

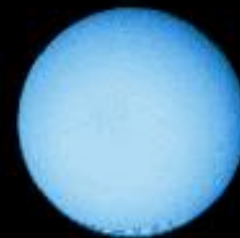
The Jovian Planets



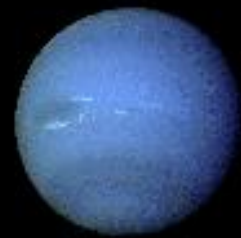
Jupiter



Saturn












Uranus



Neptune

Similarities & Differences to Inner Planets

TABLE 6.1 Planetary Data*

Photo	Planet	Relative Size	Average Distance from Sun (AU)	Average Equatorial Radius (km)	Mass (Earth = 1)	Average Density (g/cm ³)	Orbital Period	Rotation Period	Axis Tilt	Average Surface (or Cloud Tops) Temperature [†]	Composition	Known Moons (2004)	Rings?
	Mercury	•	0.387	2,440	0.055	5.43	87.9 days	58.6 days	0.0°	700 K (day) 100 K (night)	Rocks, metals	0	No
	Venus	•	0.723	6,051	0.82	5.24	225 days	243 days	177.3°	740 K	Rocks, metals	0	No
	Earth	•	1.00	6,378	1.00	5.52	1.00 year	23.93 hours	23.5°	290 K	Rocks, metals	1	No
	Mars	•	1.52	3,397	0.11	3.93	1.88 years	24.6 hours	25.2°	240 K	Rocks, metals	2	No
	Jupiter	●	5.20	71,492	318	1.33	11.9 years	9.93 hours	3.1°	125 K	H, He, hydrogen compounds [§]	61	Yes
	Saturn	●	9.54	60,268	95.2	0.70	29.4 years	10.6 hours	26.7°	95 K	H, He, hydrogen compounds [§]	31	Yes
	Uranus	●	19.2	25,559	14.5	1.32	83.8 years	17.2 hours	97.9°	60 K	H, He, hydrogen compounds [§]	24	Yes
	Neptune	●	30.1	24,764	17.1	1.64	165 years	16.1 hours	29.6°	60 K	H, He, hydrogen compounds [§]	13	Yes
	Pluto	•	39.5	1,160	0.0022	2.0	248 years	6.39 days	112.5°	40 K	Ices, rock	1	No

A close-up view of the planet Jupiter, showing its characteristic orange and white bands and the Great Red Spot. The planet is set against a dark background, and the word "Jupiter" is overlaid in white text.

Jupiter

Jupiter: Basic Characteristics

Mass = 1.898×10^{27} kg (*318 x Earth*)

Radius = 71,492 km (*11x Earth*)

Albedo (reflectivity) = 0.34 (Earth = 0.39)

Average distance from Sun = *5.20 A.U.*

Orbital period (Revolution) = *4332.59 Earth days*

Rotation period = *9.9 Earth hours* (fastest in the solar system)

Jupiter has an *axis of 3.13 degrees*, which means it does **not** experience large changes in *seasons*

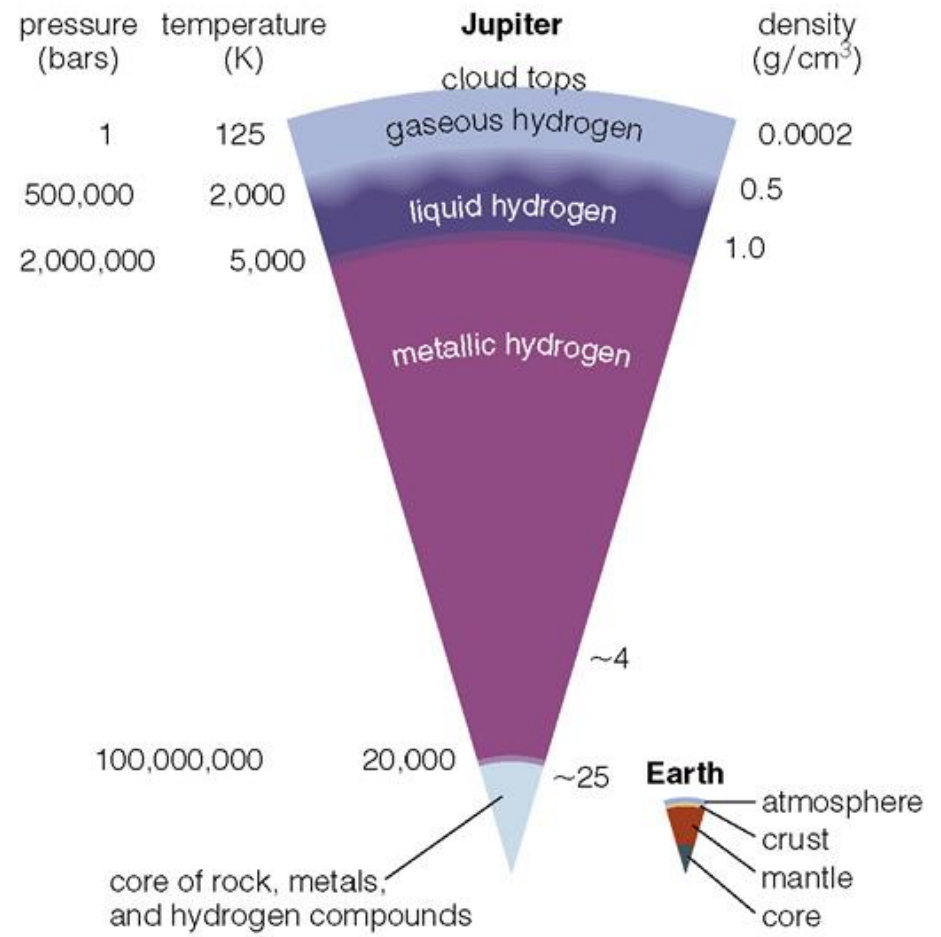


Jupiter: Key Concepts

- (1) Internal Structure:** the temperature and density of H and He increase as depth increases; core is rocky
- (2) Appearance:** Jupiter's colored stripes are due to clouds formed at different levels in the atmosphere
- (3) Weather:** The Great Red Spot is a high pressure (no rain) storm system that has been around for several hundred years
- (4) Satellites:** Jupiter has 67 known moons
- (5) Rings:** Jupiter has rings, just like every other Jovian planet

