Chapter 11

(b)

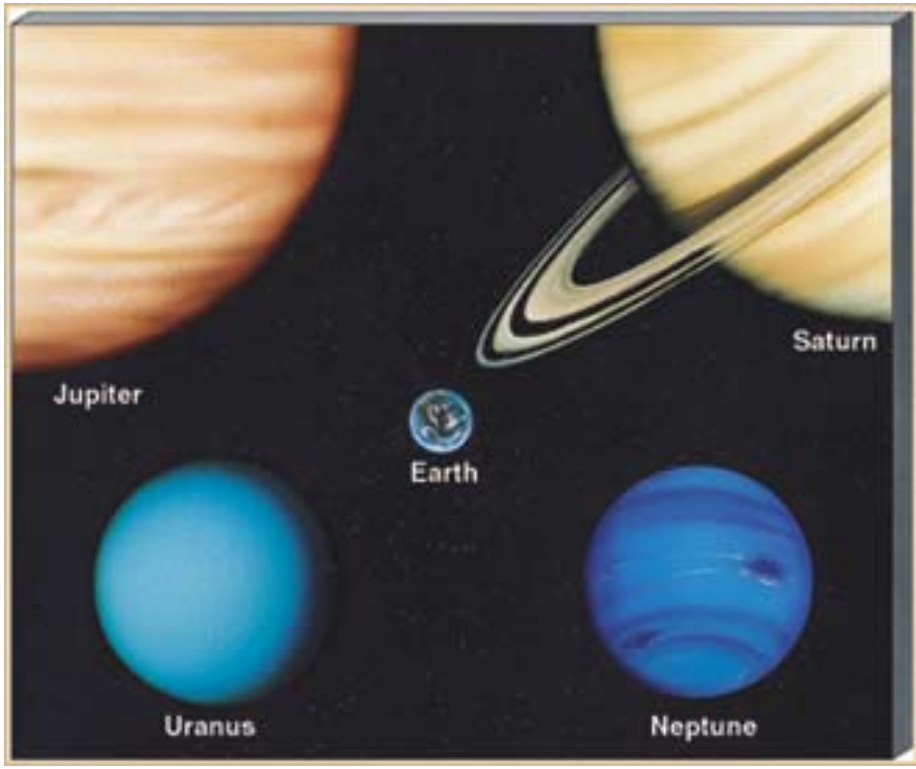
Jovian Planet Systems

Topics

- Jovian Planets Compared
- Jupiter
- Saturn
- Discovery of Uranus and Neptune
- Jovian Atmospheres and Interiors
- Jovian Moons

Jovian Planets Compared

Planet	**R/R_E**	**M/M_E**
Jupiter	11.21	317.8
Saturn	9.45	95.2
Uranus	4.01	14.5
Neptune	3.88	17.1

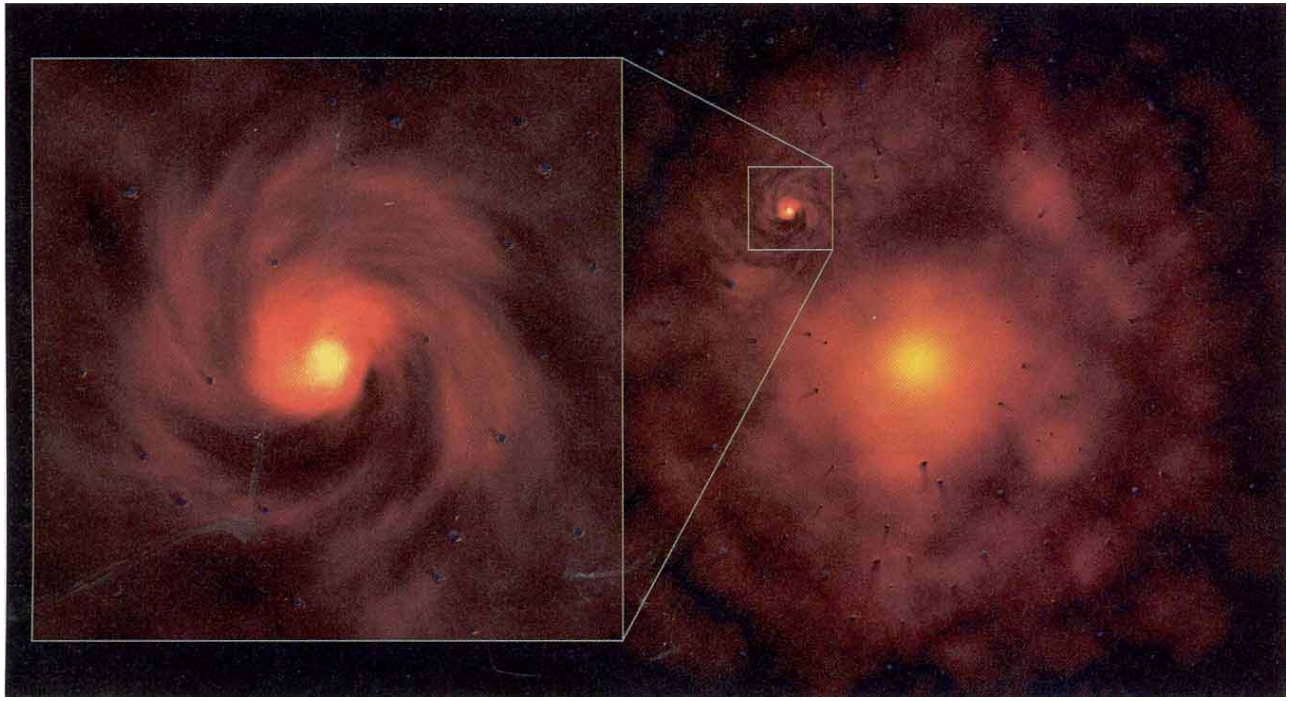


Jovian Planet Properties

- Compared to the terrestrial planets, the Jovians:
  - are much larger & more massive
  - are composed mostly of Hydrogen, Helium, & Hydrogen compounds
  - have no solid surfaces
  - rotate more quickly
  - have slightly “squashed” shapes
  - have many moons
  - have ring systems

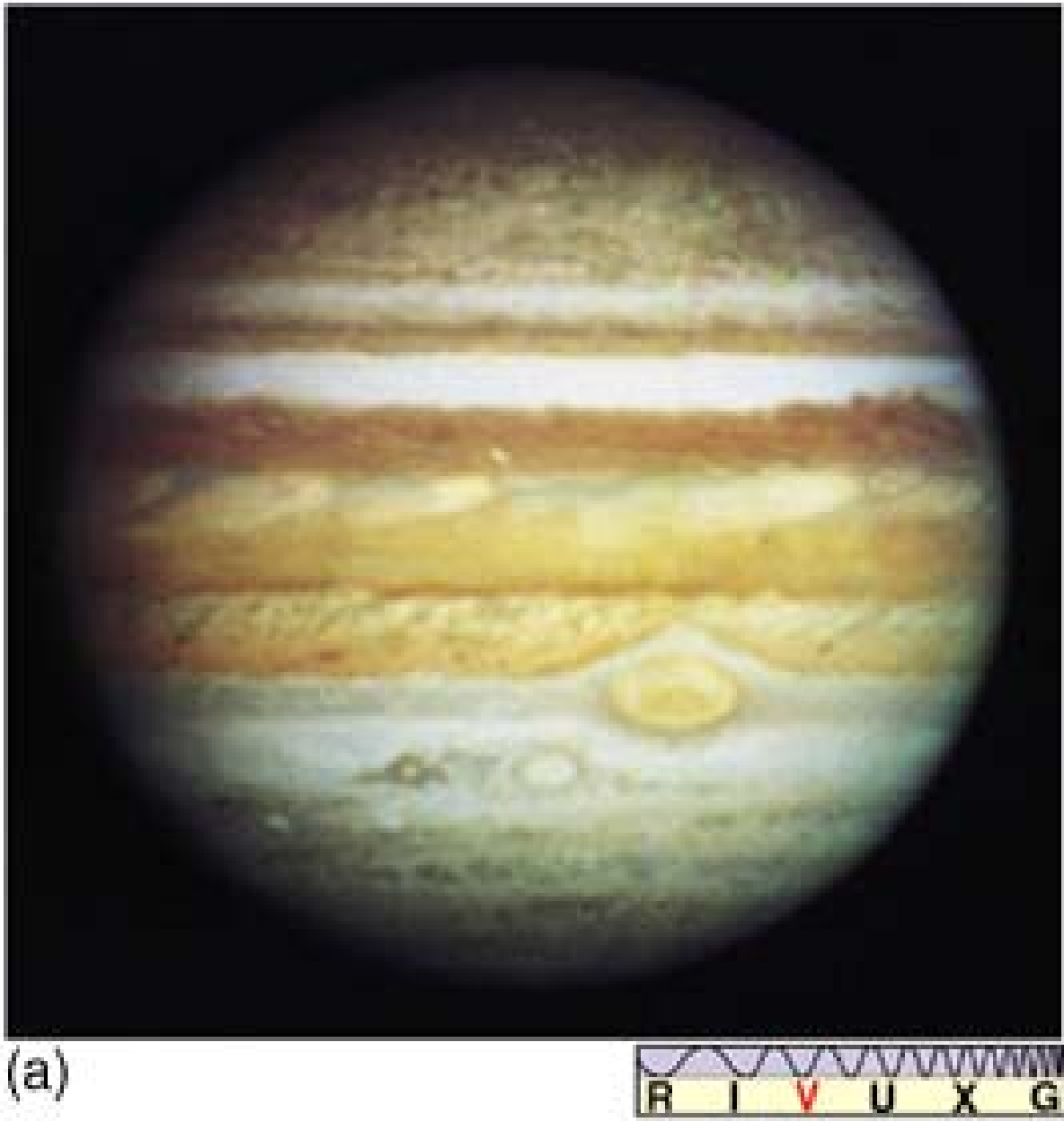
Why are the Jovian Planets so Different?

- They formed beyond the frost line to form large, icy planetesimals which were massive enough to…
- Capture H/He far from Sun to form gaseous planets.
- Each Jovian planet formed its own "miniature" solar nebula.
- Moons formed out of these disks.



