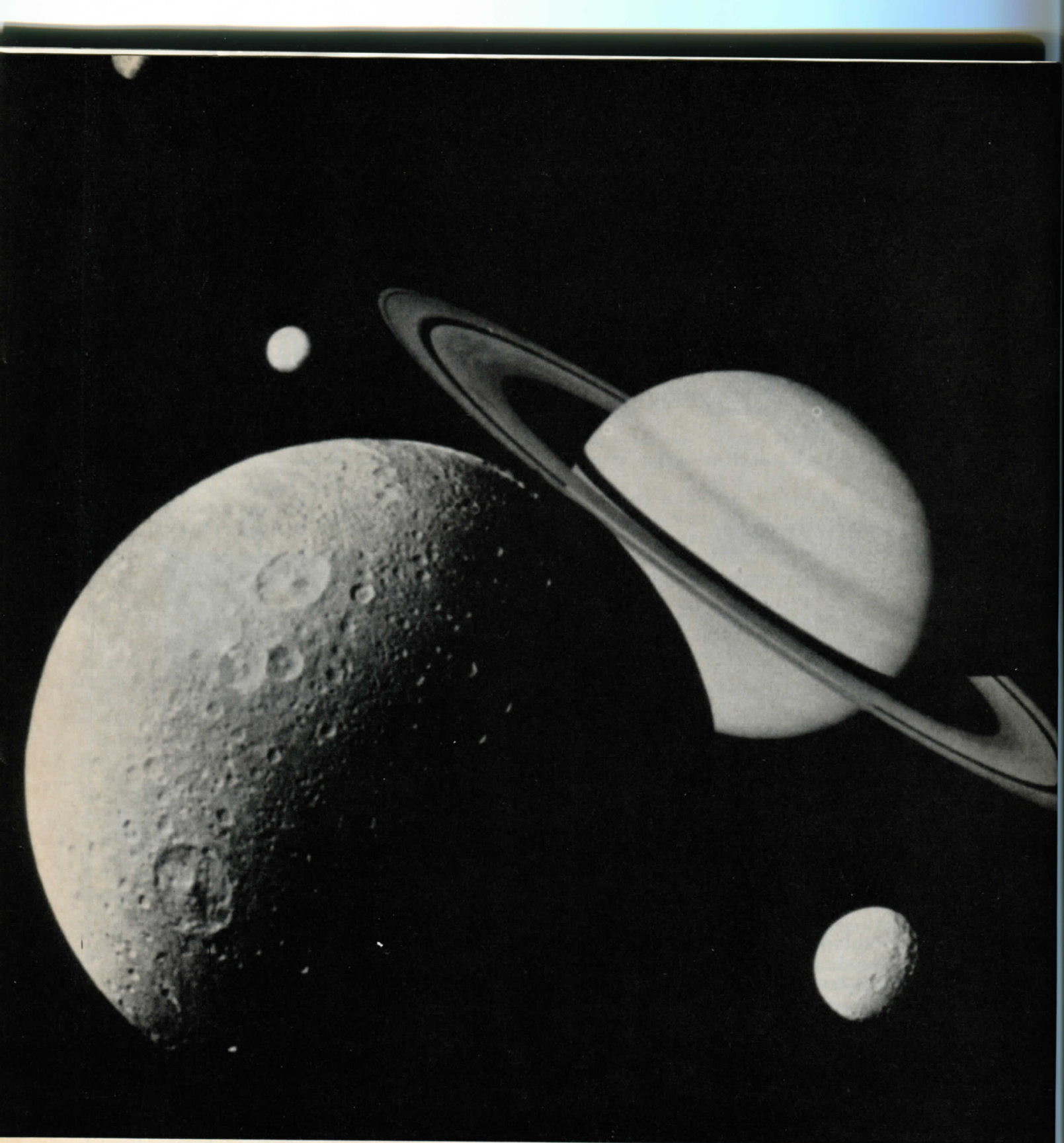


STAR STRUCK

The Voyager Missions: Taking Us on a Grand Tour of the Planets

Written by Phil Konstantin and Robyn Mellon
Photos courtesy of NASA

This montage of the Saturnian system shows Saturn in the middle surrounded by her moons: Dione in front, Tethys, Mimas at right, Enceladus, Rhea at left and Titan top right. Titan is the only moon with an appreciable atmosphere. Its methane-based environment seems to have many of the same chemical components that experts feel were present on Earth when life began.

