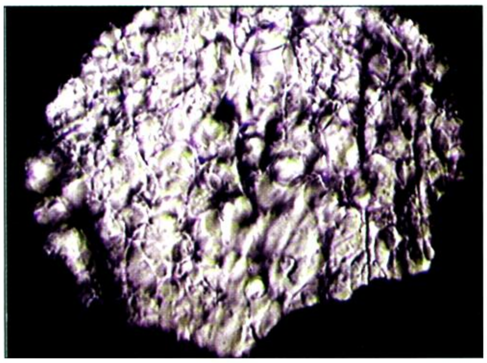


Superbugs. Microbes carve liquid veins (purple) in ice, where they survive under extraordinarily high pressure.

placing two chiseled diamonds on the ends of opposing cylinders and screwing them together. The Carnegie group layered a film of water and bacteria between the diamonds and began cranking. On page 1514, they report that molecular spectroscopy inside the anvil revealed metabolic activity in the two common bacterial species used, the gut microbe *Escherichia coli* and *Shewanella oneidensis*, which breaks down metals. Under 1.6 gigapascals, roughly 1% of the bacteria lived to tell the tale.

The findings "could expand the habitable zone to areas of great pressure," says John Baross, a professor of oceanography and astrobiology at the University of Washington, Seattle.

Studying microbes under high pressure is technically tricky, but in this case the clarity of diamonds allowed Sharma's team to gaze through the gems with a microscope. To monitor the bacteria's behavior, the group added a dye to the solution. The dye turns clear in cells capable of breaking down an organic compound called formate. By melding observations of the dye with spectroscopy data that revealed peaks and valleys indicative of formate metabolism, the team could determine how many bacteria survived. Test microbes killed with heat before being squished, in contrast, failed to signal life.

The pressure was so great that the solution turned into a form of room-temperature ice known as ice-VI. Of roughly 1 million bacteria, 10,000 remained viable after 30 hours, consuming formate and creating liquid pockets within the once-solid ice. When the researchers turned their diamond anvil upside down, the bacteria hung upside down as well—suggesting that their tails were functional enough for the microbes to cling to a surface or swim.

But whether motility and metabolism are enough to qualify the bacteria as viable is contentious. "My measure of a live cell would be one that can grow and divide," says Art Yayanos, an oceanographer at the Scripps Institution of Oceanography in La Jolla, California. Although Scott points out that the bacteria elongated and displayed characteristics suggestive of early cell division, he agrees that his group has not determined whether the bugs can divide. "I'm certain that what we're seeing is survival," he says. "But I don't know if the cells … will be able to replicate."

Bacteria don't often encounter squeezed-together diamonds, but plenty of people would like to know whether similar creatures live in other extraordinarily high-pressure environments. It's hard to tell how the new results might translate to life on Earth or elsewhere, however. The rate of bacterial survival was low in this study, says microbiologist Derek Lovley of the University of Massachusetts, Amherst, who wonders if many microbes could endure long term. Baross would like to test how microbes that are adapted to extreme environments—unlike *E. coli*—would fare.

In addition, high pressure is normally accompanied by extremes in temperature—generally hot, but on certain icy planets, very cold—and these high-pressure survivors were kept at a comfortable room temperature. Still, by bumping microbe hardiness to a new level, the study expands the range of the search for extraterrestrial life. "When people think about setting up missions to look for life, they tend to think about looking for it on the surface," says Scott. "You might want to look underneath."

–JENNIFER COUZIN

MASS EXTINCTIONS

No 'Darkness at Noon' To Do In the Dinosaurs?

Try as they might, geologists have yet to find clear signs that any day in the past half-billion years was as bad as that one 65 million years ago, when a mountain-size asteroid or comet slammed into the Yucatán Peninsula. Life suffered mightily, the dinosaurs disappeared, and mammals seized the day. The immediate cause of death has long been listed as starvation after the 100-million-megaton impact threw up a sun-shrouding pall of dust. Even a lesser impact's dust could threaten civilization, some warned.

