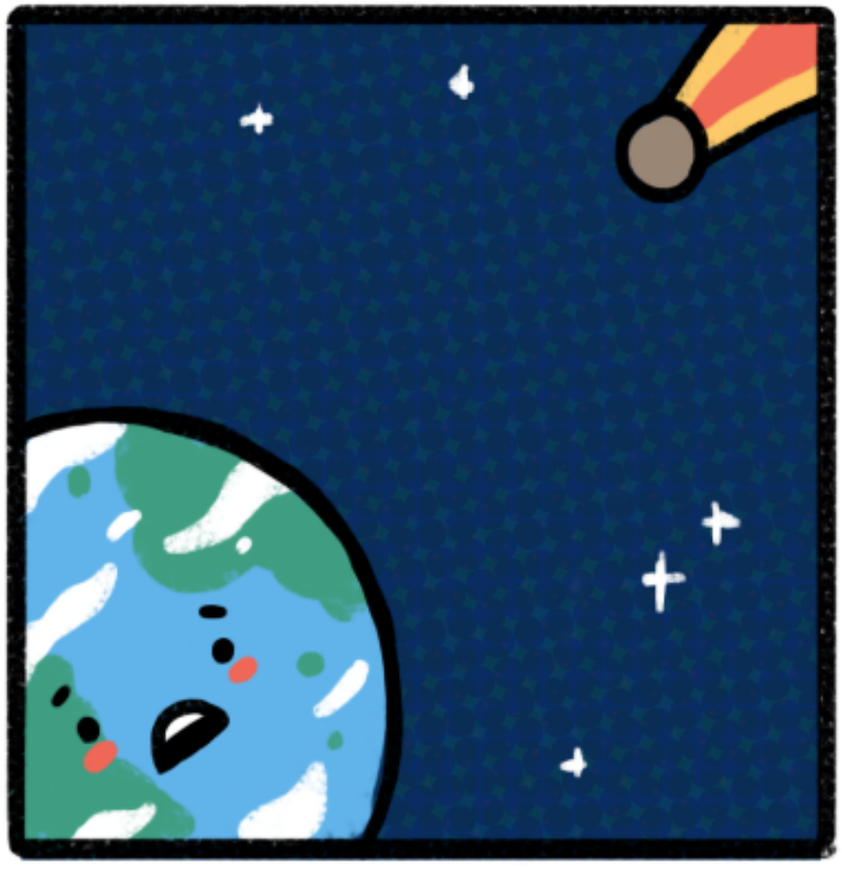
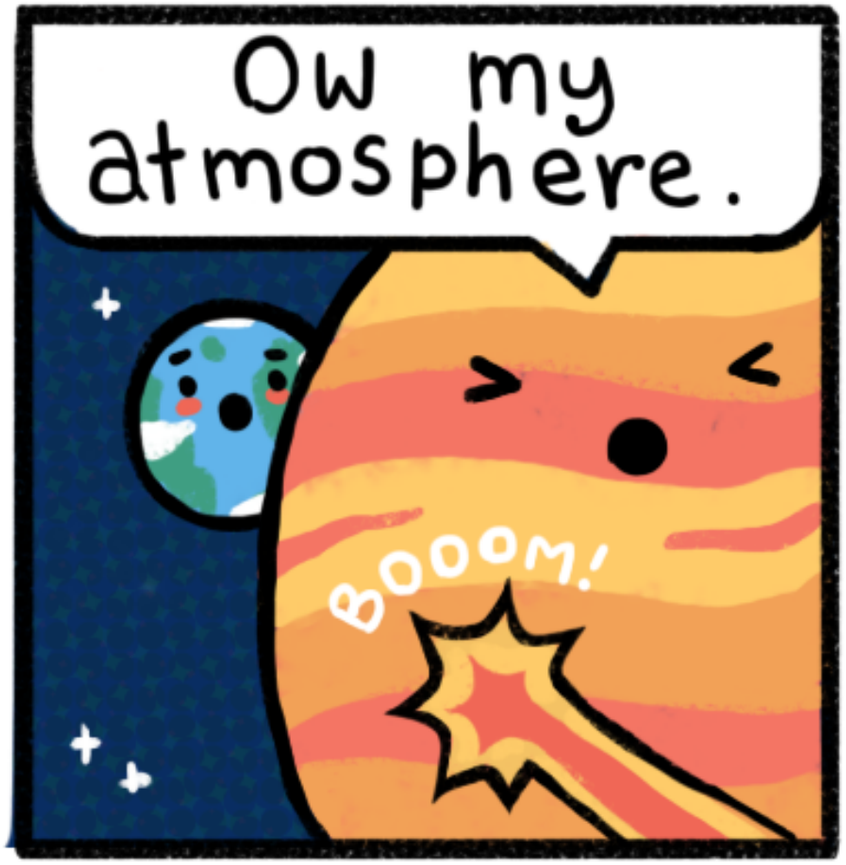
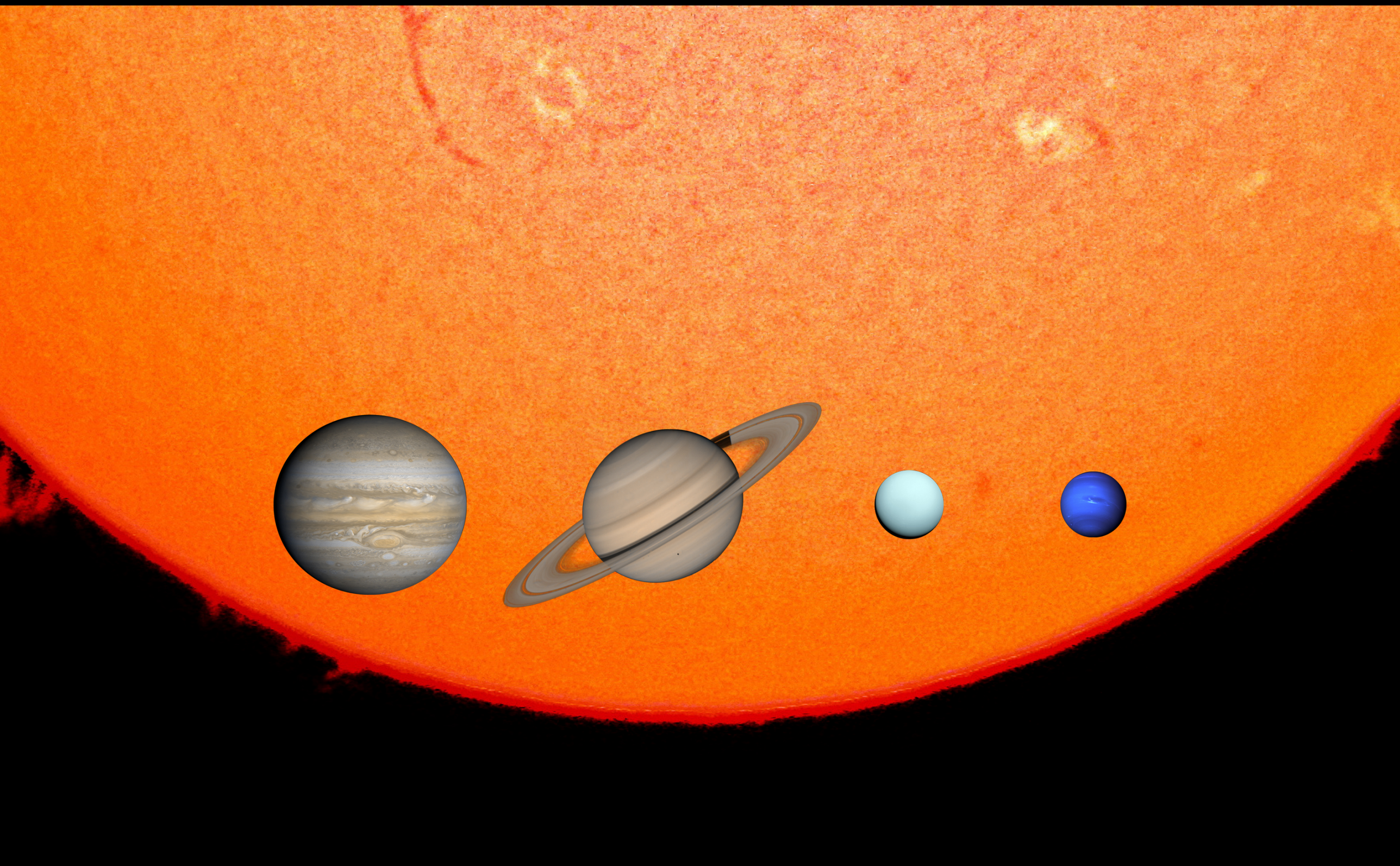


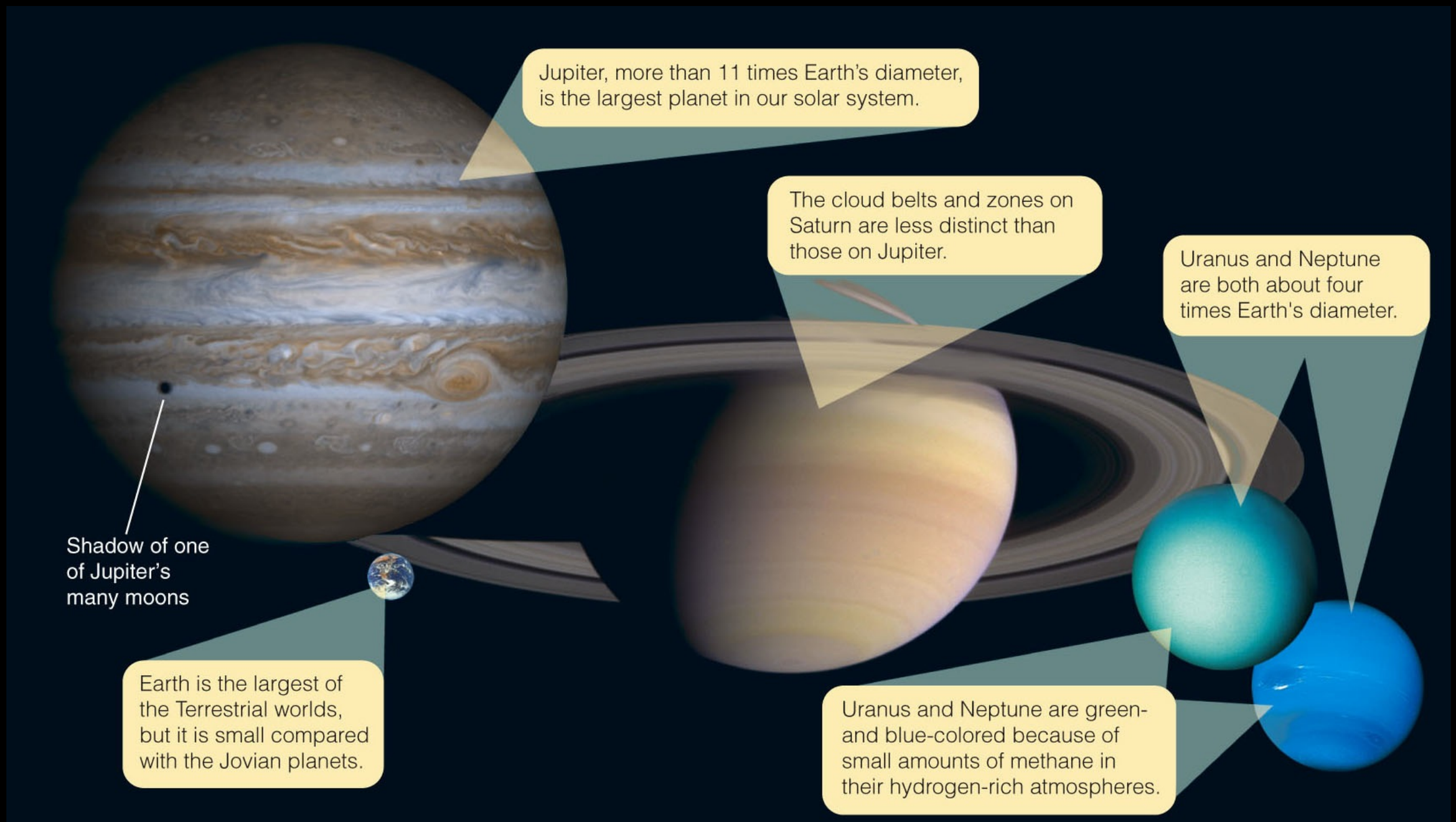


TIMECOWBOY

The Giant Planets



The outermost planets in our solar system are Jupiter, Saturn, Uranus, and Neptune.

