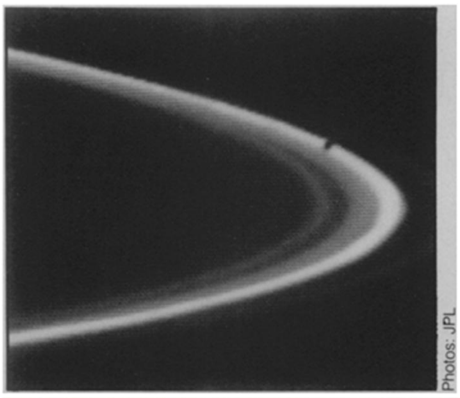
Secrets of Saturn: Anything but elementary

Last November, the Voyager 1 spacecraft flew through the Saturn system and raised a host of new questions about the planet, its diverse satellites and in particular its incredibly complex rings. Voyager 2, following along behind, was radically reprogramed to look into its predecessor's findings, but last week's flyby seems in many ways to have deepened the mysteries.

A major item on the agenda, for example, was to find out more about the thin F-ring, some 4,400 kilometers outside the main ring system and found in some of Voyager 1's photos to consist of as many as three separate strands that looked as if they were twisted or "braided" together. Voyager 2's cameras tracked selected portions of the F-ring for extended periods, in hopes of seeing whether the odd structures moved relative to one another, and found ... no braids at all. Much of the ring was not photographed at sufficient resolution to show the thin features anyway, but the result was still a jolt—particularly when some of the photos showed as many as *five* strands, lying in smooth, concentric array like the ringlets that populate most of the far broader ring expanse closer to the planet. Among the numerous hypotheses previously offered to explain the braids was the idea that the effect might be triggered when the two tiny satellites bracketing the ring (and believed to account for its thinness) were directly across from each other, but a photo showing both moonlets and a long span of F-ring revealed not a trace of braiding.

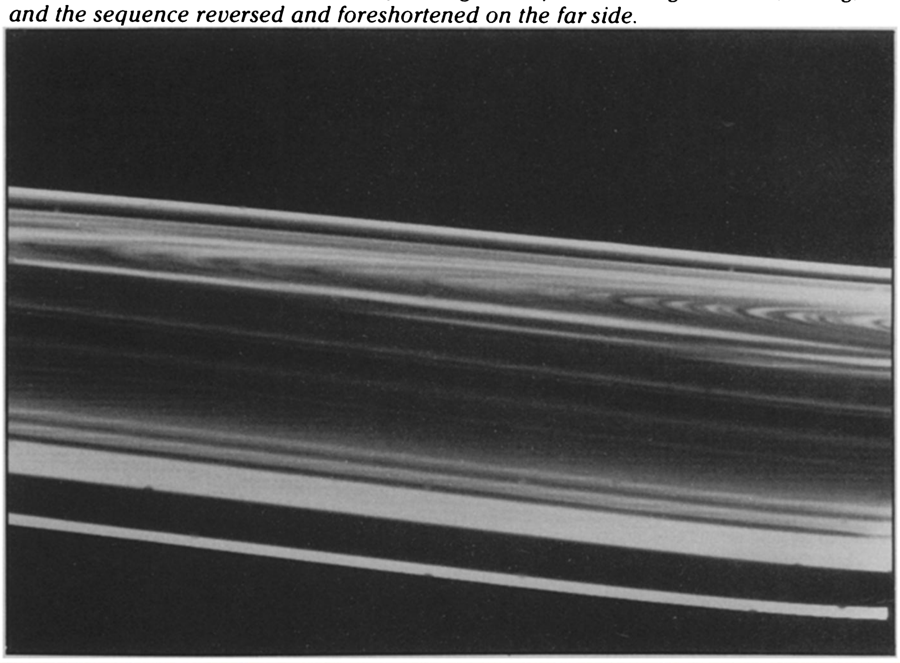
Another theory left in the lurch had suggested that the major gaps in the main ring system, such as the 340-km-wide Encke gap in the A-ring, might be held open by the gravitational effects of small moons

