Looking Back at Uranus: Strangeness Confirmed

Only four days after the Voyager 2 spacecraft's Jan. 24 flyby of Uranus produced the first close look at that distant planet, world attention was abruptly wrenched earthward again by the explosion of the space shuttle Challenger. But while NASA struggles to get back up off the ground, the Voyager scientists have been poring over their data, learning their way around the strange Uranian system.

The first results of their studies — as opposed to the "instant science" of the days immediately following the encounter — were published in the July 4 SCIENCE. And not only have they markedly refined many of the quick-look details, such as the sizes of the planet's 15 known moons (10 of which were Voyager 2's discoveries), but Uranus and its attendant phenomena turn out to be at least as dramatic as the initial results had hinted.

The Satellites of Uranus

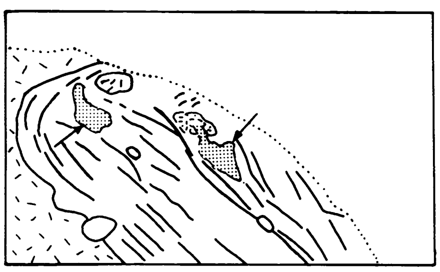
Satellite name	Diameter (km)	Distance from Uranus center (10^3 km)	Orbital period (hours)	Density (g cm^{-3})	Normal albedo
1986U7	~40*	49.7	8.0		<0.1*
1986U8	~50*	53.8	9.0		<0.1*
1986U9	~50*	59.2	10.4		<0.1*
1986U3	~60*	61.8	11.1		<0.1*
1986U6	~60*	62.7	11.4		<0.1*
1986U2	~80*	64.6	11.8		<0.1*
1986U1	~80*	66.1	12.3		<0.1*
1986U4	~60*	69.9	13.4		<0.1*
1986U5	~60*	75.3	14.9		<0.1*
1985U1	170 ± 10	86.0	18.3		0.07 ± 0.02
Miranda	484 ± 10	129.9	33.9	1.26 ± 0.39	0.34 ± 0.02
Ariel	1160 ± 10	190.9	60.5	1.65 ± 0.30	0.40 ± 0.02
Umbriel	1190 ± 20	266.0	99.5	1.44 ± 0.28	0.19 ± 0.01
Titania	1610 ± 10	436.3	208.9	1.59 ± 0.09	0.28 ± 0.02
Oberon	1550 ± 20	583.4	323.1	1.50 ± 0.10	0.24 ± 0.01

Data adapted from SCIENCE

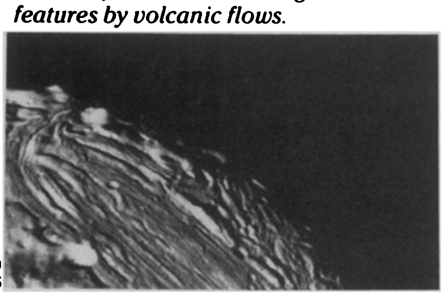
Revised from initial estimates (see SN: 2/1/86, p. 73). *These minor satellite diameters represent upper limits.

The moons: Outermost Oberon, besides revealing a mountain that the images show to be protruding at least 20 kilometers above the horizon, bears a number of straight and curved escarpments that the Voyager scientists believe to be evidence of a "global-scale tectonic episode" in the past. Titania, too, shows an extensive pattern of faulting that seems to harken back to some process that caused a global extension of the crust, they report, such as might have resulted from "the late stages of freezing in the interior of the satellite."

Umbriel, much darker than the four other major moons and "strikingly" uniform in its somber complexion, leaves scientists puzzling over the question of where all the dark material might have come from on the presumably ice-rich satellite. One suggestion is that another object struck Umbriel and shattered, generating dark fragments that later settled all over the surface. A problem with such a scenario, however, is that unless such an impact were relatively recent, there ought to be evidence of later impacts that punched through the dark stuff to reveal lighter material below. Unless, of course, the surface and subsurface material are similarly dark, and "extremely uniform to a substantial depth on a global scale."



Arrows on sketch map of Miranda's "ridged ovoid" (also in photo below) indicate possible smoothing of some features by volcanic flows.