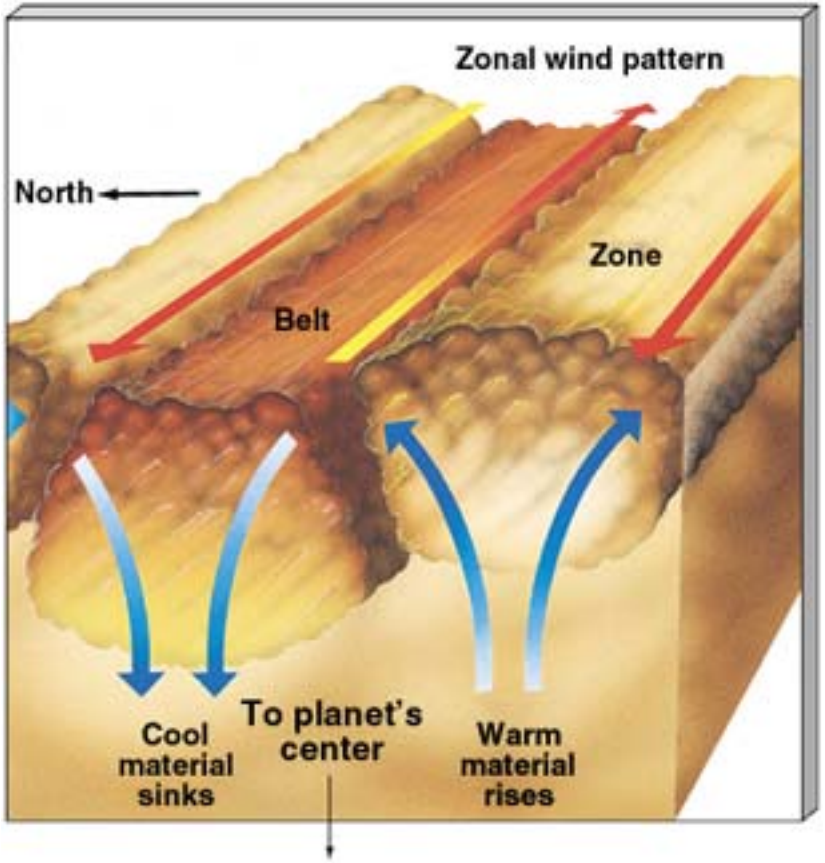
Jupiter

- Namesake of Jovian planets
- nearsest and largest
- 3rd brightest object in night sky
- known since ancient times
- 2nd most massive object in SS

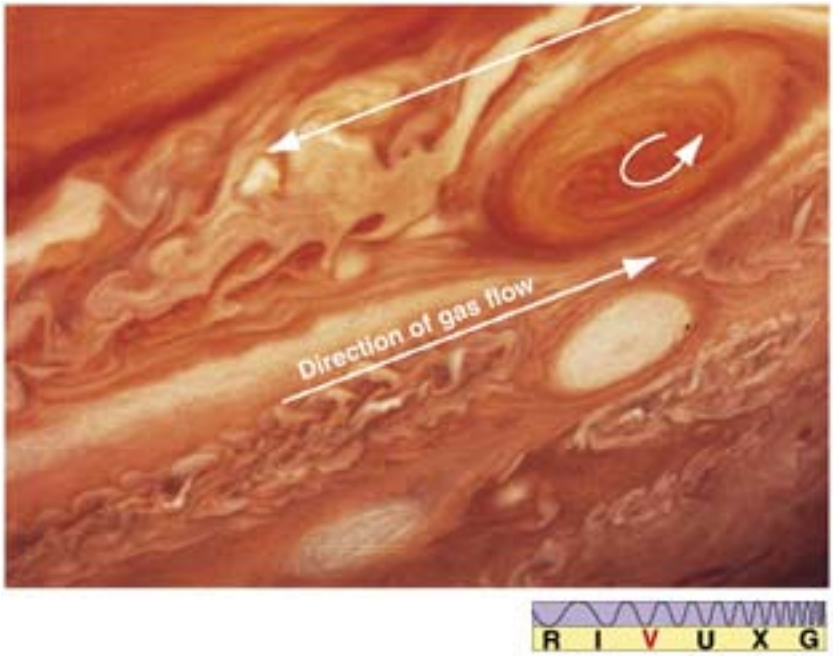


Zone-Belt Circulation System

Caused byJupiter's rapid rotation (9 hr) and internal heat source

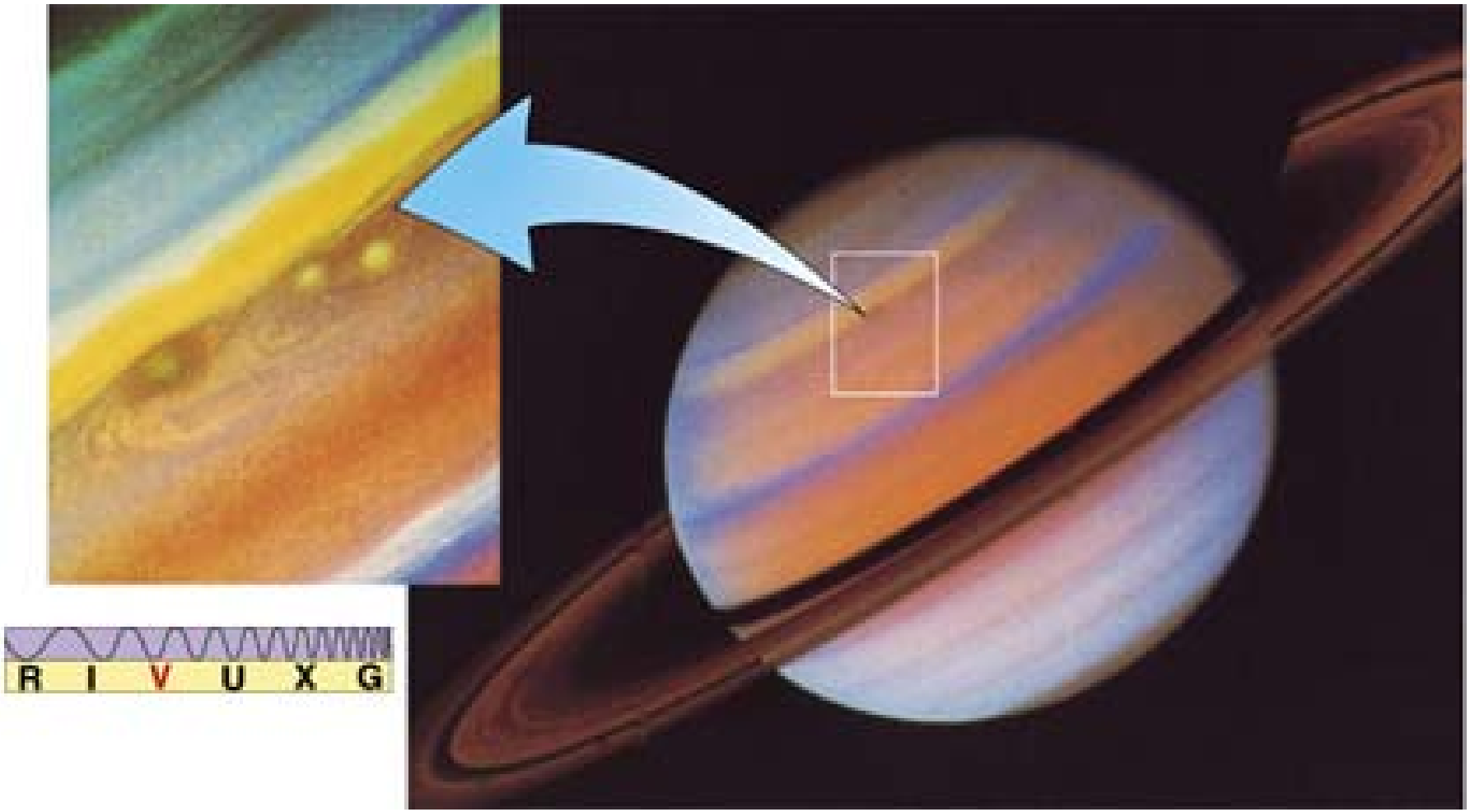


Great red spot



Saturn

Saturn's Belt System



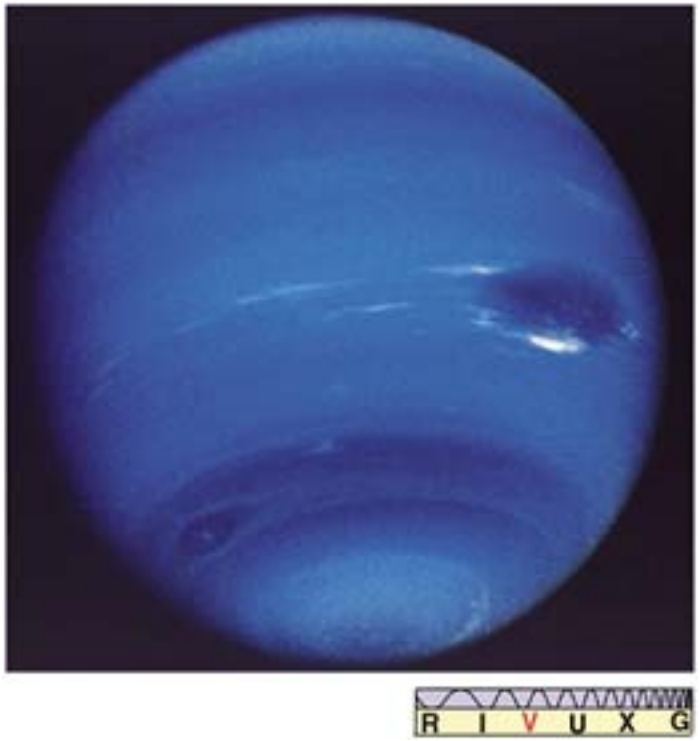
Discovery of Uranus

- 1781 by William Herschel (England)
- serendipidous discovery
- survey of the sky using a Newtonian reflector he built himself

