

SATURN

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Introduction

No planet in the solar system is adorned like Saturn.

Its exquisite ring system is unrivaled. Like Jupiter, Saturn is composed mostly of hydrogen. But in contrast to the vivid colors and wild turbulence found in jovian clouds, Saturn's atmosphere has a more subtle, butterscotch hue, and its markings are muted by high-altitude haze.

Given Saturn's somewhat placid-looking appearance, scientists were surprised at the high-velocity equatorial jet stream that blows some 1,770 kilometers (1,100 miles) per hour.

Three American spacecraft have visited Saturn.

Pioneer 11 sped by the planet and its moon Titan in September 1979, returning the first close-up images.

Voyager 1 followed in November 1980, sending back breathtaking photographs that revealed for the first time the complexities of Saturn's ring system and moons.

Voyager 2 flew by the planet and its moons in August 1981.

The rings are composed of countless low-density particles orbiting individually around Saturn's equator at progressive distances from the cloud tops.

Analysis of spacecraft radio waves passing through the rings showed that the particles vary widely in size, ranging from dust to house-sized boulders. The rings are bright because they are mostly ice and frosted rock.

The rings might have resulted when a moon or a passing body ventured too close to Saturn. The unlucky object would have been torn apart by great tidal forces on its surface and in its interior. Or the object may not have been fully formed to begin with and disintegrated under the influence of Saturn's gravity. A third possibility is that the object was shattered by collisions with larger objects orbiting the planet.

Unable either to form into a moon or to drift away from each other, individual ring particles appear to be held in place by the gravitational pull of Saturn and its satellites. These complex gravitational interactions form the thousands of ringlets that make up the major rings.

Radio emissions quite similar to the static heard on an AM car radio during an electrical storm were detected by the Voyager spacecraft. These emissions are typical of lightning but are believed to be coming from Saturn's ring system rather than its atmosphere, where no lightning was observed. As they had at Jupiter, the Voyagers saw a version of Earth's auroras near Saturn's poles.

The Voyagers discovered new moons and found several satellites that share the same orbit.

We learned that some moons shepherd ring particles, maintaining Saturn's rings and the gaps in the rings. Saturn's 18th moon was discovered in 1990 from images taken by Voyager 2 in 1981.

Voyager 1 determined that Titan has a nitrogen-based atmosphere with methane and argon - one more like Earth's in composition than the carbon dioxide atmospheres of Mars and Venus. Titan's surface temperature of -179 degrees Celsius (-290 degrees Fahrenheit) implies that there might be water-ice is-

lands rising above oceans of ethane-methane liquid or sludge. Unfortunately, Voyager 1's cameras could not penetrate the moon's dense clouds.

Continuing photochemistry from solar radiation may be converting Titan's methane to ethane, acetylene and - in combination with nitrogen - hydrogen cyanide. The latter compound is a building block of amino acids.

These conditions may be similar to the atmospheric conditions of primeval Earth between three and four billion years ago. However, Titan's atmospheric temperature is believed to be too low to permit progress beyond this stage of organic chemistry.

The Rings

- * The Pioneer Saturn flyby in 1979 made several new discoveries about the rings:
- * The rings consist largely of particles several centimeters in diameter. They are extremely cold and possibly composed of frozen water and other ices.
- * An extensive cloud of hydrogen was discovered around the rings.
- * Two new rings (called F and G) were discovered, and a gap between rings was confirmed.
- * Voyager 1 provided much more detail on the beauty, complexity, and sometimes baffling nature of the rings. Among the discoveries were
- * The six known rings are actually composed of hundreds of tiny, thin ringlets with intervening spaces, so that the whole ring system looks something like

the grooves in a phonograph record. Even the Cassini division, once thought to be empty space between the A and B rings, contains several dozen ringlets. There are far too many rings to be explained by our present theories of how planetary rings form and remain stable.

- * Elongated radial features that last from hours to days were observed in the B-ring. These “spokes” may be clouds of electrified dust rotating around Saturn above the plane of the rings.

