

# The moons of Saturn

September 14 2015, by Matt Williams

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Saturn and its largest moons. Credit: NASA/JPL/SSI

Saturn is well known for being a gas giant, and for its impressive ring system. But would it surprise you to know that this planet also has the second-most moons in the Solar System, second only to Jupiter? Yes, Saturn has at least 150 moons and moonlets in total, though only 53 of them have been given official names.

Most of these moons are small, icy bodies that are little more than parts of its impressive ring system. In fact, 34 of the moons that have been named are less than 10 km in diameter while another 14 are 10 to 50 km in diameter. However, some of its inner and outer moons are among the largest and most dramatic in the Solar System, measuring between 250 and 5000 km in diameter and housing some of greatest mysteries in the Solar System.

## **Discovery and Naming:**

Prior to the invention of telescopic photography, eight of Saturn's moons were observed using simple telescopes. The first to be discovered was Titan, Saturn's largest [moon](#), which was observed by Christiaan Huygens in 1655 using a telescope of his own design. Between 1671 and 1684, Giovanni Domenico Cassini discovered the moons of Tethys, Dione, Rhea and Iapetus – which he collectively named the "Sider Lodoicea" (Latin for "Louisian Stars", after King Louis XIV of France).

In 1789, William Herschel discovered Mimas and Enceladus, while father-and-son astronomers W.C Bond and G.P. Bond discovered Hyperion in 1848 – which was independently discovered by William Lassell that same year. By the end of the 19th century, the invention of long-exposure photographic plates allowed for the discovery of more moons – the first of which Phoebe, observed in 1899 by W.H. Pickering.

In 1966, the tenth satellite of Saturn was discovered by French astronomer Audouin Dollfus, which was later named Janus. A few years

later, it was realized that his observations could only be explained if another satellite had been present with an orbit similar to that of Janus. This eleventh moon was later named Epimetheus, which shares the same orbit with Janus and is the only known co-orbital in the Solar System.

By 1980, three additional moons were discovered and later confirmed by the Voyager probes. They were the trojan moons (see below) of Helene (which orbits Dione) as well as Telesto and Calypso (which orbit Tethys).

The study of the outer planets has since been revolutionized by the use of unmanned space probes. This began with the arrival of the Voyager spacecraft to the Cronian system in 1980-81, which resulted in the discovery of three additional moons – Atlas, Prometheus, and Pandora – bringing the total to 17. By 1990, archived images also revealed the existence of Pan.

This was followed by the Cassini-Huygens mission, which arrived at Saturn in the summer of 2004. Initially, Cassini discovered three small inner moons, including Methone and Pallene between Mimas and Enceladus, as well as the second Lagrangian moon of Dione – Polydeuces. In November of 2004, Cassini scientists announced that several more moons must be orbiting within Saturn's rings. From this data, multiple moonlets and the moons of Daphnis and Anthe have been confirmed.

The study of Saturn's moons has also been aided by the introduction of digital charge-coupled devices, which replaced photographic plates by the end of the 20th century. Because of this, ground-based telescopes have begun to discover several new irregular moons around Saturn. In 2000, three medium-sized telescopes found thirteen new moons with eccentric orbits that were of considerable distance from the planet.

In 2005, astronomers using the Mauna Kea Observatory announced the discovery of twelve more small outer moons. In 2006, astronomers using Japan's Subaru Telescope at Mauna Kea reported the discovery of nine more irregular moons. In April of 2007, Tarqeq (S/2007 S 1) was announced, and in May of that same year, S/2007 S 2 and S/2007 S 3 were reported.

The modern names of Saturn's moons were suggested by John Herschel (William Herschel's son) in 1847. In keeping with the nomenclature of the other planets, he proposed they be named after mythological figures associated with the Roman god of agriculture and harvest – Saturn, the equivalent of the Greek Cronus. In particular, the seven known satellites were named after Titans, Titanesses and Giants – the brothers and sisters of Cronus.

