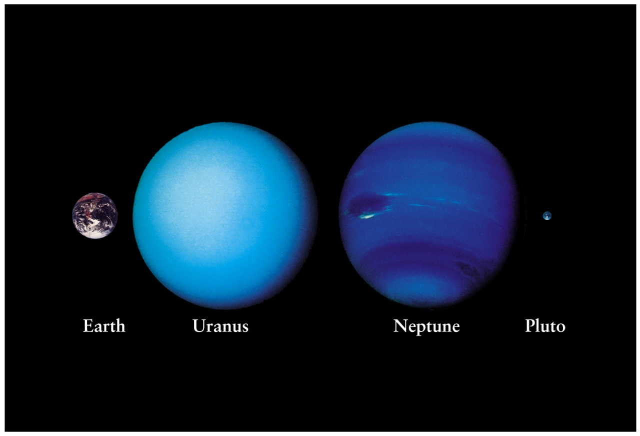
Neptune



The Jovian Planets

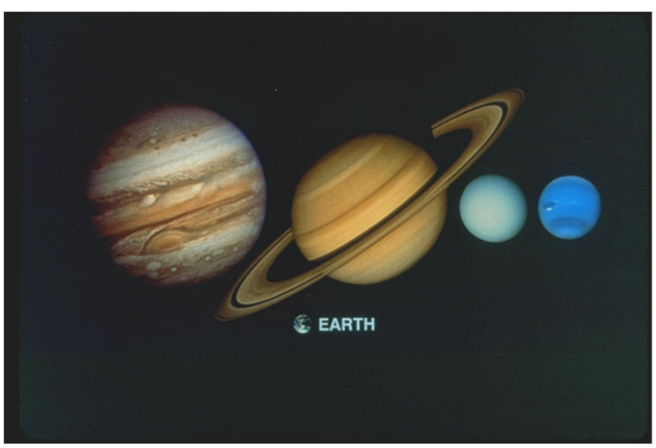
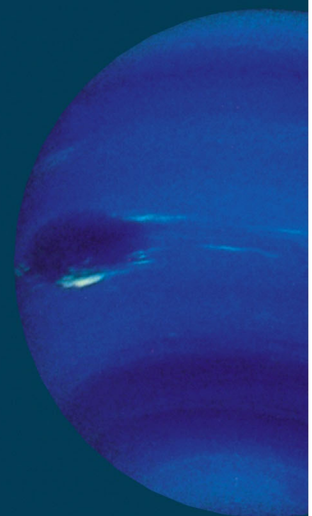


Table 16-2 Neptune Data

Average distance from Sun:	30.066 AU = 4.498×10^9 km
Maximum distance from Sun:	30.367 AU = 4.543×10^9 km
Minimum distance from Sun:	29.765 AU = 4.453×10^9 km
Eccentricity of orbit:	0.010
Average orbital speed:	5.5 km/s
Orbital period:	164.86 years
Rotation period (internal):	16.11 hours
Inclination of equator to orbit:	29.56°
Inclination of orbit to ecliptic:	1.77°
Diameter:	49,528 km = 3.883 Earth diameters (equatorial)
Mass:	1.024×10^{26} kg = 17.15 Earth masses
Average density:	1638 kg/m^3
Escape speed:	23.5 km/s
Surface gravity (Earth = 1):	1.1
Albedo:	0.51
Average temperature at cloudtops:	−218°C = −360°F = 55 K



(NASA)

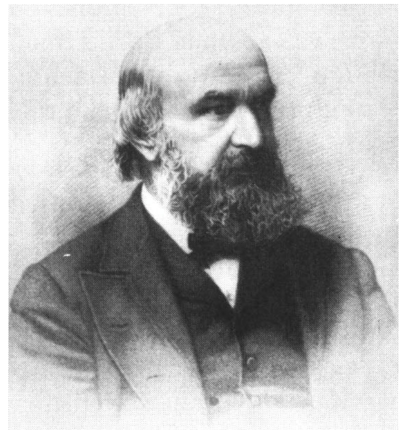
Discovery of Neptune

Neptune was found as the result of mathematical prediction. By 1800's, it was apparent that Uranus' position was not quite where predicted. Since this difference was totally unacceptable in gravitational theory, it seemed clear that there must be an unknown planet providing additional gravitational perturbations on Uranus.

