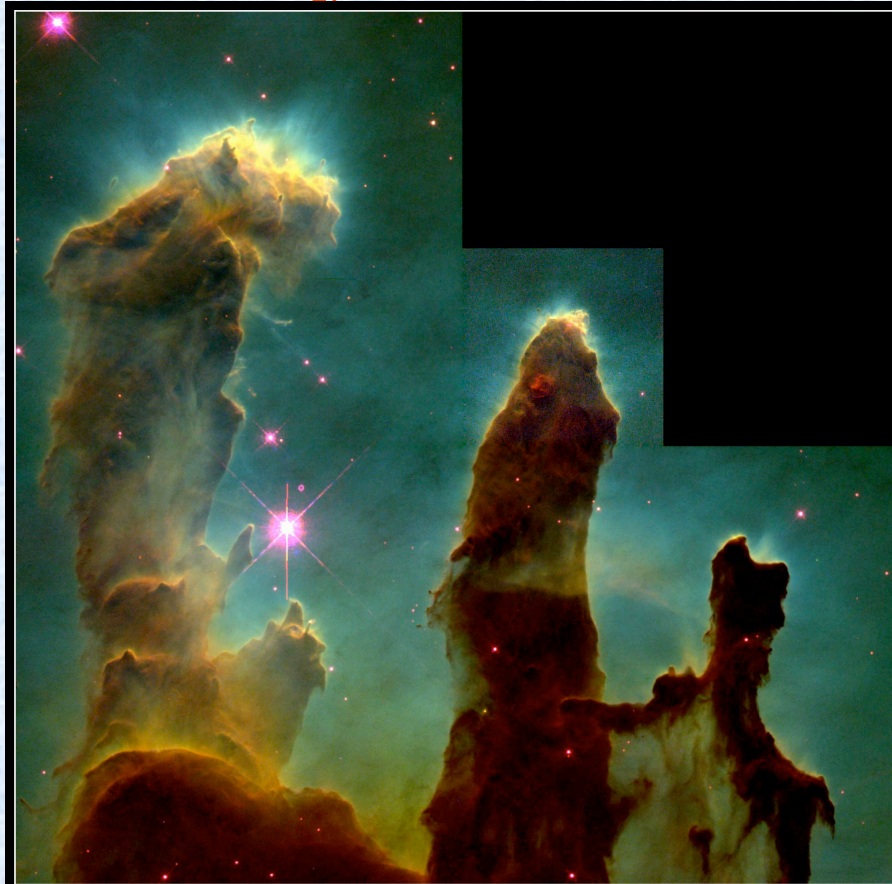


# Astronomy 1 – Winter 2011



**Gaseous Pillars in M16 • Eagle Nebula**  
Hubble Space Telescope • WFPC2

PRC95-44a • ST ScI OPO • November 2, 1995 • J. Hester and P. Scowen (AZ State Univ.), NASA

Lecture 17; February 14 2011

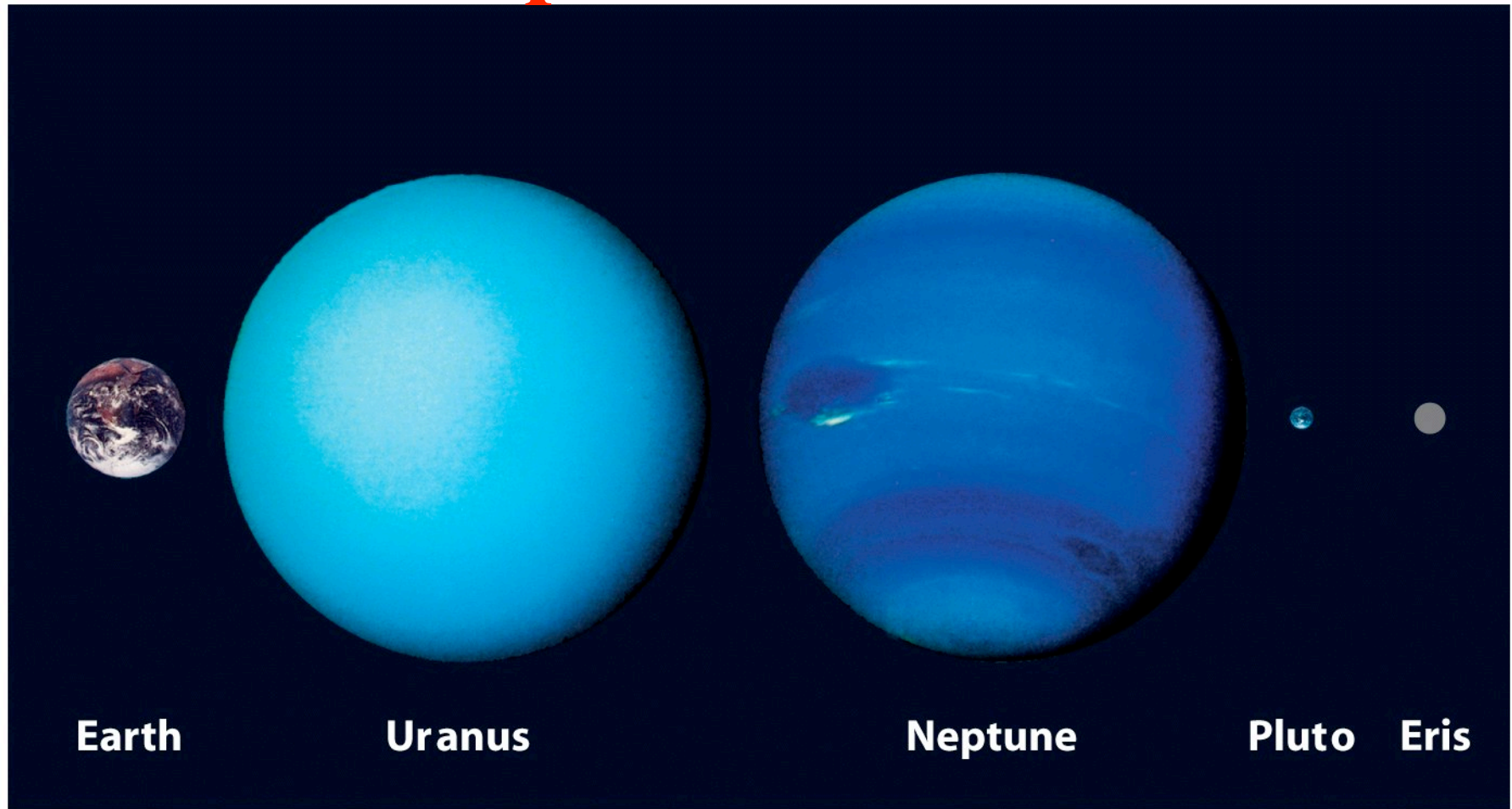
# Previously on Astro-1

- **The satellites of Jupiter and Saturn. A wonderful microcosm of the solar system**
  - **Jupiter's giant satellites**
  - **Crusts and cores**
  - **Volcanism and internal activity**

# Today on Astro-1

- **Beyond the giant planets**
  - **Uranus**
  - **Neptune**
  - **Pluto and the other TNOs**

# Outer planets in context



Earth

Uranus

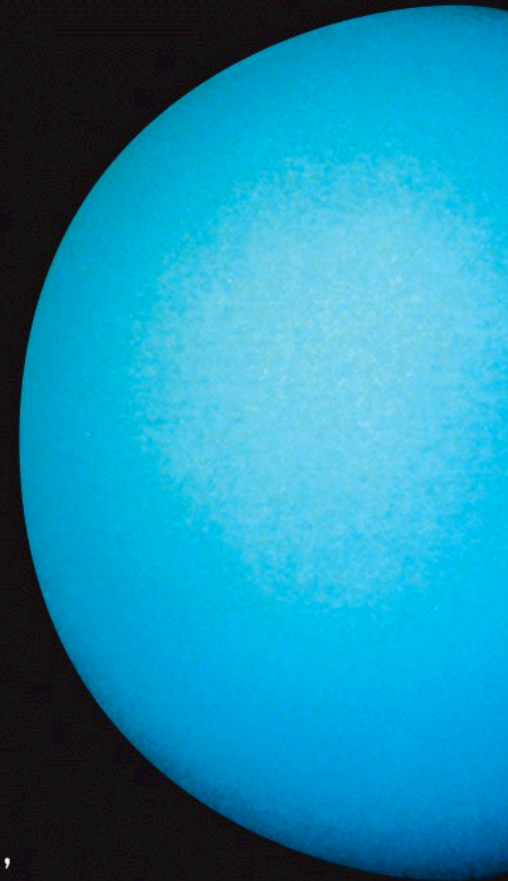
Neptune

Pluto

Eris

## Table 14-1 Uranus Data

Average distance from Sun:	19.194 AU = $2.871 \times 10^9$ km
Maximum distance from Sun:	20.017 AU = $2.995 \times 10^9$ km
Minimum distance from Sun:	18.371 AU = $2.748 \times 10^9$ km
Eccentricity of orbit:	0.0429
Average orbital speed:	6.83 km/s
Orbital period:	84.099 years
Rotation period (internal):	17.24 hours
Inclination of equator to orbit:	97.86°
Inclination of orbit to ecliptic:	0.77°
Diameter:	51,118 km = 4.007 Earth diameters (equatorial)
Mass:	$8.682 \times 10^{25}$ kg = 14.53 Earth masses
Average density:	1318 kg/m <sup>3</sup>
Escape speed:	21.3 km/s
Surface gravity (Earth = 1):	0.90
Albedo:	0.56
Average temperature at cloudtops:	-218°C = -360°F = 55 K
Atmospheric composition (by number of molecules):	82.5% hydrogen (H <sub>2</sub> ), 15.2% helium (He), 2.3% methane (CH <sub>4</sub> )
Average distance from Sun:	30.066 AU = $4.498 \times 10^9$ km
Maximum distance from Sun:	30.367 AU = $4.543 \times 10^9$ km