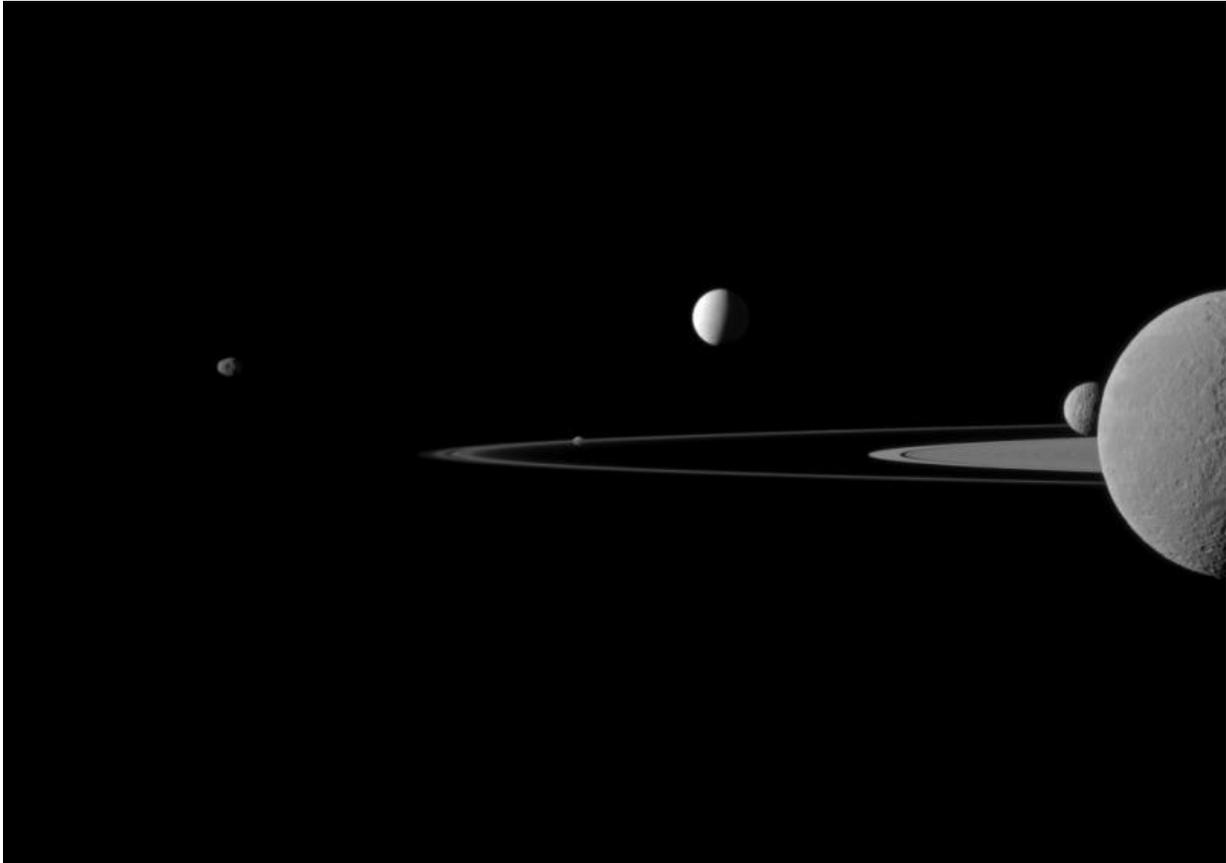
In 1848, Lassell proposed that the eighth satellite of Saturn be named Hyperion after another Titan. When in the 20th century, the names of Titans were exhausted, the moons were named after different characters of the Greco-Roman mythology, or giants from other mythologies. All the irregular moons (except Phoebe) are named after Inuit and Gallic gods and Norse ice giants.

## **Inner Large Moons:**

Saturn's moons are grouped based on their size, orbits, and proximity to Saturn. The innermost moons and regular moons all have small orbital inclinations and eccentricities and prograde orbits. Meanwhile, the irregular moons in the outermost regions have orbital radii of millions of kilometers, orbital periods lasting several years, and move in retrograde orbits.

Saturn's Inner Large Moons, which orbit within the E Ring (see below), include the larger satellites Mimas, Enceladus, Tethys, and Dione. These

moons are all composed primarily of water ice, and are believed to be differentiated into a rocky core and an icy mantle and crust. With a diameter of 396 km and a mass of  $0.4 \times 10^{20}$  kg, Mimas is the smallest and least massive of these moons. It is ovoid in shape and orbits Saturn at a distance of 185,539 km with an orbital period of 0.9 days.



Saturn's moons (from left to right) Janus, Pandora, Enceladus, Mimas and Rhea. Rhea is on top of Saturn. Credit: NASA/JPL-Caltech/Space Science Institute

Enceladus, meanwhile, has a diameter of 504 km, a mass of  $1.1 \times 10^{20}$  kg and is spherical in shape. It orbits Saturn at a distance of 237,948 km and takes 1.4 days to complete a single orbit. Though it is one of the

smaller spherical moons, it is the only Cronian moon that is endogenously active – and one of the smallest known bodies in the Solar System that is geologically active. This results in features like the famous "tiger stripes" – a series of continuous, ridged, slightly curved and roughly parallel faults within the moon's southern polar latitudes.

