weird science

Bacteria Turns Microgears in Bio-Inspired Experiment

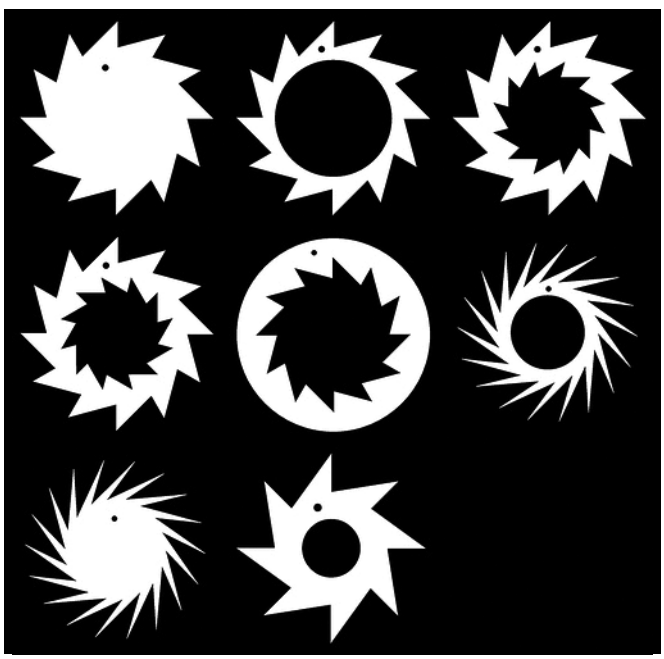
Who knew what a few hundred bacteria could do with a little cooperation? Andrey Sokolov of Princeton University, Igor Aronson from the Argonne National Laboratory and Bartosz Grzybowski and Mario Apodaca from Northwestern University found out after placing microgears (380 microns long with slanted spokes) in a solution with the common aerobic bacteria *Bacillus subtilis*. The scientists observed that the bacteria appeared to swim randomly but occasionally collided with the spokes of the gears and turned them.

"In our experiment, the gears turned for about five to seven minutes, then the bacteria runs out of food, film evaporates, etc." says Igor Aronson, an Argonne materials scientist. "In principle, the constant flow of a micro-fluidic device in rotation can be sustained over much longer time."

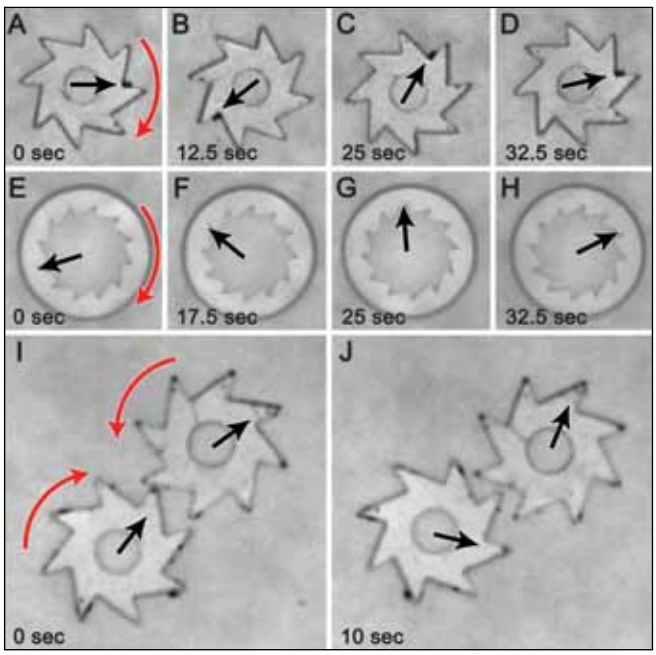
The ability to harness and control the power of bacterial motion is an important requirement for further development of hybrid mechanical systems driven by microorganisms, according to Aronson. When multiple gears are placed in the solution with the spokes connected, the bacteria will turn both gears in opposite directions, causing the gears to rotate in synchrony for long stretches of time.

"There exists a wide gap between man-made hard materials and living tissues; biological materials, unlike steel or plastics are 'alive,'" Aronson says in an Argonne Laboratory press release. "Our discovery demonstrates how microscopic swimming agents, such as bacteria or man-made nanorobots, in combination with hard materials, can constitute a smart material, which can dynamically alter its microstructures, repair damage or power microdevices."

The speed of the gears can be controlled through the manipulation of oxygen in the suspended liquid. By decreasing the amount of oxygen, researchers can slow down the gears' movement while eliminating the oxygen halts the movement entirely. If the oxygen is reintroduced, the bacteria "wakes up" and begins swimming again.



Silhouettes of several gear designs that could be turned by *Bacillus subtilis* bacteria (courtesy of Argonne National Laboratory).



This diagram tracks the movement of the gears turned by the bacteria (courtesy of Argonne National Laboratory).

Bacillus subtilis is a bacterium commonly recovered from water, soil, air and decomposing plant residue and does not possess traits that cause disease. It is not considered pathogenic or toxigenic to humans, animals or plants. But it may hold the key in the future for bio-inspired materials that can be controlled, manipulated and used as energy.

"The fact that bacteria, working together, can power gears million times heavier than themselves was one of the most significant findings in the experiment," Aronson says.

In addition to its energy use, the discovery could be developed as a natural means to repair damage. The bacteria possess nutrients and skin tissue qualities that are able to adapt to the environment and heal themselves to a certain extent.

The research at Argonne was supported by the Department of Energy's Office of Science (SC), and the work at Northwestern University was supported as part of the Non-Equilibrium Energy Research Center (NERC), an Energy Frontier Research Center also funded by SC.

Before Argonne National Laboratory began powering gears via bacteria, its researchers have helped millions of travelers fight jet lag, invented a method to help save heart attack victims by injecting their lungs with a slurry of fine ice crystals and helped prove that Beethoven suffered from lead poisoning. Argonne scientists, including the founder of the laboratory, Enrico Fermi, have won three Nobel Prizes in physics. For more information on this and other Argonne research projects, visit *www.anl.gov*.