R I V U X G  
(NASA/JPL)

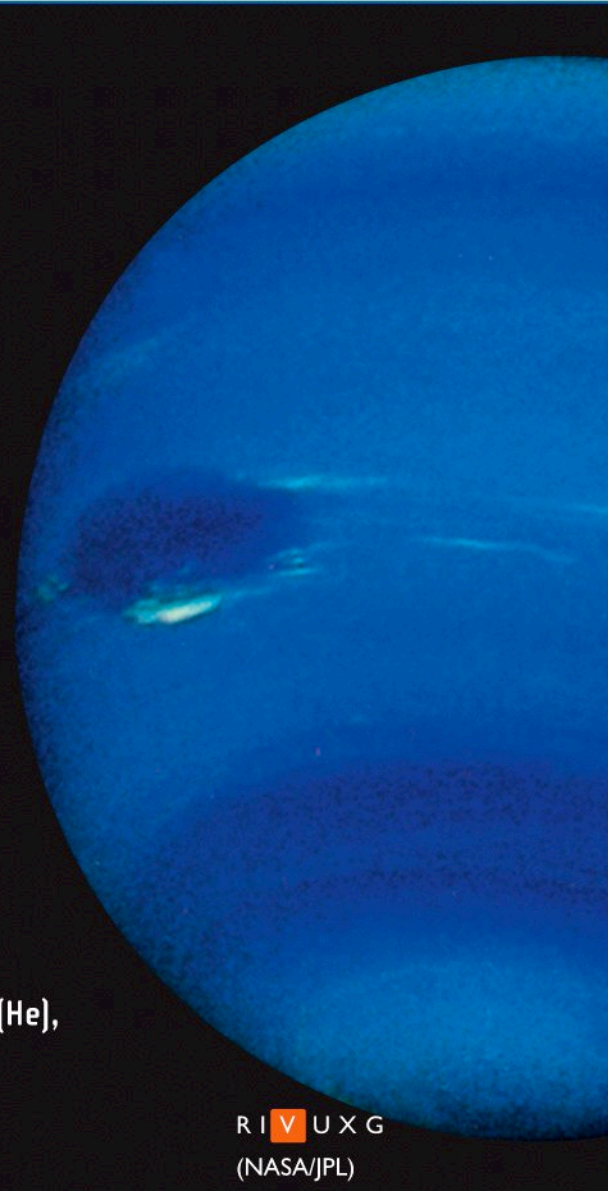
Table 14-1

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## Table 14-2 Neptune Data

Average distance from Sun:	30.066 AU = $4.498 \times 10^9$ km
Maximum distance from Sun:	30.367 AU = $4.543 \times 10^9$ km
Minimum distance from Sun:	29.765 AU = $4.453 \times 10^9$ 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:	$1.024 \times 10^{26}$ kg = 17.15 Earth masses
Average density:	1638 kg/m <sup>3</sup>
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
Atmospheric composition (by number of molecules):	79% hydrogen (H <sub>2</sub> ), 18% helium (He), 3% methane (CH <sub>4</sub> )
Average distance from Sun:	30.066 AU = $4.498 \times 10^9$ km
Maximum distance from Sun:	30.367 AU = $4.543 \times 10^9$ km



R I V U X G  
(NASA/JPL)

Table 14-2

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# Voyager 2 view of Uranus



**South pole**

Figure 14-1

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**South pole**

**Cloud bands**

# HST view of Uranus

**Northern hemisphere storms**

**Figure 14-2**

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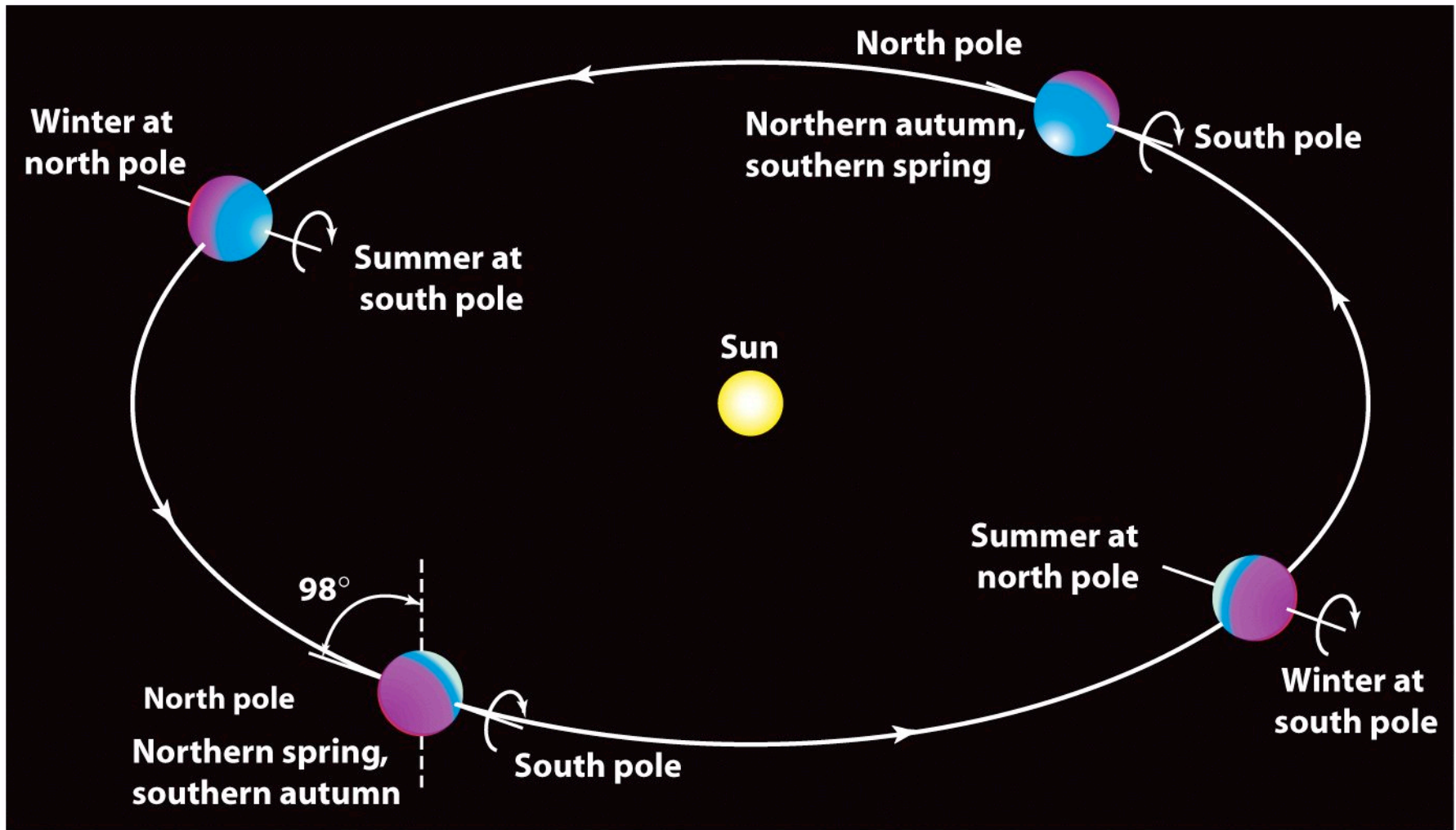


Figure 14-3  
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## Question 17.1 (iclickers!)