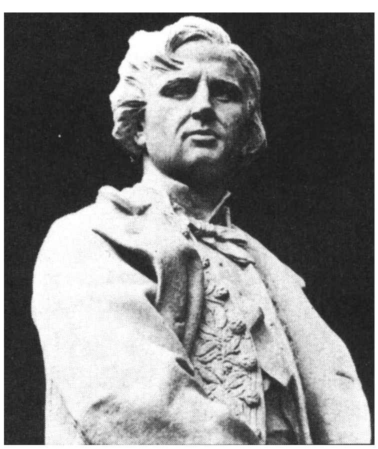
Discovery of Neptune

John Couch Adams
[1819 - 1892, England]

In September and October 1845, he tried to get Astronomer Royal George Biddell Airy to observe it. When Airy finally wrote back on November 5, he was skeptical.



Discovery of Neptune



Urbain Jean Joseph Leverrier
[1811 - 1877, France]

On November 10, he had completed the first part of his calculation and had them published in a French journal. During the winter and spring of 1846, he completed his analysis, and got a position within 1^{o} of Adams'.

Discovery of Neptune

This convinced Airy to begin the observations. However, the Cambridge astronomers did not have up-to-date star charts against which to compare suspected planets, so their progress was slow.

Leverrier completed his final calculations and presented his paper to the French Academy on August 31. Leverrier did not have Adams' problem of establishing his credibility; his work was warmly received. On the other hand, Leverrier had no success whatsoever convincing the French astronomers that they should bother to look for the new planet. Wrote to his friend, Johann Galle, at Berlin. On Galle's first night of observing, September 23, Neptune was found.

A search of old records revealed two pre-discovery observations made in 1795. Also, Galileo may have seen it!

Appearance and Rotation

UC Regents / Lick Observatory

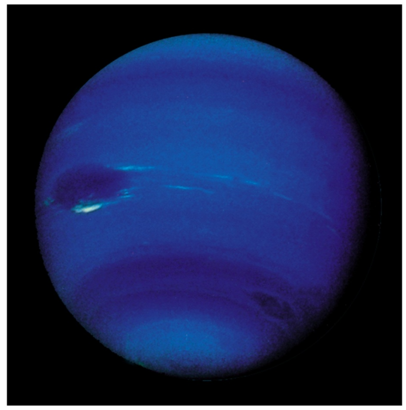
Cannot see much through a telescope. The rotation period of Neptune is 16^h06^m. The axis is tilted by 29^o.

Exploration

Voyager 2 in 1989.

Voyager carried 11 instruments.

UC Regents / Lick Observatory



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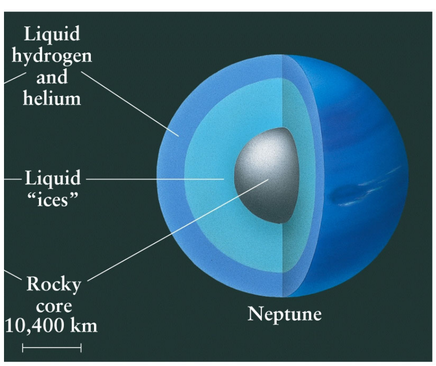
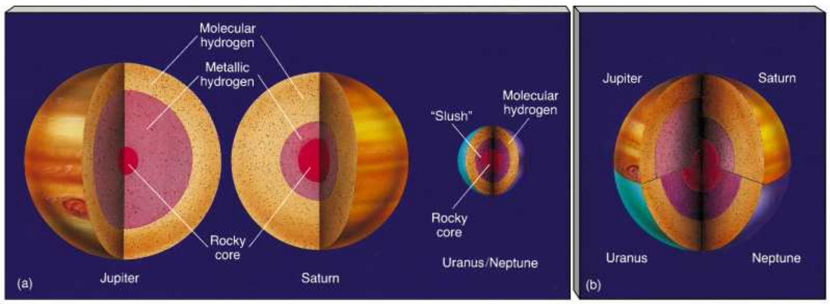
Composition and Structure



Universe by Geller, Freedman, and Kaufmann

Neptune does not have any metallic hydrogen. On Jupiter and Saturn, the cores constitute only a few percent of the total mass. However, most of the mass of Neptune (and Uranus) resides in these cores, demonstrating that these two planets were unable to attract massive quantities of hydrogen and helium. The core is composed of heavier materials – presumably the original rock-and-ice bodies.

Comparison of Jovian Interiors



Astronomy Today by Chaisson and McMillan

Internal Heat Source

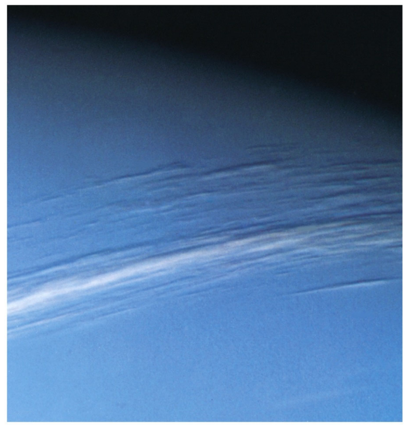
Uranus and Neptune are different. Neptune has a small internal heat source, while Uranus does not emit enough internal heat for it to have been measured.