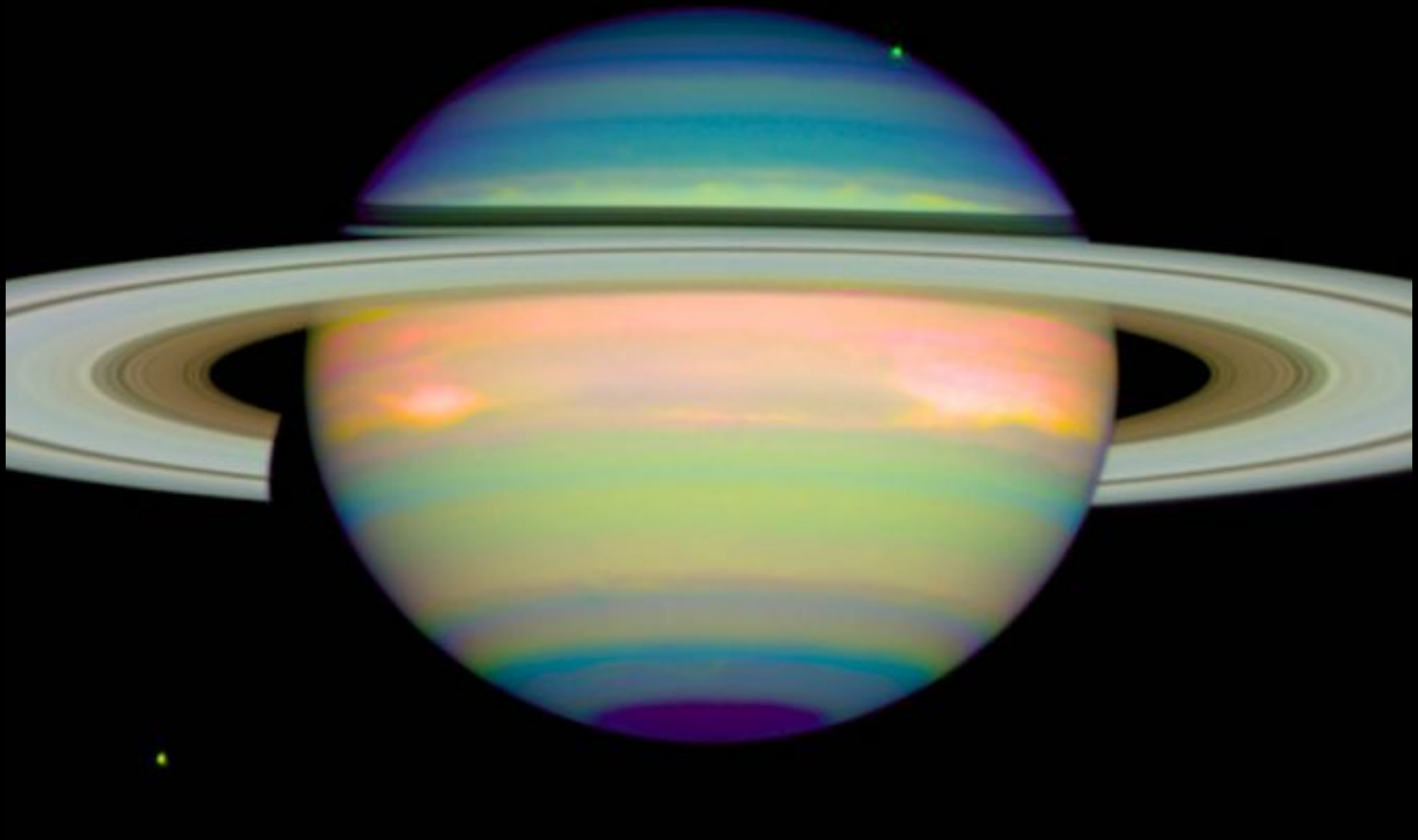


Jupiter is the largest and most massive of the planets.

-It contains 71 percent of all the planetary matter in the entire solar system.

-It is only 1.3 times more dense than water.

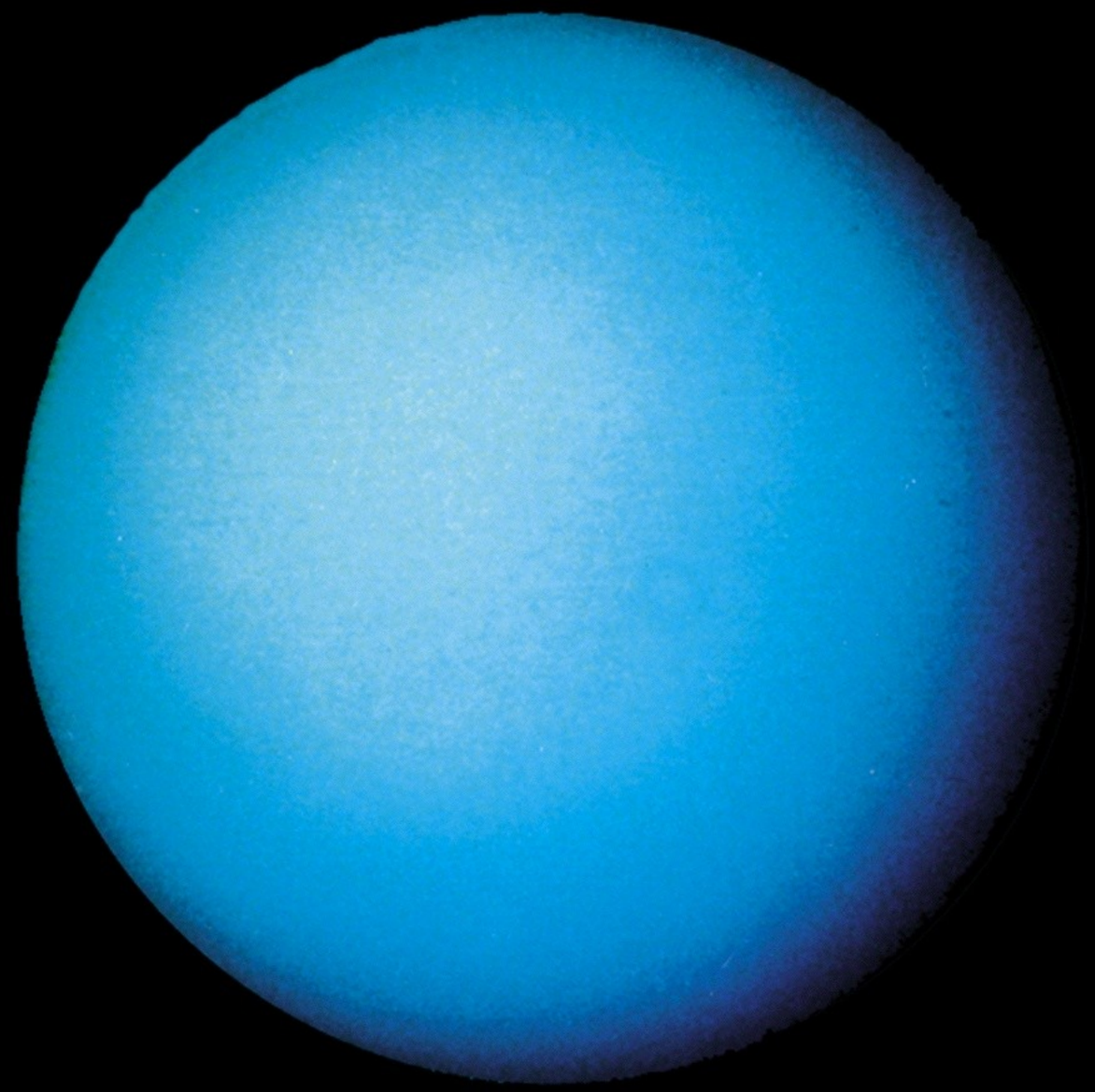
Saturn is best known for its extensive ring system.
While massive, it is actually less dense than water!



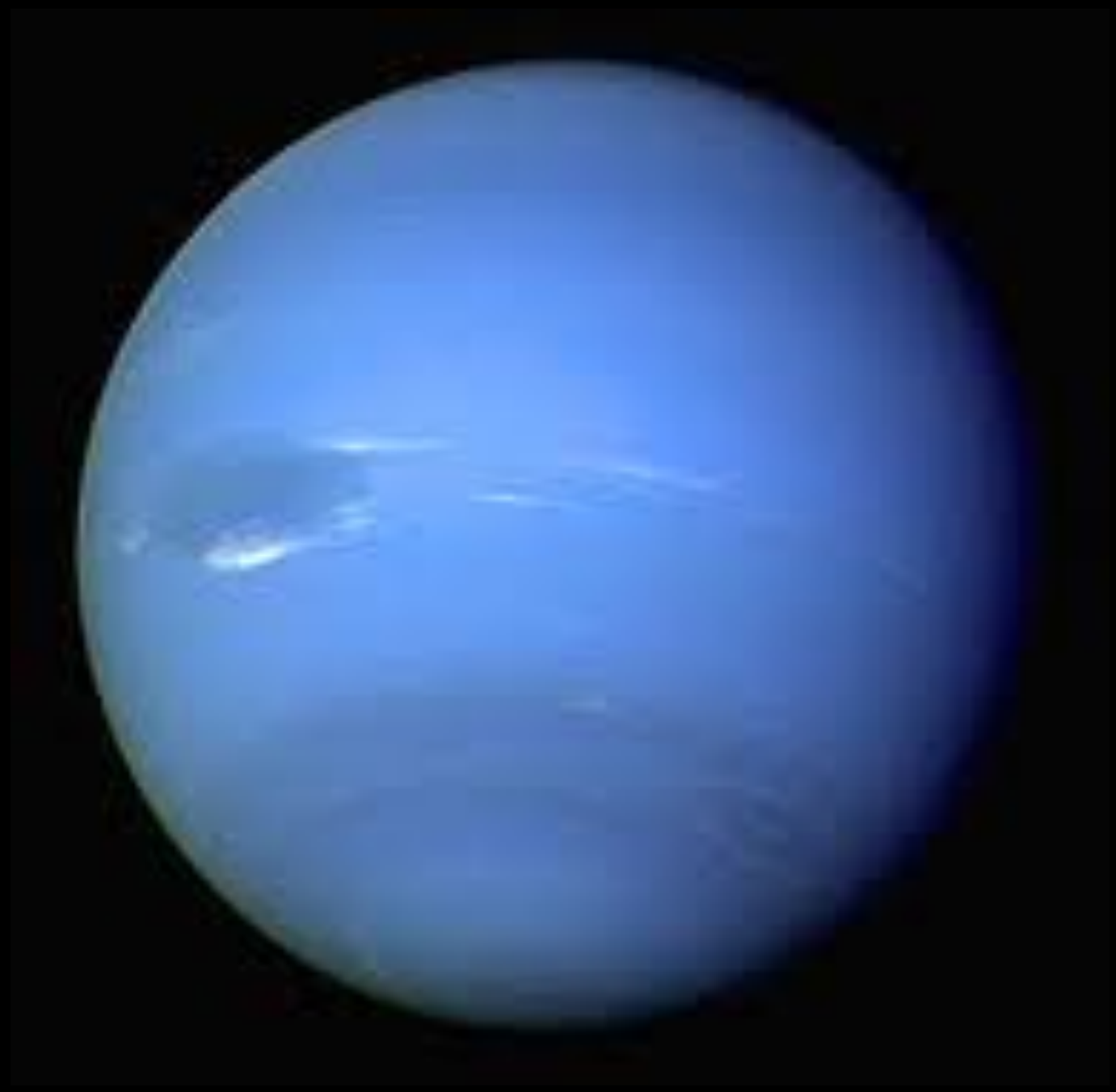
Uranus was discovered in 1781 by the scientist William Herschel

- Uranus is only a third the diameter of Jupiter and only a twentieth as massive.