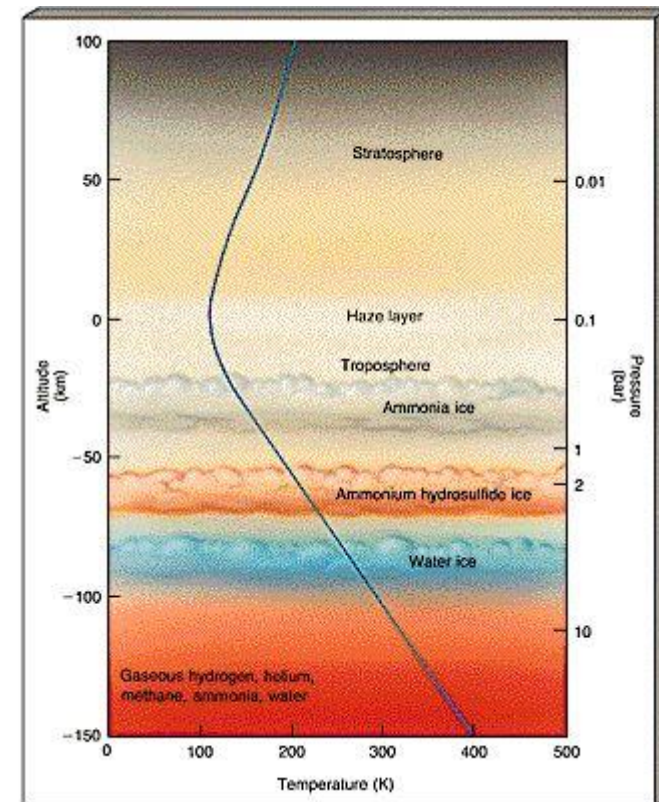
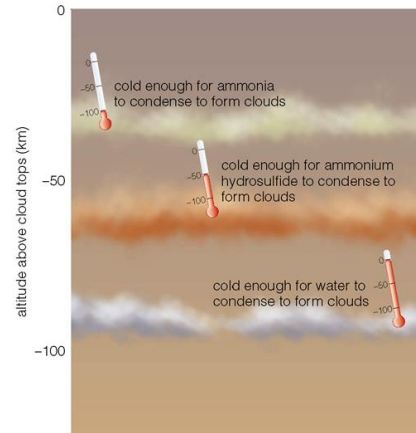
(1) Jupiter's interior is not uniform in density and temperature

- *Temperature and density increase as depth increases*
- Made up *mostly of Hydrogen & Helium*, except the core
- *Core is rock, metals* and Hydrogen compounds



(2) Jupiter's colored stripes are due to *clouds formed at different levels in the atmosphere*

- **WHITE – Ammonia** clouds condense at the ‘top’ of Jupiter’s atmosphere.
- **BROWN and RED – Ammonium hydrosulfide** condense at -50 km below (we in fact don’t know why it is red).
- **WHITE – Water vapor** condenses at 100 km below.



(3) The Great Red Spot is a storm system

- Great Red Spot is a storm that has *lasted several hundred years*
- High pressure system – it rotates counter clockwise in the southern hemisphere
- Big enough to *hold 2-3 Earths*



(4) Jupiter has *67 known moons*

- Made of rocky materials and lots of water (no H or He)
- Large and medium moons: all spherical
 - Rotate and revolve in the same direction as Jupiter
- Small moons: irregular shapes and no orbital pattern



The Galilean Moons of Jupiter

Four largest moons of Jupiter were first discovered by Galileo Galilei in the early 1600's

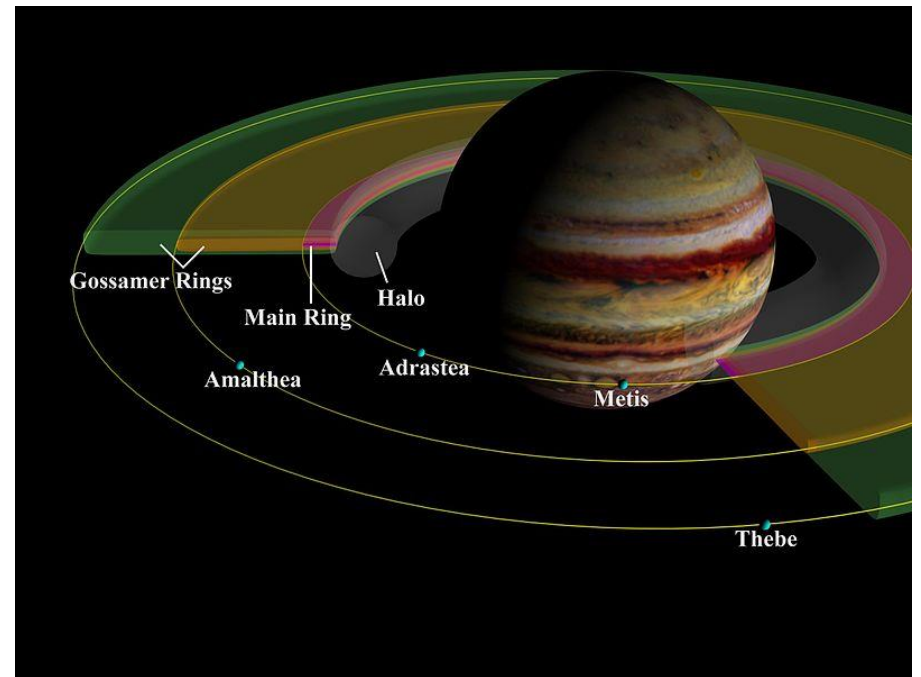
- **Io:** active volcanism
- **Europa:** under surface water, atmosphere of oxygen
- **Ganymede:** larger than Mercury!
- **Callisto:** heavily cratered; barely smaller than Mercury



(5) Jupiter has rings

Jupiter has *faint* planetary *ring* system with *three main segments* made *of dust* (not ice)

1. Inner “halo” ring
2. Main ring – brightest
3. Outer “gossamer” ring





Saturn

Saturn: Basic characteristics

Mass = 5.685×10^{26} kg (*95x Earth*)