JPL

Far more complex-looking is Ariel, with valleys, cliffs and other scars in profusion. Yet the floors of many of its features are surprisingly smooth, as is an extensive, irregularly shaped plain. Whatever did the smoothing, the researchers maintain, "has clearly been emplaced, at least in part, as a flow or sequence of flows that overlaps and partially buries older craters." The nature of the flows on Ariel, and on Titania as well, is uncertain. Water ice, assumed to be the major component of the satellites, has a melting point about 200 K (360° C) higher than the ambient surface temperature, according to the Voyager team, though an ice mixture of ammonia and water could do the job with far less heat. Another possibility could be "tidal heating," caused by the same multi-satellite gravitational tug-of-war believed to drive the volcanism on Jupiter's active moon Io.

Strangest of all is Miranda (SN: 2/15/86, p. 103), with at least three large, closed patterns of light and dark bands, scarps and ridges, from about 100 to 300 km wide. At first look, the baffled Voyager imaging team dubbed them "circi maximi," after the ancient Roman racetrack; now they have been separately — though not much more commitally — named the "trapezoid," the "banded ovoid" and the "ridged ovoid," while the scientists wonder what caused Miranda's tortured geologic evolution.

"Miranda probably was catastrophically disrupted and reaccreted several times," they say, "by impact of objects large enough to produce a crater equal to or larger than the diameter of the satellite." In fact, they suggest, "Ariel was probably disrupted and accreted at least once; Umbriel may have been disrupted once. There is a fair chance that Titania was also disrupted."

The only one of the 10 newly discovered satellites to be even blurrily photographed, designated 1985U1, provided a different kind of surprise by turning out to be unexpectedly spherical. Most such small solar system objects are irregularly shaped, lacking the self-gravitation to pull them into roundness, yet 1985U1, about 170 km across, even survived an impact big enough to form a 45-km crater.

The rings: In addition to the nine rings previously known from earth-based ob-

The Principal Rings of Uranus

Feature	Distance from Uranus center (10^3 km)	Width (km)
1986U2R	37–39.5	~2500
6 ring	41.85	1–3
5 ring	42.24	2–3
4 ring	42.58	2–3
α	44.73	7–12
β	45.67	7–12
η	47.18	0–2
γ	47.63	1–4
δ	48.31	3–9
1986U1R	50.04	1–2
ε	51.16	22–93

Data adapted from SCIENCE

Varying widths and optical depths, and possible ring arcs (from photopolarimeter data) not shown.

servations of their blockage of starlight, Voyager 2 photographed "on the order of 10^2 new ringlike features . . . interspersed within the main rings, as well as a broad, diffuse, low-optical-depth ring just inside the main ring system." Besides cameras, the spacecraft carried an instrument called a photopolarimeter, which tracked the light of two stars *through* the ring system and recorded the resulting blinks. In addition to measuring the thickness (less than 150 meters) of the outermost of the nine previously known rings, the instrument showed that many of the rings vary not only in width but also in "optical depth," or density. It also revealed a number of "partial rings," or "ring arcs," a phenomenon that had been thought to be improbable at best until earth-based, stellar-occultation observations indicated what appear to be such arcs around the planet Neptune.

One striking characteristic of the Uranian ring system is that it turns out to have almost none of the extremely tiny, "smoke- to dust-sized" particles that scientists expected to be common among the larger chunks. One inference from the missing dust has been the view of some scientists that various processes may be sweeping the finest particles away. This, combined with the observed variations in ring opacity and apparent ring arcs, suggests to some of the Voyager researchers that the rings may be a constantly evolving phenomenon, and perhaps quite young.

The magnetic field: The finding that Uranus even *has* a magnetic field resolved a baffling riddle, which had been fueled by earth-based satellite observations showing what seemed to be an aurora (presumed signs of a field) while Voyager's radioastronomy instrument kept failing to pick up radio emissions that should also have been present. Only five days short of Uranus, the device finally picked up the signals, and then found out the reason for the delay: The axis (dipole) of the Uranian magnetic field is tilted about 60° away from the planet's axis of rotation, presumably directing the signals in a different direction. Furthermore, the Voyager magnetometer team suggests, the radical tilt may be a sign that the polarity of the field is undergoing a reversal, a phenomenon long assumed to have taken place on earth, based on past geologic data, but never actually measured in progress for any planet.

The radioastronomy instrument was also able to determine the length of a Uranian day, 17.24 hours, based on the modulation period of the radio signals.