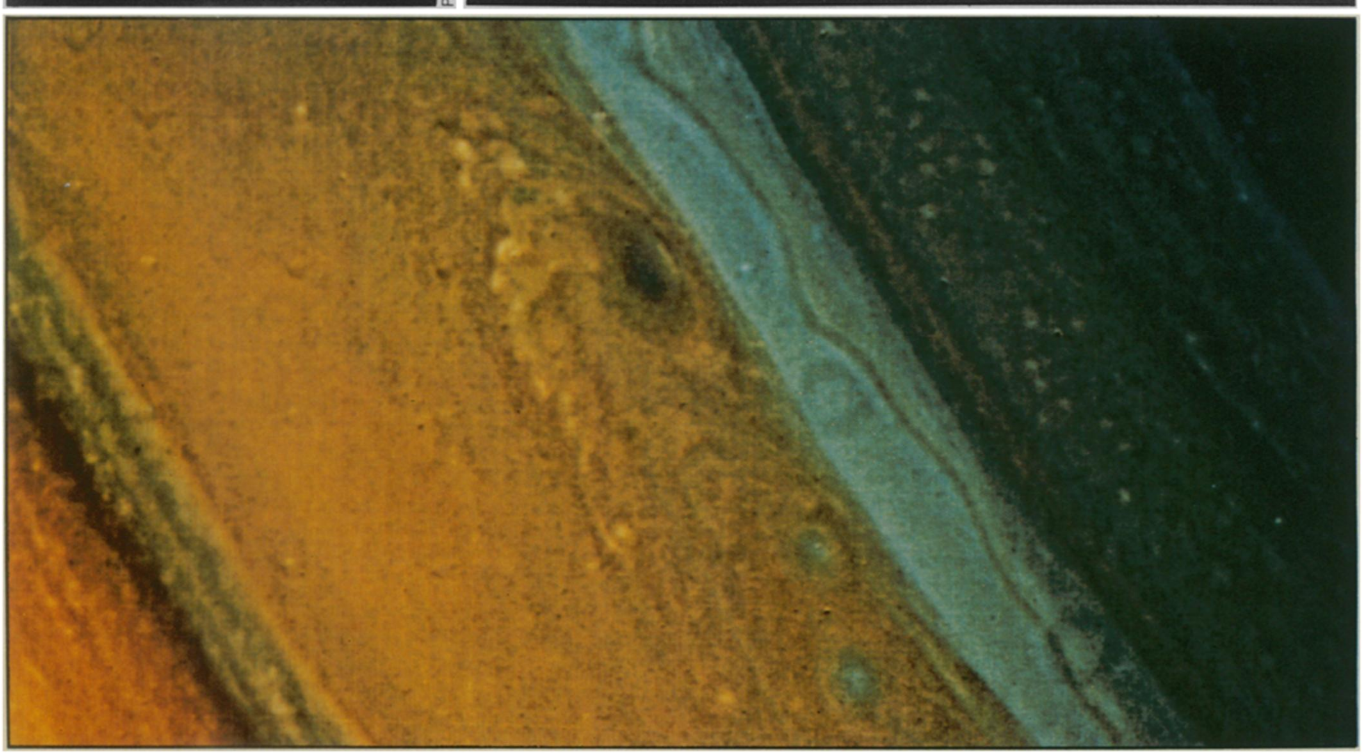
Below: The F-ring, "braided" and erratic in Voyager 1 images, shows more and smoother strands to Voyager 2.



Photos: JPL

Below: Nearly edge-on view of rings (Voyager 2's Saturn latitude was 0°22'), with planet off right, shows F-ring in bottom foreground; then A-ring with Encke gap; Cassini division (dark band in center); B-ring, with spokes as bright streaks; C-ring; and the sequence reversed and foreshortened on the far side.





Above: False-color image of Saturn's cloudtops shows convective storms (blue spots) being driven by the shear between winds blowing east at 540 kilometers per hour (light blue band) and west at 72 kph (wide yellow band).

within them, pushing the lesser ring particles away in both directions. A careful search revealed no such moons of the expected sizes—about 30 km in Encke's case — and Encke, in fact, kept up the ring system's reputation for new strangeness at every turn by turning out to possess a particularly unusual ringlet of its own. Besides being oddly distorted or "kinky" (and with no sign of the moonlets that might have been expected to produce such an appearance), it runs right down the middle of the gap in one image while another view shows it hugging the inner edge. This could mean that the ringlet is "merely" eccentric, a phenomenon discovered in other examples by Voyager 1 and multiplied by Voyager 2, which showed even the huge B-ring's outer edge to differ in radius by more than 50 km on different sides of Saturn. But the project's scientists, conditioned by now to expect almost anything where the rings are concerned, leave open the possibility that there could be more than one Encke ringlet, each varying so much in density that it is virtually invisible over parts of its circumference.

