developed on earth, the progression of complexity continued to the level of formation of limited living organisms and ultimately the wide diffusion of life we now observe. It is already known that conditions in the atmosphere of Jupiter are very similar to this hypothetical model for the primitive earth. A logical first step in the investigation of the outer planets from the biological point of view would be further investigation of the atmospheres to determine how fav- orable conditions are for the abiogenic formation of organic compounds. Are there warm regions in the lower atmospheres? Are electrical discharges present? What solvents are available? What chemical reactions are occurring in the upper atmosphere? The next step in sophistication is a search for the com- plex organic substances themselves. It has already been sug- gested that some of the coloring matter observed in the Jovian atmosphere could be organic polymers dissolved in the cloud material. Laboratory experiments using mixtures of methane and ammonia, subjected to electrical discharges, have produced col- ored substances, thereby lending support to this interpretation. An unequivocal identification has not yet been achieved. To finally resolve these ambiguities it is essential to probe the atmosphere of these planets and make in situ measurements. A prime objective of outer planetary exploration is, therefore, the characterization of lower atmospheric environments in terms of biologically significant parameters and a search for and an identification of organic substances of importance to life. Atmospheric Circulation We would like to understand the terrestrial atmosphere much better than we do. The usual way of acquiring an understand- ing of a physical system is to do experiments on it. If it were unique, we would be stuck. But fortunately, there are other planets around, in fact at least three others that are reasonably accessible, so we have at least four examples of atmospheres to work with. While we still cannot do exper- iments, we can do the next best thing, which is to observe several atmospheres of different scale, structure, and compo- I2 sition, and thus acquire a deeper understanding of atmospheres in general, and ours in particular. Studies of motions in the atmosphere of Jupiter have re- cently begun to achieve a quantitative status and are leading to new ideas about the behavior of rapidly rotating atmospheres and the interaction of clouds and planetary motions. Recent developments in the study of the atmosphere of Venus have led to a new understanding of the circulation originally proposed many years ago by Hadley for the earth; current work on the diurnal circulations on Mars is leading to a fresh appreciation of diurnal effects in terrestrial boundary layers. We may anticipate benefits of a similar nature to meteorology and to other branches of atmospheric physics from the studies of the atmosphere of Jupiter and the other outer planets. An object- ive of the exploration program should be the study of the dy- namics of the atmospheres of the major planets. The energy source driving the motions is unknown. They may be due to internal thermal sources or to the external torques due to the moon. The moon, Venus, and Mars do not possess a magnetic field of internal origin. It is not clear whether the absence of a magnetic field on Venus is due to the lack of rotation or lack of a satellite, while the absence of electrically conducting materials in the in- terior of the moon and Mars is generally thought to explain the lack of a magnetic field on these bodies. Jupiter has a very strong magnetic field as is evidenced by radio emissions from high-energy particles trapped by the field. The source of the field on Jupiter is not known; it could be in the deep interior or in an electrically conducting outer shell. Jupiter is the only planet, other than the earth, known to have belts of electrically charged particles temporarily trapped by the external magnetic field of the planet. Radia- tion belts were discovered by in situ observations with a Geiger-MUller tube flown on the first American satellite, Explorer I. Those of Jupiter were identified shortly there- after by the analysis of the nonthermal decimetric radio noise of that planet. The moon, Venus, and Mars do not have radia- tion belts. It is not known whether the other major planets have magnetic fields or trapped radiation since nonthermal I3 radio emissions from these planets have not been observed. Detailed observation of the magnetic fields and radiation belts at the planets will provide information vital to the understanding of these planetary phenomena. Because of this, a prime objective of the exploration of the outer solar system should be a detailed study of the external magnetic field and charged-particle populations in the vicinity of the major planets. This information will be most valuable if concomi- tant observations of the nonthermal radio emissions origina- ting through cooperative phenomena are made in situ. Interaction of the Solar Wind with the Outer Planets and of Their Satellites with Their Magnetospheres Three examples of flow of magnetized solar plasma past a dense body in the solar system have been studied. In the case of the earth, the external magnetic field dominates the situation and the solar wind is held off at a great distance from the earth by its magnetic field. In the case of the moon, which has no intrinsic field,. In the case of Venus, which has little if any magnetic field but does have a highly conducting ionosphere, the magnetic field of the solar wind cannot quickly penetrate the ionosphere and the solar wind does not flow unimpeded into the atmosphere. The solar wind flows around Venus, and there is evidence for a wake on the downstream side of that planet. It is of great interest to learn whether the solar-wind flow past other planets and their satellites can be classified as one of those three types or whether there are new and sur- prising modes of interaction. The Nature of the Solar Wind and Magnetic Fields at Great Distances The solar wind cannot continue to flow outward from the sun to indefinite distances. Somewhere it must merge into the inter- stellar gas and the galactic magnetic field. This transition zone joining the solar system with the rest of the galaxy is of great interest. The zone should not be regular in its plasma properties and magnetic fields, and there may be substantial fluxes of energetic particles covering a great range of energies. The study of these interactions can lead to major advances in the understanding of plasma physics. Further advances in the understanding of plasma physics can be expected from clarification of the role played by large- scale coherence in natural radio emissions from the planets. Galactic and Solar Cosmic Rays Knowledge of the composition and energy spectrum of galactic cosmic rays is of considerable importance in the understanding of a wide range of cosmological phenomena, including the origin of the elements. The understanding of galactic cosmic rays will be very much enhanced by observation in a location un- affected by the solar magnetic fields and free of energetic solar particles that are so abundant at l AU in the plane of the ecliptic. These kinds of observations are needed if we are to untangle the effects of local magnetic fields on the properties of the cosmic rays. We recommend that space- craft of this class and capability be maintained and utilized as appropriate for further missions. Further exploration of the outer solar system will require larger scientific payloads and much more sophisticated instru- mentation. We recommend the following missions in order of scientific significance: Jupiter deep entry probe and flyby.