Large geysers have also been observed in the southern polar region that periodically release plumes of water ice, gas and dust which replenish Saturn's E ring. These jets are one of several indications that Enceladus has liquid water beneath its icy crust, where geothermal processes release enough heat to maintain a warm water ocean closer to its core. With a geometrical albedo of more than 140%, Enceladus is one of the brightest known objects in the Solar System.

At 1066 km in diameter, Tethys is the second-largest of Saturn's inner moons and the 16th-largest moon in the Solar System. The majority of its surface is made up of heavily cratered and hilly terrain and a smaller and smoother plains region. Its most prominent features are the large impact crater of Odysseus, which measures 400 km in diameter, and a vast canyon system named Ithaca Chasma – which is concentric with Odysseus and measures 100 km wide, 3 to 5 km deep and 2,000 km long.

With a diameter and mass of 1,123 km and  $11 \times 10^{20}$  kg, Dione is the largest inner moon of Saturn. The majority of Dione's surface is heavily cratered old terrain, with craters that measure up to 250 km in diameter. However, the moon is also covered with an extensive network of troughs and lineaments which indicate that in the past it had global tectonic activity.

## **Large Outer Moons:**

The Large Outer Moons, which orbit outside of the Saturn's E Ring, are

similar in composition to the Inner Moons – i.e. composed primarily of water ice and rock. Of these, Rhea is the second largest – measuring 1,527 km in diameter and  $23 \times 10^{20}$  kg in mass – and the ninth largest moon of the Solar System. With an orbital radius of 527,108 km, it is the fifth-most distant of the larger moons, and takes 4.5 days to complete an orbit.

Like other Cronian satellites, Rhea has a rather heavily cratered surface, and a few large fractures on its trailing hemisphere. Rhea also has two very large impact basins on its anti-Saturnian hemisphere – the Tirawa crater (similar to Odysseus on Tethys) and an as-yet unnamed crater – that measure 400 and 500 km across, respectively.



A composite image of Titan's atmosphere, created using blue, green and red spectral filters to create an enhanced-color view. Credit: NASA/JPL/Space

At 5150 km in diameter, and  $1,350 \times 10^{20}$  kg in mass, Titan is Saturn's largest moon and comprises more than 96% of the mass in orbit around the planet. Titan is also the only large moon to have its own atmosphere, which is cold, dense, and composed primarily of nitrogen with a small fraction of methane. Scientists have also noted the presence of polycyclic aromatic hydrocarbons in the upper atmosphere, as well as methane ice crystals.

The surface of Titan, which is difficult to observe due to persistent atmospheric haze, shows only a few impact craters, evidence of cryovolcanoes, and longitudinal dune fields that were apparently shaped by tidal winds. Titan is also the only body in the Solar System beside Earth with bodies of liquid on its surface, in the form of methane–ethane lakes in Titan's north and south polar regions.

With an orbital distance of 1,221,870 km, it is the second-farthest large moon from Saturn, and completes a single orbit every 16 days. Like Europa and Ganymede, it is believed that Titan has a subsurface ocean made of water mixed with ammonia, which can erupt to the surface of the moon and lead to cryovolcanism.

Hyperion is Titan's immediate neighbor. At an average diameter of about 270 km, it is smaller and lighter than Mimas. It is also irregularly shaped and quite odd in composition. Essentially, the moon is an ovoid, tan-colored body with an extremely porous surface (which resembles a sponge). The surface of Hyperion is covered with numerous impact craters, most of which are 2 to 10 km in diameter. It also has a highly unpredictable rotation, with no well-defined poles or equator.

At 1,470 km in diameter and  $18 \times 10^{20}$  kg in mass, Iapetus is the third-largest of Saturn's large moons. And at a distance of 3,560,820 km from Saturn, it is the most distant of the large moons, and takes 79 days to complete a single orbit. Due to its unusual color and composition – its leading hemisphere is dark and black whereas its trailing hemisphere is much brighter – it is often called the "yin and yang" of Saturn's moons.



The moons of Saturn, from left to right: Mimas, Enceladus, Tethys, Dione, Rhea; Titan in the background; Iapetus (top) and Hyperion (bottom). Credit: NASA/JPL/Space Science Institute

### **Irregular Moons:**

Beyond these larger moons are Saturn's Irregular Moons. These satellites are small, have large-radii, are inclined, have mostly retrograde orbits, and are believed to have been acquired by Saturn's gravity. These moons are made up of three basic groups – the Inuit Group, the Gallic Group, and the Norse Group.