Indeed, there may be quite a crowd in what was once thought to be an empty clearing. One of Voyager 2's major triumphs was the use of its photopolarimeter to track the light of a star through the ring system's entire radius, recording the flickering starlight as an indicator of the widths, densities and separations of the thousands of ringlets down to a resolution of 100 meters. Each significant dip in the lightcurve may represent a separate ringlet, and even a preliminary look at the instrument's prodigious output — a kilometer-long stripchart with 10 data points to the centimeter—yields as many as 10 such dips in the Encke gap, 10 more around the F-ring, and so much fine detail over the rest of the rings that elated team leader Arthur L. Lane of Jet Propulsion Laboratory was wondering last week about how he would ever find room to publish his results. The actual ringlets, in fact, notes colleague Larry Esposito of the University of Colorado, may be skinnier still, extending "maybe down to the individual particle size."

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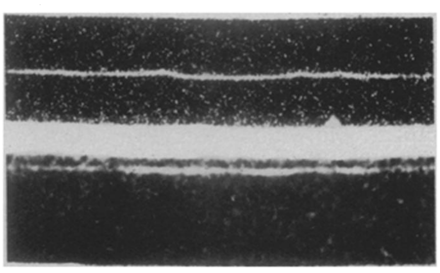
Two views of the A-ring's Encke gap reveal either a single newly discovered ringlet that is eccentric, or two ringlets whose visibility varies with longitude. Other data suggest there may be several more.



Longest-yet synthetic gene: interferon

In what is both a technical tour de force and a practical step toward understanding and improving upon the activities of interferon, British scientists have assembled a stretch of genetic material 514 paired nucleotides in length. The longest gene to be pieced together in a laboratory thus far, it is by design not quite identical to the natural gene for human leukocyte interferon, the sequence of which was determined by other researchers last year. The newly synthesized gene is a modification encoding the same protein, but designed to be more amenable to chemical synthesis and to expression by bacteria.

Michael D. Edge and colleagues at ICI, a British chemical and pharmaceutical company, devised the modifed sequence and then synthesized 67 different DNA chains, each containing approximately 15 nucleotides. They used a novel synthetic method in which the growing chain is bound to a solid support. The ICI scientists say this technique increases the rate of DNA synthesis ten-fold, and is more reliable than previous methods. The shorter DNA chains were joined into the 514 paired-nucleotide length, which includes the signals for starting and stopping protein synthesis and sites for inserting the fragment into a plasmid, the ring of DNA used to transfer genes between cells. The lab-made interferon gene, in its plasmid, was reproduced in bacterial cells, and the biological properties of its product, presumably the protein interferon, will be described in a forthcoming paper, the scientists say.

The advantage of synthesizing the gene, rather than simply snipping it from a chromosome, is the greater potential for altering its product. Natural materials usually can be modified to make more efficient drugs. In the case of interferon, a whole family of genes occurs naturally, and its members exhibit somewhat different activities (SN: 3/7/81, p. 148). Now it is possible to systematically vary the synthetic gene to acquire a variety of interferon proteins. "The availability of a large pool of synthetic fragments clearly extends the range of interferon analogues which can be prepared," Edge and colleagues say in the Aug. 20 NATURE. "The wider implication is that classical medicinal chemistry structure-activity analysis should be possible in relatively large peptides."

While praising the ICI accomplishment, a commentary in NATURE cautions that the reported modifications of DNA-synthesizing techniques fall far short of allowing scientists to assemble a complete copy of an organism's genetic material, its genome. It still takes more than an hour to add each pair of nucleotides to the synthetic ICI chain. NATURE calculates that at this rate it should be possible to assemble 5,000 nucleotides in a year, "...or a whole genome in..., well, a few centuries." □