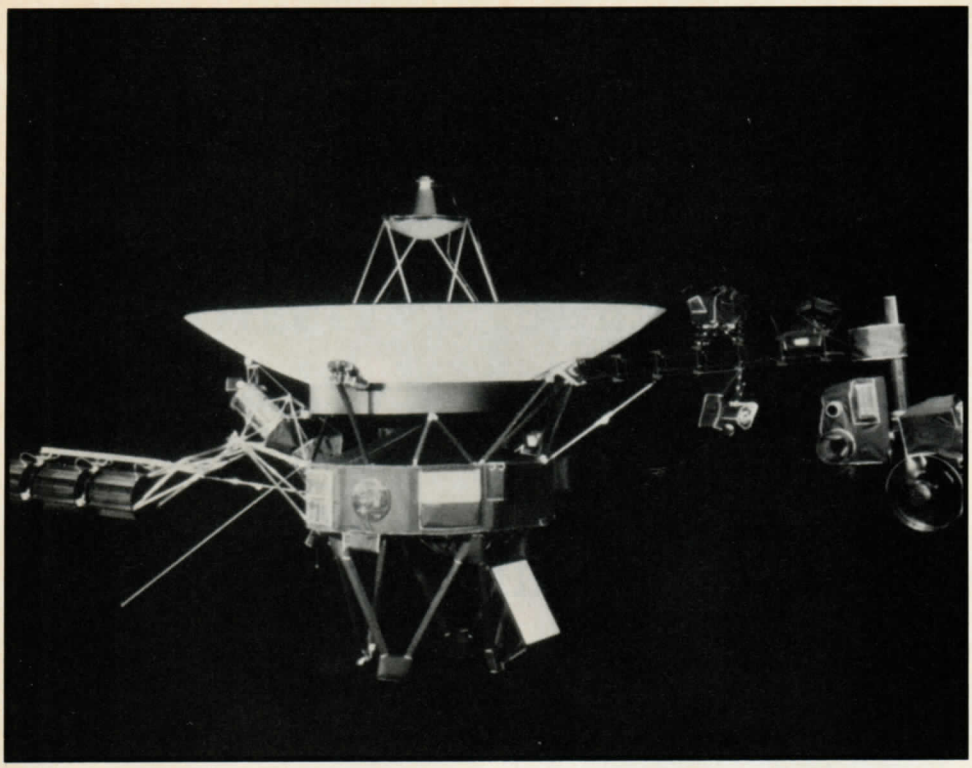
On May 5, 1989, the United States resumed its interplanetary missions with the launch of the space shuttle Atlantis, whose crew then set free the $550 million Magellan spacecraft for its voyage to Venus. Magellan will reach Earth's nearest planetary neighbor on August 10, 1990, for an eight-month orbital picture-taking sesson and sophisticated radar "look" at Venus.

But Americans won't have to wait until next year to learn more about another of our planetary sisters. This August 5, NASA's Voyager II, which was launched in 1977, has a date with Neptune and will pass within 2,700 miles of that planet. At that time, Neptune will be approximately 2.8 billion miles from Earth, but the photographs are expected to be dramatically revealing.

