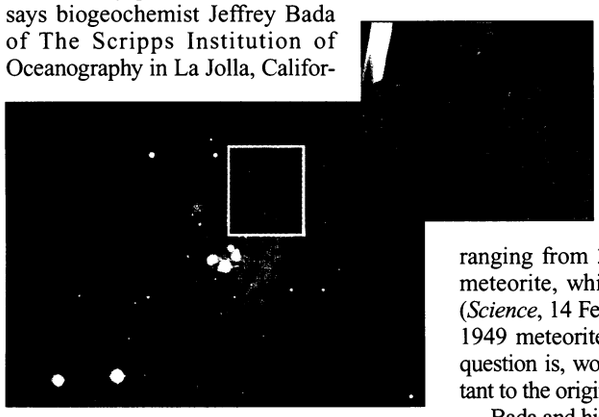
that hit Earth this century and thinks such space-borne amino acids might have set the pattern for ones made later on Earth. Origin-of-life experts have a different spin. "There are so many problems" with the scenario, says biogeochemist Jeffrey Bada of The Scripps Institution of Oceanography in La Jolla, California, who doubts that large quantities of amino acids from space would have survived the journey to Earth or hung around long enough to influence early biology. "I doubt this will settle the issue of how homochirality arose."



DAVID MALIN/ANGLO-AUSTRALIAN OBSERVATORY (INSET) DUANE WILLIAM DIETZ/VISUALS UNLIMITED

Stellar spin. Polarized light from part of the Orion Nebula (box) may form amino acids with a twist, such as those in the Murchison meteorite *(inset)*.

Those who favor an unearthly genesis for homochirality have for years pointed to circular polarization as a possible trigger. Astronomers have seen high levels of such radiation near binary stars and in other exotic settings with strong magnetic fields. Now, Bailey's team has found it in an environment much like the one that spawned our solar system. They studied the Orion Molecular Cloud, a cauldron of star formation, with an infrared camera on the 3.9-meter Anglo-Australian Telescope. They found that up to 17% of the infrared light streaming from Orion was circularly polarized, presumably by scattering off fine dust grains aligned in a magnetic field. "That was a big surprise," says Bailey, who had expected levels of 1% to 2%.

Infrared light, however, does not pack the energy needed to destroy organic molecules. That would take UV light. Although Bailey's colleagues could not see UV light from Orion because of obscuring dust, they calculate that a similar percentage of UV light should also be circularly polarized. If such light from a nearby star cascaded through our early solar system, it could have broken the bonds in enough D amino acids to yield one extra L amino acid for every 10 molecules—enough of an excess for early organisms to seize upon and amplify. Other planetary systems, depending on the direction of polarization, might see an excess of D amino acids.

Even so, Bailey and Hough acknowledge, many events must fall into place to render their scenario plausible. Those steps include making huge amounts of amino acids in space and delivering them to Earth without losing the surplus to "racemization"—the spontaneous transformation of homochiral molecules to an even-handedness that happens quickly at high temperatures and in water. "I consider each of those steps to be possible," says planetary scientist Christopher Chyba of the University of Arizona, Tucson, noting Cronin's recent discovery of L amino acid excesses ranging from 3% to 9% in the Murchison meteorite, which fell in Australia in 1969 (*Science*, 14 February 1997, p. 951), and in a 1949 meteorite from Kentucky. "The open question is, would such an excess be important to the origin of life?"

Bada and his colleague at the University of California, San Diego, chemist Stanley Miller, think not. "Once the amino acids get to Earth, they would racemize in very short order," Miller says. "I've always felt that homochirality arises by chance." **–ROBERT IRION**

Robert Irion is a science writer in Santa Cruz, California.

ORIGIN OF LIFE

A Sulfurous Start for Protein Synthesis?

Although Charles Darwin proposed that life originated in a warm, nourishing broth, new evidence supports a less cozy idea: that the cradle of life was more like a Puritan minister's version of hell—a sulfurous swirl of superheated water and oozing magma. On page 670, chemist Claudia Huber and patent attorney Günter Wächtershäuser report that they have re-created a crucial step in assembling the ingredients of living cells—the linking together of amino acids into short, proteinlike chains called peptides—under just such harsh conditions.