- The expected seasonal changes on Uranus because of its orbital and spin axis alignments, compared to those on Earth will be
  - A) The same, because the tilt of the spin axis is the same as that of Earth
  - B) Much less because its orbit is circular
  - C) Absent because the spin axis is perpendicular to the orbital plane
  - D) Very much exaggerated, because the spin axis is almost in the orbital plane

# Voyager 2 view of Neptune

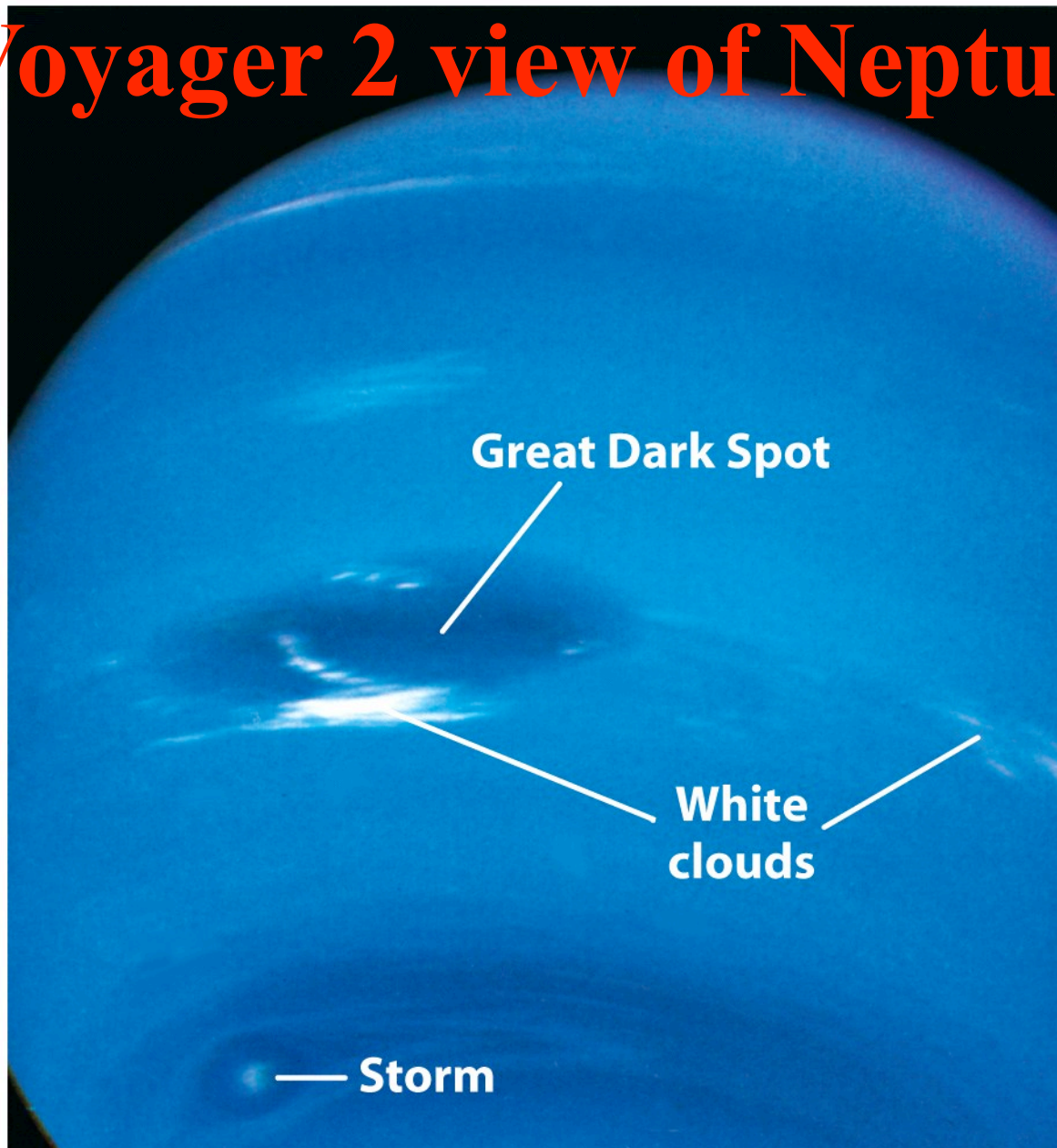
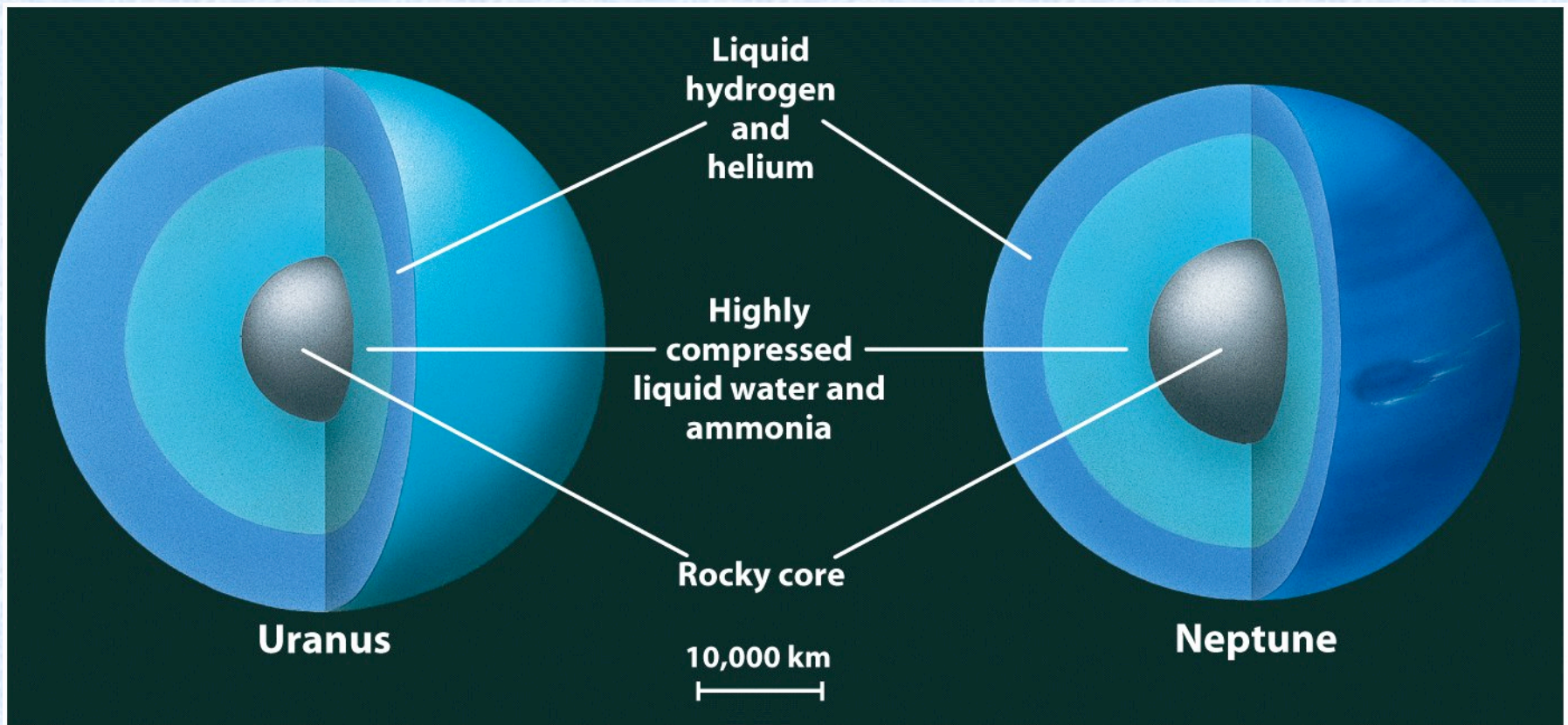