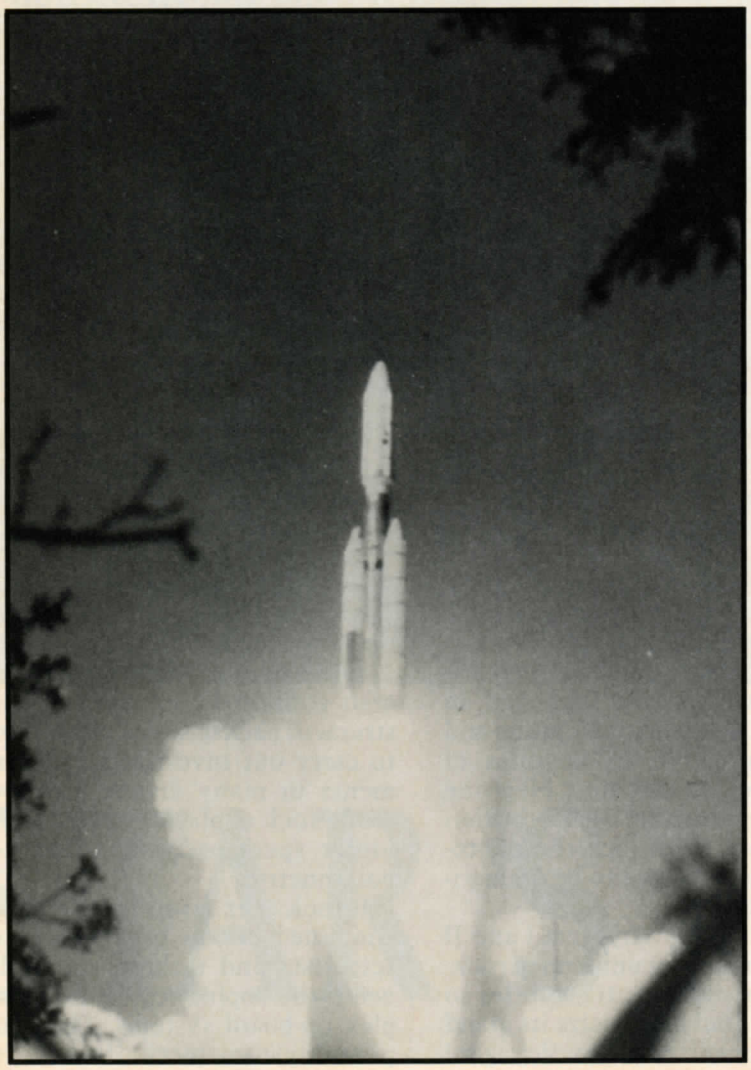
Back in 1977, Voyagers I and II were launched on unmanned rockets and on different trajectories so that each could maximize its grand tour of our solar system. Voyager I flew by Jupiter and Saturn before heading out of our galaxy. Voyager II also approached those two planets, but at a different angle, as well as Uranus before heading for its rendezvous with Neptune this summer.

California facilities have been the backbone of the Voyager missions, with the Jet Propulsion Laboratory (JPL) in Pasadena controlling each mission, and the Goldstone Radiotelescope in the Mojave Desert transmitting instructions and receiving the gathered observations and data. Both spacecraft contain 11 sophisticated instrument packages that allow them to carry out investigative experiments in many diverse fields of study such as plasma waves, ultraviolet spectroscopy and photopolarimetry.

It took over seven years and the combined efforts of hundreds of scientists and technicians to develop the sophisticated and complex on-board systems. The computer system (actually two in-



Two Voyager spacecraft were launched in 1977 from Kennedy Space Center in Florida. They are expected to exit the heliosphere (the outer edges of the solar wind) in the 1990s.