As a result, these two planets have almost the same effective temperatures, in spite of the greater distance of Neptune from the Sun.

Atmosphere and Clouds

Composition is primarily H and He, although methane (CH_4) and ammonia (NH_3) were identified first.

Neptune's atmosphere has about the same abundance of helium as does Jupiter's.



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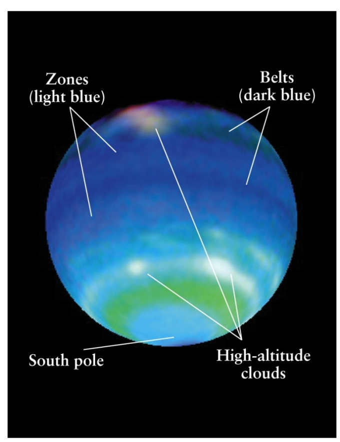
Bands and Zones

Neptune differs dramatically from Uranus in its appearance, although the basic atmospheric structures and temperatures are almost identical.

The upper clouds are composed of methane, which forms a thin cloud near the top of the troposphere at a temperature of 70 K and a pressure of 1.5 bars. Above this level it is clear and transparent, with less haze than on Uranus. Scattering of sunlight lends a deep blue color like that of the Earth's atmosphere.



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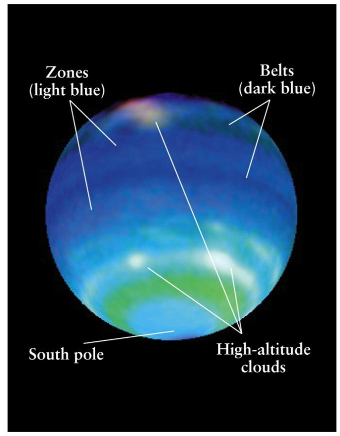
Bands and Zones

The **main difference** between Uranus and Neptune **is the presence of convection currents** from the interior, powered by Neptune's internal heat source. These currents carry warm gas above the 1.5 bar cloud level, forming additional clouds at elevations about 75 km higher.

The high-altitude clouds form bright white patterns against the blue planet beneath. They can even cast distinct shadows on the methane cloud tops.



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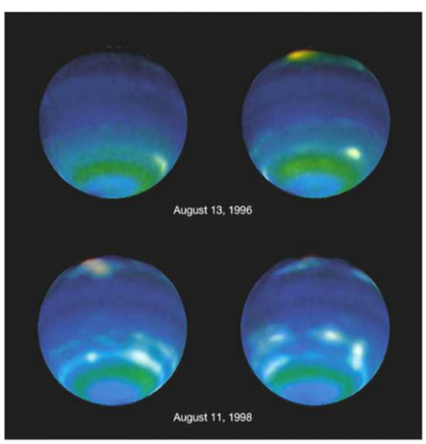
Weather



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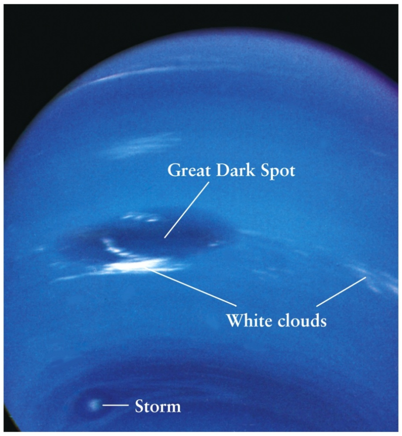
Neptune's weather is characterized by strong east-west winds similar to those observed on Jupiter and Saturn. The highest wind speeds near the equator reach 2100 km/hr, which is faster than the peak winds on Saturn. The equatorial jet stream actually approaches super-sonic speeds. Deep convection carries warmer gas up from the interior, also contributing to giant spots.