NASA Voyager 2

Discovery of Neptune

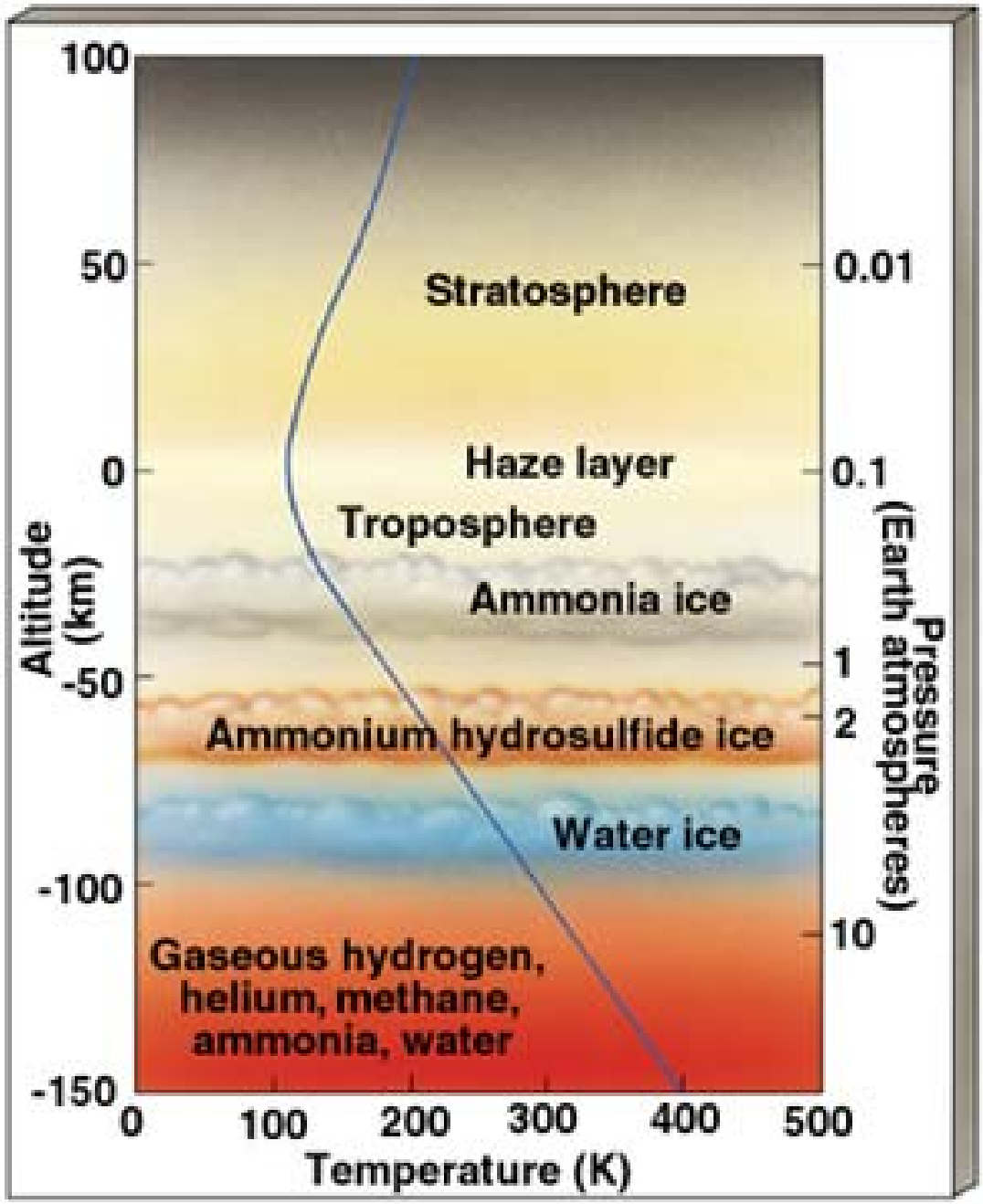
- Existence predicted by John Adams (1845) and Urbain Leverrier (1846)
- analyzed Uranus' orbit, which showed gravitational influence of unseen planet
- Telescopic confirmation by Johann Galle (1846)



NASA Voyager 2

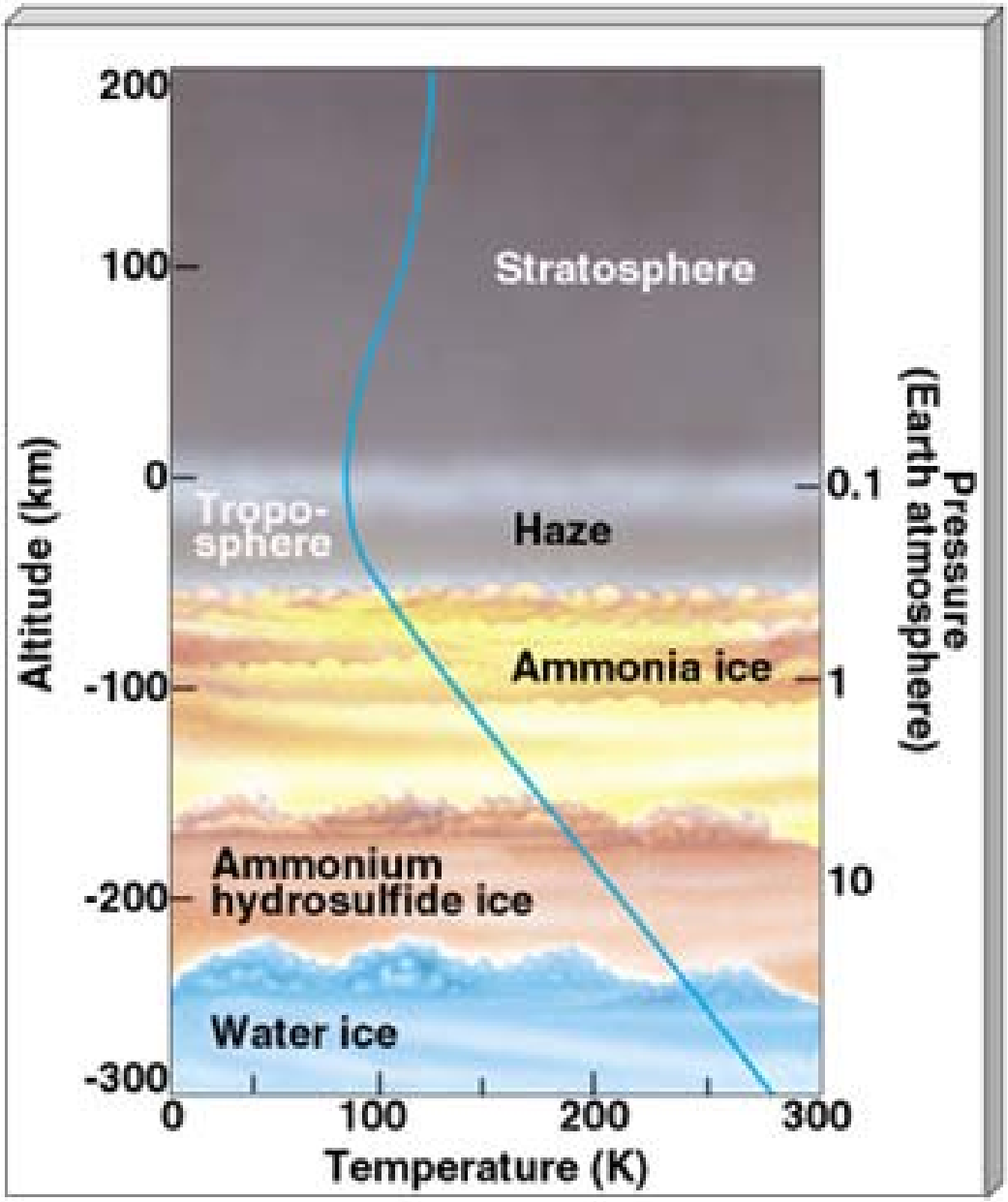
Jupiter's Atmosphere

- H (86%), He (14%)
- small amounts of CH_4, NH_3, H_2O which freeze to form ice layers
- => we think this is similar to composition of solar nebula
- H & He retained by Jupiter's high gravity



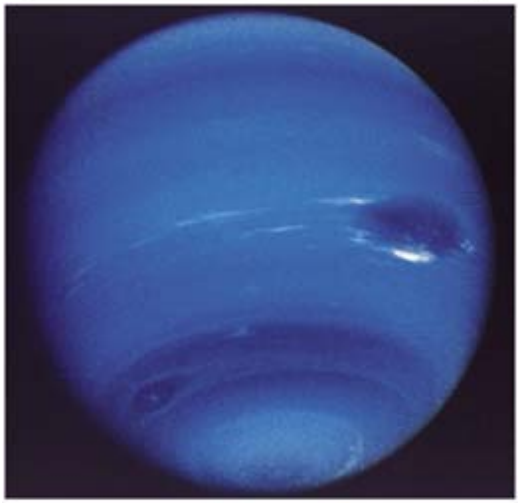
Saturn's Atmosphere

- H (93%), He (7%)
- trace amounts of CH_4, NH_3, H_2O which freeze to form ice layers
- haze layer mutes belted appearance
- thicker cloud layers due to S's weaker gravity rel. to J.

