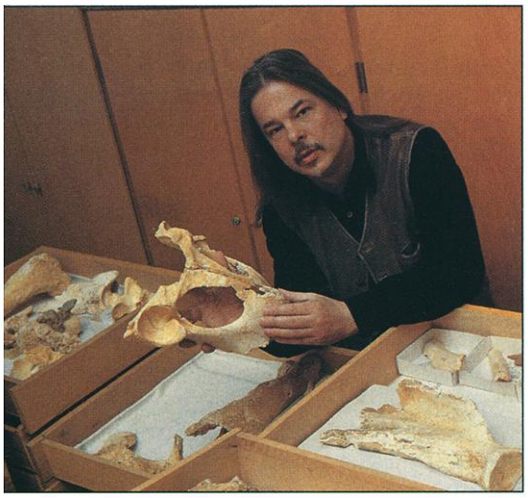


Ancient riches. Ralf-Dietrich Kahlke oversees one of the world's largest collections of fossil mammals.

than 100 institutes helped persuade the government to save the institute, and it became part of the University of Jena.

But the match was not an ideal one. The elder Kahlke retired and Ralf-Dietrich became director, but as the only paleontologists at the university, the Weimar researchers had trouble securing enough funding. "We were going under," the younger Kahlke says.

Again colleagues came to the rescue. Senckenberg Museum director Fritz Steininger, an Austrian paleontologist who used the Weimar collection, helped persuade the German Science Council and the state governments that the Weimar research would complement the work at Senckenberg, which had few specialists in the quaternary period. In January 2000, the institute became a research station outpost of the Senckenberg.

The full picture. To understand ancient climates and ecosystems, paleontologists need more than isolated bones of hulking mammals. The Weimar researchers are careful to document the smallest details: One lab holds millions of tiny snail shells, another, thousands of peppercorn-sized rodent teeth. The fossils, carefully sifted from tons of sediment, are important clues to the state of the ecosystem at the time the animals lived and can also help assign dates to large fossils from sites with fewer geologic time signatures, micromammal expert Lutz Christian Maul explains.

It is the large fossils, however, that pose the most pressing practical challenge. Like its local forerunner, the institute is running out of space. In the building that houses the main collection, ceilings are braced by huge metal supports resembling overgrown car jacks. To ease the strain, the institute sorts its collection partly by weight, with the heaviest fossils on the lower floors. Although the structure is well built, Kahlke says, "it was not designed for storing tons and tons of elephant bones." Despite the difficult conditions, the institute is a model of conservation, says Mol: "Ralf and his team are an example for how other teams should behave with their fossils."

Indeed, Ralf-Dietrich Kahlke is keenly aware of his legacy to future generations of researchers: One of the reasons the institute employs a full-time artist and photographer is to document excavations and fossils for the monographs. "Our views will change, but the bones will not change," Kahlke says. "Documentation keeps its value forever. No one can have more information about the excavated sites than we have included in the monograph." It is a legacy he hopes may last at least another 300 years.

—GRETCHEN VOGEL

MEETING ASTROBIOLOGY SCIENCE CONFERENCE

Astrobiologists Try to 'Follow the Water to Life'

MOUNTAIN VIEW, CALIFORNIA—That slogan, expressed by a speaker at the biannual Astrobiology Science Conference held 8 to 11 April here at NASA's Ames Research Center, unified most of the talks heard by more than 700 astronomers, biologists, chemists, geologists, planetary scientists, and even virologists. Among the topics raised within the cavernous 60-meter-high Hangar One—which once housed a pre–World War II Navy dirigible—were the liquid milieu in which the first cells may have formed and the effects of water and ice on an Arctic impact crater.

A Fresh Start for Life?

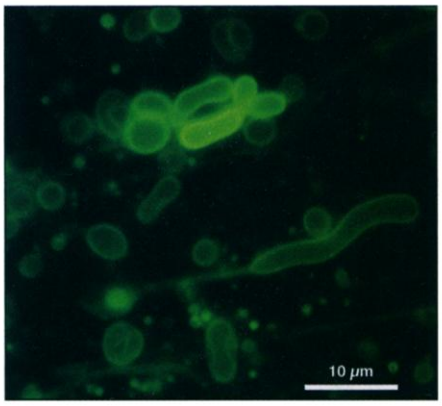
Salty water is a comforting home for life today, but it probably was too harsh for the first cells. That's the surprising conclusion of new laboratory studies, which found that primitive membranes and chains of basic genetic material assemble far more easily in fresh water. The research suggests that life arose in ponds on the earliest continents, rather than in tide pools or the deep sea, as many researchers have assumed.

