Exploration of the Planets – 1971

Narrator: For thousands of years, man observed the rising and setting Sun, the cycle of seasons, the fixed stars, and those he called wanderers, or planets. And from these observations evolved his notions of the universe. The naked eye extended its vision through instruments that saw the craters on the Moon, the changing colors of Mars, and the rings of Saturn. The fantasies, dreams, and visions of space travel became the reality of Apollo.

Early in 1970, President Nixon announced the objectives of a balanced space program for the United States that would include the scientific investigation of all the planets in the solar system. Of the nine planets circling the Sun, only the Earth is known to us at firsthand. But observational techniques on Earth and in space have given us some idea of the appearance and movement of the planets. And enable us to depict their physical characteristics in some detail.

Mercury, only slightly larger than the Moon, is so close to the Sun that it is difficult to observe by telescope. It is believed to be one large cinder, with no atmosphere and a day-night temperature range of nearly 1,000 degrees. Venus is perpetually cloud-covered. Spacecraft report a surface temperature of 900 degrees Fahrenheit and an atmospheric pressure 100 times greater than Earth's. We can only guess what the surface is like, possibly a seething netherworld beneath a crushing, poisonous carbon dioxide atmosphere. Of Mars, the Red Planet, we have evidence of its cratered surface, photographed by the Mariner spacecraft. In this painting of the planet seen from its inner moon, dust storms sweep the rust-colored surface. Jupiter, nearly half a billion miles from the Sun, is the largest of the planets, larger than 1300 Earths. It outweighs all the other planets, moons, and debris in the solar system combined. Saturn, encircled by a halo of brilliant white rings, is the second largest planet and is twice as far away as Jupiter. In this rendering, Saturn is seen from its moon Titan. Uranus is a pale blue-green ball two billion miles from Earth traveling a great orbital arc in the intense cold and darkness of the outer solar system. Neptune is the farthest of the giant planets, so far from Earth that no features have ever been seen or photographed. Here Neptune floats above Triton, one of its two moons. Pluto, nearly four billion miles away, is probably a snow-covered rock in the dim light of a remote Sun.

Only once every 175 years are the major planets – Jupiter, Saturn, Uranus, and Neptune – so aligned that a spacecraft can visit all four on a single flight. The last such planetary arrangement occurred in 1800, when Thomas Jefferson was elected president and the development of the cotton gin stood at the forefront of American technology. The rare opportunity to probe these planets occurs in this decade, the 1970s, and will not recur until the middle of the twenty-second century.

Until the flyby of Mariner 4 in 1965, it was thought that Mars was much like the Earth. But the photographs of the Martian surface reveal that the planet was more like the Moon. Later missions photographed more than 2,000 miles of craters. In fact, the famed canals, once believed by some to be the work of intelligent creatures, proved to be chains of craters. This bright Martian desert either escaped the devastation of meteorite bombardment or was smoothed by some powerful eroding process. Yet Mars apparently has no running water that cuts and fills, so the scouring agent was more likely a wind-borne material. Another Marscape called chaotic terrain brought more surprises to scientists and more questions to be answered. It appears as a maze-like region of jumbled ridges and steep ravines.

That Mars is a world of contrasts we now know. The newly acquired knowledge has only whetted man's appetite for continued and more thorough investigations of Mars. The early Mariners flew within several thousand miles of the Martian surface, gathering and sending to Earth TV pictures and measurements of temperatures, pressures, and atmospheric and surface chemical composition. The exploration of Mars takes on a major new aspect in the present decade with the intensive investigations by the Mariner 9 orbiter and the Viking landing missions.

Mariner 9 is designed to operate in Mars' orbit for a minimum of three months. Its science experiments are similar to those made two years earlier, but data will be gathered over a much longer period. The single 2200-pound spacecraft is capable of performing much of the mission originally planned for two orbiting Mariners. It arrives at Mars after a 5 ½ month flight from Cape Kennedy and powers its way into an orbit that takes it around Mars once every 12 hours. Primarily a mapping mission, the Mariner television cameras photograph about 80 percent of the planet. Thermo and chemical maps of the same areas are made with data from other instruments. The overlapping wide angle and spot-coverage narrow angle pictures are taken at Mariner 9's lowest altitude, about 750 miles. Objects as small as 300 feet across may be seen in the pictures. Mariner's orbit was designed to produce a continuous swathe around Mars once each 17 days, making it possible to study seasonal effects on the Red Planet at 17-day intervals. One objective is to investigate what appears to be a wave of darkening that originates at the poles and spreads toward the equator as the polar caps recede, apparently responding to springtime increases in temperature and humidity. During the 90-day period, Mariner 9 transmits to Earth thousands of pictures and several billion other science measurements.