Storms



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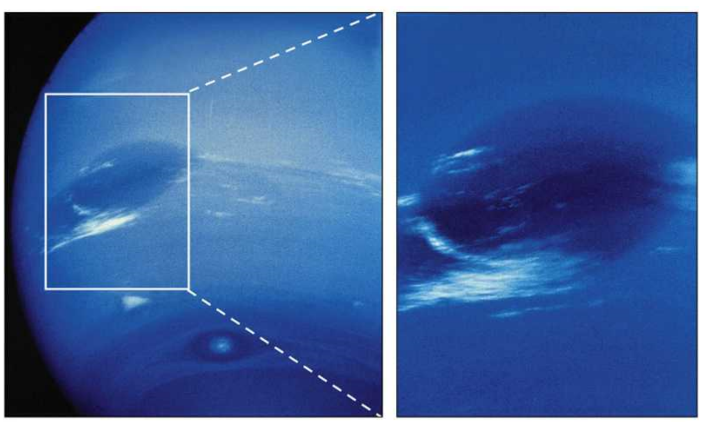
In spite of its smaller size and different cloud composition, Neptune has an atmospheric feature surprisingly similar to the Jovian Great Red Spot.

Neptune's **Great Dark Spot** is nearly 10,000 km long. Like Jupiter's Great Red Spot, it is found at latitude 20^{o} S, and its size and shape are similar relative to the size of the planet. This Great Dark Spot rotates in an anti-cyclonic direction with a period of 17 days.

Great Dark Spot



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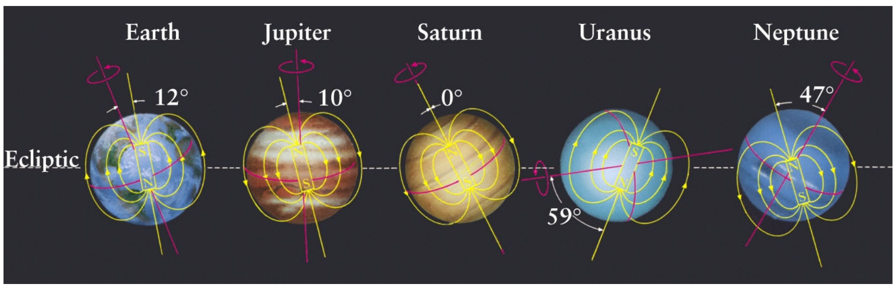
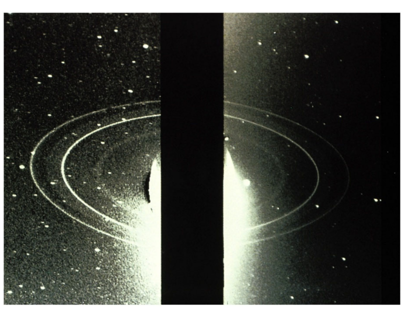
Magnetosphere

The magnetic field was not discovered until the Voyager flyby. Its strength is comparable to that of Uranus, about what would be expected from the size of the planet. Like Uranus' field, it is offset from the center of the planet, but to an even greater degree (by about one-half of the planet's radius). In addition, the magnetic field is tilted by 47° with respect to the axis of rotation.



Universe by Geller, Freedman, and Kaufmann

Neptune's Rings



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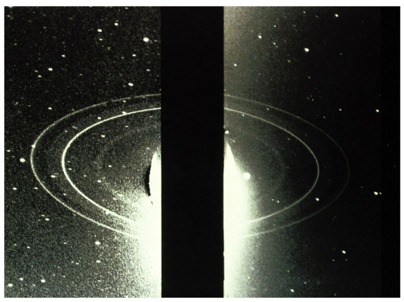
The rings of Neptune are invisible from the Earth. They were discovered by occultations of starlight.

In 1985 several occultations were observed, but their meaning remained in dispute. Unlike the symmetrical occultations seen at Uranus, the obscuration of starlight by the rings on one side were not repeated on the other side. During some occultations, the stars did not dim at all.

It was inferred that if there really were rings, they must be discontinuous or clumpy.

Neptune's Rings



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Voyager 2 saw real rings, but they are much fainter than the rings of Uranus. They are composed of dark particles and appear to contain a larger proportion of fine material (dust) than do the Uranian rings.

With one exception, they are too tenuous to block starlight and thus generate an observable occultation. That exception applies to three arcs in the main ring, each about 10^{o} in length, which are the features that were detected previously.

Moons of Neptune

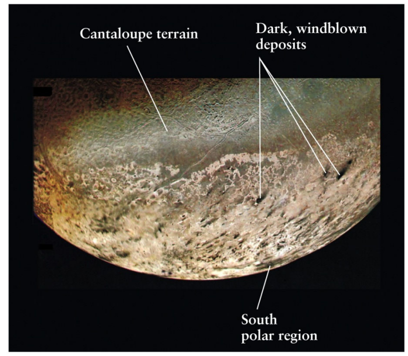
Prior to the Voyager 2 flyby, **Triton** and **Nereid** were the only two moons of Neptune that were known. Voyage 2 discovered 6 new moons, and now the total number is 14 moons.