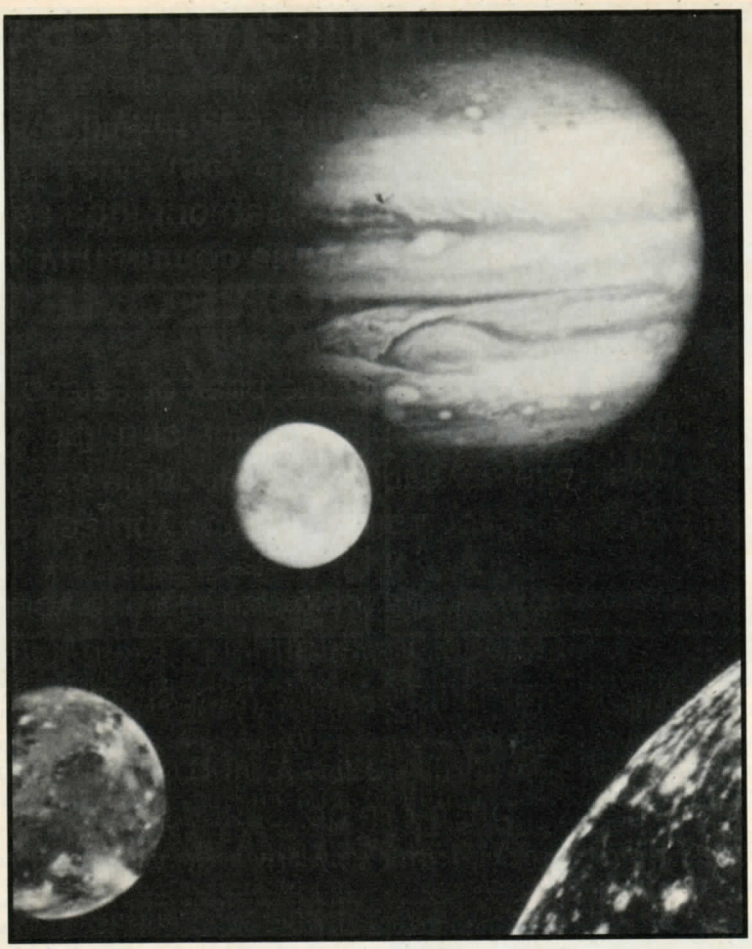


dependent computers) that controls and guides the spacecraft is so well designed that it is capable of making its own decisions when Earth-based instructions would take too long to cross the vast distances involved.

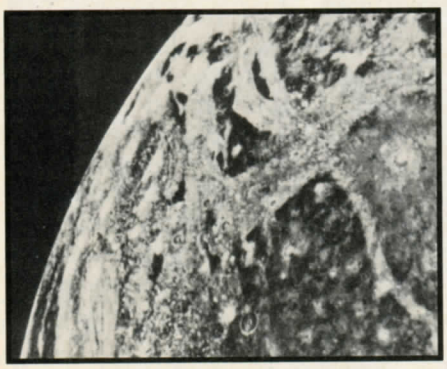
Each Voyager has two video cameras which have been transmitting the images that have captivated the public's imagination. In fact, it was Voyager I that took the famous (and first!) photo of the moon and the Earth together from outer space.

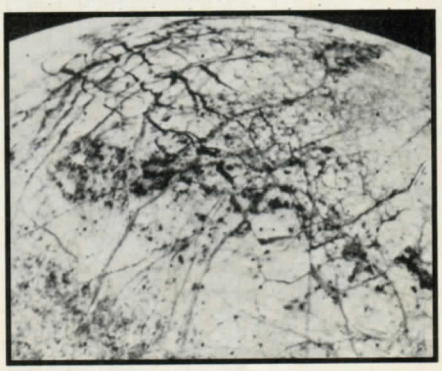
Through the two spacecraft, numerous discoveries have been made. Jupiter alone provided a veritable treasure trove of new information in 1979. It was found to have a previously unknown ring system over 3,600 miles wide! Before Voyager's trip, only Saturn's and Uranus' rings were discernable to astronomers. Also, by piecing together a series of photos of the mysterious Red Spot of Jupiter, scientists were able to make a movie of it, thus revealing the Spot's motion. This 300-year-old storm, which is as large as several Earths, now viewed "in motion" has helped experts understand more about the violent storms in Jupiter's upper atmosphere. Also, enormous magnetic and radiation fields have been discovered by the Voyagers' sensitive instruments, some of which are active in the audio ranges — Jupiter is actually making its own "music"!

The two spacecraft provided numerous close-ups of the major moons of Jupiter, which has 16 (although there is evidence suggesting there are more). Ganymeade, the largest of Jupiter's moons and larger than the planet Mercury, was dotted with vast mountain ranges and valleys deeper than our Grand Canyon. Europa looked like a billiard ball with painted-on cracks. Io proved to be loaded with active volcanos — the



Jupiter, above, is pictured with moons Io, Europa, Ganymede and Callisto. Below are close-ups of Ganymede (left) and Europa.





only body in the solar system, other than Earth, discovered so far to have volcanic activity. Io, also the nearest of the major moons to Jupiter, was found to be losing about a ton of its surface every day due to the strength of the electromagnetic and radiation fields of its "parent" planet.

Almost two years later, both Voyagers visited Saturn as they moved farther away from Earth. Saturn, with its rings visible to even the ancient astronomers, has fascinated mankind for centuries. And they were no disappointment to the scientists involved in the Voyager missions.

Previously, it was thought that Saturn's rings were several separate bands possibly comprised of planetary debris. As the cameras sent back closer and closer images of the rings, however, and as other instrument packages probed their energy spectrums, the "rings" dissolved into one enormous layer of fist-sized particles. Scientists now believe that Saturn's moons are continually reshaping the "rings" by their gravitational fields, which cause different density levels that give the "rings" their separated appearance.

Saturn's largest moon is Titan and is the only moon with an appreciable atmosphere. This methane-based environment seems to have many of the same chemical components that experts feel were present on Earth when life began developing here. However, due to both the extreme cold and weak sunlight reaching Titan, the chance of life as we know it developing there (a photosynthetic-based organism) is highly unlikely.

