

URANUS, ITS MOONS, AND ITS RINGS AS SEEN BY THE VOYAGER 2 SPACECRAFT, JANUARY 14, 1986.

#### VITAL STATISTICS

- 7th Planet from Sun, between Saturn and Neptune. ■ Average Distance from Sun: 2,870,000,000 km (1,765,000,000 mi) (19 times as far as Earth). ■ Length of Year (One Trip Around Sun): 84 Earth-years. ■ Diameter: 51,800 km (32,200 mi) about 4 times diameter of Earth.
- Length of Day (One Rotation on Axis): 17 hours, 18 minutes. ■ Magnetic Field: about as strong as Earth's or Saturn's; inclined at 60 degrees to rotation axis (largest known inclination in solar system); offset about 7700 km (4800 mi) from center of planet; generates strong radiation belts (Van Allen Belts) around planet.

#### NATURE OF SURFACE

- Unknown. May be deep layers of ice and rock.
- Invisible beneath deep, thick atmosphere.

#### NATURE OF ATMOSPHERE

- Composition: about 15 percent helium (He), 83 percent hydrogen (H<sub>2</sub>) (similar to Sun, Jupiter); about 2 percent methane (CH<sub>4</sub>), minor ammonia (NH<sub>3</sub>), water (H<sub>2</sub>O). ■ Corona of hydrogen atoms extends from upper atmosphere to out beyond rings.
- Blue-green color of planet caused by methane, which absorbs red light. ■ Atmosphere unusually clear: rare clouds observed in upper atmosphere.
- Weak color bands in atmosphere, parallel to latitude lines despite intense solar heating of polar regions. ■ Polar haze (hydrocarbon smog?) observed over south pole, possibly formed by decomposition of methane? ■ Temperature at top of atmosphere: 60 K (-213°C). ■ Temperature uniform throughout atmosphere, contrary to theories. ■ Jet stream winds observed, velocity 100 meters/sec (Earth: 40 meters/sec); winds move in same direction as rotation, contrary to theory.
- Auroras ("Northern Lights") seen on nightside.

#### MOONS AND RINGS

- Five large moons: Miranda (inner, diameter 484 km), Ariel (1190 km), Umbriel (1160 km), Titania (1610 km), Oberon (1550 km). ■ At least 10 smaller moons, generally less than 80 km in diameter. ■ Two small moons "shepherding" one of large rings (epsilon ring). ■ Moons made largely of ice, little rock; densities only about 1.4 times water.
- Surface temperatures low: 86 K or -187°C.
- All moons heavily cratered from intense, long meteorite bombardment. ■ Large moons show extensive crustal activity—fractures, scarps, trenches, possible floods of "lava" (liquid ammonia? water?).
- Miranda a bizarre "patchwork" of strange landscapes—possibly broken up by ancient meteorite impacts and reassembled? ■ Umbriel puzzling: old, dark, cratered, little or no surface activity. ■ Eleven thin rings around planet; nine discovered from ground. ■ Rings narrow, generally only 1–100 km wide; one ring 2500 km wide.
- Rings thin: all less than 150 km thick. ■ Rings lack fine particles; possibly removed continuously by hydrogen atoms in corona? ■ Rings and moons all dark gray to black; color possibly due to carbon compounds on surface, formed by breakdown of methane by space radiations. ■ Moons and rings dynamic, changing; may be relatively young.

#### ORIGIN

- Uranus formed in cold outer solar system. Original material relatively unchanged by later planetary evolution. ■ Has approximate composition of Sun, Jupiter, Saturn (mostly hydrogen, helium). ■ Has higher density than Jupiter, Saturn; indicates that Uranus has heavier elements (carbon, oxygen, nitrogen, silicon? iron?). ■ Uranus seems to be an ice-rock mixture similar to that proposed for comets. Some theories suggest that comets may have formed near Uranus in original solar system.

#### HISTORY, MYTHOLOGY, AND TRIVIA

- Discovery: First seen by Charles Herschel (March 13, 1781). First planet to be discovered in historic times. ■ Name: From Uranus, the Roman god of the heavens (father of Saturn, grandfather of Jupiter). Other briefly-used names: "Herschel" and "George's Star" (for King George III). ■ Symbol: ♅ Also alchemical symbol for Platinum. (In Medieval alchemy, certain metals were thought to be related to certain planets.) ■ First planet to be discovered by use of telescope. ■ Unexpected discovery greatly expanded size of known solar system. ■ Irregular orbital movements of Uranus provided clue to later discovery of more distant planet Neptune. ■ First thought to be a comet by Herschel until orbit shown to be circular, like other planets. ■ Uranus discovered by accident. Herschel's main interest was in stars, stellar evolution, structure of Milky Way galaxy. ■ Herschel's sister (Caroline) and son (John) also became well-known astronomers. Caroline especially active in discovering comets.

#### MILESTONES IN STUDY

- Planet discovered (1781). ■ Moons discovered: Titania, Oberon (by Herschel, 1787); Ariel, Umbriel (by Lassell, 1851); Miranda (by Kuiper, 1948). ■ Ring system discovered (1977); thin, dark rings. Only discovered by accident while observing Uranus passing (occulting) a star. ■ Discovery of possible auroras ("Northern Lights") in planet's atmosphere (1982); evidence for existence of magnetic field.
- First spacecraft encounter: Voyager 2 (January, 1986).

#### UNIQUE FEATURES OF PLANET

- Axis of rotation tipped 82° from vertical; nearly horizontal to plane of solar system. Planet "rolls" around sun, rather than spinning like top.
- Magnetic field strongly offset from center and rotation axis of planet. ■ No evidence for excess heat being radiated from planet, unlike other giant planets (Jupiter, Saturn, Neptune). ■ Extensive geological activity on small moons despite icy character and low surface temperatures.

#### MYSTERIES AND UNANSWERED QUESTIONS

- Why is Uranus tilted on its side? ■ Why is the magnetic field so strongly offset from the center of the planet and the rotation axis? ■ Why are the temperatures and circulation of the atmosphere so different from predictions based on pre-Voyager theories? ■ What are the temperatures and pressures deep within its atmosphere? ■ Is there a thick layer of superheated water (a "planetary ocean") below the outer atmosphere? ■ Does Uranus really have a deep rocky core at its center? ■ Why are the moons and rings so dark? ■ How old are the moons and rings? Are they still changing today? ■ Why do the rings have no small particles in them? ■ What caused so much geological activity (fracturing, "lava" eruptions) on the moons? ■ Is the formation of Uranus related to the origin of comets?

URANUS. Seen in computer-processed colors, the planet's featureless blue atmosphere reveals subtle bands of structure (orange and yellow colors) surrounding the South Pole.

NAS 1.43  
Ur 1/11

## EXPLORING URANUS

THE RINGS. Uranus is surrounded by several thin dark rings composed of dust and tiny pieces of rock and ice. The detailed structure of a single ring (the "gamma" ring) is shown in this picture made from data obtained by Voyager's photopolarimeter instrument.

URANUS (FAREWELL). Already on its way to Neptune, Voyager 2 took this view of Uranus from about a million kilometers (620,000 miles) beyond Uranus to record this crescent view of the blue planet.

MIRANDA. This tiny moon is a bizarre patchwork of alien landscapes, possibly assembled from pieces of other, destroyed moons. (The moon's actual color, a very dark gray, has been artificially tinted in this picture.)

TITANIA. Uranus' largest moon, probably made of mingled rock and ice, shows a heavily cratered terrain gashed by deep fractures.