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Robot Ribosome

Nanotechnology: Researchers make a small-molecule machine that can string together three amino acids

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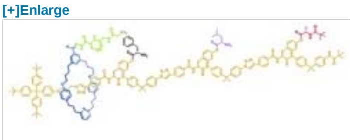
Over the past decade or so, nanotechnology has produced small-molecule machines that can walk, perform basic chemical reactions, or do mechanical tricks, such as spin around or ratchet. Yet the field has been criticized for failing to live up to its initial hype—claims that nanofactories would soon be widespread, doing useful work for humans at the molecular scale.

A new molecular machine may reawaken that initial promise by attempting to mimic, on a proof-of-principle level, one of biology's most important machines. David A. Leigh and colleagues at the University of Manchester, in England, have made a rudimentary version of the ribosome, a protein- and RNA-based factory that strings together amino acids (*Science,* DOI: 10.1126/science.1229753).

IN ACTION
This animation shows how a stripped-down ribosome analog works.
Credit: Miriam Wilson

One-thousandth the size of the original, this stripped down ribosome analog is made of four main components. The first is a molecular axle, a track on which three amino acids are sequentially attached. The second is a molecular ring that is threaded onto the axle. The third, a chemical cap, is then attached to prevent the ring from slipping backward off the axle. Meanwhile, the first amino acid blocks the ring from moving too far forward along the axle, Leigh explains.

[+]Enlarge



Credit: Courtesy of David Leigh

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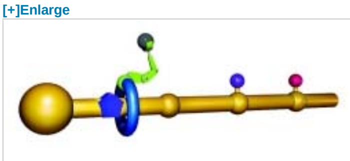

Credit: Miriam Wilson

A macrocycle ring (blue) moves along an axle, picking up amino acids (black, purple, red) with a reactive arm (green) that forms a peptide on the ring.

The fourth component is a reactive arm attached to the ring. This arm can pick up amino acids located on the axle by means of a transacylation reaction and place them sequentially in another place on the ring through chemical ligation, thereby forming a peptide that sits on the ring. As each amino acid moves from the axle to the growing peptide, the ring can slip forward to the next amino acid. After the third amino acid adds to the peptide, the ring slips off the axle with the tripeptide attached.

The proof-of-principle study "shows that an ingeniously designed artificial small-molecule machine can fulfill some of the tasks accomplished by much larger and more sophisticated biological motors," comments J. Fraser Stoddart, a Northwestern University chemist, who did not participate in the research.

Leigh is quick to point out that many improvements can be made to the machine. As more amino acids add to the growing peptide, the distance between the spot where the arm plucks off a building block and the site where it is adds to the growing peptide becomes longer. His team is working on a new design that gets around this issue and on other improvements that will allow longer and more complicated peptides to be formed.

"They've done some really beautiful chemistry here," comments R. Dean Astumian, a physical chemist at the University of Maine. "But ultimately I'm more excited that the work could help resolve a dichotomy in the field" about how synthetic molecular machines fundamentally operate. Astumian notes that researchers currently debate to what extent these machines operate stochastically—requiring noise and random motion to get the job done—and to what extent they operate in a sequential, deterministic manner.

Astumian hopes time-resolved spectroscopy can be used to detect the motion of the robot ribosome. The observations should help the field resolve this fundamental conundrum as well as provide researchers with essential information to engineer better, functional nanomachines.

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very very intereting, and very easy to understand
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