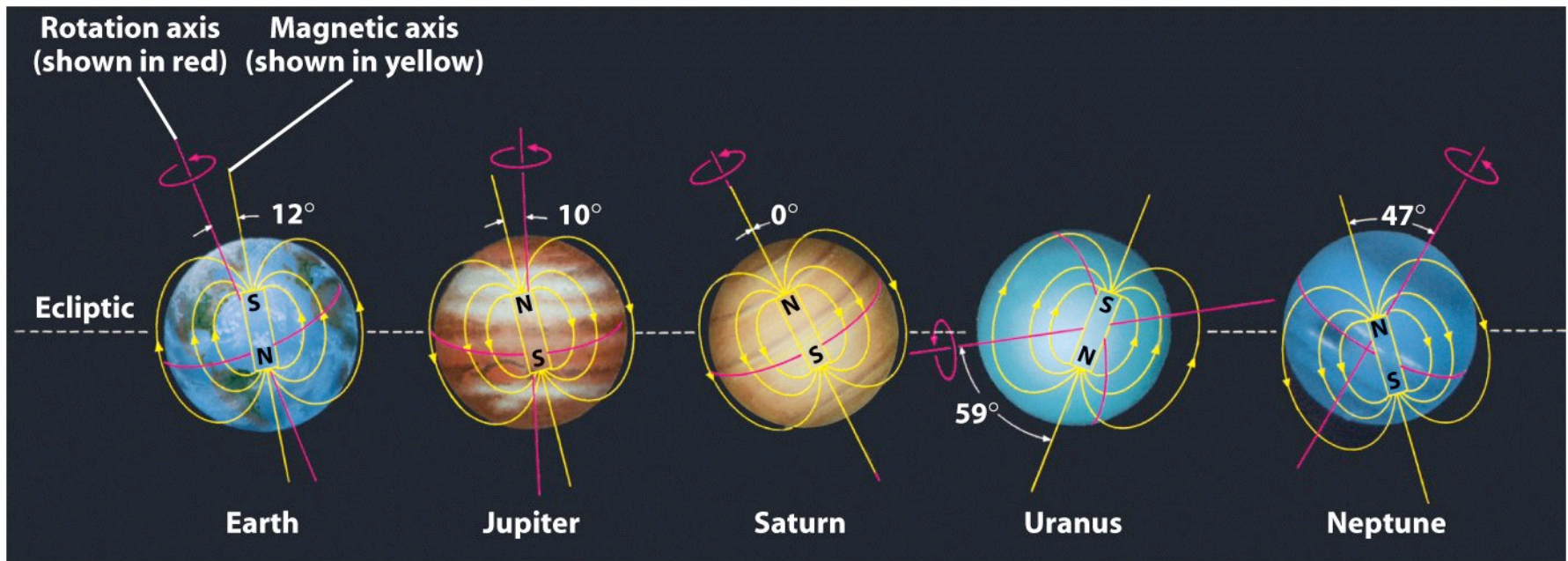
Figure 14-4  
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**Figure 14-7**  
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## Question 17.2 (iclickers!)

- Uranus and Neptune are about the same size, yet Neptune shows spots and bands in its atmosphere while Uranus is almost featureless. Why this difference?
  - A) Uranus and Neptune are at vastly different distances from the Sun and the resulting difference in temperature causes the atmospheres to behave very differently
  - B) The two planets, while of similar size, have atmospheres which differ vastly in composition
  - C) The difference can be traced to the fact that Uranus is lying with its rotation axis almost in the plane of its orbit and Neptune is not
  - D) Neptune is still contracting and giving out energy which warms the lower layers of its atmosphere while Uranus is not.