Despite the uncertainties that still shroud the chemistry of the young Earth, "this is a real wake-up call," says mineralogist Robert Hazen of the Carnegie Institution of Washington in Washington, D.C. "We've assumed that life formed in the ocean, but encapsulation in freshwater bodies on land appears more likely."

In a popular origin scenario, life required an enclosed membrane, or vesicle, to protect and confine the first chemical chains capable of copying themselves. The simplest vesicles are made of amphiphiles—long molecules with a head that latches to water and an oily, carbon-rich tail that repels water. Two layers of amphiphiles can naturally bind together to form a sandwich: The water-loving heads point outward, and the oily chains link together inside. If this bilayer wraps into a tiny blob, a bare-bones vesicle is born.

A team led by astrochemist Jason Dworkin of NASA Ames showed last year that such vesicles can arise from the icy ingredients in comets and interstellar space. Ultraviolet light transforms carbon-rich ices into simple hydrocarbons, such as fatty acids, in space. Then, the hydrocarbons coalesce into vesicles when exposed to water on Earth. In this way, the team reasoned, cosmic seeding of early Earth supplied the organics needed to build the first cells. But to explore just where that might have happened, team member David Deamer, a biochemist at the University of California, Santa Cruz, decided to test the reactions in various solutions in his lab.

In one experiment, graduate student Charles Apel found that stable vesicles formed in water and a dash of alcohol. However, when he added sodium chloride or ions of magnesium or calcium—at levels less than the saltiness of today's ocean—the



They're fresh. Simple membranes, such as these made in the lab, break up in salt water.

CREDITS: (TOP TO BOTTOM) THOMAS KORN/SENCKENBERG WEIMAR; C. APEL, P.-A. MONNARD, D. DEAMER/UC SANTA CRUZ membranes fell apart and crystallized. In further work, postdoctoral researcher Pierre-Alain Monnard demonstrated that the salty compounds also impeded the growth of chains of the genetic molecule RNA in a "protocell" system that Deamer's team devised to mimic the first cells. Their analysis will appear in an upcoming issue of *Astrobiology*.

Deamer finds the combined results compelling. "It seems possible to me to concede now that life did not have a marine origin," he says. "These processes don't work very well in seawater." An independent boost came from geologist Paul Knauth of Arizona State University in Tempe, who stated at the meeting that Earth's early oceans were up to twice as salty as they are today. Vast salt deposits that formed on the continents made the oceans less saline as time went on, Knauth says. Briny seawater was an even less likely habitat for the first cells, Deamer maintains.

However, the salinity of life's womb may not have been crucial if self-replicating systems arose on minerals rather than in a solution (*Science*, 15 March, p. 2006). At the meeting, chemist James Ferris of Rensselaer Polytechnic Institute in Troy, New York, described a way to build primitive RNA molecules by concentrating the ingredients on the surfaces of clays—regardless of the saltiness of water washing over them. "This system has the potential for the essence of life in its crudest, simplest fashion," Ferris says. If so, then the first membranes—which Ferris regards as more complex and prone to leakage—probably came later to encapsulate these glimmerings of life.

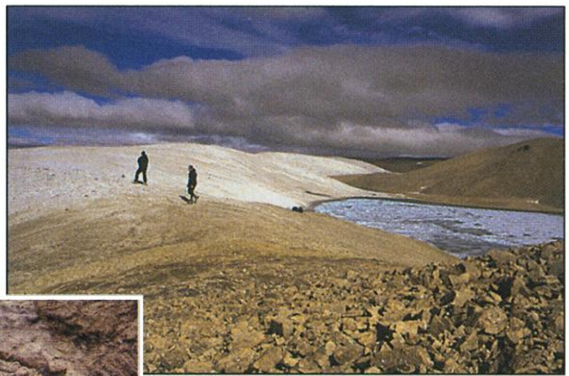
The distinction is more than a semantic debate over when a system is "alive," Hazen notes. "The biggest problem in the origin of life is not where the molecules came from, but how they were selected and concentrated," he says. If that occurred for the first time within fragile cells, as Deamer believes, then the sea may have been a barren cradle.