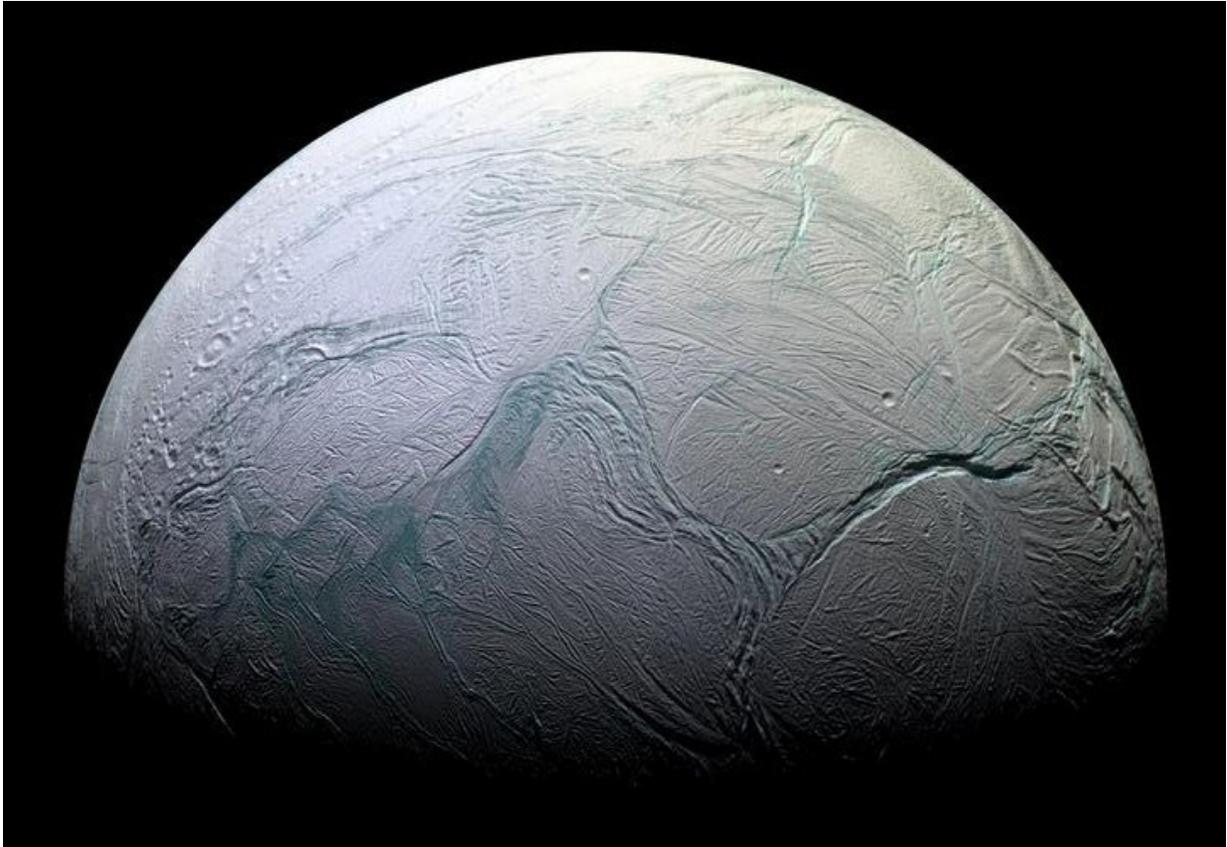
The Inuit Group consists of five irregular moons that are all named from

Inuit mythology – Ijiraq, Kiviuq, Paaliaq, Siarnaq, and Tarqeq. All have prograde orbits that range from 11.1 to 17.9 million km, and from 7 to 40 km in diameter. They are all similar in appearance (reddish in hue) and have orbital inclinations of between 45 and 50°.

The Gallic group are a group of four prograde outer moons named for characters in Gallic mythology -Albiorix, Bebhionn, Erriapus, and Tarvos. Here too, the moons are similar in appearance and have orbits that range from 16 to 19 million km. Their inclinations are in the 35°-40° range, their eccentricities around 0.53, and they range in size from 6 to 32 km.