**Figure 14-8**  
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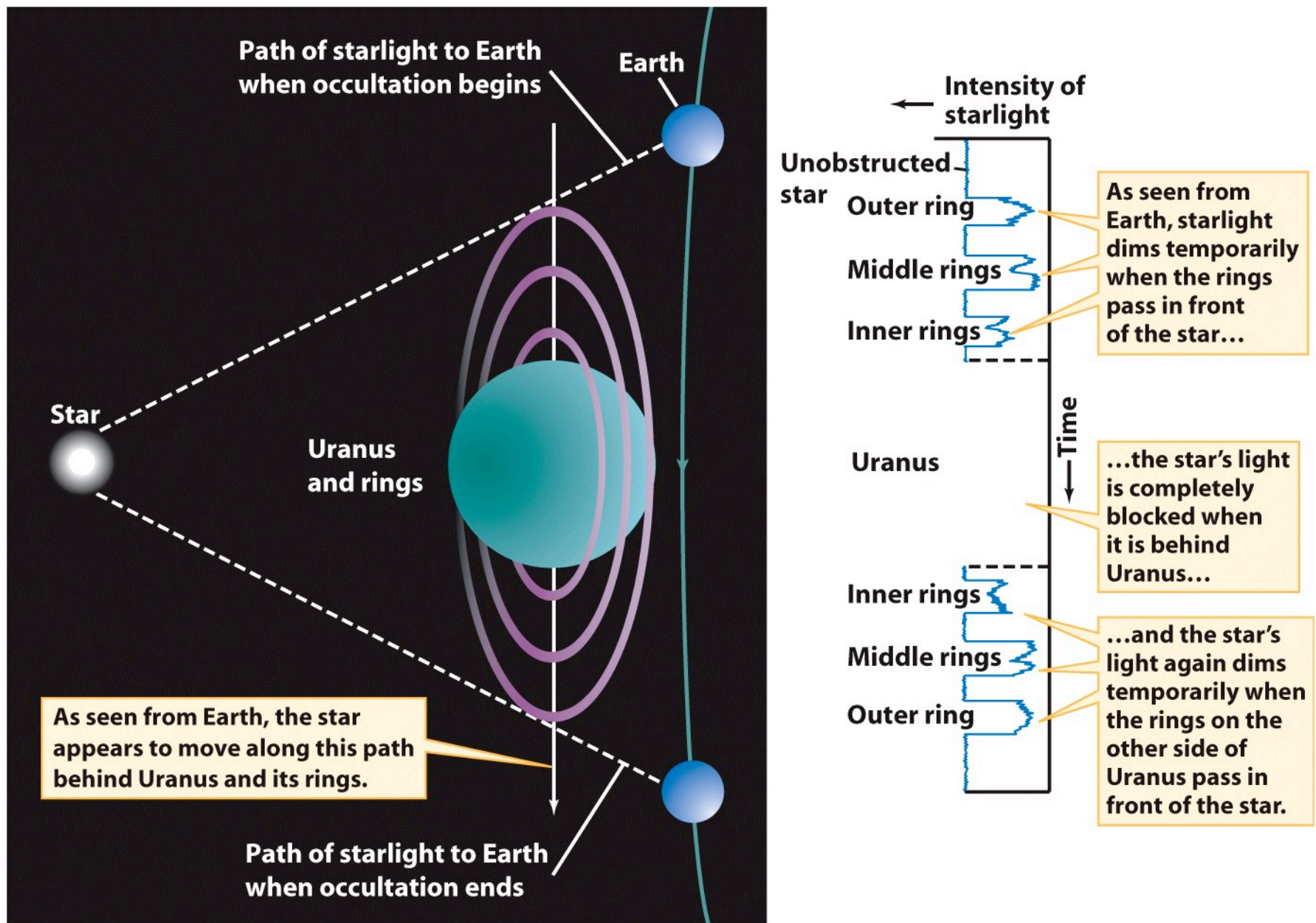


Figure 14-9

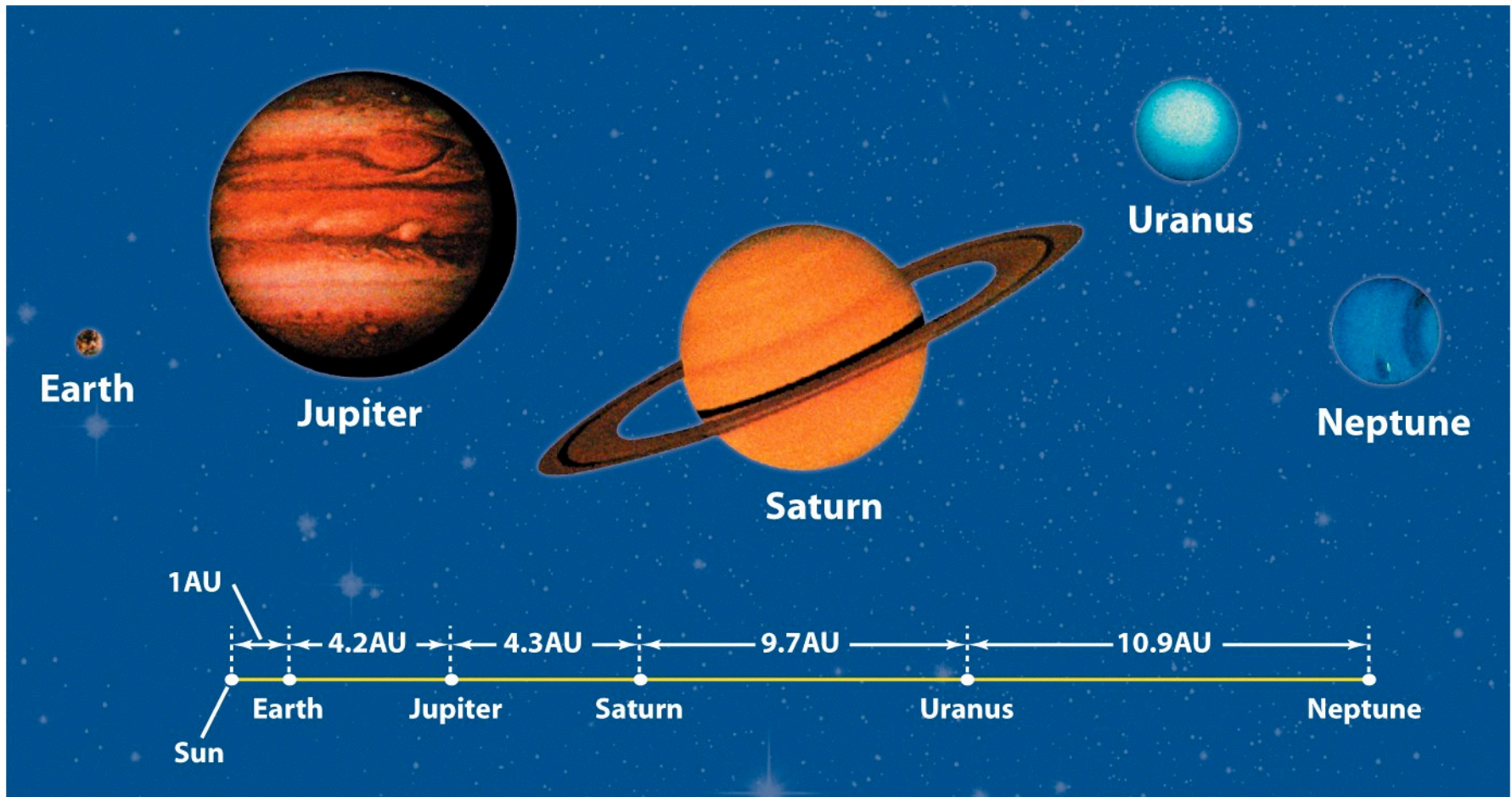
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	Interior	Surface	Rings	Atmosphere	Magnetic Field
<b>Jupiter</b>	Terrestrial core, liquid metallic hydrogen shell, liquid hydrogen mantle	No solid surface, atmosphere gradually thickens to liquid state, belt and zone structure, hurricanelike features	Yes	Primarily H, He	19,000× Earth's total field; at its cloud layer, 14× stronger than Earth's surface field
<b>Saturn</b>	Similar to Jupiter, with bigger terrestrial core and less metallic hydrogen	No solid surface, less distinct belt and zone structure than Jupiter	Yes	Primarily H, He	570× Earth's total field; at its cloud layer, $\frac{2}{3}$ × Earth's surface field
<b>Uranus</b>	Terrestrial core, liquid water shell, liquid hydrogen and helium mantle	No solid surface, weak belt and zone system, hurricanelike features, color from methane absorption of red, orange, yellow	Yes	Primarily H, He, some CH <sub>4</sub>	50× Earth's total field; at its cloud layer, 0.7× Earth's surface field
<b>Neptune</b>	Similar to Uranus	Like Uranus	Yes	Primarily H, He, some CH <sub>4</sub>	35× Earth's total field; at its cloud layer, 0.4× Earth's surface field

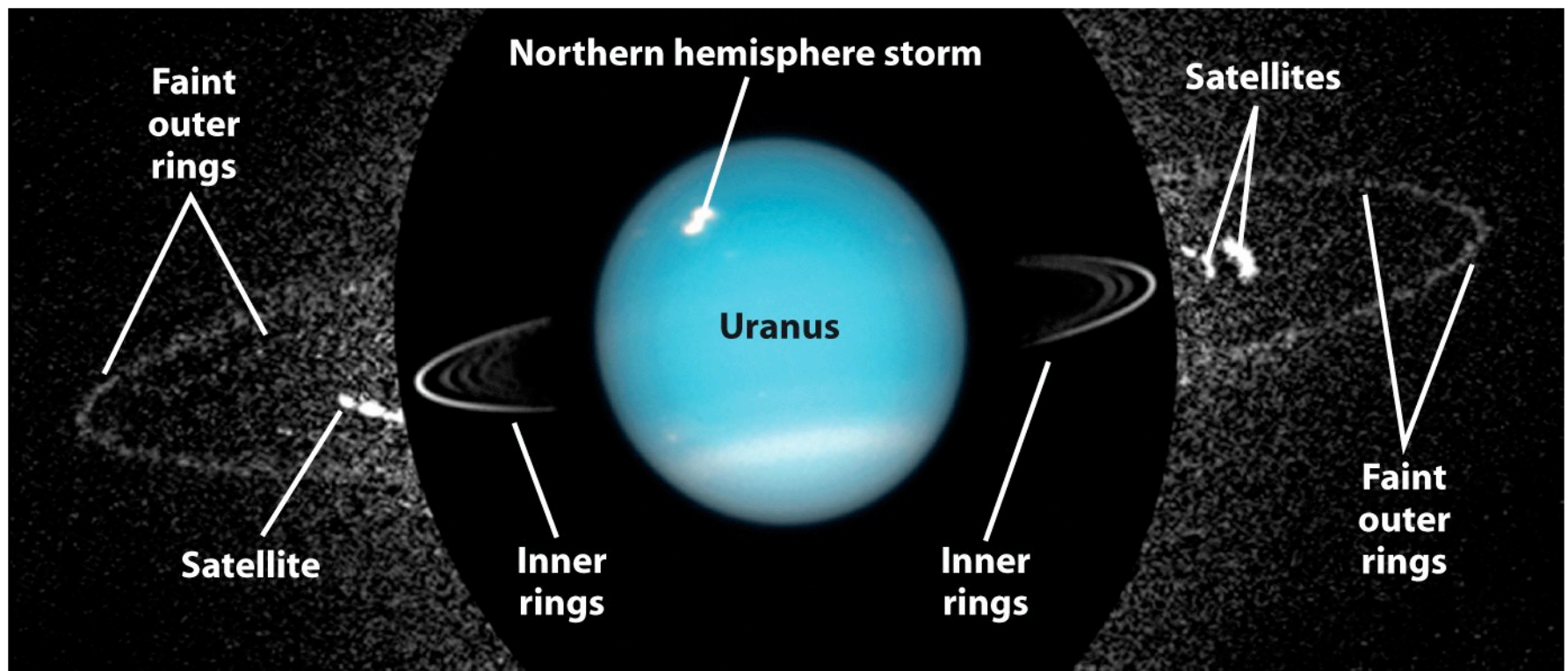
For detailed comparisons between planets, see Appendices 1 and 2.  
 \* To see the orientations of these magnetic fields relative to the rotation axes of the planets, see Figure 14-8.





Cosmic Connections 14b  
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If distance to Mercury is scaled to distance to SB,  
 Earth would be 25m away, Neptune 700 miles