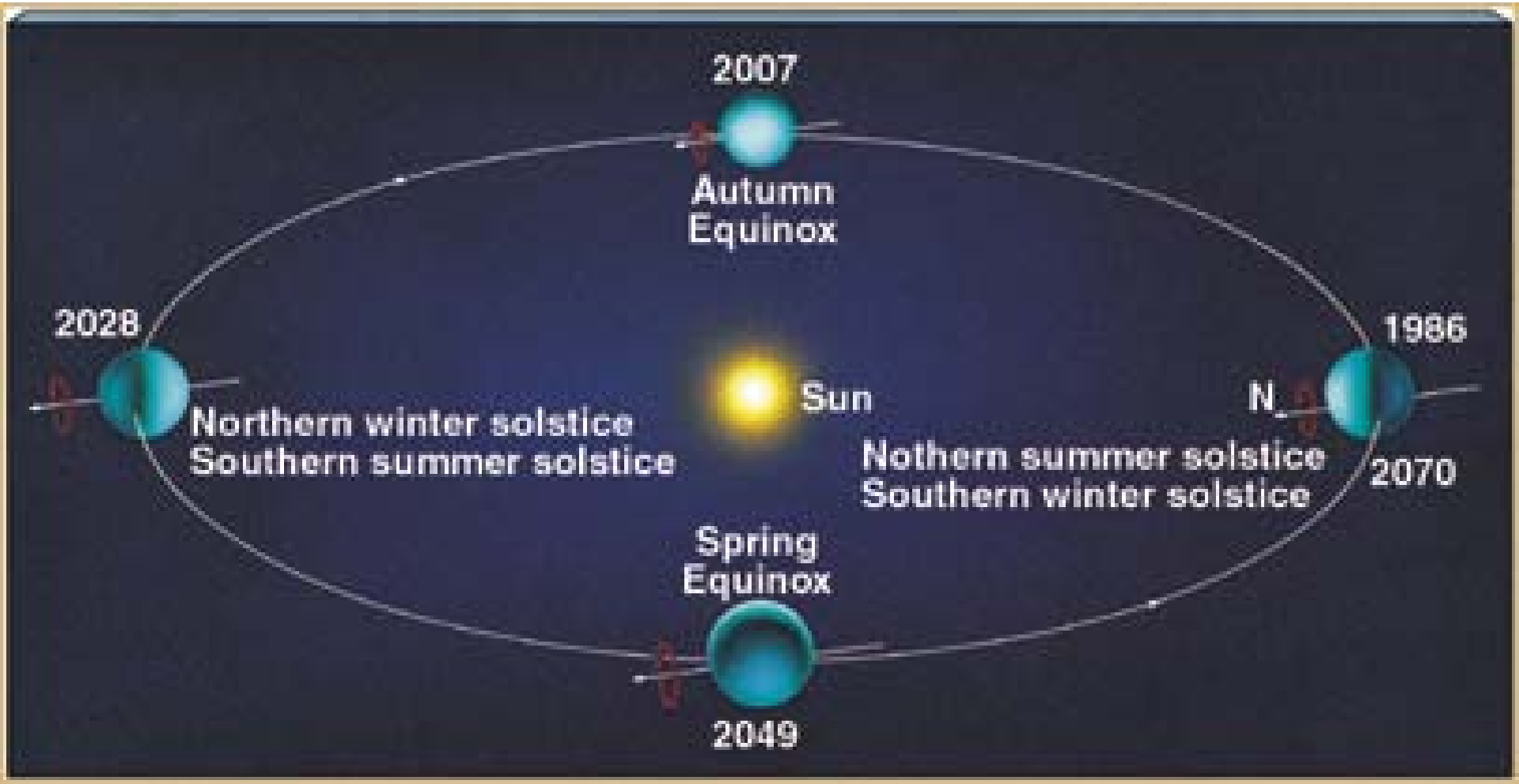


Atmospheres of Uranus and Neptune

- Similar in composition to Jupiter's (H/He)
- relatively more methane than ammonia due to lower temperatures
- methane responsible for blueish color (absorbs red light)

