Making molecules that copy themselves

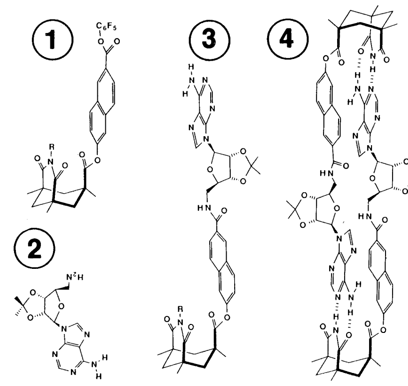
Imagine building a machine whose physical structure provides instructions for its own construction and whose parts do double duty as the construction tools. Such a machine might even manage to make a copy of itself. Chemists at MIT have now assembled a rudimentary molecular machine of this sort, and they say it could serve as a model for probing the origins of the self-replicating biochemical systems inside cells.

"At best this can be regarded as a primitive sign of life," suggest Julius Rebek Jr. and his coauthors in the Jan. 31 JOURNAL OF THE AMERICAN CHEMICAL SOCIETY. At the very least, they say, their self-copying molecule should help scientists address a profound question of biochemistry: How did nucleic acids such as DNA and RNA come to embody a blueprint for making proteins — the stuff of hair, muscles and key biological molecules such as enzymes?

The researchers assembled one of the system's two reactants, pentafluorophenyl ester, by covalently bonding it to one arm of a U-shaped molecular frame (Fig. 1 at right). With weaker hydrogen bonds, the second reactant — called amino adenosine (Fig. 2) — temporarily sticks to the frame's other arm. Amino adenosine closely resembles adenosine, a building block of nucleic acids. The specific patterns of hydrogen bonds that form between nucleic acid components endow the nucleic acids with their ability to carry and duplicate genetic information.

Thus positioned on the U-shaped frame, the reactants readily link to form an amide bond, the same kind of bond that links amino acids into proteins. The newly formed molecule, at first joined to both arms of the frame, jackknifes upward as the amino adenosine severs its hydrogen bonds with the frame and snaps in place over the ester. This yields an upright assembly (Fig. 3) whose chemical features form a template that attracts, positions and helps bond another pair of reactants (Fig. 4).

"My work shows how you can take information that exists in base pairs [as in the hydrogen-bonded pairs in DNA] and use it to drive chemical reactions that make amide and peptide bonds [as in proteins]," Rebek says. Still, he cautions, the system's limitations make it a stepping stone on the path to more sophisticated self-replicating reactions rather than an end unto itself. For instance, once the second pair of reactants links up, the resulting molecule tends to stay on the frame instead of vacating it so that new reactants can come in.



Rebek et al./JACS

Steps toward self-replication in a laboratory-made molecule.

Chemist Jonathan Sessler of the University of Texas in Austin ranks the ongoing quest to duplicate the protein-making and information-carrying feats of biochemical systems as one of the grandest in science. "To succeed would represent a landmark achievement in the history of chemistry," he says. Although two other groups in the mid-1980s described laboratory-created replicating systems based on small nucleic acid molecules, Sessler says Rebek's work takes a step beyond them by using molecules with properties of both nucleic acids and proteins.

— *I. Amato*

Drilling hits birthplace of Pacific plate

After many failed attempts over the last two decades, oceanographers have finally located the earliest portion of the Pacific plate, dating back 170 million years to Earth's Jurassic period. This piece of seafloor, identified during a drilling expedition in the Pigafetta basin southeast of Japan, holds information from an unstudied chapter in the history of the world's oceans.

During the Jurassic, a huge ocean stretched uninterrupted across most of the planet while the continents sat huddled to one side. Almost all of the seafloor from that majestic superocean has since disappeared into the Earth's interior through the process of subduction, and until now scientists have lacked any seafloor rocks from middle of that ocean.

"It's all gone, it's all been subducted, except for this part," says Roger Larson of the University of Rhode Island in Narragansett. He served as co-chief scientist on the Ocean Drilling Program's Leg 129, which ended Jan. 19.

In the early 1970s, Larson and others hypothesized that Jurassic portions of Pacific plate should lie buried in the deep western part of the ocean, near where the plate plunges into the Mariana trench. Yet he and his colleagues failed to find it in several previous expeditions. Each time, the drill bit struck a thick layer of hard volcanic rock from a more recent period in Earth's history.

This time, Larson and colleagues located thin patches in the volcanic layer through a technique known as seismic reflection profiling, which bounces acoustic waves off rock formations under the seafloor. The crew successfully penetrated the volcanic layer and drilled several hundred meters into the underlying Jurassic material.

The Jurassic rocks offer clues to the climate and biology of that era. The scientists say the sedimentary rocks contain abundant fossils from silica-shelled plankton but none from carbonate-shelled plankton. Since silica-shelled organisms withstand nutrient-poor conditions better than their carbonate counterparts, Larson suggests the Jurassic ocean had weak current systems that delivered only meager nutrient supplies from deeper waters. However, it is difficult to generalize about the entire ocean with sediments from only one site, he says.

The Pacific plate today covers about one-quarter of the Earth's surface, but during the late Jurassic it was hardly bigger than the United States, Larson says. The rest of the ocean floor consisted of other, unknown plates that have since disappeared as the Pacific plate grew.

— *R. Monastersky*

LDEF's space damage

Early looks at test samples left in space for nearly six years aboard NASA's Long Duration Exposure Facility (LDEF) have revealed surface scars from microscopic meteoroids, thin layers of various materials that were either partially degraded or eroded away, and other signs of damage from the space environment.

Engineers at Kennedy Space Center in Florida this week began removing the trays containing 57 LDEF experiments, which NASA will distribute to more than 200 investigators. LDEF was placed in orbit April 6, 1984, for a stay of 12 to 18 months, but scheduling problems and the 1986 Challenger disaster delayed its recovery. Shuttle astronauts finally retrieved it Jan. 13.

LDEF was planned to provide measurements of the effects of atomic oxygen, radiation, human-generated debris, vacuum and other conditions in space (SN: 11/11/89, p.314). Researchers will take detailed looks at such objects as two trays whose plastic-film covers NASA describes as "peeled back like a sardine can." Another LDEF experiment shows discoloration around high-voltage leads.

NASA officials involved in planning the space station are particularly interested in learning how well LDEF survived its unexpectedly long orbital stay. □