a **moon** by any other name

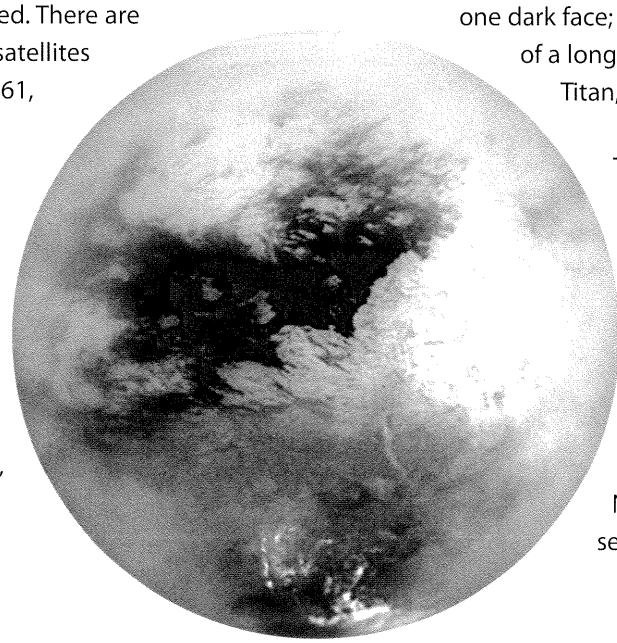
by Hugh McDonald

In July of 2004, the *Cassini* spacecraft went into orbit around Saturn, becoming the first earth-born object to navigate through the giant planet's magnificent rings. During the summer, the craft sent back hundreds of incredible images of the shadowed rings, the planet's wavy cloud tops, and, potentially, four hitherto-unknown satellites. New moons! Of course, new moons around the outer planets are continually being discovered as spacecraft approach and instrumentation is refined. There are now over 130 known planet-orbiting satellites in our solar system: Jupiter leads with 61, and Saturn's in second place with 35. (Different sources give somewhat different numbers; our source is NASA.)

Upon closer inspection, however, two of the new discoveries—known as S/2004 S1 and S/2004 S2—don't look much like moons, as we know them, at all. They're pretty small, for a start: Each is less than five miles across, miniscule compared with our moon's 2,160-mile (3,476-kilometer) diameter. They're also not round but are instead irregular hunks of rock, bulging and dented. You might be forgiven for wondering whether they even deserve moon status.

But Saturn does have "proper" moons that are large, round, and, well, moonlike, such as Enceladus, whose highly reflective surface may be covered in ice; Iapetus, an enigma with one bright and one dark face; Mimas, with its huge impact crater telling of a long-ago cataclysm. And, of course, there's Titan, giant among the planet's companions.

Titan is, in fact, a primary goal of the Cassini-Huygens mission: In December, the *Cassini* spacecraft will release the *Huygens* probe, which will descend through Titan's thick atmosphere and make the first exploration of that moon—a world whose chemical signatures suggest the presence of molecules that could eventually bring forth life. Next to Titan, S/2004 S1 and S/2004 S2 seem positively unmoonlike.



This stunning, detailed composite image of Titan, Saturn's largest moon and a primary focus of the Cassini-Huygens mission, was taken by the *Cassini* spacecraft during its first close encounter in October 2004.

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The Cassini-Huygens Mission to Saturn

The spacecraft *Cassini* began orbiting Saturn last July, and it's expected to do so for the next four years. *Cassini* will circumnavigate the planet on various orbital paths, allowing it to investigate the giant moon Titan (45 flybys are planned) and several other Saturnian satellites.

A separate exploration of Titan will take place this winter. The *Huygens* probe, which has hitched a ride aboard *Cassini*, will separate from the orbiter in December and begin coasting toward Titan. In January, *Huygens* will descend through Titan's hazy atmosphere, collecting atmospheric data for more than two hours before reaching the moon's surface.

In addition to learning about Titan and other moons, the mission will study Saturn's magnificent rings, the planet's atmosphere, and its puzzling magnetic environment.

To learn more about Saturn-related activities at the museum, see page 6.

All images courtesy of NASA/JPL.

