groups, one led by Dan Gottschling of the University of Chicago and the other by UCSF's Blackburn and Michael McEachen, isolated telomerase RNA from two different species of yeast (*Science*, 21 October 1994, p. 404).

In Toronto, several groups presented results indicating the pace in this field is accelerating. Harley announced that his group, led by Bryant Villeponteau, with Greider's, has cloned the gene for human telomerase RNA, making it the first mammalian telomerase component to be captured. The researchers are pretty sure they have the right gene because the RNA is found in the same fraction as telomerase activity when researchers attempt to purify telomerase activity from cells. But, Harley says, most important, mutating the RNA gene creates mutated telomerase activity.

Perhaps even more encouraging was Greider's announcement that her group has isolated telomerase proteins from the organism where the search began: *Tetrahymena*. Greider's team pulled out two proteins, one with a molecular weight of 80,000 and the other 95,000. Armed with partial amino acid sequences of these proteins, the team cloned the genes. Surprisingly, telomerase isn't closely related to any other enzyme that synthesizes DNA, although it is very slightly related to an ancient viral RNA synthesizing enzyme.

Telomere researchers welcomed the discovery with excitement. "We have been waiting for these proteins for 10 years," says Morin. Many researchers hope that having the *Tetrahymena* telomerase protein genes will help identify those from higher organisms.

But even without the protein, the RNA component of the human telomerase will "greatly speed research into the developmental regulation and tumorigenic activation of telomerase," according to Morin. Using this information, researchers hope to devise strategies to battle cancer by inhibiting telomerase activity—rendering cells "mortal" once more.

Several groups are on the trail of such inhibitors. "We are aggressively pursuing drugs to inhibit telomerase," says Harley. Southwestern's Shay says his group is looking for the cell's own telomerase inhibitor, the one that turns the enzyme off during development, in hopes of reactivating it in cancer cells. They have evidence that human chromosome 3 carries a gene for such an inhibitor.

No matter which method succeeds, progress reported in Toronto suggests researchers may soon begin to find ways to counteract the deadly immortality telomerase promotes—a development that would only help keep telomeres and telomerase in the limelight.

–Lisa Seachrist

Lisa Seachrist is a writer with United Press International.

MEETING BRIEFS

Physics Festival Brightens Rainy San Jose

A week after floodwaters surged through parts of San Jose's downtown, a flood tide of physicists—almost 6000 of them—appeared for the annual March meeting of the American Physical Society (APS). Gloom and drizzle continued for the first 4 days of the gathering, but there were plenty of bright spots inside the hall.

Pinpoint Chemistry

Its ability to explore and reshape atomic-scale hills and valleys with its microscopic tip has long made the atomic force microscope (AFM) a favorite tool among devotees of nanotechnology. Most of the fans have been physicists, but now chemists are getting in on the fun: A mixed group of chemists and physicists, all from the University of California, Berkeley, and Lawrence Berkeley National Laboratory, has developed an AFM that wields a catalytic tip to transform the chemical landscape of a surface, molecule by molecule. "By moving this 'pen' around we're able to localize the chemistry and 'draw' a chemical reaction," physicist David Klein told an audience at the APS meeting.

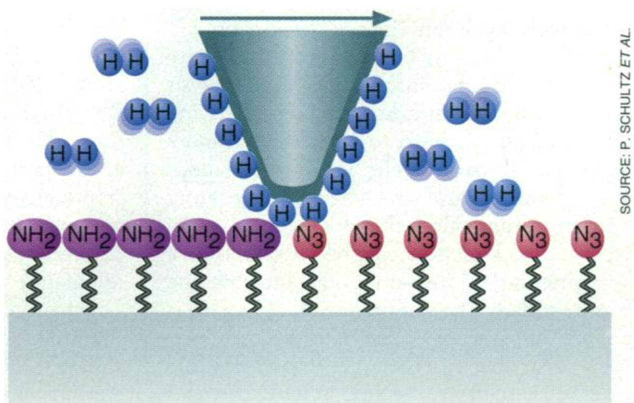
So far, the group has done no more than a proof-of-principle experiment. But the effort, led by chemist Peter Schultz, could eventually offer a new way to dissect catalytic reactions by precisely controlling how the reactants and the catalyst interact. A catalytic AFM could also build complex structures, such as electronic circuits or micromachines, on a scale of nanometers (billionths of a meter), says Klein. "I think it will be very important for making prototype devices," agrees University of Texas, Austin, physicist Alex De Lozanne, who chaired the APS session at which Klein spoke.

