'Backpacking' bacteria

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To the ranks of horses, donkeys, camels and other animals that have served humanity as pack animals or beasts of burden, scientists are now enlisting bacteria to ferry nano-medicine cargos throughout the human body. They reported on progress in developing these "backpacking" bacteria -- so small that a million would fit on the head of a pin -- here today at the 243rd National Meeting & Exposition of the American Chemical Society (ACS).

"Cargo-carrying bacteria may be an answer to a major roadblock in using nano-medicine to prevent, diagnose and treat disease," David H. Gracias, Ph.D., leader of the research team said. Gracias explained that nanotechnology is the engineering of ultra-small machines and other devices. These devices generally lack practical self-sustaining motors to move particles of medication, sensors and other material to diseased parts of the body. So why not attach such cargo to bacteria, which have self-propulsion systems, and have them hike around the human body?

"Currently, it is hard to engineer microparticles or nanoparticles capable of self-propelled motion in well-defined trajectories under biologically relevant conditions," Gracias said. He is with Johns Hopkins University in Baltimore, Maryland. "Bacteria can do this easily, and we have established that bacteria can carry cargo."

In addition, bacteria can respond to specific biochemical signals in ways that make it possible to steer them to desired parts of the body. Once there, bacteria can settle down, deposit their cargo and grow naturally. Bacteria already live all over the body, particularly in the large intestine,

with bacterial cells outnumbering human cells 10-to-1. Despite their popular reputation as disease-causers, there are bacteria in the human body, especially in the intestinal tract, that are not harmful, and the backpackers fall into that category.

Gracias' bacteria don't really carry little nylon or canvas backpacks. Their "backpacks" are micro- or nano-sized molecules or devices that have useful optical, electrical, magnetic, electrical or medicinal properties. The cargos that the team tested also varied in size, shape and material. So far, the team has loaded beads, nanowires and lithographically fabricated nanostructures onto bacteria.

Other scientists are seeking to enlist bacteria in transporting nano-cargo. They already have established, for instance, that large numbers of bacteria — so-called "bacterial carpets" — can move tiny objects. Gracias' research focuses on attaching one piece of cargo to an individual bacterium, rather than many bacteria to much larger cargo. The bacteria, termed "biohybrid devices," can still move freely, even with the cargo stuck to them.

"This is very early-stage exploratory research to try and enable new functionalities for medicine at the micro- and nanoscale by leveraging traits from bacteria," explained Gracias. "Our next steps would be to test the feasibility of the backpacking bacteria for diagnosing and treating disease in laboratory experiments. If that proves possible, we would move on to tests in laboratory mice. This could take a few years to complete."

More information:

Abstract

We present "backpacking bacteria" – biohybrid devices comprised of bacteria attached to micro/nano scale cargo. Backpacking bacteria combine the advantages of bacteria and cargo for use in diagnostic and

therapeutic applications. Bacteria offer numerous advantages on account of their sizes, their ability to respond to diverse stimuli, to convert chemical energy into motion and to grow naturally in niches within the body. Recent advances in micro/nanotechnologies have enabled the fabrication of micro/nano scale cargo of controlled sizes, shapes, geometries with tunable properties such as optical, electrical or magnetic properties. In our work, we investigate mechanisms of conjugating bacteria to cargo via non-specific, charge or antibody based interactions. Additionally, we vary the size, shape and material of the cargo conjugated to the bacteria. We investigate the properties of the resultant biohybrid such as the motility/chemotactic response of bacteria and magnetic/optical properties of the cargo. Prospects of utilizing backpacking bacteria for extra and/or intracellular delivery of diagnostic or therapeutic cargo are envisioned.

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