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**

A.M. VAN OIJEN

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.

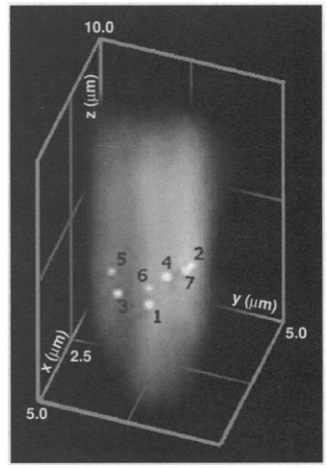
Molecular imaging has been hampered by the diffraction limit, an intrinsic blurring of light that prevents two sources from being resolved when they are close together. Only near-field microscopy, which makes use of tiny optical fibers that are narrower than a single wavelength, can pinpoint fluorescent 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



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

Rob van den Berg is a science writer in Leiden.