Joseph Veverka of Cornell University.

"For the first time we understand why Jupiter has rings and how the rings actually work," he says. Veverka and his colleagues unveiled the Galileo images at a Cornell press briefing.

All four moons appear dark, red, and heavily cratered, indicating that they have been bombarded by meteoroids, which are fragments of asteroids and comets. Correspondingly, the rings contain tiny, reddish particles that resemble dark soot. Galileo viewed the rings almost edge-on, lit from behind by the sun, an arrangement that made micrometer-size particles highly visible.

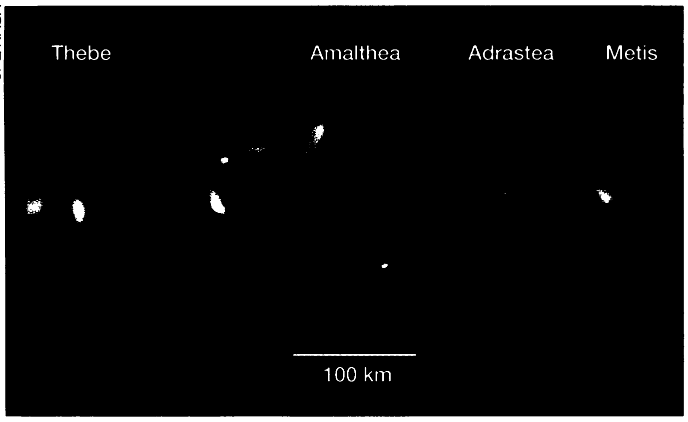
The angles at which the satellites orbit Jupiter, relative to the planet's equatorial plane, correlate with the vertical extent, or height, of the rings. Adrastea and Metis orbit Jupiter almost exactly in the equatorial plane. Such orbits do not wobble, and dust lifted from the surface of these moons forms a flat ring.

In contrast, the paths of Amalthea and Thebe tilt. Over several months, their orbits precess about the equator like gyrating hula hoops. Dust from these moons create rings with significant height, like the gossamer rings.

Because the ring particles eventually spiral into Jupiter, the rings would vanish without a supply of new material, Veverka says. The moons provide this reservoir as long as debris continue to pelt them. In a similar fashion, he adds, the small moons orbiting Uranus and Neptune may be the source of the faint dust rings surrounding those planets.

Saturn's famous rings, which are much more massive and contain larger, icy particles, are thought to have a different origin—either the breakup of a giant, frozen body or collisions between several large, icy moons. The Cassini mission, expected to reach Saturn in 2004, will fly through the ice rings. In December 2000, the craft will swing past Jupiter and is scheduled to view the dust rings from a different angle than Galileo did, notes Carl D. Murray of Queen Mary and Westfield College in London.

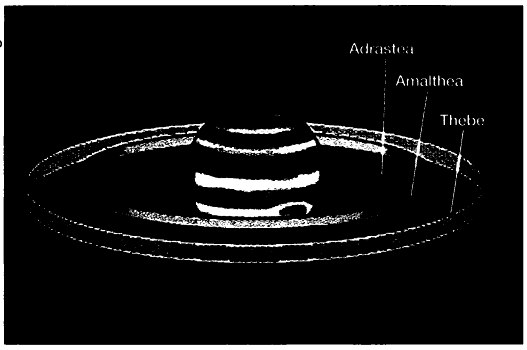
JPL/NASA



The four small, inner moons of Jupiter differ in size.

Closer to home, the Mars Global Surveyor has found another example of a body that appears to have been pounded by debris. In this case, the surface is pulverized into dust that stays on the moon.

Jim Houghton



Position of three of the small, inner Jovian moons relative to the main ring (interior) and the two gossamer rings. Metis lies just inside the main ring. The vertical extent of the gossamer rings is greater than that of the main ring.

Temperature measurements of the Martian moon Phobos reveal that it rapidly loses heat after sunset. Although Phobos completes one revolution in just 7 hours, its sunlit side has an average temperature of -4°C, far higher than the night side's average of -112°C.

Solid rock or boulders retain heat, but powder cannot, explains Philip R. Christensen of Arizona State University in Tempe. The large temperature variation on Phobos and the moon's lack of jagged surface features suggest that its topmost layer has been ground into a fine powder that might be as deep as 1 meter, he says. NASA announced the finding last week.

The powder "could be the future source of a dust ring around Mars," says Murray. *—R. Cowen*

Fish enzyme flexes to adapt to the cold

In the chilly seawater around Antarctica, fish thrive at temperatures that would turn warm-water species into fish-sicles. Now, researchers at Stanford University's Hopkins Marine Station in Pacific Grove, Calif., have proposed how an enzyme in the cold-water species accommodates those frigid temperatures.

Marine biologists Peter A. Fields and George N. Somero looked at the enzyme lactate dehydrogenase from closely related species of cold-water fish called notothenioids. They studied nine Antarctic species that live at temperatures as low as -1.86°C, the freezing point of seawater, and three South American species that swim in waters having temperatures up to 10°C.

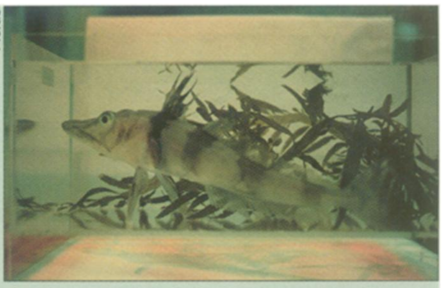
During metabolism, lactate dehydrogenase, a well-characterized enzyme found in many animals, converts a compound called pyruvate into one called lactate. The researchers isolated this enzyme from the fishes' muscles.

In the notothenioids, lactate dehydrogenase converts pyruvate at speeds comparable to those in animals with higher body temperatures, even though cold generally slows such reactions. To determine how the enzyme maintains its speed, the researchers examined differences between the sequences of amino acids that make up lactate dehydrogenases in the different fish.

They found that the variation is concentrated in areas close to the enzyme's active site, the region that binds to pyruvate. Those changes "seem to be increasing the flexibility and mobility, greasing the hinges so that the enzyme can move more quickly," Fields says. Flexibility in the molecule appears to compensate for any slowdown caused by the cold.

The agility, however, has a price. The more flexible enzyme can more easily twist into shapes that can't wrap tightly around pyruvate, so overall, it doesn't bind its substrate as well as its warmth-adapted counterparts do. Fields and Somero report their findings in the Sept. 15 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

Fields



An Antarctic icefish, Chaenocephalus aceratus.

Aside from insight into the fishes' biochemistry, says ichthyologist Joseph T. Eastman of Ohio University in Athens, the results provide clues to the evolution of notothenioids. For example, the amino acid sequence from one South American species resembled those from the Antarctic species, suggesting that it migrated from Antarctica.

"I thought it was a really nice study," Eastman says. "It was a tremendous amount of work to get such a wide ecological sample." *—C. Wu*