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Chapter 4 : NASA: 60 Years and Counting - Exploring Our Solar System

Pioneer and Voyager: The Outer Solar System and Beyond Two series of spacecraft led the way in NASA's exploration of the outer solar system: Pioneer and Voyager. Although there were Pioneer flights to the Sun and Venus, the best known were Pioneer 10 and 11, which made NASA's first visits to Saturn and Jupiter in

September 30, Currently, there are several active missions led by NASA as well as other space agencies exploring planets and other rocky objects in the solar system. For example, the Juno probe is studying Jupiter, and the Curiosity rover is exploring Mars. Planned missions to Mars, Mercury, Jupiter and other celestial bodies in our solar system and beyond are also in the works. The Mars rover will use a drill to collect core samples of rocks and soils, and then examine those samples on a microscopic level to search for biosignatures, or chemicals that could be indicative of ancient life on the Red Planet. The Mars drill will probe much deeper into the Martian surface than the drill on Curiosity. Samples collected by the Mars rover could potentially be returned to Earth in a future mission. Three potential landing sites have been selected and include an ancient lake bed called the Jezero crater, the edge of the Syrtis Major volcanoes and a hot-spring site called Columbia Hills. Mission scientists hope that, after it touches down on the Red Planet, the rover will explore the Martian surface for two years. This mission offers a unique opportunity to prepare for future human exploration of Mars, mission team members have said. Once it has landed on the Red Planet, the probe will spend a full Mars year Earth days surveying its surroundings. The ExoMars rover mission is designed to search for signs of ancient life that may have once existed on Mars. The golf-cart-size rover will be equipped with a drill to collect samples, as well as a panoramic camera system for stereoscopic imaging and ground-penetrating radar to search for ice beneath the Martian surface. The ExoMars rover is scheduled to launch in the spring of The probe is expected to launch in and later settle into orbit around Jupiter in Europa, Callisto and Ganymede. The mission includes a carrier spacecraft called the Mercury Transfer Module MTM â€" which supplies electrical power during interplanetary cruising â€" and two separate orbiters: The spacecraft will take about seven years to get into orbit around Mercury, using several gravity assists from Earth and Venus. The mission will perform 24 close flybys of the sun â€" some of which will bring the spacecraft within just 3. The spacecraft will include an orbiter, a lander, an ascender and an Earth re-entry module. Google Lunar X Prize The Google Lunar X Prize is an international challenge to land a robot on the lunar surface , have it travel at least 1, feet meters , and send high-definition photos and videos back to Earth. To qualify for the Lunar X Prize, teams must complete their lunar missions by March 31, The mission launched on Sept. Asteroids are leftovers from the formation of planets and carry blueprints of the early solar system. Samples collected from Bennu will therefore help astronomers learn more about the evolution of our solar system and how planets formed. The spacecraft launched on Dec. Hayabusa2 will spend a year studying the asteroid before collecting samples to return to Earth in December The asteroid, called 16 Psyche, is located in the belt between Mars and Jupiter. Therefore, learning more about this asteroid will help scientists better understand the cores of Earth, Mars, Mercury and Venus. The mission provided the first-ever up-close view of Pluto, revealing new details about its icy surface and largest moon, Charon. Since accomplishing this amazing feat, the probe is still going strong and is set on a new object deeper in the Kuiper Belt, located approximately 1 billion miles 1. This ancient object is also expected to help paint a clearer picture of what the early solar system was like. The probe and its twin, Voyager 2, are still in contact with Earth. The twin spacecraft launched two weeks apart in â€" Voyager 2 on Aug. Over the course of the mission, the Voyager probes have captured up-close views of Jupiter, Saturn, Uranus, Neptune and many of the moons of these giant planets. In August , Voyager 1 became the first spacecraft ever to reach interstellar space , and Voyager 2 is currently flying through the bubble of solar material that marks the boundary between the solar system and interstellar space. Original article on Space.