- * The thin outer F-ring, discovered by Pioneer Saturn, was resolved into three distinct but intertwined ringlets. This braided ring structure is very difficult to explain; it seems likely that both electrical and gravitational forces are at work.

- * Two small moons, one on each side of the F-ring, may act as “shepherds,” their gravitational attraction keeping the ring particles on track between the orbits of the two moons.

The Moons

- * Nine (possibly ten) moons had been detected from Earth. The encounter of Pioneer Saturn (September, 1979) provided several new discoveries:

- * At least two new moons were discovered by Pioneer and ground-based observations.

- * Accurate masses were determined for the moons Rhea and Iapetus.

- * The cloud-top temperature of Titan was found to be very low, about -200°C (-330°F), and a hydrogen cloud was discovered around Titan.

* A much closer look at several of Saturn's moons was provided by Voyager 1. The new results included:

* Six tiny, unnamed moons were photographed, some of them for the first time. Satellites 10 and 11 share the same orbit and must frequently undergo some orbital "evasive actions" to avoid colliding. Satellite 12 shares the orbit of the larger moon Dione. The shepherd Satellites 13 and 14, on either side of the thin F-ring, may exert gravitational forces to keep the ring in place, while Satellite 15, located just outside the large A-ring, likewise may help keep that ring in place.

* The inner moons Mimas, Tethys, Dione, and Rhea all have heavily cratered surfaces like those of the Moon and Mercury, although Saturn's moons are composed largely of water ice. This shows that meteorite bombardment, even as far out as Saturn, has been a major process in shaping the solar system. Mimas is marked by a huge impact crater that is fully one-fourth the diameter of Mimas itself. This crater makes Mimas look like a staring eyeball, and the impact that formed it was almost intense enough to blast Mimas into fragments.

* The inner moons also show traces of internal geological activity. Tethys has a rift-like valley that stretches 800 kilometers (500 miles) across its surface. Dione shows several sinuous, branching valleys. Both Dione and Rhea have bright, wispy streaks on their surfaces.

* Although Enceladus orbits between two heavily cratered moons, Mimas and Dione, it seems smooth and entirely uncratered, as viewed from Voyager 1.

* Titan, Saturn's largest moon, has a diameter of 5,120 kilometers (3,180 miles),

which makes it smaller than Jupiter's moon Ganymede.

- * Titan's dense, hazy atmosphere is at least 400 kilometers (250 miles) thick and completely shrouds the surface from view. Titan's atmosphere was found to be mostly nitrogen (like the Earth's), with minor methane and other hydrocarbons. At the surface, the pressure of Titan's atmosphere is at least twice that on the Earth. The surface temperature, about 175° C (280° F), is low enough to permit lakes and streams of liquid nitrogen to form on its surface.

- * Long-range Voyager 1 photographs of Iapetus, an outer satellite, confirmed Earth-based observations by showing that the satellite has light and dark faces, but no explanation for this puzzling difference was found.

- * Saturn is named for the Roman god of reaping.

- * Saturn's symbol is a curved sickle.

- * This is the sixth planet from the Sun.

- * Saturn is the second largest planet.

- * This is the least dense planet in our solar system.

- * Saturn travels around the Sun every 29.48 Earth years.

- * Saturn's day is 10 hours, 39 minutes, and 20 seconds long.

- * The diameter of Saturn is 74,400 miles.

- * The gravity on Saturn is 1.07 of Earth's gravity.

- * The first close-up of Jupiter was taken by Pioneer 11, in 1979.

- * Saturn has at least a thousand rings.
- * Saturn has 21 moons.
- * Saturn's atmosphere is made up of hydrogen and helium.
- * This planet has no solid surface.
- * Titan, a moon of Saturn, is the second largest known moon in our solar system.
- * Titan has a nitrogen-based atmosphere.
- * Spacecrafts Pioneer 10 and 11 and Voyager 1 and 2 have visited Saturn.

Source: NASA