Radius = 60,268 km (*9x Earth*)

Albedo (Reflectivity) = 0.34 (Earth = 0.39)

Average distance from Sun = *9 A.U.*

Orbital period (Revolution) = *10,759 Earth days* (29.5 Earth years)

Rotation period = *10 hours, 32 minutes (Earth hours)*

Saturn's axis is tilted 26.73 degrees, resulting in seasons



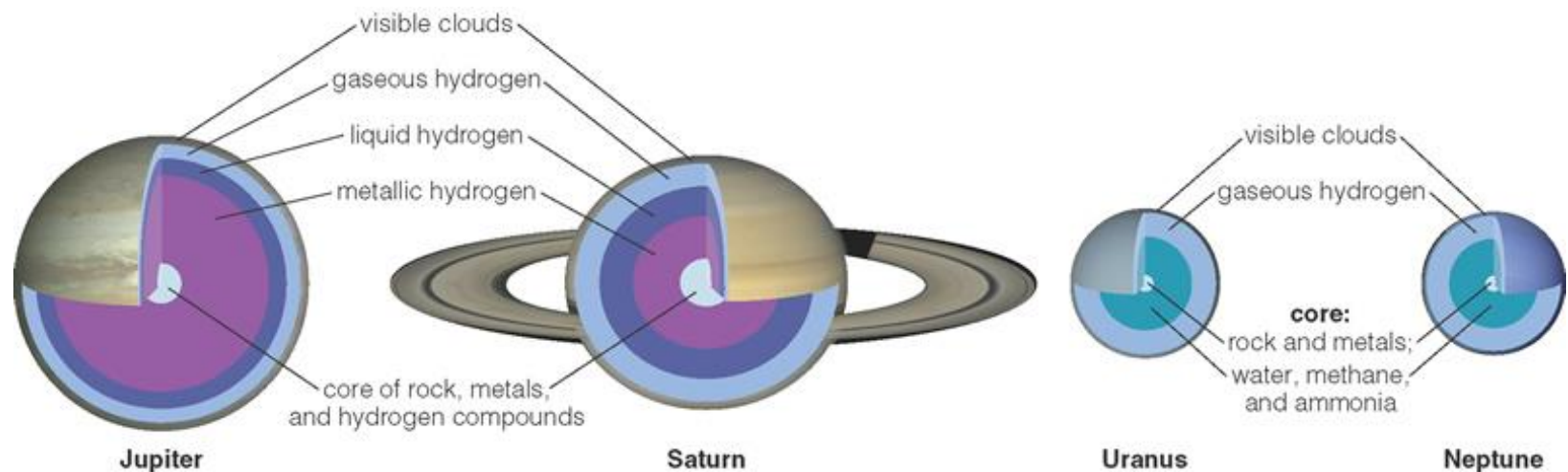
Saturn: Key Concepts

- (1) **Internal Structure:** the interior of Saturn is solid, surrounded by a middle liquid layer and outer gaseous layer.
- (2) **Appearance:** Saturn's colored stripes are due to clouds formed at different levels in the atmosphere
- (3) **Weather:** Saturn's bands indicate active weather
- (4) **Satellites:** Saturn has 62 known moons, the largest being Titan
- (5) **Rings:** Saturn's rings are made up of a variety of orbiting objects including ice and rocky debris

(1) Saturn is solid, surrounded by a middle liquid layer and outer gaseous layer.

Similar to Jupiter, Saturn has a *rocky core, surrounded by Hydrogen and Helium*

Temperature, pressure, and density increase as you move toward the core



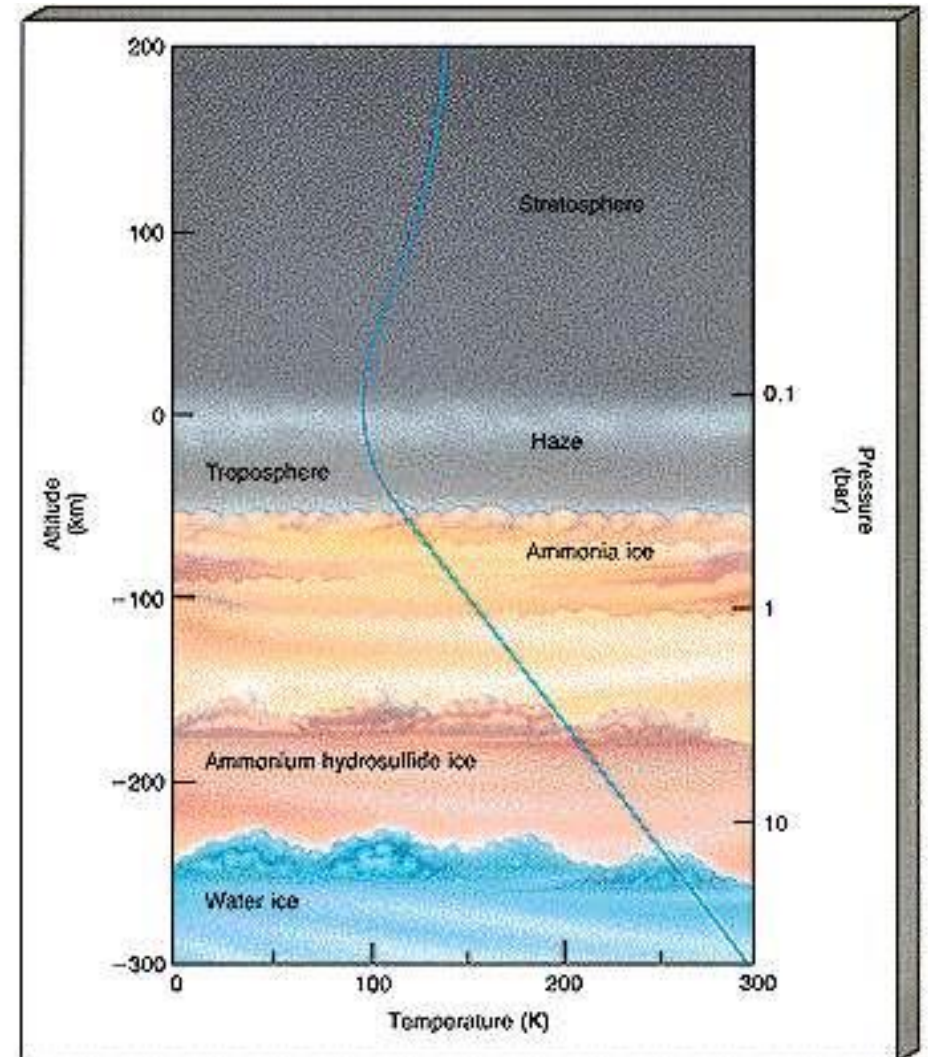
(2) Saturn's colored stripes are due to *clouds formed at different levels in the atmosphere*