**Figure 14-10**  
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# Voyager 2 view of Neptune's Rings

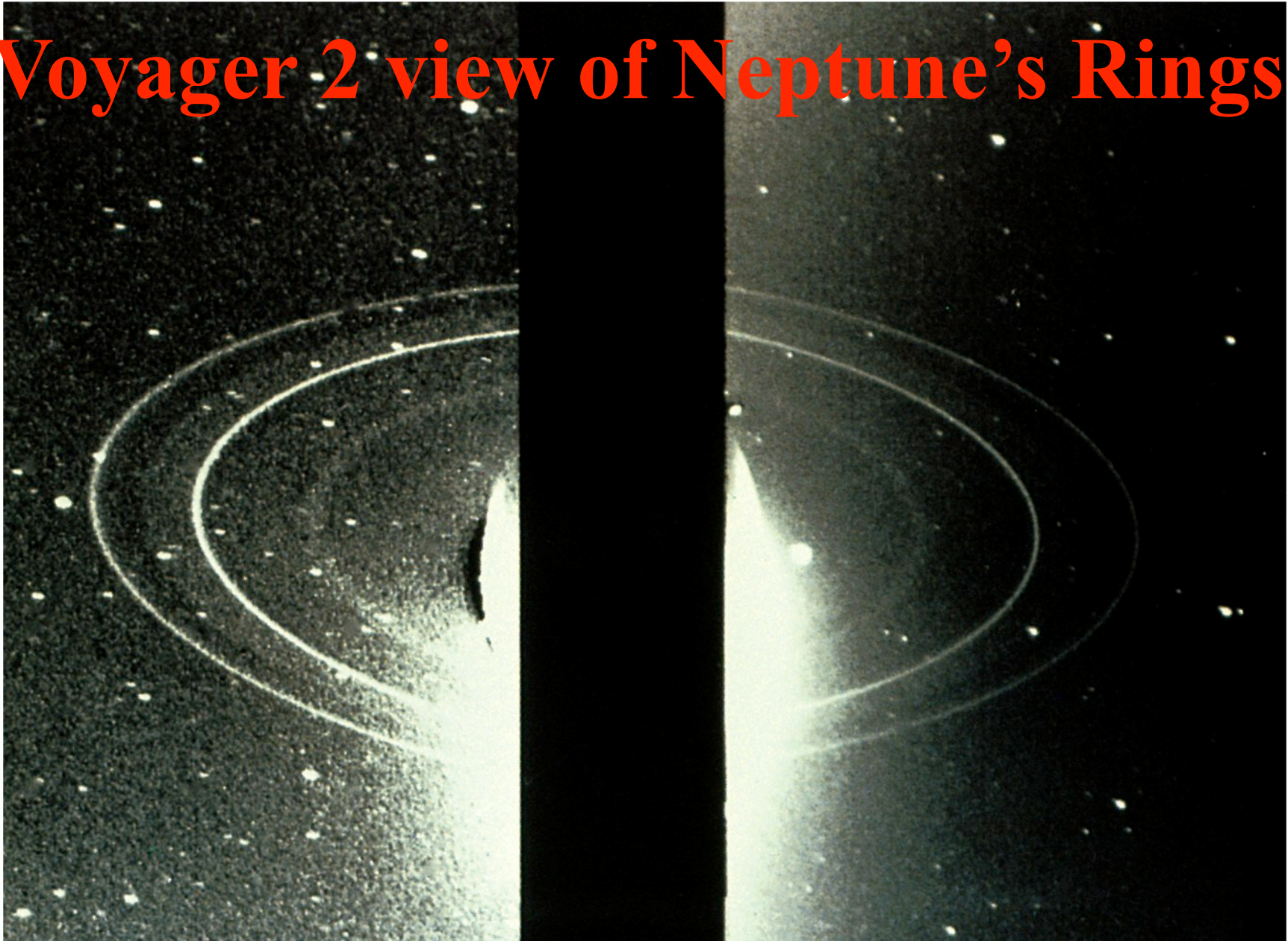
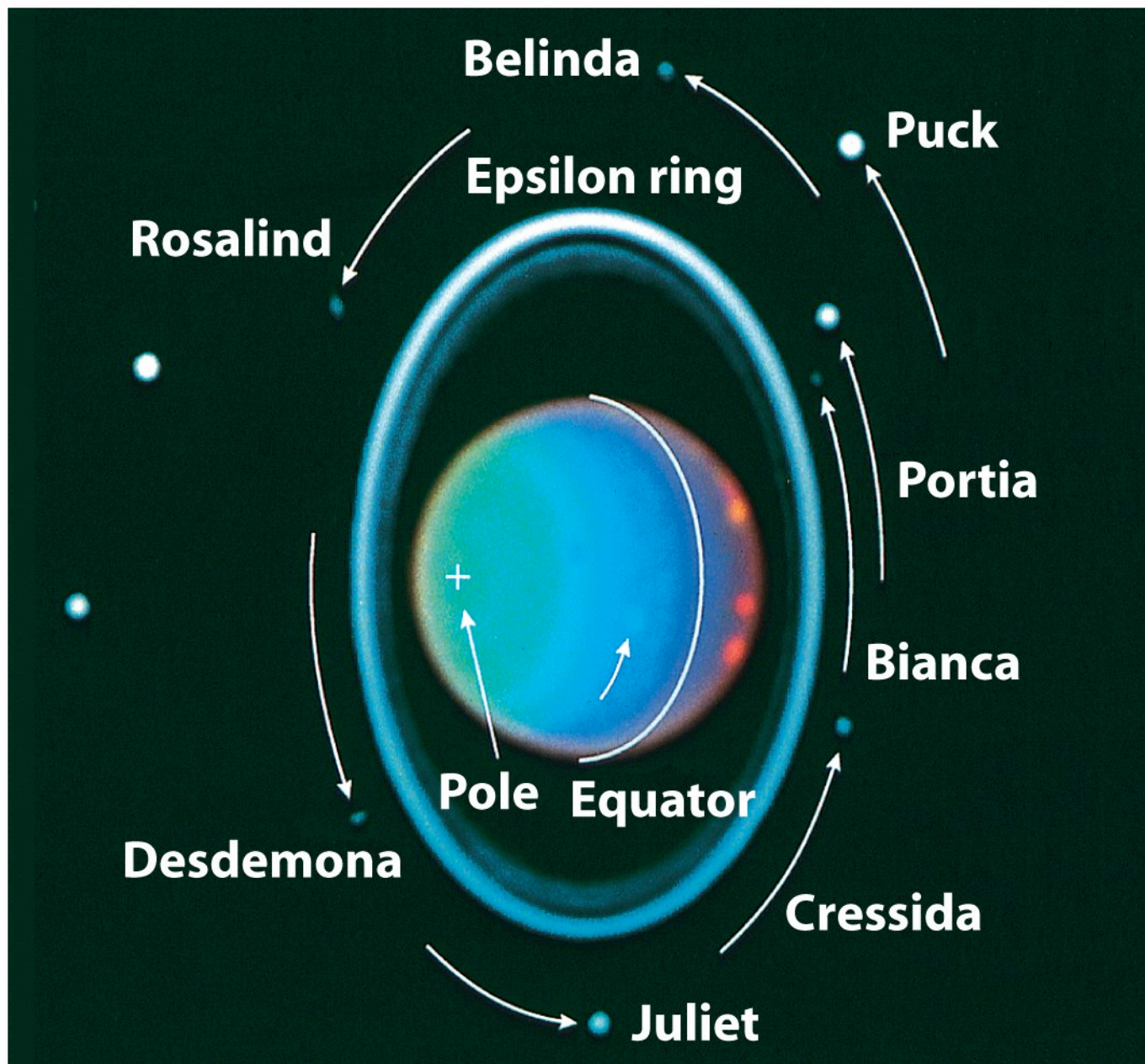


Figure 14-12

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F  
U  
© Uranus rings and satellites