Last, there is the Norse group, which consists of 29 retrograde outer moons that take their names from Norse mythology. These satellites range in size from 6 to 18 km, their distances from 12 and 24 million km, their inclinations between 136° and 175°, and their eccentricities between 0.13 and 0.77. This group is also sometimes referred to as the Phoebe group, due to the presence of a single larger moon in the group – which measures 240 km in diameter. The second largest, Ymir, measures 18 km across.

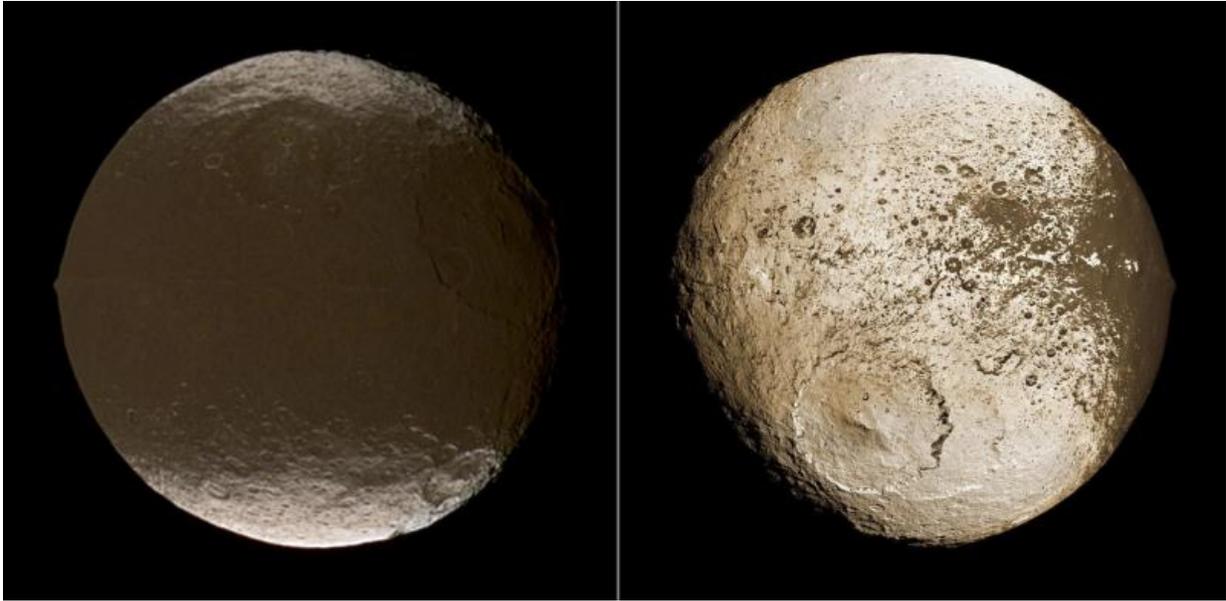
Within the Inner and Outer Large Moons, there are also those belonging to Alkyonide group. These moons – Methone, Anthe, and Pallene – are named after the Alkyonides of Greek mythology, are located between the orbits of Mimas and Enceladus, and are among the smallest moons around Saturn.



Saturn's moon of Enceladus. Credit: NASA/JPL/Space Science Institute

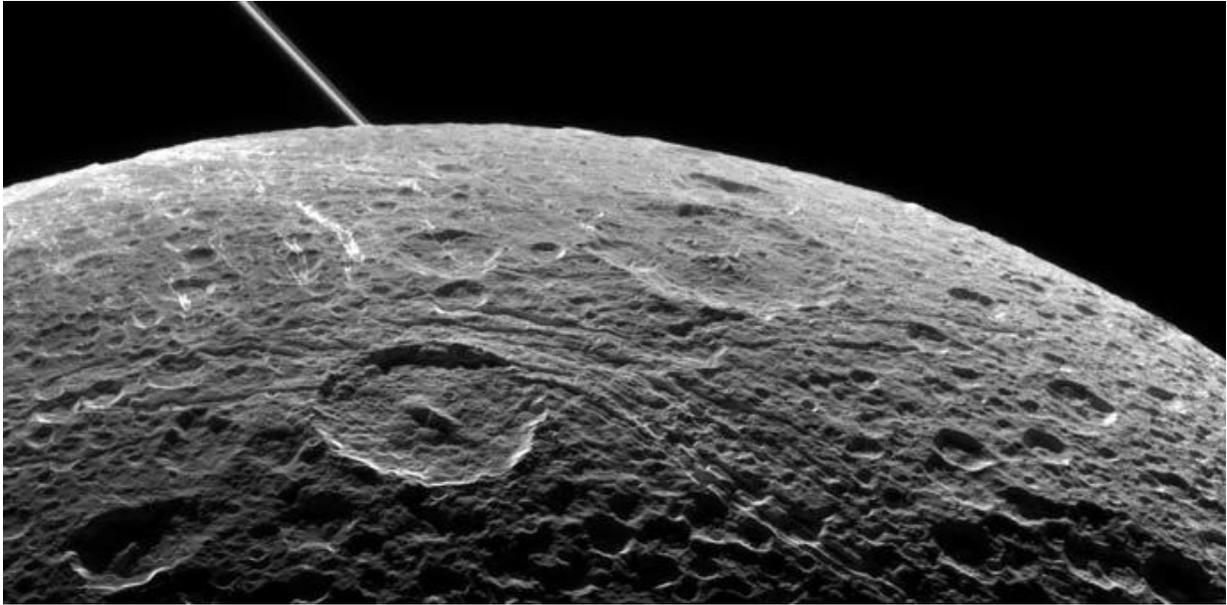
Some of the larger moons even have moons of their own, which are known as Trojan moons. For instance, Tethys has two trojans – Telesto and Calypso, while Dione has Helene and Polydeuces.