Chapter 5 : Exploring the Outer Solar System | The Colorado Chautauqua Association

The subtitle is "Exploring and Settling the Outer Solar System". By page count, the emphasis is on the exploring part. Out of a total of pages, the first are devoted to the exploration of the outer planets up to the present.

Students will understand the scientific evidence that supports theories that explain how the universe and the solar system developed. They will compare Earth to other objects in the solar system. Analyze Earth as part of the solar system, which is part of the Milky Way galaxy. Evaluate the conditions that currently support life on Earth biosphere and compare them to the conditions that exist on other planets and moons in the solar system e. Introduction Size comparison on the four outer planets known as the gas giants. These are the four planets farthest from the Sun. The outer planets are much larger than the inner planets and share much in common with regards to their composition. These planets are often referred to as the Gas Giants. Like the inner solar system, there are bits and pieces of materials scattered around. The Kuiper Belt contains dwarf planets, comets, and asteroids while the Oort cloud is almost primarily made up of comets. In the outer solar system, water is abundant. Much of it is locked away in icy comets floating around in the Oort cloud. Astronomers think that most of the nebula was hydrogen and helium. The inner planets lost these very light gases. Currently we have discovered some very large gas giants very close to their star in other solar systems. The ideas of why our inner planets lack these gasses while the outer planets have an abundance are being challenged. Graph showing escape velocity needed by atoms to escape the gravity of each planet graphed temperature. When the Sun and planets were beginning their formation the inner solar system was very hot. Some estimates put this temperature at 2, Kelvin 3, F. At this temperature lighter elements would have defiantly been in the gaseous phase and possibly had enough molecular energy to escape the gravity of the small inner planets. The more mass a planet has, the more gravity it has. The more gravity, the hotter the planet can be before it begins to loose lighter elements like hydrogen, helium and others. For example, according to the graph, Pluto would not be able to hold on to much atmosphere at all if it were to be as close to the Sun as we are. Jupiter by contrast, could get very hot and still be able to hold on to hydrogen because of its immense gravity. Another idea involves the solar winds. You might know that there is no actual wind in space like there is down here on Earth. That is because space is a vacuum. There is no air in space to move around like there is here. A solar wind consists of charged particles and energy that are ejected from the Sun at tremendous speeds. This idea could explain very well why Mercury has nearly no atmosphere being so close to the Sun often subject to the brunt of most of the solar flares. Jupiter, being the largest of all eight planets, lives up to its name, so to speak. Jupiter is quite far from the Earth. The planet is more than five times as far from the Sun as Earth. Despite this, Jupiter is still the third brightest object in the night sky after the Moon and Venus. Jupiter is made mostly of hydrogen, with some helium, and small amounts of other elements. The outer layers of the planet are gas. Since Jupiter is a gas giant, do you think a spacecraft could land on its surface? The answer is no. There is no solid surface at all! Deeper within the planet, the intense pressure condenses the gases into a liquid called metallic hydrogen. At the core of Jupiter, it is believed that there is a rocky core made out of similar materials as the inner planets. Close up shot from the Cassini spacecraft as it flew by Jupiter on its way to Saturn. There are also small amounts of other gases that contain hydrogen, like methane, ammonia and water vapor. This