Ammonia Ice (Upper Cloud Layers) - form where temperatures are between 100-160K and pressure is between 0.5-2 bar

Water ice clouds – form where temperatures are between 185-270K and pressure is 2.5-9.5 bar

Ammonium Hydrosulfide Ice – form where temperatures are between 290–235 K. and pressure is 3-6 bar (mixed with water ice)

Water Droplets/Ammonia (Lower Cloud Layers) – form where temperatures are between 270–330 K, and pressure is 10-20 bar

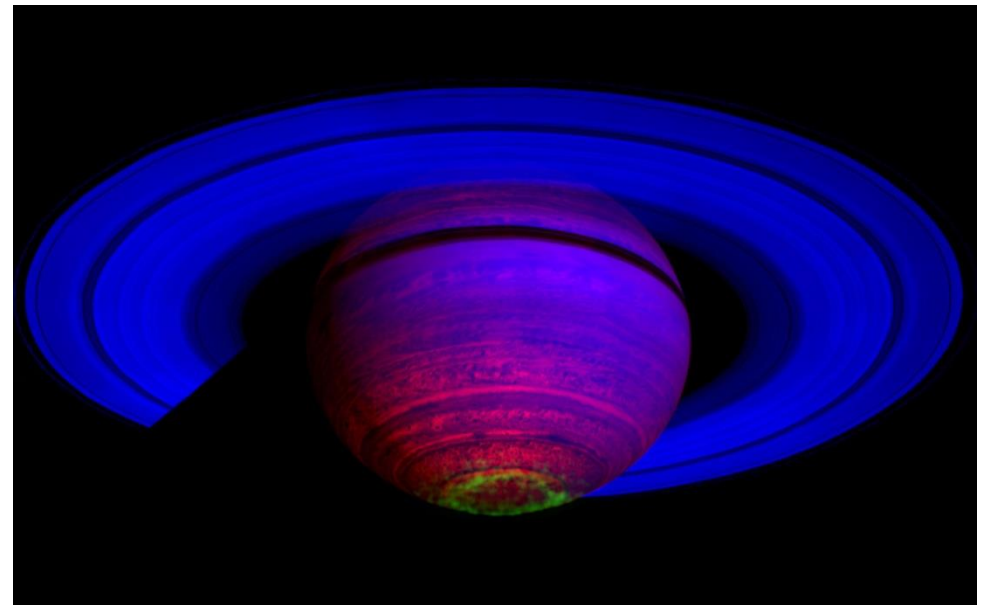
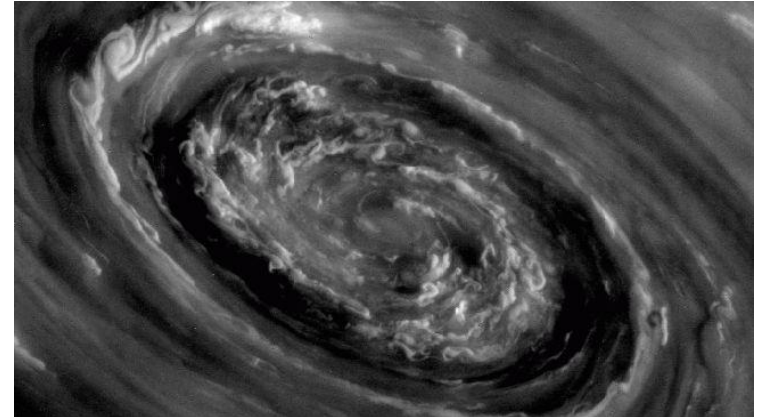


(3) Saturn's Active Weather

Saturn is considerably colder than Jupiter being further from the Sun,
the Sun,

Average temperature of about
-285 degrees F.

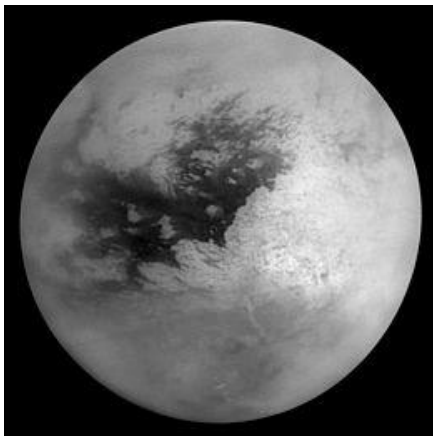
Wind speeds on Saturn are extremely high, slightly more than 1,000 mph, considerably higher than Jupiter.



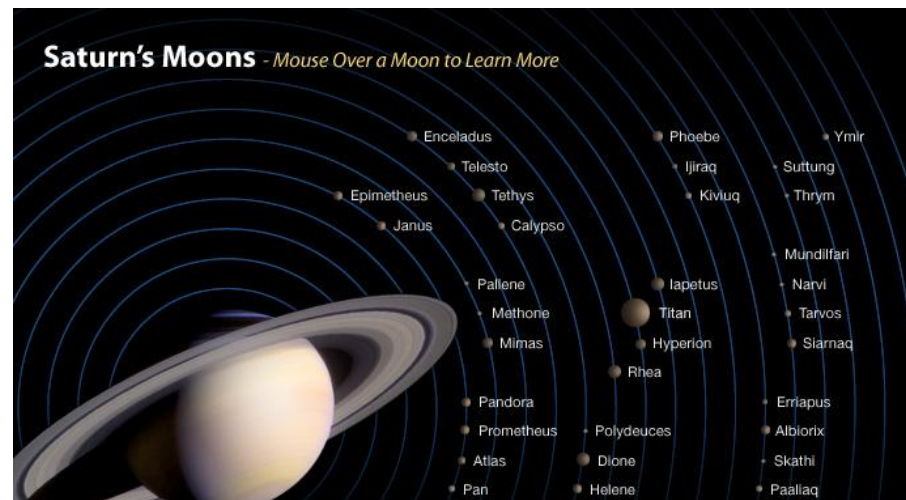
Glowing aurora on Saturn from winds & strong magnetic field