There is far more in the Voyager 2 data bank, and scientists are likely to study everything to the *n*th degree, given the uncertainty of when another spacecraft may pass that way again. Voyager 2, meanwhile, is due at Neptune in 1989.

— J. Eberhart

Con(tra)ception: Hormonal coin toss

Two research teams at the Salk Institute in La Jolla, Calif., have discovered a reproductive hormone that may one day be useful in the treatment of certain kinds of infertility. Another reproductive hormone, also recently isolated by one of the same research groups, may have potential as a contraceptive. In an unusual demonstration of the body's thriftiness, the hormones are a matched set: Although opposite in activity, they are largely rearrangements of the same components.

The newly discovered hormones are intriguing because they act specifically on the production of follicle-stimulating hormone (FSH), which triggers the development of ova and the production of sperm. Inhibin, one of the recently isolated hormones, acts on the pituitary gland to decrease FSH secretion without affecting levels of other hormones that are often released in tandem. Because of that specificity, says Kenneth Klivington, spokesperson for the research groups, "inhibin provides a potential ideal contraceptive for both men and women."

Unexpected findings during the research on inhibin led to the discovery of a substance that works in the opposite direction, stimulating release of FSH. That substance was reported in the June 19 NATURE. Two forms were isolated at Salk — one named follicle-stimulating hormone releasing protein (FRP) by a group led by Wylie Vale, and the other called activin by a group led by Roger Guillemin. Klivington says it may someday lead to a "choice treatment" for infertility.

Modern contraceptive technology is prone to problems. Even though birth control pills succeed in blocking fertility in women, there are side effects that ripple throughout the hormonal system; and there is no male hormonal contraceptive available at all. The problem for researchers has been the body's intricate dovetailing of the hormones that orchestrate reproductive events.

Scientists have long known that much of the regulation occurs in a hypothalamus-pituitary-gonad hormonal loop: The hypothalamus in the brain stimulates the pituitary to secrete two hormones, FSH and luteinizing hormone (LH), which, among other things, stimulates the production of sex steroids like estrogen and testosterone. Most birth control pills for women use estrogens and other steroids, which can disturb the rest of the hormonal balance. When researchers have attempted to use FSH-inhibiting substances as male birth control, they have been unable to block the release of FSH without also inhibiting LH. That meant that while production of sperm stopped, levels of sex steroids dropped as well — and so did the steroid-controlled sex drive.

But a contraceptive based on inhibin might block production of sperm or ova without "fouling up background levels of sex steroids," Klivington says. In using it, "you wouldn't mess up the psychological aspects of reproductive behavior."

The activating compounds may turn out to be valuable treatments for men and women who are infertile because of low levels of FSH, Klivington says. Currently, hypothalamic hormone is used to treat some of these cases of infertility, but that hormone is a blunt tool, raising levels of LH along with FSH. That can be a particular problem for women, because inappropriately high levels of LH at the end of the menstrual cycle may actually inhibit follicle selection and egg development.

Applications of the newly discovered hormones are still very much in the realm of the theoretical, researchers warn. For one thing, the work at Salk has used inhibin from animals and has so far been done only in test tubes. But inhibin in humans is very similar to that from animals, according to Anthony Mason at the San Francisco-based biotechnology firm Genentech. Mason worked with Guillemin on the isolation of inhibin. Another recent announcement, in the May 31 LANCET, is encouraging to the researchers: The paper confirms that inhibin can be found circulating in the blood in humans. (According to the researchers, led by Robert McLachlan at Prince Henry's Hospital in Melbourne, Australia, blood levels of inhibin may eventually be used to signal the best time for *in vitro* fertilization.)

One of the most striking aspects of the discoveries has nothing to do with the function of the hormones, according to the Salk Institute researchers, but with the way they are put together. Inhibin is made up of an alpha subunit and one of two possible beta subunits. The activating hormones consist of two of the beta subunits linked together.

The rearrangement to produce different proteins seems to occur at the level of the subunits, the researchers say, rather than at the level of the genes which code for them. Examples of such rearrangements are rare. "If such rearrangements of several gene products are the norm, rather than the exception," Guillemin's team writes, "this process clearly extends the diversity of the final products (and their biological activity) derived from a limited number of genes."

— L. Davis