The researchers do not yet know exactly how the varying levels of PKG activity change foraging behavior, but other work suggests that the PKG signaling pathway affects the excitability of nerve cells. Higher levels of the enzyme could thus cause nerve cells involved in sensing food or in controlling foraging movements to fire more readily, increasing foraging behavior.

Meanwhile, other recent work by Sokolowski and her colleagues has pointed to why the sitter variant exists in wild populations. In her early experiments she had shown that sitters aren't really lazy. When there is no food, sitter larvae and adults wander just as far as rovers do to look for sustenance. The different behaviors come into play only after the flies have eaten, and results reported by the Sokolowski team in the 8 July issue of the *Proceedings of the National Academy of Sciences* help explain why.

Starting with wild populations of fruit flies, Sokolowski and her colleagues put mixtures of rovers and sitters into jars that contained either 50 or 800 to 1200 individuals. The researchers removed extra flies to keep those numbers steady for 73 generations. In that time, the ratio of rovers to sitters increased in the crowded jars and decreased in the uncrowded ones. Those changes make sense, says Sokolowski. Moving takes a lot of energy, so larvae that do not have fierce competition for food do better to move less, while those in crowded conditions gain an edge if they go out searching for food ahead of their jarmates. "It seems empirically that [the sitter behavior] has an adaptive significance," says Hall.

However, Sokolowski says that many questions remain to be answered. She still has to pin down the specific cells that control foraging behavior. In addition, the *dg2* gene produces three different versions of the enzyme, and it's not yet known whether just one or all three forms of the kinase are involved. Most likely, other, as yet unidentified genes will prove important to foraging behavior as well. But even with these unknowns, Sokolowski's colleagues salute her persistence. "She had the tenacity and whiz to stick with it," says Hall. "She's to be congratulated."

–Elizabeth Pennisi

PLANETARY SCIENCE

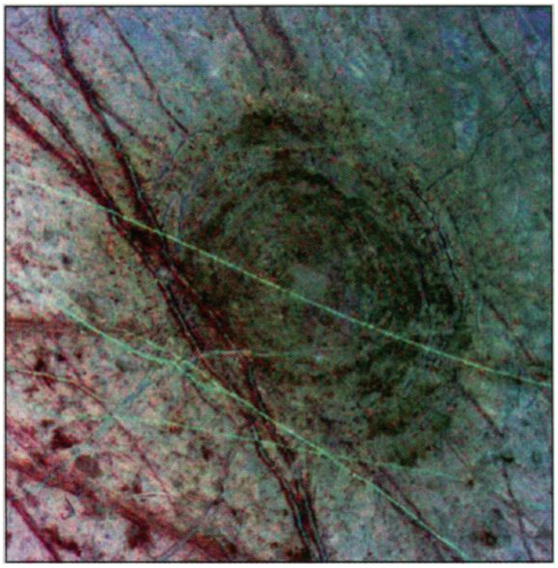
Once, Maybe Still, an Ocean on Europa

BOSTON—Does the mightiest ocean in the solar system lie beneath the ice-sheathed surface of Jupiter's moon Europa? Planetary scientists are piling up the evidence, and even the skeptics are now finding it hard to resist. Images of the moon's tortured surface returned by the Galileo spacecraft had persuaded some, but not all, researchers that an ocean tens of kilometers deep lies beneath the ice (*Science*, 18 April, p. 355). But the evidence was indirect, and skeptics argued that a solid layer of ice slightly warmed by Europa's internal heat could mimic the effects of a deep ocean by slowly churning, reshaping the surface without ever melting.

At last week's annual meeting here of the Division for Planetary Sciences of the American Astronomical Society, however, researchers presented new analyses of Europa's surface scars that had even the skeptics agreeing that, either now or in the recent past, an ocean stirred just beneath the icy surface. "It's likely that at the time that the surface we see formed, there was an ocean," says Robert Pappalardo of Brown University, a Galileo team member and self-described skeptic. That may not have been so long ago, he says, judging from the fresh appearance of the surface.

A deep pool of seawater on another world is sure to nurture speculations about the possibility of life there. But Pappalardo stresses that Europa's deep waters could have frozen up since they left their traces on the surface: "I'm still a skeptic [about a present-day ocean]; we have to prove it by some direct technique." That may be more than Galileo can deliver, even when it shifts its orbit about Jupiter late this year to begin an extended mission devoted to Europa.

