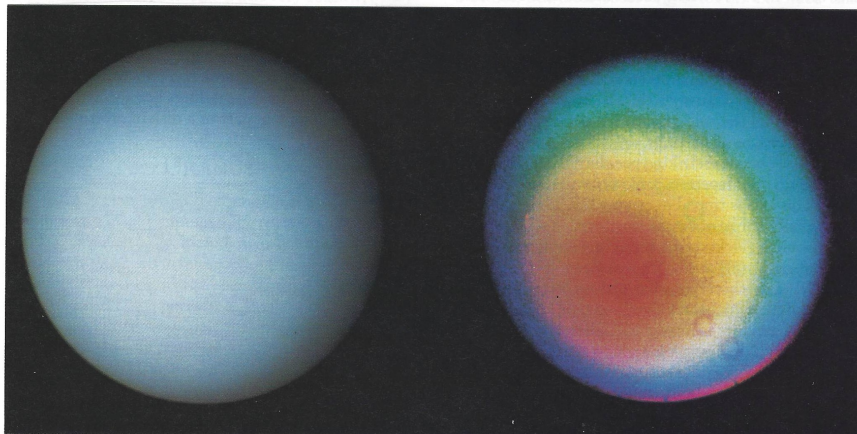


## Chapter 15. The Outer Planets



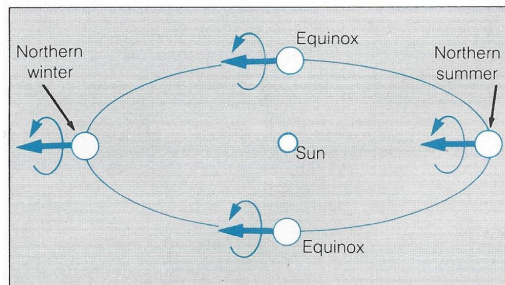
**Figure 15.4.** Uranus as seen by Voyager. The image on the right is color enhanced to show bands.

**Note.** In this section we survey physical properties of Uranus, Neptune, and Pluto.

**Note.** Some general facts about Uranus include:

Orbital Period	84 years
Rotation Period	17 hours 14 minutes
Mass	14.5 times Earth's mass
Surface Gravity	0.89 of Earth's
Albedo	34%
Satellites	15 known

**Note.** Uranus was discovered in 1781 by William Herschel. It has a ring system discovered in 1977. The rotational axis is tilted  $98^\circ$ . The satellites orbit in the equatorial plane indicating that whatever caused the tilt caused it before the satellites formed.



**Figure 15.3.** Seasons on Uranus.

**Note.** The composition of Uranus is similar to that of Jupiter and Saturn with hydrogen, helium, and methane common. The methane gives Uranus a blue-green color. There is no excess heat, but circulation patterns are similar to those of Jupiter and Saturn with belts and zones. Voyager detected occasional white clouds near the equator.

**Note.** Uranus has a magnetic field with magnetic axis tilted  $60^\circ$  to the rotational axis. The interior is poorly known; there is no metallic hydrogen since Uranus is too small for this.

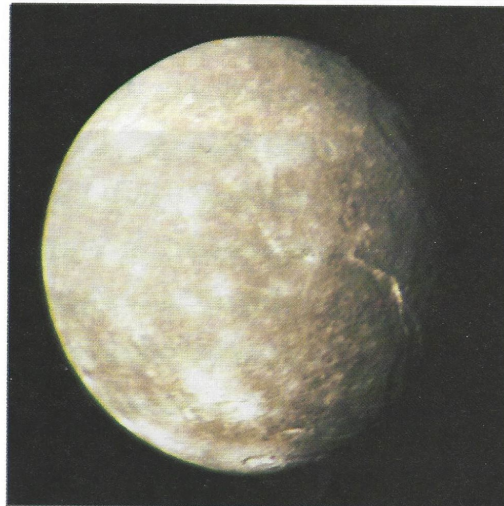
**Note.** All 15 moons of Uranus are in synchronous rotation. There are shepherd satellites for the rings, as with Saturn. The five major satellites (listed in far to near Uranus order):

**Oberon.** It has a heavily cratered surface with mountains and scarps, implying past geological activity, but none at the present.



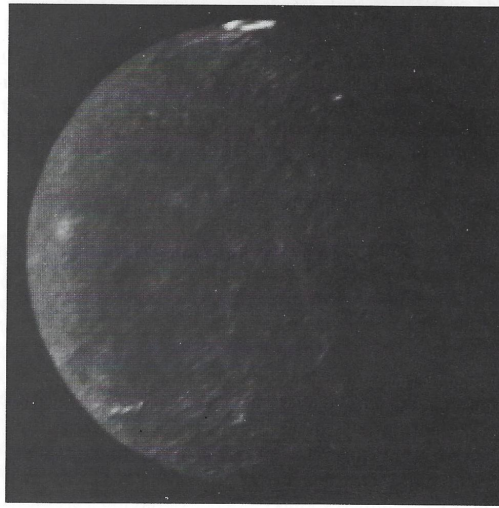
**Figure 15.11.** Oberon.

**Titania.** It has a younger surface with some recent cratering; it is the largest of Uranus' moons.



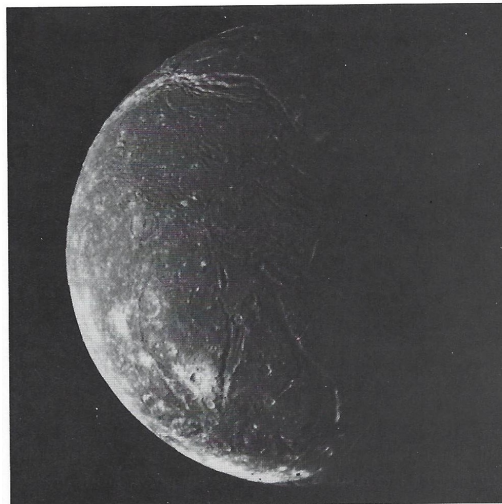
**Figure 15.12.** Titania.