Arctic Crater May Presage Mars

All planets have one thing in common: a relentless pounding by renegade cosmic debris. About 23 million years ago, one such wanderer slammed into the Canadian High Arctic, blasting a 20-kilometer-wide scar. Now called Haughton crater, the impact has researchers seeing red—not just in the minerals at the crater's dead hydrothermal pipes, but by comparison to Mars.

Five summers of fieldwork at Haughton have shown that the crater and its frigid site, uninhabited Devon Island, is a promising "Mars analog" setting on Earth, says planetary scientist Pascal Lee of the Mountain View–based SETI Institute. Early work focused on eerie similarities between features on Mars and those on the island, such as networks of small valleys that Lee and his team believe were carved beneath a fixed sheet of melting ice (*Science*, 9 October 1998, p. 210).

At the meeting, Lee discussed other studies that reveal just how well the Arctic has preserved Haughton's history. For instance, paleobotanist Leo Hickey of Yale University in New Haven, Connecticut, has extracted unpetrified bone and wood from the frozen layers of sediments left by a lake that filled the crater soon after the impact. In and around the crater, geologists Gordon Osinski and John Spray of the University of New Brunswick in Fredericton, Canada, have joined Lee to map a suite of nearly pristine deposits laid down by hot springs spawned by the impact. Many of these rust-colored formations ring the margins of the crater, where fluids emerged after migrating underneath the fractured basin.



Cold crater. Lake sediments (*left*) at northern Canada's Haughton crater may shed light on similar sites on Mars.

CREDIT: PASCAL LEE/SETI INSTITUTE AND NASA HAUGHTON-MARS PROJECT

"What we have learned is that impact craters in cold deserts do indeed represent important targets for well-preserved and least-disturbed paleoenvironmental and geologic records," says Lee. If that's true on Earth, he adds, "it's likely to be true on Mars."

The combination of high latitude, a former lake, and remnant hot springs makes Haughton a good model for how to look for signs of martian life, says planetary geologist Jack Farmer of Arizona State University in Tempe. "Even if we can't identify a discrete hydrothermal site from orbit, the ejected rocks from an impact could be a way to sample the subsurface environment—where biosignatures are most likely—without having to drill," Farmer says. One such site, the 150-kilometer Gusev crater in the southern midlatitudes, is on the short list of possible landing sites for one of the twin Mars Exploration Rovers, scheduled for launch in just over a year.

Farmer and Lee both caution that any Mars analog on our planet is far from perfect. Citing data from the Mars Global Surveyor spacecraft, Farmer says, "We are completely baffled and puzzled by what we see in the MOC [Mars Orbiter Camera] images at high latitudes. There are cryosphere-driven and atmosphere-driven processes that simply have no parallels on Earth."

To try to find the parallels that do exist, scientists must study many sites that may offer insights into martian landscapes and processes, says James Garvin, lead scientist of NASA's Mars Exploration Program in Washington, D.C. These include Iceland, Antarctica's Dry Valleys, the Popigai impact crater in Siberia, and extreme deserts such as Atacama in Chile. Still, Garvin praises Lee's "sheer entrepreneurial spirit and cleverness" for setting up an active international research program via dozens of private and public sources of funds, including NASA. Haughton crater, he notes, may provide an important test site for future Mars technology because of the infrastructure in place there.

Meanwhile, Lee and his team are preparing for a sixth field season at Haughton, starting in July. He believes that talks with Inuit leaders in the nearby hamlet of Grise Fiord have clarified what Lee calls a "misunderstanding" about the scope of the team's land-access permit, which kept them out of much of the crater's interior during the last two summers (*Science*, 21 September 2001, p. 2189). "There is an atmosphere of optimism that bodes well for future access to the crater," he says—both on Devon Island and, it seems, somewhere on Mars.

—ROBERT IRION