is what creates the different colors we see. The Great Red Spot is an enormous, oval-shaped storm, a hurricane. Clouds in the storm rotate counterclockwise. They make one complete turn every six days or so. The Great Red Spot has been on Jupiter for at least years. It may have been observed as early as It is possible that this storm is a permanent feature on Jupiter. No one knows for sure. Launched in , Voyager has been imaging the solar system and sending its data back to Earth. Currently Voyager 1 is flying out past our solar system into space. It is estimated to last until where it will lack sufficient power to send message back to Earth. Photos from the Voyager missions showed that Jupiter has a ring system. This ring system is very faint, so it is very difficult to observe from Earth. Jupiter has lots of moons. As of , we have discovered over 67 natural satellites of Jupiter. Four are big enough and bright enough to be seen from Earth using a pair of binoculars. These four moons were first discovered by Galileo in They are called the Galilean moons. These moons are named Io, Europa, Ganymede, and Callisto. The Galilean moons are larger than even the biggest dwarf planets, Pluto and Eris. Actual distance not shown in image. Kevin Gill, Feb First discovered in by Galileo with his primitive telescope. They are significant to the developing story of our understanding of the Universe and how it works. This observation was the first real proof that objects could orbit something other than our own home planet, Earth. The Galilean moons are as large as small planets. Europa is the smallest of the Galilean moons. This is exciting because we believe there is a possibility of life here. Io contains over active volcanoes giving it the distinction of being the most geologically active volcano in the entire solar system. Io is yellow because the surface is covered with sulfur and sulfur dioxides. Io orbits Jupiter very closely. Enough where tidal forces on the moon from Jupiter cause the planet to be very hot inside. Ganymede is the biggest moon in the solar system. It is even larger than the planet Mercury! In fact it is the 9th largest object in the solar system. Ganymede is a rocky moon with a vast ocean that may contain more water than the oceans of Earth. The dark line on the planet is a shadow cast by the rings of this massive gas giant. Here you can see the rings shining in the light of the sun. The distant point of light that can be see just right of the middle of the photo is Earth. Jason Major, Jul Saturn is famous for its beautiful rings. The rings are so reflective that they can be seen with a regular telescope from Earth. The rings appear tilted. The Voyager 1 spacecraft visited Saturn in Voyager 2 followed in These probes sent back detailed pictures of Saturn, its rings, and some of its moons. The Cassini spacecraft has been in orbit around Saturn since From the Voyager and Cassini data, we learned what the rings were made of and discovered that there are several gaps in the rings. Despite its large size, Saturn is the least dense planet in our solar system. Saturn is actually less dense than water. In Roman mythology, Saturn was the father of Jupiter. Saturn orbits the Sun once about every 30 Earth years. The planet is made mostly of hydrogen and helium. These elements are gases in the outer layers and liquids in the deeper layers. Saturn may also have a small solid rocky core. These clouds rotate rapidly around the planet. But Saturn has fewer storms than Jupiter. Photo from Cassini spacecraft showing Saturn with a few of its moons in view.

Chapter 6 : After Cassini: 14 Epic Planetary Science Missions to Get Excited About

Outer Solar System proposes a program for the exploration of the outer reaches of the solar system in the years to Of course, the technological requirements of the many-year missions and the vast distances represent new and difficult challenges in many technological areas such as communication, reliability, and miniaturization.