Much of this information will be used in planning the 1975 Viking Lander mission to Mars. One of the most important and dramatic investigations to be conducted during the next 10 years is the search for life beyond Earth. If extraterrestrial life does exist in the solar system, it is most likely on Mars. For that reason, Mars remains the prime target of the planetary exploration program. The Viking Landers will carry life detection instruments right to the surface of Mars for some firsthand fieldwork. The two Vikings are double spacecraft, orbiters similar to Mariner 9 and landers sealed inside biocanisters and sterilized to prevent Earth microbes from reaching Mars and complicating the search for life. The Lander will touchdown gently, then prepare itself for an onsite scientific investigation of the planet. Viking will tell its story in its own voice about its observations on Mars, about the surface, the velocity of the wind, the humidity and pressure of the thin atmosphere, and most important, whether there is any evidence of life now or in the past. Meanwhile, the orbiter remains overhead, keeping watch on the landing site, operating as a relay station, and conducting its own science experiments and photographic mapping. Their missions completed, the Orbiters will continue circling the planet with Martian moons Phobos and Deimos for many years. The Viking surface laboratories will remain and may provide landmarks for the first Earth men who visit Mars, just as Surveyor stood in wait of the Apollo astronauts.

To astronomers, Venus has been perhaps the most frustrating object in the skies. The most powerful telescope on Earth cannot penetrate the dense cloud cover that hides its surface features. In 1973 another Mariner, tenth in the series, will set out for Venus, this time to continue on to Mercury, the Sun's innermost and smallest satellite. The spacecraft will be the first to use a natural resource of the solar system, the gravity of one of its planets, to help it reach another planet. Venus will change Mariners speed and flight path, aim it at Mercury, and make it possible to explore two planets for the price of one. The spacecraft will skim past Venus at an altitude of about 3,000 miles, make an abrupt turn, and encounter Mercury on its altered trajectory.

A pair of television cameras will take several thousand pictures of each planet; both will be equipped with powerful telescopes. Other instruments will analyze the solar wind, a perpetual flow of low energy particles from the Sun, producing a kind of interplanetary weather; high energy charged particles that bombard the planets and vary in intensity as the Sun rages and subsides; temperatures of the cloud tops at Venus; and the structure and composition of the planet's upper atmosphere.

As the spacecraft approaches Venus, the planet is almost between the Sun and Mariner. Only a slender, lighted crescent is visible. The crescent grows as the two TV cameras alternately take pictures, beginning about 25 minutes and 10,000 miles from Venus. Cloud motion, cloud layer separation, and sunrise and sunset on the planet will be studied in the pictures. Scientists are hopeful that the Venus pictures may show a glimpse of the surface through a hole in the apparently solid blanket of clouds. Thus far, only radar beams from Earth have been able to penetrate the cloud layer. Bright spots in this radar map, made in 1969, may be mountain ranges or possibly huge depressions.

Mercury travels a tight three-month orbit around the Sun. Just a few years ago, it was thought that Mercury's rotational and orbital rates were synchronous, that is one day equals one year with the same side always facing the Sun. But recent radar astronomy has shown that the tiny planet rotates 1 ½ times each orbit. Mariner's high resolution pictures of Mercury will cover the planet something like this during the first hour after encounter, and like this during the following hour. Experimenters studying Mercury may receive a substantial science bonus. Six months after Mariner flies by the planet, while Mercury swings twice around the Sun, Mariner will have gone one full circle and the two again cross paths. This time scientists will view the planet from a different angle, looking down at the north pole. These computer generated plots show how Mercury will appear to the passing Mariner.

Early in this decade, the United States will make the first reconnaissance flights to Jupiter in a search for basic facts about the giant gas ball and some clues to the origin of the solar system. Two spacecraft called Pioneers begin their long voyages in 1972 and 1973. Thirteen science experiments will study the uncharted regions of space beyond the orbit of Mars during the 600- to 900-day flights. The Pioneers will spend six months to a year crossing the asteroid belt, a vast no man's land of space debris that orbits the Sun between Mars and Jupiter.

The asteroid belt is 150 million miles wide. Several thousand asteroids are large enough to be assigned numbers, and some even names. An objective of the Pioneer mission is to determine the risk factor involved in traversing the belt. Mission planners believe the chance of being struck by a particle large enough to jeopardize the mission is quite low. Sizes and numbers of particles will be measured by counting penetrations of these cells. Four telescopes will observe the brightness, speed, and direction of asteroids. Another instrument will measure sunlight reflected from asteroids and cosmic dust. A continuous stream of information will be transmitted back to scientists: measurements of interplanetary magnetic fields, the solar wind, galactic and solar protons and electrons, and the elements that make up cosmic ray particles. Even at the speed of light, these messages take nearly three quarters of an hour to reach Earth.