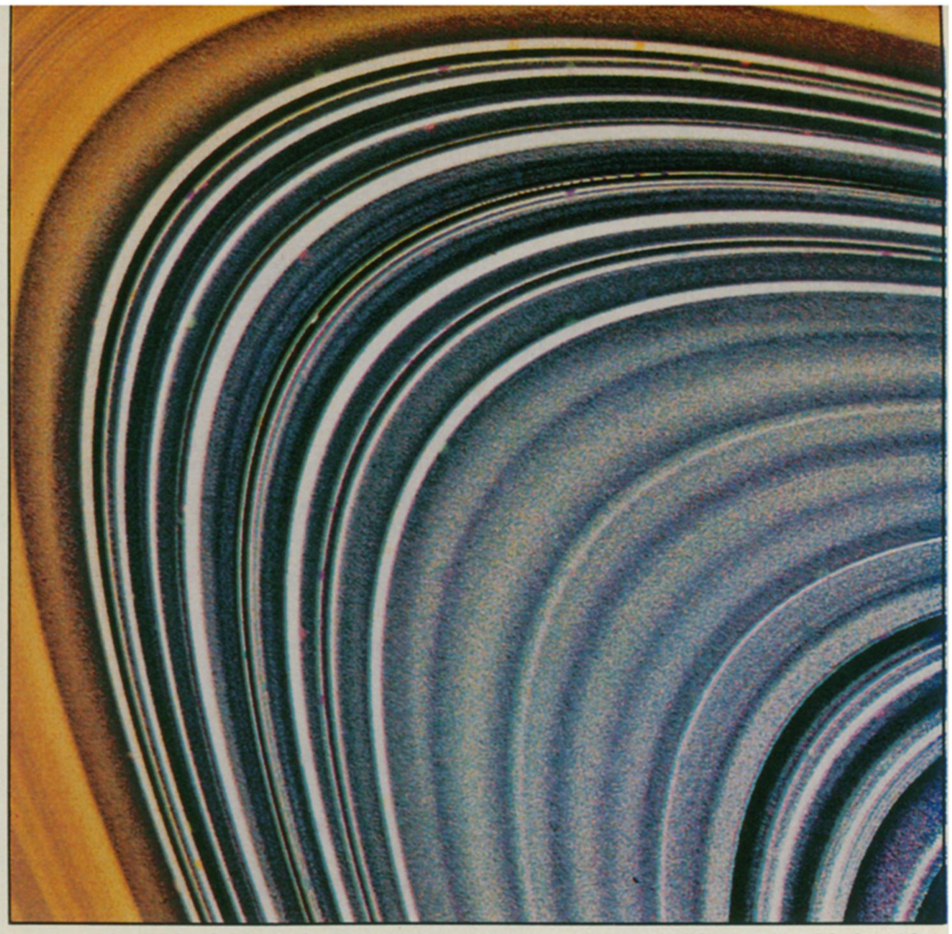
A dash of morphine in the milk

Both human and cow milk are naturally spiced with a small amount of morphine, and how it gets there is anyone's guess. Scientists at the Wellcome Research Laboratories in Research Triangle Park, N.C., report finding 200 to 500 nanograms of morphine in the milk they examined. While there is a small possibility that the substance is not chemically identical to morphine, Eli Hazum, Pedro Cuatrecasas and colleagues are quite confident of their identification, which is based on a series of chemical, biological, pharmacological and immunological tests.

Plants in the diet are a likely source of the morphine in milk. Hay and lettuce, for example, have measurable amounts of morphine, the scientists find. "We postulate that morphine may be a ubiquitous constituent of plant-derived foods.... Perhaps, in addition, an active concentrating mechanism exists in the mammary gland," they say in the Aug. 28 SCIENCE. Other scientists have reported that after experimental administration of morphine, the drug can be detected in milk.

The amount of morphine reported in a liter of milk is only a few percent of the normal oral dose of morphine as it is used as a painkiller. But the scientists say it could have important, but as yet unknown, pharmacological significance. An unidentified substance that may turn out to be morphine has been found in mammalian brains and intestinal tracts.

With the discovery of morphine in milk, the mystery of the brain's morphine receptors has come full circle. When the receptors were first discovered, scientists believed it was unlikely that the mammalian brain would have evolved sites just to bind morphine, a component of poppy plants, however striking its pharmacological effects. The resultant search for the "body's own morphine" led to the discovery of endogenous substances, the enkephalins, whose role in pain perception and other physiological functions is currently the focus of extensive research. But one of two classes of brain receptors still binds morphine more effectively than it binds enkephalin. With morphine in milk, scientists may conclude the most important natural function of these receptors is to bind morphine, after all. The Wellcome scientists point out that for a variety of substances, such as vitamins, the body makes specific receptors or enzymes although the substances are ingested rather than made internally. □



Above left: Titan's orangish atmosphere is topped by a bluish haze of submicron-size particles, illuminated by scattered light with the sun almost halfway around from Voyager 2. Above right: Green and ultraviolet images are combined in this false-color view, revealing reflectivity variations that may represent different surface compositions between Saturn's C-ring (blue) and B-ring (yellow). A few yellow ringlets show in the C-ring too. Below: Matched photos of opposite sides of the B-ring's outer edge show the two sides to differ in radius by about 50 km, believed due to gravitational influence of Mimas. Nearby ringlets show similar mismatches, possibly a propagating-wave effect.

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The same experiment also enabled Lane to calculate that the ring at Encke's inner edge is only 100 to 150 meters thick, even though the ring system from one outside edge of the A-ring to the other spans more than 272,000 km. A phonograph record of the same proportions would be nearly five kilometers across.

