CELL BIOLOGY

Miniature movers take on heavy lifting

Unicellular algae can be put to work as light-guided workhorses, offering an all-natural solution for scientists looking to develop innovative micromachines.

No doubt about it, moving a big load is hard work—just ask a trucker. Conversely, moving a tiny cargo presents challenges of its own, and in the absence of microscopic mules or truck drivers, researchers need creative solutions to direct the transport of micro- and nanoscale objects. As usual, nature offers many inspiring solutions, and several groups have focused on isolating, engineering or reconstituting systems based on the proteins that generate power for such processes as muscular contraction or the motion of flagella. George Whitesides' research group at Harvard University has taken a step back from this approach; rather than replicating or transplanting the engine from an organism—a tricky and labor-intensive process—they've put the whole organism to work, creating what they describe as a 'microscale beast of burden'.

The Whitesides group turned to the unicellular algae *Chlamydomonas reinhardtii* (*CR*), which uses dual flagella to travel at speeds of up to 200 microns per second. According to postdoc Doug Weibel, lead author on the group's recent article on 'microoxen', *CR* is easy to culture and offers another important benefit: "This organism has the ability to sense light… which we were interested in, because it would allow us to guide these with light. It also has a bunch of other phenotypes for guiding its movements—it's chemotactic, geotactic, gyrotactic… so we figured that we'd look at light, and if that didn't pan out, we'd look at something else."

Weibel and his colleagues conjugated polystyrene beads with a photocleavable chemical group that binds to the *CR* algal wall, and used LED lights to guide algae through clumps of beads. The cells readily picked up individual beads and could easily be steered back and forth between two light sources, exhibiting high sensitivity and rapid response to changing stimuli (**Fig. 1**). The beads stayed attached throughout but could be removed via cleavage of the chemical linker with ultraviolet light. The beads generally posed no obstacle to full-speed travel, and even bigger loads are possible. "We've seen cells carrying loads with a volume approximately double their size," he says. "Cells will move smaller loads tens of centimeters… [and] will probably shuttle larger loads over these distances, but the velocity will be much slower."

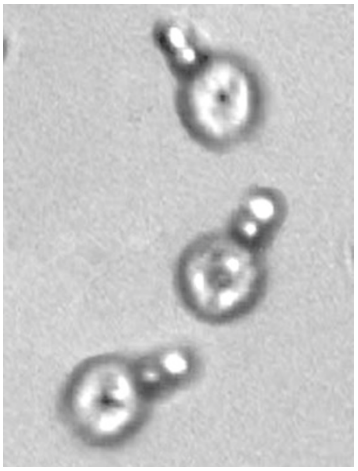

Figure 1 | *CR* transporting a bead. Three overlaid time-lapse images—taken roughly 1/30 second apart—demonstrate the light-guided movement of a single cell transporting a bead. Image courtesy of Doug Weibel.

These microoxen offer many potential applications, such as biosensing operations in which functionalized algae could be dispersed in a sample to collect or detect small molecules or microbes, then summoned back for further analysis. More immediately, however, the Whitesides group is trying to better understand what makes *CR* tick, and are now developing a tool to measure changes in flagellar force as the algae respond to different stimuli and environmental conditions. "We're very interested in how they see," says Weibel, "they have a simple eye that contains a series of photoreceptors, and it isn't clear how the system works in detail. We think we can use the tool we are building to gather a lot of information about how the eye works, and possibly, about how energy is transduced in this organism."

Michael Eisenstein

RESEARCH PAPERS

Weibel, D.B. *et al.* Microoxen: microorganisms to move microscale loads. *Proc. Natl. Acad. Sci. USA* **102**, 11963–11967 (2005).