4) Saturn has *62 known moons*

- Titan, the largest, comprises more than 90% of the mass in orbit around Saturn, including the rings.
- Titan is the only satellite in the solar system with a major atmosphere
- Saturn's second largest moon, Rhea may have a tenuous ring system of its own, along with a tenuous atmosphere
- ¹ Many of the other moons are very small: 34 are less than 10 km in diameter and another 14 less than 50 km
- Saturn's moon Enceladus has often been regarded as a potential base for microbial life due to its “ocean-like” lakes but has cryovolcanism (water/ice volcanoes!)



Titan, Saturn's largest moon



(5) Saturn's Rings are the largest and most visible in our solar system

Rings extend from 6,630 km to 120,700 km above Saturn's equator,

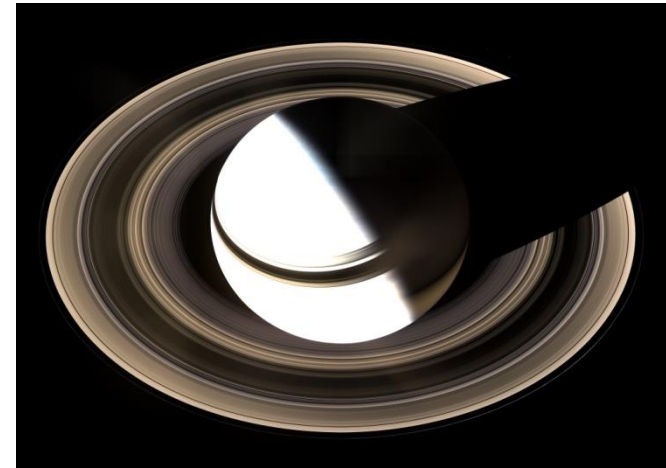
They average approximately 20 meters in thickness

Composed of 93% water ice and 7% amorphous carbon

The particles that make up the rings range in size from specks of dust up to 10 m

Theories of their origin:

1. rings are remnants of a destroyed moon of Saturn.
2. rings are left over from the original nebular material from which Saturn formed.





Uranus

Uranus: Basic Characteristics

Mass = 8.681×10^{25} kg (**14x Earth**)

Radius = 25,559 km (**4x Earth**)

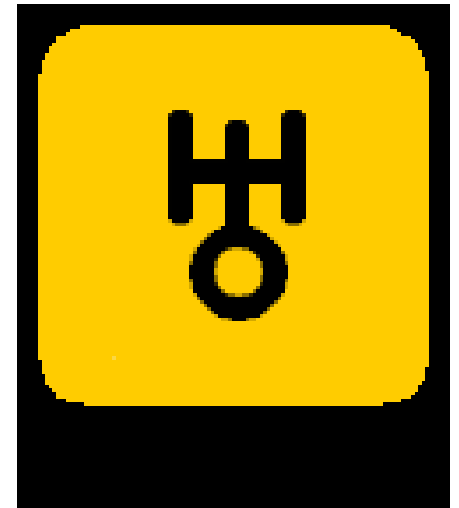
Albedo = 0.30 (Earth = 0.39)

Average distance from Sun = **19.2 A.U.**

Orbital period (Revolution) = 84.3 Earth years

Rotation period = 17 hours, 14 minutes

Rotation axis of Uranus is **tilted** by **97.77 degrees** (parallel with solar system)



Uranus: Key Concepts

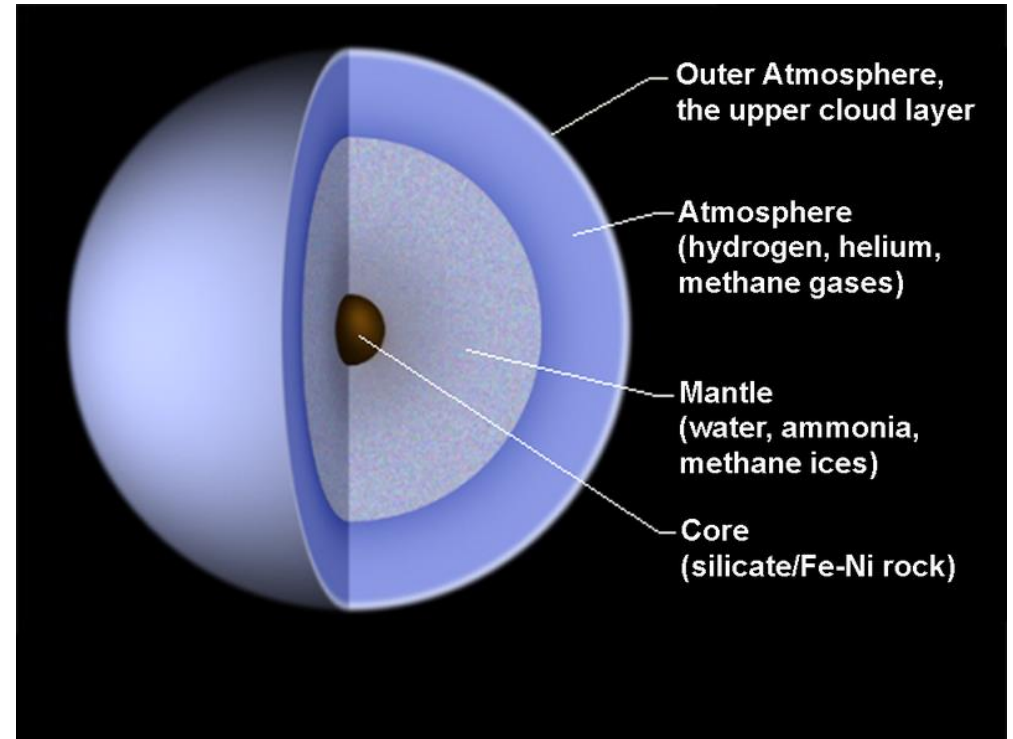
- (1) **Internal Structure:** the interior of Uranus is mostly ices such as water, ammonia & methane
- (2) **Appearance:** Uranus appears blue because of methane gas and clouds
- (3) **Weather:** Uranus has bands, showing strong winds and weather
- (4) **Satellites:** Uranus has 27 known moons
- (5) **Rings:** There are 13 distinct rings of Uranus