Nereid has the ***most eccentric orbit*** of any Solar System moon and **Triton has a *retrograde* orbit**. It is possible that these worlds were captured.

The two outermost moons have orbital periods greater than 20 years!

Triton

Triton is the smallest of the seven "large" moons (2710 km). Its density of 2.1 g/cm^3 is relatively large for such an object. It is the same as Pluto, which Triton resembles in size. Like Pluto, it is probably composed of a mixture of about 75% rock and 25% water ice.



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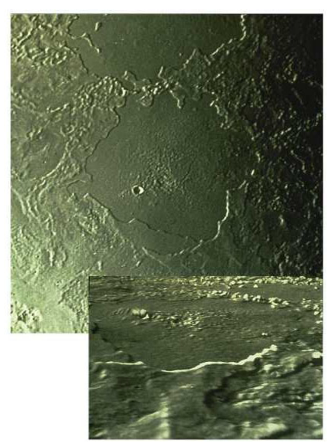
Triton

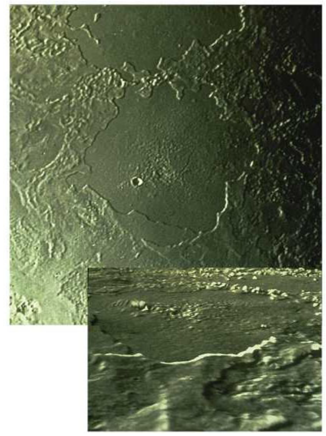
The surface material is fresh ice or frost, with a reflectivity of about 80%. This frost may include mixtures of water, methane, and nitrogen, all of which are frozen at Triton's temperature. Because its albedo is so high, its surface temperature is low – between 35 and 40 K.



NASA

Triton

Most gases are frozen at these temperatures, but a small quantity of nitrogen vapor persists to form **an atmosphere**. The surface pressure is only 16 millionths of a bar, yet this is sufficient to maintain a substantial ionosphere and to support hazy cloud layers.



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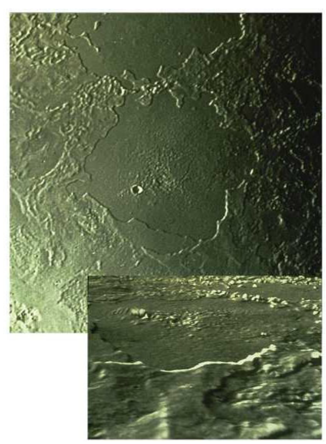
Triton

Triton's surface reveals a long history of geological evolution.

(a) While there are some impact craters, there are also may regions that have been flooded by "lava" (water mixtures) during past epochs of endogenic activity.

(b) There are several frozen "lava lakes" more than 100 km across.

(c) There are also mysterious regions of jumbled or mountainous terrain that resemble the mountainous regions of Ganymede.

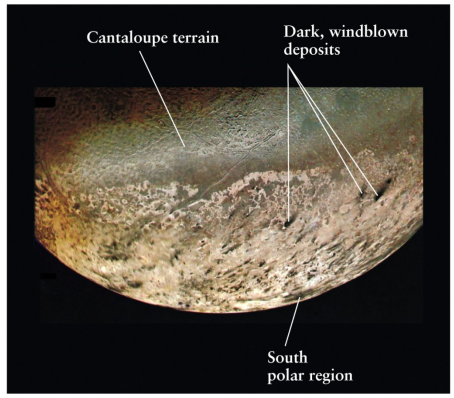


NASA

Triton

At the time of the Voyager flyby, the southern hemisphere had a **polar cap**, which was apparently evaporating along its northern edge.

This polar cap may consist of frozen nitrogen, deposited during the previous winter.

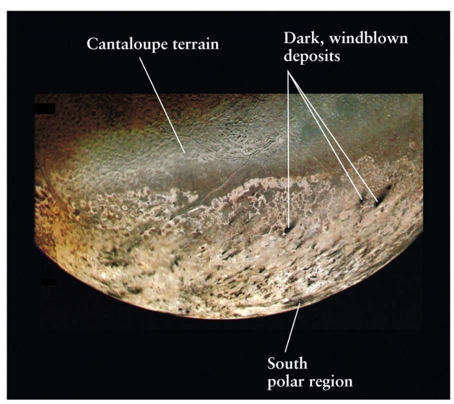


NASA

Triton

The evaporation seems to generate **geysers or volcanic plumes of nitrogen** that fountain to altitudes of about 10 km above the surface.

These plumes differ from the volcanoes of Io in their composition, and also in that they derive their energy from sunlight warming the surface rather than from endogenic heat.



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