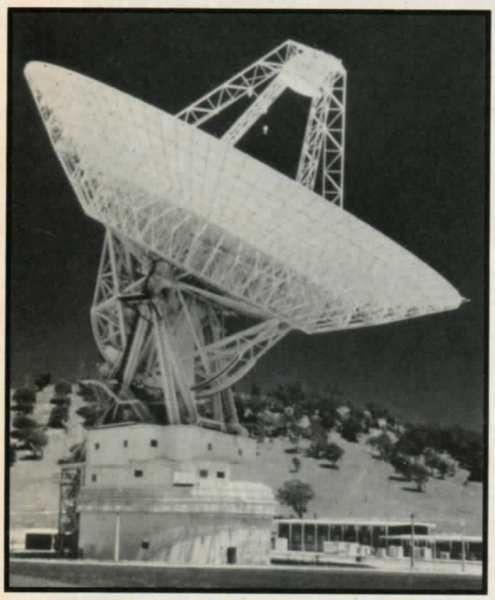
Early in 1986, Voyager II flew by Uranus, revealing even more information. Several new rings were discovered (nine were known previously) as well as 10 new smaller moons, bringing the total to 15. Uranus has proved to be highly unusual in other ways, too. The angle at which the planet rotates is almost horizontal (compared to Earth's nearly verticle rotation), and its magnetic field was found to be 60° different than its rotation and offset from the center as well, making it the most unusual planet in the solar system so far. While much smaller than Jupiter, it seems to be much denser, and it has a thin atmosphere which shines with an ultraviolet glow.

Larry Soderblom, a member of the Voyager Imaging Science team, describes Uranus' innermost major moon, Miranda, as "... the most exotic body in the solar system. It's as if geological terrains were stolen from throughout the solar system and assembled in one object." Miranda has mountains with cliffs 16 miles high! If you were to drop a rock off the top of one of these cliffs, it would take nine minutes for it to hit the ground. Viewing the photos of Miranda, you can see it is truly an extraordinary satellite.

The Voyager II has traveled tremendously vast distances, and very large numbers are needed to represent them. And yet, some parts of the Voyager mission will be accomplished on an almost microscopic scale.

Voyager broadcasts its signal

The Space Flight Operations Facility in California is the center of a world-wide communications network known as the Deep Space Network, which communicates 24 hours a day with several unmanned spacecraft traveling on journeys through our solar system. Data is received from and transmitted to three tracking stations in Madrid, Spain; Tidbinbilla, Australia; and Goldstone, California. There are three antennas at each station, such as the one below located in Australia.