- It never grew massive enough to capture large amounts of gas from the nebula as Jupiter and Saturn did.

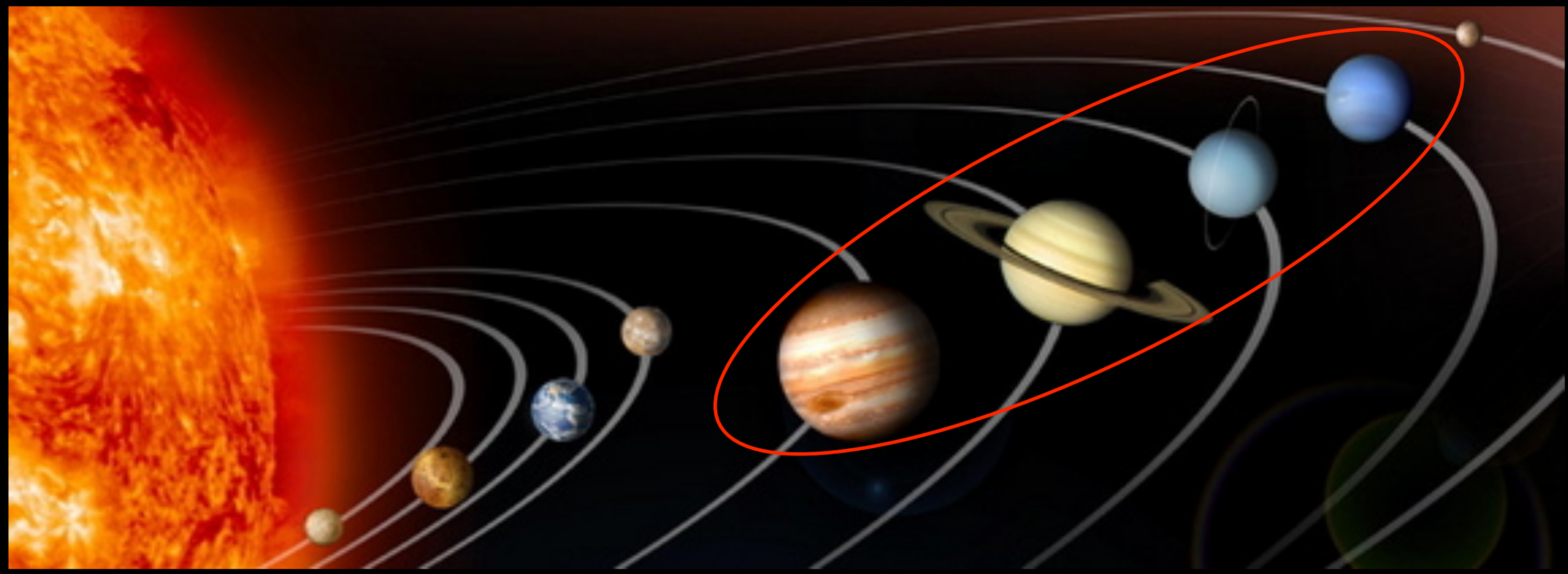


A British and a French astronomer independently calculated the existence and location of Neptune from irregularities in the motion of Uranus.



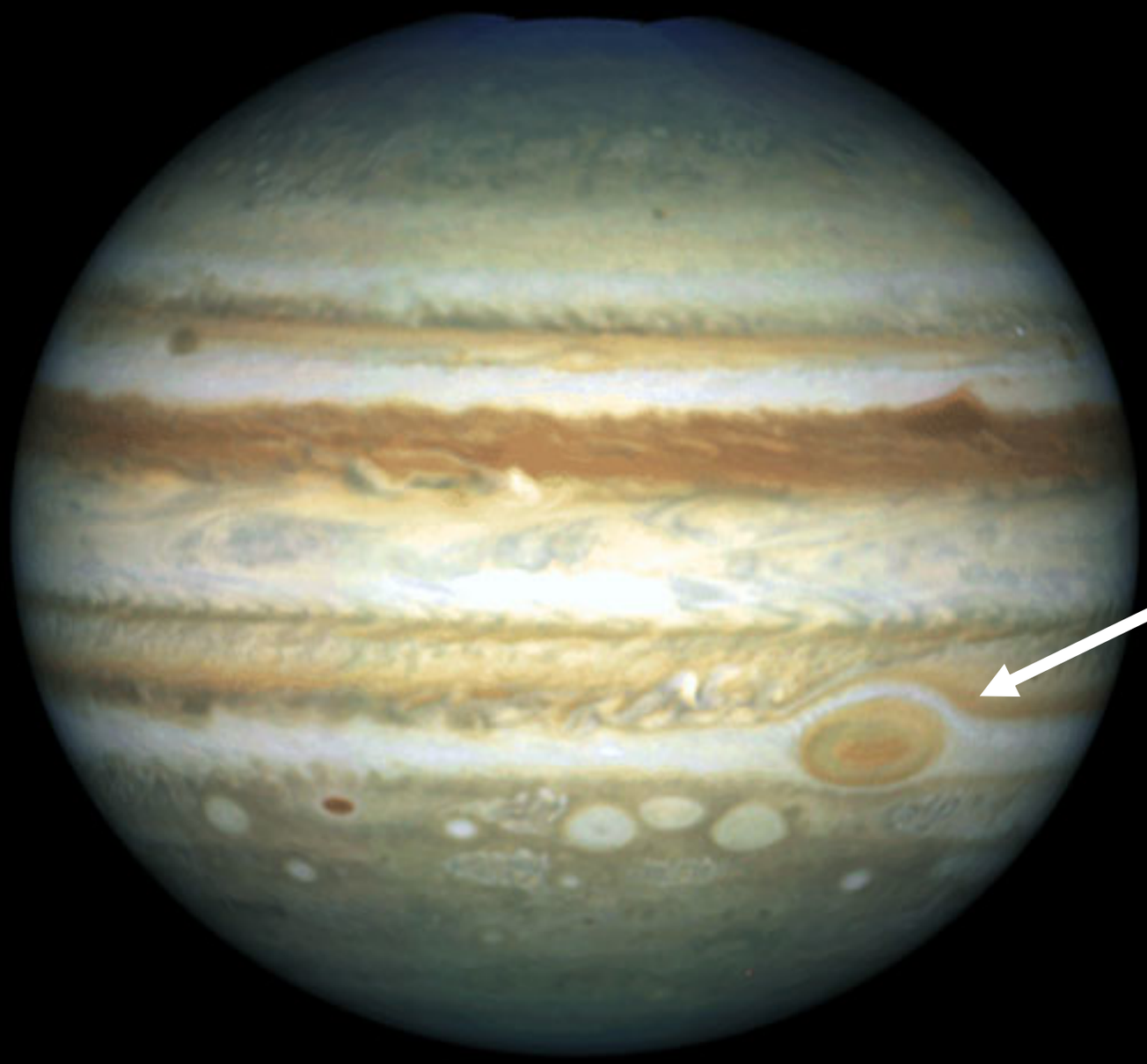
There are multiple aspects of the giant planets that we will focus on

1) Interiors
2) Atmospheres
3) Magnetic fields
4) ~~Surfaces~~



Atmospheres

The four Jovian worlds have hydrogen-rich atmospheres filled with clouds

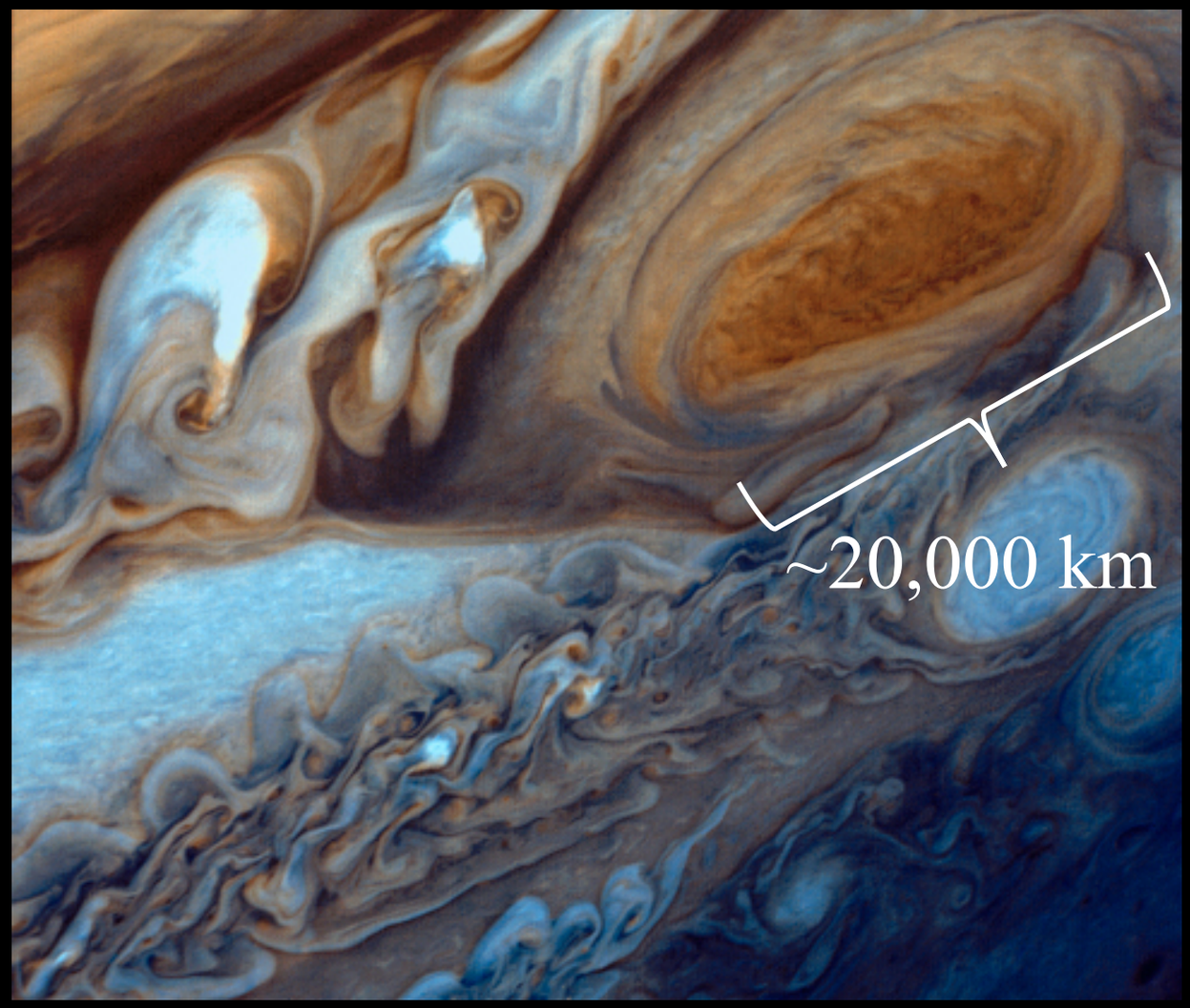


Great Red Spot-
Seen in 1643!

