Enzymes illuminate switch to a DNA world

In one scenario of how life on Earth began billions of years ago, RNA was a biochemical jack-of-all-trades. The molecule could not only transfer information in cells, as it still does, it could also catalyze reactions and perhaps even make copies of itself (SN: 8/10/96, p. 93).

At some point, however, various RNA functions got parceled out to other molecules, eventually leading to the strict division of labor that exists today. Now, except in some viruses, DNA acts as the blueprint for genetic information. Enzymes catalyze reactions, and RNA only carries information from DNA to the cellular machinery that synthesizes proteins.

Two studies in the Jan. 21 Proceedings of the National Academy of Sciences suggest what may have happened during that transition from an RNA to a DNA world. By examining important enzymes in present-day organisms, scientists have shed light on what these enzymes may have been like long ago.

In one of the studies, an international team of researchers analyzed an enzyme from *Pyrococcus furiosus*, an archaebacterium that thrives in boiling-hot, oxygen-poor conditions (SN: 3/11/95, p. 150). That enzyme, ribonucleotide reductase, converts the building blocks of RNA into the building blocks of DNA.

Ribonucleotide reductases from other organisms fall into three distinct categories, based on their amino acid sequences and biochemical functions. The *P. furiosus* reductase, however, "falls between categories," says Frank T. Robb, acting director of the University of Maryland's Center of Marine Biotechnology in Baltimore. "The reaction mechanism goes one way and the [amino acid sequence similarity] goes another."

Because the enzyme combines characteristics from all three classes of reductase, it appears to be a kind of "missing link," Robb says. "The term is overused, but it really does apply."

The modern forms of the ribonucleotide reductase probably evolved from something similar to the *P. furiosus* version, he says. That original reductase would have been one of the keys that opened the door to a DNA-centered world.

The team's next project is to synthesize enough of the enzyme to determine its three-dimensional structure, Robb says. The enzyme is very difficult to purify from *P. furiosus*, so he and his colleagues, Marc Fontecave and Joan Riera of the Joseph Fourier University in Grenoble, France, and Robert Weiss of the University of Utah in Salt Lake City, are trying to get a common bacterium to produce it in large quantities.

The determination of another enzyme's three-dimensional structure was essential to the second study, conducted by Stephen P. Goff and his colleagues at Columbia University and at Rutgers University in Piscataway, N.J. They looked at a leukemia virus' DNA polymerase, an enzyme that connects the building blocks of DNA.

A model of the polymerase's structure, put together by Wayne A. Hendrickson of Columbia, showed which part of the enzyme recognizes the DNA building blocks. The researchers found that exchanging just one of the amino acids in that part enabled the enzyme to synthesize RNA as well as DNA. They replaced a bulky phenylalanine with a smaller valine, which gave the RNA building block a more comfortable fit.

"These enzymes [RNA and DNA polymerases] share a lot of similarities in structure, and so rather subtle changes—in this case just one amino acid—are enough to alter that specificity," Goff says.

The DNA polymerase is a reverse transcriptase, the kind of enzyme that HIV and other retroviruses use to copy their RNA-encoded genetic information into an infected cell's DNA (SN: 5/9/92, p. 308).

"The origin of reverse transcriptase is murky and controversial," Goff says. "[Transcriptases] could be indeed very primitive and related to some of the very earliest forms of replication. The alternative view is that they devolved from some more advanced polymerase." The results of the study support the former scenario, suggesting that all polymerases evolved from the same ancestor molecule, the authors assert.

The mutant polymerase the researchers created is "rather poor," Goff says. It makes RNA chains that are only about six building blocks long. "We're trying to make it better through other mutations," he adds.

The researchers are also characterizing dozens of other mutant forms of the polymerase to learn more about its various features. — *C. Wu*

Europa ice flows hint at watery interior

Ever since it reached Jupiter in 1995, the Galileo spacecraft has thrilled astronomers with close-up views of the giant planet and its companions. Jupiter's moon Europa has excited special interest because of the possibility that its interior harbors water. New photos of Europa released by NASA last week buoy hopes of finding water—and perhaps life—under the frozen moon's surface.

These photos, the sharpest ever taken there, show giant ribbons of once-mobile ice covering parts of Europa. The discovery provides evidence that geologic activity heats ice under the surface to a near-liquid state, which allows it to gush through the solid ice crust, say scientists.

"[These are] the first flows we've seen on any of the icy moons of Jupiter," says Ronald Greeley of Arizona State University in Tempe. Wide flows can be traced for hundreds of kilometers in the photos. "This would suggest that [they are] a really thick, viscous mass, probably water-ice," says Greeley.

Planetologists must add this icy volcanism to the list of processes forever smoothing the moon's face, says Robert Sullivan, also of Arizona State. Besides the rivers of water-ice, portions of Europa's icy crust break apart and move in ways that resemble Earth's plate tectonics. Smooth patches in the photos may result from ice evaporating into space.

Much smoother than other Jovian moons, Europa bears relatively few scars from its encounters with meteors. Because few craters dot the moon's surface, Sullivan suggests it was repaved recently, within the last few million years.

"Europa is unlike any other body in the solar system," says Paul Schenk of the Lunar and Planetary Institute in Houston, noting that its combination of solid core and icy crust makes it unusual.

The exotic conditions on Europa may be able to support life, according to Sullivan. Along with relatively common organic chemicals, the moon possesses water (SN: 7/6/96, p. 8) and some internal energy to power its ice flows. The new discovery of these flows causes scientists to wonder whether internal heat could melt enough ice to form an ocean beneath the planet's surface.

It is not likely that Galileo will conclusively determine whether Europa has interior oceans, says physicist James W. Head of Brown University in Providence, R.I., who says that challenge awaits future explorers. — *D. Vergano*


NASA

Passing 700 kilometers above Europa, Galileo captured this photo of an ice flow (circled in red), which has obliterated part of a surface ridge.