The work isn't the first venture into nanocatalysis. Berkeley chemist Gabor Somorjai last year led a team that performed a similar feat with the platinum-coated tip of a scanning probe microscope (STM), a device that utilizes an electrically charged probe that hovers a few atoms' widths above a surface (*Science*, 2 September 1994, p. 1415). Hoping to take a somewhat more direct approach, Schultz, Klein, and their colleagues instead mounted their platinum catalyst on the tip of an AFM, which actually touches the surface.

They staged their first test of the device by soaking the tip in a hydrogen-containing solvent, then applying it to a so-called self-assembled monolayer—an orderly array of molecules that Klein likens to a field of wheat. At the end of each stalklike molecule is a collection of three nitrogen atoms known as an azide group. The hydrogen-imbued platinum, the group hoped, would add hydrogen to the azides to transform them into amines, which contain one nitrogen atom and two hydrogen atoms each.

And so it did, the Berkeley researchers found when they scanned the catalytic tip over a square of the monolayer measuring 10 microns by 10 microns. A fluorescent tag that binds to amine groups but not to azides lit up a green, glowing square exactly where the tip had passed. "We see a nice clear signal where the AFM scan was done, indicating catalysis," says Klein.

This fine control could help researchers explore questions such as how long a catalyst must be in contact with a target to drive a reaction. "You could set up some nice chemical experiments, we hope," says Klein. But Klein and his colleagues also think that with the right choice of reactants and catalyst, they might be able to assemble complex nanostructures, such as transistors, by hooking on molecules other than fluorescent tags.



A special touch. A platinum-coated AFM tip adds hydrogens to azide groups (N_3), transforming them to amines (NH_2).

If AFM or STM catalysis is to become more than a laboratory tool, however, Klein and his colleagues will have to improve the technique's speed and reliability. The tip tends at times to pick up contaminants that block the chemical reaction. Furthermore, Somorjai cautions that neither AFM nor STM catalysis can keep up with proven manufacturing processes like lithography, in which a material such as silicon is simply cut away to create minuscule devices. "The tip is so slow by commercial standards," he says. But then again, fine needlework never could be hurried.

Ironing Out Life on Mars

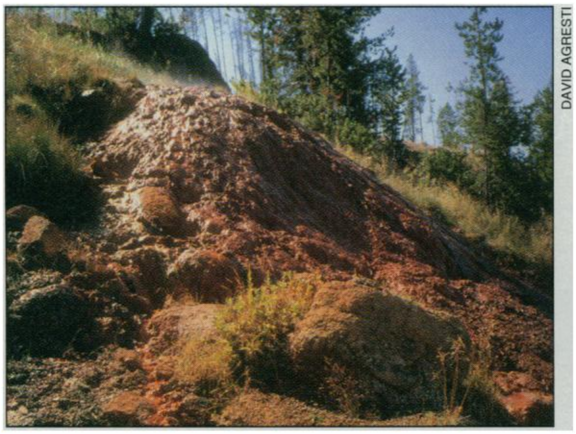
Martians wielding death rays may have gone the way of the canals, but the possibility of life on Mars holds an abiding fascination. The Viking spacecraft found no signs of life when they landed there in the late 1970s, but some researchers still cling to the hope that primitive life flourished in the red planet's past, when it was warmer and liquid water flowed on or just beneath its surface. As space agencies plan a second generation of Mars landers, researchers have been wondering where to look for signs of this ancient life.

One place to focus the search, University of Alabama, Birmingham (UAB), physicist David Agresti told the APS meeting, may be the planet's red pigment. He and his colleagues have been working with an instrument, under consideration for a future Mars lander, that will distinguish the various forms of the iron that give the planet its color. The main purpose of the device is to provide clues to the processes that have shaped Mars' surface. But Agresti and his colleagues, inspired by the discovery of iron deposits associated with the primitive bacteria that inhabit hot springs on the ocean floor and on land, think iron could also be a clue to ancient life on Mars.

In a project funded by the National Aeronautics and Space Administration (NASA), Agresti and his colleagues at UAB and Johnson Space Center have been building a miniature Mössbauer spectrometer, a device that can distinguish among various iron-containing minerals by probing them with gamma rays and detecting "resonances"—wavelengths at which iron nuclei efficiently absorb gamma rays. The resonant wavelengths vary depending on the crystal structure the iron is locked in, making the device ideal for distinguishing materials such as hematite from magnetite—two forms of iron oxide thought to be common on Mars.