(1) Uranus is mostly ices such as water, ammonia & methane

Core: small amount of iron and nickel rock

Mantle (largest): water, ammonia & methane ices

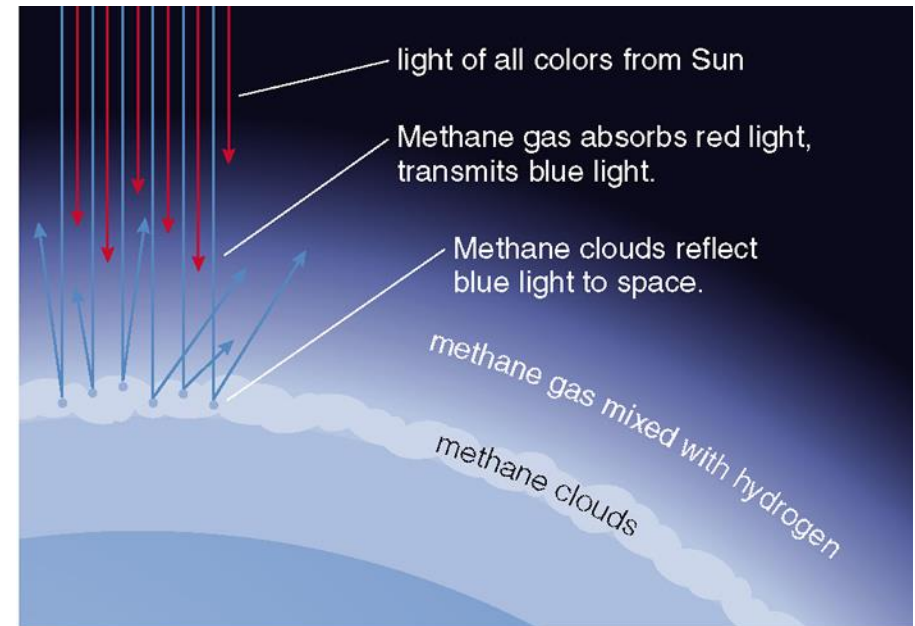
Atmosphere: hydrogen, helium & methane gases



(2) Uranus appears blue because of methane gas and clouds

Methane gas absorbs red light, and transmits blue light

Methane clouds reflect blue light into space (what we see)



(3) Uranus's active weather

Bands of color indicate winds and weather

Wind speeds up to 560mph

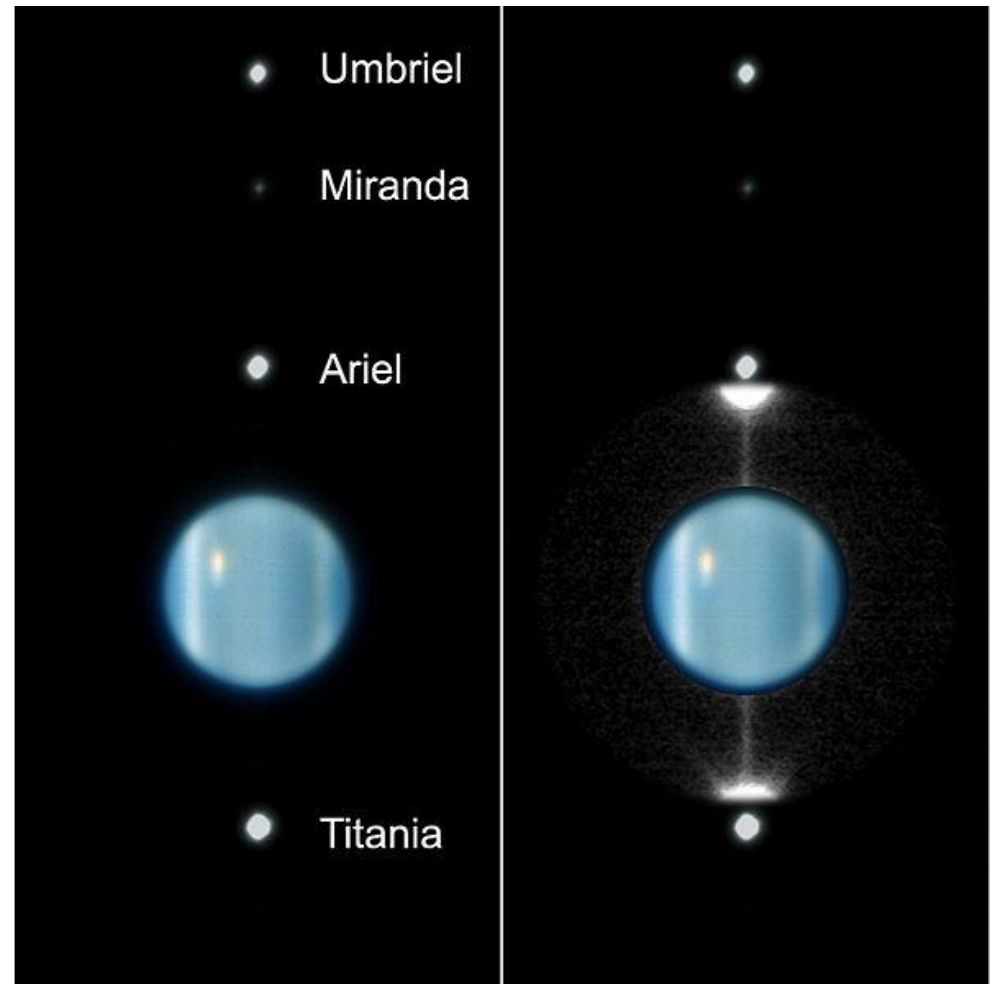
Less visible bands than other giants, but they are increasing over the past several years as it reaches equinox