Making even the skeptics edge toward tentative belief in an ocean are geologic features such as fractures pulled open in the ice, stress cracks formed from the weight of ridges, and disrupted crustal blocks. The sizes and distributions of these features imply that when the features formed, the brittle outer crust of ice was less than 6 kilometers thick—and perhaps as thin as a few hundred meters, says Pappalardo. Below this thin, brittle crust



JPL/NASA

Telltale blemish. The debris-ringed 140-kilometer impact scar Tyre (in false color) is almost perfectly flat, suggesting it formed on a thin skin of ice floating on water.

was presumably a layer of warmer, and therefore ductile, churning ice, he says, which implies that temperatures were rising so sharply from the surface into the interior that liquid water would have been found not much farther down.

Supporting the idea that the ductile ice beneath the surface gave way in turn to liquid water is a different set of features: 7- to 15-kilometer-wide pits, domes, and spots. James Head of Brown, Pappalardo, and their Galileo teammates argue that heat-driven convection in the ductile ice beneath the surface is responsible for these blemishes. Plumes of warm, rising ice hit the underside of the cold, brittle surface layer, they say, pushing the surface upward to form a dome. Plumes that carried enough heat could have caused some of the surface ice to sublimate away or melt, forming pits and spots.

If all these features do share a common origin, their spacing—every 5 to 20 kilometers, on average—says something about the thickness of the ductile ice layer. Convection tends to space its rising or falling plumes about as far apart as the depth of the convecting layer, the researchers note. The 20 kilometers of ice inferred from the spacing would leave plenty of room for liquid water, because the subtle gravity variations Galileo detected during its Europa flybys imply that the water or ice layer sheathing the moon's rock core is some 150 kilometers thick.

Places where large impacts have battered Europa's icy shell also point to a deep ocean beneath. At the meeting, Jeffrey Moore of NASA's Ames Research Center in Mountain View, California, and his colleagues argued that some of the so-called maculae of Europa—huge dark splotches 60 to 140 kilometers across—are debris-encircled craters produced by asteroid or comet impacts. Unlike the high-rimmed, bowl-shaped impact craters that form in solid rock, maculae are flat—the 45-kilometer crater Callanish, for example, is roughened by just 100-meter variations in the height of the surface. The lack of relief implies that Europa's icy surface was weak, and therefore thin, when the meteorite hit; Moore estimates that the ice floated on liquid water just 10 kilometers below.

All these features look very fresh to geologists, so they have little trouble imagining that the ocean they imply is still there today. But they are reserving final judgment about the age of Europa's surface to a small subgroup of their colleagues—the crater counters. These specialists count the number of impact craters in a given area, estimate the rate at which asteroids and comets have been bombarding the surface—a far more contentious question—and from those two quantities calculate how long it has been since geologic processes last wiped the surface clean of craters.

So far, the cratering ages have been in conflict. At the meeting, Clark Chapman and his colleagues at the Southwest Research Institute in Boulder, Colorado, offered an age of 1 million to 10 million years, a geologic blink of an eye, for one area that for all the world looks like Arctic ice floes caught in a freshly frozen sea. Such recent resurfacing would persuade even the most skeptical geologist that an ocean is reshaping the surface even now. But Gerhard Neukum of the German Aerospace Research Organization (DLR) in Berlin, like Chapman a Galileo team member, has been advocating a truly ancient age for parts of Europa: 3 billion years. Few would agree with Neukum's pivotal assumption—that a swarm of asteroid impacts billions of years ago, rather than the steadier rain of comets assumed by Chapman, dominates Europa's cratering record—but most geologists take the controversy as a sign that the final age for the surface of Europa is not in.

Variations in Europa's surface features also make some geologists hesitate to endorse a present-day ocean. While the maculae suggest a thin ice layer, noted Moore, the large crater Pwyll looks more like a classic crater, suggesting the ice there was far thicker at the time of impact. Pappalardo also notes that the fractures and ridges, apparently formed when the ice was thin, seem to have preceded the pits, domes, and spots that formed when a thicker layer of warm ice was convecting. That would suggest that at least in some places, the ice has been thickening in geologically recent times. Europa's interior may be cooling because the store of heat from its formation is dwindling or because of variations in another source of heat, the tidal massaging of the moon by Jupiter's gravity.

Proving that a global ocean or even local lakes still lie below the Europan ice could take a while. Galileo will take an even closer look during its extended mission starting in December, improving the resolution of its best images from 70 meters to 10 meters. If an even sharper look at Europa fails to convince everyone, the job will probably fall to a future geophysics mission in which a spacecraft would orbit the moon and probe it with ice-penetrating radar, finally plumbing the depths beneath its tantalizing exterior.