# Voyager 2 view of Miranda

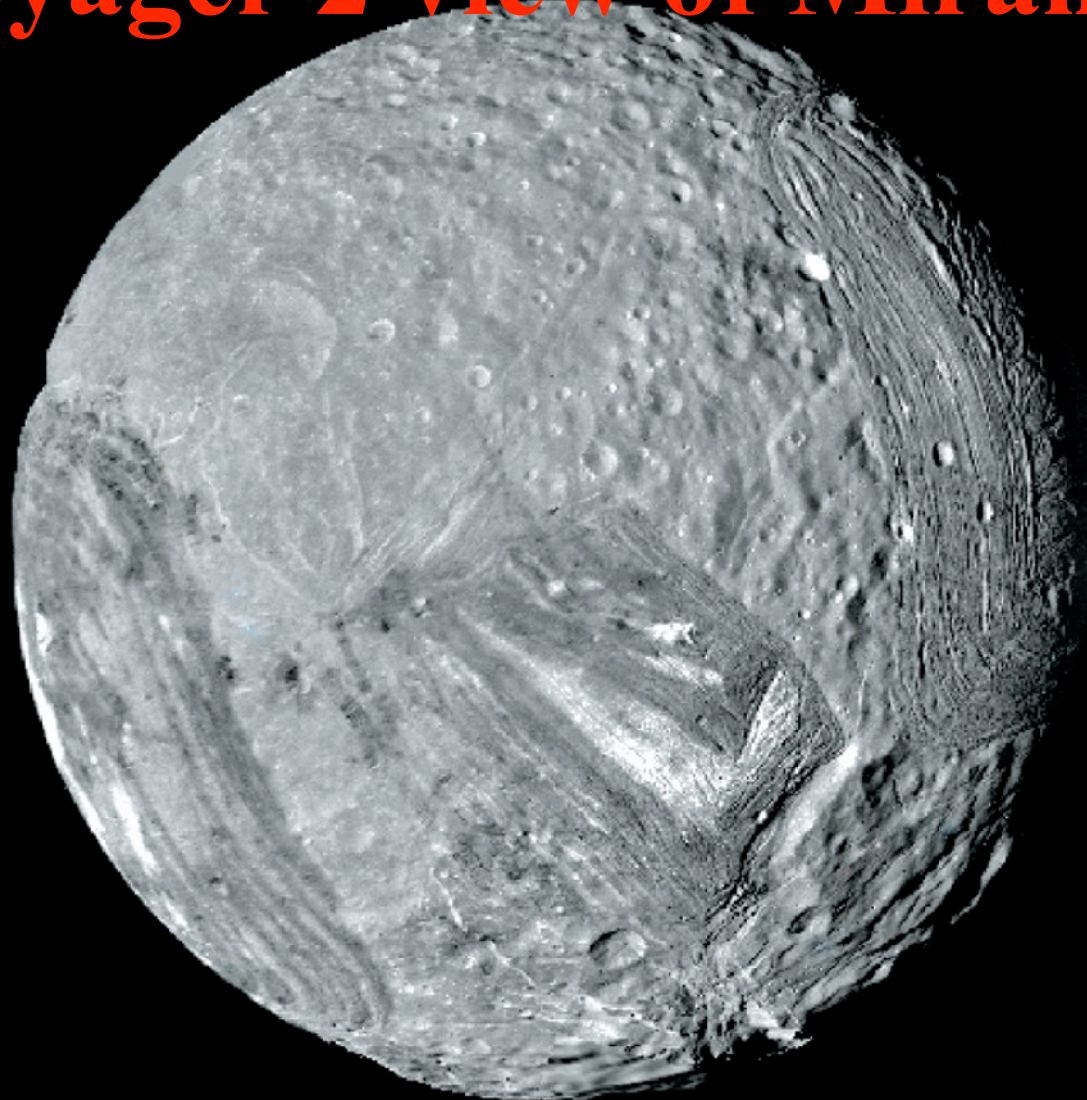
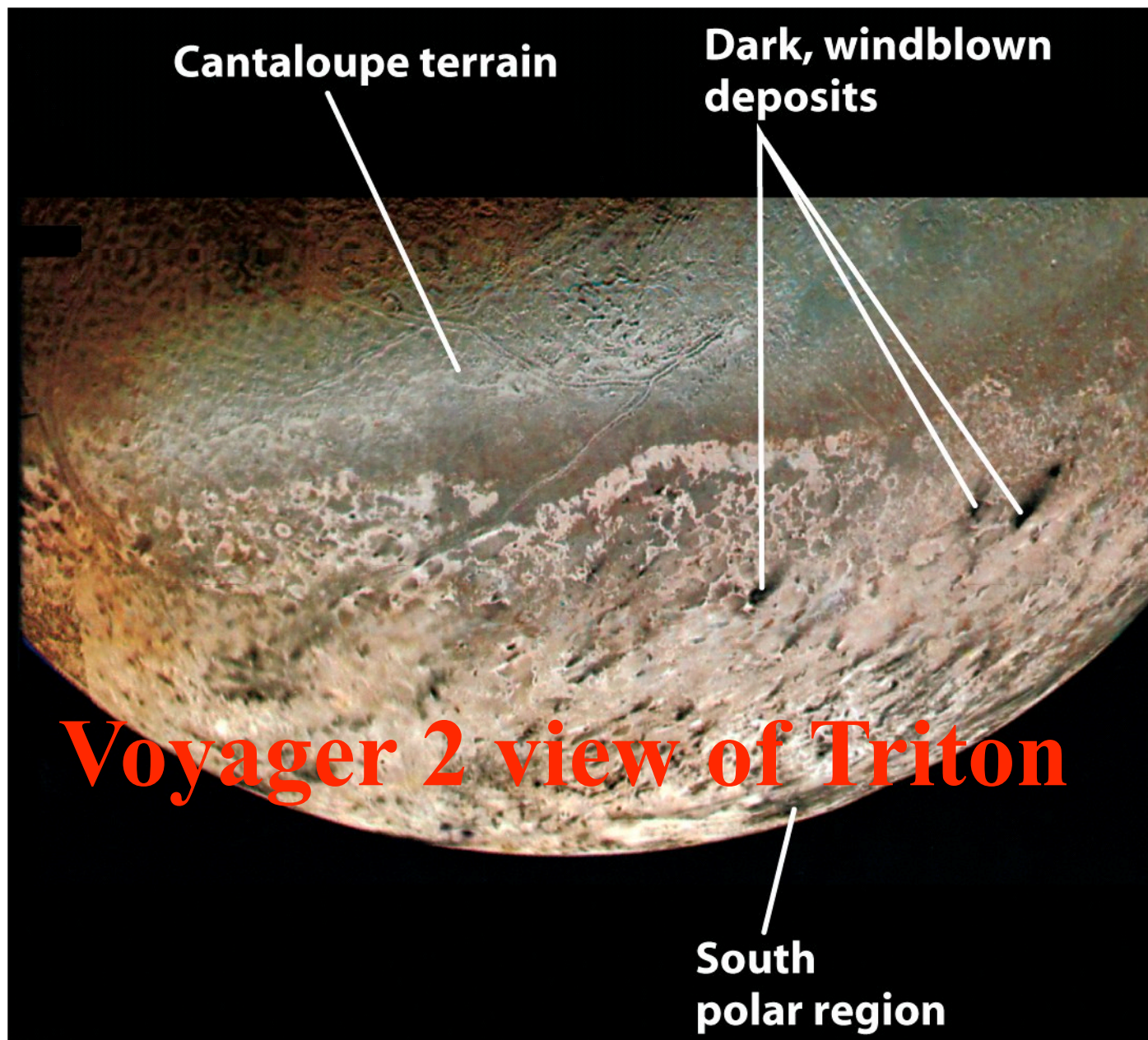


Figure 14-15

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# Voyager 2 view of Triton

Figure 14-16

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# **Beyond Neptune**

# 2006 IAU RESOLUTION B5: Definition of a Planet in the Solar System

- Contemporary observations are changing our understanding of planetary systems, and it is important that our nomenclature for objects reflect our current understanding. This applies, in particular, to the designation "planets". The word "planet" originally described "wanderers" that were known only as moving lights in the sky. Recent discoveries lead us to create a new definition, which we can make using currently available scientific information.



# 2006 IAU RESOLUTION B5: Definition of a Planet in the Solar System

- The IAU therefore resolves that planets and other bodies, except satellites, in our Solar System be defined into three distinct categories in the following way:
  - (1) A planet is a celestial body that
    - (a) is in orbit around the Sun,
    - (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and
    - (c) has cleared the neighborhood around its orbit.
  - (2) A "dwarf planet" is a celestial body that
    - (a) is in orbit around the Sun,
    - (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape<sup>2</sup>,
    - (c) has not cleared the neighborhood around its orbit, and
    - (d) is not a satellite.

# 2006 IAU RESOLUTION B5: Definition of a Planet in the Solar System

- The IAU therefore resolves that planets and other bodies, except satellites, in our Solar System be defined into three distinct categories in the following way:
  - (3) All other objects, except satellites, orbiting the Sun shall be referred to collectively as "Small Solar System Bodies".
- Notes:
  - The eight planets are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.
  - An IAU process will be established to assign borderline objects to the dwarf planet or to another category.
  - Class 3 currently includes most of the Solar System asteroids, most Trans-Neptunian Objects (TNOs), comets, and other small bodies.

## 2006 IAU RESOLUTION B6: Pluto

- The IAU further resolves:
  - Pluto is a "dwarf planet" by the above definition and is recognized as the prototype of a new category of Trans-Neptunian Objects.
  - An IAU process will be established to select a name for this category.