## **Formation:**



The two sides of Iapetus, “Saturn’s yin yang moon”. Credit: NASA/JPL

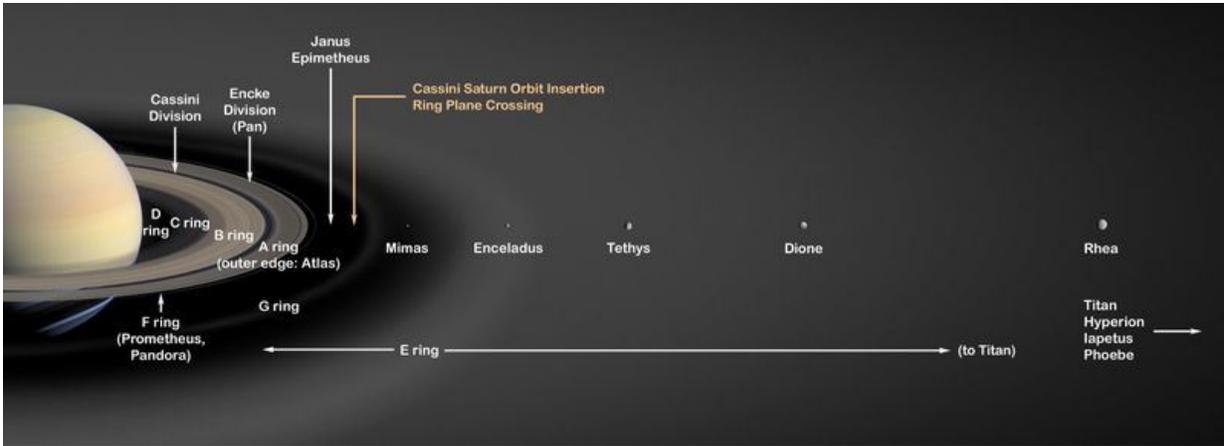
It is thought that Saturn's moon of Titan, its mid-sized moons and rings developed in a way that is closer to the Galilean moons of Jupiter. In short, this would mean that the regular moons formed from a circumplanetary disc, a ring of accreting gas and solid debris similar to a protoplanetary disc. Meanwhile, the outer, irregular moons are believed to have been objects that were captured by Saturn's gravity and remained in distant orbits.



Dione's heavily cratered surface, as observed by the Cassini flyby in June, 2015.  
Credit: NASA/JPL

However, there are some variations on this theory. In one alternative scenario, two Titan-sized moons were formed from an accretion disc around Saturn; the second one eventually breaking up to produce the rings and inner mid-sized moons. In another, two large moons fused together to form Titan, and the collision scattered icy debris that formed to create the mid-sized moons.

However, the mechanics of how the moon's formed remains a mystery for the time being. With additional missions mounted to study the atmospheres, compositions and surfaces of these moons, we may begin to understand where they truly came from.



Saturn's rings and moons Credit: NASA

Much like Jupiter, and all the other gas giants, Saturn's system of satellites is extensive as it is impressive. In addition to the larger moons that are believed to have formed from a massive debris field that once orbited it, it also has countless smaller satellites that were captured by its gravitational field over the course of billions of years. One can only imagine how many more remain to be found orbiting the ringed giant.

Source: [Universe Today](https://www.universe-today.com)

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