How have they changed? Is there life out there? Over the last 60 years, NASA has launched a variety of spacecraft to explore our solar system. The Moon, the closest celestial body to Earth, was the logical first target. Subsequent fleets of space probes started exploring other planetsâ€"those relatively close and those in the more distant reaches of our solar systemâ€"as well as comets, asteroids, and other small bodies. Satellite communication stations on Earth make these flights into deep space possible. The missions are providing insights into the physical nature, chemistry, and biology of worlds outside of ours. They will help inform future searches for life beyond Earth and opportunities for human exploration and habitation. Mariner missions in the s flew by Mars, taking as many pictures as possible. Orbiters with landers came next. The Viking 1 lander took this photograph shortly after it touched down on Mars. The primary objectives of the Viking mission, which was composed of two spacecraft, were to obtain high-resolution images of the Martian surface, characterize the structure and composition of the atmosphere and surface, and search for evidence of life on Mars. The selfie was compiled from many smaller images, which is why the mechanical arm holding the camera is not visibleâ€"although its shadow is! The image also shows dark layered rocks, the light colored peak of Mount Sharp, and the rusting red sand that pervades Mars. The strata in the foreground dip towards the base of Mount Sharp, indicating flow of water toward a basin that existed before the larger bulk of the mountain formed. Voyager 1 and 2 also made observations of Jupiter and Saturn, and in the s Voyager 2 became the first spacecraft to fly by Uranus and Neptune. Pioneer 10 was the first spacecraft to travel beyond the orbit of the farthest planet, and in Voyager 1 became the first human-made object to reach interstellar space. NASA Pioneer Plaque In addition carrying images of itself and two humans, the plaque mounted aboard Pioneer 10 and 11 showed where an alien civilization could look for Earth. NASA Golden Record Recognizing that the Voyager spacecraft might on some distant day cross paths with an alien civilization, scientists placed a disk on each craft containing information about where Earth is located. Uranus as seen by Voyager 2 Image Credit: It also discovered 11 moons and two rings that had been previously undetected. The temperature of the equatorial region, which receives less sunlight over a Uranian year, is nevertheless about the same as that at the poles The Moon Since NASA first set its sights on the Moon 60 years ago, newer planetary probes continually improve what we can see and learn. The Lunar Reconnaissance Orbiter LRO , launched in , is providing information that will prove useful for future exploration of the Moon. It shows the surface shape and features over nearly the entire moon with a pixel scale close to feet. At about 89, miles in diameter, Jupiter, the largest planet in the solar system, could swallow 1, Earths. The spot is a storm three and a half times the size of our planet. Long, linear cracks and ridges that crisscross the surface indicate disrupted terrain where the surface ice crust has been broken up and re-frozen into new patterns. Cassini-Huygens Cassini was a sophisticated spacecraft that explored the Saturnian system from to Titan is the only moon in our solar system that has clouds and a dense atmosphere, mostly made of nitrogen and methane. It is also the only other place in the solar system known to have an earthlike cycle of liquids evaporating, raining, and flowing across its surface. But on Titan, instead of water, the clouds, rain, rivers, seas, and lakes are made of liquid hydrocarbons. Vesta is a rocky body, while Ceres is believed to contain large quantities of ice. The set of three craters known as the "snowman" can be seen at the top left. New Horizons at Pluto Launched on Jan. After a swing past Jupiter for a gravity boost and scientific studies, the spacecraft conducted a six-month flyby study of Pluto and its moons in The mission will help scientists investigate how planets formed and how life began, as well as improve our understanding of asteroids that could impact Earth. Simulated-color radar image of Venus from Magellan data Image Credit: The data showed a planet with covered with volcanic flows, but with no evidence of plate tectonics. It has been capturing images of dynamic solar eruptionsâ€"such as solar flares and coronal mass ejectionsâ€"since In addition to watching our star, SOHO has become the most prolific discoverer of comets in astronomical history: A solar flare seen in different wavelengths by instruments aboard the Solar Dynamics Observatory. The mission studies what creates solar activity that causes various space weather effects. Deep Space Network Image Credit: Three satellite stations, each placed a third of the way around the globe, ensure that any satellite in deep space is able to communicate with at least one station at all times.

Chapter 7 : NASA Spacecraft Ready To Explore Outer Solar System | NASA

Many parts of the outer Solar System have been considered for possible future colonization. Most of the larger moons of the outer planets contain water ice, liquid water, and organic compounds that might be useful for sustaining human life.

Chapter 8 : Outer Solar System: A Program for Exploration, Report of a Study | The National Academies P

The story of the outer solar system began to unfold when the Voyager 1 and Voyager 2 spacecrafts left the inner solar system and headed out toward the boundary between our solar system and interstellar space.

Chapter 9 : Exploring the Planets | National Air and Space Museum

In the past few years, planetary scientists have learned that some of the moons around the solar system's biggest planets are full of water.