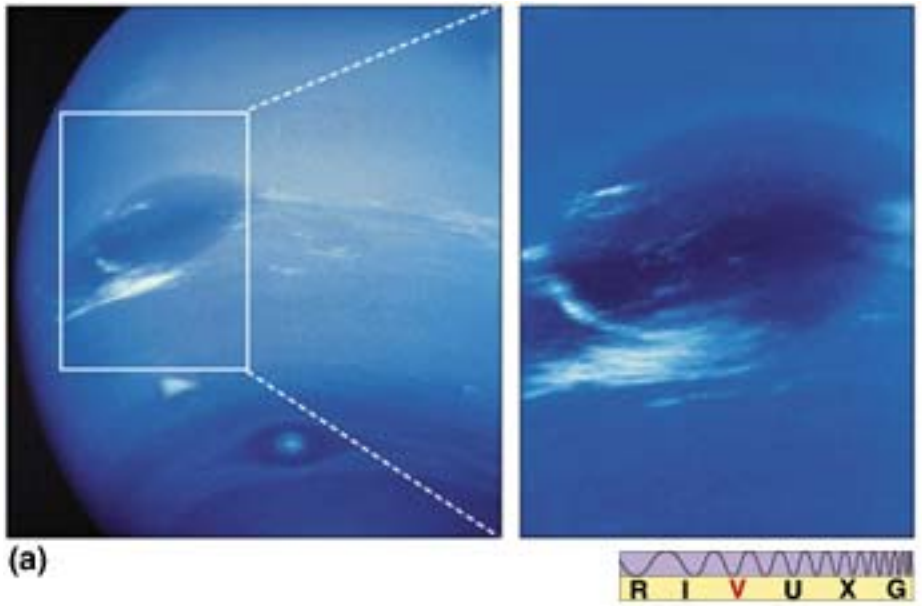


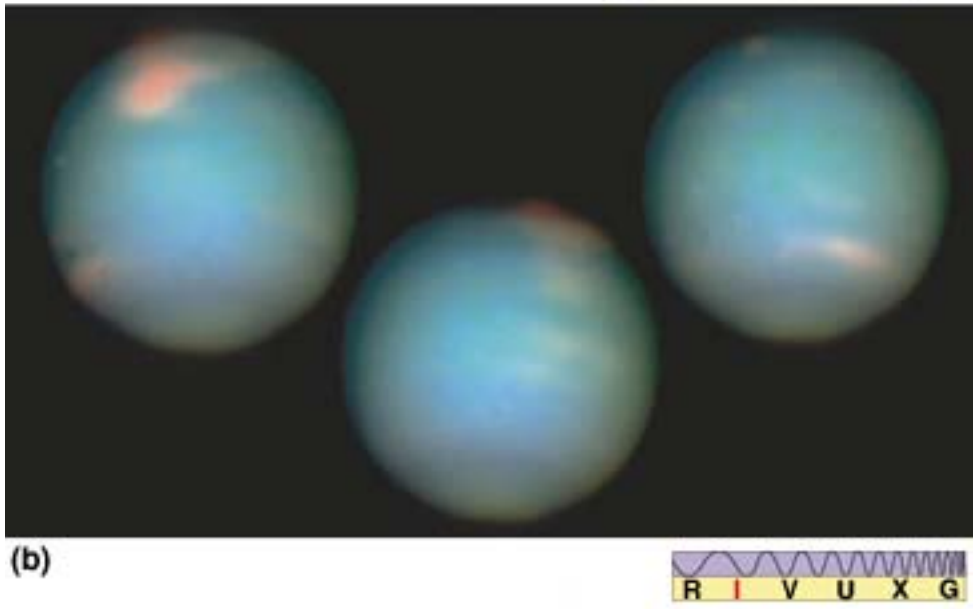
Uranus' Extreme Seasons



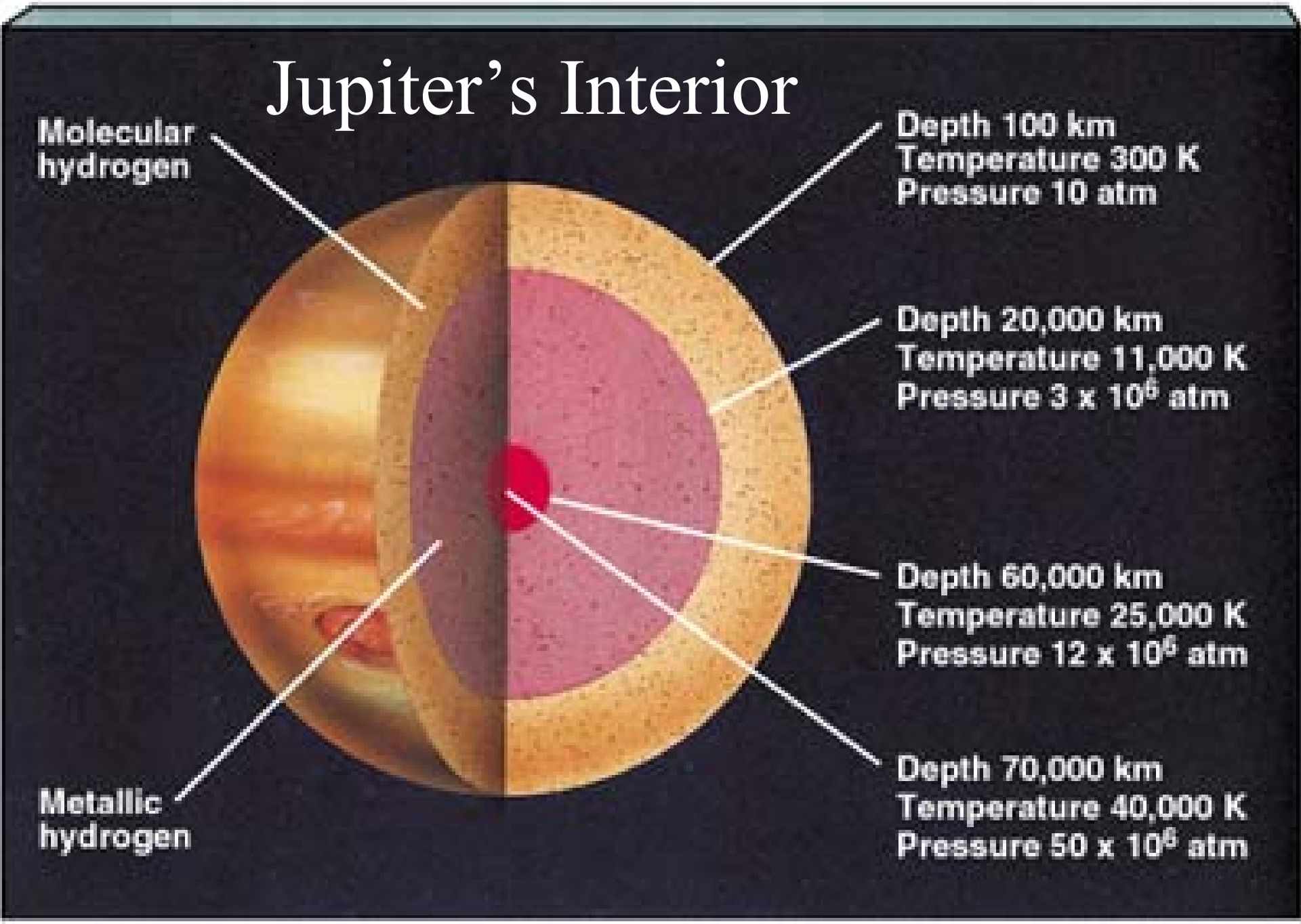
Neptune's Weather

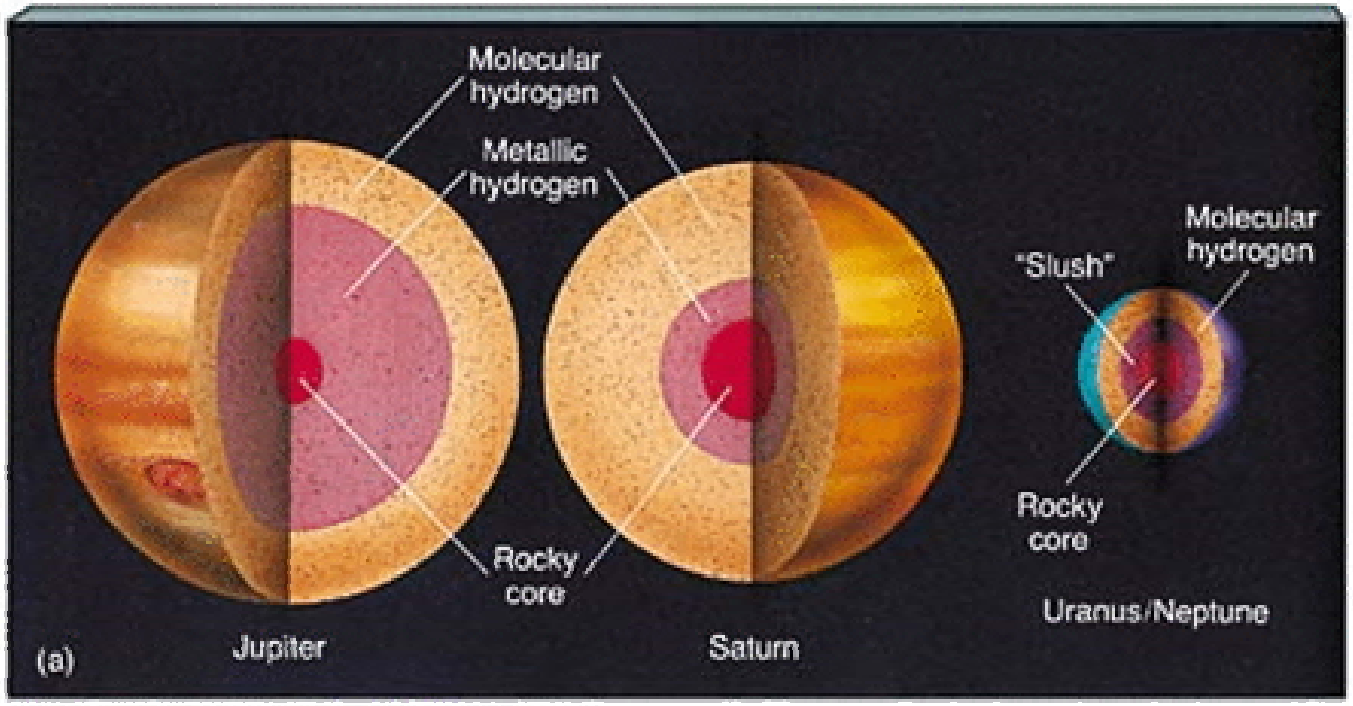
- Dark Spot: atmospheric cyclone similar to J's Great Red Spot
- comes and goes
- methane gives planet its blue-green color
- white clouds are methane ice crystals

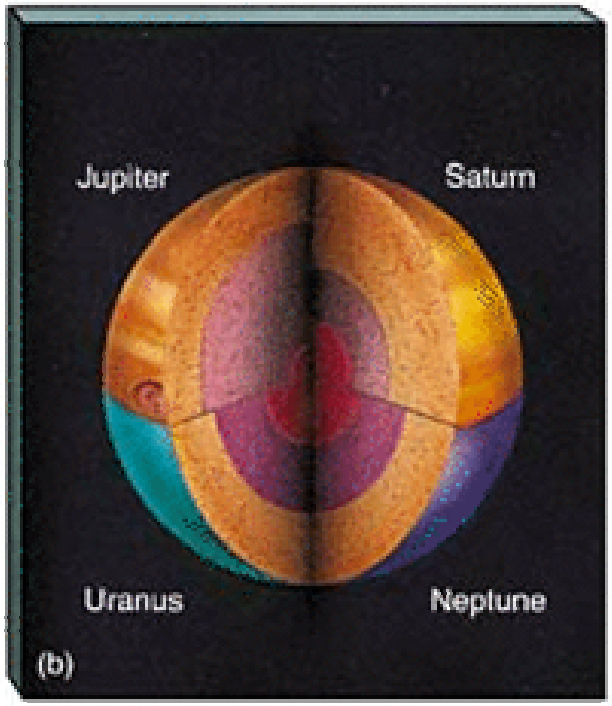




Jupiter's Interior





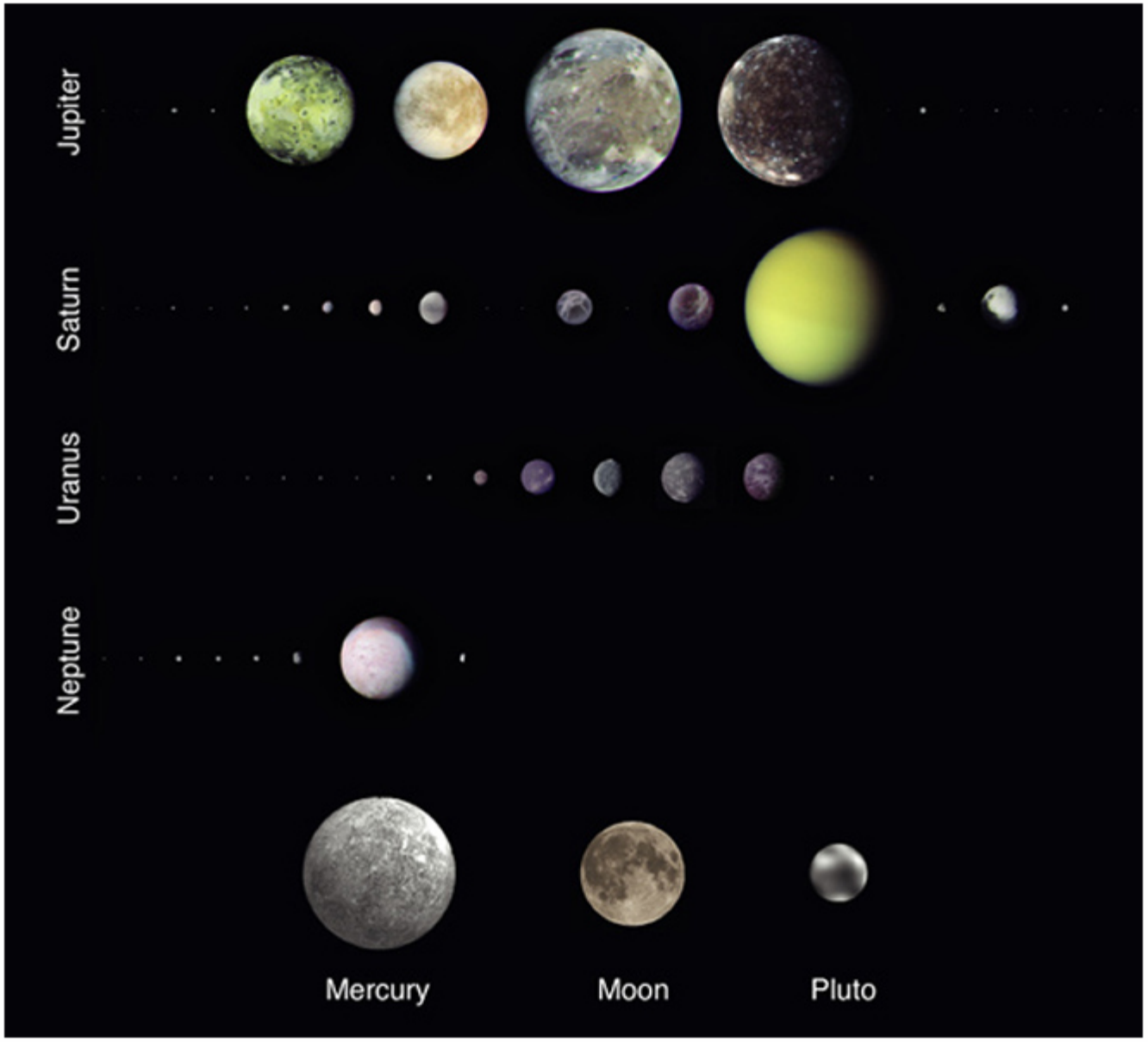


Jovian Interiors Compared

Jovian Moons

- Total number: 90 (and counting)
- Three sizes:
  - Small: < 300 km
  - Medium: 300 km -1500 km
  - Large: > 1500 km
- Medium and large moons orbit in the same direction and plane as the solar system
- Small ones in various orbits=>captured

Jovian Moons: A Host of Diverse Worlds

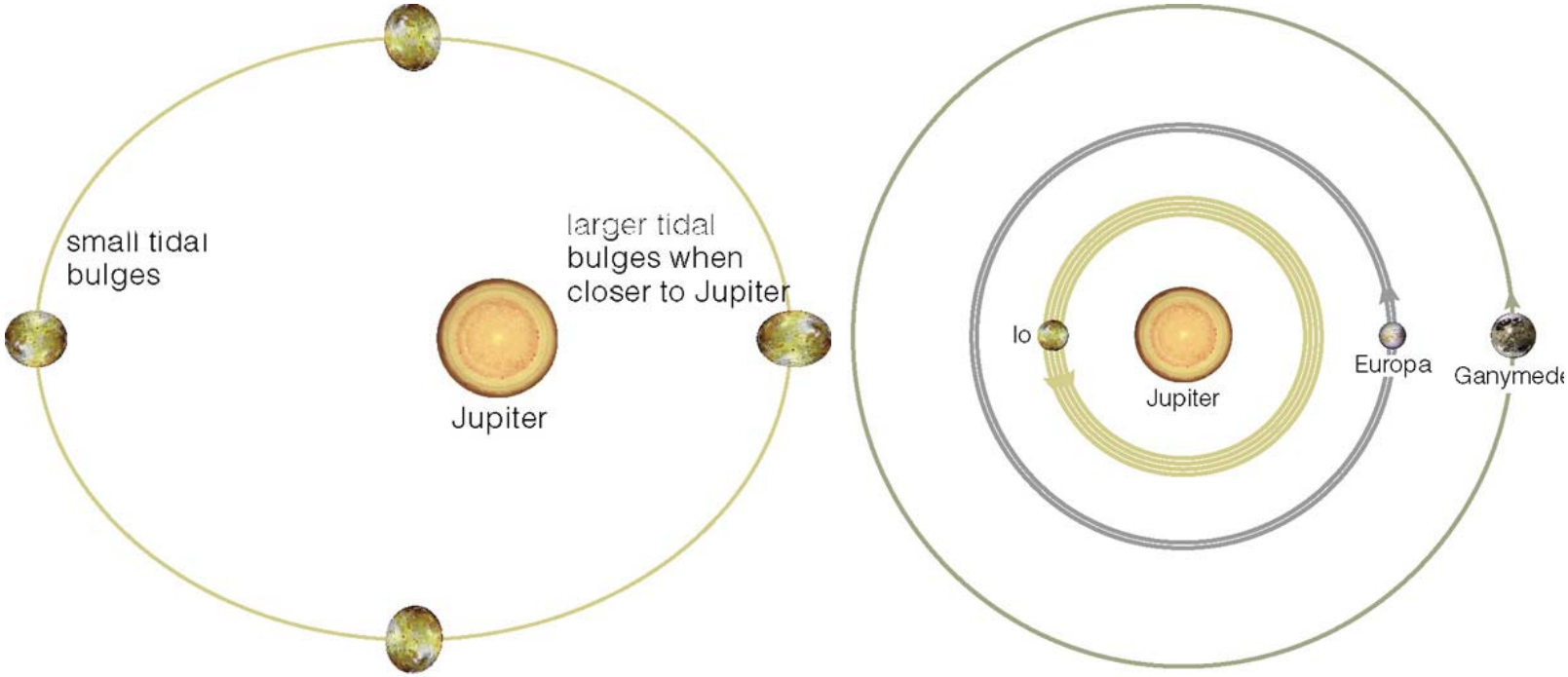


The Large Jovian Moons

- Jupiter
  - Io — sulfur volcanoes
  - Europa — world of water ice (and liquid?)
  - Ganymede — active ice world
  - Callisto — dead & dirty ice world
- Saturn
  - Titan — has a thick atmosphere (N_2 & CH_4)
- Neptune
  - Triton — nitrogen volcanoes, retrograde orbit

The Jovian Moons

- The moons of Jupiter become less dense as you get farther from Jupiter
  - "mini Solar System"
- Gravitational tidal heating keeps the interiors of the inner moons hot.



