Synchronized swimming of algae

July 23 2009

Using high-speed cinematography, scientists at Cambridge University have discovered that individual algal cells can regulate the beating of their flagella in and out of synchrony in a manner that controls their swimming trajectories. Their research was published on the 24th July in the journal *Science*.

The researchers studied the unicellular organism *Chlamydomonas reinhardtii*, which has two hair-like appendages known as flagella. The beating of flagella propels *Chlamydomonas* through the fluid and simultaneously makes it spin about an axis.

The researchers found that cells can beat their flagella in two fundamentally distinct modes: synchronised, with nearly identical frequencies and positions, and unsynchronised, with two rather different frequencies. Using a specialised apparatus to track the swimming trajectories of individual cells, the group showed that the periods of synchrony correspond to nearly straight-line motion, while sharp turns result from the asynchronous beating. Whereas previous studies had suggested that these modes were associated with different subpopulations of cells, the new work shows that the cells actually control the frequencies and thereby switch back and forth between the two modes. In essence, this suggests *Chlamydomonas* has two 'gears'.

Moreover, the researchers have developed a mathematical analysis that describes the two beating flagella as "coupled oscillators," in a way similar to models of synchronised flashing of fireflies and the "Mexican wave" of people in a stadium. Analyzing terabytes of data on the patterns of synchronisation, they showed that the strength of the coupling was consistent with it arising from the fluid flows set up by the beating flagella. These observations constitute the first direct demonstration that hydrodynamic interactions are responsible for synchronisation, which has long been predicted to lead to such coordination.

Professor Raymond E. Goldstein, the Schlumberger Professor of Complex Physical Systems in the Department of Applied Mathematics and Theoretical Physics (DAMTP) and lead author of the study, said: "These results indicate that flagellar synchronization is a much more complex problem than had been appreciated, and involves a delicate interplay of cellular regulation, hydrodynamics, and biochemical noise."

Funded by the Biotechnology and Biological Sciences Research Council (BBSRC), the work is part of a larger effort to improve our knowledge of evolutionary transitions from single-cell organisms (like *Chlamydomonas*) to multicellular ones. In addition, the flagella of *Chlamydomonas* cells are nearly identical to the cilia in the human body. In many of life's processes, from reproduction to respiration, coordinated action of cilia plays a crucial role. For this reason, insight into synchronization and its control may have significant implications for human health and disease.

More information: The article 'Chlamydomonas swims with two `gears' in a eukaryotic version of run-and-tumble locomotion' was published Friday 24th July in the journal *Science*.

Source: University of Cambridge (news : web)