Pioneer will pass within 100,000 miles of Jupiter, increasing in velocity as it feels the pull of the planet's enormous gravity. From here, Jupiter fills the sky, colorful in stripes of pink and blue, pale grays, browns, and yellows. Scientists want to know what chemicals produce these colors, why a planet so large can rotate more than twice as fast as Earth, whether it has a solid surface below the seething layers of clouds, and why Jupiter radiates three times the energy it receives from the Sun. What causes the enormous red spot several times the diameter of Earth? And why does the dark red oval float at random with respect to the planet's motion? Conditions on Jupiter today may be very much like those most scientists think existed on primitive Earth several billion years ago when life began. Pioneer experimenters will attempt to establish proportions of some of the elements that make up this primeval atmosphere. Instruments will measure Jupiter's magnetic field and trapped radiation, both believed to be many times as strong as those on Earth. Temperatures, which may range from minus 200 degrees at cloud tops to thousands of degrees above zero in the interior, will be measured. A comfortable zone may exist somewhere in the atmosphere.

After its swing by Jupiter, one Pioneer will eventually escape the solar system, the first man-made object to do so. And the other may leave the plane in which the planets orbit the Sun, passing millions of miles above the orbits of the inner planets. What we learn about the gravitational effects of Jupiter will be used in planning multi-planet missions to the outer planets in the last half of the decade.

Observations made with Earth telescopes have provided only tantalizing bits of information about the far-ranging outer planets. We look to spaceflight for some of the answers.

Saturn is the only planet with rings. Why? When were they formed? Are the rings the remnants of a former Saturnian moon? Or are they made up of tiny ice crystals? The thickness of the rings has been estimated to be anywhere from a few inches to a few miles.

On Uranus, seasons of the year must be odd in the extreme. The planet's rotational axis is in the plane of its orbit around the Sun, making Uranus appear to lie on its side. Each pole is in sunlight for 42 years, then remains in chill darkness during the other half of its 84-year orbit.

Neptune is virtually unknown. It is about the size of Uranus, abides near the frigid edge of the solar system, and is circled by two moons. One, Triton, is almost as large as the planet Pluto. It has been suggested that Pluto may be an escaped moon of Neptune.

Moons abound in the regimes of the outer planets. Jupiter alone has 12; four of them are large enough to have been discovered by Galileo's simple telescope and are called the Galilean satellites. They are Io; Europa; Ganymede, larger than the planet Mercury; and Callisto, larger than Earth's Moon. Io is distinctly orange and appears to be brighter when it emerges from Jupiter's shadow than when it goes into eclipse. Saturn has 10 moons. One, Titan, is larger than Earth's Moon and is known to have an atmosphere. Overhead, Titan's sky may be like Earth's, blue instead of black. Another Saturnian moon, Iapetus, could be the strangest of all; it varies in brightness as it orbits Saturn, six times brighter on one side of the planet than on the other. Why? No one can explain.

If a spacecraft were launched from Earth directly to Neptune or Pluto, the journey would take 30 years. But there is an intriguing indirect way of getting to the most remote precincts of the solar system in less than one-third that time. Jupiter is the key. Its immense gravity adds momentum to a passing spacecraft, slinging it towards the next planet in a multi-planet tour. The spacecraft virtually steals a bit of energy from Jupiter, which will never be missed. Using this technique, engineers and scientists are planning missions to explore all of the outer planets during the 1970s and 1980s. These missions, each directed toward three planets, so that all five outer planets will be visited, are called Grand Tours. Beginning in 1976 and 1977, Grand Tour spacecraft would fly past Jupiter, Saturn, and on out to Pluto. The complete trip would take about nine years. Jupiter again is the initial target in 1979, then on to Uranus and Neptune. By 1988, scientists could be analyzing data gathered at close hand from every major body in the solar system.

The dominant feature of the Grand Tour spacecraft is its radio antenna, about 14 feet in diameter. Power is supplied by small nuclear generators that convert heat into electricity. Science instruments are mounted at the opposite end of the spacecraft and on long booms far from the radioactive source. At the Neptune or Pluto phase of a mission, the need for almost total independence from Earth's control is essential. The time for radio signals to travel from Neptune to Earth is about four hours. Thus it would take twice that long, eight hours, for ground controllers to become aware of a spacecraft malfunction and make the necessary correction by radio command. Any trouble in the Grand Tour spacecraft would be detected, diagnosed, and remedied by a special computer, the spacecraft brain. Normal operation would resume without ground control intervention.

Besides satisfying the compelling urge of man to explore the unknown, exploration of the planets is returning information to help us better understand our own planet Earth, how it began, how it is evolving, and how to maintain the delicate environmental balance which provides us such a comfortable home in space. Astronomers and cosmologists have estimated there may be as many as 100,000 other planetary systems, many similar to our own, among the stars of the Milky Way. Future generations will not lack for new worlds to explore. But our generation of the 1970s will have pointed the way.