Although other researchers have achieved a similar feat in the lab, they generally did so with the help of additives or conditions not likely on early Earth. The amino acids had to be kept dry, for instance, or be activated by compounds not found in nature. In contrast, Wächtershäuser says, his system "uses nothing more than what is available in volcanic exhalations"—the magma and pressurized gases that suddenly hit cooler ocean water at cracks in Earth's crust. James Ferris of the Rensselaer Polytechnic Institute in Troy, New York, agrees: "These peptides are made under plausible prebiotic conditions. You don't have to throw anything in that is artificial."

Indeed, says evolutionary biologist Norman Pace of the University of California, Berkeley, the peptide formation is "very ex-

ScienceScope

INDIA TELESCOPE CUTS PHONE DEAL

An 11th-hour agreement was expected to be signed this week to prevent a global mobile phone system from interfering with India's new $17 million Giant Metrewave Radio Telescope (GMRT), an array of 40 huge antennas near Pune. Iridium India Telecom, a Motorola subsidiary, is planning on 23 September to start up a system that will send satellite transmissions to a gateway only 80 km from the telescope (*Science*, 28 November 1997, p. 1569). Now, astronomer Govind Swarup, the "father" of GMRT, says, "we have arrived at an agreement with Iridium"—details yet to come—to avoid interference from emissions in the 1610-MHz band, a frequency important for probing star-forming regions.

SELLING ONCE-SECRET, ONCE-SOVIET SCIENCE

Russia's beleaguered nuclear scientists are about to get help from a new program to get them into commercially productive research. Announced 24 July in Moscow by Vice President Al Gore and Russia Prime Minister Sergei Kiriyenko, the Nuclear Cities Initiative (NCI) aims to boost U.S. private-sector investment in the once–top-secret cities.

Times are tough in these towns. Last week, scientists in Sarov, 400 km east of Moscow, struck for a day to protest months of unpaid wages. And some researchers, it is believed, have resorted to aiding Iran's missile program. To get scientists more positively engaged, the U.S. Department of Energy (DOE) has sunk

ВНИИ

Logo of nuclear facility in Sarov

$30 million this year into applied research in science cities. But the problem is so great, says Janet Hauber, NCI manager at DOE, that "we don't think that model will respond quickly enough." Under the NCI, U.S. investment will be sought for projects at three nuclear cities—Sarov, Snezhinsk, and Zheleznogorsk. There's no new government money for the initiative, says Hauber, but hopes are that there will be enough private sector enthusiasm to expand it to seven more cities.

Contributors: Eliot Marshall, Susan Biggin, Pallava Bagla, Richard Stone.

UNIVERSITY OF WASHINGTON

Hot chemistry. Life's precursors can form in conditions like those at deep-sea vents.

citing," both for its novel chemistry and for what it may imply about life's origins. These experiments support Wächtershäuser's theory, originally proposed in 1988, of how the first ingredients of living organisms might have assembled on the surface of minerals near underwater volcanic gas vents.

Wächtershäuser had made his suggestion in the wake of reports from geologists that cast doubt on the idea that the first life-forms on Earth might have arisen in what Darwin called a "warm little pond." Those reports suggested that such a temperate pond might not have existed 4 billion years ago, when life is thought to have had its genesis, because Earth was much hotter then, seething with volcanoes and enduring a bombardment of comets and asteroids.

So, Wächtershäuser, who holds a Ph.D. in organic chemistry, proposed instead that the iron and nickel sulfide minerals that collect near the volcanic vents might have catalyzed the formation of the first biomolecules from carbon monoxide and other gases belched from escaping magma. The sulfide minerals carry a positive charge on their surfaces, and Wächtershäuser believes organic molecules with negative charges would have accumulated there and continued to react with each other, forming many of the precursors for life.

The basic biomolecules he had to explain include amino acids, the building blocks of proteins. Last year, Wächtershäuser and Huber, of the Technical University of Munich, took one step toward demonstrating the feasibility of making amino acids in conditions similar to those at the vents. They showed they could make activated acetic acid, a starting material for amino acid synthesis, by mixing carbon monoxide and hydrogen sulfide with a slurry of nickel sulfide and iron sulfide particles at 100 degrees Celsius (*Science*, 11 April 1997, p. 245).

The researchers have not yet shown that this recipe can produce actual amino acids, but the current work indicates that if amino acids do form at the vents, they could hook up to form peptides. Huber and Wächtershäuser added amino acids to the same sulfide slurry, and within a few days they could detect a range of dipeptides, consisting of two amino acids linked together, as well as a few tripeptides, containing three amino acids. The researchers propose that, catalyzed by the iron and nickel sulfides, carbon monoxide and hydrogen sulfide bind to the amino acids and convert them into a reactive form.