Next most common element is helium,
but molecules like methane, ammonia also present..

Jupiter's Great Red Spot

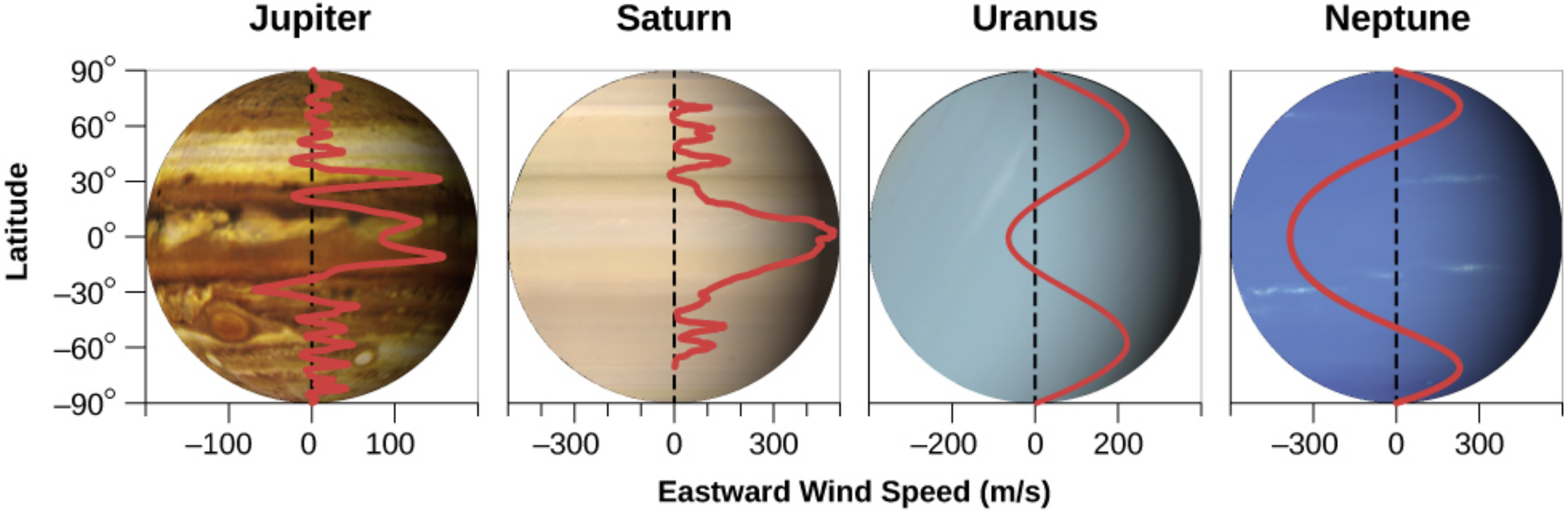
- A high-pressure storm region
- Material rotates once every ~6 days
- It seems to be shrinking very slowly
- The largest of several oval-shaped storms on Jupiter



Faster Rotation, Complex Winds

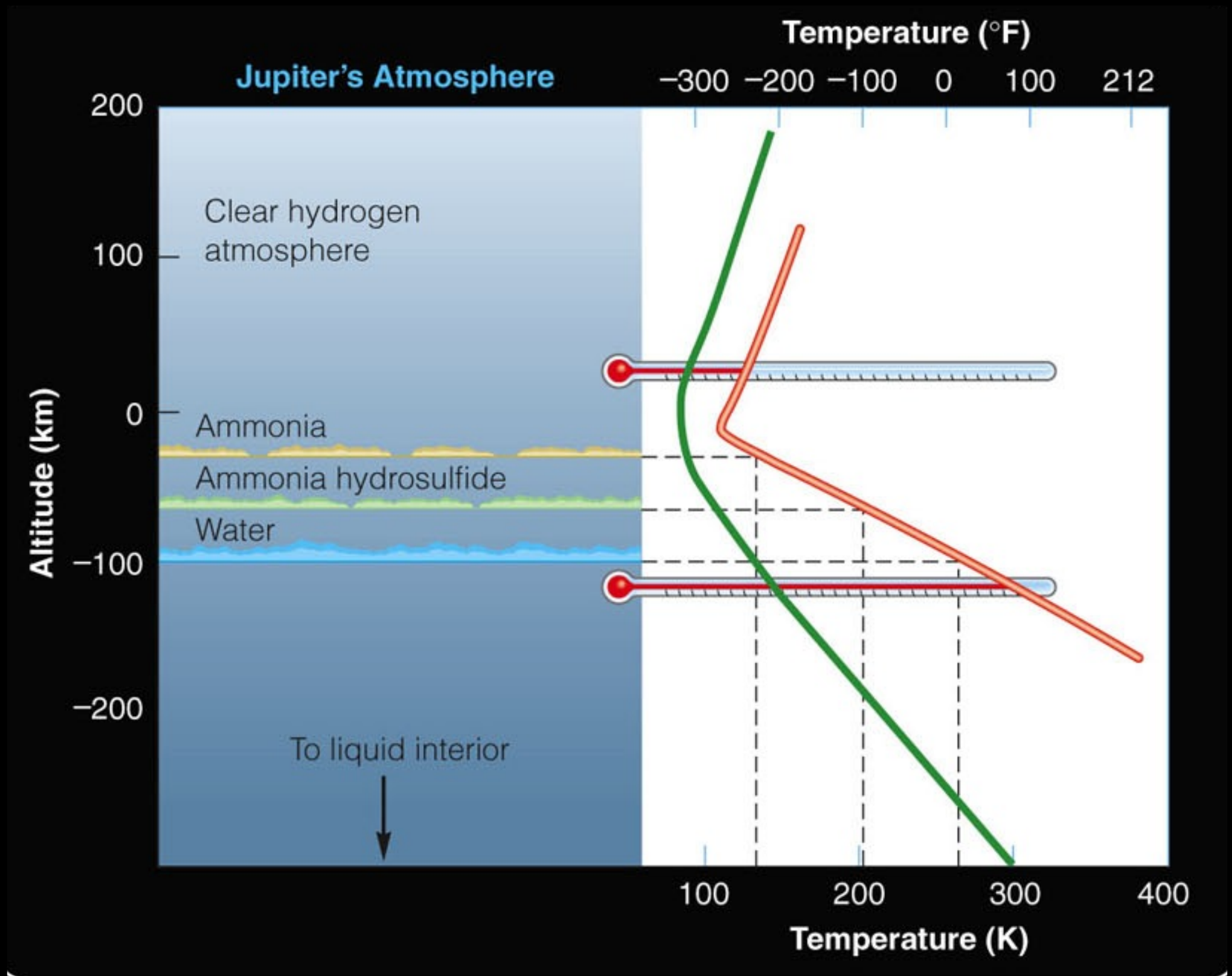
The jovian planets rotate faster than Earth so it is not surprising that the wind patterns are complex.

Winds in the zones and belts blow in opposite directions, at 100-1000 kilometers per hour!

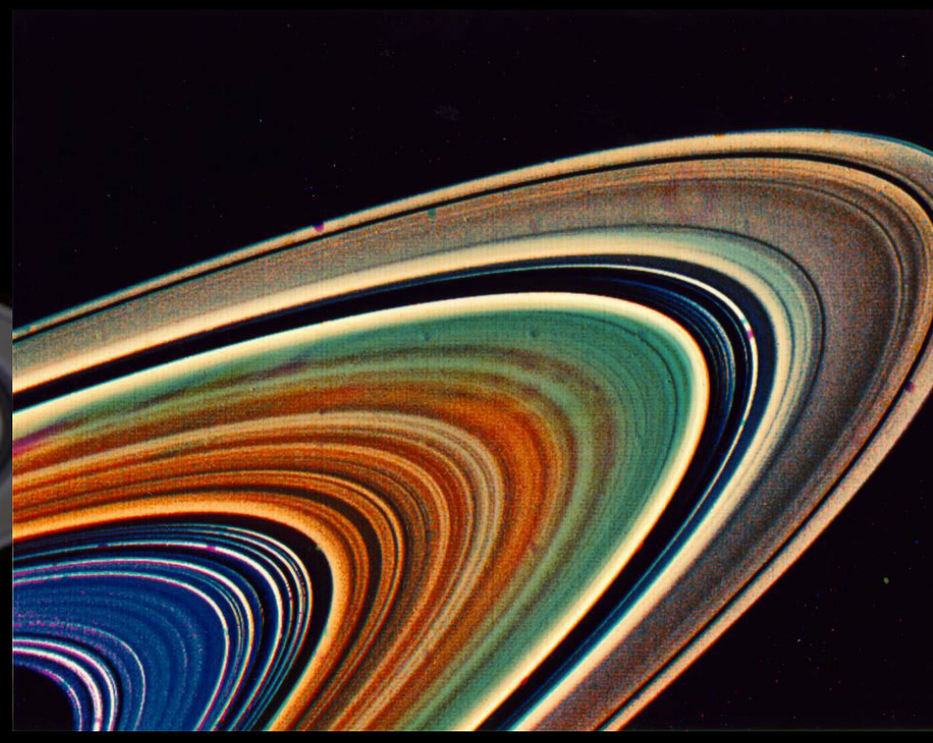


The positions of the cloud layers lie at certain temperatures within the atmosphere where ammonia (NH_3), ammonium hydrosulfide (NH_4SH), and water (H_2O) can condense.

Jupiter



Saturn is most famous for its beautiful rings

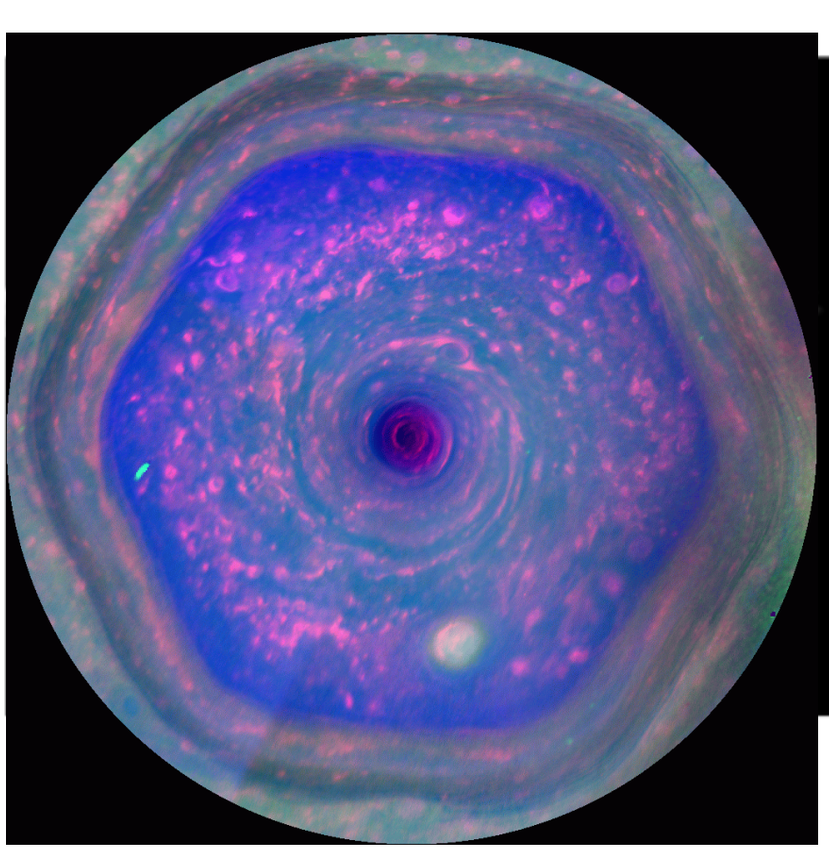


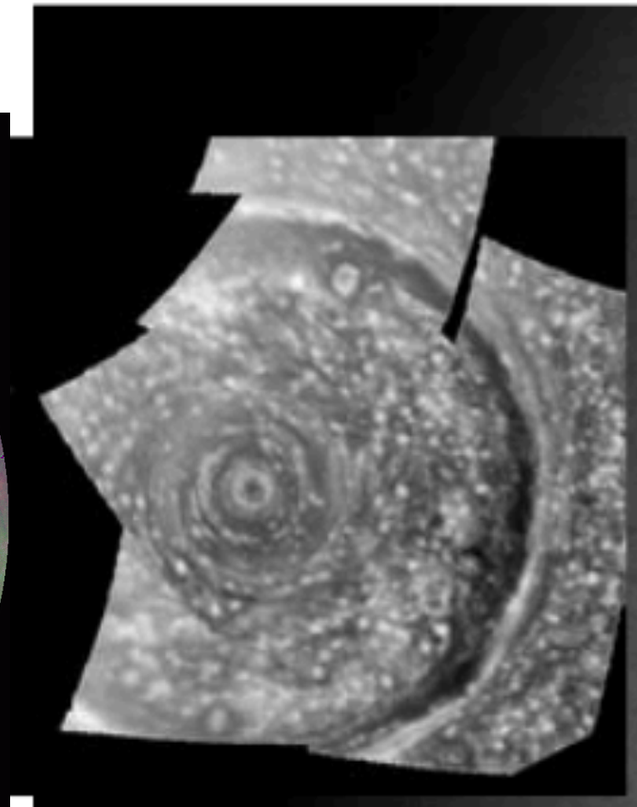
Its belts and zones on Saturn are less visible because they occur deeper in the cold atmosphere—below a layer of methane haze.

