Tiny earthquakes tamed in the laboratory

In the heart of an earthquake, action moves at a furious pace. Fractures spread through rock at more than 7,000 kilometers per hour, literally faster than a speeding bullet. That lightning motion has long hampered scientists who model earthquakes in the laboratory. But a team of U.S. and Soviet researchers has slowed the clock on the cracking process, providing new insight into the way rocks fracture.

David A. Lockner of the U.S. Geological Survey in Menlo Park, Calif., and his colleagues developed a system that retards crack growth within a rock sample, prolonging for minutes or hours an event that normally takes less than a millisecond. In one experiment, says Lockner, "We went almost a day. I went home and went to bed and let it keep going."

The researchers studied cylinders of granite a little larger than beer bottles. Pressure exerted on the end of the cylinder by a metal ram causes the granite to fracture.

Lockner's group altered the standard experimental procedure by mounting six sensors on the cylinder to listen for the ultrasonic "sound" of microcracks that develop as the granite breaks. By feeding the acoustic information into the system that pushes on the granite, the researchers can control the rate of fracturing: If the rock starts cracking too fast, the apparatus quickly compensates by easing off the pressure to slow down the breaking process.

The sensors also serve as a miniature version of the seismometer networks used to locate earthquakes and faults. A computer determines the position of the microcracks by analyzing the time it takes the ultrasonic waves to reach each sensor. This allows the researchers to monitor action inside the cylinder and provides an unprecedented image of the way fractures grow, Lockner says.

The first microcracks develop in an unorganized fashion throughout the granite sample as it absorbs stress from the advancing ram, he and his co-workers report in the March 7 NATURE. But at some point, the action concentrates in one spot as the microcracks coalesce to form a virtual fracture. That crack expands until it cleaves the cylinder.

Among the surprises to come out of the experiment was the finding that as the fracture advances through rock, it leaves a quiet zone in its wake. Scientists see the same activity in real earthquakes but had not observed it in lab experiments. Because rock samples in the lab are so small, researchers had presumed it impossible to catch this type of behavior in experiments, says Lockner.

While scientists in Japan have previously succeeded in slowing crack growth, Lockner's group is the first to both retard fracturing and use acoustic emissions to track the developing crack, says Tengfong Wong of the State University of New York at Stony Brook. This technique will improve mathematical descriptions of the way rocks fracture, aiding efforts to study and predict earthquakes, Wong says. *– R. Monastersky*

Intimate chemistry of a symbiotic odd couple

Symbiosis, like a happy marriage between seemingly mismatched lovers, succeeds through a subtle chemistry. Each partner benefits, even though they may differ so radically that one wonders how they ever communicate.

By eavesdropping on a chemical conversation between one symbiotic couple – the soybean plant and its bacterial sidekick – two biochemists have discovered a surprisingly intimate collaboration.

In the March 8 SCIENCE, Indu Sangwan and Mark R. O'Brian from the State University of New York at Buffalo report that the soybean and the bacteria seem to share in the making of a vital molecule called heme. "It's the only example I know of where a higher organism supplies an intermediate product in a pathway of another organism," says biochemist Winston J. Brill, who has studied these bacteria and who now runs a scientific consulting firm in Madison, Wis.

Soybean plants, like many other legumes, thrive in poor soils because they link up with bacteria that convert air's nitrogen into a form the plant can use. In return, the plant encases the nitrogen-fixing microbes within pea-sized nodules along its roots and keeps them supplied with nutrients.

To fix nitrogen, the bacteria need lots of energy and oxygen – and, consequently, lots of heme. They use the molecule to make energy-generating proteins called cytochromes. Nodules hold a rich supply of heme, which helps transport oxygen and tints the nodule interior red.

Scientists have long wondered where all this heme originates. Does it come from the plant, the bacteria, or both? The nodules seem to contain heme only when bacteria are also present, suggesting the plant relies on supplies from its microbial partners. To find out more about the bacteria's role, O'Brian and Sangwan mixed a genetically altered strain of the nitrogen-fixing *Bradyrhizobium japonicum* with newly germinated soybean seedlings. The mutant microbes could not make a chemical called ALA (delta-aminolevulinic acid), the initial precursor for heme.

The researchers found that the bacteria could not make heme on their own, but heme was still produced in the nodules. "What it hints at is that both the plant and the bacteria play a role in making the heme," says Brill.

"We'd love to know if this is what happens normally," adds Mary Lou Guerinot, a molecular geneticist at Dartmouth College in Hanover, N.H., who engineered the mutant strain in 1986 and proposed that soybean might "rescue" heme-deficient bacteria.

O'Brian thinks that even unaltered *B. japonicum* may rely on its plant partner for some ALA and may somehow prod the plant into producing more of it. For example, he and Sangwan found that the bacteria produce about the same quantity of ALA whether or not they have linked up with a plant, but the amount of *heme* increases when the bacteria live symbiotically. In soybeans with bacterial collaborators, "the ability to make ALA is almost 10 times as good as in a plant that has not seen any bacteria," O'Brian explains. "The bacteroid [symbiotic bacterium] seems to be telling the plant to turn up the [ALA-making] activity."

– E. Pennisi

Most birth defects don't rise with age

Many women who postpone childbearing until their late 30s wonder whether their age increases the odds of having a child with a birth defect. For certain chromosomal disorders such as Down's syndrome, the unfortunate answer is yes. But a study of birth defects that result from unknown causes – representing more than three-quarters of all congenital defects – offers good news for thirty-something women.

Researchers at the University of British Columbia in Vancouver have completed what they call the first rigorous analysis of whether nonchromosomal birth defects increase with maternal age. The team, led by Patricia A. Baird, obtained records for the more than 500,000 live births occurring in British Columbia between 1966 and 1981. These records, they say, provide reliable data on maternal age and defects observed at birth. In order to include congenital defects not diagnosed at birth, the researchers tracked each child for up to seven years. In all, they identified roughly 27,000 children with birth defects of unknown cause.

In analyzing data on women who gave birth between their early teens and late 40s, Baird and her colleagues found no association between birth defect rates and advancing maternal age. Of the 43 types of birth defects studied, only three

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