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# SPECIAL ISSUE: ORIGINS

## DARWIN'S DANGEROUS IDEA

*Like "Universal Acid," Evolutionary Theory Eats Through Every Other Explanation for Life, Mind and Culture*

*by* DANIEL C. DENNETT

# An Early Earth?

*Jupiter's moon Europa could be a good model of what our planet looked like four billion years ago*

"THE PAST IS A FOREIGN COUNTRY," THE ENGLISH WRITER L. P. Hartley observed in his novel *The Go-Between*. For Jeffrey Bada and other proponents of an ice-covered early earth, however, the past might well be orbiting around another planet. Searching for evidence to bolster their theories, they have combed the solar system for worlds that might shed light on the geophysical and geochemical processes that once held sway closer to home. One of the most promising candidates is a frigid body slightly smaller than the earth's moon and five times as far from the sun as the earth is. It is Europa, the next-to-innermost large moon of the planet Jupiter.

In February, Europa made headlines when astronomers studying images from the Hubble Space Telescope concluded that oxygen is present in its atmosphere. The oxygen is a byproduct of water vapor rising from the material on Europa's surface: a thick shell of slightly dirty, rock-hard $H_2O$—water ice. It is the ice, not the oxygen, that excites Bada and other investigators. As Europa orbits Jupiter, tidal stresses from the giant planet's varying gravitational pull squeeze the moon, causing internal friction. In the early 1980s the planetary scientist Ray T. Reynolds of the NASA Ames Research Laboratory in Moffett Field, California, and other investigators showed that, in theory, the friction should generate enough heat to maintain a layer of liquid water beneath the surface. The result could be a global ocean capped with a frozen ceiling kilometers or even tens of kilometers thick.

In short, Europa might resemble a scaled-down working model of Bada and Miller's frozen earth. That could be a godsend for theorists trying to trace the evolution of our planet—if the hidden ocean is really there. Is it? Nobody can be sure, Reynolds cautions, but there is some tantalizing circumstantial evidence. Images transmitted back to the earth in the 1970s by Pioneer and Voyager space probes revealed that the icy surface of the Jovian moon is scored with dark lines that look like fissures. Apart from that, however, Europa is amazingly smooth—a sharp contrast to the meteor-pocked exteriors of its neighboring moons Ganymede and Callisto.

"There should be craters of all ages on the surface, and we don't observe them," Reynolds says. "What that means is that something is removing them."

That something could be a sign of a sub-Europan ocean. If liquid water does flow beneath the surface, then, Reynolds suspects, the relatively warm ice above it would tend to creep, gradually erasing large craters. Small craters could perish more dramatically, when fractures in the ice reach the ocean, unleashing geysers of cold steam that recondense in a rain of frost. In principle, such geysers could be detected from the earth by a sharp rise in the water content of Europa's atmosphere. No one has ever seen anything like that, but Reynolds says he will be looking hard at the high-resolution images the *Galileo* space probe will send back when it reaches the Jovian system in early December.

All of which is a far cry from saying that Europa does, or could, harbor life. On the contrary, says Doyle T. Hall, an atmospheric scientist at Johns Hopkins University and a member of the team that discovered the oxygen: every part of Europa is hostile if not inimical to life. The atmosphere is negligible. The ocean, if one exists, is swathed in perpetual darkness and burdened with immense pressure from the overlying ice. And in between, on the moon's surface, lies a radioactive hell.

"Europa is orbiting inside Jupiter's magnetic field, and inside that magnetic field there are a lot of energetic particles—radiation to you and me," Hall says. "If you could magically go there and stand on Europa, it would probably be like getting a chest X ray every second or two. Basically, any organic matter on the surface is going to be torn apart."

That's a pity, because in some respects Europa has the makings of an attractive piece of real estate. Five billion years from now, Reynolds says, the sun will enter the red-giant phase of stellar evolution. As it swells to engulf Mercury and Venus, its heat will turn the earth into a cinder and, somewhat later, melt all the ice on Europa. "It won't last very long, but it looks as if there will be a period of a few hundred million years, very far in the future, when there may be oceans on Europa."

—PAMELA SUE FROST