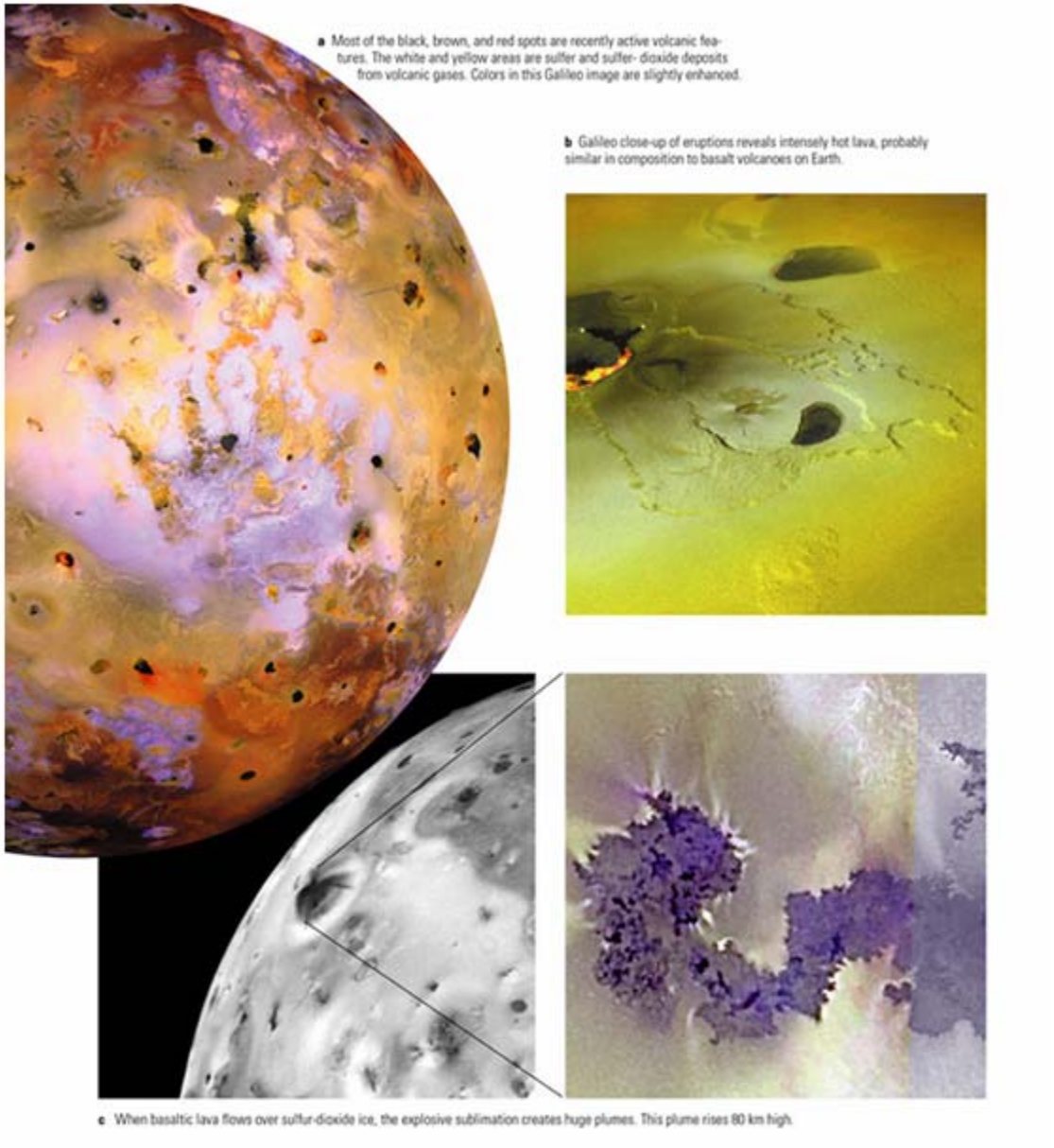
Small Jovian Moons: Indistinguishable from Asteroids

Io:

Most Geologically Active Body in SS

10x the volcanic activity of Earth

Cause: tidal heating

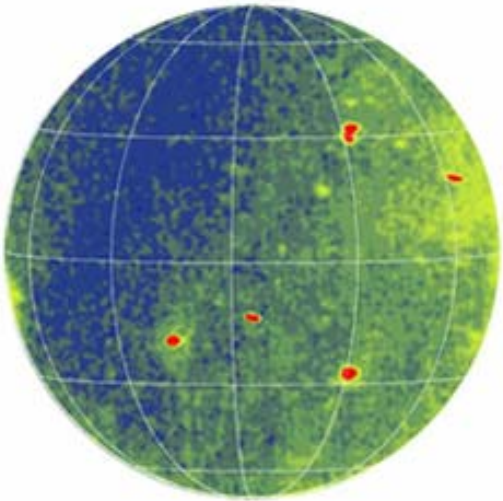


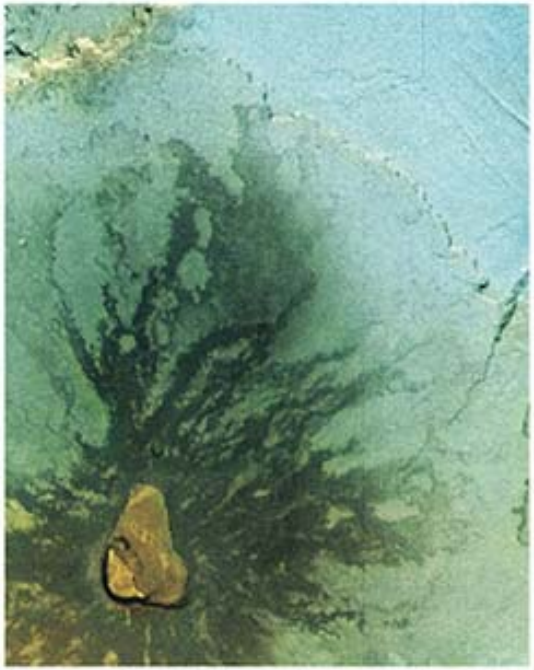
Volcanos on IO

Galileo mission

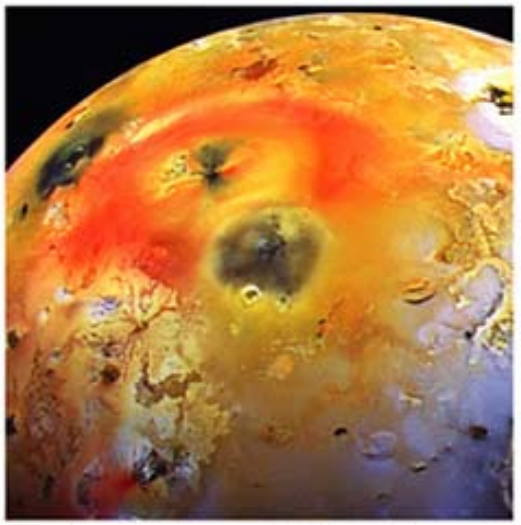
d The reddish color surrounding this volcano comes from sulfur gas expelled from the lava.

f This false-color photo shows the glow of Io's volcanic vents (red) and atmosphere (green) when Io is in the darkness of Jupiter's shadow.





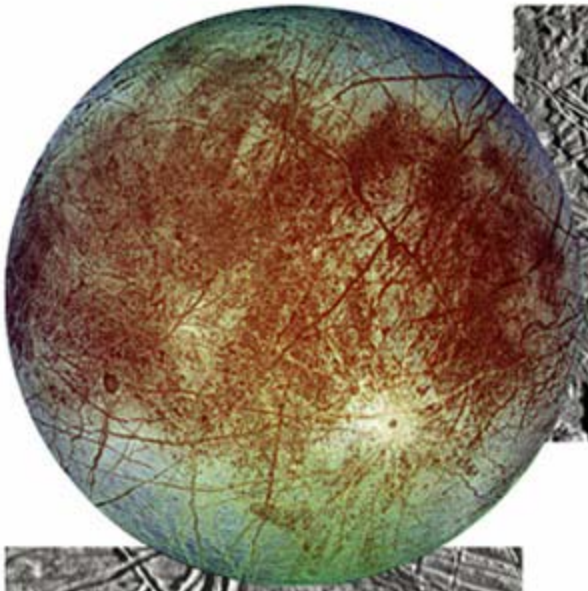
e This photo shows a shield volcano on Io that may be made of basaltic lava.



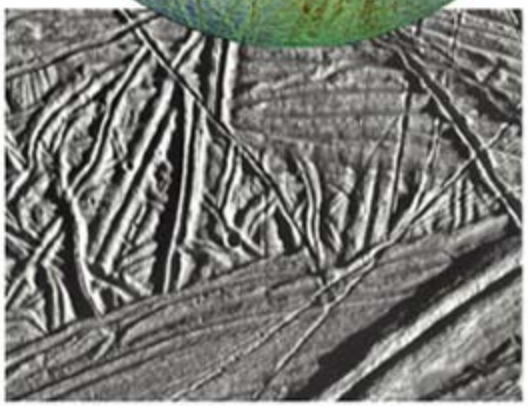
g This enhanced-color photo shows fallout (dark patch) from a volcanic plume on Io. The fallout region covers an area the size of Arizona. (The orange ring is the fallout from another volcano.)