Saturn's Atmosphere

Storms are visible on Saturn, but they are far less colorful and much shorter lived.

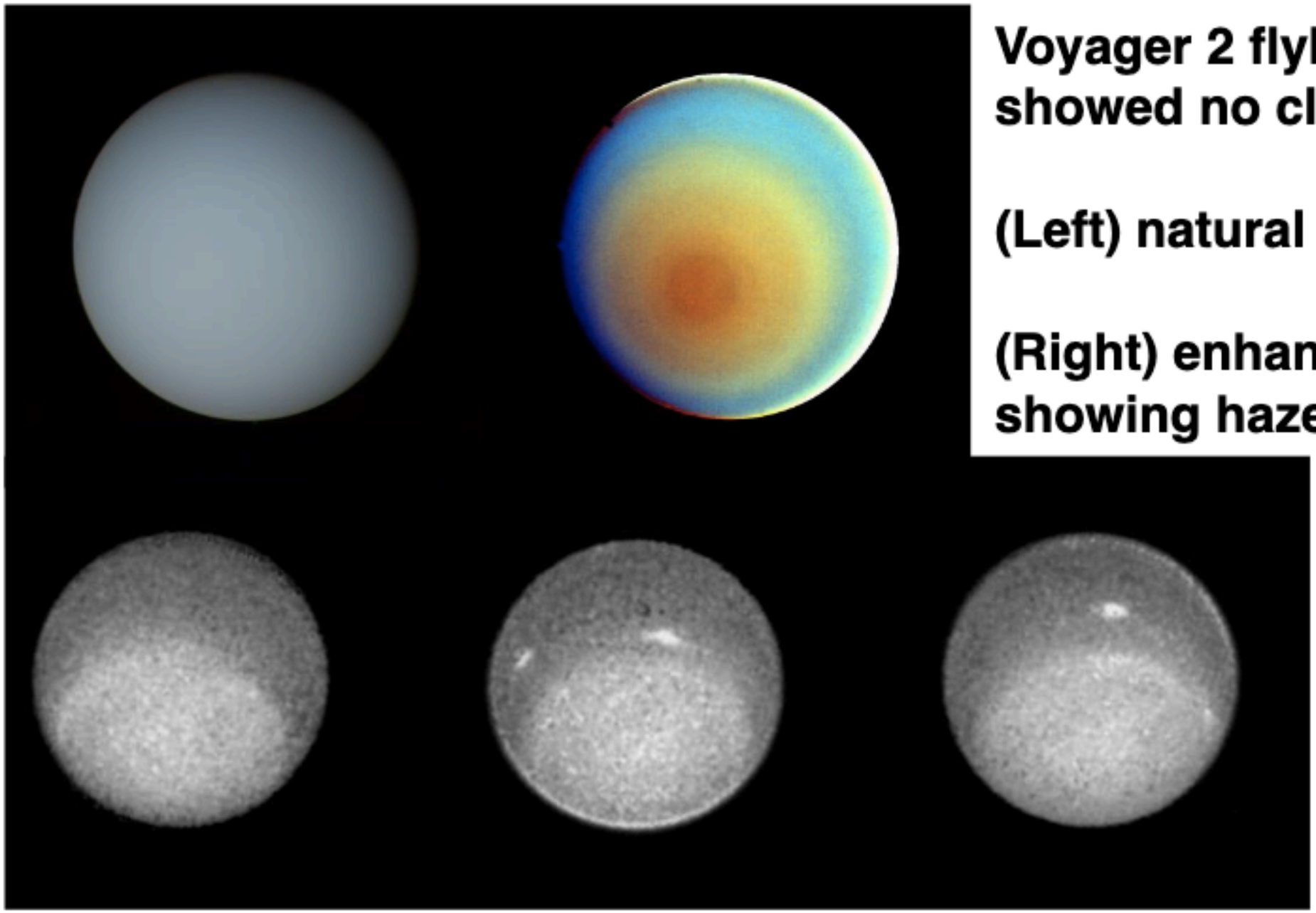
New infrared observations of storms at Saturn's poles is reviving interest in Saturn's atmosphere.





The Atmosphere of Uranus

Uranus' unusual heating from the Sun may play a role in its "blank" atmosphere. Seasonal changes may produce formation of clouds or storms.



Voyager 2 flyby images (1986) showed no clouds or storms.

(Left) natural color,

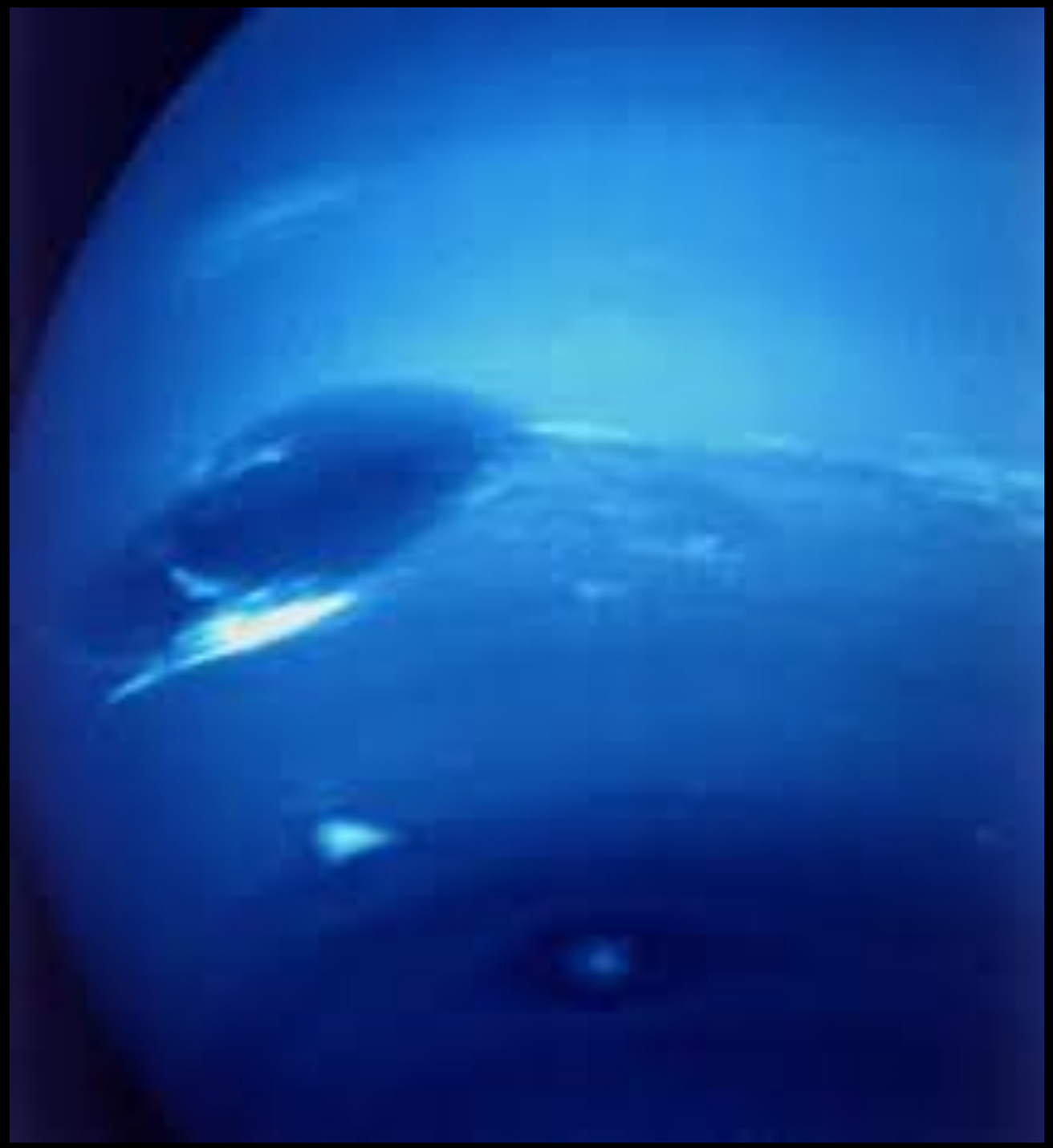
(Right) enhanced color showing haze over pole.

Hubble Space Telescope images (1999)

- Images made by the Hubble Space Telescope and modern Earth-based telescopes reveal changing clouds and cloud bands in both hemispheres of Uranus.