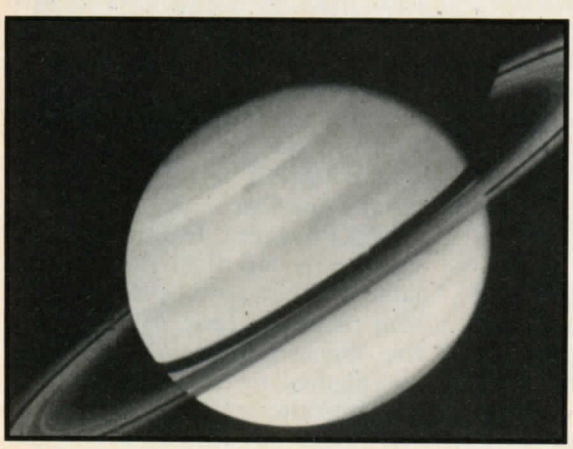


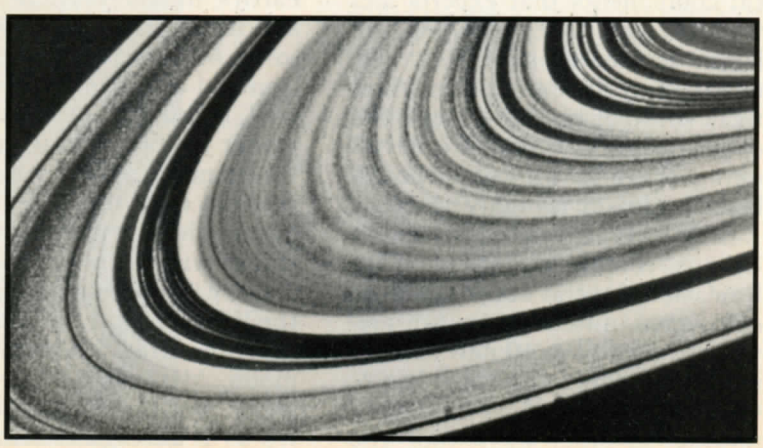
back to Earth at 22 watts of power, compared to a normal AM radio station which broadcasts at 5,000 watts. But, due to the enormous distance that the radio wave will have to travel from Neptune, it will reach us here on Earth as a faint signal of less than one billionth of a millionth of a watt (.000,000,000,000,001).

JPL scientists have had to redesign Voyager II's programming (from Earth) to take full advantage of its limited computer data-storage system and its now-feeble broadcast capabilities. Because the available sunlight on Neptune is only one-fourth that of Uranus (which wasn't that much), new programming had to be designed with instructions for longer exposures. This additional exposure time would normally mean fewer photos could be taken, so engineers and programmers also redesigned the storage/retrieval/broadcast systems in such a way that, while less data is sent to Earth, we will see the same results as the earlier photos. This will allow Voyager to take and transmit more photos than it would have with the previous programming. So, in many ways, it is a better spacecraft now than it was when it was launched over a decade ago. There have been some mechanical failures, but the craft has survived the extreme cold and innumerable hazards of deep space remarkably well.

As Voyager II swoops down toward Neptune's surface, some scientists expect to find frozen water at -300°F, which would make it as hard as steel. Others speculate Voyager will discover an atmosphere of methane and other gases, but only time will tell. Neptune's largest moon, Triton, should

Voyager II flew by Saturn in August 1981, sending back dramatic photographs (below) and instrument readings suggesting that Saturn's moons are continually reshaping the "rings" by their gravitational fields, which cause different density levels that give the "rings" their separated appearance.



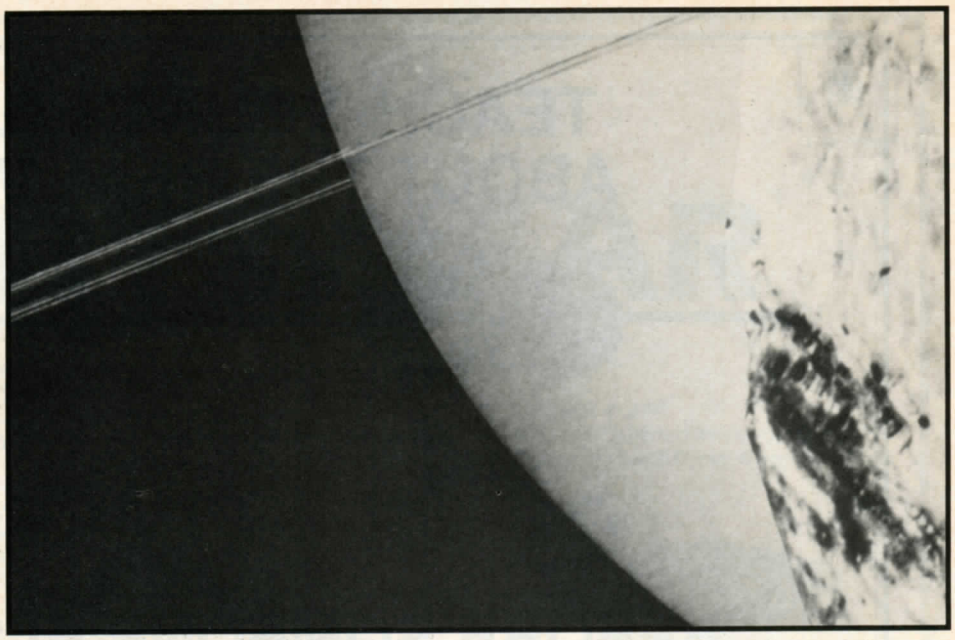


also provide many new wonders for modern civilization to puzzle over.