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So does it make sense to think of these discoveries as moons at all? How are moons different from the other chunks of rock—round or lumpy, big or small—that populate the solar neighborhood? You might think that size would be a key determinant, but the astronomical community hasn't established a minimum size constraint on what makes a moon. But at least planets are always bigger than moons, right? With a diameter of 3,200 miles (5,150 km), Titan is not only considerably bigger than our own moon, it's bigger than the planets Mercury (3,032 mi/4,880 km) and Pluto (1,442 mi/2,320 km). (Of all the known moons in the solar system, only Jupiter's 3,270-mile [5,262-km] Ganymede is larger than Titan.)

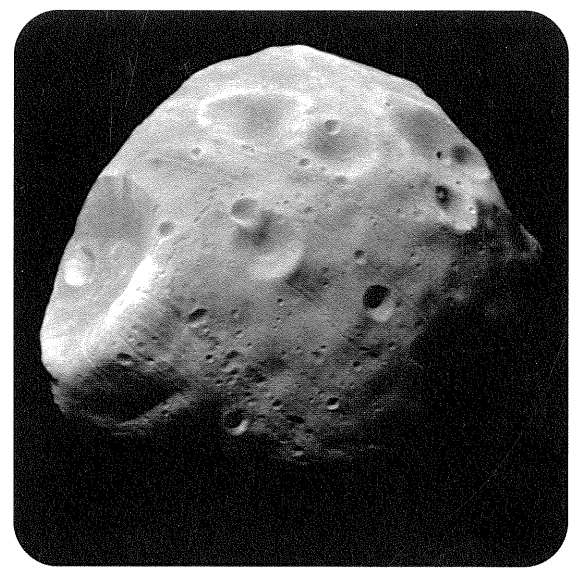
Giant Ganymede, one of Jupiter's moons, is the largest moon in our solar system—even larger than the planets Mercury and Pluto.

What about shape? It might seem compelling to reserve the title "moon" for objects with rounded profiles, but again, we have no system for determining when a body is too lumpy to be called a moon. (Size and shape, incidentally, are fundamentally related: The larger the object of a particular material, the more mass it contains, and the more gravity is exerted on the object's exterior. Rocky bodies over a certain size—around 60 miles (100 km) in diameter—exert so much gravity that large protrusions tend to crush the rocks beneath them, gradually rounding the craggy profiles of younger moons. Moons composed of different blends of materials become rounded at greater or lesser sizes.)

did you know?

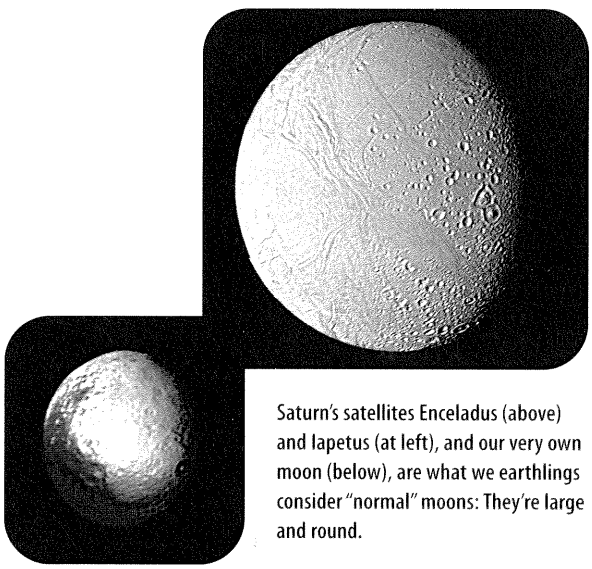
The bright rings of Saturn have a very impressive width—about 174,000 miles (280,000 km) across. But the rings are extraordinarily thin, having a depth of about half a mile (less than 1 km). If you could shrink the rings down to the size of San Francisco, they would be as thin as a sheet of paper.

Just as with terrestrial real estate, location may be the key quality that makes a moon a moon. Take the moons of Mars: Phobos (which means "fear" in Greek) is a mere 22 miles (35 km) in diameter, while Deimos (which means "panic") is only 12 miles (19 km) across. (Fear and Panic were demons and sons of Ares, the God of War in Greek mythology; Mars is the equivalent of Ares in Roman mythology.) Neither look at all moonlike: They're undistinguished boulders, commonly referred to as potato-shaped. Yet because they orbit Mars and not the sun, it's completely reasonable to think of them as full-fledged moons.



Mars's potato-shaped moon, Phobos, is one of the smallest known satellites in the solar system.