Now, a geologist is questioning whether that ancient impact produced that much dust after all; perhaps the "darkness at noon" dust scenario was more like a dim winter's day in Seattle. The impact still gets the blame, but other killing mechanisms—an obscuring acid haze, global fires and smoke, or a combination of mechanisms—may have done the dirty work. The finding, if it stands up, might help explain the seeming absence of other impact crises and reduce, at least marginally, the potential hazard to civilization if another massive body were to strike.

The challenge to the dust scenario comes from the latest attempt to estimate the amount of the smallest bits of debris from the impact. To cut off photosynthesis and starve the dinosaurs, copious amounts of submicrometer particles would have to have floated in the atmosphere for months. But this fine dust can't be measured directly in the 3-millimeter-thick, global layer of impact debris because it would have weathered away to clay.

Geologist Kevin Pope of Geo Eco Arc Research in Aquasco, Maryland, scoured the literature for reports of the size and abundance of larger, more rugged bits of impact debris—typically quartz grains averaging 50 micrometers in size—found in the global layer, which consists mostly of relatively large spherules condensed from the plume of vapor that rose from the impact. From these measurements, Pope tried to understand the dispersal of the dust cloud.

In the February issue of *Geology*, Pope reports that the size of this larger debris dropped off sharply with increasing distance from the impact, as if it had fallen from wind-blown debris clouds rather than being blasted around the globe by the impact. Indeed, when Pope modeled debris dispersal by winds alone, the modeled drop-off in both size and mass of debris grains resembled that seen in the global layer, but only if the total amount of debris produced by the impact was relatively small.

In addition, assuming that the impact debris had a distribution of particle sizes similar to that of volcanic ash, Pope concludes that less than 1% of the debris consisted of submicrometer particles. Therefore, the dust in the global layer "is two to three orders of magnitude less than that needed to shut down photosynthesis," he writes.

Beginning of the dinosaurs' end. Global fires triggered by the impact rather than obscuring dust may have done in the great beasts.

Researchers are generally cautious about setting aside dust as a killer. "This is a very complicated problem," says atmospheric physicist Brian Toon of the University of Colorado, Boulder. "We're all inferring this. The relation between big and small particles is not obvious."

Planetary physicist Kevin Zahnle of NASA's Ames Research Center in Mountain View, California, tends to agree that dust was not the likely killer, but he's not persuaded by Pope's evidence. He, Toon, and others have estimated that 10-kilometer impactors would produce huge amounts of dust. But Zahnle acknowledges that if dust really can trigger major extinctions, there should have been many impact-triggered extinctions in the past few hundred million years, because there have been many impactors larger than the few-kilometer minimum for a global dust cloud. Yet, none besides the dinosaur killer has been proven, so Zahnle now leans toward global fire and its sun-blocking smoke. Such fires would come from vapor condensing into blazing-hot droplets that fall to the surface, radiating heat on the way down; only an impactor 10 kilometers in size or larger could throw up enough vapor to set the planet on fire.

"Everyone has their own favorite mechanism," says Zahnle. "We don't know the facts, so you operate from your intuition."

If dust really isn't to blame, then the environmental punch of larger impacts would be less than researchers have generally assumed, and encounters with smaller objects might be less disastrous. But, as Zahnle cautions, because the only data come from a single huge example, taking a lesson from the death of the dinosaurs is fraught with difficulty.

–RICHARD A. KERR

ANALYTICAL CHEMISTRY

New Test Could Speed Bioweapon Detection

Last fall's anthrax attacks in the United States exposed more than the potential dangers of terrorism by mail. They also showed that current schemes for detecting the deadly bacterium carry an unwelcome trade-off: They're either fast but prone to mistakes, or highly accurate but slow (*Science*, 9 November 2001, p. 1266).

Much the same can be said for tests to detect other pathogens, including both potential biowarfare agents such as smallpox and botulism and more common threats such as the bacteria that cause strep throat and other infections. But a new way to detect specific DNA sequences offers hope for swift and accurate microbe detection.

On page 1503, three researchers at Northwestern University in Evanston, Illinois, report creating simple electronic chips that can detect DNA from anthrax and other organisms in minutes. The chips appear to be vastly more sensitive than other high-speed techniques. And, unlike many such tests, they don't rely on the polymerase chain reaction. This procedure, commonly used to amplify snippets of DNA, can be tricky to carry out and sometimes introduces unwanted errors.