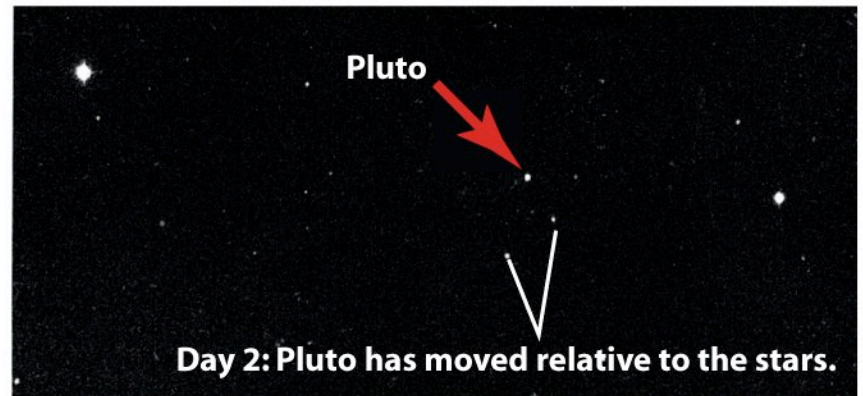
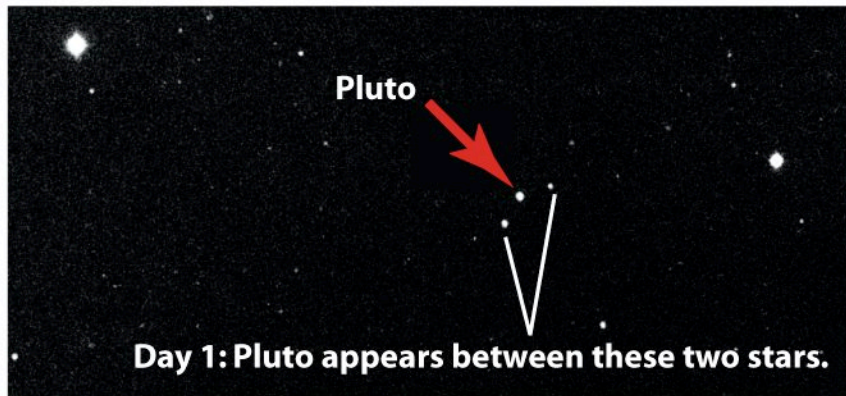
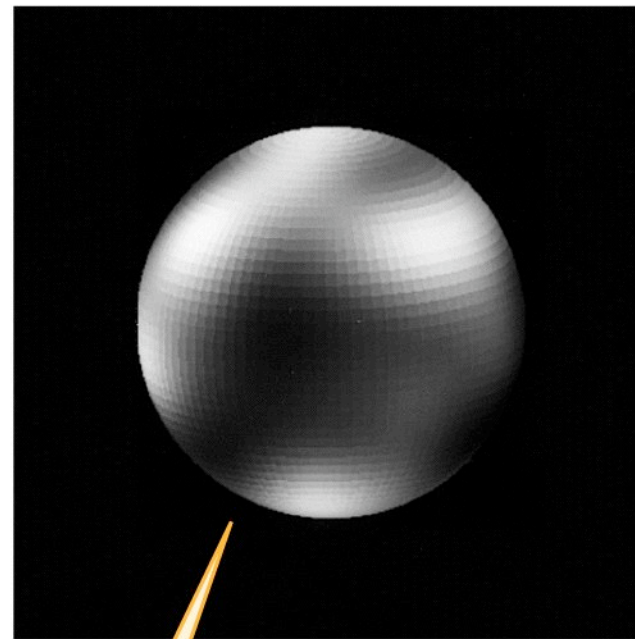
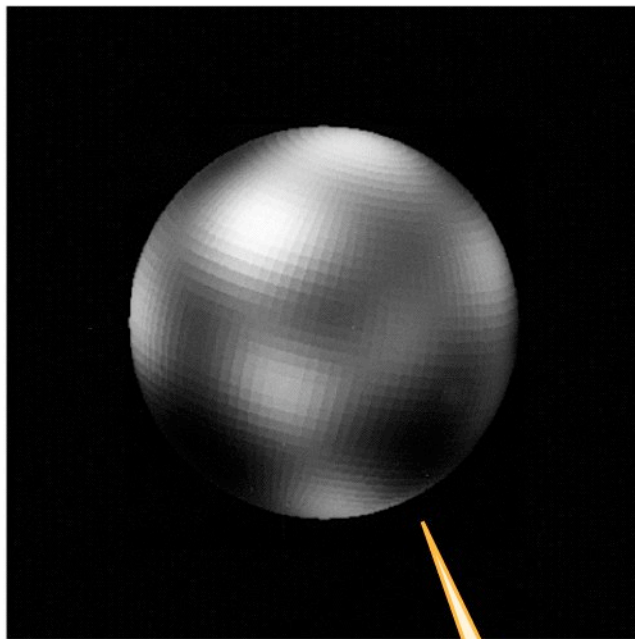
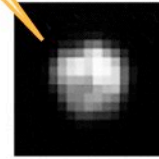
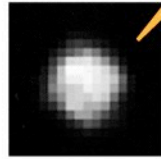


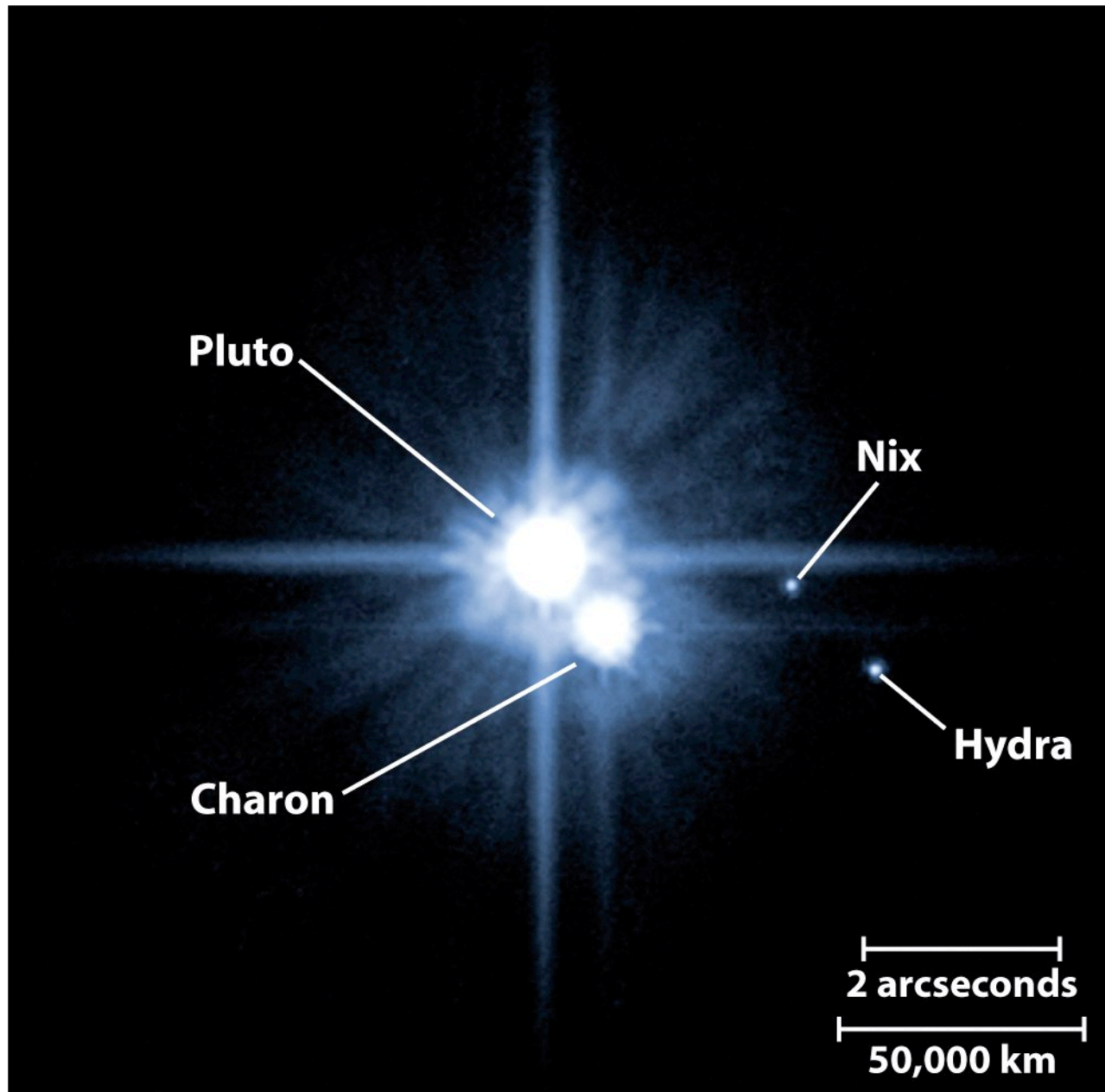
Figure 14-17  
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**Hubble Space Telescope images  
of Pluto's two hemispheres.**



**Computer processing shows dark and  
bright areas on the two hemispheres.**

**Figure 14-18**  
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**Figure 14-19**

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Figure 14-20

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## Question 17.3 (iclickers!)

- Charon is about 1200 km in diameter and is about 18490km away from the surface of Pluto. How large an angle does it subtend when viewed from Pluto?
  - A) 37 arcsec
  - B) 0.5 degrees
  - C) 3.7 degrees
  - D) 57 degrees



# Summary

- **Uranus was discovered by chance, Neptune with calculations!**  
(although probably Galileo saw it!)
- **Higher fraction of heavy elements than Jupiter and Saturn**
- **How did they form?**
  - Formed closer in and then thrown out?
  - Young hot star nearby vaporized light elements (but J/S were shielded)
- **Tilted and offset magnetic fields (what sustains it?)**
  - Reversal?
  - Impact?
- **Dark Rings**
  - Those of Neptune appear to be evaporating!

# Summary

- **Uranus main characteristics**
  - **Foggy atmosphere of He H and NH<sub>3</sub> - bluish color**
  - Tilted axis of rotation (impact?)
  - No internal heat
  - Many satellites, tidally heated in the past?
  - Smaller satellites recently captured?
- **Neptune main characteristics**
  - Similar atmosphere but more weather (maybe due to internal heat)
  - Axis of rotation similar to Earth
  - Many small satellites
  - Most interesting one is Triton; retrograde, hence probably captured;
    - Geyser-like activity from tidal heating
    - Spiraling inward due to tidal interactions!
- **Pluto**
  - Not a planet; small satellites; similar to Triton

**The End**

See you on wednesday!