Europa: Icy Moon

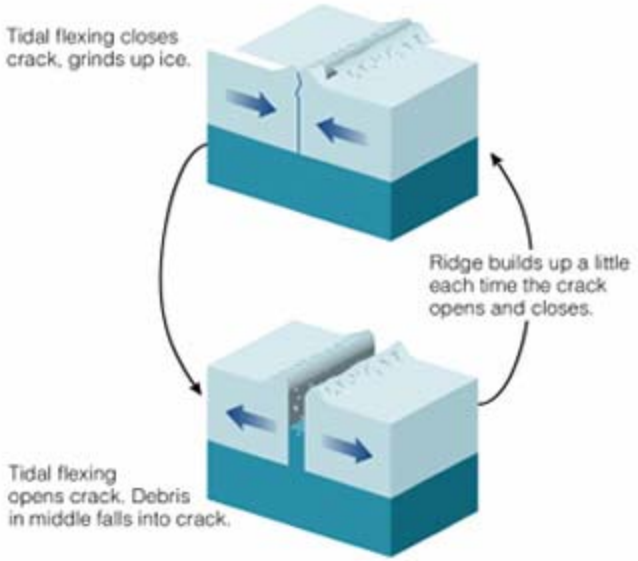
a Europa's icy crust is criss-crossed with cracks.



b Some regions show jumbled crust with icebergs, apparently frozen in slush.



c Close-up photos shows that surface cracks have a double-ridged pattern.

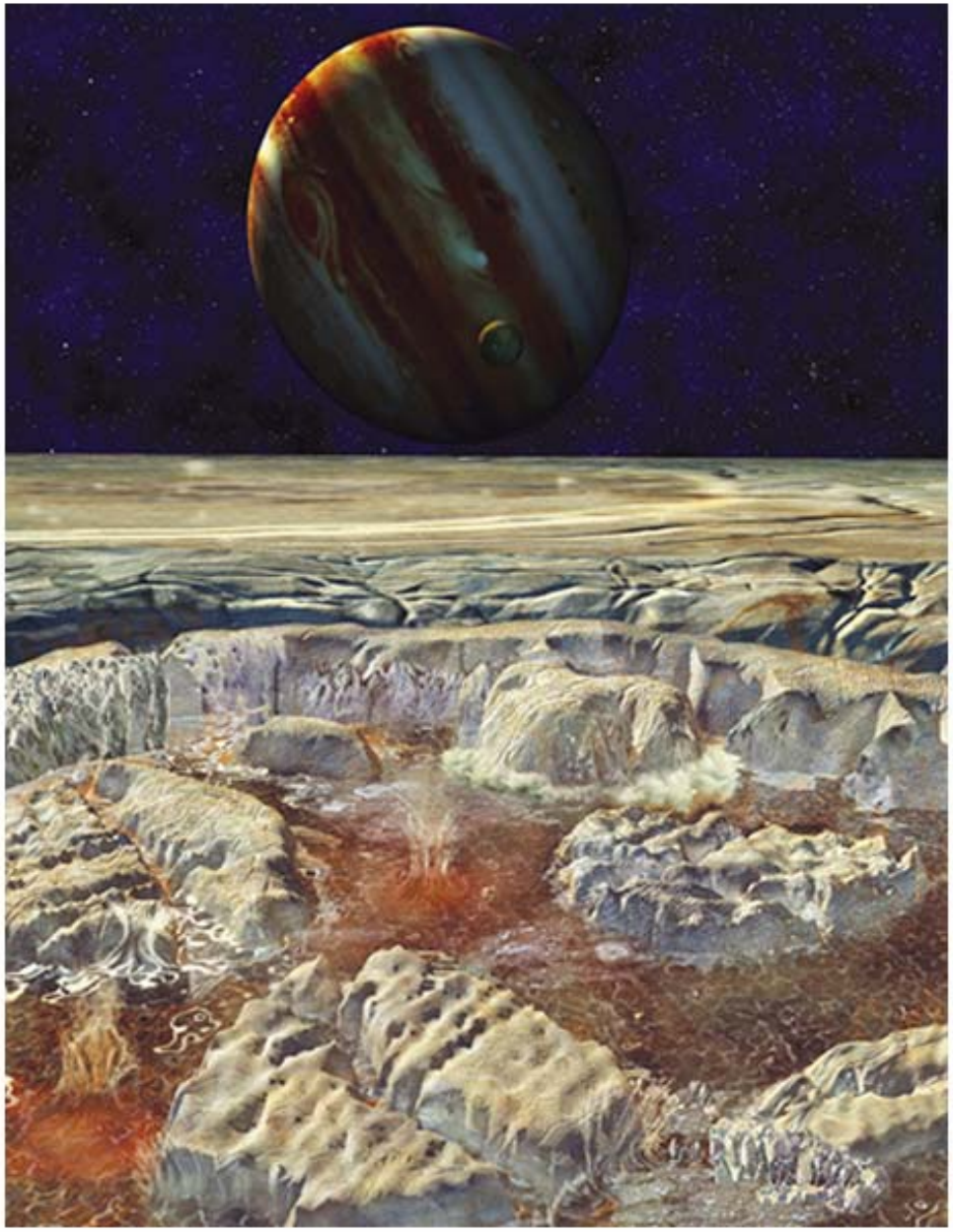


d A possible mechanism for making the double-ridged surface cracks.

Europa:
Ocean World?

Tidal heating may generate
Enough heat to keep water liquid beneath the frozen surface

Surface disrupted by undersea volcanoes



Artist conception

Ganymede
Largest moon in solar system

Craters imply surface older than Europa
Grooved surface

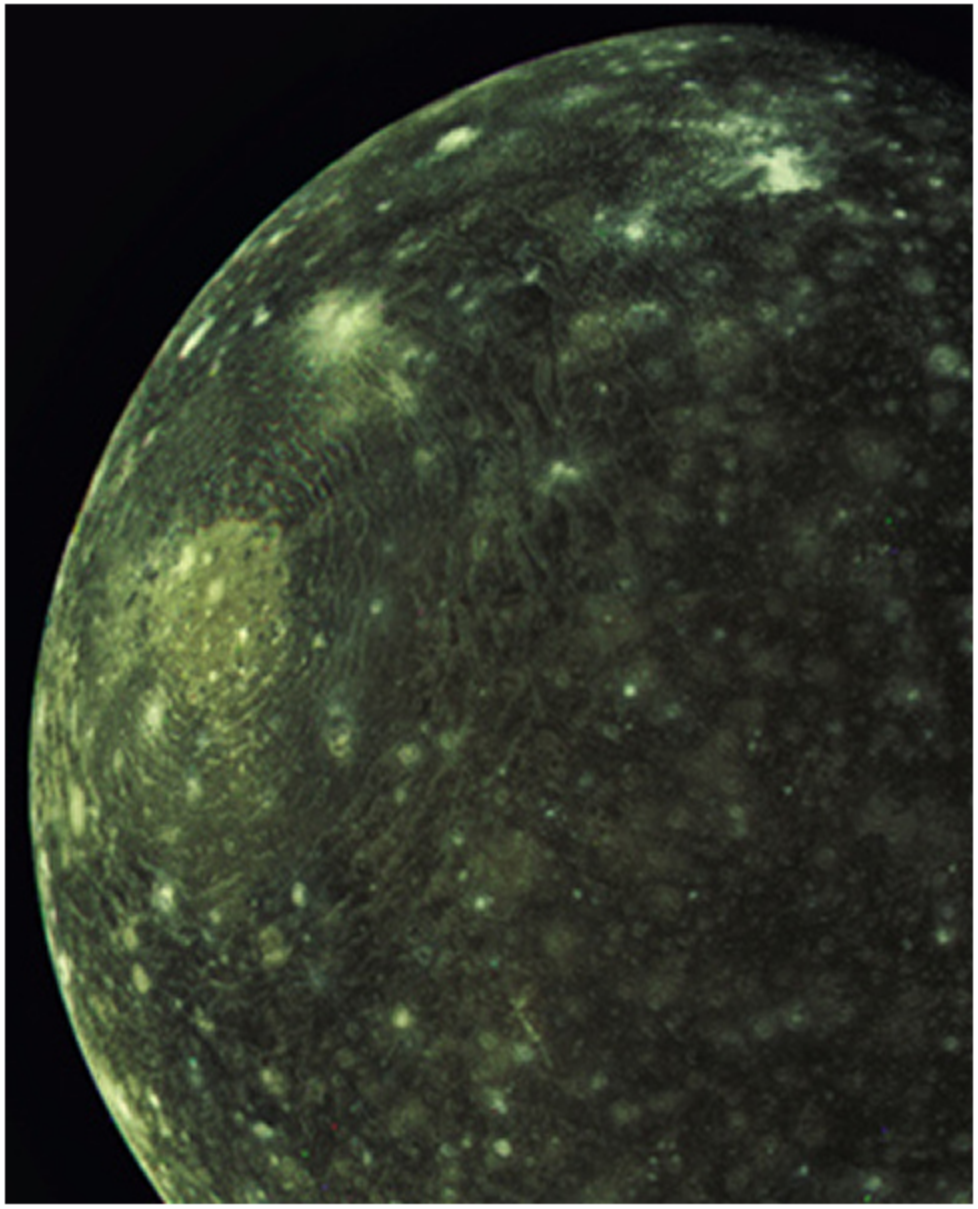
Callisto

Frozen ice ball

Mixture of ice and rock

Heavily cratered, implying old surface

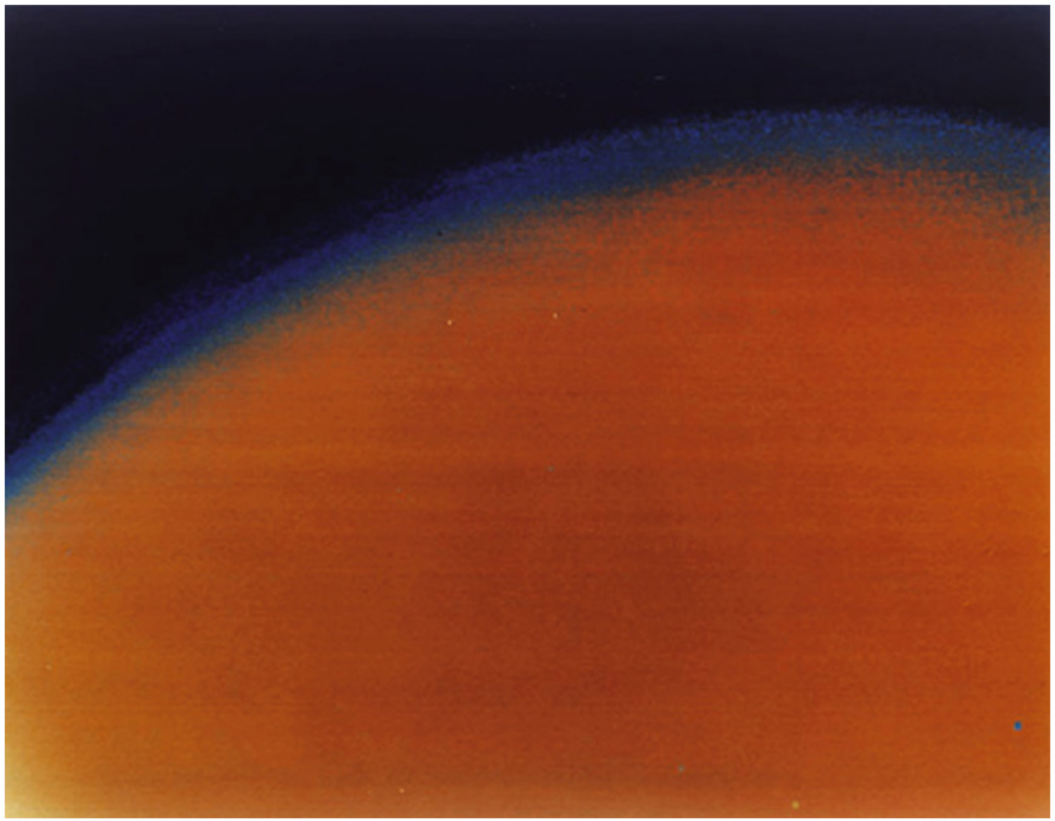
Concentric cracks from large impact, dredging up deeper material