–Richard A. Kerr

Additional Reading
Abstracts from the Division for Planetary Sciences meeting can be found at http://www.aas.org/~dps/

ASTRONOMY

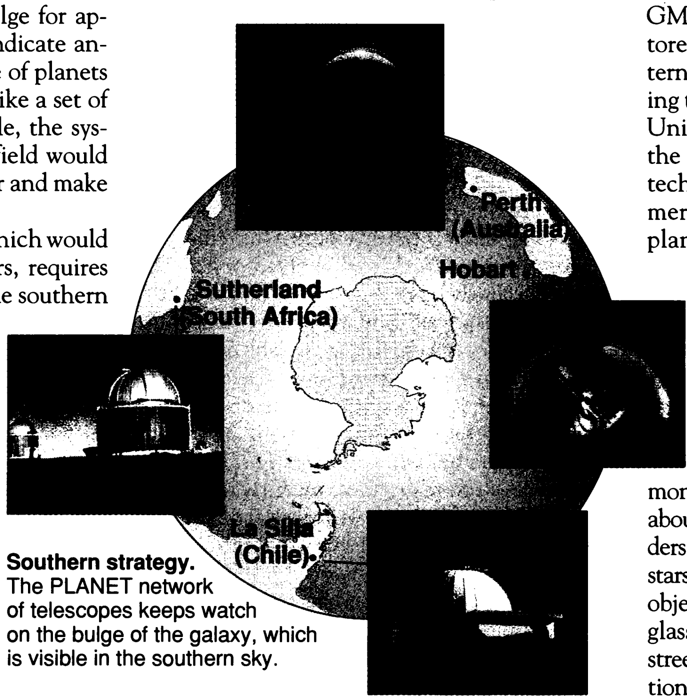
Flickers From Far-Off Planets

The telescopes of the South African Astronomical Observatory (SAAO) are thousands of kilometers from their hemispheric counterparts in Australia and South America. But two and a half years ago, SAAO's John Menzies joined a project that turned this geographic isolation to advantage. Called PLANET—for Probing Lensing Anomalies Network—the project monitors stars in the Milky Way's crowded central bulge for apparent brightenings that could indicate another, dimmer star with a retinue of planets drifting across the line of sight. Like a set of lenses passing in front of a candle, the system's complicated gravitational field would bend light rays from the bulge star and make it seem to flash and dim.

Tracking these fluctuations, which would take place over a matter of hours, requires round-the-clock monitoring of the southern sky, where the galactic bulge can be seen. So SAAO's perch between collaborators in Chile and Australia was crucial to the project. And now the lonely watching may have paid off. In recent months, this unusual collaboration has uncovered two strong candidates for companions circling stars thousands of light-years from Earth. The most spectacularly fluctuating event, sketchily described in Internet alerts by PLANET team members as they observed it through June and July, is "exactly what one would expect for a Jupiter-mass planet orbiting around a solar-mass star," says Abraham Loeb, a theorist at the Harvard-Smithsonian Center for Astrophysics (CfA) in Cambridge, Massachusetts.

The team still has to complete mathematical modeling of the event to nail down the arrangement of bodies that produced it, says Penny Sackett of the Kapteyn Astronomical Institute in the Netherlands, who, along with Kailash Sahu of the Space Telescope Science Institute in Baltimore, founded PLANET in early 1995. She and Loeb, who is not a member of PLANET, both caution that the system responsible for the flicker could turn out to be, say, a binary star rather than a single star with a planet. But the data themselves are likely to be solid, as another international collaboration called GMAN (*Science*, 7 March, p. 1416) monitored the same star and saw a similar pattern of brightening and dimming, according to team member David Bennett of the University of Notre Dame in Indiana. If the planet discoveries are confirmed, the technique could take its place as astronomers' most sensitive means of finding planets around other stars.

The idea of searching for planets by watching for gravitational lensing can be traced to Shude Mao of CfA and Bohdan Paczyński of Princeton University. Paczyński had realized that by scanning large chunks of the sky for stars that gradually brighten over weeks or months, astronomers could say something about how often unseen stars or stellar cinders drift across the lines of sight to those stars. The symmetric gravity of each passing object would act like a single magnifying glass slowly passing in front of a distant streetlight. That insight spawned collaborations including MACHO (Massive Com-



Southern strategy. The PLANET network of telescopes keeps watch on the bulge of the galaxy, which is visible in the southern sky.