Tiny scallop-like robotic swimmers could deliver drugs to treat diseases

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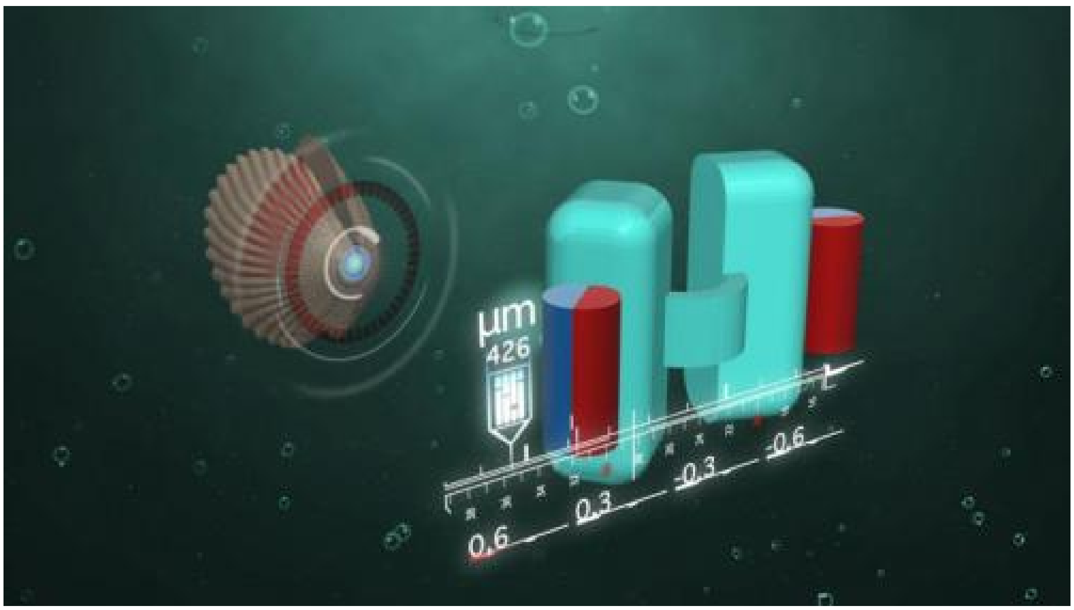

Artificial micro-swimmer in the shape of a scallop Credit: Alejandro Posada/MPI-IS

Researchers at the Max Planck Institute in Germany have developed a tiny robot small enough to travel through the bloodstream—and it doesn't require an engine or batteries. In their paper published in *Nature Communications*, the researchers describe their new robot and how it might one day be used to treat a variety of human ailments.

Scientists have dreamed of using [tiny robots](#) to treat diseases for years, but until now, the technology to make it happen hasn't kept up with our imagination. In the past few years, researchers have come up with a wide variety of such robots that work in a wide variety of different ways. One common obstacle however, that all must overcome is the means by which such robots are powered. Creating an engine small enough has proven, thus far, too difficult. Instead scientists have looked to using chemicals inside the body as fuel, or external magnets to drag them around. Another problem has been that fluids inside the body are generally of the non-Newtonian variety, which means the viscosity changes as pressure changes. That means motors that are used in water, such as spinning screws, won't work. In this new effort, the researchers have addressed both problems to come up with a super tiny robot that can be moved via an external magnetic power source.

The idea for the new robot was inspired by the lowly scallop, which moves around by opening and closing a pair of shells. The robot moves through a non-Newtonian fluid by performing what looks like horizontal jumping jacks, though the forward motion in this case is fast, while the backward motion is done slowly. The flapping occurs due to the presence of a magnet. The result is a robot that pulls itself through a fluid. Notably, the magnet, applied from outside the body, doesn't pull the robot along, instead, it causes the flapping, which in turn is what causes the movement.

Because the robot has no motor, it can be made extremely small, (the test robots were 800 microns wide by 300 microns thick)—small enough to swim around in the bloodstream, in the eyeballs or anywhere else there is fluid. The design has other advantages as well, the tiny bots can be printed on a 3D printer, and many of them could be directed at once with a single magnet.

The team doesn't have any particular applications in mind for their robots, but it's clear that they could be used to send medication to single spot, such as to kill a tumor, or to provide missing substances, such as occurs in the joints as people age.

More information: Swimming by reciprocal motion at low Reynolds number, *Nature Communications* 5, Article number: 5119 DOI: 10.1038/ncomms6119

Abstract
Biological microorganisms swim with flagella and cilia that execute nonreciprocal motions for low Reynolds number (Re) propulsion in viscous fluids. This symmetry requirement is a consequence of Purcell's scallop theorem, which complicates the actuation scheme needed by microswimmers. However, most biomedically important fluids are non-Newtonian where the scallop theorem no longer holds. It should therefore be possible to realize a microswimmer that moves with reciprocal periodic body-shape changes in non-Newtonian fluids. Here we report a symmetric 'micro-scallop', a single-hinge microswimmer that can propel in shear thickening and shear thinning (non-Newtonian) fluids by reciprocal motion at low Re. Excellent agreement between our measurements and both numerical and analytical theoretical predictions indicates that the net propulsion is caused by modulation of the fluid viscosity upon varying the shear rate. This reciprocal swimming mechanism opens new possibilities in designing biomedical microdevices that can propel by a simple actuation scheme in non-Newtonian biological fluids.