4) Uranus has *27 known moons*

All are named after characters from works of Alexander Pope and Shakespeare

Relatively small: largest (Titania) is less than half the size of Earth's moon



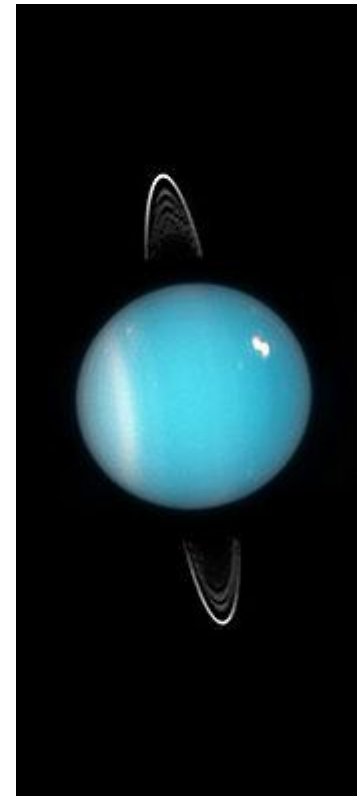
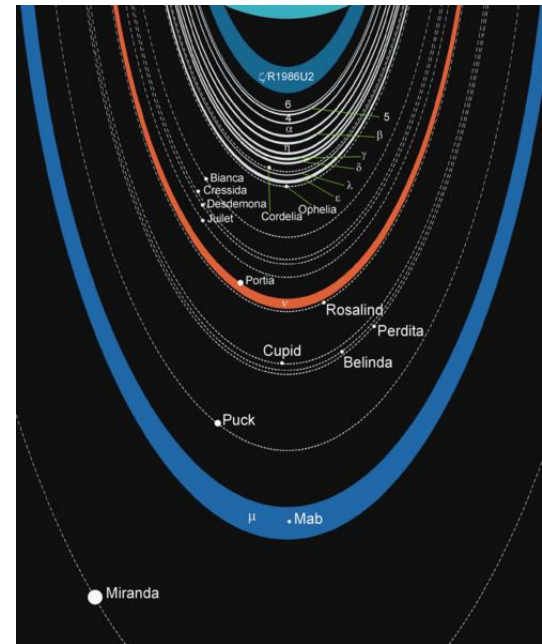
(5) Uranus's Dark Rings

Second to be discovered (after Saturn)

Thirteen rings, made up of small (< 1 meter) dark particles

Largest ring is called epsilon

Thought to have formed from moon that broke up from collision





Neptune

Neptune: Basic Characteristics

Mass = 1.024×10^{26} kg (**17x Earth**)

Radius = 24,764 km (**4x Earth**)

Albedo = **0.29** (Earth = 0.39)

Average distance from Sun = **30.1 A.U.**

Orbital period (**Revolution**) = 164.79 Earth years

Rotation period = 19.1 hours

Rotation axis of Neptune is tilted by **28.32 degrees**

Seasons are similar to that of Earth, but they each last 40 years!



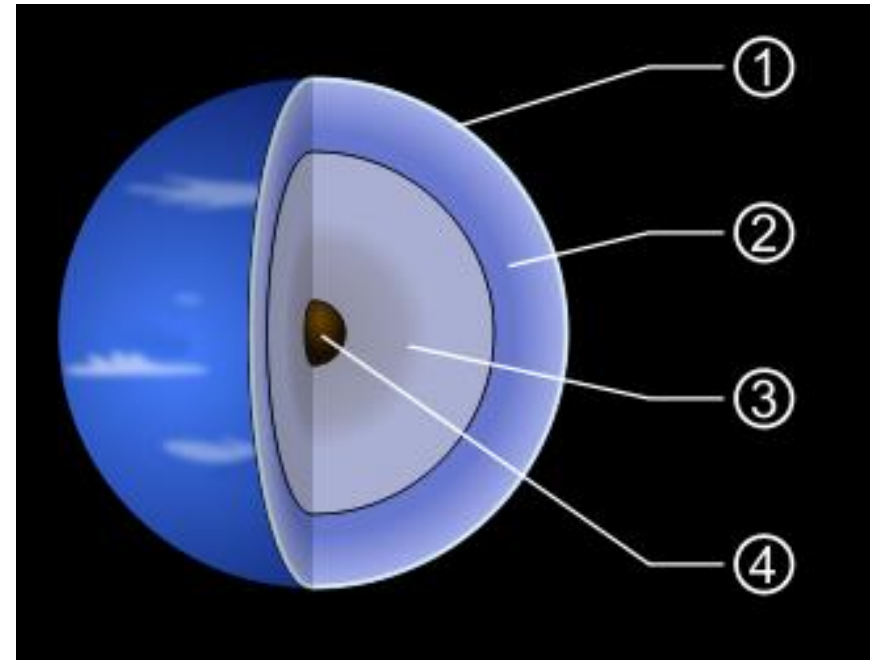
Neptune: Key Concepts

- (1) Internal Structure:** the interior of Neptune is primarily composed of ices and rock, with water, ammonia & methane ices in mantle
- (2) Appearance:** Neptune appears blue because of methane gas and clouds
- (3) Weather:** Neptune has active weather, including anti-cyclonic storms, like Jupiter
- (4) Satellites:** Neptune has 13 known moons
- (5) Rings:** The rings of Neptune are icy and have a reddish hue

Fun Fact: Neptune was predicted before it was observed!