The experiment's highest compliment may have come from imaging team leader Bradford Smith of the University of Arizona, who had had to sacrifice 2 hours 20 minutes of prime-time photography to make it possible. Looking through a door at the unrolling stripchart and then at Lane, he said, "It was worth giving up the time."

The two experiments worked well together. Although Voyager 1's cameras first saw the three little satellites credited with confining the F-ring and maintaining the A-ring's sharp outer edge (see diagram, SN: 8/15/81, p. 107), even the more sensitive cameras of Voyager 2 failed to detect still tinier "moonlets" that some of the researchers expected to find embedded in the rings as the cause of several thin "gaplets." An alternative explanation posed by Smith and others was that some of the rings' fine structure, such as concentrations and rarefactions, might result from gravitationally produced density waves, generated by resonances with the larger satellites and propagating across the ring plane. And sure enough, portions of the photopolarimeter's lightcurve show sequences of dips with just the sort of increasing spacing that such a propagation effect might produce, like the increasing distances between the expanding ripples caused by a pebble tossed into a pond.

But other mysteries remain. The inner edge of the C-ring, innermost of Saturn's substantive rings, is relatively sharp, yet there seems to be neither a nearby moonlet nor a major satellite resonance to hold it in place. The rings' bizarre details seem to inspire—and perhaps require—bizarre explanations, and one researcher is said to be considering the possibility that the C-ring may be confined by an effect of Saturn's atmosphere — 15,000 km below. As convective storms carry helium up from the mostly hydrogen atmosphere's depths, the idea goes, perhaps the low temperatures aloft cause the helium to condense into droplets that represent enough concentrated mass to gravitationally influence the ring.

Saturn's ring system may have affected more than the scientists on the Voyager 2 mission. On the night of August 25, 36 minutes after its closest approach to Saturn, the spacecraft passed "behind" the planet, temporarily cutting off its communications with earth. During the blackout, its trajectory took it down through the ring plane, a feat already accomplished safely by Voyager 1 and Pioneer 11. A few minutes after communications were restored, however, flight controllers at JPL discovered that the craft's scan platform — the computer-steered mounting for the cameras, photopolarimeters and two other sensors — would no longer move in azimuth. A checkout soon revealed misaimed photos and other observations (belying engineering data to the contrary), changes in frequency of the radio receiver ... and a startling indication from one of the scientific instruments, a plasma-wave

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sensor, recorded right at the ring-plane crossing. "The data just went crazy," said project manager Esker Davis, and chief plasma-wave experimenter Frederick L. Scarf of TRW described a signal whose intensity rose and fell 1,000-fold in three minutes. Yet the signal's frequency range extended too low for it to be either a plasma wave or a radio wave. One possible inference was that Voyager 2 had hurtled through a cloud of charged particles that vaporized from the impact, sending a pulse through the spacecraft. No ring material was expected to be there — the crossing took place several thousand kilometers outside even the faint G-ring, which lies about 30,000 km outside even the F-ring and still further from the main ring structure — and Pioneer 11 had penetrated at virtually the same radial distance (though with no plasma-wave sensor) and emerged apparently unscathed. Unfortunately, the point was also well outside the precision probing of Voyager 2's star-tracking photopolarimeter, so there remained only the circumstantial evidence of timing to link the plasma-wave detector's anomaly with the rings or the stuck scan platform.

No other systems seemed to have been adversely affected, however, and although some valuable close-in data were lost during Voyager 2's outbound leg, Davis's crew turned increasingly toward the conclusion that the culprit was a stray particle (from whatever source) caught in the scan platform's gears. A similar problem had afflicted Voyager 1 early in its flight from earth, and as in that case, Voyager 2's platform responded over the next few days to a careful series of motion commands, moving a bit more freely each time.

Meanwhile, the scientists' work continued. In the case of the rings, not all of the questions concern details of their present structure, but such fundamental issues as how they formed in the first place. Are the ring particles pieces of would-be satellite that never quite came together, or debris from a large object that broke apart? The matter is far from resolved, but false-color images made by combining photos taken through Voyager 2's various filters have brought out spectral-reflectance variations suggesting to some researchers that the A-, B- and C-rings have characteristic differences. If these represent differences in surface composition, the message could be that the three major rings are the remains of three independently captured objects. Confirmation of such a view will not be easy.

Voyager 2 is now on its way to the third stop on its itinerary, a January 1986 encounter with Uranus. For the present, however, its scientists have their hands and computers full with Saturn data that will be the last of its kind for many years to come. Next week in SN: Moons, magnetosphere and more. □