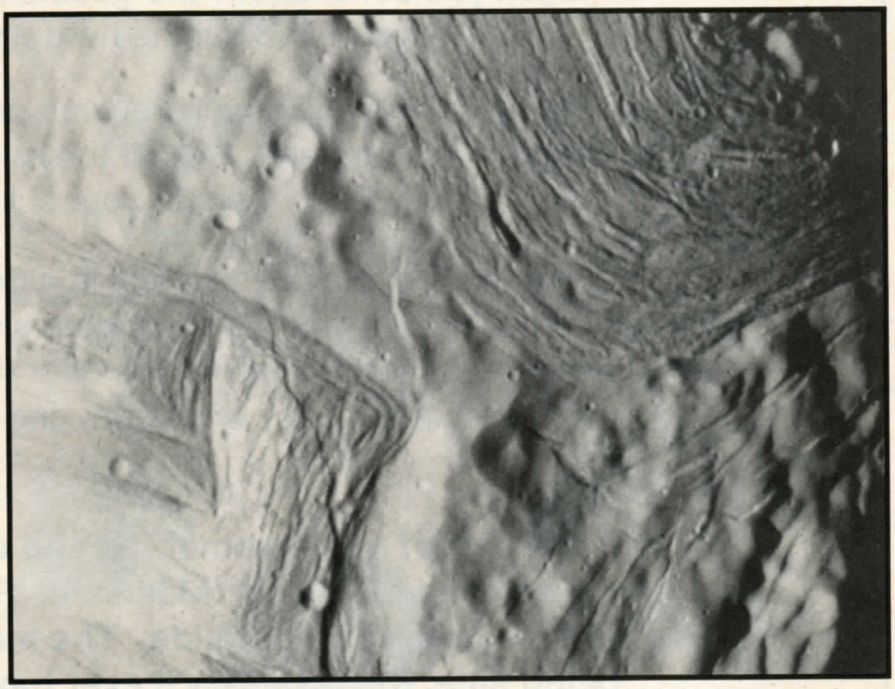
Voyagers I and II have sent back to Earth an enormous array of photo images and scientific data, both answering and generating hundreds of questions about the many properties of our solar system. If that achievement were not grand enough by itself, consider also that they were *sending* information about Earth and mankind out to the stars. Attached to each Voyager craft is a record, made of gold to withstand the severe radiation and other hazards of deep space, containing 116 digitized photographs of Earth scenes and 87½ minutes of music. The music ranges from the songs of the humpback whales to Senegal percussion to Peruvian pan-pipes to Bach, Mozart and even Chuck Berry.

Astronomers Carl Sagan and Timothy Ferris were two of the experts who decided what items (photos, music, etc.) would be selected as our introduction to any intelligent extraterrestrials who might find one of the Voyagers. Timothy Ferris told me, "Earth may be one of many worlds, but it also contains many worlds." Thus a wide variety of sights and sounds were sent into space to tell whoever or whatever is out there who we are, where we are and what we were like in our 21st century.

Although it may take millions of years before any "E.T.s" find the Voyagers and their records of us, we will continue to reap the benefits of the knowledge our spacecraft send us, enabling us to understand our physical universe that much better. However, should "aliens" happen across our craft, and assuming they will be successful in deciphering its codes, what will they think of Earth? And what kind of message would they send us back? Perhaps, "Send more Chuck Berry!" STOP



Voyager II encountered distant Uranus, seventh planet from the Sun, in January 1986. At the point of closest approach, the spacecraft flew 50,600 miles above Uranus' cloudtops, returning thousands of images and volumes of other data on the planet, its system of rings and its moons. Ten moons were discovered, where only five were previously known, as were new details in the rings and the planet's atmosphere. Above, Uranus is viewed from her moon, Miranda. And, below, Miranda is photographed from only 26,000 miles, revealing this unusual "chevron" pattern on her surface.



OUR 9 PLANETS

SYMBOL	NAME	MEAN DISTANCE FROM THE SUN MILLION MILES	PERIOD OF REVOLUTION IN DAYS OR YEARS	EQUATORIAL DIAMETER IN MILES
☿	Mercury	36.0	88.0 d.	3,031
♀	Venus	67.2	224.7 d.	7,521
⊕	Earth	92.9	365.26 d.	7,926
♂	Mars	141.5	687.0 d.	4,220
♃	Jupiter	483.4	11.86 y.	88,048
♄	Saturn	886.0	29.46 y.	74,564
♅	Uranus	1783.9	84.01 y.	31,566
♆	Neptune	2792.0	164.8 y.	30,199
♇	Pluto	3674.6	247.7 y.	2,113