Not all specialists in the origins of life are convinced that this lab demonstration proves that the same thing could have happened naturally, however. Stanley Miller, a biochemist at the University of California, San Diego, says that concentrations of carbon monoxide, which activates the amino acids in Wächtershäuser's reaction, are much lower in nature than in the experiment. And even if the reaction could occur in nature, it would not be adequate to form proteins that contain many amino acids, says Miller, who favors a cooler beginning for biomolecules.

Pace adds a caution that applies to any lab effort to create biomolecules. "It's a very long leap," he says, "from [mineral] surface chemistry to a living cell." **–GRETCHEN VOGEL**

MICROSCOPY

Molecular Imaging Beats Limits of Light

LEIDEN, THE NETHERLANDS—Researchers can map single atoms or molecules on surfaces almost as routinely as cartographers map hills and lakes, thanks to instruments like the scanning tunneling microscope. But below the surface, they start to lose their bearings. Microscopes equipped with sensitive detectors can pick up individual fluorescent molecules in a liquid or solid, but they generally cannot distinguish the molecules if they are separated by less than a wavelength of light. In today's issue of *Chemical Physics Letters*, however, physicists bring new accuracy to subsurface molecular imaging.

The researchers, Jürgen Köhler of Leiden University and his colleagues, took advantage of tiny differences in the way chemically identical fluorescent molecules respond to light, depending on their immediate surroundings. Even close neighbors can be distinguished if they are probed with a laser that delivers light at a very precise frequency, the group showed. They managed to determine the positions of seven molecules in a matrix of another material to within a few tens of nanometers, perhaps a tenth of a wavelength of light. That is more than 10 times the resolution of earlier techniques—"a beautiful experimental demonstration of a way to increase the resolution of optical measurements," says W. E. Moerner of the University of California, San Diego, a pioneer in single-molecule spectroscopy.

Molecular imaging has been hampered by the diffraction limit, an intrinsic blurring of light that prevents two sources from being resolved when they are close together. Only near-field microscopy, which makes use of tiny optical fibers that are narrower than a single wavelength, can pinpoint fluorescent molecules with subwavelength accuracy. However, it sacrifices depth information for two-dimensional precision.

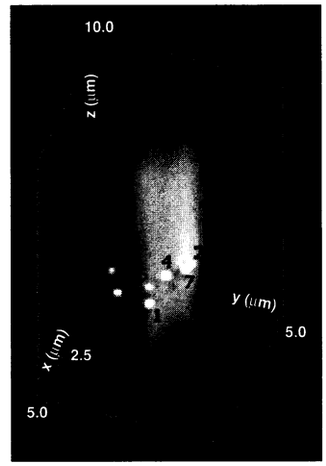
In 1995, Eric Betzig, of NSOM Enterprises, proposed a way to get around the diffraction limit. Each molecule in a solid matrix finds itself in a slightly different structural environment because of random strains and imperfections. As a result, each one has an absorption line at a slightly different frequency. This shift is generally very small, but at low temperatures it can be resolved with a tunable laser that generates a precise frequency of light. "Molecules which can normally not be spatially separated are clearly distinguished," says Köhler.

Köhler and his colleagues illustrated the method on a sample of pentacene, an aromatic hydrocarbon, in a host crystal of p-terphenyl. Pentacene fluoresces strongly when excited by laser light. By moving the focus of the laser through the sample in three dimensions and determining the position of the fluorescence maximum for each molecule, the group could pinpoint its location with an accuracy well below the diffraction limit.

Thomas Schmidt of the University of Linz in Austria thinks that by using more strongly fluorescing molecules and computerizing the setup, the group should be able to image molecules in minutes rather than hours. That could open the way to minute, three-dimensional mapping of the cell. Researchers might, for example, label genes with different fluorescent molecules, then determine the precise positions of these marker molecules to learn, say, how the DNA twists and coils. Köhler and his colleagues, says Niek van Hulst of the University of Twente in the Netherlands, "are pushing optical microscopy to its limits."

–ROB VAN DEN BERG

Rob van den Berg is a science writer in Leiden.



A.M. VAN OIJEN

Tiny beacons. Single fluorescent molecules, detected with subwavelength resolution.