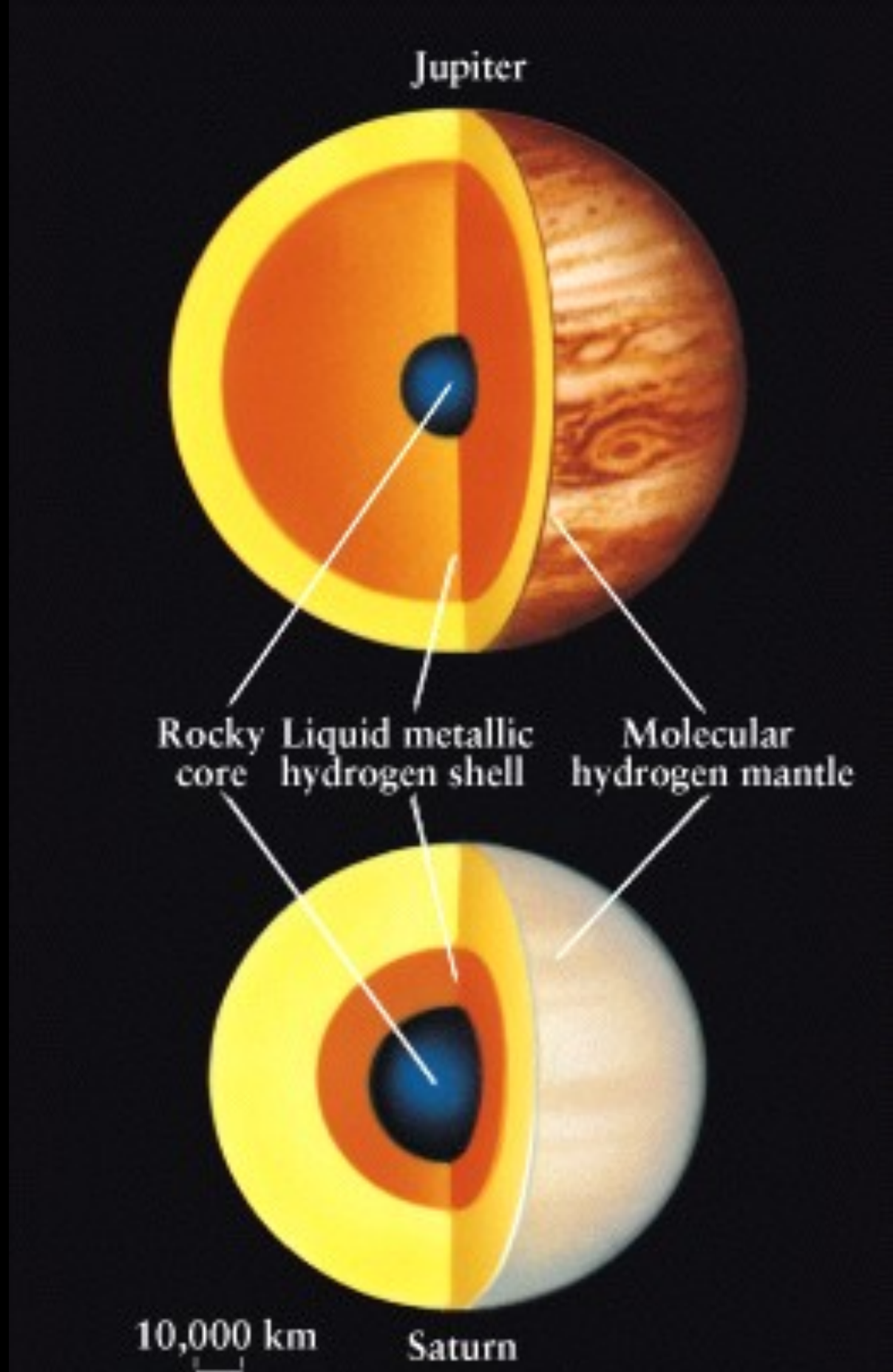
- When Voyager 2 flew by Neptune in 1989, the largest feature was the Great Dark Spot.
  - Roughly the size of Earth, the spot seemed to be an atmospheric circulation—much like Jupiter's Great Red Spot.

- By the 1990s, the spot was gone!



Interiors

Models based on observations indicate that, below their atmospheres, Jupiter and Saturn are mostly liquid.

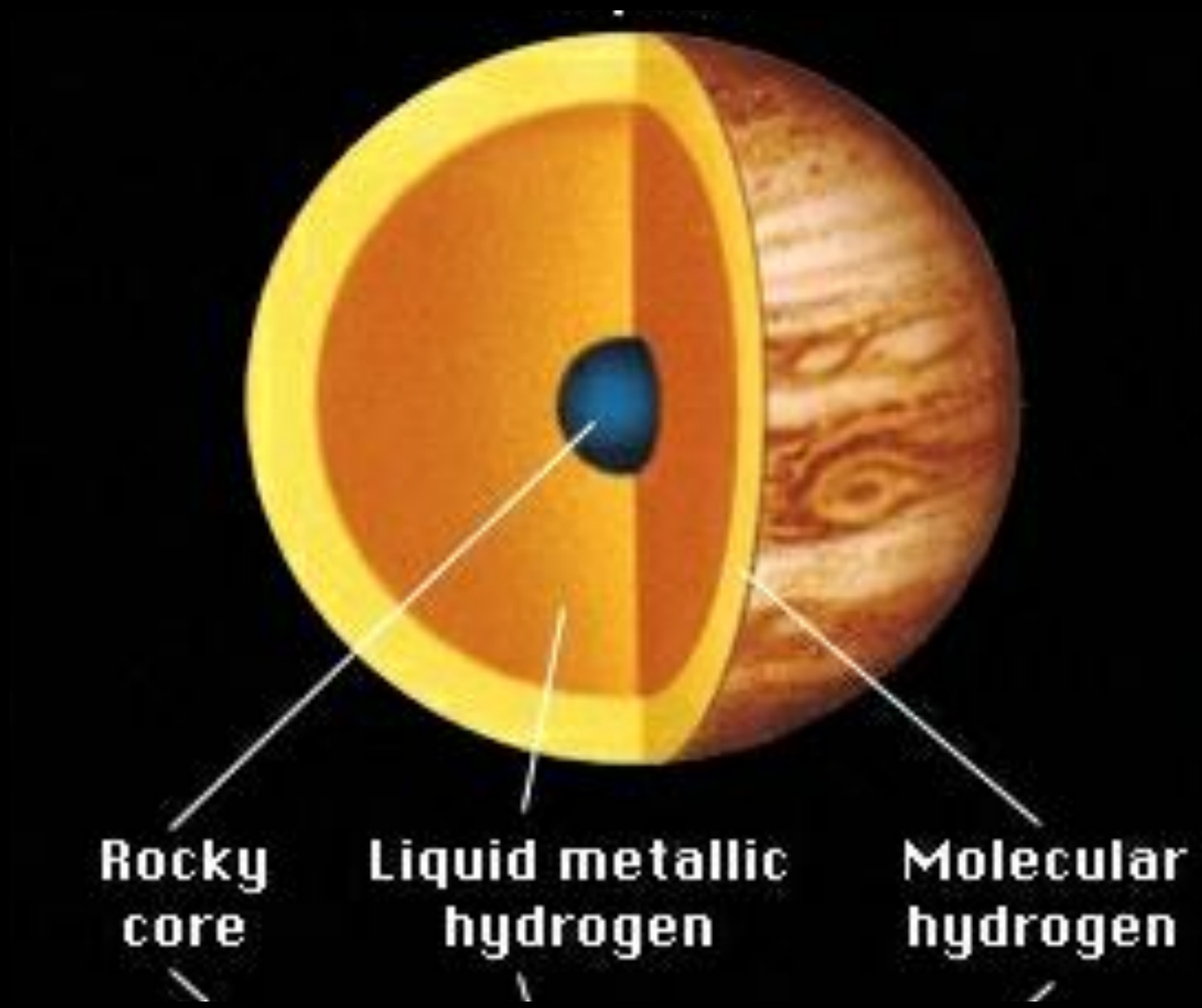


- Jupiter's oblateness—the fraction by which its equatorial diameter exceeds its polar diameter—combined with its average density helps astronomers model the interior.
  - Models indicate that the interior is mostly liquid hydrogen.

- Under very high pressure, liquid hydrogen becomes liquid metallic hydrogen.
  - This is a very good conductor of electricity.
  - Most of Jupiter's interior is composed of this material.

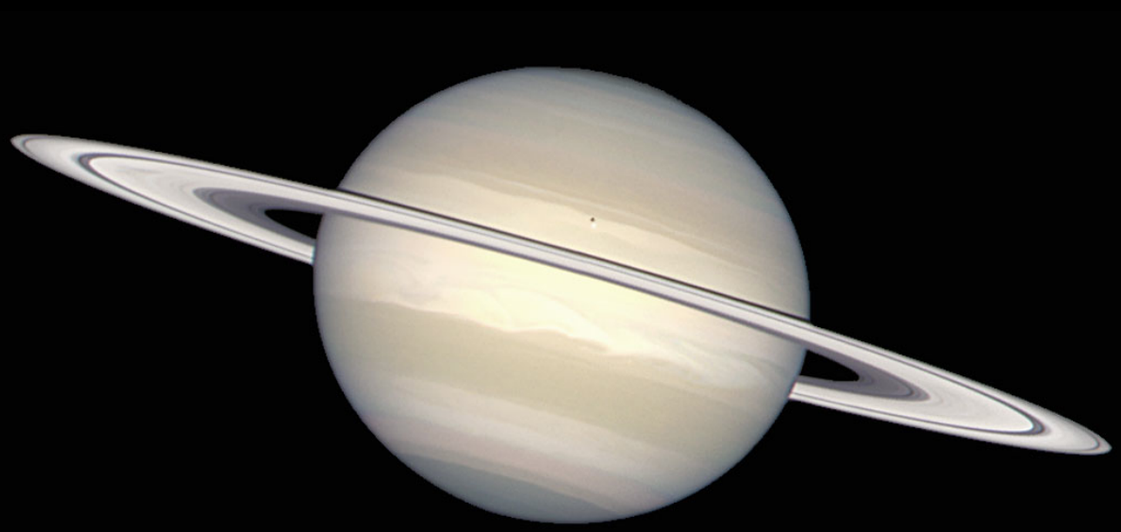
At Jupiter's center, a so-called rocky core contains heavier elements—such as iron, nickel, and silicon.

- The term *rocky core* refers to the chemical composition, not to the properties of the material.

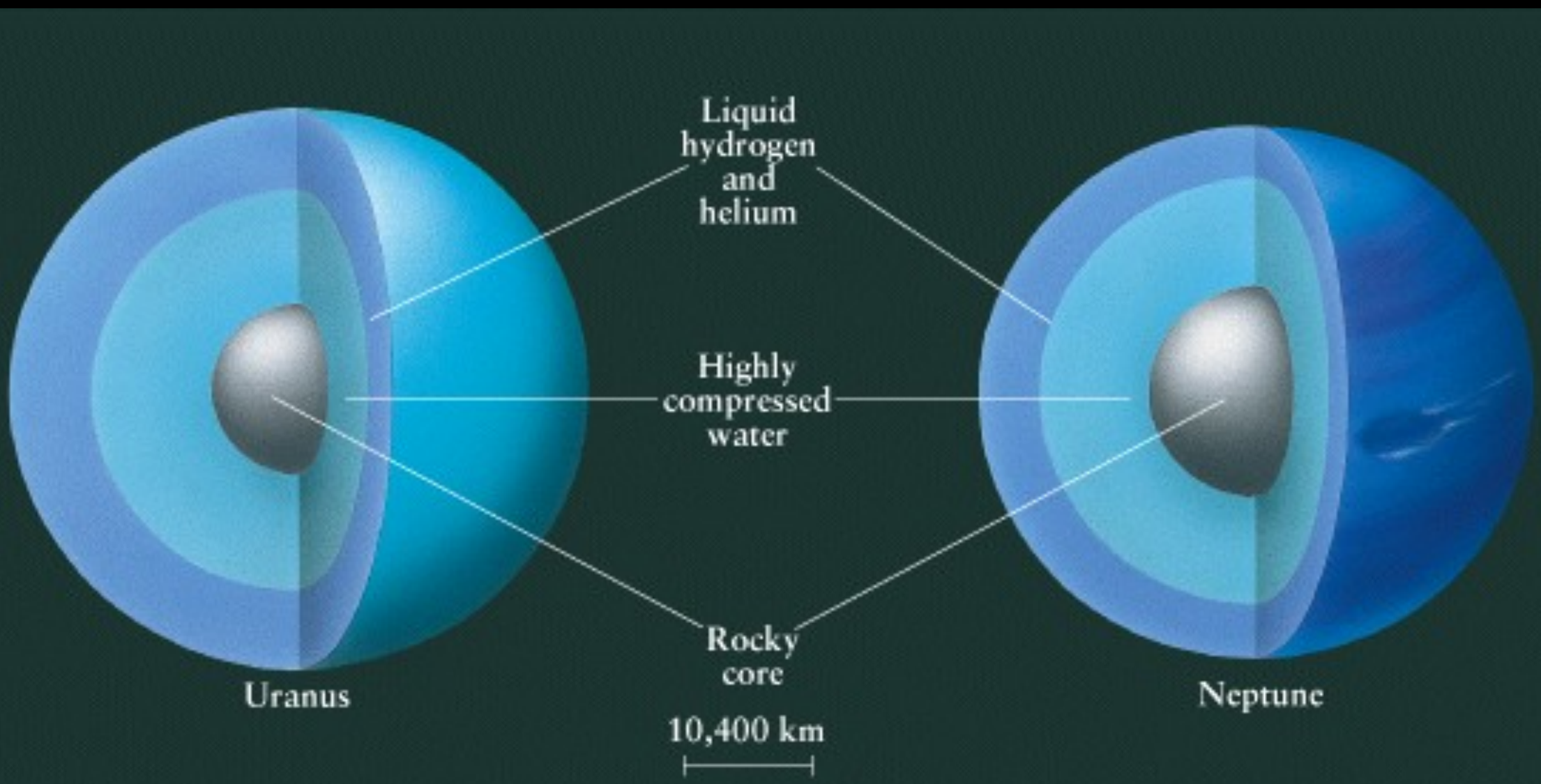


- Saturn is less dense than water—it would float!
  - This suggests that it is, like Jupiter, rich in hydrogen and helium.