Callisto Close Up

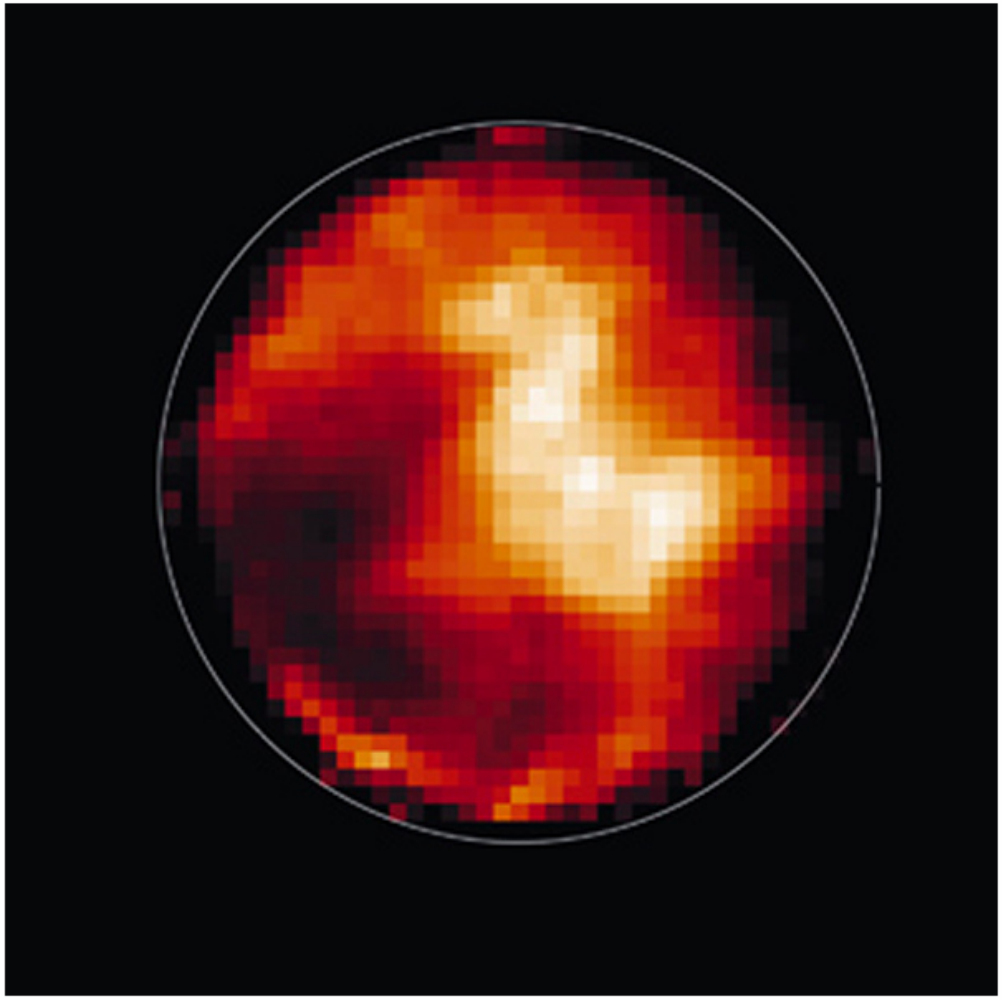
Dark material in valleys interpreted as result of early volcanic activity

Titan: A Moon with an Atmosphere

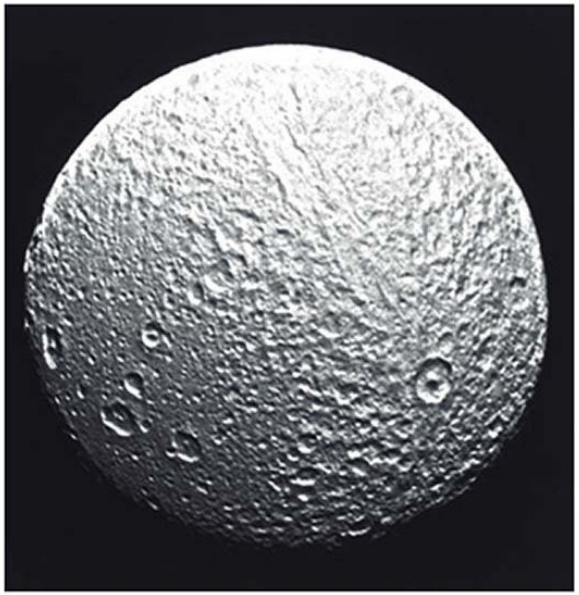


Titan in Infrared Light

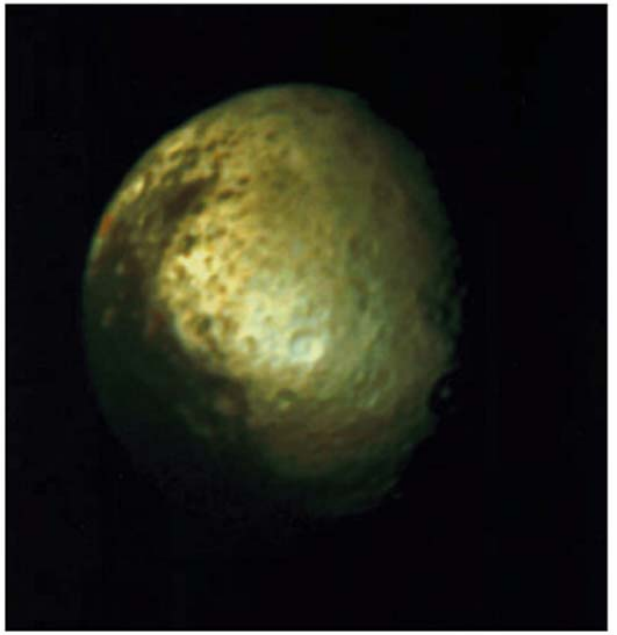
- Temperatures are warm enough for liquid water to exist
- Dark spots may be oceans
- NASA Cassini mission to Titan will map surface and pro atmosphere



Enceladus



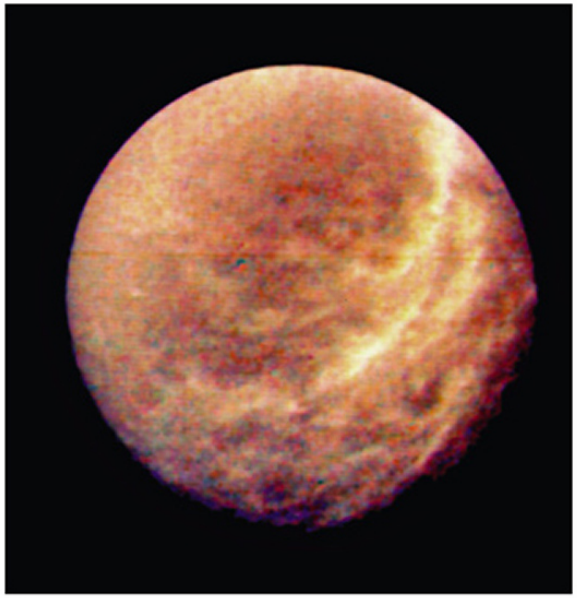
Tethys



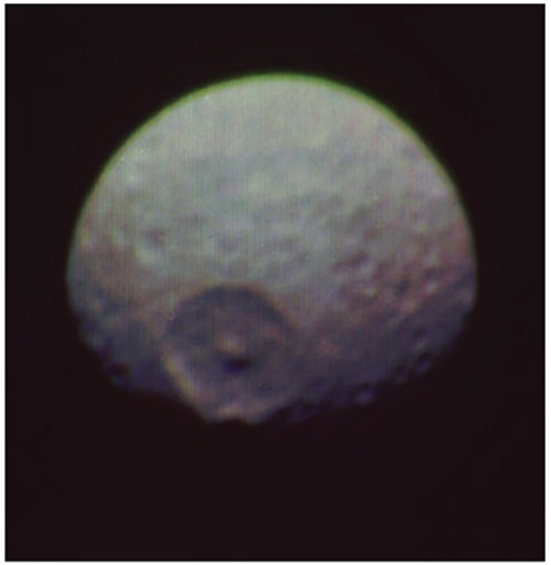
Iapetus

Saturn's Brood of Medium Sized Moons

Dione



Rhea



Mimas

Calculating Relative Surface Gravity

Let m be mass of test body and M and R be mass and radius of planet, respectively. G is Newton's constant.
Then:

$$F_{Jupiter} = GmM_{Jupiter} / R^2_{Jupiter}$$

$$F_{Earth} = GmM_{Earth} / R^2_{Earth}$$

$$\therefore \frac{F_{Jupiter}}{F_{Earth}} = \frac{GmM_{Jupiter} / R^2_{Jupiter}}{GmM_{Earth} / R^2_{Earth}} = \frac{(M_{Jupiter} / M_{Earth})}{(R_{Jupiter} / R_{Earth})^2}$$

$$= \frac{317.8}{(11.21)^2} = 2.53$$

(see Table 2B, Appendix A)