Molecular freight: Synthetic nanoscale transport system modeled on nature

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(PhysOrg.com) -- Just like our roads, there is a lot of traffic within the cells in our bodies, because cell components, messenger molecules, and enzymes must also be brought to the right places in the cell. One of these transportation systems functions like a kind of railway: a system of molecular tracks is used to transport vesicles and their contents to their target destinations.

In imitation of this natural "cargo transport", Japanese researchers have developed a synthetic molecular transport system. The scientists, led by Youichi Tsuchiya and Seiji Shinkai, report in the journal Angewandte Chemie that this could form the basis for the development of a method for transporting therapeutic genes into cell nuclei.

The cellular rail system uses actin filaments for tracks. Actin filaments are strong strands of protein that form a network inside a cell. Acting as both motor proteins and wheels are myosin molecules, which move along the tracks. The vesicle being transported hangs on to the tail end of the myosin. The myosin head consists of ATPase, an enzyme that degrades ATP. ATP is cellular fuel; its decomposition releases energy. In the process of splitting the ATP, the angle of the myosin head attached to the actin filament changes, which causes the myosin to move along the filament like a wheel on a track, bringing its cargo along for the ride.

The researchers also incorporated actin, myosin, and ATP as components for their synthetic transport system. For their container, they chose schizophyllan, a triple-stranded helical polysaccharide from fungi.

In certain solvents the helix unravels; when placed back in water, the polysaccharide twists back up into a helix. In this process, it can wrap around large molecules or nanoparticles, packaging them up. In their study, the researchers loaded these molecular containers with carbon nanotubes. They used cobalt ions to dock on several myosin units, and these wheels did indeed move the tiny freight train along the actin track. With an average speed of about 95 nm/s, the freight cars crossed the amazing distance of about 5 µm.

Transport along cellular actin tracks always moves in only one direction. The filaments are bound to each other at junctions, creating a transportation network that also allows for changes in direction within the cell. The synthetic molecular freight trains can also change from one filament to another at junctions in the network. Because the direction of the actin track leads into the cell nucleus, the artificial transport system may be useful in gene therapy, because it could wrap up the therapeutic genes and carry them into the cellular nucleus.

More information: Seiji Shinkai, A Polysaccharide-Based Container Transportation System Powered by Molecular Motors, *Angewandte Chemie International Edition*, dx.doi.org/10.1002/anie.200904909

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