- Photos show that Saturn is the most oblate of the planets.
  - That evidence shows that its interior is mostly liquid with a small core of heavy elements.



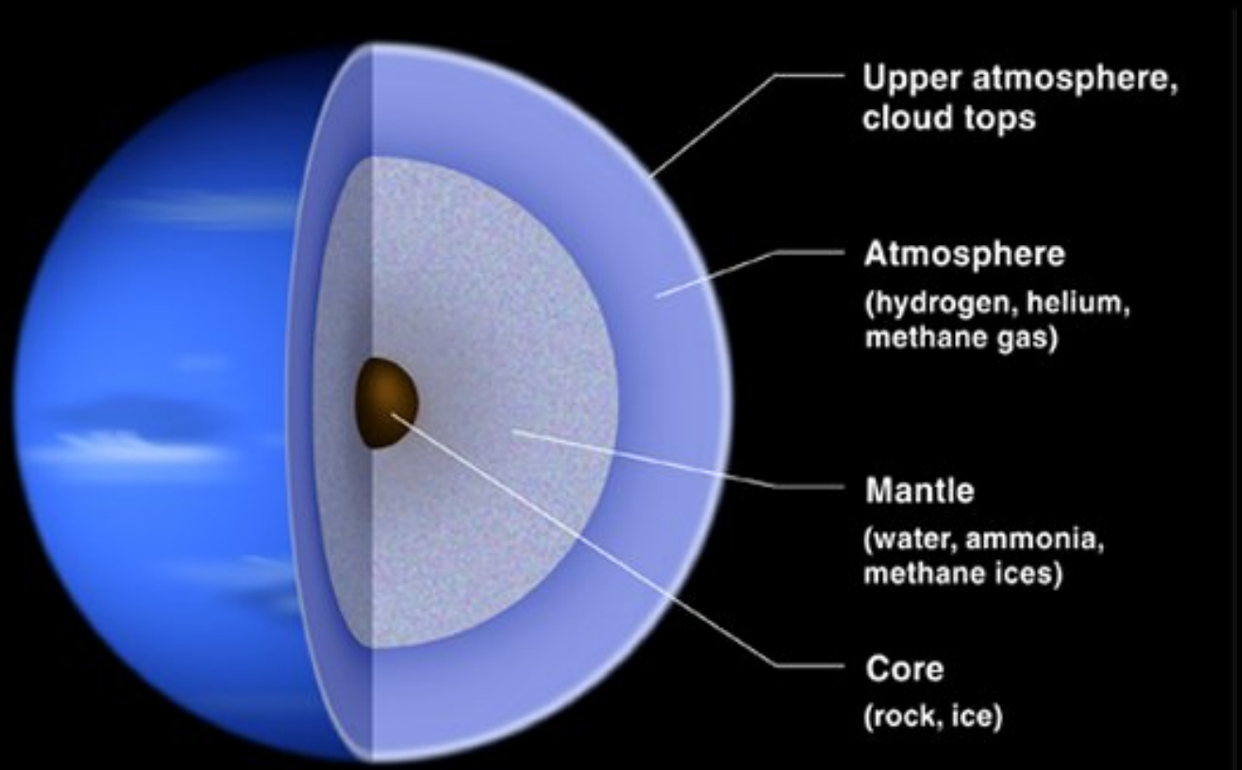
Uranus and Neptune– the “ice giants”– have similar interiors



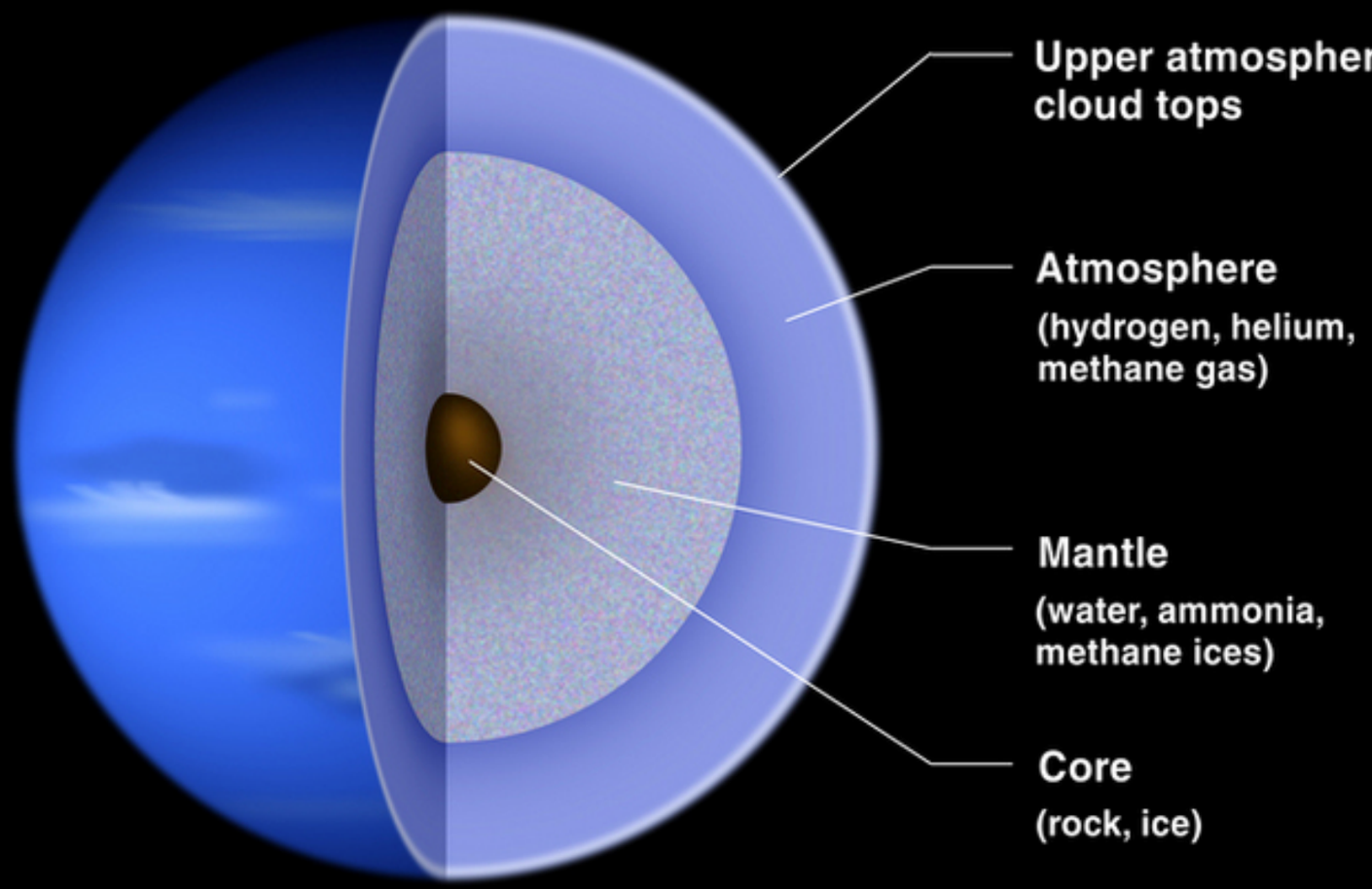
- Uranus' mantle contains rocky material and dissolved ammonia and methane.
  - Circulation in this electrically conducting mantle may generate the planet's peculiar magnetic field—which is highly inclined to its axis of rotation.

- Above the mantle lies the deep hydrogen and helium atmosphere

- "Ice" does not necessarily mean frozen

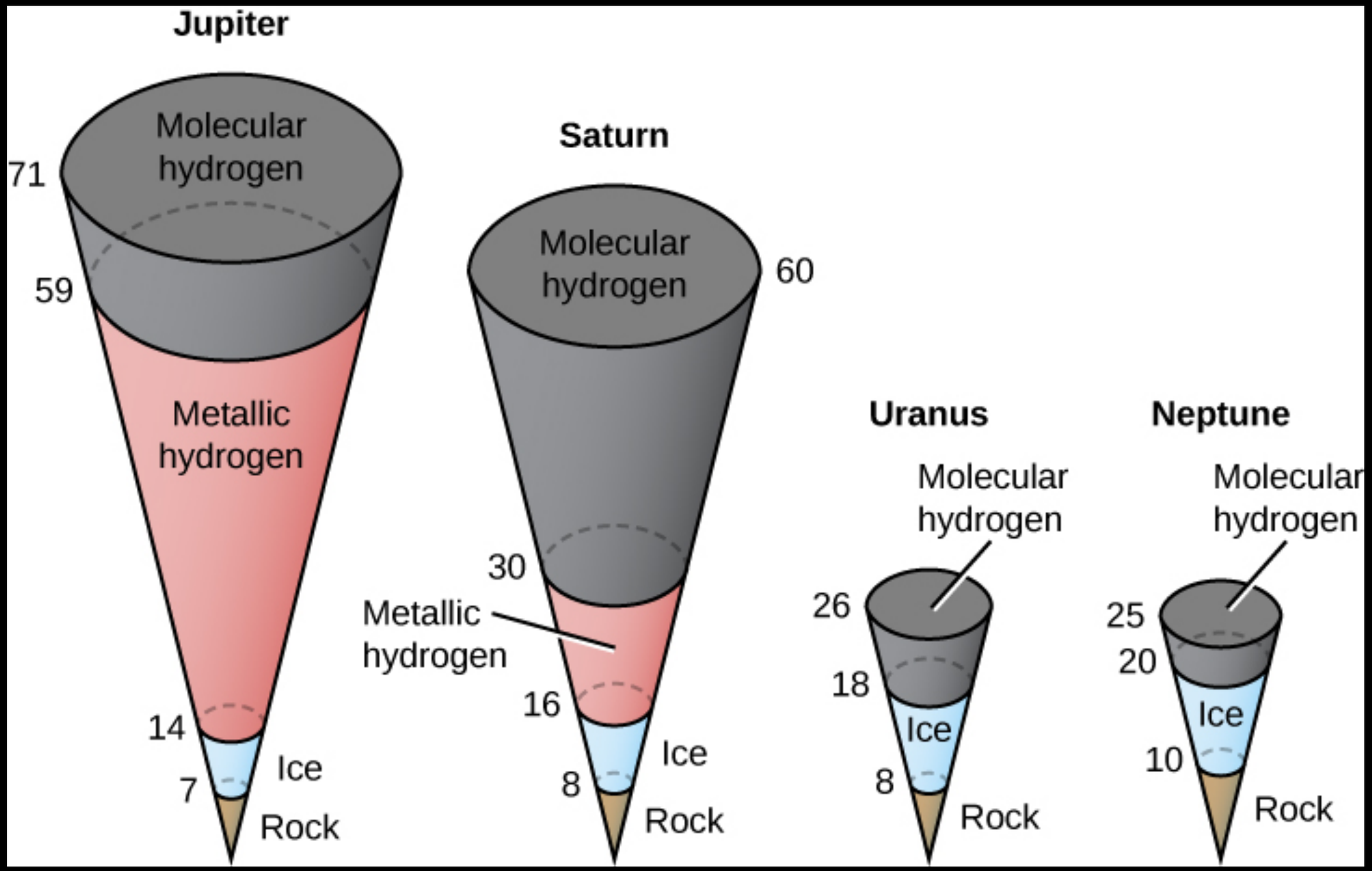


- A small core of heavy elements lies within a slushy mantle of water, ices, and minerals (rock) below a hydrogen-rich atmosphere.