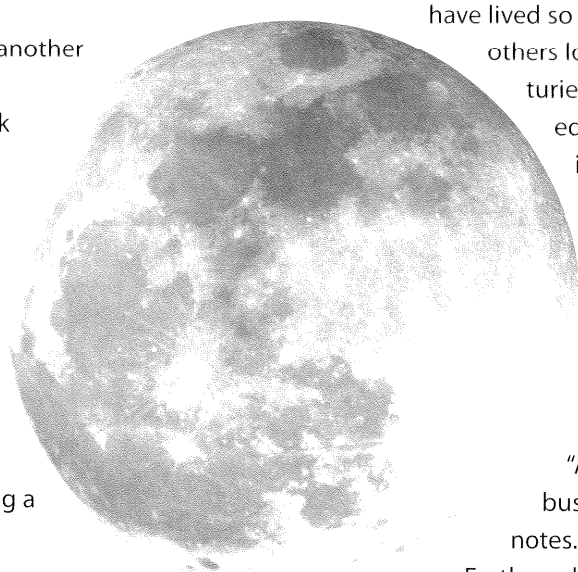
But surely an object's size plays some role in whether we call it a "moon?" There may indeed be some undefined size threshold below which an object should be denied the designation "moon." After all, as science writer Robert Roy Britt points out, we don't call the rocks that make up Saturn's rings "moons," and they orbit a planet. Interestingly, scientist and science writer Isaac Asimov once drew that line between Phobos and Deimos: "One of Mars's two moons is not a moon at all in our sense of the word. I refer to Deimos,



Saturn's satellites Enceladus (above) and Iapetus (at left), and our very own moon (below), are what we earthlings consider "normal" moons: They're large and round.

the outer of the two, which is nothing but a mountain on the loose." If we were to go along with this classification, "moons" might have to have diameters exceeding 12 miles (19 km). But while smaller satellites are sometimes called "inner moons" or "moonlets," nobody has rushed to support a 12-mile (19-km) limit in moon classification.

So would we have to call a moon by another name if it orbited a different parent? Consider comets, which certainly look and behave differently than moons; the most spectacular ones we see sport evanescent gas tails spreading over millions of miles of night sky. Comets are chunks of rock and ice ("dirty snowballs" in astronomer Fred Whipple's colorful description) whose surfaces warm up and release volatile gases as they approach the sun. But a similar hunk of rock orbiting a planet might well be called a moon.



Pluto is also thought to be little more than a block of rock and ice, but its comparatively circular orbit around the sun makes it a planet. If Pluto were somehow magically transported to the belt between Mars and Jupiter, we might be happy to call it an asteroid (or, more properly, a "minor planet"), as we do the other denizens of that neighborhood. And if it circled the sun in a highly elliptical orbit, close at one extreme and far away at the other, we might think of Pluto as a comet. (In fact, some voices have called for Pluto to be reclassified as an asteroid or comet, given its diminutive size and far-flung orbit. However, the International Astronomical Union [IAU], which is responsible for naming space rocks, has yet to agree.)

Similarly, asteroids captured by planets become moons, and Uranus's motion against the background stars initially suggested it was a comet; it was reclassified as a planet when its orbit around the sun was found to be more circular than elliptical.

did you know?

In 1610, Galileo's small telescope gave him the first glimpse of Saturn's rings—but he had no idea what he was looking at. He perceived a large planet possibly flanked by two smaller ones—what looked to him like a planet with "ears." It took Dutch scientist Christiaan Huygens, armed with a more powerful telescope in 1655, to deduce the ring nature of Saturn's apparent appendages.

The problem, like so many others, is one of perspective: We have lived so long with a particularly grand moon that others look puny by comparison. In fact, for centuries, we only knew of one body that orbited a planet—our own planetary companion. "In the old days of astronomy, before Galileo, there was just the Moon," writes Britt. "Then scientists had to accept the clear and visible evidence of four objects orbiting Jupiter." Our own satellite has set the terms for our use of the word "moon"—and those terms actually turn out to be rather unusual: "A planet the size of the Earth has no business with such a huge moon," Asimov notes. "The Moon is 1/80 the mass of the Earth, and no other satellite in this system even approaches a mass that large in comparison to its primary." (With the discovery of Pluto's moon, Charon, however, Asimov's observation is no longer true.) Still, after millennia with a huge, round, very moonlike moon, it's not hard to understand why we wonder whether something resembling a flying spud should be called a moon at all.