**Umbriel.** It is dark (albedo of 19%) and the surface is covered with dark dust.



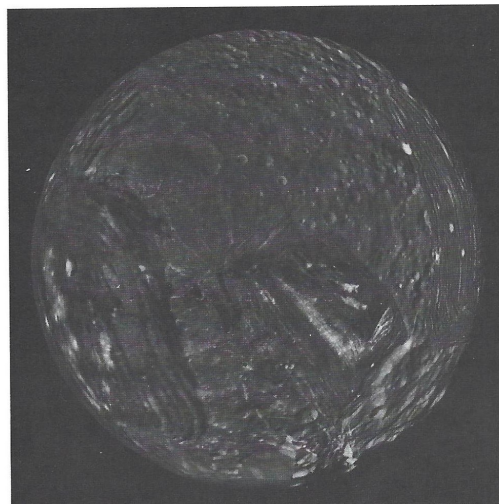
**Figure 15.13.** Umbriel.

**Ariel.** It has fault systems with icy flows, yielding a bright, young surface.



**Figure 15.14.** Ariel.

**Miranda.** It has grooved regions with uplifted surfaces. There are sharp drop offs, implying recent geological activity.



**Figure 15.15.** Miranda.

The rings are made of roughly one-meter-in-size particles.

**Note.** Some general facts about Neptune include:

Orbital Period	165 years
Rotation Period	16 hours
Mass	17 times Earth's mass
Albedo	29%
Satellites	8 known

This information is from June Kinoshita's "Science in Pictures: Neptune," *Scientific American*, **261**(5), 82–91, November 1989.

**Note.** Neptune was discovered by Johann Gottfried Galle in 1846. Its position had been predicted due to disturbances in Uranus' orbit. Little was known until Voyager 2 flew by it in August 1989 (after the publication of our textbook, so this information is from the *Scientific American* article mentioned above). The atmosphere is very turbulent. High thin clouds of methane were found above the main cloud deck. Striations and dark storm spots were found, one called the *Great Dark Spot*. There is a magnetic field and the presence of auroras (auroras were also observed on its moon Triton). Neptune has four rings which are complete, but have thick and thin regions.

**Note.** There are two main moons of Neptune:

**Nereid.** It resembles an asteroid.

**Triton.** It orbits retrograde and has a very thin atmosphere (0.00001 atmospheres) of mostly nitrogen. The surface has vast canyons, craters, and peaks. There is evidence of past volcanic activity and a suggestion that it may still be active.

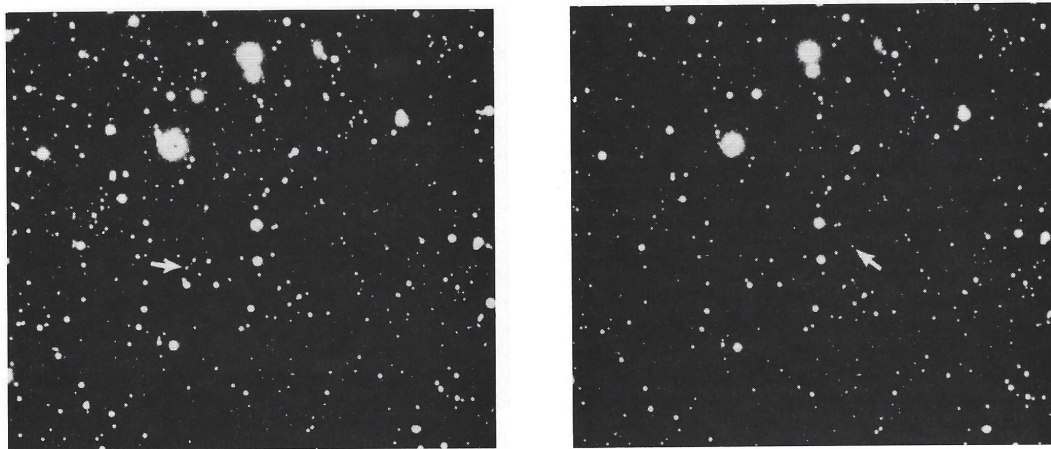
Voyager 1 visited flew by Jupiter and Saturn, and Voyager 2 flew by Jupiter, Saturn, Uranus, and Neptune (completing the "grand tour"). This project cost \$2.40 per U.S. citizen.

**Note.** Some general facts about Pluto include:

Orbital Period	249 years
Orbital Inclination	17°
Rotation Period	6.4 days
Mass	0.002 times Earth's mass
Surface Gravity	0.04 times Earth's
Albedo	40%
Satellites	1

This information is based in part on Richard P. Binzel's "Pluto," *Scientific American*, **262**(2), 50–59, June 1990.

**Note.** Pluto was discovered by Clyde Tombaugh in 1930. Its orbit is highly elliptical and the orbital plane is at an angle to that of other planets. Pluto has methane ice and a methane atmosphere that condenses out in the "winter." Pluto may have once been a satellite of Neptune. Pluto itself has a moon, Charon.



**Figure 15.22.** The discovery of Pluto. Pluto was discovered in 1930 based on its movement relative to the background stars.