The Mössbauer device might also detect a third type of iron that could be a trace of ancient martian bacteria, speculate Agresti and Thomas Wdowiak, an astrophysicist at UAB. On Earth, mats of bacteria that thrive around hydrothermal vents on the deep-sea floor are usually covered with iron minerals that precipitate from the hot water. When a vent stops flowing, the bacteria die, but the iron deposits persist as their legacy. In the late 1980s, Wdowiak and Agresti began to wonder whether the bacterial iron might have a unique Mössbauer spectrum.

To find out, they obtained samples of iron deposits from a deep-sea vent in the Pacific. Much of the iron, they found, takes the form of nanometer-sized particles, crystals much smaller than the bacteria themselves. And



DAVID AGRESTI

Telltale blush? Iron deposits like these, from a hot spring at Yellowstone, could provide a clue to ancient life on Mars.

this "nanophase" iron did indeed appear to have a special fingerprint: As it is cycled over a wide range of temperatures, its Mössbauer spectrum varies. Since then, the UAB duo have confirmed their findings on iron samples from certain hot springs in Yellowstone National Park, collected in collaboration with paleontologist Jack Farmer of NASA's Ames Research Center.

Agresti and Wdowiak believe the bacteria may somehow modify the crystal growth of the iron as it accretes, creating the fine particle structure and distinctive Mössbauer spectrum. Others aren't as certain. "I'm still skeptical this has anything to do with biology," admits Farmer. Indeed, instead of a sign of life, Farmer thinks nanophase iron may simply be a type of iron minerals produced by hot springs. If so, he says, the spectrometer could still pick out the best sites in which more sophisticated landers could search for signs of ancient microbes.

Agresti, Wdowiak, and Farmer aren't giving up on the possibility that the spectrometer might be able to detect other, surer signs of past life. For instance, many bacteria produce oxygen as part of their metabolism and may influence the oxidation of nearby iron, altering its Mössbauer spectrum—a possibility he and his colleagues hope to test by doing a more systematic survey of samples from Yellowstone. That's a worthy goal, says Martin Marietta's Benton Clark, an exobiologist who worked on the Viking missions, noting that perhaps more than in any other field, "speculation is legitimate in exobiology." And if the speculation is borne out, perhaps a future mission to Mars can turn up iron-clad evidence for past life.

The Sandman Speaks

Interspersed among talks on nanotechnology and high-tech analysis at the APS meeting were reports of simpler forays into the natural world. One put a new spin on a question almost every physics student faces at some point in his or her schooling: What shape does the surface of a bucket of water form when it is spun? The answer, explains physicist G. W. Baxter of Pennsylvania State University's Behrend College, is a bowllike depression with the shape of a simple paraboloid. But what happens if the water is replaced by a granular material, like sand?

As Baxter reported at APS, he and his students have found that the same internal friction that allows sand to form stable piles also modifies the shape of the pit that forms in a spinning bucket. The competition between friction, gravity, and centrifugal force has complex results, ranging from an inverted cone to something more like a funnel.

"We literally started this experiment in an undergraduate physics lab with a coffee can," Baxter recalls. When he and his students peeked into the rotating can, which they had filled with sand and spun on a turntable, they found a surprise: "For water, you got a parabola; for sand, you clearly didn't." To get a clearer picture of the shape, Baxter and undergraduate student Mike Vavrek spun sand in a more sophisticated apparatus that traces the surface with a stylus. As centrifugal forces pushed the sand outward, the surface height of the sand at the center began to drop, while it rose along the walls. Eventually, the sand sculpted itself into an inverted cone. And at the highest rotation rates, a small, deep hole formed at the cone's apex.

The reason the sand responds differently from water, explains Baxter, is that the centrifugal force has an easier time deforming the water. "Sand and other granular material can support some stresses without moving; water cannot," he says. Instead of flowing to minimize stress, the sand resists for a while before yielding. "Every time you change the rotation rate, you get little avalanches that change the surface shape," says Baxter.

To understand how this process gives rise to the observed shapes, Baxter and Vavrek have tried to model it mathematically. As they reported in the November 1994 *Physical Review E*, this effort largely matched the experimental data. But the model wasn't perfect, notes Baxter, who now hopes to modify it based on further tests of granular materials of different shapes and sizes. Next on the list are rice and green peas—and perhaps a new set of physics problems for harried students.

–John Travis