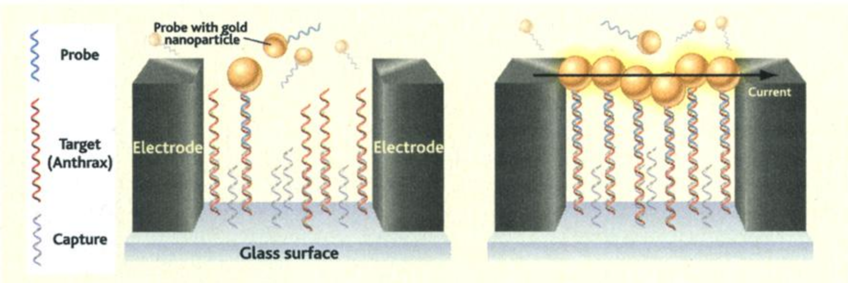
The new test is "a very clever idea that would lend itself to very inexpensive [diagnostic] devices," says Stephen Morse, a molecular biologist at Columbia University's Mailman School of Public Health and former program manager of the Advanced Diagnostics Program at the Defense Advanced Research Projects Agency. "It sounds like this technique has a lot of potential."

The work grew out of earlier experiments, in which Northwestern University chemist Chad Mirkin and colleagues linked DNA to microscopic specks of metal, known as nanoparticles, to create chemical complexes that changed color in the presence of a target DNA strand (*Science*, 22 August 1997, p. 1036). But because it takes a fair amount of target DNA to produce the color change, Mirkin decided to look for a more sensitive test.

Mirkin and group members So-Jung Park and T. Andrew Taton (who is now at the University of Minnesota, Twin Cities) devised a two-part scheme for first capturing their DNA-based target, then converting that DNA into a wire to carry an electrical current between two electrodes. The researchers started by placing a pair of electrodes 20 millionths of a meter apart atop a glass microscope slide. To the glass surface between the electrodes, they anchored numerous identical snippets of single-stranded DNA, each designed to bind to one end of complementary DNA from the target organism: the anthrax bacterium. The team then immersed the setup in a beaker containing the target DNA and waited a few minutes while the chip-bound DNA yanked the target strands out of solution, filling the space between the electrodes with a patchy lawn of anthrax DNA.

To turn those DNA strands into a wire, Mirkin's group created a second set of single-stranded DNAs, called "probe" strands. One end of each probe was designed to bind to the free end of the target DNA strand; the other end toted a tiny gold particle. When the probes were added to the solution and found their targets, they towed the gold particles into position between the two electrodes. These gold particles act like steppingstones in a river to carry electrical current between the shores of the two electrodes, Mirkin says. The electrical DNA detector could spot anthrax DNA in concentrations of just 500 femtomolar, orders of magnitude more sensitive than current high-speed detection schemes.

The test turned out to be highly selective as well. All current DNA hybridization techniques are plagued by mismatches in which DNA strands that differ from the target by just one or two nucleotide bases also bind to capture strands, threatening false-positive readings. Because mismatched DNA doesn't bind as tightly to its partner as perfectly matched pairs do, researchers typically dislodge mismatched strands by heating their samples. But that requires additional equipment to heat and cool the samples.



Golden gate. New technique detects target DNA (here, anthrax) by using it to link fixed "capture strands" with "probe strands" attached to current-carrying gold nanoparticles.

ILLUSTRATION: A. STONEBRAKER

Mirkin's team found that adding a little salt produces the same result. Adding a solution with the right amount of salt, the Northwestern researchers discovered, forced target strands with even a single mismatch to shake loose, leaving behind only the fully complementary DNA sequences they were seeking.

"The salt work is a very nice development," says Dan Feldheim, a chemist at North Carolina State University in Raleigh. Eliminating the need for heating and cooling elements, he says, should make future DNA-detection devices both small and cheap.

Another potential advantage is versatility. Mirkin and colleagues can pack their electrical DNA detectors into arrays that look for different target DNAs simultaneously. Such multitasking could pave the way for hand-held readers that scan for a battery of different infectious agents. Mirkin is already associated with a company called Nanosphere that he says is likely to commercialize this work.

–ROBERT F. SERVICE