NEPTUNE

Jovian planet comparison



Magnetic Fields

Magnetic Fields: ingredients

1. Fast rotating planet
2. Interior with electrically conducting fluid
3. Hot interior that is convecting (overturning material)

How fast do the Jovian planets rotate?

A. 1-5 hours
B. 10-20 hours
C. 1-7 days
D. 1-5 months

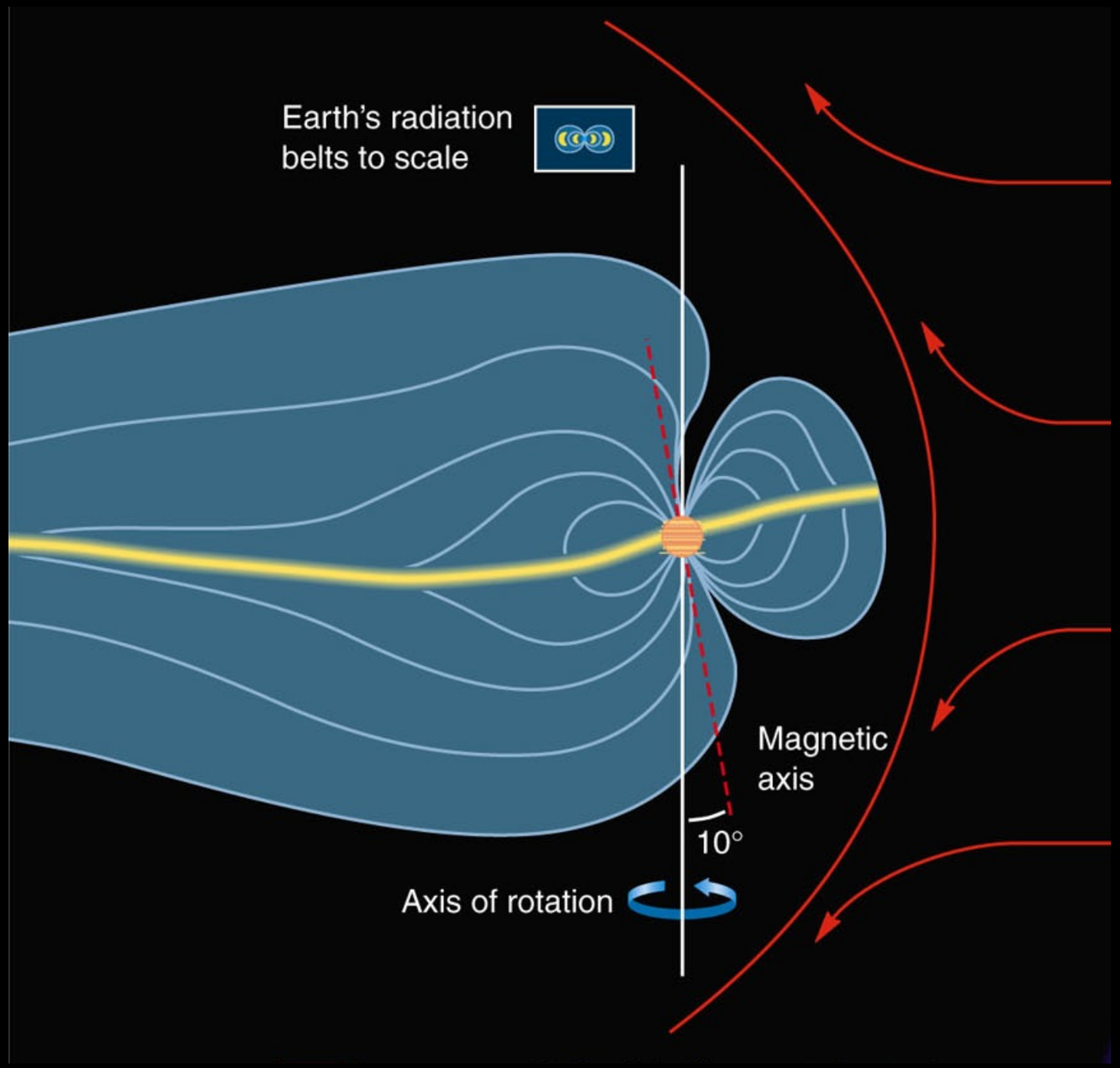
How fast do the Jovian planets rotate?

A. 1-5 hours
B. 10-20 hours (*fast* for such large bodies)
C. 1-7 days
D. 1-5 months

Jupiter

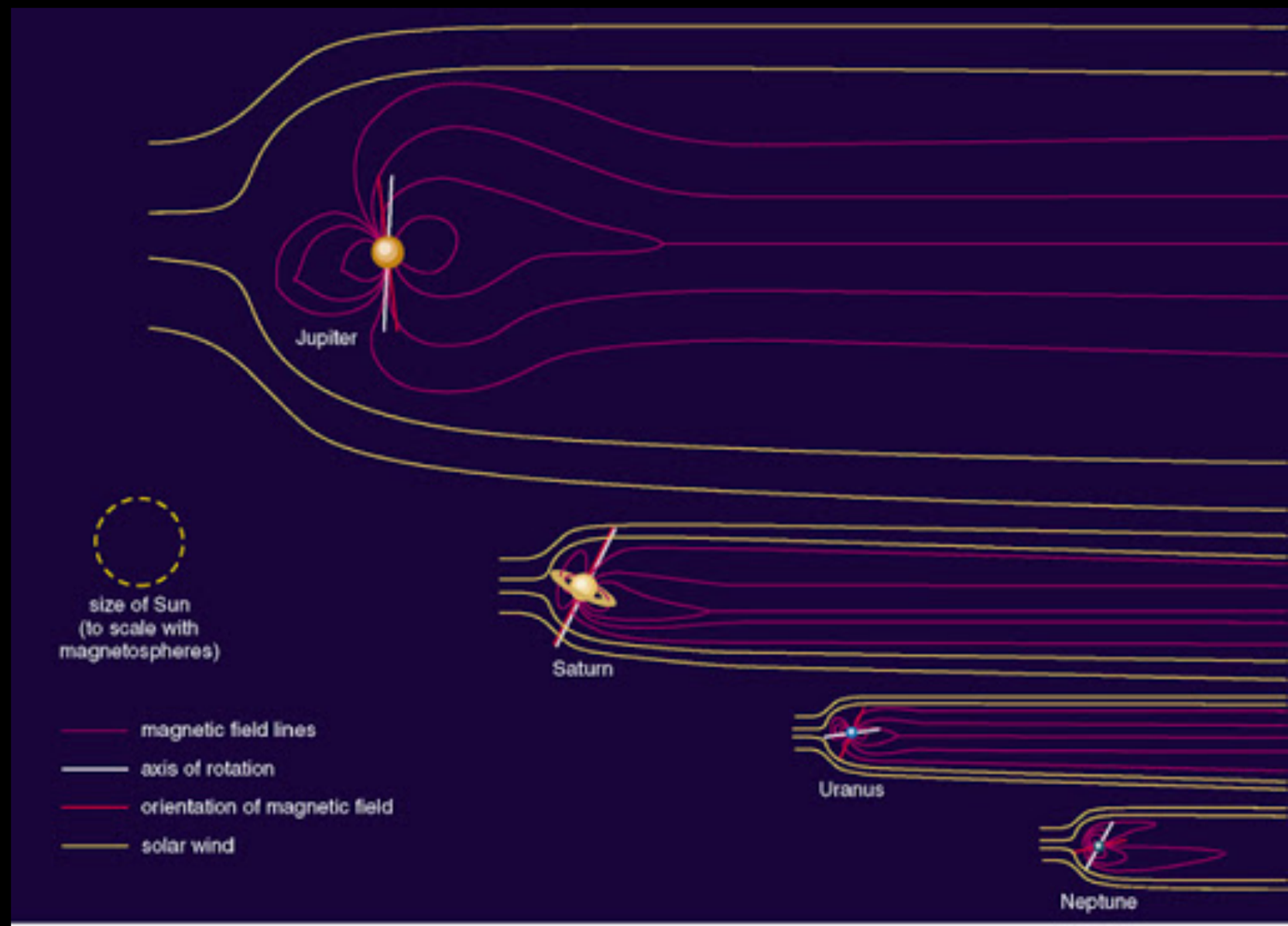
- The large mass of conducting liquid is stirred by convection currents and spun by the planet's rapid rotation.

- As a result, it generates a powerful magnetic field
  - Jupiter's field is over 20,000 times stronger than Earth's

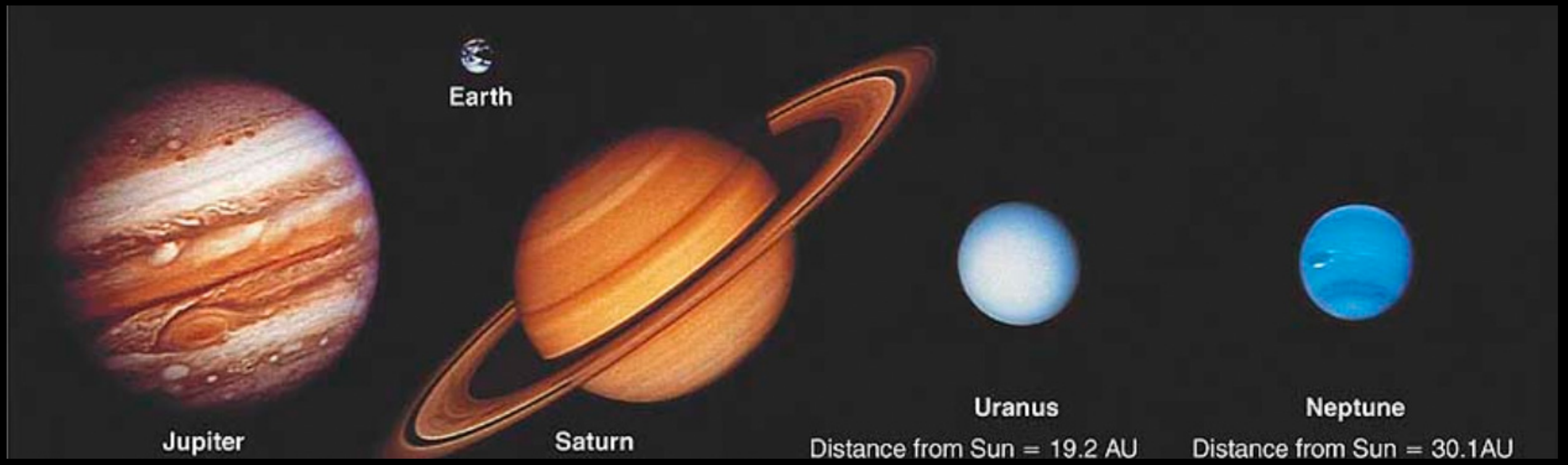


All four giant planets

- Saturn: 600x Earth's magnetic field
- Uranus & Neptune: about 50x Earth's magnetic field



Comparing the giant planets



Property	Jupiter	Saturn	Uranus	Neptune
Atmosphere	H, He, methane, ammonia, sulfides in different proportions			
Magnetic Field	X	X	X	X
Moons	79+ - 4 Galilean	80+	27+	14

Terrestrial vs. Jovian Planets