(1) Neptune is primarily composed of ices and rock

1. Upper atmosphere, top clouds
2. Atmosphere: made of hydrogen, helium and methane gas
3. Mantle: made of water, ammonia and methane ices
4. Core: made of rock (silicates and nickel-iron)



The internal structure of Neptune:

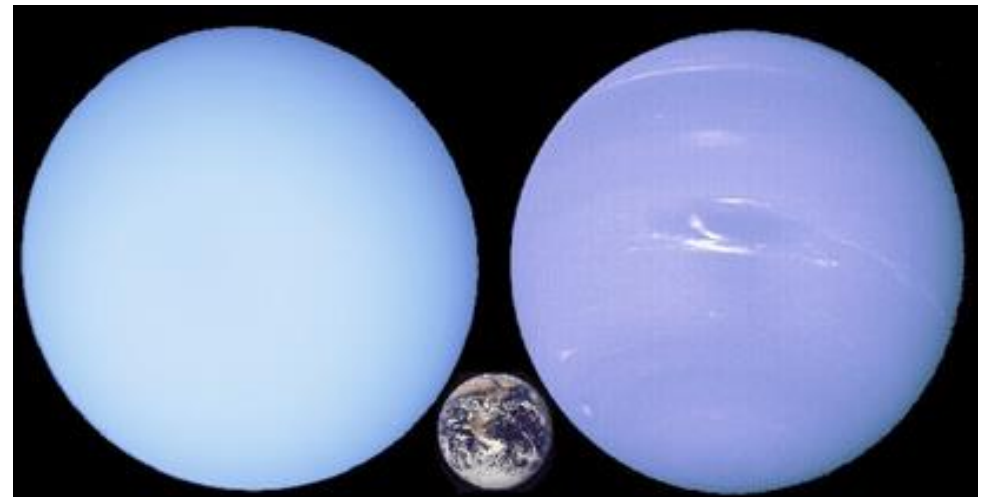
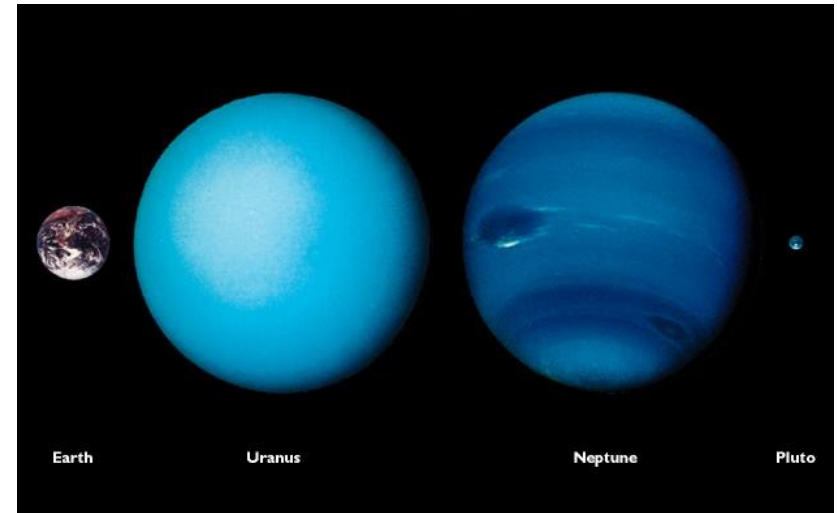
1. Upper atmosphere, top clouds
2. Atmosphere consisting of hydrogen, helium and methane gas
3. Mantle consisting of water, ammonia and methane ices
4. Core consisting of rock (silicates and nickel-iron)

(2) Neptune appears blue because of methane gas and clouds

Similar to Uranus, methane gas and clouds are responsible for blue color

However, Neptune is darker blue than Uranus, and has less methane.

We don't know what else makes it darker blue yet.



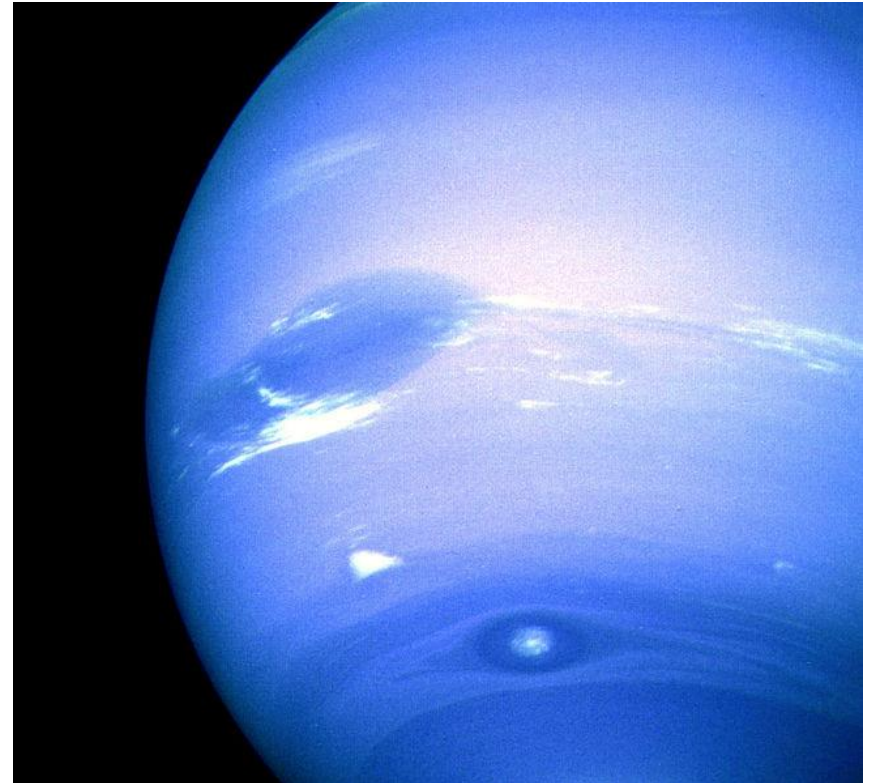
(3) Neptune's active weather

Neptune has dynamic storms with very fast winds

Great Dark Spot is a large storm, resembling the Great Red Spot on Jupiter

- Discovered 1989 (Voyager 2)
- Gone by 1994 (Hubble Telescope)

Other storms (Small Dark Spot, Scooter, etc.) appear, showing constant weather



The Great Dark Spot (top), Scooter (middle white cloud), and the Small Dark Spot (bottom), with contrast exaggerated.

4) Neptune has *13 known moons*

Largest moon, Triton, has a retrograde orbit (that's weird!)

Triton is the only moon of Neptune that is spherical; all others are irregularly shaped

Since Neptune is the god of the sea, all moons are named after lesser sea gods



Neptune (top), Triton (bottom)



Proteus, one of Neptune's small moons

(5) Neptune's rings are icy and have a reddish hue

Rings may consist of ice particles coated with silicates or carbon-based material, which most likely gives them a reddish hue

Rings have a clumpy structure – we don't know why

